iC-PD3948

preliminary

5-CHAN. PHASED ARRAY SINE ENCODER 39-2048

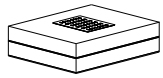
FEATURES

- Compact encoder sensor with differential scanning and sine outputs
- Phased-array design for excellent signal matching
- Reduced cross talk due to moderate track pitch
- Ultra low dark currents for operation to high temperature
- Low noise amplifiers with high transimpedance of typ. 4 MΩ
- Short-circuit-proof, low impedance voltage outputs for enhanced EMI tolerance
- Space saving QFN and optoBGA packages (RoHS compliant)
- Low power consumption from single 4.5 to 5.5 V supply
- Operational temperature range of -40 to +110 °C
- Code disc available
  (2048 PPR +C/D 1 PPR, diameter ∅39 mm)

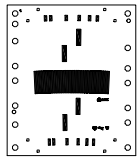
APPLICATIONS

- Incremental sine encoders with commutation information
- Motor feedback encoder
- AC and BLDC motor systems

PACKAGES

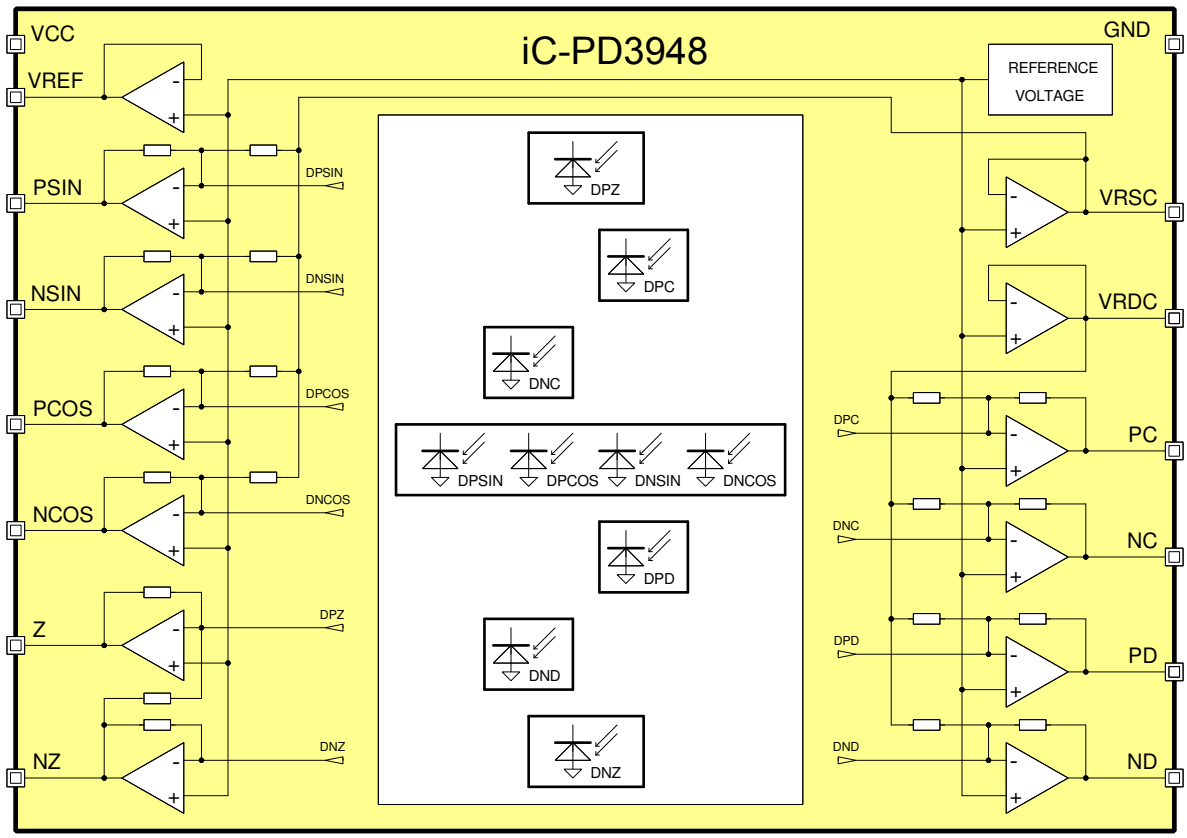


32-pin optoQFN
15-pin optoBGA



Chip
2.88 mm x 3.37 mm

BLOCK DIAGRAM



DESCRIPTION

iC-PD3948 is an optical sensor IC with integrated photodiodes whose signal currents are converted into output voltages by low-noise transimpedance amplifiers.

Due to a high transimpedance gain of typically 4 MΩ, output signal voltages of several hundred Millivolts are obtained at illumination levels of just 1 to 3 mW/cm^2. In most cases complicated noise suppression measures are thus rendered unnecessary.

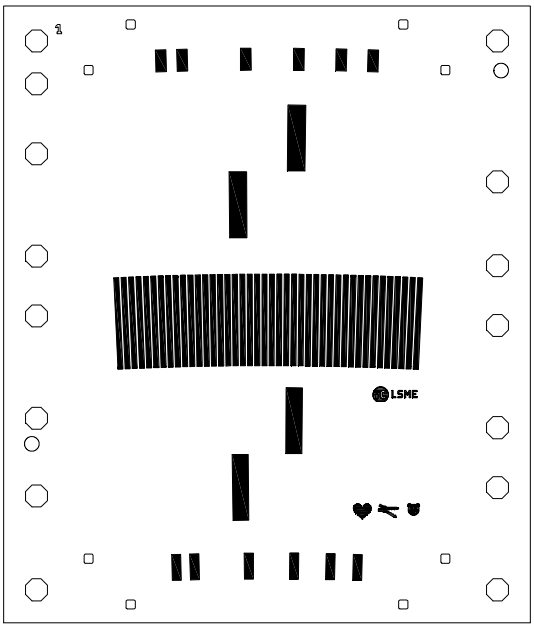
As the pin names would suggest, iC-PD3948 is typically applied as a sine encoder for motor feedback systems. To this end, iC-PD3948 provides sine and cosine signals with both a high resolution of 2048 PPR (plus an additional index signal) and a low resolution of 1 PPR (at C/D).

All code disc signal tracks are evaluated differentially; the high resolution sine signals are read by photodiodes in a phased array. The layout of the signal amplifiers is such that there is good paired channel matching, reducing the time and effort required for calibration to an absolute minimum.

The spectral sensitivity ranges from visible to near infrared light, with the maximum sensitivity close to a wavelength of 680 nm. An output voltage of 1 V is typical in low light conditions, for instance when iC-PD is illuminated at only 2 mW/cm^2 by a 740 nm LED. A relatively low LED current is enough to operate the sensor, proving beneficial to the life expectancy of the LED at high operating temperatures.

PACKAGES AND CHIP LAYOUT INFORMATION

PAD LAYOUT (2.88 mm x 3.37 mm)

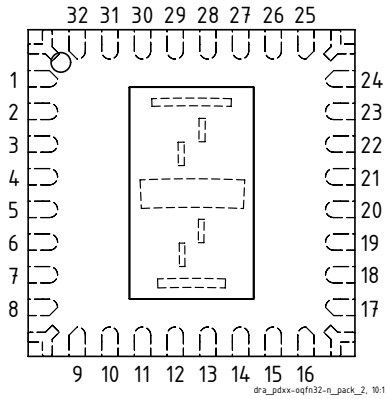


PAD FUNCTIONS

No.	Name	Function
1	VCC	+4.5...5.5 V Supply Voltage
2	VREF	Reference Voltage Output
3	PSIN	Sine Track +
4	NSIN	Sine Track -
5	PCOS	Cosine Track +
6	NCOS	Cosine Track -
7	Z	Z Index Signal
8	NZ	Z Index Track -
9	ND	D Track -
10	PD	D Track +
11	NC	C Track -
12	PC	C Track +
13	VRDC	D/C Track Reference
14	VRSC	S/C Track Reference
15	GND	Ground

Notes: All outputs are analog voltage outputs.

PIN CONFIGURATION
oQFN32-5x5, oQFN32-N5x5 (5 mm x 5 mm)



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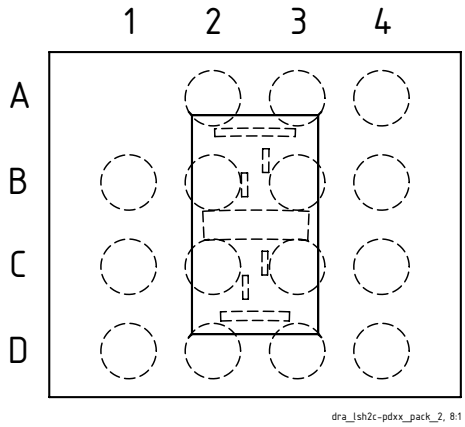
6	NCOS	Cosine Track -
7	Z	Z Index Signal
8	NZ	Z Index Track -
9	ND	D Track -
10	PD	D Track +
11	NC	C Track -
12	PC	C Track +
13	VRDC	D/C Track Reference
14	VRSC	S/C Track Reference
15	GND	Ground
	BP	Backside pad (oQFN32-5x5 only): not intended as an electrical connection point; when using as shield a single link to GND is permissible.

PIN CONFIGURATION
oBGA LSH2C (6.2 mm x 5.2 mm)



PIN FUNCTIONS

No.	Name	Function
A2	VCC	+4.5...5.5 V Supply Voltage
A3	VREF	Reference Voltage Output
A4	GND	Ground
B1	PSIN	Sine Track +
B2	NSIN	Sine Track -
B3	VRDC	D/C Track Reference
B4	VRSC	S/C Track Reference
C1	PCOS	Cosine Track +
C2	NCOS	Cosine Track -
C3	NC	C Track -
C4	PC	C Track +
D1	Z	Z Index Signal
D2	NZ	Z Index Track -
D3	ND	D Track -
D4	PD	D Track +

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	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

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
T01	Ta	Operating Ambient Temperature Range	package oBGA LSH2C package oQFN32-N5x5 package oQFN32-5x5* (extended temperature range on request)	-40 -40 -40		110 110 110	°C °C °C
T02	Ts	Storage Temperature Range	package oBGA LSH2C, package oQFN32-N5x5, oQFN32-5x5*	-40		110	°C
T03	Tpk	Soldering Peak Temperature	package oBGA LSH2C tpk < 20 s, convection reflow tpk < 20 s, vapor phase soldering TOL (time on label) 8 h; Please refer to customer information file No. 7 for details.			 245 230	 °C °C
T04	Tpk	Soldering Peak Temperature	package oQFN32-N5x5, oQFN32-5x5* 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

*) Package qualification pending.

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 = 4.5...5.5 V, Tj = -40..125 °C, unless otherwise stated

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Total Device							
001	VCC	Permissible Supply Voltage		4.5		5.5	V
002	I(VCC)	Supply Current	no load, photocurrents within op. range		12	16	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(λ)max	400		950	nm
102	λpk	Peak Sensitivity Wavelength			680		nm
103	Aph()	Radiant Sensitive Area	DPSIN, DNSIN, DPCOS, DNCOS DPC, DNC, DPD, DND DPZ, DNZ		0.075 0.033 0.042		mm^2 mm^2 mm^2
104	S(λ)	Spectral Sensitivity	λ_{LED} = 740 nm		0.5		A/W
105	S(λpk)max	Maximum Spectral Sensitivity	λ_{LED} = λpk		0.55		A/W
106	E()mx	Irradiance For Maximum Signal Level	λ_{LED} = 740 nm, Vout() not saturated DPSIN, DNSIN, DPCOS, DNCOS DPC, DNC, DPD, DND DPZ, DNZ	 1.2 3.0 2.8	 2.0 4.5 4.2	 3.2 6.5 6.0	 mW/cm^2 mW/cm^2 mW/cm^2
Photocurrent Amplifiers							
201	Iph()	Permissible Photocurrent Operating Range		0		280	nA
202	η()r	Photo Sensitivity (light-to-voltage conversion ratio)	λ_{LED} = 740 nm	0.8	1.2	2.0	V/µW
203	Z()	Equivalent Transimpedance Gain	Z = Vout() / Iph()	2.69	4.0	5.46	MΩ
204	TCz	Temperature Coefficient of Transimpedance Gain			-0.12		%/°C
209	ΔZ()pn	Transimpedance Gain Matching Of Paired Amplifiers	P.. channel vs. corresponding N.. channel	-0.2		0.2	%
210	ΔVout()pn	Signal Matching	no illumination, any output to any output	-35		35	mV
211	ΔVout()pn	Signal Matching	no illumination, P vs. N path per diff. channel	-2.5		2.5	mV
212	fc()hi	Cut-off Frequency (-3 dB)		120	180	280	kHz
213	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 Maximum Output Voltage	illumination to E()mxr, linear gain	2.45	2.72	3.02	V
302	Vout()d	Dark Signal Level	no illumination, load 20 kΩ vs. +2 V	600	770	1000	mV
303	Vout()acmx	Maximum Signal Level	Vout()acmx = Vout()mx - Vout()d	1.48	1.96	2.35	V
304	Isc()hi	Short-Circuit Current hi	load current to ground	100	420	800	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
Signal References VRSC, VRDC							
401	Vout()	Reference Voltage		600	770	1000	mV
402	Isc()hi	Short-Circuit Current hi	current to ground	100	420	800	µA
403	Isc()lo	Short-Circuit Current lo	current to IC	250	480	700	µA
404	Ri()	Internal Output Resistance		70	110	180	Ω

ELECTRICAL CHARACTERISTICS

Operating conditions: VCC = 4.5...5.5 V, Tj = -40..125 °C, unless otherwise stated

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Reference Voltages VREF							
501	Vout()	Reference Voltage	I(VREF) = 0...+1.6 mA	600	770	1000	mV
502	dVout()	Load Balancing	I(VREF) = 0...+1.6 mA	-10		+10	mV
503	Isc()hi	Short-Circuit Current hi	current to ground	200	420	800	µA
504	Isc()lo	Short-Circuit Current lo	current to IC	2	4.5	10	mA

APPLICATION CIRCUITS

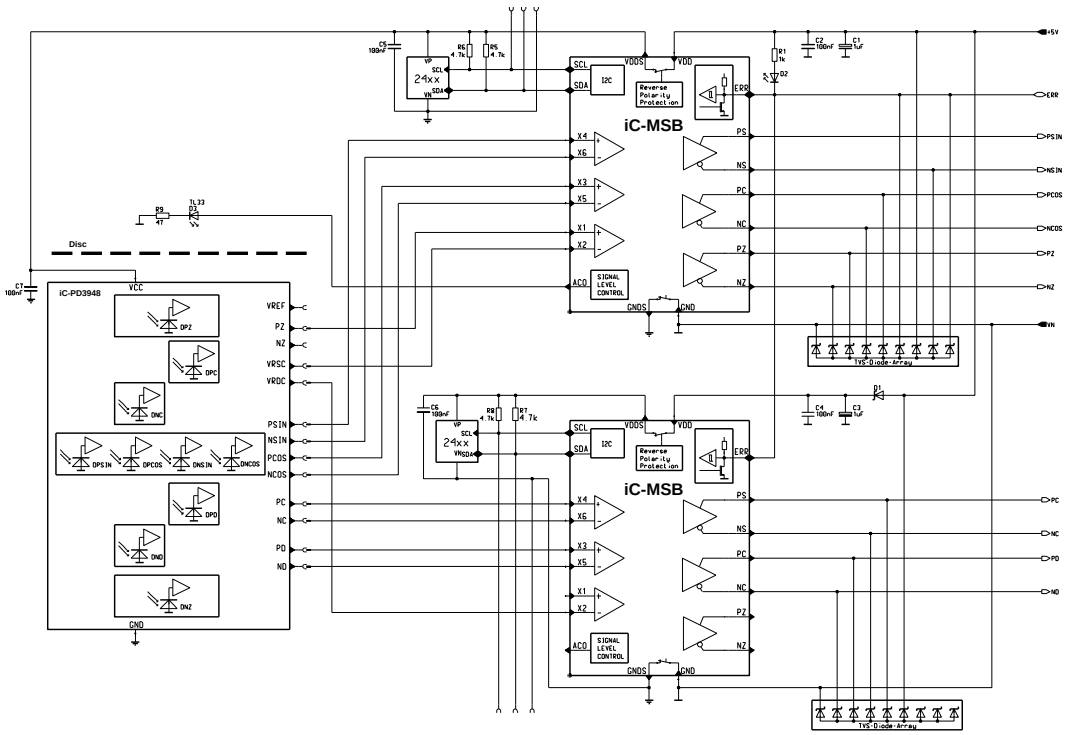


Figure 1: Application example motor feedback encoder

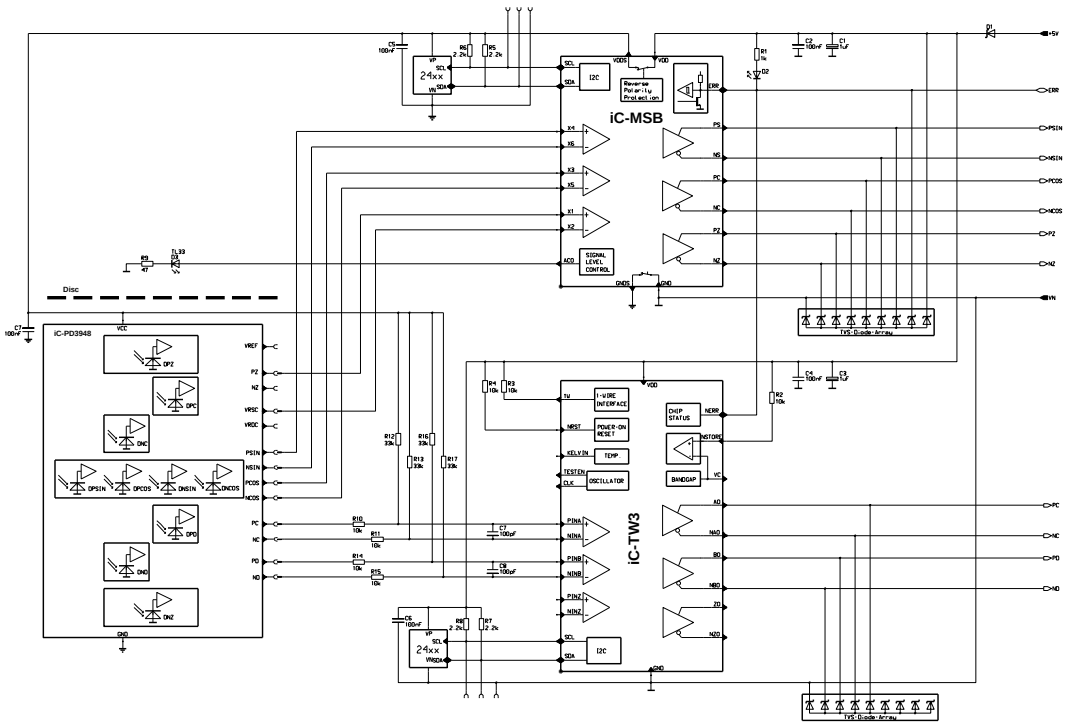


Figure 2: Application example motor feedback encoder

ORDERING INFORMATION

Type	Package	Options	Order Designation
iC-PD3948	-		iC-PD3948 chip
	32-pin optoQFN, 5 mm x 5 mm x 0.9 mm (backside paddle exposed)		iC-PD3948 oQFN32-5x5
	32-pin optoQFN 5 mm x 5 mm x 1.4 mm		iC-PD3948 oQFN32-N5x5
	15-pin optoBGA 6.2 mm x 5.2 mm		iC-PD3948 oBGA LSH2C
		Code Disc 2048+1 PPR OD/ID ∅39/13 mm	PD2S 39-2048

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

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