

# iC-PX Series

## REFLECTIVE OPTO ENCODERS



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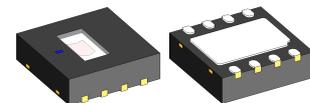
### FEATURES

- ◆ Lensless, reflective opto-encoder iCs, compact, high-resolution, incremental
- ◆ Suitable reflective code discs of  $\varnothing 26$  mm,  $\varnothing 30$  mm,  $\varnothing 32$  mm,  $\varnothing 36$  mm and  $\varnothing 43$  mm
- ◆ Monolithic *HD Phased Array* with excellent signal matching
- ◆ Integrated blue LED, *EncoderBlue*<sup>®</sup>
- ◆ LED power control with 20 mA driver
- ◆ Low-noise signal amplifiers with high EMI tolerance
- ◆ Pin-selectable operation modes: Digital A/B (x1, x2, x4, x8, x16 interpolated)
- ◆ Short-circuit-proof, current-limited, +/- 4 mA push-pull outputs
- ◆ Operating temperature range of -40 °C to +105 °C
- ◆ Low power consumption from single 4.5V to 5.5V supply
- ◆ Compact and lensless optoDFN mold package
- ◆ Evaluation kits on request

### APPLICATIONS

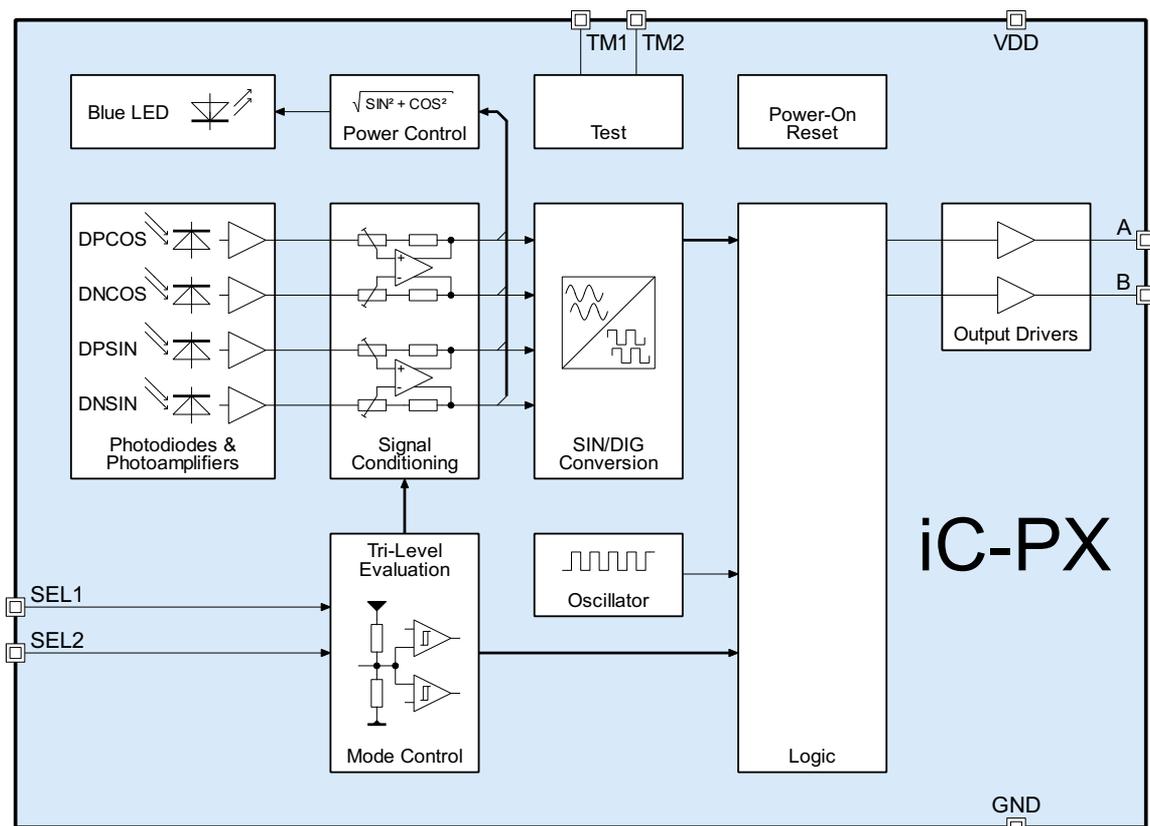
- ◆ Incremental encoders
- ◆ Miniature motors and actuators
- ◆ X-Y and linear stages
- ◆ Factory automation robots
- ◆ Consumer robots

### PACKAGES



8-pin optoDFN  
3 mm x 3 mm x 0.9 mm  
RoHS compliant

### BLOCK DIAGRAM



### DESCRIPTION

iC-PX series devices are advanced optical, reflective, lensless encoder iCs featuring integrated HD Phased Array photosensors and a blue LED chip. They provide high signal quality with relaxed alignment tolerances. Digital A/B outputs with or without interpolation are available. Typical applications are incremental encoders for motor control.

*Blue-enhanced* photosensors are adapted to the short wavelength of the embedded blue LED, and provide low-jitter outputs due to improved signal contrast. The unique assembly technology of the blue LED emitter and the sensors results in a low optical crosstalk.

Low-noise transimpedance amplifiers, arranged in a paired layout to ensure excellent channel matching, are used to convert the sensor signals into voltages of several hundred millivolts. Subsequent fully-differential signal conditioning amplifiers provide optimal signal levels for the following SIN/DIG conversion.

Precision comparators with hysteresis generate digital signals, either native or interpolated, which are evaluated and then output by  $\pm 4$  mA push-pull drivers.

Various operation modes are selectable via tri-level inputs SEL1 and SEL2: Digital A/B outputs with native (x1) or interpolated resolution (x2, x4, x8 or x16).

The built-in LED power controller with its 20 mA driver keeps the optical power constant regardless of aging effects, varying temperature or changes in the air gap (iC vs. code disc).

iC-PX devices feature a low power consumption and run at single-sided supplies of 4.5 V up to 5.5 V.

#### **iC-PX2604**

Code disc  $\varnothing$ : 26.0 mm  
Native CPR: 360

#### **iC-PX3212**

Code disc  $\varnothing$ : 30.0 mm  
Native CPR: 500

Code disc  $\varnothing$ : 32.0 mm  
Native CPR: 512

Code disc  $\varnothing$ : 36.0 mm  
Native CPR: 625

Code disc  $\varnothing$ : 43.0 mm  
Native CPR: 720

#### **General notice on materials under excessive conditions**

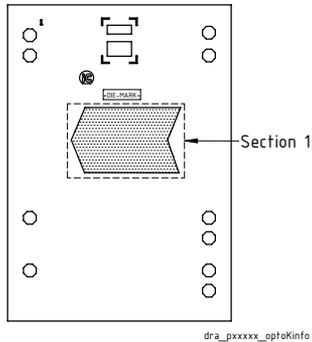
Epoxy resins (such as solder resists, IC package and injection molding materials, as well as adhesives) may show discoloration, yellowing, and surface changes in general when exposed longterm to high temperatures, humidity, irradiation, or due to thermal treatments for soldering and other manufacturing processes.

Equally, standard molding materials used for IC packages can show visible changes induced by irradiation, among others when exposed to light of shorter wavelengths, blue light for instance. Such surface effects caused by visible or IR LED light are rated to be of cosmetic nature, without influence to the chip's function, its specifications and reliability.

Note that any other material used in the system (e.g. varnish, glue, code disc) should also be verified for irradiation effects.

### PACKAGING INFORMATION

#### SENSOR LAYOUT



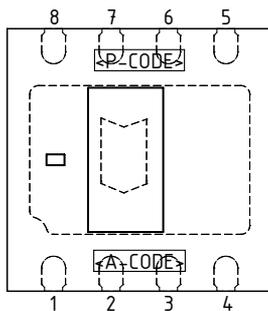
#### AOI CRITERIA

<Die Mark>	<Section>	<Area Class> <sup>1</sup>
iC PXnnnn	1	A20

<sup>1</sup> Inspection class for the optical inspection of detector areas. Refer to Customer Information #27 for description.

#### PIN CONFIGURATION

oDFN8-3x3 (3 mm x 3 mm)



#### PIN FUNCTIONS

##### No. Name Function

- |   |      |                                  |
|---|------|----------------------------------|
| 1 | TM1  | <sup>1</sup> Test Mode Input 1   |
| 2 | TM2  | <sup>1</sup> Test Mode Input 2   |
| 3 | SEL1 | Mode Selection Input 1           |
| 4 | SEL2 | Mode Selection Input 2           |
| 5 | B    | Incr. Output B                   |
| 6 | A    | Incr. Output A                   |
| 7 | VDD  | Supply Voltage Input 4.5V...5.5V |
| 8 | GND  | Ground                           |

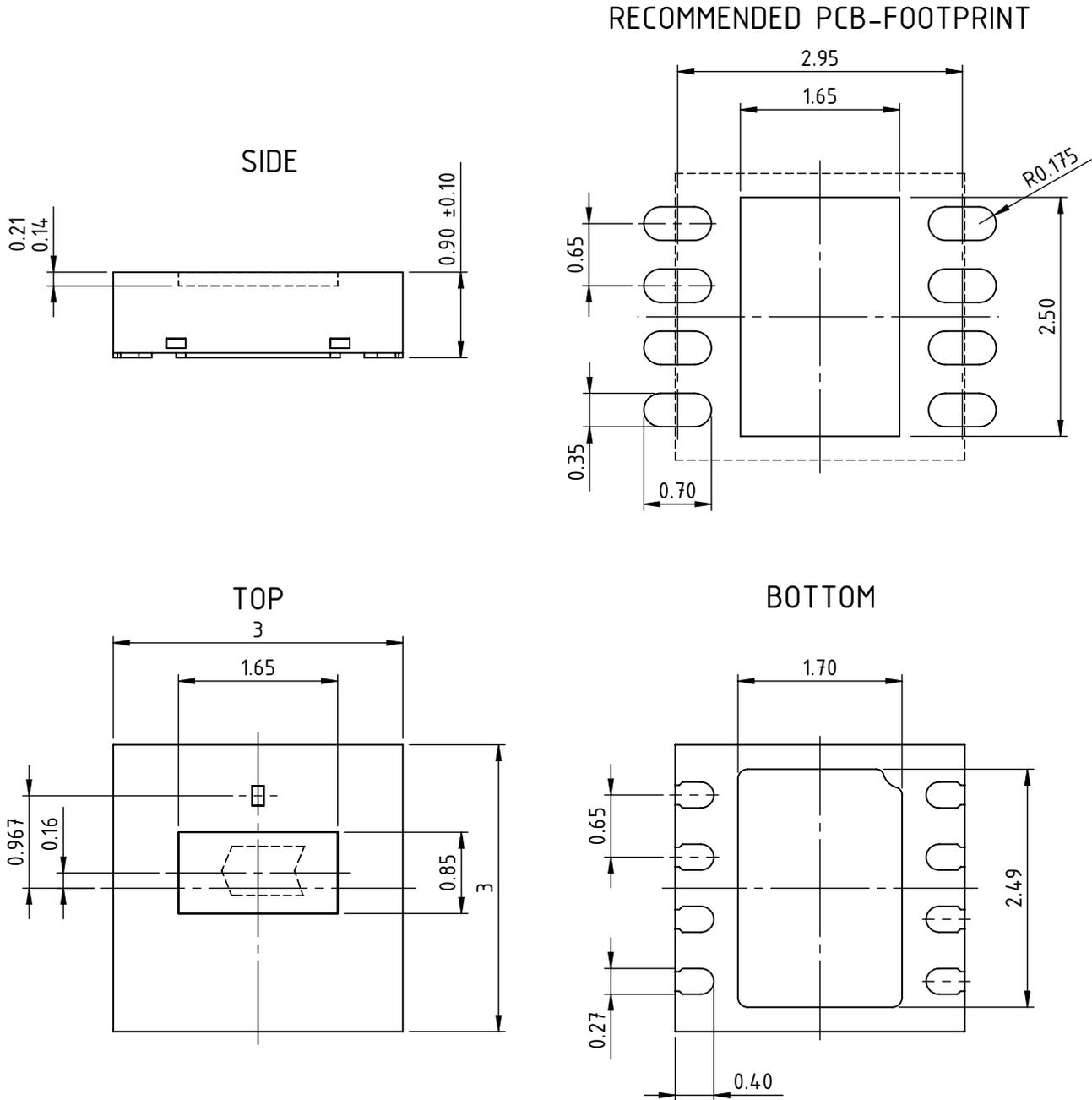
BP Backside Paddle <sup>2</sup>

IC top marking: <P-CODE> = product code, <A-CODE> = assembly code (subject to changes);

<sup>1</sup> The test pins may remain unconnected. TM1 and TM2 can be tied to GND to increase the noise immunity.

<sup>2</sup> The backside paddle has to be connected by a single link to GND. A current flow across the paddle is not permissible.

### PACKAGE DIMENSIONS



All dimensions given in mm. Tolerances of form and position according to JEDEC MO-229.  
 Positional tolerance of sensor pattern:  $\pm 70\mu\text{m}$  /  $\pm 1^\circ$  (with respect to center of backside pad).  
 Maximum molding excess  $+20\mu\text{m}$  /  $-75\mu\text{m}$  versus surface of glass.

### ABSOLUTE MAXIMUM RATINGS

These ratings do not imply operating conditions; functional operation is not guaranteed. Beyond these ratings device damage may occur.

Item No.	Symbol	Parameter	Conditions	Limits		Unit
				Min.	Max.	
G001	VDD	Voltage at VDD		-0.3	6	V
G002	I(VDD)	Current in VDD		-20	100	mA
G003	V()	Pin Voltage, all remaining pins		-0.3	VDD + 0.3	V
G004	I()	Pin Current, all signal outputs		-20	20	mA
G005	Vd()	Electrostatic Discharge	Margin vs. ESD Susceptibility according to JEDEC, all pins <sup>1,2</sup>	2		
G006	T <sub>j</sub>	Junction Temperature		-40	150	°C
G007	T <sub>s</sub>	Chip Storage Temperature		-40	150	°C

<sup>1</sup> JEDEC document JEP 155A, Jan 2012: 500V HBM allows safe manufacturing with a standard ESD control process

<sup>2</sup> JEDEC document JEP 157, Oct 2009: 250V CDM allows safe manufacturing with a standard ESD control process

### THERMAL DATA

Operating conditions: VDD = 4.5...5.5 V

Item No.	Symbol	Parameter	Conditions	Limits			Unit
				Min.	Typ.	Max.	
T01	T <sub>a</sub>	Operating Ambient Temperature Range		-40		105	°C
T02	T <sub>s</sub>	Permissible Storage Temperature Range		-40		105	°C
T03	T <sub>pk</sub>	Soldering Peak Temperature	tpk < 20 s, convection reflow tpk < 20 s, vapor phase soldering  MSL 5A (max. floor live 24 h at 30 °C and 60 % RH); Please refer to customer information file No. 7 for details.			245 230	°C °C
T04	R <sub>thja</sub>	Thermal Resistance Chip to Ambient	Package mounted on PCB according to JEDEC standard		50		K/W

All voltages are referenced to ground unless otherwise stated.

All currents flowing into the device pins are positive; all currents flowing out of the device pins are negative.

### ELECTRICAL CHARACTERISTICS

Operating conditions: VDD = 4.5...5.5 V, Tj = -40...105 °C, unless otherwise noted

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
<b>Total Device</b>							
001	VDD	Permissible Supply Voltage		4.5		5.5	V
002	I(VDD)	Supply Current	Photoamplifiers within op. range, f <sub>out</sub> () ≤ 250 kHz, no load, refer to Table 5 for typ. values at 1.5 mm and 2.0 mm air gap		13		mA
<b>Digital Outputs A, B</b>							
101	f <sub>out</sub> ()	Maximum Output Frequency	Mode DX1 Mode DX2 Mode DX4 Mode DX8 Mode DX16	0.2 0.4 0.8 1.6 1.85			MHz MHz MHz MHz MHz
102	AArel	A/B Duty Cycle Variation	Mode DX1 Modes DX2, DX4, DX8, DX16 refer to Figure 2	-5 -10		5 10	% %
103	HysD	Digital Hysteresis of Interpolator	Hysteresis with respect to one A/B period in mode DX1		5.6		°
104	Vs() <sub>lo</sub>	Saturation Voltage low	I() = 4 mA see also Figure 1			0.4	V
105	Isc() <sub>lo</sub>	Short-Circuit Current low	V() = VDD	7		110	mA
106	Vs() <sub>hi</sub>	Saturation Voltage high	Vs() <sub>hi</sub> = VDD - V(), I() = -4 mA see also Figure 1			0.4	V
107	Isc() <sub>hi</sub>	Short-Circuit Current high	V() = 0 V	-110		-7	mA
108	Tedc()	Edge Distance Control Time		45	80	135	ns
<b>Tri-Level Programming Inputs SEL1, SEL2</b>							
201	Vt() <sub>lo</sub>	Tri-Level Threshold Voltage low		5			%VDD
202	Vt() <sub>hi</sub>	Tri-Level Threshold Voltage high				95	%VDD
203	Vt() <sub>mid</sub>	Tri-Level Threshold Voltage mid		30		70	%VDD
204	V0()	Pin-Open Voltage		45	50	55	%VDD
205	Rpd()	Pull-Down Resistor	V() = VDD	65		140	kΩ
206	Rpu()	Pull-Up Resistor	V() = GND	65		140	kΩ
<b>LED Power Control</b>							
301	Iop()	Permissible LED Current		0.5		20	mA
302	Ictrl()	Controlled LED Output Current	Refer to Table 5 for details		5..10		mA

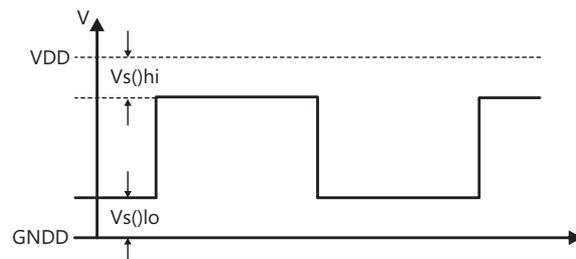


Figure 1: Digital Signal Levels.

### SIGNAL DEFINITIONS

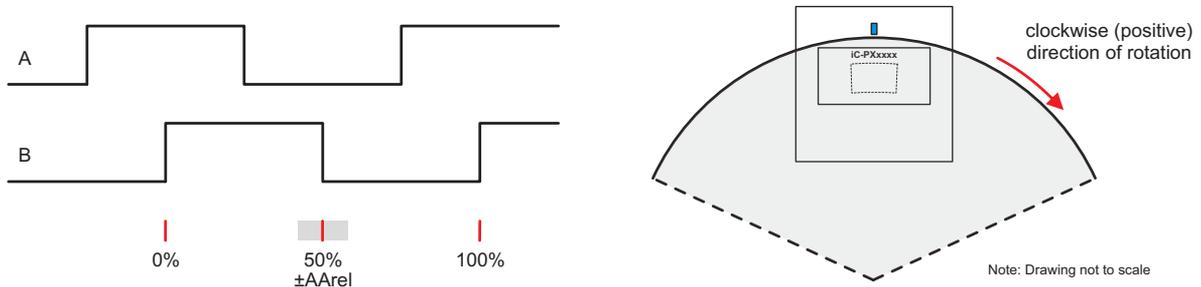


Figure 2: Signal definitions for clockwise (positive) direction of rotation.

### OPERATION MODES

iC-PX features 5 operation modes, which are selectable by the voltages applied to the pins SEL1 and SEL2, as summarized in Table 4 and illustrated in Figure 3.

These tri-level inputs might be connected to a voltage below  $V_t()_{lo}$  (low, see Elec. Char. 201), a voltage above  $V_t()_{hi}$  (high, see Elec. Char. 202) or a voltage between the specified values of  $V_t()_{mid}$  (open, see Elec. Char. 203). The function is undefined for any other voltage.

The pin-open configuration can be easily obtained by an external voltage divider. Alternatively, when the pin is left unconnected, the iC itself biases the input at 50% VDD (see Elec. Char. 204).

Note: Static pin voltages at SEL1 and SEL2 are required during operation. If changing the setting of SEL1 or SEL2 during operation, a power cycle of iC-PX is required.

SEL1	SEL2	Mode	Description
low	high	DX1	digital A/B (x1 interpolation)
high	low	DX2	digital A/B (x2 interpolation)
high	high	DX4	digital A/B (x4 interpolation)
low	open	DX8	digital A/B (x8 interpolation)
high	open	DX16	digital A/B (x16 interpolation)

Table 4: Operation modes selectable by pins SEL1 and SEL2.

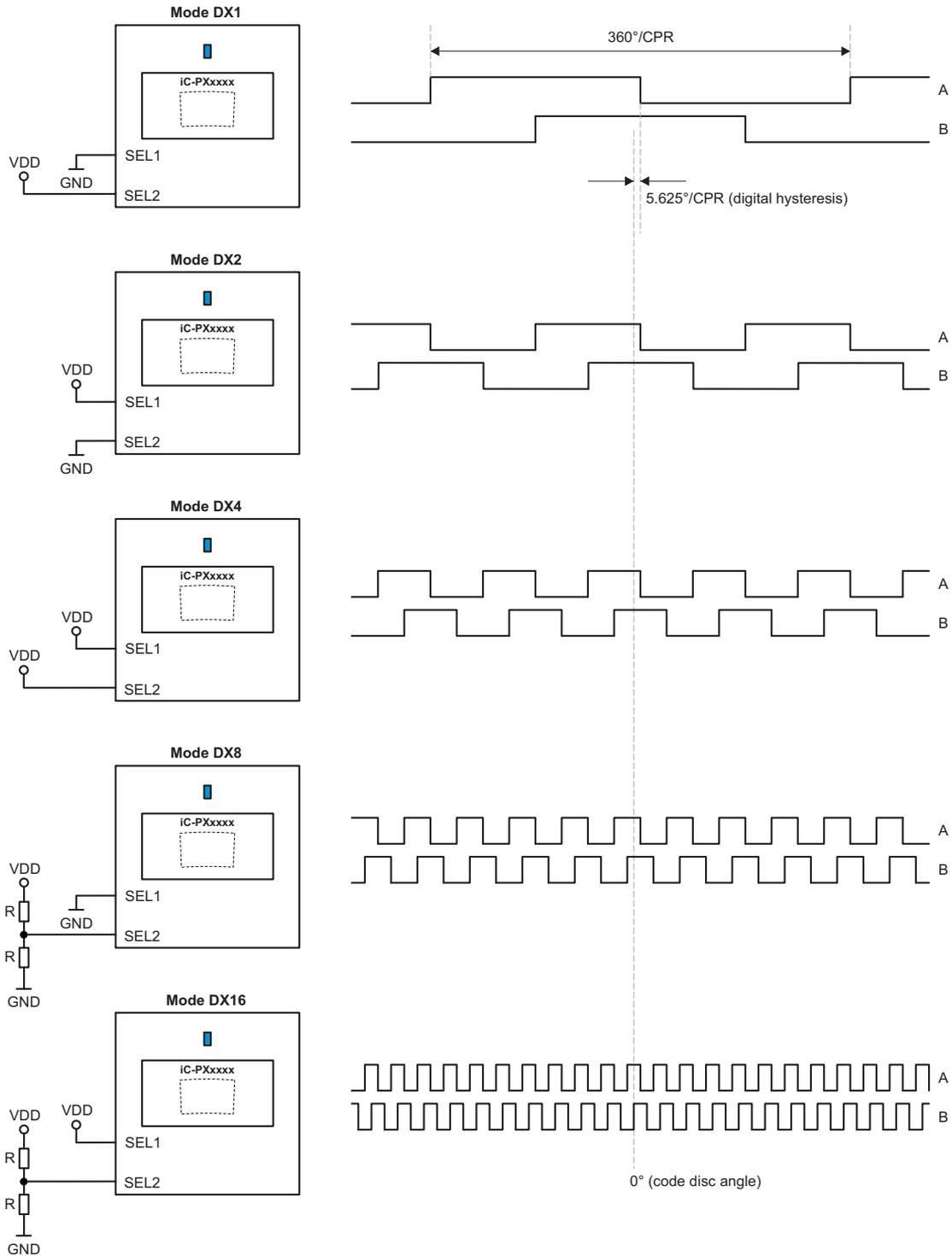


Figure 3: Illustration of operation modes selectable by pins SEL1 and SEL2.

### DIGITAL HYSTERESIS

iC-PX features a digital angle hysteresis of  $\frac{360^\circ}{64 \cdot \text{CPR}}$  (see Elec. Char. 103), i.e., 1 LSB of the resolution in mode DX16. As illustrated in Figure 4, the digital angle hysteresis avoids spurious switching of the A/B outputs at the reversing point when the direction changes, e.g. from cw to ccw or vice versa.

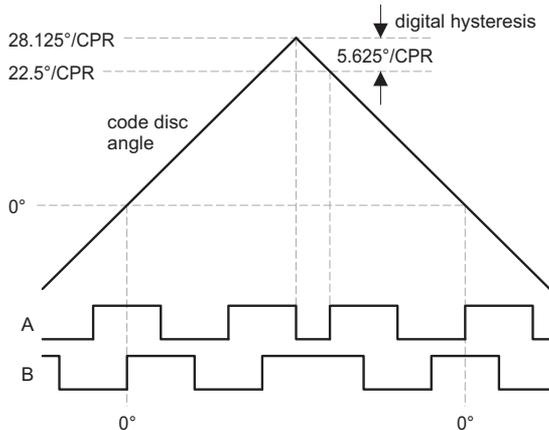


Figure 4: Digital hysteresis in mode DX16.

### MINIMAL EDGE DISTANCE

The edge distance is defined as the time between

two consecutive AB edges, as depicted in Figure 5. iC-PX features a minimal edge distance of 80 ns (typical value).

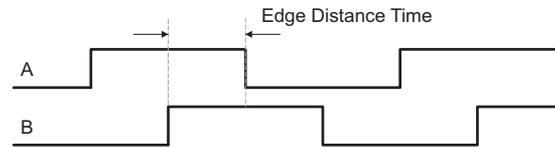


Figure 5: Definition of the edge distance time.

### STARTUP BEHAVIOR

When iC-PX is powered on, the digital outputs are kept in a defined state:

$$A = B = \text{low}$$

Once the logic has detected and verified the code disc, valid A/B signals are then output.

Note: iC-PX will also enter or remain in the startup state, if the supply voltage is too low or if the regulated LED current exceeds a specific value, e.g. due to a misalignment of the code disc. Once the LED current returns to a valid range, the logic again evaluates the code disc and valid A/B signals are output afterwards.

### POWER CONTROL

iC-PX regulates the current of the integrated blue LED, keeping the optical power constant regardless of aging effects, varying temperature or changes in the air gap (iC vs. code disc).

In case of a strong code disc misalignment or in the absence of any code disc, a maximum current is sent

through the LED, which corresponds to an overall supply current of typ. 80 mA.

When code disc and iC-PX are properly aligned, the LED current is significantly reduced and depends then on the code disc type and the air gap (see Table 5 for typ. supply currents).

**SAFETY ADVICE**

Depending on the mode of operation, these devices emit highly concentrated visible blue light which can be hazardous to the human eye.

Products which incorporate these devices have to follow the safety precautions given in IEC 60825-1 and IEC 62471.

**HANDLING ADVICE**

Because of the specific housing materials and geometries used, these LED devices are sensitive to rough handling or assembly and can thus be easily damaged

or may fail in regard to their electro-optical operation. Excessive mechanical stress or load on the LED surface or to the glass windows must be avoided.

### DEVICE OVERVIEW

Device	CPR Native	Code Disc		Supply Current / mA		Max. RPM	
		P/O Code	Type	1.5 mm <sup>1</sup>	2.0 mm <sup>1</sup>	DX1/2/4/8	DX16
<b>∅ 26 mm</b>							
iC-PX2604	360	PX01S	F	11	13	32 000	18 000
<b>∅ 30 mm</b>							
iC-PX3212	500	PX04S	F	16	21	23 000	13 000
<b>∅ 32 mm</b>							
iC-PX3212	512	PX02S	F	16	21	23 000	13 000
<b>∅ 36 mm</b>							
iC-PX3212	625	PX03S	F	16	21	18 000	10 000
<b>∅ 43 mm</b>							
iC-PX3212	720	PX05S	F	16	21	16 000	9 000

Type M = Metal  
 Type P = Polycarbonate  
 Type F = Film  
 Type [ ] = Glass

Reflectance of Al-coated bars >85%.

Device and code disc availability on request.

Table 5: Device overview

<sup>1</sup> Air gap (iC vs. code disc)

### APPLICATION NOTES

Application notes for iC-PX series devices are available separately.

# iC-PX Series

## REFLECTIVE OPTO ENCODERS



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### REVISION HISTORY

Rel.	Rel. Date*	Chapter	Modification	Page
A1	2016-05-24		Initial release	all

Rel.	Rel. Date*	Chapter	Modification	Page
A2	2017-03-21	DESCRIPTION	Added "General notice on materials under excessive conditions"	2
		ABSOLUTE MAXIMUM RATINGS	G002: Changed max. value	5
		THERMAL DATA	T04: Corrected unit	5
		ELECTRICAL CHARACTERISTICS	105/107: Max./Min. value changed to +110/-110 mA 205/206: Added max. value	6
		DEVICE OVERVIEW	Corrected iC-PR2604 to iC-PX2604	10
			Typical supply current values updated	10
		ORDERING INFORMATION	Added Evaluation kit, Mother board	14

Rel.	Rel. Date*	Chapter	Modification	Page
B1	2017-11-09	OPERATION MODES	Description of minimal edge distance added	9
		DESIGN REVIEW: Notes On Chip Functions	Chapter added	11

Rel.	Rel. Date*	Chapter	Modification	Page
B2	2020-06-08	PACKAGING INFORMATION	AOI criteria added	3
		ELECTRICAL CHARACTERISTICS	Added figure for Vs() <sub>low</sub> and Vs() <sub>hi</sub>	6
		SAFETY ADVICE	Section added	10
		HANDLING ADVICE	Section added	10

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\* Release Date format: YYYY-MM-DD

# iC-PX Series

## REFLECTIVE OPTO ENCODERS



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### ORDERING INFORMATION

Type	Package	Options	Order Designation
iC-PXnnnn	8-pin optoDFN, 3 mm x 3 mm, 0.9 mm thickness RoHS compliant	nnnn = device version	iC-PXnnnn oDFN8-3x3
Evaluation kit	Kit with Reflective Encoder IC PX1M (61mm x 64 mm), Code Disc	nnnn = device version	iC-PXnnnn EVAL PX1M
Mother board	Adapter PCB (80 mm x 110 mm)	incl. ribbon cable	iC-PR EVAL PR2M

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