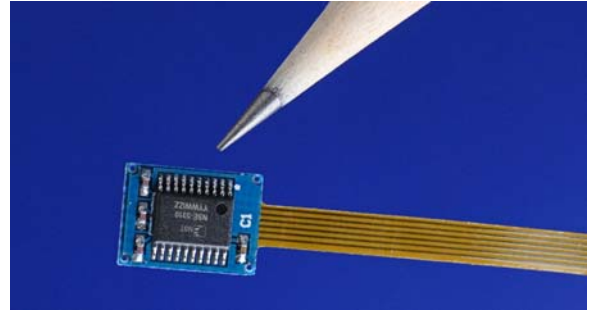


TRK-1T02 Tracker[™] Miniature Position Sensor with Integrated On-chip Encoder



Benefits

- **Smallest size**
- **Highest resolution**
- Lower cost than miniature optical encoders
- Robust, non-contact sensing
- Works in bright and high-particulate environments
- On-chip encoder eliminates external quadrature counters
- Linear or off-axis rotary encoder

Features

- **Complete system-on-chip**
- **Direct digital output with I²C protocol**
- 2 μ m resolution
- 2 μ m repeatability
- Built-in zero reference
- On-chip automatic gain and offset correction
- High immunity to external magnetic fields

Smallest encoder with highest resolution in a robust, cost-effective package

With 2 micron resolution and smallest size, the TRACKER position sensor is a robust, cost-effective alternative to miniature optical encoders. Integrated on-chip encoding provides direct digital output using standard I²C protocol, compatible with microprocessors. This eliminates the need for external pulse counters: the microprocessor can query multiple TRACKER position sensors and read position information directly.

The TRACKER position sensor is the highest-resolution magnetic encoder available. Unlike miniature optical encoders, it is insensitive to visible and IR light and withstands shock, vibration, and high-particulate environments. It can be used as a linear encoder or off-axis rotary encoder.

The TRACKER position sensor is ideal for use in optical and imaging systems, consumer electronics, precision biomedical devices, instrumentation and automation, and automotive applications. Its small size makes it ideal for creating tiny, integrated closed-loop motion systems using micro motors such as New Scale's SQUIGGLE[®] motor.

System Overview

The TRK-1T02 incorporates New Scale's NSE-5310 magnetic encoder in a TSSOP mounted on a printed circuit board (fig. 1). A linear array of eight Hall-effect sensors on the chip measures the spatially varying magnetic field produced by a moving multi-pole magnetic strip positioned above the sensor (fig. 2).

The output of the sensors is automatically scaled on-chip to remove DC bias and converted to SIN and COS signals that are interpolated with 10 bit (1024) resolution, which corresponds to 2 μ m position resolution. The length of the magnetic strip determines the maximum measured stroke. Requirements for the magnetic strip are listed in section 3.

Figure 1: TRK-1T02 with magnetic strip

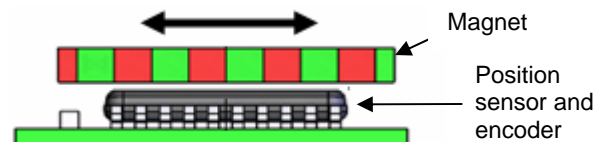
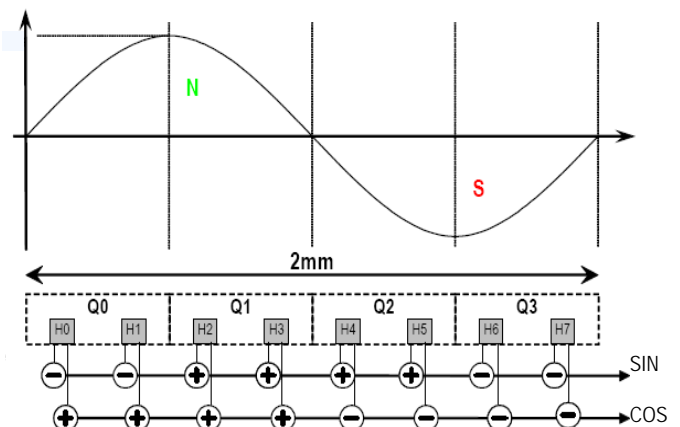


Figure 2: Hall-effect sensors measure the sinusoidally varying magnetic field produced by a moving magnetic strip



1. Functional description

The TRK-1T02 position sensor uses the NSE-5310 sensor and encoder IC (fig. 3). Moving a multi-pole magnetic strip over the Hall array generates internal sinusoidal (SIN) and phase-shifted sinusoidal (COS) signals. These signals are filtered and transformed into angular (ANG) and magnitude (MAG) values. These values represent the absolute linear position of a 2 mm long pole pair on a magnetic encoder strip. The position information is read via an I²C interface (SDA, SCL).

Automatic gain control (AGC) adjusts for DC bias in the magnetic field and provides for a large dynamic input range of the magnetic field. It also provides an absolute magnitude of the magnetic field intensity, which can be used to detect the end of the magnetic strip and thereby serve as a built-in zero reference.

The TRACKER is factory configured to use 10 bits of position resolution (out of a total of 12 bits) to achieve maximum speed and minimize noise. The maximum measurement speed is 20 mm/sec.

2. Package and schematic

The TRK-1T02 includes a printed circuit board with FPC connector, ready for use with the MC-31MB interface card and New Scale software suite or other customer-supplied I²C interface. For qualified OEMs, we also develop custom chip-on-board position sensors to your requirements, or we can provide the NSE-5310 encoder in TSSOP or dice-on-foil packaging.

Figure 3: NSE-5310 functional block diagram

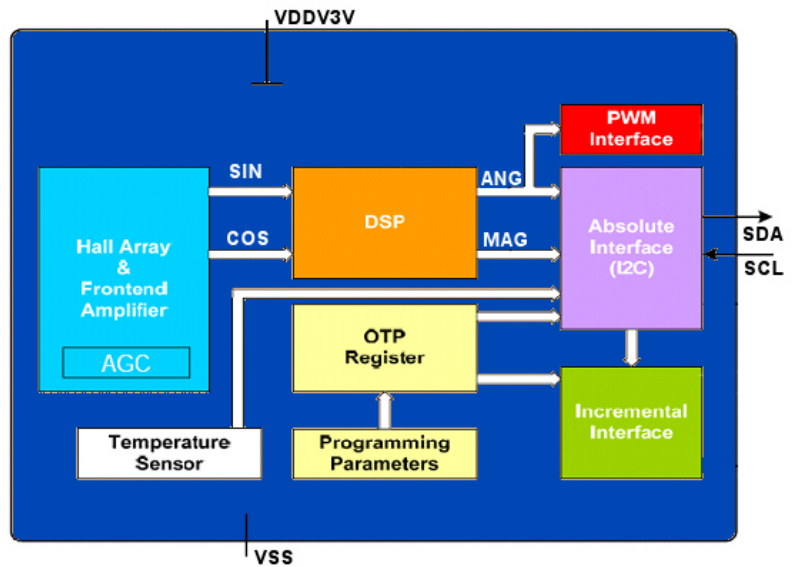


Table 1: TRK-1T02 Connections

FPC pad	Symbol	Definition
1	SCL (CLK)	[Schmitt trigger] Serial interface CLK (up to 400 KHz)
2/5	VSS	Ground
3	VDD3V3	Positive I/O supply voltage
4	SDA (DO)	Data output via I2C serial interface
6	A0	Address (0 or 1) for use with two position sensors

Table 2: Operating conditions

Parameter	Min	Max
Positive I/O supply voltage VDD3V3 (V)	3	3.6
Negative supply voltage VSS (V)	0	0
Ambient temperature (°C)	-30	+70
Supply current (mA)		21

Figure 4: TRK-1T02 TRACKER position sensor schematic

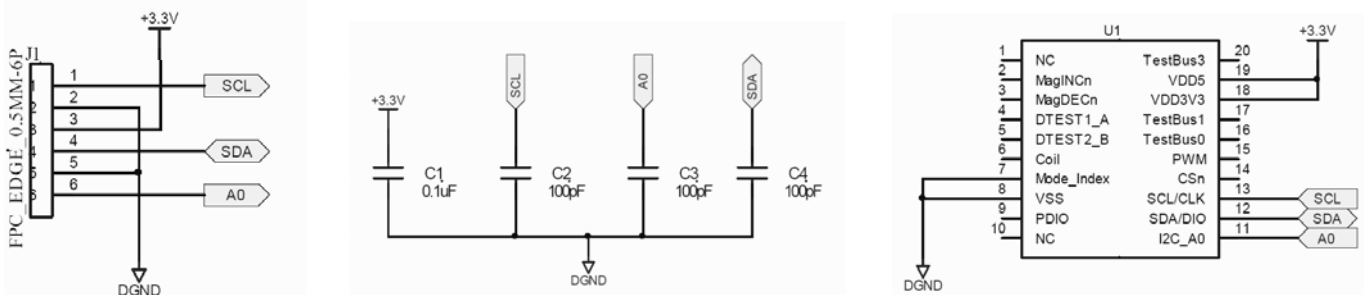
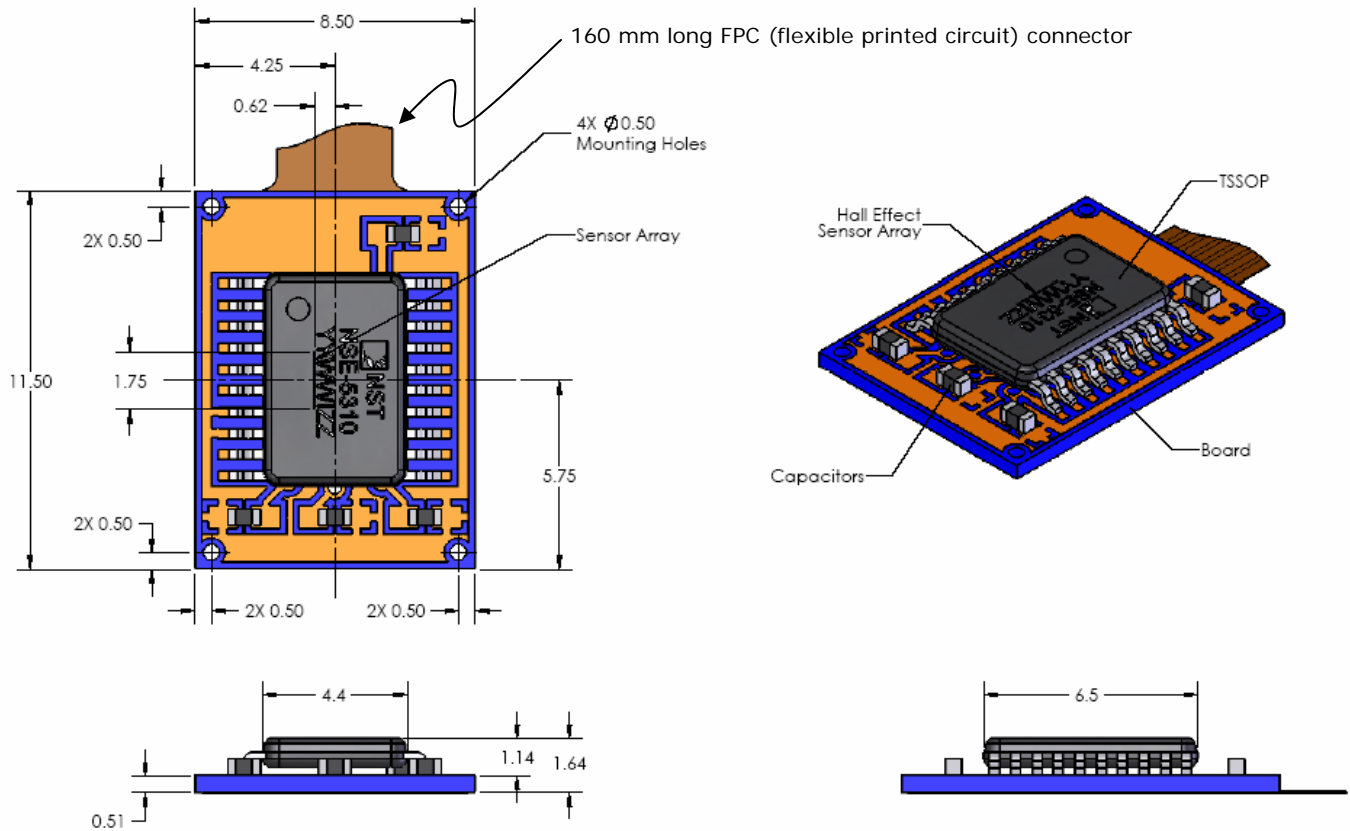


Figure 5: TRK-1T02 TRACKER Dimensions



3. Magnetic strip requirements

The Tracker requires a magnetic strip with alternate poles (North-South) of pole length of 1 mm and pole pair length of 2 mm. A half pole is required at each end of the strip. The length of the strip determines the maximum measured stroke; it must be 3 mm greater than the stroke in 1 mm increments.

A circular magnet may be used to achieve off-axis rotary encoding.

Figure 6: Magnetic strip positioned over TRACKER position sensor

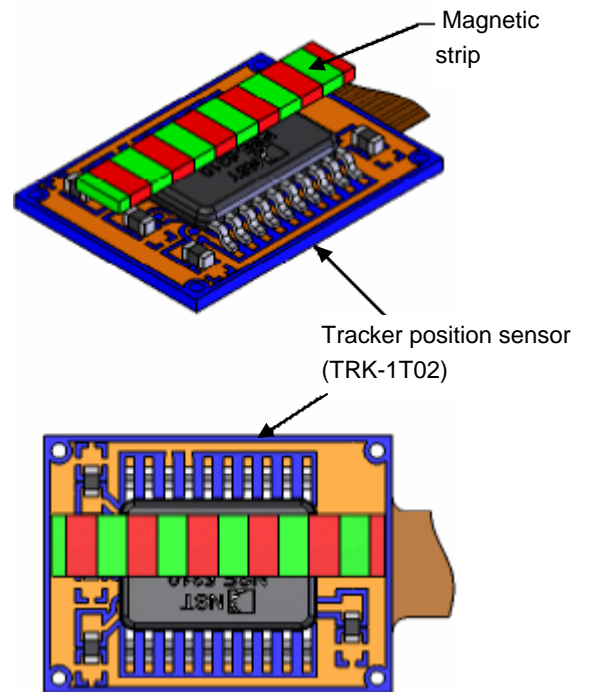


Table 3: magnetic strip requirements

Parameter	value	note
Pole length	1 mm	
Pole pair length	2 mm ± 1.2%	Accuracy of magnetic pole length determines accuracy of linear measurement.
Magnetic strip length	Stroke + 3 mm	The magnet strip must be in 1 mm increments. A ½ pole is required at each end.
Magnetic strip area	1 mm X 2 mm	Size recommended for TSSOP package.
Magnetic field temp drift	-0.2%/K max	Recommended - for example Samarium Cobalt ReComa28 is -0.035%/K

Figure 7: Magnetic strip alignment

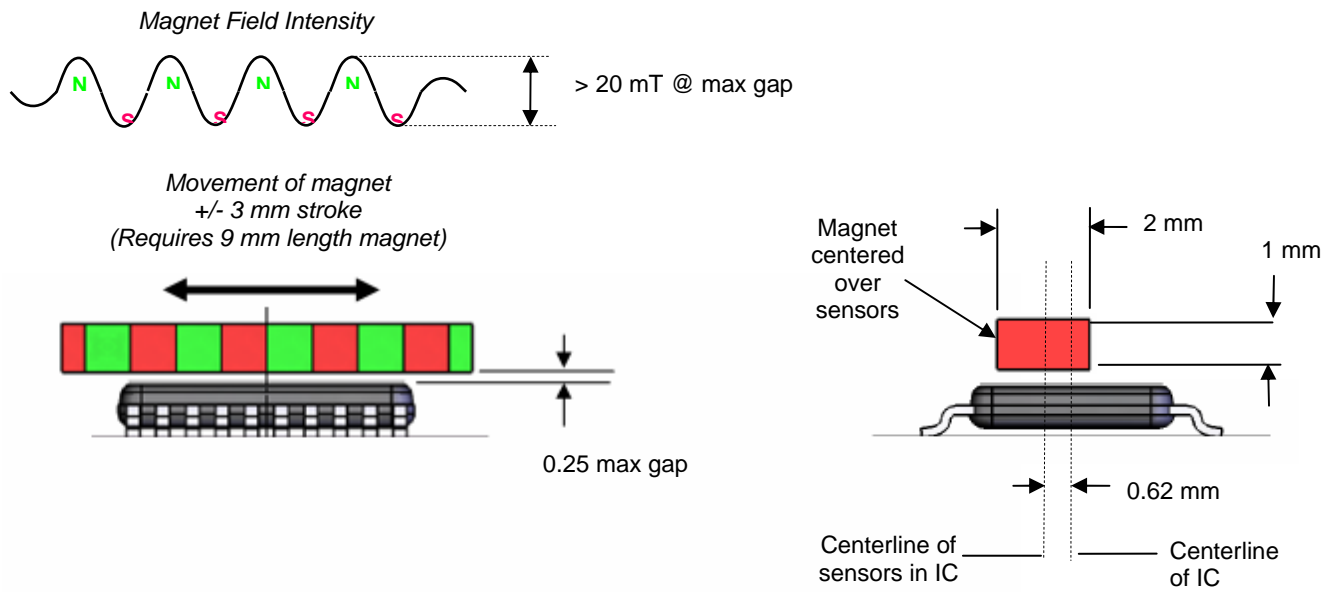
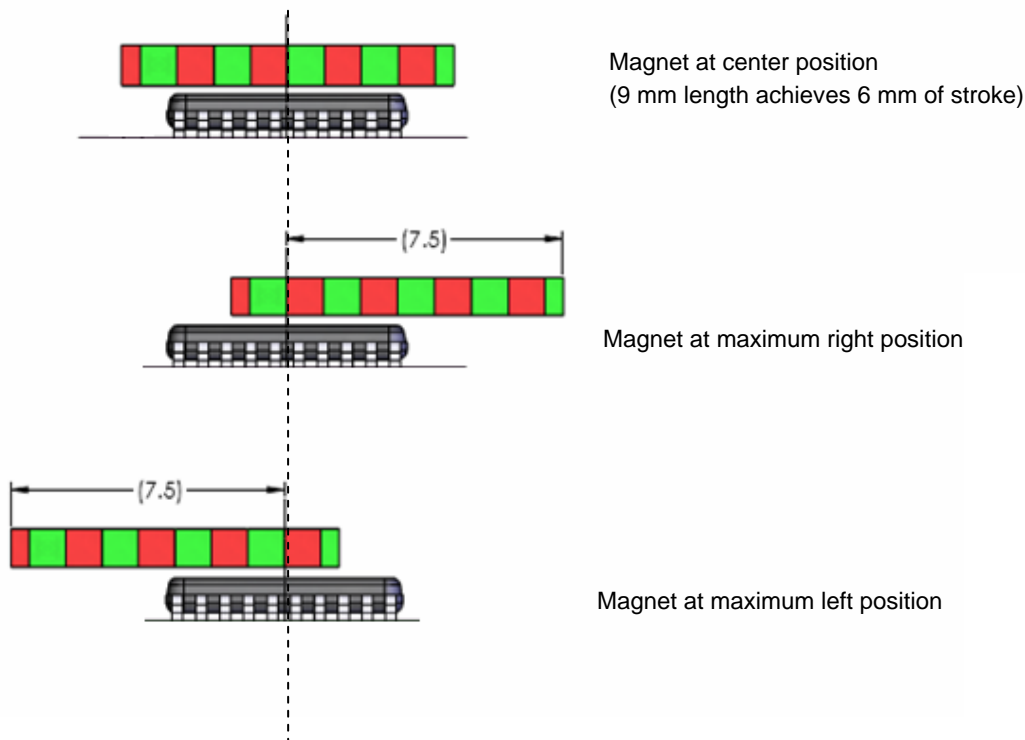


Figure 8: Magnetic strip motion

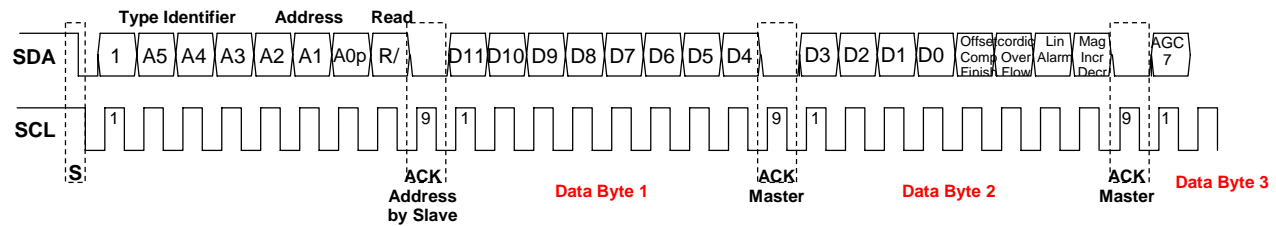


4. I²C interface

The TRK-1T02 uses an I²C compatible interface. The default address is A<6:0>1000000.

Timing constraints are according to I²C-Bus Specification V2.1 / 2000.

I²C Position information read out by a μC-master



D11 - D0: linear position (12 bits). Only bits D2-D11 (10 bits) are used.

Offset Compensation Finished: “high” indicates a data valid.

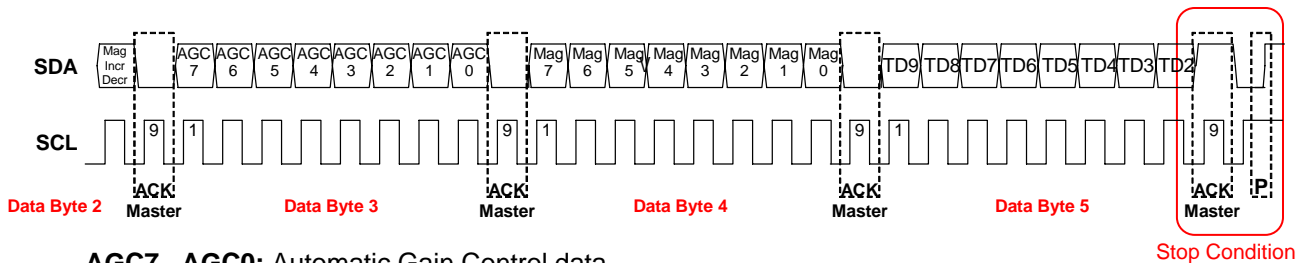
CORDIC Overflow: “high” indicates a CORDIC DSP calculation overflow.

Linearity Alarm: “high” indicates the ADC input range exceeds +/-625mV (filter overflow).

MagIncr / MagDecr: “high” OR connection: indicates changing magnitude and non-valid input range.

Additional I²C information

In addition to the position data, the I²C can be used to read the AGC value, magnitude and temperature sensor information.



AGC7 –AGC0: Automatic Gain Control data

Mag7 –Mag0: MSB CORDIC magnitude value

TD9 –TD2: MSB temperature data

Not all five data bytes need to be read every time. The host may terminate by using the stop condition P. For example, if you only want to read position, the stop condition can be initiated after Data Byte 2.

Temperature Calculation

$$\text{Temp [}^\circ\text{C]} = \text{TD} \times 0.667 \text{ [}^\circ\text{C/TDcount]} - 75\text{[}^\circ\text{C]}$$

Example: TD = 0x91 or 145 decimal: 21.7 °C = (145 x 0.667) - 75

5. General device specifications

Absolute Maximum Ratings (non-operating)

Stresses beyond these “Absolute Maximum Ratings” may cause permanent damage to the device. *These are stress ratings only. Functional operation of the device at these conditions is not implied.* Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

PARAMETER	SYMBOL	MIN	MAX	UNIT	NOTE
Input Pin Voltage VDD3V3	VinVDD3V3		5	V	
Input Current (latchup immunity)	Iscr	-100	100	mA	Norm: Jedec 78
Electrostatic Discharge	ESD	+/-2		kV	Norm: MIL 883 E method 3015
Storage Temperature	Tstrg	-55	125	°C	
Humidity non-condensing		5	85	%	
Thermal Package Resistance	Rth		114.5	°C/W	TSSOP20 / still air

IC Electrical Specifications

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT	NOTE
Resolution	RES			12	bit	0.5 um (max. 12bit / 2mm pole pair)
Integral non-linearity (optimum)	INL _{opt}			± 5.6	µm	Maximum error with respect to best line fit. Ideal magnet, T _{amb} =25 °C.
Integral non-linearity (optimum)	INL _{temp}			± 10	µm	Maximum error with respect to the best line fit. Ideal magnet T _{amb} = -30 to +70 °C.
Integral non-linearity	INL			± 40	µm	Best line fit = (Err _{max} – Err _{min}) / 2 including magnet error T _{amb} = -30 to +70 °C (Note 1)
Differential non-linearity	DNL			±0.97	µm	10bit, no missing codes
Transition noise	TN			0.3	µm RMS	1 sigma
Power-up time	t _{PwrUp}			80	ms	
System propagation delay	t _{delay}			384	µs	
Internal sampling rate for absolute output	f _s	2.48	2.61	2.74	kHz	T _{amb} = 25°C
		2.35	2.61	2.87		T _{amb} = -30 to +70°C
Hysteresis	Hyst	2		8	LSB	Incremental output / 12bit resolution Hyst =0 for absolute serial output
I ² C Read-out frequency	CLK		400	800	kHz	Max. clock frequency to read out serial data

Note 1: System integral non-linearity is limited by magnetic source