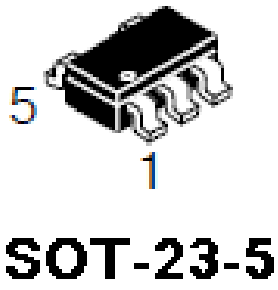
1. General Description

The SL2733 is a DC/DC boost converter that can provide constant and precise drive currents for multiple LEDs synchronously. With a fixed switching frequency of 1MHz, the SL2733 can be used with external ceramic capacitors and inductors with small consumption. Also, the SL2733 can drive multiple LEDs connected in series via an adjustable current set by an external resistor R1. And the SL2733 might prove most useful in driving LEDs of the same type, with 9 white LEDs at most connected in series simultaneously, or driving

LED brightness adjustment of up to 32 volts through one DC voltage, one logic or pulse width modulation (PWM) signal. What's more, the（SHDN） allows the device to operate in power-down mode with extremely low quiescent current.

So in addition to thermal shutdown and overload current limit, it can also turn its chips, available in SOT23-5 small outline package, into ultra-low power consumption mode in the event of an open-circuit failure in LED.

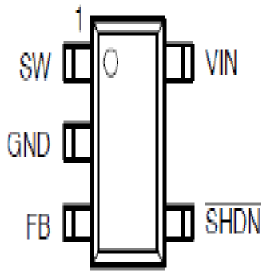
2. Features



- Peak Switching Current 1A
- Driving Voltage Maximum 32V
- Power Efficiency up to 90%
- Shutdown currents less than 10uA
- Fixed frequency of 1MHz with less noise
- Limited surge current during a soft start
- Overvoltage protection in the event of an open-circuit failure in LED
- Auto-lockdown under 3.3 voltage
- Overheat protection

3. Pin Descriptions

1) The SW pin is connected to the drain side of the boost converter's internal CMOS power switch. The inductor and the anode of Schottky diode should be combined with the SW pin. And the connection of SW pin ought to be as short as possible for smaller loop areas. With one overvoltage detection circuit connected to the SW pin, the device would automatically turn itself into a low-power safe mode at 37V so as to prevent the SW voltage from exceeding the maximum rating.



2) The GND pin, a reference zero voltage pin, should be directly connected to the PCB.

3) The FB pin is a feedback pin with its potential clamped at 0.3 V. There is a resistor R1 on the way between the FB and GND to set the LED currents. The following Formula 3.1 could tell the exact current size:

$$I_{LED} = \frac{0.3V}{R1} \qquad 3.1$$

4) Please notice that the LED's cathode of lowest potential should be connected to the FB pin.

5) SHDN is a shutdown controller for the logic input. The device would automatically shut down, something akin to the zero-current mode, when the voltage at this pin plumps below 0.4; and would restart as the voltage rises above 1.5 V.

6) The VIN pin is a power input pin for internal logic circuits, with its input voltage range from 3.3V to 32V. And it is advisable to place a bypass ceramic capacitor (4.7uF) between the VIN and the GND pin. The device would immediately shut itself down once the VIN' voltage falls below 3.3 V.

Table 3.1 Pin Descriptions

Number	Name	Function
1	SW	the switch pin, the drain of the internal power switch
2	GND	the ground pin connected to the ground
3	FB	the feedback pin connected to the cathode of the last LED
4	$\overline{SHDN}$	the shutdown pin (low logic level) set high to enable driver
5	VIN	the voltage input pin

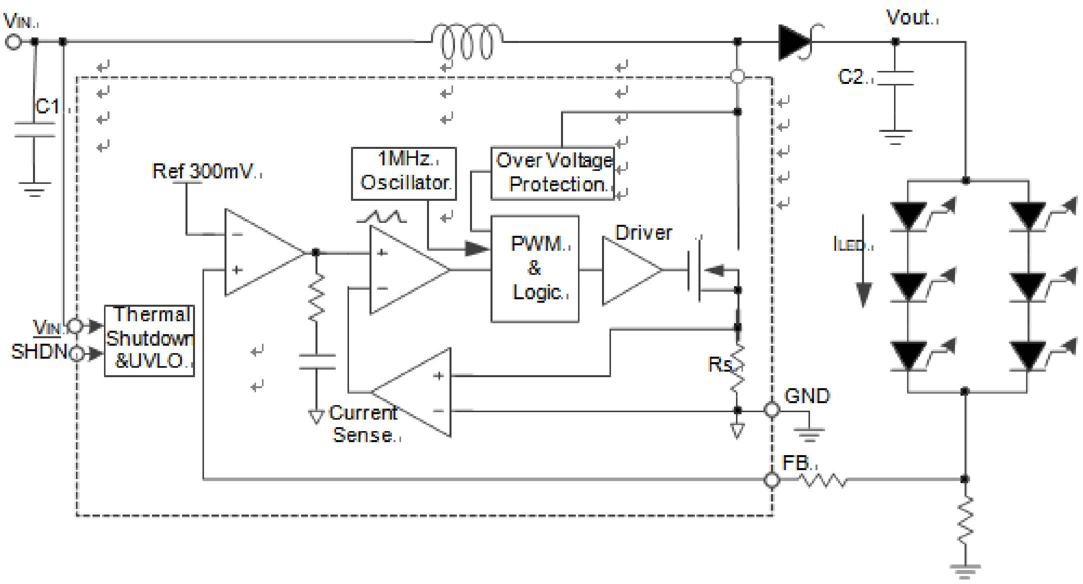


Figure 3-1 Chip Fundamental Architecture

4. Device Operating Description

1) The SL2733 is an inductive boost converter with fixed frequency of 1MHz and less noise. It can provide devices with constant currents of favorable linearity and load regulation. And there is a high-voltage NMOS switch between the SW and the GND pin to drive the inductor. The energy stored in the inductor would be released to the load via the Schottky diode when the switch is off.

2) The duty cycle of the NMOS switch is adjusted and controlled via the feedback voltage at the end of the FB within the device; and a constant regulated voltage of 0.3 would be ultimately released at the FB pin. So here is an inverse relationship between the size of currents flowing through the LED and the resistor's resistance (I=0.3V/R1).

3) The duty cycle of the internal NMOS switch is limited to throttle surge currents and provide a soft-start work mode when the device powers on for the first time.

4) If an open-circuit failure occurs in LED, the feedback control loop would unlock with the output voltage growing. An excess of 37V would activate the internal protection circuit to turn the device into a low-power safe mode.

5) Overheat protection circuits are also contained in the device to instantly shut the device down when its junction temperature rises above 150°C, and to restart it below 130°C.

5. Applications

The SL2733 can be used in GPS navigation systems, portable multimedia players, and other hand-held devices. If you want to figure out how exactly it works, the typical application circuit illustrated in Figure 5-1, 5-2 and 5-3 may help. Note here, the LED's spec in Figure 5-1 is 3.3V/20mA, and 2.1V/250mA in both Figure 5-2 and 5-3.

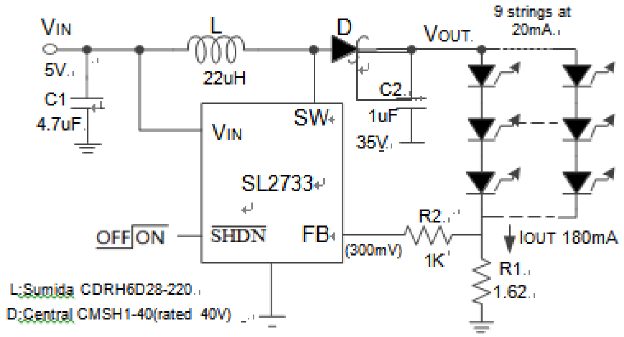


Figure 5-1 Typical Application Circuit 1

Table 5.1 Absolute Maximum Ratings

Parameter	Symbol	Parameter range	Unit	Remark
VIN Voltage	V_{IN}	-0.3～+42	V	
FB Voltage	V_{FB}	-0.3～+7	V	
SHDN Voltage	V_{SHDN}	-0.3～+40	V	
SW Voltage	V_{SW}	-0.3～+40	V	
Storage Temperature Range	Tstg	-40～+150	℃	
Junction Temperature Range	Tj	-40～+150	℃	
Soldering Temperature Range	$T_{soldering}$	300	℃	
Thermal Resistance	Rthj-a	220	K/W	
ESD Voltage Resistance	$V_{ESD-HBM}$	±2000	V	Human Body Model (HBM) [1]
	$V_{ESD-CDM}$	±1000	V	Charge Device Model (CDM) [2]

Note: Devices would get damaged in excess of the absolute maximum ratings in Table 5.1. And all functions are supposed to work within the range listed below.

[1] ESD-HBM based on the JESD22-A114.

[2] ESD-CDM based on the JESD22-C101E.

Table 5.2 Recommended Operating Conditions（Refer to Figure 5-1）

Parameter	Value	Unit
VIN Pin Voltage Range	3.6～30	V
SW Pin Voltage Range	0～32	V
Operating Temperature Range	-40～+150	℃

Note: The thermal resistance of the SOT23-5' package stands at JA= 220C/W as the device is soldered to the PCB.

Table 5.3 DC Characteristics

(VIN=3.6V，Ta=25°C, unless otherwise specified)

Symbol	Parameter	Test condition	Min	Type	Max	Unit
IQ	Quiescent Current	VFB = 0.2V		0.8	1.5	mA
		VFB = 0.4V		0.1	0.6	
I_{SD}	Shutdown Current	VSHDN=0V		6	10	uA
V_{FB}	FB Pin Voltage	IOUT = 180mA	285	300	315	mV
I_{FB}	FB Input Current				1	uA
V_{ENH}	Enable Signal Threshold	Enable Signal High Threshold		1	1.5	V
V_{ENL}		Enable Signal Low Threshold	0.4	0.5		
F_{SW}	Switch Frequency		0.8	1.0	1.3	MHz
I_{LIM}	Switch Current Limit	VIN=3.6V	600			A
		VIN=5V	750			
R_{SW}	Switch Resistance	ISW = 100 mA		1.0	2.0	Ω
L_{LEAK}	Switch Leakage Current	EN=0V，VSW=5V			1	uA
T_{SD}	Thermal Shutdown			150		℃
T_{HYST}	Thermal Hysteresis			20		℃
V_{UVLO}	Threshold Voltage			3.3		V
V_{OV-DET}	Overvoltage Threshold Detection			37		V
V_{OCL}	Output Clamp Voltage	An Open circuit failure in the LED，FB<0.2		37		V
DC	Maximum Duty Cycle			92		%
	Minimum Duty Cycle			16		

Table 5.4 Typical Characteristics

（VIN=5.0 V, IOUT = 180 mA, TAMB = 25℃, unless otherwise specified. Please refer to the typical application current in Figure 5-1）

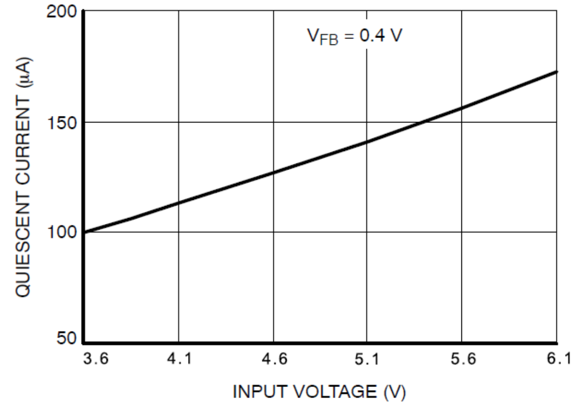


Figure 5-4 Quiescent Current VS Input Voltage

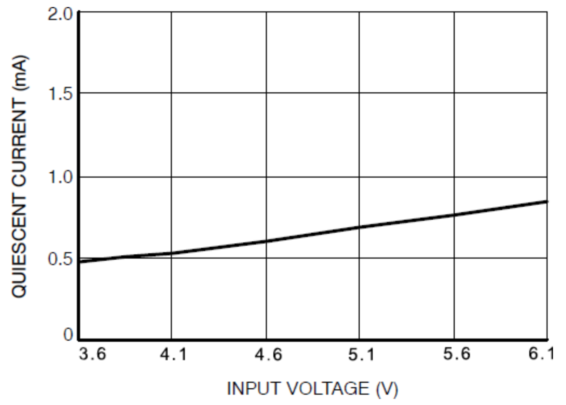


Figure 5-5 Quiescent Current VS Input Voltage（working）

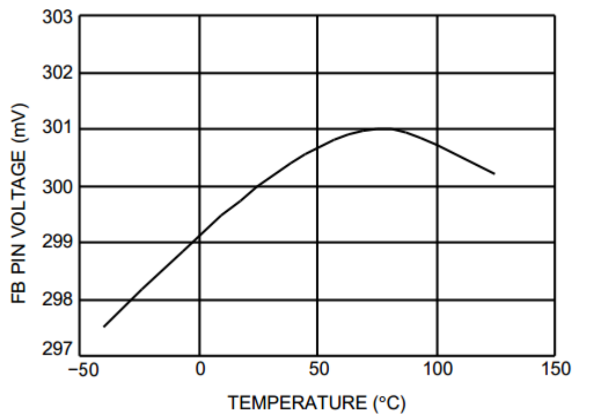


Figure 5-6 FB Pin Voltage VS Operating Temperature

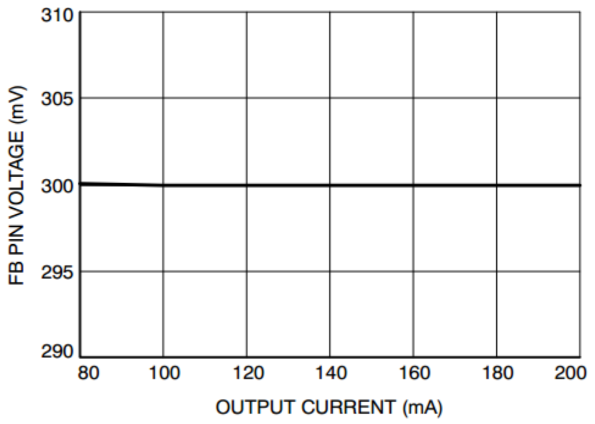


Figure 5-7 FB Pin Voltage VS Input Current

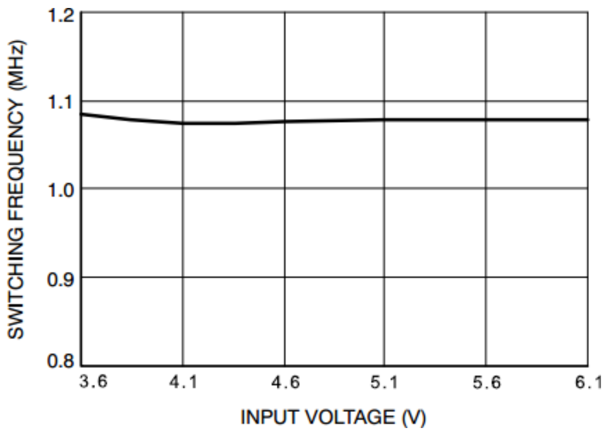


Figure 5-8 Switching frequency VS Power Voltage

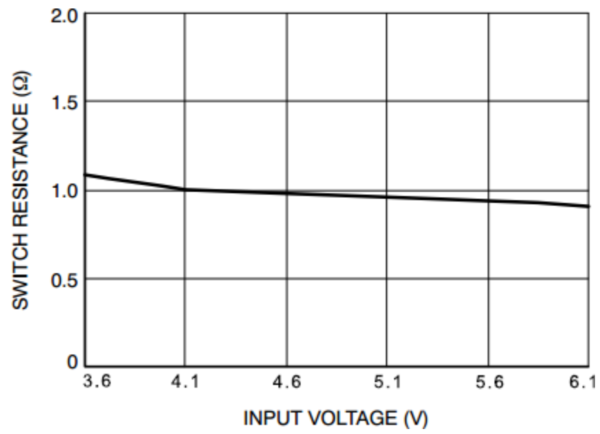


Figure 5-9 On-State Resistance VS Input Voltage

Table 5.5 Typical Characteristics

（VIN=5.0 V, IOUT = 180 mA, TAMB = 25℃, unless otherwise specified. Please refer to the typical application current in Figure 5-1）

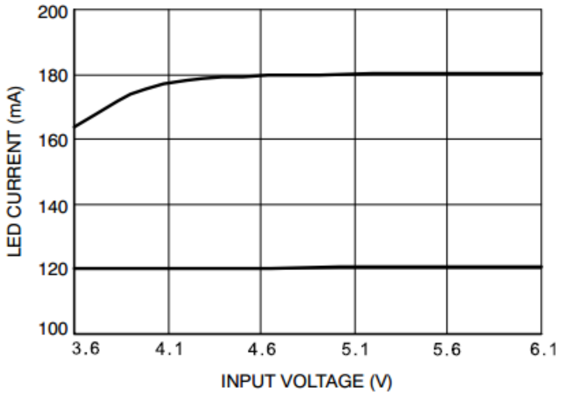


Figure 5-10 Output Current VS Input Voltage

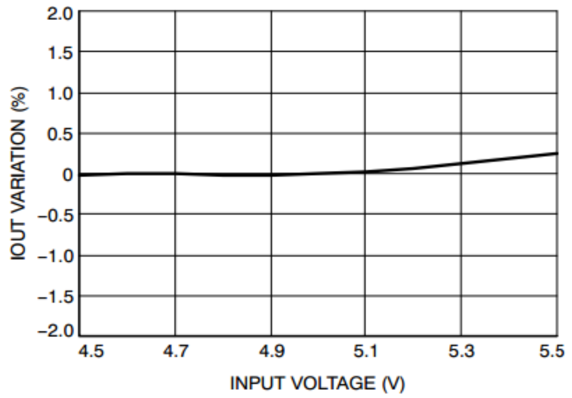


Figure 5-11 Output Current VS Input Voltage

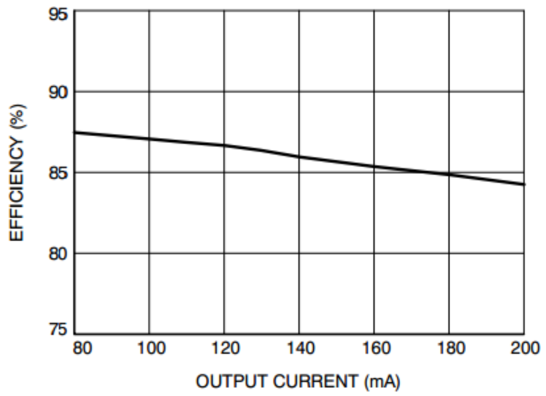


Figure 5-12 Efficiency VS Output Current

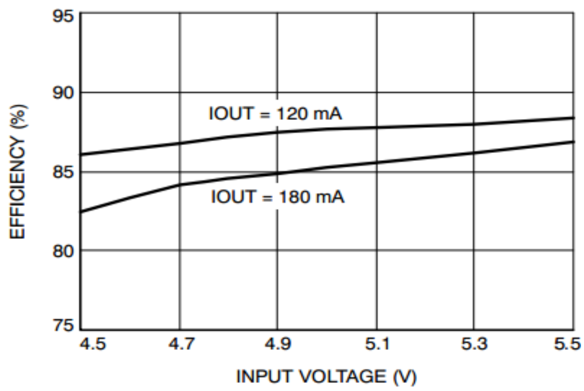


Figure 5-13 Efficiency VS Input Voltage

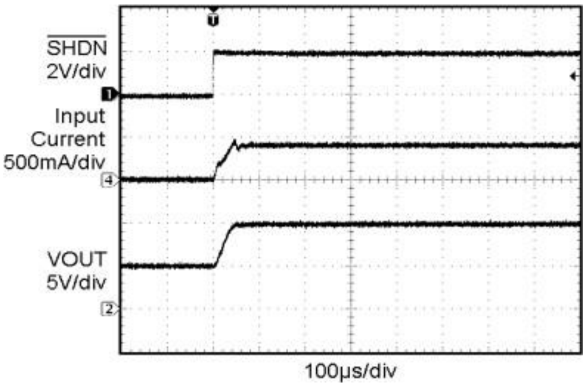


Figure 5-14 Power-on with load currents of 180mA

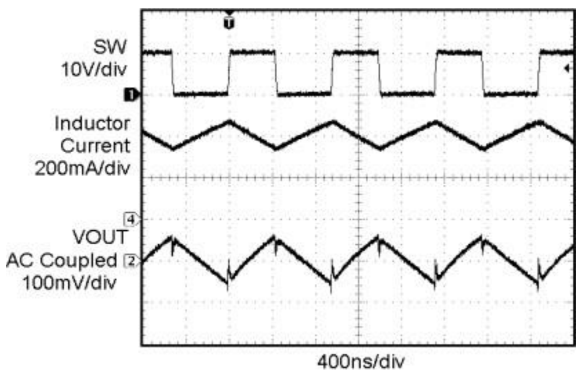


Figure 5-15 Switch Current Waves

Table 5.6 Typical Characteristics

（VIN=5.0 V, IOUT = 180 mA, TAMB = 25℃, unless otherwise specified. Please refer to the typical application current in Figure 5-1）

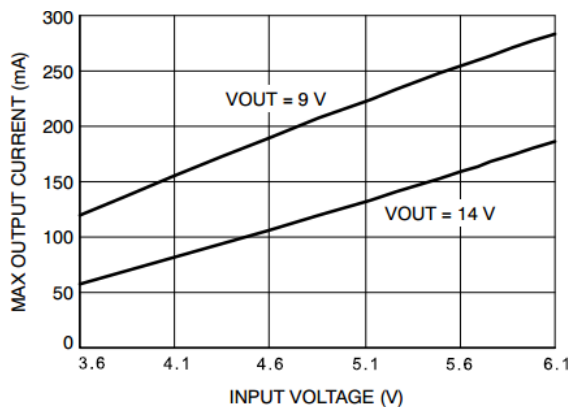


Figure 5-16 Max Output Current VS Input Voltage

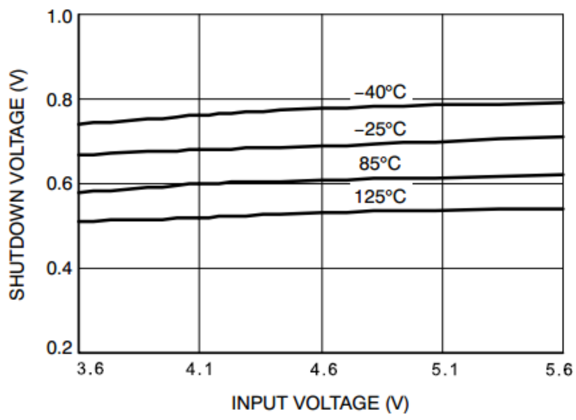


Figure 5-17 Shutdown Voltage VS Input Voltage

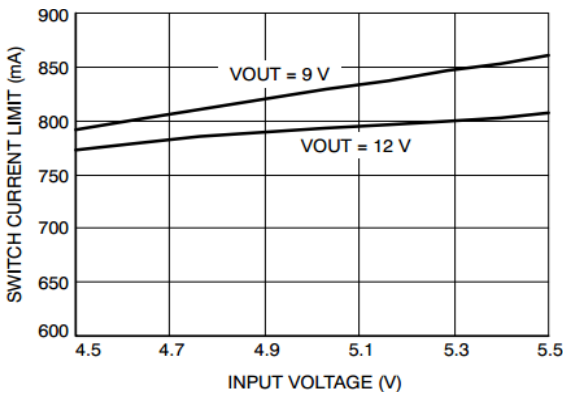


Figure 5-18 Switch Current Limit VS Input Voltage

6. Application Information

6.1 External Component Selection

6.1.1 Capacitor

The SL2733 requires a 4.7uF ceramic capacitor connected in parallel at its input end, and a 1uF one at the output. A 4.7uF input capacitor can be effective enough under normal conditions, yet more output power may require a 10uF or even larger one. So the X5R and X7R capacitors are highly recommended for its stronger stability within a particular temperature range.

6.1.2 Inductor

A 22uH inductor is preferred in the typical application circuit shown in Figure 5-1. If the circuits prioritize efficiency, an inductor with low series resistance would be the top choice. And inductors with a saturation current equal to or greater than 800mA are also advisable. It would strongly recommend using the 22uF Sumida CDRH6D28-220 inductor with 1.2A rated saturation current and 128mΩ directive current resistance (D.C.R).

6.1.3 Schottky Diode

The rated currents of a Schottky diode must outsize the peak currents flowing through it. And measuring the size of given currents that flow through the Schottky diode can specify its performance: the lower the forward voltage, the more efficient the diode. Besides, response time is equally important when the device is working at 1MHz. So it is suggested that customers use Central Semiconductor's Schottky rectifier CMSH1-40 (rated currents up to 1A).

6.1.4 LED Current Setting

The LED currents are set by the external resistor R1 connected between the feedback pin (FB) and ground. And the relationship between resistor and current is shown below in Formula 6.1:

$$R1 = \frac{0.3V}{LED\_current} \tag{6.1}$$

Table 6.1 R1 VS LED Current

LED Current (mA)	R1(Ω)
20	15
25	12
30	10
100	3
300	1

6.1.5 Open-circuit Protection

If an open circuit failure occurs in one of the LEDs, the SL2733 would bring the output voltage up to its maximum level of roughly 37V, above which the internal protection circuits would immediately turn the device into the low-power mode. And the total input power would be limited at some 6 mW (the input voltage of approximately 3.6V and input current1 6V). As the SW pin has a maximum clamp voltage of 37V, it is not necessary to place a Zener diode between the VOUT and FB pin, but a capacitor with voltage resistance greater than 37V is instead required to avoid overvoltage damage to devices in the event of an open-circuit failure.

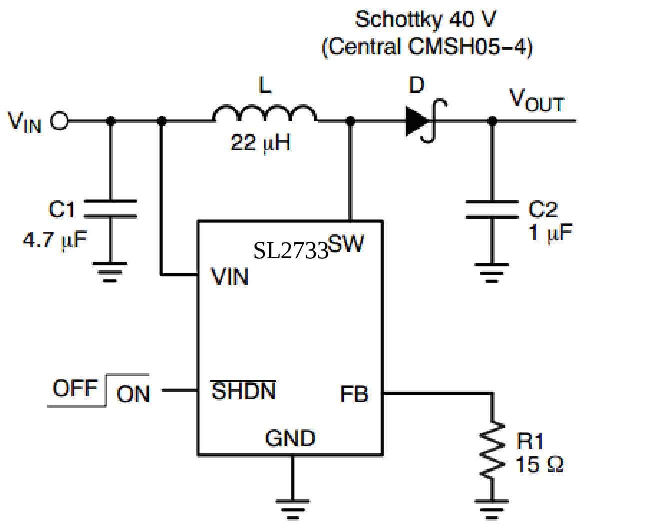


Figure 6-1 LED Open Circuit Protection Circuit

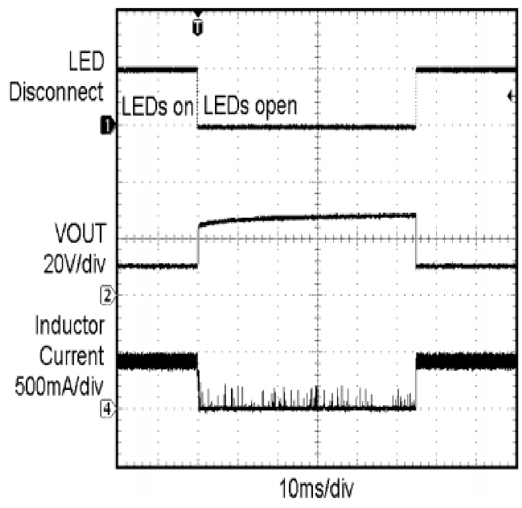


Figure 6-2 Cut-off and Reconnect

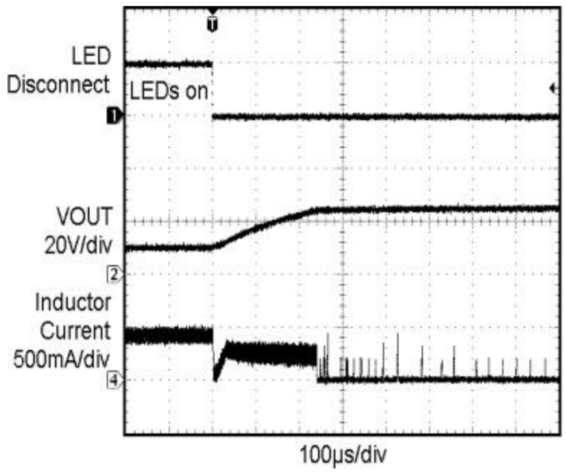


Figure 6-3 LED Switch-off

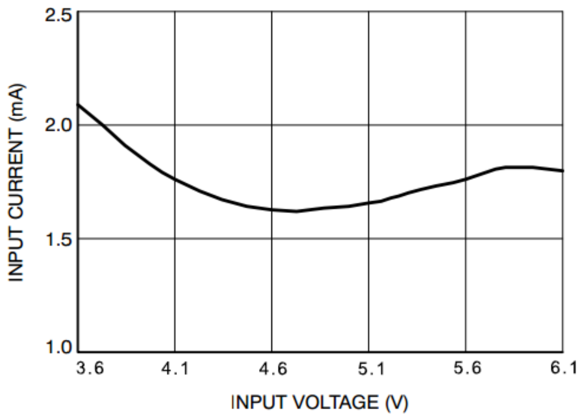


Figure 6-4 Supply Current at an Open Circuit of LED

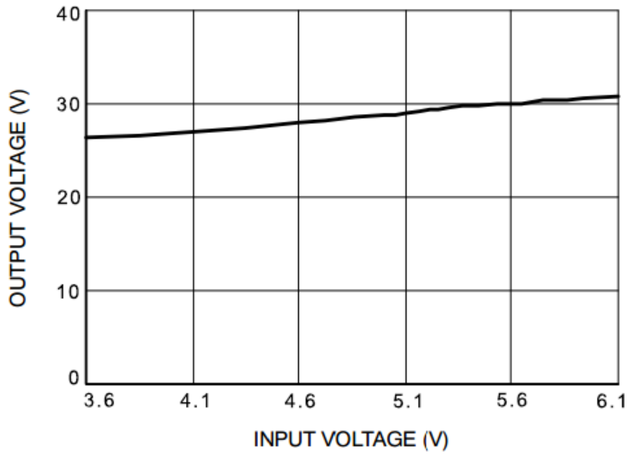


Figure 6-5 Output Voltage at an Open Circuit of LED

7. Brightness Control

There are several ways to control the brightness of LEDs:

7.1 Using the $\overline{\text{SHDN}}$ Pin to Generate PWM Signals

The brightness of LED can be adjusted via PWM signals from the SHDN pin. As the current switch of LEDs is repeatedly off and on, its average currents are thereby inversely related to the duty cycle. So the $\overline{\text{SHDN}}$ always stay at high levels when the duty cycle reaches 100%, with the LED current of 0.3/R1 that goes with it. Figure 7-1 shows the relationship between the waves of the PWM and the LED current, where the input waves of the $\overline{\text{SHDN}}$ pin has a frequency of 1KHz and a duty cycle of 50%.

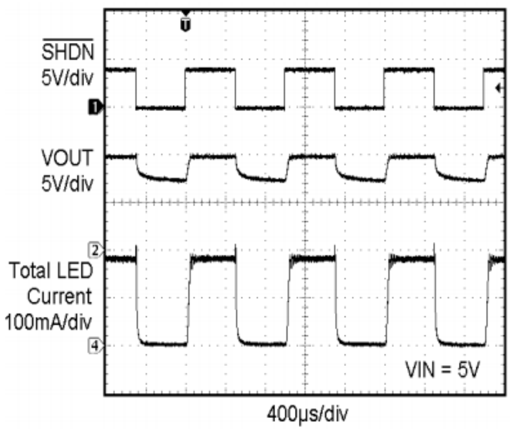


Figure 7-1 Switching waves when a 1kHz PWM signal is loaded onto the $\overline{\text{SHDN}}$ pin

7.2 PWM Signal Filtering

A filtered PWM signal can be used as a variable DC voltage to control the LED currents. Figure 7-2 suggests the connection between the PWM control circuit and the FB pin of the SL2733. It can be seen that the PWM signal ranges from 0V~ 2.5V, the LED currents from 0mA~20mA, and the frequency of PWM signal from 20kHz dramatically up to 200kHz.

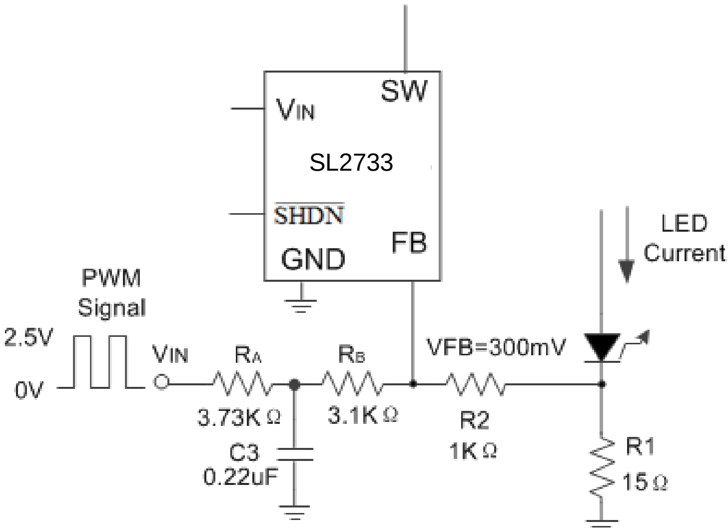


Figure 7-2 PWM Signal Filtering Circuit

When the PWM signal falls to 0V or 0% duty cycle, the maximum LED currents would reach about 22 mA; while as it has a duty cycle of 93% or greater, the currents would dive to 0 mA. And the relationship between the PWM duty cycle and the LED currents is illustrated below in Figure 7-3:

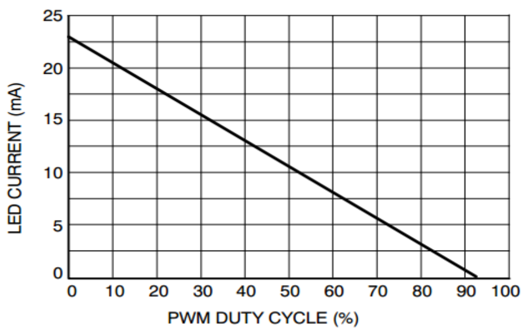


Figure 7-3 PWM Duty Cycle VS LED Current (0V to 2.5V)

8. Circuit Board

The SL2733 is a high-frequency switching regulator. So the routing of its switching currents must be exquisitely laid out on the board to minimize EMI, ripples and noise. The bolded lines in Figure 8-1 below show the routes of these high-frequency switching currents. All these routes must be as short as, as wide as possible to reduce parasitic inductance and resistance. Figure 8-1 shows a current loop when the SL2733's internal switch is off, while Figure 8-2 highlights the loop when the switch is open. And both of these loop areas should be as compact as possible.

Besides, capacitor C1 must be placed as close as possible to the VIN and GND pin; and capacitor C2 must be connected to the anode of the LED's highest potential. It is high recommended to connect capacitors directly to the ground. What's more, resistor R1 also must be straight connected to the GND pin of the SL2733.

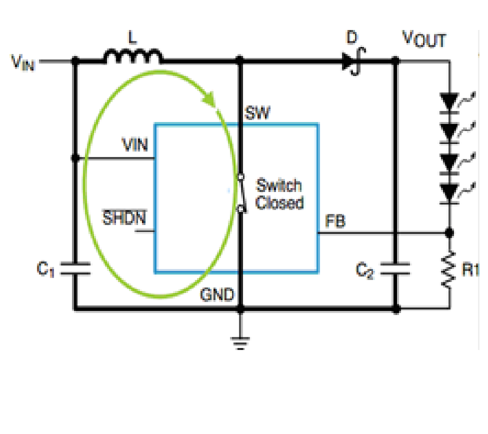


Figure 8-1 Current loop at Switch-off

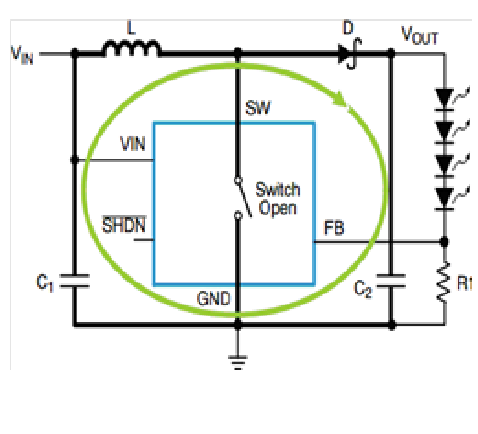


Figure 8-2 Current loop at Switch-on

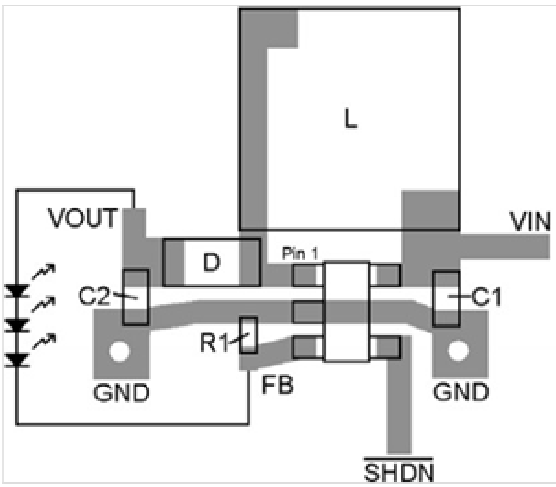
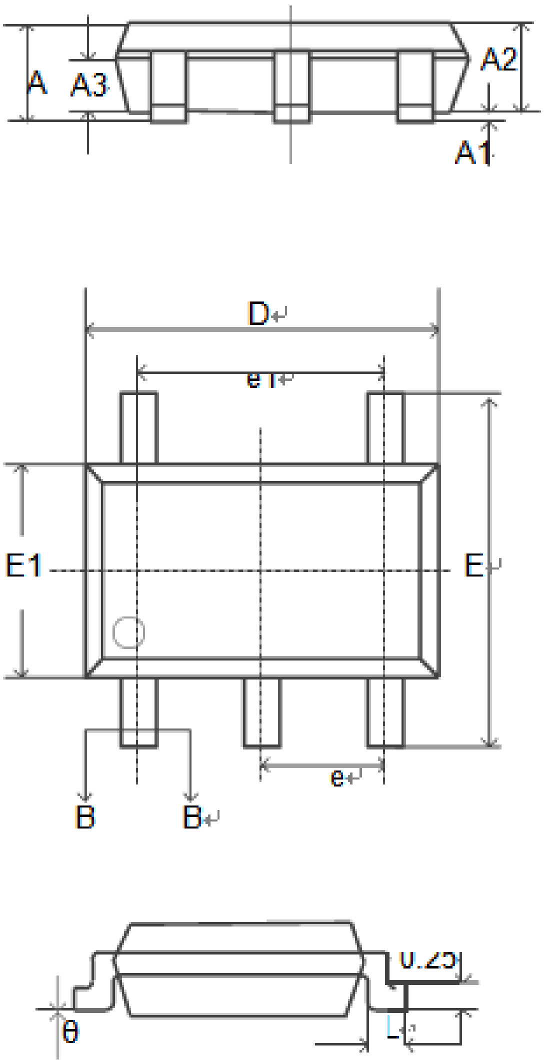


Figure 8-3 Recommended PCB Layout

9. Package Specifications



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	----	----	1.25
A1	0.04	----	0.10
A2	1.00	1.10	1.20
A3	0.55	0.65	0.75
b	0.38	-----	0.48
b1	0.37	0.40	0.43
c	0.11	-----	0.21
c1	0.10	0.13	0.16
D	2.72	2.92	3.12
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	0.95 BSC		
e1	1.90 BSC		
L	0.30	----	0.60
θ	0	----	8°

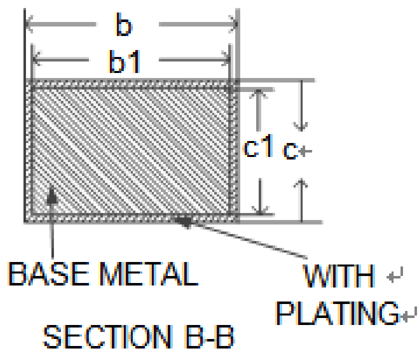


Figure 9-1 SOT23-5L Package Measurement