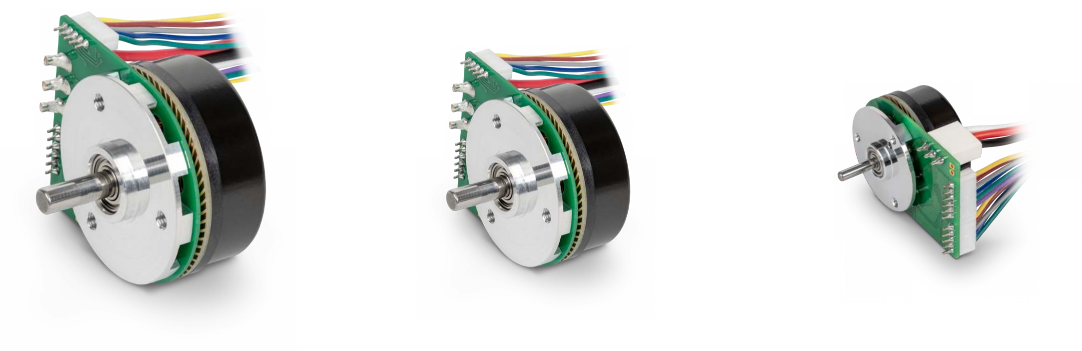
ENX MILE

Product Information



ENX MILE
Product Information
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TRADEMARKS AND BRAND NAMES

ENX MILE – Product Information

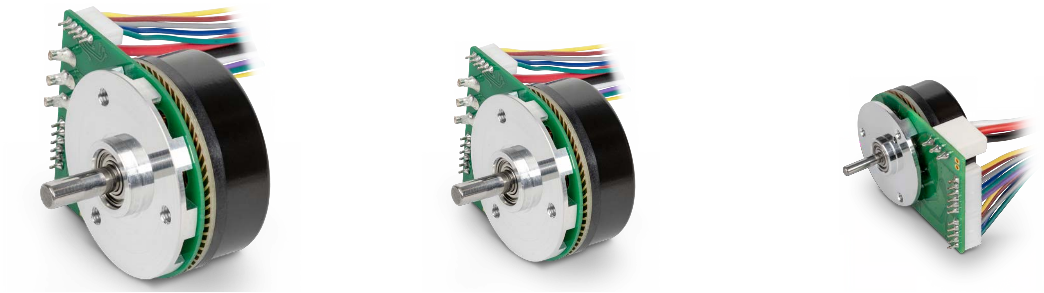

Figure 1 ENX 42 MILE, ENX 32 MILE, ENX 22 MILE

The MILE encoder uses an inductive angle measurement system to generate incremental square signals. It has two channels (A, B) with differential signals up to 2048 pulses per revolution.

The encoder is designed for maximum robustness in industrial applications. It can operate in an open environment of an EC flat motor and has additional ESD protection circuits. Due to the robustness of MILE technology concerning electromagnetic interference, the encoder could be integrated into the ECX flat series with minimal dimensional changes compared to a motor without an encoder.

The pin assignment is compatible with most maxon controllers with an encoder interface.

Note

The listed data are for informational purposes only. None of the stated values or information may be used as an indicator of guaranteed performance.

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1 TECHNICAL DATA

1.1 Preconditions for operation

Preconditions for trouble-free operation

- *The encoder must be supplied with voltage before the motor is rotated. Thereby, take a power-up time of up to 15 ms into account.*
- *Voltage ripples (V_{pp}) in the supply voltage (V_{cc}) with an amplitude ≥ 0.4 mV affect the repeatability of the encoder.*

1.2 Absolute maximum rating

Parameter	Conditions	Min	Max	Unit
Supply voltage (V_{cc})		–0.3	+6	V
Voltage at signal output (V_{signal})	Incremental signals	–0.3	V_{CC}+0.3	V
	Hall signals		+27	
Operating temperature (T_{amb})		–40	+100	°C
Storage temperature (T_{store})		–40	+105	°C
Humidity	condensation not permitted	+20	+80	%rH

1.3 General data

Parameter	Conditions	Min	Typ	Max	Unit
Supply voltage (V_{cc})		+4.5	+5	+5.5	V
Supply current (I_{dd})	Output pulse frequency <100 kHz, Load resistance ≥10 kΩ		15		mA
Power-on time				15	ms

1.4 Incremental interface

Parameter	Conditions	Min	Typ	Max	Unit
Number of channels	ChA, ChB		2		—
Impulses per turn	ENX 22 MILE		1'024		cpt
	ENX 32 MILE, ENX 42 MILE		2'048		
Pulse frequency (f_{pulse})	Max. output pulse frequency		1'000		kHz
Signal output current (I_{signal})	Limits the optional minimum differential load resistance R_1 to 1.375 kΩ	–4		+4	mA
Signal voltage high (V_{high})	I_{signal} ≤4 mA, V_{cc} =5 V	4.5			V
Signal voltage low (V_{low})	I_{signal} ≤4 mA, V_{cc} =5 V			0.5	V
Transition time (t_{trans})	Rise time/fall time ChA/ChB @Load resistance 1 kΩ, Cload 25 pF		20		ns

1.5 Commutation interface (open collector)

Parameter	Conditions	Min	Typ	Max	Unit
Number of channels	H1, H2, H3		3		—
Supply voltage (V_{Hall})		2.7	—	24	V
Supply current (I_{Hall})		1.5	3	4.5	mA
HIGH-level output current (I_{OH})	V_{Hall} - VOH < 0.5 V		0.1	2	mA
LOW-level output current (I_{OL})	Limits the minimum external pull-up	-20			
HIGH-level output voltage (V_{OH})	I_{OH} = 2mA	V_{CC} - 0.5			
LOW-level output voltage (V_{OL})	I_{OL} < 20 mA			0.5	
Duty cycle			16	35	us
Delay time			6		us
Pulse frequency (f_{pulse})	Maximum output pulse frequency	30	50		kHz
Slew rate (t_{trans})	Rise time H1/H2/H3 (10…90%) R_{PU} = 1 kΩ			1	µs
	Fall time H1/H2/H3 (90…10%) R_{PU} = 1 kΩ			1	
Maximum commutation angle error (maxCAE), hall signals			15	21	°e

1.6 Angle measurement

Conditions *All values at T=25°C, n=5'000 rpm, V_{cc}=5 V unless otherwise specified.*

Definitions *See ➔Page 7.*

Parameter	Conditions	Min	Typ	Max	Unit
Counting direction of incremental signals (Dir)	Movement of the motor shaft for signal phase position "A before B," viewed from the shaft end		CW		
Counting direction of commutation signals	Movement of the motor shaft for signal phase position "H1 before H2 before H3," viewed from the shaft end		CW		
State length (L_{state})		70	90	110	°e
Minimum state duration (t_{state})			125		ns
Integral nonlinearity (INL)			1	1.8	°m
Differential nonlinearity (DNL)			0.4	1.1	LSB
Repeatability (Jitter)			0.6	1.2	LSB
Phase delay A to B (Phase θ)		70	90	110	°e
Angular hysteresis (Hyst)			1		LSB
Delay time of the digital signal path	Typical latency of digital signal processing		2.2		µs

1.7 Mechanical data

Parameter	Conditions	Value	Unit
Moment of inertia of the pulse disc (Jt)		3.5	g cm²
Standard cable length (LC)		300	mm

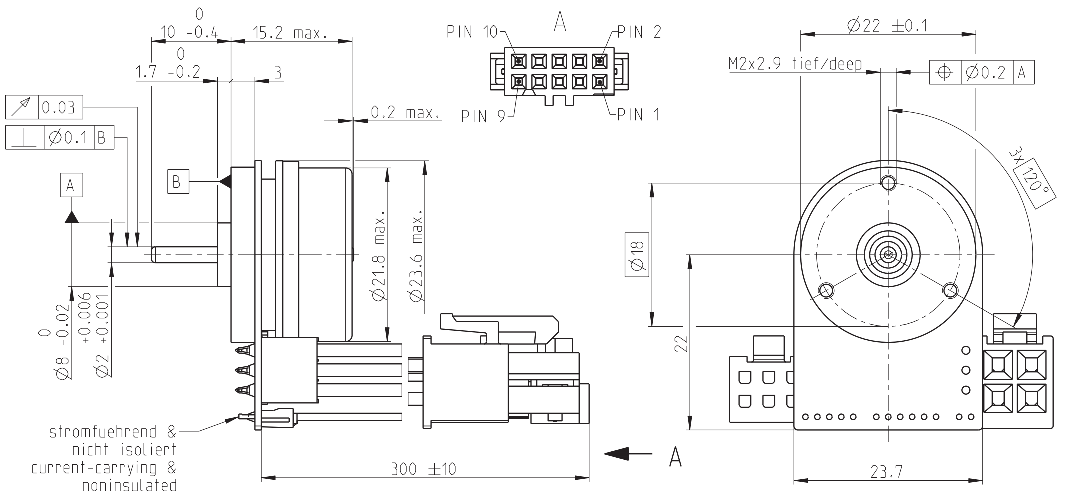


Figure 2 ENX 22 MILE - Dimensional drawing

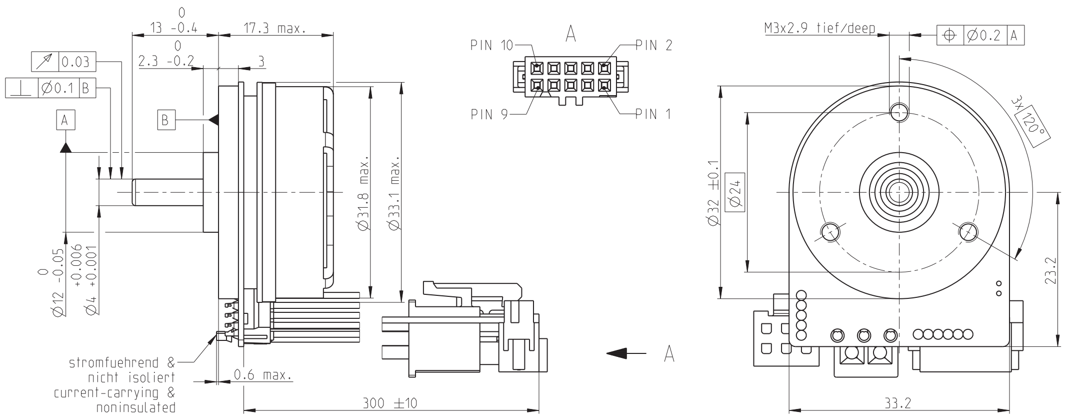


Figure 3 ENX 32 MILE - Dimensional drawing

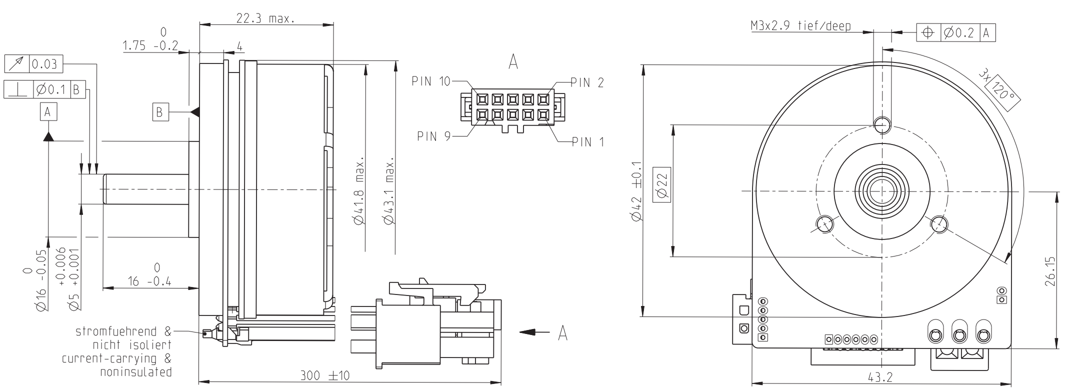
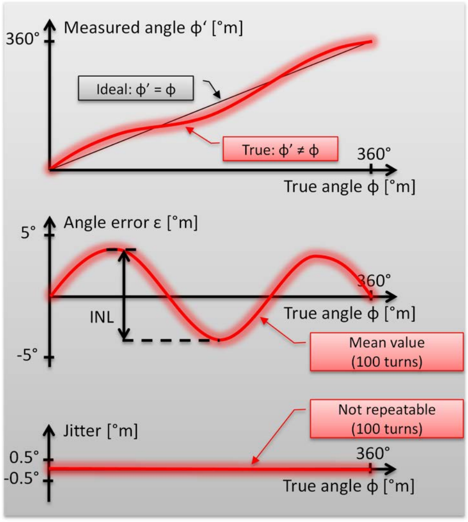
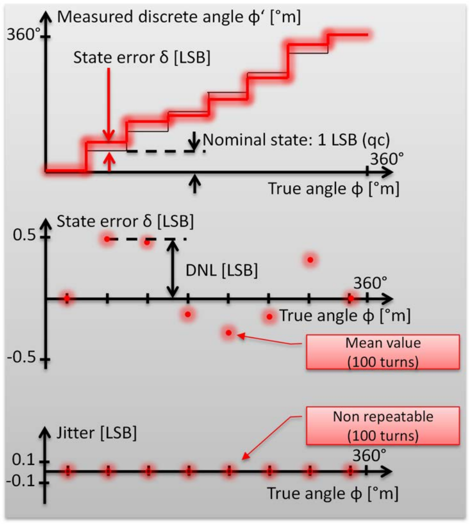
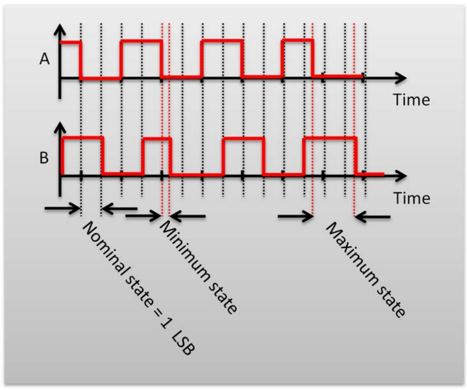


Figure 4 ENX 42 MILE - Dimensional drawing

2 DEFINITIONS

Metric	Definition	Illustration
Angle Error [°m]	Difference of measured and true angular shaft position at each position.	
Average Angle Error [°m]	Average of Angle Error at each position, over a given number of turns.	
Integral Nonlinearity (INL) [°m]	Peak-to-peak value of Average Angle Error.	
Jitter (Repeatability) [°m] or [LSB]	Six standard deviations of Angle Error per turn (at each position, over a given number of turns). **Jitter [°m]** is typically independent of the resolution and defines the maximum useful positioning repeatability. **Jitter [LSB]** is resolution-dependent. At given Jitter [°m], the value is roughly proportional to resolution.	
Least Significant Bit [LSB]	Minimum measurable difference between two angle values at given resolution (= quadcount, = State).	
State Error [LSB]	Difference between actual state length and average state length.	
Average State Error [LSB]	Average of State Error over a number of turns for each state of a turn.	
Differential Nonlinearity [DNL]	Maximum positive or negative Average State Error.	
Minimum State Length [°e]	Minimum measured state length within a number of turns relative to pulse length.	
Maximum State Length [°e]	Maximum measured state length within a number of turns relative to pulse length.	
Minimum State Duration [ns]	By chip limited minimum time separation between two A/B transitions.	

Continued on next page.

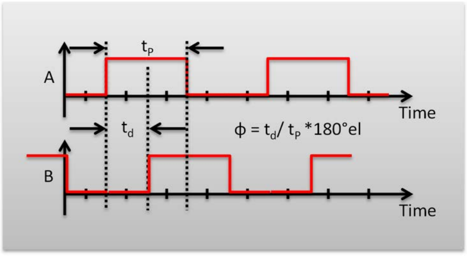
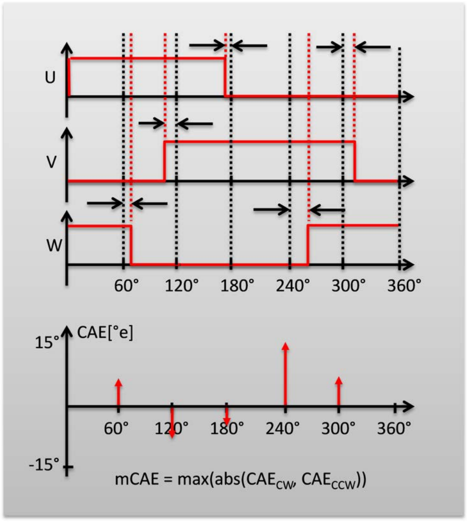
Metric	Definition	Illustration
Phase delay θ [°e]	Time difference of rising edge A to B relative to duration of positive level of A.	
Maximum commutation angle error (maxCAE) [°e]	Minimum positive or negative deviation of the individual switching points of the commutation signals (reference signals), determined over a certain number of turns.	

Table 1 Definitions

3 TYPICAL MEASUREMENT RESULTS

3.1 Angle error per turn

The following diagrams show angular error measurements of an ENX 22 MILE, an ENX 32 MILE and an ENX 42 MILE under the following conditions:

Measurement of 20 revolutions at: V_{cc} = 5 V, n = 2'000 min-1, T = 25°C

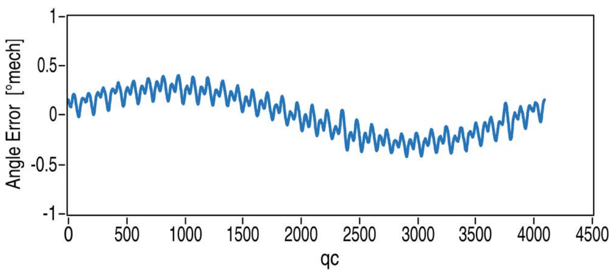
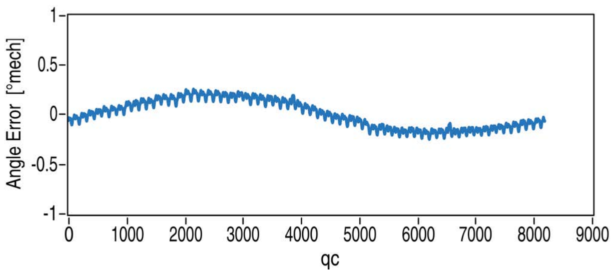
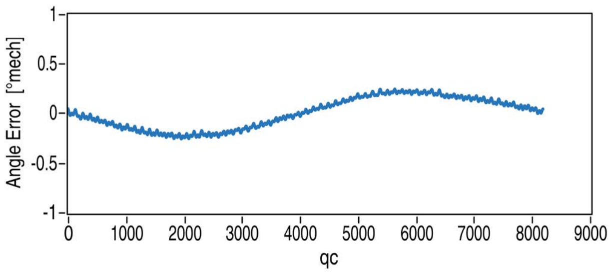
Resolution	Graph	Analysis	
1'024 (ENX 22 MILE)		INL Jitter DNL Min State Max State Min Phase Max Phase	0.8°m 0.04°m 0.5 LSB 0.2 LSB 0.85 LSB 1.15 LSB 78°e 103°e
2'048 (ENX 32 MILE)		INL Jitter DNL Min State Max State Min Phase Max Phase	0.5°m 0.03°m 0.6 LSB 0.15 LSB 0.85 LSB 1.1 LSB 78°e 101°e
2'048 (ENX 42 MILE)		INL Jitter DNL Min State Max State Min Phase Max Phase	0.5°m 0.01°m 0.3 LSB 0.11 LSB 0.89 LSB 1.1 LSB 79°e 100°e

Table 2 Typical Measurement Results

3.2 Oscilloscope traces

Figure 5 shows the incremental signals A, B, and A/, B/ of an ENX 22 MILE (N=1024 cpt), recorded in CW rotation direction at VCC = 5 V, n = 2'500 min-1, T = 25°C.

Signals: C1 = ChA; C2 = ChA/; C3 = ChB; C4 = ChB/; C8 = Reference signal 360°m (extract); 5 µs/div; 2 V/div

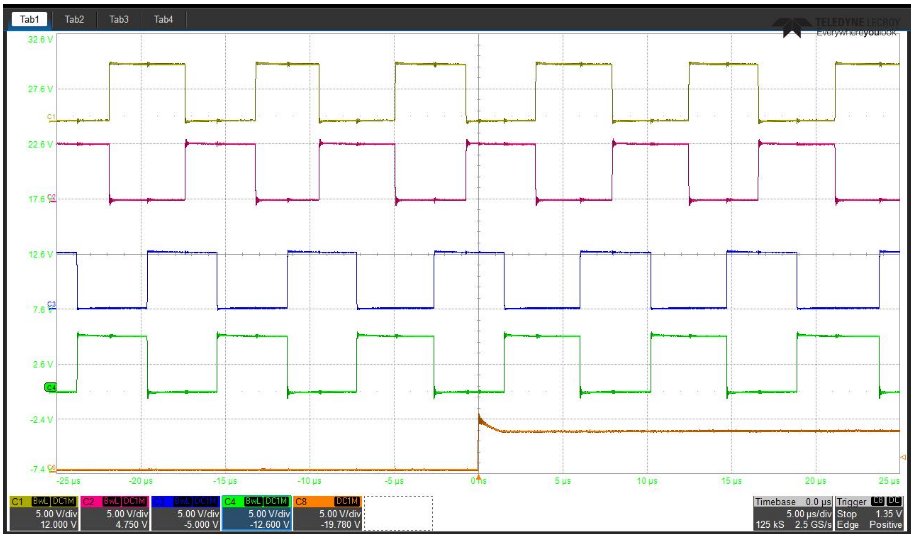


Figure 5 Incremental signals ENX 22 MILE

Figure 6 shows the hall signals HS1, HS2, and HS3 of an ENX Flat 22, recorded in CW rotation direction at V_{CC} = 5 V, n = 2'500 min^{-1}, T = 25°C.

Signals: C1 = HS1; C2 = HS2; C3 = HS3; C8 = Reference signal 360°m; 5 µs/div; 2 V/div

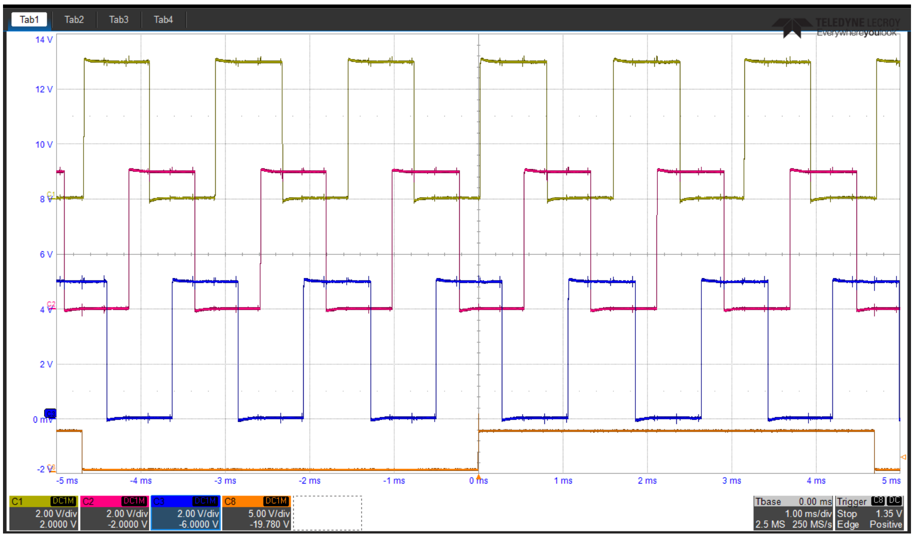


Figure 6 Hall signals ENX 22 MILE

3.3 Temperature dependence

Figure 7 shows the temperature dependence of ten ENX 32 MILE under the following conditions:

V_{CC} = 5 V, 2'000 min^{-1}, 2'048 cpt

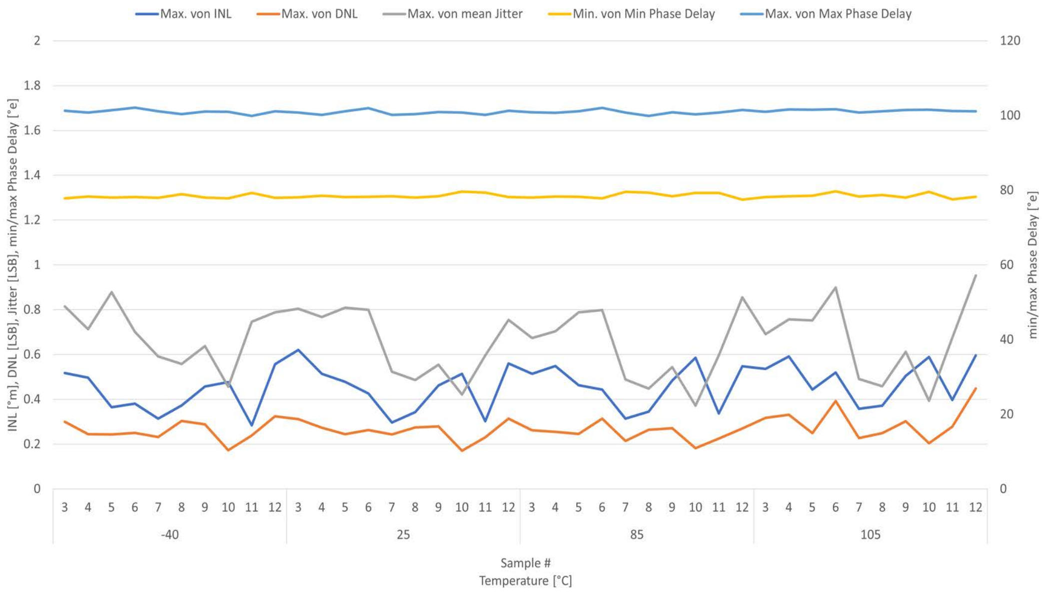


Figure 7 Temperature Dependence

3.4 Rotation rate dependence

Figure 8 shows the rotation rate dependence of ten ENX 32 MILE under the following conditions:

V_{CC} = 5 V, 1'000…8'000 min^{-1}, 2'048 cpt

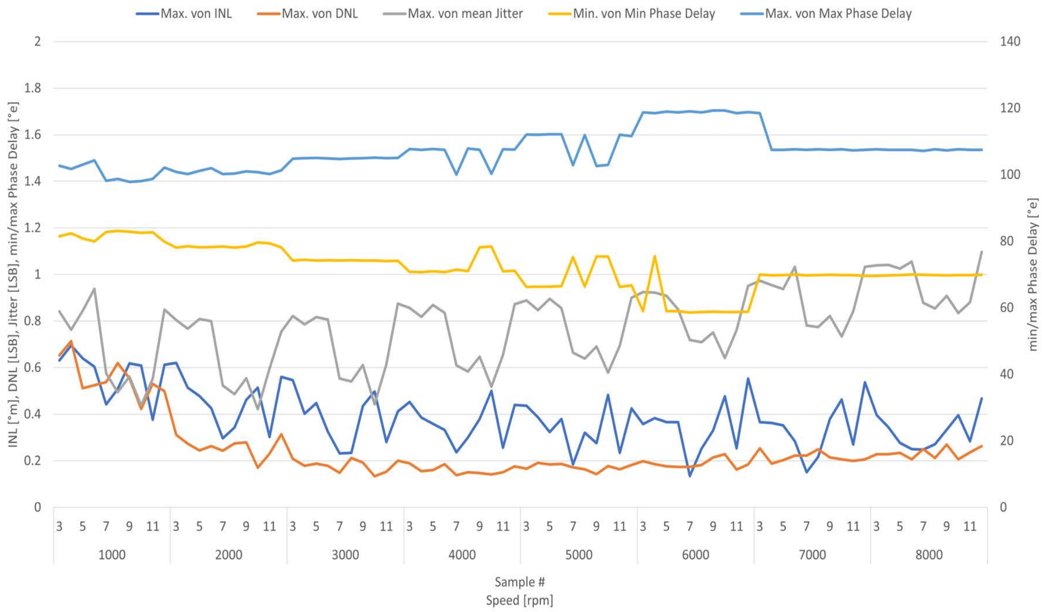


Figure 8 Rotation rate dependence

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3.5 Compliance to regulations

Parameter	Description
Electrostatic discharge immunity (DIN EN 61000-4-2)	Direct discharge on conductive surfaces – ±8 kV
Reliability [a]	Reliability prediction of electronic devices according to MIL-HDBK-217F Environment: Ground, benign (GB) Ambient temperature: 329 K (55°C) Component stress: In accordance with the circuit diagram and rated power Mean Time Between Failures (MTBF = MTTF = MTTFd) = 5'580'525 hours Failure rate: 180 FIT
Compatibility UL [b]	See conditions listed below

Table 3 Compliance to regulations

[a] *MTTFd (Mean Time To Dangerous Failure) is specified as the reliability characteristic for maxon encoders and considered equal to MTBF (Mean Time Between Failures) and MTTF (Mean Time To Failure) using the following conservative assumptions:*

- *All component failures may significantly distort the sensor information and result in a dangerous failure of the encoder.*
- *maxon encoders are not repairable.*

A deeper analysis of the sensor behavior in case of individual component failures may lead to a lower failure rate. The specified MTTFd value only considers the electronic components of the encoder (i.e. no connectors, cables or mechanical support structures). The calculation method and the underlying data basis for determining the MTTFd for maxon encoders are based on the standard EN ISO 13849-1.

[b] *The following conditions are fulfilled by the product or must be fulfilled in the customer's overall system in order to have a drive unit equipped with an ENX MILE encoder certified according to UL:*

- *As per UL 840 chapter 8:*
  The encoder is considered as “low voltage equipment” because it has a supply voltage below 50 V and all electrically conducting parts are separated by at least 0.2 mm from the next adjacent metal part that is or could be electrically connected to an outside potential.
- *As per UL 746C chapter 3.34 section b:*
  The maximum power consumption of the device is less than 15 W. The voltage supply must guarantee that, even in case of defect of at the encoder, the maximum power consumption is limited to 15 W (for example by current limiting circuitry).
- *A surrounding system with circuitry operating at voltages between 50 V and 125 V must either guarantee an isolation distance of at least 1.6 mm between all parts at the voltages and the encoder or such conductors must use UL-listed isolations.*

4 PIN ASSIGNMENT

Maximum permitted Supply Voltage
- *Make sure that supply power is within stated range. Supply voltages exceeding the stated range—or wrong polarity—will destroy the unit.*
- *Connect the unit only when supply voltage is switched off (V_{cc}=0).*

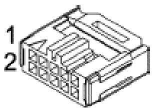

Figure 9 Connector plug

Pin	Signal	Description
1	—	not connected
2	Vcc	Power supply voltage
3	GND	Ground
4	—	not connected
5	A\	Channel A\ complement
6	A	Channel A
7	B\	Channel B\ complement
8	B	Channel B
9	—	not connected
10	—	not connected

Table 4 Pin assignment

ENX MILE encoder connector with radial cable outlet (P/N 723837)	
Connector plug	Spring connector, 2.54 mm pitch, 5 × 2-pin
Mating connector	Pin header, 2.54 mm pitch, 5 × 2-pin (EN 60603-13/DIN 41651)

Table 5 Connector plug specification

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5 OUTPUT CIRCUITRY

The following figures shown the conceptual output schematics.

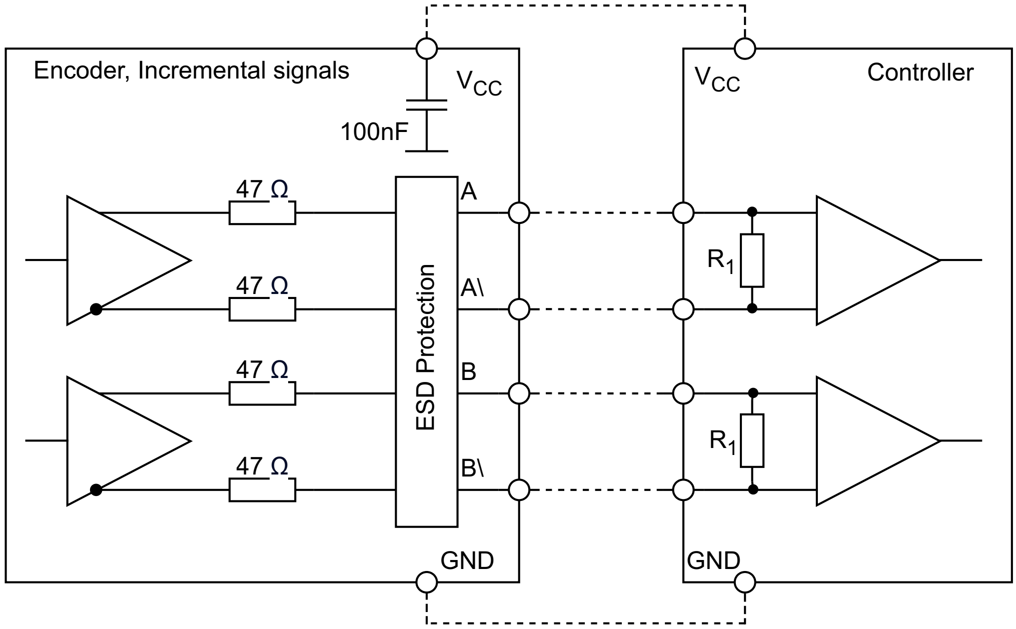

Figure 10 Output Circuitry incremental interface

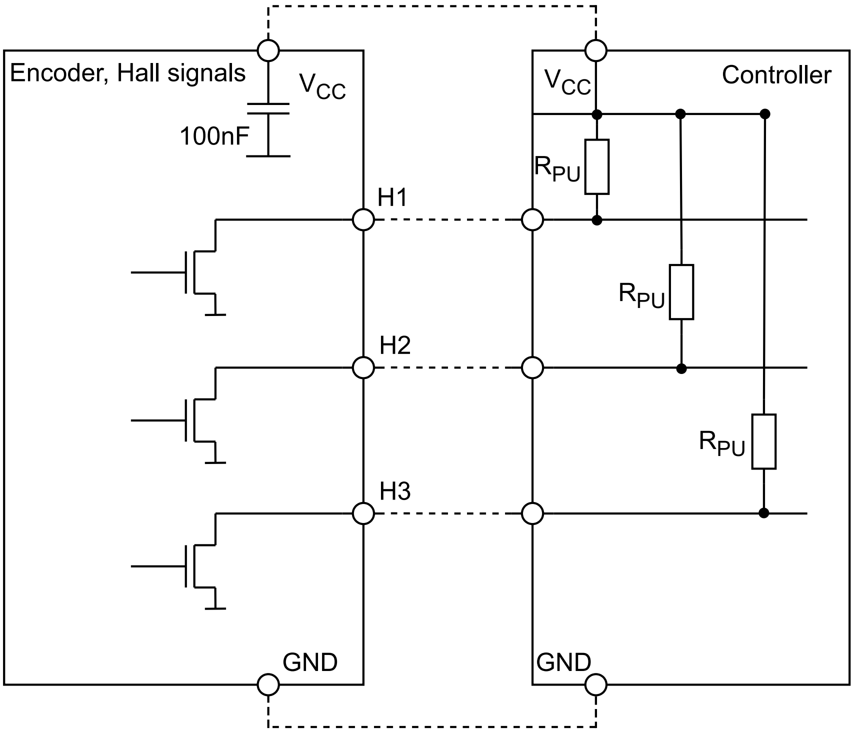

Figure 11 Output Circuitry commutation interface

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