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ENX RIO

Product Information

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ENX RIO Encoders – Product Information

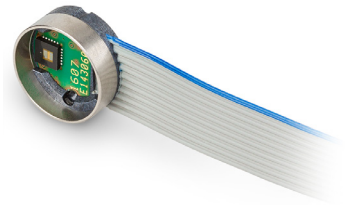


Figure 1 ENX 16 RIO

The high-resolution optical reflective encoders of the ENX RIO series are particularly suitable for highly accurate and yet dynamic position control as well as very precise speed control. They are characterized by the following qualities:

- Three-channel incremental encoder with differential RS422-compatible interface.
- Resolution of 512 to 65‘536 counts per turn.
- Output pulse frequency of at least 3 MHz and speeds of up to 40‘000 rpm.
- Very compact and extremely robust casing of 16 mm diameter and 7 mm overall length.
- Insensitive to electrical and magnetic interferences and dust-proof encapsulation as to protection class IP54.
- Design and connectors largely compatible with the known ENX 16 EASY series.

The ENX RIO Encoders are factory-configurable and available on a wide range of high-grade motors. Electrical connections are compatible with all maxon controllers with incremental encoder input and a pitch of 2.54 mm.

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.

1 TECHNICAL DATA

1.1 Absolute Maximum Rating

Parameter	Conditions	Min	Max	Unit
Supply voltage (V_{cc})		–0.3	+6.0	V
Voltage at signal output (V_{signal})		–0.3	+6.0	V
Supply current (I_{dd})		–40	+150	mA
Signal output current (I_{signal})		–50	+30	mA
ESD voltage (V_{esd}), all pins	HBM 100 pF, 1.5 kΩ		4	kV
Operating temperature (T_{amb})		–40	+105	°C
Storage temperature (T_{store})		–40	+105	°C
Humidity	condensation not permitted	20	80	%rH

1.2 General Data

Parameter	Conditions	Min	Typ	Max	Unit
Supply voltage (V_{cc})		+4.5	5	+5.5	V
Supply current (I_{dd})	With line receiver EIA-422, load resistor 120 Ω		115		mA
Analog cut-off frequency *1			200		kHz

Annotation **1 For number of impulses <4096 cpt, this results in a possible speed of approximately 45‘000 rpm. For number of impulses >4096 cpt, the speed will be limited by the maximal output frequency.*

1.3 Incremental Interface

Parameter	Conditions	Min	Typ	Max	Unit
Number of channels	ChA, ChB, ChI		3		–
Counts per turn (N)	factory-configurable in steps of 256 impulses	512		65‘536	cpt
Pulse frequency (f_{pulse})	Maximum output pulse frequency		3.125		MHz
Signal output current (I_{signal})	With Line Receiver EIA-422	–20		+20	mA
Signal voltage high (V_{high})	I_{signal} <20 mA, V_{cc} = 4.5 V	2.7			V
Signal voltage low (V_{low})	I_{signal} <20 mA, V_{cc} = 5.5 V			0.5	V
Transition time (t_{trans})	Rise time/fall time ChA/B/I @ load resistor 120 Ω, C_{load} ≤200 pF		5	20	ns

1.4 Angle Measurement

Conditions *All values at T = 25°C, n = 5000 rpm, V_{cc} = 5 V unless otherwise specified.*

Definitions *See ➔page 7.*

Parameter	Conditions	Min	Typ	Max	Unit
Counting direction of incremental signals (Dir)	Motor shaft movement for signal phase alignment “A leads B” as seen from the shaft end		CW		
State length (L_{state}) and index pulse width (L_{index} synchronized with ChA/B)	N=512…8‘192 cpt	75	90	105	°e
	N=8‘448…16‘384 cpt	60	90	120	
	N=16‘640…65‘536 cpt	30	90	150	
Minimum state duration (t_{state})			40		ns
Integral Nonlinearity (INL)	All number of impulses		0.25	0.5	°m
Differential Nonlinearity (DNL)	N=512…8‘192 cpt		0.2	0.4	LSB
	N=8‘448…16‘384 cpt		0.5	0.75	
	N=16‘640…65‘536 cpt			1	
Repeatability (Jitter)	N=512…8‘192 cpt		<0.5		LSB
	N=8‘448…16‘384 cpt		1		
	N=16‘640…65‘536 cpt		4		
	All number of impulses		0.005		°m
Phase delay A to B (Phase θ)	N=512…8‘192 cpt	75	90	105	°e
	N=8‘448…16‘384 cpt	60	90	120	
	N=16‘640…65‘536 cpt	30	90	150	
Angle hysteresis (Hyst)	All number of impulses		0.005		°m
Delay of digital signal path	Typical latency of digital signal processing		2		µs

1.5 Mechanical Data

Parameter	Conditions	Value	Unit
Dimensions (D x L), without flange (➔Figure 2)	ENX 16 RIO	Ø15.8 x 7	mm
Moment of inertia (Jt)	motor shaft Ø1.5…8 mm	0.05…1.2	g cm²
Standard cable length (Lc)	ENX 16 RIO	300 / 1‘000	mm
Protection against foreign particles and water	Interior encoder housing	IP54	—

1.6 Dimensional Drawing

For details ➔section “1.5 Mechanical Data”.

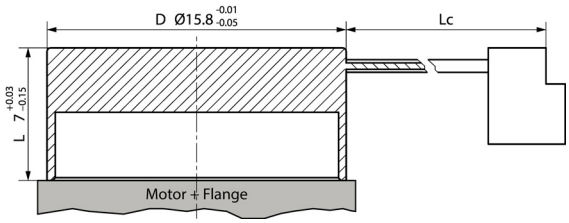
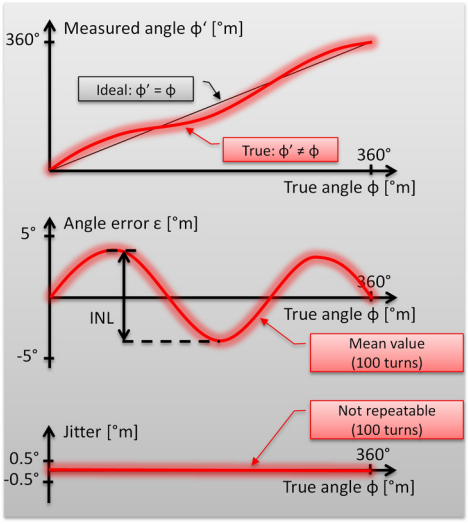
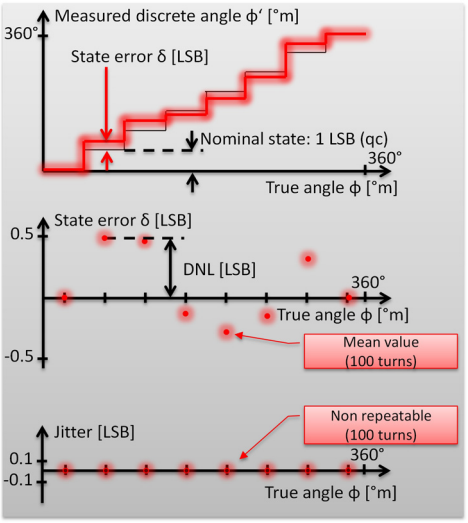


Figure 2 ENX 16 RIO – Dimensional Drawing [mm]

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.	

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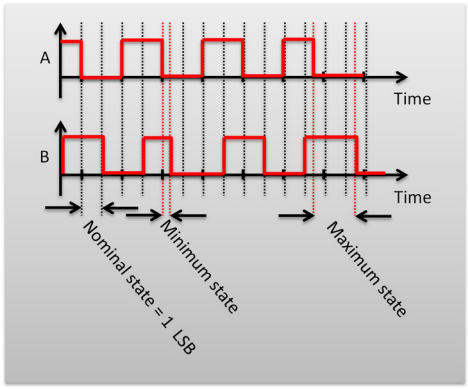
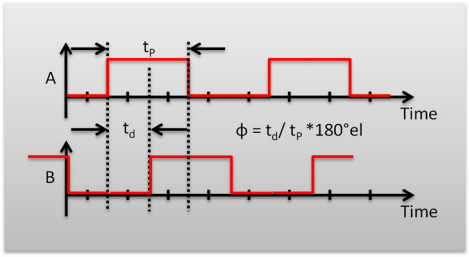
Metric	Definition	Illustration
Minimum State Length [°e]	Minimum measured state length within a number of turns relative to pulse length.	
Maximum State Length [°e]	Maximum measured state length within a number of turns relative to pulse length.	
Minimum State Duration [ns]	By chip limited minimum time separation between two A/B transitions.	
Phase delay θ [°e]	Time difference of rising edge A to B relative to duration of positive level of A.	

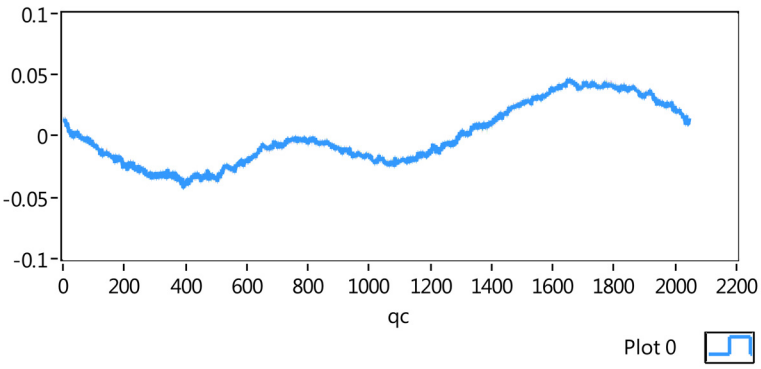
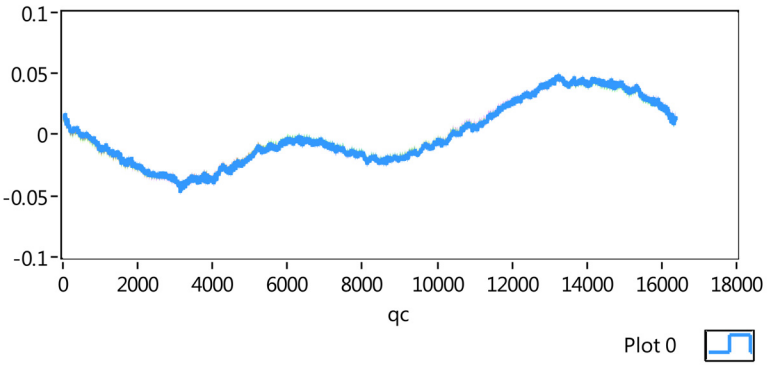
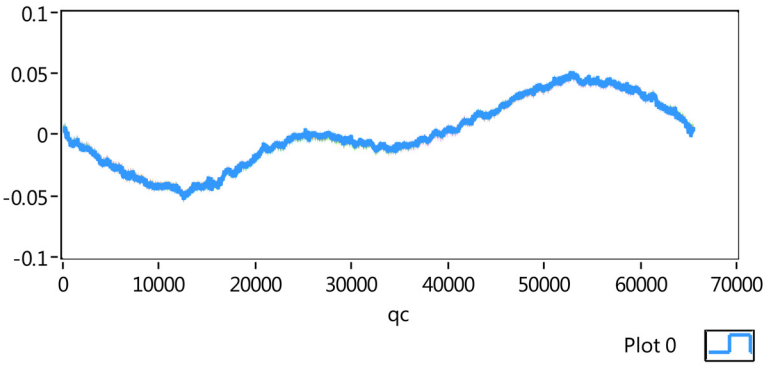
Table 1 Definitions

3 TYPICAL MEASUREMENT RESULTS

3.1 Angle Error per Turn, calibrated

The average angle error [°m] and the repeatability (Jitter) [°m] are independent of the chosen resolution. The metrics given in LSB are resolution-dependent.

Below graphs show angle error measurements of an incremental encoder configured in various resolutions under following conditions: Measurement of 25 turns at V_{cc}=5 V, n=5‘000 rpm, 120 Ω load, T=25°C.

Counts per turn (N)	Graph	Analysis	
512 cpt		INL DNL Min State Max State Min Phase Max Phase	0.1°m 0.025 LSB 0.98 LSB = 88°e 1.02 LSB = 92°e 88°e 92°e
4‘096 cpt		INL DNL Min State Max State Min Phase Max Phase	0.1°m 0.1 LSB 0.9 LSB = 81°e 1.1 LSB = 99°e 80°e 95°e
16‘384 cpt		INL DNL Min State Max State Min Phase Max Phase	0.1°m 0.3 LSB 0.75 LSB = 70°e 1.25 LSB = 110°e 60°e 95°e

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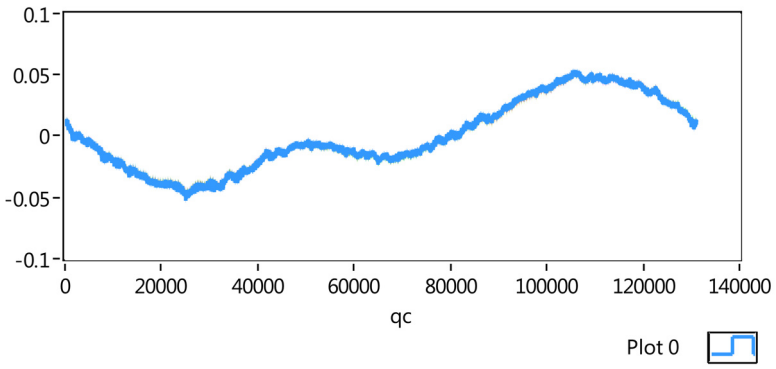
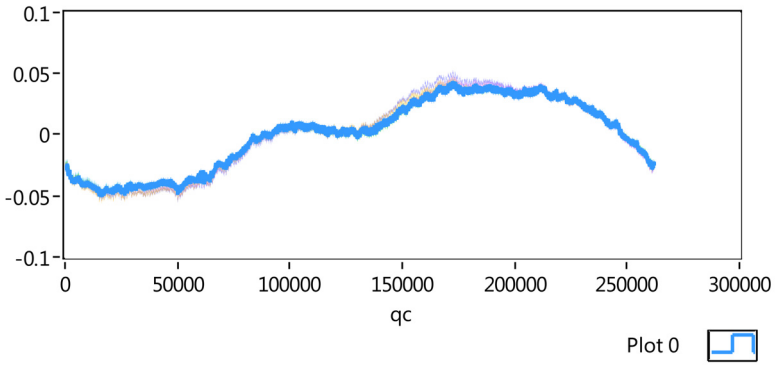
Counts per turn (N)	Graph	Analysis	
32‘768 cpt		INL DNL Min State Max State Min Phase Max Phase	0.1°m 0.5 LSB 0.5 LSB = 45°e 1.5 LSB = 135°e 50°e 100°e
65‘536 cpt		INL DNL Min State Max State Min Phase Max Phase	0.1°m 0.5 LSB 0.5 LSB = 45°e 1.5 LSB = 135°e 45°e 110°e

Table 2 Typical Measurement Results

3.2 Oscilloscope Plots

Figure 3 shows the incremental signals A, B, I of a RIO encoder (N=8‘192 cpt), recorded in direction of rotation CW at V_{cc}=5 V, n=2‘500 rpm, 120 Ω load, T=25°C.

Signals: C2 = ChA; C3 = ChB; C4 = ChI; 2 µs/div; 2 V/div

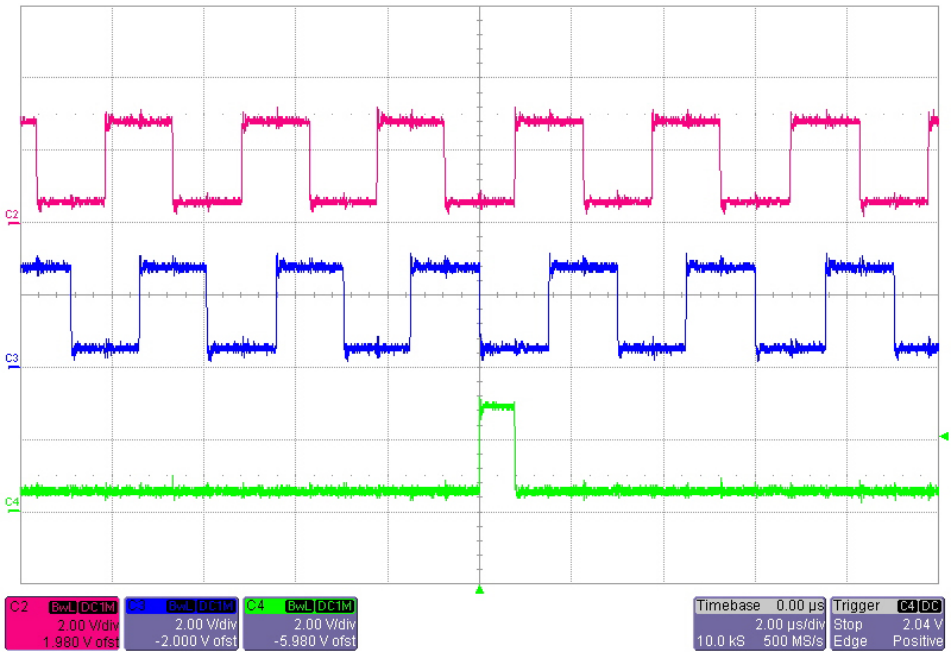


Figure 3 Oscilloscope Plots

Figure 4 shows the incremental signals A, B, I of a RIO encoder (N=8‘192 cpt), recorded in direction of rotation CW at V_{cc}=5 V, n=2‘500 rpm, 120 Ω load, T=25°C after evaluation with a line receiver EIA-422.

Signals: C1 = ChA; C2 = ChB; C3 = ChI; 2 µs/div; 2 V/div

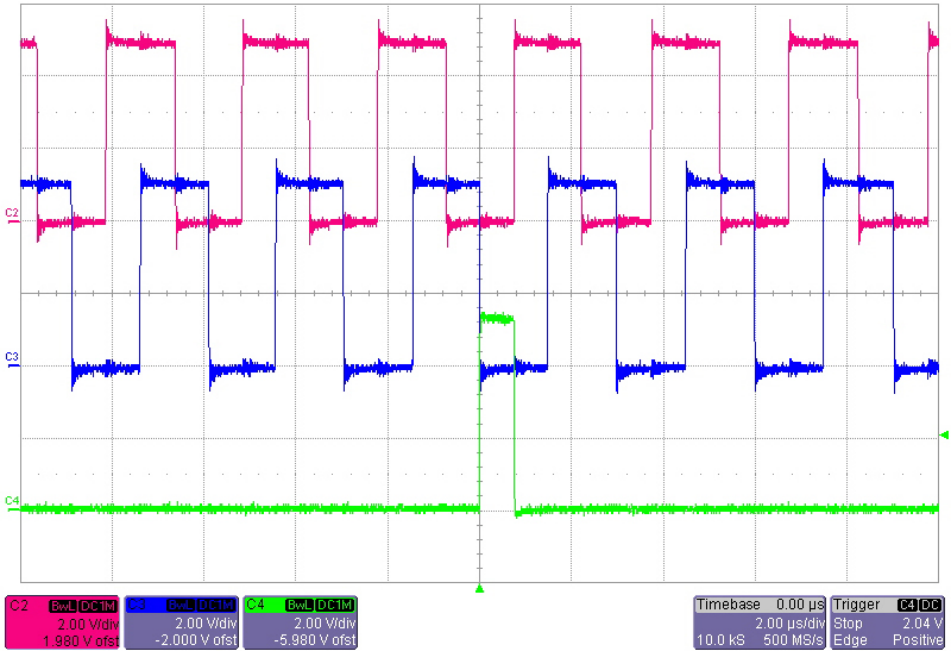


Figure 4 Oscilloscope Plots with Line Receiver

3.3 Temperature Dependence

INL, DNL, state duration, and phase delay are basically temperature-independent.

Figure 5 shows the temperature dependence of ten different RIO encoders under the following conditions: V_{CC}=5 V, 5'000 rpm, 120 Ω Belastung, 16'384 cpt

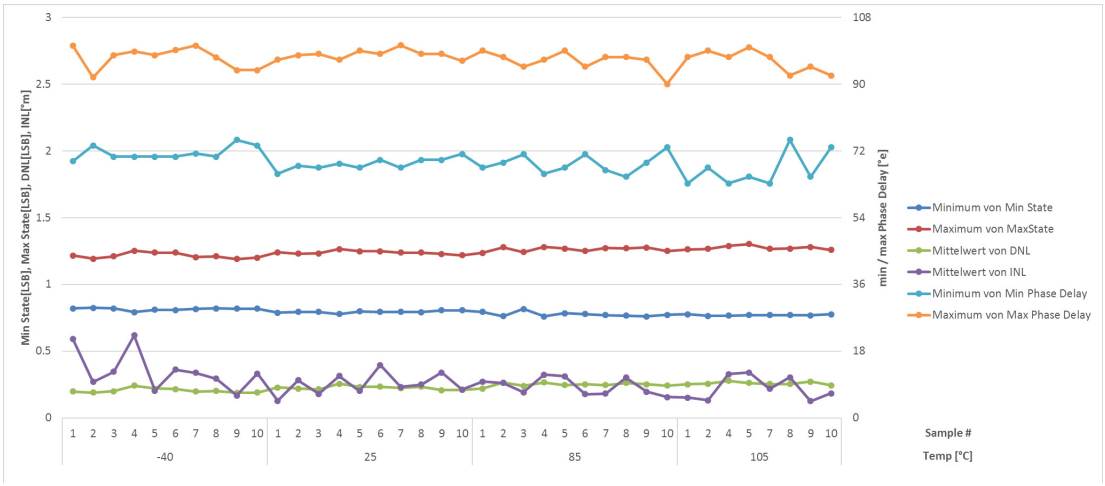


Figure 5 Temperature Dependence

3.4 Resolution Dependence

INL is independent of resolution (➔Table 2). Resolution-dependent metrics deteriorate with increased resolution.

Figure 6 shows the resolution dependence of ten different RIO encoders under following conditions: V_{CC}=5 V, n=7'500 rpm, 120 Ω load, T=25°C

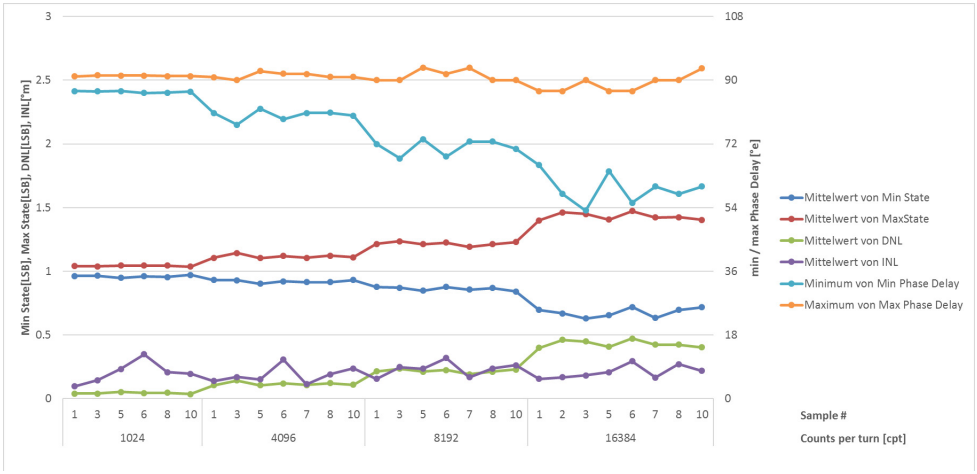


Figure 6 Resolution Dependence (binary Resolutions)

4 PIN ASSIGNMENT

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

Figure 7 ENX 16 RIO – Cable Plug

Pin	Color	Signal	Description
1	blue	not connected	—
2	gray	V_{cc}	Power supply voltage
3	gray	GND	Ground
4	gray	not connected	—
5	gray	ChA/	Channel A complement
6	gray	ChA	Channel A
7	gray	ChB/	Channel B complement
8	gray	ChB	Channel B
9	gray	ChI/	Channel I (index) complement
10	gray	ChI	Channel I (Index)

Table 3 ENX 16 RIO – Pin Assignment

Cable Plug ENX 16 RIO	
Connector	IDC socket, pitch 2.54 mm, 5 x 2 poles
Mating plug	Pin header, pitch 2.54 mm, 5 x 2 poles (EN 60603-13/DIN 41651)

Table 4 ENX 16 RIO – Specifications Cable Plug

5 OUTPUT CIRCUITRY

The following figure shows the conceptual output schematics.

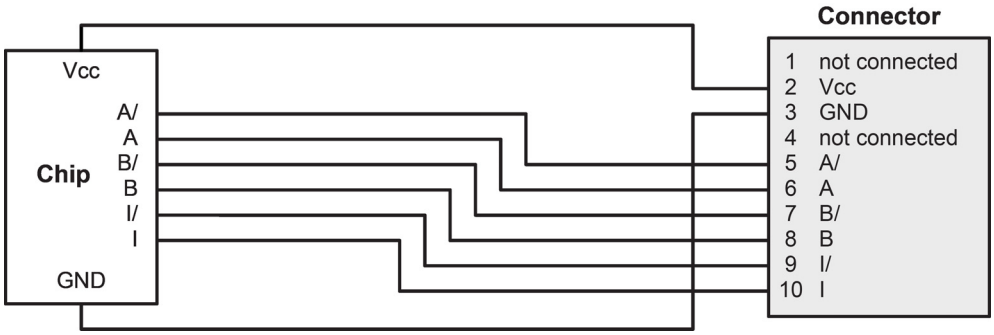


Figure 8 ENX 16 RIO – Output Circuitry

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