iC-PNH3348 EncoderBlue®
PHASED ARRAY NONIUS ENCODER

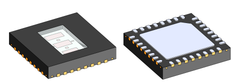
FEATURES

- Compact, high resolution absolute encoder IC for up to 24 bit singleturn resolution (with nonius interpolation)
- For code disc of ⌀ 33 mm
- Monolithic 3-channel *HD Phased Array* with excellent signal matching
- Moderate track pitch for reduced cross talk
- Ultra low dark currents for operation up to high temperature
- Low noise amplifiers with high transimpedance gain
- Enhanced EMI tolerance by low impedance differential, short-circuit-proof, analog sine/cosine outputs
- Embedded sector detection by 2 digital tracks (2-bit Gray code)
- Low power consumption from single 4.1 to 5.5 V supply
- Operational temperature range of -40 °C to +125 °C
- Space saving optoQFN package (RoHS compliant)
- Evaluation kit with LED and code disc available for sampling

APPLICATIONS

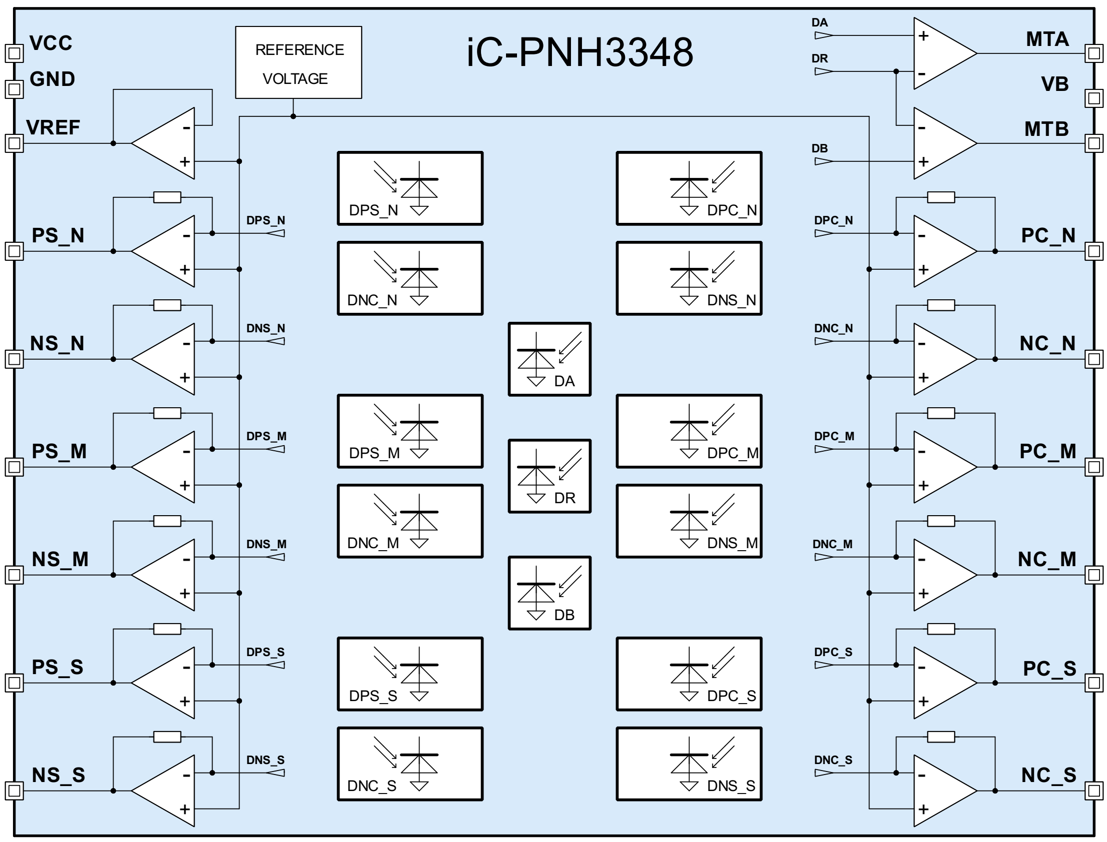
- Absolute position encoders
- AC servo feedback

PACKAGES



32-pin optoQFN
5 mm x 5 mm x 0.9 mm
RoHS compliant

BLOCK DIAGRAM



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DESCRIPTION

The iC-PNH3348 represents an advanced optical encoder IC featuring monolithically integrated photosensors arranged as an *HD Phased Array*, providing excellent signal fidelity at relaxed alignment tolerances.

Its precision sine/cosine output signals allow a high-resolution interpolation by subsequent devices: a singleturn position can be resolved with up to 24 bit utilizing the 3-channel nonius interpolation of iC-MN.

The typical application of iC-PNH3348 are absolute position encoders for motion control and drive applications.

iC-PNH3348 scans 5 tracks in total, whereof 3 analog tracks feature phased-arrays of multiple photosensors, each per track, generating positive and negative going sine signals, as well as positive and negative going cosine signals. An excellent matching and common mode behavior of the differential signal paths is obtained by a paired amplifier design. Due to a typical transimpedance gain of 1 MΩ, the output signal level reaches a few hundred millivolts at low light conditions already.

Additionally, 2 digital tracks are implemented for sector detection to separate a repeated nonius scale. For instance, the standard code disc for iC-PNH3348 features two nonius scales per turn and provide a 2-bit Gray code to distinguish this.

Sector detection can be used already at low supply voltages from 1.6 V up; the power consumption is low unless other sections are biased. Full operation requires a single-sided supply of 4.1 V to 5.5 V.

iC-PNH3348 EncoderBlue®
Optical radius 14.5 mm, code disc ∅ 33.2 mm;
(2x 1023/1024/992 CPR)

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

EncoderBlue is a trademark of iC-Haus GmbH.

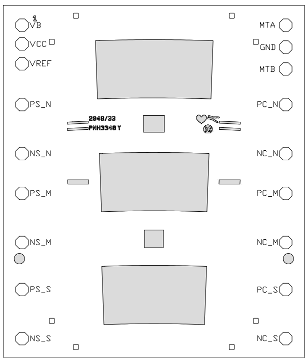
General notice on materials under excessive conditions
Epoxy resins (such as solder resists, IC package and injection molding materials, as well as adhesives) may show discoloration, yellowing, and surface changes in general when exposed longterm to high temperatures, humidity, irradiation, or due to 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

PAD LAYOUT

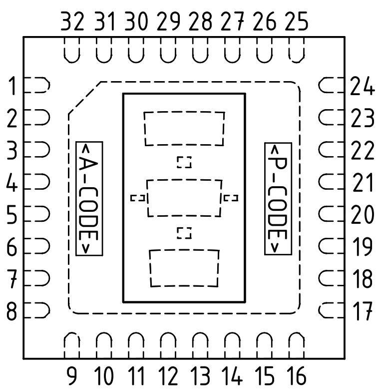


PAD FUNCTIONS

No. Name Function

Chip layout example.
Grey sections represent sensor layout areas; fill factors vary.

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



PIN FUNCTIONS

No.	Name	Function
1	VCC	+4.1..5.5 V Supply Voltage
2	VREF	Reference Voltage Output
3	PS_N	N-Track Sine +
4	NS_N	N-Track Sine -
5	PS_M	M-Track Sine +
6	NS_M	M-Track Sine -
7	PS_S	S-Track Sine +
8	NS_S	S-Track Sine -
9..16	n.c. [1]	
17	NC_S	S-Track Cosine -
18	PC_S	S-Track Cosine +
19	NC_M	M-Track Cosine -
20	PC_M	M-Track Cosine +
21	NC_N	N-Track Cosine -
22	PC_N	N-Track Cosine +
23	MTB	Digital Output B
24	GND	Ground
25	MTA	Digital Output A
26..31	n.c. [1]	
32	VB [2]	+1.8..5.5 V Auxiliary Supply Voltage
	BP [3]	Backside paddle

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

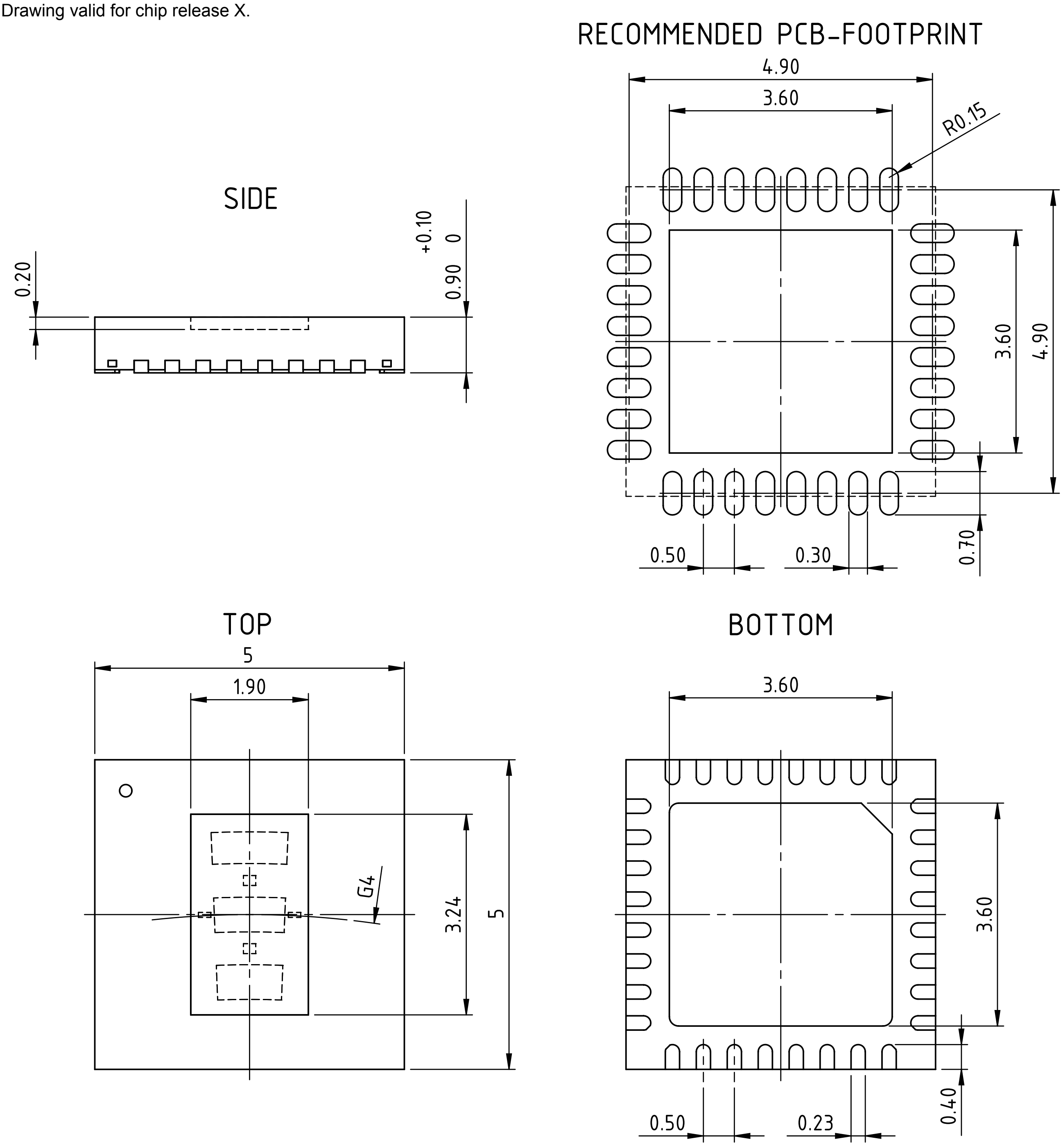
[1] Pin numbers marked n.c. are not connected.

[2] If there is no auxiliary supply available, connect pin 32 either to VCC or GND (for chip release Y, and X).
For chip release Z1, do not wire pin 32 or connect pin 32 to GND.

[3] Connecting the backside paddle is recommended by a single link to GND. A current flow across the paddle is not permissible.

PACKAGE DIMENSIONS

Drawing valid for chip release X.



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.

drd_oqfn32-5x5-2_pnhxxxx_x_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, VB		-0.3	6	V
G002	I(VCC)	Current in VCC, VB		-20	20	mA
G003	V()	Pin Voltage, all signal outputs		-0.3	VCC + 0.3	V
G004	I()	Pin Current, all signal outputs		-20	20	mA
G005	Vd()	ESD Susceptibility, all pins	HBM, 100 pF discharged through 1.5 kΩ		2	kV
G006	Tj	Junction Temperature		-40	150	°C
G007	Ts	Chip Storage Temperature		-40	150	°C

THERMAL DATA

Operating conditions: VCC = 4.1...5.5 V

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
T01	Ta	Operating Ambient Temperature Range		-40		125	°C
T02	Ts	Storage Temperature Range		-40		125	°C
T03	Tpk	Soldering Peak Temperature	tpk < 20 s, convection reflow tpk < 20 s, vapor phase soldering MSL 5A (max. floor life 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 = 4.1...5.5 V, VB = 0 V, Tj = -40..125 °C, unless otherwise stated

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Total Device							
001	VCC	Permissible VCC Supply Voltage	regular operation	4.1		5.5	V
002	I(VCC)	VCC Supply Current	no load, Vout() < Vout()mx		9.5	15	mA
003	Vc()hi	Clamp-Voltage hi at all pins	I() = 4 mA			11	V
004	Vc()lo	Clamp-Voltage lo at all pins	I() = -4 mA	-1.2		-0.3	V
Photosensors							
101	λar	Spectral Application Range	Se(λar) = 0.25 x S(λpk)	400		700	nm
103	Aph()	Radiant Sensitive Area	sensors of N/M/S tracks; chip releases Z1, and Y chip release X sensors of MTA, MTB tracks; all chip releases		 0.074 0.058 0.031		 mm^2 mm^2 mm^2
104	S(λ)	Spectral Sensitivity	λ_{LED} = 460 nm		0.3		A/W
105	E()mxr	Irradiance For Max. Signal Level	λ_{LED} = 460 nm, Vout() not saturated; chip releases Z1, and Y chip release X		 3.0 3.8		 mW/cm^2 mW/cm^2
Photocurrent Amplifiers							
201	Iph()	Permissible Photocurrent Operating Range		0		1120	nA
202	η()r	Photo Sensitivity (light-to-voltage conversion ratio)	λ_{LED} = 460 nm		0.23		V/µW
203	Z()	Equivalent Transimpedance Gain	Z = Vout() / Iph()	0.7	1.0	1.4	MΩ
204	TCz	Temperature Coefficient of Transimpedance Gain			-0.12		%/°C
205	ΔZ()pn	Transimpedance Gain Matching	P.. channel vs. corresponding N.. channel	-0.2		0.2	%
206	ΔVout()pn	Signal Matching	no illumination; any output vs. any output P.. output vs. corresponding N.. output	-35 -2.5		35 2.5	mV mV
207	fc()hi	Cut-off Frequency (-3 dB)			400		kHz
208	VNoise()	RMS Output Noise	illuminated to 500 mV signal level above dark level, 500 kHz band width		0.5		mV
Signal Outputs							
301	Vout()mx	Permissible Max. Output Voltage	refer to Figure 1	2.0			V
302	Iout()mx	Permissible Max. Load Current		-100		250	µA
303	Vout()d	Dark Signal Level	no illumination, I() $\leq$ 50 µA	575	770	1000	mV
304	Isc()hi	Short-Circuit Current hi	load current to ground	100	420	1300	µA
305	Isc()lo	Short-Circuit Current lo	load current to IC	250	480	700	µA
306	Ri()	Internal Output Resistance	f = 1 kHz	70	110	180	Ω
307	ton()	Power-On Settling Time	VCC = 0 V $\rightarrow$ 5 V			100	µs
Reference Voltage VREF							
401	VREF	Reference Voltage	I(VREF) = -100...+300 µA	575	770	1000	mV
402	dVout()	Load Balancing	I(VREF) = -100...+300 µA	-10		+10	mV
403	Isc()hi	Short-Circuit Current hi	load current to ground	200	420	2000	µA
404	Isc()lo	Short-Circuit Current lo	load current to IC	0.5	4.5	10	mA

ELECTRICAL CHARACTERISTICS

Operating conditions: VCC = 4.1...5.5 V, VB = 0 V, Tj = -40..125 °C, unless otherwise stated

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Digital Outputs MTA, MTB (chip release iC-PNH3348_Z1)							
501	VCC	VCC Supply Voltage for MTA/MTB Operation		1.6		5.5	V
502	I(VCC)	VCC Supply Current for MTA/MTB Operation	no load; VCC = 1.6 V VCC = 2.0 V			1000 3000	µA µA
503	Vs()lo	Saturation Voltage lo at MTA	I() = 1.6 mA VCC = 1.6 V, I() = 100 µA			0.8 0.2	V V
504	Rpu()	Pull-up Resistor at MTA		80		180	kΩ
505	Vs()hi	Saturation Voltage hi at MTB	Vs()hi = V() - VCC; I() = -1.6 mA VCC = 1.6 V, I() = -100 µA			0.8 0.2	V V
506	Rpd()	Pull-down Resistor at MTB		80		180	kΩ
507	SR()hi, lo	Slew Rate hi/lo at MTA, MTB	VCC = 4.1 ... 5.5 V VCC = 1.6 V	0.3 0.027		2.0 3.4	V/µs V/µs
508	ton_LED	Recommended Illumination Time for Low Power Operation	Gray-code scanning by DA, DB, DR sensors: Iph(DA, DB) = 100...260 nA, Iph(DR) = 180 nA; VCC = 1.6 V VCC = 1.8 V	 10 4			 µs µs
509	tset_LED	Recommended Illumination Start for Low Power Operation	relative to power-up: VCC = 0 V → 1.6 V	-1		0	µs
510	tv()	Output Validity for Low Power Operation	output V(MTA, MTB) = 10% ←→ 90% versus power-up (for tset_LED = -1 ... 0 µs); VCC = 0 V → 1.6 V, ton_LED ≥ 10 µs VCC = 0 V → 1.8 V, ton_LED ≥ 4 µs		 25 25	 60 50	 µs µs
Digital Outputs MTA, MTB and Auxiliary Supply VB (chip release iC-PNH3348_Y, and X)							
601	VB	Auxiliary Supply VB for MTA/MTB Operation	VCC < 0.5 V, or as #001 with 100 µs ahead	1.8		5.5	V
602	I(VB)	Supply Current in VB	VCC = 1.8 ... +5.5 V, MTA, MTB not loaded			300	µA
603	I(VB)cyc	Averaged Supply Current in VB	VCC = 0 V, VB on-cycle 15 µs, illuminated for 3 µs, MTA, MTB not loaded			80	µA
604	ton(VB)	VB Power-Up Settling Time for MTA/MTB Operation	VB = 0 V → 1.8 V, without illumination; refer to Figure 3			10	µs
605	ton(VCC)	VCC Power-Up Settling Time for MTA/MTB Operation	VB = 0 V, without illumination; refer to Figure 2			100	µs
606	toff(VCC)	VCC Power-Down Delay Time for MTA/MTB Operation	Validity delay after VCC < 0.5 V; refer to Figure 4			40	µs
607	Vs()hi	Saturation Voltage hi at MTA, MTB	VB = 0 V, Vs()hi = VCC - V(), I() = -130 µA VB as #601, Vs()hi = VB - V(), I() = -130 µA			0.4 0.4	V V
608	Vs()lo	Saturation Voltage lo at MTA, MTB	VB = 0 V or as #601; I() = 200 µA			0.4	V
609	ton_LED	Recommended Illumination Time	VB = 0 V or as #601; Gray-code scanning by DA, DB, sensors: Iph(DA, DB) = 100...260 nA, Iph(DR) = 180 nA	3			µs
610	tp1()	Output Validity at MTA, MTB	VB = 0 V or as #601; see Figure 5; output stable for readout after LED on			3	µs
611	tp2()	Output Validity at MTA, MTB	VB = 0 V or as #601; see Figure 5; output stable for readout after LED off	1			µs
612	Vout()max	Maximum Output Voltage at MTA, MTB	VB = 0 V VB as #601			VCC VB	V V

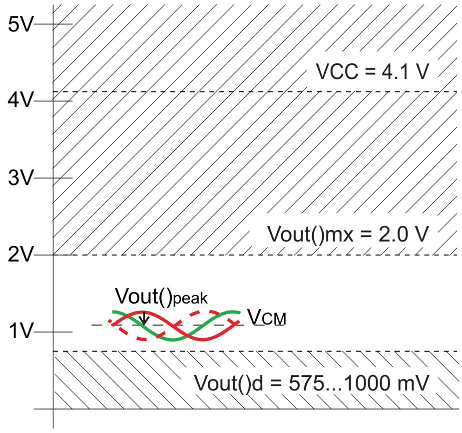


Figure 1: Permissibe maximum output voltage range and example of typical output voltage.

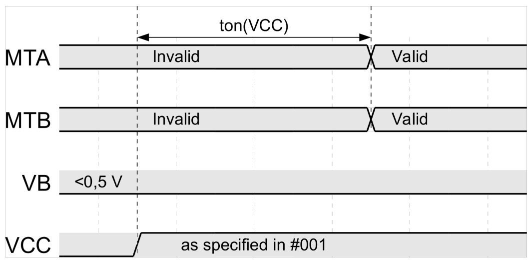


Figure 2: Outputs MTA and MTB operated from main supply VCC.

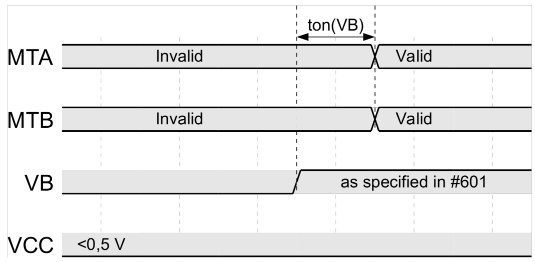


Figure 3: Outputs MTA and MTB operated from auxiliary supply VB.

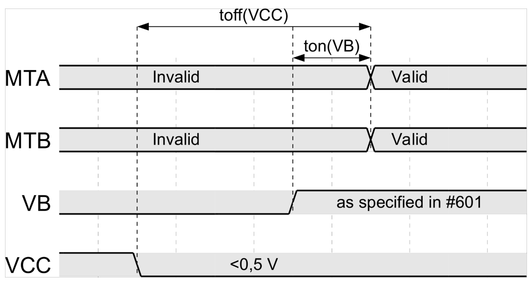


Figure 4: Intersection from main supply VCC to auxiliary supply VB.

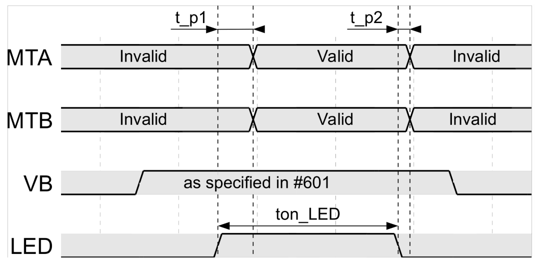


Figure 5: MTA and MTB output validity depending on LED flash.

APPLICATION CIRCUITS

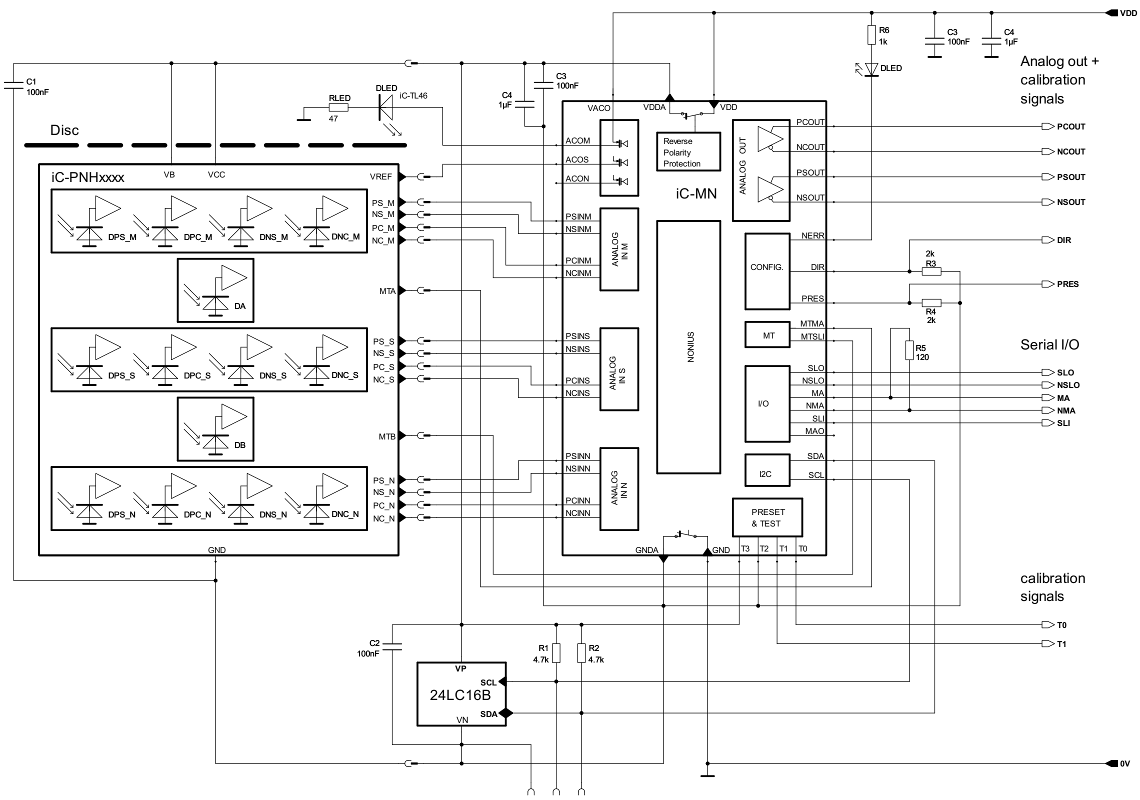


Figure 6: Application example of absolute encoder circuit.

DESIGN REVIEW: Notes On Chip Functions

iC-PNH3348 .		
No.	Function, Parameter/Code	Description and Application Hints
1		Refer to datasheet iC-PNH3348 release B1, 2014.

Table 4: Notes on chip functions regarding iC-PNH3348 chip release 0.

iC-PNH3348 Z1		
No.	Function, Parameter/Code	Description and Application Hints
1	*HD Phased Array*	Chip release utilizes a high definition phased array layout.
2	iC-PNH3348 EncoderBlue®	Spectral application range optimized for short wavelength (new reference of 460 nm).

Table 5: Notes on chip functions regarding iC-PNH3348 chip release Z1.

iC-PNH3348 Y, X		
No.	Function, Parameter/Code	Description and Application Hints
1	Supply VB	Auxiliary supply input VB connects to reserved pin 32. For recommendations on wiring, refer to footnotes on Page 3
2	Outputs MTA and MTB	Refer to Elec. Char. for changes of specifications.
3	Package Dimensions	Chip release X: thickness of glass lid changed to 200 µm.

Table 6: Notes on chip functions regarding iC-PNH3348 chip release Y, and X.

REVISION HISTORY

Rel.	Rel. Date[1]	Chapter	Modification	Page
A1	2011-07-25	...	Initial release for iC-PNH3348.	all

Rel.	Rel. Date[1]	Chapter	Modification	Page
B1	2014-05-22	...	Refer to iC-PNH3348 datasheet release B1.	

Rel.	Rel. Date[1]	Chapter	Modification	Page
C2	2015-05-11	All	Updated release for iC-PNH3348 EncoderBlue® Inclusion of chip release Y.	all
		ELECTRICAL CHARACTERISTICS	Item 302 supplemented: permissible max. load current	

Rel.	Rel. Date[1]	Chapter	Modification	Page
C3	2016-01-18	BLOCK DIAGRAM	Update to chip rel. Y (pin VB)	1
		ELECTRICAL CHARACTERISTICS	Items 303, 401: min. limit, items 304, 403: max. limit Item 602: new entry, item 603: condition updated	6ff
		APPLICATION CIRCUITS	Fig. 1 updated	8

Rel.	Rel. Date[1]	Chapter	Modification	Page
C4	2016-07-20	DESCRIPTION	General notice added	2
		PACKAGING INFORMATION	VB pin name and footnote 2 on wiring	3
		ABSOLUTE MAXIMUM RATINGS	Item G001, G002: pin VB supplemented	5
		THERMAL DATA	OTR extended to 125 °C	5
		ELECTRICAL CHARACTERISTICS	Operting conditions: VB supplemented Items 003, 004: moved to 501, 502 Item 101: max value, item 303: condition Item 608: conditions and limits	6ff
		APPLICATION CIRCUITS	Fig. 1, iC-PNHxxx symbol corrected	8

Rel.	Rel. Date[1]	Chapter	Modification	Page
D2	2018-02-13	PACKAGING INFORMATION	Package drawing updated: minimum thickness 0.9 mm Footnote supplemented for chip release X	3
		ELECTRICAL CHARACTERISTICS	Item 103, 105: chip release X added Item 304, 403: max. limits Item 608: min./max. limits Item 609 added	6
		DESIGN REVIEW: Notes On Chip Functions	Supplemented for chip release X	9

Rel.	Rel. Date[1]	Chapter	Modification	Page
E1	2019-05-24	PACKAGING INFORMATION	Package drawing updated for chip release X	5
		ELECTRICAL CHARACTERISTICS	Item 301: hint to 1 added Items 601: update of condition; Item 604: update of name and condition Items 605, 606, 610, 611: added as new items Items 607, 608, 612: update of conditions and limits Figures 1, 2, 3, 4, and 5 added	6ff

[1] Release Date format: *YYYY-MM-DD*

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ORDERING INFORMATION

Type	Package	Options	Order Designation
iC-PNH3348	32-pin optoQFN, 5 mm x 5 mm, 0.9 mm thickness RoHS compliant		iC-PNH3348 oQFN32-5x5
Code Disc	Glass disc 1.0 mm		PNH1S 33-2048
Evaluation Kit	Kit with Scanner Module IC273 (61 mm x 64 mm), blue LED Module IC274 and Code Disc		iC-PNH3348 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
Adapter Board	Adapter PCB, connects IC273 to MN1D (41 mm x 41 mm)	incl. ribbon cable	iC306 EVAL IC306

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