POSITAL
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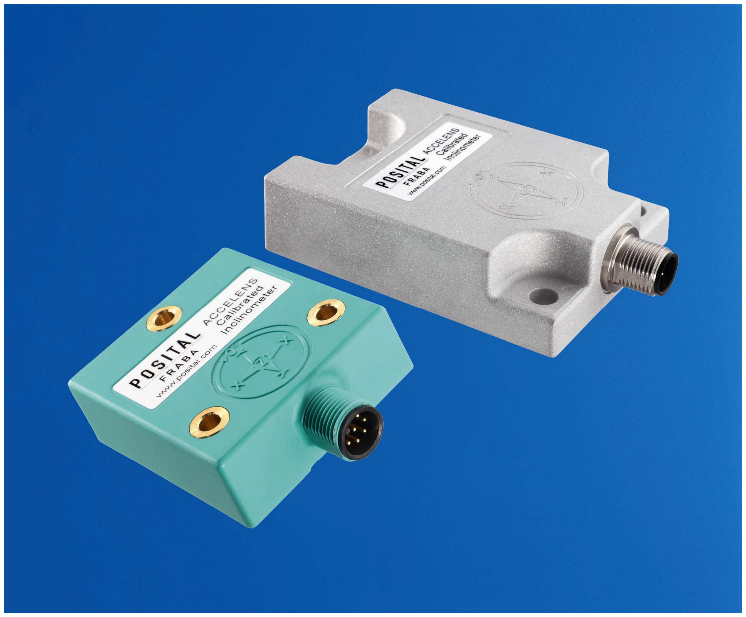
ACCELENS (ACS) INCLINOMETER WITH CANOPEN INTERFACE



CANopen®

User Manual

AMERICAS
FRABA Inc.
1800 East State Street, Suite 148
Hamilton, NJ 08609-2020, USA
T +1 609 750-8705, F +1 609 750-8703
www.posital.com, info@posital.com

EUROPE
POSITAL GmbH
Carlswerkstrasse 13c
D-51063 Köln, GERMANY
T +49 221 96213-0, F +49 221 96213-20
www.posital.eu, info@posital.eu

ASIA
FRABA Pte. Ltd.
60 Alexandra Terrace,
#02-05 The Comtech, SINGAPORE 118502
T +65 6514 8880, F +65 6271 1792
www.posital.sg, info@posital.sg

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General Safety Advice

Important Information

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 POSITAL 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

Background

This user manual explains how to install and configure the ACS inclinometer with a CANopen interface with illustrations from a Schneider TWIDO® PLC.

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FRABA PTE LTD
60 Alexandra Terrace,
#02-05 The Comtech, SINGAPORE 118502
T +65 6514 8880

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User Annotation

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1. Introduction

This manual explains how to install and configure the ACS gravity referenced inclinometers (suitable for industrial, military and heavy duty applications) with a CANopen interface. The products are fully compliant with CANopen DS410 standards.

1.1 Accelens (ACS)

ACCELENS 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 ACS 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.

The MEMS sensor cell in ACS consists of a micromechanical structure with an array of electrodes for better accuracy. Under the influence of gravity, the distance between some electrodes change and this distance can be detected by measuring the capacitance between the electrodes, as explained above. This technology is available in different grades and lower grades have entered mass markets like mobile phones or tablet computers.

The ACS series of inclinometers are available in two variants. First, a single axis measurement variant with a range of 0-360° (either clockwise or counter-clockwise) and the other variant, a dual axis measurement capable ACS model with a range of ±80°.

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.

Benefits of ACS:

- Small Size and Cost Efficient
- High Protection Class
- High Accuracy
- Very Robust

1.2 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 ACS.

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)

1.3 ACS CANopen

The ACS CANopen inclinometer corresponds to the class 2 inclinometer profile with DS 410 CANopen standards, in which the characteristics of inclinometers with CANopen interface are defined. The ACS is available in a completely molded and rugged plastic housing.

The ACS CANopen series of inclinometers are available in two variants. First, a single axis measurement variant with a range of 0-360° (either clockwise or anti-clockwise) and the other variant, a dual axis measurement capable ACS model with a range of ±80°.

In addition to high resolution, accuracy and protection class of IP69K, it has in-built active linearization and temperature compensation. This makes ACS 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 ≥ 1).

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

The CANopen bus interface on the ACS inclinometers, permit transmission rates of up to 1MB (30 m/100 ft cable for a maximum speed of 1MB, 5000 m/ 16,500 ft cable for a maximum speed of 10 kB).

The ACS-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 CAN objects in the ACS 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. (Refer to section 3.1)

1.4 Typical Applications of ACS

- Cranes and Construction Machinery
- Medical Systems
- Elevated Platforms
- Mobile Lifts and Fire Engines
- Automated Guided Vehivles (AGV)
- Automatic Assembling Machinery
- Boring and Drilling Applications
- Levelling and Flattening Machinery

2. ACS – Modes and Parameters

The purpose of this chapter is to describe all the available configuration parameters of the ACS 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 (like a driver in an operating system).

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. During the configuration phase, each node receives the COB-ID(s) of the frame(s) for which it is the provider (or consumer).

NMT (Network Management Protocol)
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.

2.1 Operating Modes

2.1.1 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 a node to pre-operational mode, the master must send the following message:

Identifier	Byte 0	Byte 1	Description
0 h	80 h	00	NMT-PreOp, all nodes
0 h	80 h	NN	NMT-PreOp, NN

NN: node number

2.1.2 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 can use PDOs or SDOs.

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

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

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

NN: node number

2.1.3 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
0 h	02 h	00h	NMT-Stop, all nodes
0 h	02 h	NN (in hex)	NMT-Stop, NN

NN: node number

2.1.4 Re-initialization of the Inclinometer

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

Identifier	Byte 0	Byte 1	Description
0 h	82 h	00h	Reset Communication
0 h	81 h	NN (in hex)	Reset Node

NN: node number

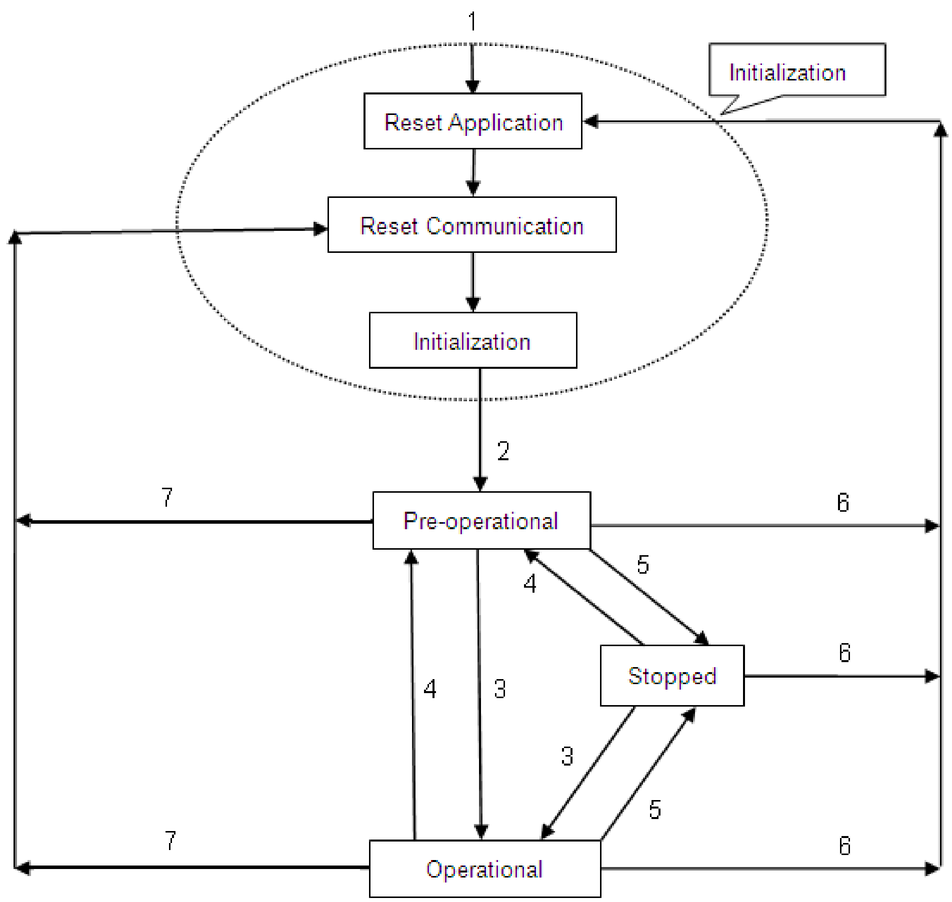
After reinitialization, the inclinometer accesses the bus in pre-operational mode.

2.2 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.

2.3 Boot-up Procedure

The general boot-up procedure for the ACS 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

3. Installation

3.1 Accessories

Article No	Article	Description
ACS360/080	Inclinometer	ACS series of Inclinometers (Industrial / Heavy-Duty)
Download	Datasheet*	ACS Datasheet, specifications and drawings
Download	User Manual*	Installation and Configuration User Manual (English)
Download	EDS-File*	Electronic Datasheet (EDS) file for configuration
10001978	PAM5	Female M12, 5pin A-coded connector, with 2m PUR shielded cable
10012182	PAM5 2m	Female M12, 5pin A-coded connector, with 5m PUR shielded cable
10005631	Terminal Resistor	External terminal resistors for higher baud rate transmissions

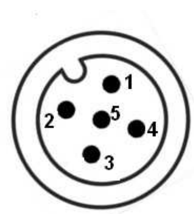
* The documentation and the EDS file can also be downloaded from our website **http://www.posital.sg/**

3.2 Pin Assignement

The inclinometer is connected via a 5-pin round M12 connector.

(Standard M12, Male side at sensor, Female at connector counterpart
Or connection cable).

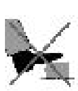
Signal	5 pin round connector pin number
CAN Ground	1
V_S Supply Voltage	2
0 V Supply Voltage	3
CAN High	4
CAN Low	5



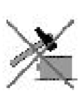
Pin Assignment

3.3 Installation Precautions

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



Do not stand on the inclinometer!



Avoid mechanical load!

3.4 Mounting Instructions

ACS 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 ACS 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. We recommend hex-head screws with M4 or UNC bolts #6 (ACS Industrial) and M6 or UNC bolts #12 (ACS Heavy-Duty) 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 – 2.5Nm for the screws. The M12 connectors are to be perfectly aligned and screwed till the end with a tightening torque in the range of 0.4-0.6Nm. Use all the three screws for mounting and also note to use the same tightening torque for all the screws.

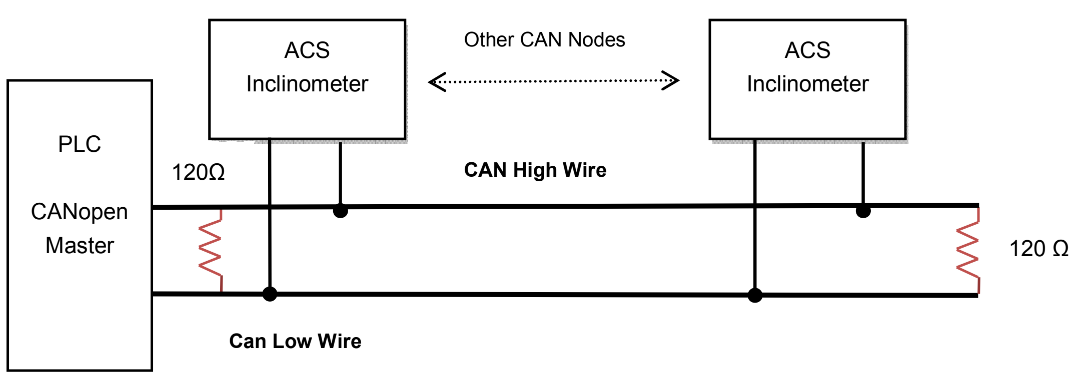
Prior to installation, please check for all connection and mounting instructions to be complied with. Please also observe the general rules and regulations on low voltage technical devices. ACS Inclination sensors that are based on a MEMS principle are optimal for fast measurements.

3.5 Bus Termination

If the inclinometer is connected at the end or beginning of the bus or for higher transmission baud rates (≥50 kB) 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.

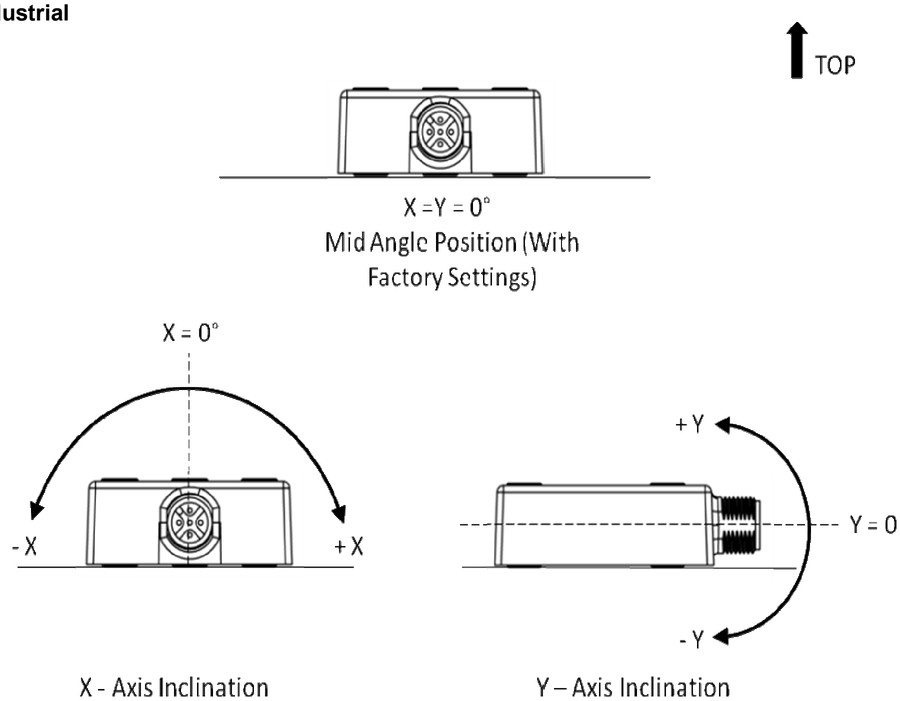
The following diagram shows the the components for the physical layer of a two-wire CAN-bus:



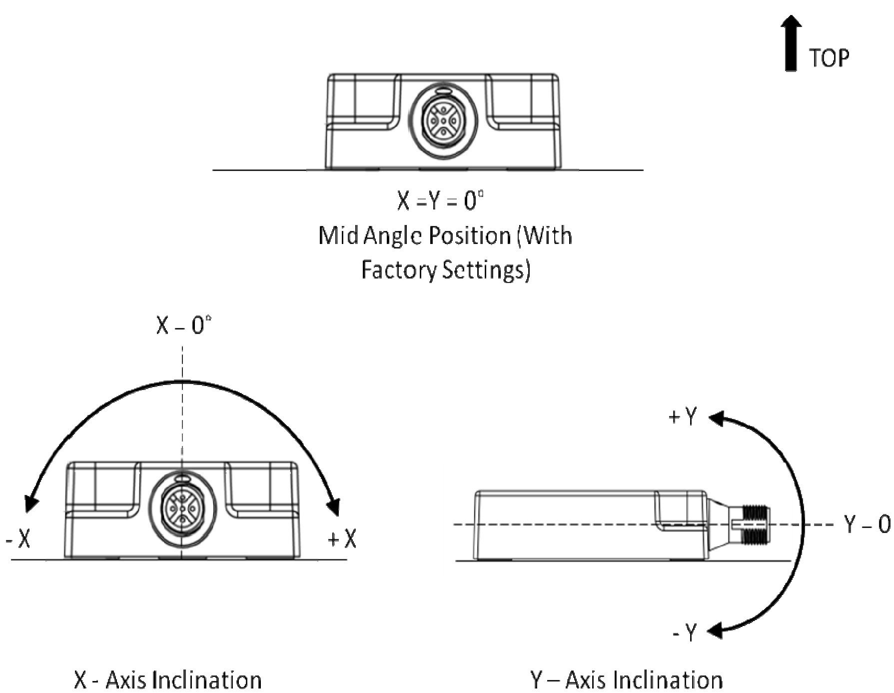
3.6 Measurement Axes

3.6.1 ACS80

Industrial

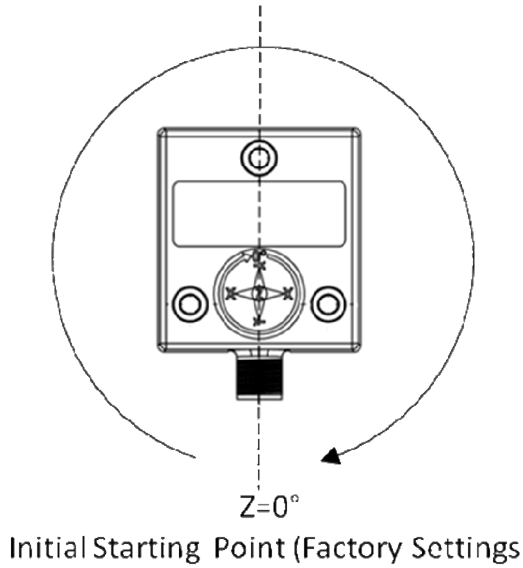


Heavy-Duty

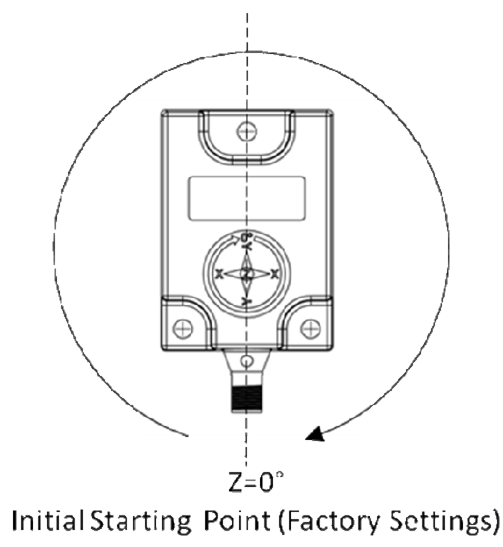


3.6.2 ACS360

Industrial



Heavy Duty



4. ACS Software Configuration

This chapter succeeds the hardware configuration (i.e. installation) as in real time. ACS 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- One describing the methodology for putting the ACS into operation and the other the PDO/SDO programming of ACS.

4.1 Important Factory Settings

Description	Object	Value
Device Type	1000h	0 x 4019A
Cyclic Timer	2200h	00h (0ms)
Resolution	6000h	64h (0.01°)
Node Number [1]	3000h	1Fh (32)
Baud Rate[2]	3001h	00h (20kB)
ACS080 PDOs	6110h,6120h,6010h,6020h	
ACS360 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 ACS inclinometers compatible with the controller or the already existing CAN bus to which it is going to be installed on.

4.2 Active Programming Objects

Active CANopen objects depending on the state of ACS:

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

[1] The forthcoming ACS inclinometers will be programmed to a default of 1

[2] The forthcoming ACS inclinometers will have a default setting of 125kB.

4.3. Programmable Parameters

Objects are based on the CiA 410 DS V1.2: CANopen profile for inclinometer (www.can-cia.org). 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	Domain Download	Request	Parameter to ACS
60h	Domain Download	Confirmation	Parameter received
40h	Domain Upload	Request	Parameter request
43h, 4Bh, 4Fh (*)	Domain Upload	Reply	Parameter to Master
80 h	Warning	Reply	Transmission error

Table 1: Command Description

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

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 CANopen ACS inclinometer. The whole list of objects is available in Appendix A.

Position Value (Objects 6010h, 6020h)	The objects 6010h and 6020h are used to get the inclination positions from ACS080 in the range of ±80° and the object 6010h is used to get the inclination position from ACS360 in the range of 0 - 360°.
Store Parameters (Objects 1010h, 2300h)	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 ACS.

Resolution Per 1°[3] **(Object 6000h)**	The parameter, resolution per degree is used to program the desired number of angular divisions per revolution. The values 1, 10, 100, and 1000 can be programmed.
Preset Value **(Objects 6012h / 6013h)**	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 pre-set.
Baudrate **(Object 3001h)**	The Baud rate can be programmed via SDO **(default 20kB[4]).**
Node Number **(Object 3000h)**	The setting of the node number is achieved via SDO-Object. Possible (valid) addresses lie between 1 and 96 but each address can only be used once. **For inclinometers programmed via SDO, the default is 20Hex = Node Number 32 [5]**
Filters **(Objects 3100h/3200h)**	Filters can be used to adjust the frequency of measurements and calculation of position values.

Appendix A has a detailed list of all the objects that can be programmed with ACS 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.

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[3] The resolution programming functionality is not yet fully operational.
[4] The forthcoming ACS sensors will have a default baud rate of 125kB.
[5] The forthcoming ACS sensors will have a default node number of 1.

4.4 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
0 0h	Number of sub indices	Unsigned 8	5	ro	yes
01h	COB-ID	Unsigned 32	180h + Node ID	rw	yes
02h	Transmission Mode	Unsigned 8	FE	rw	yes
03h	Inhibit Time	Unsigned 32	0	rw	yes
04h	Not Available				
05h	Event Timer	Unsigned 32	64h or 0	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	1	rw	yes
03h	Inhibit Time	Unsigned 32	0	rw	yes
04h	Not Available				
05h	Event Timer	Unsigned 32	0	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	Synchronous	Asynchronous	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 request
253					X	Update data and send PDO on remote request
254				X		Send PDO on event
255				X		Send PDO on Event

Inhibit Time

For "Transmit PDOs", 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 a transmit PDO. 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 65536ms. When enabled, the ACS 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

4.5 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 an "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 client sends a request indicating the object to be read.

The server returns the data contained within the object.

For an Upload SDO:

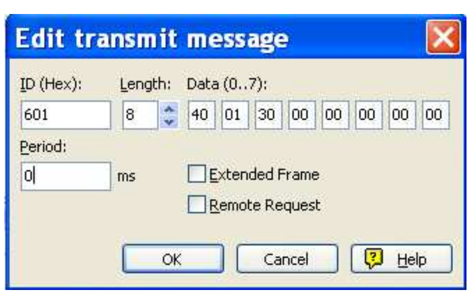
The client sends a request indicating the object to be written to and the desired value.

After the object has been updated, the server returns a confirmation message.

For an unprocessed SDO:

In both cases, if an SDO could not be processed, the server returns an error code.

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



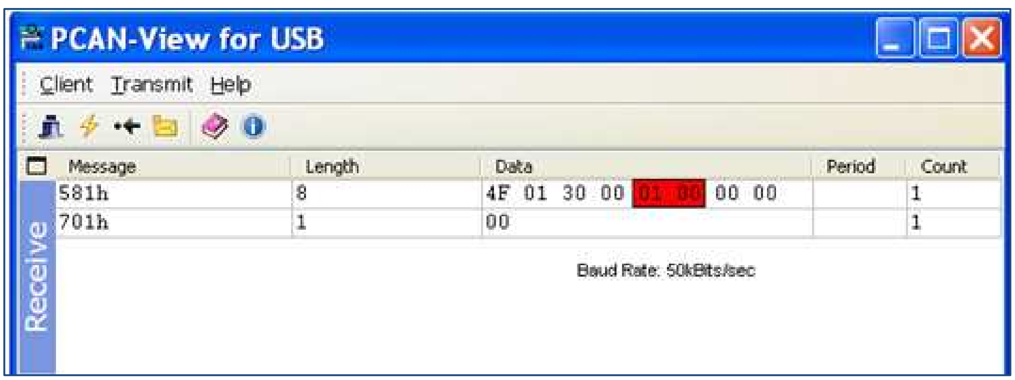
SDO passed as a new message to the device

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.

[To learn more about Peak CAN click here]

- Object 3001h is to read the baud rate value from the inclinometer.
- Transmit Message
  - ID: 601- Message to NN1
  - Length: 8bit word
  - Data 0: Read (40) / Write (22)
  - Data 1 & 2 : Object in Big Endian (3001s is 0130 in Big Endian format)
  - Data 3: Sub-Index (NA)
  - Data 4-7: Data to be written (NA in read command)
- The Received message 581h reads out the data



Received Message from the Device

So, SDOs can be used to explicitly read or write data in ACS CANopen inclinometers. 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 domain downloaded. In this case it is the baud rate as indicated in the above figure.

5. Working with Schneider PLC

5.1 Introduction

An ACS360, single axis inclinometer was connected to a TWIDO programmable logic controller with a CANopen communication interface.

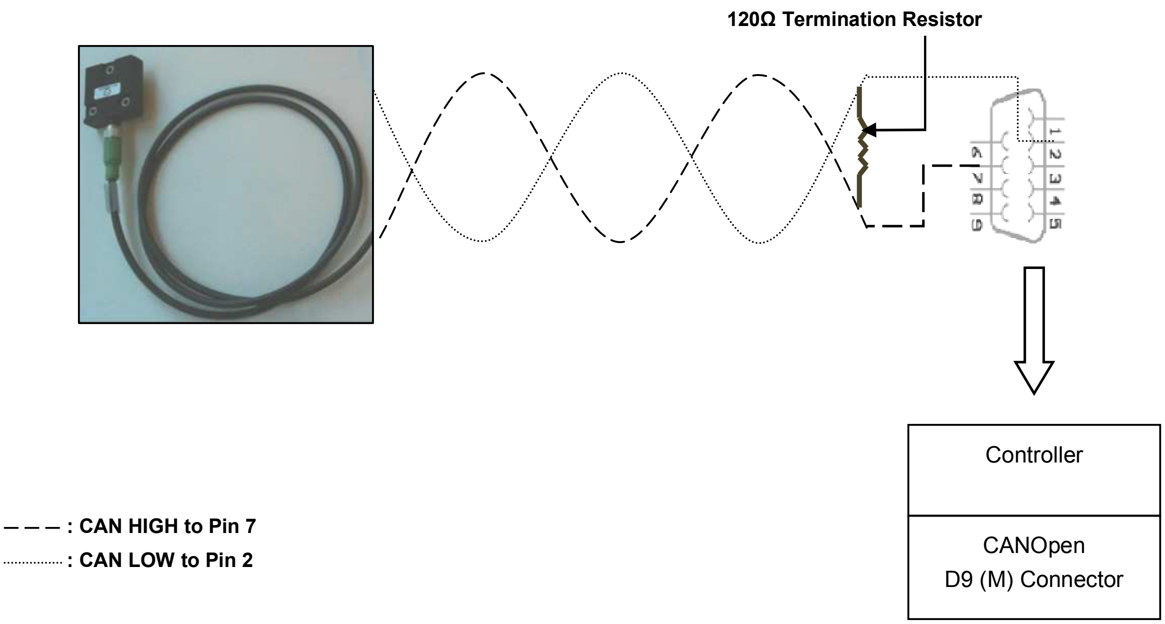
The step-by-step connection procedure and the working of inclinometer in a CAN bus is illustrated in the following sections. Please note that, the programming in other control systems may vary individually. Please have this section as a reference for ACS's working with programmable logic controllers..

5.2 Network Initialization

5.2.1 Hardware

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

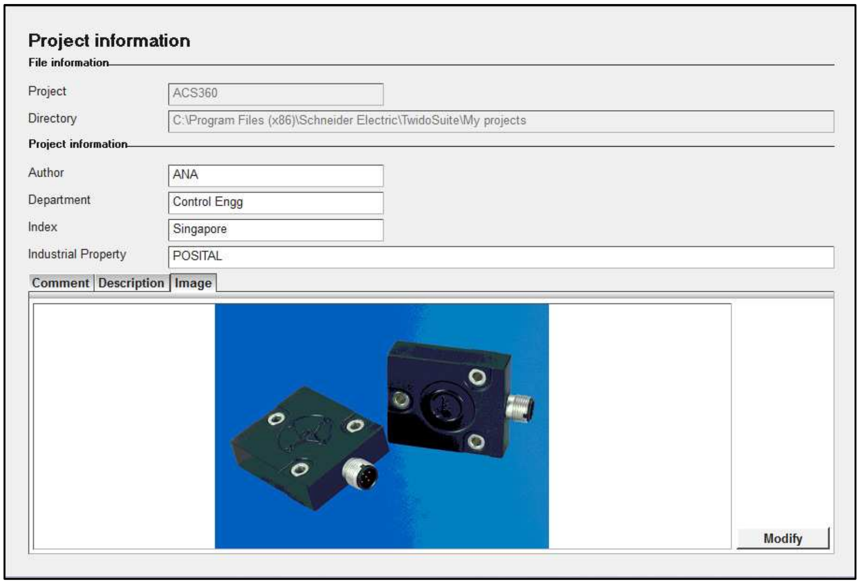
It is very important to add termination resistors to the ACS inclinometers which are used at the start or end of the CANopen bus in order to prevent data corruption or missing of data at higher transmisiion bandwidths (≥50 kB).



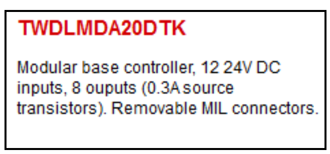
Hardware Setup and Wiring

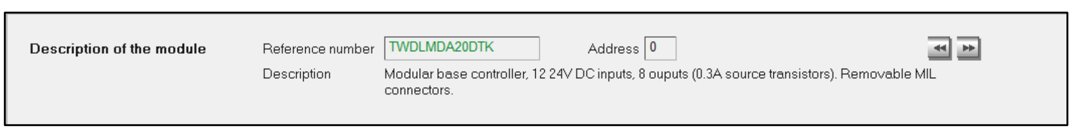
5.2.2 Software Project Information

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

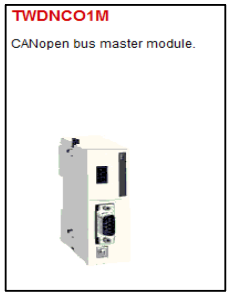


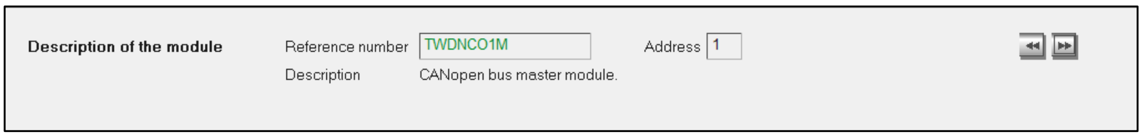
- **Controller Description**





- **CANopen Master Configuration**

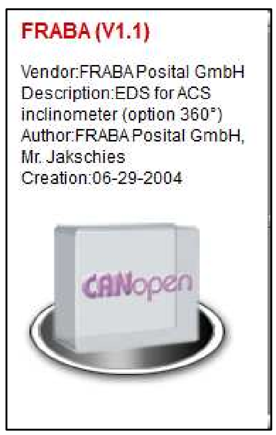




- **ACS360 Inclinometer – Electronic Data Sheet (EDS)**

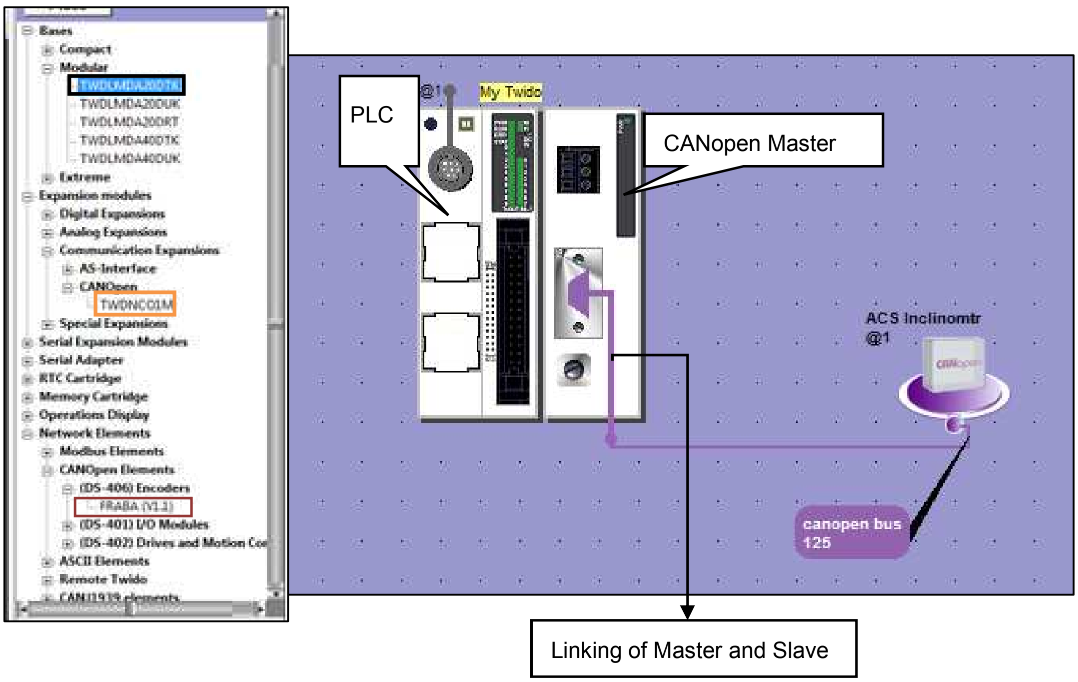
The ACS EDS file once uploaded will load all the objects including the PDOs to the controller. The Schneider system automatically identifies the PDOs and maps them on to the slave device.

.



- **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.

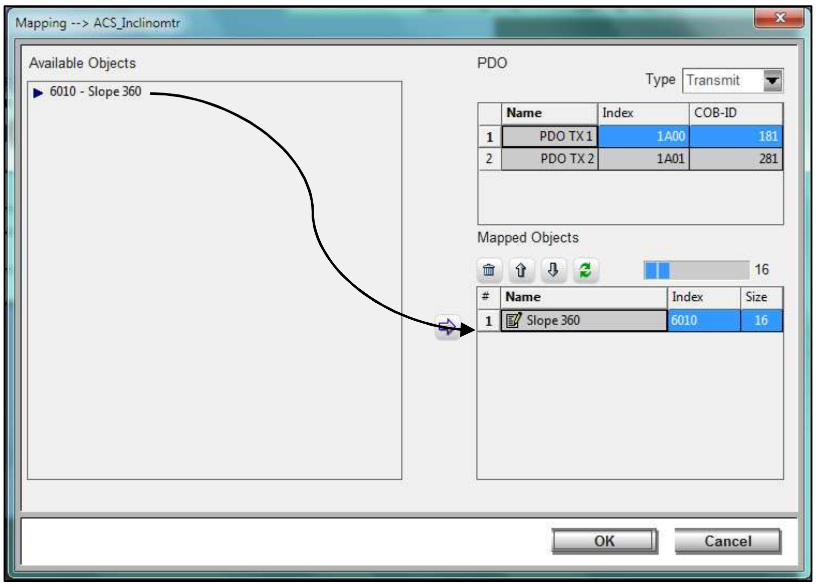
This picture is the overall description of the setup, with the TWIDO TWDLMDA20DTK controller, TWDNCO1M CANopen communication expansion module and the ACS360 EDS file.

5.3 Configuration

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

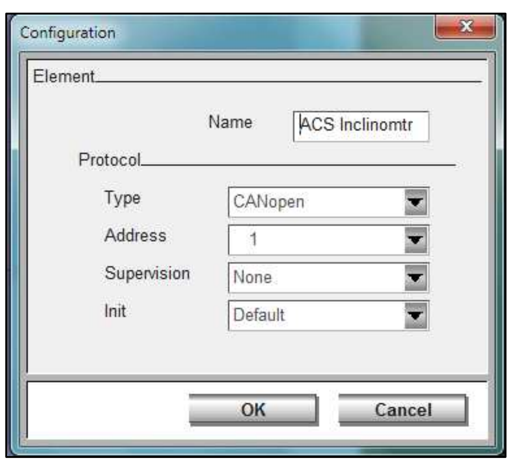
The list of available objects is pre-programmed in the EDS file. Select the ACS inclinometer on the bus and click on Configuration. A list of all the mapped PDOs appear.

Then, according to the need, the objects are mapped on to the Transmit-PDO's of the ACS.



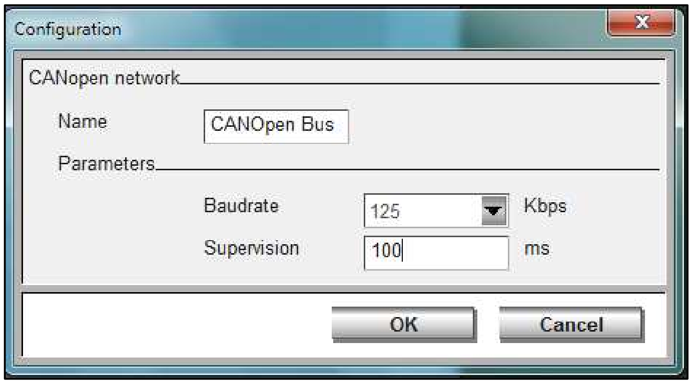
- **ACS CANopen Node Configuration**

Click on the ACS 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.



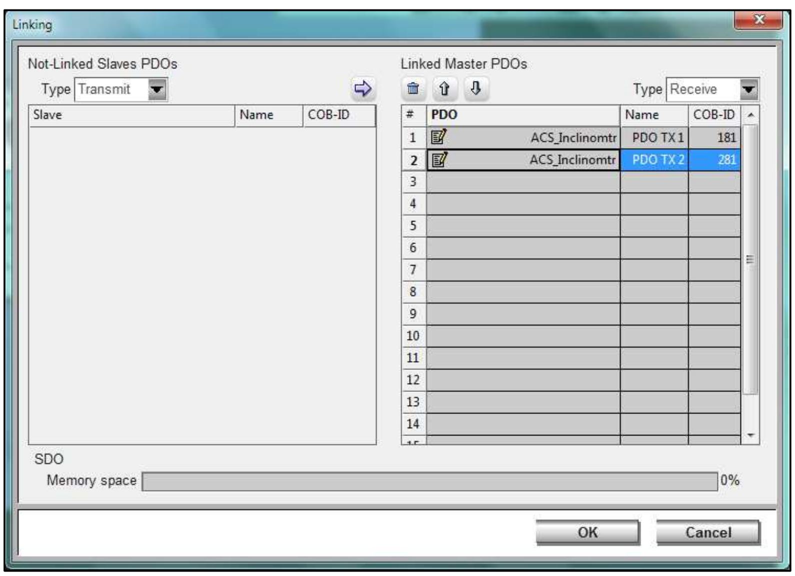
- **CANopen bus network configuration**

Click on the bus connecting the ACS 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 ACS is programmed to the appropriate baud rate as that of the bus.



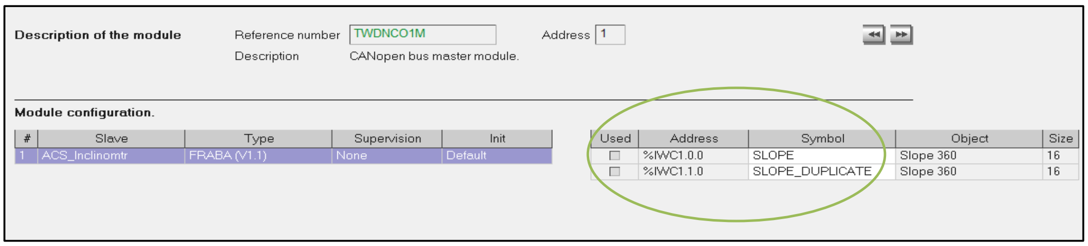
- **Linking of CANOpen Master and ACS Transmit-PDOs**

Select the CANopen link on the controller. Click on the configuration option. The PDOs of the slave are mapped on to 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.



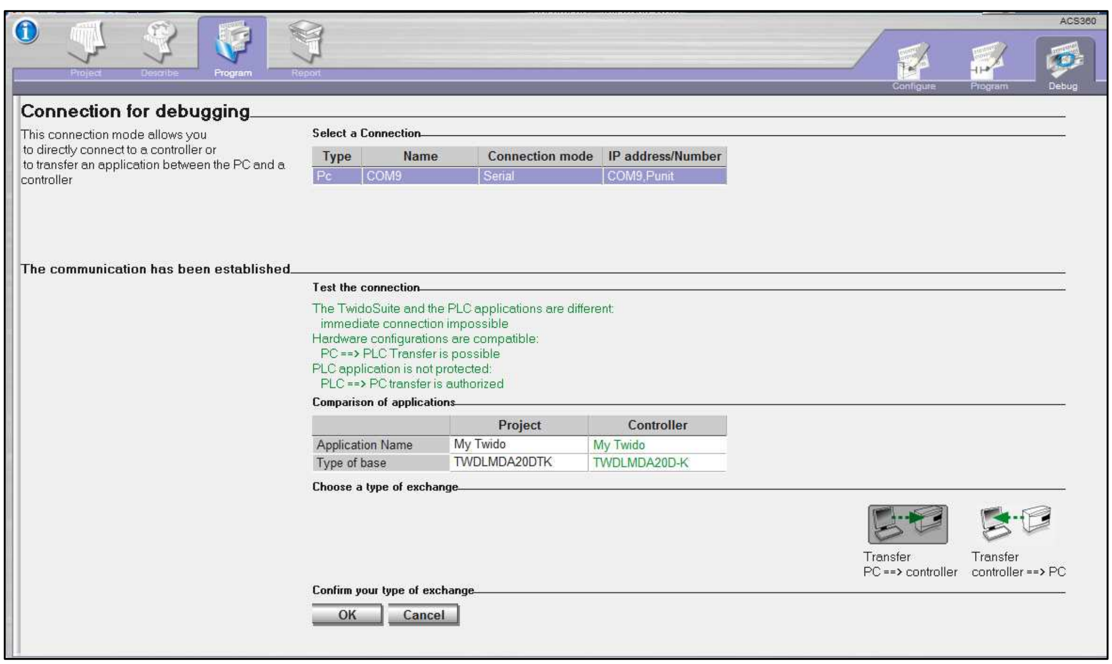
- **ACS & Controller Memory Configuration**

The current and updated position values from the ACS 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 ACS when the controller is Online.

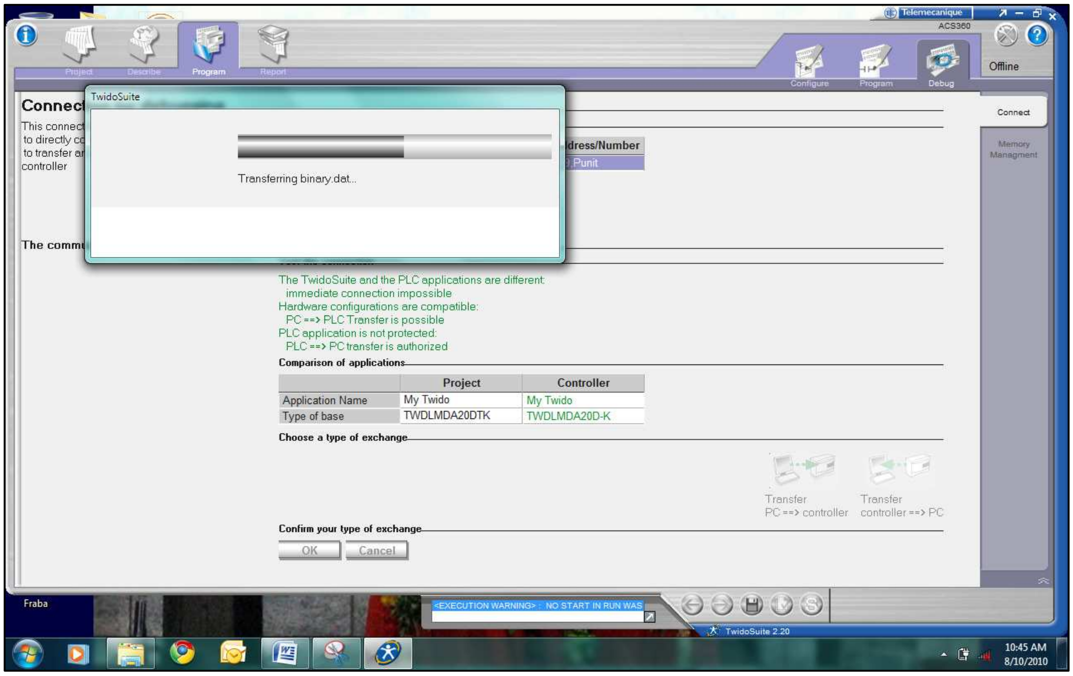


5.4 Debugging

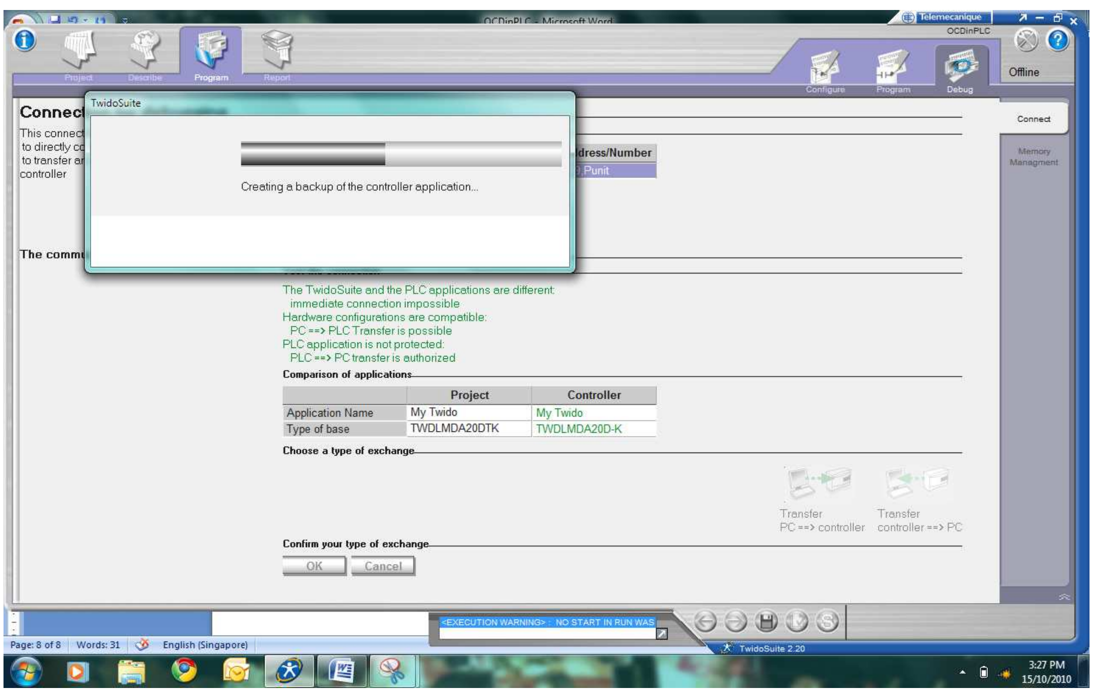
The debugging stage is done on completing the configuration of the PDO's. It involves the following steps:



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.



Converting all the programmed parameters to binary format……….

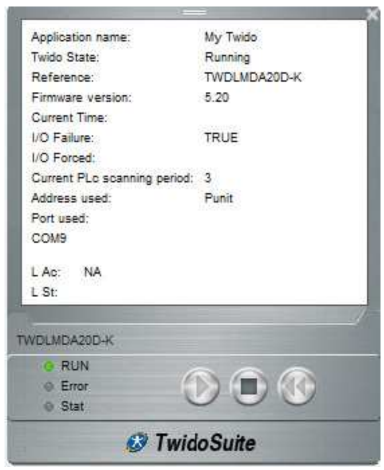


Creating a back up of the controller parameters before going into online mode…….

Once the controller goes into the online mode, the PDOs cannot be changed. But, we can program the SDOs as need arises.

5.4 Run

Once debugged, the controller goes into online mode. We then, 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

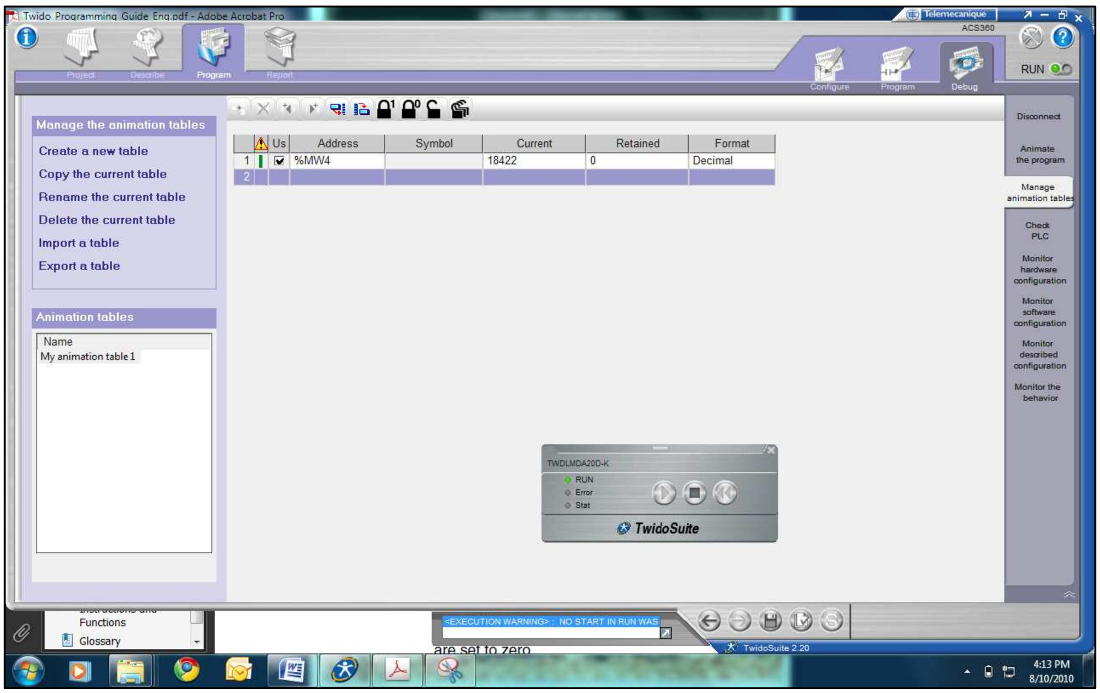
```
0  *                LD     1
1  2/*              [ %MW0  := 16#0002 ]
2  1/*              [ %MW1  := 16#0001 ]
3  1                LD     %SW81:X3
4  * /*             [ CAN_CMD1 %MW0:2 ]
5  0                LDN    %SW81:X4
```

Position Readout

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

Position Value

Readout Using Animation Table



The position Readout is 18422 through the memory location %MW4 (Shown in the programming). We know that the resolution is set to 0.01.

ACS Position Value = 18422 * 0.01 = 184.22°

Illustration of measurement over full range:

At initial position (approximately 0°):

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

ACS Position Value = 32 * 0.01 = 0.32°

At approximately 90°:

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

ACS Position Value = 9138 * 0.01 = 91.38°

At approximately 180°:

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

ACS Position Value = 18052 * 0.01 = 180.52°

At approximately 270°:

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

ACS 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.

6. Troubleshooting

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

  Problem:

  If the bus is active, then, 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 value occasional malfunctions occur. The CAN bus can be temporabily in the bus off state also

  Possible solution:

  Please check if the last bus nodes have the terminal resistor. If the last bus node is an inclinometer the terminal resistor is to be added.

- **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 baudrate. Even if one node has a different baudrate, 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 ACS 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, then follow the next few steps to set the required node number to a selected device.

  1. Calculate the required node number in hexadecimal. (ACS is internally programmed to add 1 to any node number change fed to it, in order to avoid the node number 0)

For example if we want a NN=28 decimal, we need to feed 27 decimal(27+1=28). So the NN 1B hex has to be fed in order to set the selected device to node number 28.

2. Send a write telegram to the particular node, with 1B as data on the object 3000h.
3. Use 2300h to save the parameters with the reset.
4. A boot up message with the new node number pops us.

Appendix A: ACS CANopen Objects

(ro- Read Only, wo- Write Only & rw – Read or Write)

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 32	0X3019A* 0X4019A **	ro	no

* Dual Axis **Single Axis

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

Object 1003h: Pre-Defined Error Field

The object holds 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. Sub-index 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 sub-index 0 of object 1003.

Object 1005h: COB-ID Sync

This object contains the synchronization message identifier.

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

Object 1008h: Mfr Device Name

This object contains the device name.

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

Object 1009h: Mfr Hardware Version

This object contains the article name of the circuit board.

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

Object 100Ah: Mfr Software Version

This object contains the manufacturer software version. The new encoder line 2008 starts with version 4.00.

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

Object 100Ch: Guard Time

This object contains the guard time in milliseconds.

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

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

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 corressponding sub-index of the device.

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

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 save the parameters to non volatile memory the access signature “load” has to be sent to the corresponding subindex 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. Please check all parameters before you store them to the non volatile memory.

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 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)

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

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

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 necessary.

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

Object 2600h: Preset X/Z-Axis

In ACS080 inclinometers, this object sets the X-axis to a desired value. In ACS360 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

***Currently available only in ACS360 versions. Although it is given both Read and Write access, it is preferable to use only write command for setting the Preset value of ACS. Upon setting the Preset value a save command has to be given in order to set the Preset value finally.**

Object 3000h: Node Number

This object contains the node number of the device. The POSITAL standard node number is 32decimal [5].

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Node Number	Unsigned 8	1Fh	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)

***Upon changing the node number please use 2300h object to save the set node number.**

Object 3001h: Baudrate

This object contains the baud rate of the device.

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

Eight different baud rates are provided. To adjust the baud rate only one byte is used.

The default baud rate is 20 kB[6].

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

[6] Forthcoming ACS model will have a default baud rate of 125kB.

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 100d.

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

*** Not implemented yet. Will be available in the first quarter of 2011.**

Four different possible resolutions can be used:

Actual Angular Resolution	Value decimal	Byte hex
1°	1	1 h
0.1°	10	A h
0.01°	100	64 h
0.001°	1000	3E8 h

Object 6010h: Position Value X/Z-Axis

In ACS080 inclinometers, this object provides the X-axis value. In ACS360 inclinometers, this object provides the Z-axis value.

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

Object 6012h: Preset X/Z-Axis

In ACS080 inclinometers, this object sets the X-axis to a desired value. In ACS360 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

Object 6020h: Position Value Y-Axis

In ACS080 inclinometers, this object provides the Y-axis value. In ACS360 inclinometers, this object is NOT functional.

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

Appendix B: Ordering Code

ACS - Industrial

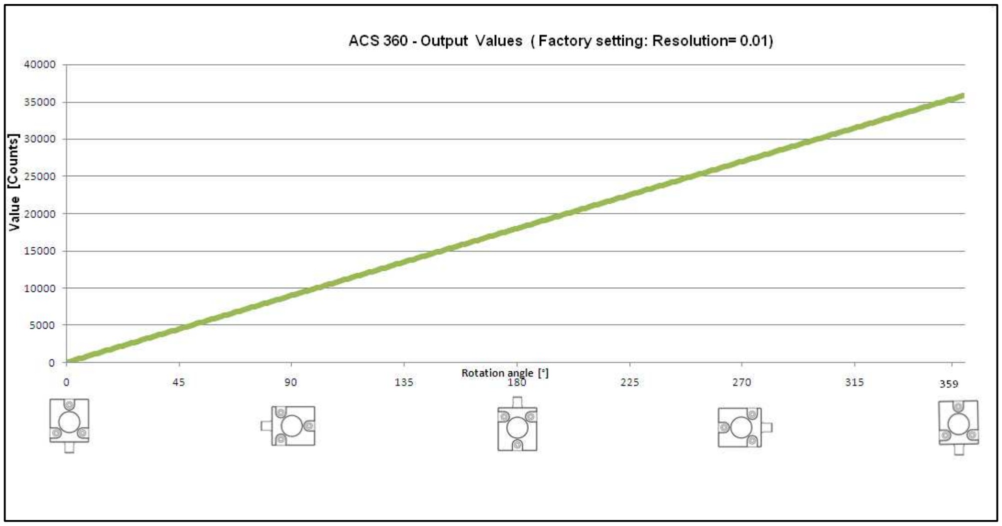
Description	Type key								
	ACS-	XXX-	X-	XX	XX-	X	X	X-	XX
Range	360° (1 axis)	360							
	± 80° (2 axis)	080							
Number of axis	One for 360° Version		1						
	Two for ± 80° Version		2						
Interface	CANopen			CA					
Version	Software Version				01				
Mounting	Vertical for 360° Version					V			
	Horizontal for ± 80° Version					H			
Housing Material	Industrial (PBT)						E		
Inclinometer Series	ACS II							2	
Connection	Connector								PM

ACS – Heavy-Duty

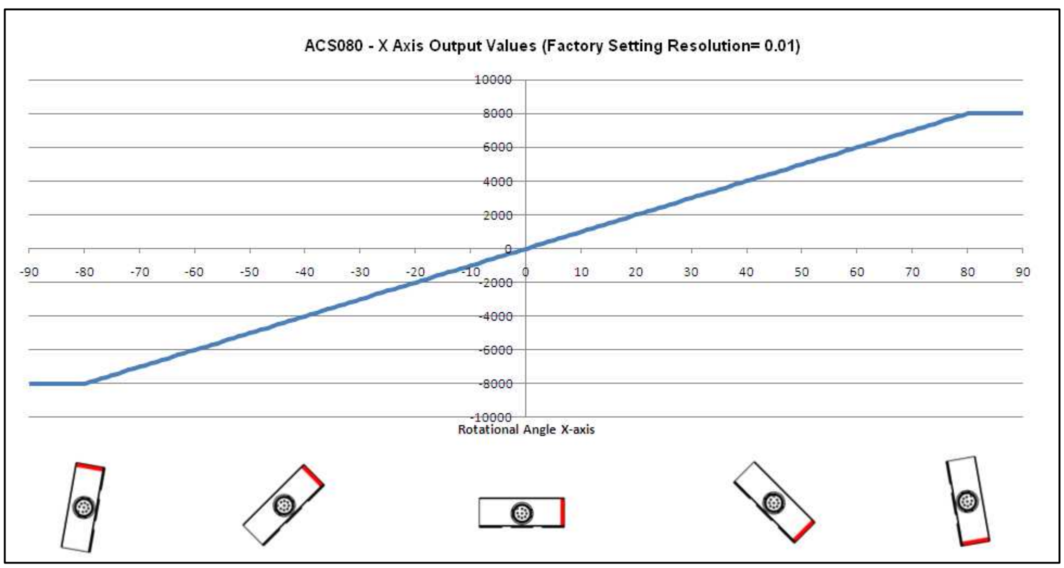
Description	Type key								
	ACS-	XXX-	X-	XX	XX-	X	X	X-	XX
Range	360° (1 axis)	360							
	± 80° (2 axis)	080							
Number of axis	One for 360° Version		1						
	Two for ± 80° Version		2						
Interface	CANopen			CA					
Version	Software Version				01				
Mounting	Vertical for 360° Version					V			
	Horizontal for ± 80° Version					H			
Housing Material	Heavy-Duty (Aluminium)						H		
Inclinometer Series	ACS II							2	
Connection	Connector								PM

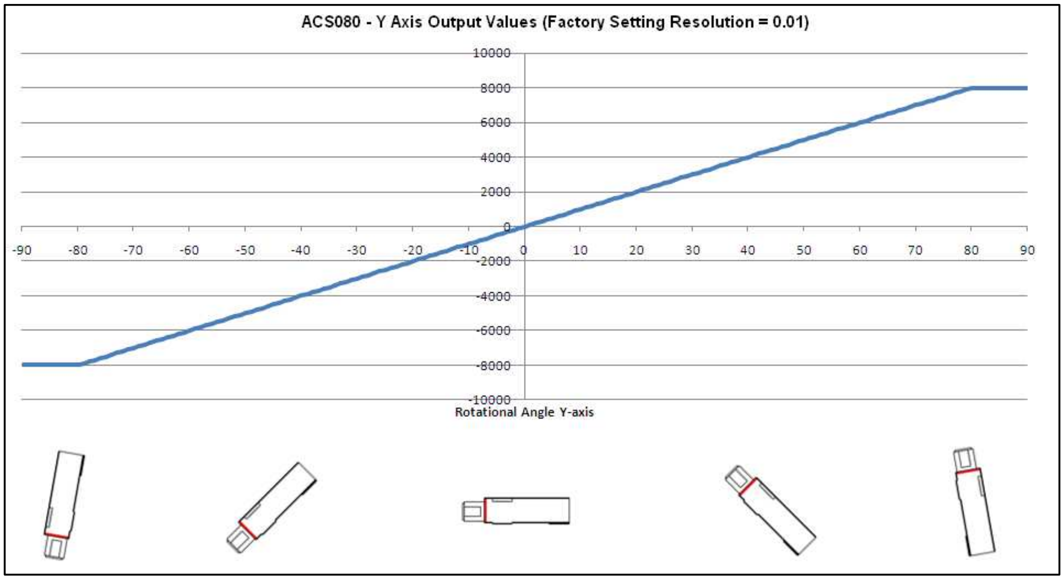
Appendix C : Output Graphs

ACS 360: CANopen Output Values



ACS 080 : CANopen Output Values





Glossary

A

Address	Number, assigned to each node, irrespective of whether it is a master or slave. The inclinometer address (non-volatile) is configured in the base with rotary switches.
APV	Absolute Position Value.

B

Baud rate	Transmission speed formulated in number of bits per second. Bus node Device that can send and/or receive or amplify data by means of the bus.
Byte	8-bit unit of data = 1 byte.

C

CAL	CAN application layer.
CAN	Controller Area Network or CAN multiplexing network.
CANopen	Application layer of an industrial network based on the CAN bus.
CCW	Counter-clockwise

CiA	CAN In Automation, organization of manufacturers and users of devices that operate on the CAN bus.
COB	Elementary communication object on the CAN network. All data is transferred using a COB.
COB-ID	COB-Identifier. Identifies an object in a network. The ID determines the transmission priority of this object. The COB-ID consists of a function code and a node number.
CW	Clockwise

F

FC Function code.	Determines the type of message sent via the CAN network.

L

Line terminator	Resistor terminating the main segments of the bus.
LMT	Network management object. This is used to configure the parameters of each layer in the CAN. Master "Active" device within the network, that can send data without having received a request. It controls data exchange and communication management.

N

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

P

PCV	Process Value
PDO	Communication object, with a high priority for sending process data.
PV	Preset Value: Configuration value

R

RO	Read Only: Parameter that is only accessible in read mode.
ROMAP	Read Only MAPable: Parameter that can be polled by the PDO.

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.

Disclaimer

For more information:

ACS - Absolute Inclinometers

ACS CANopen - Datasheet

ACS CANopen EDS File

For information on other products, please visit:

POSITAL - Absolute rotary encoders and Inclinometers

INTACTON - Optical Motion Sensors

VITECTOR - Protection Sensors

Document History

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NOTES