SIKO
Precision in Motion

User manual

Inclinometer
with CANopen-Interface

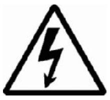
IK360

Table of content

1 General Safety Advice

Read these instructions carefully and have a look at the equipment to become familiar with the device before trying to install, operate or maintain it.

The following special messages may appear throughout this documentation & on the equipment to warn of potential hazards or to call attention towards information that clarifies / simplifies a procedure.



The addition of this symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury, if the instructions are not followed.

This is the safety alert symbol. It is used for alerting, in case of potential personal injury or hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

Please Note

Electrical equipment should be serviced only by qualified personnel. No responsibility is assumed by SIKO for any consequences arising out of the use of this material. This document is not intended as an instruction manual for untrained persons.

About this manual

This user manual explains how to install and configure the IK360 inclinometer with a CANopen interface by illustrations.

2 Introduction

2.1 IK360

IK360 inclinometers sense and measure the angle of tilt (Inclination/Slope/Elevation) of an object with respect to the force of gravity. The angle is measured with the relative change in electrical capacitance.

The basic principle behind this IK360 inclinometer is a Micro-Electro-Mechanical Systems (MEMS) sensor cell, that is embedded to a fully molded ASIC. A simplified version of the sensor consists of two electrodes, one is fixed, and the other is flexible (connected with spring elements). When the inclinometer is parallel to the surface of measurement, a corresponding capacitance is measured. If the sensor is tilted, the flexible electrode will change its position relative to the fixed electrode. This results in a change of the capacitance between the two electrodes, which is measured by the sensor cell. The change of the capacitance is converted to a corresponding inclination value.

Absolute inclinometers identify all the points of a movement by means of an unambiguous signal. Due to their capacity to give clear and exact values to all inclinations positions, inclinometers have become one of the interesting alternatives to singleturn absolute (and incremental) encoders and a link between the mechanical and control systems.

2.2 CANopen interface

CANopen is based on the Controller Area Network (CAN), that was developed by automotive industries in the 80s and is nowadays used in many industrial applications. The application protocol CANopen was introduced by the multi vendor association CAN in Automation (CiA) to ensure a full compatibility of industrial automation products. It is a multiple access system (maximum: 127 nodes), which means that all devices can access the bus. These devices/nodes are the components of the CANopen bus and in our case the node is the IK360 inclinometer.

In simple terms, CANopen works as a client-server model. Each device checks whether the bus is free and if it is free the device can send messages. If two devices try to access the bus at the same time, the device with the higher priority level (lowest ID number) has permission to send its message.

Devices with the lowest priority level must cancel their data transfer and wait before re-trying to send their message. Data communication is carried out via messages. These messages consist of a unique COB-ID (refer to glossary) followed by a maximum of 8 bytes of data. The COB-ID, which determines the priority of the message, consists of a function code and a node number. The node number corresponds to the network address of the device. It is and has to be unique on a bus in order to distinguish nodes and prevent any conflict of interests.

The function code varies according to the type of message being sent:

- Management messages (LMT, NMT)
- Messaging and service (SDOs)
- Data exchange (PDOs)
- Predefined messages (Synchronization, Emergency messages)

2.3 IK360 CANopen

The IK360 CANopen inclinometer corresponds to the CANopen device profile for inclinometer DS 410, in which the characteristics of inclinometers with CANopen interface are defined.

In addition to high resolution, accuracy and protection class of IP69K, it has in-built active linearization and temperature compensation. This makes IK360 suitable for rugged environments and versatile applications in industrial, heavy duty and military applications.

The inclinometer supports the following operating modes:

- **Polled mode:** The position value is transmitted only on request.

- **Cyclic mode:** The position value is sent cyclically (regular, adjustable intervals) on the bus.

- **SYNC mode:** The position value is sent, after a synchronization message (SYNC) is received. The position value is sent every n SYNCs ($n \geq 1$).

- **State change mode:** The position value is transmitted, whenever the position of the inclinometer, in continuous operation, changes.

The CANopen interface of the IK360 inclinometer permits transmission rates of up to 1 MBaud/s (30 m / 100 ft cable for a maximum speed of 1 MBaud/s, 5000 m / 16,500 ft cable for a maximum speed of 10 kBaud/s).

The IK360 CANopen is a flexible measurement device. This is proved by the fact, that it has easily programmable parameters like resolution, preset and software filters. Other functions such as offset values, baud rate and node number can also be configured using CANopen objects in the IK360 inclinometers with ease and according to the network.
Various software tools for configuration and parameter-setting are available from different suppliers. It is easy to align and program the inclinometers using the EDS (electronic data sheet) configuration file provided.

3 IK360 – Modes and Parameters

The purpose of this chapter is to describe all the available configuration parameters of the IK360 inclinometers with a CANopen interface.

Before going into details the following information describes useful technical terms and acronyms for CANopen network communication.

EDS (Electronic Data Sheet)

An EDS file describes the communication properties of a device on the CAN network (baud rates, transmission types, I/O features, etc.). It is provided by the device manufacturer and is used in the configuration tool to configure a node.

PDO (Process Data Object)

CANopen frame containing I/O data.
We distinguish between:

- Transmit-PDOs (TPDOs with data provided by a node).
- Receive-PDOs (RPDOs with data to be consumed by a node).

The transmission direction is always seen from a node's point of view.

SDO (Service Data Object)

CANopen frames containing parameters. SDOs are typically used to read or write parameters, while the application is running.

COB-ID (Communication Object Identifier)

Each CANopen frame starts with a COB-ID working as the identifier in the CAN frame. Duringthe configuration phase each node receives the COB-ID(s) of the frame(s), for which it is the provider (or consumer).

The NMT protocols are used to issue state machine change commands (i. e. to start and stop the devices), detect remote device boot ups and error conditions.

NMT (Network Management Protocol)

3.1 Operating modes

3.1.1 Mode: Preoperational

When the device is in this state, its configuration can be modified. However, only SDOs can be used to read or write device-related data.

The device goes into "Pre-Operational" state:

- after the power up or
- on receiving the "Enter Pre-Operational" NMT indication, if it was in operational state.

When configuration is complete, the device goes into one of the following states on receiving the corresponding indication:

- "Stopped" on receiving the "Stop Remote Node" NMT indication
- "Operational" on receiving the "Start Remote Node" NMT indication.

To set one or all nodes to pre-operational mode, the master must send the following message:

Identifier	Byte 0	Byte 1	Description
0h	80h	00	NMT: Pre-operational Mode, all nodes
0h	80h	NN (in hex)	NMT: Pre-operational Mode, NN

NN: node number

3.1.2 Mode: Start Operational

The device goes into the "Operational" state, if it was in the "Pre-Operational" state on receiving the "Start Remote Node" indication. When the CANopen network is started using the "Node start" NMT services in "Operational" state, all device functionalities can be used. Communication is possible by PDOs or SDOs.

NOTE: Modifications to the configuration in "Operational" mode may have unexpected consequences and should therefore only made in "Pre-Operational" mode.

To put one or all nodes in the operational state, the master has to send the following message:

Identifier	Byte 0	Byte 1	Description
0h	01h	00h	NMT: Start Remote Node, all nodes
0h	01h	NN (in hex)	NMT: Start Remote Node, NN

NN: node number

3.1.3 Mode: Stop Operation

The device goes into the "Stopped" state on receiving the "Node stop" indication (NMT service), if it was in "Pre-Operational" or "Operational" state. In this state, the device cannot be configured. No service is available to read and write device-related data (SDO). Only the slave monitoring function "Node Guarding" remains active.

To put one or all nodes in the stop operational state, the master has to send the following message:

Identifier	Byte 0	Byte 1	Description
0h	02h	00h	NMT: Stop Remote Node, all nodes
0h	02h	NN (in hex)	NMT: Stop Remote Node, NN

NN: node number

3.1.4 Reset of the inclinometer

If a node is not operating correctly, it is advisable to carry out a reinitialization.

Identifier	Byte 0	Byte 1	Description
0h	81h	00h	NMT: Reset Node
0h	81h	NN (in hex)	NMT: Reset Node

NN: node number

After reinitialization the inclinometer accesses the bus in pre-operational mode.

3.1.5 Reset communication of the inclinometer

If the communication of a node is not operating correctly, it is advisable to carry out a reset of the communication.

Identifier	Byte 0	Byte 1	Description
0h	82h	00h	NMT: Reset Communication
0h	82h	NN (in hex)	NMT: Reset Communication

NN: node number

After reset of the communication, the inclinometer accesses the bus in pre-operational mode.

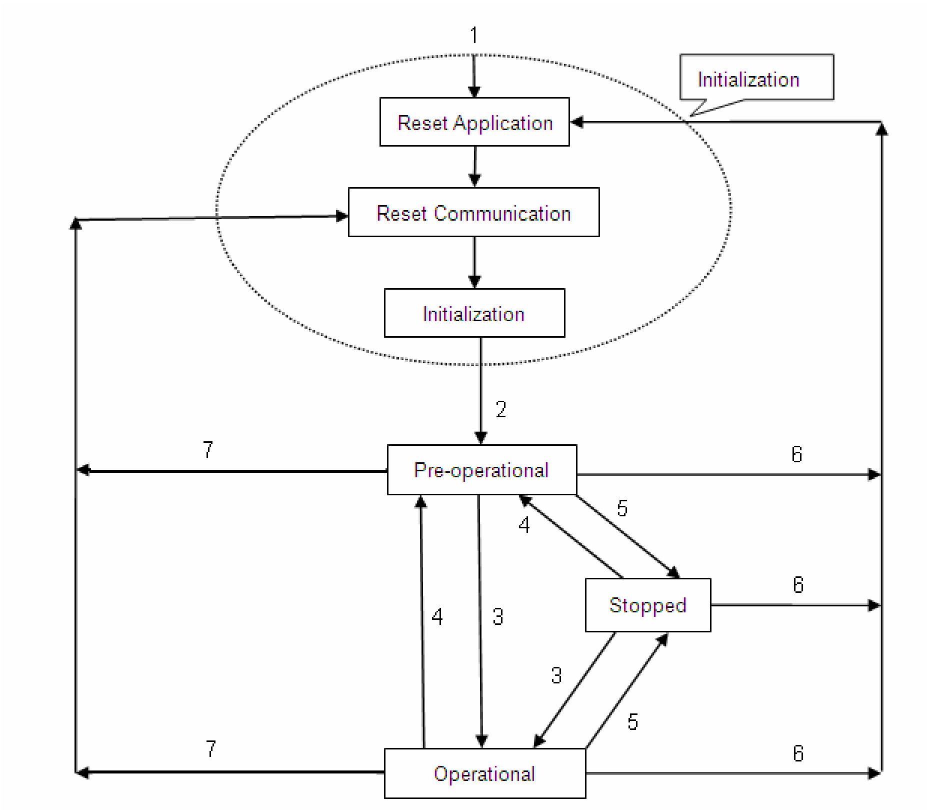
3.2 Transmission modes

Polled mode	By a remote-transmission-request telegram the connected host calls for the current process value. The inclinometer reads the current position value, calculates eventually set-parameters and sends back the obtained process value by the same identifier.
Cyclic mode	The inclinometer cyclically transmits (without being called by the host) the current process value. The cycle time can be programmed in milliseconds for values between 0 ms and 65536 ms.

SYNC mode	After receiving a SYNC telegram by the host the inclinometer answers with the current process value. If more than one node number (encoder) shall answer after receiving a SYNC telegram, the answer telegrams of the nodes will be received by the host in order of their node numbers. The programming of an offset-time is not necessary. If a node should not answer after each SYNC telegram on the CAN network, the parameter sync counter can be programmed to skip a certain number of sync telegrams before answering again.

3.3 Boot-up procedure

The general boot-up procedure for the IK360 CANopen and the mapping of various modes are illustrated below.



Number	Description
1	Module Power up
2	After initialization, the module automatically goes into pre-operational mode
3	NMT: Start Remote Node
4	NMT: Pre-operational Mode
5	NMT: Stop Remote Node
6	NMT: Reset Node
7	NMT: Reset Communication

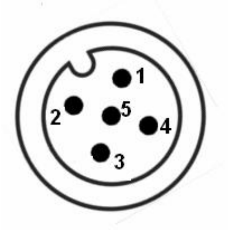
To set one or all nodes to pre-operational mode, the master must send the following message.

4 Installation

4.1 Pin assignment

The inclinometer is connected via a 5 pin round M12 connector (Standard M12, male connector on IK360, female connector at connection cable).

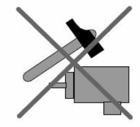
Pin	Description
1	CAN Ground
2	10-30 V supply voltage
3	0 V supply voltage
4	CAN High
5	CAN Low



4.2 Installation precautions

ATTENTION !!!
Do not remove or mount while the inclinometer is under power!

Avert any modifications to the plastic molding!



Avoid mechanical load!

4.3 Mounting instructions

IK360 is a pre-calibrated device, which can be put into immediate operation, upon simple and easy installation with a three point mount and setting of preset. Its compact design and installation "anywhere" makes it versatile.

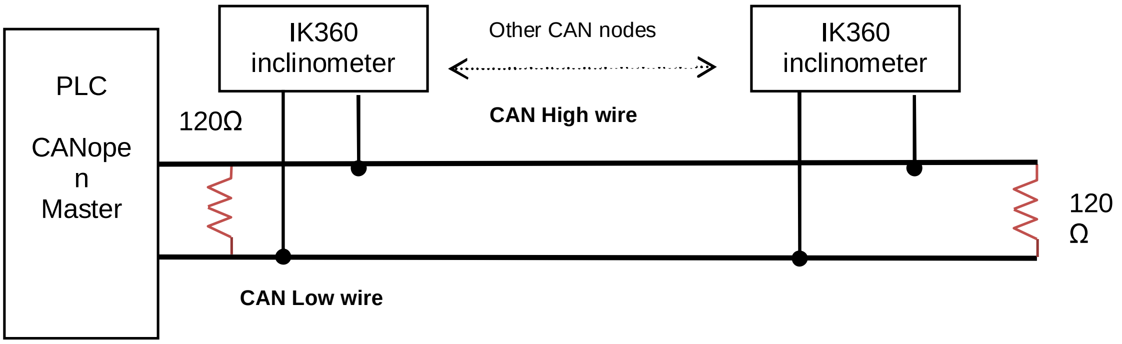
The IK360 inclinometer can be mounted in any number of fashions, depending on the situation. The mounting surface must be plane and free of dust and grease. It is absolutely necessary, that the IK360 inclinometer is connected to potential equalization in a workmanlike manner. For mounting we recommend cheese head screws with metrical thread M4 or UNC bolts #6 for the best possible and secure mounting. Use all the 3 screws for mounting, but restrict the tightening torque in the range of 1,5 – 2,5 Nm for the screws. The M12 connectors are to be perfectly aligned and screwed till the end with a tightening torque in the range of 0,4 -0,6 Nm. Use all the three screws for mounting and also note to use the same tightening torque for all the screws. An appropriate and well secured counter connector is also an important constraint for attaining the stated IP69K protection.

Prior to installation, please check for all connection and mounting instructions to be complied with. Please also observe the general rules and regulations on low voltage technical devices, for safety and sustainability of IK360 Inclinometers over long period of time.

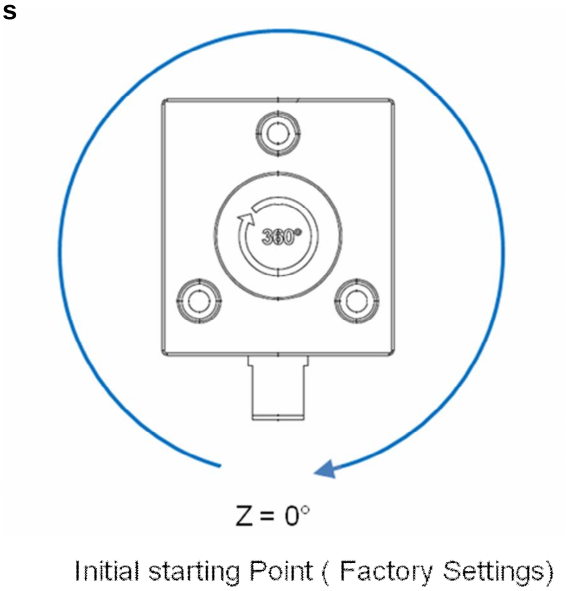
4.4 Bus termination

If the inclinometer is connected at the end or beginning of the bus for higher transmission baud rates (≥ 50 kBaud/s) a termination resistor of 120 Ohm must be used in order to prevent the reflection of information back into the CAN bus.
The bus wires can be routed in parallel, twisted or shielded form in accordance with the electromagnetic compatibility requirements. A single line structure minimizes reflection.

The following diagram shows the components for the physical layer of a two-wire CAN-bus:



4.5 Measurement axis



Measurement axis and mid angle position (factory setting ~ connector facing down)

5 IK360 Software Configuration

This chapter succeeds the hardware configuration (i. e. installation) as in real time. IK360 is a very flexible device and hence all the parameters can be programmed via CAN bus itself even when attached. This enables remote configuration. This chapter is primarily divided into two parts. In first part the methodology is described for putting the IK360 into operation and in the second part the PDO/SDO programming of IK360.

5.1 Important factory settings

Description	Object	Value
Device Type	1000h	0 x 3019A
Cyclic Timer	2200h	00h (0 ms)
Resolution	6000h	0Ah (0.01°)
Node Number	3000h	00h (NN = 1)
Baud Rate	3001h	03h (125 kB)
PDOs	6010h	

Note: The factory settings should be noted carefully upon installation. Few of the parameters have to be re-programmed in order to make the IK360 inclinometers compatible with the controller or the already existing CAN bus to which it is going to be installed on.

5.2 Active programming objects

Active CANopen objects depending on the state of IK360. The crosses in the table below indicate, which CANopen objects are active in each state.

	Initialization	Pre-Operational	Operational	Stopped
PDO Object			X	
SDO Object		X	X	
Boot-Up	X		X	
NMT		X	X	X

5.3 Programmable parameters

Objects are based on the CiA 301 DS and CiA 410 DS V1.2. The following table gives the list of command identifiers sent and received by the inclinometer. These are the standard commands used for communication and transmission between a master and slave in the CAN bus. It is quite useful for the analysis of communication logs between the master and slave and for better understanding of the system under observation.

Command	Function	Telegram	Description
22h	SDO Upload	Request	Parameter to IK360
60h	SDO Upload	Confirmation	Acknowledge “Parameter received”
40h	SDO Download	Request	Parameter request
43h, 4Bh, 4Fh (*)	SDO Download	Reply	Parameter to Master
80h	Warning	Reply	Transmission error

Table 1: Command description

(*) The value of the command byte depends on the data length of the called parameter (see table 2).

Command	Data length	Data length
43h	4 Byte	Unsigned 32
4Bh	2 Byte	Unsigned 16
4Fh	1 Byte	Unsigned 8

Table 2: Data length of commands

The following list of objects is the most frequently used objects, while programming the IK360 inclinometer. The whole list of objects is available in appendix A.

<table>
<tr><td>Position Value
(Object 6010h)</td><td>The object 6010h is used to get the inclination position from IK360 in the range of 0 - 360°.</td></tr>
<tr><td>Store Parameters
(Objects 1010h, 2300h)</td><td>These objects are used to store any re-configured parameters. Object 1010h just stores the parameters, whereas 2300h stores and saves the parameters upon reset of the IK360.</td></tr>
<tr><td>Resolution per 1°
(Object 6000h)</td><td>The parameter, resolution per degree, is used to program the desired number of angular divisions per revolution. The values 1, 10, 100 can be programmed.</td></tr>
<tr><td>Operating Parameter
(Object 6011h)</td><td>With the operating parameter it is possible to change the sense of rotation (inversion) and switch on/off the scaling. For using the preset function the scaling has to be switched on.

Low byte of the object data
<table>
<tr><td>x</td><td>x</td><td>x</td><td>r</td><td>r</td><td>r</td><td>s</td><td>i</td></tr>
</table>
MSB LSB
<table>
<tr><td>field</td><td>value</td><td>definition</td></tr>
<tr><td rowspan="2">s (scaling)</td><td>0b</td><td>scaling not enabled</td></tr>
<tr><td>1b</td><td>scaling enabled</td></tr>
<tr><td rowspan="2">i (inversion)</td><td>0b</td><td>inversion not enabled</td></tr>
<tr><td>1b</td><td>inversion enabled</td></tr>
<tr><td>r</td><td>0b</td><td>reserved</td></tr>
<tr><td>x</td><td></td><td>manufacturer-specific</td></tr>
</table></td></tr>
<tr><td>Preset Value
(Object 6012h)</td><td>The preset value is the desired position value, which should be reached at a certain physical position of the axis. The position value is set to the desired process value by the parameter preset, when scaling (Object 6011h) is switched on.</td></tr>
<tr><td>Node Number
(Object 3000h)</td><td>The setting of the node number is achieved via SDO-Object. Possible (valid) addresses lie between 1 and 127, but each address can only be used once.</td></tr>
<tr><td>Baud rate
(Object 3001h)</td><td>The baud rate can be programmed via SDO.</td></tr>
<tr><td>Filter
(Object 3100h)</td><td>Filter can be used to adjust the frequency of measurements and calculation of position values. It is implemented an average moving filter, which means, that the output position value is an average of the last n position values. N can be maximal 250.</td></tr>
</table>

Appendix A has a detailed list of all the objects, that can be programmed with IK360 CANopen. The data type, data size, default value, r/w access definition and all sub-indexes are mentioned in it. It is necessary to read the appendix A for clear knowledge before programming. Appendix A has a lot of important programming tips, which are necessary for the proper use of the inclinometer.

5.4 PDO Transmission

Process Data Objects (PDOs) communicate process information / data and enable them to be exchanged in real time. A CANopen device's PDO set describes the implicit exchanges between this device and its communication partners on the network. The exchange of PDOs is authorized, when the device is in "Operational" mode.

Note: The PDOs can be directly mapped in to memory locations on the controller and can be viewed upon reading those memory locations. An example is provided in the next section with a SCHNEIDER-TWIDO controller.

Object 1800h: 1st Transmit PDO communication parameter

This object contains the communication parameter of the 1st transmit PDO.

Subindex *	Description	Data Type	Default Value	Access	Restore after BootUp
00h	Number of sub indices	Unsigned 8	5	ro	yes
01h	COB-ID	Unsigned 32	180h + Node ID	rw	yes
02h	Transmission Mode	Unsigned 8	0xFE	rw	yes
03h	Inhibit Time	Unsigned 32	0x00	rw	yes
04h	Not Available				
05h	Event Timer	Unsigned 32	0x00	rw	yes

* Subindex: Second degree identifier used in combination with the object. (Follows the object number)

Object 1801h: 2nd Transmit PDO communication parameter

This object contains the communication parameter of the 2nd transmit PDO.

Subindex *	Description	Data Type	Default Value	Access	Restore after BootUp
00h	Number of sub indices	Unsigned 8	5	ro	yes
01h	COB-ID	Unsigned 32	280h + Node ID	rw	yes
02h	Transmission Mode	Unsigned 8	0xFE	rw	yes
03h	Inhibit Time	Unsigned 32	0x00	rw	yes
04h	Not Available				
05h	Event Timer	Unsigned 32	0x00	rw	yes

* Subindex: Second degree identifier used in combination with the object. (Follows the object number)

Transmission mode
The transmission mode (Sub index 2) for Objects 1800 and 1801 can be configured as described below.

Transfer Value (Dec)	Transmission Mode					Notes
	Cyclic	Acyclic	Synchr-onous	Asynchr-onous	RTR Only	
0		X	X			Send PDO on first sync message following an event
1-240	X		X			Send PDO every x sync messages
241-251	Reserved					
252			X		X	Receive sync and send PDO on remote transmit request
253					X	Update data and send PDO on remote transmit request
254				X		Send PDO on event (event-timer is expired)
255				X		Send PDO on Event (position value has changed)

Inhibit Time
The "inhibit time" for PDO transmissions can be entered in this 16 bit field. If data is changed, the PDO sender checks whether an "inhibit time" has expired since the last transmission. A new PDO transmission can only take place, if the "inhibit time" has expired. The "inhibit time" is useful for asynchronous transmission (transmission mode 254 and 255), to avoid overloads on the CAN bus.

Event Timer
The "event timer" only works in asynchronous transmission mode (transmission mode 254 and 255). If the data changes before the "event timer" expires, a temporary telegram is sent. If a value > 0 is written in this 16-bit field, the transmit PDO is always sent after the "event timer" expires. The value is written in sub index 5 of the object 1800 or 1801. The data transfer also takes place with no change to data. The range is between 1-65536 ms.

Cyclic Timer
The cyclic timer is useful to set the position transmission to cyclic mode. The cyclic timer can be programmed from 0ms to 65536 ms. When enabled, the IK360 transmits the position value contained in the PDO at constant prescribed intervals, even if there is no change in the position value. Object 2200h is used to set the cyclic timer value.

Object 1A00h: 1st Transmit PDO Mapping parameter

This object contains the mapping parameter of the 1st transmit PDO.

Subindex *	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of sub indices	Unsigned 8	1	ro	yes
1	Mapped object	Unsigned 32	6010 00 10	rw	yes

Object 1A01h: 2nd Transmit PDO Mapping parameter

This object contains the mapping parameter of the 2nd transmit PDO.

Subindex *	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of sub indices	Unsigned 8	1	ro	yes
1	Mapped object	Unsigned 32	6010 00 10	rw	yes

5.5 Explicit Exchanges (SDO)

Service Data Objects (SDOs) allow a device's data to be accessed by using explicit requests. The SDO service is available, when the device is in "Operational" or "Pre-Operational" state.

Types of SDO

There are two types of SDO:

- Read SDOs (Download SDOs),
- Write SDOs (Upload SDOs).

The **SDO protocol** is based on a 'Client / Server' model:

For a download SDO:

- The server sends a request, indicating the object to be read. The client returns the data contained within the object.

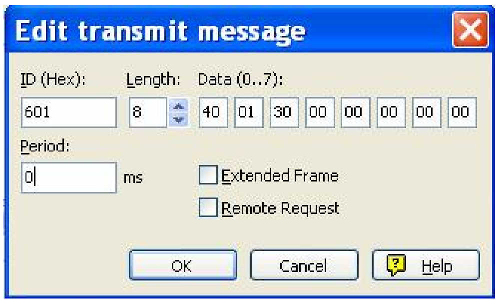
For an upload SDO:

The server sends a request, indicating the object to be written to and the desired value. After the object has been updated, the client returns a confirmation message.

For an unprocessed SDO:

- In both cases, if a SDO could not be processed, the device / master returns an error code.

A typical illustration of SDO for reading the current baud rate value explicitly is given below:



SDO passed as a new message to the device

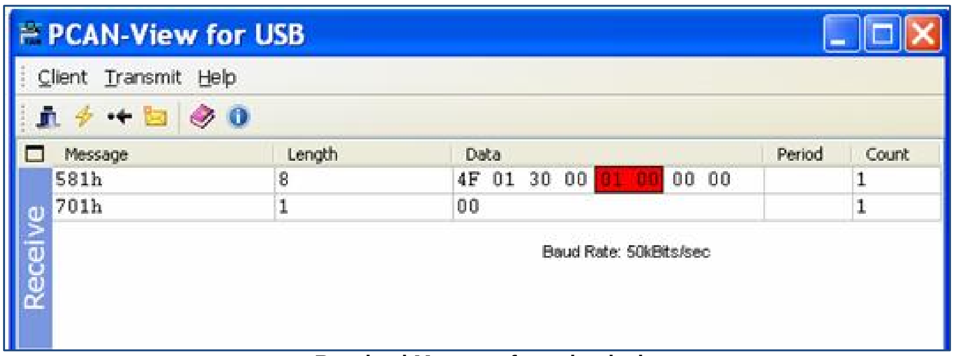
We used a PEAK™ CAN master for this illustration. The PCAN®-USB adapter enables simple connection to CAN networks.

The PCAN®-USB's compact plastic casing makes it suitable for mobile applications. It works as a master on the CAN bus connection via D-Sub, 9-pin and in accordance with CiA 102 standards.

- Object 3001h is to read the baud rate value from the IK360.

Transmit message
- ID: 601h - Message to node number 1
- Length: 8 byte
- Data 0: Read (40h)
- Data 1 & 2 : Object in big endian (30 01 is 01 30 in big endian format)
- Data 3: Sub-Index (NA)
- Data 4-7: Data to be written (NA in read command)

The received message
- ID: 581h - message from node number 1
- Data 0: length of data is 1 byte
- Data 4-7: 01 equates 50 kBaud/s



Received Message from the device

So, SDOs can be used to explicitly read or write data in IK360. All the relevant objects, that can be configured, are described in Appendix A.

In the above example 701h is the boot up message received. Then once we transmit the SDO command as shown above, we receive a reply. The received message, 581h, consists of the SDO downloaded.

6 Working with Schneider PLC

6.1 Introduction

An IK360, single axis inclinometer was connected to a TWIDO programmable logic controller with a CANopen communication interface.

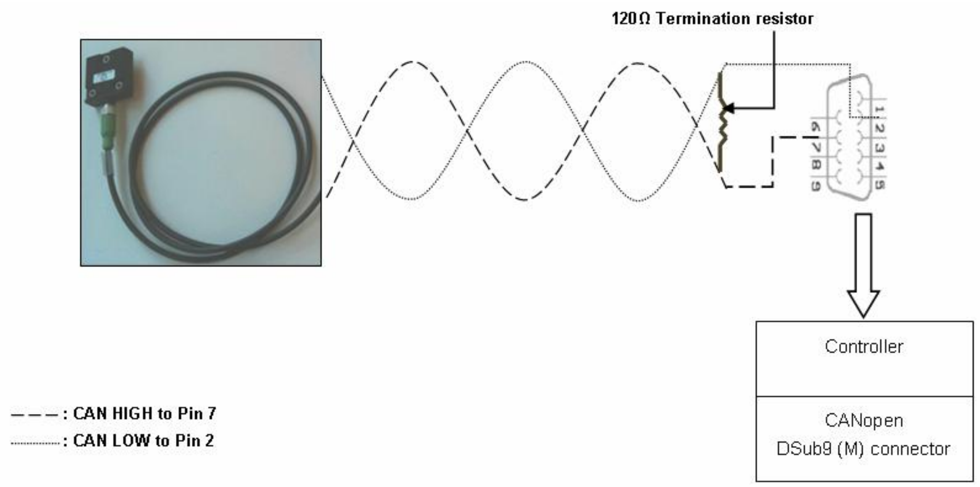
The step-by-step connection procedure and the working of inclinometer in a CAN bus is illustrated in the following sections. Please note, that the programming in other control systems may vary individually. Please have this section as a reference for IK360's working with programmable logic controllers.

6.2 Network initialization

6.2.1 Hardware

The initial step in setting up an IK360 is integrating it into the existing hardware. The following illustration shows an IK360 integrated into a PLC with an CANopen communication interface.

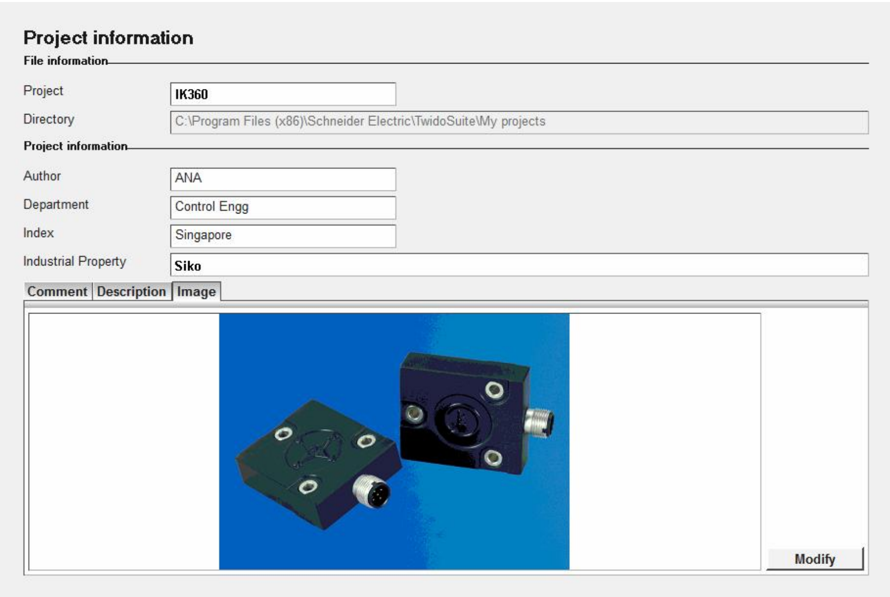
It is very important to add termination resistors to the IK360, which are used at the start or end of the CANopen bus in order to prevent data corruption or missing of data at higher transmission bandwidths (≥ 50 kB).



Hardware setup and wiring

6.2.2 Software project information

Once the hardware setup is done, the IK360 should be configured in such a way, that it is compatible to the already existing setup and gives a proper position output.



- **Controller Description**

TWDLMDA20DTK

Modular base controller, 12 24V DC inputs, 8 ouputs (0.3A source transistors). Removable MIL connectors.

Description of the module Reference number: TWDLMDA20DTK Address: 0

Description: Modular base controller, 12 24V DC inputs, 8 ouputs (0.3A source transistors). Removable MIL connectors.

- **CANopen Master Configuration**

TWDNCO1M

CANopen bus master module.

Description of the module Reference number: TWDNCO1M Address: 1

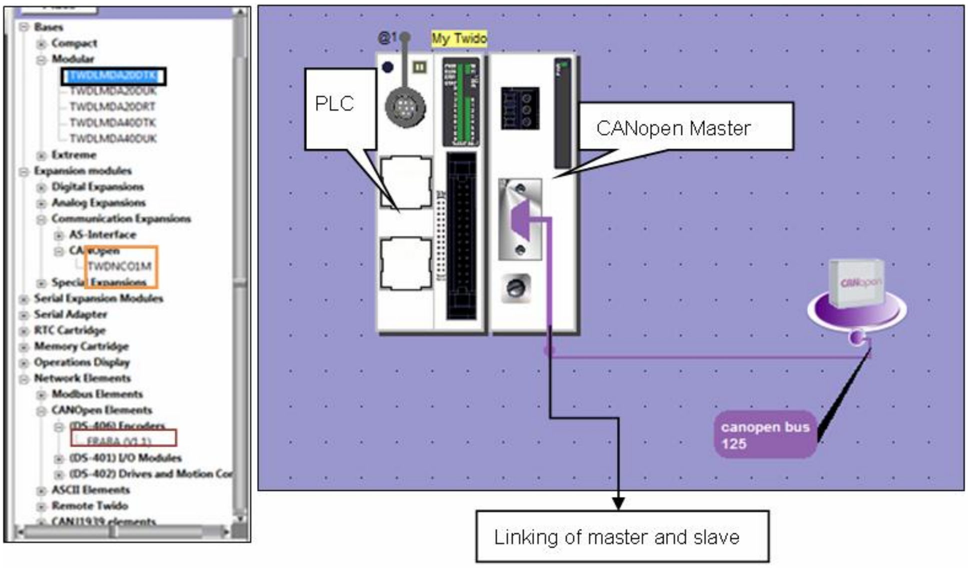
Description: CANopen bus master module.

- **IK360 inclinometer – Electronic Data Sheet (EDS)**

The IK360 EDS file once uploaded will load all the objects including the PDOs to the controller. The Schneider system automatically identifies the PDOs and maps them on to the slave device.

- **Connection network setup**

The illustration below describes the connection of the elements in the CAN bus. At first the CANopen communication interface is connected to the main controller. Then the inclinometer is connected to the CANopen communication interface.

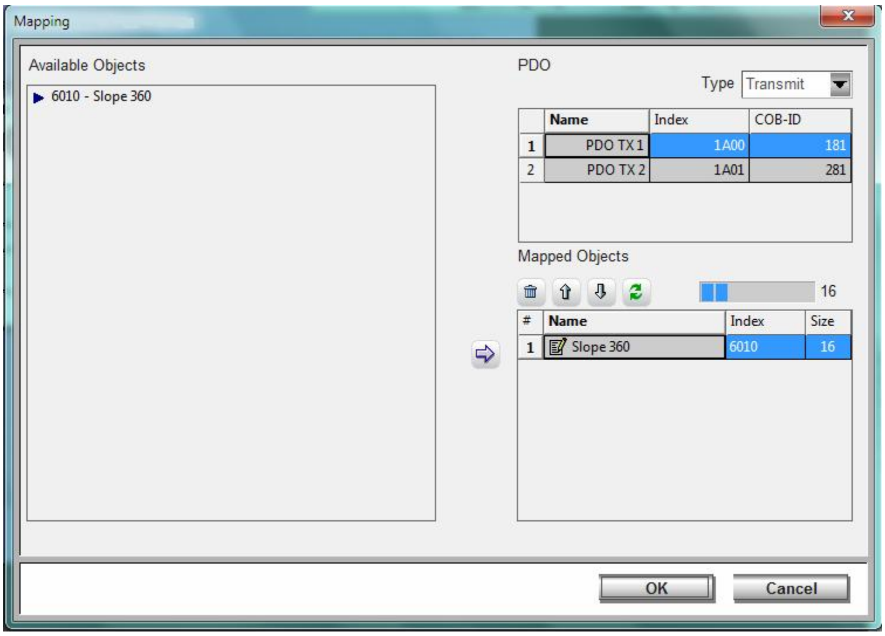


The next step after the setup of the network is the configuration of all the parameters and settings, to facilitate the communication between the master, slave and the controller.
This picture is the overall description of the setup, with the TWIDO TWDLMDA20DTK controller, TWDNCO1M CANopen communication expansion module and the IK360 EDS file.

6.3 Configuration

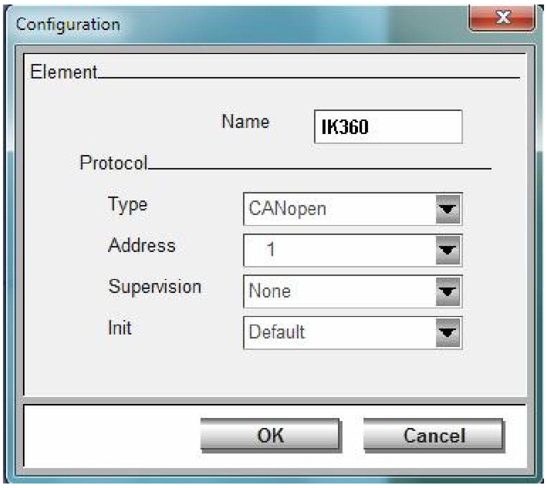
- **IK360 Process Data Objects (PDO) Mapping**

The list of available objects is pre-programmed in the EDS file. Select the IK360 inclinometer on the bus and click on “Configuration”. A list of all the mapped PDOs appear. Then, according to the need, the objects are mapped on to the Transmit-PDO’s of the IK360.



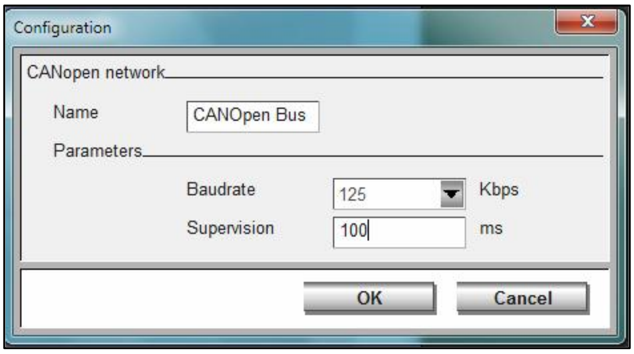
- **IK360 CANopen node configuration**

Click at the IK360 inclinometer on the bus and select the CANopen configuration option. It is used to define the name, type, address and supervision of the node. Make sure the node number and the address coincide for the inclinometer selected.



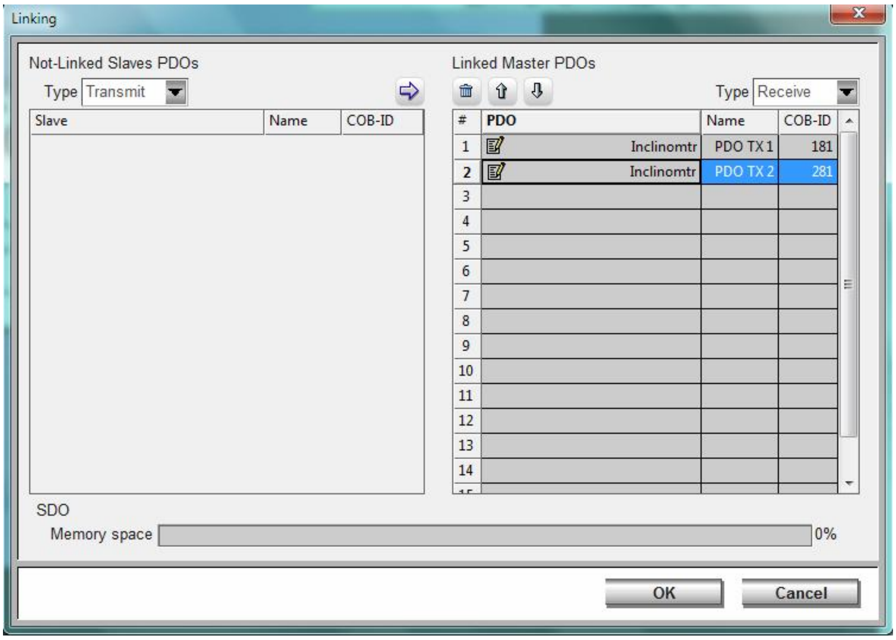
- **CANopen bus network configuration**

Click on the bus connecting the IK360 inclinometer and the PLC. Select the bus configuration option to define the name of the bus, the transmission speed and supervision time. Make sure, that the IK360 is programmed to the appropriate baud rate as that of the bus.



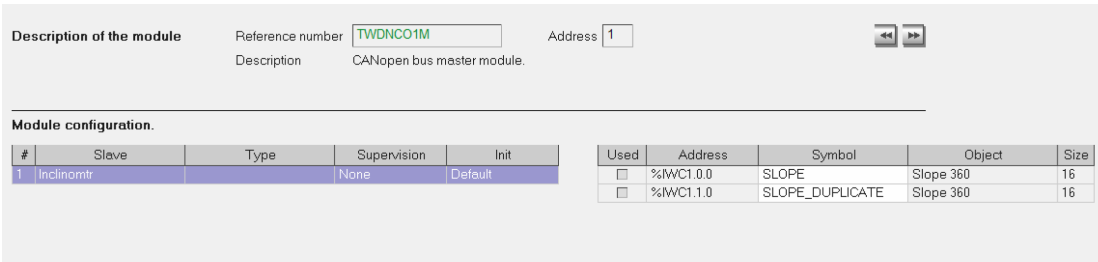
- **Linking of CANopen master and IK360 Transmit-PDOs**

Select the CANopen link of the controller. Click on the configuration option. The PDOs of the slave are mapped on the CANopen master, so that the information contained in the objects at the slave end are transmitted and saved on to the controller's memory.



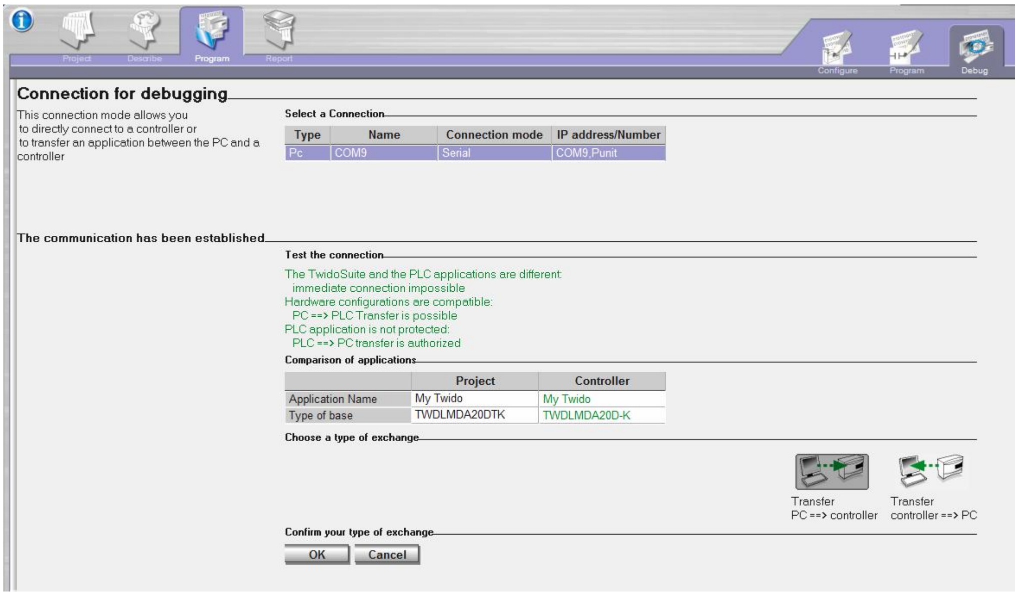
- **IK360 & Controller memory configuration**

The current and updated position values from the IK360 encoder are mapped on to an EEPROM memory location in the controller. This memory location, in this case %IWC1.0.0 and IWC1.1.0 will always contain the slope values, obtained from the object 6010h of the IK360, when the controller is online.

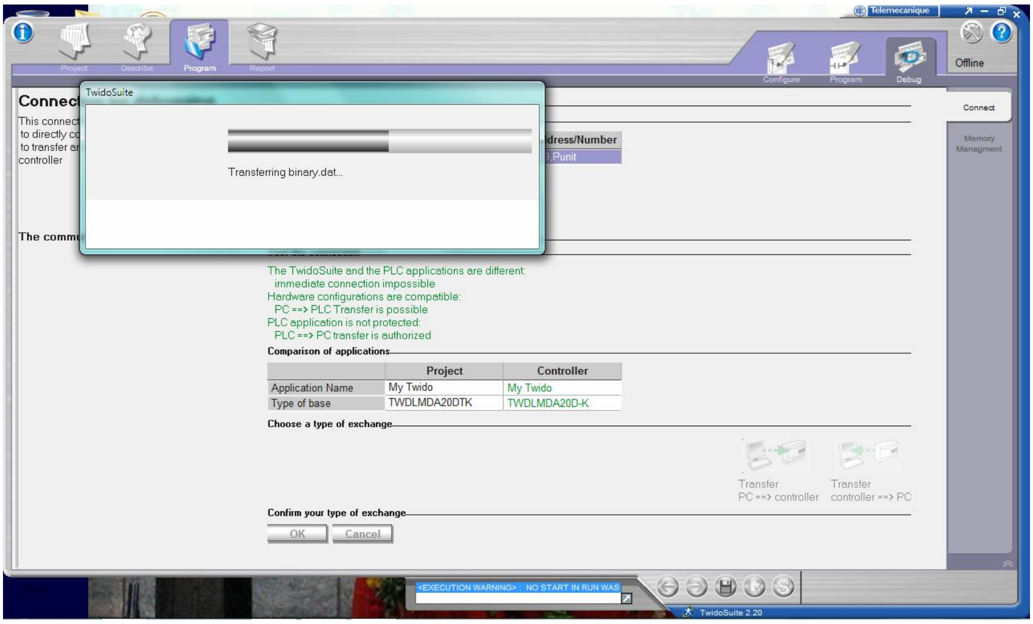


6.4 Debugging

The debugging stage is done on completing the configuration of the PDO's. It involves the following steps:



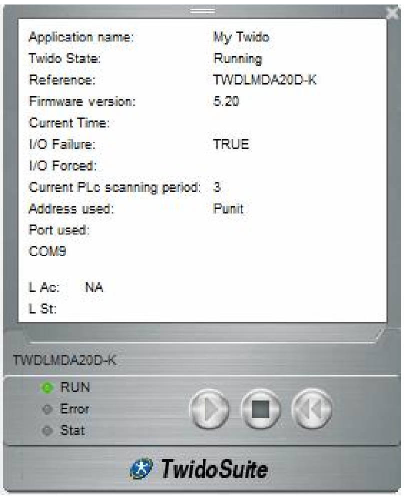
The serial communication port is selected and PC-> controller transfer is initiated. Once the transfer is initiated the configured parameters and the programming done on the PC is debugged and transferred to the controller for real time application. The following illustrations are the intermediate tasks during debugging.



Creating a backup of the controller parameters before going into online mode…….
Once the controller goes into the online mode, the PDOs cannot be changed. But, we can program the SDOs as need arises.

6.5 Run

Once debugged, the controller goes into online mode. After we can program the SDOs if needed and then run the controller.



Upon start up, we can create an animation table to monitor the necessary controller parameters and the system variables, which contain the position value. Now we will program the PLC in order to obtain the position values.

Resetting CANopen communication

```
0  *                                    LD    1
1  1/*                                  [ %MW0 := 16#0001 ]
2  0/*                                  [ %MW1 := 16#0000 ]
3  1                                    LD    %SW81:X3
4  * /*                                 [ CAN_CMD1 %MW0:2 ]
5  0                                    LDN   %SW81:X4
```

Resetting CANopen nodes

```
0  *                                    LD    1
1  1/*                                  [ %MW0 := 16#0001 ]
2  1/*                                  [ %MW1 := 16#0001 ]
3  1                                    LD    %SW81:X3
4  * /*                                 [ CAN_CMD1 %MW0:2 ]
5  0                                    LDN   %SW81:X4
```

Switch to operational mode

```
0  *                                    LD    1
1  2/*                                  [ %MW0 := 16#0002 ]
2  1/*                                  [ %MW1 := 16#0001 ]
3  1                                    LD    %SW81:X3
4  * /*                                 [ CAN_CMD1 %MW0:2 ]
5  0                                    LDN   %SW81:X4
```

Position readout

```
0  *                                           LD    1
1  3/*                                         [ %MW0  := 16#0003 ]
2  1/*                                         [ %MW1  := 16#0001 ]
3  24592/*  <- position value                  [ %MW2  := 16#6010 ]
4  0/*                                         [ %MW3  := 16#0000 ]
5  18416/*                                     [ %MW4  := 16#0000 ]
6  0/*                                         [ %MW5  := 16#0000 ]
7  * /*                                        [ CAN_CMD1 %MW0:6 ]
```

Readout using animation table

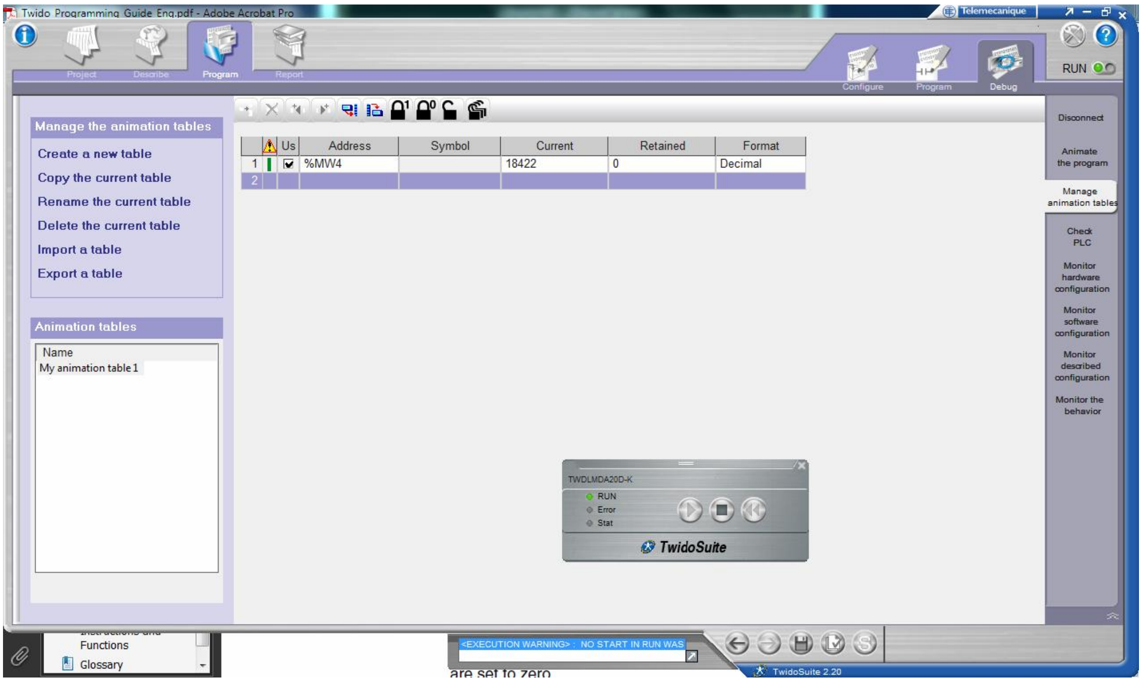


Illustration of measurement over full range:

At initial position (approximately 0°):

	⚠	Us	Address	Symbol	Current	Retained	Format
1	▌	☑	%MW4		32	0	Decimal
2							

IK360 position value = 32 * 0.01 = 0.32°

At approximately 90°:

	⚠	Us	Address	Symbol	Current	Retained	Format
1	▌	☑	%MW4		9138	0	Decimal
2							

IK360 position value = 9138 * 0.01 = 91.38°

At approximately 180°:

	⚠	Us	Address	Symbol	Current	Retained	Format
1		☑	%MW4		18052	0	Decimal
2							

IK360 position value = 18052 * 0.01 = 180.52°

At approximately 270°:

	⚠	Us	Address	Symbol	Current	Retained	Format
1		☑	%MW4		27256	0	Decimal
2							

IK360 position value = 27256 * 0.01 =272.56°

All the above position values where obtained by programming the position value output explicitly. The other method is very simple and direct.

Just run the controller and same position values are obtained. The position is mapped with the memory location %IWC1.0.0 or %IWC1.1.0 through PDO mapping done in the earlier steps. The steps for the mapping have been illustrated in above parts so that, in real time application, end users can directly follow the above steps to read out the position values from the mapped memory locations.

7 Troubleshooting

- **Power on – Inclinometer doesn't respond**

Problem:
If the bus is active, than the installed inclinometer is transmitting a false node number. If the bus is inactive, then it was connected with an incorrect baud rate.

Possible solution:
- Modus pre-operational
- Adressing the inclinometer via SDO
- Reset or power off
- Reprogram the baud rate

- **Malfunction of the position value during transmission**

Problem:
During the transmission of the position valueoccasional malfunctions occur. The CAN bus also can be temporabily in the bus off state.

Possible solution:
Please check, if the last bus nodes have the terminal resistor. If the last bus node is an inclinometer, add a terminal resistor.

- **Too many ERROR-Frames**

Problem:
The bus load is too high in case of too many error frames.

Possible solution:
Check, if all bus nodes have the same baud rate. Even if one node has a different baud rate, error frames are produced automatically.

- **Unexpected module / Module missing / Wrong module**

Problem:
Improper definition of node address or improper loading of EDS file.

Solution:
Reinitialize the CAN bus or re-install the EDS file.

- **Node state stopped upon loading and initialization**

Problem:
Mostly because the bus transmission timeout is defined lesser than the IK360 transmission time.

Solution:
Increase the bus timeout period (approximately 2-3 seconds).

- **Unable to change to another node number**

If all nodes are found to be in operational mode, than follow the next few steps to set the required node number to a selected device.

1. Calculate the required node number in hexadecimal. (IK360 is internally programmed to add 1 to any node number change fed to it, in order to avoid the node number 0)
2. For example: If we want a Node Number = 28 dec, we need to feed 27 decimal (27 + 1 = 28). So the Node Number 1B hex has to be fed in order to set the selected device to node number 28.
3. Send a write telegram to the particular node, with 1B as data on the object 3000h.
4. Use 2300h to save the parameters with the reset.
5. A boot up message with the new node number pops us.

8 IK360 CANopen objects

8.1 Object 1000h: Device Type

The object at index 1000h describes the type of device and its functionality. It is composed of a 16-bit field, which describes the device profile, that is used, and a second 16-bit field, which gives additional information about optional functionality of the device. The additional information parameter is device profile specific.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 8	0X3019A	ro	no

8.2 Object 1001h: Error Register

This object is used by the device to display internal faults. When a fault is detected, the corresponding bit is therefore activated.

The following errors are supported:

Bit	Description	Comments
0	Generic Error	The generic error is signaled at any error situation.

The object description for error register.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 8	N/A	ro	no

8.3 Object 1003h: Pre-Defined Error Field

The object hold the errors, that have occurred on the device and have been signaled via the Emergency object. The error code is located in the least significant word and additional information is located in the most significant word. Subindex 0 contains the number of recorded errors.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of recorded errors	Unsigned 8	0	rw	no
1	Most recent errors	Unsigned 32	-	ro	no

To clear error Log: Write data “0” into Subindex 0 of object 1003.

8.4 Object 1005h: COB-ID Sync

The object contains the synchronization message identifier.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 32	00000080h	rw	no

8.5 Object 1008h: Mfr Device Name

The object contains the device name.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	String	-	ro	no

8.6 Object 1009h: Mfr Hardware Version

The object contains the article name of the circuit board.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	String	-	ro	no

8.7 Object 100Ah: Mfr Software Version

The object contains the manufacturer software version.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	String	-	ro	no

8.8 Object 100Ch: Guard Time

The object contains the guard time in milliseconds.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 16	0	rw	yes

8.9 Object 100Dh: Life Time Factor

This object contains the life time factor parameters. The life time factor multiplied with the guard time gives the life time for the node guarding protocol.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 8	0	rw	yes

8.10 Object 1010h: Store Parameters

This object is used to store device and CANopen related parameters to non volatile memory.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of sub indices	Unsigned 8	1	ro	no
1	Store all parameters	Unsigned 32	"save"	rw	no

Storing Procedure: To save the parameters to non-volatile memory, the access signature "save" has to be sent to the coressponding (sub-)index of the device.

	Most significant word		Least significant word	
ASCII	e	v	a	s
Hex value	65h	76h	61h	73h

8.11 Object 1011h: Restore Parameters

This object is used to restore device and CANopen related parameters to factory settings.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of sub indices	Unsigned 8	1	ro	no
1	Restore all parameters	Unsigned 32	"load"	rw	no

Storing procedure: To load the parameters from non volatile memory the access signature "load" has to be sent to the corresponding (sub-)index of the device.

	Most significant word		Least significant word	
ASCII	d	a	o	l
Hex value	64h	61h	6Fh	6Ch

Note: The restoration of parameters will only be taken into account after a power up or reset command.

8.12 Object 1016h: Consumer Heartbeat Time

The consumer heartbeat time defines the expected heartbeat cycle time in ms. The device can only monitor one corresponding device. If the time is set to 0 the monitoring is not active. The value of this object must be higher than the corresponding time (object 1017) of the monitored device.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of sub indices	Unsigned 8	1	ro	no
1	Consumer heartbeat time	Unsigned 32	0	rw	yes

The context of subindex 1 is as follows:

Bit	31 to 24	23 to 16	15 to 0
Value	0h (reserved)	Address of monitored device	Monitoring time (ms)

8.13 Object 1017h: Producer Heartbeat Time

The object contains the time interval in milliseconds, in which the device has to produce a heartbeat message.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 16	0	rw	yes

8.14 Object 2200h: Cyclic Timer

This object contains cyclic time of the event timer in ms of PDO.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 16	-	ro	yes

8.15 Object 2300h: Save Parameter with Reset

With this object all parameters can be stored in the non volatile memory. After storing the parameters a reset is executed.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Access code	Unsigned 32	55AAAA55h	wo	no

8.16 Object 2600h: Preset Z-Axis

In IK360 inclinometers this object sets the Z-axis to a desired value.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Integer 16	-	rw	no

8.17 Object 3000h: Node Number

This object contains the node number of the device. The standard node number is 1h.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Node Number	Unsigned 8	1h	rw*	yes

NOTE: To avoid the node number zero (0), one (1) will be added to the value of this object.

E. g.: 1Fh+1h = 20h = 32 (dec

8.18 Object 3001h: Baud rate

This object contains the baud rate of the device.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Baud rate	Unsigned 8	-	rw*	yes

Eight different baud rates are provided (see table below). To adjust the baud rate only one byte is used. The default baud rate is 125 kB.

Baud rate in kB	Byte
20	00h
50	01h
100	02h
125	03h
250	04h
500	05h
800	06h
1000	07h

8.19 Object 3100h: Moving Average Filter

This object contains the number of values, which are averaged.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Moving Average Filter	Unsigned 16	0	rw	yes

Range of values accepted: 0d to 250d.

8.20 Object 6000h: Resolution

This object sets the resolution per 1°.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Resolution	Unsigned 16	-	rw	no

Three different possible resolutions can be used:

Actual angular resolution	Value decimal	Byte hex
1°	1	1h
0.1°	10	Ah
0.01°	100	64h

8.21 Object 6010h: Position value Z-axis

In IK360 inclinometers this object provides the Z-axis value.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Integer 16	-	ro	no

8.22 Object 6011h: Operating parameter

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Operating paramters	Unsigned 16	-	rw	no

Low byte of the object data

x	x	x	r	r	r	s	i

MSB LSB

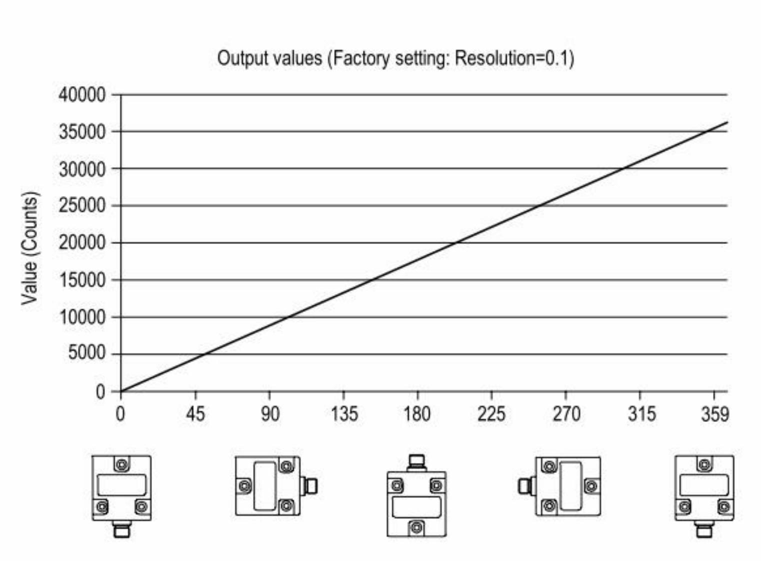
Field	Value	Definition
s (scaling)	0b	scaling not enabled
	1b	scaling enabled
i (inversion)	0b	inversion not enabled
	1b	inversion enabled
r	0b	reserved
x		manufacturer-specific

8.23 Object 6012h: Preset Z-axis

In IK360 inclinometers this object sets the Z-axis to a desired value.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Integer 16	-	rw	no

9 Output graphs



Glossary

B

Baudrate	Transmission speed formulated in number of bits per second

C

CAN	Controller Area Network
CANopen	Application layer of an industrial network based on the CAN bus.
CiA	CAN In Automation. Organization of manufacturers and users of devices that operate on the CAN bus.
COB-ID	COB-Identifier. Identifies an object in a CAN network. The ID determines the transmission priority of this object. The COB-ID consists of a function code and a node number.

N

NMT	Network management object. This is responsible for managing the execution, configuration and errors in a CAN network.
NN	Node number

P

PDO	Communication object, with a high priority for sending process data.

Precision in Motion

R

RO	Read Only: Parameter that is only accessible in read mode.
RW	Read/Write: Parameter that can be accessed in read or write mode.

S

SDO	Communication object with a low priority for messaging (configuration, error handling, diagnostics). Slave bus node, that sends data at the request of the master. The inclinometers are always slaves.

W

WO	Write Only: Parameter that is only accessible in write mode.