

Data Sheet

Rev. 1.1 / August 2010

ZLED7010

40V LED Driver with Temperature Compensation



ZLED7010

40V LED Driver with Temperature Compensation



Brief Description

The ZLED7010, one of our ZLED Family of LED control ICs, is an inductive step-down converter that is optimal for driving a single LED or multiple LEDs (connected in series) from a voltage source greater than the voltage rating of the LED. The ZLED7010 operates in continuous mode. Capable of operating efficiently with voltage supplies ranging from 6 VDC to 40 VDC, it is ideal for low-voltage lighting applications. The ZLED7010 minimizes current consumption by remaining in a low-current standby mode (output is off) until a voltage of $\geq 0.3V$ is applied to the ADJ_I pin.

In operating mode, the ZLED7010 can source LEDs with an output current of $\leq 750mA$ (≤ 30 watts of output power*) that is externally adjustable. The ZLED7010's integrated output switch and high-side current sensing circuit use an external resistor to adjust the average output current. LED control is achieved via an external control signal at the ZLED7010's ADJ_I pin, implemented as a pulse-width modulation (PWM) waveform for a gated output current or a DC voltage for continuous current.

The ZLED7010 provides a temperature compensation function for maintaining stable and reliable LED operation. LED over-temperature conditions are detected via a negative temperature coefficient (NTC) thermistor mounted close to the LEDs. If an over-temperature condition occurs, the NTC value reaches the value of a threshold resistor and the IC reduces LED current automatically. After the circuit recovers to a safe temperature, current returns to the set value.

ADJ_O outputs and ADJ_I inputs of consecutive ICs can be interconnected as a driver chain deploying the temperature compensation information of the predecessor. This reduces the part count because only the first stage of the series requires an NTC.

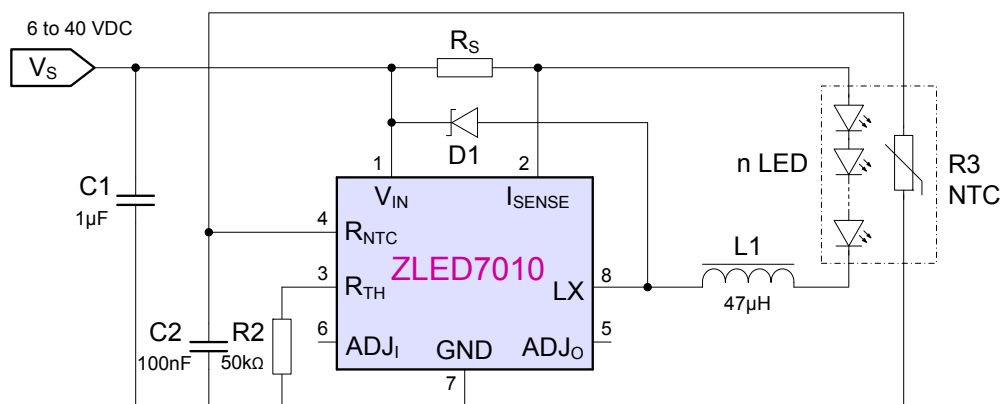
Features

- Capable of 95% efficiency*
- Operates in continuous mode with a wide input range from 6 VDC to 40 VDC
- Integrated 40V power switch
- One-pin on/off or brightness control via DC voltage or PWM control signal
- Switching frequency: $\leq 1MHz$
- Dimming rate: 1200:1 (typical)
- Output current accuracy: 5% (typical)
- Built-in temperature compensation and open-circuit protection for LEDs
- Thermal shutdown protection for the ZLED7010
- Very few external components needed for operation
- Broad range of applications: outputs up to $\leq 750mA$
- SOP-8 package

Application Examples

- Illuminated LED signs and other displays
- LED traffic and street lighting (low-voltage)
- Architectural LED lighting, including low-voltage applications for buildings
- Halogen replacement LEDs (low-voltage)
- LED flood-lighting
- LED backlighting
- General purpose exterior and interior LED lighting, including applications requiring low-voltage
- General purpose low-voltage industrial applications

ZLED7010 Application Circuit



* See section 2.3 for details

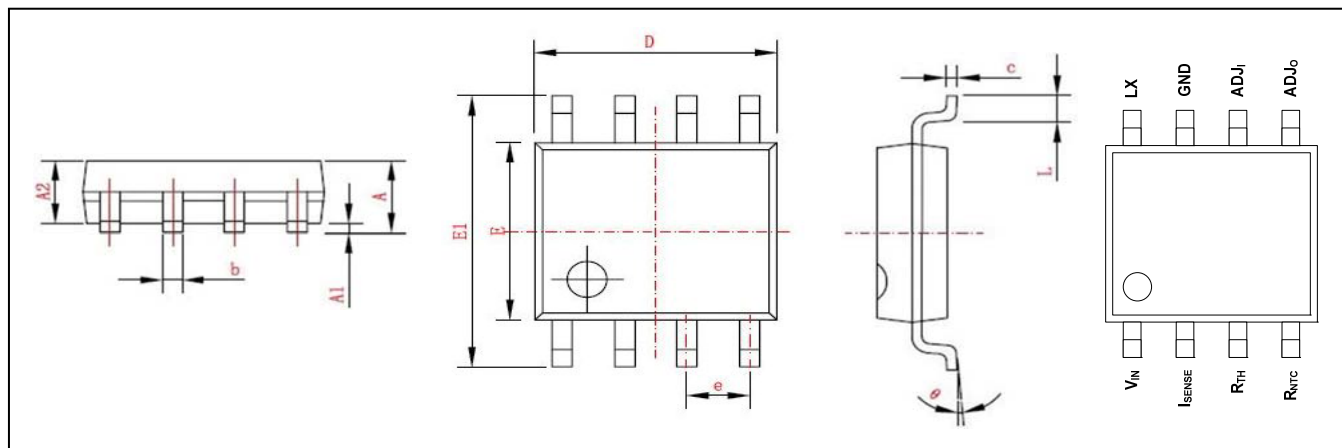
ZLED7010

40V LED Driver with Temperature Compensation



ZMDI
The Analog Mixed Signal Company

SOP-8 Package Dimensions and Pin Assignments



Symbol	Dimension (mm)		Symbol	Dimension (mm, except θ)	
	Min	Max		Min	Max
A	1.350	1.750	E	3.800	4.000
A1	0.100	0.250	E1	5.800	6.240
A2	1.450 Typical		e	1.270 Typical	
b	0.350	0.490	L	0.400	1.270
c	0.178	0.250	θ	0°	8°
D	4.800	5.000			

Ordering Information

Product Sales Code	Description	Package
ZLED7010-ZI1R	ZLED7010 – 40V LED Driver with Temperature Compensation	SOP8 (Tape & Reel)
ZLED7010KIT-D1	ZLED7010 Demo Board with LED on Cool Body 12VAC/VDC	Kit
ZLED-PCB1	Test PCB with one 3W white HB-LED, cascable to 1 multiple LED string	Printed Circuit Board
ZLED-PCB2	10 unpopulated test PCBs for modular LED string with footprints of 9 common HB-LED types	Printed Circuit Board

Sales and Further Information

www.zmdi.com

LED_Drivers@zmdi.com

Zentrum Mikroelektronik Dresden AG (ZMD AG)

Grenzstrasse 28
01109 Dresden
Germany

Phone +49 (0)351.8822.7.533
Fax +49(0)351.8822.8.7533

ZMD America, Inc.

8413 Excelsior Drive
Suite 200
Madison, WI 53717
USA

Phone +1 (608) 829-1987
Fax +1 (631) 549-2882

Zentrum Mikroelektronik Dresden AG, Japan Office

2nd Floor, Shinbashi Tokyu Bldg.
4-21-3, Shinbashi, Minato-ku
Tokyo, 105-0004
Japan

Phone +81.3.6895.7410
Fax +81.3.6895.7301

ZMD Far East, Ltd.

3F, No. 51, Sec. 2,
Keelung Road
11052 Taipei
Taiwan

Phone +886.2.2377.8189
Fax +886.2.2377.8199

DISCLAIMER: This information applies to a product under development. Its characteristics and specifications are subject to change without notice. Zentrum Mikroelektronik Dresden AG (ZMD AG) assumes no obligation regarding future manufacture unless otherwise agreed to in writing. The information furnished hereby is believed to be true and accurate. However, under no circumstances shall ZMD AG be liable to any customer, licensee, or any other third party for any special, indirect, incidental, or consequential damages of any kind or nature whatsoever arising out of or in any way related to the furnishing, performance, or use of this technical data. ZMD AG hereby expressly disclaims any liability of ZMD AG to any customer, licensee or any other third party, and any such customer, licensee and any other third party hereby waives any liability of ZMD AG for any damages in connection with or arising out of the furnishing, performance or use of this technical data, whether based on contract, warranty, tort (including negligence), strict liability, or otherwise.

ZLED7010

40V LED Driver with Temperature Compensation



Contents

1	IC Characteristics	6
1.1.	Absolute Maximum Ratings	6
1.2.	Operating Conditions	6
1.3.	Electrical Parameters	6
1.4.	Characteristic Operating Curves	8
2	Circuit Description	10
2.1.	Voltage Supply	10
2.2.	ZLED7010 Standby Mode	10
2.3.	Output Current Control	10
2.3.1.	Output Current and R_S	10
2.3.2.	PWM Control	11
2.3.3.	External DC Voltage Control of Output Current	11
2.3.4.	Microcontroller LED Control	12
3	Application Circuit Design	13
3.1.	External Component – Inductor L1	13
3.2.	External Component – Capacitor C1	14
3.3.	External Component – Diode D1	14
3.4.	Output Ripple	15
4	Operating Conditions	16
4.1.	Thermal Conditions	16
4.2.	Thermal Shut-Down Protection	16
4.3.	Open-Circuit Protection	16
4.4.	External Temperature Compensation of Output Current	16
5	Chaining Multiple ZLED7010 ICs	19
6	ESD/Latch-Up-Protection	20
7	Pin Configuration and Package	20
8	Layout Requirements	22
8.1.	Layout Considerations for ADJ_I (Pin 6)	22
8.2.	Layout Considerations for LX (Pin 8)	22
8.3.	Layout Considerations for V_{IN} (Pin 1) and the External Decoupling Capacitor (C1)	22
8.4.	Layout Considerations for GND (Pin 7)	22
8.5.	Layout Considerations for ADJ_O (Pin 5)	22
8.6.	Layout Considerations for R_{TH} and R_{NTC} (Pins 3 and 4)	22
8.7.	Layout Considerations for High Voltage Traces	22
8.8.	Layout Considerations for the External Coil (L1)	22
8.9.	Layout Considerations for the External Current Sense Resistor (R_S)	22
9	Ordering Information	23
10	Document Revision History	23

ZLED7010

40V LED Driver with Temperature Compensation



List of Figures

Figure 1.1	Characteristic Operating Curves 1	8
Figure 1.2	Characteristic Operating Curves 1	9
Figure 2.1	Directly Driving ADJ _I Input with a PWM Control Signal.....	11
Figure 2.2	External DC Control Voltage at ADJ _I Pin.....	11
Figure 2.3	Driving ADJ _I Input from a Microcontroller	12
Figure 3.1	Output Ripple Reduction	15
Figure 4.1	Temperature Compensation.....	16
Figure 4.2	Temperature Compensation Graphs	18
Figure 5.1	ZLED7010 Chain Connections	19
Figure 5.2	ZLED7010 System Application.....	19
Figure 7.1	Pin Configuration ZLED7010.....	20
Figure 7.2	SOP-8 Package Drawing.....	21

List of Tables

Table 4.1	Pin Description SOP-8.....	20
Table 7.2	Package Dimensions SOP-8	21



1 IC Characteristics

1.1. Absolute Maximum Ratings

No.	PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
1.1.1	Input voltage	V_{IN}		-0.3		50	V
1.1.2	I_{SENSE} voltage	V_{ISENSE}	$V_{in} > 5V$	$V_{IN} - 5$		$V_{IN} + 0.3$	V
			$V_{in} < 5V$	0		$V_{IN} + 0.3$	V
1.1.3	LX output voltage	V_{LX}		-0.3		50	V
1.1.4	Control pin input voltage	$V_{ADJ}, V_{ADJO}, R_{TH}, R_{NTC}$		-0.3		6	V
1.1.5	Switch output current	I_{LX}				900	mA
1.1.6	Power dissipation	P_{tot}	SOP-8			1.2	W
1.1.7	Storage temperature	T_{ST}		-55		150	°C
1.1.8	Junction temperature	T_{JMAX}				150	°C

1.2. Operating Conditions

No.	PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
1.2.1	Operating temperature	T_{OP}		-40		+85	°C
1.2.2	Input voltage	V_{IN}		6		40	V

1.3. Electrical Parameters

Production testing is at 25°C. At other temperatures within the specified operating range, functional operation of the chip and specified parameters are guaranteed by characterization, design, and process control.

Test conditions are $T_{amb} = 25^{\circ}C$; $V_{IN} = 12V$ except as noted.

No.	PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
1.3.1	Quiescent supply current with output off	I_{INQoff}	ADJ _I pin grounded	40	60	80	μA
1.3.2	Quiescent supply current with output switching	I_{INQon}	ADJ _I pin floating		450	600	μA
1.3.3	Mean current sense threshold voltage	V_{SENSE}	Measured on I_{SENSE} pin with respect to V_{IN} ; ADJ _I pin floating	91	95	101	mV
1.3.4	Sense threshold hysteresis	$V_{SENSEHYS}$			±15		%
1.3.5	I_{SENSE} pin input current	I_{SENSE}	$V_{SENSE} = 0.1V$		8	10	μA
1.3.6	Internal reference voltage	V_{REF}	Measured on ADJ _I pin with pin floating		1.2		V
1.3.7	External control voltage range on ADJ _I pin for DC brightness control	V_{ADJI}		0.3		1.2	V

ZLED7010

40V LED Driver with Temperature Compensation



No.	PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
1.3.8	DC voltage on ADJ _I pin to switch chip from active (ON) state to quiescent (OFF) state	V _{ADJloff}	V _{ADJl} falling	0.15	0.2	0.25	V
1.3.9	DC voltage on ADJ _I pin to switch chip from quiescent (OFF) state to active (ON) state	V _{ADJlon}	V _{ADJl} rising	0.2	0.25	0.3	V
1.3.10	R _{TH} and R _{NTC} pin offset voltage	V _{OS}			10		mV
1.3.11	Continuous LX switch current	I _{LXmean}			0.65	0.75	A
1.3.12	LX switch leakage current	I _{LX(leak)}				1	μA
1.3.13	ADJ _O terminal voltage	V _{ADJO}	No temperature compensation, ADJ _I pin floating I _{ADJO} =30μA		1.20		V
1.3.14	LX Switch ON resistance	R _{LX}			0.9	1.5	Ω
1.3.15	Continuous LX switch current	I _{LXmean}			0.65		A
1.3.16	Resistance between ADJ _I pin and V _{REF}	R _{ADJl}			500		kΩ
1.3.17	Brightness control range at low frequency PWM signal	D _{PWM(LF)}	PWM frequency =100Hz PWM amplitude=5V, V _{in} =15V, L=27μH, driving 1 LED		1200:1		
1.3.18	Brightness control range at high frequency PWM signal	D _{PWM(HF)}	PWM frequency =10kHz PWM amplitude=5V, V _{in} =15V, L=27μH, driving 1 LED		13:1		
1.3.19	Operating frequency	f _{LX}	ADJ _I pin floating L=100μH (0.82Ω) I _{OUT} =350mA @ V _{LED} =3.4V, driving 1 LED		154		kHz
1.3.20	Minimum switch ON time	T _{ONmin}	LX switch ON		200		ns
1.3.21	Minimum switch OFF time	T _{OFFmin}	LX switch OFF		200		ns
1.3.22	Recommended maximum operating frequency	f _{LXmax}				1	MHz
1.3.23	Recommended duty cycle range of output switch at f _{LXmax}	D _{LX}		0.2		0.8	
1.3.24	Internal comparator propagation delay	T _{PD}			50		ns
1.3.25	Thermal shutdown temperature	T _{SD}			140		°C
1.2.26	Thermal shutdown hysteresis	TSD-HYS			20		°C

ZLED7010

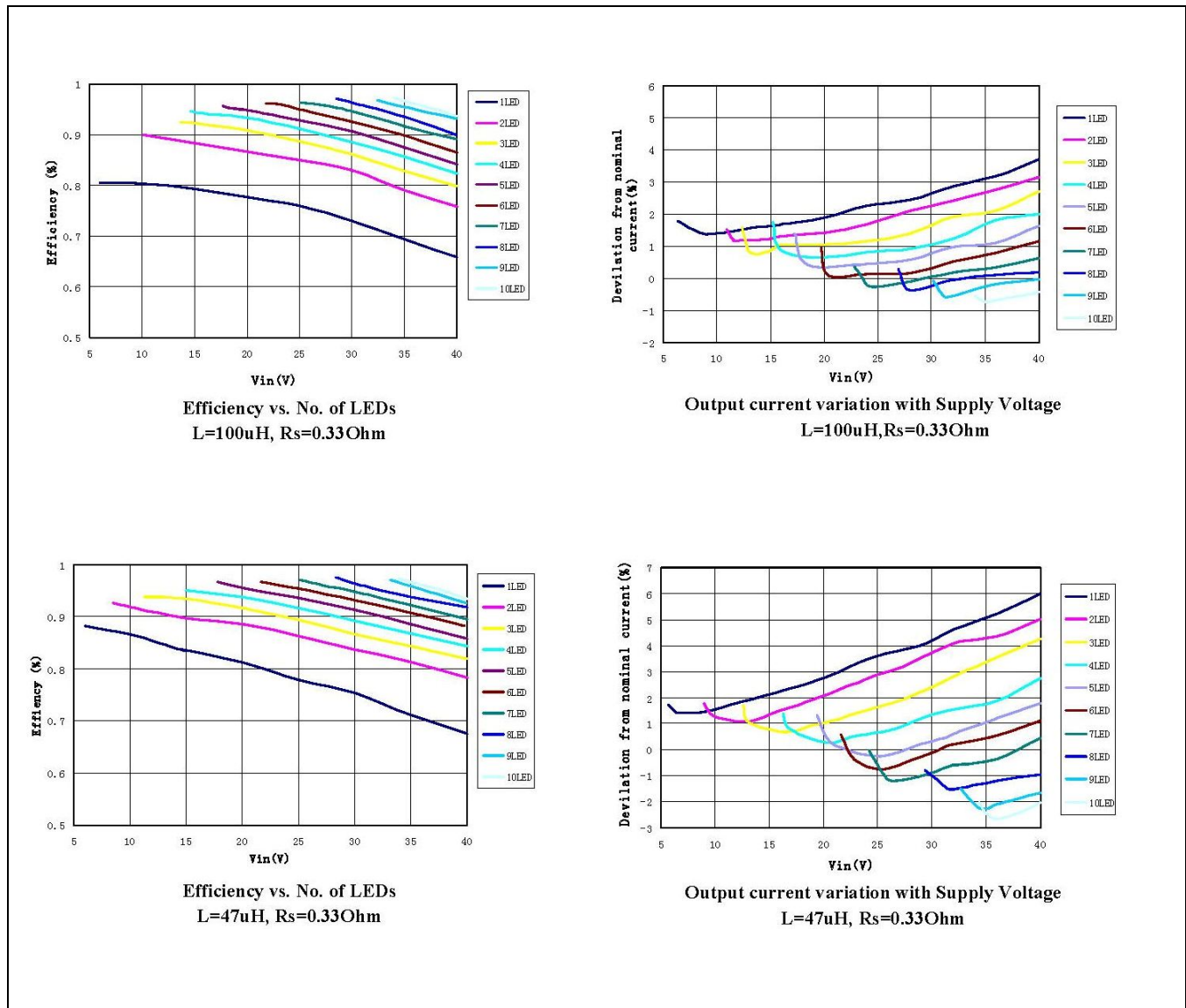
40V LED Driver with Temperature Compensation



1.4. Characteristic Operating Curves

The curves are valid for the typical application circuit and $T_{amb} = 25^{\circ}\text{C}$ unless otherwise noted.

Figure 1.1 Characteristic Operating Curves 1

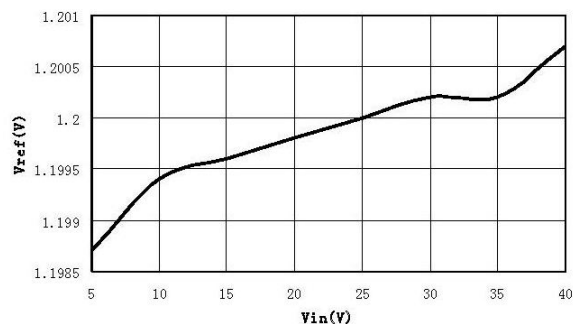


ZLED7010

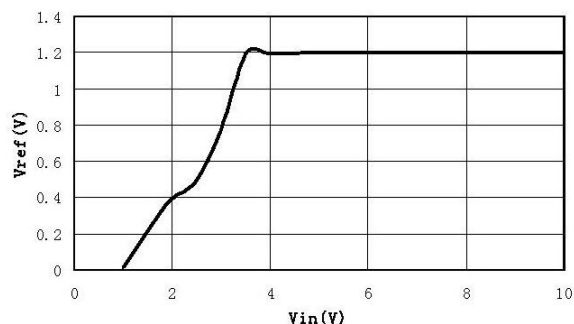
40V LED Driver with Temperature Compensation



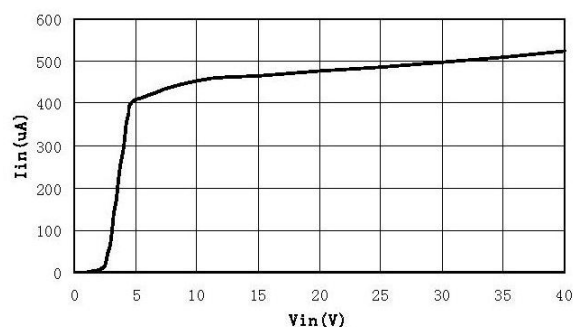
Figure 1.2 Characteristic Operating Curves 1



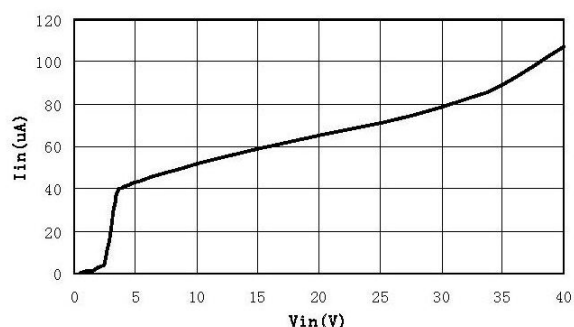
Vref vs. Vin over nominal supply voltage range



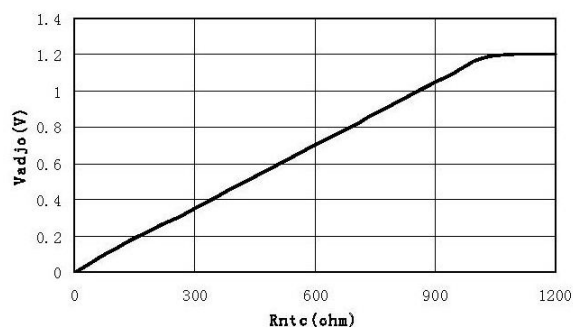
Vref vs. Vin at low supply voltage



Supply Current vs. Vin (Operating)



Shutdown Current vs. Vin (Quiescent)



**Vadjo vs. Rntc
Rntc falling, Rth=1 kohm**



2 Circuit Description

The ZLED7010 is an inductive step-down converter for driving LEDs. It operates in continuous mode, enabling proper LED current control. The ZLED7010 supports linear or PWM control of the LED current. It provides temperature compensation to maintain stable and reliable operation of the LEDs. Only a few external components are needed for typical applications.

2.1. Voltage Supply

The ZLED7010 has an internal regulator that disables the LX output until the voltage supply rises above a start-up threshold voltage set internally as needed to ensure that the power MOSFET on-resistance is low enough for proper operation. When the supply voltage exceeds the threshold, the ZLED7010 begins normal operation.

Important: The ZLED7010 must be operated within the operating voltage range specified in section 1.2 to avoid conditions that could result in thermal damage to the ZLED7010. Operating with the supply voltage below the minimum can result in a high switch duty cycle and excessive ZLED7010 power dissipation, risking over-temperature conditions (also see section 4.1 regarding thermal restrictions) which could result in activation of the ZLED7010's thermal shut-down circuitry (see section 4.2). With multiple LEDs, the forward drop is typically adequate to prevent the chip from switching below the minimum voltage supply specification (6V), so there is less risk of thermal shut-down.

2.2. ZLED7010 Standby Mode

Whenever the ADJ_I pin voltage falls below 0.2V, the ZLED7010 turns the output off and the supply current drops to approximately 60μA. This standby mode minimizes current consumption.

2.3. Output Current Control

The LED control current output on the LX pin is determined by the value of external components and the control voltage input at the ADJ_I pin. Selection of the external component R_S is discussed below, and other external components are discussed in section 3. The subsequent sections describe the two options for control voltage input at the ADJ_I pin: a pulse width modulation (PWM) control signal or a DC control voltage.

The ADJ_I pin has an input impedance[†] of 500kΩ ±25%.

2.3.1. Output Current and R_S

The current sense threshold voltage and the value of the external current sense resistor (R_S) between V_{IN} and I_{SENSE} set the output current through the LEDs (I_{OUT}). Equation (1) shows this basic relationship. Unless the ADJ pin is driven from an external voltage (see section 2.3.3), the minimum value for R_S is 0.13Ω to prevent exceeding the maximum switch current (see section 1.3).

$$I_{OUT} = \frac{95mV}{R_S} \quad (1)$$

Where

I_{OUT} = Nominal average output current through the LED(s)

R_S ≥ 0.13Ω

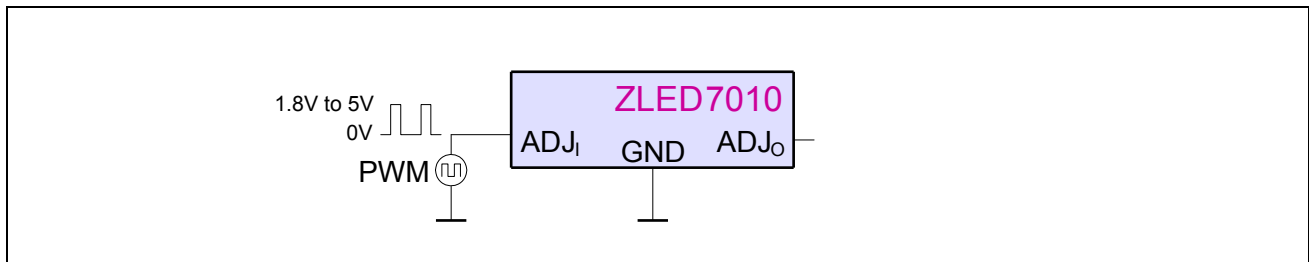
[†] At room temperature.



2.3.2. PWM Control

The output current on LX can be set to a value below the nominal average value determined by resistor R_S by using an external PWM signal as the control signal applied to the ADJ_I pin. This control signal must be capable of driving the ZLED7010's internal 500k Ω pull-up resistor. See Figure 2.1 for an illustration. The minimum signal voltage range is 0V to 1.8V; the maximum voltage range is 0V to 5V. See section 1.3 for the specifications for the signal's duty cycle D_{PWM} . Any negative spikes on the control signal could interfere with current control or proper operation of the ZLED7010.

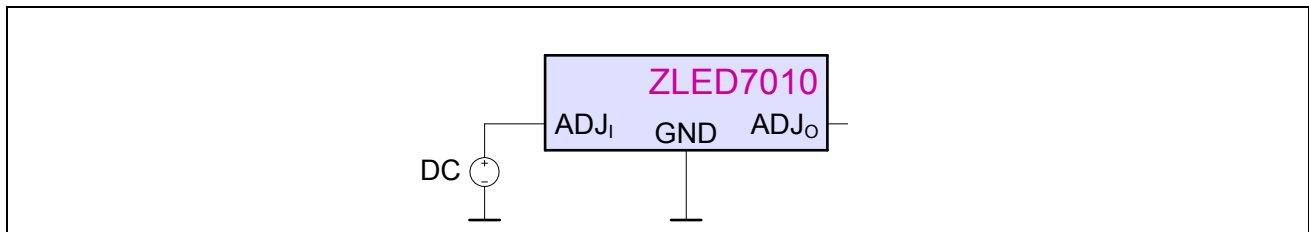
Figure 2.1 Directly Driving ADJ_I Input with a PWM Control Signal



2.3.3. External DC Voltage Control of Output Current

The output current on LX can be set to a value below the nominal average value determined by resistor R_S by using an external DC voltage V_{ADJ} ($0.3\text{ V} \leq V_{ADJ} \leq 1.2\text{ V}$) to drive the voltage at the ADJ_I pin. This allows adjusting the output current from 25% to 100% of $I_{OUT_{nom}}$. See Figure 2.2 for an illustration. The output current can be calculated using equation (2). If V_{ADJ} matches or exceeds V_{REF} (1.2V), the brightness setting is clamped at its maximum (100%).

Figure 2.2 External DC Control Voltage at ADJ_I Pin



$$I_{OUT_DC} = \frac{0.079 * V_{ADJ}}{R_S} \quad (2)$$

Where

I_{OUT_DC} = Nominal average output current through the LED(s) with a DC control voltage

V_{ADJ} = External DC control voltage: $0.3\text{ V} \leq V_{ADJ} \leq 1.2\text{ V}$

$R_S \geq 0.13\Omega$

ZLED7010

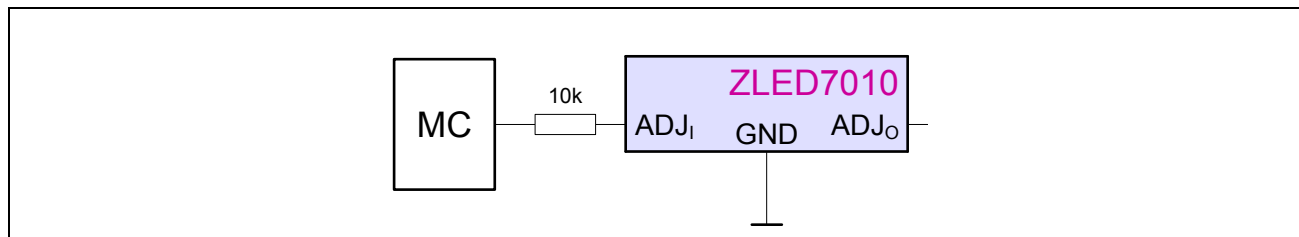
40V LED Driver with Temperature Compensation



2.3.4. Microcontroller LED Control

The open-drain output of a microcontroller can control current to the LEDs by outputting a PWM control signal to the ADJ_I input. See Figure 2.3 for an example circuit.

Figure 2.3 Driving ADJ_I Input from a Microcontroller





3 Application Circuit Design

3.1. External Component – Inductor L1

Select the inductor value for L1 as needed to ensure that switch on/off times are optimized across the load current and supply voltage ranges. Select a coil that has a continuous current rating above the required average output current to the LEDs and a saturation current exceeding the peak output current. Recommendation: Use inductors in the range of 15μH to 220μH with saturation current greater than 1A for 700mA output current or saturation current greater than 500mA for 350mA output current. For higher supply voltages with low output current, select higher values of inductance, which result in a smaller change in output current across the supply voltage range (refer to the graphs in section 1.4). See section 8.8 for layout restrictions.

Equations (3) and (4) illustrate calculating the timing for LX switching for the example application circuit shown on page 2. As given in section 1.3, the minimum period for T_{ON} is 200ns; the minimum period for T_{OFF} is also 200ns.

LX Switch OFF Time (T_{OFF} in s)

$$T_{OFF} = \frac{L * \Delta I}{V_{LED} + V_D + I_{AVG} * (R_S + r_L)} \quad (3)$$

LX Switch ON Time (T_{ON} in s)

$$T_{ON} = \frac{L * \Delta I}{V_{IN} - V_{LED} - I_{AVG} * (R_S + r_L + R_{LX})} \quad (4)$$

Where

L	Coil inductance in H
ΔI	Coil peak-peak ripple current in A *
V_{LED}	Total LED forward voltage in V
V_D	Diode forward voltage at the required load current in V
I_{AVG}	Required average LED current in A
R_S	External current sense resistance in Ω
r_L	Coil resistance in Ω
V_{IN}	Supply voltage in V
R_{LX}	Switch resistance in Ω

* With the ZLED7010, the current ripple ΔI is internally set to an appropriate value of $0.3 * I_{AVG}$.

The inductance value has an equivalent effect on Ton and Toff and therefore affects the switching frequency. For the same reason the inductance has no influence on the duty cycle for which the relation of the summed LED forward voltages $n * V_F$ to the input voltage V_{IN} is a reasonable approximation. Because the input voltage is a factor in the ON time, variations in the input voltage affect the switching frequency and duty cycle.

ZLED7010

40V LED Driver with Temperature Compensation



The following calculation example yields an operating frequency of 122kHz and a duty cycle of 0.33:

Input data: $V_{IN}=12V$, $L=220\mu H$, $r_L=0.48\Omega$, $V_{LED}=3.4V$, $I_{AVG}=333mA$ and $V_D=0.36V$

$$T_{OFF} = \frac{220\mu H * 0.3 * 0.333A}{3.4V + 0.36V + 0.333A * (0.48\Omega + 0.3\Omega)} = 5.47\mu s \quad (5)$$

And

$$T_{ON} = \frac{220\mu H * 0.3 * 0.333A}{12V - 3.4V - 0.333A * (0.3\Omega + 0.48\Omega + 0.9\Omega)} = 2.73\mu s \quad (6)$$

3.2. External Component – Capacitor C1

To improve system efficiency, use a low-equivalent-series-resistance (ESR) capacitor for input decoupling because this capacitor must pass the input current AC component. The capacitor value is defined by the target maximum ripple of the supply voltage; the value is given by equation (7).

$$C_{MIN} = \frac{I_F * T_{ON}}{\Delta V_{MAX}} \quad (7)$$

Where

I_F	Value of output current
ΔV_{MAX}	Maximum ripple of power supply
T_{ON}	Maximum ON time of MOSFET

In the case of an AC supply with a rectifier, the capacitor value must be chosen high enough to make sure that the DC voltage does not drop below the maximum forward voltage of the LED string plus some margin for the voltage drops across the coil resistance, shunt resistor, and ON resistance of the switching transistor.

Recommendation: Use capacitors with X5R, X7R, or better dielectric for maximum stability over temperature and voltage. Do not use Y5V capacitors for decoupling in this application. For higher capacitance values, aluminum electrolytic caps with high switching capability should be used. In this case improved performance can be reached by an additional X7R/X5R bypass capacitor of at least 100nF.

3.3. External Component – Diode D1

For the rectifier D1, select a high-speed low-capacitance Schottky diode with low reverse leakage at the maximum operating voltage and temperature to ensure maximum efficiency and performance.

Important: Choose diodes with a continuous current rating higher than the maximum output load current and a peak current rating above the peak coil current. When operating above 85°C, the reverse leakage of the diode must be addressed because it can cause excessive power dissipation in the ZLED7010.

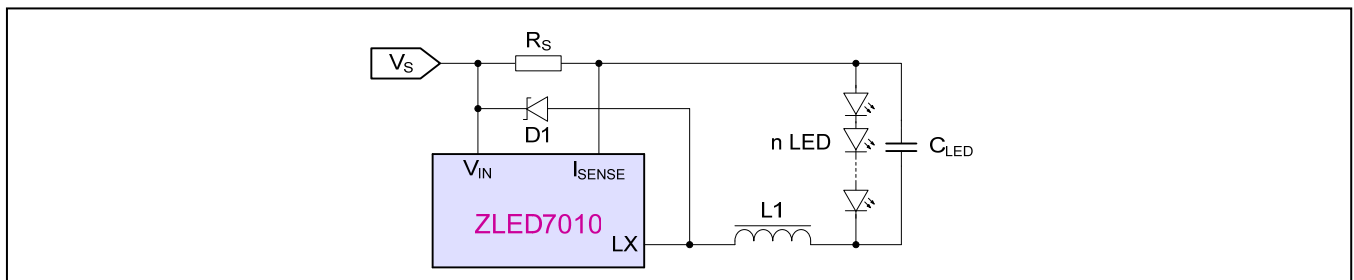
Note: Silicon diodes have a greater forward voltage and overshoot caused by reverse recovery time, which can increase the peak voltage on the LX output. Ensure that the total voltage appearing on the LX pin, including supply ripple, is within the specified range (see section 1.3).



3.4. Output Ripple

Shunt a capacitor C_{LED} across the LED(s) as shown in Figure 3.1 to minimize the peak-to-peak ripple current in the LED if necessary.

Figure 3.1 Output Ripple Reduction



Low-ESR capacitors should be used because the efficiency of C_{LED} largely depends on its ESR and the dynamic resistance of the LED(s). For an increased number of LEDs, using the same capacitor will be more effective. Lower ripple can be achieved with higher capacitor values, but it will increase start-up delay by reducing the slope of the LED voltage. The capacitor will not affect operating frequency or efficiency. For a simulation or bench optimization, C_{LED} values of a few μF are an applicable start point for the given configuration.



4 Operating Conditions

4.1. Thermal Conditions

Refer to section 1.1 for maximum package power dissipation specifications for the ZLED7010's SOP-8 package. Exceeding these specifications due to operating the chip at high ambient temperatures (see section 1.2 for maximum operating temperature range) or driving over the maximum load current (see section 1.3) can damage the ZLED7010. The ZLED7010 can be used for LED current applications up to 750mA when properly mounted to a high wattage land pattern. Conditions such as operating below the minimum supply voltage or inefficiency of the circuit due to improper coil selection or excessive parasitic capacitance on the output can cause excessive chip power dissipation.

4.2. Thermal Shut-Down Protection

The ZLED7010 includes an on-board temperature sensing circuit that stops the output if the junction exceeds approximately 160°C.

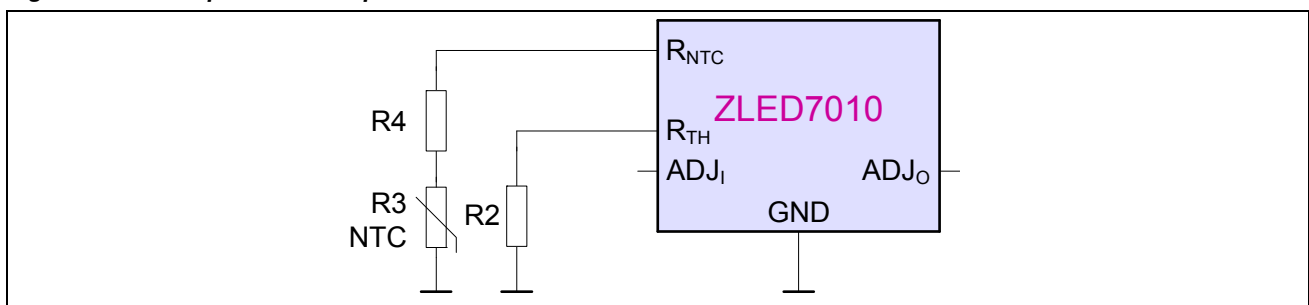
4.3. Open-Circuit Protection

The ZLED7010 is inherently protected if there is an open-circuit in the connection to the LEDs because in this case, the coil is isolated from the LX pin. This prevents any back EMF from damaging the internal switch due to forcing the drain above its breakdown voltage.

4.4. External Temperature Compensation of Output Current

The ZLED7010's temperature compensation feature is useful in applications that require a temperature compensated LED control current to ensure stability and reliability over temperature, such as high luminance LEDs. When output current compensation is needed, use an external temperature sensing network, typically with negative temperature coefficient (NTC) thermistors/diodes, located close to the LED(s) and connected to the R_{NTC} and R_{TH} inputs. With this circuit configuration, the internal circuitry of the ZLED7010 reduces the output current if the temperature sensing input indicates a rising temperature.

Figure 4.1 Temperature Compensation



As shown in Figure 4.1, the temperature compensation curve is determined by R2, R3 (NTC) and R4. When the LED temperature increases, the resistance of R3 decreases. As R3 reaches the point that R3 plus R4 equal R2, the temperature compensation function starts to work by reducing I_{OUT} .

ZLED7010

40V LED Driver with Temperature Compensation



The I_{OUT} current with temperature compensation can be calculated with the following equations:

For $0.3V \leq V_{ADJI} \leq 1.2V$:

$$I_{OUT_DC} = \frac{0.079V * V_{ADJI}}{R_S} * \left(\frac{R3 + R4}{R2} \right) \quad (8)$$

For $V_{ADJI} > 1.2V$:

$$I_{OUT_DC} = \frac{0.095V}{R_S} * \left(\frac{R3 + R4}{R2} \right) \quad (9)$$

R3 and R4 determine the slope of temperature compensation. If R4 is just 0Ω , the slope is solely driven by the NTC component's characteristic β -constant. Larger values of R4 will decrease the slope.

When dimensioning R2, consider that larger values will make the R_{TH} pin more noise sensitive and lower values will increase power consumption therefore values from 1k to 100k are recommended. For a selected temperature compensation threshold, larger R3 and R4 require larger R2 to match and vice versa.

Also see section 5 regarding driver chains and temperature compensation.

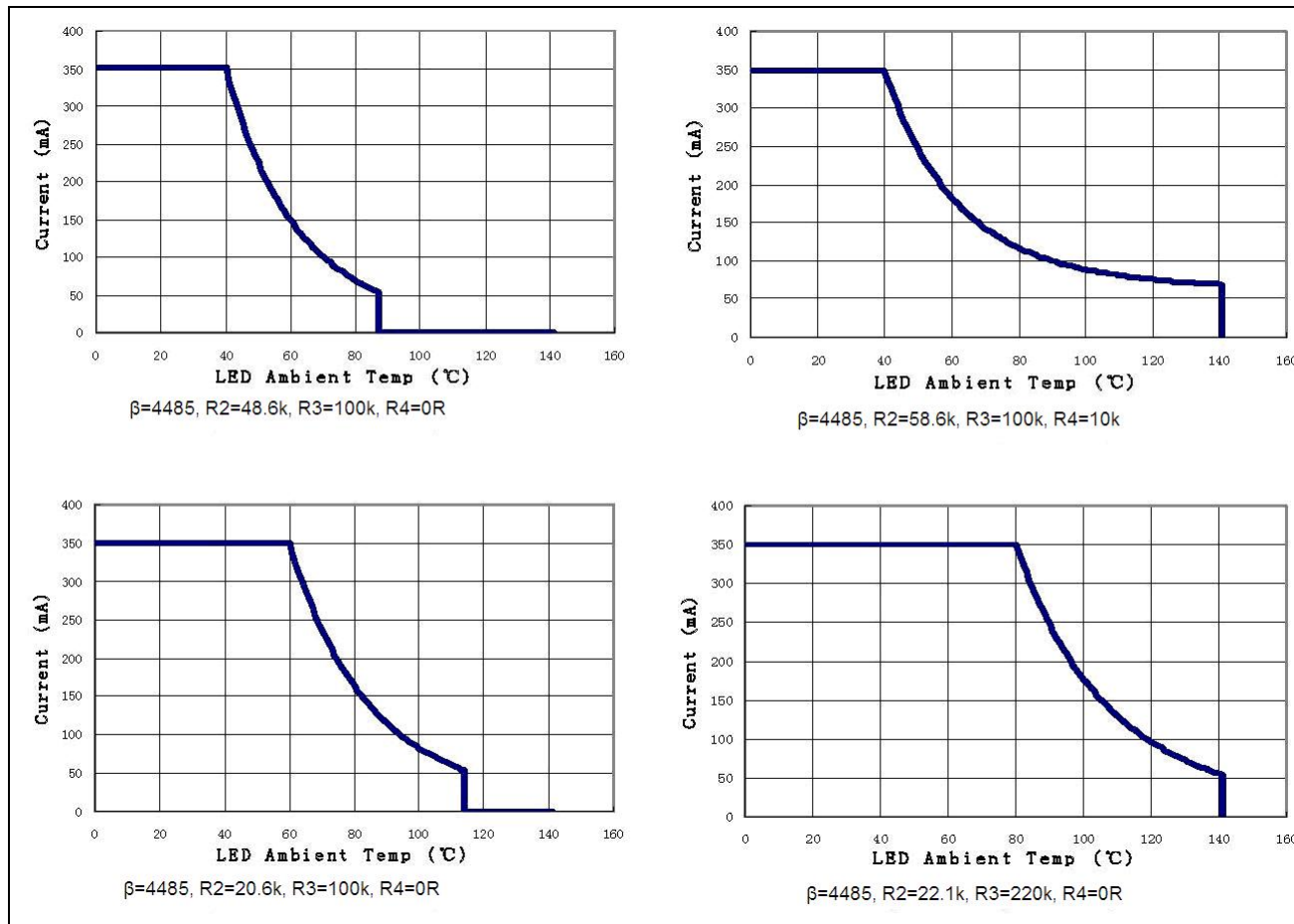
Figure 4.2 shows some examples of current-temperature curves resulting from different dimensioning of the three resistors.

ZLED7010

40V LED Driver with Temperature Compensation



Figure 4.2 Temperature Compensation Graphs



ZLED7010

40V LED Driver with Temperature Compensation



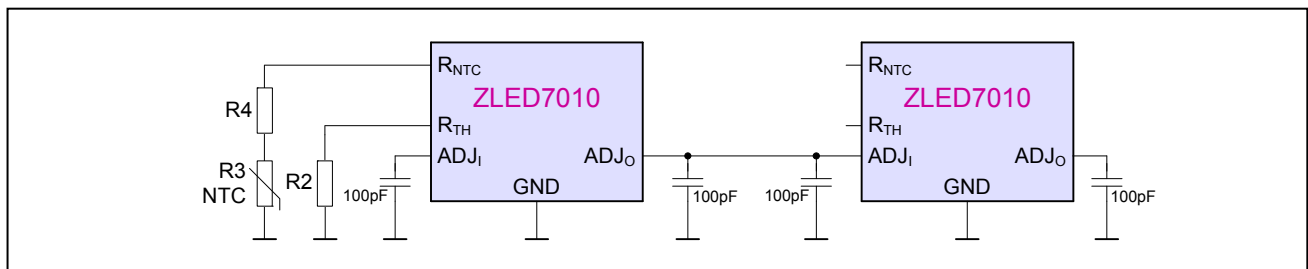
5 Chaining Multiple ZLED7010 ICs

Figure 5.1 shows a typical circuit for chaining multiple ZLED7010s using the ADJ_i and ADJ_o pins and a temperature sensing network of R2, R4, and R3, which is an NTC component. Note that only one temperature sensing network is needed.

When $R3+R4 > R2$, $V_{ADJ_o} = V_{ADJ_i}$.

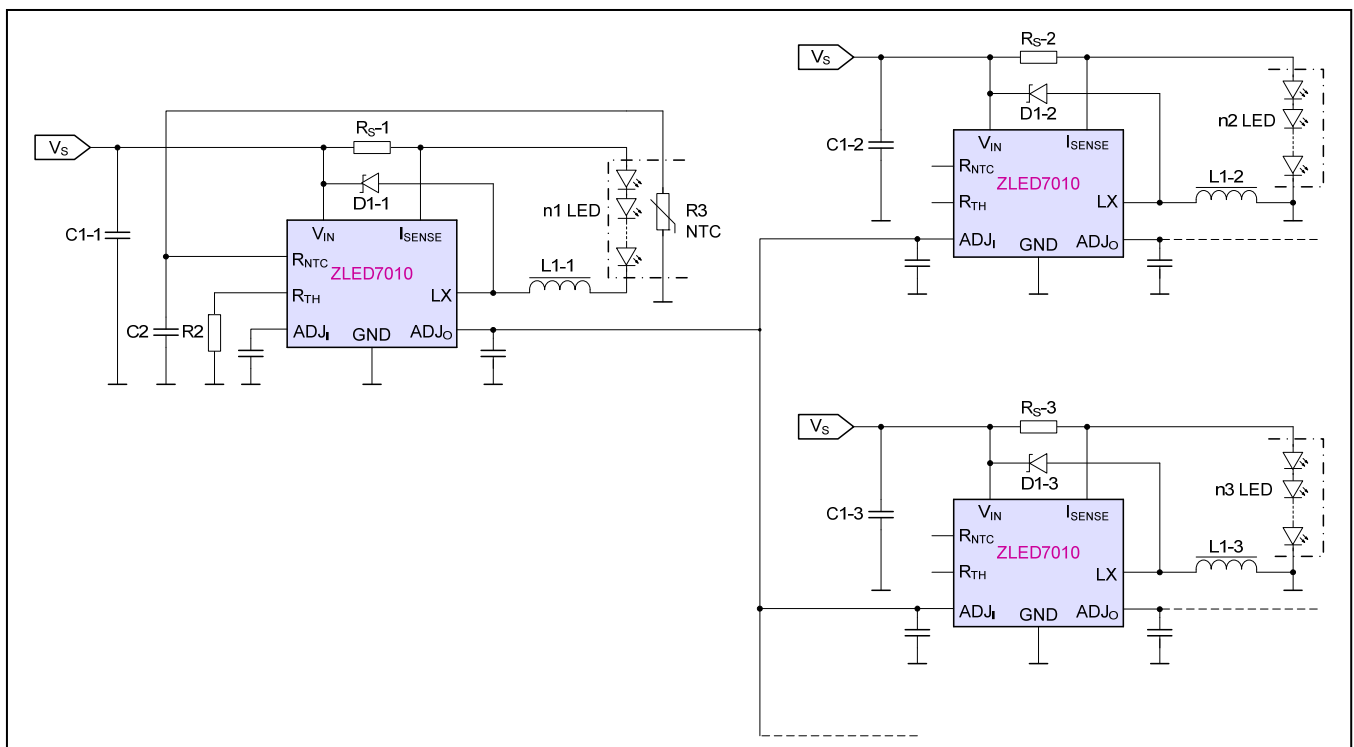
When $R3+R4 < R2$, the ADJ_o pin outputs the ADJ_i input voltage with temperature compensation information.

Figure 5.1 ZLED7010 Chain Connections



In Figure 5.2, note that each ZLED7010 can drive up to three slave ICs in the next stage. Using more than three stages to maintain current coherence is not recommended. Up to thirteen ZLED7010 can be connected in one system.

Figure 5.2 ZLED7010 System Application



ZLED7010

40V LED Driver with Temperature Compensation



6 ESD/Latch-Up-Protection

All pins have an ESD protection of $>\pm 2000\text{V}$ according the Human Body Model (HBM) except for pin 8, which has a protection level of $>\pm 1000\text{V}$. The ESD test follows the Human Body Model with $1.5\text{ k}\Omega/100\text{ pF}$ based on MIL 883-G, Method 3015.7.

Latch-up protection of $>\pm 100\text{mA}$ has been proven based on JEDEC No. 78A Feb. 2006, temperature class 1.

7 Pin Configuration and Package

Figure 7.1 Pin Configuration ZLED7010

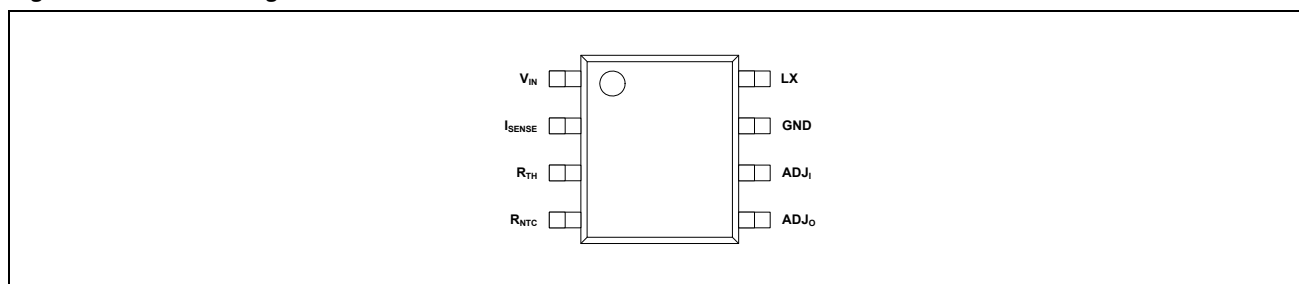


Table 4.1 Pin Description SOP-8

Pin Name	No.	Description
VIN	1	Supply voltage (6V to 40V)—see section 8 for layout considerations.
ISENSE	2	Nominal average output current is set by the value of a resistor RS connected from ISENSE to VIN. See section 2.3.1 for details.
RTH	3	Threshold input from external temperature sensing network. Sets the starting temperature of temperature compensation via an external resistor. See section 4.4 for details.
RNTC	4	NTC input from external temperature sensing network. See section 4.4 for details.
ADJO	5	Output for control signal for LED driver chain applications
ADJI	6	Output current control pin—see section 2.3 for details
GND	7	Ground (0V)—see section 8.4 for layout considerations
LX	8	Power switch drain

ZLED7010

40V LED Driver with Temperature Compensation



Figure 7.2 SOP-8 Package Drawing

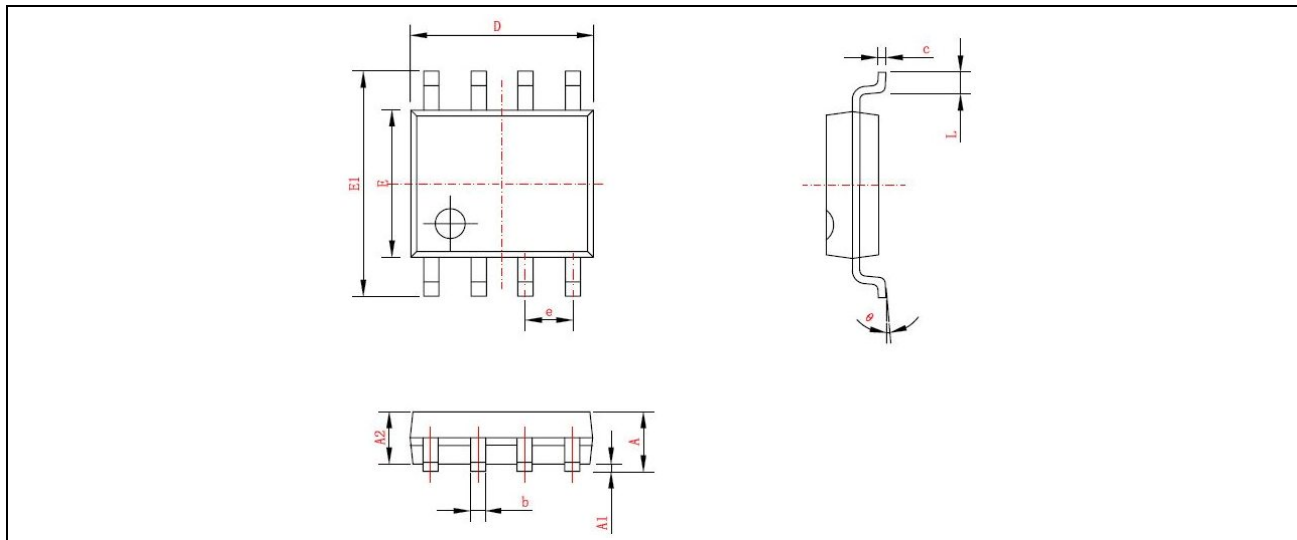


Table 7.2 Package Dimensions SOP-8

Symbol	Dimension (mm)		Symbol	Dimension (mm, except θ)	
	Min	Max		Min	Max
A	1.350	1.750	E	3.800	4.000
A1	0.100	0.250	E1	5.800	6.240
A2	1.450 Typical		e	1.270 Typical	
b	0.350	0.490	L	0.400	1.270
c	0.178	0.250	θ	0°	8°
D	4.800	5.000			

The SOP-8 package has a thermal resistance (junction to ambient) of $R_{\theta JA} = 128 \text{ K/W}$.



8 Layout Requirements

8.1. Layout Considerations for ADJ_I (Pin 6)

For applications in which the ADJ_I pin is unconnected, minimize the length of circuit board traces connected to ADJ_I to reduce noise coupling through this high impedance input.

8.2. Layout Considerations for LX (Pin 8)

Minimize the length of circuit board traces connected to the LX pin because it is a fast switching output.

8.3. Layout Considerations for V_{IN} (Pin 1) and the External Decoupling Capacitor (C1)

The C1 input decoupling capacitor must be placed as close as possible to the V_{IN} pin to minimize power supply noise, which can reduce efficiency. See section 3.2 regarding capacitor selection.

8.4. Layout Considerations for GND (Pin 7)

The ZLED7010 GND (ground) pin must be soldered directly to the circuit board's ground plane to minimize ground bounce due to fast switching of the LX pin.

8.5. Layout Considerations for ADJ_O (Pin 5)

When the application requires a driver chain of multiple ZLED7010s, noise might be coupled in if there are longer PCB traces from the driving ADJ_O pin to next stage ADJ_I pin. In this case, a 200pF (maximum) capacitor must be connected between the line and ground to filter out the noise. The best practice is to connect one capacitor each close to the ADJ_O output pin and the next stage ADJ_I input pins. The total capacitance in addition to the parasitic capacitance from the ADJ_O pin to ground must not exceed 200pF. See Figure 5.1.

8.6. Layout Considerations for R_{TH} and R_{NTC} (Pins 3 and 4)

The PCB trace from R2 to the R_{TH} pin should be as short as possible to minimize noise coupling. Because the NTC thermistor R3 is mounted close to the LEDs and remote from the ZLED7010, the PCB trace from R3 to R_{NTC} pin is longer and more susceptible to noise. A 100nF capacitor from the R_{NTC} pin to ground and close to the R_{NTC} pin is recommended to filter the noise and provide protection against high voltage transients.

8.7. Layout Considerations for High Voltage Traces

Avoid laying out any high voltage traces near the ADJ pin to minimize the risk of leakage in cases of board contamination, which could raise the ADJ pin voltage resulting in unintentional output current. Leakage current can be minimized by laying out a ground ring around the ADJ pin.

8.8. Layout Considerations for the External Coil (L1)

The L1 coil must be placed as close as possible to the chip to minimize parasitic resistance and inductance, which can reduce efficiency. The connection between the coil and the LX pin must be low resistance.

8.9. Layout Considerations for the External Current Sense Resistor (R_S)

Any trace resistance in series with R_S must be taken into consideration when selecting the value for R_S .

ZLED7010

40V LED Driver with Temperature Compensation



9 Ordering Information

Product Sales Code	Description	Package
ZLED7010-ZI1R	ZLED7010 – 40V LED Driver with Temperature Compensation	SOP8 (Tape & Reel)
ZLED7010KIT-D1	ZLED7010 Demo Board with LED on Cool Body 12VAC/VDC	Kit
ZLED-PCB1	Test PCB with one 3W white HB-LED, cascable to one multiple LED string	Printed Circuit Board
ZLED-PCB2	10 unpopulated test PCBs for modular LED string with footprints of 9 common HB-LED types	Printed Circuit Board

10 Document Revision History

Revision	Date	Description
1.0	June 10, 2010	Production release version
1.1	August 12, 2010	Revision to equation (5) for Toff. Update for contact information.

Sales and Further Information

www.zmdi.com

LED_Drivers@zmdi.com

Zentrum Mikroelektronik Dresden AG (ZMD AG)

Grenzstrasse 28
01109 Dresden
Germany

Phone +49 (0)351.8822.7.533
Fax +49(0)351.8822.8.7533

ZMD America, Inc.

8413 Excelsior Drive
Suite 200
Madison, WI 53717
USA

Phone +1 (608) 829-1987
Fax +1 (631) 549-2882

Zentrum Mikroelektronik Dresden AG, Japan Office

2nd Floor, Shinbashi Tokyu Bldg.
4-21-3, Shinbashi, Minato-ku
Tokyo, 105-0004
Japan

Phone +81.3.6895.7410
Fax +81.3.6895.7301

ZMD Far East, Ltd.

3F, No. 51, Sec. 2,
Keelung Road
11052 Taipei
Taiwan

Phone +886.2.2377.8189
Fax +886.2.2377.8199

DISCLAIMER: This information applies to a product under development. Its characteristics and specifications are subject to change without notice. Zentrum Mikroelektronik Dresden AG (ZMD AG) assumes no obligation regarding future manufacture unless otherwise agreed to in writing. The information furnished hereby is believed to be true and accurate. However, under no circumstances shall ZMD AG be liable to any customer, licensee, or any other third party for any special, indirect, incidental, or consequential damages of any kind or nature whatsoever arising out of or in any way related to the furnishing, performance, or use of this technical data. ZMD AG hereby expressly disclaims any liability of ZMD AG to any customer, licensee or any other third party, and any such customer, licensee and any other third party hereby waives any liability of ZMD AG for any damages in connection with or arising out of the furnishing, performance or use of this technical data, whether based on contract, warranty, tort (including negligence), strict liability, or otherwise.

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[ZMDI:](#)

[ZLED7010Kit-D1](#)