SM8237

1.2MHz STEP-UP CONVERTER

REV. 1.3

Aug 28, 2007

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1.2MHz STEP-UP CONVERTER

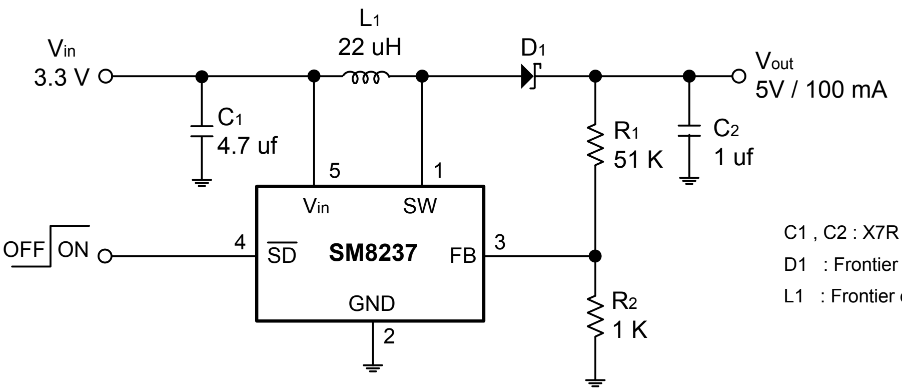
GENERAL DESCRIPTION

The SM8237 is a step-up DC/DC converter specifically designed to drive white LEDs with a constant 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 SM8237 switches at 1.2 MHz, allowing the use of tiny external components. The output capacitor can be as small as 0.22μF, saving space and cost versus alternative solutions. A low 95mV feedback voltage minimizes power loss in the current setting resistor for better efficiency.

FEATURES

* Inherently matched LED current
* High efficiency : 84% typical
* Drives up to four LEDs from a 2.8V supply
* Drives up to six LEDs from a 5V supply
* 36V rugged bipolar switch
* Fast 1.2MHz switching frequency
* Uses tiny 1 mm tall inductors
* Requires only 0.22μF output capacitor
* Low profile TSOT package

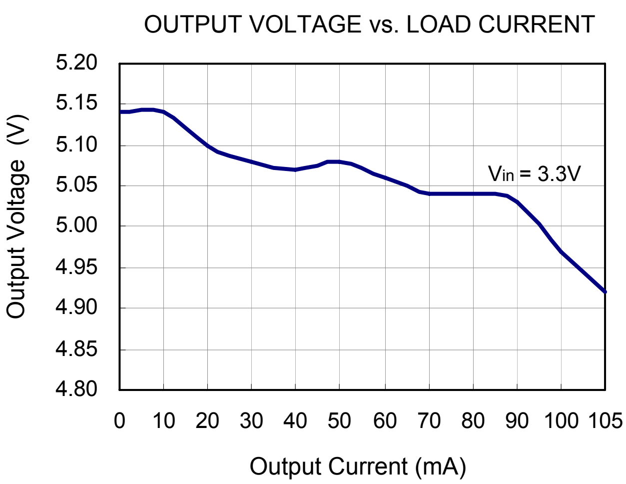
TYPICAL APPLICATION

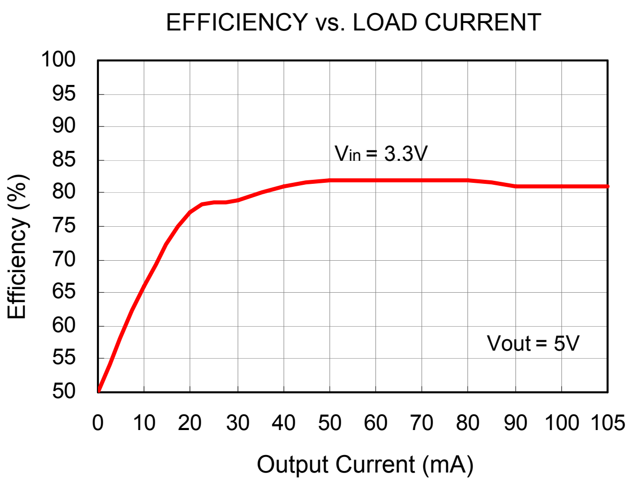


C1 , C2 : X7R Dielectric

D1 : Frontier electronics SS14

L1 : Frontier electronics CSS0218P-22ON-LFR

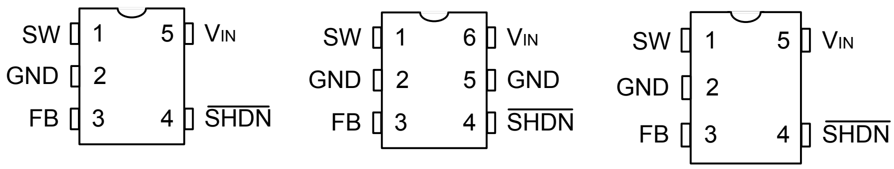




APPLICATIONS

* Cellular phone
* PDAs, handheld computer
* Digital camera
* MP3 player
* GPS receiver
* DC to DC Converter

PIN ASSIGNMENTS (TOP VIEW)



SOT-25 SOT-26 TSOT-25 (TSOT-23-5)

PIN DESCRIPTIONS

NO.	Pin name	Function
1	SW	Switch Pin. Connect inductor / diode here. Minimize trace area at this pin to reduce EMI.
2	GND	Ground Pin. Connect directly to local ground plane
3	FB	Feedback Pin. Reference voltage is 95mV. Connect cathode of lowest LED and resistor here. Calculate resistor value according to the formula: R_{FB} =95mV/I_{LED}
4	$\overline{SHDN}$	Shutdown Pin. Connect to 1.5V or higher to enable device; 0.4V or less to disable device.
5	GND (SOT-26)	Ground Pin. Connect to Pin 2 and local ground plane.
6	V_{IN} (SOT-26)	Input supply Pin. Must be locally bypassed.

MAXIMUM RATINGS

Characteristic	Rating	Unit
Input voltage (V_{IN})	10	V
SW voltage	36	V
FB voltage	10	V
$\overline{SHDN}$ voltage	10	V
Operating temperature range	- 40 ~ 85	°C
Maximum junction temperature	125	V
Storage temperature range	- 65 ~ 150	V
Lead temperature (soldering, 10 sec)	300	V

1.2MHz STEP-UP CONVERTER

ELECTRICAL CHARACTERISTICS

(T_A =25°C , V_{IN} =3V, $V_{\overline{SHDN}}$ = 3V, unless otherwise noted)

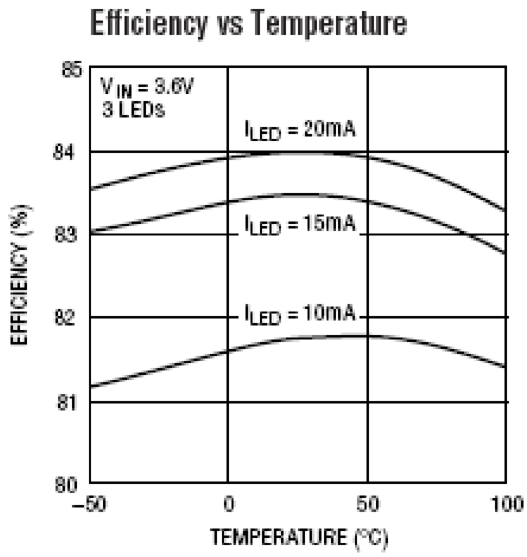
Characteristic	Condition	Min.	Typ.	Max.	Unit
Minimum operating voltage		2.5	-	-	V
Maximum operating voltage		-	-	10	V
Feedback voltage	I_{SW} =100mA, Duty cycle=66%	86	95	104	mV
FB pin bias current		10	45	100	nA
Supply current		-	1.9	2.5	mA
	$\overline{SHDN}$=0V	-	0.1	1.0	μA
Switching frequency		0.8	1.2	1.6	MHz
Maximum duty cycle		85	90	-	%
Switch current limit		-	320	-	mA
Switch V_{CESAT}	I_{SW} =250mA	-	350	-	mV
Switch leakage current	V_{SW} =5V	-	0.01	5	μA
$\overline{SHDN}$ voltage high		1.5	-	-	V
$\overline{SHDN}$ voltage low		-	-	0.4	V
$\overline{SHDN}$ pin bias current		-	65	-	μA

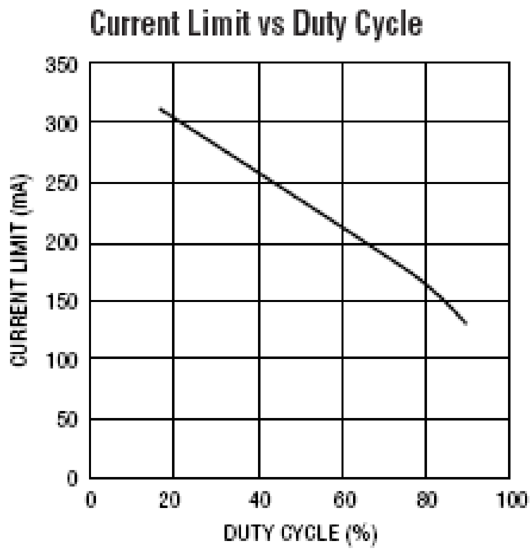
Note :

1. Absolute maximum ratings are those values beyond which the life of the device may be impaired.
2. The SM8237 is guatanteed to meet specification from 0 °C to 70 °C. Specification over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

1.2MHz STEP-UP CONVERTER

TYPICAL PERFORMANCE CHARACTERISTICS





FUNCTIONAL BLOCK DIAGRAM

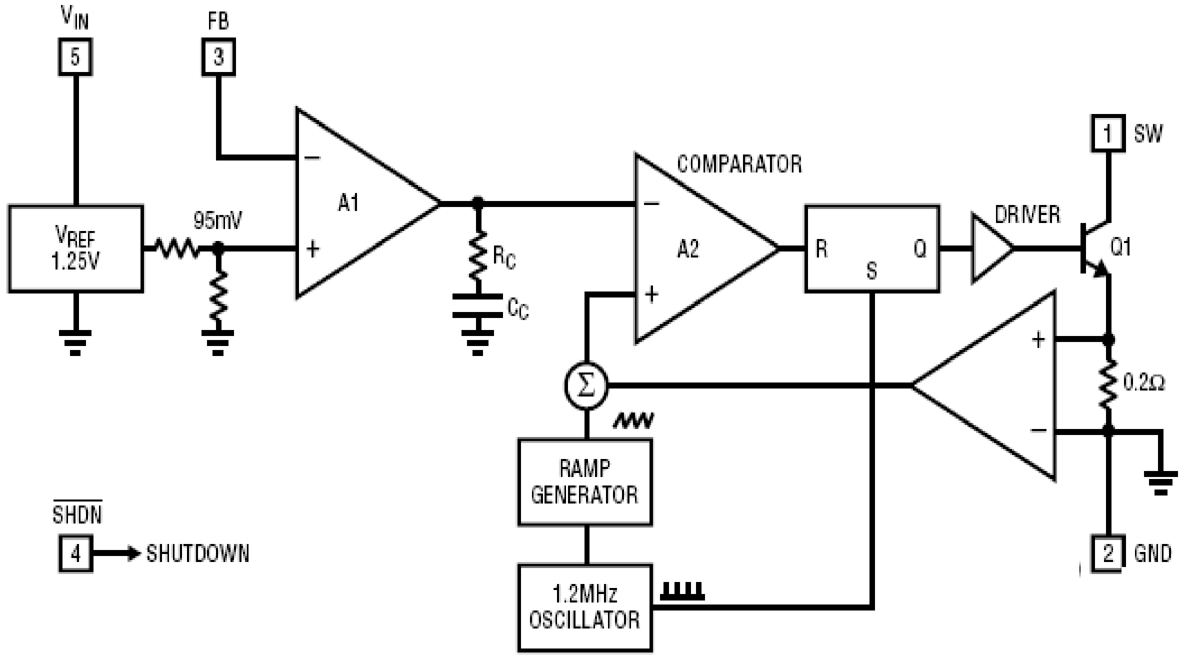
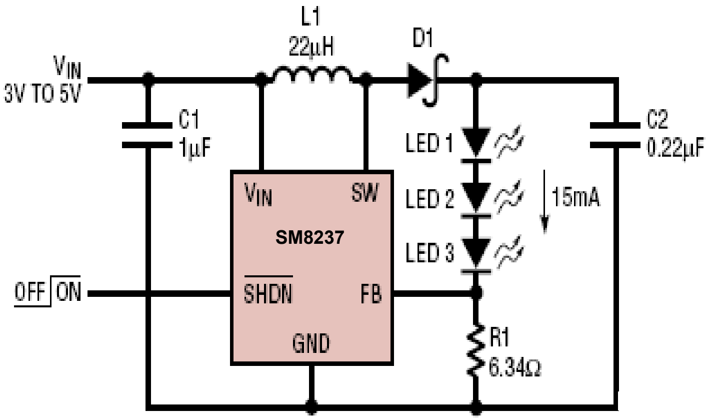
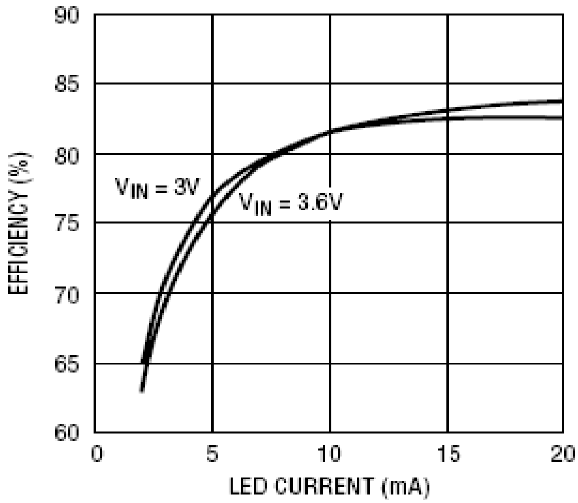


Figure 1. SM8237 function block diagram

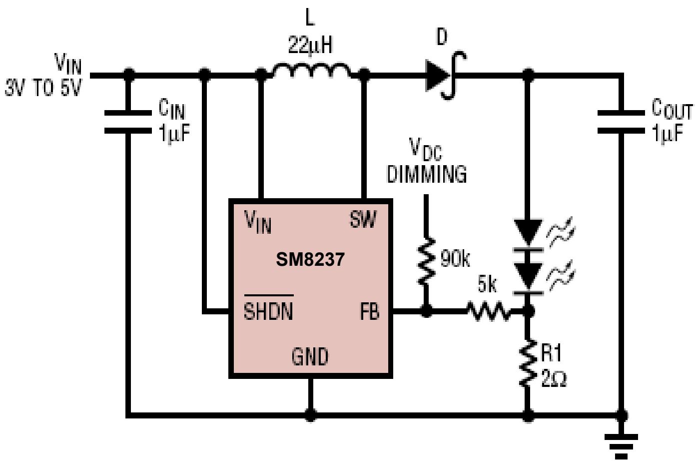
TYPICAL APPLICATION



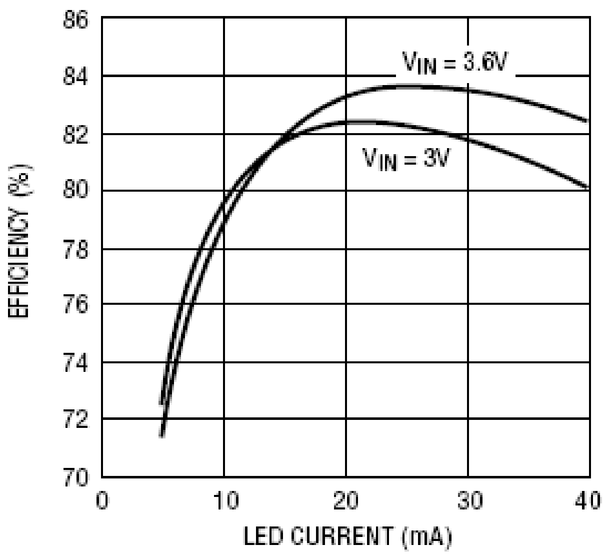
Conversion Efficiency



Li-Ion to Two White LEDs

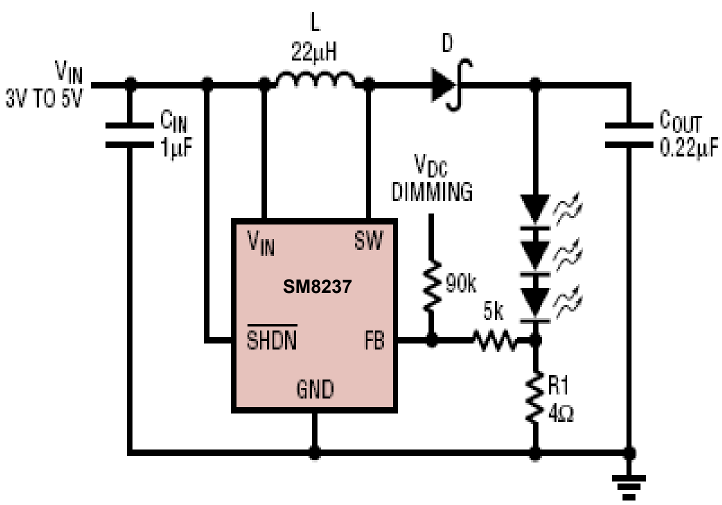


Two LED Efficiency

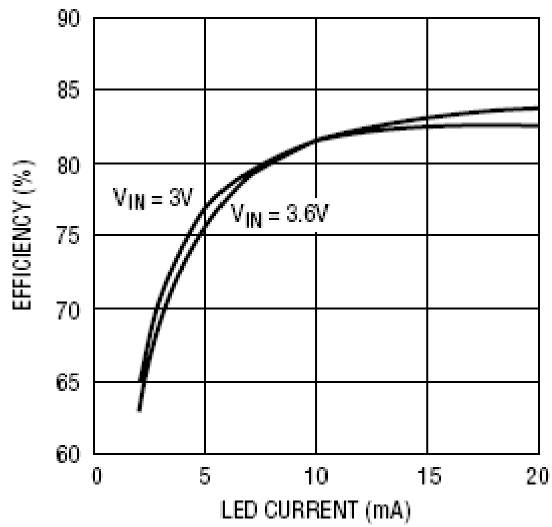


TYPICAL APPLICATION

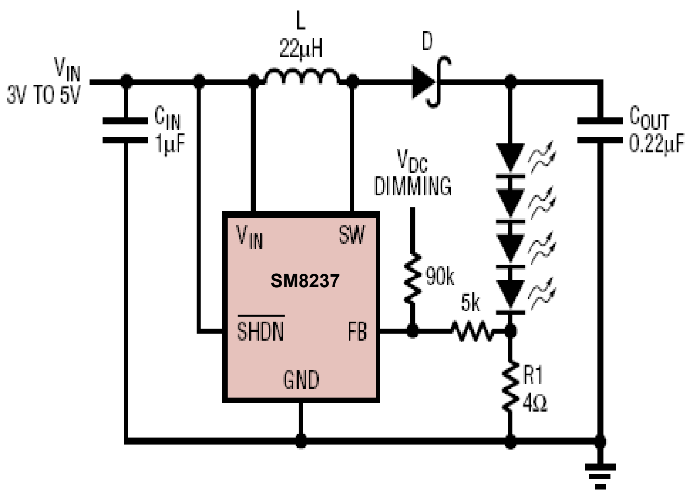
Li-Ion to Three White LEDs



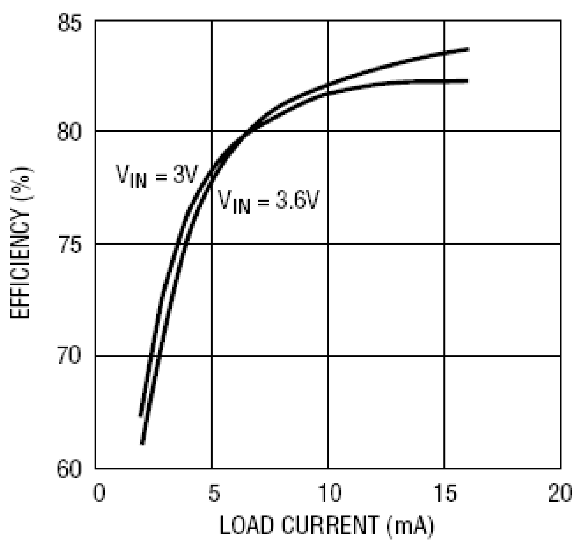
Three LED Efficiency



Li-Ion to Four White LEDs

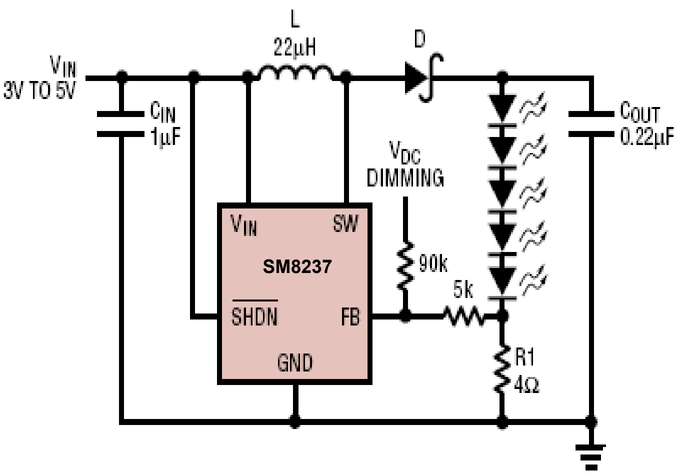


Four LED Efficiency

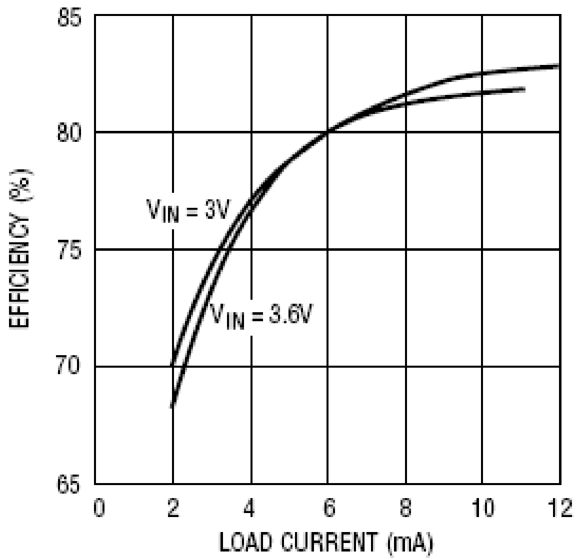


TYPICAL APPLICATION

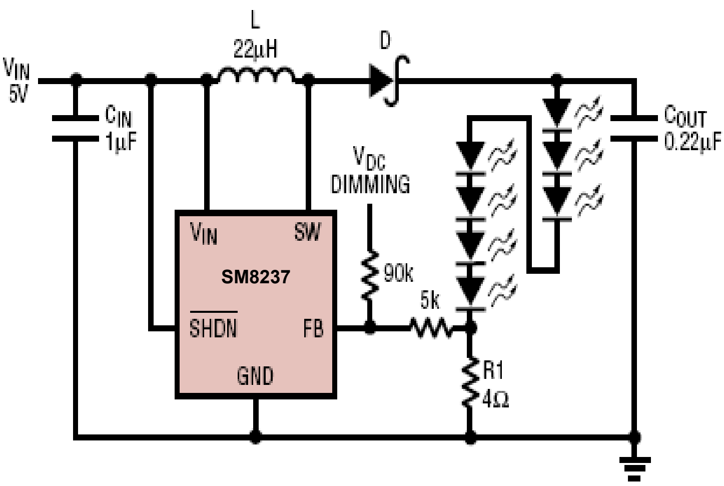
Li-Ion to Five White LEDs



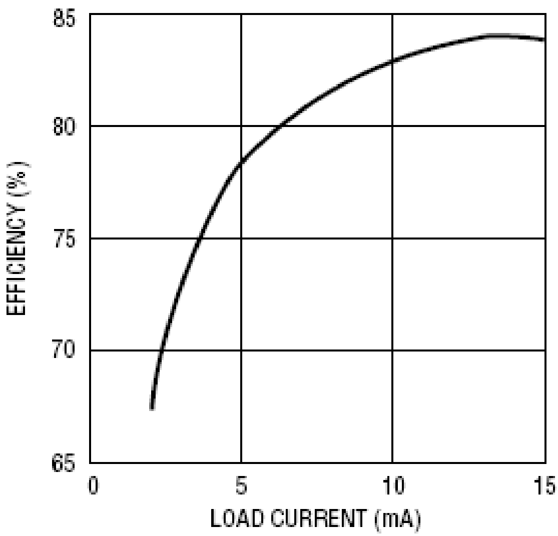
Five LED Efficiency



5V to Seven White LEDs



Seven LED Efficiency



OPERATION

The SM8237 uses 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 1. 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 pf 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

The SM8237 can regulate three series LEDs connected at low output currents, 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.

APPLICATIONS INFORMATION

Inductor selection

A 22u H inductor is recommended for most SM8237 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.

Capacitor selection

The small size of ceramic capacitors makes them ideal for SM8237 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 of SM8237 applicaiotns.

Diode selection

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for SM8237 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 SM8237. A Schottky diode rated at 100mA to 200mA is sufficient for most SM8237 applications.

Part number	DCR (Ω)	Current rating (mA)	Manufacturer
LQH3C220	0.71	250	Murata
ELJPC220KF	4.0	160	Panasonic
CDRH3D16-220	0.53	350	Sumida
LB2012B220M	1.7	75	Taiyo Yuden
LEM2520-220	5.5	125	Taiyo Yuden

Table 1. Recommended inductors

Part number	Forward current (mA)	Voltage drop (V)	Diode capacitance (pF)	Manufacturer
CMDSH-3	100	0.58 at 100mA	7.0 at 10V	Central
CMDSH2-3	100	0.49 at 200mA	15 at 10V	Central
BAT54	200	0.53 at 100mA	10 at 25V	Zetex

Table 2. Recommended Schottky diodes

APPLICATIONS INFORMATION

LED current control

The LED current is controlled by the feedback resistor. The feedback reference is 95mV. The LED current is 95 mV/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.

(1) R1 = 95 mV / I_{LED}

Table 1. R1 resistor value selection

ILED (mA)	R1 (Ω)
5	19.1
10	9.53
12	7.87
15	6.34
20	4.75

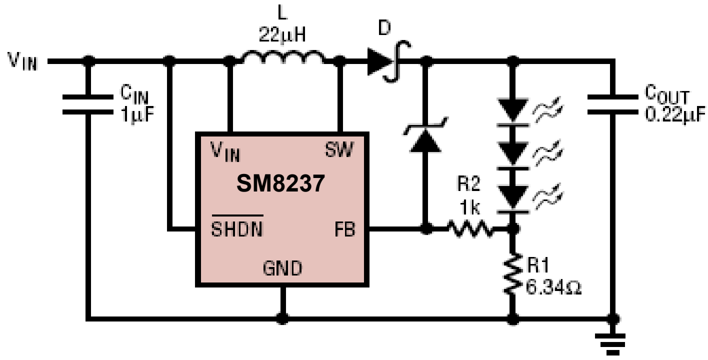


Figure 2. LED driver with open-circuit protection

Setting the output voltage for DC to DC Converter

Set the output voltage by selecting the resistive voltage divider ratio. Using 51 KΩ for the High-side resistor R_1 of the voltage divider. Determine the Low-side resistor R_2 according to the following formula:

$$R_2 = \frac{R_1 \cdot V_{FB}}{V_{out} - V_{FB}}$$

Where Vout is the output voltage for R_1= 51 KΩ and V_{FB} = 0.095 V, then R_2 (KΩ) = 4.845 / Vout -0.095

Please see the typical application on page 1.

Open-circuit protection

In the cases of output circuit, when the LEDs are disconnected from the circuit or the LEDs fail, the feedback voltage will be zero. The SM8237 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 2). The zener voltage should be larger than the maximum forward voltage of the LED string. The current rating zener should be larger than 0.1mA.

Dimming control

There are four different types of dimming control circuits:

1. Using a PWM signal to $\overline{\text{SHDN}}$ pin

With the PWM signal applied to the $\overline{\text{SHDN}}$ pin, the SM8237 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 SM8237 and corresponds to zero full 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 $\overline{\text{SHDN}}$ voltage high.

APPLICATIONS INFORMATION

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 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 curent. For V_{DC} range from 0V to 2V, the selection of resistors in figure 3 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 6.

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 5. 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 1.

Start-up and inrush current
To achieve minimum start-up delay, no internal soft-start circuit is included in SM8237. When first turned on without an external soft-start circuit, inrush current is about 200mA . If soft-start is desired, the recommended circuit and the waveforms are shown in figure 6. If both soft-start and dimming are used, a 10kHz PWM signal on SHDN is not recommended. Use a lower frequency or implement dimming through the FB pin as shown in figure 3,4 or5 .

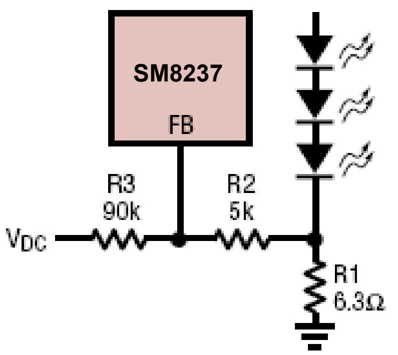


Figure 3 Dimming control using a DC voltage

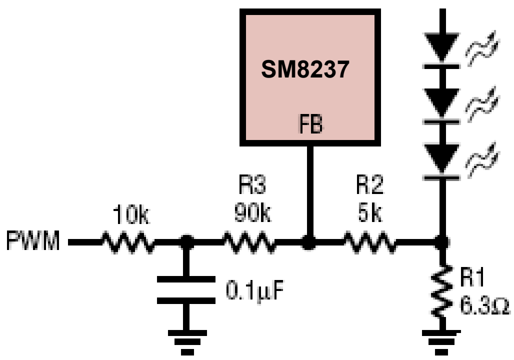


Figure 4. Dimming control using a filtered PWM control

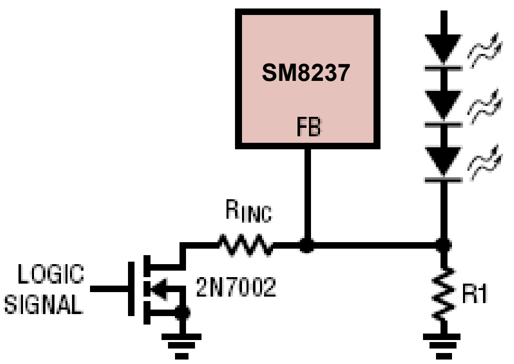


Figure 5. Dimming control using a logic signal

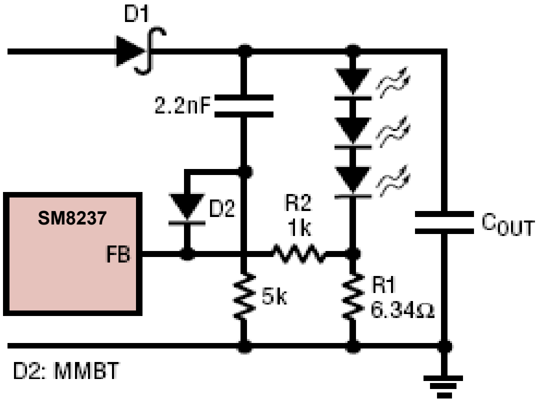
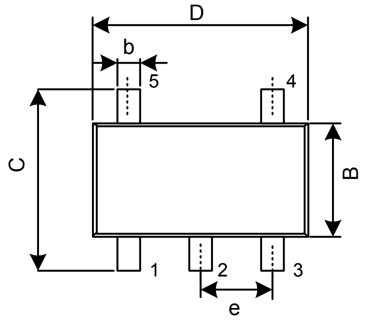


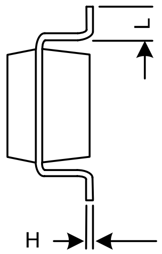
Figure 6. Recommended soft-start circuit

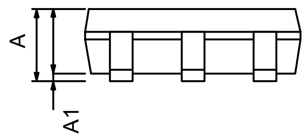
PACKAGE

SM8237 Surface Mount SOT-25

Unit : mm





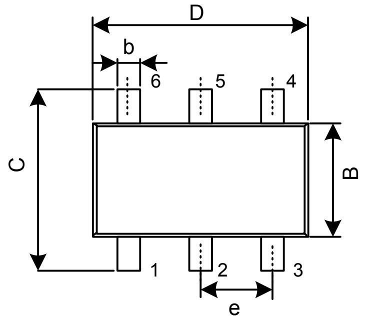


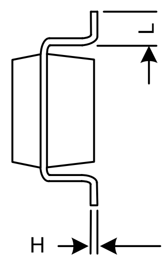
SYMBOL	MIN.	MOM.
A	0.889	1.295
A1	0.000	0.152
B	1.397	1.803
b	0.356	0.559
C	2.591	2.997
D	2.692	3.099
e	0.838	1.041
H	0.080	0.254
L	0.300	0.610

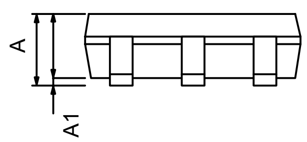
PACKAGE

SM8237 Surface Mount SOT-26

Unit : mm





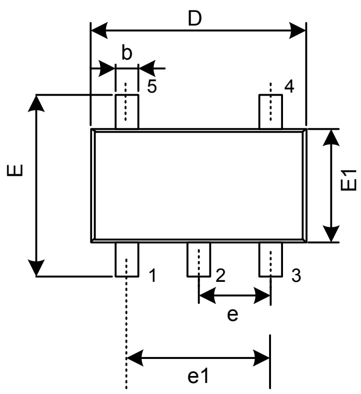


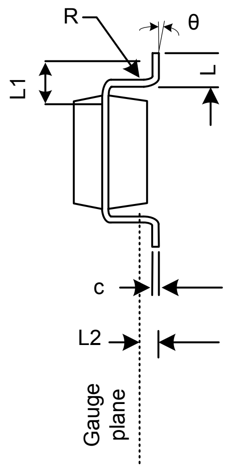
SYMBOL	MIN.	MOM.
A	0.889	1.295
A1	0.000	0.152
B	1.397	1.803
b	0.250	0.560
C	2.591	2.997
D	2.692	3.099
e	0.838	1.041
H	0.080	0.254
L	0.300	0.610

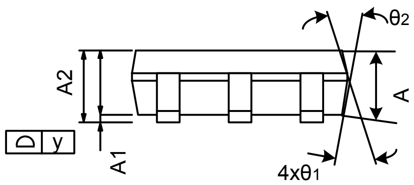
PACKAGE

SM8237 Surface Mount TSOT-25 (TSOT-23-5)

Unit : mm







SYMBOL	MIN.	MOM.	MOM.
A	0.75	-	0.90
A1	0.00	-	0.10
A2	0.70	0.75	0.80
b	0.35	-	0.51
c	0.10	-	0.25
D	2.80	2.90	3.00
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
e	0.95 BSC		
e1	1.90 BSC		
L	0.37	-	-
L1	0.60 REF		
L2	0.25 BSC		
y	-	-	0.10
R	0.10	-	-
θ	0°	-	8°
$θ_1$	7° Nom		
$θ_2$	5° Nom		