NIP Module
Functional Description

Version 2.4 from 2007-05-21

TABLE OF CONTENTS

1 INTRODUCTION

1.1 General Information

The NIP Module (NIP = **N**ode for **I**nter**p**olation) has been developed for locally digitizing of sensitive analog signals of incremental devices, i.e. probes, encoders (=> short analog cabling).
It is available with up to three independent channels and various input interfaces. A linear interpolation of the input signals increases the measurement resolution significantly.
The digitized measurement values are transmitted to the attached control computer (i.e. PLC) via the integrated fieldbus interface (Profibus-DP or CAN).

Fig. 1: NIP25.CCC.DP

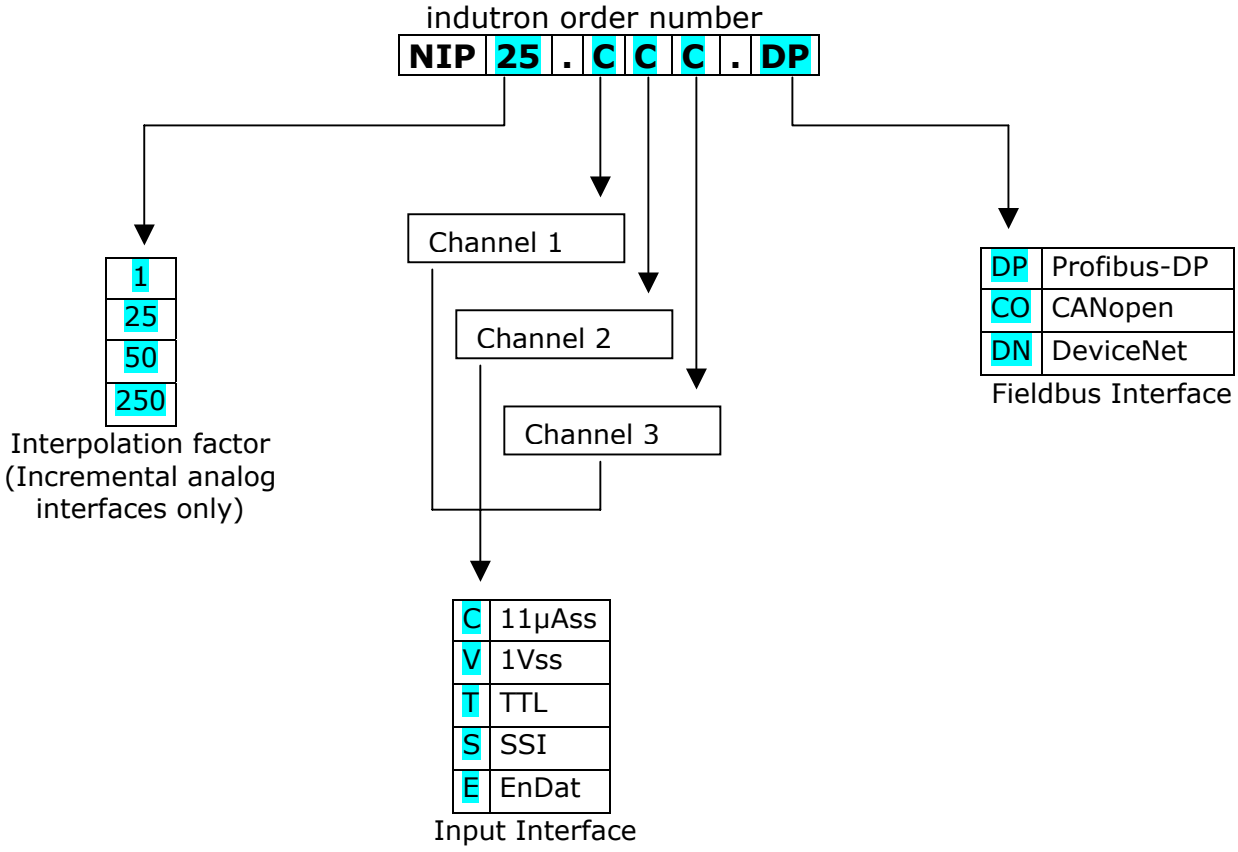
1.2 Features

There are various types of the NIP Module available. These are different in terms of:

- Number of input channels: One up to three channels. All input channels work totally independent from each other. Even different interface types are possible.
- Type of input interface:
  - 11µAss current interface for incremental probes like Heidenhain probes
  - 1Vss voltage interface for incremental probes like ROD encoders
  - TTL digital interface for incremental probes like incremental encoders
  - SSI digital interface for absolute encoders
  - EnDat digital interface for absolute encoders
- Interpolation factor (in combination with analog incremental interfaces 11µAss and 1Vss only).
- Type of fieldbus interface: Profibus-DP or CAN

1.2.1 Type number

The Type number (indutron order number) includes the types of the input interface(s) and the type of the fieldbus interface.



2 INPUT INTERFACES

There are various interface types for incremental and absolute probes available.

2.1 Incremental Interfaces

Incremental interfaces are based on two analog or digital input signals with a 90° phase shift.
There are different analog and digital incremental interfaces available.

2.1.1 Common Features

A description of the common features of the incremental interfaces follows.

2.1.1.1 Incremental Counter

All incremental interfaces are based on an internal 32 bit incremental counter giving a signed counter value. The incremental counter counts the periods of the input signal. According to the requested fold type (1, 2 or 4fold) there are up to four count pulses in each period of the input signal.

The incremental counter always runs with a counting frequency of 2 MHz, resulting in a maximum input frequency f_{max} of 500 kHz when using the 4fold input signal evaluation.

2.1.1.2 Reference Signal Evaluation

Incremental devices commonly provide a so-called reference signal. This marks a certain reference position (i.e. zero pulse at encoders or reference mark at probes).
The NIP Module is able to evaluate this reference signal. If the reference signal evaluation is enabled, the internal incremental counter is cleared every time the reference position is reached. The resulting counter/measurement values are relative to the reference position.
This kind of measurement is useful for measurements relative to the measurement equipment (instead of relative within the DUT).

Notice: With the reference evaluation mode enabled, the reference position must be hit first before measurement results are transmitted. The Status Register (see 4.2.4.2) reports this.

2.1.1.3 Common Failures

A description of possible failures, which apply to all incremental interface types follows.

2.1.1.3.1 Reference position not hit initially

This failure occurs with enabled reference signal evaluation only. It signals that the reference position has not been hit for the first time after initialization. Therefore no measurement value can be reported. The kind of this type of failure is „critical" (error). This failure must be reset using the Preset Command (see 4.2.3.1). No measurement values are reported as long as this failure is pending.

2.1.1.3.2 Maximum input frequency exceeded

This failure is reported at invalid transitions of the counting edges of the input signals (i.e. when the maximum input frequency is exceeded). The kind of this type of failure is „critical" (error). This failure must be reset using the Init Command (see 4.2.3.1). No measurement values are reported as long as this failure is pending.

2.1.1.3.3 Maximum motion speed exceeded

Similar to the failure "maximum input frequency exceeded" described previously. The maximum motion speed depends on the type of probe (=> selectable via input parameter) and is always less than the maximum input frequency. Exceeding the maximum motion speed may result in erroneous counter transitions due to hardware restrictions of the attached probe. The integrated supervision detects this. The kind of this type of failure is „critical" (error). This failure must be reset using the Init Command (see 4.2.3.1). No measurement values are reported as long as this failure is pending.

2.1.2 Incremental analog interfaces 11µAss and 1Vss

Using this analog interface types, a linear interpolation of the input signals is done. The periods of the measurement signal are divided (= interpolated) in order to increase the measurement resolution. Depending on the NIP type, interpolation values up to 250 are possible.

2.1.2.1 Measurement value evaluation

The measurement value is composed of the parts **incremental counter value** (see 2.1.1.1) and **interpolation value**.

The internal measurement evaluation is very fast (approx. 150µs). Every second more than 6000 measurement values can be evaluated. The number of values transmitted to the control may be less and depend on the fieldbus settings.

Interpolation

In parallel to the counting of the measurement periods the interpolation takes place. This results in an additional linear classification of the periods of the input signal and thus increases the measurement resolution.
Caused by internal restrictions the interpolation takes only place below a maximum input frequency of f_{IP} = 10kHz (= 10mm/sec. using a probe with a 10µm scale). Above f_{IP} the measurement result is based on the incremental counter value only. If the motion speed decreases and the input frequency drops below f_{IP}, the interpolation value is added automatically to the measurement result.
The Status Register (see 4.2.4.2) signals if the measurement result contains an interpolation value or not.

For practical use, the missing interpolation part at higher motion speeds is no disadvantage, since the measurement result is changing very quickly due to the short distance of the counting edges.

Annotation: In contrary to other methods the interpolation has no impact of the incremental counter and does not reduce the maximum input frequency. The input signal periods are counted always using the maximum speed (2 MHz) independent of the interpolation.

2.1.2.2 Specific Failures

2.1.2.2.1 Input levels out of range

The amplitudes of the input signals are supervised. If they are out of the internal range (i.e. probe is dirty or defect), this failure is reported. The kind of this type of failure is „critical" (error). This failure must be reset using the Init Command (see 4.2.3.1). No measurement values are reported as long as this failure is pending.

2.1.2.2.2 Missing interpolation part

Above input frequencies of f_{IP} no interpolation value is evaluated.
The kind of this type of failure is „not critical" (warning). There is no acknowledging of this failure necessary. Measurement values are reported even if this failure is pending.

2.1.3 Digital Incremental Interface TTL

2.1.3.1 Measurement value evaluation

The measurement result is based on the **incremental counter** (see 2.1.1.1) only.

2.2 Digital Absolute Interfaces

IN PREPARATION.

2.2.1 EnDat Interface

IN PREPARATION.

2.2.2 SSI Interface

IN PREPARATION.

3 FIELDBUS INTERFACE

The fieldbus interface is used for connecting the NIP Module to the control computer. The NIP Module is available with Profibus-DP or CAN interface.

All kinds of fieldbus interfaces are using opto couplers and galvanic isolation.

3.1 Profibus-DP Interface

3.1.1 General

All common baud rates from 9,6kBaud up to 12MBaud are supported.
The bus address can be selected using two rotary switches (located inside the case) in the range from 01 – 99.

3.1.2 Bus image

The number of input and output bytes, which are used by the NIP Module in the Profibus memory, depends on the number of channels and the mode, i.e. a NIP Module with two input channels uses twice the memory compared to a one channel model.

The data structure is application specific (see 4.2.2.2) and depends on various parameters like type of input channel, mode etc.

3.1.3 GSD File

The parameters necessary for integrating the NIP Module in the Profibus are stored in the file **NIP.GSD**. At the configuration level of the fieldbus the type of the NIP Module (i.e. NIP25.C.DP) can be selected from a list.

3.2 CAN Interface

3.2.1 General

All common baud rates from 10kBit/s up to 1MBit/s are supported.
The node id can be selected using two rotary switches (located inside the case) in the range from 01 – 99. The baud rate is selected using DIP switches (also located inside the case).

4 SOFTWARE INTERFACE

4.1 Common

The NIP Module is usable in various applications like distance measurement, angle measurement etc.
Each input channel of the NIP Module is programmed independently. Using different channels in different modes is also possible.

4.1.1 Modes

The NIP Module has various internal modes, which depend on the type of application it is used in. A detailed description of these modes follows in the description of the corresponding application.

4.1.2 Error states

The NIP Module detects various error states like exceeding the maximum input frequency. Errors are reported via the Status Register (see 4.2.4.2).
The errors are divided into non-critical failures (warning – measurement evaluation continues) and critical failures (error – measurement evaluation is stopped until the error is confirmed).

4.1.3 Data structures

The structure of the transmit and receive memory of the fieldbus depends on the selected application mode and is described in the respective application mode.

4.1.4 Low-Level Interface

In the following chapters the low-level communication with the NIP Module via the fieldbus will be described.
Normally the low-level communication is integrated in libraries, like the PdpNipDistMeasFB for OpCon/FlexCon in order to provide the application programmer an application specific high-level interface.

Therefore the information shall be treated as additional.

4.1.5 Using OpCon/FlexCon

For using the NIP Module with OpCon/FlexCon a special library **indutronPdpNip.lib** is available. This library contains subroutines for the different application types in order to standardize and ease the integration of the NIP Module in the whole application program.

4.2 Application: Incremental Distance Measurement

This contains for example the length measurement using Heidenhain probes.

The following description refers to firmware version **2.20** of the NIP Module.

4.2.1 Internal States

After applying power, the NIP Module expects the Init Command in order to initialize the input channel(s). Following, the internal state is changed automatically into the so-called "continuous mode". In this state actual measurement values are transmitted permanently. The actual measurement value may be frozen using the Store Command.

4.2.2 Data structures

Currently the two main modes **Standard Mode** and **Enhanced Mode** are supported. The Enhanced Mode has more functions than the Standard Mode, like supervision of maximum motion speed, hold-up detection etc., and is selected by setting DIP switch #1 to "On".

4.2.2.1 Profibus-DP (Standard Mode)

Each input channel uses 4 output and 6 input bytes (from the point of view of the control computer) in the bus memory.

Output data

Label	Data type	Byte length	Description
Command	BYTE	1	Command Register (see 4.2.3.1)
Mode	BYTE	1	Mode Register (see 4.2.3.2)
Resolution	UINT	2	Resolution of the attached probe; uses fixed point notation [0.01µm] (see 4.2.3.3)

Input data

Label	Data type	Byte length	Description
CmdAck	BYTE	1	Command Acknowledge Register (see 4.2.4.1)
Status	BYTE	1	Status Register (see 4.2.4.2)
Value	DINT	4	Measurement result using fixed point notation [0.01µm] (see 4.2.4.3)

4.2.2.2 Profibus-DP (Enhanced Mode)

Each input channel uses 10 output and 18 input bytes (from the point of view of the control computer) in the bus memory.

Output data

Label	Data type	Byte length	Description
Command	BYTE	1	Command Acknowledge Register (see 4.2.4.1)
Mode	BYTE	1	Mode Register (see 4.2.3.2)
Resolution	UINT	2	Resolution of the attached probe; uses fixed point notation [0.01µm] (see 4.2.3.3)
SpeedLimit	UINT	2	Maximum acceptable motion speed; uses fixed point notation [0.1m/min] (see 4.2.3.4)
HldUpDistance	UINT	2	Distance for hold-up detection; uses fixed point notation [0.1µm] (see 4.2.3.5)
HldUpInterval	UINT	2	Time base [ms] for hold-up detection and speed measurement (10-1500ms) (see 4.2.3.5)

Input data

Label	Data type	Byte length	Description
CmdAck	BYTE	1	Command Acknowledge Register (see 4.2.4.1)
Status	BYTE	1	Status Register (see 4.2.4.2)
Value	DINT	4	Measurement result using fixed point notation [0.01µm] (see 4.2.4.3)
Speed	DINT	4	Current motion speed; uses fixed point notation [0.1mm/min] (see 4.2.4.4)
MaxSpeed	DINT	4	Maximum of motion speeds detected; uses fixed point notation [0.1mm/min] (see 4.2.4.5)
RefValue	DINT	4	Last reference value; uses fixed point notation [0.01µm] (see 4.2.4.6)

4.2.3 Output Registers

4.2.3.1 Command Register

Predefined commands are asserted to the requested channel via the fieldbus interface using the Command Register. The transition (leading = start of command, trailing = end of command) of the command bit is important for some commands.
The following commands are defined:

- **Init**. Setting the parameters (resolution of the probe etc.) and the mode of the selected channel. Must be the first command. Also used for acknowledging of critical failures (errors).
  Annotation: With reference signal evaluation enabled after the Init Command, the reference mark must be hit first, before measurements are taken.
- **Preset.** Sets the current position to zero -> all subsequent measurement values are relative to this position. Applies only when the motion of the probe is stopped. Also used for acknowledging of critical failures (errors).
  Annotation: Using OpCon/FlexCon non-zero values may be preset using the indutronPdpNipXX-FB.
- **Store**.
  Leading Edge: The current measurement value is frozen and may be read decoupled later by the control computer.
  Trailing Edge: The measurement value is not frozen any longer. Actual measurement values are transmitted again permanently.

Important: Only one command may be active at any time!

Structure of the Command Register:

Bit	Label	Description
0	NIP_MCTRL_INIT	Init Command
1	NIP_MCTRL_PRESET	Preset Command
2	NIP_MCTRL_STORE	Store Command
3		Reserved – must be 0
4		Reserved – must be 0
5		Reserved – must be 0
6		Reserved – must be 0
7		Reserved – must be 0

4.2.3.2 Mode Register

The Mode Register contains 8 bits for mode setting.

Mode Register Structure:

Bits	Description	Values	Comment
1,0	Edge evaluation type	00: 4fold 01: Reserved – do not use 10: Reserved – do not use 11: Reserved – do not use	Currently only 4fold evaluation selectable
2	Reference signal evaluation	0: off 1: on	
5,4,3	Reserved	Must be 0	
7,6	Main mode	00: linear 01: Reserved – do not use 10: Reserved – do not use 11: Reserved – do not use	Currently only linear mode selectable

4.2.3.3 Resolution Register

The Resolution Register contains 16 bits for setting the resolution of the attached probe. This integer register uses a fixed-point notation of [0.01µm].
Examples:
1.00µm -> 100
10µm -> 1000
20µm -> 2000

4.2.3.4 SpeedLimit Register

The SpeedLimit Register (Enhanced Mode only) contains 16 bits for setting the supervision of the maximum motion speed of the probe attached. This integer register uses a fixed-point notation of [0.1m/min].
Examples:
1.00m/min -> 10
10m/min -> 100
25cm/sec -> 150

4.2.3.5 Hold-up and Speed Detection

For hold-up and speed detection (Enhanced Mode only) the two 16 bit registers HldUpDistance and HldUpInterval are used. If the motion speed of the probe drops below the ratio HldUpDistance/HldUpInterval, hold-up is signaled. The HldUpInterval is also used as the time base for speed detection.
The HldUpDistance Register is an integer register and uses a fixed-point notation of [0.1µm].
Examples:
1.00µm -> 10
10µm -> 100
100µm -> 1000
The HldUpInterval Register is an integer register and uses a fixed-point notation of [1ms].
Examples:
10ms -> 10
100ms -> 100

4.2.4 Input Registers

4.2.4.1 Command Acknowledge Register (CmdAck)

Using this register the NIP Module acknowledges commands asserted via the Control Register. The CmdAck Register uses exactly the same structure as the Command Register. After execution of the requested command the corresponding bit in the CmdAck Register will be set. At this time the Status Register is valid and contains the information about the execution of the command requested.
After clearing the control bit in the Command Register the corresponding bit in the CmdAck Register will be cleared. The CmdAck Register always mirrors the value of the Control Register when the NIP Module has recognized the change.

4.2.4.2 Status Register

The Status Register contains 8 bits with status and error information belonging to the corresponding input channel or measurement value. It has a bit wise structure, meaning more than one bit may be set at the same time.

Acknowledging the failure states is different. The following table contains the details.

Status Register Structure:

Bit	Label	Description	Acknowledgement
0	NIP_MSTAT_NOIP	Measurement value contains no interpolation part	Automatically with the next value with regular interpolation part
1	NIP_MSTAT_STOPPED	Probe stopped (Enhanced Mode only)	N.A.
2		Reserved	
3	NIP_MSTAT_NOREF	Reference position not hit for the first time	Preset Command
4	NIP_MSTAT_SPDERR	Maximum input frequency exceeded or maximum speed exceeded (Enhanced Mode only)	Init Command
5	NIP_MSTAT_SIGERR	No probe attached / input levels to low	Init Command
6	NIP_MSTAT_PARERR	Parameter Error	Init Command
7	NIP_MSTAT_STATEERR	Command not possible in current state	Automatically when command bit is cleared

4.2.4.3 Value Register

The Value Register contains the measurement result value. This 32-bit integer register uses a fixed-point notation of [0.01µm].
Examples:
1.00µm -> 100
10µm -> 1000
20µm -> 2000

4.2.4.4 Speed Register

The Speed Register (Enhanced Mode only) contains the actual motion speed of the probe. This 32-bit integer register uses a fixed-point notation of [0.1mm/min].
Examples:
1.00m/min -> 10000
10m/min -> 100000
25cm/sec -> 150000

4.2.4.5 MaxSpeed Register

The MaxSpeed Register (Enhanced Mode only) contains the maximum motion speed of the probe detected since the last Init Command. This 32-bit integer register uses a fixed-point notation of [0.1mm/min].
Examples:
1.00m/min -> 10000
10m/min -> 100000
25cm/sec -> 150000

4.2.4.6 RefValue Register

The RefValue Register (Enhanced Mode only) contains the actual value of the reference position for information purpose. This 32-bit integer register uses a fixed-point notation of [0.01µm].
Examples:
1.00µm -> 100
10µm -> 1000
20µm -> 2000

4.2.5 Sequence for relative measurements (without reference signal evaluation)

This kind of measurement is based on a (normal) variable reference position, located within the machine or the DUT.

Sequence:

1. Assert Init Command (once)
2. Move to reference position, wait until motion stopped
3. Assert Preset Command: the measurement value is cleared.
4. Move to measure position, wait until motion is stopped
5. Assert leading edge of Store Command (not necessary if the measurement result will be read in before the measure position is left): the measurement value will be frozen.
6. Wait until NIP Module acknowledges Store Command
7. Read in measurement value
8. Assert trailing edge of Store Command: continuous measurement evaluation is started again
9. Go to step 2.

4.2.6 Sequence for quasi-absolute measurements (using reference signal evaluation)

This kind of measurement is based on the reference mark of the attached probe and provides a quasi-absolute measurement.

Sequence:

1. Assert Init Command (once)
2. Ensure that reference mark is hit for the first time.
3. Move to measurement position, wait until motion stopped.
   Important: The reference mark must be hit since the last Init Command or no measurement values will be transmitted.
4. Assert leading edge of Store Command (not necessary if the measurement result will be read in before the measure position is left): the measurement value will be frozen.
5. Wait until NIP Module acknowledges Store Command
6. Read in measurement value. Add calibration/offset value. This value must be taken in before a calibration sequence, using a test part with known measurement result.
7. Assert trailing edge of Store Command: continuous measurement evaluation is started again
8. Go to step 3.

Annotation:
It is important to calibrate the measurement sometimes before using a test part with a known result value. This offset value must be stored in the control computer and added later to the measurement result sent by the NIP Module.

4.3 Angle measurement

IN PREPARATION.

5 APPENDIX

5.1 Technical data for „C" and „V" models (11µAss resp. 1Vss)

This applies for models NIP25.Cc.DP and NIP25.Vv.DP.

Power supply of electronics	
Nominal input voltage	24V DC
Input voltage range	19V...30V
Input current	200mA max.
Reverse polarity protection	Yes
Overload protection	750mA, reversible
Power connector	Three-pole IEC 60130-9
Fieldbus	Profibus-DP
Baud rates	9,6kBaud – 12MBaud
Connectors	M12 5-pole (IN) + M12 5-pole (OUT)
Input channel	i.e. probe
Power supply	5V DC, 150mA max. Provided internally, short circuit protected
Connector type	„C" type: M23 9-pole „V" type: M23 12-pole
Evaluation electronics	
Input signal range	„C" type: 7-16µAss „V" type: 0,6-1,2Vss
Fold evaluation	4-fold
Incremental counter	32 bits
Max. Input frequency (f_{max})	2 MHz
Interpolation factor	25x
Cut-off frequency of interpolation (f_{IP})	10 kHz
Acquisition time	Approx. 150µs (including interpolation)
Reference signal	Evaluation optional
Error detection	• No probe attached / poor input signals • Maximum input frequency exceeded • Maximum motion speed exceeded
Software Interface	
	• Measurement value in fixed point notation of 1/100µm • Incremental counter at reference signal • Current and maximum motion speed • Error status
General	
Protection class	IP65
Ambient Temperature	0°C...+50°C
Weight	800g
Dimensions (mm) L x W x H Incl. Flange sockets	197 x 115 x 57

Status 08/05. Subject to change without notice.

5.2 Technical data for „T" models (TTL, RS422)

This applies for models NIP25.Tt.DP.

Power supply of electronics	
Nominal input voltage	24V DC
Input voltage range	19V...30V
Input current	200mA max.
Reverse polarity protection	Yes
Overload protection	750mA, reversible
Power connector	Three-pole IEC 60130-9
Fieldbus	Profibus-DP
Baud rates	9,6kBaud – 12Mbaud
Connectors	M12 5-pole (IN) + M12 5-pole (OUT)
Input channel	i.e. probe
Power supply	5V DC, 150mA max. Provided internally, short circuit protected
Connector type	„T" model: M23 12-pole
Evaluation electronics	
Input signal range	„T" model: 5V (RS422)
Termination (internal)	120Ω
Fold evaluation	4-fold
Incremental counter	32 bits
Max. Input frequency (f_{max})	2 MHz
Interpolation factor	None
Acquisition time	Approx. 100µs
Reference signal	Evaluation optional
Error detection	• Probe signaling failure (in preparation) • Maximum input frequency exceeded • Maximum motion speed exceeded
Software Interface	
	• Measurement value in fixed point notation of 1/100µm • Incremental counter at reference signal • Current and maximum motion speed • Error status
General	
Protection class	IP65
Ambient Temperature	0°C...+50°C
Weight	800g
Dimensions (mm) L x W x H Incl. Flange sockets	197 x 115 x 57

Status 07/06. Subject to change without notice.