BSC74K1937

BRAVE SEMICONDUCTOR

STEP-UP CONVERTER WHITE LED CONSTANT CURRENT DRIVER

GENERAL DESCRIPTION

The BSC74K1937 is a step-up DC/DC converter specifically designed to drive white LEDs with a constant pre-set current.

The device can drive two, three or four LEDs in series from a Li-Ion cell. Series connection of the LEDs provides identical LED currents resulting in uniform brightness and eliminating the need for ballast resistors.

The output capacitor can be as small as 0.22µF, saving critical board space compared alternative solutions.

The BSC74K1937 is offered in an industry standard SOT-25 package.

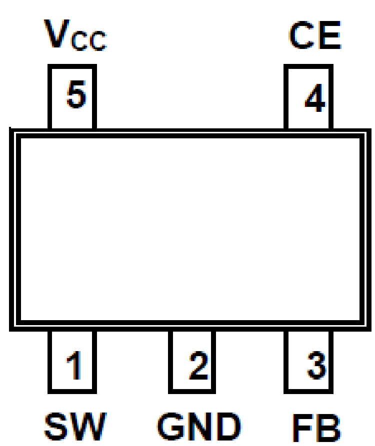
FEATURES

- **High Efficiency: 84% Typical**
- **36V internal Switch**
- **Fast 1.2MHz Switching Frequency**
- **Drives Up to three LEDs from a 2.8V Supply**
- **Drives Up to six LEDs from a 5V Supply**
- **External Matched LED Current**
- **Uses Tiny 1mm height inductor**
- **Requires Only 0.22µF Output Capacitor**
- **Low profile TSOT package**

APPLICATIONS

LED Flashlight
Digital Cameras, MP3 Players
Handheld Electronics

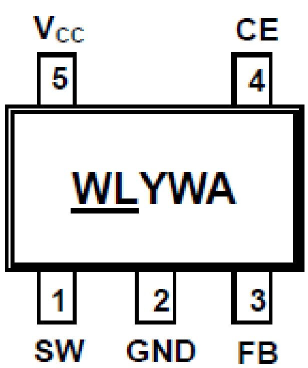
PIN CONFIGURATION

Package Designator	Pin Configuration (Top view)
SOT-25	

PIN DESCRIPTION

No.	Pin	Description
1	SW	Switch Pin, (Minimize trace area at this pin to reduce EMI.)
2	GND	Ground connection for the IC.
3	FB	Feedback Pin. Reference voltage is 95 mV. (Calculate resistor value according to the formula RFB=95 mV / I_{LED} .)
4	CE	Shutdown Pin (Connect to 1.5 V or higher to enable device; 0.4 V or less to disable device)
5	Vcc	Input Supply Pin. (Must be locally bypassed)

DEVICE MARKING



WL: Device Code, Green Product
Y: Year
W: Week code
A: Assembly/testing site

ORDERING INFORMATION
Operating Temperature Range: -40°C To +85°C

Order Part No.	Package	QTY/Reel
BSC74K1937-TR	SOT-25, Lead-free	3000

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Ratings	Unit
Maximum Supply Voltage	V_{IN}	10	V
Maximum Voltage at pin SW	V_{SW}	36	V
Maximum Voltage at pin FB	V_{FB}	10	V
Maximum Voltage at pin CE	V_{CE}	10	V
Continuous Total Power Dissipation – SOT-25	P_D	300	W
Lead Temperature (Soldering, 10 sec)		+ 300	°C

Note 1: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Ratings	Unit
Operating Ambient Temperature	T_A	-40…+85	°C
Storage Temperature	T_{STG}	-65…+150	°C

ELECTRICAL CHARACTERISTICS

T_A = 25℃, Vcc = 3V, V_{CE} = 3V, unless otherwise noted

Parameter	Symbol	Conditions	Value			Unit
			Min	Typ	Max	
Supply Current	$I_{CC(ON)}$			1.9	2.5	mA
	$I_{CC(OFF)}$	V_{CE} = 0		0.1	1.0	µA
Feedback Voltage	V_{FB}	I_{SW} = 100mA, Duty Cycle = 66%	86	95	104	mV
FB Pin Bias Current	I_{FB}		10	45	100	nA
Switching Frequency	f_{SW}		0.8	1.2	1.6	MHz
Maximum Duty Cycle	D_{MAX}		85	90		%
Switch Leakage Current	I_{LEAK}	V_{SW} = 5V		0.001	5	µA
Switch Current Limit	I_{SW}			320		mA
Switch V_{CESAT}	V_{SAT}	I_{SW} = 250mA		±3	±5	%
CE Voltage High			1.5			V
CE Voltage Low					0.4	V
CE Pin Bias Current	I_{CE}			65		µA

TYPICAL PERFORMANCE CHARACTERISTICS

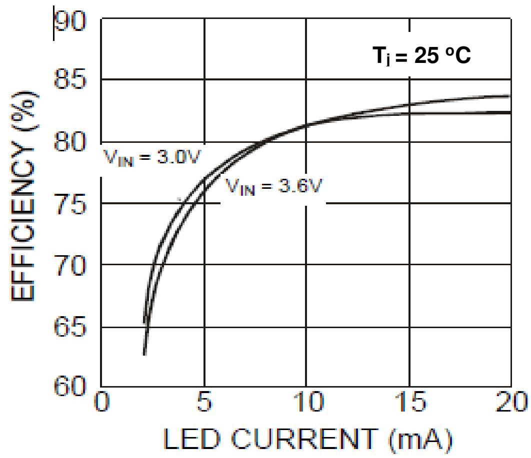
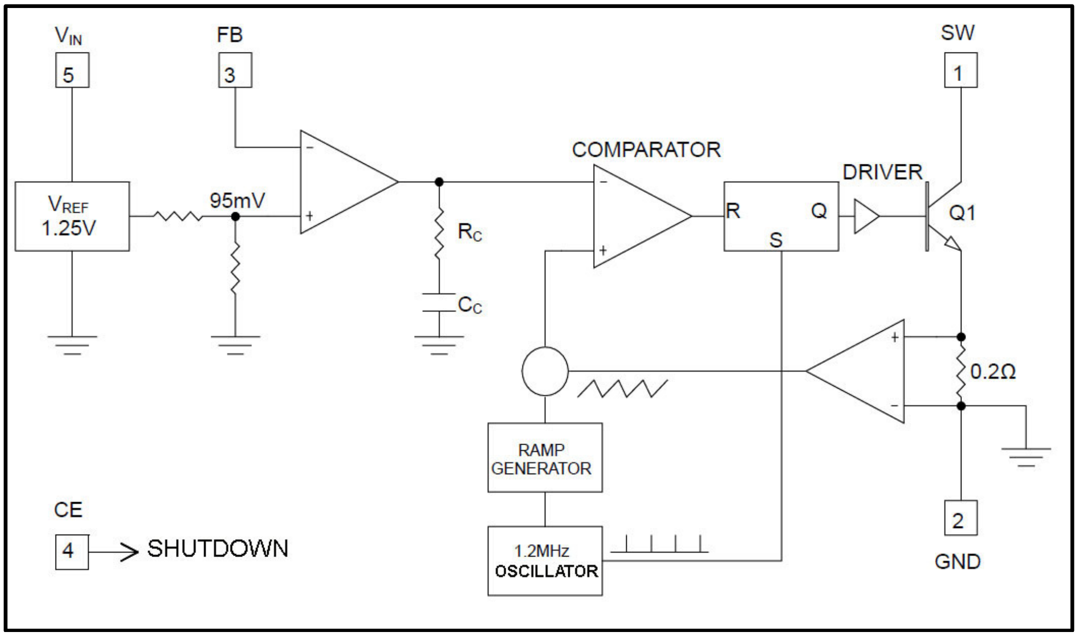


Figure 2 LED Current vs. % Efficiency

FUNCTIONAL BLOCK DIARGAM



APPLICATION INFORMATION

BSC74K1937 is designed with a constant frequency, current mode control scheme to provide excellent line and load regulation. Operation can be best understood by referring to the block diagram in Figure 2. At the start of each oscillator cycle, the SR latch is set, which turns on the power switch Q1. A voltage proportional to the switch current is added to a stabilizing ramp and the resulting sum is fed into the positive terminal of the PWM comparator A2. When this voltage exceeds the level at the negative input of A2, the SR latch is reset turning off the power switch. The level at the negative input of A2 is set by the error amplifier A1, and is simply an amplified version of the difference between the feedback voltage and the reference voltage of 95mV. In this manner, the error amplifier sets the correct peak current level to keep the output in regulation. If the error amplifier's output increases, more current is delivered to the output; if it decreases, less current is delivered.

MINIMUM OUTPUT CURRENT

BSC74K1937 can regulate three series LEDs connected a low output current. down to approximately 4mA from a 4.2V supply, without pulse skipping, using the same external components as specified for 15mA operation. As current is further reduced, the device will begin skipping pulses. This will result in some low frequency ripple, although the LED current remains regulated on an average basis down to zero.

INDUCTOR SELECTION

A 22mH inductor is recommended for most BSC74K1937 applications. Although small size and high efficiency are major concerns, the inductor should have low core losses at 1.2MHz and low DCR (copper wire resistance). Some inductors in this category with small size are listed in Table 1.

Table 1 Recommended Inductors

Part Number	DCR (Ω)	Current Rating (mA)	Manufacturer
LQH3C220	0.71	250	Murata
ELJTC220KF	4.0	160	Panasonic
CDRH3D16-220	0.53	350	Sumida
LB2023B220M	1.7	75	Taiyo Yuden
LEM2520-220	5.5	125	Taiyo Yuden

CAPACITOR SELECTION

The small size of ceramic capacitors makes them ideal for BSC74K1937 applications. X5R and X7R types are recommended because they retain their capacitance over wider voltage and temperature ranges than other types such as Y5V or Z5U. A 1μF input capacitor and a 0.22μF output capacitor are sufficient for most BSC74K1937 applications.

DIODE SELECTION

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for BSC74K1937 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the diode, while the diode capacitance (C_T or C_D) represents the switching losses. For diode selection, both forward voltage drop and diode capacitance need to be considered. Schottky diodes with higher current ratings usually have lower forward voltage drop and larger diode capacitance, which can cause significant switching losses at the 1.2MHz switching frequency of the BSC74K1937. A Schottky diode rated at 100mA to 200mA is sufficient for most BSC74K1937 applications. Some recommended Schottky diodes are listed in Table 2.

Table 2 Recommended Diodes

Part Number	Forward Current (mA)	Voltage Drop (V)	Diode Capacitance (pF)	Manufacturer
CMDSH-3	100	0.58 @ 100mA	7.0 @10V	Central
CMDSH2-3	200	0.49 @ 200mA	15 @10V	Central
BAT54	200	0.53 @ 100mA	10 @25V	Zetex

LED CURRENT CONTROL

The LED current is controlled by the feedback resistor (R1 in Figure 1). The feedback reference is 95mV. The LED current is 95mV/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 3 Resistor Value Selection

I_{LED} (mA)	R1 (Ω)
5	19.1
10	9.53
12	7.87
15	6.34
20	4.75

OPEN CIRCUIT PROTECTION

In the cases of output open circuit, when the LEDs are disconnected from the circuit or the LEDs fail, the feedback voltage will be zero. The BSC74K1937 will then switch at a high duty cycle resulting in a high output voltage, which may cause the SW pin voltage to exceed its maximum 36V rating. A zener diode can be used at the output to limit the voltage on the SW pin (Figure 3). The zener voltage should be larger than the maximum forward voltage of the LED string. The current rating of the zener should be larger than0.1mA.

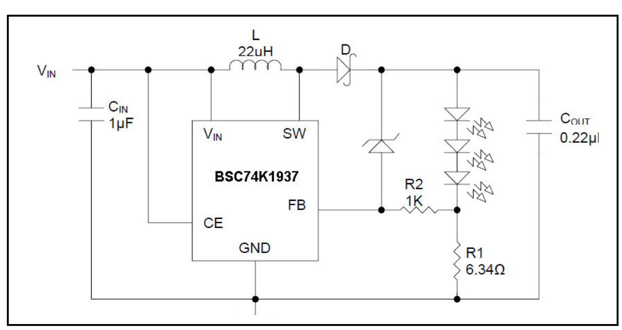


Figure 3 LED Driver with Open-Circuit Protection

DIMMING CONTROL

There are four different types of dimming control:

1. Using a PWM Signal to *SHDN* Pin

With the PWM signal applied to the CE pin, the BSC74K1937 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 BSC74K1937 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 CE voltage high.

2. Using a DC Voltage

For some applications, the preferred method of brightness control is a variable DC voltage to adjust the LED current. The dimming control using a DC voltage is shown in Figure 4. 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 VDC range from 0V to 2V, the selection of resistors in Figure 4 gives dimming control of LED current from 0mA to 15mA.

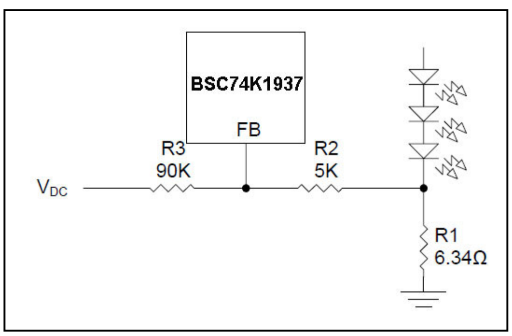


Figure 4 Dimming Control Using a DC Voltage

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 5.

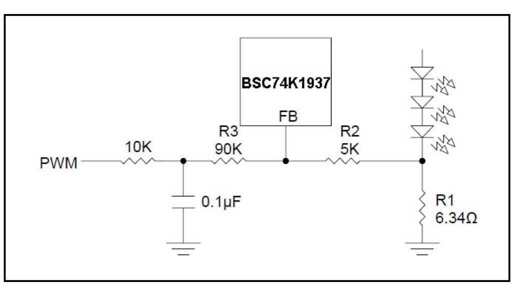


Figure 5 Dimming Control Using a Filtered PWM Signal

4. Using a Logic Signal

For applications that need to adjust the LED current is discrete steps, a logic signal can be used as shown in Figure 6. R1 sets the minimum LED current (when the NMOS is OFF). RINC sets how much the LED current increases when the NMOS is turned on. The selection of R1 and RINC can be found in table 3

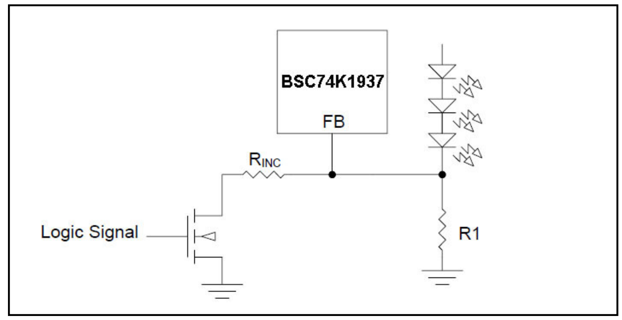
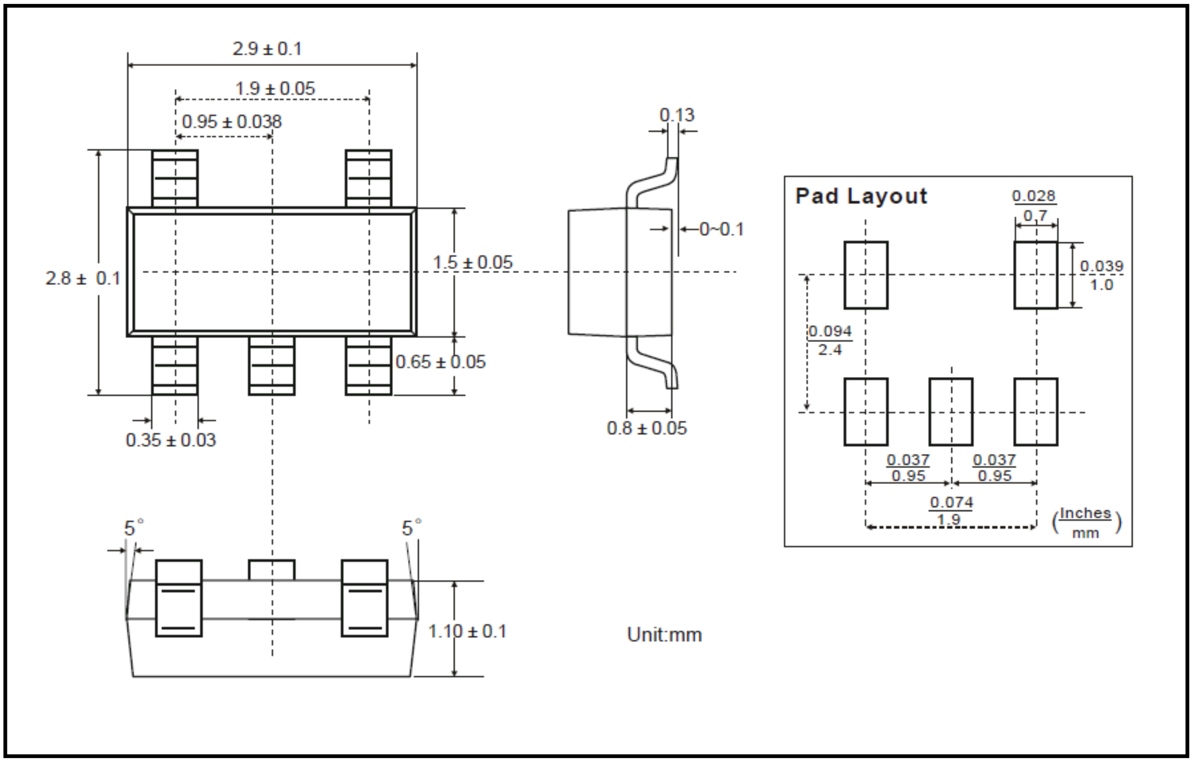


Figure 6 Dimming Control Using a Logic Signal

PACKAGE INFORMATION

SOT-25



TYPICAL APPLICATION CIRCUIT

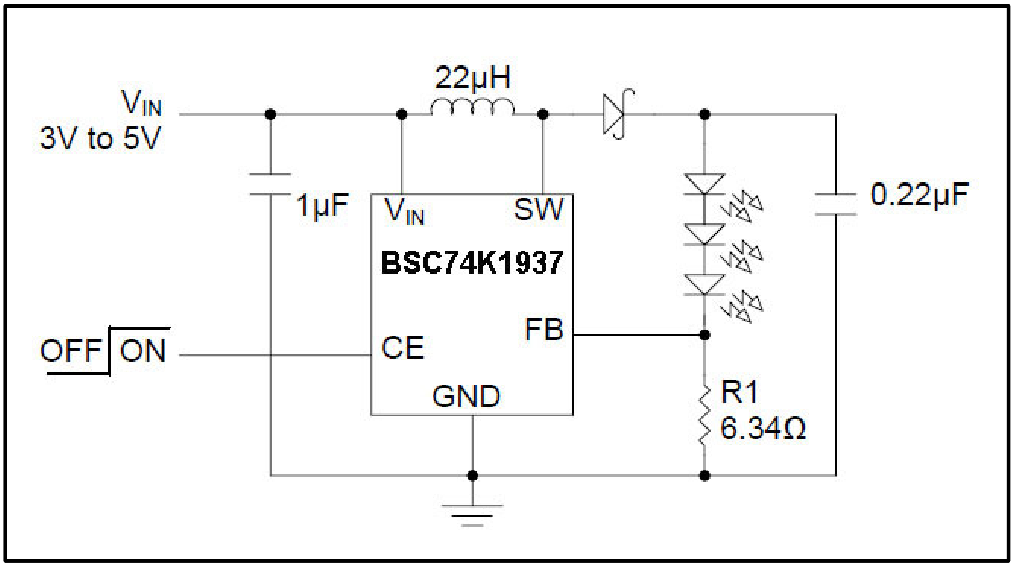


Figure 7 Typical Application Circuit (Li-Ion Powered Driver for Three White LEDs)

REVISION HISTORY

Revision	Detail Information	Date
A	Initial release	2020.08.01