iC-OG

8-BIT DIFFERENTIAL SCANNING OPTO ENCODER

preliminary

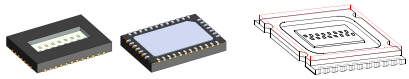
FEATURES

- Monolithic construction with integrated photodiodes ensures excellent matching and technical reliability
- Short track spacing of 600 µm
- Elimination of dark currents through differential scanning
- Photocurrent amplifier with high cut-off frequency
- Comparators with precise signal-related hysteresis
- Current-limited push-pull outputs
- Adjustable LED current control for constant received power
- Integrated power driver for the LED
- LED current monitor with error message output
- Integrated test aid
- Low power consumption from 5 V supply voltage
- Space-saving 38-pin optoQFN with extended temperature range of -40 to +120 °C
- 20-pin BLCC package with protective glass lid
- Options: custom reticle assembly, customized COB modules

APPLICATIONS

- Linear and rotary position sensors
- Absolute Gray-code encoders
- Mixed incremental/absolute encoders

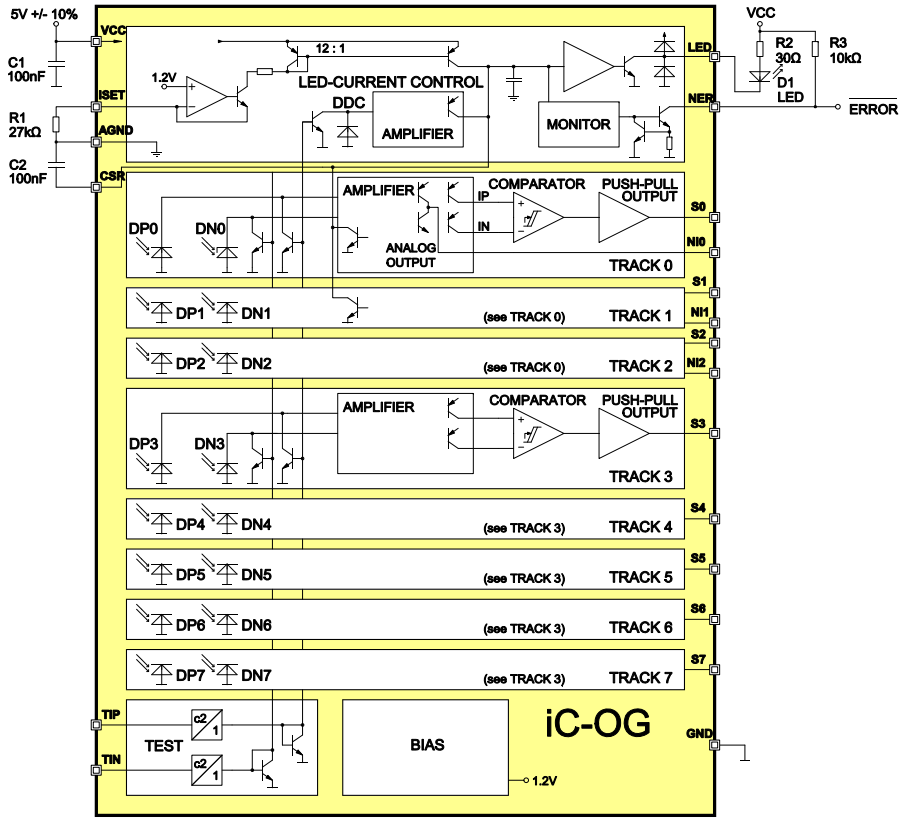
PACKAGES



oQFN38-7x5
(7 mm x 5 mm)

BLCC OGC
(8.2 mm x 9.5 mm)

BLOCK DIAGRAM



DESCRIPTION

iC-OG is an optoelectronic sensor IC for linear and rotary motion control systems, such as glass scales or shaft encoders, for example.

Photodiodes, amplifiers, comparators and TTL-compatible push-pull output drivers are integrated monolithically. Each of the 8 tracks is evaluated differentially; 3 tracks feature additional high-side and low-side current sources and output a push-pull analog signal.

The integrated LED current control with its driver stage connects to the encoder LED and ensures a constant optical received power. A series resistor is used here as current limiter, and thus defines the control's operating range. If the LED current control reaches operating limits, error message output NER indicates a low signal (LED end-of-life, or open loop conditions).

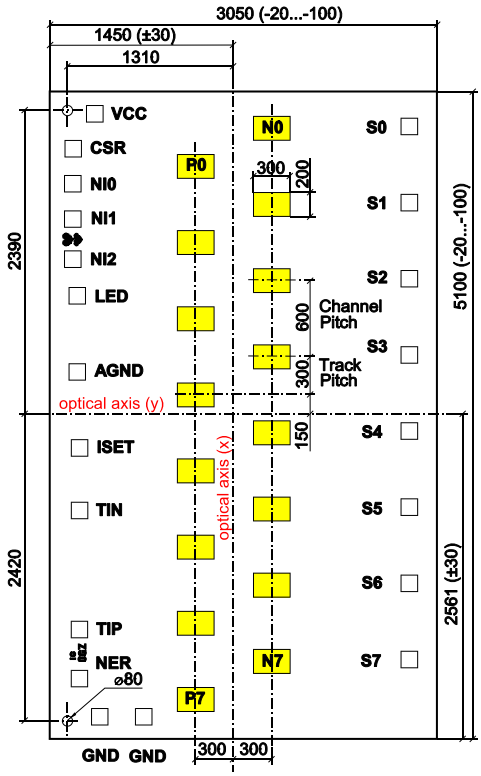
Tracks 0 and 1 with their differential scanning photodiodes provide a sum current for LED controlling, averaged by the capacitor at pin CSR. The sum current is compared with the setpoint adjusted by the external resistor at pin ISET.

Two test pins (TIP, TIN) allow a full test of all chip functions to be carried out excluding the photodiodes.

All push-pull and analog outputs are protected against ESD and short-circuit damage. The error message output NER is also protected against short-circuiting and can be used in bus systems due to its open-collector output.

PACKAGES

PAD LAYOUT / CHIP LAYOUT
Chip size 3.05 mm x 5.1 mm



PAD FUNCTIONS

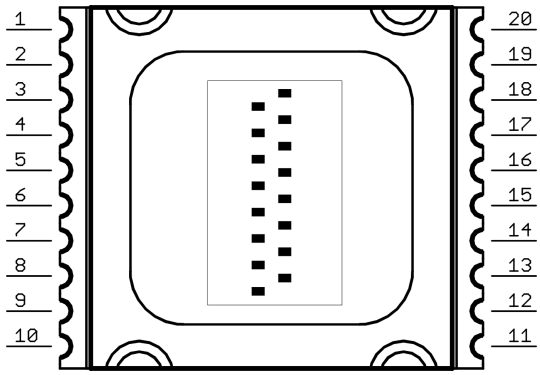
No.	Name	Function
		See pin functions.

Notes The optical sensor axis is not exactly the chip center.

PIN CONFIGURATION BLCC OGC

9.5 mm x 8.2 mm x 1.8 mm; lead pitch 0.8 mm;

A package datasheet is available separately.

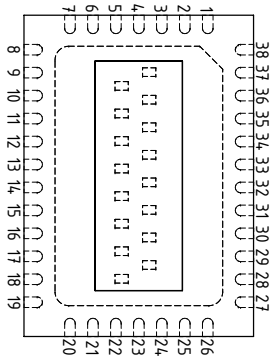


PIN FUNCTIONS

No.	Name	Function
1	CSR	External capacitor for LED control
2	NI0	Track 0 Analog Push-Pull Output
3	NI1	Track 1 Analog Push-Pull Output
4	NI2	Track 2 Analog Push-Pull Output
5	LED	LED Driver Output
6	AGND	Reference Ground for ISET and CSR Circuitry
7	ISET	LED Current Control Setup
8	TIN	Negative Test Aid Input
9	TIP	Positive Test Aid Input
10	NER	Error Message Output, low active
11	GND	Ground
12	S7	Track 7 Push-Pull Output
13	S6	Track 6 Push-Pull Output
14	S5	Track 5 Push-Pull Output
15	S4	Track 4 Push-Pull Output
16	S3	Track 3 Push-Pull Output
17	S2	Track 2 Push-Pull Output
18	S1	Track 1 Push-Pull Output
19	S0	Track 0 Push-Pull Output
20	VCC	+5 V Supply Voltage

PIN CONFIGURATION oQFN38-7x5

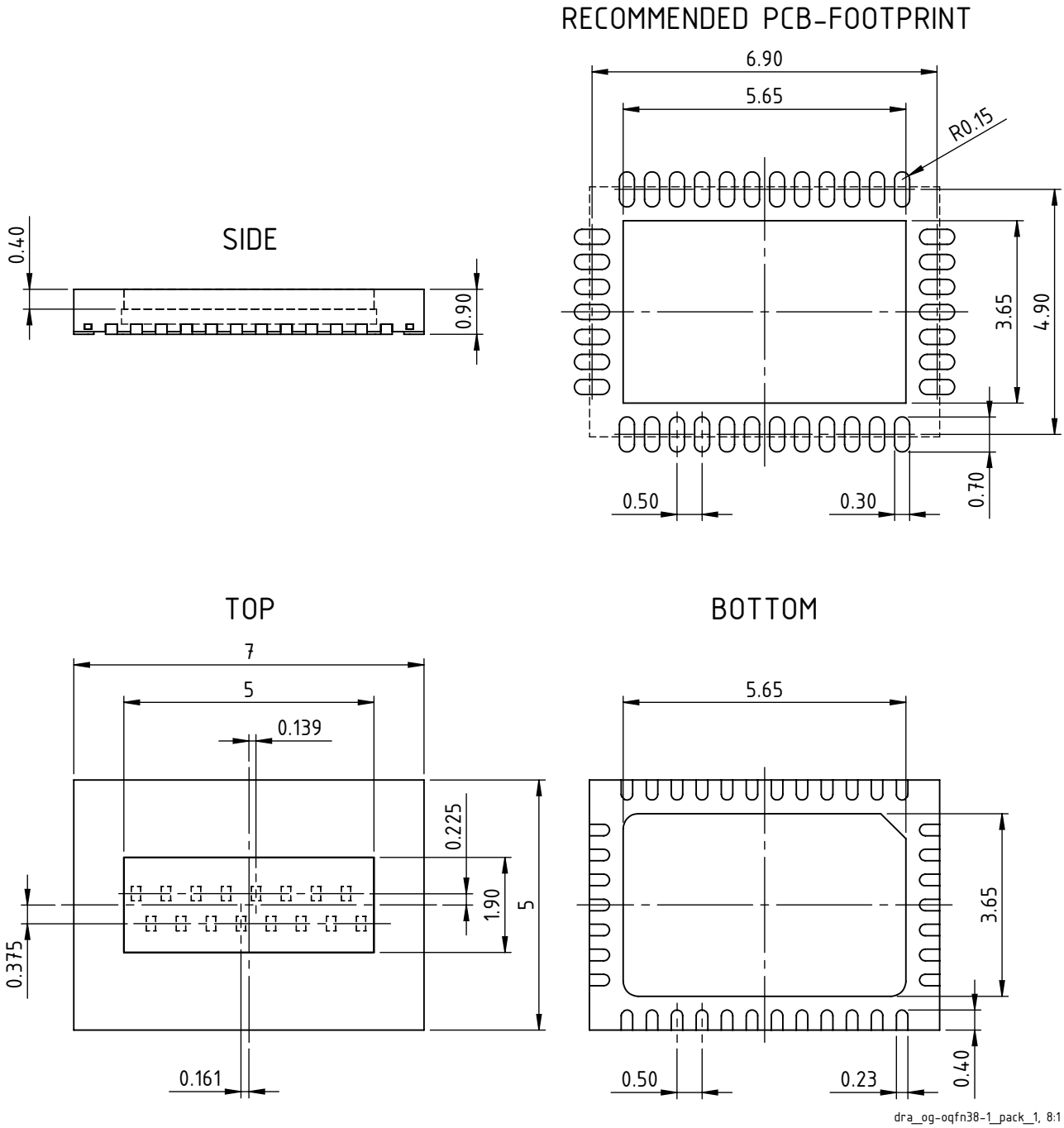
7.0 mm x 5.0 mm x 0.9 mm; lead pitch 0.5 mm; in qualification;



PIN FUNCTIONS

No.	Name	Function
1...7	n.c.	
8	VCC	+5 V Supply Voltage
9	CSR	External capacitor for LED control
10	NI0	Track 0 Analog Push-Pull Output
11	NI1	Track 1 Analog Push-Pull Output
12	NI2	Track 2 Analog Push-Pull Output
13	LED	LED Driver Output
14	AGND	Reference Ground for ISET and CSR Circuitry
15	ISET	LED Current Control Setup
16	TIN	Negative Test Aid Input
17	TIP	Positive Test Aid Input
18	NER	Error Message Output, low active
19	GND	Ground
20...26	n.c.	
27	S7	Track 7 Push-Pull Output
28	S6	Track 6 Push-Pull Output
29	n.c.	
30	S5	Track 5 Push-Pull Output
31	n.c.	
32	S4	Track 4 Push-Pull Output
33	n.c.	
34	S3	Track 3 Push-Pull Output
35	n.c.	
36	S2	Track 2 Push-Pull Output
37	S1	Track 1 Push-Pull Output
38	S0	Track 0 Push-Pull Output
	n.c.	Pin not connected.

PACKAGE DIMENSIONS oQFN38-7x5



Maximum molding excess +0 µm / -50 µm versus surface of glass.
All dimensions given in mm.

ABSOLUTE MAXIMUM RATINGS

Beyond these values damage may occur; device operation is not guaranteed.

Item No.	Symbol	Parameter	Conditions	Min.	Max.	Unit
G001	VCC	Voltage at VCC		-0.3	6	V
G002	V(S)	Voltage at Output S0..7		-0.3	VCC +0.3	V
G003	I(S)	Current in Outputs S0..7	V(S) < 0 V or V(S) > VCC	-3	3	mA
G004	V(NI)	Voltage at Analog Outputs NI0..2		-0.3	VCC +0.3	V
G005	I(NI)	Current in Analog Outputs NI0..2		-3	3	mA
G006	I(TIP), I(TIN)	Current in TIP, TIN		-1	1	mA
G007	I(ISET)	Current in ISET		-1	0.1	mA
G008	I(AGND)	Current in AGND		-5	5	mA
G009	I(LED)	Current in LED	V(LED) < 0 or V(LED) > VCC	-3	3	mA
G010	I(LED)	Current in LED	0 < V(LED) < VCC	0	150	mA
G011	V(CSR)	Voltage ar CSR		-0.3	VCC +0.3	V
G012	I(CSR)	Current in CSR		-3	3	mA
G013	V(NER)	Voltage at NER		-0.3	6	V
G014	Vd()	ESD Susceptibility	HBM, 100 pF discharged through 1.5 kΩ		2	kV
G015	Tj	Junction Temperature		-40	125	°C
G016	Ts	Chip Storage Temperature		-40	125	°C

THERMAL DATA

Operating conditions: VCC = 5 V ±10%
For package oQFN38-7x5 only; for BLCC OGC refer to the relevant package specification, available separately.

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 = 5 V ±10%, Tj = -40 to 125 °C, unless otherwise noted.

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 in VCC, Outputs S0..7 hi	LED control active: R(ISET/AGND) = 140 kΩ, I(LED) ≈ 8 mA, NER = hi; I(DP0..7) = 30 nA, I(DN0..7) = 3 nA, I(S0..7) = 0;		10		mA
003	I(VCC)	Supply Current in VCC, Outputs S0..7 lo	LED control active: R(ISET/AGND) = 14 kΩ, I(LED) ≈ 80 mA, NER = hi; I(DP0..7) = 3 nA, I(DN0..7) = 30 nA, I(S0..7) = 0;		10		mA
004	fc()	Cut-off Frequency, tracks 0..7	sinusoidal waveform, I(DP0..7) = 3...30 nA I(DN0..7) = 30...3 nA	100			kHz
005	tp()	Propagation Delay	see No. 4			2.5	µs
006	fc()	Cut-off Frequency, tracks 0..7	sinusoidal waveform, I(DP0..7) = 6...60 nA I(DN0..7) = 60...6 nA	200			kHz
007	tp()	Propagation Delay	see No. 6			1.5	µs
Photodiodes and Amplifiers, tracks 0..7							
101	Aph(D)	Radiant Sensitive Area	0.2 mm x 0.3 mm		0.06		mm^2
102	S(λ)max	Spectral Sensitivity	λ = 850 nm		0.5		A/W
103	λar	Spectral Application Range	S(λar) = 0.1 x S(λ)max	500		1050	nm
104	Iph(D)	Permissible Photocurrent				90	nA
105	CM()	Common Mode DPi to DNi		0.85	1	1.15	
Difference Comparators, tracks 0..7							
201	Hys	Hysteresis referred to [I(DPi) + I(DNi)] / 2		8	11	17	%
Push-Pull Outputs S0..7							
301	Vs()hi	Saturation Voltage hi	Vs()hi = VCC - V(); I() = -40 µA Tj = 27°C		0.69	0.95	V V
302	Vs()hi	Saturation Voltage hi	Vs()hi = VCC - V(); I() = -400 µA Tj = 27°C		0.83	1.05	V V
303	Vs()lo	Saturation Voltage lo	I() = 1.6 mA; Tj = 27°C		0.22	0.4	V V
304	Isc()hi	Short-Circuit Current hi	V() = 0 V...VCC - 1.2 V	-7	-4.6	-1.4	mA
305	Isc()lo	Short-Circuit Current lo	V() = 0.4 V...VCC	1.8	7.3	13	mA
306	SR()hi	Slew-Rate hi	CL = 30 pF; Tj = 27°C	24	61	130	V/µs V/µs
307	SR()lo	Slew-Rate lo	CL = 30 pF; Tj = 27°C	40	115	380	V/µs V/µs
308	Vc()hi	Clamp Voltage hi	Vc()hi = V() - VCC; S() = hi, I() = 3 mA	0.4		1.5	V
309	Vc()lo	Clamp Voltage lo	S() = lo, I() = -3 mA	-1.5		-0.4	V
Analog Outputs NI0..2							
501	CR()	Current Ratio I(NIi) / (I(DPi) - I(DNi))	V(NIi) = 0.3 V...VCC - 1.2 V, I(DPi) = 3...90 nA, I(DNi) = 90...3 nA; Tj = 27°C	550	720	1250	
502	I0()	Leakage Current	V(NI) = 0.3 V...VCC - 1.2 V, I(DPi,DNi) = 0	-1.5		1.5	µA
503	fc()	Cut-off Frequency	V(NIi) = constant, sinussoidal waveform, I(DPi) = 3...30 nA, I(DNi) = 30...3 nA	100			kHz
504	fc()	Cut-off Frequency	V(NIi) = constant, sinussoidal waveform, I(DPi) = 6...60 nA, I(DNi) = 60...6 nA	200			kHz
505	fc()	Cut-off Frequency	R(VCC/NIi) = 50 kΩ, R(NIi/GND) = 50 kΩ, CL() = 30 pF	50	80		kHz
506	Vc()hi	Clamp Voltage hi	Vc()hi = V() - VCC; I() = 3 mA	0.4		1.5	V
507	Vc()lo	Clamp Voltage lo	I() = -3 mA	-1.5		-0.4	V

ELECTRICAL CHARACTERISTICS

Operating conditions: VCC = 5 V ±10%, Tj = -40 to 125 °C, unless otherwise noted.

Item No.	Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Test Aid TIP, TIN							
601	CR()	Current Ratio I(TIP) / I(DPi,DDC) and I(TIN) / I(DNi)	Test aid active, I() = 2...200 µA	750	1100	1600	
602	It()	Pull-Down Current (Test Aid Turn-on Threshold)	V() = 0.4 V; Tj = -40°C Tj = 27°C Tj = 85°C Tj = 125°C	2.5	 14 19 25 28	125	µA µA µA µA µA
603	V()on	Turn-on Voltage	Test aid active, I(TIP) = 2...200 µA and I(TIN) = 100 µA, or I(TIP) = 100 µA and I(TIN) = 2...200 µA; Tj = -40°C Tj = 27°C Tj = 85°C Tj = 125°C	 1.9 1.6 1.2 1.1	 2.4 2.1 1.8 1.6	 2.7 2.4 2.1 1.9	 V V V V
LED Current Control ISET, AGND, LED, CSR							
701	ISUM	Permissible Sum Current of photodiodes DP0, DN0, DP1, DN1	ISUM = I(DP0) + I(DN0) + I(DP1) + I(DN1)	0		360	nA
702	I(LED)	Permiss. Driver Current in LED		0		80	mA
703	Vs(LED)	Saturation Voltage at LED	I(LED) = 80 mA, I(ISET) > 20 µA, V(CSR) = VCC; Tj = -40°C Tj = 27°C Tj = 85°C Tj = 125°C		 0.96 0.88 0.79 0.72	1.35	V V V V V
704	V(ISET)	Voltage at ISET	R(ISET/AGND) = 10...150 kΩ	1.15	1.22	1.35	V
705	CR()	Current Ratio I(ISET) / I(CSR)	V(CSR) = 0.3V, ISUM = 0, R(ISET) = 10...150 kΩ; Tj = -40°C Tj = 27°C Tj = 85°C Tj = 125°C	8	 12.0 11.9 11.75 11.65	15	
706	CR()	Current Ratio I(CSR) / ISUM	V(CSR)= 1..3V, I(ISET)= 0	70	92	130	
707	Vc()hi	Clamp Voltage hi at ISET, LED, CSR	Vc()hi = V() - VCC; I() = 3 mA	0.4		1.5	V
708	Vc()lo	Clamp Voltage lo at ISET, LED, CSR	VCC = 0 V, I() = -3 mA	-1.5		-0.4	V
Control Monitor NER							
801	Vs()	Saturation Voltage lo	I(NER) = 3.2 mA		0.27	0.4	V
802	Isc()lo	Short-Circuit Current lo	V(NER) = VCC		15	27	mA
803	I0()	Collector Off-state Current	NER: off, V(NER) = 0...6 V			10	µA

DESCRIPTION OF FUNCTIONS

LED current control

The integrated LED current control with a driver stage controls the LED in accordance with the sum of the photocurrents from the tracks 0 and 1. Compensation is made for age and dirt, as well as for the reduced efficiency of the LED caused by rises in temperature.

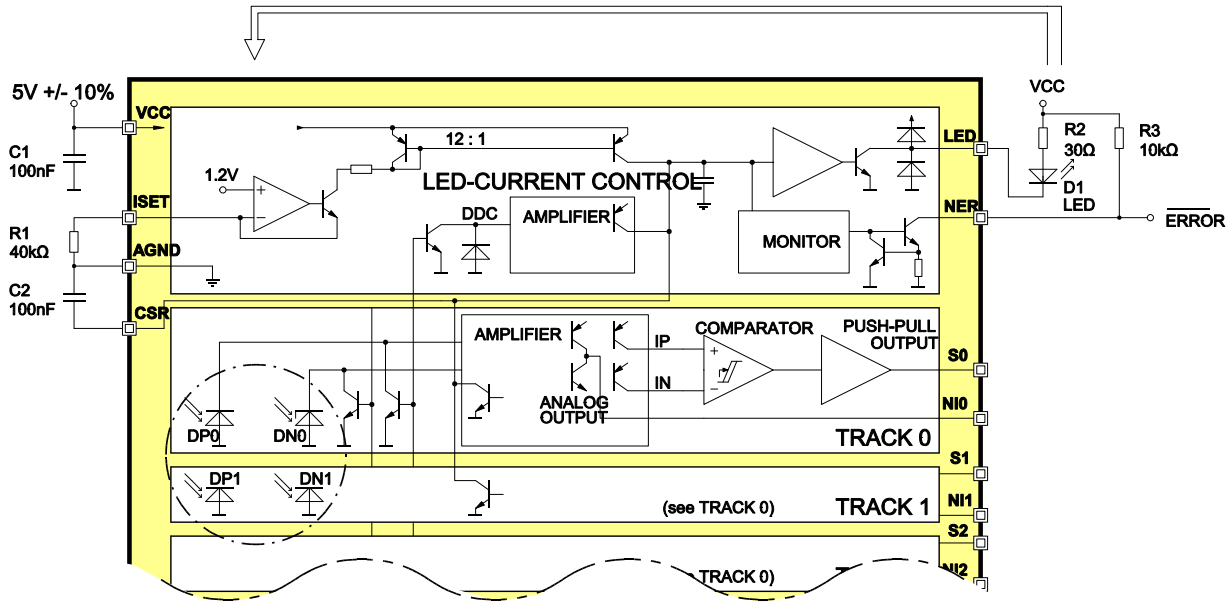


Figure 1: LED current control and monitoring.

The photodiodes DPO, DNO, DP1 and DN1 act as reference diodes. The sum is output via a current sink to the comparison point pin CSR. Simultaneously, the resistor R1 at pin ISET (the voltage at the ISET pin is kept at a constant of approximately 1.22 V) supplies a reference current for the current source from VCC, which also works towards the comparison point pin CSR. The comparison point also receives the amplified current from the compensation diode DDC in order to compensate for dark currents and for the amplifier input currents.

If there is an optical feedback from the LED to the reference photodiodes, the voltage at the CSR pin adjusts to satisfy the needs of the power driver for the required transmit current at pin LED. In this instance, the ratio between I(ISET) and the sum of the photodiode current ISUM is constant (Electrical Characteristics Nos. 705 and 706). The current flowing through the resistor R1 is the setpoint for the control and directly presets the desired level of illumination.

An internal capacitor ensures that the control is stable. The comparison point pin CSR is lead out additionally, enabling an external capacitor C2 to be connected to adapt the control behavior. Lower values for R1 require larger values for C2, which also improve the power-supply rejection ratio for the control. Values from 10 nF upwards are recommended.

A resistor in series with the LED limits the current in pin LED and sets the operating limits of the control.

The optical feedback between the LED and the reference photodiodes should be good enough to establish an LED current of less than 15 mA at room temperature. The power driver needs to have a sufficient current reserve to correct the LED's decline in efficiency even at high temperatures.

Control Monitor and Error Message Output

The control monitor observes the potential at the CSR pin. Voltages which bring the power driver to saturation or off-state are recognized and indicated at the open-collector output by NER = low.

APPLICATIONS INFORMATION

Using the test aid

The threshold current defined in the electrical characteristic No. 602 must be exceeded at both pins TIP and TIN simultaneously to activate the iC-OG's built-in test aid. Once it has been activated, the test aid does not switch back to off-state until the current drops below approx. 1 µA.

A clamp circuit as shown in Figure 2 also prevents falling below the test aid turn-on threshold for a short time. The output polarity of the iC-OG is to be changed over with the switch.

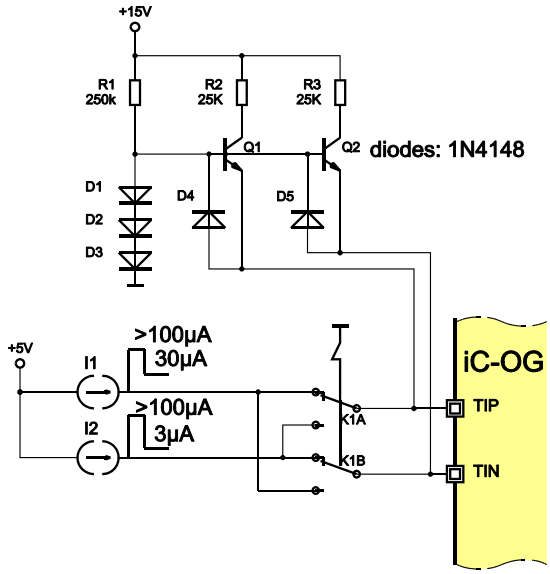


Figure 2: Wiring the test aid.

ORDERING INFORMATION

Type	Package	Options	Order Designation
iC-OG	38-pin optoQFN	glass lid custom reticle	iC-OG oQFN38-7x5 iC-OG oQFN38-7x5-xR
iC-OG	20-pin BLCC OGC	glass lid custom reticle	iC-OG BLCC OGC-1L iC-OG BLCC OGC-xR

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