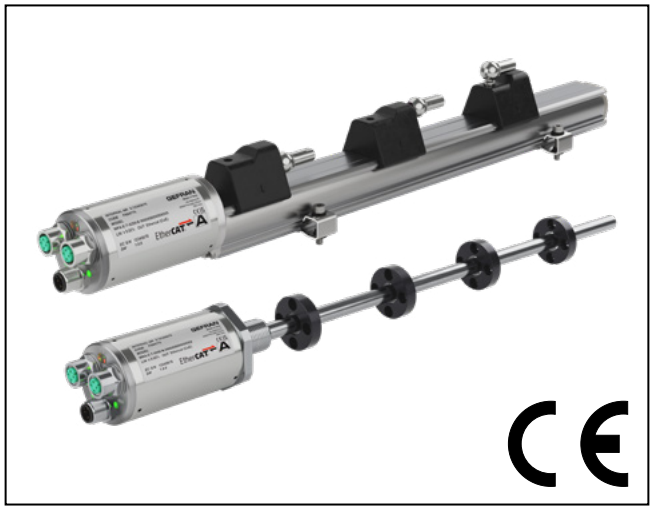
GEFRAN

WPA-E / WRA-E

CONTACTLESS MAGNETOSTRICTIVE LINEAR POSITION TRANSDUCER (ETHERCAT IO OUTPUT)



USER MANUAL

Cod. 80785 Edit. 11/2023 - ENG

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1. INTRODUCTION

WPA-E / WRA-E magnetostrictive transducer implements CANopen over EtherCAT (CoE) protocol.
EtherCAT is a digital communication standard developed by Beckoff and maintained by EtherCAT Technology Group (ETG).
The digital communication allows the transfer of data between the Device (the WPA-E/WRA-E transducer) and the Master (PLC) through a network.
These data are:

- Process data, such as position, speed, status of the device
- Acyclic data, as parameterization, statistic, diagnostic data

EtherCAT standard provides a descriptor file called ESI (EtherCAT Slave Information, based in XML format).
This file allows a clear identification of the device and comprehension of data provided and exchanged.
Please refer to Gefran website for the download of ESI file.
This manual is not designed to describe the EtherCAT protocol, please refer to EtherCAT website (https://www.ethercat.org/) for any information about EtherCAT protocol standard.

2. INSTALLATION AND ELECTRICAL CONNECTIONS

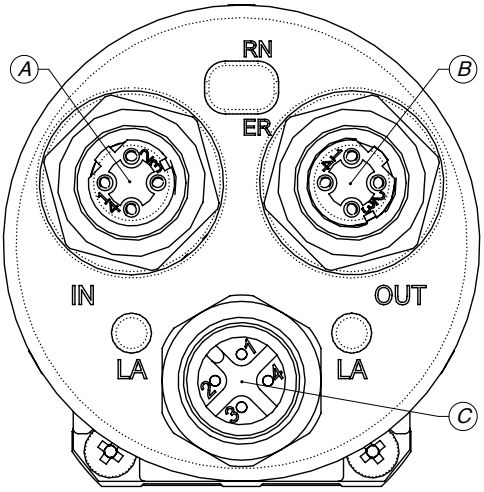
2.1. General precautions

The system must be used only in accordance with the required protection level.
The sensor must be protected against accidental knocks and used in accordance with the instrument's ambient characteristics.
The sensors must be powered with non-distributed networks.

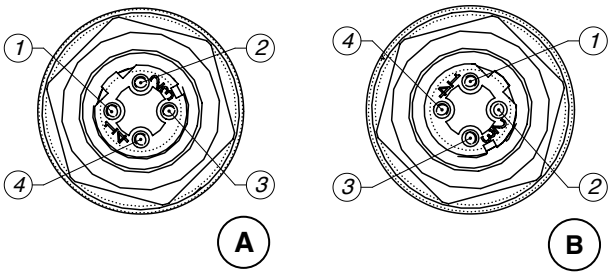
2.2. Electrical installation

The transducer must be grounded (normally through the machine body or equipment it is installed on).
Connect cables shielding to ground at cabinet side (control equipment or PLC).
To prevent interference, separate the power cables from signal cables.
The WPA-E/WRA-E transducer provides 3 connectors on its head:

- 2x M12 Female 4 poles D coded for Fieldbus connection (A-B in the image below)
- 1x M12 Male 4 poles A coded for bringing Power Supply to the device (C in the image below)

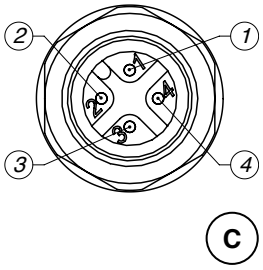


IN - OUT M12 4P Female D-coded connector connection



M12 Female 4 poles D coded connector (IN - OUT)	Pinout
1	Tx+
2	Rx+
3	Tx-
4	Rx-

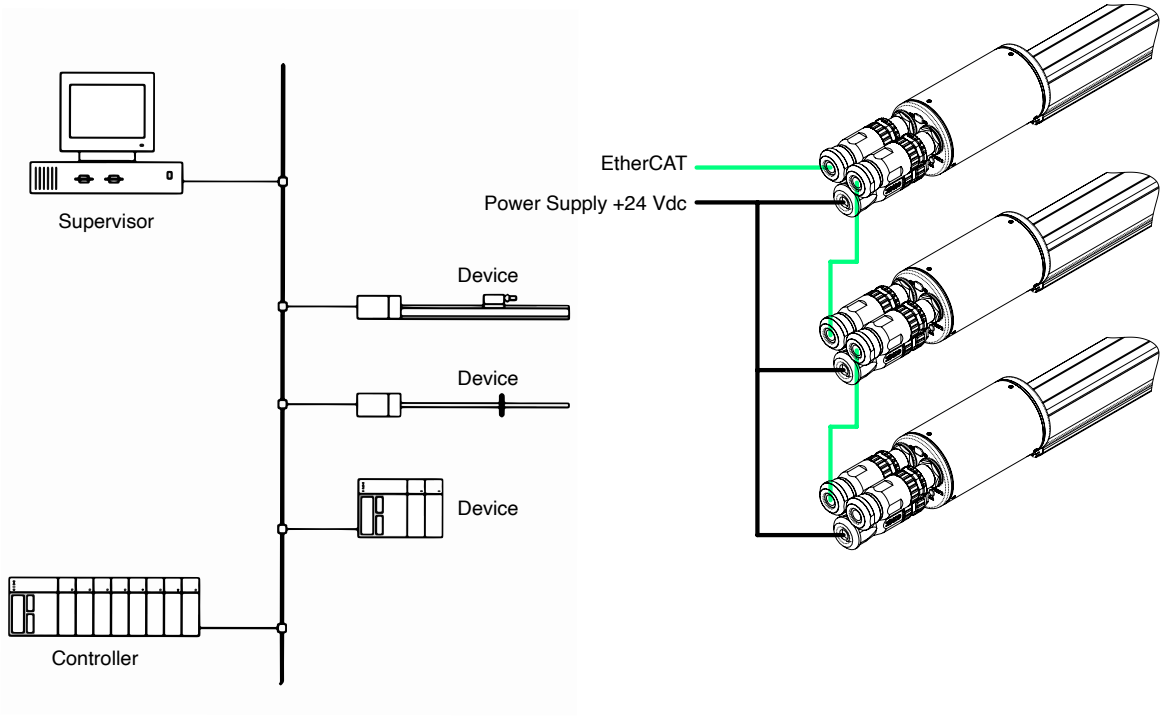
Power Supply M12 4P Male A-coded connector connection



M12 Male 4 poles A coded connector (Power Supply)	Pinout
1	V+
2	NC
3	0V
4	NC

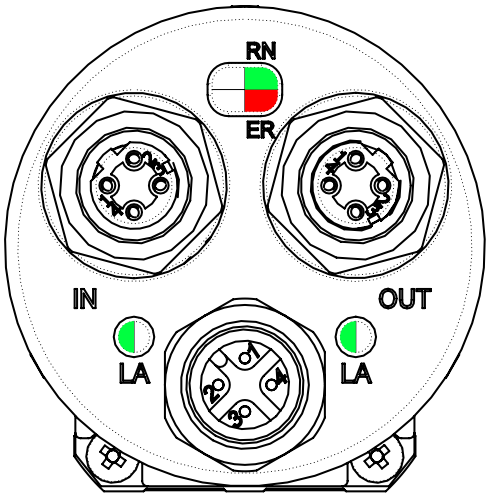
2.3. Ethercat Structure And Connection

We recommend the use of a CAT5 Ethernet cable or above STP or UTP. The maximum distance between two Ethernet network nodes must be less than 100m.
For Power Supply use a shielded cable with metal connector and shield connected to connector case.



2.4. Status LEDS

The WPA-E/WRA-E provides leds on transducer head in order to give diagnostic information compliant with ETG 1300 standard.



RN Led (Green) - RUN	Function
OFF	The device is in state INITIALISATION
Blinking	The device is in state PRE-OPERATIONAL
Single Flash	The device is in state SAFE-OPERATIONAL
ON	The device is in state OPERATIONAL

ERR Led (Red) - ERROR	Function
OFF	No Error
ON	Application controller failure
Double Flash	EtherCAT Watchdog Timeout
Single Flash	Slave device has changed the EtherCAT state autonomously, due to local error
Blinking	Invalid Configuration

IN LA Led (Green) – IN Link Activity	Function
OFF	Port Close
ON	Port Open
Flickering	Port Open and in Activity State

OUT LA Led (Green) – OUT Link Activity	Function
OFF	Port Close
ON	Port Open
Flickering	Port Open and in Activity State

3. MAIN COMMUNICATION FEATURES

With EtherCAT CoE protocol process data and alarms are always transferred in real time, data object and profile are described in ESI file.
WPA-E can be operated in Free Run mode or in Synchronous mode. WPA-E in Distributed Clocks (DC) mode offers synchronous communication with a minimum cycle time of 250us

Ethernet Baud Rate	Max 100 Mbit/s
Data Transport Layer	Ethernet II, IEEE 802.3
EtherCat Protocol	CoE
EtherCAT Vendor ID	0x00000093
CoE Profile	DS406, Class 1
Communication Min. Cycle Time	250us

4. COMMUNICATION AND SENSOR PARAMETERS

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4.1. Process Data Structure

The device WPA-E / WRA-E offers different process data and different configuration for process data.
The process variables available are:
Position (32 bit signed), for each of the cursors installed. For resolution refer to configuration options.

31..0
Position

Velocity (32 bit signed), for each of the cursors installed. For resolution refer to configuration options.

31..0
Velocity

Status (16 bit unsigned), composed as following:

- bit0..bit2: Fixed to zero (reserved use)
- bit3: Status bit, if the bit is set an error has been detected (magnet missing or too many magnets)
- bit4..bit8: Number of magnet detected
- bit9..bit15: fixed to zero (reserved use)

15…9	8..4	3	2..0
Reserved Use	Magnet Number	Status bit	Reserved Use

The sensor, when not configured, has the following TPDO mapping by default:

Index	Sub	DataFormat	Name	Access	Note
$1A00_h$	01_h	Unsigned16	Status	RW	Magnet Status (Object: 2002_h, sub 00_h)
	02_h	Signed32	Position	RW	Position Value (Object: 6020_h, sub 01_h)
	03_h	Signed32	Velocity	RW	Velocity Value (Object: 6030_h, sub 01_h)
	04_h	Signed32	Acceleration	RW	Not yet implemented (Object: 6040_h, sub 01_h)

The PDO mapping is not fixed. The master can configure the objects and the TPDO mapping (from $1A00_h$ to $1A10_h$) different from the default.

4.2. SENSOR PARAMETERS

4.2.1. System Parameters

System parameters in according to CiA 301 CANopen Standard.

Device type:

Index	Sub	DataFormat	Name	Access	Value
1000_h	00_h	Unsigned32	Device Type	RO	EtherCAT Device Type

Error register:

Index	Sub	DataFormat	Name	Access	Value
1001_h	00_h	Unsigned8	Error register	RO	0: No Error 1: An Error Occurred

Identity Object:

Index	Sub	DataFormat	Name	Access	Value
1018_h	01_h	Unsigned32	Vendor ID	RO	Gefran Vendor ID
	02_h	Unsigned32	Production Code	RO	WPA-E/WRA-E Production Code
	03_h	Unsigned32	Revision	RO	Revision Version
	04_h	Unsigned32	Serial Number	RO	Serial Number of Sensor

4.2.2. Manufacturer-specific Parameters

The position and speed data can be configured using 2000h object:

Index	Sub	DataFormat	Name	Access	Values: meaning (bold default)
2000_h	01_h	Unsigned8	Filter mode	RW	**0: Filter type disabled** 1: Filter type simple average (FIR) 2: Filter type endless response average (IIR)
	02_h	Unsigned8	Filter nr. of samples	RW	**2**..16
	03_h	Unsigned8	Velocity nr. of samples	RW	2..**8**..16
	04_h	Unsigned8	Output Direction	RW	**0: Forward** 1: Reverse
	05_h	Unsigned8	Number of configured Cursors	RW	**0**..15: **1**...16
	06_h	Unsigned32	Nominal Length of Stroke	RO	Stroke length (um)
	07h	Unsigned32	Calibration Data	RO	Calibration Data (YYWWNNNN)

Explanation:

- Filter mode: different types of filters on process data can be set by user:
  - Disabled: no filter applied
  - Simple average (FIR): only the number of samples corresponding to parameter “Filter nr. of samples” are considered to define the process data; the filter method used on these samples is moving average
  - Endless response average (IIR): not only the number of samples corresponding to parameter “Filter nr. of samples” but also the previous data are considered to define the process output value
- Filter nr. of samples: it defines the number of samples used to filter the position data; values allowed are 2…16
- Velocity nr. of samples: it defines the number of position samples used to calculate velocity; values allowed are 2…16
- Output Direction: it defines the increasing direction of position and velocity data, values allowed are:
  - Forward: it means that values increase positively from sensor head to the end of stroke
  - Reverse: it means that values increase positively from sensor end of stroke towards the head

- Number of configured cursors: it defines the number of expected cursors on sensor stroke; this value will be responsible for Position failure alarm in respect to the real number of cursors detected by the sensor; values allowed are 0…15 (corresponding to cursors 1…16)
- Nominal Lenght of Stroke: it's the full range stroke of the device as defined in the ordering code, with 1um resolution.

Additional diagnostic and statics data can be found in 2001h object:

Index	Sub	DataFormat	Name	Access	Values: meaning (bold default)
2001_h	01_h	Unsigned16	Power Supply	RO	Current Power Supply (mV)
	02_h	Signed16	Temperature	RO	Current Sensor Temperature (0,1°C)
	03_h	Signed16	Max Temperature	RO	Max Sensor Temperature Measured (0,1°C)
	04_h	Unsigned32	Sync Counter	RO	If the EtherCAT master runs in DC mode, the counter is incremented each clock event.
	05_h	Unsigned8	Number of Cursors Alarm	RW	0: Number of cursors different than configured 1: Number of cursors higher than configured 2: Number of cursors lower than configured **3: Cursor alarm disabled**
	06_h	Unsigned8	Voltage Supply Alarm	RW	0: Supply voltage higher or lower than limits 1: Supply voltage lower than limits 2: Supply voltage higher than limits **3: Voltage supply alarm disabled**
	07_h	Unsigned8	Reset Operating Time	WO	Write 1 to reset the Operating Time
	08_h	Unsigned8	Reset Preset Values	WO	Write 1 to reset the Preset Values

Explanation:

- Power Supply: The Voltage supply measured by device (1mV resolution, 200mV sensitivity)
- Temperature: it's the temperature measured internally by electronics, with 0,1°C resolution.
- Temperature Max: it's the maximum temperature measured internally by electronics, with 0,1°C resolution.
- Number of Cursors Alarm: it is possible to set an alarm referred to the number of cursors detected/configured; The alarm is reported in the Status variable. The values allowed are:
  - 0: Number of cursors detected different than configured
  - 1: Number of cursors detected higher than configured
  - 2: Number of cursors detected lower than configured
  - 3: Cursor alarm disabled
- Voltage Supply Alarm: the device measures its Voltage supply; it is possible to set an alarm referred to its level; values allowed are:
  - 0: Supply voltage higher or lower than limits
  - 1: Supply voltage lower than limits
  - 2: Supply voltage higher than limits
  - 3: Voltage supply alarm disabled
- Reset Operating Time: Reset the Operating Time reported in the 6508h object (See Profile Parameters paragraph)
- Reset Preset Values: Reset the Preset and Offset Values reported in the 6010h and 650Ch object (See Profile Parameters paragraph)

Status Manufacturer-specific (see 4.1 Process Data Structure Paragraph)

Index	Sub	DataFormat	Name	Access	Value
2002_h	00_h	Unsigned16	Status	RO	bit0..bit2: Fixed to zero (reserved use) bit3: Status bit, Magnet missing or too many magnets bit4..bit8: Number of Magnet detected bit9..bit15: fixed to zero (reserved use)

4.2.3. Profile Parameters

For any further information about the following objects, see the CiA 406 CANopen Standard.

Linear encoder measuring step settings

Index	Sub	DataFormat	Name	Access	Values: meaning (bold default)
6005_h	00_h	Unsigned8	Highest sub-index supported	const	3
	01_h	Unsigned32	Position step setting[a]	RW	**1000: 1 micron** The value shall be given in 1 nm step.
	02_h	Unsigned32	Speed step setting[b]	RW	**100**: **1 mm/sec** The value shall be given in 0.01 mm/sec step.
	03_h	Unsigned32	Acceleration step setting	RW	**0: Not yet implemented** The value shall be given in 0.1 m/s^2 step.

Note a: The native position values are expressed in um, the position setting allows to scale the position values in 1 nm step (e.g: 500 = 0.5um, 2000 = 2um, 10000 = 10um).
Note b: The native velocity values are expressed in mm/sec, the speed setting allows to scale the velocity values in 0.01 mm/sec step (e.g: 10 = 100 μm/sec, 100 = 1 mm/sec, 1000 = cm/sec)

Preset values for multi-sensor devices

Index	Sub	DataFormat	Name	Access	Value
6010_h	00_h	Unsigned8	Highest sub-index supported	const	16
	01_h	Signed32	Preset Value 1	RW	Preset Value for Magnet 1
	02_h	Signed32	Preset Value 2	RW	Preset Value for Magnet 2
	03_h	Signed32	Preset Value 3	RW	Preset Value for Magnet 3
	04_h	Signed32	Preset Value 4	RW	Preset Value for Magnet 4
	05_h	Signed32	Preset Value 5	RW	Preset Value for Magnet 5
	06_h	Signed32	Preset Value 6	RW	Preset Value for Magnet 6
	07_h	Signed32	Preset Value 7	RW	Preset Value for Magnet 7
	08_h	Signed32	Preset Value 8	RW	Preset Value for Magnet 8
	09_h	Signed32	Preset Value 9	RW	Preset Value for Magnet 9
	10_h	Signed32	Preset Value 10	RW	Preset Value for Magnet 10
	11_h	Signed32	Preset Value 11	RW	Preset Value for Magnet 11
	12_h	Signed32	Preset Value 12	RW	Preset Value for Magnet 12
	13_h	Signed32	Preset Value 13	RW	Preset Value for Magnet 13
	14_h	Signed32	Preset Value 14	RW	Preset Value for Magnet 14
	15_h	Signed32	Preset Value 15	RW	Preset Value for Magnet 15
	16_h	Signed32	Preset Value 16	RW	Preset Value for Magnet 16

Note: The preset value shall be in the same resolution unit set in 6005h sub 01h object (if the resolution unit is changed, the preset values are updated automatically).

Position values for multi-sensor device

Index	Sub	DataFormat	Name	Access	Value
6020_h	00_h	Unsigned8	Highest sub-index supported	const	16
	01_h	Signed32	Position Value 1	RO	Position Value for Magnet 1
	02_h	Signed32	Position Value 2	RO	Position Value for Magnet 2
	03_h	Signed32	Position Value 3	RO	Position Value for Magnet 3
	04_h	Signed32	Position Value 4	RO	Position Value for Magnet 4
	05_h	Signed32	Position Value 5	RO	Position Value for Magnet 5
	06_h	Signed32	Position Value 6	RO	Position Value for Magnet 6
	07_h	Signed32	Position Value 7	RO	Position Value for Magnet 7
	08_h	Signed32	Position Value 8	RO	Position Value for Magnet 8
	09_h	Signed32	Position Value 9	RO	Position Value for Magnet 9
	10_h	Signed32	Position Value 10	RO	Position Value for Magnet 10
	11_h	Signed32	Position Value 11	RO	Position Value for Magnet 11
	12_h	Signed32	Position Value 12	RO	Position Value for Magnet 12
	13_h	Signed32	Position Value 13	RO	Position Value for Magnet 13
	14_h	Signed32	Position Value 14	RO	Position Value for Magnet 14
	15_h	Signed32	Position Value 15	RO	Position Value for Magnet 15
	16_h	Signed32	Position Value 16	RO	Position Value for Magnet 16

Note: The Position values are in resolution unit set in 6005_h sub 01_h object.

Speed values for multi-sensor device

Index	Sub	DataFormat	Name	Access	Value
6030_h	00_h	Unsigned8	Highest sub-index supported	const	16
	01_h	Signed32	Speed Value 1	RO	Speed Value for Magnet 1
	02_h	Signed32	Speed Value 2	RO	Speed Value for Magnet 2
	03_h	Signed32	Speed Value 3	RO	Speed Value for Magnet 3
	04_h	Signed32	Speed Value 4	RO	Speed Value for Magnet 4
	05_h	Signed32	Speed Value 5	RO	Speed Value for Magnet 5
	06_h	Signed32	Speed Value 6	RO	Speed Value for Magnet 6
	07_h	Signed32	Speed Value 7	RO	Speed Value for Magnet 7
	08_h	Signed32	Speed Value 8	RO	Speed Value for Magnet 8
	09_h	Signed32	Speed Value 9	RO	Speed Value for Magnet 9
	10_h	Signed32	Speed Value 10	RO	Speed Value for Magnet 10
	11_h	Signed32	Speed Value 11	RO	Speed Value for Magnet 11
	12_h	Signed32	Speed Value 12	RO	Speed Value for Magnet 12
	13_h	Signed32	Speed Value 13	RO	Speed Value for Magnet 13
	14_h	Signed32	Speed Value 14	RO	Speed Value for Magnet 14
	15_h	Signed32	Speed Value 15	RO	Speed Value for Magnet 15
	16_h	Signed32	Speed Value 16	RO	Speed Value for Magnet 16

Note: The Speed values are in velocity unit set in 6005_h sub 02_h object.

Acceleration values for multi-sensor device

Index	Sub	DataFormat	Name	Access	Value
6040_h	00_h	Unsigned8	Highest sub-index supported	const	16
	01_h	Signed32	Acceleration Value 1	RO	Not yet implemented
	02_h	Signed32	Acceleration Value 2	RO	Not yet implemented
	03_h	Signed32	Acceleration Value 3	RO	Not yet implemented
	04_h	Signed32	Acceleration Value 4	RO	Not yet implemented
	05_h	Signed32	Acceleration Value 5	RO	Not yet implemented
	06_h	Signed32	Acceleration Value 6	RO	Not yet implemented
	07_h	Signed32	Acceleration Value 7	RO	Not yet implemented
	08_h	Signed32	Acceleration Value 8	RO	Not yet implemented
	09_h	Signed32	Acceleration Value 9	RO	Not yet implemented
	10_h	Signed32	Acceleration Value 10	RO	Not yet implemented
	11_h	Signed32	Acceleration Value 11	RO	Not yet implemented
	12_h	Signed32	Acceleration Value 12	RO	Not yet implemented
	13_h	Signed32	Acceleration Value 13	RO	Not yet implemented
	14_h	Signed32	Acceleration Value 14	RO	Not yet implemented
	15_h	Signed32	Acceleration Value 15	RO	Not yet implemented
	16_h	Signed32	Acceleration Value 16	RO	Not yet implemented

Note: The object is implemented for future use

Operating time

Index	Sub	DataFormat	Name	Access	Value
6508_h	00_h	Unsigned32	Operating Time	RO	The value is given in multiples of 0.1 hours

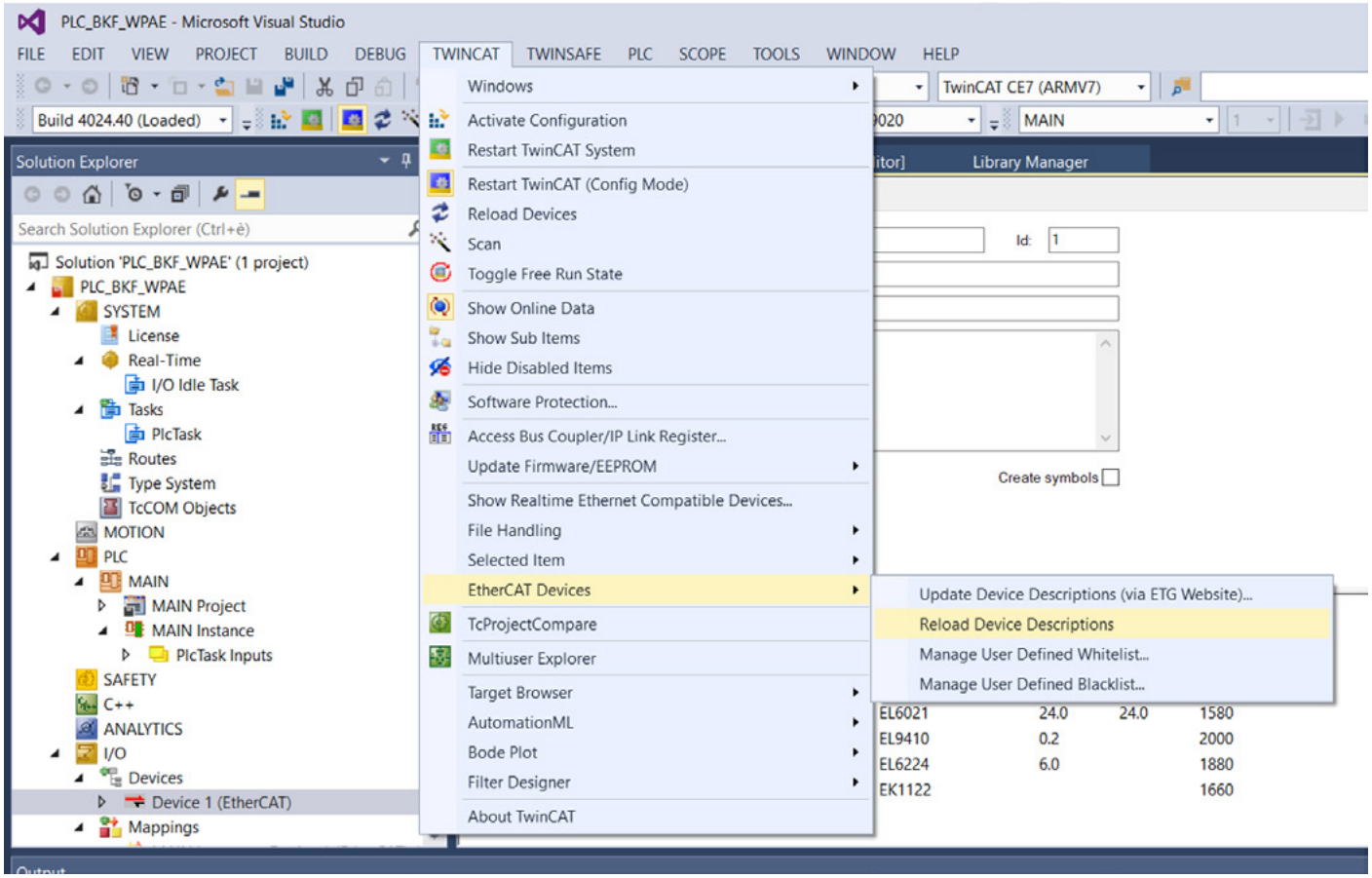
Offset values for multi-sensor device (values written by preset function)

Index	Sub	DataFormat	Name	Access	Value
650C$_h$	00$_h$	Unsigned8	Highest sub-index supported	const	16
	01$_h$	Signed32	Offset Value 1	RO	Offset Value for Magnet 1
	02$_h$	Signed32	Offset Value 2	RO	Offset Value for Magnet 2
	03$_h$	Signed32	Offset Value 3	RO	Offset Value for Magnet 3
	04$_h$	Signed32	Offset Value 4	RO	Offset Value for Magnet 4
	05$_h$	Signed32	Offset Value 5	RO	Offset Value for Magnet 5
	06$_h$	Signed32	Offset Value 6	RO	Offset Value for Magnet 6
	07$_h$	Signed32	Offset Value 7	RO	Offset Value for Magnet 7
	08$_h$	Signed32	Offset Value 8	RO	Offset Value for Magnet 8
	09$_h$	Signed32	Offset Value 9	RO	Offset Value for Magnet 9
	10$_h$	Signed32	Offset Value 10	RO	Offset Value for Magnet 10
	11$_h$	Signed32	Offset Value 11	RO	Offset Value for Magnet 11
	12$_h$	Signed32	Offset Value 12	RO	Offset Value for Magnet 12
	13$_h$	Signed32	Offset Value 13	RO	Offset Value for Magnet 13
	14$_h$	Signed32	Offset Value 14	RO	Offset Value for Magnet 14
	15$_h$	Signed32	Offset Value 15	RO	Offset Value for Magnet 15
	16$_h$	Signed32	Offset Value 16	RO	Offset Value for Magnet 16

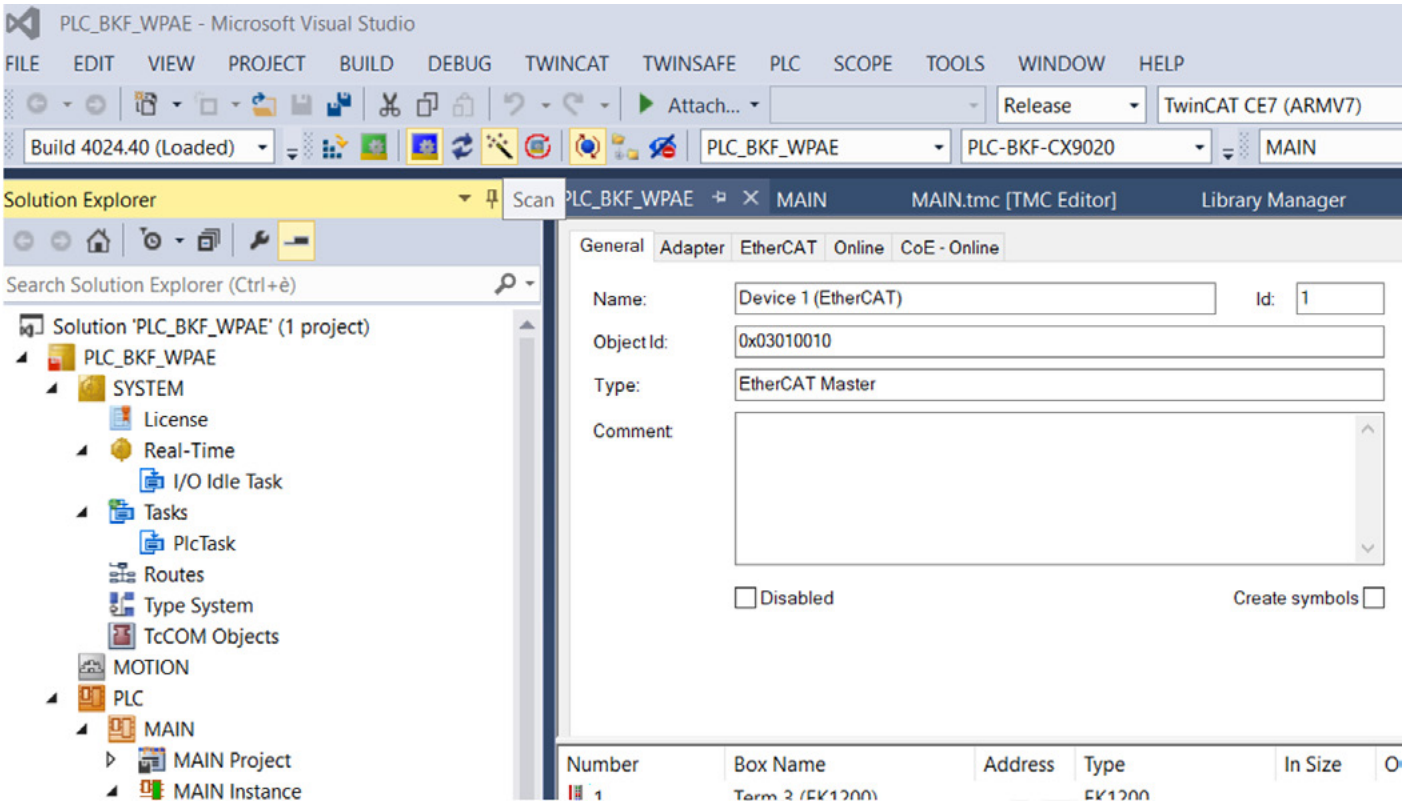
5. EXAMPLE OF PLC CONFIGURATION

5.1. Configuration example

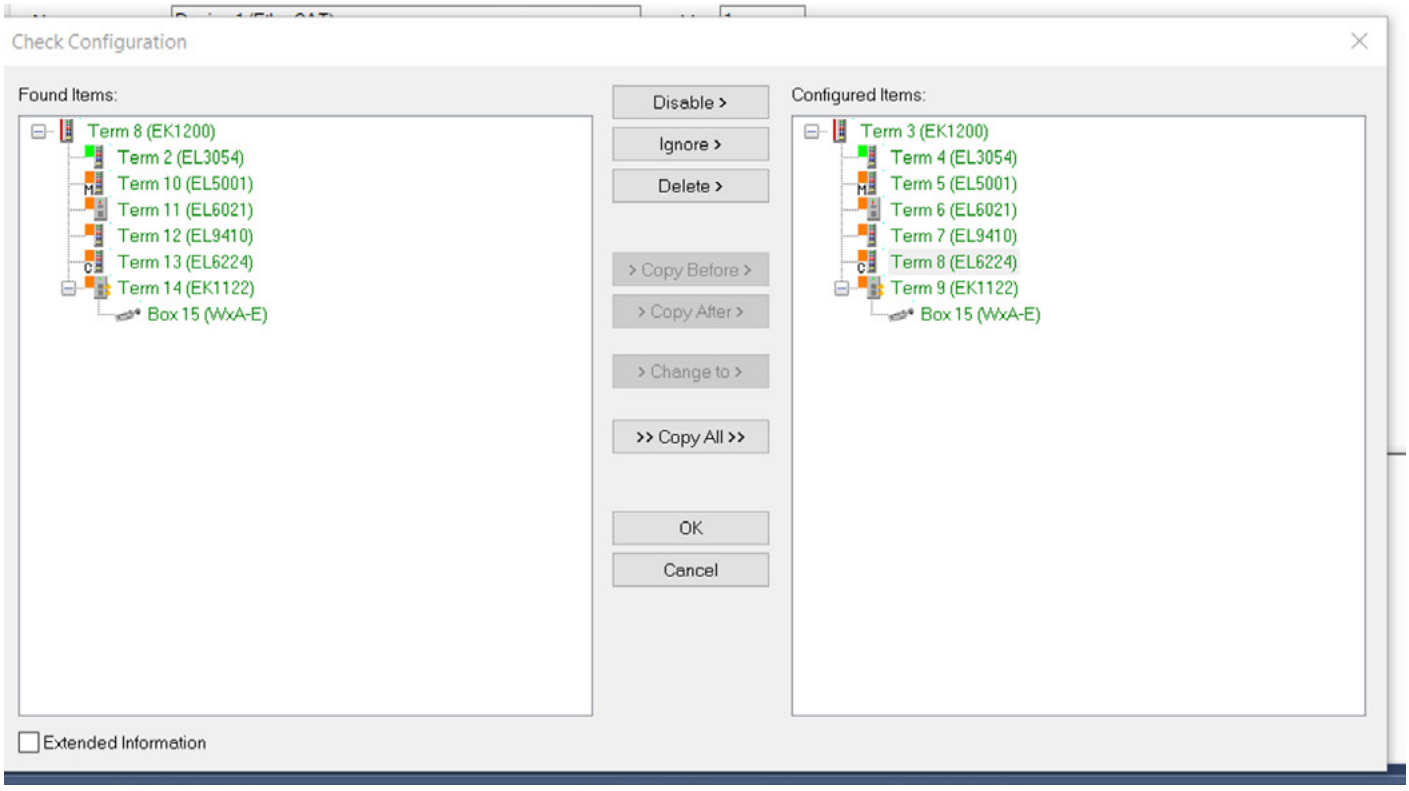
This section provides a configuration example for using a WxA-E sensor with a Beckhoff PLC. The following instructions should be adapted to suit your network configuration and Beckhoff PLC model. For further information and assistance, please refer to the PLC manufacturer's website.
To integrate the WxA-E sensor into the TwinCAT software, you must provide the ESI file of the WxA-E sensor. The ESI file contains the relevant information (dictionary object, process data information, supported functions) of the slave device.
The WxA-E ESI file is available for download from our website (www.gefran.com). After downloading the ESI file, unpack it and save the ESI file (.xml) in the TwinCAT 3 installation directory in the subdirectory "Config\Io\EtherCAT".
The TwinCAT software must reload its EtherCAT device database in order to recognise the newly copied ESI file (see figure below)



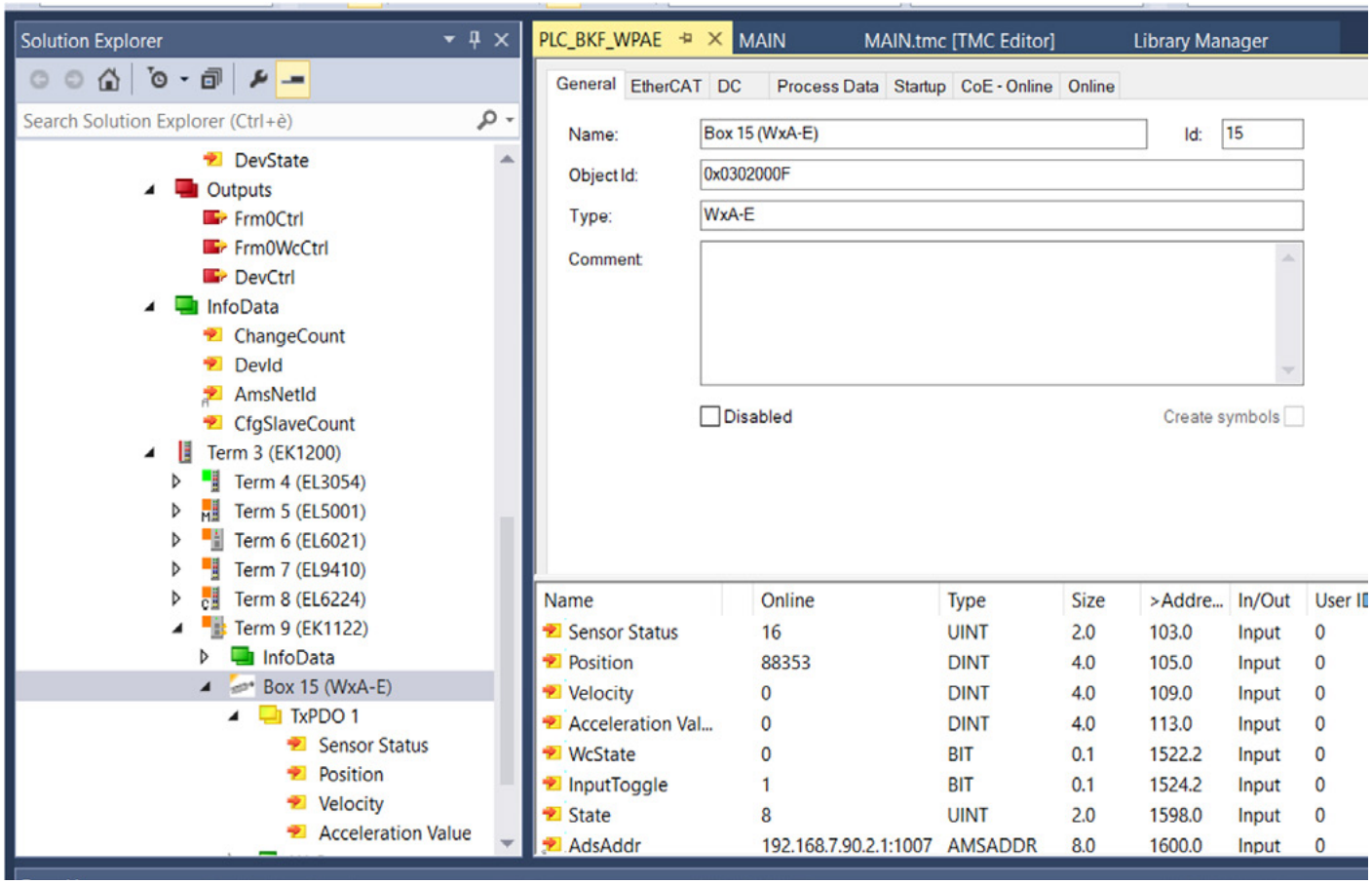
To add the WxA-E sensor to your project, put the Beckhoff PLC into configuration mode, select the EtherCAT master device and click on the Scan button.



The TwinCAT software shows you the device found after scanning. Select the WxA-E and copy the device into your project.



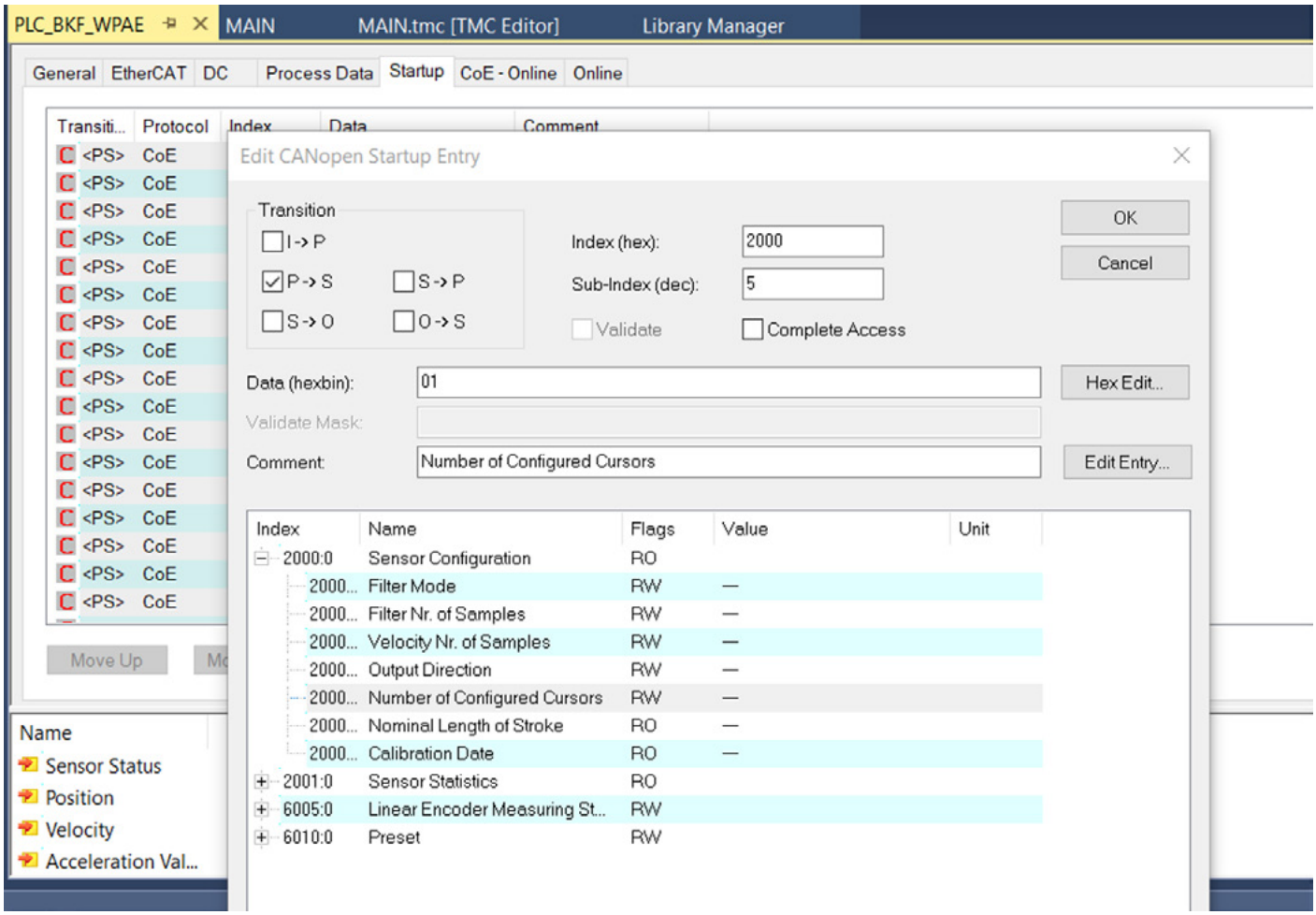
The WxA-E device should appear in the EtherCAT device list. Compile and download this configuration to your PLC.
The control window allows you to view the real-time process data and read/write the dictionary objects via SDO protocol.



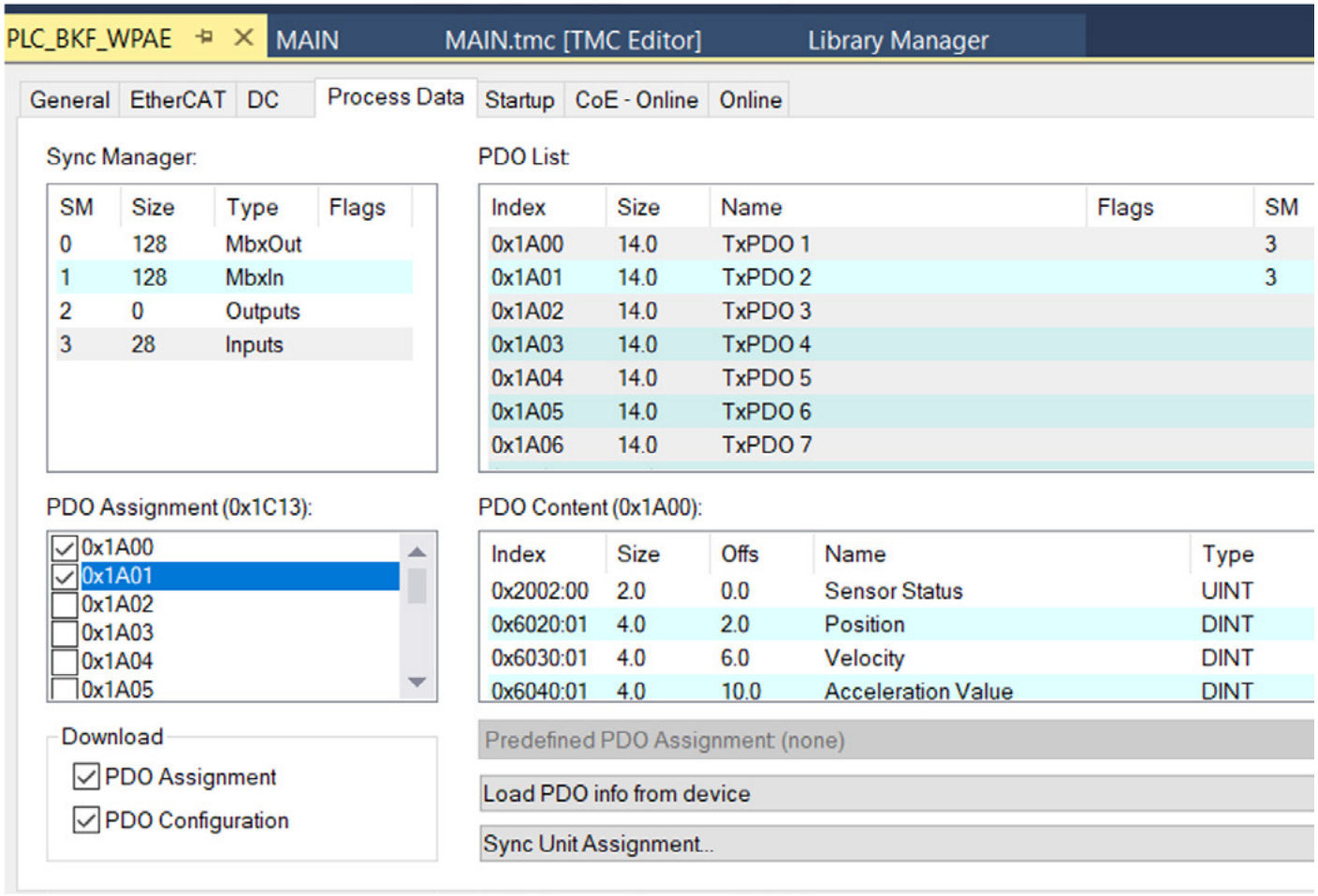
5.2. Configuration of two or more cursors

The WxA-E sensor is configured by default to measure one cursor position and to transmit only one TxPDO as process data. If only one cursor is used, no further configuration is required.
The WxA-E can measure two or more cursor positions (up to 16), to enable this function it's necessary to activate two (or more) TxPDOs and set the correct number of cursors in the configuration parameter.

The Beckhoff PLC allows you to configure the number of supported cursors at startup using the Startup tab.



The number of TxPDO can be enabled (or disabled) in the Process Data tab (PDO assignment).



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