Description

The YB1506 is a step-up(Boost) DC-DC converter; operate as current source to drive up to 5 white LEDs in series. Series connecting of the LEDs provides identical LED currents resulting in uniform brightness and eliminating the need for ballast resistors. The light intensity of these LEDs is proportional to the current passing through them. The low off-time permits the use of tiny, low profile inductors and capacitors to minimize footprint and cost in space consideration applications for cellular phone backlighting or other hand held equipment.

The YB1506 can drive up to 5 white LEDs from a single Li-Ion battery DC 2.2V to 6.5V; can be turn on by putting more than 1.2 volt at pin 4 (SHDN). To control LED brightness, the LED current can be pulsed by applying a PWM (pulse width modulated) signal with a frequency range of 100Hz to 50KHz to the SHDN pin.YB1506 has integrated Over Voltage Protection that prevents damage to the device in case of a high impedance output due to faulty LED.

Features

- Internal switch
- Adjustable output voltage up to 22V
- 2.2V to 6.5V input range
- 0.1uA shutdown current
- Small 5-Lead SOT-23 package
- High efficiency
- Drives 5 white LEDs
- Over voltage protection

Applications

- LCD Display Module
- White LED Backlighting
- PDAs
- Digital Cameras
- Portable Application
- Cellular Phone
- Electronic books

Typical Application Circuit (Li-Ion battery 2.5 volt to 6.5 volt is recommended.)

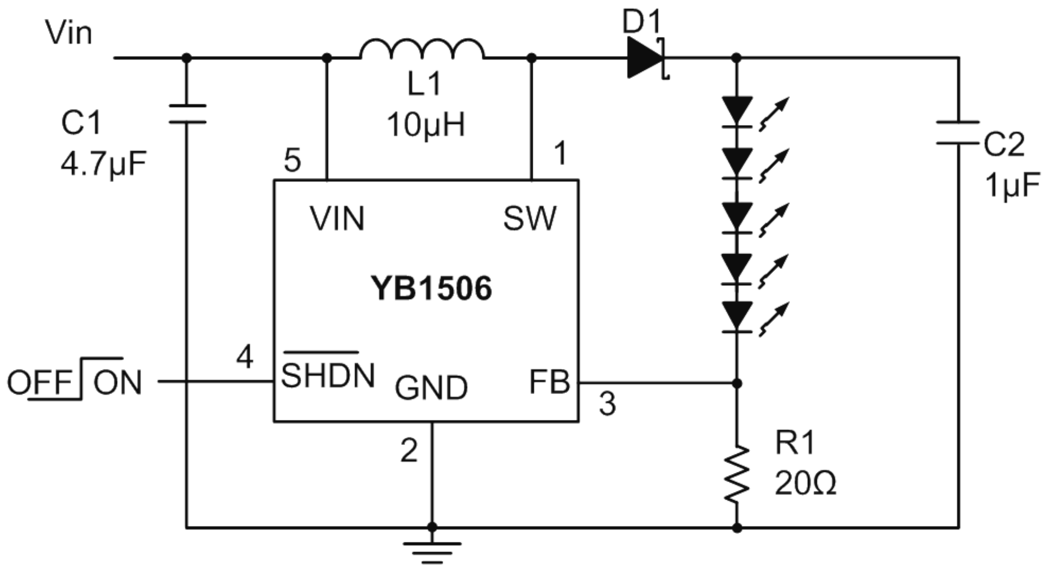


Figure 1：Typical Application Circuit

Pin Description

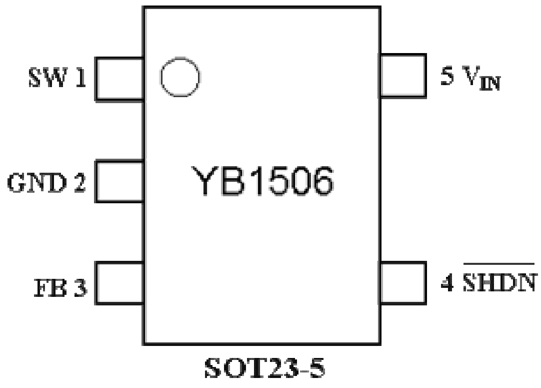


Figure 2：YB1506 SOT23-5

Pin Designator

Table 1 :

Pin	NAME	Description
1	SW	Switching Pin. This is the drain of the internal NMOS power switch. Connect to inductor and diode. Minimize the metal trace area connected to this pin to reduce EMI.
2	GND	Ground Pin. Connect directly to local ground plane.
3	FB	Feedback Pin. Set the WLED current by selecting value of R1 using: $I_{LED} = \frac{0.4V}{R2}$
4	$\overline{SHDN}$	Shutdown Pin. The shutdown pin is an active low control. Tie this pin above 0.9V to enable the device, below 0.6V to turn off the device.
5	V_{IN}	Input Supply Pin. Bypass this pin with a capacitor as close the device as possible.

Ordering Information

Table 2:

Order Number	Package Type	Supplied as	Package Marking
YB1506	SOT23-5	3000 units Tape & Reel	Y56

Absolute Maximum Retings

Vin	7V
SW voltage	28V
FB	Vin
$\overline{SHDN}$	Vin+0.3V
Maximum Junction Temp,Tj (note 2)	150 °C
Lead Temperature (Soldering 10 sec)	300 °C
Thermal Resistance	195 °C

Absolute Maximum Retings

Operating Temperature (note 3)	-40℃~ +85℃
Supply Voltage	2.2V~6.5V
Maximum SW Voltage	22V

Electricity Characteristics

Table 3 : (TA=25°C , Vin=3V unless otherwise noted)

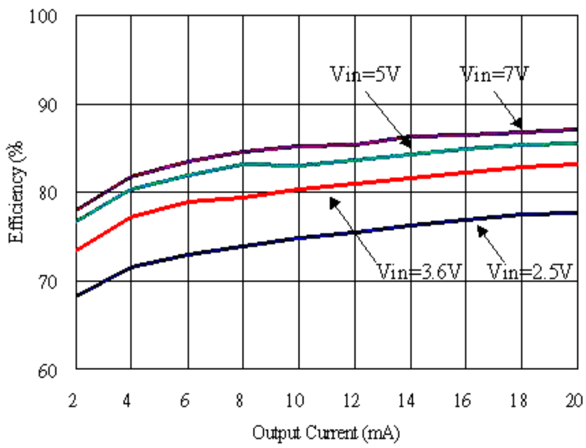
Symbol	Function Parameter	Test Conditions	Min	Typ	Max	Units
V_{IN}	Input Voltage Range		2.2		6.5	V
I_Q (Quiescent Current)	Not Switching	FB = 0.5V		70	90	uA
	Shutdown	$\overline{SHDN}$ =0V		0.1		
V_{FB}	Feedback Voltage		0.38	0.4	0.42	V
I_{CL}	Switch Current Limit		350	450	550	mA
I_B	FB Pin Bias Current	FB=2V		30	120	nA
I_{LKG}	SW Leakage Current	V_{SW}=20V		0.05	0.1	uA
T_{OFF}	Switch Off Time			350	400	nS
T_{ON}	Switch On Time			4		uS
$R_{DS(ON)}$	Switch $R_{DS(ON)}$			0.7	1.6	Ω
I_{SD}	$\overline{SHDN}$ PIN Current	$\overline{SHDN}$ =GND or Vin			80	nA
UVP	Input Under-Voltage Protection	ON-OFF Threshold		1.6	2.0	V
OVP	Output Over-voltage Protection		22.5	23.5	24.5	V
$\overline{SHDN}$ Threshold	$\overline{SHDN}$ Low				0.6	V
	$\overline{SHDN}$ High		0.9			
θ_{JA}	Thermal Resistance			220		℃/W

Note：

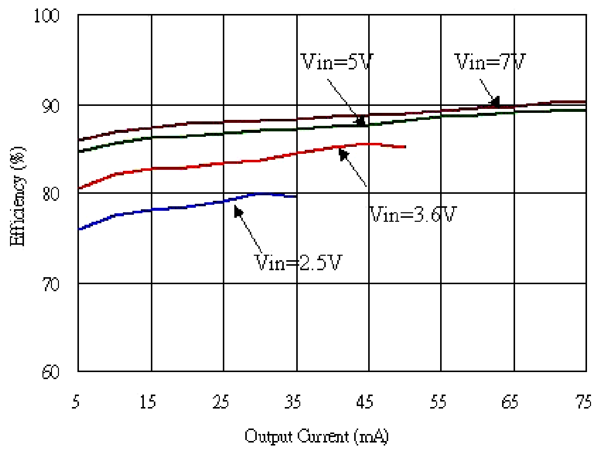
1. Absolute maximum ratings are limits beyond which damage to the device may occur.
2. The maximum allowable power dissipation is a function of maximum function temperature , $T_{J(max)}$, the junction to ambient thermal resistance, θ_{JA} , and the ambient temperature. The maximum allowable power dissipation at any ambient temperature is calculated using: $P_{D(MAX)}= [T_{J(max)}-T_A]/\theta_{JA}$. Exceeding the maximum allowable power dissipation will cause excessive die temperature.
3. All limits at temperature extremes are guaranteed via correlation using standard statistical methods

Typical Performance Characteristics

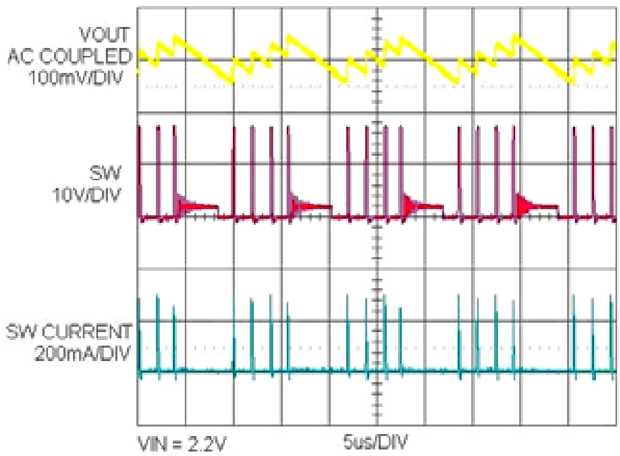
Efficiency vs Output Current (Vout=21V)



Efficiency vs Output Current (Vout=12V)

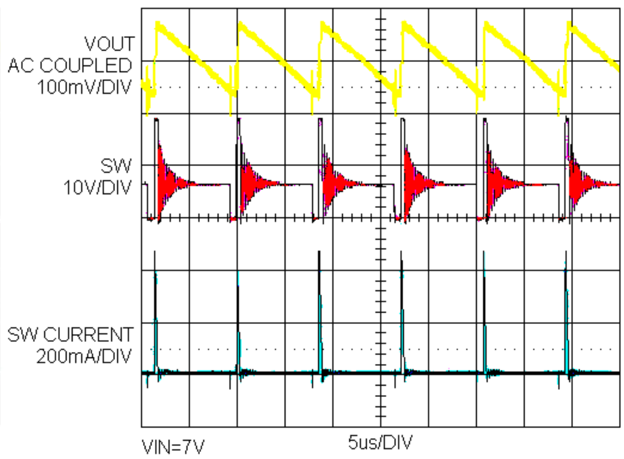


OUTPUT RIPPLE



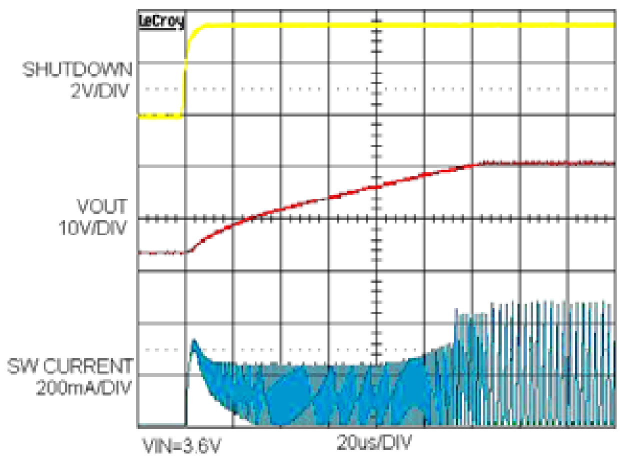
VIN = 2.2V
VOUT=18V
LOAD CURRENT = 9mA

OUTPUT RIPPLE



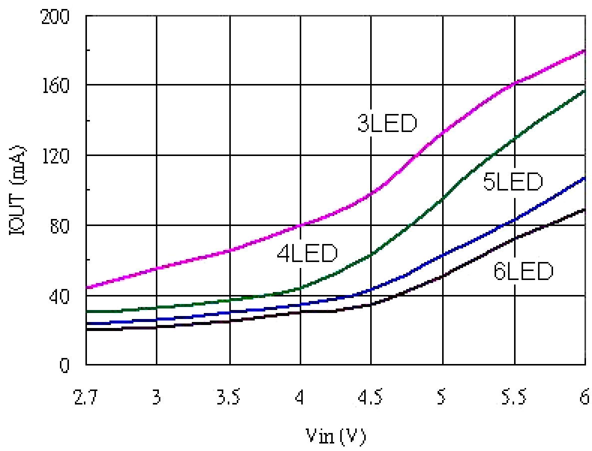
VIN=7V
VOUT=18V
LOAD CURRENT=9mA

SOFT START



VIN=3.6V
6 WLED
LED CURRENT=10mA

Maximum Output Current vs Vin



L=10uH
Rsense=40 Ohm

Function Block

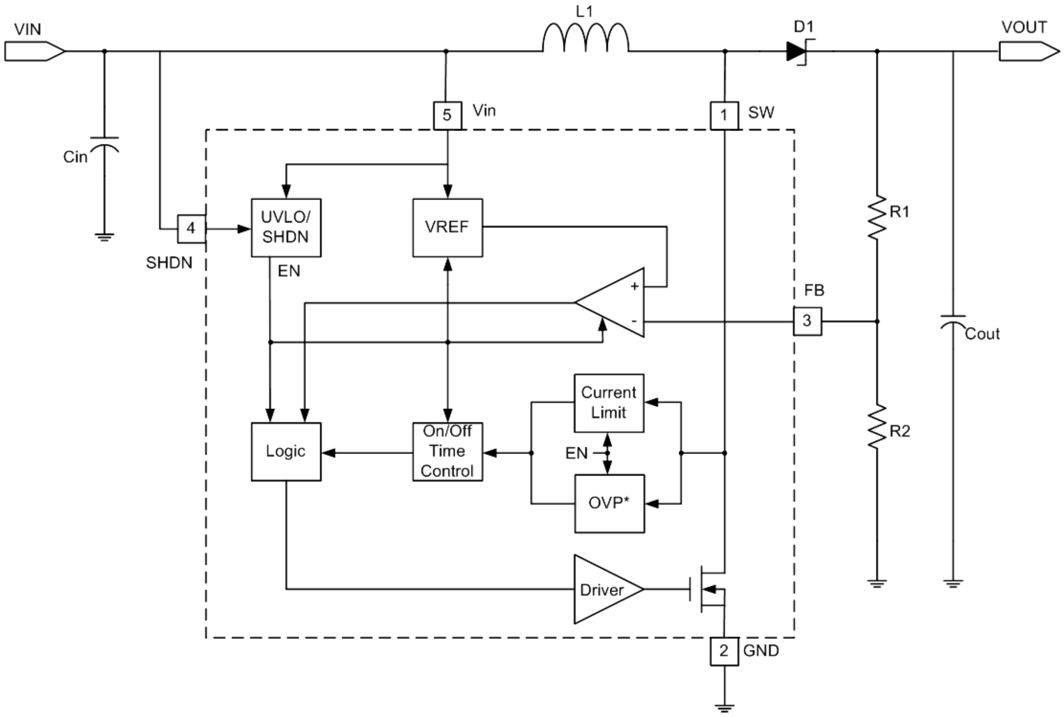


Figure 3：Function Block

Application Information

The YB1506 features a constant off-time control scheme. The Housekeeping provides a bandgap reference used to control the output voltage. When the voltage at the FB pin is less than trip point, the input comp amplifier enables the device and the NMOS switch is turned on pulling the SW pin to ground. When the NMOS switch is on, current begins to flow through inductor L while the load current is supplied by the output capacitor Cout. Once the current in the inductor reaches the current limit, the CL Comp trips and the timer turns off the NMOS switch. The inductor current will now begin to decrease. At the same time, the energy stored in the inductor transferred to Cout and the load. After the 400ns off time the NMOS switch is turned on and energy is stored in the inductor again.

When FB reaches the trip point, the input comp amplifier then disables the device and turns off the NMOS switch. The $\overline{\text{SHDN}}$ pin can be used to turn off the device. In the shutdown mode the output voltage will be a diode drop lower than the input voltage.

Inductor Selection

The appropriate inductor for a given application is calculated using the following equation:

$$L = \left(\frac{V_{OUT} - V_{IN,MIN} + V_D}{I_{CL}}\right) T_{OFF}$$

Where V_D is the schottky diode voltage, I_{CL} is the switch current limit found in the Typical Performance Characteristics section, and T_{OFF} is the switch off time. When using this equation be sure to use the minimum input voltage for the application, such as for battery-powered application.

Choosing inductor with low ESR decrease power losses and increase efficiency.

Diode selection

To maintain high efficiency, the average current rating of the schottky diode should be large than the peak inductor current, IPK. Schottky diode with a low forward drop and fast switching speeds are ideal for increase efficiency in portable application. Choose a reverse breakdown of the schottky diode large than the output voltage.

Capacitor selection

Choose low ESR capacitors for the output to minimize output voltage ripple. Multilayer capacitors are a good choice for this as well. A 4.7uF capacitor is sufficient for most applications. For additional bypassing, a 100nF ceramic capacitor can be used to shunt high frequency ripple on the input.

Layout consideration

The input bypass capacitor Cin, as shown in Figure 1, must be placed close to the IC. This will reduce copper trace resistance which effect input voltage ripple of the IC. For additional input voltage filtering, a 100nF bypass capacitor can be placed in parallel with Cin to shunt any high frequency noise to ground. The output capacitor, Cout, should also be placed close to the IC. Any copper trace connections for the Cout capacitor can increase the series resistance,
which directly effect output voltage ripple. The feedback network, resister R2 should be kept close to the FB pin to minimize copper trace connections that can inject noise into the system. The ground connection for the feedback resistor network should connect directly to an analog ground plane. The analog ground plane should tie directly to the GND pin. If no analog ground plane is available, the ground connection for the feedback network should tie directly to the GND pin. Trace connections made to the inductor and schottky diode should be minimized to reduce power dissipation and increase overall efficiency.

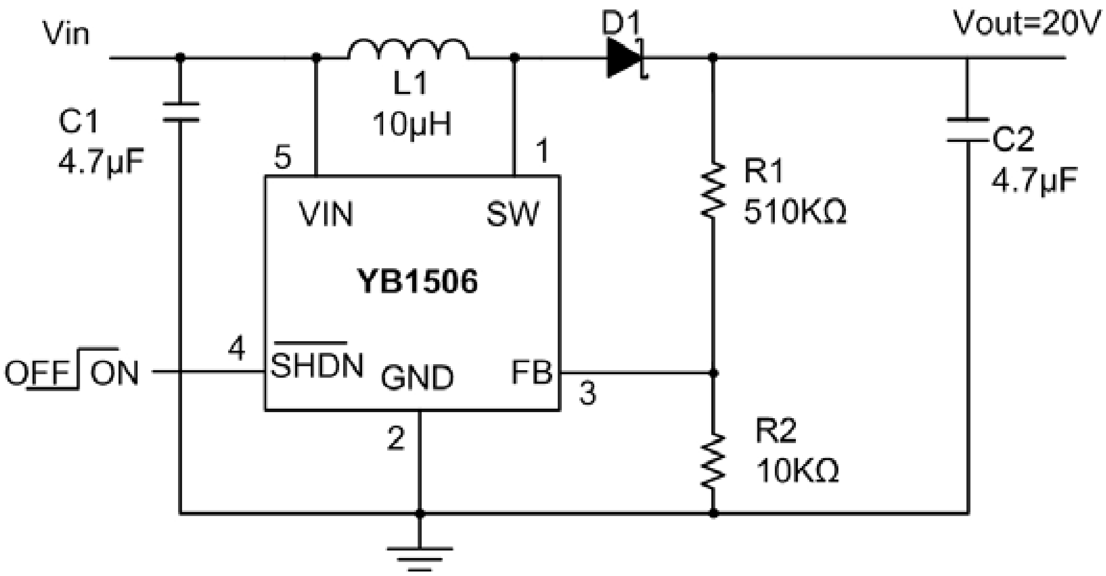


Figure 4： 20V Application

LED Current Control

The LED current is controlled by the feedback resistor (R1 in Figure 1). The feedback reference is 400mV. The LED current is 400mV/R1. In order to have accurate LED current, precision resistors are preferred (1% is recommended).
The formula and table for R1 selection are shown below.

$R1 = 95mV/I_{LED}$

Table 4. R1 Resistor Value Selection

I_{LED}(mA)	R1(Ω)
20	20
15	26.6
10	40
5	80
1	400

Dimming Control

There are four different types of dimming control circuits:

1. Using a PWM Signal to SHDN Pin

With the PWM signal applied to the SHDN pin, the YB1506 is turned on or off by the PWM signal. The LEDs operate at either zero or full current. The average LED current increases proportionally with the duty cycle of the PWM signal. A 0% duty cycle will turn off the YB1506 and corresponds to zero LED current. A 100% duty cycle corresponds to full current. The typical frequency range of the PWM signal is 1kHz to 10kHz. The magnitude of the PWM signal should be higher than the minimum SHDN voltage high.

2. Using a DC Voltage

For some applications, the preferred of brightness control is a variable DC voltage to adjust the LED current. The dimming control using a DC voltage is shown in Figure 5. As the DC voltage increases, the voltage drop on R2 increases and the voltage drop on R1 decreases. Thus, the LED current decreases. The selection of R2 and R3 will make the current from the variable DC source much smaller than the LED current and much larger than the FB pin bias current. For V_{DC} range from 0V to 2V, the selection of resistors in Figure 5 gives dimming control of LED current from 0mA to 15mA.

3. Using a Filtered PWM Signal

The filtered PWM signal can be considered as an adjustable DC voltage. It can be used to replace the variable DC voltage source in dimming control. The circuit is shown in Figure 7.

4. Using a Logic Signal

For applications that need to adjust the LED current in discrete steps, a logic signal can be used as shown in Figure 6. R1 sets the minimum LED current (when the NMOS is off). R_{INC} sets how much the LED current increases when the NMOS is turned on. The selection of R1 and R_{INC} follows formula (1) and Table 4.

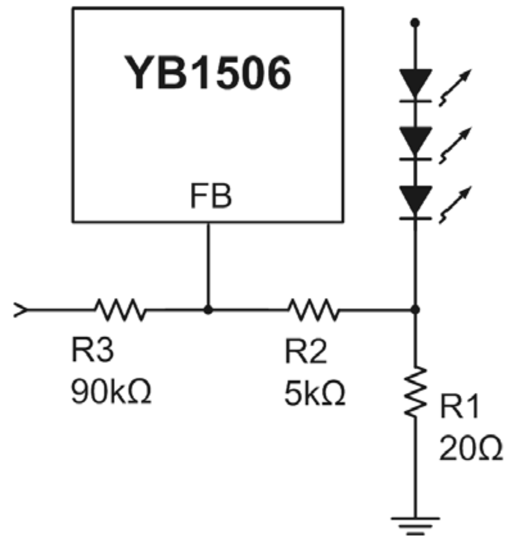


Figure 5 ：Dimming Control using a DC voltage

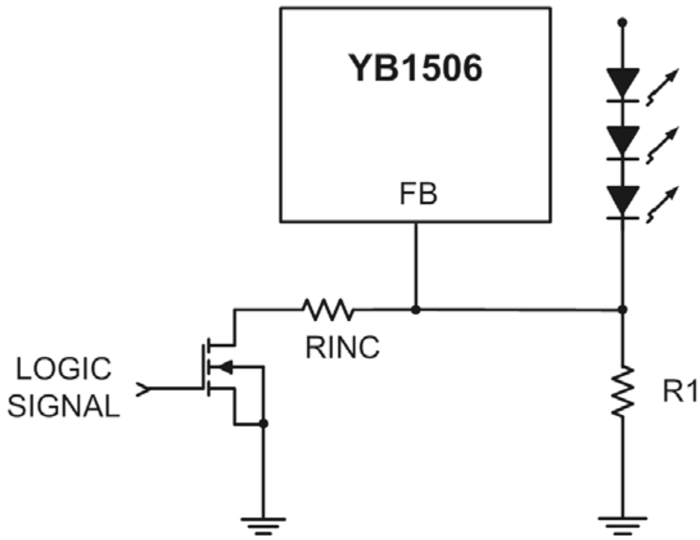


Figure 6 ：Dimming Control using a LOGIC SIGNAL

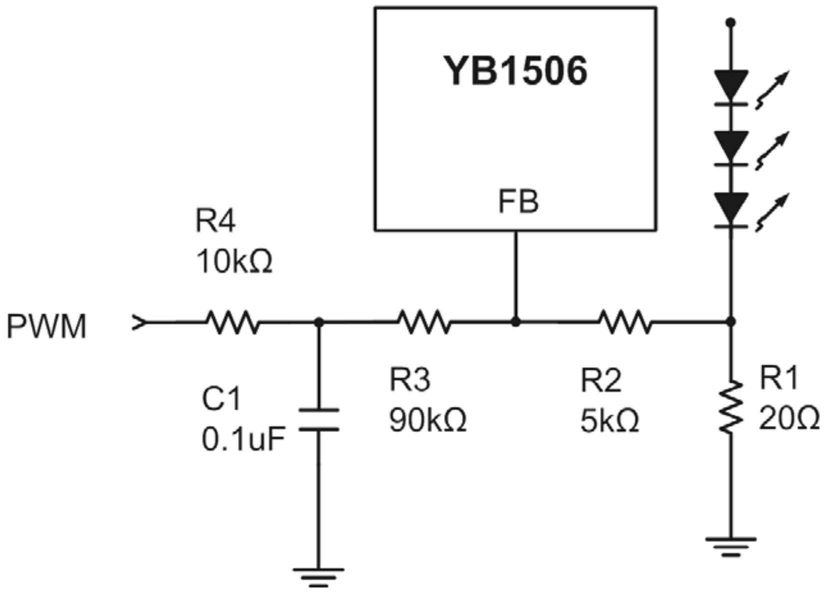


Figure 7 ：Dimming Control using a PWM

APPLICATION EXAMPLE

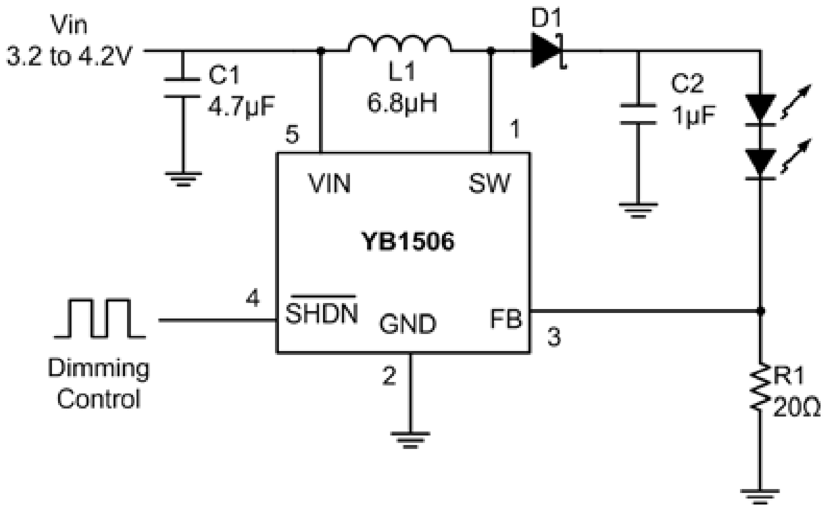


Figure 8 ：Two White LEDs Application in Li-Ion Battery

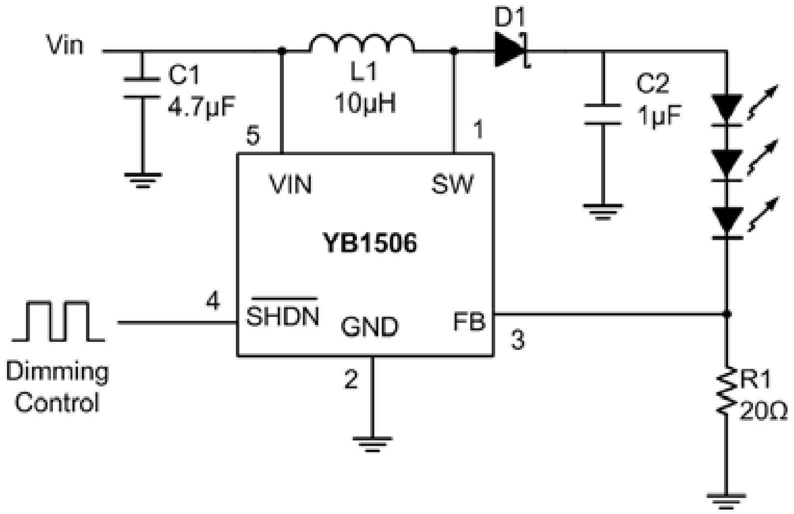


Figure 9 ：Three White LEDs Application

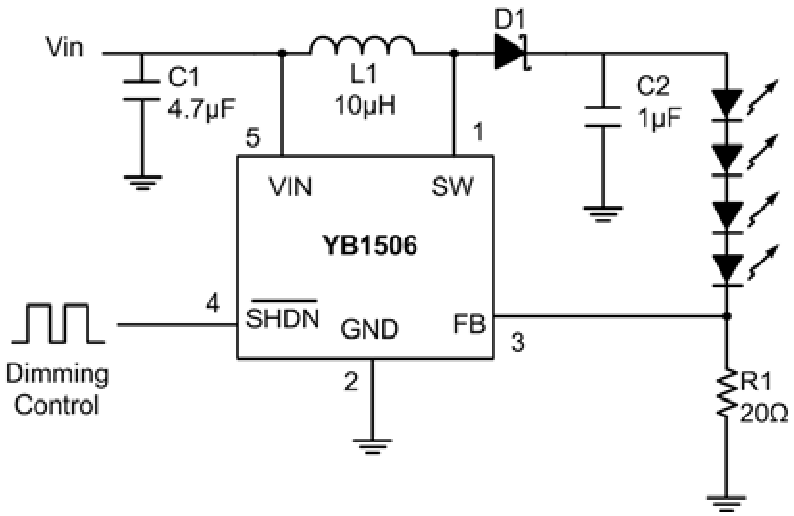
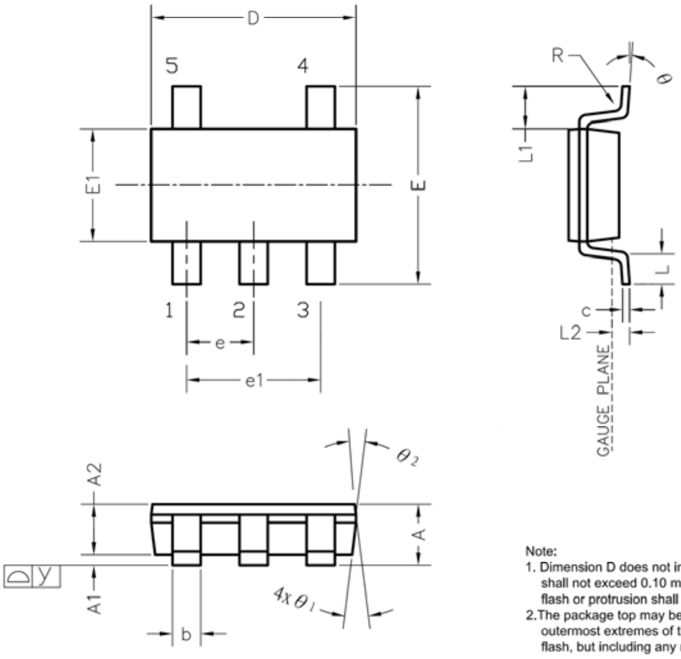


Figure 10 ：Four White LEDs Application

SOT-25 Package Information



Symbol	inch			mm		
	Min	Nom	Max	Min	Nom	Max
A	0.030	-	0.035	0.75	-	0.90
A1	0.000	-	0.004	0.00	-	0.10
A2	0.028	0.030	0.031	0.70	0.75	0.80
b	0.014	-	0.020	0.35	-	0.51
c	0.004	-	0.010	0.10	-	0.25
D	0.110	0.114	0.118	2.80	2.90	3.00
E	0.102	0.110	0.118	2.60	2.80	3.00
E1	0.059	0.063	0.067	1.50	1.60	1.70
e	0.0374 BSC			0.95 BSC		
e1	0.0748 BSC			1.90 BSC		
L	0.015	-	-	0.37	-	-
L1	0.0236 REF			0.60 REF		
L2	0.0098 BSC			0.25 BSC		
y	-	-	0.004	-	-	0.10
R	0.004	-		0.10	-	-
θ	0°	-	8°	0°	-	8°
θ1	7° NOM			7° NOM		
θ2	5° NOM			5° NOM		

Note:
1. Dimension D does not include mold flash, protrusions or tate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.10 mm PER end. Dimension E1 does not include interlead flash or protrusion. Interlead flash or protrusion shall not exceed 0.15 mm PER side.
2.The package top may be smaller than the package bottom. Dimensions D and E1 are determined at the outermost extremes of the plastic body exclusive of mold flash, tie bar burrs, gate burrs and interlead flash, but including any mismatch between the top and bottom of the plastic body.

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