

# iC-PT 3313

6-CH. PHASED ARRAY OPTO ENCODER (33-1250)

preliminary



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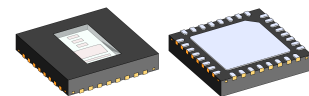
## FEATURES

- Monolithic photodiode array with excellent signal matching
- Very compact size for small encoders
- Moderate track pitch for relaxed assembly tolerances
- Low noise signal amplifiers with high EMI tolerance
- Single-pin programming of 3 operating modes: analog, digital, and x2 interpolation
- A-AND-B gated Z index signal
- Complementary outputs: A, B, Z and NA, NB, NZ
- U, V, W commutation signals, analog and digital
- All outputs +/- 4 mA push-pull, current-limited and short-circuit-proof
- Illumination control with 40 mA high-side LED drive
- Single 3.5 V to 5.5 V operation and low power consumption
- Operating temperature range of -40 to +85 °C (optional -40 to +120 °C)
- Suitable code disc: PT1S 33-1250 (glass)
- OD  $\varnothing$ 33.2 mm, ID  $\varnothing$ 13.0 mm, optical radius 14.5 mm, 1250 ppr and 3 ppr commutation (120°)

## APPLICATIONS

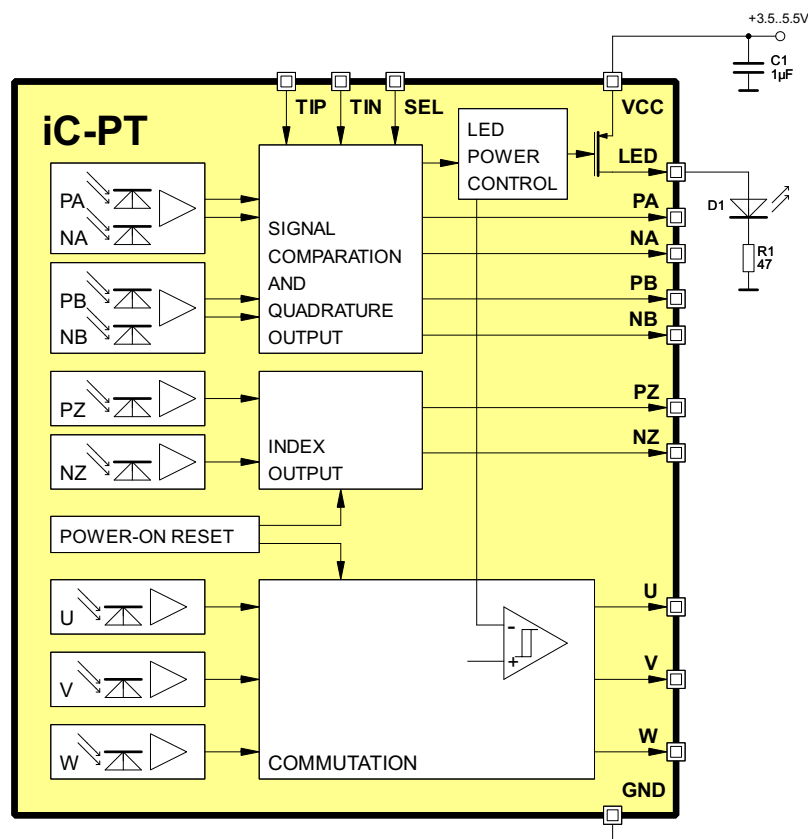
- Incremental encoder
- BLDC motor commutation

## PACKAGES



optoQFN32-5x5  
5 mm x 5 mm x 0.9 mm

## BLOCK DIAGRAM



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## DESCRIPTION

iC-PT3313 is an optical sensor IC with integrated photosensors whose signals are converted into voltages by low-noise transimpedance amplifiers. Precise voltage comparators with hysteresis are used to generate the digital signals, supplied to the output pins via differential +/- 4 mA push-pull drivers.

The built-in LED current controller with its 40 mA driver stage permits a direct connection of the encoder LED. Regardless of aging or changes in temperature the received optical power is kept constant. An external resistor presets the photocurrent operating point and thus the desired illumination level.

Selection input SEL chooses for three different operating modes: regular A/B operation, A/B operation with 2-fold interpolation, or analog operation. With

analog operation the amplified signal voltages are available at the outputs, easing setting-up operation and optical alignment procedures.

Typical applications of iC-PT devices are incremental and motor feedback encoders. To this end, device version iC-PT3313 provides differential A/B tracks and a differential index track, each consisting of multiple photo sensors. The layout of the signal amplifiers is such that there is an excellent paired channel matching, eliminating the needs for signal calibration in most cases.

Additionally, three more signal tracks are provided (U, V and W), which can be used to provide motor commutation information, for example with 120 degree phase-shifted signals.

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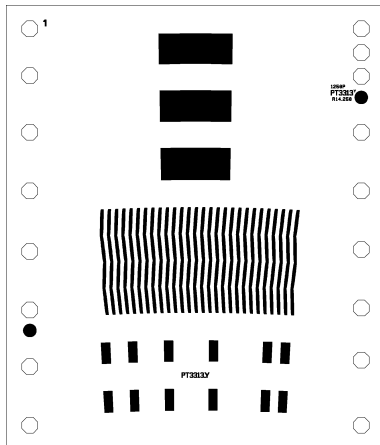


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## PACKAGES

### PAD LAYOUT

Chip size 2.88 mm x 3.37 mm



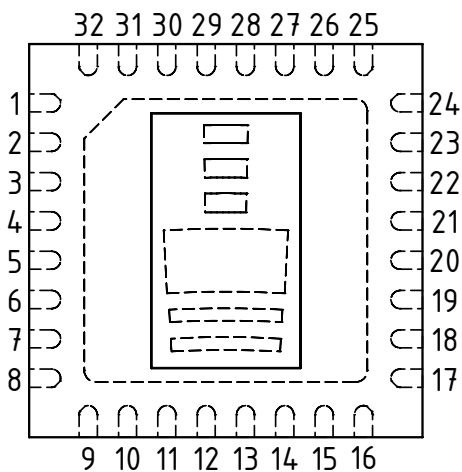
### PAD FUNCTIONS

No. Name Function

See pin configuration.

### PIN CONFIGURATION

oQFN32-5x5 (5 mm x 5 mm)



### PIN FUNCTIONS

No. Name Function

1	VCC	+3.5..5.5 V Supply Voltage
2	LED	LED Controller, High-Side Current Source Output
3	PA	Push-Pull Output A+ / Test Sig. Sin+
4	NA	Push-Pull Output A- / Test Sig. Sin-
5	PB	Push-Pull Output B+ / Test Sig. Cos+
6	NB	Push-Pull Output B- / Test Sig. Cos-
7	PZ	Push-Pull Output Z+ / Test Sig. Z+
8	NZ	Push-Pull Output Z- / Test Sig. Z-
9..16	n.c.	
17	SEL	Op. Mode Selection Input: lo = digital hi = x2 interpolated open = analog (alignment)
18	W	Push-Pull Output W / Test Signal W
19	TIN	Negative Test Current Input
20	V	Push-Pull Output V / Test Signal V
21	TIP	Positive Test Current Input
22	U	Push-Pull Output U / Test Signal U
23	n.c.	
24	GND	Ground
25..32	n.c.	
	BP	Backside Paddle

Pin numbers marked n.c. are not in use. The backside paddle is not intended as an electrical connection point; when used as shield a single link to GND is permissible. The test pins TIP and TIN may remain unconnected. Capacitive pin loads must be avoided when using the analog test signals for alignment purposes.

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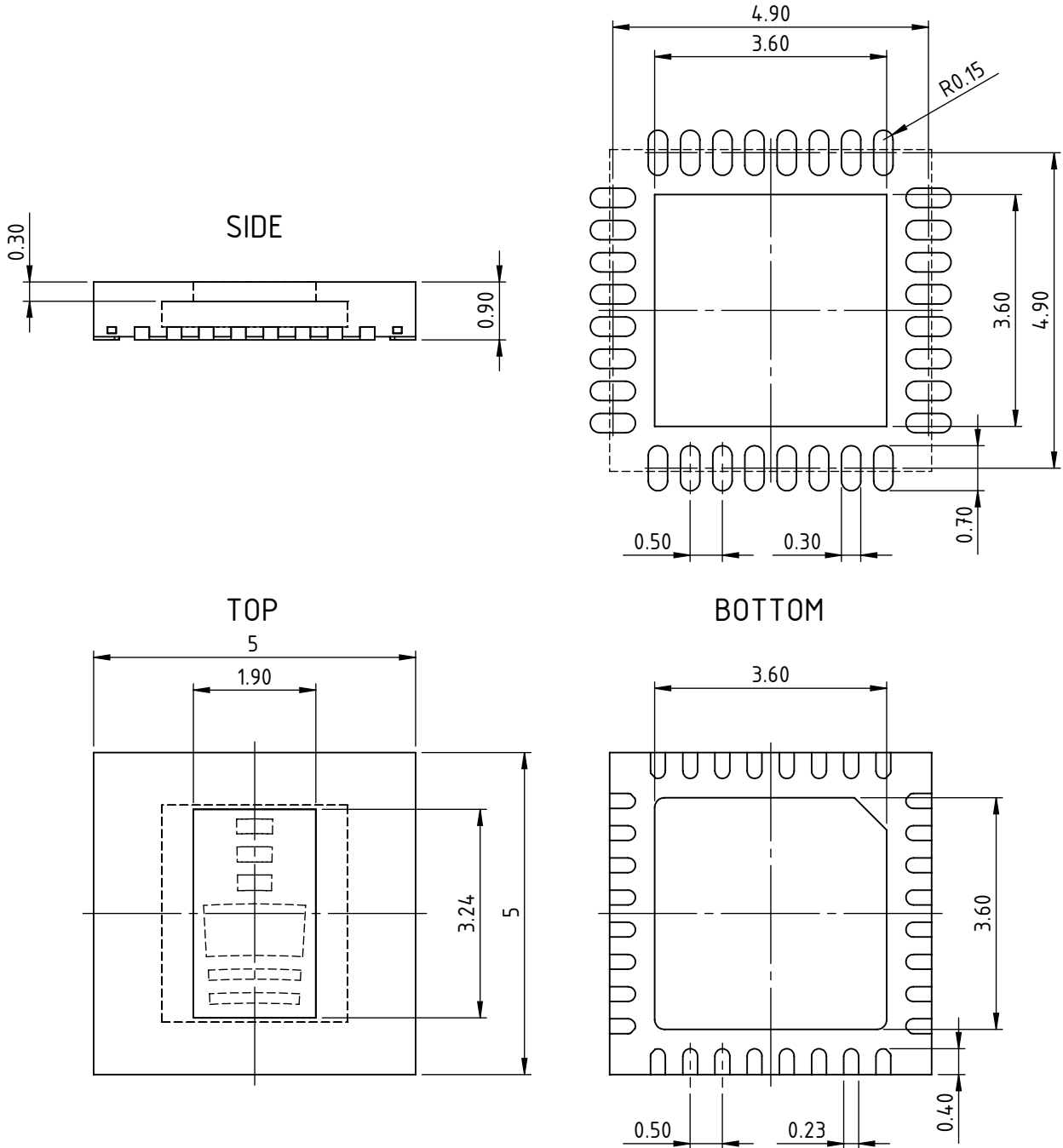
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## PACKAGE DIMENSIONS

### RECOMMENDED PCB-FOOTPRINT



dra\_pt33xx-oqfn32-2\_pack\_1, 10:1

Maximum molding excess +20 µm / -200 µm versus surface of glass.  
All dimensions given in mm.

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## 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	Min.   Max.		Unit
				Min.	Max.	
G001	VCC	Supply Voltage		-0.3	6	V
G002	I(VCC)	Current in VCC		-20	20	mA
G003	V()	Voltage at Output Pins PA, NA, PB, NB, PZ, NZ, U, V, W		-0.3	VCC + 0.3	V
G004	I()	Current in Output Pins PA, NA, PB, NB, PZ, NZ, U, V, W		-20	20	mA
G005	V()	Voltage at LED		-0.3	VCC + 0.3	V
G006	I()	Current in LED		-120	20	mA
G007	V()	Voltage at TIP, TIN, SEL		-0.3	VCC + 0.3	V
G008	I()	Current in TIP, TIN, SEL		-20	20	mA
G009	Vd()	ESD Susceptibility, all pins	HBM, 100 pF discharged through 1.5 kΩ		2	kV
G010	Tj	Junction Temperature		-40	150	°C
G011	Ts	Chip-Storage Temperature		-40	150	°C

## THERMAL DATA

Item No.	Symbol	Parameter	Conditions	Min.   Typ.   Max.			Unit
				Min.	Typ.	Max.	
T01	Ta	Operating Ambient Temperature Range (extended range on request)		-40		85	°C
T02	Ts	Permissible Storage Temperature Range		-40		85	°C
T03	Tpk	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

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.

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### ELECTRICAL CHARACTERISTICS

Operating conditions: VCC = 3.5...5.5 V, Tj = -40...125 °C,  $\lambda_{LED} = \lambda_r = 740$  nm, unless otherwise noted

Item No.	Symbol	Parameter	Conditions				Unit
				Min.	Typ.	Max.	
<b>Total Device</b>							
001	VCC	Permissible Supply Voltage		3.5		5.5	V
002	I(VCC)	Supply Current in VCC	no load, photocurrents within op. range		3	10	mA
003	Vc(lo)	Clamp-Voltage lo at all pins	I() = -4 mA, versus GND	-1.2		-0.3	V
004	Vc(hi)	Clamp-Voltage hi at all pins	I() = 4 mA			11	V
005	Vc(hi)	Clamp-Voltage hi at LED, PA, NA, PB, NB, PZ, NZ, U, V, W	I() = 4 mA, versus VCC	0.3		1.2	V
006	Vc(hi)	Clamp-Voltage hi at SEL, TIP, TIN	I() = 4 mA, versus VCC	0.7		2.2	V
<b>Photosensors</b>							
101	$\lambda_{ar}$	Spectral Application Range	$Se(\lambda_{ar}) = 0.25 \times S(\lambda)_{max}$	400		950	nm
102	$\lambda_{pk}$	Peak Sensitivity Wavelength			680		nm
103	Aph()	Radiant Sensitive Area	PA, PB, NA, NB (sum of segments) U, V, W (per segment) PZ, NZ (sum of segments)		0.128 0.128 0.0648		mm <sup>2</sup> mm <sup>2</sup> mm <sup>2</sup>
104	S( $\lambda_r$ )	Spectral Sensitivity	$\lambda_{LED} = 740$ nm		0.5		A/W
105	S( $\lambda$ )max	Maximum Spectral Sensitivity	$\lambda_{LED} = \lambda_{pk}$		0.55		A/W
106	E()mxpk	Permissible Irradiance	$\lambda_{LED} = \lambda_{pk}$ , Vout() < Vout()mx;  PA, PB, NA, NB  U, V, W  PZ, NZ		1.3  0.9  2		mW/cm <sup>2</sup> mW/cm <sup>2</sup> mW/cm <sup>2</sup> mW/cm <sup>2</sup>
<b>Photocurrent Amplifiers</b>							
201	Iph()	Permissible Photocurrent Operating Range		0		550	nA
202	$\eta()$ r	Photo Sensitivity (light-to-voltage conversion ratio)	for PA, PB, NA, NB for PZ, NZ, U, V, W	0.1 0.2	0.3 0.4	0.5 0.6	V/ $\mu$ W V/ $\mu$ W
203	Z()	Equivalent Transimpedance Gain	Z = Vout() / Iph(), Tj = 27 °C; for PA, PB, NA, NB for PZ, NZ, U, V, W	0.56 0.66	0.75 1.0	1 1.36	M $\Omega$ M $\Omega$
204	TCz	Temperature Coefficient of Transimpedance Gain			-0.12		%/°C
205	$\Delta Z()$ pn	Transimpedance Gain Matching	SEL open, P vs. N path per diff. channel	-0.2		0.2	%
206	$\Delta V_{out}()$	Dark Signal Matching of A, B	SEL open, output vs. output	-8		8	mV
207	$\Delta V_{out}()$	Dark Signal Matching of U, V, W	SEL open, output vs. output	-12		12	mV
208	$\Delta V_{out}()$	Dark Signal Matching of A, B, Z, U, V, W	SEL open, any output vs. any output	-24		24	mV
209	$\Delta V_{out}()$ pn	Dark Signal Matching	SEL open, P vs. N path per diff. channel	-2.5		2.5	mV
211	fc(hi)	Cut-off Frequency (-3 dB)			400		kHz
<b>Analog Outputs PA, NA, PB, NB, PZ, NZ, U, V, W</b>							
301	Vout()mx	Maximum Output Voltage	illumination to E()mxpk	1.04	1.27	1.8	V
302	Vout()d	Dark Signal Level	load 100 k $\Omega$ vs. +2 V	640	770	985	mV
303	Vout()acmx	Maximum Signal Level	Vout()acmx = Vout()mx - Vout()d	0.3	0.5	0.75	V
304	Isc(hi)	Short-Circuit Current hi	SEL open, load current to ground	100	1800	3000	$\mu$ A
305	Isc(lo)	Short-Circuit Current lo	SEL open, load current to IC	20	40	200	$\mu$ A
306	Ri()	Internal Output Resistance	f = 1 kHz	250	750	2250	$\Omega$

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### ELECTRICAL CHARACTERISTICS

Operating conditions: VCC = 3.5...5.5 V, Tj = -40...125 °C, λ<sub>LED</sub> = λ<sub>r</sub> = 740 nm, unless otherwise noted

Item No.	Symbol	Parameter	Conditions				Unit
				Min.	Typ.	Max.	
<b>Comparators</b>							
401	Vt() <sub>hi</sub>	Upper Comparator Threshold	$I_{ph}()_p \times Z()_p > I_{ph}()_n \times Z()_n$ , resp. $I_{ph}()_p \times Z()_p > \text{internal VREF}$	5	12	25	mV
402	Vt() <sub>lo</sub>	Lower Comparator Threshold	$I_{ph}()_p \times Z()_p < I_{ph}()_n \times Z()_n$ , resp. $I_{ph}()_p \times Z()_p < \text{internal VREF}$	5	12	25	mV
403	Vt() <sub>hys</sub>	Comparator Hysteresis	$Vt()_{hys} = Vt()_{hi} - Vt()_{lo}$	10	24	50	mV
<b>LED Current Controller</b>							
501	I <sub>op</sub> ()	Permissible LED Output Current		-40		0	mA
502	Vs() <sub>hi</sub>	Saturation Voltage hi	$Vs()_{hi} = VCC - V(\text{LED})$ ; I() = -40 mA	0.25	0.5	1	V
503	Isc() <sub>hi</sub>	Short-Circuit Current hi	V() = 0 V	-150		-50	mA
<b>Digital Outputs PA, NA, PB, NB, PZ, NZ, U, V, W</b>							
601	Vs() <sub>lo</sub>	Saturation Voltage lo	VCC = 4.5...5.5 V, I() = 4 mA, Tj = 70 °C			0.4	V
602	Vs() <sub>lo</sub>	Saturation Voltage lo	VCC = 4.5...5.5 V, I() = 4 mA, Tj = 85 °C			0.5	V
603	Vs() <sub>lo</sub>	Saturation Voltage lo	VCC = 3.5...4.5 V, I() = 4 mA			0.6	V
604	Isc() <sub>lo</sub>	Short-Circuit Current lo	V() = VCC	7		70	mA
605	Vs() <sub>hi</sub>	Saturation Voltage hi	$Vs()_{hi} = VCC - V()$ , I() = -4 mA; VCC = 4.5...5.5 V			0.4	V
606	Vs() <sub>hi</sub>	Saturation Voltage hi	$Vs()_{hi} = VCC - V()$ , I() = -4 mA; VCC = 3.5...4.5 V			0.6	V
607	Isc() <sub>hi</sub>	Short-Circuit Current hi	V() = 0 V	-70		-7	mA
<b>Selection Input SEL</b>							
701	Vt1() <sub>hi</sub>	Upper Threshold Voltage hi	for A/B mode with x2 interpolation	78	80	82	%VCC
702	Vt1() <sub>lo</sub>	Upper Threshold Voltage lo	for A/B mode with x2 interpolation	68	70	72	%VCC
703	Vt1() <sub>hys</sub>	Upper Threshold Hysteresis	$Vt1()_{hys} = Vt1()_{hi} - Vt1()_{lo}$	8	10	12	%VCC
704	Vt2() <sub>hi</sub>	Lower Threshold Voltage hi	for A/B mode	28	30	32	%VCC
705	Vt2() <sub>lo</sub>	Lower Threshold Voltage lo	for A/B mode	18	20	22	%VCC
706	Vt2() <sub>hys</sub>	Lower Threshold Hysteresis	$Vt2()_{hys} = Vt2()_{hi} - Vt2()_{lo}$	8	10	12	%VCC
707	V <sub>0</sub> ()	Pin-Open Voltage	for analog mode	45	50	55	%VCC
708	R <sub>pd</sub> ()	Pull-Down Resistor	SEL to GND, V(SEL) = VCC	70	100	140	kΩ
709	R <sub>pu</sub> ()	Pull-Up Resistor	VCC to SEL, V(SEL) = 0 V	70	100	140	kΩ
710	V <sub>pd</sub> ()	Pull-Down Voltage vs. VCC/2	$V_{pd}() = V() - VCC/2$ ; I() = 0...5 μA			0.5	V
711	V <sub>pu</sub> ()	Pull-Up Voltage vs. VCC/2	$V_{pu}() = V() - VCC/2$ ; I() = -5...0 μA	-0.5			V
<b>Test Circuit Inputs TIP, TIN</b>							
801	I() <sub>test</sub>	Permissible Test Current Range	test mode active	10		600	μA
802	V() <sub>test</sub>	Test Pin Voltage	test mode active, I() = 200 μA	1.25	1.5	1.75	V
803	I <sub>pd</sub> ()	Test Pin Pull-Down Current	test mode not active, V() = 0.4 V	60	100	160	μA
804	I <sub>pd</sub> ()	Test Pin Pull-Down Current	V() = VCC	0.7	2	3	mA
805	I <sub>t</sub> () <sub>on</sub>	Test Mode Activation Threshold		80	130	190	μA
806	CR()	Test Mode Current Ratio I()/I <sub>ph</sub> ()	test mode active, I() = 200 μA	1500	3000	5000	
<b>Power-On-Reset Circuit</b>							
901	VCC <sub>on</sub>	Turn-on Threshold VCC (power-on release)	increasing voltage at VCC		2.6	3.45	V
902	VCC <sub>off</sub>	Turn-off Threshold VCC (power-down reset)	decreasing voltage at VCC	1.4	2.4		V
903	VCC <sub>hys</sub>	Threshold Hysteresis	$VCC_{hys} = VCC_{on} - VCC_{off}$	50	170	300	mV

### Z INDEX SIGNAL

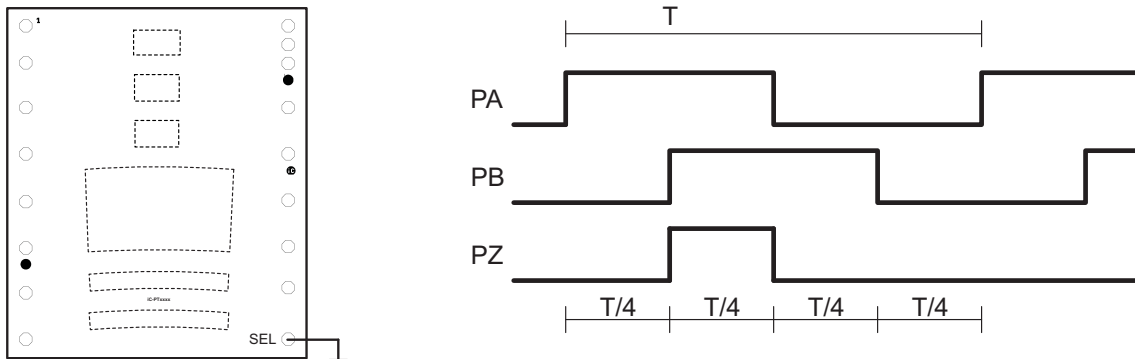


Figure 1: A-AND-B gated Z index signal at x1 interpolation (SEL = lo)

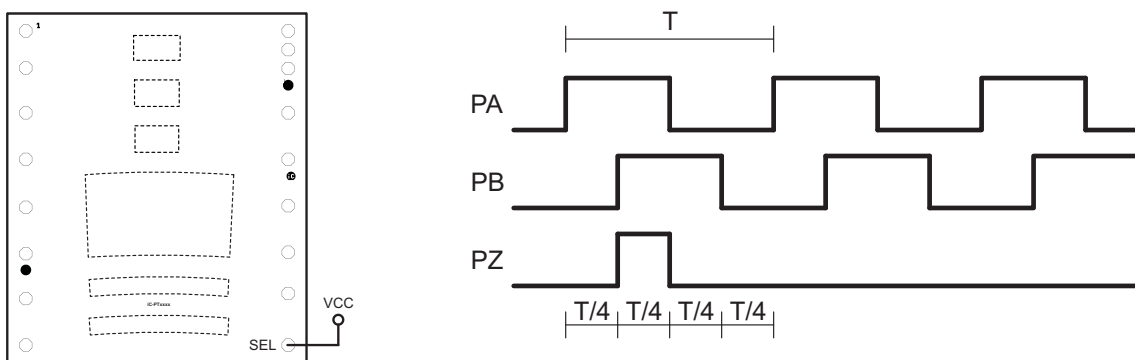


Figure 2: A-AND-B gated Z index signal at x2 interpolation (SEL = hi)



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## APPLICATION CIRCUITS

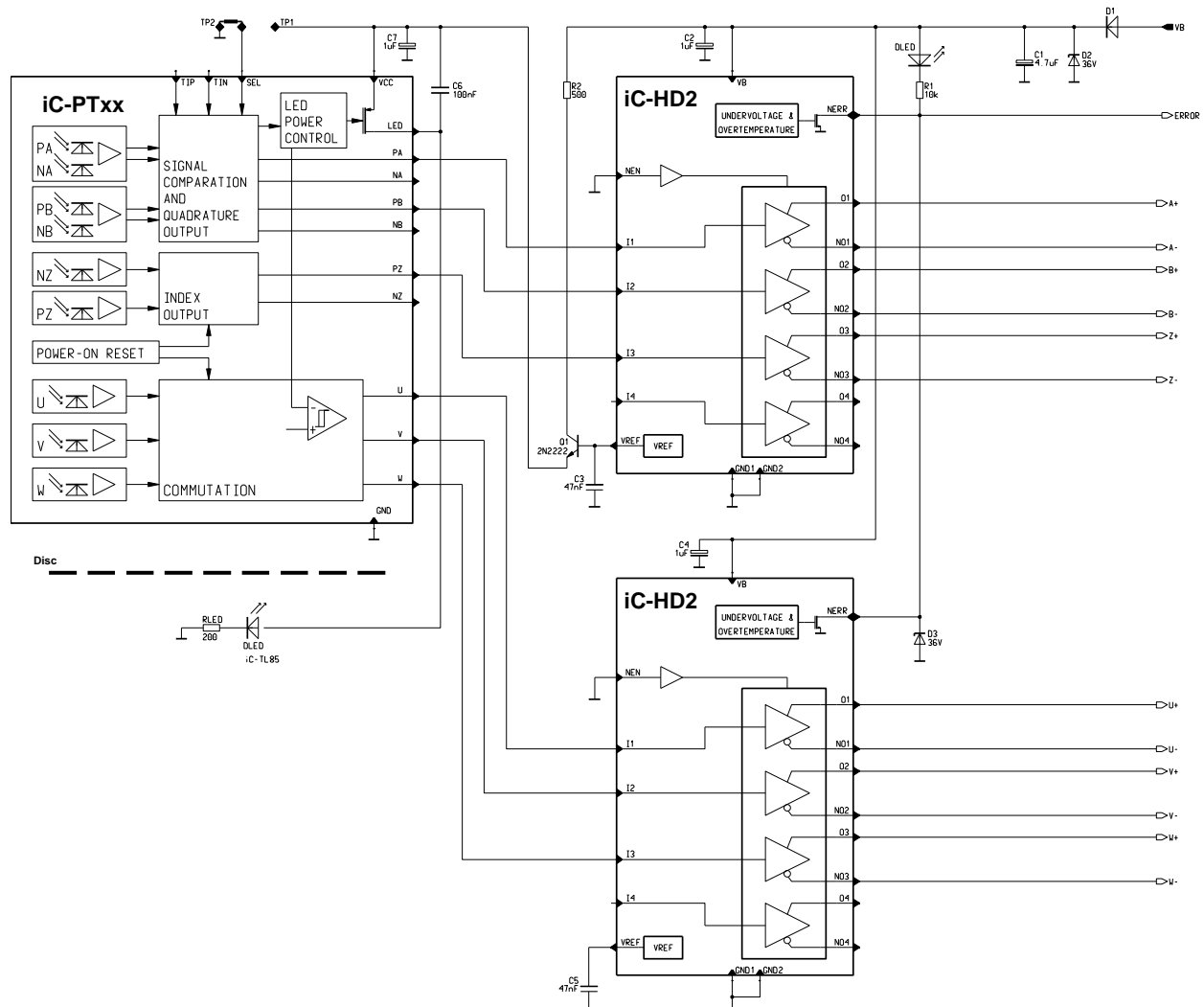


Figure 3: Circuit example of an incremental/commutation encoder with RS422 line drivers for 5 V applications.

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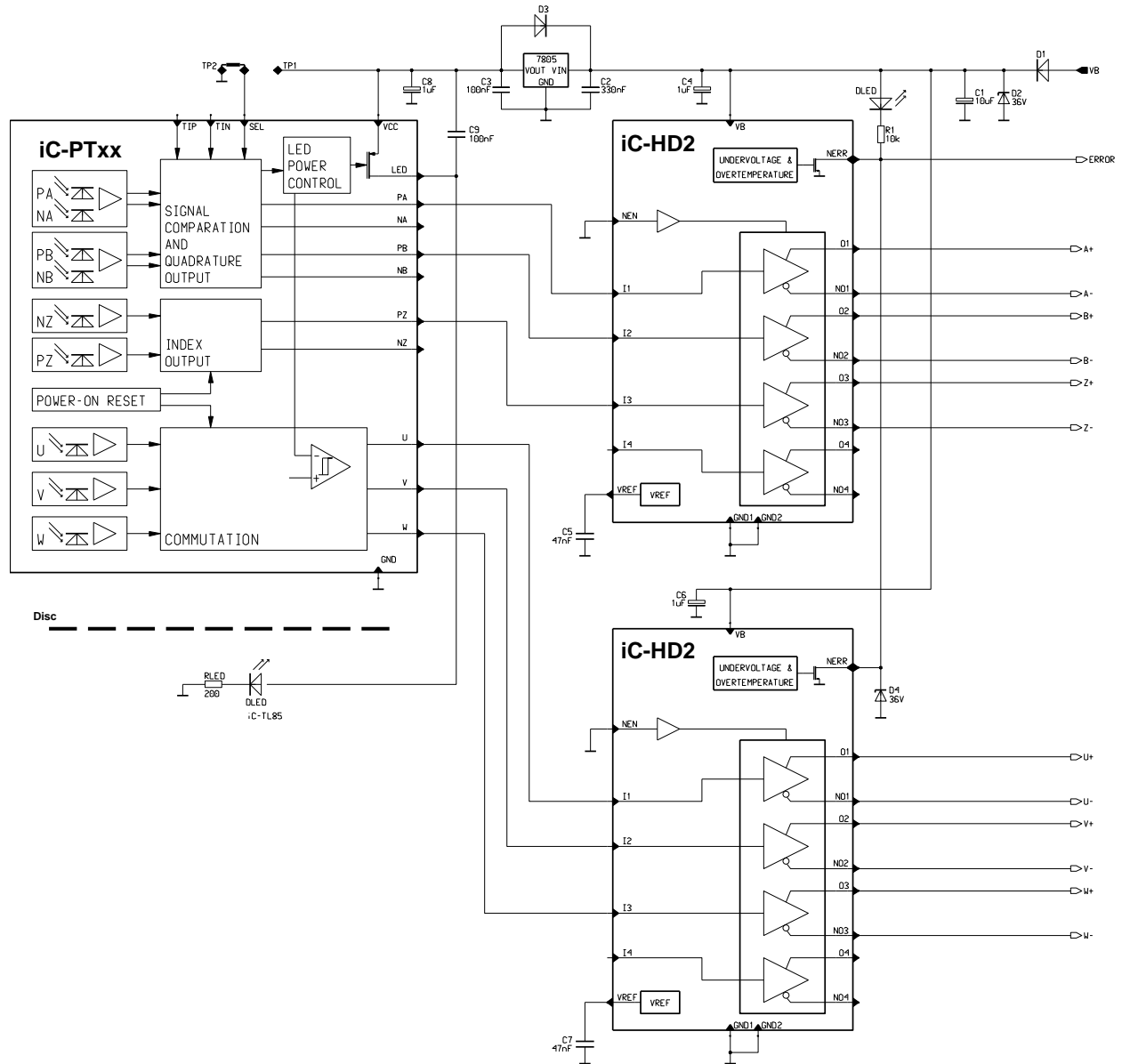


Figure 4: Circuit example of an incremental/commutation encoder with differential line drivers for a supply voltage range of 10V to 30V.

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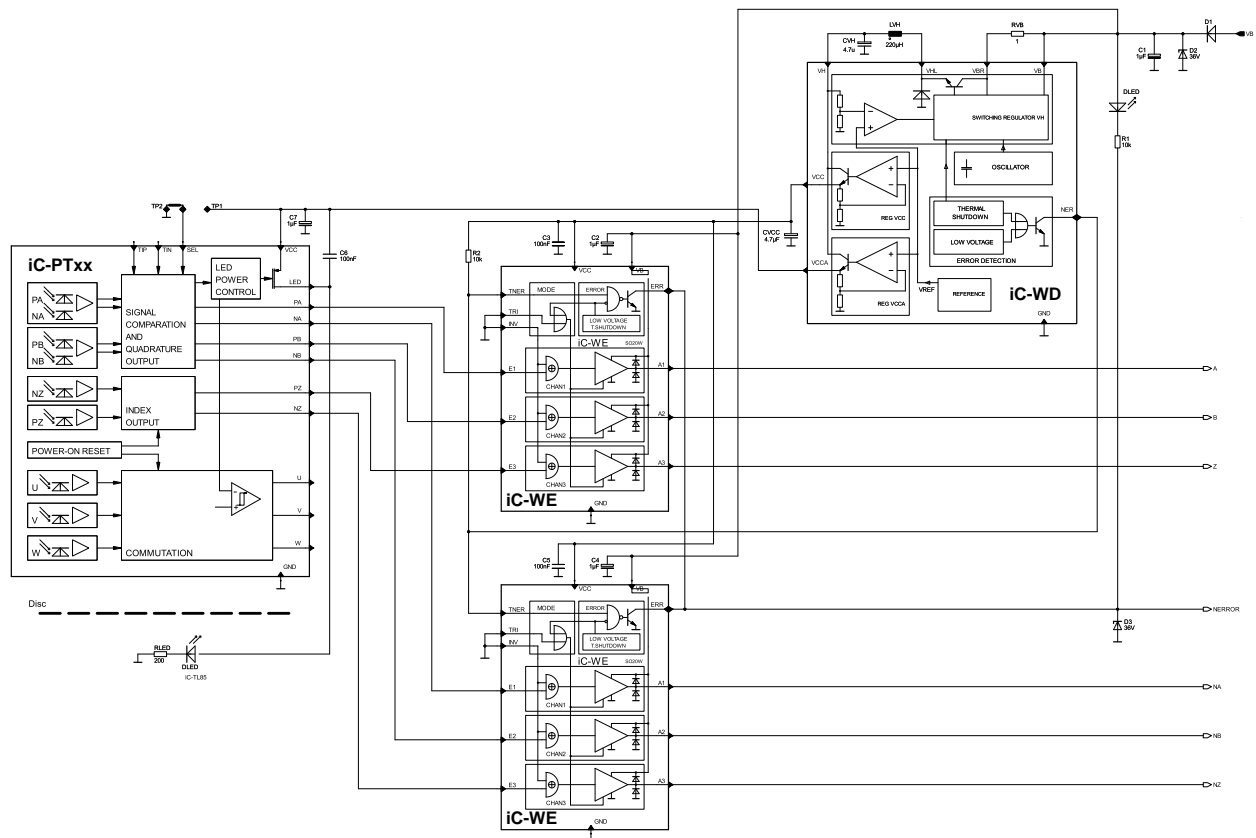


Figure 5: Circuit example of an incremental encoder for 24 V applications and long cables (supply voltage range of 10 V to 30 V, cable length of up to 100 m).

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## ORDERING INFORMATION

Type	Package	Options	Order Designation
iC-PT3313	32-pin optoQFN, 5 mm x 5 mm, 0.9 mm thickness	glass lid  Encoder Disc  1250 PPR +3 PPR, OD/ID $\varnothing$ 33.2/13 mm, glass	iC-PT3313 oQFN32-5x5   PT1S 33-1250

For technical support, information about prices and terms of delivery please contact:

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