MICRO-EPSILON

Instruction Manual

combiSENSOR 64x0

Contents

## 1.	Safety

Knowledge of the operating instructions is a prerequisite for equipment operation.

### 1.1	Symbols Used

The following symbols are used in this instruction manual:

⚠ **CAUTION**   Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.

NOTICE   Indicates a situation which, if not avoided, may lead to property damage.

➡   Indicates a user action.

i   Indicates a user tip.

### 1.2	Warnings

⚠ **CAUTION**   Disconnect the power supply before touching the sensor surface.
> Danger of injury through static discharge

Connect the power supply and the display/output device in accordance with the safety regulations for electrical equipment.
> Danger of injury

> Damage to or destruction of the sensor and/or controller

NOTICE   Avoid shock and vibration to the sensor and controller.
> Damage to or destruction of the sensor and/or controller

The power supply may not exceed the specified limits.
> Damage to or destruction of the sensor and/or controller

Protect the sensor cable against damage
> Destruction of the sensor

> Failure of the measuring device

1.3   Notes on CE Marking

The following apply to the combiSENSOR 64x0:
- EU Directive 2014/30/EU
- EU Directive 2011/65/EU, "RoHS" Category 9

Products which carry the CE mark satisfy the requirements of the quoted EU directives and the European standards (EN) listed therein. The EU declaration of conformity is kept available according to EU directive, article 10 by the authorities responsible at

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The measuring system is designed for use in industrial environments and meets the requirements.

1.4   Intended Use

- The combiSENSOR 64x0 measuring system is designed for use in industrial and laboratory applications. It is used for
  - measuring film thickness of plastics
  - measuring layer thickness of insulators
- The system must only be operated within the limits specified in the technical data, see 2.3.
- The system must be used in such a way that no persons are endangered or machines and other material goods are damaged in the event of malfunction or total failure of the controller.
- Take additional precautions for safety and damage prevention in case of safety-related applications.

1.5　　　Proper Environment

- Protection class:　　　　IP 40
- Operating temperature:
  - Sensor:　　　　　　　　-10 ... +85 °C (+14 to +185 °F)
  - Sensor cable:　　　　　-10 ... +85 C (+14 to +185 °F) or 100 °C for maximum 10,000 hours
  - Controller:　　　　　　+10 ... +60 °C (+50 to +140 °F)
- Humidity:　　　　　　　　5 - 95 % (non-condensing)
- Ambient pressure:　　　　Atmospheric pressure
- Storage temperature:
  - Sensor:　　　　　　　　-10 ... +100 °C (+14 to +212 °F)
  - Sensor cable:　　　　　-10 ... +85 °C (+14 to +185 °F)
  - Controller:　　　　　　-10 ... +75 °C (+14 to +167 °F)
- The space between the sensor surface and the target must have an unvarying dielectric constant.
- The space between the sensor surface and the target may not be contaminated (for example water, rubbed-off parts, dust, etc.)

2.   Functional Principle, Technical Data

2.1   Measuring Principle

The construction of the measurement coil and measurement electrodes is concentric. Both therefore measure against the same target (measuring object). The signal of the capacitive displacement sensor is a function of the working distance, the thickness of the insulator and ε_r. At the same time the eddy current displacement sensor measures the distance to the ground electrode (for example flat sheet or to a metal roller positioned behind the film). The measurements are output as analog voltages of 0 to 10 VDC and digital signals through Ethernet or EtherCAT at the following controller.

2.1.1   Capacitive Principle

The principle of capacitive distance measurement is based on the parallel plate capacitor.

If a constant AC current I_c flows through the sensor capacitor, the amplitude of the AC voltage U_c at the sensor is proportional to the distance d between the capacitor electrodes.

Ground
Screening electrode (guarding)
Measuring electrode
Measuring object: electrical conductor

$$X_c = \frac{U_c}{I_c} = \frac{1}{\omega C}$$

$$C = \varepsilon_o \, \varepsilon_r \, \frac{A}{d}$$
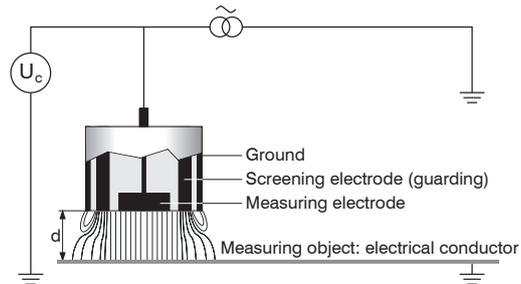
$$U_c = \frac{I_c \, d}{\omega \varepsilon_o \varepsilon_r A} \quad >> \quad \boxed{U_c \sim d}$$

Fig. 1 Electric field of a capacitive sensor, no insulator material in the gap.

The measured AC voltage is demodulated, amplified and output as an analog voltage. The sensor design with guard ring electrodes guarantees that the ideally necessary homogenous electrical field is realized for all practical purposes.

i   A measurement object that is too small and curved (uneven) measurement surfaces also produce a non-linear characteristic.

2.1.2 Eddy Current Principle

The eddy current principle is used for making measurements on targets made of either ferromagnetic or non-ferromagnetic electrically conductive materials.

High-frequency alternating current flows through a coil in the sensor.

The electromagnetic coil field induces eddy currents in the conductive target thus changing the AC resistance of the coil.

This change in impedance is interpreted by demodulation controllers which generate an electrical signal proportional to the distance of the target from the sensor.

A compensation technique reduces temperature-dependent measuring errors to a minimum.

i If the material of the counter electrode is changed, the measuring system must be rebalanced.

2.1.3 Thickness Measurement

The main field of application is the traversing thickness measurement of plastic film or of plastic coating on metal plates. Arithmetical coupling of the two sensor signals provides compensation of mechanical changes, for example thermal expansion, deflections, eccentricity in the measurement device. Through the redundancy of this combined sensor principle, the measured thickness value remains unaffected by any changes in the measurement setup. The target thickness T is calculated from both sensor signals.
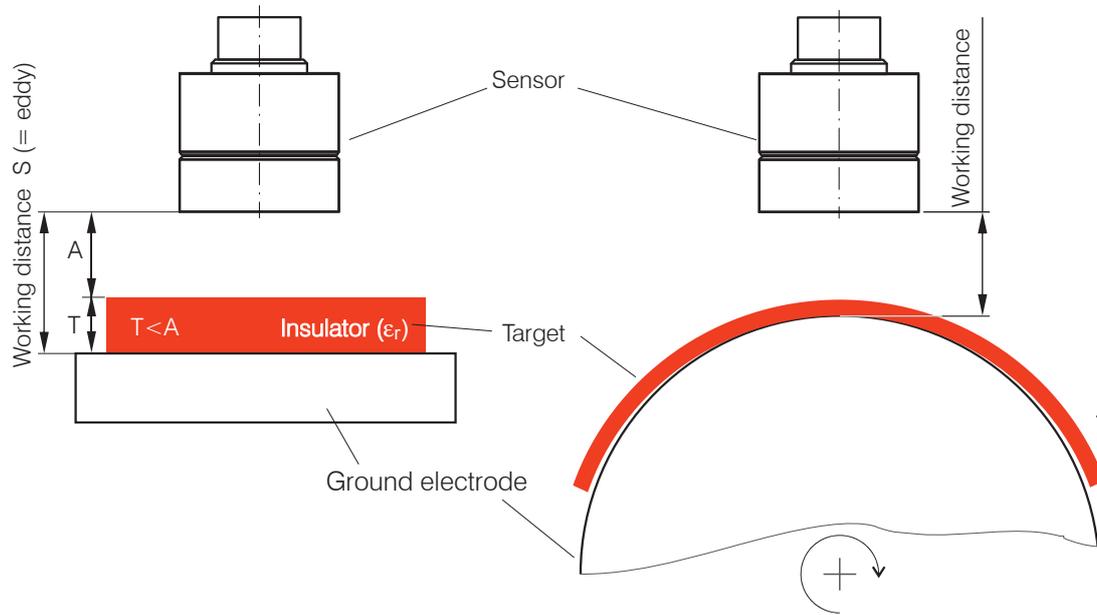
Fig. 2 Sensor arrangement for thickness measurement

The thickness of the insulator is calculated from the following factors: max. working distance, capacitive displacement signal A and the dielectric constant of the insulator:

$$T = \left[S\,(eddy) - A\,(capa) \right] * \left[\frac{\varepsilon_r}{\varepsilon_r - 1} \right] * \frac{WD}{100\,\%} + Offset$$

T	Target thickness [μm]
S	Signal eddy sensor [%]
A	Signal capacitive sensor [%]
ε_r	Dielectric constant (insulator)
WD	Working distance [μm]
Offset	Constant [μm], standard value = 0

A constant dielectric constant of the target is required in order to obtain correct measuring results.

The thickness value can be calculated and output directly in the controller.

i   With measurement objects presenting a structured surface, a target thickness up to a maximum of 50 % of the working distance is recommended. If necessary, use a sensor with a larger target thickness instead.

In contrast to the capacitive signal of the sensor, the output signal of the eddy current signal is not being affected by the materials in the measuring gap and is therefore determined by the distance between the sensor and the ground electrode.

2.2   Structure

The non-contact, single-channel measuring system, see Fig. 3, installed in aluminium housings, consists of:

- a KSH5 or a KSH10 sensor
  with sensor cable,
- a KSS64x0 controller.

Fig. 3 Single-channel measuring system with sensor and controller

2.2.1   Sensor

In its sensor housing the combiSENSOR combines an eddy current displacement sensor and a capacitive displacement sensor. In order to obtain accurate measuring results, the surface of the sensor must be kept clean and free from damage. The capacitive measuring process is area-related. The combiSENSOR requires a minimum area of ø 45 mm (KSH5) or ø 65 mm (KSH10).

2.2.2 Sensor Cable

The sensor and controller are connected by a special, double screened, 1 m (3 ft) long sensor cable KC1.

➡️ Do not shorten or lengthen these special sensor cable. Do not crush the sensor cable. Do not modify the sensor cable. This leads to a loss of functionality or of the specified technical data.

➡️ Install the sensor cable in a protected area.

A damaged cable can not be repaired. The sensor cable is not suitable for cable carriers. Minimum bending radius: 20 mm (once), 80 mm (permanently).

i Switch off the power supply of the controller, when plugging and removing connectors.

2.2.3 KSS64x0 Controller

The controller contains an oscillator and a signal conditioning electronics for the sensor. The capacitive and eddy current part of the sensor are synchronized with each other.

Ethernet / EtherCAT

Sensor

Power supply, Trigger In

Eddy and capa signal
differential and temperature signal
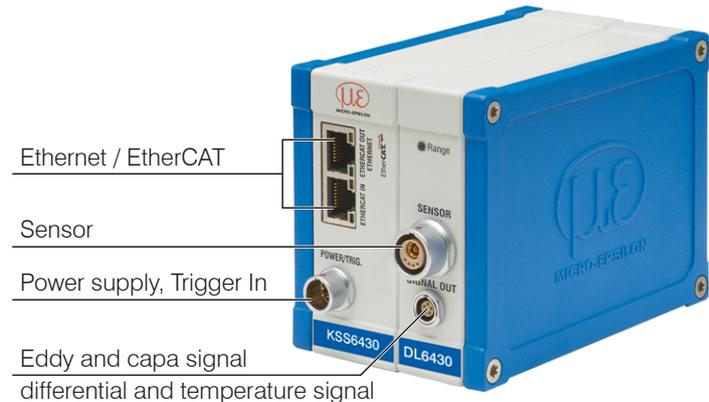
Fig. 4 Controller measuring system

2.3 Technical Data

Controller		KSS6420	KSS6430	KSS6420(01)	KSS6430(01)
Sensor		KSH5(01)		KSH10	
Target thickness insulator		40 µm ... 3 mm		40 µm ... 6 mm	
Resolution [1]	static, 104 Sa/s	0.0018 %	0.0004 %	0.0030 %	0.0006 %
	dynamic, 3.9 kSa/s	0.0075 %	0.0015 %	0.0120 %	0.0025 %
Bandwidth		analog: 1 kHz (3 dB) [2], digital: 2.6 … 3900 Sa/s (adjustable)			
Linearity		± 0.05 %			
Temperature stability [4]	Sensor	± 50 ppm (+10…+60 °C)			
Temperature stability	Controller	± 50 ppm	± 50 ppm	± 50 ppm	± 70 ppm
Temperature range		controller: +10…+50 °C; sensor:+10…+50 °C; sensor cable: -10…+125 °C			
Power supply		12…36 VDC (5.5 W)			
Output	Analogue	capacitive, eddy current and differential signal: 0-10 V (short circuit proof); internal sensor temperature signal (not scaled)			
	Ethernet	capacitive, eddy current, differential and internal temperature signal: 24 Bit			
	EtherCAT	capacitive, eddy current, differential and internal temperature signal: float			
Trigger		TTL, 5 V			
Target geometry		Straight surface or min. diameter 200 mm [3]			
Working distance		2 ... 5 mm		4 ... 10 mm	
Min. diameter measurement surface		45 mm		65 mm	
Protection class		sensor: IP 54, controller: IP 40			
Weight		sensor: 80 g ; controller: 750 g			
Storage temperature		sensor, cable: -10…+100 °C, controller: 0…75 °C			

[1] Difference signal of the digital output, measured with working distance = 50 % FSO

[2] Only valid when sampling rate = 3900 Sa/s

[3] Reference material ground electrode: VA steel (1.4571) or aluminium.
   Changes of the ground electrode (material or geometry) require a recalibration of sensor and controller by the manufacturer.

[4] Circumferential clamping starts 5 mm behind the sensor surface, see Fig. 7.

3.   Delivery

3.1   Unpacking, Included in Delivery

- 1 Controller KSS64x0
- 1 Sensor (KSH5 or KSH10)
- 1 Sensor cable KC1
- 1 Instruction manual
- 1 Power supply and trigger cable PC6200-3/4, 3 m long
- 1 Network cable
- 1 Conversion kit (Springs for mounting on DIN-rail, mounting plates for wall fastening)

➡ Carefully remove the components of the measuring system from the packaging and ensure that the goods are forwarded in such a way that no damage can occur.

➡ Check the delivery for completeness and shipping damage immediately after unpacking.

➡ If there is damage or parts are missing, immediately contact the manufacturer or supplier.

3.2   Storage

- Storage temperature
  - Sensor, sensor cable -10 °C to +100 °C (+14 to +212 °F)
  - Controller 10 to +75 °C (+50 to +167 °F)
- Humidity 5 - 95 % (no condensation)

4. Installation and Assembly

4.1 Precautionary Measures

No sharp-edged or heavy objects may come into contact with the sensor cable sheath.

In pressurised rooms the cable must be protected against pressure loads.

The minimum bending radius is 20 mm (.79 inch). Kinks must be avoided at all cost.

The connections must be checked for tight fit.

i A damaged cable cannot be repaired.

4.2 Sensor

➡ When assembling, make sure that the polished sensor surface is not scratched.

i The target must not touch the sensor surface. Comply with the working distance.

Legend
mm (inches)
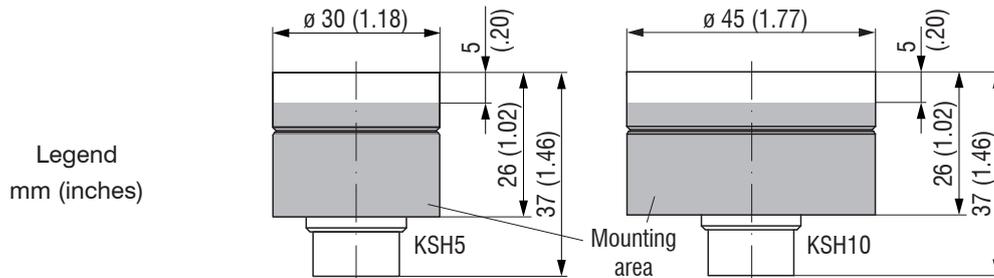
Fig. 5 Sensor dimensions

Fig. 6 Free space with *no* metallic conductive objects

➡ Make sure when assembling the sensor that there are no metallic conductive objects within the gray marked area, see Fig. 6. Else the linearity may be changed of the eddy current sensor by up to about 1 % of measuring range.

Circumferential clamping

This sensor mounting option offers maximum reliability because the sensor is clamped around its cylindrical housing.

It is absolutely necessary in difficult installation environments, for example on machines, production plants et cetera.

Mounting with a clamping ring
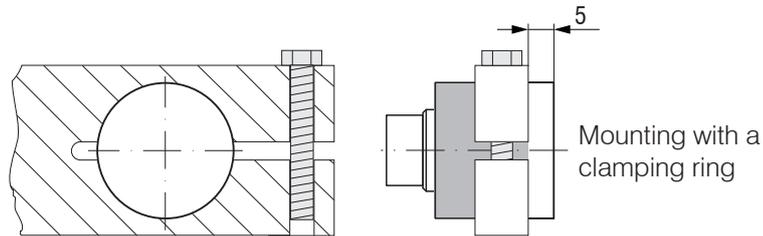
Fig. 7 Circumferential clamping

i   Pulling on the cable is inadmissible.

4.3   Sensor Cable

The sensor cable connects the sensor with the controller.

➡️ Connect the sensor to the controller by the sensor cable.

The connection is made by simple plugging. The connector locks automatically. The tight fit can be checked by pulling the connector housing (cable bushing).

i   A damaged cable cannot be repaired.

Legend
mm (inches)
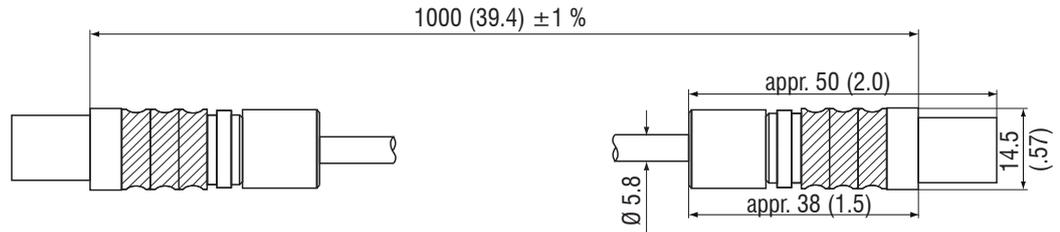
Fig. 8 Dimensions sensor cable

4.4 Controller

Legend
mm (inches)
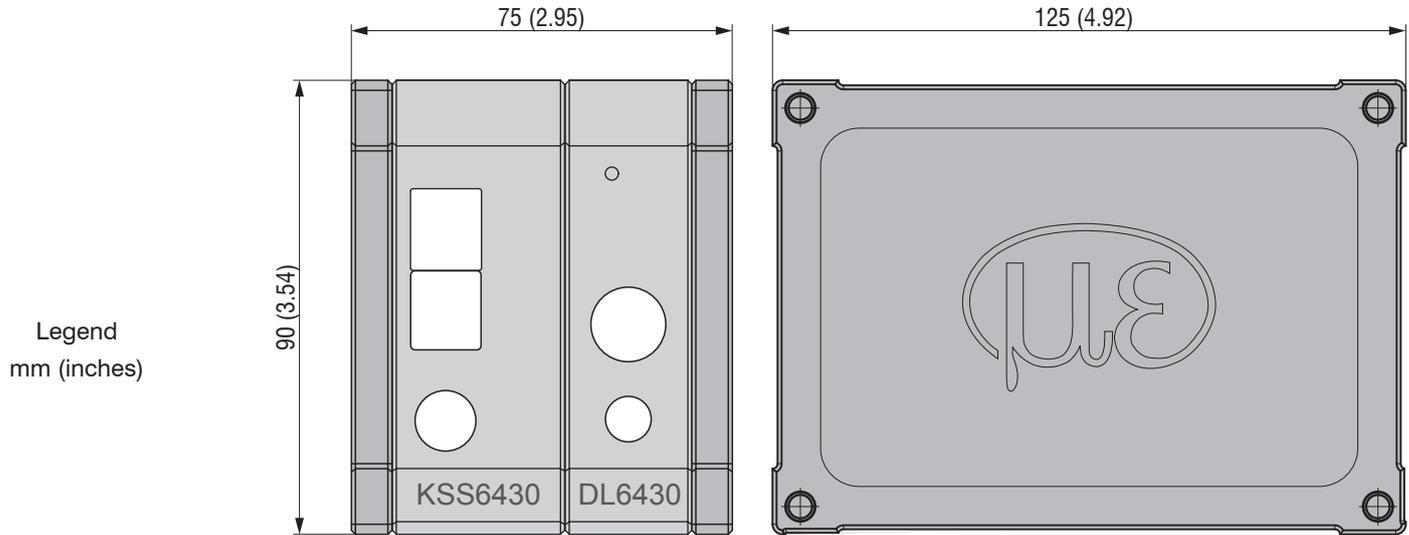
Fig. 9 Dimensional drawing controller with basic unit, demodulator module and housing cover
Dimensions in mm (inches), not to scale

Mounting hole M4 for
wall fastening respectively
mounting on DIN-rail
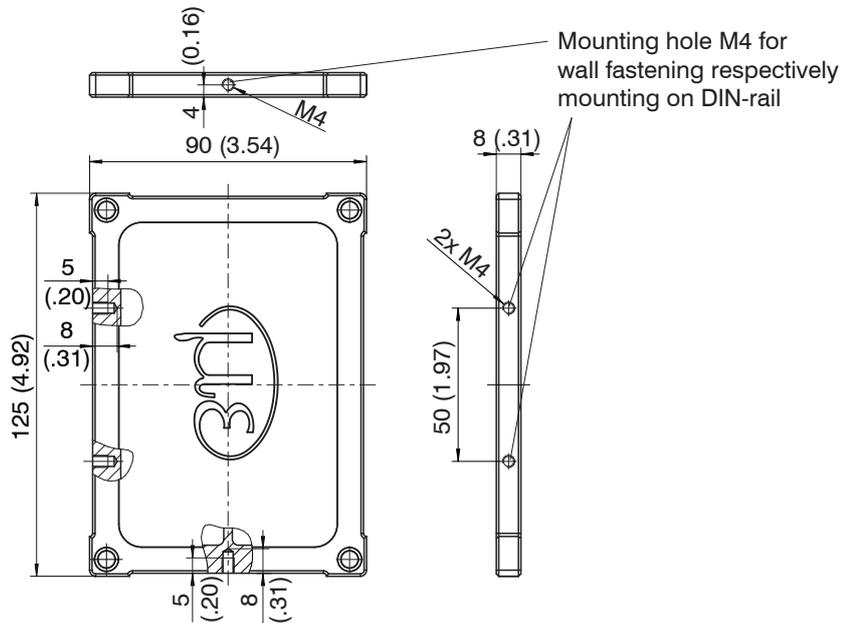
Fig. 10 Dimensional drawing housing cover

Dimensions in mm (inches), not to scale

The controller is mounted using mounting plates or holding clamps for a mounting on DIN-rail which are included with the conversion kit supplied.

4.5 Ground Connection, Earthing

➡ Make sure you have a sufficient grounding of the measuring object, for example connect it with the sensor or the supply ground.

If necessary use the ground connection on the housing cover. The ground connection is included with the conversion kit supplied.

4.6 Electrical Connections

4.6.1 Connectivity Options

The power supply and the signal output are located at the front side of the controller.
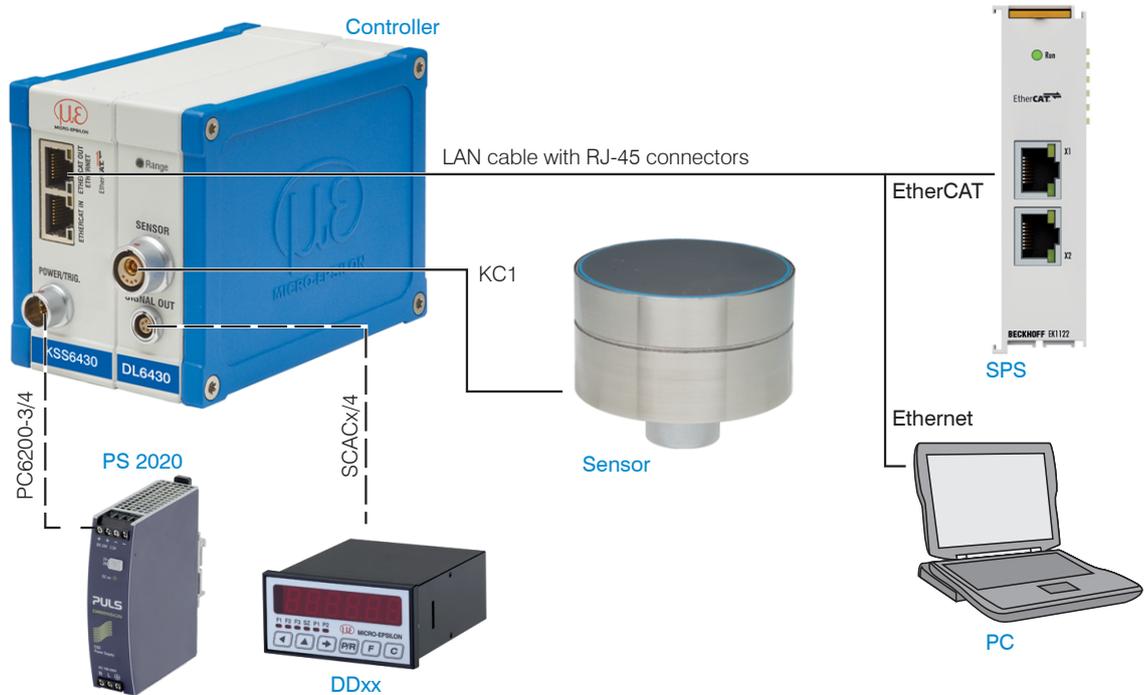
Fig. 11 Measuring system assembly

4.6.2   Pin Assignment Supply, Trigger

PIN	Color PC6200-3/4	Signal	Description
1	brown	+24VIN	+24 VDC Supply
2	white	Zero VIN	GND Supply
3	yellow	TRI_IN+	Trigger IN+, TTL level
4	green	TRI_IN-	Trigger IN-
shield			

PC6000-3/4 is a 3 m (13.12 ft) long, pre-assembled power supply and trigger cable.
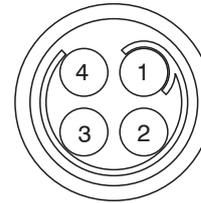
View on solder pin side, 4-pole ODU female cable connector
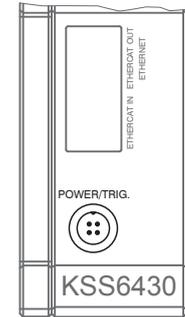
Power supply input on controller, 4-pole male cable connector

4.6.3   Analog Output

The signals are output via the 5-pin built-in female connector. See the drawing and table for the pin assignment.

PIN	Assignment
1	Differential signal 0 ... 10 V (eddy current - capacitive signal) or thickness
2	Capacitive signal 0 ... 10 V
3	Eddy current signal 0 ... 10 V
4	Sensor temperature signal, not scaled
5	GND
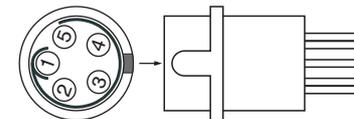
Solder pin side male cable connector

The SCAC3/5 is a 3 m (9.84 ft) long, pre-assembled 5-wire output cable. It is supplied as an optional accessory.

PIN Assignment and color code:

PIN	Color	Assignment
1	white	Differential signal (= eddy current - capacitive signal) or thickness signal, 0 ... 10 V
2	grey	Capacitive signal (0 ... 10 V)
3	yellow	Eddy current signal (0 ... 10 V)
4	green	Sensor temperature signal, not scaled
5	brown	GND

5.   Operation

5.1   Starting Up

➡ Connect the display/output devices through the signal output socket, see 4.6, before connecting the device to the power supply and switching on the power supply.

ⅰ Allow the measuring system to warm up before the first measurement or calibration for approximately 15 min.
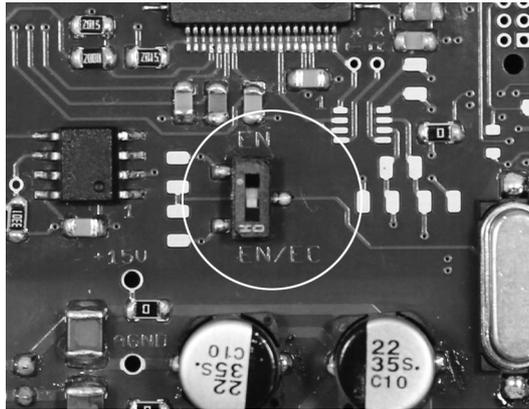
Fig. 12 Change Ethernet/EtherCAT, basic module KSS6420

A switch between Ethernet and EtherCAT, is possible via a hardware switch, see Fig. 12 or via software on the basic unit KSS64x0, see 7.2.

If the switch is in position EN (Ethernet) , always the Ethernet interface is active independent of the software setting. If the switch is in position EN/EC (Ethernet/EtherCAT), then the active interface depends on the software setting. To change the interface it is necessary to restart the controller.

5.2 LED's on the Controller

LED	Color	Function
Range	green	Target within working distance
	red	Working distance exceeded
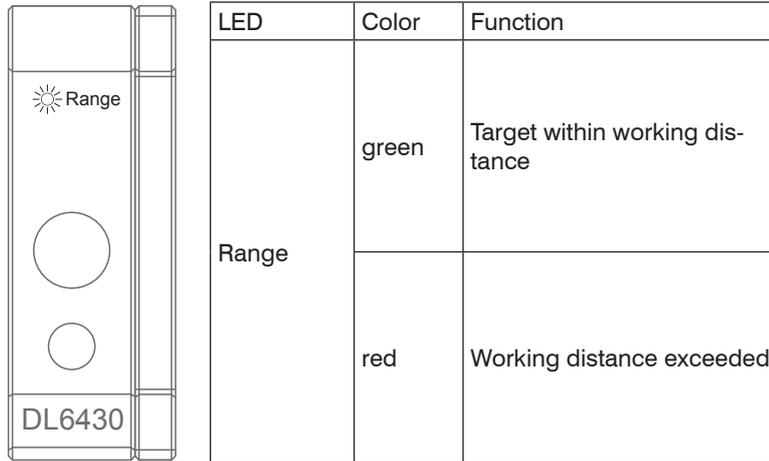
5.3 Triggering

The measuring value output on combiSENSOR 64x0 is controllable by an external electrical trigger signal or command. Here, only the digital output is affected.

Triggering release by:
- Trigger input (pin 3 and pin 4 on 4-pole power supply connector, see 4.6.2 or
- Software command $GMD, see 6.4.3
- U_{IN}, HIGH ≥ 2,0 V
- U_{IN}, LOW ≤ 0,8 V

Fig. 13 Trigger Input
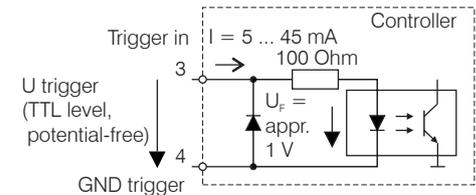
The trigger type is determined by the command $TRGn, see 6.4.2 or
- the web interface, see 6.5.4

Level triggering (high level). Continuous measurement output with adjusted data rate, as long as the selected level is active. After that the controller stops the output of the measuring values.

Fig. 14 Active high level trigger (U $_I$), relevant digital signal (D $_o$)
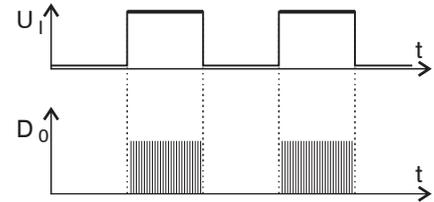
Edge triggering. Starts measuring value output, as soon as the rising edge on the trigger input is active. If trigger conditions are met, the controller outputs a measuring value. The set data rate must be higher than the maximum trigger frequency. If triggering is faster than the set data rate, individual measuring values are transmitted twice, because internally no new measuring values of the AD converter are active.

The duration of the pulse must be at least 5 μs.

Fig. 15 Rising edge trigger (U $_I$), relevant digital signal (D $_o$)
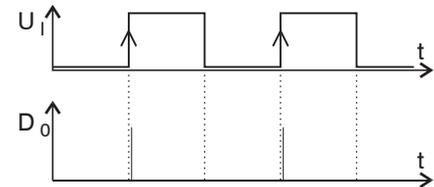
Gate rising edge. Starts measuring value output with set data rate, as soon as the rising edge on the trigger input is active. Another rising edge stops the measuring value output respectively switches it on again.

Fig. 16 Rising edge trigger (U $_I$), relevant digital signal (D $_o$)
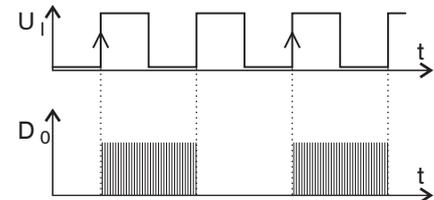
Software triggering ($GMD). A measuring value is output per channel, as soon as a command is sent. The point of time is not defined as accurately.

No trigger is set ex factory. The controller starts the data transfer immediately after the switching on.

5.4 Measurement Averaging

5.4.1 Introduction

Measurement averaging is performed before the output of measuring values via the Ethernet interfaces.

Measurement averaging improves the resolution, allows masking individual interference points or "smoothes" the reading.

$\mathbf{i}$ Linearity is not affected by averaging. Averaging has no effect on measuring frequency.

The controller is delivered ex factory without measurement averaging.

5.4.2 Moving Average

The definable number N for successive measurements (window width) is used to calculate the arithmetic average M_{mov} according to the following formula:

$$M_{mov} = \frac{\sum\limits_{k=1}^{N} MV}{N}$$

MV = Measuring value
N = Number
k = Continuous index
M_{mov} = Average value

Fig. 17 Formula for the moving average

Method

Each new measured value is added, and the first (oldest) value is removed from the averaging.

Example with N = 7:

.... 0 1 $\boxed{2\ 3\ 4\ 5\ 6\ 7\ 8}$ gets to $\dfrac{2+3+4+5+6+7+8}{7}$ Average value n

.... 1 2 $\boxed{3\ 4\ 5\ 6\ 7\ 8\ 9}$ gets to $\dfrac{3+4+5+6+7+8+9}{7}$ Average value n +1

5.4.3   Arithmetic Average Value

The arithmetic average value M is set and output over the selected number N of successive measuring values.

Method

Measuring values are collected and the average value is calculated consequently. This method leads to a reduction of the amount of data, because an average value is output only after every Nth measuring value. Example with N = 3:

.... 0 1 $\boxed{2\ 3\ 4}$ ...   gets to $\dfrac{2+3+4}{3}$ Average value n

.... 3 4 $\boxed{5\ 6\ 7}$ ...   gets to $\dfrac{5+6+7}{3}$ Average value n + 1

5.4.4   Median

A median value is formed from a preselected number of measurements. For this, the incoming values are sorted after each measurement. Then, the average value is provided as the median value.

If an even value is selected for the average number N, middle both measuring values are added and divided by two.

Example with N = 7:

... 2 4 $\boxed{0\ 1\ 2\ 4\ 5\ 1\ 3}$ Sorted measuring value   0 1 1 $\boxed{2}$ 3 4 5 Median $_n$ = 2

... 4 0 $\boxed{1\ 2\ 4\ 5\ 1\ 3\ 4}$ Sorted measuring value   1 1 2 $\boxed{3}$ 4 4 5 Median $_{n+1}$ = 3

5.4.5   Dynamic Noise Rejection

This filter removes the noise of the measurement signal completely, but keeps the original bandwidth of the measurement signal.

For that purpose the signal noise is calculated dynamically and measurement changes are only transferred, if they exceed this calculated noise. Thereby at a change in direction of the measurement signal small hysteresis effects in the size of the calculated noise can occur.

6.   Ethernet Interface

You will achieve especially high resolutions if you readout the measurements in digital form via the Ethernet interface.

For that purpose. use the web interface or a special program. MICRO-EPSILON supports you by the driver MEDAQLib, containing all commands for combiSENSOR 64x0.

You can find the current driver routine including documents at:
www.micro-epsilon.com/download
www.micro-epsilon.com/download/software/MEDAQLib.zip

6.1   Hardware, Interface

The data logging of all channels is synchronous.

➡ Connect the combiSENSOR 64x0 to an available Ethernet interface at the PC. Use a crossover cable.

For a connection with the combiSENSOR 64x0 you will require a defined IP address of the network interface card inside the PC. Go to `Control Panel\Network Connections.` Set up, if applicable, a new LAN connection. For more information, contact your network administrator.
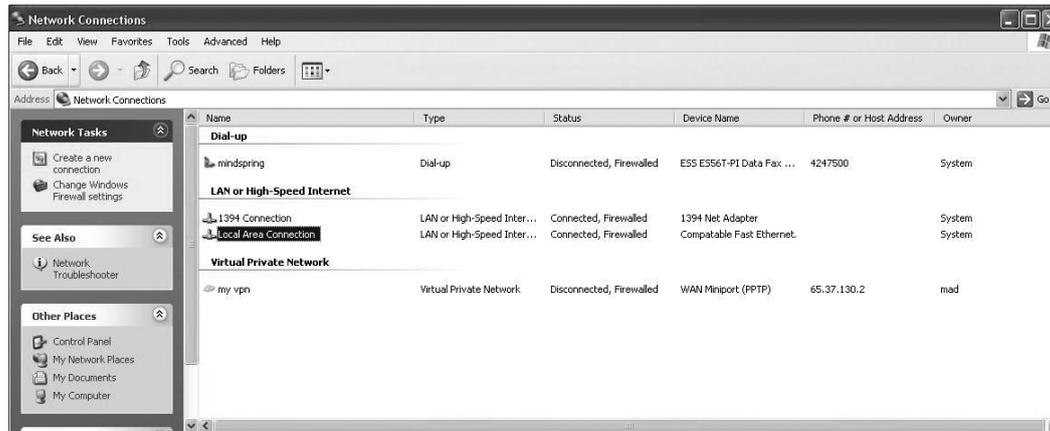
Fig. 18 LAN connection of a PC

➡ Define the following address in the properties of the LAN connection:

IP address: 169.254.168.1

Subnet mask: 255.255.0.0
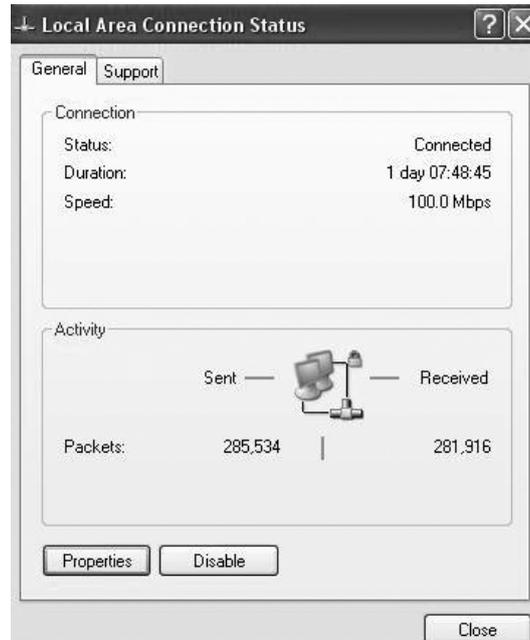
➡ Select `Properties`.
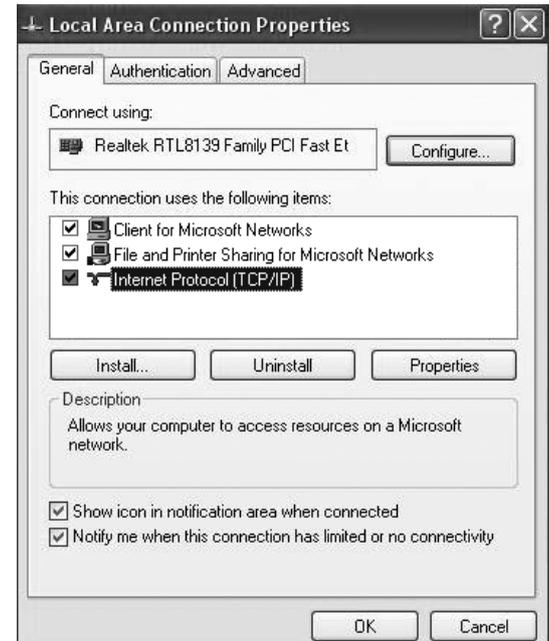
➡ Select `Internet Protocol (TCP/IP)` > `Properties`.
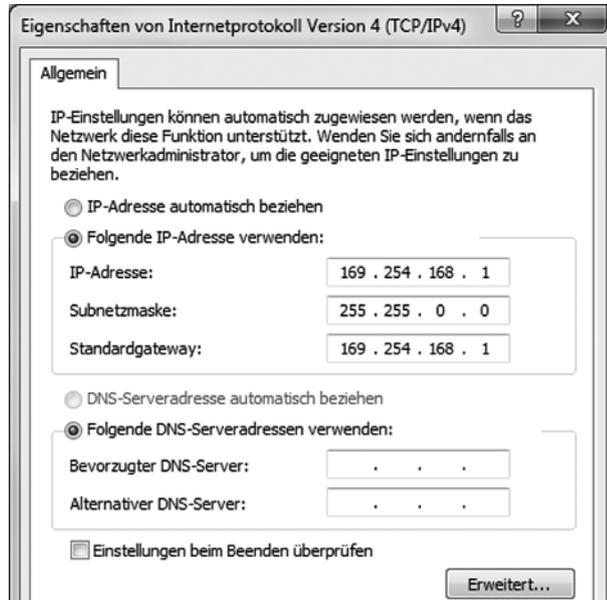
By default, the IP address of the controller is set to 169.254.168.150. Communication with the controller is done on the data port 10001 for measurement transmission. A command port (Telnet, port 23) is used for sensor commands.

The IP settings and the data port can be changed at any time:
- by using the web browser. Enter the current IP address into the address bar. Go to the menu `Settings > Digital Interfaces > Ethernet settings` to set a new IP address, activate DHCP or change the data port.
- by using software commands, see 6.4.
- by using the `sensorTOOL` software.

If you activate DHCP, access to the controller via a DHCP host name is possible. The host name contains the device name and serial number. Structure: NAME_SN e.g. KSS6420_1001.

The controller supports UPnP. If you use an operational system with activated UPnP client e. g. standard with Windows 7, the controller is listed in the explorer as a device automatically. This is helpful, if you do not know the IP address of the controller.

6.2 Data Format of Measuring Values

All measuring values, recorded at a time, are combined into a measuring value frame (One measuring value per channel).

Several measuring value frames are combined to a measuring value block and then transmitted together with a header as a TCP packet.

All measuring values and the header are transmitted in little-endian format.

Contents	Size	Description
Preamble	32 bit	„MEAS" as an ASCII text
Order number	32 bit	Order number of sensor as int
Serial number	32 bit	Serial number of sensor as int
Channels (Bit field)	64 bit	Bit field, which channel available. Two bits per channel are used: „00"= Channel is not available; „01"=channel available. The lowest channel is on the most low-order bit ->Thereby determining the number of channels N possible.
Status	32 bit	Is not used.
Frame number M / bytes per frame	16 bit / 16 bit	One frame = one measuring value per channel
Measuring value counter	32 bit	Measuring value counter (of 1st frame)
Measuring value frame 1 [number channels N]	N * 32 bit	Measuring values all channels, starting with the lowest channel number
Measuring value frame 2 [number channels N]	N * 32 bit	"
....	...	...
Measuring value frame M [number channels N]	N * 32 bit	"

All measuring values are transmitted as Int32. The measuring value resolution is 24 bits i.e only the most low-order 24 bits of integer number are used. Hexadecimal range: 0 ... $FFFFFF_{16}$.

Scaling of measuring values:

$$\text{Measurement in } \mu m = \frac{\text{Digital value (Int)}}{\text{0xFFFFFF}} * \text{Max. working distance in } \mu m$$

Example: Max. working distance sensor KSH5 $= 5000\,\mu m$; digital value $= 7\text{FFFFF}_{16}$

Measurement $= 2500\,\mu m$

Channel number:
- 0: Differential signal (= eddy current - capacitive signal) or Thickness signal
- 1: Capacitive signal
- 2: Eddy current signal
- 3: Sensor temperature signal

By default, the measuring values are continuously output with the set data rate via the data port.

However, there is also a trigger mode, with can be used to get the individual measuring values, see 6.4.2.

6.3   Settings

Operating modes:
- Continuous transmission with fixed data frequency
- Trigger mode (recall hardware trigger input or individual measuring values, see 5.3.

Data rate:

It is possible to adjust different data rates between 2.5 Sa/s and 3.9 kSa/s. The data rate applies to all channels.

Filter/Measuring value averaging:

The following filters are selectable:
- Moving average
- Arithmetic average (only each nth value will be output)
- Median
- Dynamic Noise Rejection

The setting for the averaging applies to all channels.

6.4   Commands

All commands are transmitted via port 23 (Telnet). Each command starts with a $ character.

The controller ignores all characters, which are transmitted before the $ character.

The controller immediately returns all transmitted characters back as echo.

Commands are transmitted in ASCII format.

A time out is reached approximately 10 seconds after the last character input.

Commands always have to end with <CR> or <CRLF>.

6.4.1   Data Rate (STI)

Changes the sample time in μs (respectively sample rate) for all channels, which are used to transmit the measuring values. The requested sample time in μs is sent to the controller. Because any sample time is not possible, the controller replies with the next available sample time in μs. This is active from then.

	STI = Set Sample Time
Command	$STIn<CR> Example: $STI1200<CR>
Response	$STIn,mOK<CRLF> Example: $STI1200,960OK<CRLF>
Index	n = designated new sample time in μs (TARGET)
	m = new sample time in μs (ACTUAL)
Possible sample times	
n (in μs)	corresponds to data rate
384000	2.6 Sa/s
192000	5.2 Sa/s
96000	10.4 Sa/s
64000	15.6 Sa/s
38400	26 Sa/s
32000	31.3 Sa/s
19200	52.1 Sa/s
16000	62.5 Sa/s
9600	104.2 Sa/s
1920	520.8 Sa/s
960	1041.7 Sa/s
480	2083.3 Sa/s
256	3906.3 Sa/s
Request sample time	
Command	$STI?<CR>
Response	$STI?nOK<CRLF>

6.4.2   Trigger Mode (TRG)

There are three possible settings regarding the trigger input, see 5.3.

Irrespective of the trigger mode set, a single measured value per channel can be called up by means of a software command, see 5.4.3.

If the trigger mode is turned off, the combiSENSOR 64x0 will send the measurement values without interruption and with the adjusted data rate.

	TRG
Command	$TRGn<CR>
Response	$TRGnOK<CRLF>
Index	n = 0: Continuous transmission (default setting)
	n = 1: Triggermode 1 (rising edge)
	n = 2: Triggermode 2 (high level)
	n = 3: Triggermode 3 (gate rising edge)
	? = Request trigger mode
Request Trigger mode	
Command	$TRG?<CR>
Response	$TRG?nOK<CRLF>

6.4.3   Get Measured Data (GMD)

In the trigger mode, one measuring value is transmitted per channel.

	GMD
Command	$GMD<CR>
Response	$GMDOK<CRLF> + Measuring value in binary mode (format as in operating mode "continuous transmission") via data port

6.4.4   Filter, Averaging Type (AVT)

Mode of measurement averaging

	AVT
Command	$AVTn<CR>
Response	$AVTnOK<CRLF>
Index	n = 0: No averaging (Default setting)
	n = 1: Moving average
	n = 2: Arithmetic average (outputs only each nth measuring value)
	n = 3: Median
	n = 4: Dynamic noise rejection
	? = Request averaging type
Request averaging type	
Command	$AVT?<CR>
Response	$AVT?nOK<CRLF>

6.4.5   Filter, Averaging Number (AVN)

Number of measuring values used to calculate the average (adjustable from 2 … 8)

	AVN
Command	$AVNn<CR>
Response	$AVNnOK<CRLF>
Index	n = 2 ... 8
	? = Request averaging number
Request averaging number	
Command	$AVN?<CR>
Response	$AVN?nOK<CRLF>

6.4.6   Thickness Measurement (THM)

Sets the thickness measuring function on channel 1 (instead of a difference signal)

	THM
Command	$THMa,b,c<CR>
Response	$THMa,b,cOK<CRLF>
Index	a = dielectric constant (Float >1)
	b = offset in μm of the result (Float)
	c = max. working distance in μm of the used sensor (e.g. 5000 with KSH5)

Example: $THM3.3,10.23,5000<CR> (thickness function with dielectric constant 3.3 / max. working distance of the sensor = 5000 μm and offset = 10.23 μm)

Delete function: $THM0<CR> (Instead of the thickness value the controller outputs the difference signal eddy minus capa)

6.4.7   Thickness Zeroing (THZ)

Sets the value of an offset for a thickness function therewith 0 μm is output for thickness.

	THZ
Command	$THZ<CR>
Response	$THZOK<CRLF>

6.4.8   Channel Status (CHS)

Specifies in increasing order in which channels there is a module. (0 = no channel available, 1 = channel available, 2 = thickness function is output on this channel)

	CHS
Command	$CHS<CR>
Response	$CHS2,1,1,1OK<CRLF> (Example: Channel 1,2,3,4 available, channel 1 with thickness function)

6.4.9   Status (STS)

Reads all settings at once.

The individual parameters are separated by a semicolon. The structure of the respective responses corresponds to those of the individual requests.

	STS
Command	$STS<CR>
Response	$STSSTln;AVTn;AVNn;CHS…;TRG.OK<CRLF>

6.4.10   Version (VER)

Requesting the current software version.

	VER
Command	$VER<CR>
Response	$VERDT6400;V1.2a;8010079<CRLF>

6.4.11   Ethernet Settings (IPS)

Changes the IP settings of the controller.

	IPS
Command	$IPSm,<IPAddress>,<SubnetAddress,<GatewayAddress> <CR>
Example	$IPS0,169.254.168.150,255.255.0.0,169.254.168.1<CR>
Response	$IPSm,<IPAddress>,<SubnetAddress>,<GatewayAddress>OK<CRLF>
Index	m = 0: static IP address m = 1: activates DHCP* * If DHCP is active, no IP subnet- and gateway address has to be transmitted.
Request settings	
Command	$IPS?
Response	$IPS? m,<IPAddress>,<SubnetAddress>,<GatewayAddress>OK<CRLF>

6.4.12   Change between Ethernet and EtherCAT (IFC = Interface)

Command switches between Ethernet and EtherCAT interface. Effective only, if the switch `Ethernet/ EtherCAT` is in the position `ECAT/Auto`. Otherwise always the Ethernet interface is active. The new interface is activated after a restart of the controller.

	IFC
Command	$IFCm<CR> Example: $IFC1<CR>
Response	$IFCmOK<CRLF>
Index	m = 0: Ethernet m = 1: EtherCAT
Request	
Command	$IFC?
Response	$IFC?mOK<CRLF>

6.4.13   Query Data Port (GDP)

Queries the port number of the data port.

Command	$GDP<CR>
Response	$GDP<Port number>OK<CRLF> Example: $GDP10001OK<CRLF>

6.4.14   Set Data Port (SDP)

Sets the port number of the data port. Range: 1024 ...65535.

Command	$SDP<Portnumber><CR> Example: $SDP10001OK<CR>
Response	$SDP<Portnumber>OK<CRLF>

6.4.15   Access Channel Information (CHI)

Reads channel-specific information (e.g. serial number of the display board).

Command	$CHIm<CR>
Response	$CHIm:ANO...,NAM...,SNO...,OFS...,RNG...,UNT...,DTY...OK<CRLF>
Index	m (Channel number): 1 - 4 ANO = Article number NAM = Name SNO = Serial number OFS = Offset RNG = Max. working distance UNT = Unit (e.g. μm) DTY = Data type of measuring value (1 = measuring value as INT, 0 = no measuring value)

6.4.16   Access Controller Information (COI)

Reads information of the controller (e.g. serial number).

Command	$COI<CR>
Response	$COIANO...,NAM...,SNO...,OPT...,VER...OK<CRLF>
Index	ANO = Article number NAM = Name SNO = Serial number OPT = Option VER = Firmware version

6.4.17   Login for Web Interface (LGI)

Changes the user level for the web interface on `professional`.

Command	$LGI<Password><CR>
Response	$LGI<Password><OK>CRLF
Index	Password = Password of the device. When delivered, no password is assigned. The field can remain empty.

6.4.18   Logout for Web Interface (LGO)

Changes the user level for the web interface on `user`.

Command	$LGO<CR>
Response	$LGOOK<CRLF>

6.4.19   Change Password (PWD)

Changes the password of the device (required for the web interface and the SensorFinder).

Command	$PWD<oldpassword>,<newpassword>,<newpassword><CR>
Response	$PWD<oldpassword>,<newpassword>,<newpassword>OK<CRLF>

A password can be from 0-16 characters and must contain only letters and numbers. When delivered, no password is assigned. The field can remain empty/blank. |

6.4.20   Change Language for the Web Interface (LNG)

Changes the language of the web interface.

Command	$LNGn<CR>
Response	$LNGnOK<CRLF>
Index	0 = System 1 = English 2 = German

6.4.21   Default Messages
- Unknown command: (ECHO) + $UNKNOWN COMMAND<CRLF>
- Wrong parameter after command: (ECHO) + $WRONG PARAMETER<CRLF>
- Timeout (approximately 15 s after last input) (ECHO) + $TIMEOUT<CRLF>
- Wrong password: $WRONG PASSWORD<CRLF>

6.5   Operation Using Ethernet

Dynamic web pages are generated in the controller which contain the current settings of the controller and the peripherals. Operation is only possible while there is an Ethernet connection to the controller.

6.5.1   Requirements

You need a web browser with HTML5 support (e.g. Mozilla Firefox ≥ 3.5 or Internet Explorer ≥ 10) on a PC with a network connection. To support a basic first commissioning of the controller, the controller is set to a direct connection.
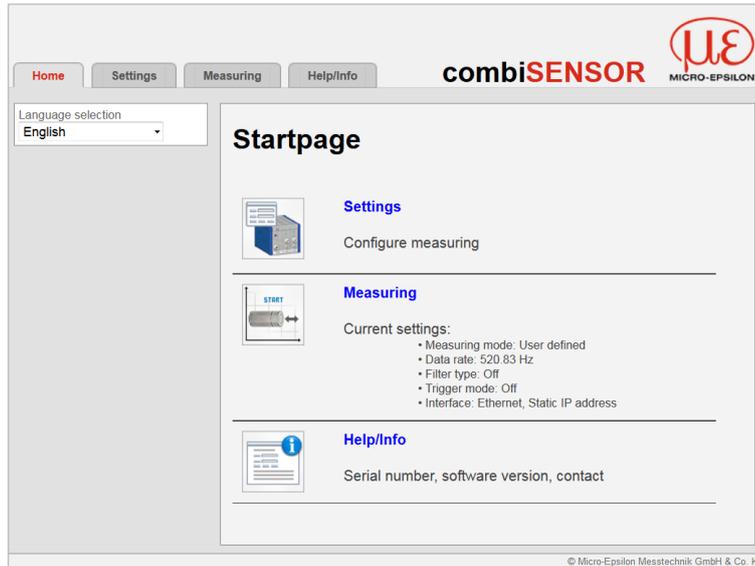
If you have configured your browser to access the internet via a proxy server, in the browser settings you will need to add the IP address of the controller to the list of addresses which should not be routed through the proxy server.

"Javascript" must be enabled in the browser so that measurement results can be displayed graphically.

Direct connection to PC, controller with static IP (Factory setting)		Network
PC with static IP	PC with DHCP	Controller with dynamic IP, PC with DHCP
➡ Connect the controller to a PC using a direct Ethernet connection (LAN). Use a LAN cable with RJ-45 connectors for this.		➡ Connect the controller to a switch using a direct Ethernet connection (LAN). Use a LAN cable with RJ-45 connectors for this.
➡ Now start the `sensorTOOL` program. ➡ Click the button `Start Scan`. Select the designated controller from the list. In order to change the address settings, click the button `Change IP...` • Address type: static IP address • IP address: 169.254.168.150 [1] • Subnet mask: 255.255.0.0 ➡ Click the button `Apply` to transmit the changes to the controller. ➡ Click the button `Start Browser` to connect the controller with your default browser. 1) Requires that the LAN connection on the PC uses, for example, the following IP address: 169.254.168.1.	Wait until Windows has established a network connection (Connection with limited connectivity). ➡ Now start the `sensorTOOL` program. ➡ Click the button `Start Scan`. Select the designated controller from the list. ➡ Click the button `Start Browser` to connect the controller with your default browser.	➡ Enter the controller in the DHCP / register the controller in your IT department. The controller gets assigned an IP address from your DHCP server. You can check this IP address with the `sensorTOOL` program. ➡ Now start the `sensorTOOL` program. ➡ Click the button `Start Scan`. Select the designated controller from the list. ➡ Click the button `Start Browser` to connect the controller with your default browser. Alternatively: If DHCP is used and the DHCP server is linked to the DNS server, access to the controller via a host name of the structure "KSS6430_<serial_number>" is possible. ➡ Start a web browser on your PC. To achieve a controller with the serial number "01234567", type in the address bar on your browser "KSS6430_01234567".
Interactive web pages for setting the controller and peripherals are now shown in the web browser.		

The `sensorTOOL` program is available online at https://www.micro-epsilon.com/download/software/sensorTool.exe.

6.5.2 Access via Web Interface

Use the upper navigation bar to access additional features (e. g. `Settings`).

All settings on the web page are applied immediately in the controller after pressing the `Submit` button.

Fig. 19 First interactive web page after calling the IP address

Parallel operation with web interface and Telnet commands is possible; the last setting applies.

The appearance of the web pages may vary depending on functions and peripherals. Each page contains parameter descriptions and tips on completing the controller.

Operating Menu, Set Controller Parameter

Preliminary Notes to the Settings

You can program the combiSENSOR 64x0 at the same time in two different kinds:
- Using a web browser via the sensor web interface
- With ASCII command set and terminal program via Ethernet (Telnet)

Login, Changing User Level

Assigning passwords prevents unauthorized changes to controller settings. Password protection is not enabled as a factory setting. After the controller has been configured, you should enable password protection.

i   A firmware update will not change the custom password.

User can do the following:

	User	Professional
Password required	no	yes
View settings	yes	yes
Change settings, change password	no	yes
Start measuring	yes	yes
Scale graphs	yes	yes

Fig. 20 Permissions within the user hierarchy

Login	
Logged in as	User
Password	Submit

Enter the password into the `Password` box and click `Submit` to confirm.

To change to user mode, click the `Logoff` button.

Fig. 21 Changing to professional level

In `professional` mode, you can use the change password features to assign a custom password.

Password	Value	All passwords are case-sensitive. Numbers are allowed, but special characters are not permitted
User level at restart	User / Professional	Defines the user level that is enabled when the sensor starts the next time. MICRO-EPSILON recommend to select User level.

With the first-time assignment of a password the `Old Password` field remains free.

6.5.3 Thickness Measurement

The differential signal of channel 1 can be directly converted into a thickness value and be output when the relative dielectric constant ε_r of the insulator to be measured is known. The offset can be optionally added to the result. In order to scale the result, the maximum working distance of the combiSENSOR (e.g. 5000 μm) must be entered. The thickness value can be calculated as follows:

$$T = \left[S\,(eddy) - A\,(capa) \right] * \left[\frac{\varepsilon_r}{\varepsilon_r - 1} \right] * \frac{WD}{100\,\%} + Offset$$

T	Target thickness [μm]
S	Signal eddy sensor [%]
A	Signal capacitive sensor [%]
ε_r	Dielectric constant (insulator)
WD	Working distance [μm]
Offset	Constant [μm], standard value = 0

Thickness measurement

Dielectric constant εr	3.37267232	
Offset (optional)	-10.136962896	µm
Max. working distance sensor	5000	µm

Submit	Zero thickness
Clear	

Calculate dielectric constant εr

Difference signal without target	0.14750672	%	Set current position
Difference signal with target	14.217491152	%	Set current position
Max. working distance sensor	5000	µm	
Thickness object		µm	
Dielectric constant εr			

Calculate

Fig. 22 Menu Settings > Thickness measurement

Thickness measurement	Dielectric constant ☐r	*Value*	Dielectric constant of the target used. When the dielectric constant is calculated, the controller replaces the original value.
	Offset	*Value*	*Standard value: 0. Adds a constant [µm] to the thickness value.*
	Max. working distance sensor	*Value*	*Working distance sensor [µm], value range: 5000 µm or 10000 µm.*
	Clear		*This button deletes the thickness measurement function, channel 1 outputs the difference = Eddy - Capa.*
	Zero thickness		*This button sets the value of the offset in such a way that the thickness signal is 0 µm.*
	Submit		*Clicking onto this button permanently stores the values in the controller. Subsequently, the controller calculates based on the new values.*
Calculate dielectric constant ☐r	Difference signal without target	*Value*	*Step 1: Remove the measurement object from the measuring gap, click onto the button Set current position.*
	Difference signal with target	*Value*	*Step 2: Move the measurement object into the measuring gap, click onto the button Set current position.*
	Max. working distance sensor	*Value*	*Step 3: Enter the value [µm] for the maximum working distance. Value range: 5000 µm or 10000 µm.*
	Thickness object	*Value*	*Step 4: Enter the thickness value [µm] of the master target.*
	Dielectric constant ☐r	*Value*	*Calculated dielectric constant*
	Calculate		*Clicking onto the button starts the calculation of the dielectric constant ☐r .*

6.5.4   Trigger Mode

This menu item determines the trigger behavior. The triggering is released by an external electrical signal, see 4.6.2 or by the command $ GMD, see 6.4.3.

If the trigger mode is turned off, the combiSENSOR 64x0 will send the measuring values without interruption and with the adjusted data rate.

Trigger mode	Rising edge	*A measuring value is output per edge.*
	High level	*Level triggering. Measuring value output, as long as the level is active.*
	Gate rising edge	*Starts resp. stops the measuring value output alternatively.*
	Off	*Controller sends measuring values continuously.*

6.5.5   Data Rate

Data Rate	2.6 / 5.21 / 10.42 / 15.63 / 26.04 / 31.25 / 52.08 / 62.5 / 104.2 / 520.83 / 1041.67 / 2083.33 / 3906.25 Sa/s	Instructs the sensor about the frequency, with which data are output via the Ethernet interface.

6.5.6   Filter, Averaging

Average type	Off			
	Moving	*Value*	Value range 2 / 3 / 4 / 5 / 6 / 7 / 8	*Designation of averaging type. Averaging number indicates, about how many current measuring values should be averaged in the controller, before a new measuring value is output.*
	Arithmetic	*Value*		
	Median	*Value*		
	Dynamic noise rejection			

It is recommended, to use averaging for statical measuring or slowly changing measuring values. An averaging reduces noise or suppresses distortions in measuring values.

6.5.7 Digital Interfaces

Ethernet Settings	IP settings	Address type	static IP address / DHCP	Values for IP address / Gateway / Subnet mask. For static IP address only
		IP address	Value	
		Subnet mask	Value	
		Default Gateway	Value	
		DHCP Host Name	Value	
	Port settings	Data port	Value	
		MAC address	Value	
		UUID	Value	
Ethernet/ EtherCAT	Operating mode after start	Ethernet / EtherCAT		

6.6 Firmware Update

The controller has a firmware update function. We recommend to always use the latest firmware version. You can find the latest firmware version on our website and it can be installed with the attached Firmware Update Tool.

7.   EtherCAT Interface

7.1   Introduction

The EtherCAT interface allows a fast transfer of measured values. The controller supports CANopen over EtherCAT (CoE).

Service Data Objects SDO: All parameters of the controller can thus be read or modified.

Process Data Objects PDO: A PDO telegram is used for real-time transmission of measured values. Individual objects are not addressed. The content of the previously selected data is transmitted.

The displacement values are transmitted as 32 bit Float values.

7.2   Change Interface

You can not change directly to the EtherCAT interface through the web interface or command. Restart your controller to do this. Keep in mind also that the setting of the EtherCAT switch is in the correct position, see Fig. 23.
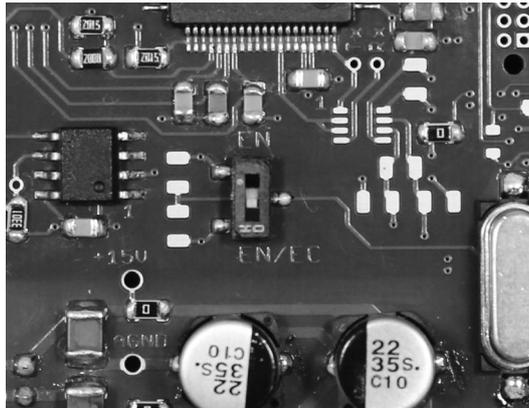
Switch position	Meaning
EN (Ethernet)	Regardless to the software setting always the Ethernet interface is active.
EN/EC (Ethernet/EtherCAT)	Active interface, which is set via the web interface or command.

Fig. 23 Switch to change the interface, basic module KSS6420

A change from the EtherCAT interface back to the Ethernet interface is possible with the hardware switch on the KSS64x0 basic unit or via the corresponding CoE Object. In both cases, then a restart of the controller is required.

To integrate the EtherCAT interface e.g. within TwinCAT an ESI-file is supplied.

You will find further instructions in the appendix, see A 2.

8. Operation and Maintenance

Please take care of the following:

▶ Make sure that the sensor surface is always clean.

▶ Switch off the power supply before cleaning.

▶ Clean with a damp cloth; then rub the sensor surface dry.

Changing the target or very long operating times can lead to slight reductions in the operating quality (long term errors). These can be eliminated by recalibration.

⚠ CAUTION

▶ Disconnect the power supply before touching the sensor surface.

> Static discharge

> Danger of injury

In the event of a defect in the controller, the sensor or the sensor cable, the parts concerned must be sent back for repair or replacement. In the case of faults the cause of which is not clearly identifiable, the whole measuring system must be sent back for repair or replacement to:

MICRO-EPSILON MESSTECHNIK
GmbH & Co. KG
Königbacher Straße 15
94496 Ortenburg / Germany

Tel. +49 (0) 8542 / 168-0
Fax +49 (0) 8542 / 168-90
info@micro-epsilon.de
www.micro-epsilon.com

9. Liability for Material Defects

All components of the device have been checked and tested for functionality at the factory. However, if defects occur despite our careful quality control, MICRO-EPSILON or your dealer must be notified immediately.

The liability for material defects is 12 months from delivery. Within this period, defective parts, except for wearing parts, will be repaired or replaced free of charge, if the device is returned to MICRO-EPSILON with shipping costs prepaid. Any damage that is caused by improper handling, the use of force or by repairs or modifications by third parties is not covered by the liability for material defects. Repairs are carried out exclusively by MICRO-EPSILON.

Further claims can not be made. Claims arising from the purchase contract remain unaffected. In particular, MICRO-EPSILON shall not be liable for any consequential, special, indirect or incidental damage. In the interest of further development, MICRO-EPSILON reserves the right to make design changes without notification.

For translations into other languages, the German version shall prevail..

10. Decommissioning, Disposal

➡ Disconnect the cable for electrical power and output signal on the controller.

Incorrect disposal may cause harm to the environment.

➡ Dispose of the device, its components and accessories, as well as the packaging materials in compliance with the applicable country-specific waste treatment and disposal regulations of the region of use.

Appendix

A 1   Accessories

SCACx/5		Signal output cable analog, x m long
PS2020		Power supply for mounting on DIN-rail input 230 VAC (115 VAC) output 24 VDC / 2.5 A; L/W/H 120 x 120 x 40 mm

A 1   EtherCAT Documentation

EtherCAT® is, from the Ethernet viewpoint, a single, large Ethernet station that transmits and receives Ethernet telegrams. Such an EtherCAT system consists of an EtherCAT master and up to 65535 EtherCAT slaves.

Master and slaves communicate via a standard Ethernet wiring. On-the-fly processing hardware is used in each slave. The incoming Ethernet frames are directly processed by the hardware. Relevant data are extracted or added from the frame. The frame is subsequently forwarded to the next EtherCAT® slave device. The completely processed frame is sent back from the last slave device. Various protocols can be used in the application level. CANopen over EtherCAT technology (CoE) is supported here. In the CANopen protocol, an object tree with Service Data Objects (SDO) and Process Data Objects (PDO) is used to manage the data.

Further information can be obtained from ® Technology Group (www.ethercat.org) or Beckhoff GmbH, (www.beckhoff.com).

A 1.1   Preamble

A 1.1.1   Structure of EtherCAT®-Frames

The transfer of data occurs in Ethernet frames with a special Ether type (0x88A4). Such an EtherCAT® frame consists of one or several EtherCAT® telegrams, each of which is addressed to individual slaves / storage areas. The telegrams are either transmitted directly in the data area of the Ethernet frame or in the data area of the UDP datagram. An EtherCAT® telegram consists of an EtherCAT® header, the data area and the work counter (WC). The work counter is incremented by each addressed EtherCAT® slave that exchanged the corresponding data.
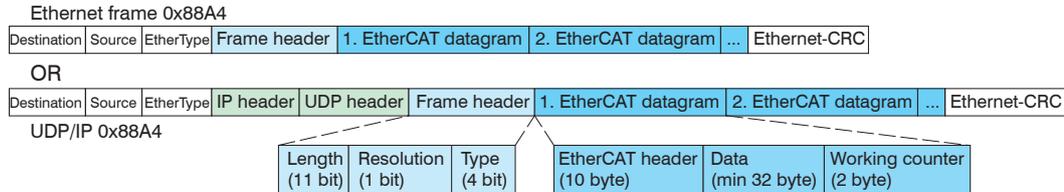

Fig. 24 Setup of EtherCAT frames

A 1.0.1   EtherCAT® Services

In EtherCAT® services for the reading and writing of data are specified in the physical memory of the slave hardware. The following EtherCAT® services are supported by the slave hardware:
- APRD (Autoincrement physical read, Reading of a physical area with auto-increment addressing)
- APWR (Autoincrement physical write, Writing of a physical area with auto-increment addressing)
- APRW (Autoincrement physical read write, Reading and writing of a physical area with auto-increment addressing)
- FPRD (Configured address read, Reading of a physical area with fixed addressing)
- FPWR (Configured address write, Writing of a physical area with fixed addressing)
- FPRW (Configured address read write, Reading and writing of a physical area with fixed addressing)
- BRD (Broadcast Read, Broadcast Reading of a physical area for all slaves)
- BWR (Broadcast Write, Broadcast Writing of a physical area for all slaves)
- LRD (Logical read, Reading of a logical storage area)
- LWR (Logical write, Writing of a logical storage area)
- LRW (Logical read write, Reading and writing of a logical storage area)
- ARMW (Auto increment physical read multiple write, Reading of a physical area with auto-increment addressing, multiple writing)
- FRMW (Configured address read multiple write, Reading of a physical area with fixed addressing, multiple writing)

A 1.1.2 Addressing and FMMUs

In order to address a slave in the EtherCAT® system, various methods from the master can be used. The KSS6430 supports as full slave:
- Position addressing
  The slave device is addressed via its physical position in the EtherCAT® segment.
  The services used for this are APRD, APWR, APRW.
- Node addressing
  The slave device is addressed via a configured node address, which was assigned by the master during the commissioning phase.
  The services used for this are FPRD, FPWR and FPRW.
- Logical addressing
  The slaves are not addressed individually; instead, a segment of the segment-wide logical 4-GB address is addressed. This segment can be used by a number of slaves.
  The services used for this are LRD, LWR and LRW.

The local assignment of physical slave memory addresses and logical segment-wide addresses is implemented via the field bus Memory Management Units (FMMUs). The configuration of the slave FMMUs is implemented by the master. The FMMU configuration contains a start address of the physical memory in the slave, a logical start address in the global address space, length and type of the data, as well as the direction (input or output) of the process data.

A 1.1.3 Sync Manager

Sync Managers serve the data consistency during the data exchange between EtherCAT® master and slaves. Each Sync Manager channel defines an area of the application memory. The KSS6430 has four channels:
- Sync-Manager-Channel 0: Sync Manager 0 is used for mailbox write transfers (mailbox from master to slave).
- Sync-Manager-Channel 1: Sync Manager 1 is used for mailbox read transfers (mailbox from slave to master).
- Sync-Manager-Channel 2: Sync Manager 2 is usually used for process output data. Not used in the sensor.
- Sync-Manager-Channel 3: Sync Manager 3 is used for process input data. It contains the Tx PDOs that are specified by the PDO assignment object 0x1C13 (hex.).

A 1.1.4   EtherCAT State Machine

The EtherCAT® state machine is implemented in each EtherCAT®. Directly after switching on the combi-SENSOR 64x0, the state machine is in the "Initialization" state. In this state, the master has access to the DLL information register of the slave hardware. The mailbox is not yet initialized, i.e. communication with the application (sensor software) is not yet possible. During the transition to the pre-operational state, the Sync Manager channels are configured for the mailbox communication. In the „Pre-Operational" state, communication via the mailbox is possible, and it can access the object directory and its objects. In this state, no process data communication occurs. During the transition to the „Safe-Operational" state, the process-data mapping, the Sync Manager channel of the process inputs and the corresponding FMMU are configured by the master. Mailbox communication continues to be possible in the „Safe-Operational" state. The process data communication runs for the inputs. The outputs are in the „safe" state. In the „Operational" state, process data communication runs for the inputs as well as the outputs.
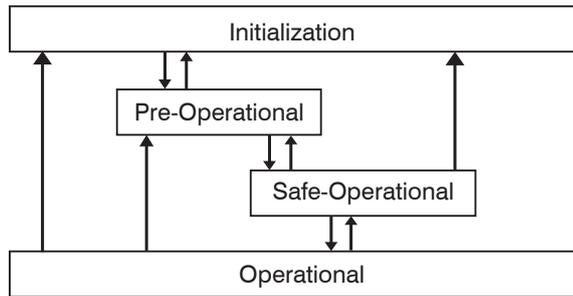

Fig. 25 EtherCAT State Machine

A 1.0.2   CANopen over EtherCAT

The application level communication protocol in EtherCAT is based on the communication profile CANopen DS 301 and is designated either as "CANopen over EtherCAT" or CoE. The protocol specifies the object directory in the sensor, as well as the communication objects for the exchange of process data and acyclic messages. The sensor uses the following message types:
  - Process Data Object (PDO). The PDO is used for the cyclic I/O communication, therefore for process data.
  - Service Data Object (SDO). The SDO is used for acyclic data transmission.

The object directory is described in the chapter CoE Object Directory.

A 1.1.5   Process Data PDO Mapping

Process Data Objects (PDOs) are used for the exchange of time-critical process data between master and slaves. Tx PDOs are used for the transmission of data from the slaves to the master (inputs), Rx PDOs are used to transmit data from the master to the slaves (outputs); not used in the combiSENSOR 64x0. The PDO mapping defines which application objects (measurement data) are transmitted into a PDO. The combiSEN-SOR 64x0 has a Tx PDO for the measuring data. The following measurements are available as process data:
  - Counter   Measurement counter (32 Bit)
  - Channel 1   Displacement Channel 1
  - Channel 2   Displacement Channel 2
  - Channel 3   Displacement Channel 3
  - Channel 4   Displacement Channel 4

A 1.1.6   Service Data SDO Service

Service Data Objects (SDOs) are primarily used for the transmission of data that are not time critical, e.g. parameter values. EtherCAT specifies the SDO services as well as the SDO information services: SDO services make possible the read/write access to entries in the CoE object directory of the device. SDO information services make it possible to read the object directory itself and to access the properties of the objects. All parameters of the measuring device can be read or changed in this way, or measurements can be transmitted. A desired parameter is addressed via index and subindex within the object directory.

A 1.2   CoE – Object Directory

The CoE object directory (CANopen over EtherCAT) contains all the configuration data of the sensor. The objects in CoE object directory can be accessed using the SDO services. Each object is addressed using a 16-bit index.

A 1.2.1   Communication Specific Standard Objects (CiA DS-301)

Overview		
Index (h)	Name	Description
1000	Device type	Device type
1001	Error register	Error register
1008	Device name	Manufacturer device name
1009	Hardware version	Hardware version
100A	Software version	Software version
1018	Identity	Device identification
1A00	TxPDO Mapping	TxPDO Mapping
1C00	Sync. manager type	Sync. manager type
1C13	TxPDO assign	TxPDO assign

Object 1000h: Device type

1000	VAR	Device type	0x00200000	Unsigned32	ro

Provides information about the used device profile and the device type.

Object 1001h: Error register

1001	VAR	Error register	0x00	Unsigned8	ro

Object 1008h: Manufacturer device name

1008	VAR	Device name	DT6230	Visible String	ro

Object 1009h: Hardware version

1009	VAR	Hardware version	V x.xxx	Visible String	ro

Object 100Ah: Software version

100A	VAR	Software version	V x.xxx	Visible String	ro

Object 1018h: Device identification

1018	RECORD	Identity			

Subindices

0	VAR	Number of entries	4	Unsigned8	ro
1	VAR	Vendor ID	0x0000065E	Unsigned32	ro
2	VAR	Product code	0x003EDE73	Unsigned32	ro
3	VAR	Revision	0x00010000	Unsigned32	ro
4	VAR	Serial number	0x009A4435	Unsigned32	ro

The article number is deposit in the product code, the serial number of the sensor in serial number.

Object 1A00h: TxPDO Mapping

1A00	RECORD	TxPDO Mapping			

Subindices

0	VAR	Number of entries	6	Unsigned8	ro
1	VAR	Subindex 001	0x0000:00	Unsigned32	ro
2	VAR	Subindex 002	0x6020:03	Unsigned32	ro
3	VAR	Subindex 003	0x6020:08	Unsigned32	ro
3	VAR	Subindex 004	0x6020:09	Unsigned32	ro
4	VAR	Subindex 005	0x6020:0A	Unsigned32	ro
6	VAR	Subindex 006	0x6020:0B	Unsigned32	ro

Object 1C13h: TxPDO assign

1C13	RECORD	TxPDO assign			
Subindices					
0	VAR	Number of entries	1	Unsigned8	ro
1	VAR	Subindex 001	0x1A00	Unsigned16	ro

A 1.2.2   Manufacturer Specific Objects

Overview

Index (h)	Name	Description
2010	Controller info	Controller information
2020	Channel 1 Info	Information and settings of channel 1
2021	Channel 2 Info	Information and settings of channel 2
2022	Channel 3 Info	Information and settings of channel 3
2023	Channel 4 Info	Information and settings of channel 4
2060	Controller Settings	Controller settings
2100	Controller Interface	Ethernet/EtherCAT settings
2200	Commands	Commands
6020	Measuring values	Measuring values

Object 2010h: Controller information

2010	RECORD	Controller info			ro

Subindices

0	VAR	Number of entries	5	Unsigned8	ro
1	VAR	Name	DT6230	Visible String	ro
2	VAR	Serial No	xxxxxxxx	Unsigned32	ro
3	VAR	Article No	xxxxxxx	Unsigned32	ro
4	VAR	Option No	xxx	Unsigned32	ro
5	VAR	Firmware version	xxx	Visible String	ro

Object 2020h: Channel information

2020	RECORD	Channel 1 info			ro

Subindices

0	VAR	Number of entries	5	Unsigned8	ro
1	VAR	Name	DL64x0	Visible String	ro
2	VAR	Serial No	xxxxxxxx	Unsigned32	ro
5	VAR	Status	Active	Enum	ro
7	VAR	Range	100	Unsigned32	rw
8	VAR	Unit	μm	Enum	ro

The structure of objects 2021h to 2023h corresponds to the object 2020h.

Object 2060h: Controller settings

2060	RECORD	Controller Settings			ro

Subindices

0	VAR	Number of entries	4	Unsigned8	ro
1	VAR	Sample rate	2083.3 Hz	Enum	rw
2	VAR	Averaging type	Off	Enum	rw
3	VAR	Averaging number	2	Enum	rw
4	VAR	Trigger	Off	Enum	rw

Object 2100h: Controller interface

2100	RECORD	Controller Interface			ro

Subindices

0	VAR	Number of entries	7	Unsigned8	ro
1	VAR	Ethernet/EtherCAT	EtherCAT	Enum	rw
3	VAR	Ethernet Adress type	Static	Enum	rw
4	VAR	Ethernet IPAddress	169.254.168.150	Visible String	rw
5	VAR	Ethernet Subnet	255.255.0.0	Visible String	rw
6	VAR	Ethernet Gateway	169.254.168.1	Visible String	rw
7	VAR	Ethernet Dataport	10001	Unsigned16	rw

Object 2200h: Commands

2200	RECORD	Commands			ro

Subindices

0	VAR	Number of entries	2	Unsigned8	ro
1	VAR	Command	AVT1	Visible String	rw
2	VAR	Command Response	AVT1OK	Visible String	ro

Any commands can be sent to the controller with the object 2200h, for example, the thickness functions as these are not defined in the COE objects.

Object 6020h: Measuring values

6020	RECORD	Measuring values			ro

Subindices

0	VAR	Number of entries	11	Unsigned8	ro
3	VAR	Counter	xxxx	Unsigned32	ro
8	VAR	Channel 1	xxxx	Float	ro
9	VAR	Channel 2	xxxx	Float	ro
10	VAR	Channel 3	xxxx	Float	ro
11	VAR	Channel 4	xxxx	Float	ro

A 1.3   Measurement Data Format

The measuring values are transmitted as Float.

The unit can be read from the channel info objects 2020h to 2023h (unit).

A 1.4   EtherCAT Configuration with the Beckhoff TwinCAT©-Manager

For example the Beckhoff TwinCAT Manager can be used as EtherCAT Master.

➡ Copy the device description file (EtherCAT®-Slave Information) `Micro-Epsilon.xml` in the directory \\TwinCAT\IO\EtherCAT (for TwinCATV2.xx) or \\TwinCAT\3.1\Config\IO\EtherCAT (for TwinCAT V3.xx), before the measuring device can be configured via EtherCAT®.

The file is available online at:

https://www.micro-epsilon.com/download/software/Micro-Epsilon_EtherCAT_ESI-File.zip.

EtherCAT®-Slave information files are XML files, which specify the characteristics of the Slave device for the EtherCAT® Master and contain information to the supported communication objects.

➡ Restart the TwinCAT Manager after copying.

Searching for a device:

➡ Select the tab `I/O Devices,` then `Scan.`

➡ Confirm with `Yes.`
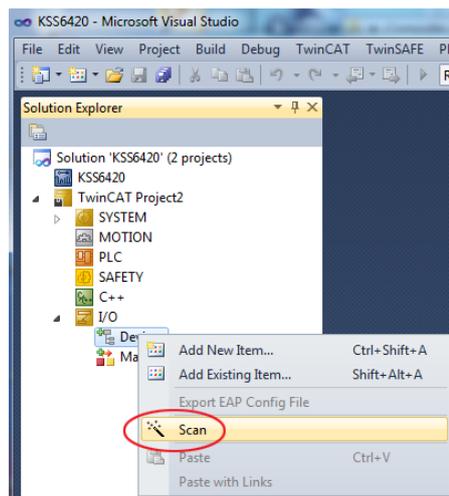
➡ Select a network card, where EtherCAT®–Slaves should be searching for.

The window `Scan for boxes` (EtherCAT®-Slaves) appears.

➡ Confirm with `Ja`.

➡ Confirm with `OK`.

The combiSENSOR 64x0 is now listed in the `Solution explorer`.
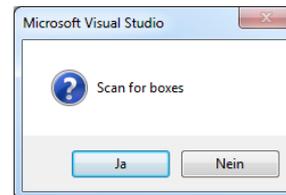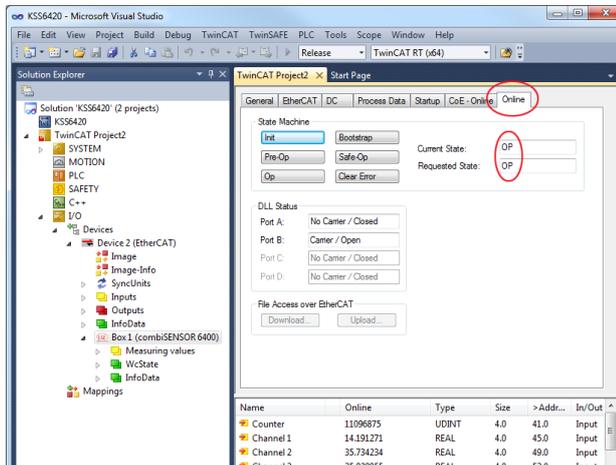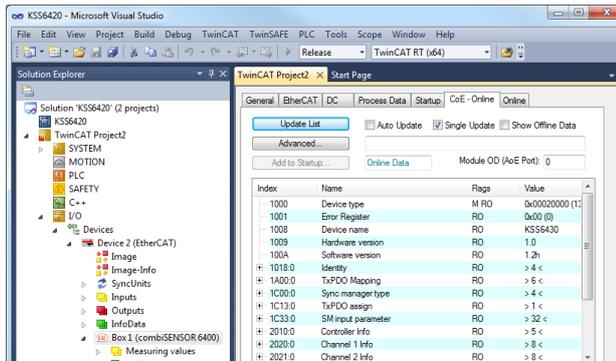
➡ Now confirm the window `Activate Free Run` with `Ja`.

The current status should be at least `PREOP,` `SAFEOP` or `OP` on the `Online` side.

Example for a complete object directory (subject to change without prior notice).

On the `Process data` side the PDO allocations can be read from the device.

The selected measuring values are transmitted as process data in the status `SAFEOP` and `OP`.

Name	Online	Type	Size	>Addr...	In/Out	User ID	Linked to
Counter	18598340	UDINT	4.0	41.0	Input	0	
Channel 1	14.168025	REAL	4.0	45.0	Input	0	
Channel 2	35.732231	REAL	4.0	49.0	Input	0	
Channel 3	35.927616	REAL	4.0	53.0	Input	0	
Channel 4	25.893494	REAL	4.0	57.0	Input	0	
WcState	0	BIT	0.1	1522.1	Input	0	

X9751369-A052032HDR