1.2MHz, 32V Step-Up LED Driver with 320mA Current Limit

General Description

LA8304 is a current mode, step-up DC-DC converter that is designed driving up to 6 series LEDs from a single cell Li-Ion battery. It utilizes PWM control scheme that switches with 1.2MHz fixed frequency and 320mA current limit.

The input voltage range is from 2.5V to 10V, and available in adjustable output up to 32V. It provides 104mV low feedback voltage to reduce power loss and improve efficiency. In portable applications, the LA8304 provides 0.1uA low shutdown current to extend battery life. The fast switching frequency of 1.2MHz allows using small size, low cost and low height capacitors and inductors.

The under voltage lockout function prevents low input voltage start up until the input voltage reaches the UVLO threshold voltage. Other features of dimming control, over voltage protection, and thermal shutdown protection are also included. The package is available in standard SOT-23-6.

Features

- Adjustable Output Voltage up to 32V
- Driving up to 6 Series LEDs
- 2.5V to 10V Input Voltage Range
- 320mA Switching Current Limit
- 1.2MHz Oscillation Frequency
- 104mV Reference Voltage
- Low Shutdown Current: 0.1uA
- Current Mode for Excellent Response
- PWM / Analog Dimming Control
- Under Voltage Lockout
- Optional 29V Over Voltage Protection
- Thermal shutdown Protection
- Standard SOT-23-6 Package
- Meet RoHS Standard

Applications

- Digital Still and Video Cameras
- Mobile Phone
- PDA, Handheld Computer
- PMP, MP3 Player
- GPS

Ordering Information

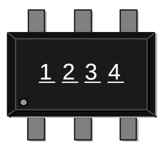
LA8304 1 2 3 4

1 (Package Type) => **C**: SOT-23
2 (Number of Pins) => **E**: 6 pin
3 (Output Voltage) => **Blank**: Adjustable
4 (Special Feature) => **Blank**: N/A

Available Part Number

LA8304CE

Marking Information

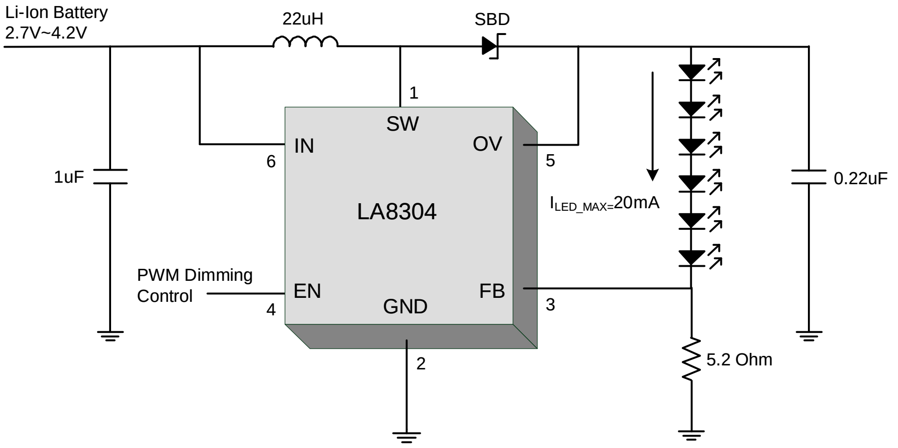


1 2 (Product Code)
LA8304CE : **LB**

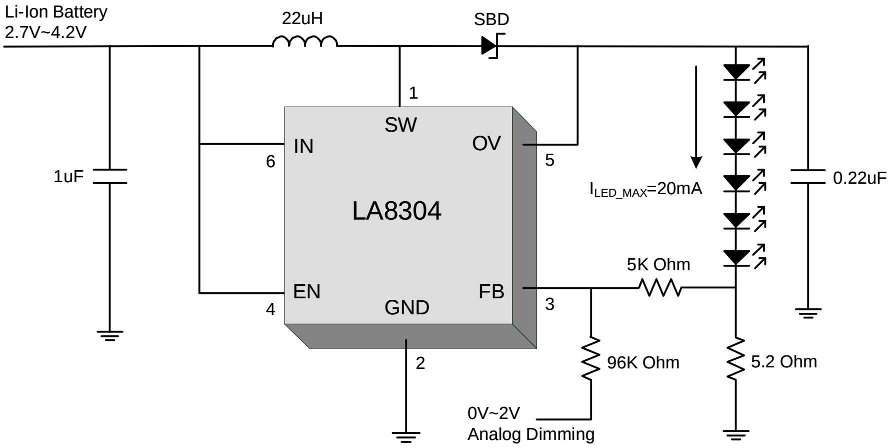
3 4 (Date Code)
For date code rule, please contact our sales representative directly.

Typical Application

Li-Ion Battery Application - For 6 Series LEDs with PWM Dimming

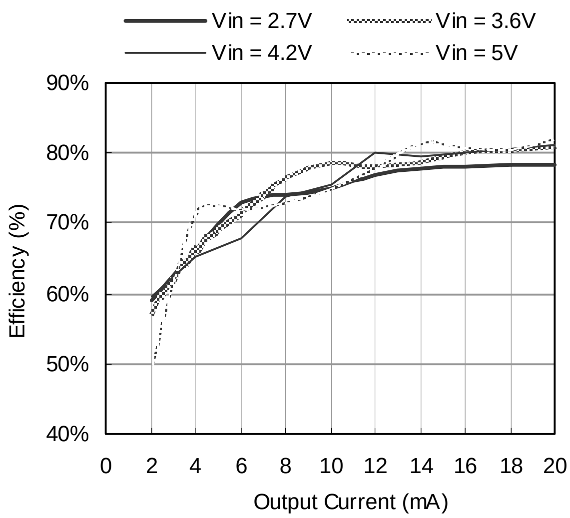


Li-Ion Battery Application - For 6 Series LEDs with Analog Dimming

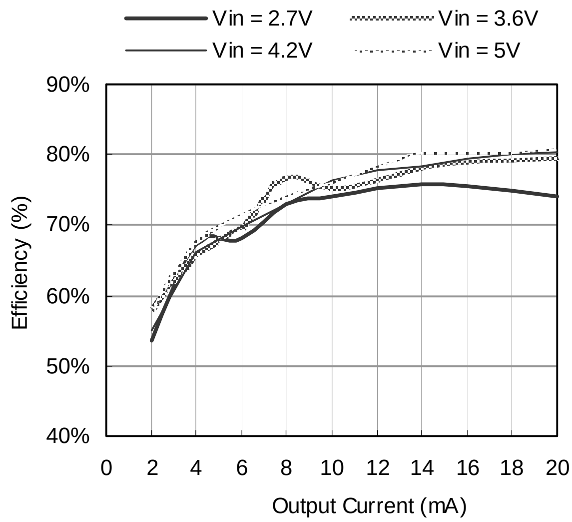


Efficiency Curve

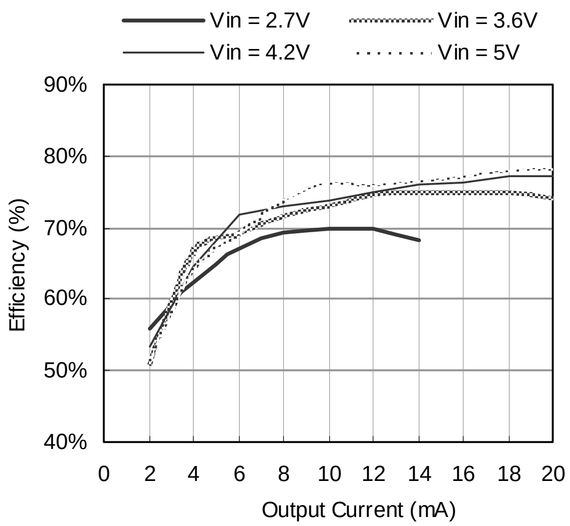
Driving 3 Series LEDs



Driving 4 Series LEDs



Driving 6 Series LEDs



Quick Design Table

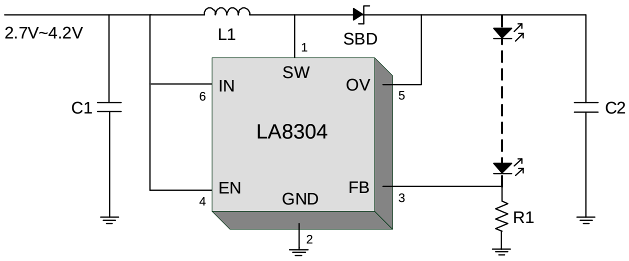
For Li-Ion Battery Application, V_{IN} = 2.7V~4.2V, continuous current mode operation.

C1: Recommended Input Capacitor

C2: Minimum Output Capacitor

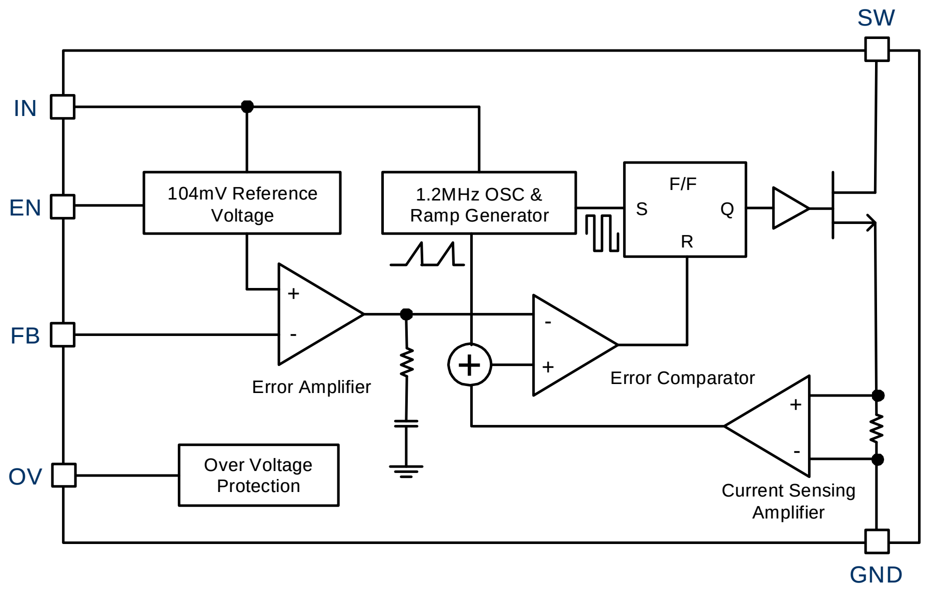
L1: Recommended Inductor

R1: Current Setting Resistor

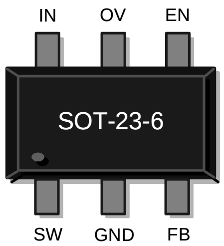


I_{LED} / LEDs	5mA	10mA	15mA	20mA
2 Series	C1 : 1uF C2 : 1uF L1 : 22uH R1 : 20.8Ohm	C1 : 1uF C2 : 2.2uF L1 : 22uH R1 : 10.4Ohm	C1 : 1uF C2 : 4.7uF L1 : 22uH R1 : 6.93Ohm	C1 : 1uF C2 : 4.7uF L1 : 22uH R1 : 5.2Ohm
3 Series	C1 : 1uF C2 : 1uF L1 : 22uH R1 : 20.8Ohm	C1 : 1uF C2 : 1uF L1 : 22uH R1 : 10.4Ohm	C1 : 1uF C2 : 2.2uF L1 : 22uH R1 : 6.93Ohm	C1 : 1uF C2 : 2.2uF L1 : 22uH R1 : 5.2Ohm
4 Series	C1 : 1uF C2 : 0.68uF L1 : 22uH R1 : 20.8Ohm	C1 : 1uF C2 : 1uF L1 : 22uH R1 : 10.4Ohm	C1 : 1uF C2 : 2.2uF L1 : 22uH R1 : 6.93Ohm	C1 : 1uF C2 : 2.2uF L1 : 22uH R1 : 5.2Ohm
5 Series	C1 : 1uF C2 : 0.22uF L1 : 22uH R1 : 20.8Ohm	C1 : 1uF C2 : 0.47uF L1 : 22uH R1 : 10.4Ohm	C1 : 1uF C2 : 0.68uF L1 : 22uH R1 : 6.93Ohm	C1 : 1uF C2 : 0.68uF L1 : 22uH R1 : 5.2Ohm
6 Series	C1 : 1uF C2 : 0.22uF L1 : 22uH R1 : 20.8Ohm	C1 : 1uF C2 : 0.22uF L1 : 22uH R1 : 10.4Ohm	C1 : 1uF C2 : 0.22uF L1 : 22uH R1 : 6.93Ohm	C1 : 1uF C2 : 0.22uF L1 : 22uH R1 : 5.2Ohm

Functional Block Diagram



Pin Configurations



Pin No.	Name	Description
1	SW	This switching pin of the converter. Connect this pin to the node between the inductor and the rectifier diode.
2	GND	The ground pin of the converter. Connect this pin to the circuit ground.
3	FB	This pin senses the feedback voltage to regulate the output voltage. Connect a voltage divider to set the output voltage. For LED applications, connect a resistor (R_{FB}) to set LED current by the following formula: I_{LED}=104mV/R_{FB}
4	EN	This pin allows an external logic control signal to turn-on/off this device. Drive this pin to low level to turn-off this device, drive it to high level to turn-on this device. Do not leave EN floating.
5	OV	The over voltage input pin. Connect this pin to output to trigger the over voltage protection and prevent the output over 29V. Leave OV floating to disable this function.
6	IN	The input pin of the converter. Connect a capacitor from this pin to ground to bypass noise on the input of this device.

Absolute Maximum Ratings

Parameter	Rating
Input Voltage	10V
SW, OV Pin Voltage Range	-0.3V ~ 34V
FB Pin Voltage Range	-0.3V ~ 10V
EN Pin Voltage Range	-0.3V ~ 10V
Storage Temperature Range	-65°C ~ 150°C
Junction Temperature	150 °C
Lead Soldering Temperature (10 sec)	300 °C

These are stress ratings only and functional operation is not implied. Exposure to absolute maximum ratings for prolonged time periods may affect device reliability. All voltages are with respect to ground.

Recommended Operating Conditions

Parameter	Rating
Input Voltage Range	2.5V ~ 10V
Ambient Temperature Range	-40°C ~ 85°C
Junction Temperature Range	-40°C ~ 125°C

These are conditions under which the device functions but the specifications might not be guaranteed. For guaranteed specifications and test conditions, please see the ***Electrical Specifications***.

Package Information

Parameter	Package	Symbol	Rating
Thermal Resistance (Junction to Case)	SOT-23-6	θ_{JC}	110 °C/W
Thermal Resistance (Junction to Ambient)		θ_{JA}	220 °C/W

Electrical Specifications

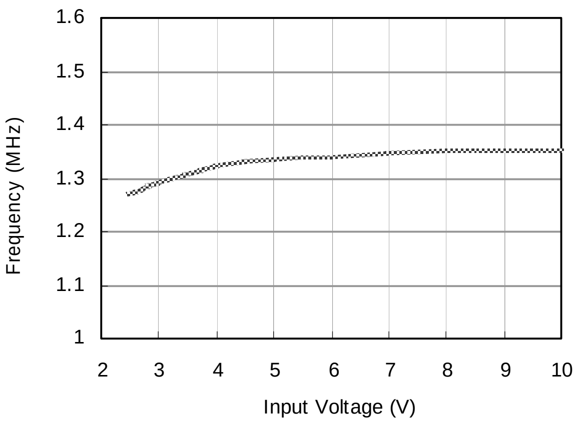
V_{IN}= V_{EN}=3.6V, T_A=25ºC, unless otherwise noted.

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Units
Feedback Voltage	V_{FB}		94	104	114	mV
Efficiency	η	Drive 3 series LEDs, I_{LED}=20mA		82		%
Oscillation Frequency	F_{OSC}		0.9	1.2	1.5	MHz
Maximum Duty Cycle	DC_{MAX}	V_{FB}=0V	85	90		%
Switch Saturation Voltage	V_{SAT}	I_{SW}=250mA		350		mV
Current Limit	I_{LIM}	Duty Cycle = 60%		320		mA
Supply Current	I_{IN}	V_{FB}=0.15V		2	2.6	mA
Shutdown Current	I_S	V_{EN}=0V		0.1	1	uA
EN Pin Input Threshold Voltage	V_{EN}	Regulator OFF		0.7	0.5	V
		Regulator ON	1			
EN Pin Bias Current	I_{EN}	Regulator OFF			1	uA
		Regulator ON			100	
Switch Leakage Current	I_{SL}	V_{SW}=5V, V_{EN}=0V		0.01	5	uA
FB Pin Bias Current	I_{FB}		0.01	0.045	1	uA
Under Voltage Lockout	UVLO	V_{IN} Rising		2.1		V
Under Voltage Lockout Hysteresis	$UVLO_{HYS}$			20		mV
Over Voltage Protection Threshold	V_{OV}	V_{OV} Rising		29		V
Line Regulation	$\triangle V_{LINE}$	V_{IN}=2.7V~4.2V Drive 3 series LEDs, I_{LED} =20mA		1		%/V
Load Regulation	$\triangle V_{LOAD}$	Drive 3 series LEDs I_{LED} = 1mA~20mA		0.1		%/mA
Over Temperature Shutdown	T_{SD}			145		ºC
Over Temperature Shutdown Hysteresis	T_{HYS}			10		ºC

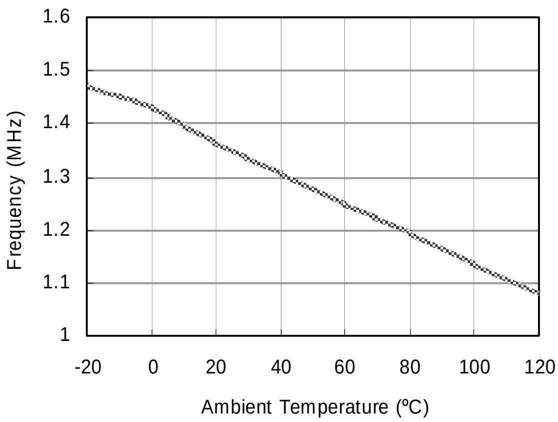
Typical Performance Characteristics

V_{IN}=3.6V, T_A=25ºC, unless otherwise noted.

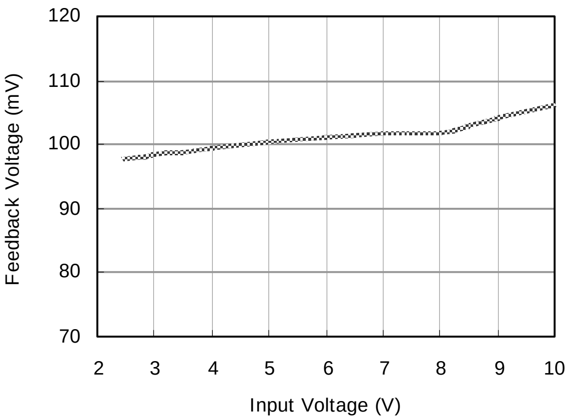
Frequency vs. Input Voltage



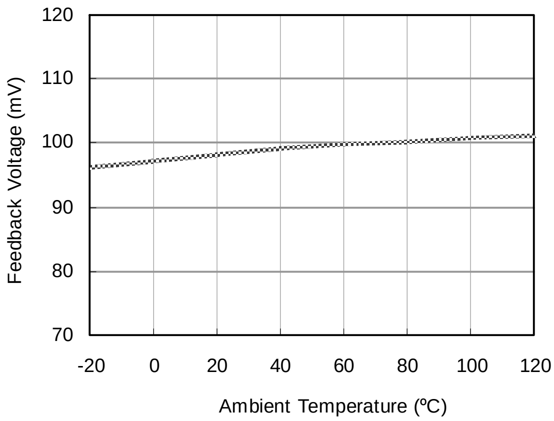
Frequency vs. Temperature



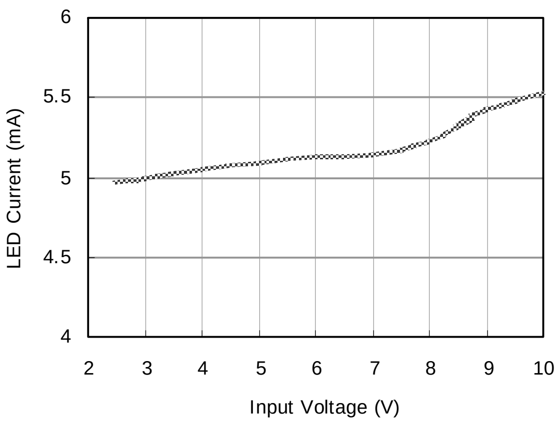
Feedback Voltage vs. Input Voltage



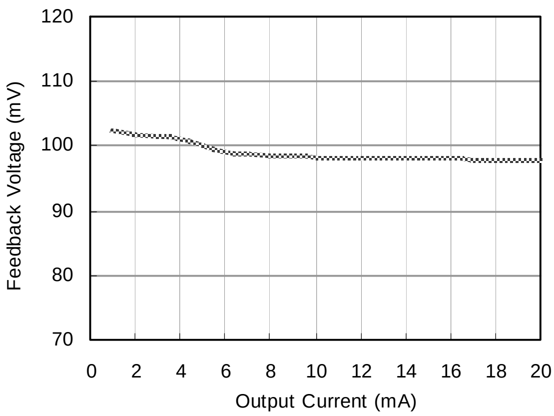
Feedback Voltage vs. Temperature



Line Regulation

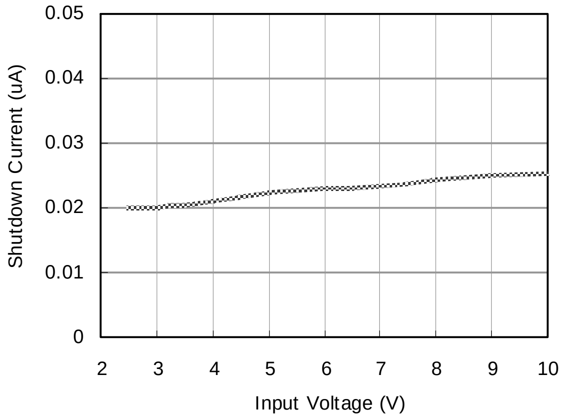


Load Regulation

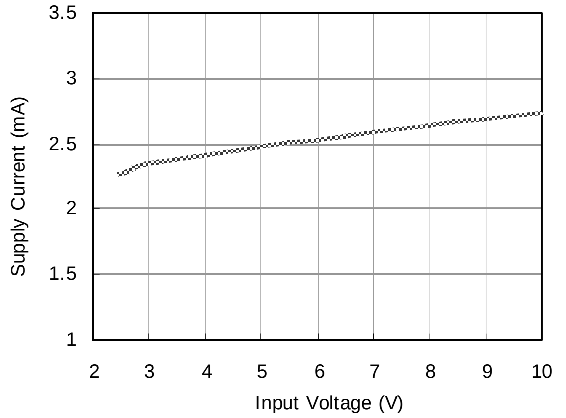


Typical Performance Characteristics (Contd.)

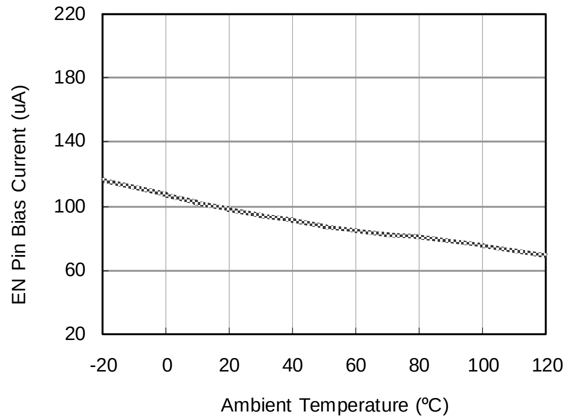
Shutdown Current vs. Input Voltage



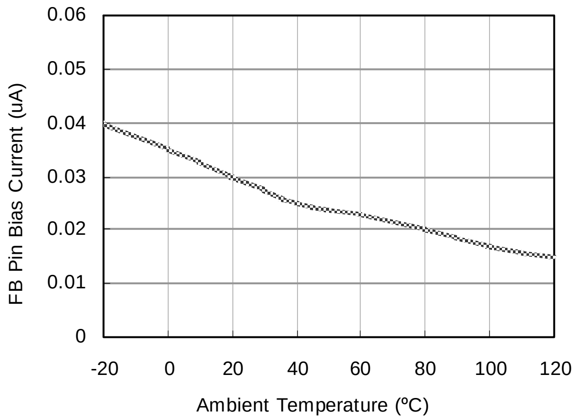
Supply Current vs. Input Voltage



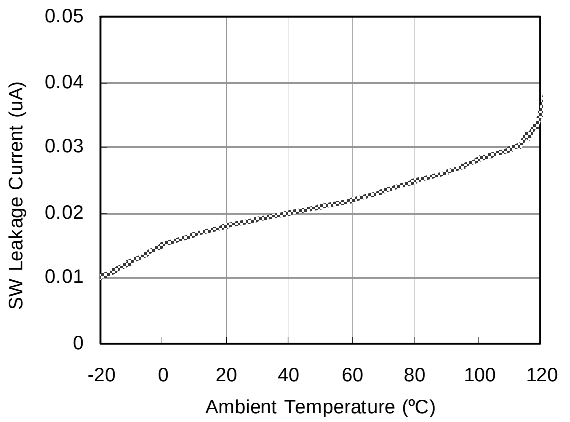
EN Bias Current vs. Temperature



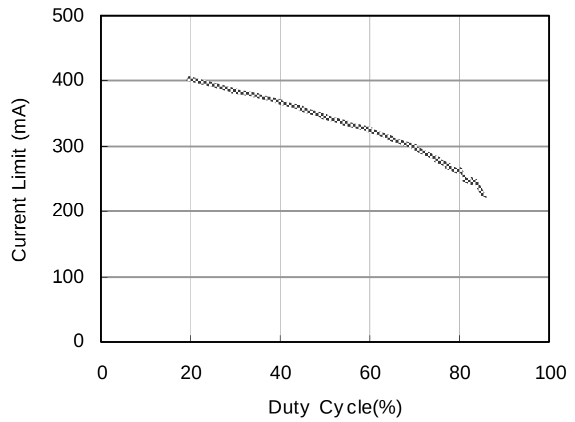
FB Bias Current vs. Temperature



SW Leakage Current vs. Temperature



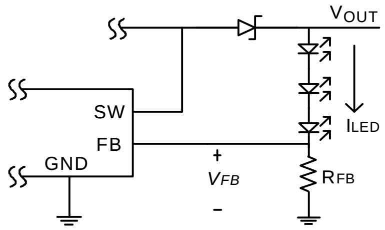
Current Limit vs. Duty Cycle



Application Information

LED Current Setting

This device is a constant current boost regulator that develops 104mV reference voltage between FB and GND. Use 1% chip resistor to set the LED current and attain the better current accuracy. The LED current can be calculated by the following formula:



$I_{LED} = V_{FB} / R_{FB}$; where V_{FB} = 104mV

Under Voltage Lockout

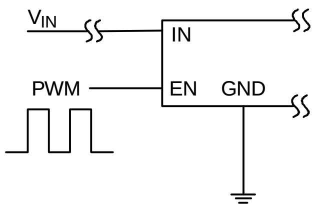
The under voltage lockout prevents this device from turning on the internal power switch at lower input voltage. It avoids wrong operation under undefined conditions. The under voltage lockout threshold is approximately 2.1V. When the input voltage drop under the threshold voltage, this device will be disabled and auto recovery once the input voltage rise above it.

Dimming Control

- PWM Dimming

Connect an external PWM signal at EN pin to turn on or off this device. It is a simple method of brightness control for LED. A 0% duty cycle will turn off this device and corresponds to zero the LED current. A 100% duty cycle corresponds to full current. The variation of the average LED current is proportionally with the PWM duty cycle.

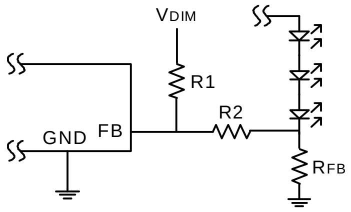
The minimum PWM frequency must higher than 100Hz, and the typical value is 1KHz. The following circuit is PWM dimming control from EN pin.



- Analog Dimming

The analog dimming control using a DC voltage (V_{DIM}) is shown in the following circuit. As the V_{DIM} increases, the voltage drop on R2 increases. Thus the LED current decreases. The R1 and R2 must make the DC source current much larger than the FB bias current and much smaller than the LED current. The LED current can be calculated by the following formula:

$$I_{LED} = \frac{V_{FB} \times (R1 + R2) - V_{DIM} \times R2}{R1 \times R_{FB}}$$



If the V_{DIM} is taken below the V_{FB}, the inverse will happen and the brightness will increase.
The analog dimming circuit can be tailored for different resistor value using the following formula:

$$R1 = \frac{(V_{DIM\_MAX} - V_{FB}) \times R2}{V_{FB} \times (1 - \frac{I_{LED\_DIMMED\_MIN}}{I_{LED\_UNDIMMED}})}$$

Example:

V_{DIM_MAX} = 2V

$I_{LED\_DIMMED\_MIN}$ = 1mA ; V_{DIM}=2V

$I_{LED\_UNDIMMED}$ = 20mA ; V_{DIM}=V_{FB}=0.104V

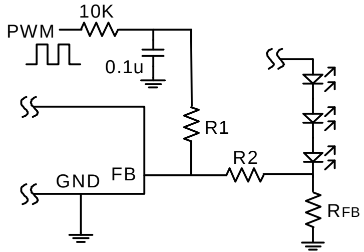
R2 = 5KOhm → R1 = 96KOhm

The analog dimming circuit can be tailored for different dimming voltage range using the following formula:

$$V_{DIM} = V_{FB} \times \frac{R1}{R2} \times (1 + \frac{R2}{R1} - \frac{I_{LED\_DIMMED\_MIN}}{I_{LED\_UNDIMMED}})$$

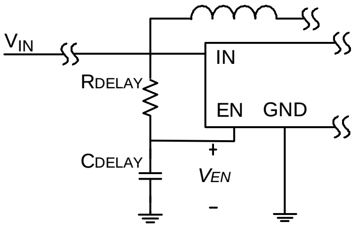
- Filtered PWM Dimming from FB

Filtered PWM circuit can be used to replace the DC voltage source in dimming control. The circuit is shown in the following figure that is suitable for the soft-start function is used, and the PWM frequency of the brightness control is too high to result in the device without fully turns on or off.



Delay Start-up

The following circuit uses the EN pin to provide a time delay between the input voltage is applied and the output voltage comes up. As the instant of the input voltage rises, the charging of capacitor C_{DELAY} pulls the EN pin low, keeping the device off. Once the capacitor voltage rises above the EN pin threshold voltage, the device will start to operate.

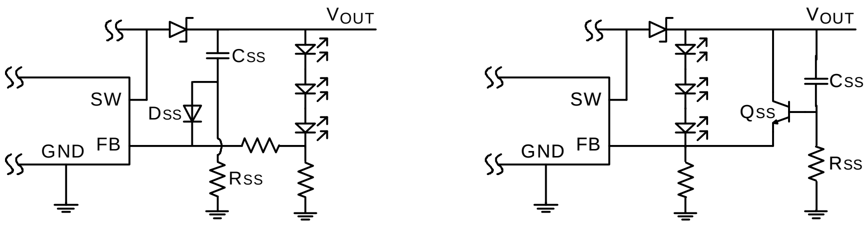


$$V_{IN} \times (1 - e^{-T/(R \times C)}) > V_{EN}$$

Where T is the start-up delay time, R is R_{DELAY}, C is C_{DELAY}, and the typical V_{EN} is 0.7V.
This feature is useful in situations where the input power source is limited in the amount of current it can deliver. It allows the input voltage to rise to a higher voltage before the device starts operating.

Soft-Start

In some application, the large start-up current or overshooting voltage maybe causes problems. The major problem occurs when the input power source to the regulator is current-limited or has poor load regulation. Both of which will cause input voltage to drop during start-up.
The following circuits are the recommended soft-start circuits those are formed by R_{SS}, C_{SS} and D_{SS} (or Q_{SS}). They prevent excessive input inrush current and output overshooting voltage during start-up. If both dimming control and soft-start are used, use a lower frequency PWM signal or implement dimming through the FB pin are recommended.



Layout Considerations

PC board layout is very important, especially for higher frequency switching regulators. A good layout minimizes EMI on the feedback path and provides best efficiency.
The following layout guides should be used to ensure proper operation of this device.

(1) Minimize the copper area and length of all trace connected to SW.
(2) The feedback path should be close to FB and keep noisy traces away; also keep them separate using grounded copper.

(3) The ground of the feedback resistor should be connect to GND directly to ensure a clean connection

(4) The (-) plate of the output capacitor should be close to GND.

(5) Keep the (-) plates of input and output capacitors as close as possible.

Component Selection

Inductor Selection

The 1.2MHz high switching frequency minimizes the inductance. Use a low DCR surface mount inductor to reduce the board size and improve the efficiency. A 22uH inductor is recommended for most applications.

Capacitors Selection

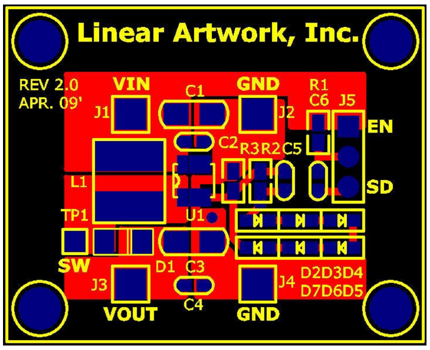
The small size, low ESR multi layer ceramic capacitors are ideal for most applications. X7R and X5R types are recommended because the stable capacitance and temperature coefficient.

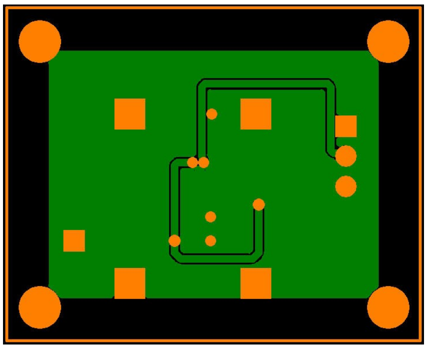
The input capacitor is required to supply current to the regulator and maintain the DC input voltage. A 1uF low ESR capacitor is preferred to provide the better performance and the less ripple voltage. The suitable value of output capacitor is 0.22uF~4.7uF or more.

Rectifier Diode Selection

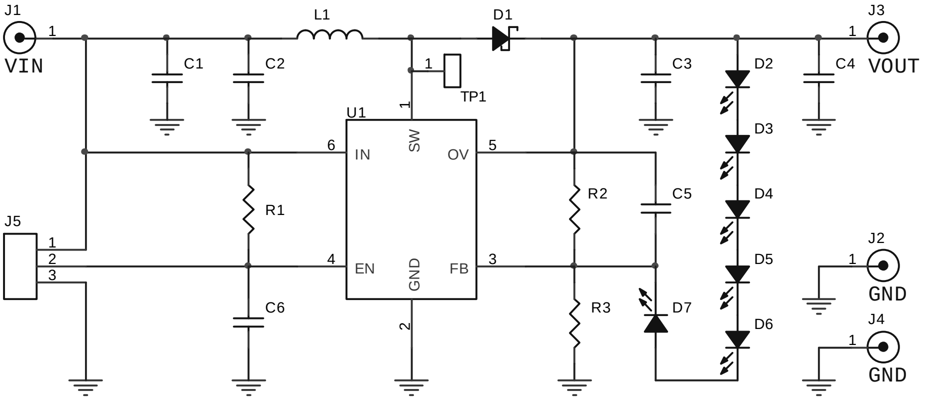
The rectifier diode provides a current path for the inductor current when the internal power switch turns off. The best solution is Schottky diode because its low forward voltage will reduce the conduction loss, and the fast recovery time (or low diode capacitance) will reduce the switch loss. Choose a Schottky diode with 100mA ~ 200mA current rating is sufficient for most application.

Evaluation Board Layout





Evaluation Board Schematic



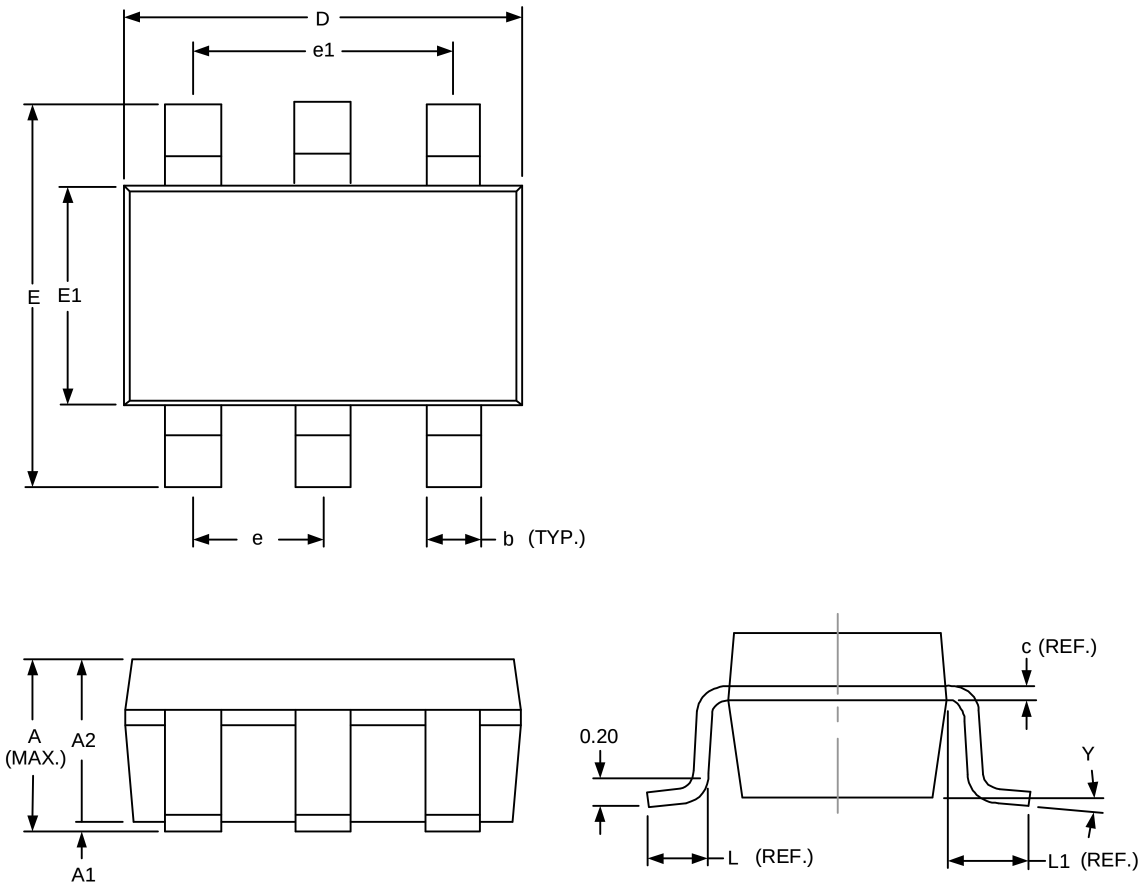
Bill of Materials

V_{IN}=2.7~4.2V, for 6 series LEDs application, I_{LED}=20mA

Designation	*Descriptions*	*Manufacturer Part #*	*Manufacturer*	*Manufacturer Website*
U1	1.2M, 32V Step-Up LED Driver, SOT-23-6 Package	LA8304CE	Linear Artwork	www.linear-artwork.com
L1	Surface Mount Inductor 22uH, 420mA, 84mOhm, 3.0*3.0*1.2mm	NR3012T220M	Taiyo Yuden	www.yuden.co.jp
D1	Schottky Diode 30V, 0.5A, 0.47V_F, SOD-323	RB551V-30	Tiptek	www.tip-tek.com.tw
C1	MLCC 1uF, 0805, X7R, 25V	TMK212BJ105KD-T	Taiyo Yuden	www.yuden.co.jp
C3	MLCC 0.22uF, 0805, X7R, 50V	UMK212BJ224KG-T	Taiyo Yuden	www.yuden.co.jp
C2,C4	MLCC 0.1uF, 0603, B, 50V	C1608JB1H104K	TDK	www.tdk.com
R1,R2,C5,C6	No Connection			
R3	Chip Resistor, 5.2Ohm, 0805, ±1%	RC0805FR-075R2L	Yageo	www.yageo.com
D2~D7	0603 Package Chip LED			
J5	Male Header 180° 3*1P 2.54mm			
J1,J2,J3,J4	Terminal Binding Post 1.6mm			
TP1	Male Header 180° 1P 2.54mm			

Package Outline

SOT-23-6



DIMENSIONS					
REF.	Millimeter		REF.	Millimter	
	Min.	Max.		Min.	Max.
A	1.45 MAX.		L	0.37 REF.	
A1	0	0.10	L1	0.60 REF.	
A2	1.10	1.30	Y	0°	10°
c	0.12 REF.		b	0.30	0.50
D	2.70	3.10	e	0.95 REF.	
E	2.60	3.00	e1	1.90 REF.	
E1	1.40	1.80			

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LIFE SUPPORT POLICY

Linear Artwork products are not designed or authorized for use as critical components in life support devices or systems without the express written approval of the president of Linear Artwork, Inc. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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