General Description

The GA8304 is a current mode, step-up DC-DC converter that is designed driving up to 6 series WLEDs 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 of GA8304 is from 2.5V to 10V. It provides a low feedback voltage 104mV to reduce power loss and improve efficiency, and allows adjustable output voltage up to 32V for customers in application.

The GA8304 provides excellent regulation during line or load transient due to the current mode operation. Other features of thermal protection and over voltage protection are also included. The under voltage lockout function prevents low input voltage start up until the input voltage reaches the UVLO threshold voltage. Due to the low saturation voltage of the internal power transistor, the GA8304 provides a high efficiency step-up application.

In portable applications, the GA8304 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. This device also provides analog dimming and PWM dimming control for WLED application.

The package is available in a small 6-lead SOT-23 package.

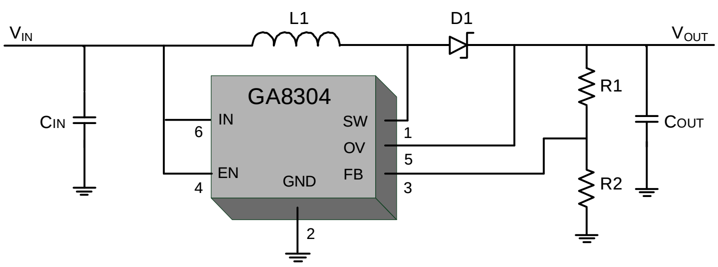
Features

- Adjustable Output Voltage up to 32V
- Operating Input Voltage from 2.5V to 10V
- Switching Current Limit: 320mA
- Drives up to 6 Series WLEDs
- Oscillation Frequency: 1.2MHz
- Low Shutdown Current: 0.1uA
- External ON/OFF Control Function
- Under Voltage Lockout
- Optional 29V Over Voltage Protection
- Thermal Protection
- Tiny SOT-23-6L Package
- All Products meet Rohs Standard

Applications

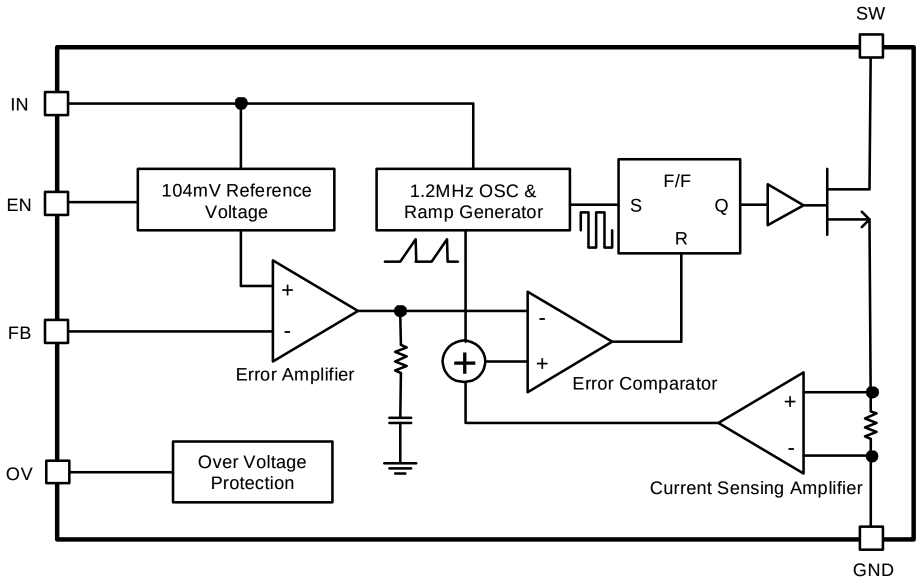
- Mobile Phone
- Digital Still Camera
- PDA, Handheld Computer
- PMP, MP3 Player
- GPS

Typical Application

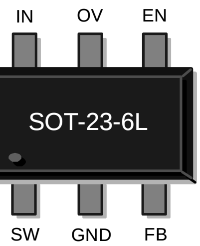


* $V_{OUT} = V_{FB} \times (1 + R1 / R2)$

Functional Block Diagram

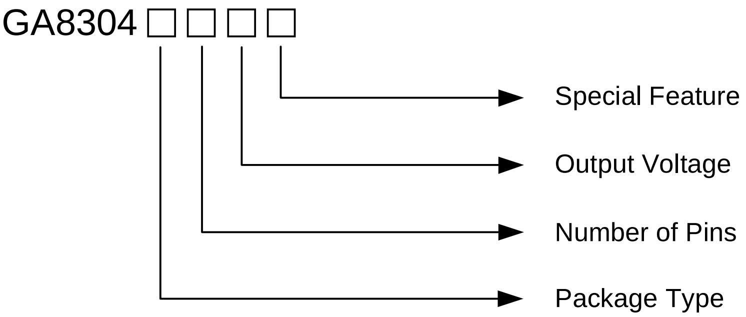


Pin Configurations



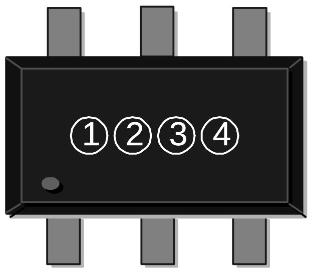
Pin No.	Name	Description
1	SW	This pin is the switching node of the converter. Connect an inductor from this pin to the input, and a rectifier diode to the output.
2	GND	The ground pin of the converter. Connect this pin to the circuit ground.
3	FB	This pin senses the feedback voltage to regulate the output voltage. Connect this pin to a resistor divider to set the output voltage. For WLED application, connect a resistor (R_{FB}) to set WLED 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 the output to trigger the over voltage protection if the output voltage reaches 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.

Ordering Information



Package Type	Number of Pins	Output Voltage	Special Feature
C: SOT-23	E: 6 pin	ADJ: Adjustable version	Blank: Original

Marking Information



①② - ***Product Code***

Part Number	Output Voltage	Package Type	Product Code
GA8304CEADJ	ADJ	SOT-23-6L	LB

③④ - ***Date Code***

Year / Month	xxx0	xxx1	xxx2	xxx3	xxx4	xxx5	xxx6	xxx7	xxx8	xxx9
01	01	11	21	31	41	51	61	71	81	91
02	02	12	22	32	42	52	62	72	82	92
03	03	13	23	33	43	53	63	73	83	93
04	04	14	24	34	44	54	64	74	84	94
05	05	15	25	35	45	55	65	75	85	95
06	06	16	26	36	46	56	66	76	86	96
07	07	17	27	37	47	57	67	77	87	97
08	08	18	28	38	48	58	68	78	88	98
09	09	19	29	39	49	59	69	79	89	99
10	0O	1O	2O	3O	4O	5O	6O	7O	8O	9O
11	0N	1N	2N	3N	4N	5N	6N	7N	8N	9N
12	0D	1D	2D	3D	4D	5D	6D	7D	8D	9D

v Absolute Maximum Ratings

Parameter	Rating
Input Voltage	10V
SW, OV Pin Voltage Range	-0.3V ~ 34V
FB, EN Pin Voltage Range	-0.3V ~ 10V
Storage Temperature Range	- 65°C ~ 165°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.

v Recommended Operating Conditions

Parameter	Rating
Input Voltage Range	2.5V ~ 10V
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*.

v Package Information

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

v Electrical Specifications

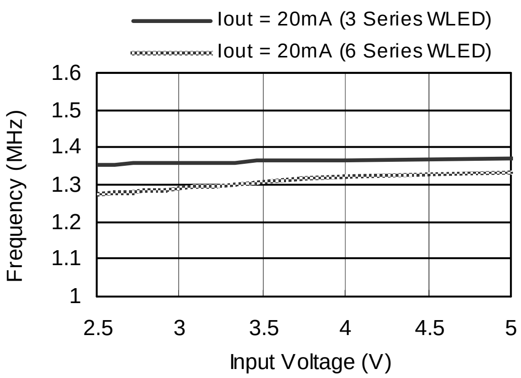
V_{IN}=V_{EN}=3.6V, T_A=25ºC, unless otherwise noted.

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Feedback Voltage	V_{FB}		94	104	114	mV
Efficiency	η	Drive 3 series WLED, I_{LED}=20mA		82		%
Oscillation Frequency	F_{OSC}		0.9	1.2	1.5	MHz
Maximum Duty Cycle	DC_{MAX}	FB pin = GND	85	90		%
Switch Saturation Voltage	V_{SAT}	I_{SW} = 250mA		350		mV
Switch Leakage Current	I_{SL}	V_{SW} = 5V, EN pin = GND		0.01	5	uA
Current Limit	I_{LIM}	Duty Cycle = 60%		320		mA
Quiescent Current	I_Q	V_{FB} = 0.15V, not switching		2	2.6	mA
Shutdown Current	I_S	EN pin = GND		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	
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
FB Pin Line Regulation	$\triangle V_{LINE}$	V_{IN} = 2.7V~4.2V, drive 3 series WLED I_{LED} = 20mA		1		%/V
FB Pin Load Regulation	$\triangle V_{LOAD}$	Drive 3 series WLED, I_{LED} = 1mA~20mA		0.1		%/mA
Over Voltage Protection Threshold	V_{OV}	V_{OV} Rising		29		V
Over Temperature Shutdown	T_{SD}			145		^{o}C
Over Temperature Shutdown Hysteresis	T_{HYS}			10		^{o}C

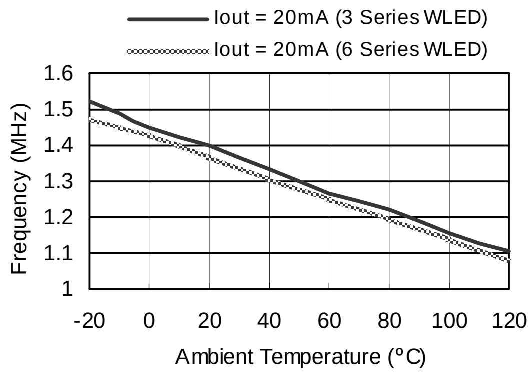
v Typical Performance Characteristics

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

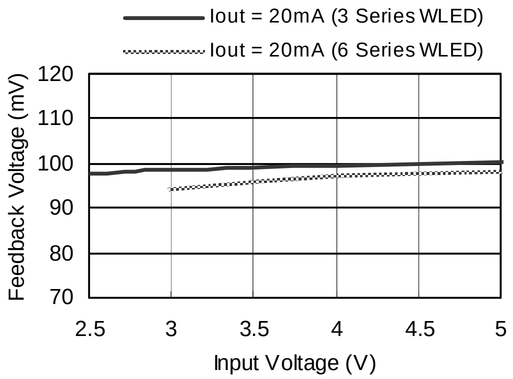
Frequency vs. Input Voltage



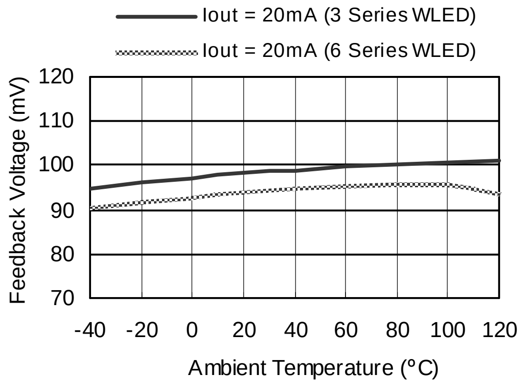
Frequency vs. Temperature



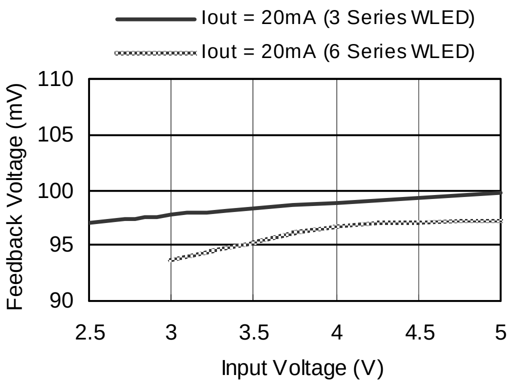
Feedback Voltage vs. Input Voltage



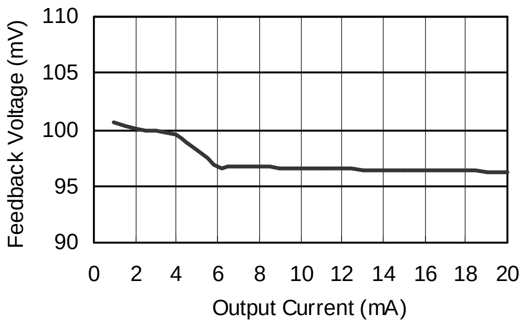
Feedback Voltage vs. Temperature



Line Regulation

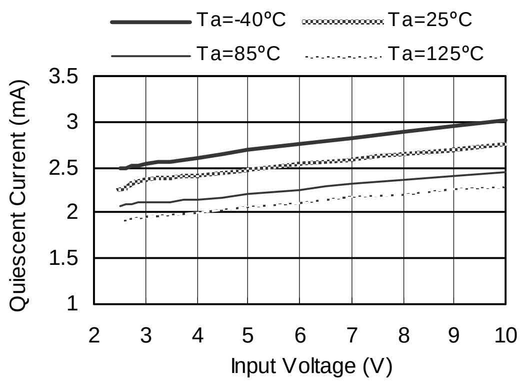


Load Regulation

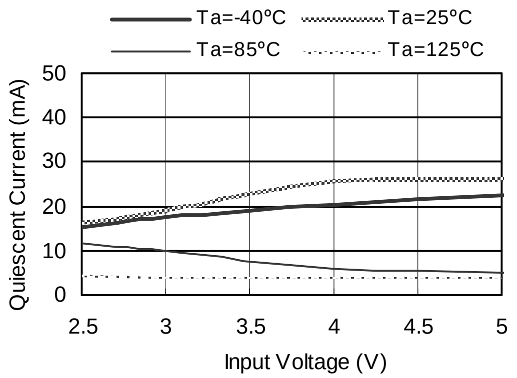


v Typical Performance Characteristics (Contd.)

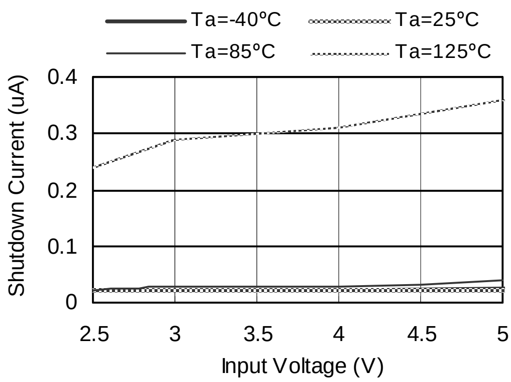
Quiescent Current vs. Input Voltage
V_{FB}>$V_{FB\ (normal)}$, not switching



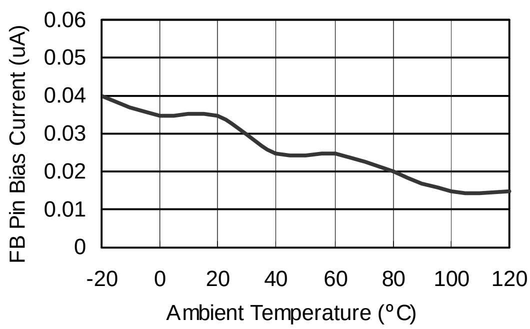
Quiescent Current vs. Input Voltage
V_{FB}<$V_{FB\ (normal)}$, switching



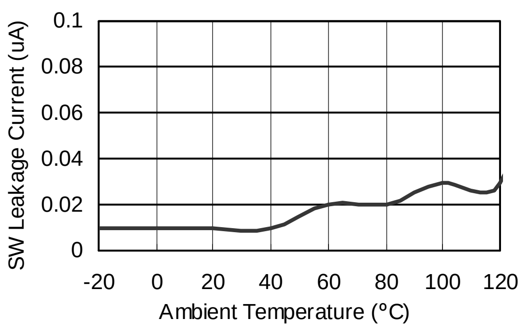
Shutdown Current vs. Input Voltage



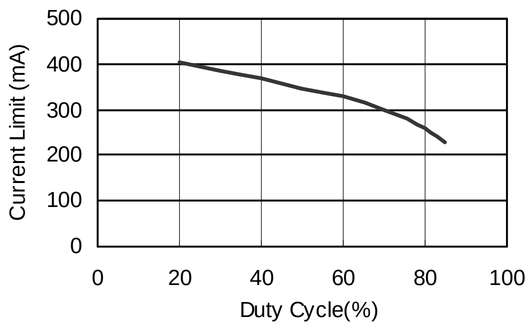
FB Pin Bias Current vs. Input Voltage



Switch Leakage Current vs. Temperature

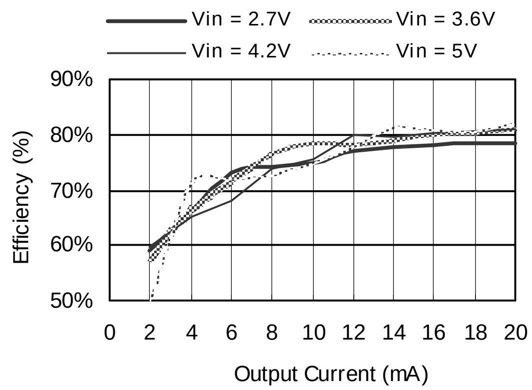


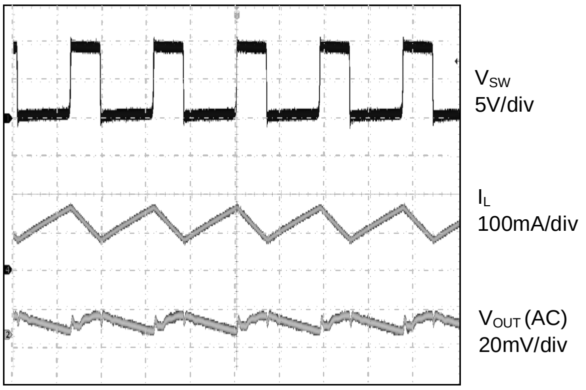
Current Limit vs. Duty Cycle



v Typical Performance Characteristics (Contd.)

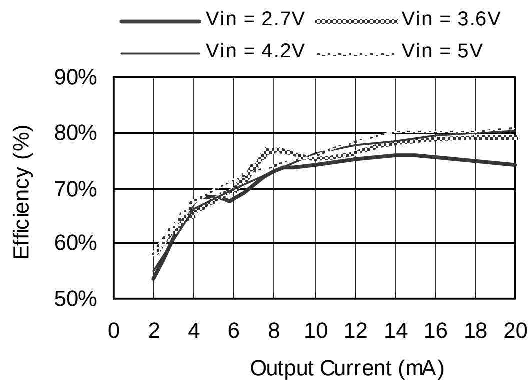
Efficiency for 3 Series WLED

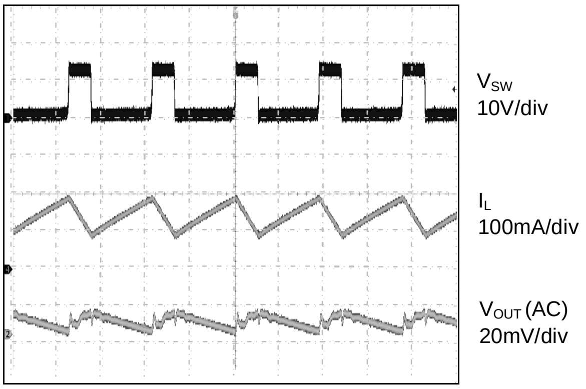




Time Base: 400ns/div

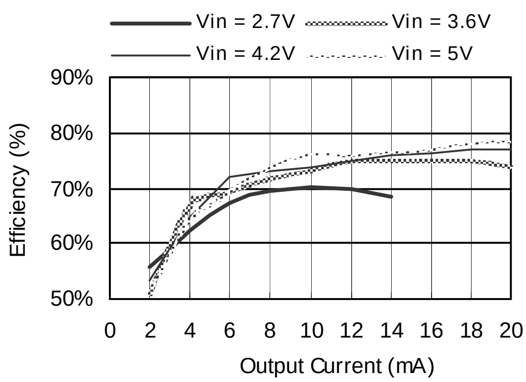
Efficiency for 4 Series WLED

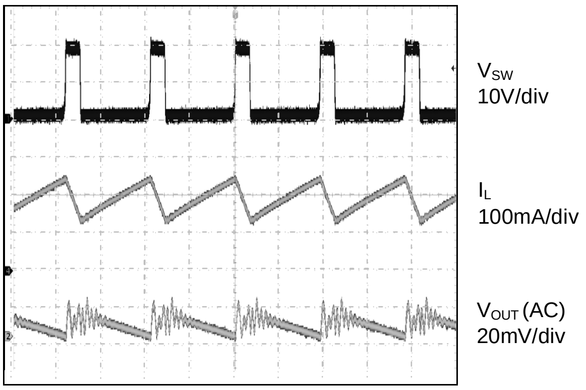




Time Base: 400ns/div

Efficiency for 6 Series WLED





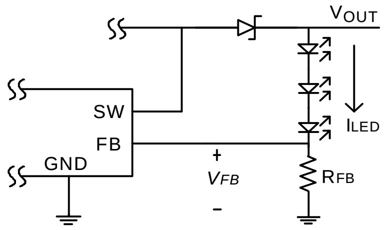
Time Base: 400ns/div

v Application Information

Setting the WLED Current

This device develops a band-gap between the feedback pin and ground pin. Therefore, the WLED current can be formed by R_{FB}. Use 1% metal film resistors for the lowest temperature coefficient and the best stability. The WLED current is given by the following formula:

$$I_{LED} = V_{FB} / R_{FB} \quad ; \text{where } V_{FB} = 0.104V$$



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.

Over Voltage Protection

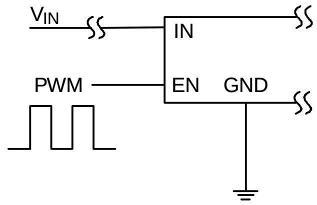
In some case, the WLED may fail, this will result in the feedback voltage goes to zero. This device will switches at maximum duty cycle to boost the output voltage higher and higher. Connect the OV pin to the top of the WLED string to sense the output voltage. If the over voltage occurs due to the open circuit condition, the OV pin will clamp the output voltage at 29V. Leave this pin floating if this function is not used.

Dimming Control

- *PWM Dimming Control*

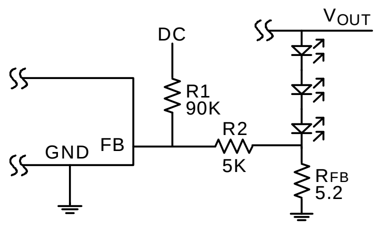
Connect an external PWM signal at EN pin to turn on or off this device. It is a simple method of brightness control for WLED. A 0% duty cycle will turn off this device and corresponds to zero the WLED current. A 100% duty cycle corresponds to full current. The variation of the average WLED current is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



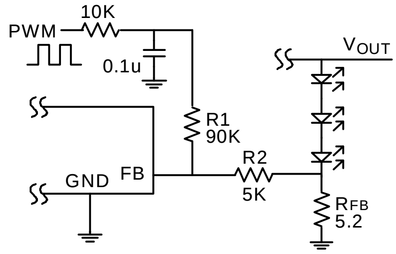
- *Analog Dimming Control*

The analog dimming control using a DC voltage is shown in the following circuit. As the DC voltage increases, the voltage drop on R2 increases. Thus the WLED current decreases. The R1 and R2 must make the DC source current much larger than the FB bias current and much smaller than the WLED current. Use a DC voltage from 0V to 2V with the resistor value shown in the following circuit can control the WLED current from 0mA to 20mA



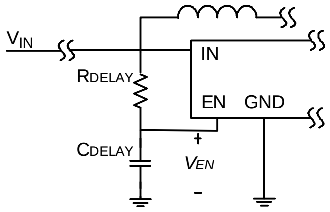
- *Filtered PWM Dimming from FB*

It can be used to replace the DC voltage source in dimming control. The circuit is shown in the following figure. It also 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.



The formula of delay time can be calculated as below:

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

Where:

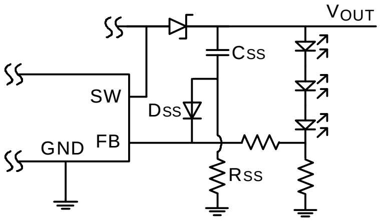
V_{EN} is EN Pin Threshold Voltage
T = Delay Time
$\tau = R_{DELAY} \times C_{DELAY}$

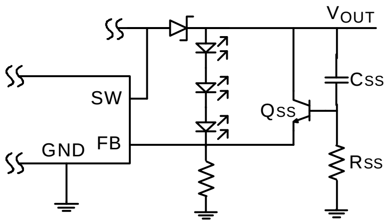
This feature is useful in situations where the input power source is limited in the amount of current it can deliver. It allows the input voltage to rise to a higher voltage before the device starts operating.

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.





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.

Capacitor 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.

Output Rectifier Diode Selection

The rectifier diode provides a current path for the inductor current when the internal power switch of the converter 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.

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 the SW pin.

(2) The feedback path should be close to the FB pin and keep noisy traces away; also keep them separate using grounded copper.

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

(4) The (+) plates of input capacitors should be close to the regulator.

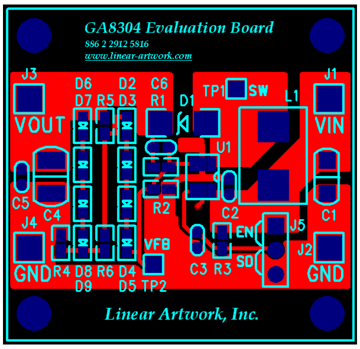
v Quick Design Table

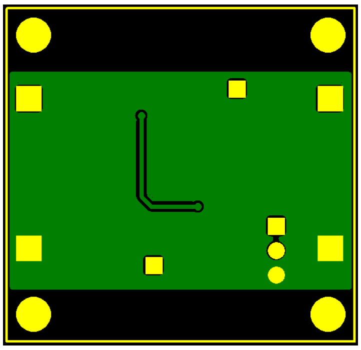
For Li-Ion battery application, V_{IN}=2.7V~4.2V, continuous mode operation

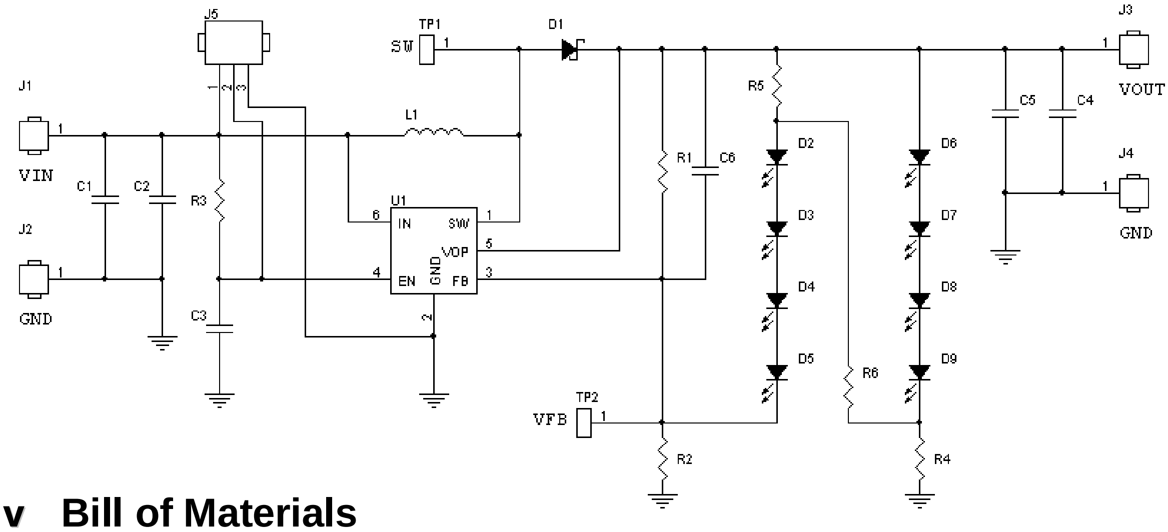
A: Input Capacitor (C_{IN})
B: Minimum Output Capacitor ($C_{OUT-MIN}$)
C: Inductor (L)
D: Feedback Resistor (R_{FB})

I_{LED} / LEDs	*5mA*	*10mA*	*15mA*	*20mA*
2 Series	A: 1uF B: 1uF C: 22uH D: 20.8Ohm	A: 1uF B: 2.2uF C: 22uH D: 10.4Ohm	A: 1uF B: 4.7uF C: 22uH D: 6.93Ohm	A: 1uF B: 4.7uF C: 22uH D: 5.2Ohm
3 Series	A: 1uF B: 1uF C: 22uH D: 20.8Ohm	A: 1uF B: 1uF C: 22uH D: 10.4Ohm	A: 1uF B: 2.2uF C: 22uH D: 6.93Ohm	A: 1uF B: 2.2uF C: 22uH D: 5.2Ohm
4 Series	A: 1uF B: 0.68uF C: 22uH D: 20.8Ohm	A: 1uF B: 1uF C: 22uH D: 10.4Ohm	A: 1uF B: 2.2uF C: 22uH D: 6.93Ohm	A: 1uF B: 2.2uF C: 22uH D: 5.2Ohm
5 Series	A: 1uF B: 0.22uF C: 22uH D: 20.8Ohm	A: 1uF B: 0.47uF C: 22uH D: 10.4Ohm	A: 1uF B: 0.68uF C: 22uH D: 6.93Ohm	A: 1uF B: 0.68uF C: 22uH D: 5.2Ohm
6 Series	A: 1uF B: 0.22uF C: 22uH D: 20.8Ohm	A: 1uF B: 0.22uF C: 22uH D: 10.4Ohm	A: 1uF B: 0.22uF C: 22uH D: 6.93Ohm	A: 1uF B: 0.22uF C: 22uH D: 5.2Ohm

v Evaluation Board







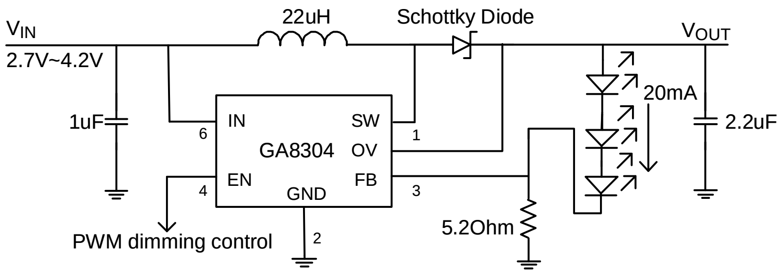
v Bill of Materials

V_{IN}=2.7~4.2V, drive 6 series WLED, I_{LED}=20mA

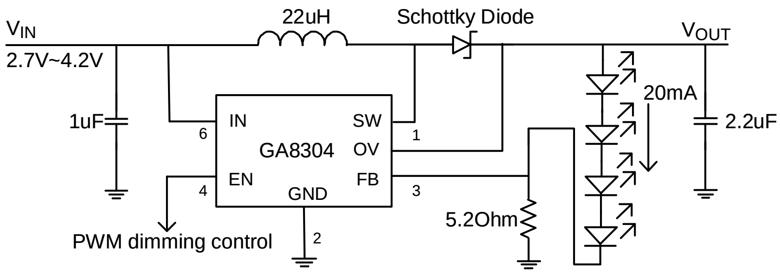
Designation	Descriptions	Manufacturer Part #	Manufacturer	Manufacturer Website
U1	1.2M, 32V WLED Driver, SOT-23-6L	GA8304CEADJ	Linear Artwork	www.linear-artwork.com
L1	Surface Mount Inductor 22uH, 420mA, 84mOhm, 3.0*3.0*1.2mm	NR3012T220M	Taiyo Yuden	www.yuden.co.jp
D1	Schottky Diode 30V, 0.5A, 0.47V_F, SOD-323	RB551V-30	Rohm	www.rohm.com
C1	MLCC 1uF, 0805, X7R, 25V	TMK212BJ105KD-T	Taiyo Yuden	www.yuden.co.jp
C4	MLCC 0.22uF, 0805, X7R, 50V	UMK212BJ224KG-T	Taiyo Yuden	www.yuden.co.jp
D8,D9,R6	Short			
C2,C3,C5C6 R1,R3,R4,R5	No Connection			
R2	Chip Resistor, 5.2Ohm, 0805, ±1%	RC0805FR-075R2L	Yageo	www.yageo.com
D2~D7	0603 Package White Chip LED			
J5	Male Header 180° 3*1P 2.54mm			
J1,J2,J3,J4	Terminal Binding Post 1.6mm			
TP1,TP2	Male Header 180° 1P 2.54mm			

v Typical Application Circuits

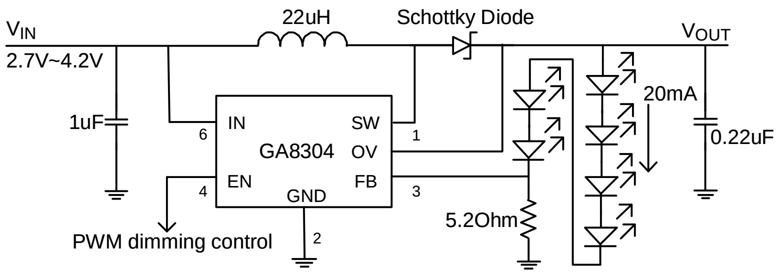
- **Li-Ion battery application for driving 3-series WLEDs**



- **Li-Ion battery application for driving 4-series WLEDs**

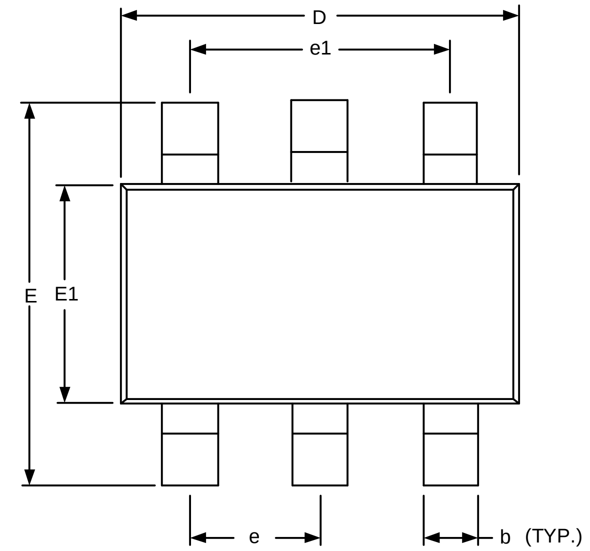


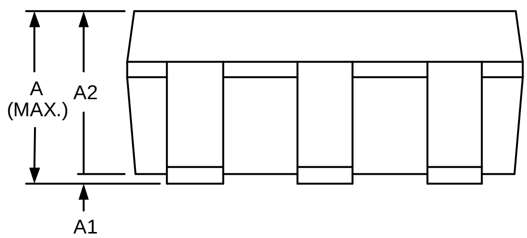
- **Li-Ion battery application for driving 6-series WLEDs**

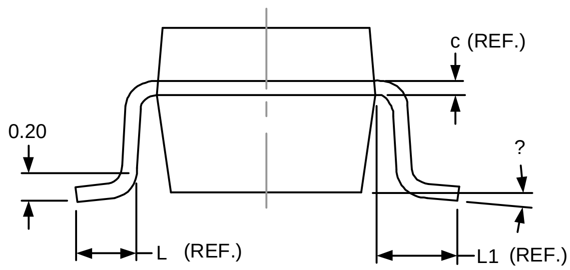


v Package Outline

SOT-23-6L







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	⊖	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			

NOTICE

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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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