Brief Description

The ZLED7x20 continuous-mode inductive step-down converter family is part of our line of LED-control ICs. It is designed for applications requiring high brightness and high current. It can efficiently drive a single LED or multiple series-connected LEDs from a voltage input higher than the LED forward voltage: Vin = 6 to 40 VDC. It provides an adjustable output current ≤1.2A, which is set via an external resistor and controlled by the ZLED7x20's integrated high-side output current-sensing circuit and high speed internal 40V power switch. An external control signal, which can be a DC voltage, PWM, or microcontroller-generated waveform, on the ADJ pin can also be used to linearly adjust a continuous output current or to control a gated output current.

The output can be turned off by applying a voltage lower than 0.2V to the ADJ pin, which puts the ZLED7x20 in a low-current standby state.

The ZLED7x20 enables diverse industrial and consumer lighting applications requiring high driving currents, wide operating voltage range, high efficiency, and variable brightness control. It offers over-temperature and LED open-circuit protection. The ZLED7x20 can also minimize bill-of-material costs because very few external components are required for most applications. Only a resistor, a diode, an inductor, and three capacitors are needed for a typical basic application.

Features

- Up to 1.2A output current
- Internal 40V power switch
- Wide DC input voltage range 6 to 40 VDC
- Output current accuracy: 3% (typical)
- Dimming ratio: 1200:1
- LED open-circuit protection
- Thermal shutdown protection

Benefits

- High efficiency: up to 98%
- Single pin on/off and brightness control using DC voltage or PWM
- Very few external components needed for operation
- Footprint compatible with our ZLED7000 depending on the application.

Available Support

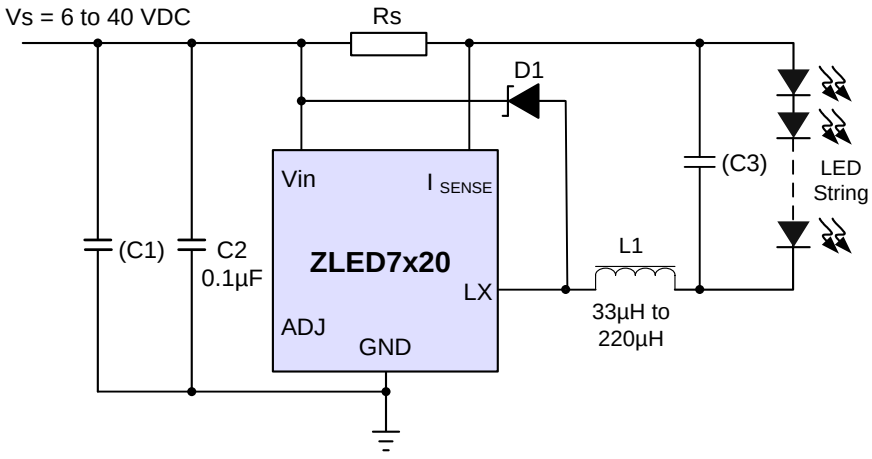
- Evaluation Kit

Physical Characteristics

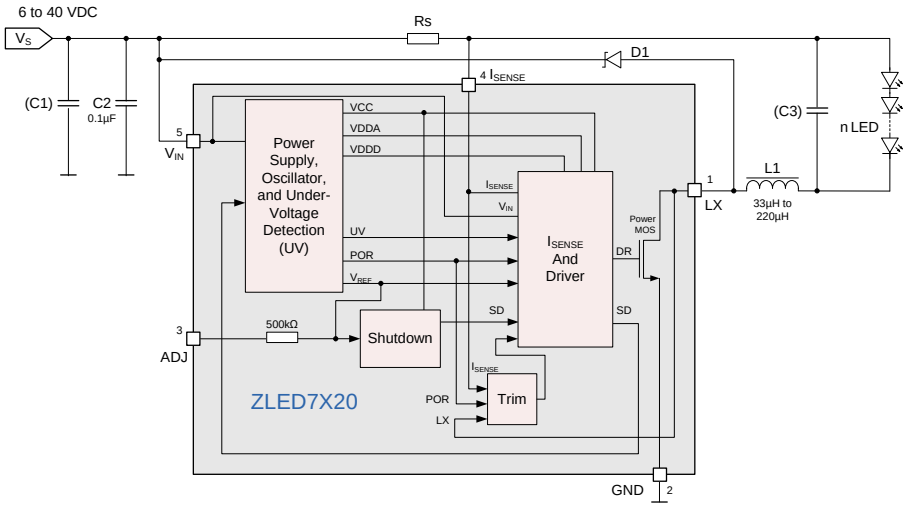
- Operating junction temperature: -40°C to 125°C
- Switching frequency: up to 1MHz

ZLED7x20 Family Selection Matrix		
Product	**Max. Current Output**	**Package**
ZLED7020	1.2A	SOT89-5
ZLED7320	1.0A	DFN-5
ZLED7520	0.75A	DFN-5
ZLED7720	0.35A	DFN-5

ZLED7x20 Typical Application Circuit



ZLED7x20 Block Diagram



Typical Applications

- *Illuminated LED signs and other displays*
- *LED street and traffic lighting (low voltage)*
- *Architecture/building LED lighting*
- *LED backlighting*
- *Interior/exterior LED lighting*
- *MR16 LED spot lights*
- *Retrofit LED lighting fixtures*
- *General purpose industrial and consumer LED applications*

Ordering Information

Product Code	Description	Package
ZLED7020ZI1R	ZLED7020 – High Current (1200mA) 40V LED Driver with Internal Switch	SOT89-5 (Tape & Reel)
ZLED7320ZI1R	ZLED7320 – High Current (1000mA) 40V LED Driver with Internal Switch	DFN-5 (Tape & Reel)
ZLED7520ZI1R	ZLED7520 – High Current (750mA) 40V LED Driver with Internal Switch	DFN-5 (Tape & Reel)
ZLED7720ZI1R	ZLED7720 – High Current (350mA) 40V LED Driver with Internal Switch	DFN-5 (Tape & Reel)
ZLED7020KIT-D1	ZLED7020-D1 Demo Board, 1 ZLED-PCB8 and 5 ZLED7020 ICs	Kit
ZLED-PCB8	Test PCB with a 5W white high brightness (HB) LED, cascadable to a multiple LED string	Printed Circuit Board (PCB)

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1 IC Characteristics

Note: Exceeding the maximum ratings given in this section could cause operation failure and/or cause permanent damage to the ZLED7x20. Exposure to these conditions for extended periods may affect device reliability.

1.1 Absolute Maximum Ratings

No.	PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
1.1.1	Input voltage (also see specification 1.2.2)	V_{IN}		-0.3		50	V
1.1.2	I_{SENSE} pin voltage	V_{ISENSE}	V_{IN}≥5V	V_{IN}-5V		V_{IN}+0.3V	V
			V_{IN}<5V	-0.3V		V_{IN}+0.3V	V
1.1.3	LX pin output voltage	V_{LX}		-0.3		50	V
1.1.4	ADJ pin input voltage	V_{ADJ}		-0.3		6	V
1.1.5	LX pin switch output current	I_{LX}				1.5	A
1.1.6	Power dissipation	P_{TOT}				0.5	W
1.1.7	ESD performance		Human Body Model	±3.5			kV
1.1.8	Junction temperature	T_J				150	°C
1.1.9	Junction to ambient thermal resistance	$R_{\theta JA}$	SOT89-5 package			100	K/W
			DFN5 package			130	K/W
1.1.10	Storage temperature	T_S		-55		150	°C

1.2 Operating Conditions

No.	PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
1.2.1	Operating junction temperature	T_J		-40		125	°C
1.2.2	Input voltage (also see specification 1.1.1)	V_{IN}		6		40	V

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1.3 Electrical Parameters

Test conditions for the following specifications are T_{amb} = 25°C typical and V_{IN} = 12V unless otherwise noted.

Production testing of the chip is performed at 25°C unless otherwise stated. Functional operation of the chip and specified parameters at other temperatures are guaranteed by design, characterization, and process control.

No.	PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
1.3.1	Quiescent supply current	I_{INQoff}	Output off—ADJ pin grounded	90	120	160	µA
		I_{INQon}	Output switching—ADJ pin floating		450	600	µA
1.3.2	Mean current sense threshold voltage	V_{SENSE}		97	100	103	mV
1.3.3	Sense threshold hysteresis	$V_{SENSEHYS}$			±15		%
1.3.4	I_{SENSE} pin input current	I_{SENSE}	$V_{SENSE} = V_{IN}$ -0.1V		8		µA
1.3.5	Internal reference voltage measured at ADJ pin	V_{REF}	ADJ pin floating		1.2		V
1.3.6	Resistance between V_{REF} and ADJ pin	R_{ADJ}			500		KΩ
1.3.7	External DC brightness control voltage on ADJ pin	V_{ADJ}		0.3		1.2	V
1.3.8	DC on-off control voltage on ADJ pin for switching ZLED7x20 from active state to quiescent state	V_{ADJoff}	V_{ADJ} falling	0.15	0.2	0.25	V
1.3.9	DC off-on control voltage on ADJ pin for switching ZLED7x20 from quiescent state to active state	V_{ADJon}	V_{ADJ} rising	0.2	0.25	0.3	V
1.3.10	LX switch continuous current	I_{LXmean_0}	ZLED7020			1.2	A
		I_{LXmean_3}	ZLED7320			1.0	A
		I_{LXmean_5}	ZLED7520			0.75	A
		I_{LXmean_7}	ZLED7720			0.35	A
1.3.11	LX switch leakage current	$I_{LX(leak)}$				1	µA
1.3.12	LX switch on resistance	R_{LX}			0.27	0.4	Ω
1.3.13	Minimum switch on time	t_{ONmin}	LX switch on		200		ns
1.3.14	Minimum switch off time	t_{OFFmin}	LX switch off		200		ns
1.3.15	Dimming rate	D_{DIM}	1 LED, f =100Hz, Vin=15V, L1 = 27µH		1200:1		

No.	PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
1.3.16	Recommended operating frequency maximum	f_{LXmax}				1	MHz
1.3.17	Recommended output switch duty cycle range at f_{LXmax}	D_{LX}		0.3		0.9	
1.3.18	Propagation delay of internal comparator	t_{PD}			50		ns
1.3.19	Thermal shutdown temperature	T_{SD}			150		°C
1.3.20	Thermal shutdown hysteresis	T_{SD-HYS}			20		K

1.4 Typical Operation Graphs

The curves are valid for the typical application circuit and T_{amb} = 25°C unless otherwise noted.

Figure 1.1 ZLED7x20 Supply Operating Current vs. Input Supply Voltage (V_{IN} = 6 to 40 V)

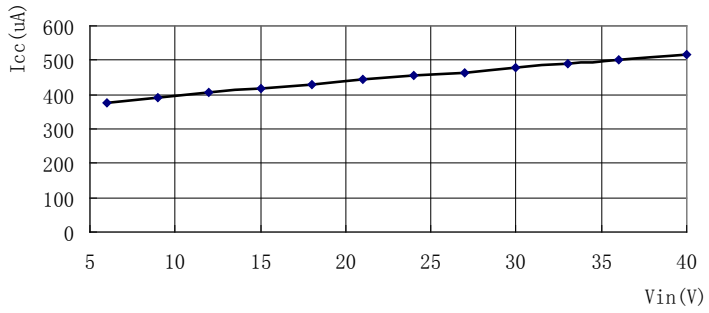


Figure 1.2 ZLED7x20 Supply Quiescent Shutdown Current vs. Input Supply Voltage (V_{IN} = 6 to 40 V)

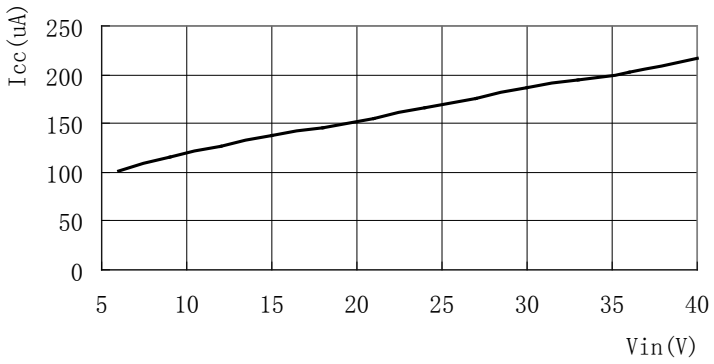


Figure 1.3 Efficiency (%) vs. Input Supply Voltage (V_{IN} = 6 to 40 V)† Per Number of LEDs (Rs=0.10Ω, L1=47µH)

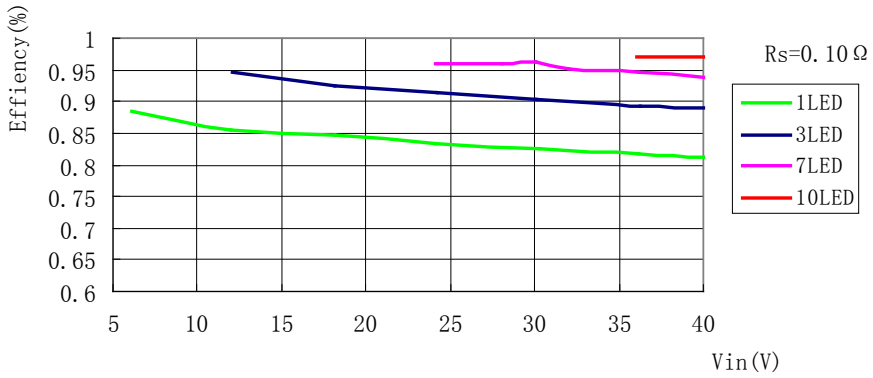
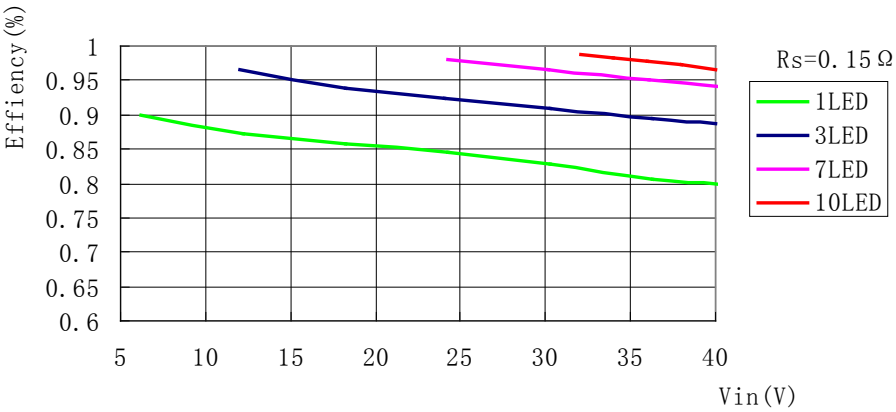


Figure 1.4 Efficiency vs. Input Supply Voltage (V_{IN} = 6 to 40 V)‡ Per Number of LEDs (Rs=0.15Ω, L1=47µH)



† Minimum V_{in} depends on number of LEDs.
‡ Minimum V_{in} depends on number of LEDs.

Figure 1.5 Efficiency vs. Input Supply Voltage (V_{IN} = 6 to 40 V)‡ Per Number of LEDs (Rs=0.30Ω, L1=47µH)

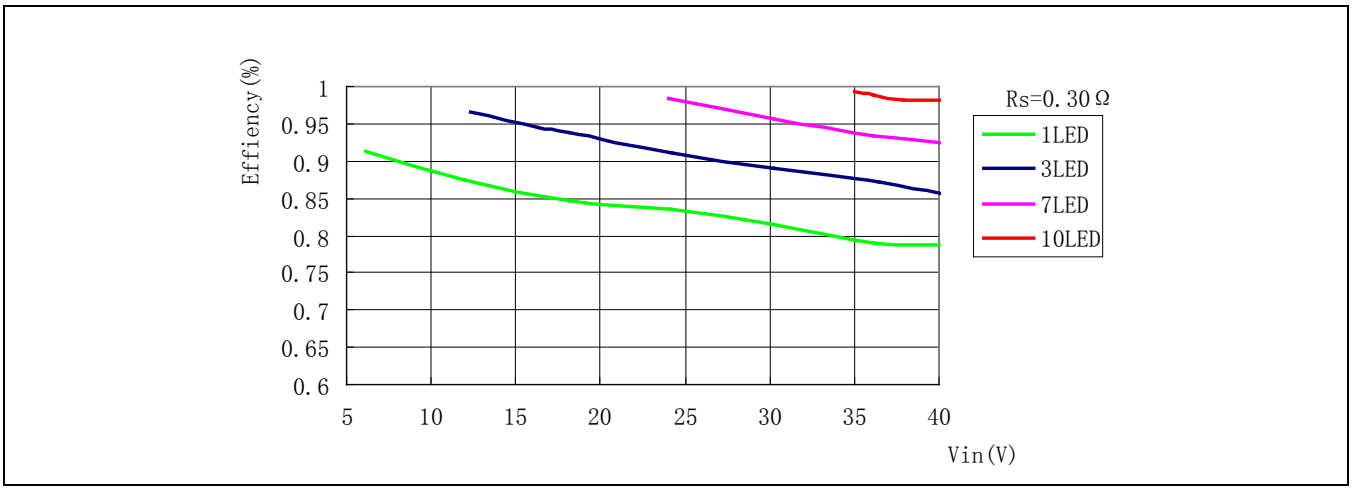
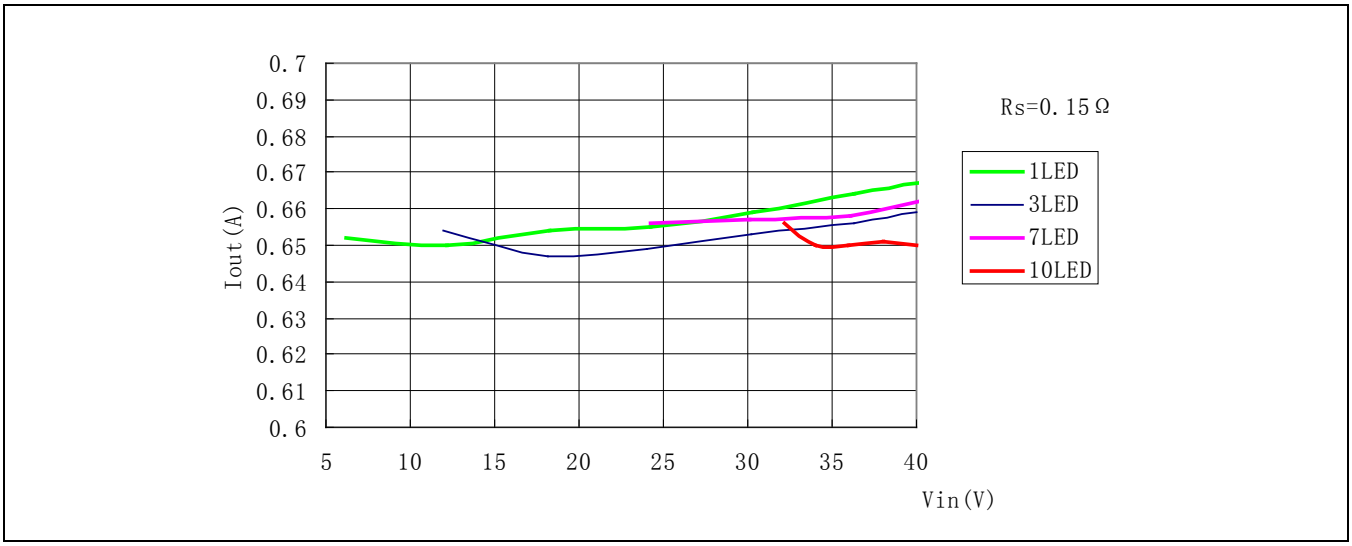


Figure 1.6 Output Current Variation vs. Input Supply Voltage (V_{IN} = 6 to 40 V)§ Per Number of LEDs (Rs = 0.15Ω, L1 = 47µH)



§ Minimum V_{in} depends on number of LEDs.

Figure 1.7 Sense Voltage vs. Operating Temperature (Rs=0.10Ω, L1=47µH, V_{IN} = 40 V)

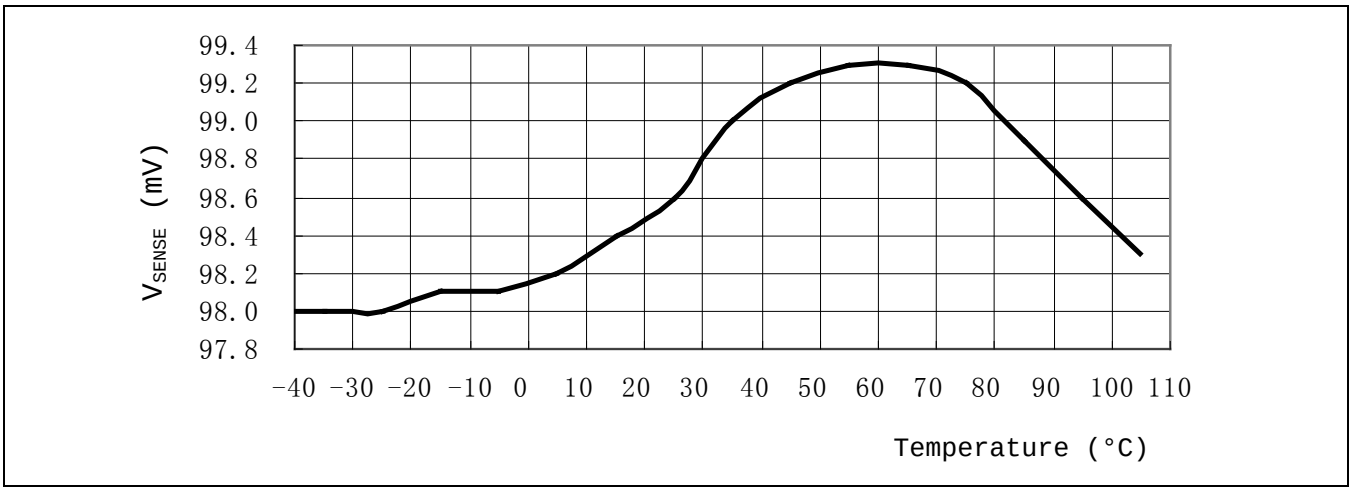


Figure 1.8 Dimming Rate with 100Hz Square Wave Control Signal (PWM) at ADJ Pin (current rise time=7.85µs)

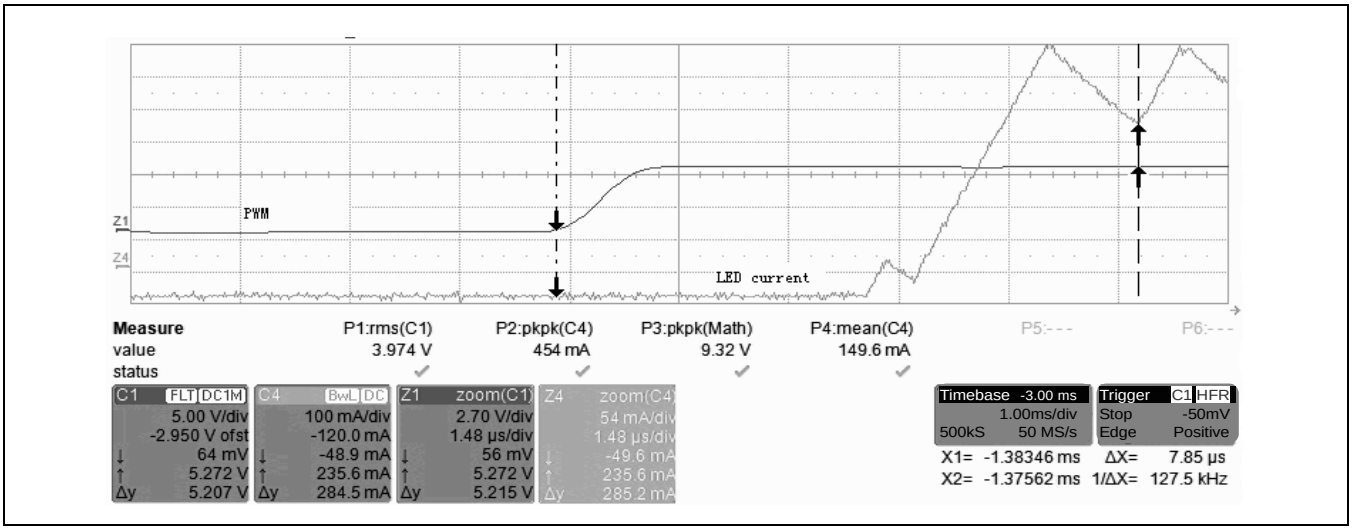
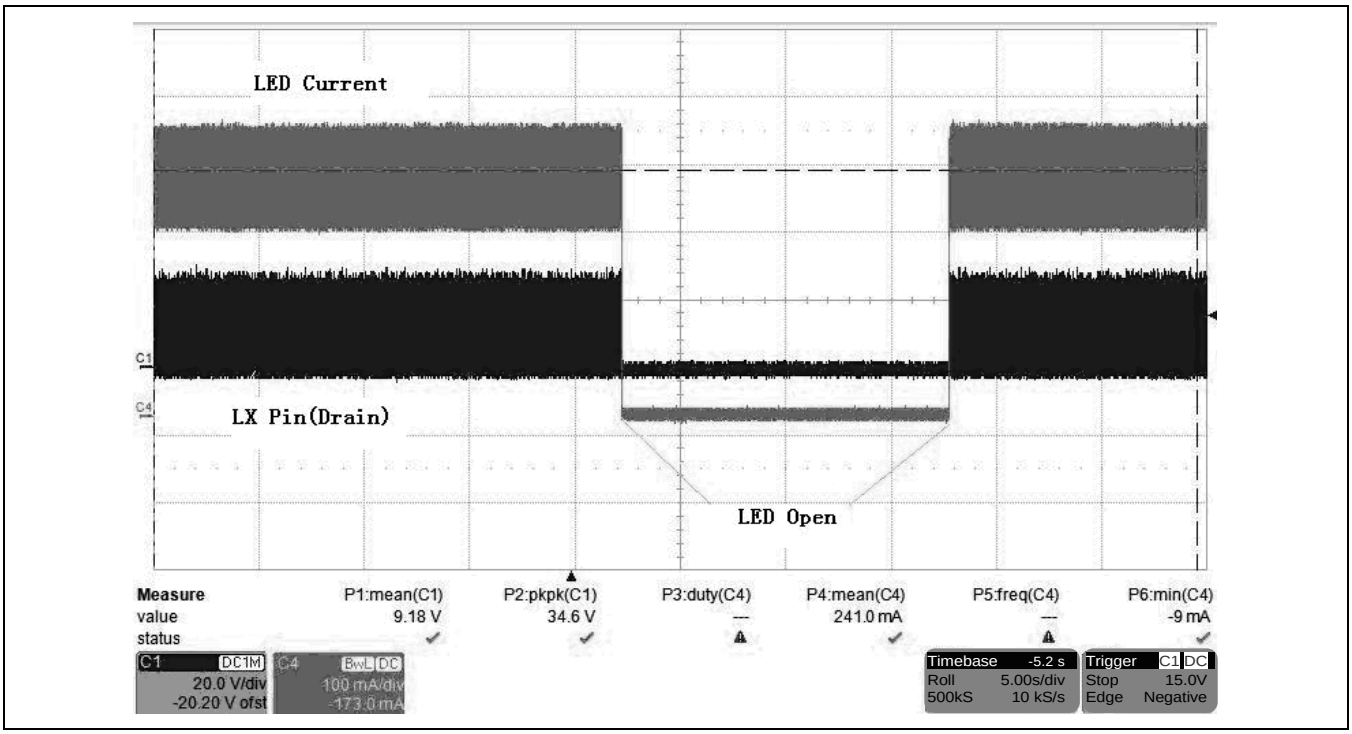


Figure 1.9 LED Open-Circuit Protection (Rs=0.30Ω, L1=47µH, V_{IN} = 24 V)



2 Circuit Description

2.1 ZLED7x20 Overview

The ZLED7x20 is a continuous-mode inductive step-down converter LED driver for driving single or multiple series-connected LEDs from a voltage input higher than the LED voltage (Vin = 6 to 40 VDC; see section 3.2.2 for important details). The ZLED7x20 provides an adjustable output current (1.2A maximum for ZLED7020; 1.0A maximum for ZLED7320; 0.75A maximum for ZLED7520; 0.35A maximum for ZLED7720), which is nominally set via an external sense resistor Rs and controlled by the ZLED7x20's integrated high-side output current-sensing circuit and output switch. An external control signal (e.g., DC voltage, PWM waveform, or microprocessor signal) on the ADJ pin can be used to linearly adjust the output for continuous, variable, or gated-output current. See page 2 for a block diagram of the ZLED7x20.

The output can be turned off by applying a voltage ≤0.2V (typical) to the ADJ pin, which puts the ZLED7x20 in a low-current standby state. See section 2.7 for a description of this shutdown mode.

Only a resistor, a diode, an inductor, and three capacitors are needed for a typical basic application. Refer to the application circuits in section 3 for the location of the components referenced in the following sections.

2.2 Control of Output Current via External Sense Resistor Rs

External sense resistor Rs, which is connected between the V_{IN} and I_{SENSE} pins as shown in Figure 3.1, sets I_{OUTnom}, the nominal average output current. Equation (1) can be used to calculate the nominal output current, which is the LX switch output current I_{LX} if the ADJ pin is floating (V_{ADJ} = V_{REF} =1.2V). See section 3.3.1 for recommended values for Rs in a typical basic application and section 3.4 for layout guidelines for Rs. Note that the peak I_{OUTnom} including ripple (see section 3.3.5) must not exceed the maximum current specifications (1.3.10).

$$I_{OUTnom} = \frac{0.1V}{Rs} \quad (1)$$

2.3 Control of Output Current via an External DC Control Voltage on the ADJ Pin

An external DC voltage (V_{ADJ}) input on the ADJ pin can control brightness by setting the output current to a value below the nominal average current I_{OUTnom} determined by R_S. With this method, the output current can be adjusted from 25% to 100% of I_{OUTnom}. The DC voltage source must be capable of driving the ADJ pin's input impedance R_{ADJ} (500kΩ ± approximately 25%; internal pull-up resistor to V_{REF}). See Figure 3.2 for a typical application circuit.

The nominal average output current I_{OUTdc} resulting from an external DC control voltage V_{ADJ} can be calculated via equation (2) where 0.3V≤ V_{ADJ} ≤1.2V:

$$I_{OUTdc} = \frac{0.083 * V_{ADJ}}{R_S} \quad (2)$$

Brightness is 100% if $V_{ADJ} = V_{REF,}$ the internal reference voltage, which can be measured on the ADJ pin when it is floating (1.2V, typical). If $V_{ADJ} \geq 1.2V$, the current is automatically clamped at 100% brightness.

Note: Absolute maximum V_{ADJ}= 6V.

2.4 Additional Requirements if the V_{IN} Input Voltage has a High Slew Rate

The analog dimming input ADJ can be used for implementing a soft-start function of the LEDs by connecting a capacitor to ground. The soft-start time constant is determined by the product of the internal pull-up resistor (500kΩ typical) and the external capacitor.

Important: If the supply voltage V_{IN} might have a high slew rate (> 1V/µs) when powered on, a resistor that is ≥ 1kΩ must be placed in series with the capacitor to guarantee correct power-on timing for the ZLED7x20 and proper loading of the current sense trimming data into the appropriate register. This resistor is not necessary if the capacitor is ≤ 470pF.

If the ADJ pin is controlled from an external voltage source or PWM signal, a series resistor is strongly recommended for noise immunity reasons and to avoid bulk current injection.

2.5 Control of Output Current via a PWM Signal on the ADJ Pin

An external pulse width modulation (PWM) control signal input on the ADJ pin can be used for brightness or gated on/off control of the output current by driving the output current to a value below the nominal average current determined by R_S. See Figure 3.3 for a typical application circuit. The PWM or gated on/off control signal can be within the range of 0 to 5 V. The logic high level must be higher than 1.2V and the logic low level must be below 0.2V. It must be capable of driving the ADJ pin's input impedance R_{ADJ} (approximately 500kΩ; internal pull-up resistor to V_{REF}).

2.6 Control of Output Current via a Microcontroller Signal on the ADJ Pin

An external control signal from the open drain output of a microcontroller can provide on/off or PWM brightness control by driving the ADJ pin. See Figure 3.4 for a typical application circuit. Diode D2 and resistor R1 shown in Figure 3.4 suppress any negative high-amplitude spikes on the ADJ input due to the drain-source capacitance of the FET in the microcontroller's output. Negative spikes on the ADJ input could cause output current errors or unintended ZLED7x20 operation. The signal input to the ADJ pin must be capable of driving the ADJ pin's input impedance R_{ADJ} (approximately 500kΩ; internal pull-up resistor to VREF).

2.7 Shutdown Mode

If the ADJ pin voltage V_{ADJ} is ≤ V_{ADJoff} (0.2V ± 0.05V), the supply current and output on the LX pin are quiescent at a low standby level (I_{INQoff} = 120µA nominal). Raising the ADJ pin voltage so that $V_{ADJ} \geq V_{ADJion}$ (0.25V ± 0.05V) will switch the output back to full operational mode.

2.8 ZLED7x20 Protection Features

2.8.1 Thermal Shut-down Protection

The ZLED7x20 automatically protects itself from damage due to over-temperature conditions. If the ZLED7x20's temperature exceeds the thermal shutdown threshold (T_{SD} = 150°C, typical), the ZLED7x20 will shut down. To avoid erratic ZLED7x20 operation, a 20K hysteresis (T_{SD-HYS}) is applied that prevents it from returning to operation until its temperature falls below the hysteresis threshold (T_{SD} - T_{SD-HYS}). Also refer to section 3.2 for additional thermal considerations.

2.8.2 LED Open Load Protection

As a step-down converter, the ZLED7x20 has inherent open-load circuit protection. Since the L1 inductor is connected in series with the LED string, the current flow is interrupted if the load is open and the LX output of the ZLED7x20 will not be damaged. This provides an advantage over other products such as boost converters, for which the internal switch can be damaged by back EMF forcing the drain above its breakdown voltage.

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3 Application Circuit Design

3.1 Applications

The ZLED7x20 is designed for applications requiring features such as high-speed switching, variable brightness control, operation with voltages up to 40V, high efficiency, or protection from over-temperature, or open LED circuit conditions.

Typical applications include MR16/MR11 LED spotlights, LED street lights, parabolic aluminized reflector (PAR) LED lights, and other general purpose industrial and consumer LED applications.

Figure 3.1, Figure 3.2, Figure 3.3, and Figure 3.4 demonstrate basic application circuits for the four options for controlling output current described in section 2.

Figure 3.1 Basic ZLED7x20 Application Circuit with Output Current Determined only by Rs

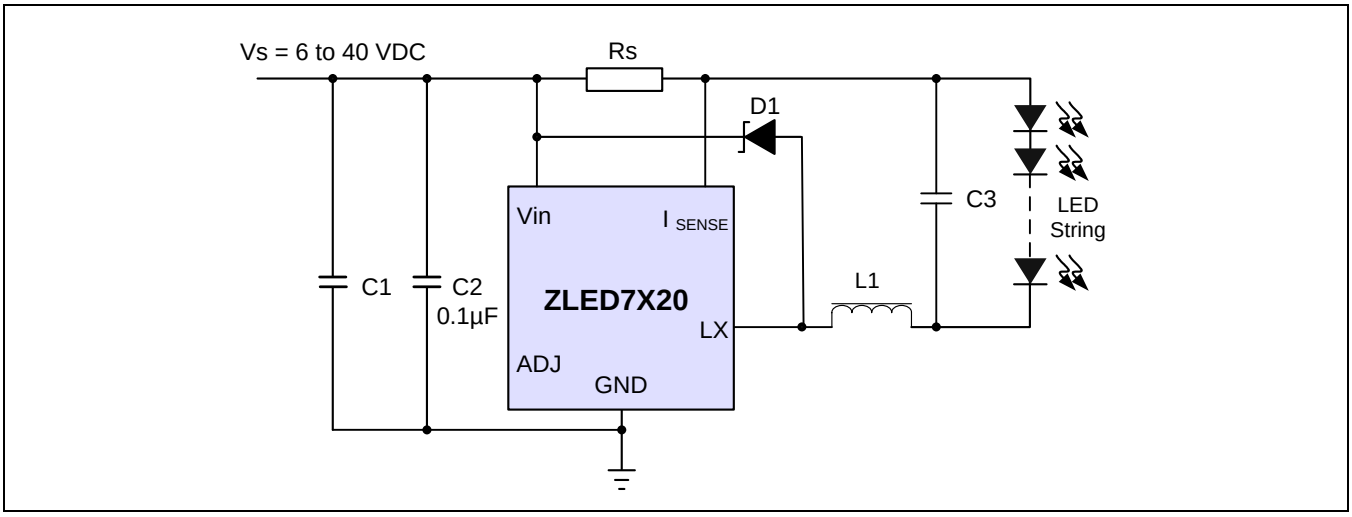


Figure 3.2 Basic ZLED7x20 Application Circuit with Output Current Controlled by External DC Voltage

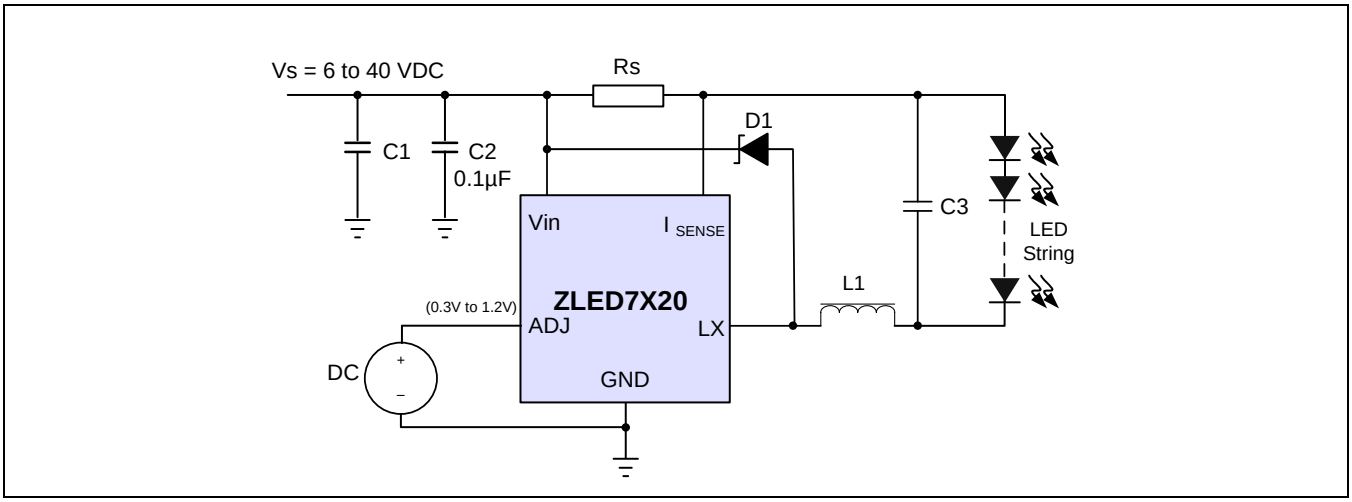


Figure 3.3 Basic ZLED7x20 Application Circuit with Output Current Set by External Square Wave Voltage (PWM)

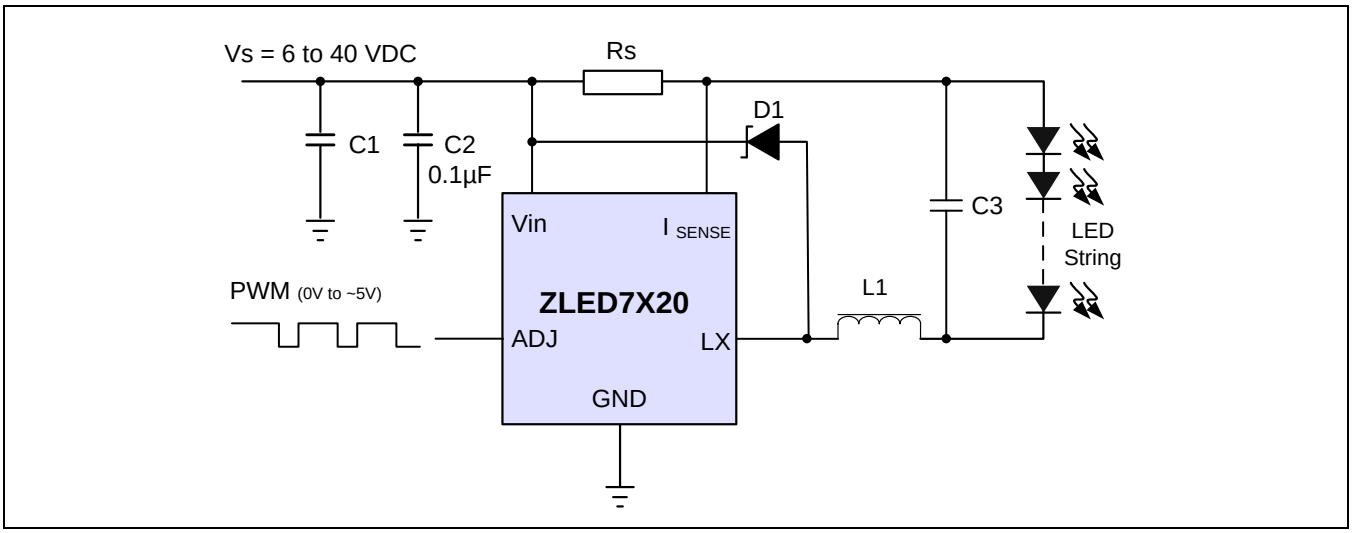
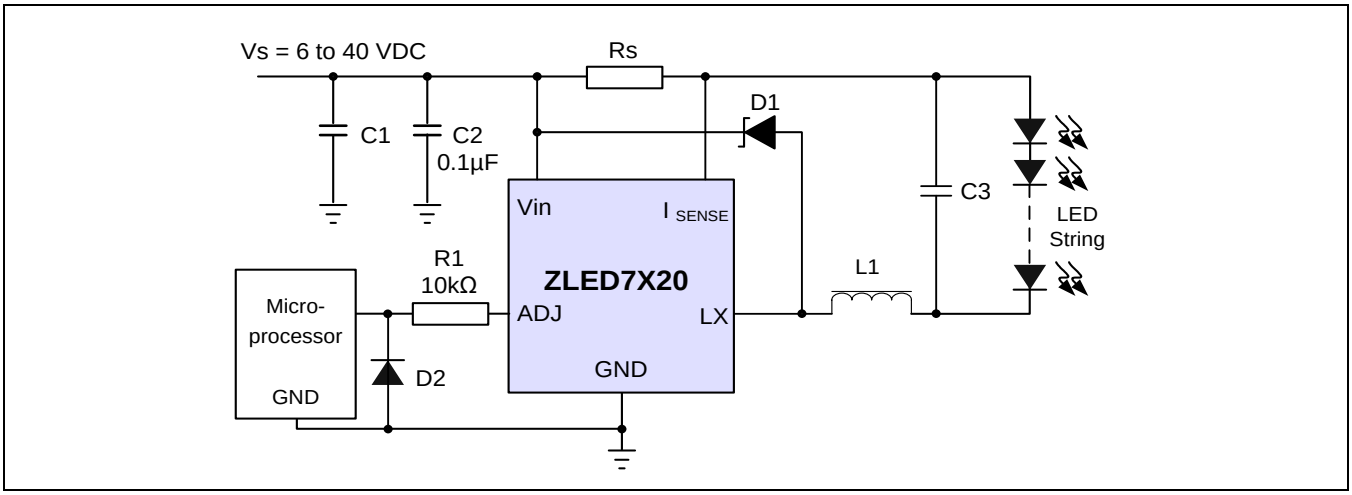


Figure 3.4 Basic ZLED7x20 Application Circuit with Output Current Controlled by External Microcontroller Signal



3.2 Thermal Considerations for Application Design

3.2.1 Temperature Effects of Load, Layout, and Component Selection

Do not exceed the package power dissipation limits by driving high load currents or by operating the chip at high ambient temperatures. Power dissipation also increases if the efficiency of the circuit is low as could result from selecting the wrong coil or from excessive parasitic output capacitance on the switch output. See the layout guidelines in section 3.4.

3.2.2 Temperature Effects of Low Supply Voltage V_{IN}

Until the supply input voltage on the V_{IN} pin has risen above the internally-set startup threshold, the ZLED7x20's internal regulator disables the drive to the internal power MOSFET output switch. Above this threshold, the MOSFET on-resistance is low enough for the chip to start to operate; however, if the supply voltage remains below the specified minimum (6V), the duty cycle of the output switch will be high and the ZLED7x20 power dissipation will be at a maximum. Avoid operating the ZLED7x20 under such conditions to reduce the risk of damage due to exceeding the maximum die temperature. When driving multiple LEDs, their combined forward voltage drop is typically high enough to prevent the chip from switching when V_{IN} is below 6V, so there is less risk of thermal damage.

3.3 External Component Selection

Note: Also see section 3.4 for layout guidelines for the following external components.

3.3.1 Sense Resistor Rs

Table 3.1 gives values for Rs under normal operating conditions in the typical application shown in Figure 3.1. These values assume that the ADJ pin is floating and at the nominal voltage of V_{REF}=1.2V.

Note: Under the conditions given in Table 3.1, in order to maintain the switch current below the maximum value specified in section 1, 0.082Ω is the minimum value for Rs for the ZLED7020, 0.1Ω for the ZLED7320, 0.13Ω for the ZLED7520 and 0.27Ω for the ZLED7720. It is possible to use different values of Rs if the ADJ pin is driven from an external voltage.

To ensure stable output current, use a 1% accuracy resistor with adequate power tolerance and a good temperature characteristic for Rs.

Table 3.1 Recommended Values for Sense Resistor Rs (ADJ pin floating at nominal voltage V_{REF}=1.2V)

Nominal Average Output Current (mA)	Value for R_S (Ω)
1200 (maximum for ZLED7020)	0.082
1000 (maximum for ZLED7320)	0.1
750 (maximum for ZLED7520)	0.13
667	0.15
350 (maximum for ZLED7720)	0.27
333	0.3

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3.3.2 Inductor L1

The recommended range for the L1 inductor is 33µH to 220µH. 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. If the application requires a high supply voltage and low output current, inductance values at the high end of this range are recommended to minimize errors due to switching delays, which can reduce efficiency and increase ripple on the output. Also see section 3.4 for layout considerations for L1. Equations (3) and (4) can be used to calculate t_{ON} and t_{OFF}.

On Time for LX Switch (t_{ONmin}>200ns):

$$t_{ON} = \frac{L * \Delta I}{V_{IN} - V_{LED} - I_{AVG} * (R_S + r_L + R_{LX})} \quad (3)$$

Off Time for LX Switch (t_{OFFmin}>200ns):

$$t_{OFF} = \frac{L * \Delta I}{V_{LED} + V_D + I_{AVG} * (R_S + r_L)} \quad (4)$$

Where:

Symbol	Description
L	L1 coil inductance in H
ΔI	L1 coil peak-peak ripple current in A (internally set to 0.3 ∗ I_{AVG})
V_{IN}	Supply voltage in V
V_{LED}	Total forward voltage in V for LED string
I_{AVG}	Nominal average LED current in A
Rs	External current sense resistor in Ω
r_L	L1 coil resistance in Ω
R_{LX}	LX switch resistance in Ω
V_D	D1 diode forward voltage at the required load current in V

The inductance value has an equivalent effect on t_{ON} and t_{OFF} and therefore affects the switching frequency. For the same reason, the inductance has no influence on the duty cycle, for which the relationship 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.

To achieve optimum performance, duty cycles close to 0.5 at the nominal average supply voltage are preferable for improving the temperature stability of the output current.

Equations (5), (6), (7), and (8) provide an example of calculating t_{ON}, t_{OFF}, operating frequency f_{LX}, and duty cycle D_{LX} when using a 220µH inductor for L1 and V_{IN}=12V, Rs = 0.30Ω, r_L=0.26Ω, V_{LED}=3.4V, I_{AVG} =333mA, V_D=0.36V, and R_{LX}=0.27Ω.

Example:

$$t_{ON} = \frac{220\mu H * 0.3 * 0.333A}{12V - 3.4V - 0.333A * (0.3\Omega + 0.26\Omega + 0.27\Omega)} = 2.64\mu s \quad (5)$$

$$t_{OFF} = \frac{220\mu H * 0.3 * 0.333A}{3.4V + 0.36V + 0.333A * (0.30\Omega + 0.26\Omega)} = 5.56\mu s \quad (6)$$

$$f_{LX} = \frac{1}{t_{ON} + t_{OFF}} = \frac{1}{2.64\mu s + 5.56\mu s} = 121.8kHz \quad (7)$$

$$D_{LX} = \frac{V_{LED}}{V_{IN}} = \frac{3.4V}{12V} \approx \frac{t_{ON}}{t_{ON} + t_{OFF}} = \frac{2.64\mu s}{2.64\mu s + 5.56\mu s} \approx 0.3 \quad (8)$$

For the L1 inductor, use a coil with a continuous current rating higher than the required mean output current and a saturation current that exceeds the peak output current by 30% to 50% for robustness against transient conditions; e.g., during start-up.

3.3.3 Bypass Capacitor C1

The bypass capacitor C1 has two functions: maintaining operating voltage and bypassing the current ripple of the switching converter. In general low ESR capacitors must be used.

If the circuit is supplied by rectified line voltage, C1 must provide enough charge to maintain the ZLED7x20's minimum operating voltage as well as the forward voltage of the LED string to keep the application working even if the rectified supply voltage periodically drops below these values. A rough estimate for the minimum capacity needed can be calculated with equation (9).

$$C1_{MIN} = \frac{I_{AVG} * t_D}{\Delta V_{MAX}} = \frac{I_F * D_{LX}}{\Delta V_{MAX} * f_{LX}} \quad (9)$$

Where:

Symbol	Description
I_{AVG}	Average nominal LED string current assuming that the contribution of the IC supply current is negligible.
t_D	Discharge time at given AC frequency. Will be a maximum of 10ms (½ period duration) at 50Hz.
ΔV_{MAX}	Peak rectified supply voltage minus LED string forward voltage or minimum ZLED7x20 supply voltage, whichever is greater.

Example: For an application with 3 LEDs with 3.2V forward voltage each driven at 0.33A and supplied with rectified 24VAC, a minimum bypass capacitor C1 of 220µF or 330µF might be adequate. Compared to the calculation, a safety margin of about 50% must be added to consider temperature effects and aging.

$$C1_{MIN} = \frac{0.33A * 10ms}{24V * \sqrt{2} - 3 * 3.2V} = 135\mu F \quad (10)$$

A second function of C1 is to bypass the current ripple of the switching converter and thus prevent it from disturbing a stable IC supply or backlash on the power supply circuit. For this reason, even in DC-supplied applications, the use of an adequate C1 might be useful. The defining parameters are now as shown in equation (11):

$$C1_{MIN} = \frac{I_{AVG} * t_{ON}}{V_{RIPPLE}} \quad (11)$$

Where:

Symbol	Description
I_{AVG}	Average nominal LED string current.
t_{ON}	On time of the internal MOSFET output switch. Note: t_{ON} must be longer than t_{ONmin}=200ns.
V_{RIPPLE}	Permissible voltage ripple on the supply voltage.

Example: For an application of 3 LEDs driven at 0.33A and supplied with 24VDC, a maximum ripple of 10% is allowed. The ZLED7x20 is operated at 150kHz with a duty cycle of 0.4 leading to an on time of 2.67µs. As calculated in equation 12, a capacitor C1 of 470nF may be adequate, again including a safety margin of about 50%.

$$C1_{MIN} = \frac{0.33A * 2.67\mu s}{24V * 0.1} = 367nF \quad (12)$$

To achieve maximum stability over temperature and voltage, an X7R, X5R, or better dielectric is recommended while Y5V must be avoided.

3.3.4 De-bouncing Capacitor C2

External capacitor C2 minimizes ground bounce during switching of the internal MOSFET output switch. Ground bounce is typically caused by parasitic inductance and resistance due to the distance between the grounds for the power supply and the ZLED7x20 GND pin. Use a 0.1µF, X7R ceramic capacitor to ground for C2.

3.3.5 Capacitor C3 for Reducing Output Ripple

If required, the C3 can be used to reduce peak-to-peak ripple current in the LED string. Low ESR capacitors should be used because the efficiency of C3 largely depends on its ESR and the dynamic resistance of the LEDs. For an increased number of LEDs, using the same capacitor will be more effective. Lower ripple can be achieved with higher capacitor values, but this will increase start-up delay by reducing the slope of the LED voltage as well as cause increased current during converter start-up. The capacitor will not affect operating frequency or efficiency. For a simulation or bench optimization, C3 values of a few µF are an applicable starting point for the given configuration. Ripple current reduction is approximately proportional to the value of C3.

3.3.6 Diode D1

The flyback diode D1 must have a continuous current rating greater than the maximum output load current and a peak current rating higher than the peak L1 coil current. Important: Use a low-capacitance, fast Schottky diode that has low reverse leakage at the maximum operating temperature and maximum operating voltage for the application to avoid excess power dissipation and optimize performance and efficiency. For silicon diodes, there is a concern that the higher forward voltage and increased overshoot from reverse recovery time could increase the peak LX pin voltage (V_{LX}). The total voltage V_{LX} (including ripple voltage) must not be >50V.

3.4 Application Circuit Layout Requirements

The following guidelines are strongly recommended when laying out application circuits:

- Important: Locate the L1 inductor and the C1 input decoupling capacitor as close as possible to the ZLED7x20 to minimize parasitic inductance and resistance, which can compromise efficiency. Use low resistance connections from L1 to the LX and V_{IN} pins.
- All circuit board traces to the LX pin must be as short as possible because it is a high-speed switching node.
- If the ADJ pin floats, all circuit board traces to the ADJ pin must be as short as possible to reduce noise pickup.
- Do not lay out high-voltage traces near the ADJ pin because if the board is contaminated, leakage current can affect the ADJ pin voltage and cause unintended output current. To further reduce this risk, use a ground ring around the ADJ pin. (Also see section 2.8 regarding the ZLED7x20's protection circuitry for preventing excessive output current.)
- To minimize ground bounce, locate the 0.1µF external capacitor C2 as close as possible to the V_{IN} pin and solder the ZLED7x20's GND pin directly to the ground plane. (Also, see section 3.3.4 regarding ground bounce.)
- Because Rs is typically a low value resistor, it is important to consider the resistance of the traces in series with R_S as part of the total current sense resistance. Use traces that are as short and wide as possible to minimize this effect.
- The ZLED7x20's thermal pad must be grounded.

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4 ESD Protection

All pins have an ESD protection of ≥ ±3500V according to the Human Body Model (HBM). The ESD test follows the Human Body Model with 1.5 kΩ/100 pF based on MIL 883-H, Method 3015.8.

5 Pin Configuration and Package

5.1 SOT89-5 Package Pin-out and Dimensions for the ZLED7020

Figure 5.1 ZLED7020 Pin Configuration – SOT89-5 Package

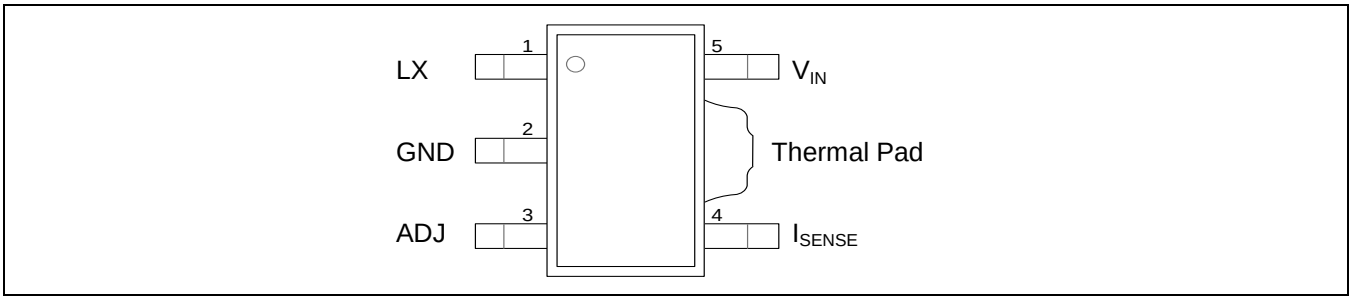
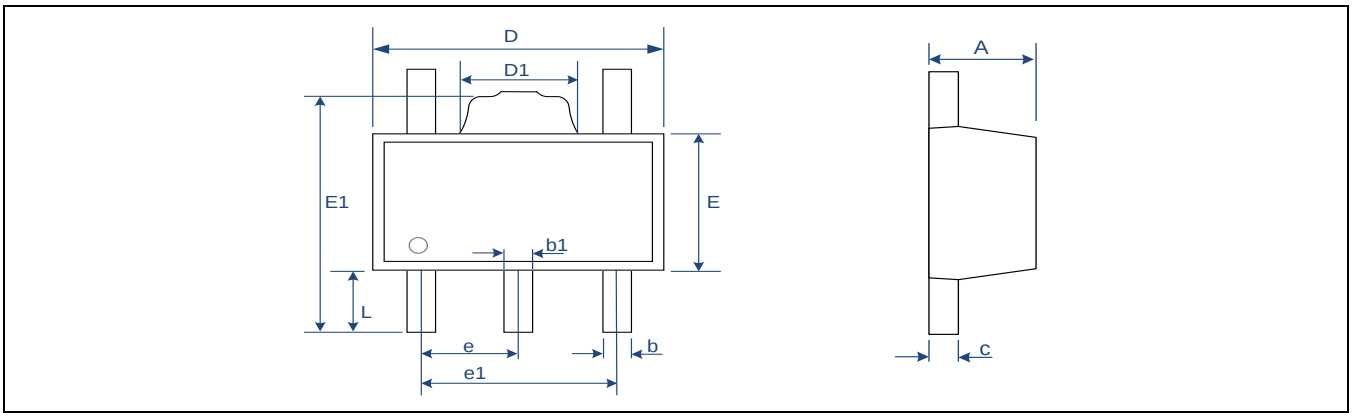


Table 5.1 ZLED7020 Pin Descriptions—SOT89-5 Package

Pin	No.	**Description** (Also see section 3.3 for layout guidelines)
LX	1	Drain of internal power switch
GND	2	Ground
ADJ	3	On/off and brightness control input
I_{SENSE}	4	Current adjustment input. Resistor R_S from I_{SENSE} to V_{IN} determines the nominal average output current. I_{OUTnom} =0.1V/R_S
Thermal Pad		Connect to GND.
V_{IN}	5	Input voltage (6V to 40V).

Figure 5.2 SOT89-5 Package Dimensions for the ZLED7020



Symbol	Dimension (mm)	
	Min	Max
A	1.400	1.600
b	0.320	0.520
b1	0.360	0.560
c	0.350	0.440
D	4.400	4.600
D1	1.400	1.800
E	2.300	2.600
E1	3.940	4.250
e	1.500 Typical	
e1	2.900	3.100
L	0.900	1.100

5.2 DFN-5 Package Pin-out and Dimensions for the ZLED7320, ZLED7520 and ZLED7720

Figure 5.3 ZLED7320, ZLED7520 & ZLED7720 Pin Configuration — DFN-5 Package

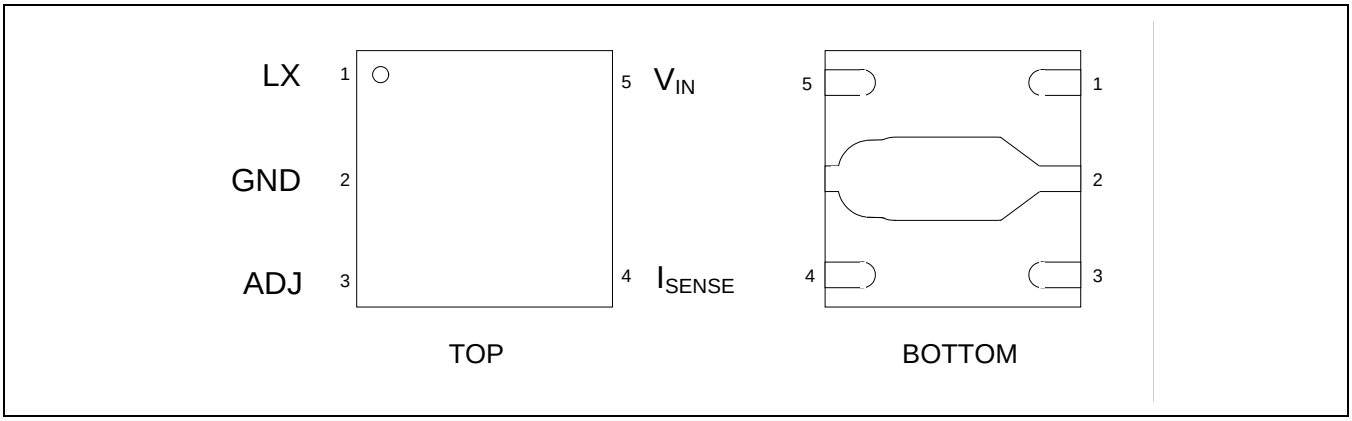
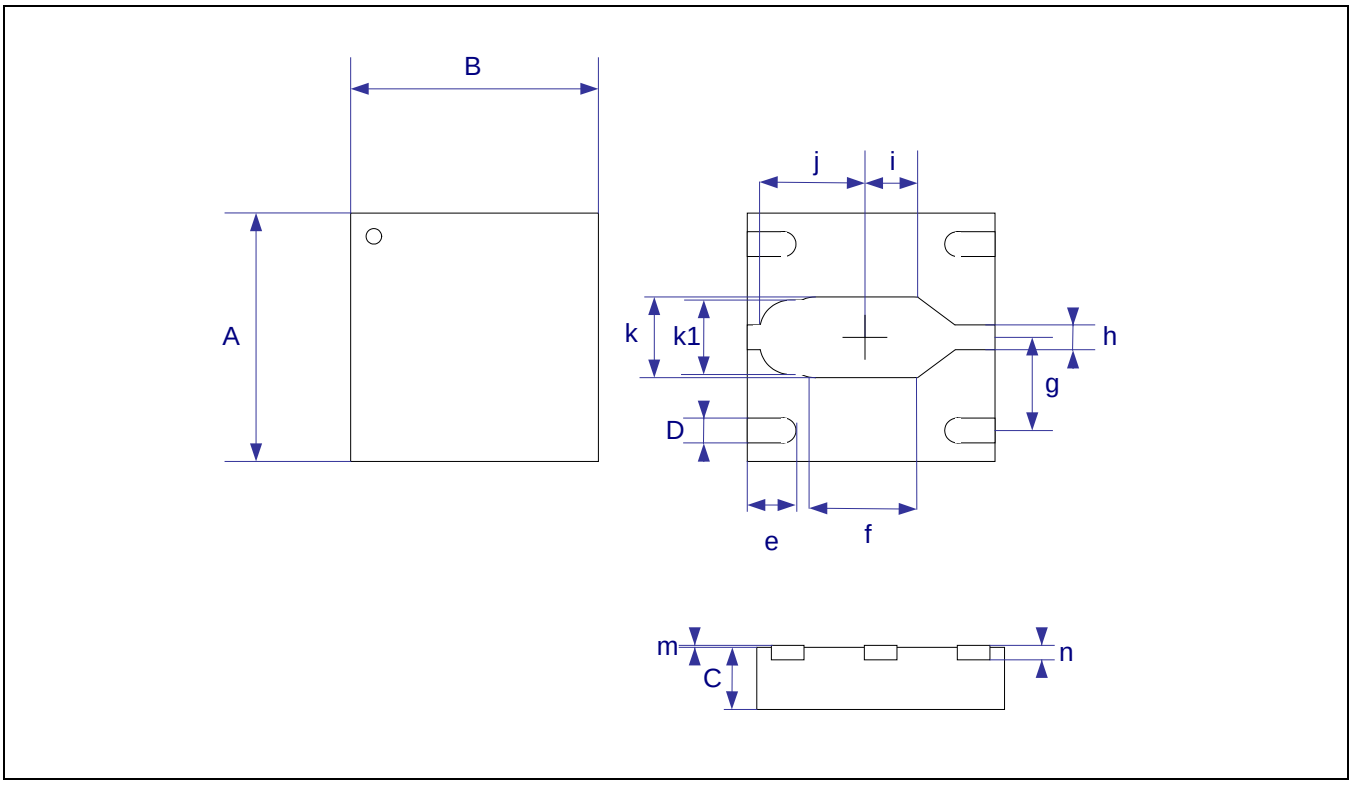


Table 5.2 ZLED7320, ZLED7520 & ZLED7720 Pin Descriptions — DFN-5 Package

Pin	No.	**Description** (Also see section 3.3 for layout guidelines)
LX	1	Drain of internal power switch
GND	2	Ground
ADJ	3	On/off and brightness control input
I_{SENSE}	4	Current adjustment input. Resistor R_S from I_{SENSE} to V_{IN} determines the nominal average output current. I_{OUTnom} =0.1V/R_S
Thermal Pad		Connect to GND.
V_{IN}	5	Input voltage (6V to 40V).

*Figure 5.4 DFN-5 (DFN4*4-05L) Package Dimensions for the ZLED7320, ZLED7520 & ZLED7720*



Symbol	Dimension (mm)	
	Min	Max
A	3.95	4.05
B	3.95	4.05
C	0.70	0.80
D	0.37	0.47
e	0.75	0.95
f	2.17	2.42
g	1.50	
h	0.41	0.51
i	0.55	
j	1.70	
k	1.75	
k1	1.40	1.55
m	0.000	0.050
n	0.200	

6 Ordering Information

Ordering Information

Product Sales Code	Description	Package
ZLED7020ZI1R	ZLED7020 – High Current (1200mA) 40V LED Driver with Internal Switch	SOT89-5 (Tape & Reel)
ZLED7320ZI1R	ZLED7320 – High Current (1000mA) 40V LED Driver with Internal Switch	DFN-5 (Tape & Reel)
ZLED7520ZI1R	ZLED7520 – High Current (750mA) 40V LED Driver with Internal Switch	DFN-5 (Tape & Reel)
ZLED7720ZI1R	ZLED7720 – High Current (350mA) 40V LED Driver with Internal Switch	DFN-5 (Tape & Reel)
ZLED7020KIT-D1	ZLED7020-D1 Demo Board, 1 ZLED-PCB8 and 5 ZLED7020 ICs	Kit
ZLED-PCB8	Test PCB with one 5W white High Brightness (HB) LED, cascadable to one multiple LED string	Printed Circuit Board (PCB)
ZLED-PCB2	10 unpopulated test PCBs for modular LED string with footprints of 9 common HB LED types	Printed Circuit Board (PCB)

7 Related Documents

Document
ZLED7x20 Feature Sheet
ZLED7020 Application Note—PCB Layout

Visit the ZLED7x20 product pages at http://www.IDT.com/ or contact your nearest sales office for the latest version of these documents.

8 Glossary

Term	Description
ESD	Electrostatic Discharge
EMF	Electromagnetic Force
ESR	Equivalent Series Resistance
PWM	Pulse Width Modulation

9 Document Revision History

Revision	Date	Description
1.00	June 27, 2011	First issue.
1.10	August 9, 2011	Update to Demo Kit description.
1.20	August 12, 2011	Update to include ZLED7520 & ZLED7720. Update for Demo Kit description
1.30	February 6, 2012	Update to include operating junction temperature.
1.40	June 11, 2014	Update to add new section 2.4 regarding requirements if V_{IN} has a high slew rate. Updates for cover and page header imagery. Updates for IDT contact information. Addition of “Related Documents” and “Glossary” sections.
	April 20, 2016	Changed to IDT branding.

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