Adjustable Linear Low Dropout LED Driver   TLE4309

Features

- Adjustable constant current up to 500 mA
- Operating supply voltage range 4.5 V to 24 V
- Maximum supply voltage up to 45 V
- Low dropout voltage
- PWM / ENABLE input
- << 1 µA quiescent current when disabled
- Overtemperature protection
- Short circuit proof
- Reverse polarity protection
- Operating junction temperature range: -40 °C to 150 °C
- Suitable for applications up to 85 °C ambient temperature.
- Green Product (RoHS compliant)

PG-TO263-7
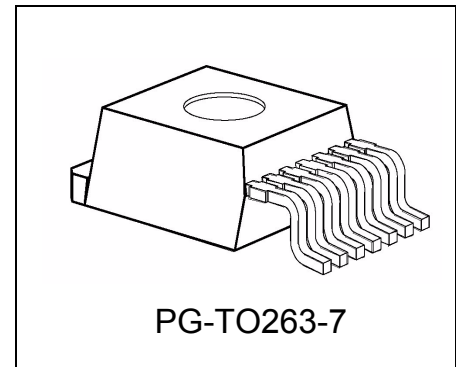
Functional Description

The TLE4309 is an integrated adjustable constant current source for driving loads up to 500 mA. The output current level can be adjusted with an external shunt resistor. Supplying high power LEDs with the TLE4309 ensures constant brightness independent from supply voltage or LED forward voltage spread. Therefore, LED lifetime is extended by protecting from overcurrent and overtemperature

The PWM/EN input permits LED brightness regulation by pulse width modulation. Setting the pin to "low" switches off the IC entirely. Due to the high impedance of the PWM/EN input, the TLE4309 can be used as a protected high side switch.

Protection circuits prevent from damage to the IC in case of overload, short circuit, and reverse polarity. A chip temperature monitoring circuit shuts off the power stage and prevents the IC from destruction under fault conditions.

In case of negative input voltage, a leakage current is flowing only from the output to the input, hence the LED are protected against reverse supply. Input voltage peaks up to 45 V are absorbed by the IC, preventing the LEDs from overcurrent.

The TLE4309G is provided in the surface mounted PG-TO-263 package with excellent thermal resistance.

Type	Package	Marking
TLE4309G	PG-TO263-7-1	TLE4309

Circuit Description

An external shunt resistor in the ground path of the connected LEDs senses the LED current. A regulation loop maintains the voltage drop across the shunt resistor at a constant level. Selecting the shunt resistance permits to adjust the appropriate constant current . The output current calculates

$$I_{Q,typ} = \frac{V_{REF}}{R_{REF}}$$

(1)

where V_{REF} is the reference voltage. (see "Electrical Characteristics" table). The equation applies in a range of $0.39\ \Omega \leq R_{REF} \leq 1.8\ \Omega$. On Page 7, the output current is shown as a function of the reference resistance.
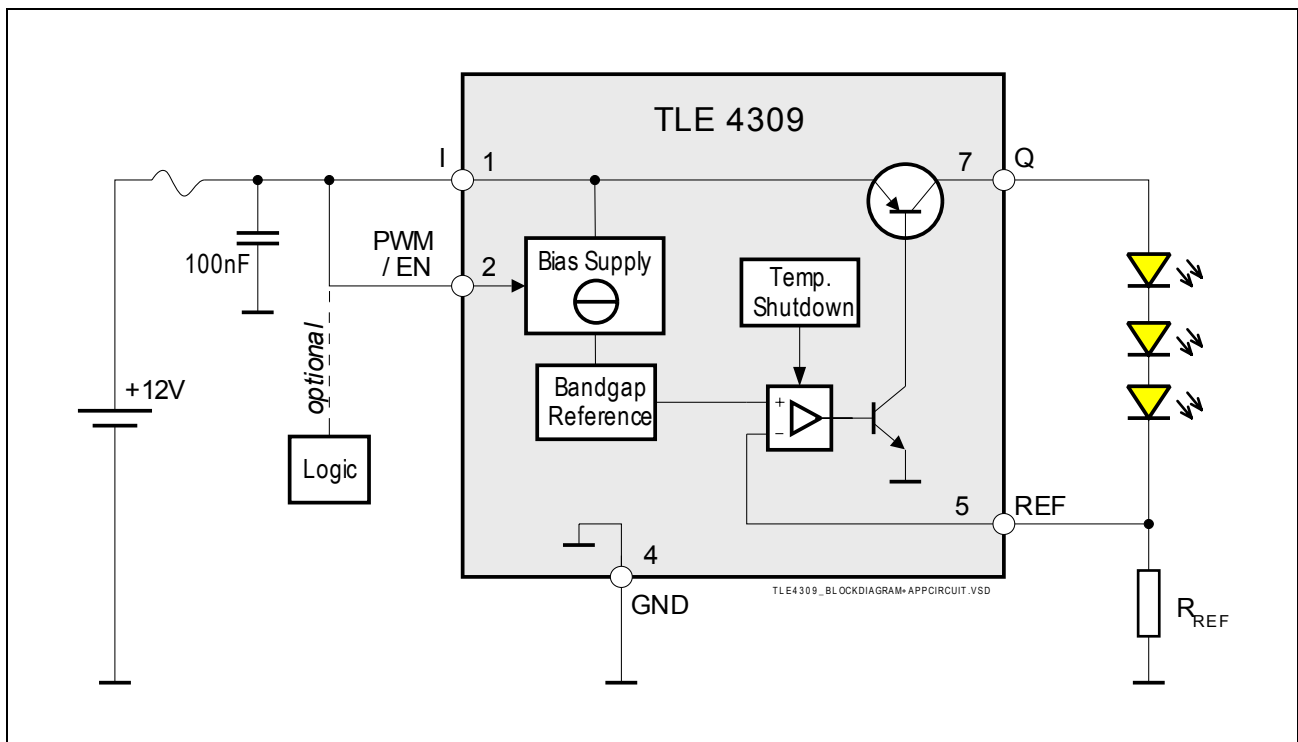

Figure 1   Block Diagram and Typical Application Circuit

During operation, the LED brightness is modifiable by adjusting the duty cycle at the PWM/EN input. This allows to dim the LEDs during operation or adapt the output current to different LED luminosity classes.

A low signal at the PWM/EN input sets the IC into sleep mode consuming less than 1 µA. Due to its high input impedance, the PWM/EN pin can be used as an enable input. Connect the pin directly to the supply line, if its function is not needed.

The minimum supply voltage calculates as the sum of the LED forward voltages, the TLE4309 dropout voltage and the maximum voltage drop across the reference resistor R_{REF} .
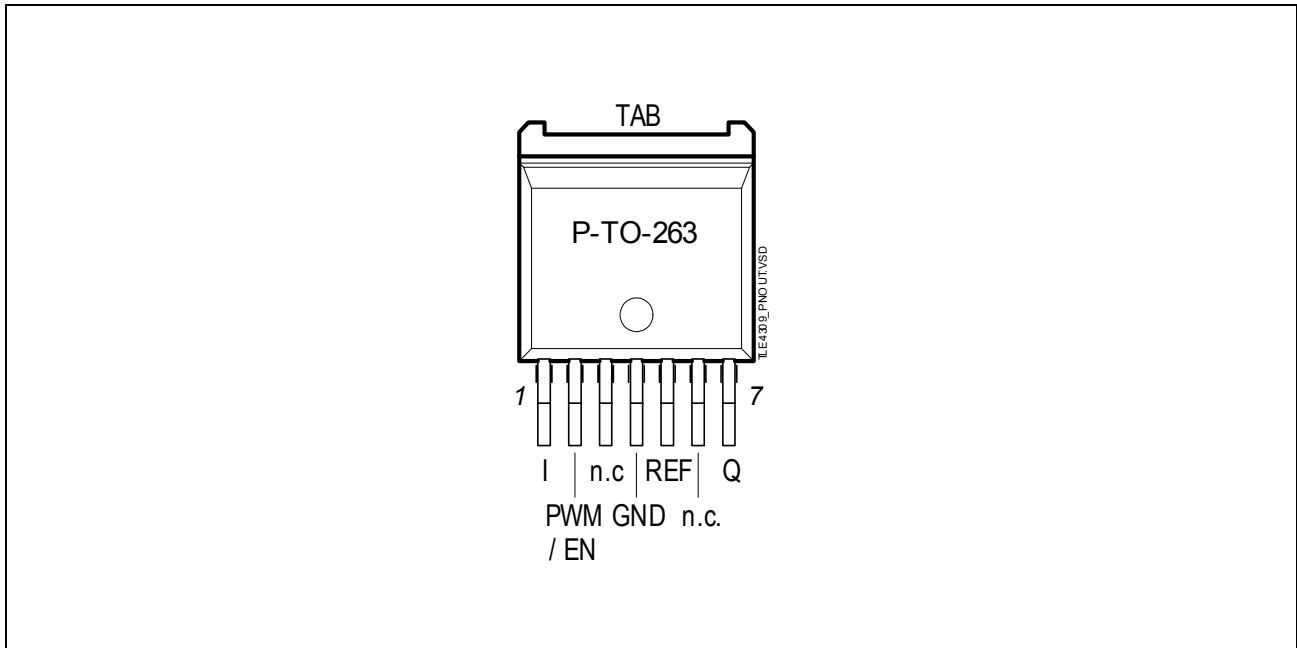
Figure 2 **Pin Configuration** (top view)

Table 1 **Pin Definitions and Functions**

Pin No.	Symbol	Function
1	I	**Input.**
2	PWM / EN	**Pulse Width Modulation Input / ENABLE input.** If not needed connect to I (pin 1).
3	n. c.	Internally not connected. Leave open.
4	GND	**Ground reference;** connect to heatsink area and to TAB.
5	REF	**Reference Input;** connect to shunt resistor.
6	n. c.	Internally not connected. Leave open.
7	Q	**Output.**
TAB		Connect to heatsink area and to GND pin.

Table 2   Absolute Maximum Ratings

Parameter	Symbol	Limit Values		Unit	Remarks
		Min.	Max.		
Input					
Voltage	V_I	-42	45	V	–
Current	I_I	–	–	mA	internally limited
Output					
Voltage	V_Q	-1	40	V	–
Current	I_Q	–	–	mA	internally limited
Reference Input					
Voltage	V_{REF}	-1	16	V	–
Current	I_{REF}	-2	2	mA	–
Pulse Width Modulation / Enable Input					
Voltage	V_{PWM}	-40	40	V	–
Current	I_{PWM}	-1	1	mA	–
Temperatures					
Junction temperature	T_j	-40	150	°C	–
Storage temperature	T_{stg}	-50	150	°C	–
ESD Susceptibility					
ESD Resistivity	$V_{ESD,HBM}$	-2	2	kV	Human Body Model[1]

1) ESD susceptibility, HBM according to EIA/JESD 22-A114B

Note: Stresses above the ones listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note: Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as "outside" normal operating range. Protection functions are not designed for continuous repetitive operation.

Table 3   Operating Range

Parameter	Symbol	Limit Values		Unit	Remarks
		Min.	**Max.**		
Input voltage	V_I	4.5	24	V	–
PWM / ENABLE voltage	V_PWM	0	24	V	–
Junction temperature	T_j	-40	150	°C	–
Reference resistor	R_REF	0	1.8	Ω	–

Note: Within the functional range the IC operates as described in the circuit description. The electrical characteristics are specified within the conditions given in the related electrical characteristics table

.

Table 4   Thermal Resistance

Parameter	Symbol	Typical Limit Values	Unit	Remarks
Junction ambient	R_thja	78	K/W	Footprint only[1]
		52	K/W	300mm^2 heat sink area[1]
		39	K/W	600mm^2 heat sink area[1]
Junction case	R_thjc	3	K/W	–

1) Worst case regarding peak temperature; mounted on PCB FR4, $80 \times 80 \times 1.5$ mm^3, 35 µm Cu, horizontal position, zero airflow.
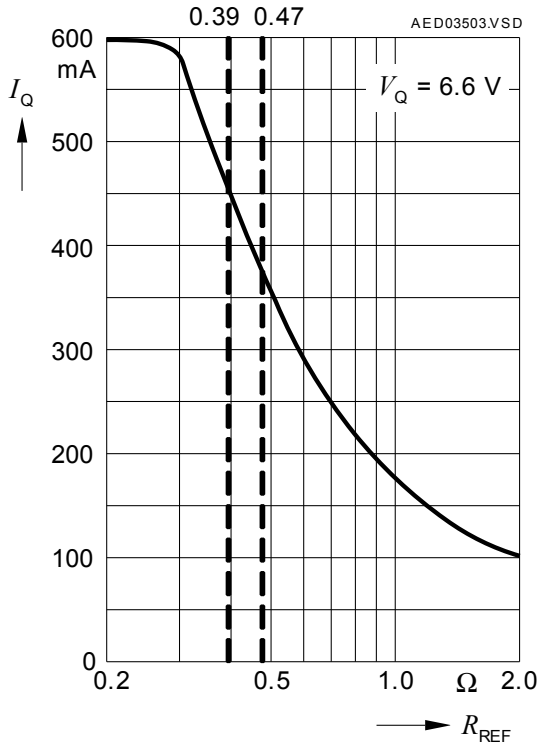
Table 5 Electrical Characteristics

$V_\text{I} = 13.5$ V; $V_\text{PWM} \geq V_\text{PWM,H}$; -25 °C < T_j < 125 °C;
all voltages with respect to ground; unless otherwise specified

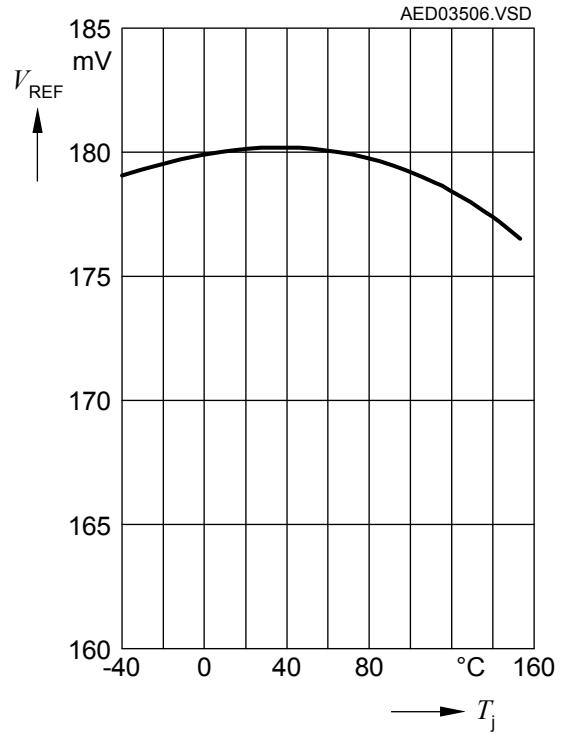| Parameter	Symbol	Limit Values			Unit	Test Condition
		Min.	Typ.	Max.		
Output						
Output current	I_Q	171	178	185	mA	$(V_\text{Q}\text{-}V_\text{REF})^{1)} = 6.6$ V; $R_\text{REF} = 1.0\ \Omega$
		438	456	474	mA	$(V_\text{Q}\text{-}V_\text{REF})^{1)} = 6.6$ V; $R_\text{REF} = 0.39\ \Omega$
Output current limit	I_Qmax	–	600	–	mA	$R_\text{REF} = 0\ \Omega$
Dropout voltage	V_dr	–	0.35	0.7	V	$I_\text{Q} = 300$ mA
Reference						
Reference Voltage	V_REF	172	178	184	mV	$0.39 < R_\text{REF} < 1.0\ \Omega$ $T_\text{j} = 25$ °C
Reference Voltage	V_REF	171	178	185	mV	$0.39 < R_\text{REF} < 1.0\ \Omega$
Reference Input Current	I_REF	-1	0.1	1	µA	$V_\text{REF} = 180$ mV
Current Consumption						
Current consumption off mode	$I_\text{q,OFF}$	–	0.1	2	µA	PWM/EN = L, $T_\text{j} < 85$ °C
Current consumption	I_q	–	12	22	mA	$V_\text{Q} = 6.6$ V; $R_\text{REF} = 0.47\ \Omega$
PWM / ENABLE						
PWM high level valid	$V_\text{PWM,H}$	2.6	–	–	V	–
PWM low level valid	$V_\text{PWM,L}$	–	–	0.7	V	–
PWM input current high level	$I_\text{PWM,H}$	–	220	500	µA	$V_\text{PWM} = 5.0$ V
PWM input current low level	$I_\text{PWM,L}$	-1	–	1	µA	$V_\text{PWM} = 0.0$ V
Turn on delay time	$t_\text{PWM,ON}$	0	15	40	µs	70% of I_Qnom
Turn off delay time	$t_\text{PWM,OFF}$	0	15	40	µs	30% of I_Qnom

1) $(V_\text{Q} - V_\text{REF})$ equals the forward voltage sum of the connected LEDs, see figure 1.
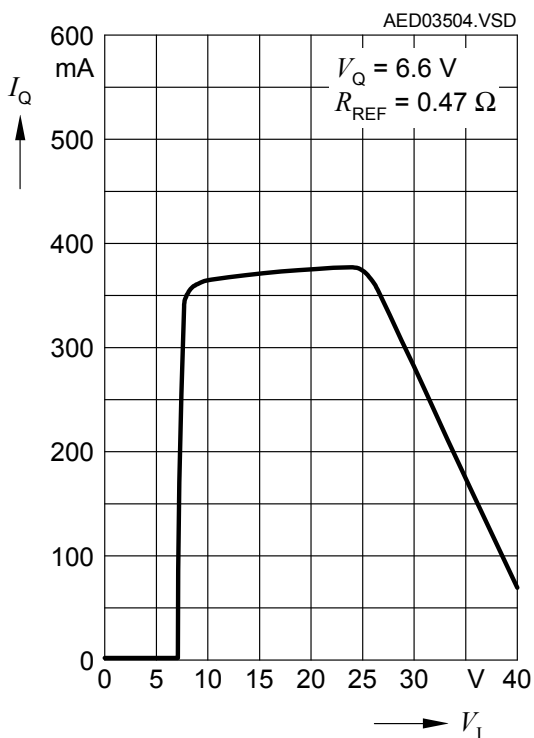
Typical Performance Characteristics
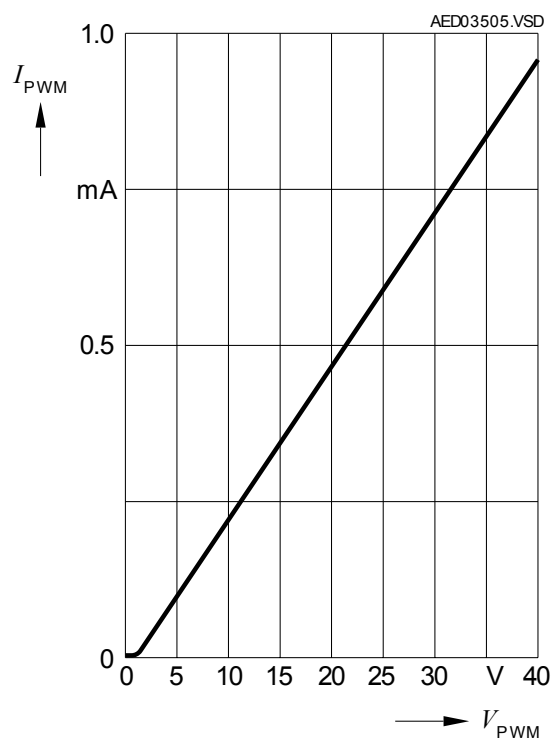
Output Current versus Reference Resistor

I_Q / mA vs R_{REF} / Ω

$V_Q = 6.6$ V

AED03503.VSD

0.39 0.47

Reference Voltage versus Junction Temperature

V_{REF} / mV vs T_j / °C

AED03506.VSD

Output Current versus Supply Voltage

I_Q / mA vs V_I / V

$V_Q = 6.6$ V
$R_{REF} = 0.47$ Ω

AED03504.VSD

PWM/EN Pin Input Current versus Voltage applied

I_{PWM} / mA vs V_{PWM} / V

AED03505.VSD

Package Outline

1) Typical
All metal surfaces tin plated, except area of cut.

GPT09114
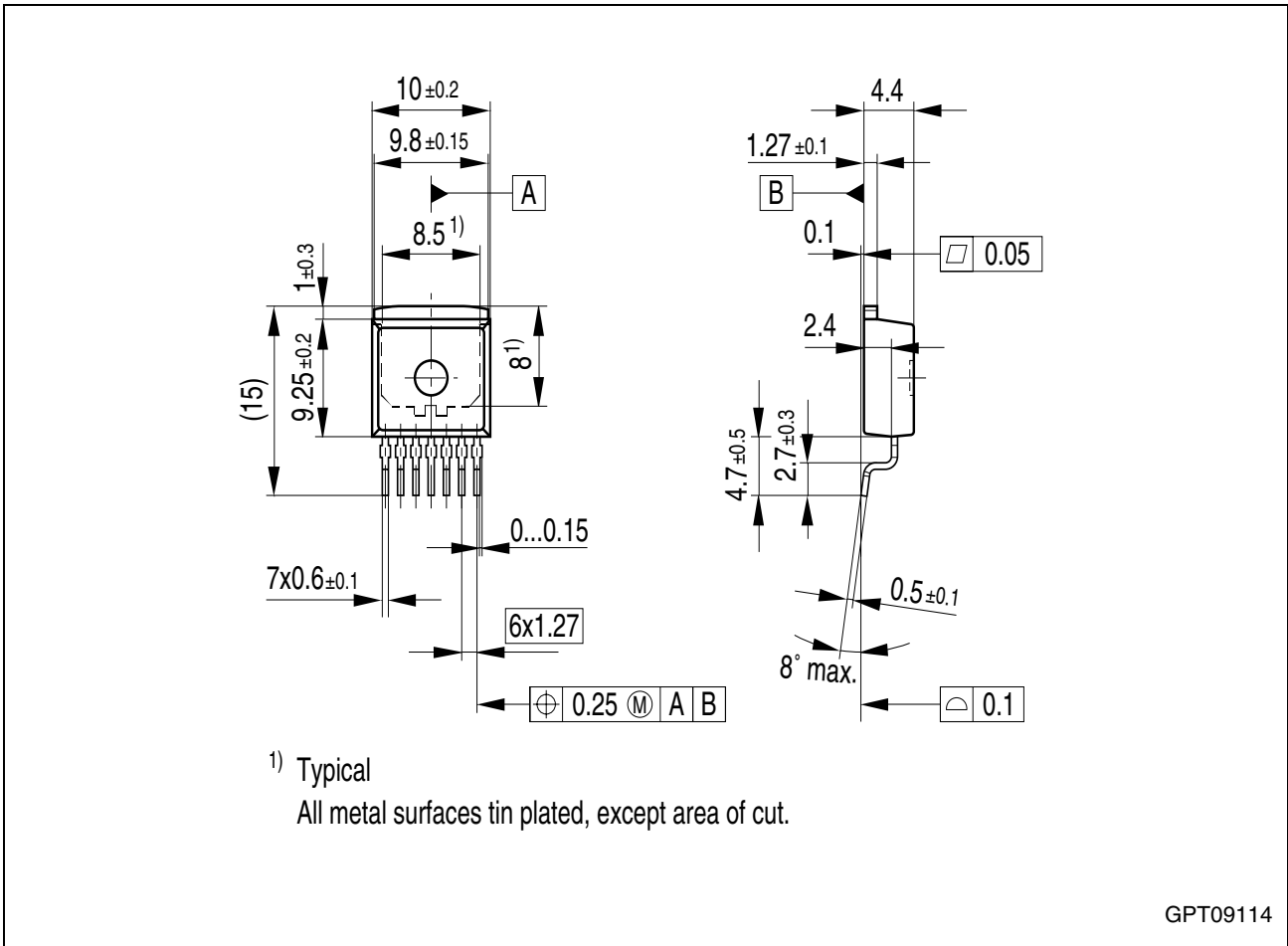
Figure 3   PG-TO263-7-1

Green Product (RoHS compliant)

To meet the world-wide customer requirements for environmentally friendly products and to be compliant with government regulations the device is available as a green product. Green products are RoHS-Compliant (i.e Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

find all packages, sorts of packing and others on the Infineon Internet Page "Packages": **http://www.infineon.com/packages**.

SMD = Surface Mounted Device   Dimensions in mm

Application Note: Thermal Considerations [1]

By describing an example, this section shows how the power dissipation and the needed thermal resistance can be estimated.

For a typical application circuit as shown in Figure 1, the following parameters shall apply:

- Number of LEDs in series: 3
- LED current desired: I_F = 260 mA
- LED minimum forward voltage: $V_{F,MIN}$ = 3.0 V
- LED maximum forward voltage: $V_{F,MAX}$ = 3.4 V
- Supply minimum DC voltage: $V_{I,MIN}$ = 11.0 V
- Supply maximum DC voltage: $V_{I,MAX}$ = 13.0 V
- Maximum ambient temperature: $T_{a,max}$ = 85 °C

1. Selecting the reference resistor:

The reference resistor R_{REF} can be selected by using the formular on page 2 or by taking the value from the typical performance graph "Output Current versus Reference Resistor" on Page 7. In order to obtain a LED forward current of I_F = 260 mA, the graph shows an reference resistor of R_{REF} = 0.68 Ω.

2. Verifying the minimum supply voltage:

In order to be able to drive the LEDs with a constant current, the minimum supply voltage needed is:

$$V_{I,MIN} = V_{F,MAX,total} + V_{dr} + V_{REF}$$

whereas $V_{F,MAX,total}$ is the maximum forward voltage sum of the LEDs connected in series, V_{dr} the dropout voltage and V_{REF} the reference voltage.

Since the power dissipation is low at a small voltage drop accross the regulator, V_{dr} = 0.35 V is assumed. The maximum reference voltags is V_{REF} = 185mV. Therefore, a minimum supply voltage of 11 V is sufficient for the example given above.

3. Determining the minimum and maximum LED forward current:

The TLE4309 has an accuracy of < 4 %. With a reference resistor of R_{REF} = 0.68 Ω, the output current I_Q will be between 251 mA and 272 mA.

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1) This information is given as a hint for the implementation of the device only and shall not be regarded as a description or warranty of a certain functionality, condition or quality of the device.

4. Calculating the maximum power dissipation:

For calculating the maximum power dissipation, the minimum forward voltage sum of the LEDs connected in series $V_{F,MIN,total}$ (= No. of LEDs * $V_{F,MIN}$) , the maximum supply voltage $V_{I,MAX}$, the IC current consumption $I_{q,MAX}$, as well as the the maximum output current $I_{Q,MAX}$ needs to be considered. Hence, the maximum power dissipation $P_{D,MAX}$ calculates:

$$P_{D,MAX} = (V_{I,MAX} - V_{F,MIN,total}) * I_{Q,MAX} + V_{I,MAX} * I_{q,MAX}$$

With assuming a maximum current consumption of 15 mA @ I_Q = 260 mA, the maximum power dissipation for the example is 1.28 W.

5. Thermal Resistance needed:

The thermal resistance from junction to ambient $R_{th,j-a}$ calculates:

$$R_{th,j-a} = (T_{j,max} - T_{a,max}) / P_{D,MAX}$$

With allowing a junction temperature of 150 °C, the $R_{th,j-a}$ needed in our example would be 50 K/W.

In case some copper area on the PCB is used as a heat sink, the area needed is approximately 6 cm^2 (board in horizontal position, no airflow). If the area is not available, several via holes to the GND-layer or to a heatsink area on the PCB backside help to distribute the heat.

For additional information on the thermal resistance see Infineon' s special subject book "Thermal Resistance - Theory and Practice" including extended package information.

Version	Date	Changes
Rev. 1.0	2007-03-20	Final Datasheet and initial version of RoHS-compliant derivate of TLE4309G **Page 1** and **Page 8**: RoHS compliance statement and green product feature added **Page 1** and **Page 8**: Package changed to RoHS compliant version Legal Disclaimer updated

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