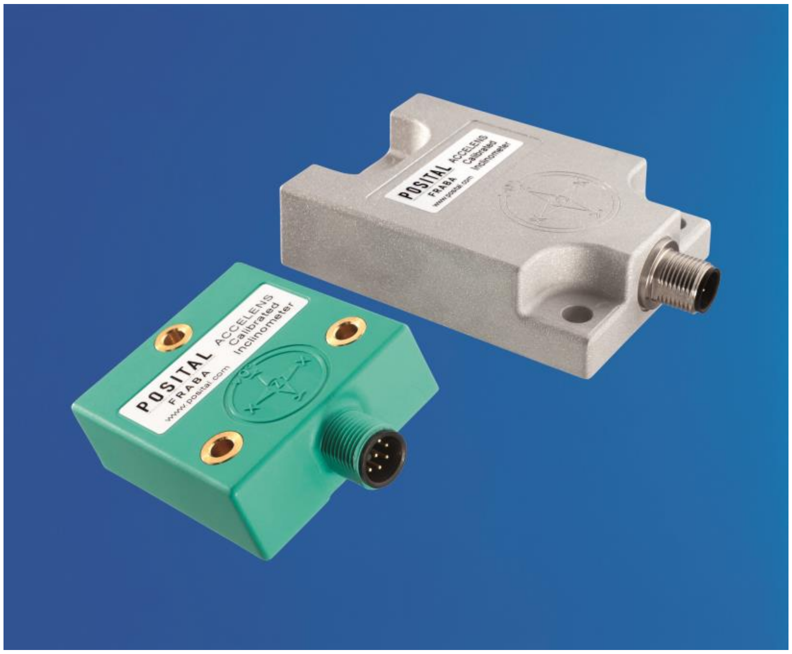
USER MANUAL

TILTIX MEMS INCLINOMETER WITH DEVICENET INTERFACE



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General Safety Advise

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 TILTIX inclinometer with a DeviceNet interface with illustrations from a Rockwell PLC.

Relate Note

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User Annotation

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USER MANUAL

TILTIX MEMS INCLINOMETER WITH DEVICENET INTERFACE

1. Introduction

This manual explains how to install and configure the TILTIX gravity referenced inclinometers (suitable for industrial, military and heavy duty applications) with a DeviceNet interface.

1.1 TILTIX Inclinometer

TILTIX 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 TILTIX 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 TILTIX 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 TILTIX series of inclinometers are available in two types. First, a single axis measurement type with a range of 0-360° (either clockwise or anti-clockwise) and the other type, a dual axis measurement capable TILTIX 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 TILTIX suitable for rugged environments and versatile applications in industrial, heavy duty and military applications.

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 encoders and a link between the mechanical and control systems.

1.2 Benefits of TILTIX:

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

2 DeviceNet Basics

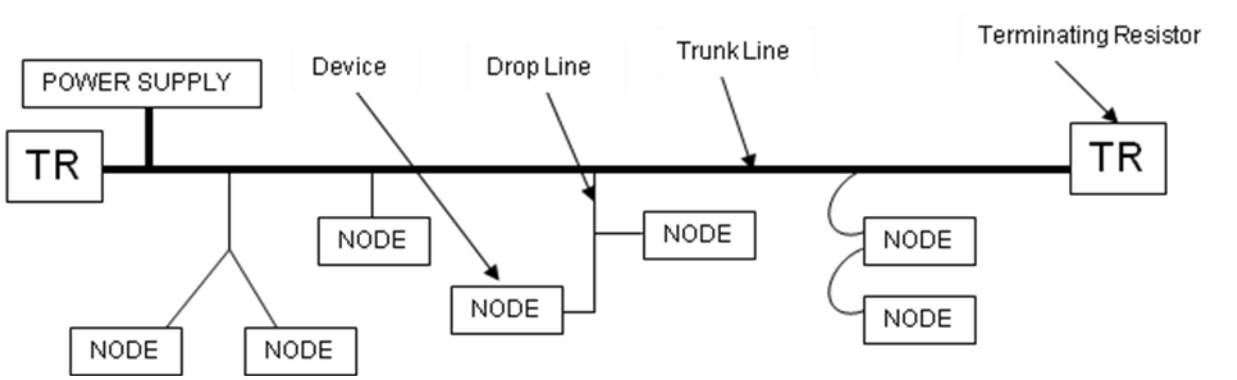
DeviceNet is a digital, multi-drop network that connects and serves as a communication network between industrial controllers and I/O devices. Each device and/or controller is a node on the network. The DeviceNet specification defines the Application Layer and the Physical Layer.

Below you can see the Basic DeviceNet Features and Functionality

Network Size	Up to 64 nodes	
Network Length	Selectable end-to-end network distance varies with speed	
	125 Kbps	500 m (1,640 ft)
	250 Kbps	250 m (820 ft)
	500 Kbps	100 m (328 ft)
Data Packets	0-8 bytes	
Bus Topology	Linear (trunk line/drop line); power and signal on the same network cable	
Bus Addressing	Peer-to-Peer with Multi-Cast (one-to-many); Multi-Master and Master/Slave special case; polled or change-of-state (exception-based)	

2.1 Physical Layer

DeviceNet uses a trunk-line/drop-line topology that provides separate twisted pair busses for both signal and power distribution. The possible variants of this topology are shown in the figure. Thick or thin cable can be used for either trunk lines or drop lines. End-to-end network length varies with data rate and cable thickness.

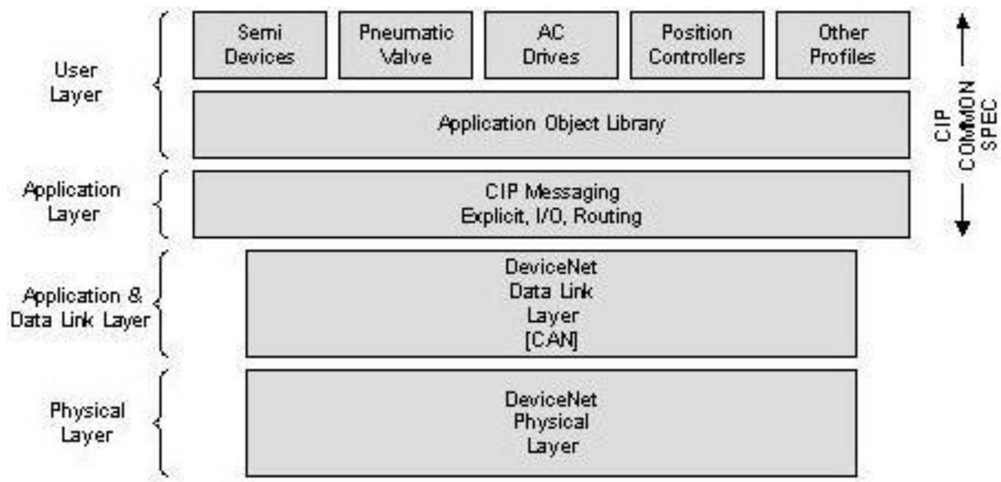


2.2 Data Link Layer

The Data Link layer is based on the CAN-specification. For the optimal industrial control will be defined two different messaging types. I/O messaging (Implicit Messaging) and explicit messaging. With Implicit Messaging becoming I/O data exchanged in real-time and with Explicit Messaging becoming data exchanged to configure a device.

CIP (Common Industrial Protocol) make for the user available four essential functions:

- Unique control service
- Unique communication service
- Unique allocation of messaging
- Common knowledge base



DeviceNet describes all data and functions of a device considering as object model. By means of that object-oriented description a device can be defined complete with single objects. An object is defined across the centralization by associated attributes (e.g. process data), his functions (read- or write access of a single attribute) as well as by the defined behavior.

DeviceNet distinction is drawn between three different objects:

- Communication object
  Define the exchange messages over DeviceNet and becoming designated as Connection Objects. (DeviceNet Object, Message Router Object, Connection Object, Acknowledge Handler Object)
- System objects
  Define common DeviceNet-specific data and functions. (Identity Object, Parameter Object)
- Applications-specific objects
  Define device-specific data and functions. (Application Object, Assembly Object)

3. Installation

3.1 Accessories

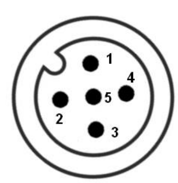
Article No	Article	Description
TILTIX360/080	Inclinometer	TILTIX series of Inclinometers
Download	Datasheet*	TILTIX Datasheet, specifications and drawings
Download	User Manual*	Installation and Configuration User Manual (English)
Download	EDS-File*	Electronic Datasheet (EDS) file for configuration
34050515	PAM 2m	Female M12, 5pin A-coded connector, with 2m PUR shielded cable
10001978	PAM 5m	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.com/

3.2 Pin Assignment

The inclinometer is connected via a 5 pin round M12 connector.
(Standard M12, Male side at sensor, Female at connector counterpart
Or connection cable).

DeviceNet Color	Signal	5 pin round connector pin number
Bare	Drain	1
Red	V_S Supply Voltage	2
Black	0 V Supply Voltage	3
White	CAN_H	4
Blue	CAN_L	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

TILTIX 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 TILTIX 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 (TILTIX Industrial) and M6 or UNC bolts #12 (TILTIX Heavy-Duty) for the 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.

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. TILTIX Inclination sensors that are based on a MEMS principle are optimal for fast measurements.

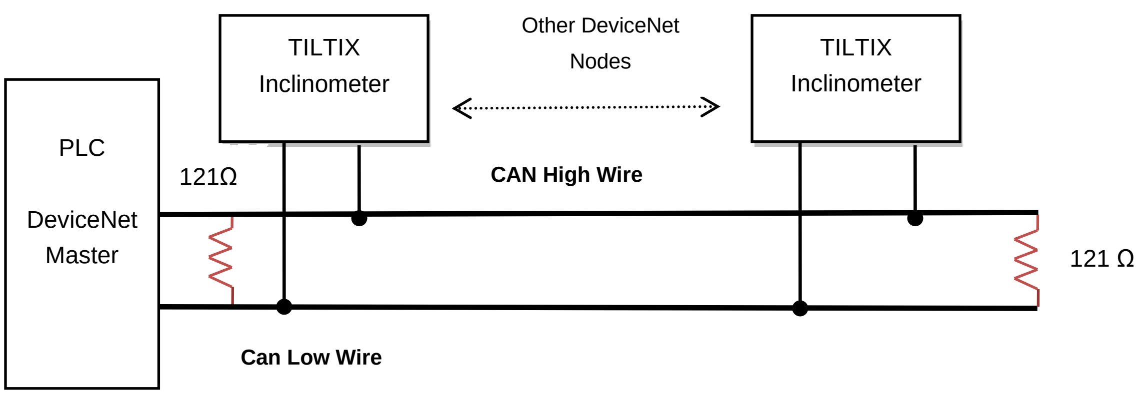
3.5 Bus Termination

If the inclinometer is connected at the end or beginning of the bus or for higher transmission baud rates (≥125 KBaud) a terminating resistor of 121 Ohm 1%, 1/4W must be used in order to prevent the reflection of information back into the 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 TILTIX Inclinometer has internal terminating resistors that can be switched on or off by setting the right parameter or by explicit messaging See chapter 5.1 for additional information.

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



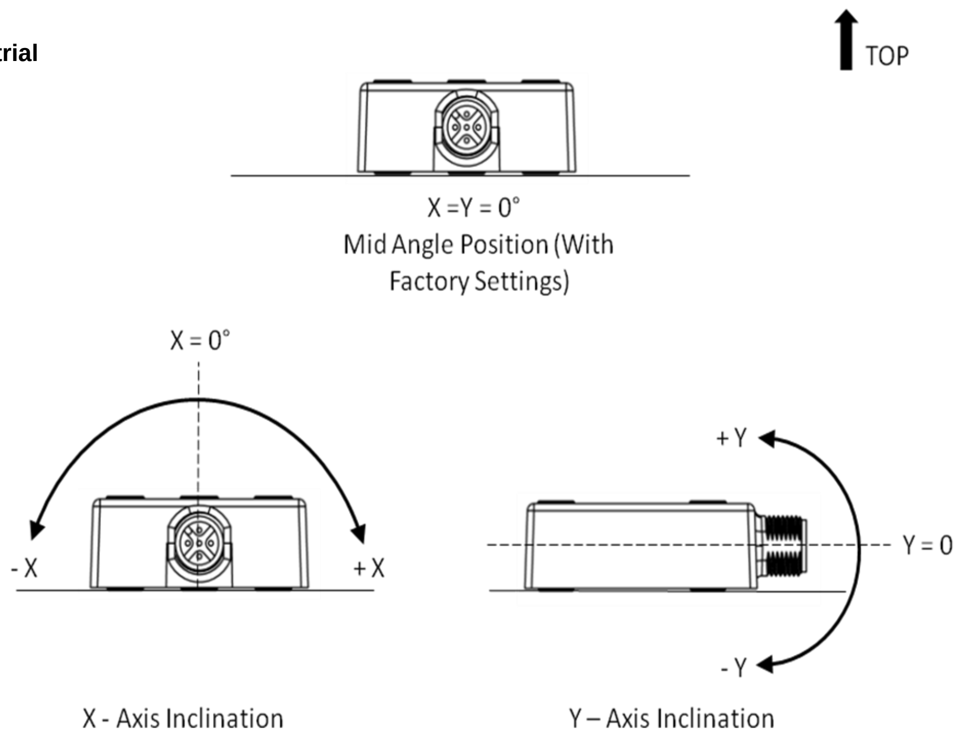
WARNING

The internal terminal resistors of the inclinometers are only functional when power is applied to the device. Care should be taken that this does not affect other devices on the DeviceNet network.

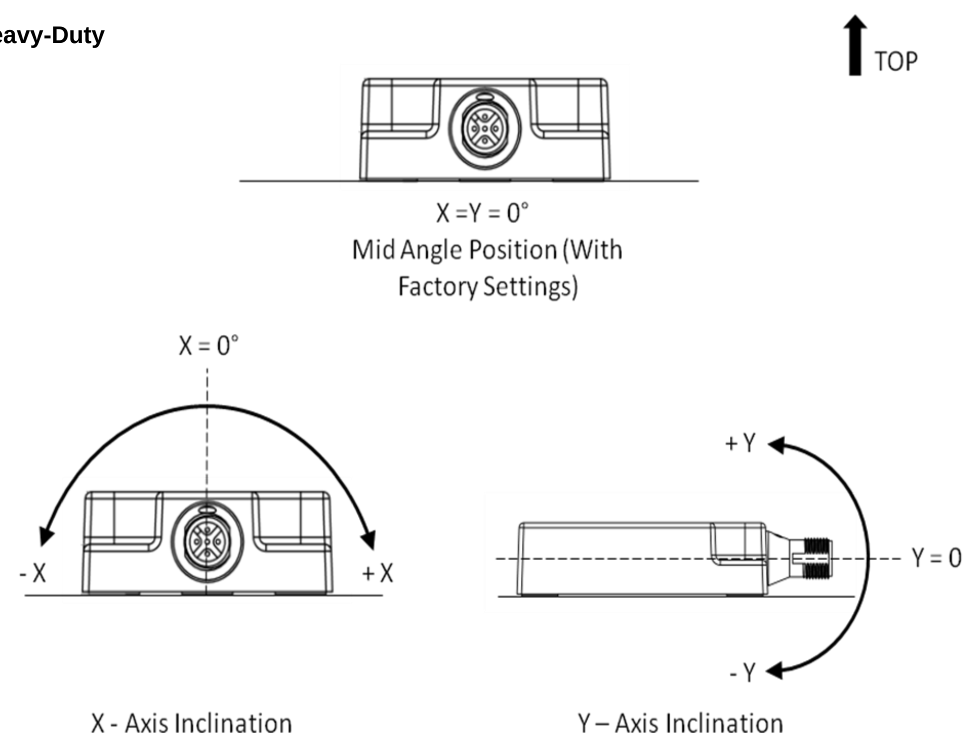
3.6 Measurement Axes

3.6.1 TILTIX80

Industrial

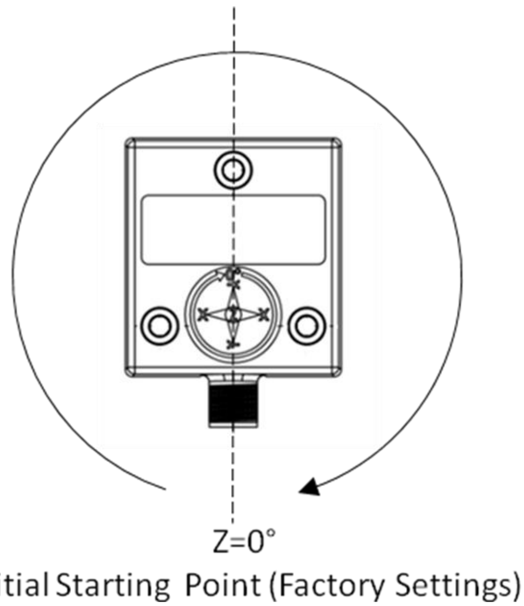


Heavy-Duty

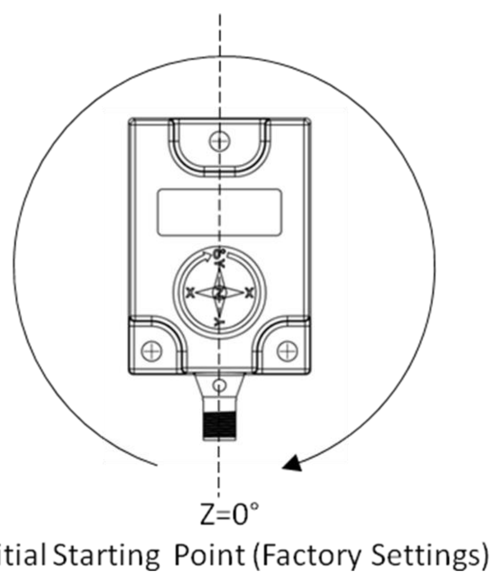


3.6.2 TILTIX360

Industrial



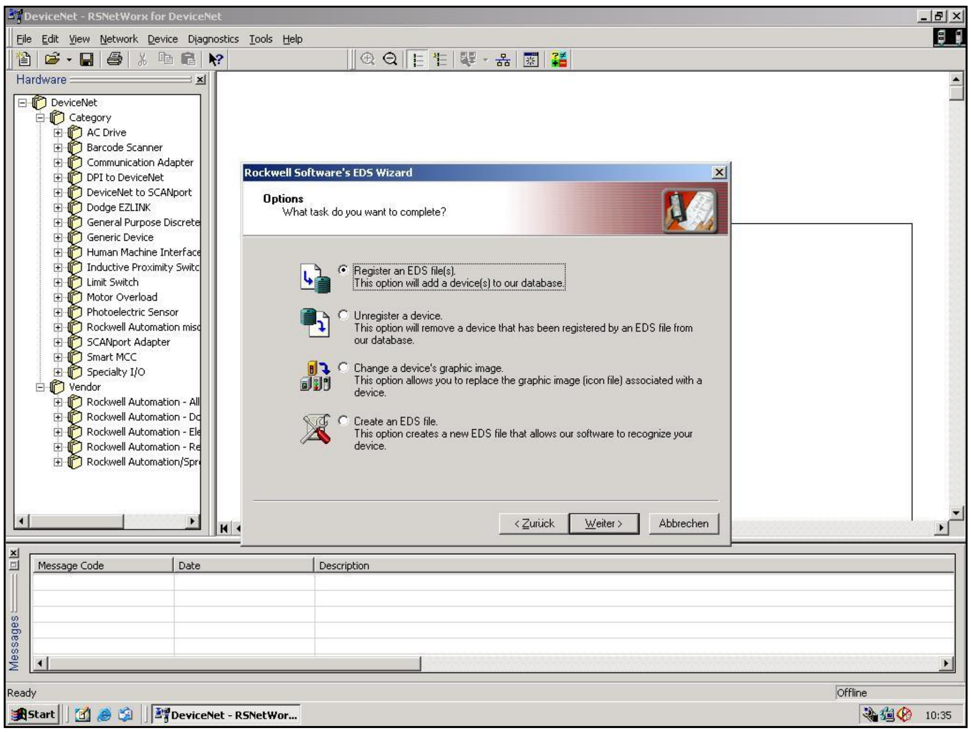
Heavy Duty



4. RSNetWorx™

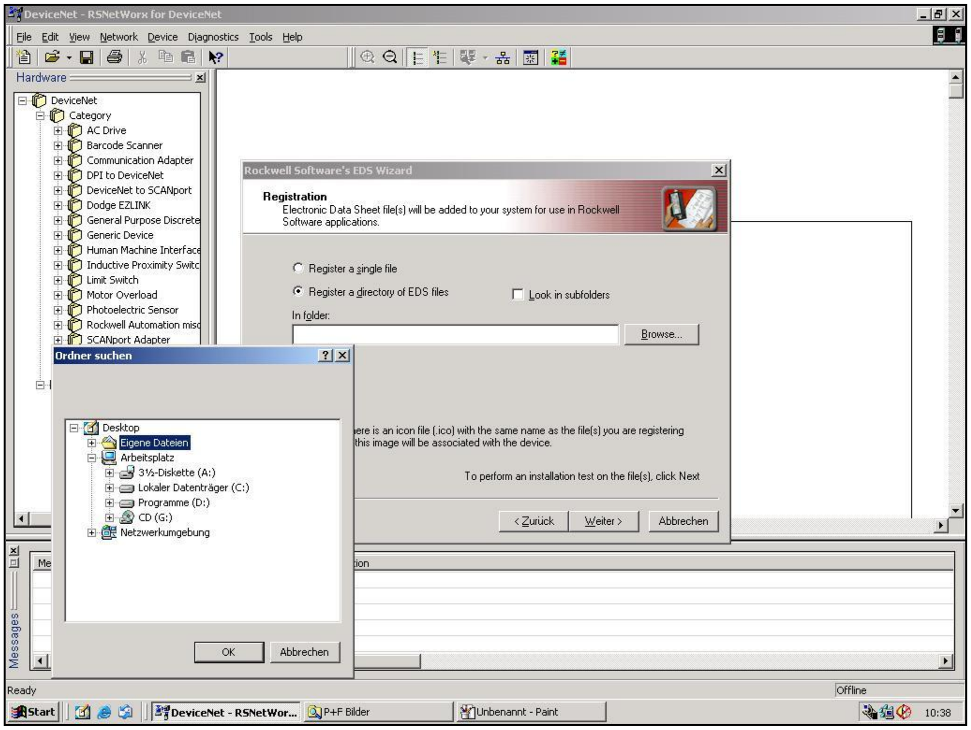
4.1. EDS Wizard

The EDS File contains information about device specific parameters as well as possible operating modes of the inclinometer With this file you have a data sheet in an electronic format, which can be used to configure the device in the network, for example with RSNetWorx from Rockwell**.**



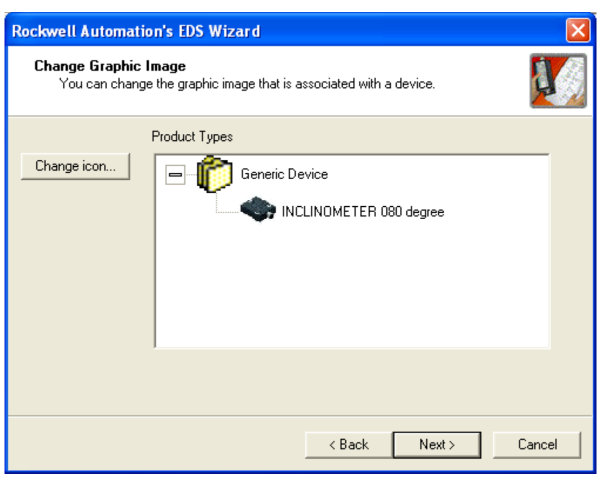
4.1 EDS Wizard

To install the EDS file the EDS Wizard has to be started, that can be done in the menu *Tools/EDS Wizard.* If the EDS Wizard is activated successfully the *Register an EDS File(s)* has to be chosen and after that the button *"Next"* In the next step the *Register a directory of EDS files* has to be chosen and with *Browse* the path of the EDS file(s). That is indicated in picture 4.2.



4.2 EDS Wizard

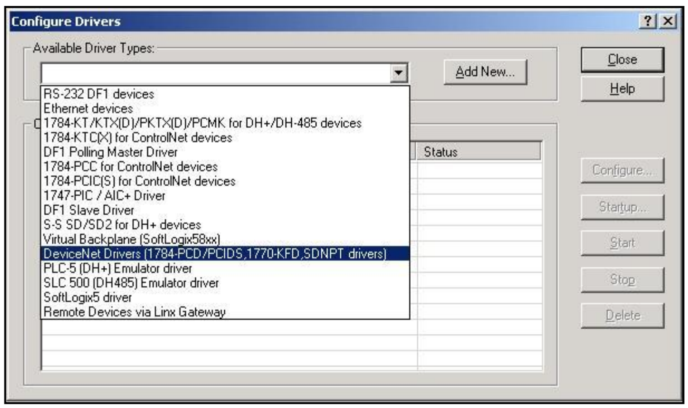
The Wizard finds all EDS files that are located in the chosen path and operates a test to check the EDS files on errors. In the next step (see picture 4.3) pictures can be selected for the used nodes. With the button "*Next"* the installation can be finished.



4.3 Device Icon Selection

4.2 Driver Configuration

After a successful registration of the EDS file the next step is to choose the suitable driver for the DeviceNet interface. With *Start/Programs/Rockwell Software/RSLinx* in the menu the program RSLinx can be started. With this program the driver corresponding to the interface device can be chosen. For this example the RS232-DeviceNet interface device 1770-KFD is being used. In the next step the window *Configure Drivers* in the menu *Communications/ Configure Drivers* has to be started. In the drop down Menu *Available Driver Types* the driver type 1770-KFD has to be chosen and confirmed with the button *Add New.* (See picture 4.4)



4.4 Configure Drivers

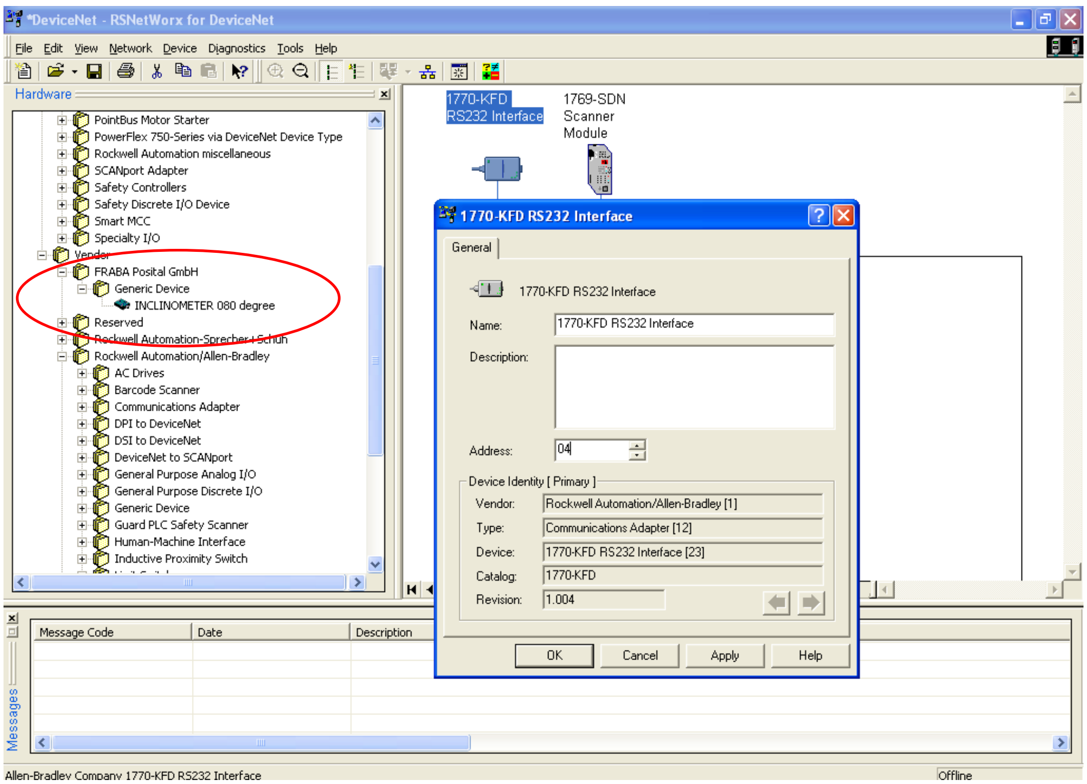
If the suitable driver is chosen it can be configured in the window *Driver Configuration.* For the KFD-1770 the Serial Port and the Data Rate has to be chosen. In this window it is also possible to set the desired Node Address (MAC ID) as well as one of the three possible Data Rates (125, 250, 500kBaud (picture 4.5). The 1770-KFD needs a "CAN acknowledge" to configure successfully. Any running device on the same bus with the same Baudrate can deliver this acknowledge. In the next step the driver can be given a custom name.

Close RSLinx but make sure it is running in the taskbar.

4.5 Driver Configuration

4.3. Building the Network

The network is built, simply by dragging and dropping the right devices actually connected on the physical bus from the Hardware list, available after an EDS file is installed. You would need to properly configure these devices, for the right Node Address, if they aren't already set at the right value. The TILTIX Inclinometer can be found under *Hardware/DeviceNet/Vendor/FRABA Posital GmbH/Generic Device/INCLINOMETER 080 degree,* for this example.



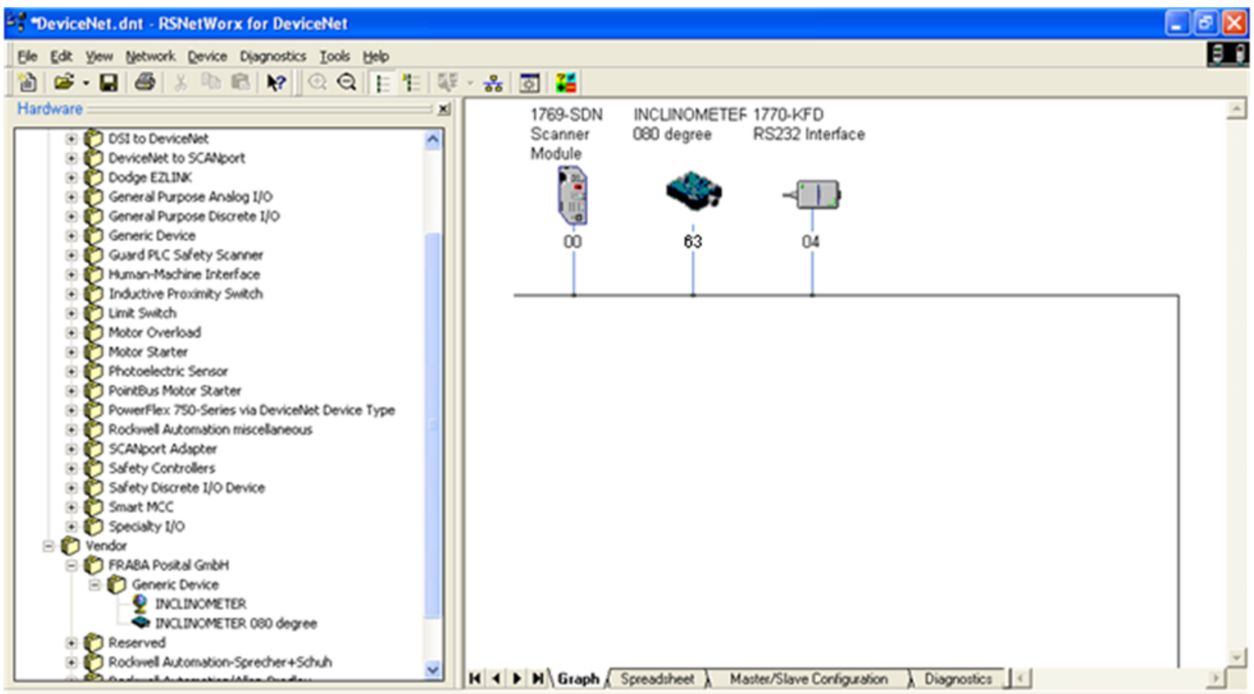
4.6 Building the network

WARNING

If a Scanner module is connected to the bus it would most likely, but not necessarily, appear at node address 0. Sometimes DeviceNet Scanners are preconfigured to a different Baud rate. One should ensure that all devices on the bus are using the same Baud rate. If the network is not using 125KBd (default), then a point to point connection must be physically realized, otherwise the network would crash

4. 4 Network Connection

This chapter will explain how to switch a network online. In the menu *Network/ Online* the window *Browse for network* will be opened. If the driver for *1770-KFD* has been chosen, this is explained in chapter 4.2, the network is online. After that RSNetWorx searches in the network for connecting nodes. That is also being showed in picture 4.7.



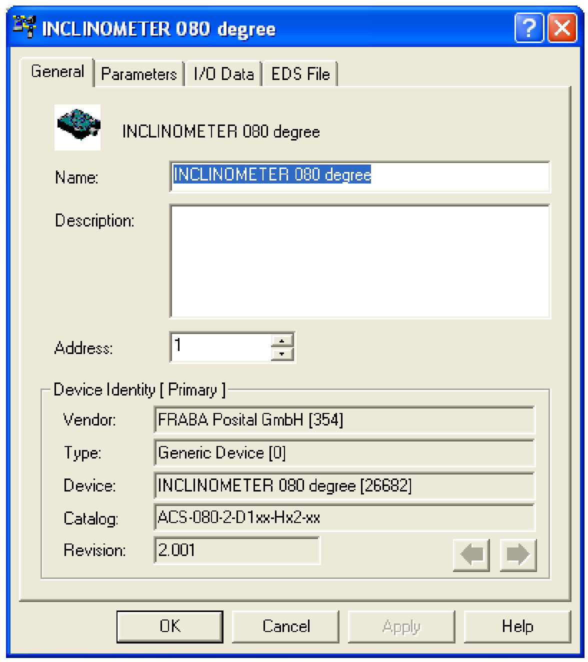
4.7 Browsing Network

4.5 Parameter Configuration

To configure the inclinometer the configuration window in the menu *Device/Properties* has to be opened, while the network is in online mode. . If parameters are changed while in offline mode, they can be saved temporarily by pressing Apply or OK. However, the new parameter values are not transferred to the device. To do so, go to online mode, double click on the device, go to the Parameters tab and press download.

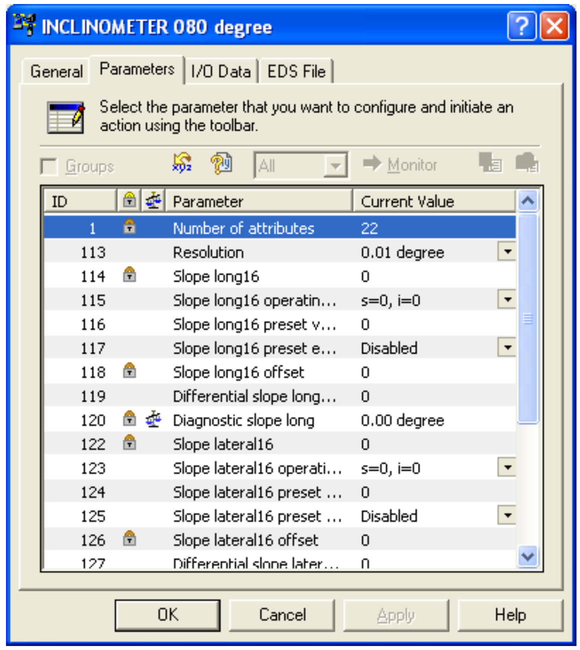
4.5.1 General Tab

In the General Tab one can see the Device Identity parameters. The Node Address can be changed. The device name can be changed or a Description can be added. Besides various vendor and device information can be seen



4.5.2 Parameters Tab

In the Parameters Tab you can click upload parameters to get the parameters from the device. Some of the TILTIX parameters are read only sensor values like the *Slope long16* and *Slope lateral16*. These are scaled slope or inclination values. If a parameter is changed and downloaded to the device, the parameter is saved non-volatile. The parameters are also available in the class instance editor via explicit messaging



IMPORTANT

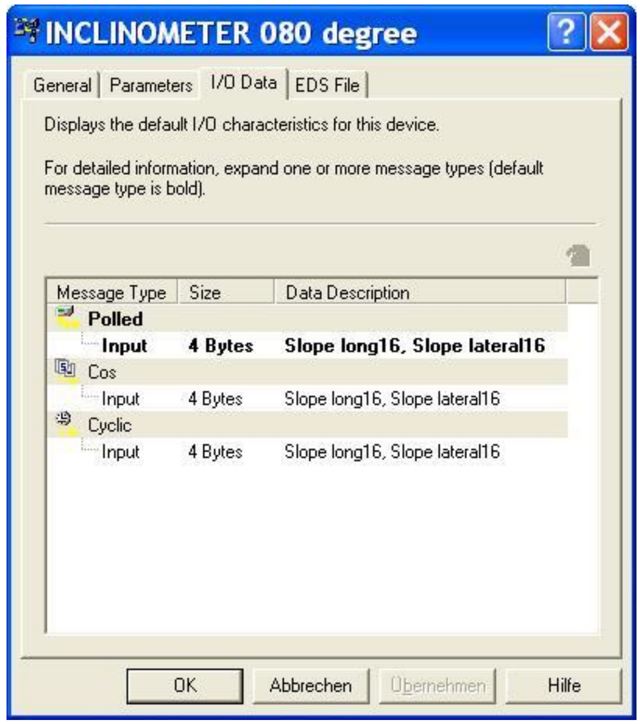
The easiest way to configure the device, without any side effects, is in the following order (the same as in the parameter tab)

- Set the desired resolution (for both axes the same)
- Set the operating parameter depending on:
  - Inversion of the axis
  - Enable scaling for the axis
- When scaling is enabled, set the preset at the desired inclination and write it with preset enable parameter if required by application.
- If scaling is enabled, set an additional differential offset if required

The parameters are explained more in detail in Chapter 5.1.2.

4.5.3 I/O Data Tab

In the I/O Data Tab you see the different available assembly instances for the different connection types (. Each connection type offers the possibility of using three different assembly instances. In the I/O Data Tab the default assembly instances of the various connections are shown. The polled connection is activated by default if mapped to a master device.



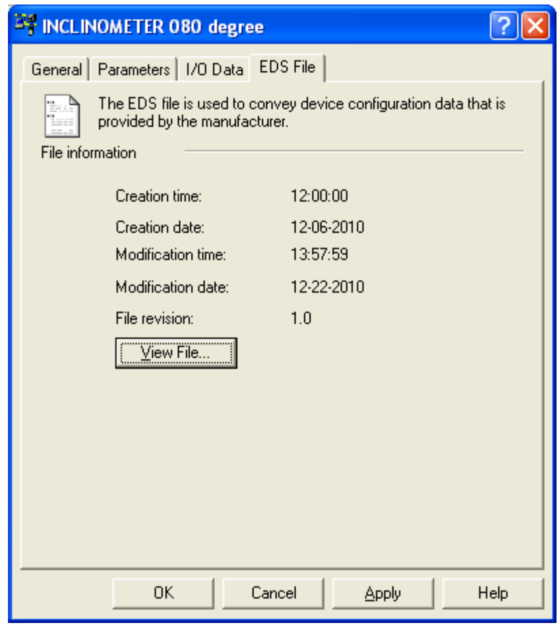
WARNING

The assembly instances can be changed with the parameters Polled assembly instance and Cyclic/COS assembly instance. This is only necessary in RSNetWorx. Additional description of the modes can be found in the table below

Polled Mode	By an I/O -request telegram the connected master calls for the current process value. The inclinometer reads the current inclination value, calculates eventually set-parameters and sends back the obtained process value. (Default Configuration).
Change-of-State Mode	The inclinometer answers with current process value, if a change of inclination is detected. Important: If a high resolution is set, the device could send out messages very fast (<1ms) due to minor inclination changes leading to a high bus load. To prevent this, it is possible to set a Delta value, which limits the output to changes specified in the parameter COS Delta.
Cyclic Mode	The inclinometer transmits cyclically - without being requested by the master - the current process value. The cycle time can be programmed in milliseconds for values between 2 ms and 65535 ms.

4.5.4 EDS File Tab

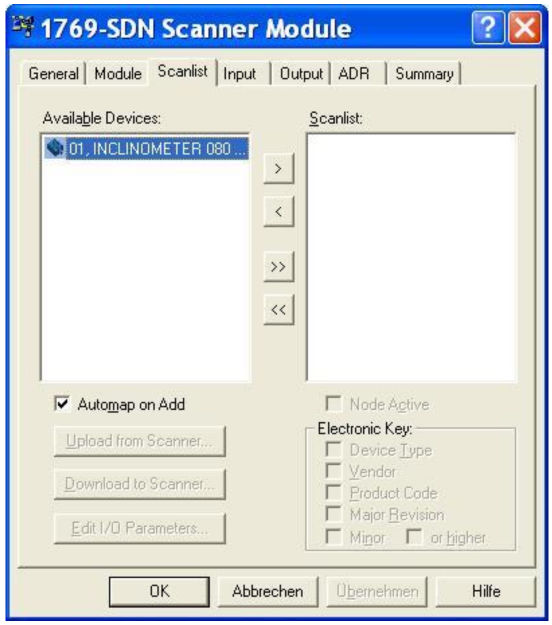
In the EDS File Tab you can get some information of the EDS file, like when it was created and so on. You can open the EDS file by clicking on View File.



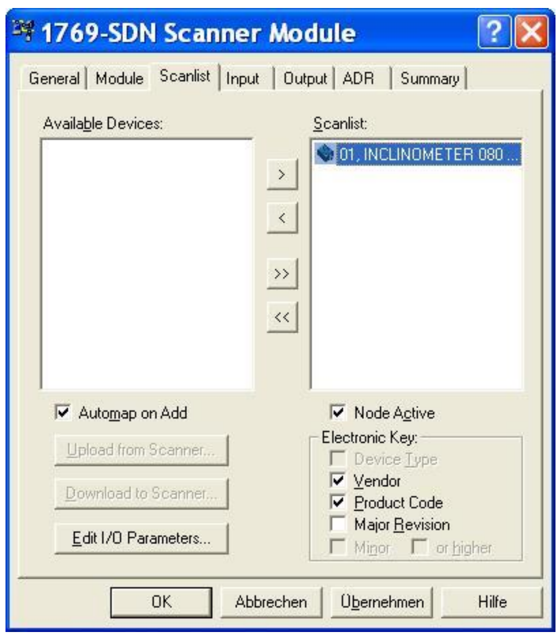
4.6 Configuration of a Master device

As an example the 1769 SDN scanner is taken. For most scanners the steps are identical.

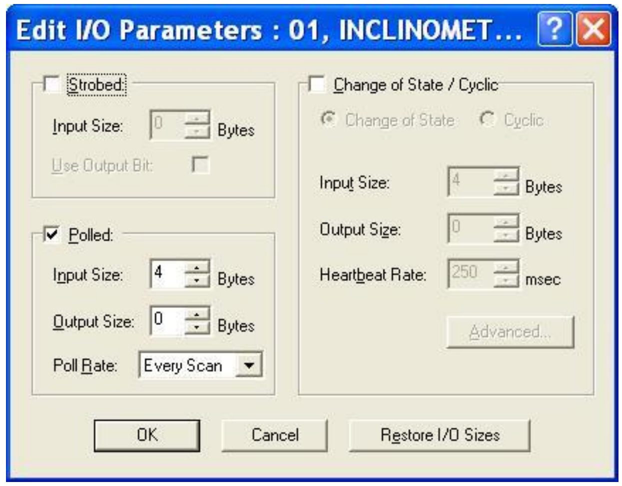
Double-click on the scanner and upload parameters from the device. Go to the tab Scan list. Select the inclinometer in the left window and add it to the scan list by clicking the upper arrow pointing to the right.



Once the inclinometer has been added to the scan list, the I/O parameters can be edited. You can do this by clicking the Edit I/O Parameters button in the lower left corner. If Automap on Add is enabled, the default I/O connection of the inclinometer is activated once added to the scan list.



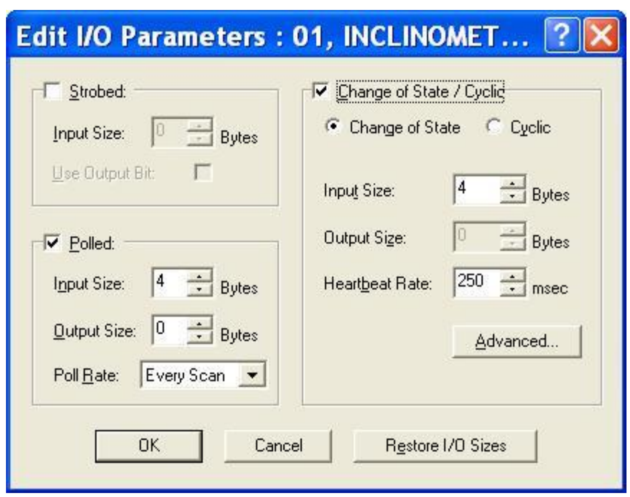
If Automap on Add is enabled, the Polled connection is activated by default. The input size (input means: input to the bus) is 4 Bytes, which corresponds to the Assembly instance 103 (Slope long16, Slope lateral16). If the Assembly instance is changed in the inclinometer to 101 (Slope long16) or 102 (Slope lateral16), the input size has to be changed here accordingly to 2 Bytes.



VERY IMPORTANT

If the Assembly instance and the input size are changed while a polled connection is established, this connection breaks down due to inconsistency and leads to a major fault. Make sure to close the polled connection before changing the Assembly instance.

The inclinometer also supports the Change of State (COS) and the Cyclic connection. For both connections, the Assembly instance 103 (Slope long16, Slope lateral16) is default. If the Assembly instance is changed in the inclinometer to 101 (Slope long16) or 102 (Slope lateral16), the input size has to be changed accordingly to 2 Bytes.



VERY IMPORTANT

If the Assembly instance and the input size are changed while a Change of State or Cyclic connection is established, this connection breaks down due to inconsistency and leads to a major fault. Make sure to close the Change of State or Cyclic connection before changing the Assembly instance.

5. Data Transmission

The data transmission in the DeviceNet network is realized by message telegrams. Basically, these telegrams can be divided into the CAN-ID and 8 following bytes as shown in the table

CAN-ID	Message Header	Message Body
11 Bit	1 Byte	7 Byte

5.1. The Object Dictionary

Instance and Attributes for all Objects.

5.1.1. Generic Objects/ Attributes

Class ID: 3h (3d)
Instance ID: 1h (1d)
Attribute ID table:

Attribute / Parameter	Attribute ID	Access	Data Type	Description
MAC ID	1h (1d)	GET/SET	UINT	The default setting for the MAC ID is 63d according to DeviceNet specification. Valid MAC IDs range from 0 to 63. The MAC ID can be changed to a different value, after being introduced on the bus so that other devices can pass the Duplicate MAC ID test on the same bus. Important: new MAC ID is adopted immediately after setting.
Baud rate	2h (2d)	GET/SET	USINT	The default setting for the Baud rate is 125 kBaud according to DeviceNet specification. Valid Baud rate settings are 125 kBaud, 250 kBaud and 500 kBaud. Important: new Baud rate is saved immediately after setting, but is adopted not until the device is powered off/on.
BOI (Bus-off Interrupt)	3h (3d)	GET/SET	BOOL	If set to FALSE and a CAN chip bus-off event is detected, the CAN chip is held in bus-off state and the device enters the Communication faulted state. If set to TRUE and a CAN chip bus-off event is detected, it may be possible to return the CAN chip to its normal operating mode and continue communicating.

Attribute / Parameter	Attribute ID	Access	Data Type	Description
Bus-off counter	4h (4d)	GET/SET	USINT	The Bus-Off Counter counts the number of times the CAN chip went to the bus-off state. The counter ranges from 0 to 255. The DeviceNet object resets the Bus-Off Counter to zero whenever it receives a Set_Attribute_Single request to the Bus-Off Counter attribute. The value of the Set_Attribute_Single has no meaning; just the request resets the counter.

5.1.1. Angle Objects/ Attributes

Class ID: 65h (101d)
Instance ID: 1h (1d)
Attribute ID table:

Attribute	Attribute ID	Access	Data Type	Implementation
Number of attributes	1h (1d)	GET	UINT	The number of publicly implemented attributes
Resolution	71h (113d)	GET/SET	USINT	The resolution parameter, based on the smallest unit of 0.001°, is used to program the desired number of steps per 1°. The values 10d, 100d and 1000d can be programmed, that correspond to a resolution of 0.01°, 0.1° and 1°. The default value is 10d or a resolution of 0.01° Important: if changed, all resolution dependent attributes' values are switched and rounded to the new resolution automatically.
Slope long16	72h (114d)	GET	INT	Inclination in x-direction (longitudinal), shown as a digital number. The real world "degree" value can be calculated as follows Inclination in degrees =*Slope long16* * *Resolution* E.g.: 16.34° = 1634d * 0.01°(10d)
Slope long16 operating parameter	73h (115d)	GET/SET	USINT	This parameter controls scaling and inversion of the *Slope long16* attribute. If Bit 0 is set, inversion of *Slope long16* is enabled. If Bit 1 is set, *Slope long16 offset* and *Differential slope long16 offset* are added to *Slope*

Attribute	Attribute ID	Access	Data Type	Implementation
				long16. Both Bits can be set at the same time.
Slope long16 preset value	74h (116d)	GET/SET	INT	This parameter defines a new, desired longitudinal slope value. Important: the *Slope long16 offset* is not calculated until it is triggered with the *Slope long16 preset enable*. Important: attribute shall be set in current resolution. Range: -80° - 80°.
Slope long16 preset enable	75h (117d)	GET/SET	USINT	At the transition from 0 to 1 the *Slope long16 preset enable* triggers the calculation of *Slope long16 offset* according to the following: *Slope long16 offset = Slope long16 preset value* – current *Slope long16 value*.
Slope long16 offset	76h (118d)	GET	INT	The *Slope long16 offset* is calculated every time *Slope long16 preset enable* transitions from 0 to 1.
Differential slope long16 offset	77h (119d)	GET/SET	INT	This attribute adds an additional, independent offset to *Slope long16* if scaling of *Slope long16* is enabled. Important: attribute shall be set in current resolution. Range: -80° - 80°.
Diagnostic slope long	78h (120d)	GET	DINT	The *Diagnostic slope long* allows access to the slope long value in the highest resolution (0.01°). This attribute can be used to get a slope value immediately based on the unit degree for diagnostic purposes. Important: this attribute is a 32-bit word.
Slope lateral16	7Ah (122d)	GET	INT	Inclination in y-direction (lateral), shown as a digital number. The real world "degree" value can be calculated as follows Inclination in degrees =*Slope lateral16 * Resolution* E.g.: 16.34° = 1634d * 0.01°(10d)
Slope lateral16 operating parameter	7Bh (123d)	GET/SET	USINT	This parameter controls scaling and inversion of the *Slope lateral16* attribute. If Bit 0 is set, inversion of *Slope lateral16* is enabled. If Bit 1 is set, *Slope lateral16 offset* and *Differential slope lateral16 offset* are added to *Slope lateral16*. Both Bits can be set at the same time.
Slope lateral16	7Ch (124d)	GET/SET	INT	This parameter defines a new, desired lateral slope value. Important: the *Slope lateral16 offset* is not

Attribute	Attribute ID	Access	Data Type	Implementation
preset value				calculated until it is triggered with the *Slope lateral16 preset enable*. Important: attribute shall be set in current resolution. Range: -80° - 80°.
Slope lateral16 preset enable	7Dh (125d)	GET/SET	USINT	At the transition from 0 to 1 the *Slope lateral16 preset enable* triggers the calculation of *Slope lateral16 offset* according to the following: *Slope lateral16 offset = Slope lateral16 preset value –* current *Slope lateral16 value*.
Slope lateral16 offset	7Eh (126d)	GET	INT	The *Slope lateral16 offset* is calculated every time *Slope lateral16 preset enable* transitions from 0 to 1.
Differential slope lateral16 offset	7Fh (127d)	GET/SET	INT	This attribute adds an additional, independent offset to *Slope lateral16* if scaling of *Slope lateral16* is enabled. Important: attribute shall be set in current resolution. Range: -80° - 80°.
Diagnostic slope lateral	80h (128d)	GET	DINT	The *Diagnostic slope lateral* allows access to the slope lateral value in the highest resolution (0.01°). This attribute can be used to get a slope value immediately based on the unit degree for diagnostic purposes. Important: this attribute is a 32-bit word.
Polled assembly instance	81h (129d)	GET/SET	USINT	With this attribute the input assembly instance for the Polling connection can be changed. There are three valid instances: - Instance ID 101: *Slope long16* [Low byte],[High byte] - Instance ID 102: *Slope lateral16* [Low byte],[High byte] - Instance ID 103: *Slope long16*, *Slope lateral16* [Low byte *Slope long16*],[High byte *Slope long16*],[Low byte *Slope lateral16*],[High byte *Slope lateral16*] Important: The number of input bytes for the polling connection must be adjusted manually in the master device, if other instance than ID103 (default setting) is

Attribute	Attribute ID	Access	Data Type	Implementation
				used. Important: If there is an open connection between master and inclinometer, then a change in input bytes results in bus-off error, which is a major unrecoverable fault. The only possible solution to get the inclinometer back online again is a power cycle.
Cyclic/COS assembly instance	82h (130d)	GET/SET	USINT	With this attribute the input assembly instance for the Cyclic/COS connection can be changed. There are three valid instances: - Instance ID 101: S*lope long16* [Low byte],[High byte] - Instance ID 102: S*lope lateral16* [Low byte],[High byte] - Instance ID 103: *Slope long16*, *Slope lateral16* [Low byte S*lope long16*],[High byte *Slope long16*],[Low byte *Slope lateral16*],[High byte *Slope lateral16*] Important: The number of input bytes for the cyclic/COS connection must be adjusted manually in the master device, if other instance than ID103 (default setting) is used. Important: If there is an open connection between master and inclinometer, then a change in input bytes results in bus-off error, which is a major unrecoverable fault. The only possible solution to get the inclinometer back online again is a power cycle.
Size of moving average filter	84h (132d)	GET/SET	USINT	This attribute controls the size of the moving average filter. If set to 0, the filter is deactivated. Valid values range from 0 to 250 (default value: 100). The values specify the number of entries in the filter array. In every program cycle, a new sensor value enters the array and the oldest value of the array is deleted. The filter output is the average over all array members.
Weighting	85h	GET/SET	UINT	This attribute controls the weighting factor of the

Attribute	**Attribute ID**	**Access**	**Data Type**	**Implementation**
factor recursive filter	(133d)			recursive filter. A recursive filter is governed by the following formula: NewSensorValue = Weighting factor * OldSensorValue + (1 – weighting factor) * NewSensorValue If set to 0, the filter is deactivated. Valid values range from 0 to 1000d corresponds internally to 0 to 1
Terminal resistor	87h (135d)	GET/SET	USINT	Enables/ disables the terminating resistor if set to 1/0
COS Delta	88h (136d)	GET/SET	USINT	A COS input message will be generated when the slope values changes by this value. Setting this attribute to 0 disables *COS Delta* and all changes in output generates a COS message. Important: attribute shall be set in current resolution. Maximum COS Delta value corresponds to 2°.

NOTE: Implementation of scaling and inversion

Slope long16 = physical inclination of slope long16 * Multiplier + *Slope long16 offset* + *Differential slope long16 offset*

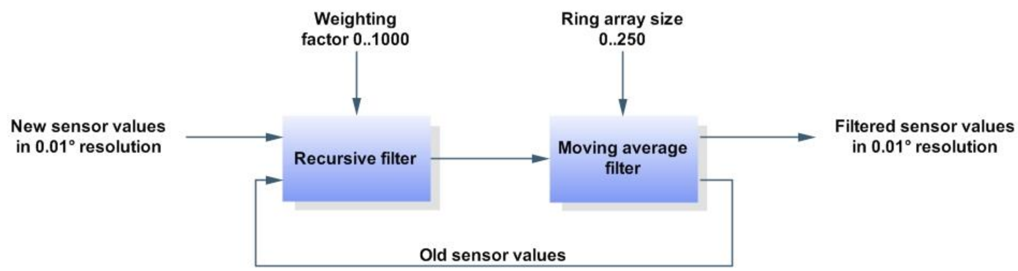
Where:

- Physical inclination of S*lope long16*: axis and direction according to manual specification
- Multiplier: if inversion is disabled: 1, if inversion is enabled: -1
- *Slope long16 offset* = *Slope long16 preset* – physical inclination of slope long16 at t_{acc} * Multiplier, with t_{acc} = preset acquisition time when *Slope long16 preset enable* transitions from 0 to 1
- *Differential slope long16 offset*: Adds an absolute value (positive or negative) to the sensor output.

Important: This is also valid for *Slope lateral16.* Be aware of the min/max values of the different attributes.

NOTE: Implementation of the two filters

The Moving average filter and the Recursive filter are configured in a series connection. The raw sensor values first run through the Recursive filter and secondly through the Moving average filter. All four possible combinations of active/inactive for both filters are valid. The filters are updated every program cycle (~700µs, depending on filter settings and I/O connections).



Filter configuration

5.2 CAN-ID and types

DeviceNet is based on the standard CAN-protocol and uses an 11Bit (2048 specifiable messages) message identifier. For the identification of a device in a DeviceNet network 6Bits are enough because there are 64 nodes or MAC-ID's in the network. The CAN-Identifier consists of the Message Group, Message ID and the MAC ID of the device. In the table below a user can see the important CAN-IDs for a certain communication type

CAN- ID Bit Number											Identity Usage	Hex Value
10	9	8	7	6	5	4	3	2	1	0		
0	GROUP 1 Message ID				Source MAC ID						GROUP 1 Message	000-3ff
0	1	1	0	1	Source MAC ID						Slave's I/O Change of State or Cyclic Message	
0	1	1	1	1	Source MAC ID						Slave's I/O Poll Response or Change of State/Cyclic Acknowledge Message	
1	0	MAC ID						Group 2 Message ID			GROUP 2 Messages	400 - 5ff
1	0	Destination MAC ID						0	1	0	Master's Change of State or Cyclic Acknowledge Message	
1	0	Source MAC ID						0	1	1	Slave's Explicit/Unconnected Response Messages	
1	0	Destination MAC ID						1	0	0	Master's Explicit Request Message	
1	0	Destination MAC ID						1	0	1	Master's I/O Poll Command/Change of State/Cyclic Message	
1	0	Destination MAC ID						1	1	0	Group 2 Only Unconnected Explicit Request Message (reserved)	
1	0	Destination MAC ID						1	1	1	Duplicate MAC ID Check Messages	

6. Details of Operating Modes

This chapter consists of detailed structure of the telegrams needed for different operating modes, used along with proprietary DeviceNet Software for advanced users with detailed knowledge of CAN

6.1 Polled Mode

For switching on the polled mode, the following telegrams are needed. In the following examples, a master with MAC ID or node address of 0A hex and a slave MAC ID of 03 hex is considered.

Allocate Master / Slave Connection Set

Allocate Polling

Byte Offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Frag [0]	XID	MAC ID					
1	R/R [0]	Service [4B]						
	Class ID [03]							
	Instance ID [01]							
	Allocation Choice [03]							
	0	0	Allocator MAC ID					

Definition CAN ID

10	9	8	7	6	5	4	3	2	1	0	Identity Usage	Hex Value
1	**0**	**Destination MAC ID**						**1**	**1**	**0**	**Group 2 Only Unconnected Explicit Request Message (reserved)**	

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
41E	0A	4B	03	01	03	0A

1. Setting the Expected_packet_rate of the Explicit Message Connection value to 0

Definition CAN-ID

10	9	8	7	6	5	4	3	2	1	0	Identity Usage	Hex Value
1	**0**	**Destination MAC ID**						**1**	**0**	**0**	**Master´s Explicit Request Message**	

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
41C	0A	10	05	01	09	00	00

1. Setting the Expected_packet_rate of the Polling Connection value to 0

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
41C	0A	10	05	02	09	00	00

Release Master / Slave Connection Set

Release Polling

Byte Offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Frag [0]	XID	MAC ID					
1	R/R [0]	Service [4C]						
	Class ID [03]							
	Instance ID [01]							
	Release Choice [03]							

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
41E	0A	4C	03	01	03

6.2 Change of State (COS) Mode

The absolute inclinometer sends data, without any request from the host, when the actual process value is changing. No telegram will occur when the position value is not changing. . However, if a high resolution is chosen, minor changes in the inclination (vibrations and so on) can lead to a bus load of up to 100%. To prevent this, one can set the COS Delta parameter to limit the sensor output to changes in inclination specified in this parameter.

Allocate Master / Slave Connection Set

Allocate COS

Byte Offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Frag [0]	XID	MAC ID					
1	R/R [0]	Service [4B]						
	Class ID [03]							
	Instance ID [01]							
	Allocation Choice [51]							
	0	0	Allocator MAC ID					

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
41E	0A	4B	03	01	51	0A

2. Setting Expected_packet_rate of the Explicit Message Connection value to 0

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
41C	0A	10	05	01	09	00	00

3. Setting Expected_packet_rate of the Change of State Connection value to 0

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
41C	0A	10	05	04	09	00	00

Release Master / Slave Connection Set

Release COS

Byte Offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Frag [0]	XID	MAC ID					
1	R/R [0]	Service [4C]						
	Class ID [03]							
	Instance ID [01]							
	Release Choice [51]							

Example:

CAN-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
41E	0A	4C	03	01	51

7. Models/Ordering Description

TILTIX Industrial

Description	Type key								
	TILTIX-	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			D1					
Version	Software Version				00				
Mounting	Vertical for 360° Version					V			
	Horizontal for ± 80° Version					H			
Housing Material	Industrial (PBT)						E		
Inclinometer Series	TILTIX II							2	
Connection	Connector								PM

TILTIX Heavy-Duty

Description	Type key								
	TILTIX-	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			D1					
Version	Software Version				00				
Mounting	Vertical for 360° Version					V			
	Horizontal for ± 80° Version					H			
Housing Material	Heavy-Duty (Aluminium)						H		
Inclinometer Series	TILTIX II							2	
Connection	Connector								PM

Disclaimer

USER MANUAL

TILTIX MEMS INCLINOMETER WITH DEVICENET INTERFACE

Document History

1st Release – Anjan Nachiappa on September 28, 2011