iC-PT...H Encoder blue® Series

preliminary

6-CH. PHASED ARRAY OPTO ENCODERS

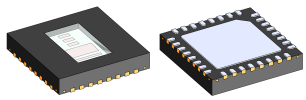
FEATURES

- For code discs of ⌀ 33 mm: iC-PT3320H, 3348H, 3325H
- Compact, high resolution incremental encoder ICs with up to 2500 CPR (native) and 10,000 CPR (interpolated)
- Monolithic *HD Phased Array* with excellent signal matching
- Moderate track pitch for relaxed assembly tolerances
- Low-noise signal amplifiers with high EMI tolerance
- Pin-selectable operating modes:
  analog, comparated (x1), interpolated (x2, x4)
- Pin-selectable index gating:
  ungated (1 T), B-gated (0.5 T), AB-gated (0.25 T)
- Complementary quadrature outputs: A, B, Z and NA, NB, NZ
- Commutation signal outputs: U, V, W
- Short-circuit-proof, current-limited, +/- 4 mA push-pull
- Analog signal output for ease of alignment and resolution enhancement by external interpolation
- LED power control with 40 mA high-side driver
- Low power consumption from single 3.5 V to 5.5 V supply
- Operating temperature range of -40 °C to +120 °C
- Evaluation kits with LED and code disc available for sampling

APPLICATIONS

- Incremental encoder
- Brushless DC motor commutation
- Industrial drives

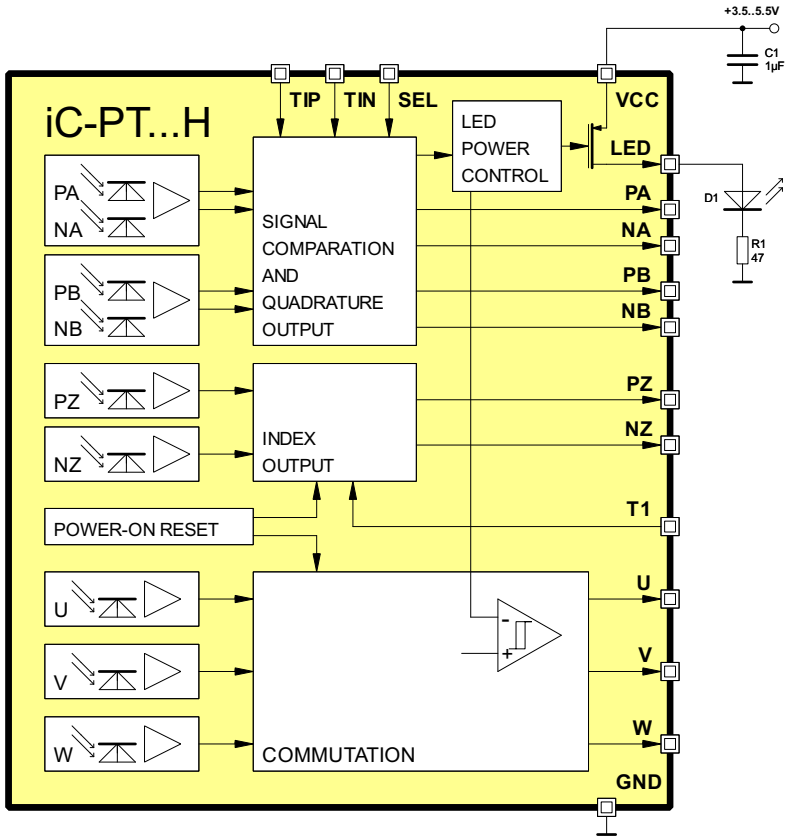
PACKAGES



optoQFN32-5x5

5 mm x 5 mm x 0.9 mm

BLOCK DIAGRAM



DESCRIPTION

The iC-PT H-series represents advanced optical encoder ICs featuring integrated photosensors arranged as an *HD Phased Array*, providing signal fidelity at relaxed alignment tolerances.

Its typical application are incremental encoders for motor speed control and commutation. To this end, the devices provide differential A/B tracks, a differential index track and three more tracks to generate block commutation signals.

Where the optical radius and the native cycles per revolution (CPR) are determined by the device version, the adaption to the motor polecount is carried out by the code disc, for instance with 4 CPR and 90 degree phase shift to operate 4-phase brushless motors[1)].

Encoder blue® series devices feature *blue-enhanced* photosensors requiring the application of a LED with short wavelenght, preferably iC-TL46. An outstanding jitter performance is the key benefit due to the improvements in signal contrast.

Low-noise transimpedance amplifiers, arranged in a paired layout to ensure excellent channel matching, are used to convert the scanner's signals into voltages of several hundred millivolts[2)].

Precision comparators with hysteresis generate the digital signals subsequently, either native or interpolated, which are then output by differential ±4 mA push-pull drivers.

The built-in averaging LED power controller with its 40 mA driver permits a direct connection of the encoder LED. The received optical power is kept constant regardless of aging effects or changes in temperature.

Various operating modes are selectable at multi-level input SEL[3)]: digital output with native (x1) or interpolated resolution (x2 or x4), analog output or mixed analog/digital output; the latter combines an output of sine/cosine signals with comparated UVW commutation signals. During analog operation the amplified signal voltages are available at the outputs for inspection and monitoring of encoder assembly, or to feed external interplation circuits.

Index gating is also pin-selectable at input T1[3)]: the options are ungated, respectively T-gated if using interpolated output, B-gated and AB-gated.

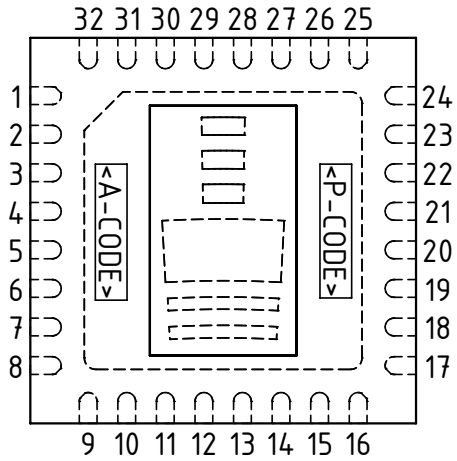
All devices run at single-sided supplies from 3.5 V up to 5.5 V and feature a low power consumption.

iC-PT33xxH Encoder blue® Series
Optical radius 14.5 mm, code disc ∅ 33.0 mm;
Native CPR: 2000, 2048, 2500.

[1)] Standard on code discs available for sampling.
[2)] Operating point varies by device version and CPR.
[3)] For ease of replacement, iC-PT H-Series pin functions are backwards compatible to iC-PT series ICs (except for iC-PT3325 which does not feature pin T1).

PACKAGING INFORMATION

PIN CONFIGURATION
oQFN32-5x5 (5 mm x 5 mm)

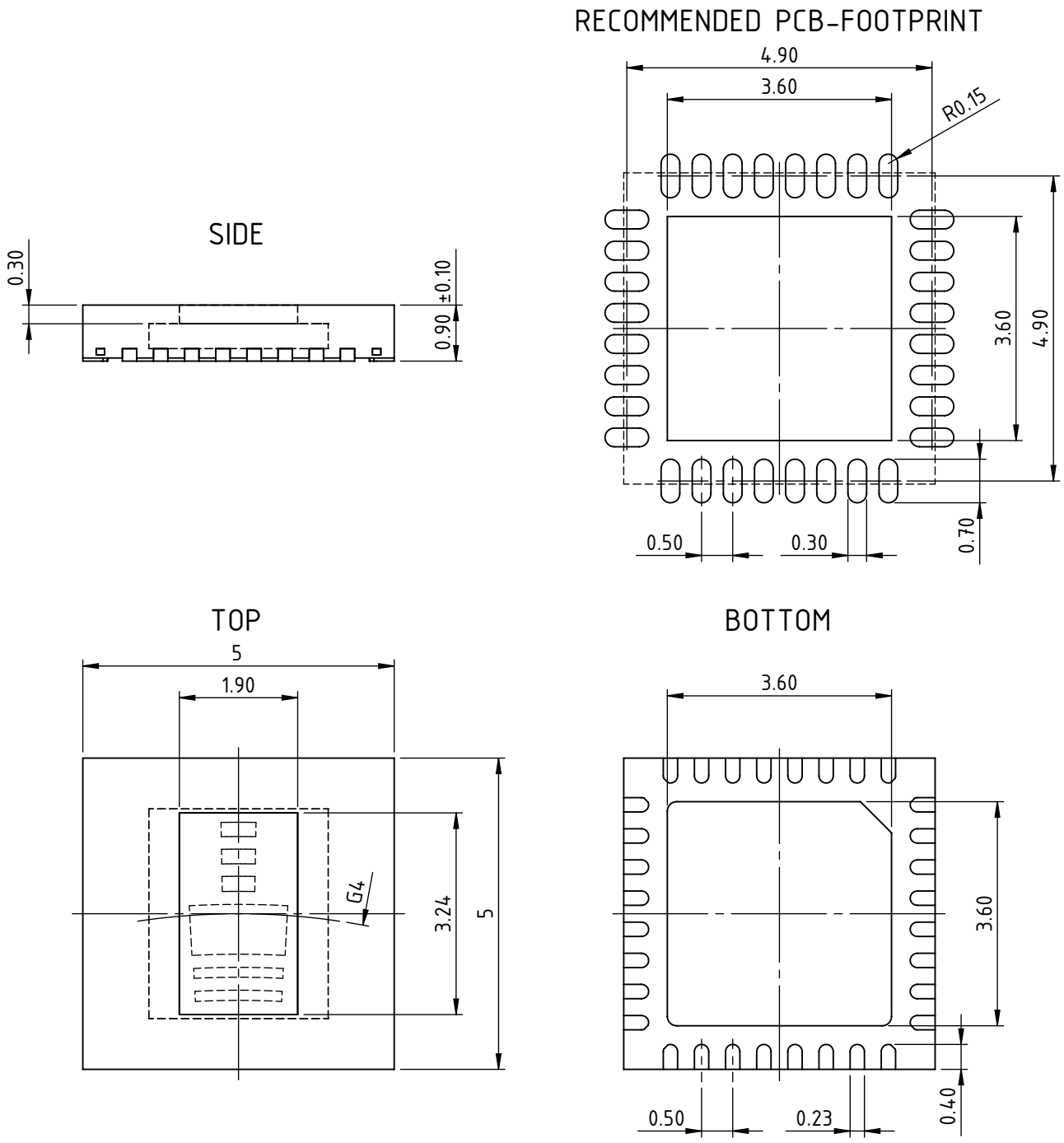


PIN FUNCTIONS

No.	Name	Function
1	VCC	+3.5 V...+5.5 V Supply Voltage
2	LED	LED Controller, High-Side Current Source Output
3	PA	Push-Pull Output A+ / Analog Sin+ [1]
4	NA	Push-Pull Output A- / Analog Sin-
5	PB	Push-Pull Output B+ / Analog Cos+
6	NB	Push-Pull Output B- / Analog Cos-
7	PZ	Push-Pull Output Z+ / Analog Z+
8	NZ	Push-Pull Output Z- / Analog Z-
9..16	n.c.[2]	
17	SEL	Op. Mode Selection Input: 100% VCC = x2 interpolated 75% VCC = ABZ analog, UVW digital 50% VCC (or pin open) = all analog 25% VCC = x4 interpolated 0% VCC = x1 interpolated
18	W	Push-Pull Output W / Analog W
19	TIN	Negative Test Current Input [3]
20	V	Push-Pull Output V / Analog V
21	TIP	Positive Test Current Input [3]
22	U	Push-Pull Output U / Analog U
23	T1	Index Gating Selection Input: lo = 0.5 T (B-gated), hi = 1 T (ungated/T-gated), open = 0.25 T (AB-gated)
24	GND	Ground
25..32	n.c.	
	BP	Backside Paddle [4]

IC top marking: <P-CODE> = product code, <A-CODE> = assembly code (subject to changes);
1) Capacitive pin loads must be avoided when using the analog output signals.
2) Pin numbers marked n.c. are not connected.
3) The test pins TIP and TIN may remain unconnected.
4) Connecting the backside paddle is recommended 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-220.
Positional tolerance of sensor pattern: ±70µm / ±1° (with respect to center of backside pad).
G4: radius of chip center (refer to the relevant encoder disc and code description).
Maximum molding excess +20µm / -75µm versus surface of glass/reticle.

drb_ptxx-oqfn32-2_pack_1, 10:1

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
G001	VCC	Voltage at VCC		-0.3	6	V
G002	I(VCC)	Current in VCC		-20	170	mA
G003	V()	Voltage at all Pins		-0.3	VCC + 0.3	V
G004	I()	Current in Output Pins PA, NA, PB, NB, PZ, NZ, U, V, W, TIP, TIN, SEL, T1		-20	20	mA
G005	I()	Current in LED		-120	20	mA
G006	Vd()	ESD Susceptibility, all pins	HBM, 100 pF discharged through 1.5 kΩ		2	kV
G007	Tj	Junction Temperature		-40	150	°C
G008	Ts	Chip Storage Temperature		-40	150	°C

THERMAL DATA

Operating conditions: VCC = 3.5...5.5 V

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
T01	Ta	Operating Ambient Temperature Range		-40		120	°C
T02	Ts	Permissible Storage Temperature Range		-40		120	°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.

ELECTRICAL CHARACTERISTICS

Operating conditions: VCC = 3.5...5.5 V, Tj = -40...125 °C, λ_{LED} = 460 nm, unless otherwise noted

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Total Device							
001	VCC	Permissible Supply Voltage		3.5		5.5	V
002	I(VCC)	Supply Current	photocurrents within op. range, no load		6		mA
Photosensors							
101	λar	Spectral Application Range	Se(λar) = 0.25 x S(λpk)	400		950	nm
Photocurrent Amplifiers							
201	Z()	Equivalent Transimpedance Gain	Z = Vout() / Iph(), Tj = 27 °C; for PA, PB, NA, NB for PZ, NZ for U, V, W		 0.5 1.25 1...1.6		 MΩ MΩ MΩ
Analog Outputs: PA, NA, PB, NB, PZ, NZ, U, V, W							
301	Vout()mx	Permissible Max. Output Voltage				1.8	V
302	Vout()ac	AC Signal Level	LED iC-TL46		0.2...0.3		Vpp
303	Vout()d	Dark Signal Level	I() < 10 µA	580	770	985	mV
304	Ri()	Output Resistance		250	750	2250	Ω
Comparators							
401	Vt()hys	Switch Hysteresis			24		mV
LED Power Control							
501	Iop()	LED Output Current Control Range		0		40	mA
502	Ictrl()	Controlled LED Output Current	refer to Table 5 for details		5...12		mA
503	Vs()hi	Saturation Voltage hi	Vs()hi = VCC - V(LED); I() = -40 mA			0.6	V
504	Isc()hi	Short-Circuit Current hi	V() = 0 V	-150		-50	mA
Digital Outputs: PA, NA, PB, NB, PZ, NZ, U, V, W							
601	fout	Maximum Output Frequency	comparated x2 interpolated x4 interpolated	400 800 1600			kHz kHz kHz
602	AArel	AB Duty Cycle Variation	AC signal according to item 302, comparated or interpolated, see Figure 1	-10		10	%
603	Vs()lo	Saturation Voltage lo	I() = 4 mA			0.6	V
604	Isc()lo	Short-Circuit Current lo	V() = VCC	7		70	mA
605	Vs()hi	Saturation Voltage hi	Vs()hi = VCC - V(), I() = -4 mA			0.6	V
606	Isc()hi	Short-Circuit Current hi	V() = 0 V	-70		-7	mA
Operating Mode Selection Input: SEL							
701	Vmod()	Mode Selection (see Figure 2)	x2 interpolated analog ABZ, digital UVW all analog x4 interpolated x1 comparated	95 70 45 20 0		100 80 55 30 5	%VCC %VCC %VCC %VCC %VCC
702	Vmod()hys	Hysteresis			10		%VCC
703	V0()	Pin-Open Voltage		45	50	55	%VCC
704	Rpd()	Pull-Down Resistor	V(SEL) = VCC	65			kΩ
705	Rpu()	Pull-Up Resistor	V(SEL) = 0 V	65			kΩ
Index Gating Selection Input: T1							
801	Vgate()	Gating Selection (see Figure 3)	ungated (1 T with interpolation) AB-gated (0.25 T) B-gated (0.5 T)	82 32 0		100 68 18	%VCC %VCC %VCC
802	Vgate()hys	Hysteresis			10		%VCC
803	V0()	Pin-Open Voltage	for index length 0.25 T (AB-gated)	45	50	55	%VCC
804	Rpd()	Pull-Down Resistor	V(T1) = VCC	65			kΩ
805	Rpu()	Pull-Up Resistor	V(T1) = 0 V	65			kΩ

ELECTRICAL CHARACTERISTICS: Diagrams

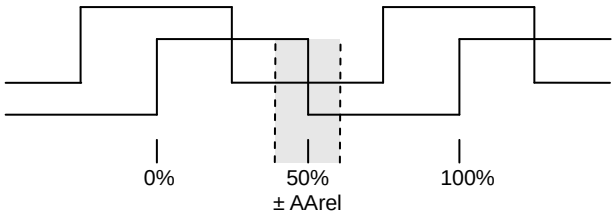


Figure 1: Definition of AB duty cycle variation.

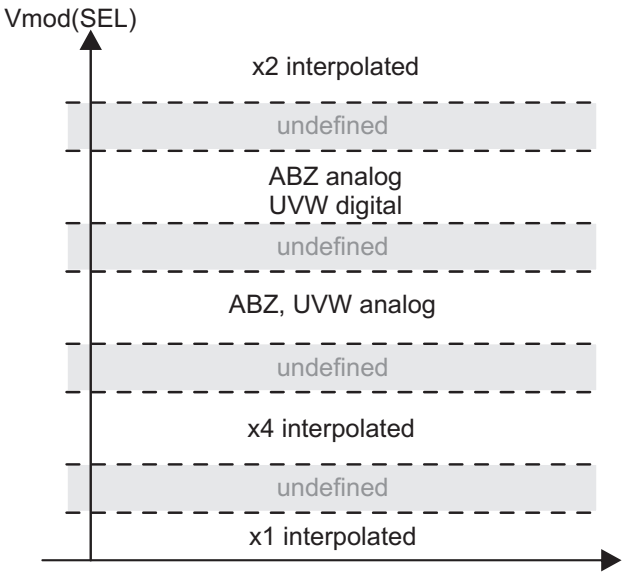


Figure 2: Operating mode selection at pin SEL.

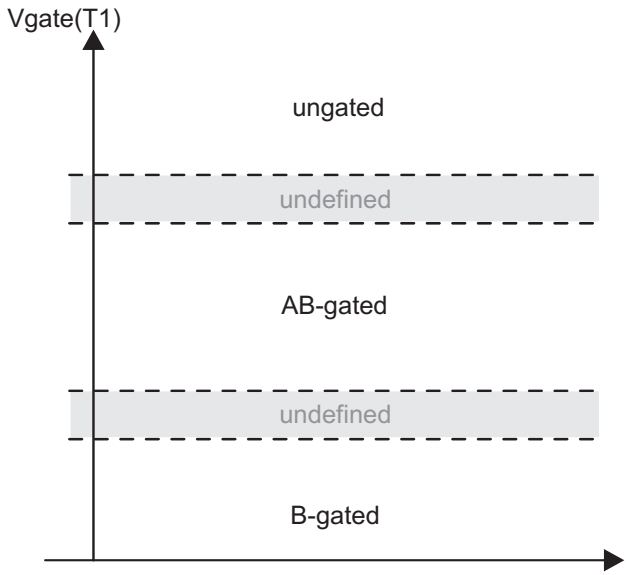


Figure 3: Index gating selection at pin T1.

DIGITAL OUTPUT SIGNALS

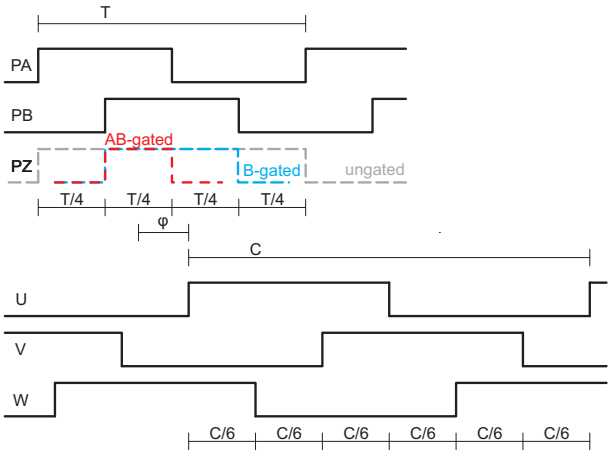


Figure 4: Encoder quadrature signals and motor commutation signals.

iC-PT H-series devices determine the optical radius and the native cycles per revolution for the quadrature outputs by its phased array design.

The U, V, W commutation signals can be configured independently of the device: the pulse count, period length and phase shift is determined by the code disc.

Standard code discs available for sampling provide 4 CPR each for U/V/W, with a period length of 90 degrees (C). A phase shift of 0 degrees (φ) between U and Z edges must be considered during alignment. Ideally, the rising edge of U meets the index Z.

For detailed specifications, refer to the relevant code disc datasheets, available separately.

ANALOG OUTPUT SIGNALS

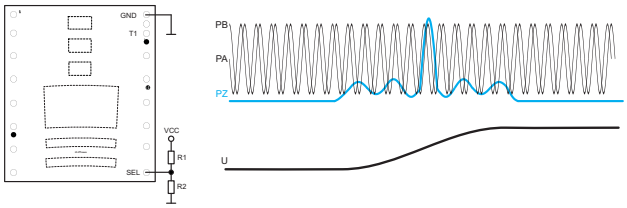


Figure 5: Example of analog ABZ / analog UVW (pin SEL = 50% VCC)

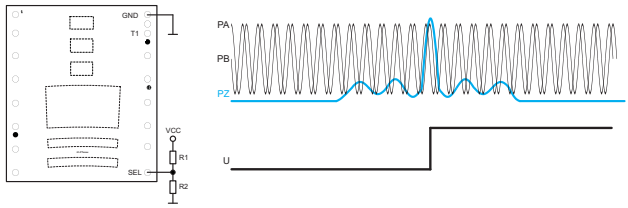


Figure 6: Example of analog ABZ / digital UVW (pin SEL = 75% VCC)

The iC-PT H-series features 5 principle operation modes which are selectable by the voltage applied to pin SEL. A voltage divider as suggested by Table 4 is the easiest way to obtain this.

SEL	R1[1)]	R2[1)]	Operation Mode
100 % VCC	0 Ω	open	x2 interpolated
75 % VCC	2.7 kΩ	8.2 kΩ	analog ABZ, dig. UVW
50 % VCC	4.7 kΩ (open)	4.7 kΩ (open)	all analog
25 % VCC	8.2 kΩ	2.7 kΩ	x4 interpolated
0 % VCC	open	0Ω	x1 interpolated
1) Exemplary values.			

Table 4: Selection of operation mode by pin SEL.

If input SEL is left open, the IC biases its input at 50% VCC and analog output signals are available for test and alignment.

Analog output signals may also be used to increase the encoder's resolution by connecting an external interpolation IC. In this case the analog signals are required permanently, so that noise immunity should be improved by wiring pin SEL to an external reference providing VCC/2.

Setting 75 % VCC may be considered to obtain analog signals at PA/PB/PZ and NA/NB/NZ outputs feeding the external interpolation IC, together with digital signals at U/V/W directly connecting a line driver. Special attention to the PCB layout should be paid to avoid cross talk; analog and digital lines should be separated carefully.

INDEX GATING AND INTERPOLATION

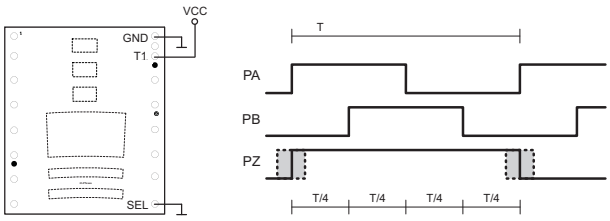


Figure 7: Ungated index (T1 = high),
x1 comparated (SEL = low).

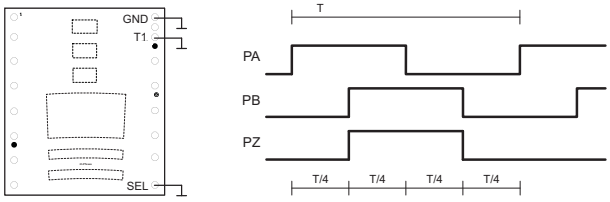


Figure 8: B-gated index (T1 = low),
x1 comparated (SEL = low).

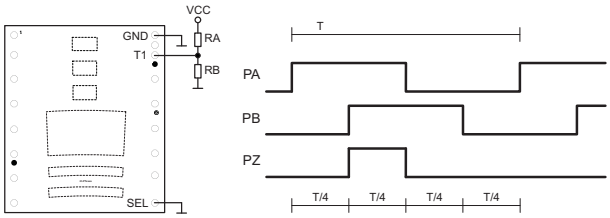


Figure 9: AB-gated index (T1 = open or VCC/2),
x1 comparated (SEL = low).

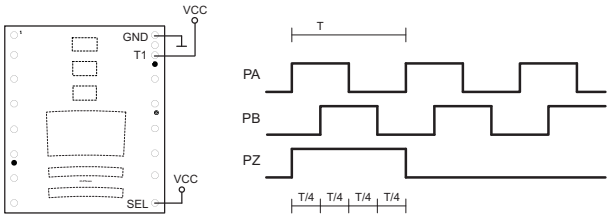


Figure 10: T-gated index (T1 = high),
x2 interpolated (SEL = high).

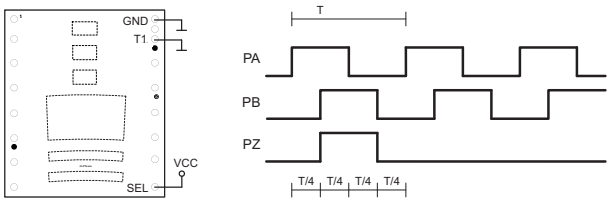


Figure 11: B-gated index (T1 = low),
x2 interpolated (SEL = high).

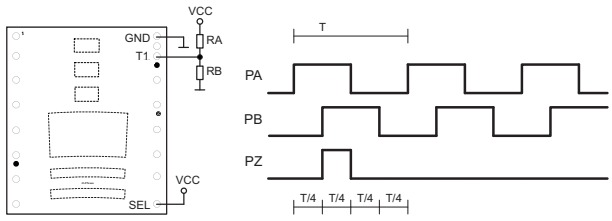


Figure 12: AB-gated index (T1 = open or VCC/2),
x2 interpolated (SEL = high).

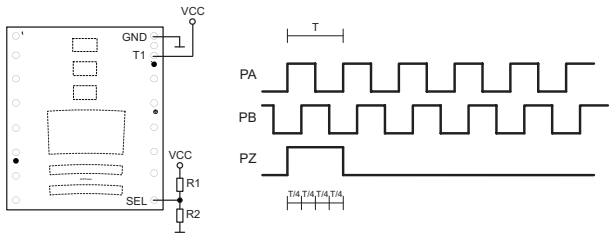


Figure 13: T-gated index (T1 = high),
x4 interpolated (SEL = 25% VCC).

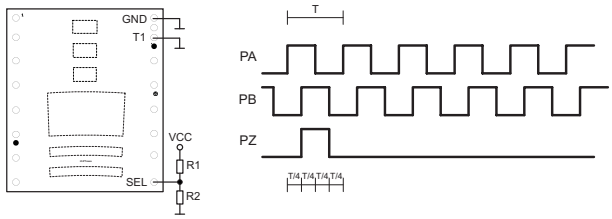


Figure 14: B-gated index (T1 = low)
x4 interpolated (SEL = 25% VCC).

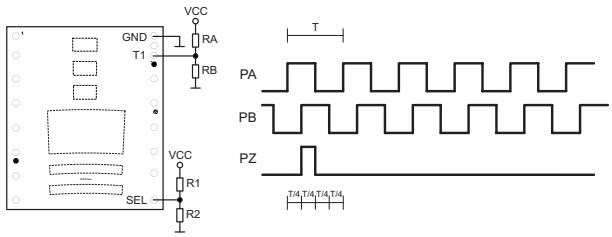


Figure 15: AB-gated index (T1 = open or VCC/2)
x4 interpolated (SEL = 25% VCC).

DEVICE OVERVIEW

Device	CPR	Code Disc		Permissible	Typ. LED Current[1)]		Comments
	native	P/O Code	Material	**Max. RPM**	iC-TL85	iC-TL46	
∅ **33 Series**							
iC-PT3320H	2000	PT04HFS 33-2000_4 PT04S 33-1250_4	film glass[2)]	12,000	n/a	9 mA	
iC-PT3348H	2048	PT17HFS 33-2048_4 PT17S 33-2048_4	film glass[2)]	11,700	n/a	8 mA	
iC-PT3325H	2500	PT05HFS 33-2500_4 PT05S 33-2500_4	film glass[2)]	9,600	n/a	6 mA	

Device availability on request.

[1]) Controlled LED output current of IC (DC average); according to Elec. Char. No. 502.

[2]) Code disc design made for iC-PTxx series.

Table 5: Device overview

DESIGN REVIEW: Notes On Chip Functions

PT3320H **PT3348H** **PT3325H**	chip release W	
No.	Function, Parameter/Code	Description and Application Hints
		None at time of printing.

Table 6: Design review

APPLICATION NOTES

Application notes for iC-PT H-series devices are available separately.

REVISION HISTORY

Rel	Rel.Date	Chapter	Modification	Page
A3	14-12-19	...	Initial release of Encoder blue series	all

ORDERING INFORMATION

Type	Package	Options	Order Designation
iC-PTnnnnH	32-pin optoQFN, 5 mm x 5 mm, 0.9 mm thickness RoHS compliant	nnnn = device version	iC-PTnnnnH oQFN32-5x5
		Encoder blue® devices	iC-PT3320H oQFN32-5x5 iC-PT3348H oQFN32-5x5 iC-PT3325H oQFN32-5x5
Code Disc	film disc 0.18 mm	nn = design number aa = diameter xxxx = AB pulse count ID u = UVW pulse count ID	PTnnHFS aa-xxxx_u
		for Encoder blue® devices	PT04HFS 33-2000_4 PT17HFS 33-2048_4 PT05HFS 33-2500_4
Evaluation Kit	Kit with Scanner Module IC273 (61 mm x 64 mm), LED Module IC274 and Code Disc	nnnn = device version	iC-PTnnnn EVAL IC273
Illumination	Blue LED module (28 mm x 29 mm)	assembled with iC-TL46 (460 nm)	iC-TL46 EVAL IC274
Mother Board	Adapter PCB (80 mm x 110 mm)	incl. ribbon cable	iC277 EVAL IC277

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