Instruction manual

EtherCAT® slave interface for digital multibus Mass Flow / Pressure instruments

Doc. no.: 9.17.063Q Date: 04-08-2021

ATTENTION
Please read this instruction manual carefully before installing and operating the instrument.
Not following the guidelines could result in personal injury and/or damage to the equipment.

Bronkhorst®

Disclaimer

The information in this manual has been reviewed and is believed to be wholly reliable. No responsibility, however, is assumed for inaccuracies. The material in this manual is for information purposes only.

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Symbols

Important information. Discarding this information could cause injuries to people or damage to the Instrument or installation.

Helpful information. This information will facilitate the use of this instrument.

Additional info available on the internet or from your local sales representative.

Warranty

Bronkhorst® products are warranted against defects in material and workmanship for a period of three years from the date of shipment, provided they are used in accordance with the ordering specifications and the instructions in this manual and that they are not subjected to abuse, physical damage or contamination. Products that do not operate properly during this period may be repaired or replaced at no charge. Repairs are normally warranted for one year or the balance of the original warranty, whichever is the longer.

See also paragraph 9 of the Conditions of sales:
http://www.bronkhorst.com/files/corporate_headquarters/sales_conditions/en_general_terms_of_sales.pdf

The warranty includes all initial and latent defects, random failures, and undeterminable internal causes.

It excludes failures and damage caused by the customer, such as contamination, improper electrical hook-up, physical shock etc.

Re-conditioning of products primarily returned for warranty service that is partly or wholly judged non-warranty may be charged for.

Bronkhorst High-Tech B.V. or affiliated company prepays outgoing freight charges when any party of the service is performed under warranty, unless otherwise agreed upon beforehand, however, if the product has been returned collect to our factory or service center, these costs are added to the repair invoice. Import and/or export charges, foreign shipping methods/carriers are paid for by the customer.

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1 GENERAL PRODUCT INFORMATION

1.1 INTRODUCTION

Ethernet for Control Automation Technology (EtherCAT) is an open high performance Ethernet-based field bus system. The development goal of EtherCAT was to apply Ethernet to automation applications which require short data update times (also called cycle times) with low communication jitter (for synchronization purposes) and low hardware costs. Bronkhorst® implemented EtherCAT[1)] on its instruments.

Typical automation networks are characterized by short data length per node, typically less than the minimum payload of an Ethernet frame. Using one frame per node per cycle therefore leads to low bandwidth utilization and thus to poor overall network performance. EtherCAT therefore takes a different approach, called "processing on the fly".

With EtherCAT, the Ethernet packet or frame is no longer received, then interpreted and copied as process data at every node. The EtherCAT slave devices read the data addressed to them while the telegram passes through the device. Similarly, input data are inserted while the telegram passes through. The frames are only delayed by a fraction of a microsecond in each node, and many nodes - typically the entire network - can be addressed with just one frame.

Short cycle times can be achieved since the host microprocessors in the slave devices are not involved in the processing of the Ethernet packets to transfer the process images. All process data communication is handled in the slave controller hardware. Combined with the functional principle this makes EtherCAT a high performance distributed I/O system: Process data exchange with 1000 distributed digital I/O takes about 30 µs, which is typical for a transfer of 125 byte over 100Mb/s Ethernet. Data for and from 100 servo axis can be updated with up to 10 kHz. Typical network update rates are 1–30 kHz, but EtherCAT can be used with slower cycle times, too, if the DMA load is too high on your PC.

*[1)] EtherCAT®: **EtherCAT® is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.***

1.2 MULTIBUS TYPES

In 2000 Bronkhorst® developed their first digital instruments according to the “multibus” principle. The basic pc-board on the instrument contained all of the general functions needed for measurement and control, including alarm, totalizing and diagnostic functions. It had **analog** I/O-signals and also an **RS232** connection as a standard feature. In addition to this there is the possibility of integrating an interface board with **DeviceNet™**, **PROFIBUS DP**, **Modbus** or **FLOW-BUS** protocol. The first generation (**MBC-I**) was based on a 16 bit Fujitsu controller. It was superseded in 2003 by the Multibus type 2 (**MBC-II)**. This version was also based on the 16 bit Fujitsu controller but it had several improvements to the MBC-I. One of them is the current steering of the valve. It reduced heat production and improved control characteristics. The latest version Multibus controller type 3 (**MBC3**) is introduced in 2011. It is build around a 72MHz 32 bit NXP ARM controller. It has AD and DA controllers on board which makes it possible to measure noise free and control valves without delays. The internal control loop runs 6 times faster compared to the MBC-II therefore control stability has improved significantly. It also has several improved functions like reverse voltage protection, inrush current limitation and overvoltage protection.

MBC3 instruments can be recognised by the “MBC3” placed on lower left side of the instrument label (see example).

1.2.1 References to other applicable documents

Manuals and guides for digital instruments are modular. General instructions give information about the functioning and installation of instruments. Operational instructions explain the use of the digital instruments features and parameters. Field bus specific information explains the installation and use of the field bus installed on the instrument.

1.2.2 Manuals and user guides:

General instructions Instrument type based

Document 9.17.022
Bronkhorst®
General instructions digital Mass Flow / Pressure

Document 9.17.031
Bronkhorst®
General instructions CORI-FLOW

Document 9.17.050
Bronkhorst®
General instructions mini CORI-FLOW

Document 9.17.044
Bronkhorst®
General instructions digital LIQUI-FLOW L30

Document 9.17.104 / 9.17.105
Bronkhorst®
Instruction manual MASS-STREAM D-6300

Document 9.17.120
Bronkhorst®
Instruction manual mini CORI-FLOW MI1x0

Operational instructions

Document 9.17.023
Operational instructions for digital multibus Mass Flow / Pressure instruments

Field bus specific information

Document 9.17.024
FLOW-BUS interface

Document 9.17.025
PROFIBUS DP interface

Document 9.17.026
DeviceNet interface

Document 9.17.035
Modbus interface

Document 9.17.027
RS232 interface with FLOW-BUS protocol

Document 9.17.063
EtherCAT interface

Document 9.17.095
PROFINET interface

Document 9.17.142
POWERLINK interface

1.2.3 Technical Drawings:

Hook-up diagram laboratory-style EtherCAT	(document nr. 9.16.098)
Hook-up diagram MI-Ethernnet variants	(document nr. 9.16.200)
Hook-up diagram ES-FLOW Ethernet interfaces	(document nr. 9.16.251)
Hook-up diagram industrial Ethernet M12	(document nr. 9.16.253)

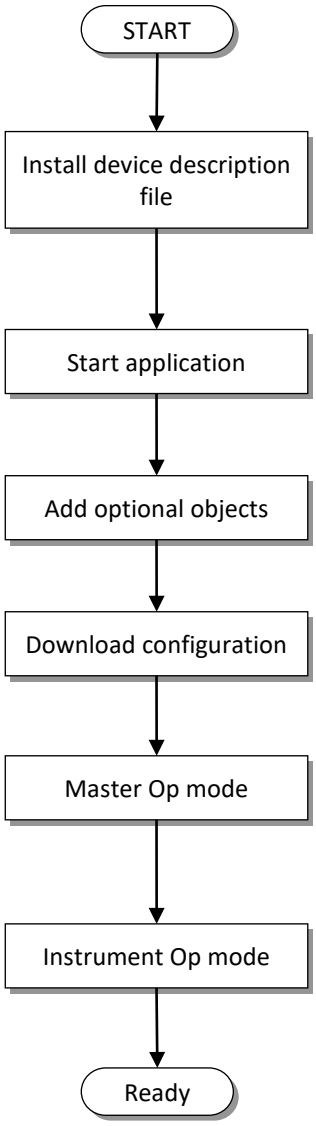
1.2.4 Software tooling:

Flowfix
FlowDDE

All these documents can be found at:
http://www.bronkhorst.com/en/downloads

1.3 SHORT FORM START-UP

All necessary settings for this module are already performed at Bronkhorst®.
To follow next steps carefully is the quickest way to get this module operational in your own EtherCAT environment.



Bronkhorst® provides an EtherCAT device description file (xml format). This file provides the master with information about the instrument to aid with its configuration. The device description file should be placed in the directory specified by the master. E.g. when using TwinCAT this could be C:\TwinCAT\Io\EtherCAT.

Start the master application.

Optional: add objects to the PDO mapping objects 0x1700 and/or 0x1B00.

Set the master application to download the configuration and activate it.

The master application indicates to run in *Op* mode

The instrument's status led indicates to run in *Op* mode

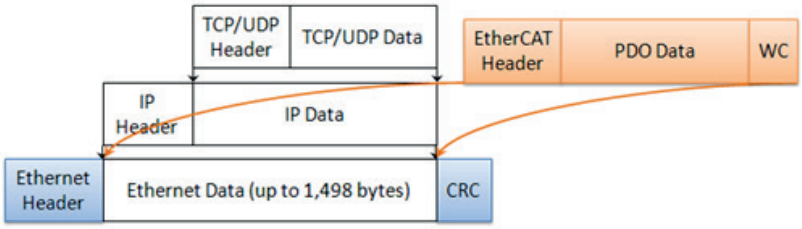
Bit 0 of object 0x6425:01 "CO Control Byte" should be 1 to activate the PID controller (bit 0 = controller on/off).

The PID controller is activated by default, but because this object is included in the process data (PDO), the value 0 can be written by the EtherCAT master after entering the operational state.

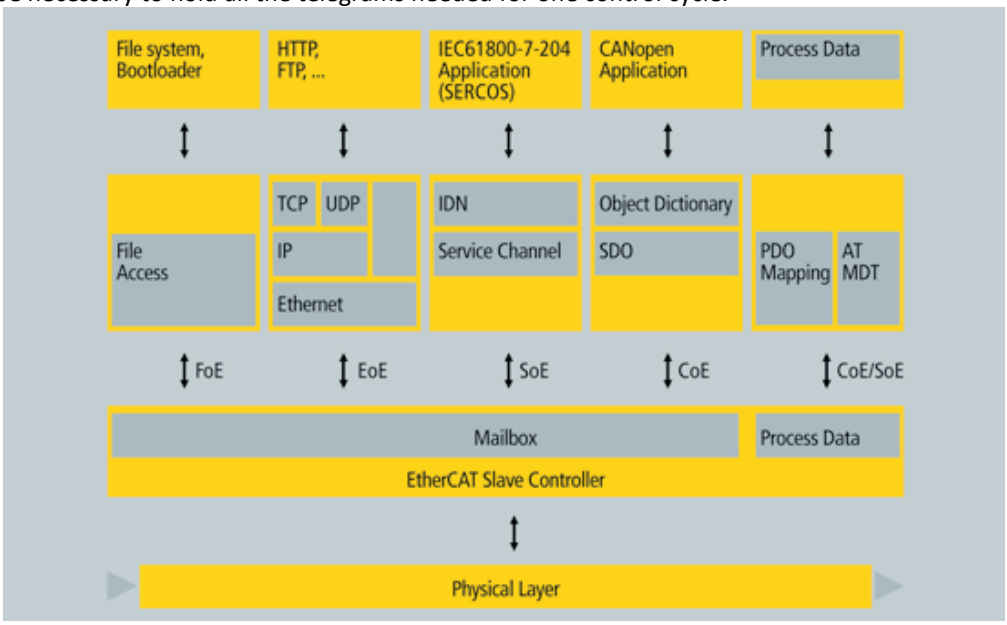
See APPENDIX A: OBJECT DICTIONARY, description of 0x6425 "CO Control byte".

2 FUNDAMENTALS OF ETHERCAT

The EtherCAT protocol transports data directly within a standard Ethernet frame without changing its basic structure. When the master controller and slave devices are on the same subnet, the EtherCAT protocol merely replaces the Internet Protocol (IP) in the Ethernet frame.

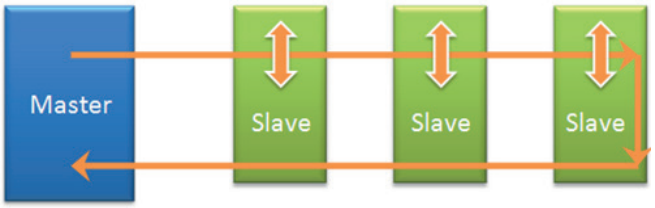


Data is communicated between master and slaves in the form of process data objects (PDOs). Each PDO has an address to one particular slave or multiple slaves, and this "data and address" combination (plus the working counter for validation) makes up an EtherCAT telegram. One Ethernet frame can contain multiple telegrams, and multiple frames may be necessary to hold all the telegrams needed for one control cycle.



Several Device Profiles and Protocols can co-exist side by side

With some real-time protocols, the master controller sends a data packet and must wait for the process data to be interpreted and copied at every slave node. However, this method of determinism may be difficult to sustain because the master controller must add and manage a certain amount of processing time and jitter per slave. EtherCAT technology overcomes these system limitations by processing each Ethernet frame on the fly. For example, suppose the Ethernet frame is a moving train, and the EtherCAT telegrams are train cars. The bits of PDO data are people in the cars who can be extracted or inserted by the appropriate slaves. The whole "train" passes through all the slave devices without stopping, and the end slave sends it back through all the slaves again.



In the same way, when device 1 encounters the Ethernet packet sent by the master, it automatically begins streaming the packet to device 2, all while reading and writing to the packet with only a few nanoseconds delay. Because the packet continues passing from slave to slave to slave, it could exist in multiple devices at the same time. What does this mean practically? Let's say you have 50 slave devices, and different data is sent to each slave. For non-EtherCAT implementations, this may mean sending out 50 different packets. For EtherCAT, one long packet that touches all slaves is sent, and the packet contains 50 devices worth of data. However, if all the slaves need to receive the same data, one short packet is sent, and the slaves all look at the same part of the packet as it is streaming through, optimizing the data transfer speed and bandwidth.

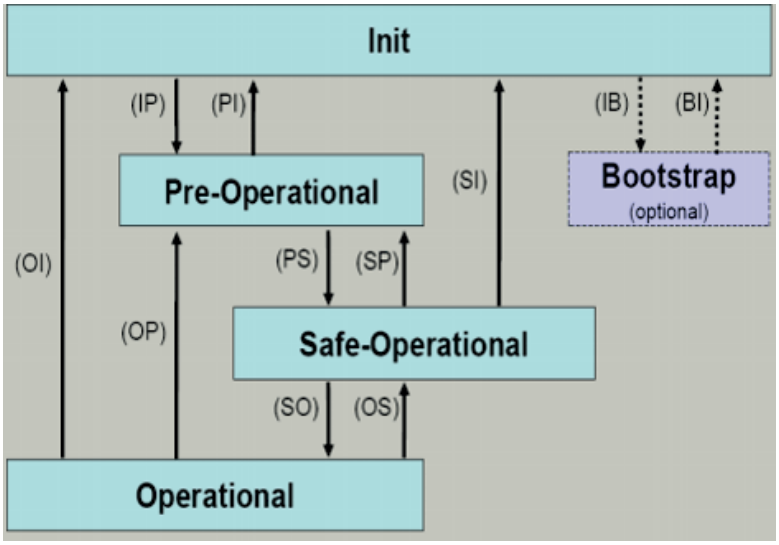
2.1 EtherCAT State Machine

The state of the EtherCAT slave is controlled via the EtherCAT State Machine (ESM). Depending upon the state, different functions are accessible or executable in the EtherCAT slave. Specific commands must be sent by the EtherCAT master to the device in each state, particularly during the boot-up of the slave.

A distinction is made between the following states:

- Init
- Pre-Operational
- Safe-Operational
- Operational
- Bootstrap

The regular state of each EtherCAT slave after boot-up is the Operational state.



Init

After power-on the EtherCAT slave is in the *Init* state. No mailbox or process data communication is possible. The EtherCAT master initializes sync manager channels 0 and 1 for mailbox communication.

Pre-Operational (Pre-Op)

During the transition between *Init* and *Pre-Op* the EtherCAT slave checks whether the mailbox was initialized correctly. In *Pre-Op* state mailbox communication is possible, but not process data communication. The EtherCAT master initializes the sync manager channels for process data (from sync manager channel 2), the FMMU channels and PDO mapping or the sync manager PDO assignment.

Safe-Operational (Safe-Op)

During transition between *Pre-Op* and *Safe-Op* the EtherCAT slave checks whether the sync manager channels for process data communication are correct. Before it acknowledges the change of state, the EtherCAT slave copies current input data into the associated DP-RAM areas of the EtherCAT slave controller (ECSC). In *Safe-Op* state mailbox and process data communication is possible, although the slave keeps its outputs in a safe state, while the input data are updated cyclically.

Operational (Op)

Before the EtherCAT master switches the EtherCAT slave from *Safe-Op* to *Op* it must transfer valid output data.
In the *Op* state the slave copies the output data of the masters to its outputs. Process data and mailbox communication is possible.

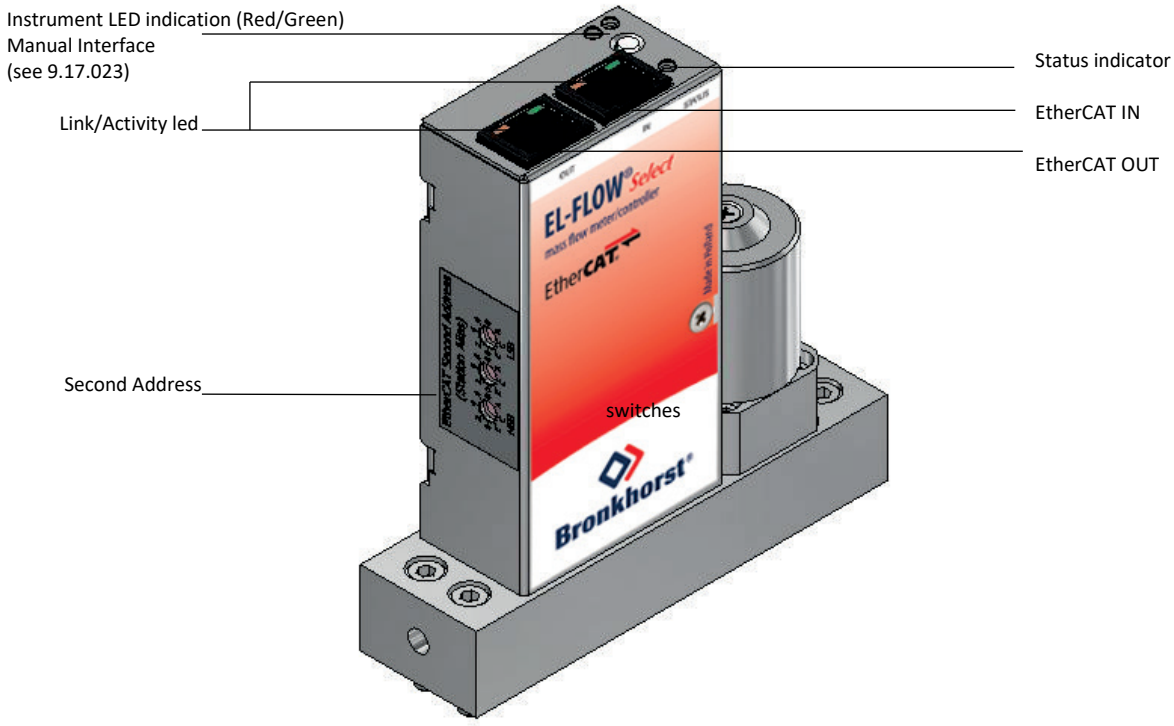
Bootstrap

In the *Bootstrap* state the slave firmware can be updated. The *Bootstrap* state can only be reached via the *Init* state.
In the *Bootstrap* state mailbox communication via the *file access over EtherCAT* (FoE) protocol is possible, but no other mailbox communication and no process data communication

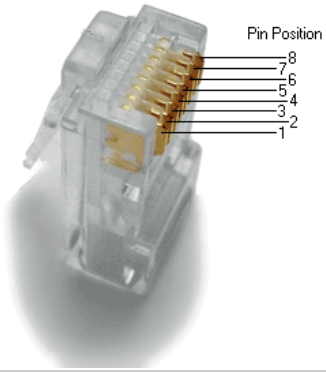
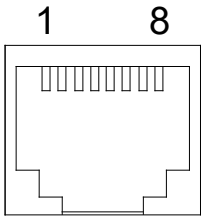
Bronkhorst® EtherCAT instruments do not support the Bootstrap *state.*

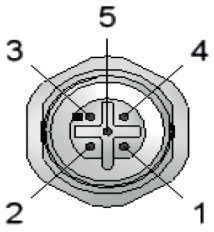
3 INSTALLATION

3.1 INSTRUMENT OVERVIEW



3.2 PIN ASSIGNMENT

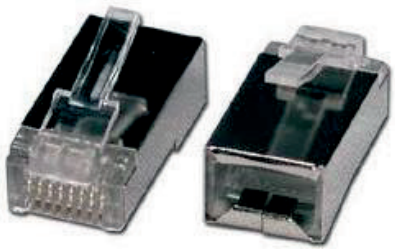
RJ45 Connector	Receptacle	Pin number	Description
		1	Transmit +
		2	Transmit -
		3	Receive +
		4	Not used
		5	Not used
		6	Receive -
		7	Not used
		8	Not used

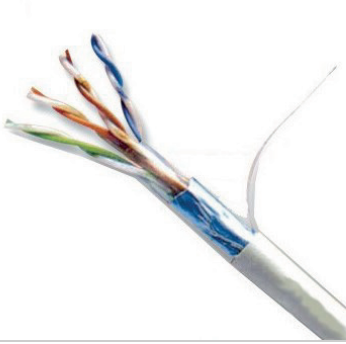
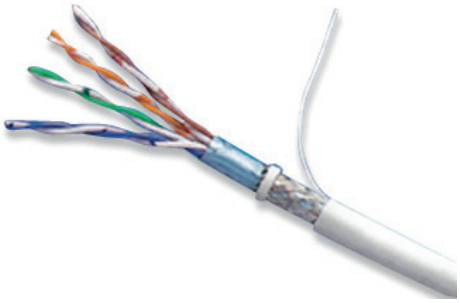
M12 –D coded male Connector	Receptacle	Pin number	Description
		1	Transmit +
		2	Receive +
		3	Transmit -
		4	Receive -
		5	Not used

3.3 CONNECTION CABLES

Ethernet patch or crossover FTP or SFTP cables in CAT5e quality can be used as the connection cables. Lengths of 0.15 to 100 m are permitted for an EtherCAT network.

If you want to make the cables yourself, be sure to select a suitable crimp tool. Afterwards check the quality with a cable tester to avoid transmission problems.

RJ45 FTP CAT.5e cable	RJ45 shielded connectors
	

FTP cable	SFTP cable
	

Example of M12-D-coded cable


CAT.5e cables are available with a wire of:
26AWG (wire diameter 0.140mm^2, with a resistance of 137 Ohm/km).
24AWG (wire diameter 0.205mm^2, with a resistance of 86 Ohm/km).

More information about cat.5e cables can be found at::
http://en.wikipedia.org/wiki/Category_5_cable

3.4 ETHERCAT CONNECTION

The Bronkhorst® instruments are equipped with a linear bus structure with two RJ45 or M12 connectors. The EtherCAT master is connected (via EtherCAT slaves, if necessary) with a shielded, twisted pair, cable to “EtherCAT IN” (RJ45 or M12). Other EtherCAT instruments are connected via “EtherCAT OUT” (RJ45 or M12).
Any topology type is possible for EtherCATnetworks (source2)

According to IEC 802.3 the maximum cable length for 100 MBaud Ethernet is 100m (100BaseT), e.g. between two instruments.

3.5 ROUTING AND SHIELDING THE BUS CABLE

Only use shielded cables and connection elements that also meet the requirements of category 5, class 2 according to IEC11801, edition 2.0.

Correct shielding of the bus cable attenuates electrical interference that may occur in industrial environments. The following measures ensure the best possible shielding:

- Manual tighten the mounting screws on the connectors, modules, and equipotential bonding conductors.
- Use only connectors with a metal housing or a metalized housing.
- Connect the shielding in the connector over a wide surface area.
- Apply the shielding of the bus cables on both ends.
- Route signal and bus cables in separate cable ducts. Do not route them parallel to power cables (motor leads)
- Route the signal cable and the corresponding equipotential bonding, if necessary, close to each other using the shortest possible route.
- Route the bus cable closely along existing grounding surfaces.

In case of fluctuations in the ground potential, a compensating current may flow via the bilaterally connected shield that is also connected to the protective earth (PE). Make sure you supply adequate equipotential bonding in such a case.

3.6 BUS TERMINATION

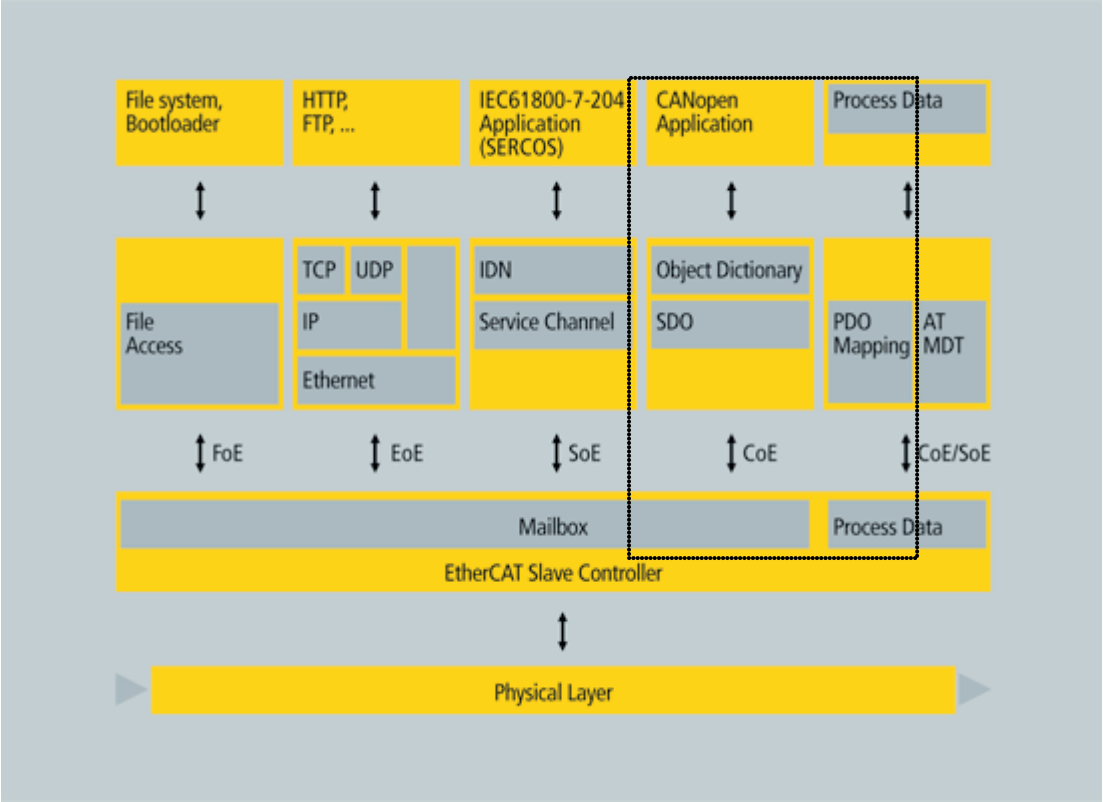
A bus terminator (e.g. using bus terminating resistors) is not necessary. If no follow-up unit is connected to an EtherCAT unit, this is automatically detected.

3.7 SECOND ADDRESS SETUP

EtherCAT supports the use of a Second Address. Bronkhorst® instruments have 3 rotary switches, with which a Second Address can be set in the range of 0 – 4095 (0xFFF).
This value of the rotary switches will be copied to the Configured Station Alias register (address 0x0012:0x0013) at instrument start-up.

4 PROTOCOLS

Bronkhorst® instruments support the following parts of EtherCAT: CAN application layer over EtherCAT (CoE) and Process Data (PDO).



4.1 CAN APPLICATION LAYER OVER ETHERCAT (COE)

Bronkhorst® instruments support the CAN application layer over EtherCAT (CoE) protocol.
This protocol enables the exchange of data between master and slave application over EtherCAT using CANopen® objects. These objects are described in the Object Dictionary. The SDO protocol is used to access (read or write) the objects in the Object Dictionary.

4.1.1 Object Dictionary

The Object Dictionary consists of 2 parts:

- objects described in the device description file.
- objects generated by the instrument itself for the parameters as described in document 9.17.023.

4.1.1.1 Object Dictionary in device description file (ESI)

The objects described in the device description file are mandatory objects. These objects are listed in Appendix A: Object Dictionary. For some objects additional information about the use in Bronkhorst® instruments can be found here as well.

The current EtherCAT ESI file can be downloaded from:
http://www.bronkhorst.com/en/products/accessories/software_tools/

4.1.1.2 Generated Object Dictionary

All available parameters in Bronkhorst® instruments are described in 9.17.023. These parameters are accessed by means of a process / process parameter number combination. For a selection of these parameters objects are generated and added to the Object Dictionary at instrument startup (in the range 0x2000 – 0x3000). The mapping from process / process parameter number combination to objects is done in the following way:

object index *= 0x2000 + process number*
subindex *= process parameter number + 1*
subindex channel 1 *= process parameter number + 1*
subindex channel 2 *= process parameter number + 1 + 100*
subindex channel 3 *= process parameter number + 1 + 200*
etc.

The sub-indexes for channel 2 and up are only applicable for multi-channel systems.

Example:
DDE parameter 8: Measure has process / process parameter number combination 1 / 0. So this parameter is mapped to object index 0x2001 (= 0x2000 + 1) and subindex 1 (= 0 + 1).

For the following DDE parameters (among others) objects are generated:

8 Measure
9 Setpoint
10 Setpoint slope
21 Capacity
24 Fluid number
92 Serial number
205 fMeasure
206 fSetpoint

4.2 PROCESS DATA (PDO)

The Process Data are organized in process data objects (PDO), which are transferred using the efficient means of EtherCAT.

Objects from the Object Dictionary, which can be mapped to the PDO, can be added to the PDO Map before activating the configuration. It is possible to add 20 objects to the RxPDO Map (0x1700) and 20 objects to the TxPDO Map (0x1B00).

Which objects from the the Object Dictionary can be mapped to the PDO, can be found in Appendix A: Object Dictionary.

All objects in the range 0x2000 – 0x3000 can be mapped to the PDO, except the ones containing strings.

5 DEVICE PROFILE DS-404 SUPPORT

Bronkhorst® instruments support the mandatory objects from the controller function block from CiA (draft) DS 404 V1.2, *Measurement Devices and Closed Loop Controllers.* These objects (0x6400 – 0x7405) are also listed in Appendix A: Object Dictionary

Object 0x6406 contains a representation of the unit for current value and setpoint. This representation is based on ETG.1004 *EtherCAT Unit specification*, which only contains SI units (see Appendix B: SI Unit AND Prefix Specification). Bronkhorst® instruments support a lot of non-SI units, which are described in Appendix C: Non-SI Unit Specification.

The unit is represented by an unsigned32 value with the following meaning:

Prefix		Numerator		Denominator		reserved	
31	24	23	16	15	8	7	0

Examples:

kg/s is represented by

Prefix	Numerator	Denominator	reserved
0x00	0x02	0x03	0x00

with

Prefix = 0x00	means no prefix
Numerator = 0x02	means kg
Denominator = 0x03	means s

mln/min is represented by

Prefix	Numerator	Denominator	reserved
0xFD	0xC0	0x47	0x00

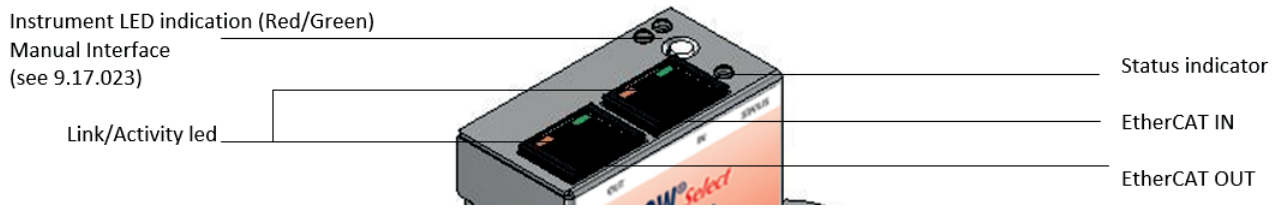
with

Prefix = 0xFD	means 10^{-3} = milli
Numerator = 0xC0	means ln
Denominator = 0x47	means min

6 DIAGNOSTICS

6.1 ETHERCAT STATUS INDICATOR

Bronkhorst® instruments contain an EtherCAT two color status led: green and red. The led indicates the actual EtherCAT run state (green) and the actual error state (red).
The status led has several indicator states, which are applicable for both green and red. They are described in the table below.



Indicator state	Definition
on	The indicator is constantly on
off	The indicator is constantly off
blinking	The indicator is repeatedly on for 200 ms and off for 200 ms
single flash	The indicator is repeatedly on for 200 ms and off for 1000 ms
double flash	The indicator shows repeatedly a sequence of two short flashes (200 ms), separated by an off phase (200 ms), followed by a long off phase (1000 ms)

6.1.1 Run indicator

Indicator state (green)	EtherCAT state
Off	Init
Blinking	Pre-Operational
Single flash	Safe-Operational
On	Operational

6.1.2 Error indicator

Indicator state (red)	Error state
Off	No error
Blinking	• invalid state change commanded by master (e.g. from Init to Operational) • request for state change to an unsupported state (e.g. Bootstrap) • request for state change to an unknown state
Single flash	• invalid mailbox configuration • invalid SyncManager configuration
Double flash	Application watchdog timeout (e.g. when EtherCAT communication cable is removed)

6.1.3 Link/Activity led

Link/Activity led	
Green OFF	Link 10Mbit or no connection
Green solid ON	Link 100Mbit
Orange OFF	No activity or no connection
Orange blinking	Activity

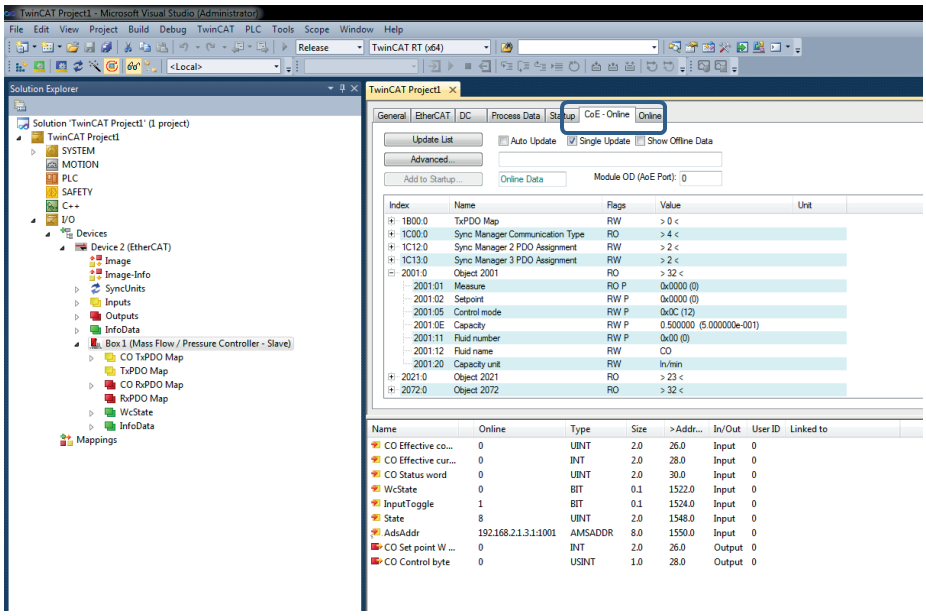
7 EXAMPLE CONFIGURATION TWINCAT SYSTEM MANAGER

7.1 CoE - Online tab

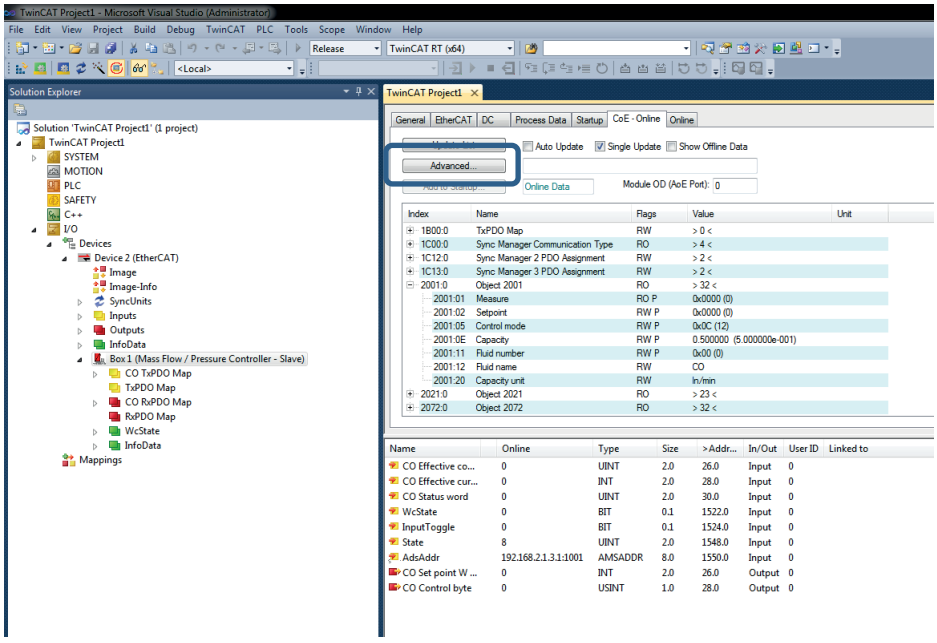
The additional *CoE - Online* tab is displayed if the EtherCAT slave supports the *CANopen over EtherCAT* (CoE) protocol. This dialog lists the content of the object list of the slave (SDO upload) and enables the user to modify the content of an object from this list. Details for the objects of the individual EtherCAT devices can be found in the device-specific object descriptions.

How to add additional Bronkhorst parameters to the CoE - Online tab in TwinCAT 3
Used version of TwinCAT 4.030319.
https://infosys.beckhoff.com/

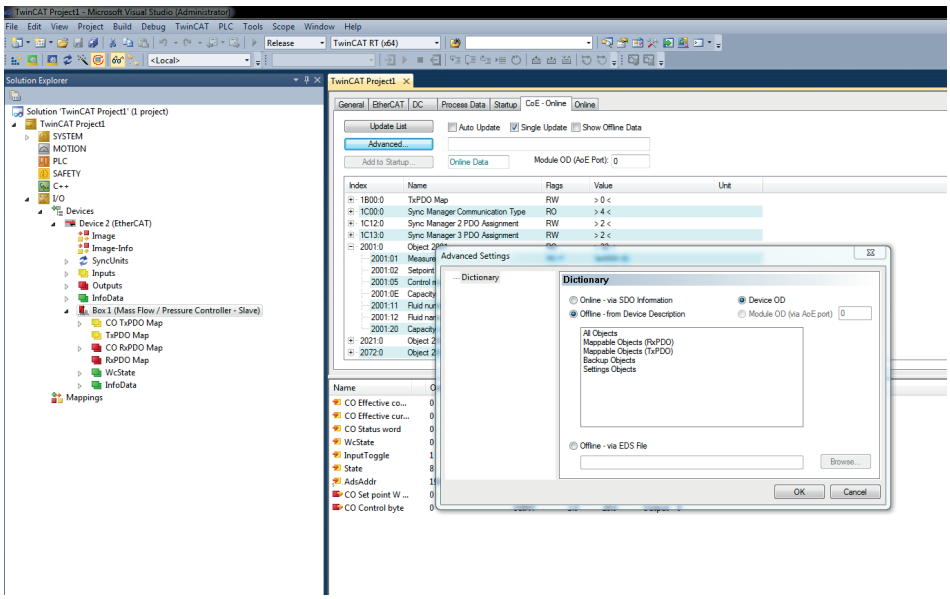
Read the instrument parameters from the XML File:



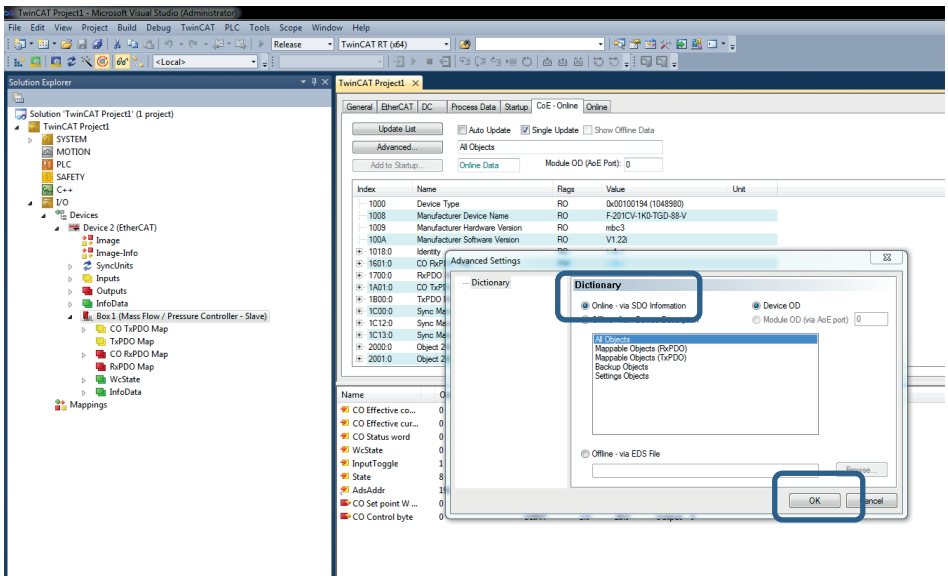
Read the instrument parameters from the Instrument:
Select the button “Advanced”

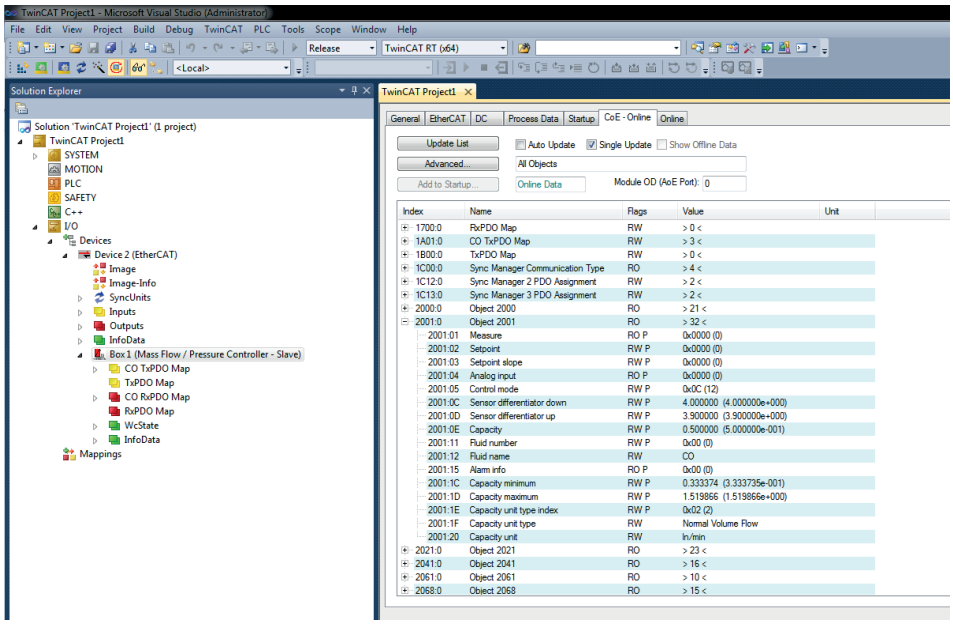


The next screen will appear:



Select: “Online- via SDO Information” Press OK





OBJECT 2001:0 Before

2001:0	Object 2001	RO	> 32 <
2001:01	Measure	RO P	0x0000 (0)
2001:02	Setpoint	RW P	0x0000 (0)
2001:05	Control mode	RW P	0x0C (12)
2001:0E	Capacity	RW P	0.500000 (5.000000e-001)
2001:11	Fluid number	RW P	0x00 (0)
2001:12	Fluid name	RW	CO
2001:20	Capacity unit	RW	ln/min

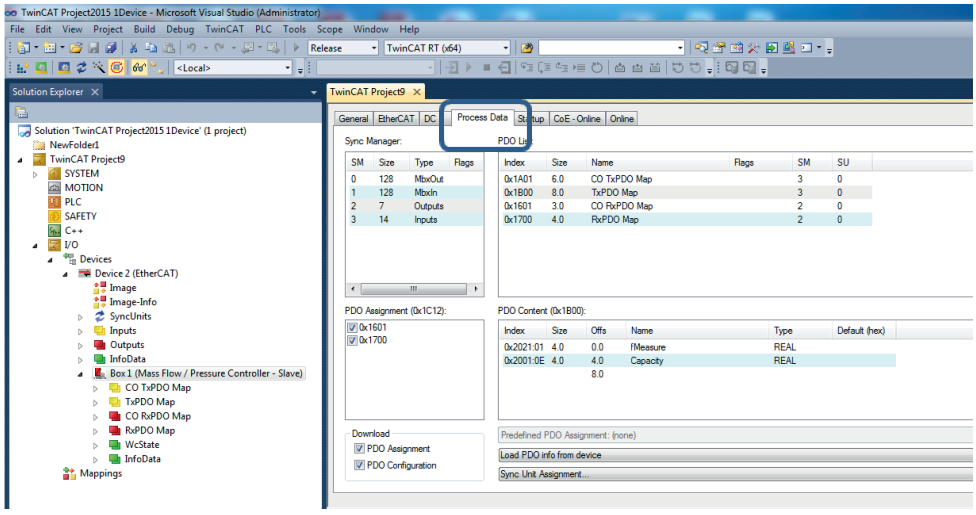
OBJECT 2001:0 After

2001:0	Object 2001	RO	> 32 <
2001:01	Measure	RO P	0x0000 (0)
2001:02	Setpoint	RW P	0x0000 (0)
2001:03	Setpoint slope	RW P	0x0000 (0)
2001:04	Analog input	RO P	0x0000 (0)
2001:05	Control mode	RW P	0x0C (12)
2001:0C	Sensor differentiator down	RW P	4.000000 (4.000000e+000)
2001:0D	Sensor differentiator up	RW P	3.900000 (3.900000e+000)
2001:0E	Capacity	RW P	0.500000 (5.000000e-001)
2001:11	Fluid number	RW P	0x00 (0)
2001:12	Fluid name	RW	CO
2001:15	Alarm info	RO P	0x00 (0)
2001:1C	Capacity minimum	RW P	0.333374 (3.333735e-001)
2001:1D	Capacity maximum	RW P	1.519866 (1.519866e+000)
2001:1E	Capacity unit type index	RW P	0x02 (2)
2001:1F	Capacity unit type	RW	Normal Volume Flow
2001:20	Capacity unit	RW	ln/min

7.2 PROCESS DATA - ONLINE TAB

How to add Bronkhorst parameters to PDO parameters in TwinCAT 3
Used version of TwinCAT 4.030319.
http://infosys.beckhoff.com/

The Example below is based on the instrument parameters Measure and Setpoint integer.
Step 1. Add a Bronkhorst slave. See Box 1(Mass flow/Pressure Controller –Slave).
Step 2. Select Process Data.

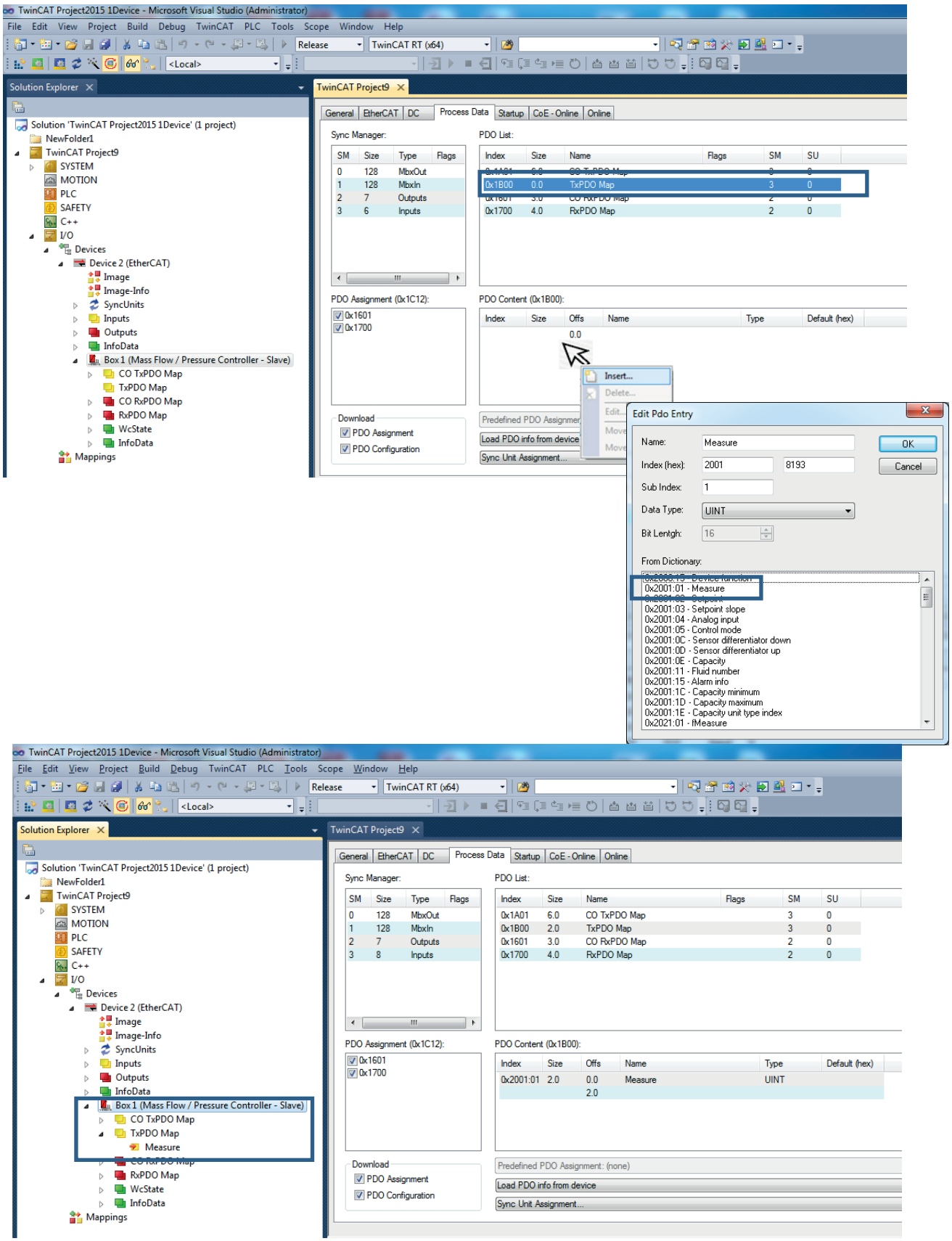


Add the Measure integer parameter to the PDO Content.

-.Select Index 0x1B00 TxPDO Map.

-. Place the cursor in the field (PDO Content (0X1B00). Right mouse click.

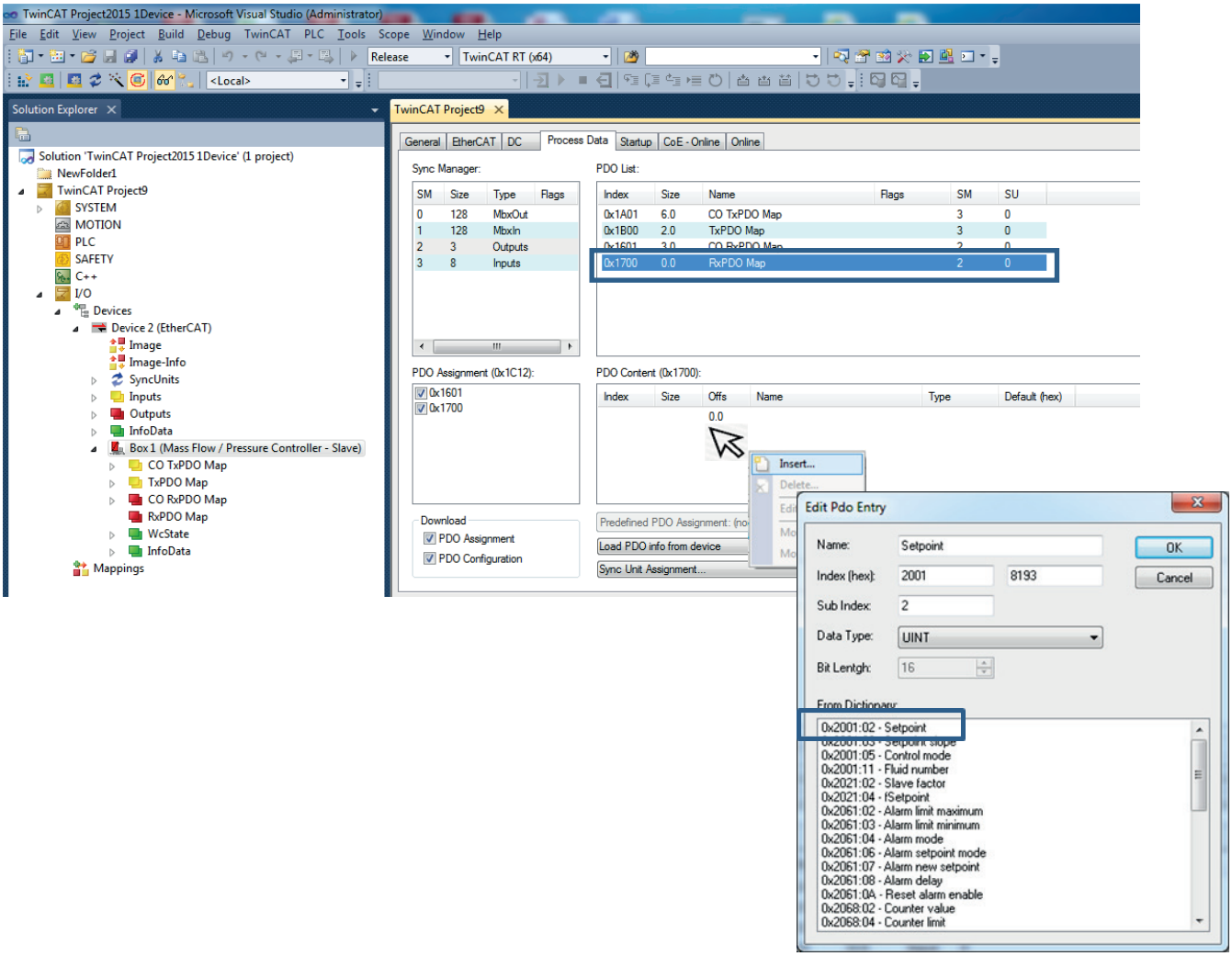
-. Select in the screen Edit Pdo Entry 0x2001:01- Measure

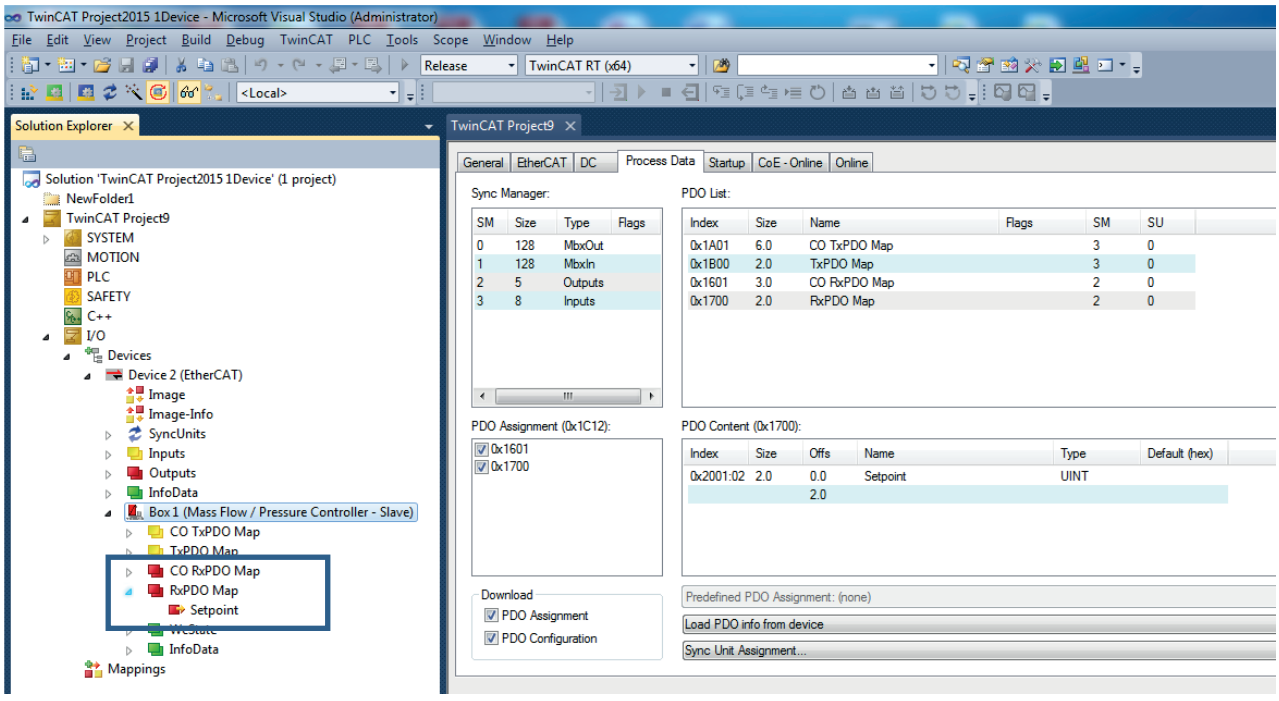

TwinCAT Project2015 1Device - Microsoft Visual Studio (Administrator)
File Edit View Project Build Debug TwinCAT PLC Tools Scope Window Help
Release
TwinCAT RT (x64)
<Local>
Solution Explorer
Solution 'TwinCAT Project2015 1Device' (1 project)
NewFolder1
TwinCAT Project9
SYSTEM
MOTION
PLC
SAFETY
C++
I/O
Devices
Device 2 (EtherCAT)
Image
Image-Info
SyncUnits
Inputs
Outputs
InfoData
Box 1 (Mass Flow / Pressure Controller - Slave)
CO TxPDO Map
TxPDO Map
CO RxPDO Map
RxPDO Map
WcState
InfoData
Mappings
TwinCAT Project9
General EtherCAT DC Process Data Startup CoE - Online Online
Sync Manager:
SM Size Type Flags
0 128 MbxOut
1 128 MbxIn
2 7 Outputs
3 6 Inputs
PDO List:
Index Size Name Flags SM SU
0x1B00 0.0 TxPDO Map 3 0
0x1700 4.0 RxPDO Map 2 0
PDO Assignment (0x1C12):
0x1601
0x1700
PDO Content (0x1B00):
Index Size Offs Name Type Default (hex)
0.0
Insert...
Delete...
Edit...
Download
PDO Assignment
PDO Configuration
Predefined PDO Assignment
Load PDO info from device
Sync Unit Assignment...
Edit Pdo Entry
Name: Measure
Index (hex): 2001 8193
Sub Index: 1
Data Type: UINT
Bit Length: 16
OK
Cancel
From Dictionary:
0x2001:01 - Measure
0x2001:03 - Setpoint slope
0x2001:04 - Analog input
0x2001:05 - Control mode
0x2001:0C - Sensor differentiator down
0x2001:0D - Sensor differentiator up
0x2001:0E - Capacity
0x2001:11 - Fluid number
0x2001:15 - Alarm info
0x2001:1C - Capacity minimum
0x2001:1D - Capacity maximum
0x2001:1E - Capacity unit type index
0x2021:01 - fMeasure

TwinCAT Project2015 1Device - Microsoft Visual Studio (Administrator)
File Edit View Project Build Debug TwinCAT PLC Tools Scope Window Help
Release
TwinCAT RT (x64)
<Local>
Solution Explorer
Solution 'TwinCAT Project2015 1Device' (1 project)
NewFolder1
TwinCAT Project9
SYSTEM
MOTION
PLC
SAFETY
C++
I/O
Devices
Device 2 (EtherCAT)
Image
Image-Info
SyncUnits
Inputs
Outputs
InfoData
Box 1 (Mass Flow / Pressure Controller - Slave)
CO TxPDO Map
TxPDO Map
Measure
RxPDO Map
WcState
InfoData
Mappings
TwinCAT Project9
General EtherCAT DC Process Data Startup CoE - Online Online
Sync Manager:
SM Size Type Flags
0 128 MbxOut
1 128 MbxIn
2 7 Outputs
3 8 Inputs
PDO List:
Index Size Name Flags SM SU
0x1A01 6.0 CO TxPDO Map 3 0
0x1B00 2.0 TxPDO Map 3 0
0x1601 3.0 CO RxPDO Map 2 0
0x1700 4.0 RxPDO Map 2 0
PDO Assignment (0x1C12):
0x1601
0x1700
PDO Content (0x1B00):
Index Size Offs Name Type Default (hex)
0x2001:01 2.0 0.0 Measure UINT
2.0
Download
PDO Assignment
PDO Configuration
Predefined PDO Assignment: (none)
Load PDO info from device
Sync Unit Assignment...

Add the Setpoint integer parameter to the map PDO.

- Select Index 0x1700 TxPDO Map.
- Place the cursor in the field (PDO Content (0X1700)). Right mouse click.
- Select in the screen Edit Pdo Entry 0x2001:02-Setpoint





8 SERVICE

For current information on Bronkhorst® and service addresses please visit our website:

http://www.bronkhorst.com

Do you have any questions about our products? Our Sales Department will gladly assist you selecting the right product for your application. Contact sales by e-mail:

sales@bronkhorst.com

For after-sales questions, our Customer Service Department is available with help and guidance. To contact CSD by e-mail:

aftersales@bronkhorst.com

No matter the time zone, our experts within the Support Group are available to answer your request immediately or ensure appropriate further action. Our experts can be reached at:

+31 859 02 18 66

APPENDIX A: OBJECT DICTIONARY

The sub-indexes 2 and up are only applicable for multi-channel systems.

Index	Sub Index	Description	Data Type	Access	PDO mapping
0x1000		Device Type [1]	Unsigned32	RO	No
0x1008		Manufacturer Device Name	Visible String	RO	No
0x1009		Manufacturer Hardware Version	Visible String	RO	No
0x100A		Manufacturer Software Version	Visible String	RO	No
0x1018	0	Identity	Unsigned8	RO	No
	1	Vendor ID [2]	Unsigned32	RO	No
	2	Product Code	Unsigned32	RO	No
	3	Revision Number	Unsigned32	RO	No
	4	Serial Number	Unsigned32	RO	No
0x1601	0	CO RxPDO Map	Unsigned8	RO	No
	1	Mapped Object 1	Unsigned32	RO	No
	2	Mapped Object 2	Unsigned32	RO	No
	3	Mapped Object 3	Unsigned32	RO	No
0x1700	0	RxPDO Map	Unsigned8	RW	No
	1	Mapped Object 1	Unsigned32	RW	No
	2	Mapped Object 2	Unsigned32	RW	No
	:				
	20	Mapped Object 20	Unsigned32	RW	No
0x1A01	0	CO TxPDO Map	Unsigned8	RO	No
	1	Mapped Object 1	Unsigned32	RO	No
	2	Mapped Object 2	Unsigned32	RO	No
	3	Mapped Object 3	Unsigned32	RO	No
0x1B00	0	TxPDO Map	Unsigned8	RW	No
	1	Mapped Object 1	Unsigned32	RW	No
	2	Mapped Object 2	Unsigned32	RW	No
	:				
	20	Mapped Object 20	Unsigned32	RW	No
0x1C00	0	SyncManager Communication Type	Unsigned8	RO	No
	1	Communication Type SM0	Unsigned8	RO	No
	2	Communication Type SM1	Unsigned8	RO	No
	3	Communication Type SM2	Unsigned8	RO	No
	4	Communication Type SM3	Unsigned8	RO	No
0x1C12	0	SyncManager 2 PDO Assignment	Unsigned8	RW	No
	1	PDO Mapping Table 0	Unsigned16	RW	No
	2	PDO Mapping Table 1	Unsigned16	RW	No
0x1C13	0	SyncManager 3 PDO Assignment	Unsigned8	RW	No
	1	PDO Mapping Table 0	Unsigned16	RW	No
	2	PDO Mapping Table 1	Unsigned16	RW	No

[1] Device Type = 0x00100194; this means that the controller function block of device profile DS-404 is implemented.

[2] Bronkhorst High-Tech B.V. Vendor ID is 1387 (0x0000056B)

Index	Sub Index	Description	Data Type	Access	PDO mapping
0x6400	0	CO Effective current value Xeff	Unsigned8	RO	No
	1	CO Effective current value Xeff 1	Float	RO	Possible
	2	CO Effective current value Xeff 2	Float	RO	Possible
	3	CO Effective current value Xeff 3	Float	RO	Possible
0x6401	0	CO Effective setpoint Weff	Unsigned8	RO	No
	1	CO Effective setpoint Weff 1	Float	RO	Possible
	2	CO Effective setpoint Weff 2	Float	RO	Possible
	3	CO Effective setpoint Weff 3	Float	RO	Possible
0x6402	0	CO Setpoint W	Unsigned8	RO	No
	1	CO Setpoint W 1	Float	RW	Possible
	2	CO Setpoint W 2	Float	RW	Possible
	3	CO Setpoint W 3	Float	RW	Possible
0x6403	0	CO 2nd Setpoint W2	Unsigned8	RO	No
	1	CO 2nd Setpoint W2 1	Float	RW	Possible
	2	CO 2nd Setpoint W2 2	Float	RW	Possible
	3	CO 2nd Setpoint W2 3	Float	RW	Possible
0x6404	0	CO Lower setpoint limit W0	Unsigned8	RO	No
	1	CO Lower setpoint limit W0 1	Float	RO	No
	2	CO Lower setpoint limit W0 2	Float	RO	No
	3	CO Lower setpoint limit W0 3	Float	RO	No
0x6405	0	CO Upper setpoint limit W100	Unsigned8	RO	No
	1	CO Upper setpoint limit W100 1	Float	RO	No
	2	CO Upper setpoint limit W100 2	Float	RO	No
	3	CO Upper setpoint limit W100 3	Float	RO	No
0x6406	0	CO Physical unit current value / setpoint	Unsigned8	RO	No
	1	CO Physical unit current value / setpoint 1	Unsigned32	RW	No
	2	CO Physical unit current value / setpoint 2	Unsigned32	RW	No
	3	CO Physical unit current value / setpoint 3	Unsigned32	RW	No
0x6407	0	CO Decimal digits current value / setpoint	Unsigned8	RO	No
	1	CO Decimal digits current value / setpoint 1	Unsigned8	RW	No
	2	CO Decimal digits current value / setpoint 2	Unsigned8	RW	No
	3	CO Decimal digits current value / setpoint 3	Unsigned8	RW	No
0x6410	0	CO Effective controller output Y	Unsigned8	RO	No
	1	CO Effective controller output Y 1	Unsigned16	RO	Possible
	2	CO Effective controller output Y 2	Unsigned16	RO	Possible
	3	CO Effective controller output Y 3	Unsigned16	RO	Possible
0x6415	0	CO Physical unit controller output	Unsigned8	RO	No
	1	CO Physical unit controller output 1	Unsigned32	RO	No
	2	CO Physical unit controller output 2	Unsigned32	RO	No
	3	CO Physical unit controller output 3	Unsigned32	RO	No
0x6420	0	CO Setpoint switch W/W2	Unsigned8	RO	No
	1	CO Setpoint switch W/W2 1	Boolean	RW	No
	2	CO Setpoint switch W/W2 2	Boolean	RW	No
	3	CO Setpoint switch W/W2 3	Boolean	RW	No

Index	Sub Index	Description	Data Type	Access	PDO mapping
0x6421	0	CO Automatic / manual mode A/M	Unsigned8	RO	No
	1	CO Automatic / manual mode A/M 1	Boolean	RW	No
	2	CO Automatic / manual mode A/M 2	Boolean	RW	No
	3	CO Automatic / manual mode A/M 3	Boolean	RW	No
0x6422	0	CO Controller on / off	Unsigned8	RO	No
	1	CO Controller on / off 1	Boolean	RW	No
	2	CO Controller on / off 2	Boolean	RW	No
	3	CO Controller on / off 3	Boolean	RW	No
0x6423	0	CO Controller mode	Unsigned8	RO	No
	1	CO Controller mode 1	Unsigned8	RW	Possible
	2	CO Controller mode 2	Unsigned8	RW	Possible
	3	CO Controller mode 3	Unsigned8	RW	Possible
0x6425	0	CO Control byte	Unsigned8	RO	No
	1	CO Control byte 1	Unsigned8	RW	Possible
	2	CO Control byte 2	Unsigned8	RW	Possible
	3	CO Control byte 3	Unsigned8	RW	Possible
0x6427	0	CO Status word	Unsigned8	RO	No
	1	CO Status word 1	Unsigned16	RO	Possible
	2	CO Status word 2	Unsigned16	RO	Possible
	3	CO Status word 3	Unsigned16	RO	Possible
0x7400	0	CO Effective current value Xeff (INT)	Unsigned8	RO	No
	1	CO Effective current value Xeff (INT) 1	Unsigned16	RO	Possible
	2	CO Effective current value Xeff (INT) 2	Unsigned16	RO	Possible
	3	CO Effective current value Xeff (INT) 3	Unsigned16	RO	Possible
0x7401	0	CO Effective setpoint Weff (INT)	Unsigned8	RO	No
	1	CO Effective setpoint Weff (INT) 1	Unsigned16	RO	Possible
	2	CO Effective setpoint Weff (INT) 2	Unsigned16	RO	Possible
	3	CO Effective setpoint Weff (INT) 3	Unsigned16	RO	Possible
0x7402	0	CO Setpoint W (INT)	Unsigned8	RO	No
	1	CO Setpoint W (INT) 1	Unsigned16	RW	Possible
	2	CO Setpoint W (INT) 2	Unsigned16	RW	Possible
	3	CO Setpoint W (INT) 3	Unsigned16	RW	Possible
0x7403	0	CO 2nd Setpoint W2 (INT)	Unsigned8	RO	No
	1	CO 2nd Setpoint W2 (INT) 1	Unsigned16	RW	Possible
	2	CO 2nd Setpoint W2 (INT) 2	Unsigned16	RW	Possible
	3	CO 2nd Setpoint W2 (INT) 3	Unsigned16	RW	Possible
0x7404	0	CO Lower setpoint limit W0 (INT)	Unsigned8	RO	No
	1	CO Lower setpoint limit W0 (INT) 1	Unsigned16	RO	No
	2	CO Lower setpoint limit W0 (INT) 2	Unsigned16	RO	No
	3	CO Lower setpoint limit W0 (INT) 3	Unsigned16	RO	No
0x7405	0	CO Upper setpoint limit W100 (INT)	Unsigned8	RO	No
	1	CO Upper setpoint limit W100 (INT) 1	Unsigned16	RO	No
	2	CO Upper setpoint limit W100 (INT) 2	Unsigned16	RO	No
	3	CO Upper setpoint limit W100 (INT) 3	Unsigned16	RO	No

Object 0x6410: CO Effective controller output Y

hexadecimal value	decimal value	percent value
0xFC18	-1000	-100.0%
:::	:::	:::
0xFE0C	-500	-50.0%
:::	:::	:::
0x0000	0	0.0%
:::	:::	:::
0x1F4	500	50.0%
:::	:::	:::
0x3E8	1000	100.0%

0x6422 CO Control On/Off

control byte	Mode
TRUE	DDE parameter 12 control mode = 0 (controller active)
FALSE	DDE parameter 12 control mode = 12 (setpoint 0%)

0x6423 CO Controller mode

control byte	Mode
0x80	manufacturer specific controller type
:::	:::
0xFF	manufacturer specific controller type

Bronkhorst® instruments only support range 0x80h – 0x96. It is used as follows:

0x80: DDE parameter 12 control mode = 0
0x81: DDE parameter 12 control mode = 1
0x82: DDE parameter 12 control mode = 2
Etc.

Essential control modes:

Nr.	Mode	Instrument action
0	Controlling	Control at setpoint value
3	Valve closed	No controller action, valve is closed
4	Controller Idle	No controller action, valve remains its position
8	Valve purge	No controller action, valve is fully open

More available control modes can be found in
"Operation instructions digital instruments" (document nr. 9.17.023).
http://www.bronkhorst.com/en/downloads/instruction_manuals/

0x6425 CO Control byte

MSB				LSB
Reserved	**Setpoint switch**	**Manual Mode**	**Self-optimisation**	**Controller on / off**
7 4	3			0

Value	Meaning
0	disable function
1	enable function

Self-optimalisation is not supported (is always 0)

0x6427 CO Status word

MSB										LSB
reserved	Net overload	Over-load	Data not valid	reserved	Optimization error	Setpoint switch	Manual Mode	Self-optimization	Controller on / off
15 11	10	9	8	7 5	4	3	2	1	0

Value	Meaning
0	not valid (not occurred)
1	valid (occurred)

The following objects are mapped to the following DDE parameters:

Index	Sub Index	Description	DDE parameter
0x6400	0	CO Effective current value Xeff	-
	1	CO Effective current value Xeff	fMeasure
0x6401	0	CO Effective setpoint Weff	-
	1	CO Effective setpoint Weff	fSetpoint
0x6402	0	CO Setpoint W	-
	1	CO Setpoint W	fSetpoint
0x6403	0	CO 2nd Setpoint W2	-
	1	CO 2nd Setpoint W2	-
0x6404	0	CO Lower setpoint limit W0	-
	1	CO Lower setpoint limit W0	Capacity 0% (read only)
0x6405	0	CO Upper setpoint limit W100	-
	1	CO Upper setpoint limit W100	Capacity (read only)
0x6406	0	CO Physical unit current value / setpoint	-
	1	CO Physical unit current value / setpoint	-
0x6407	0	CO Decimal digits current value / setpoint	-
	1	CO Decimal digits current value / setpoint	-
0x6410	0	CO Effective controller output Y	-
	1	CO Effective controller output Y	Valve output (scaled to % as described above)

Index	Sub Index	Description	DDE parameter
0x6415	0	CO Physical unit controller output	-
	1	CO Physical unit controller output	-
0x6420	0	CO Setpoint switch W/W2	-
	1	CO Setpoint switch W/W2	-
0x6421	0	CO Automatic / manual mode A/M	-
	1	CO Automatic / manual mode A/M	-
0x6422	0	CO Controller on / off	-
	1	CO Controller on / off	- (is described above)
0x6423	0	CO Controller mode	-
	1	CO Controller mode	Control mode
0x6425	0	CO Control byte	-
	1	CO Control byte	- (is described above)
0x6425	0	CO Status word	-
	1	CO Status word	- (is described above)
0x7400	0	CO Effective current value Xeff (INT)	-
	1	CO Effective current value Xeff (INT)	fMeasure [3]
0x7401	0	CO Effective setpoint Weff (INT)	-
	1	CO Effective setpoint Weff (INT)	fSetpoint [5]
0x7402	0	CO Setpoint W (INT)	-
	1	CO Setpoint W (INT)	fSetpoint [5]
0x7403	0	CO 2nd Setpoint W2 (INT)	-
	1	CO 2nd Setpoint W2 (INT)	-
0x7404	0	CO Lower setpoint limit W0 (INT)	-
	1	CO Lower setpoint limit W0 (INT)	Capacity 0% (read only) [5]
0x7405	0	CO Upper setpoint limit W100 (INT)	-
	1	CO Upper setpoint limit W100 (INT)	Capacity (read only) [5]

The value of object 0x6407:01 CO Decimal digits current value / set point is determined and optimized automatically during instrument power-up.

[5] Examples:

fMeasure = 1.15 ln/min
object 0x6407:01 CO Decimal digits current value / set point = 3
object 0x7401:01 CO Effective current value Xeff = 1.15 x (10 x 10 x 10) = 1150

object 0x6407:01 CO Decimal digits current value / set point = 4
object 0x7402:01 CO Setpoint W (INT) = 22500
fSetpoint = 22500 / (10 x 10 x 10 x 10) = 2.25 ln/min

[3] Integer16 value scaled with the value of object 0x6407:01
[5] Integer16 value scaled with the value of object 0x6407:01

APPENDIX B: SI UNIT AND PREFIX SPECIFICATION

SI Unit Specification				
Name	**Symbol**	**Notation index (hex)**	**Index**	**Description**
Kilogram	kg	0x02	0x402	Mass
Second	s	0x03	0x403	Time
Kelvin	K	0x05	0x405	Temperature
Pascal	Pa	0x22	0x422	Pressure
Degree Celcius	°C	0x2D	0x42D	Temperature
Litre	l	0x44	0x444	Volume
Minute	min	0x47	0x447	Time
Hour	h	0x48	0x448	Time
Bar	bar	0x4E	0x44E	Pressure
Cubic metre	m^3	0x59	0x459	Volume

Prefix Specification			
Prefix	**Symbol**	**Factor**	**Notation Index**
reserved	-	-	*0x13 – 0x7F*
exa	E	10^{18}	0x12
		10^{17}	0x11
		10^{16}	0x10
peta	P	10^{15}	0x0F
		10^{14}	0x0E
		10^{13}	0x0D
tera	T	10^{12}	0x0C
		10^{11}	0x0B
		10^{10}	0x0A
giga	G	10^{9}	0x09
		10^{8}	0x08
		10^{7}	0x07
mega	M	10^{6}	0x06
		10^{5}	0x05
		10^{4}	0x04
kilo	k	10^{3}	0x03
hecto	h	10^{2}	0x02
deca	da	10^{1}	0x01
		10^{0}	0x00
deci	d	10^{-1}	0xFF
centi	c	10^{-2}	0xFE
milli	m	10^{-3}	0xFD
		10^{-4}	0xFC
		10^{-5}	0xFB
micro	µ	10^{-6}	0xFA
		10^{-7}	0xF9
		10^{-8}	0xF8
nano	n	10^{-9}	0xF7
		10^{-10}	0xF6
		10^{-11}	0xF5
pico	p	10^{-12}	0xF4
		10^{-13}	0xF3
		10^{-14}	0xF2
femto	f	10^{-15}	0xF1
		10^{-16}	0xF0
		10^{-17}	0xEF
atto	a	10^{-18}	0xEE
reserved	-	-	*0xED – 0x80*

APPENDIX C: NON-SI UNIT SPECIFICATION

Name	Symbol	Notation index (hex)	Index	Description
gram-force per square centimetre	gf/cm2	0xA0	0x4A0	pressure
pound-force per square inch	psi	0xA1	0x4A1	pressure
torr pressure	torr	0xA2	0x4A2	pressure
standard atmosphere pressure	atm	0xA3	0x4A3	pressure
meter of water pressure	mH2O	0xA4	0x4A4	pressure
inch of water pressure	"H2O	0xA5	0x4A5	pressure
feet of water pressure	ftH2O	0xA6	0x4A6	pressure
meter of mercury pressure	mHg	0xA7	0x4A7	pressure
inch of mercury pressure	"Hg	0xA8	0x4A8	pressure
cubic centimetre	cc	0xB0	0x4B0	volume
cubic millimetre	mm3	0xB1	0x4B1	volume
cubic centimetre	cm3	0xB2	0x4B2	volume
cubic foot per hour	cfh	0xB3	0x4B3	volume
cubic foot per minute	cfm	0xB4	0x4B4	volume
cubic foot per second	cfs	0xB5	0x4B5	volume
litre (normal)	ln	0xC0	0x4C0	volume (normal flow)
cubic centimetre (normal)	ccn	0xC1	0x4C1	volume (normal flow)
cubic millimetre (normal)	mm3n	0xC2	0x4C2	volume (normal flow)
cubic centimetre (normal)	cm3n	0xC3	0x4C3	volume (normal flow)
cubic metre (normal)	m3n	0xC4	0x4C4	volume (normal flow)
standard cubic foot per hour	scfh	0xC5	0x4C5	volume (normal flow)
standard cubic foot per minute	scfm	0xC6	0x4C6	volume (normal flow)
standard cubic foot per second	scfs	0xC7	0x4C7	volume (normal flow)
standard cubic centimetre per minute	sccm	0xC8	0x4C8	volume (normal flow)
standard litre per minute	slm	0xC9	0x4C9	volume (normal flow)
litre (standard)	ls	0xD0	0x4D0	volume (standard flow)
cubic centimetre (standard)	ccs	0xD1	0x4D1	volume (standard flow)
cubic millimetre (standard)	mm3s	0xD2	0x4D2	volume (standard flow)
cubic centimetre (standard)	cm3s	0xD3	0x4D3	volume (standard flow)
cubic metre (standard)	m3s	0xD4	0x4D4	volume (standard flow)