iC-WG
14-BIT DIFFERENTIAL SCANNING OPTO ENCODER

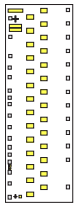
FEATURES

- Excellent matching and reliability due to monolithic construction with integrated photodiodes
- Short track pitch (600µm)
- Elimination of dark currents due to differential scanning
- Photocurrent amplifier with high cut-off frequency
- Current comparators with acurately tracked hysteresis
- Current-limited push-pull outputs
- Adjustable LED current control for constant receive power
- Integrated power driver for the transmit LED
- LED current monitor with error message output
- Integrated test aid1
- Low power consumption
- Broad operating voltage range, from 4.5V to 20V
- Available as 28-pin BLCC or as chip
- Options: extended temperature range of -30..110°C, customized packages, reticle assembly, code disc

APPLICATIONS

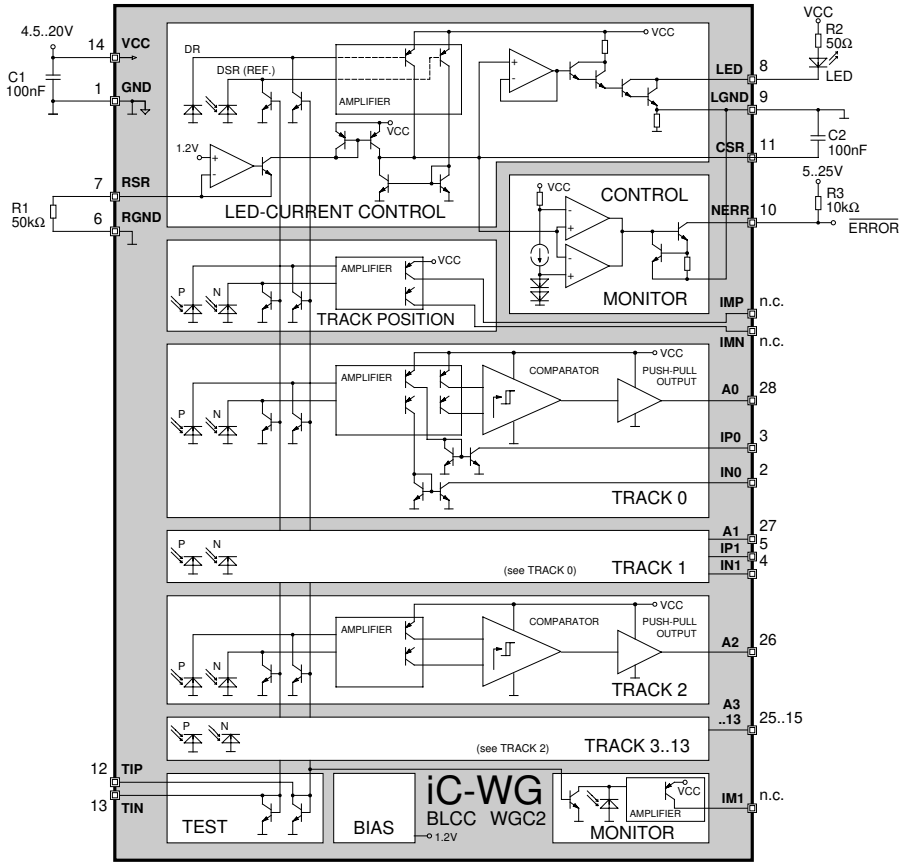
- Optical position decoding with 14-bit resolution based on the principle of differential scanning

CHIP



2.97mm × 8.71mm

BLOCK DIAGRAM



Rev B0

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DESCRIPTION

The iC-WG is an optoelectronic detector IC for linear and angle measuring systems, e.g. glass scales or rotary encoders. Monolithically integrated are photodiodes, amplifiers and comparators as well as TTL-compatible push-pull output drivers. All 14 tracks are differentially evaluated.

An integrated LED current control with driver stage makes it possible to directly connect a transmit LED with series resistor and also guarantees a constant optical received power. The setpoint for the receive current is adjusted via an external resistor. If the LED current control deviates from its working range, this is indicated at the error message output.

For the adjustment of a reticle the chip features two adjustment crosses and supplies the analog signals from three monitor photocurrent amplifiers. For exact radial alignment of the iC-WG (with reticle) to the code disk, two monitor photodiodes are arranged such that the track position can be checked (option, not available in the standard SMD package).

Two test pins permit a complete electrical functional test of the IC not including the photodiodes.

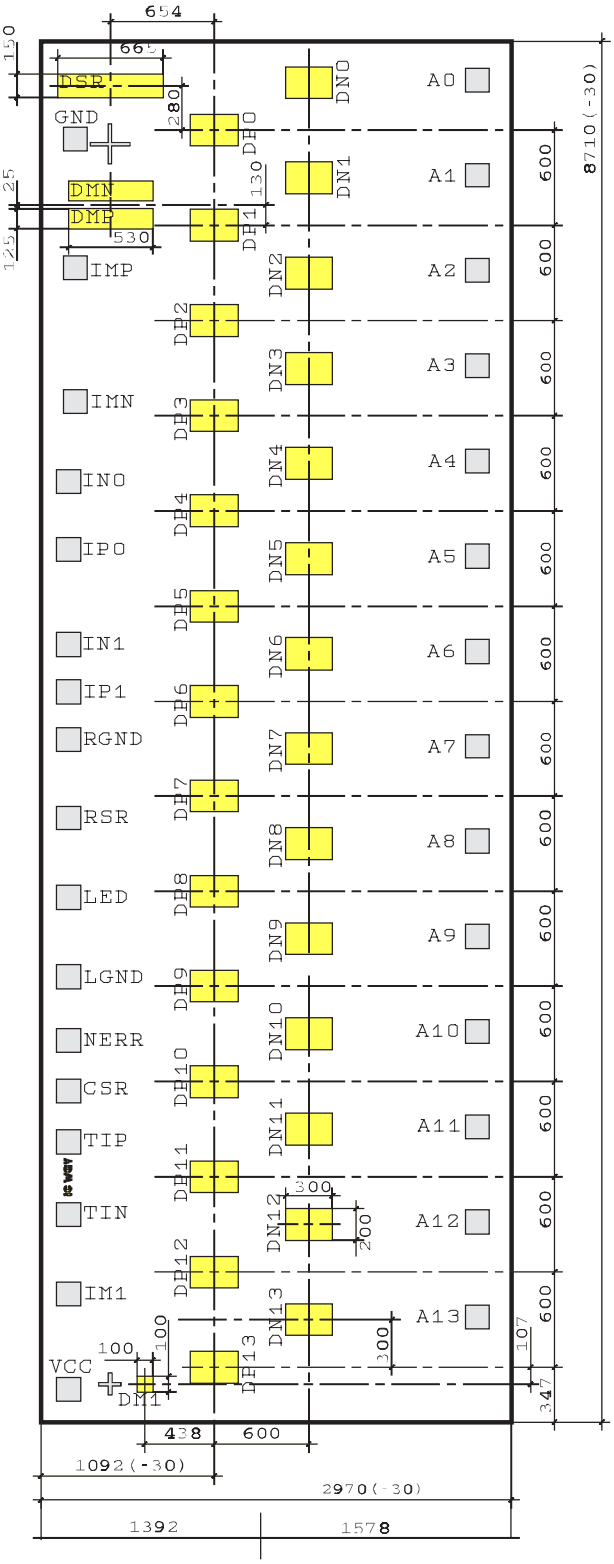
All push-pull and analog outputs are protected against ESD and short-circuits. The error message output NERR is also short-circuit-proof and due to it's open-collector design bus capable.

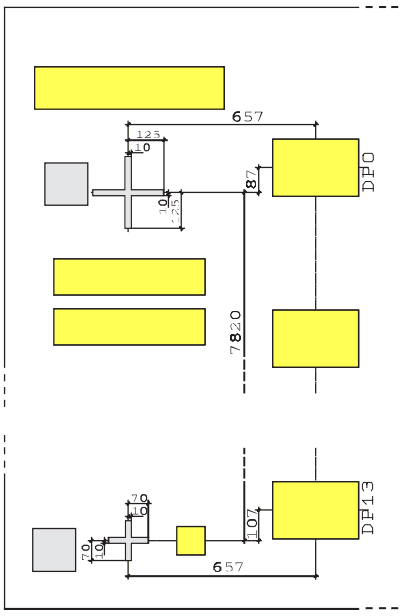
PAD DESCRIPTION

Name	Function
GND	Ground
IN0	Track N0 Analog Output (current sink)
IP0	Track P0 Analog Output (current sink)
IN1	Track N1 Analog Output (current sink)
IP1	Track P1 Analog Output (current sink)
RGND	Reference Ground for RSR circuitry
RSR	LED Current Control Setup
LED	LED Driver Output
LGND	LED Driver Power Ground
NERR	Error Message Output, low active
CSR	External capacitor for LED control
TIP	Positive Test Aid Input
TIN	Negative Test Aid Input
VCC	+5 to +20V Supply Voltage
A13	Track 13 Push-Pull Output
A12	"
..	"
A0	Track 0 Push-Pull Output

CHIP LAYOUT

dimensions in µm; chip size 2.97mm × 8.71mm





ABSOLUTE MAXIMUM RATINGS

Values beyond which damage may occur; device operation is not guaranteed.

Item	Symbol	Parameter	Conditions	Fig.	Min.	Max.	Unit
G001	VCC	Supply Voltage			0	21	V
G301	V(A)	Voltage at Outputs A0..13			0	VCC	
G302	I(A)	Current in Outputs A0..13	V(A)< 0V or V(A)> VCC		-3	3	mA
G501	I(IM1)	Current in Monitor Output IM1			-1	1	mA
G601	I(TIP) I(TIN)	Current in TIP, TIN			-1	1	mA
G701	I(RSR)	Current in RSR			-1	0.1	mA
G702	I(RGND)	Current in RGND			-5	5	mA
G703	I(LED)	Current in LED	V(LED)> VCC		0	3	mA
G704	I(LED -LGND)	Current in LED to LGND			0	150	mA
G705	I(LGND)	Current in LGND	LED and NERR open		-3	3	mA
G706	V(CSR)	Voltage at CSR			0	VCC	
G707	I(CSR)	Current in CSR			-1	1	mA
G802	I(IPi) I(INi)	Current in Analog Outputs IP0, IN0, IP1, IN1			-1	3	mA
G902	I(IMP) I(IMN)	Current in Monitor Outputs IMP, IMN			-1	1	mA
GA01	V(NERR)	Voltage at NERR	LGND at GND		0	30	V
E001	Vd()	ESD Susceptibility at all Pins	MIL-STD 883, Method 3015, HBM, 100pF discharged through 1.5kΩ			2	kV
TG1	Tj	Junction Temperature			-30	125	°C
TG2	Ts	Storage Temperature	see package specification				

THERMAL DATA

Operating Conditions: VCC= 4.5..20V

Item	Symbol	Parameter	Conditions	Fig.	Min.	Typ.	Max.	Unit
T1	Ta	Operating Ambient Temperature Range	see package specification					

All voltages are referenced to ground unless otherwise noted.
All currents into the device pins are positive; all currents out of the device pins are negative.

ELECTRICAL CHARACTERISTICS

Operating Conditions: VCC= 4.5..20V, Tj= -20..125°C, unless otherwise noted

Item	Symbol	Parameter	Conditions	Tj °C	Fig.	Min.	Typ.	Max.	Unit
Total Device									
001	VCC	Permissible Supply Voltage				4.5		20	V
002	I(VCC)	Supply Current in VCC, Outputs A0..13 hi	LED control active: R(RSR/RGND)= 140kΩ, NERR=hi I(LED)≈ 8mA, I(A0..13)= 0; I(DP0..13)=30nA, I(DN0..13)=3nA, VCC= 5V	-20 27 85 125		3.0	 5.4 5.9 6.2 6.2	10.7	mA mA mA mA mA
			see above, VCC= 20V	-20 27 85 125		3.3	 6.4 6.7 7.0 7.4	14.6	mA mA mA mA mA
003	I(VCC)	Supply Current in VCC, Outputs A0..13 lo	LED control active: R(RSR/RGND)= 14kΩ, NERR=hi I(LED)≈ 80mA, I(A0..13)= 0; I(DP0..13)=3nA, I(DN0..13)=30nA, VCC= 5V	-20 27 85 125		6.0	 11.7 12.8 13.6 13.8	25.5	mA mA mA mA mA
			see above, VCC= 20V	-20 27 85 125		6.8	 14.6 16.3 17.0 17.4	38.5	mA mA mA mA mA
004	fo	Cut-off Frequency, tracks 0..13	sinusoidal waveform, I(DP0..13)= 3..30nA I(DN0..13)= 30..3nA			100			kHz
005	tp(D-A)	Switch Delay	see No. 004					2.5	µs
006	fo	Cut-off Frequency, tracks 0..13	sinusoidal waveform, I(DP0..13)= 6..60nA I(DN0..13)= 60..6nA			200			kHz
007	tp(D-A)	Switch Delay	see No. 006					1.5	µs
Photodiodes DP0..13, DN0..13, DSR, DMP, DMN, DM1									
008	S(λ)max	Spectral Sensitivity	λ= 850nm				0.5		A/W
009	λar	Range of Spectral Sensitivity	Se(λar)= 0.1×S(λ)max			500		1050	nm
Photodiodes and Amplifiers with Analog Outputs, track 0 and 1									
801	Aph(D)	Radiant Sensitive Area				0.2 × 0.3			mm²
802	I(D)	Permissible Photocurrent						90	nA
803	Ierr	Error Current at Photodiodes		-20 27 85 125			4.7 3.6 3.2 15.5	20 15 15 25	nA nA nA nA
804	CM()	Common Mode DPi to DNi				0.85	1	1.15	
805	CR()	Current Gain I(IPi) / I(DPi), I(INi) / I(DNi)	V(IPi,INi)= 1V..VCC, I(DPi,DNi)= 3..90nA			600		900	
806	CR()	Current Gain I(IPi) / I(DPi), I(INi) / I(DNi)	VCC= 5V, V(IPi,INi)= 2V, I(DPi,DNi)= 30nA	27			740		
807	TC(CR)	Temperature Coefficient of Current Gain CR	Tj< 90°C				-0.03		%/K
808	I0(IPi) I0(INi)	Analog Output Leakage Current	V(IPi,INi)= 1V..VCC, I(DPi,DNi)= 0					10	µA

ELECTRICAL CHARACTERISTICS

Operating Conditions: VCC= 4.5..20V, Tj= -20..125°C, unless otherwise noted

Item	Symbol	Parameter	Conditions	Tj °C	Fig.	Min.	Typ.	Max.	Unit
Photodiodes and Amplifiers with Analog Outputs, track 0 and 1 (continued)									
809	fo(IPi) fo(INi)	Analog Output Cut-off Frequency	R(VCC/IPi, VCC/INi)= 50kΩ, CL(IPi,INi)= 30pF			50	80		kHz
810	fo(IPi) fo(INi)	Analog Output Cut-off Frequency	V(IPi,INi)= constant, sinussoidal waveform, I(DPi)= 3..30nA, I(DNi)= 30..3nA			100			kHz
811	fo(IPi) fo(INi)	Analog Output Cut-off Frequency	V(IPi,INi)= constant, sinussoidal waveform, I(DPi)= 6..60nA, I(DNi)= 60..6nA			200			kHz
Photodiodes and Amplifiers, tracks 2 to 13									
101	Aph(D)	Radiant Sensitive Area				0.2 × 0.3			mm²
102	I(D)	Permissible Photocurrent						90	nA
103	Ierr	Error Current at Photodiodes		-20 27 85 125			4.7 3.6 3.2 15.5	20 15 15 25	nA nA nA nA
104	CM()	Common Mode DPi to DNi				0.85	1	1.15	
Difference Comparators, tracks 0..13									
201	Hys	Hysteresis refered to [I(DPi) + I(DNi)] /2	I(DPi, DNi)= 3..30nA			8	11	14	%
Push-Pull Outputs A0..13									
301	Vs()hi	Saturation Voltage hi	Vs()hi= VCC -V(); I()= -40µA	 -20 27 85 125			 0.79 0.69 0.58 0.51	0.9	V V V V V
			Vs()hi= VCC -V(); I()= -400µA	 -20 27 85 125			 0.9 0.83 0.74 0.68	1.0	V V V V V
302	Vs()lo	Saturation Voltage lo	I()= 1.6mA	 -20 27 85 125			 0.21 0.22 0.25 0.27	0.4	V V V V V
303	Isc()hi	Short-Circuit Current hi	V()= 0V..VCC-1V			-7	-4.6	-1.5	mA
304	Isc()lo	Short-Circuit Current lo	V()= 0.4V..VCC			1.8	7.3	13	mA
305	SRhi	Slew-Rate hi	CL()= 30pF	 27		24	 61	130	V/µs V/µs
306	SRlo	Slew-Rate lo	CL()= 30pF	 27		50	 115	330	V/µs V/µs
307	Vc()hi	Clamp Voltage hi	Vc()hi= V() -VCC; I()= 3mA			0.4		1.5	V
308	Vc()lo	Clamp Voltage lo	I()= -3mA			-1.5		-0.4	V

ELECTRICAL CHARACTERISTICS

Operating Conditions: VCC= 4.5..20V, Tj= -20..125°C, unless otherwise noted

Item	Symbol	Parameter	Conditions	Tj °C	Fig.	Min.	Typ.	Max.	Unit
Test Aid TIP, TIN									
601	CR(TIP), CR(TIN)	Current Ratio I(TIP) / I(DPi,DMP,DR), I(TIN) / I(DNi,DMN,DSR), I(TIP) / I(DM1)	test aid active, I(TIP,TIN)= 2..200µA			400	1100	1600	
602	It()	Pull-Down Current at TIP, TIN; Test Aid Turn-on Threshold	V(TIP,TIN)= 0.5V			2	14	100	µA
603	V(TIP), V(TIN)	Voltage at TIP, TIN	test aid active; I(TIP)= 2..200µA and I(TIN)= 100µA, or I(TIP)= 100µA and I(TIN)= 2..200µA			1.9	2.4	2.7	V
LED Current Control and Reference Photodiode DSR									
701	Aph (DSR)	Radiant Sensitive Area				0.15 × 0.665			mm²
702	I(DSR)	Permissible Photocurrent in DSR				0		200	nA
703	I(LED)	Permissible Current in LED				0		80	mA
704	Vs(LED /LGND)	Saturation Voltage at LED vs. LGND	I(LED)= 80mA, I(RSR)> 10µA, V(CSR)= VCC, V(LGND)= 0..1V	-20 27 85 125			 0.84 0.76 0.67 0.60	1.2	V V V V V
705	V(RSR)	Voltage at RSR	R(RSR/RGND)= 10..150kΩ			1.0	1.22	1.5	V
706	CR()	Current Ratio I(RSR) / I(CSR)	R(RSR)= 10..150kΩ, V(CSR)= 0V			5.3	10	13	
707	CR()	Current Ratio I(RSR) / I(DSR)	closed LED Control, I(DSR)= 20..200nA; VCC= 5V	-20 27 85 125		340	 450 430 420 415	660	
			see above, VCC= 20V	-20 27 85 125		220	 370 350 345 340	540	
708	CG()	Current Gain I(LED) / I(RSR)	control loop open, LGND at GND, V(LED)> 1.5V, V(CSR)= VCC			15000			
709	R(LGND)	Resistance at LGND	V(LGND)= 0..2V			0.6	1.0	1.6	kΩ
Control Monitor NERR									
A01	Vs()lo	Saturation Voltage lo	LGND at GND, I(NERR)= 3.2mA				0.27	0.4	V
A02	Isc()lo	Short-Circuit Current lo	V(NERR)= VCC				15	27	mA
A03	I0()	Collector Off-State Current	NERR= off, V(NERR)= 25V					10	µA

ELECTRICAL CHARACTERISTICS

Operating Conditions: VCC= 4.5..20V, Tj= -20..125°C, unless otherwise noted

Item	Symbol	Parameter	Conditions	Tj °C	Fig.	Min.	Typ.	Max.	Unit
Monitor Photodiode DM1 with Amplifier **(not available in standard BLCC package)**									
501	Aph (DM1)	Radiant Sensitive Area					0.1 × 0.1		mm²
502	Ierr	Error Current at Photodiode DM1		-20 27 85 125			1 1 1 3.5	5 5 5 10	nA nA nA nA
503	CR()	Current Gain I(IM1) / I(DM1)	I(DM1)= 2..20nA, V(IM1)= 0..VCC-1V; VCC= 5V VCC= 20V			 3000 4000	 5500 8900	 10000 24000	
504	fo	Cut-off Frequency	sinusoidal waveform, I(DM1)= 2..20nA			100			Hz
Track Position Monitor, Photodiodes DMP und DMN **(not available in standard BLCC package)**									
901	Aph (DMP, DMN)	Radiant Sensitive Area					0.125 × 0.530		mm²
902	Ierr	Error Current at Photodiodes DMP, DMN		-20 27 85 125			3 3 3 15	20 15 15 25	nA nA nA nA
903	CR()	Current Gain I(IMP) / I(DMP), I(IMN) / I(DMN)	I(DMP,DMN)= 2..20nA, V(IMP,IMN)= 0..VCC-1V; VCC= 5V VCC= 20V			 3000 4000	 5500 8900	 10000 24000	
904	fo	Cut-off Frequency	sinusoidal waveform, I(DMP,DMN)= 2..20nA			100			Hz

DESCRIPTION OF FUNCTIONS

LED Current Control

The integrated LED current control with driver stage keeps the photocurrent of the reference photodiode DSR constant. Compensation is made for aging and dirt as well as for the decline in the efficiency of the transmit LED as the temperature rises.

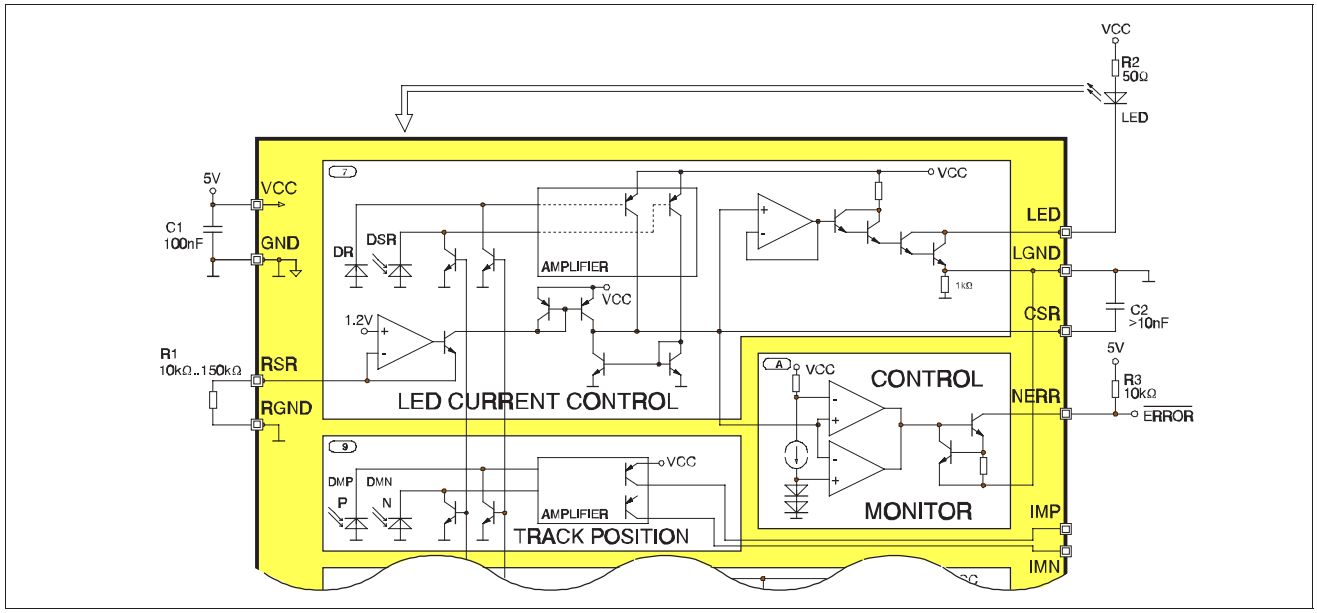


Figure 1: LED current control and control monitor

The photocurrent in the reference photodiode DSR is amplified by the differential amplifier of the LED current control and output to the comparison point pin CSR via a current sink. Simultaneously the resistor R1 at pin RSR - the voltage at pin RSR is kept at a constant approx. 1.22V - supplies a reference current for the current source from VCC which also works on the comparison point, pin CSR. To compensate for the dark current of the reference diode and the amplifier input currents, the comparison point also receives the amplified current of compensation diode DR.

If there is an optical feedback from the LED to the reference photodiode DSR, a voltage develops at pin CSR which is just high enough to satisfy the needs of the power driver for the required transmit current at pin LED. In this case the current ratio between I(RSR) and reference photodiode current I(DSR) is constant (electrical characteristics No.707). The current through resistor R1 is the setpoint for the control and presets the desired illuminance directly.

The capacitor at pin CSR ensures the stability of the control. The value selected for it should be higher than 10nF; lower values for R1 require larger values for CSR, which also improve the power supply rejection for the control.

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

The optical feedback between LED and reference photodiode should be so good that an LED current of less than 15mA develops at room temperature. Only then the power driver does have enough current reserve to also correct the declining efficiency of the LED for high temperatures too. If higher LED currents are required, the base of an external transistor can be connected to LGND to form a three-fold Darlington stage (increases the saturation voltage at error message output NERR).

Control Monitor and Error Message Output
The error message output NERR is used to signal a possible incorrect scanning due to illuminances which are too low or too high.

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 NERR= low.

If the series resistor for the LED limits the transmit current, this is indicated at NERR. Due to the principle of differential formation, however, the scanning is still guaranteed until the minimum brightness preset by the hysteresis of the comparators is achieved. As the illuminance declines, the cut-off frequency will initially drop without a faulty scanning developing in a static case (e.g. when code disk comes to standstill). Recognizing such faulty scanning necessitates an additional evaluating logic which constantly checks the code (check for unit-distance code in case of Gray code, parity check, etc.).

APPLICATIONS INFORMATION

Using the test aid
The threshold current defined in electrical characteristic No.602 must be exceeded at both pins TIP and TIN simultaneously to activate the iC-WG'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. 1µA.

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-WG is to be changed over with the switch.

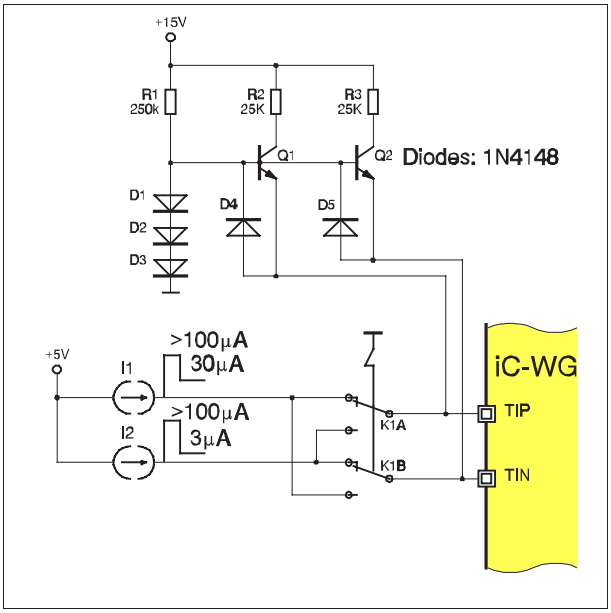


Figure 2: Wiring the test aid

Track position monitor (not available in the standard BLCC28 package)
If the code disk bears separate P/N tracks, the monitor diodes DMP and DMN can be used for radial alignment of chip with reticle. The reticle opening via DMP and DMN must be a whole-number multiple of the slot width for track 1. When the track position is correct, the analog outputs then exhibit signals equal in size and without AC components.

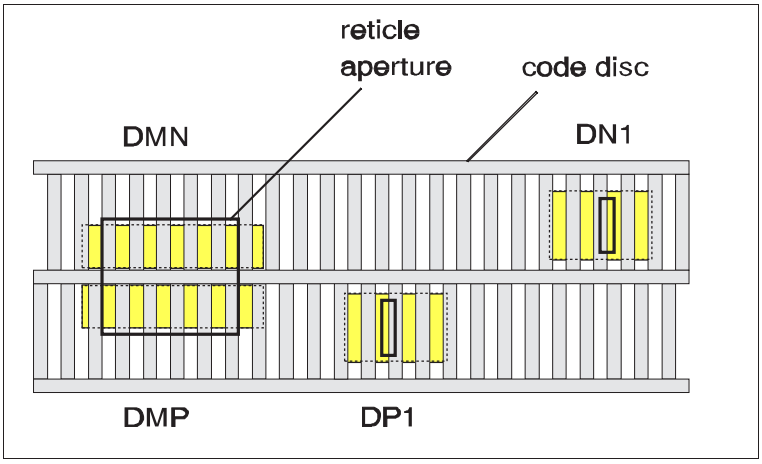


Figure 3: Position monitoring with photodiodes DMP, DMN

ORDERING INFORMATION

Type	Package	Order designation
iC-WG	-	iC-WG *Chip*
iC-WG	BLCC WGC2	iC-WG BLCC WGC2
iC-WG with reticle WG1R	BLCC WGC2	iC-WG BLCC WGC2 +WG1R
WG1S Code Disc (13-bit Gray)		WG1S

For information about prices, terms of delivery, options for other case types, etc., please contact:

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