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White LED Step-Up Converter **PT6937**

DESCRIPTION

The PT6937 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 PT6937 switches at 1.2MHz, 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.
The PT6937 is available in a low profile SOT package.

FEATURES

- High efficiency: 85% Typical
- Drives up to four LEDs from a 3.3V supply
- Drives up to ten LEDs from a 5V supply
- Fast 1.2MHz switching frequency
- Uses tiny 22µH inductors
- Requires only 0.22µF output capacitor
- Low profile SOT package

APPLICATIONS

- Cellular phones
- PDAs, Handheld computers
- Digital cameras
- MP3 players
- GPS receivers

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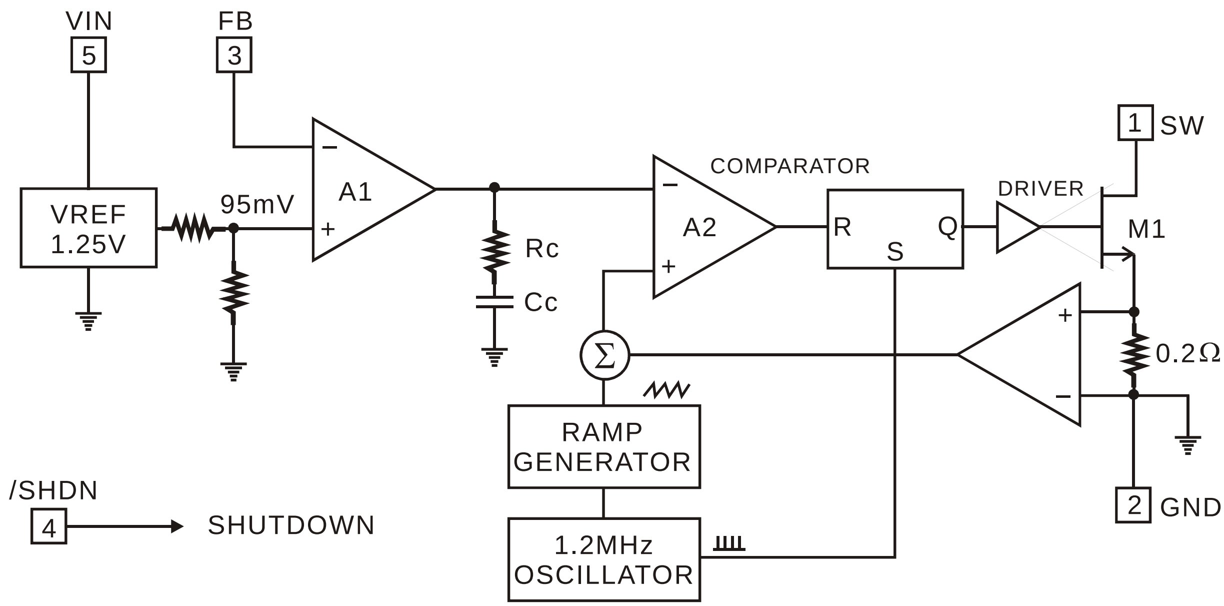
BLOCK DIAGRAM



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PIN DESCRIPTION

Pin Name	Description	Pin No.
SW	Switch Pin. Connect inductor/diode here. Minimize trace area at this pin to reduce EMI.	1
GND	Ground Pin. Connect directly to local ground plane.	2
FB	Feedback Pin. Reference voltage is 95mV. Connect cathode of lowest LED and resistor here. Calculate resistor value according to the formula: RFB=95mV/ILED	3
/SHDN	Shutdown Pin. Connect to 1.5V or higher to enable device; 0.4V or less to disable device.	4
VIN	Input Supply Pin. Must be locally bypassed.	5

APPLICATION INFORMATION

INDUCTOR SELECTION

A 22μH inductor is recommended for most PT6937 applications. Although small size and high efficiency are major concerns, the inductor should have low core losses at 1MHz and low DCR (copper wire resistance).

CAPACITOR SELECTION

The small size of ceramic capacitors makes them ideal for PT6937 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 PT6937 applications.

DIODE SELECTION

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for the PT6937 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the diode, while the diode capacitance (CT or CD) 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 PT6937. A Schottky diode rated at 100mA to 200mA is sufficient for most PT6937 applications.

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.

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

ILED (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 PT6937 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 33V rating. A zener diode can be used at the output to limit the voltage on the SW pin (Figure 1). The zener voltage should be larger than the maximum forward voltage of the LED string. The current rating of the zener should be larger than 0.1mA.

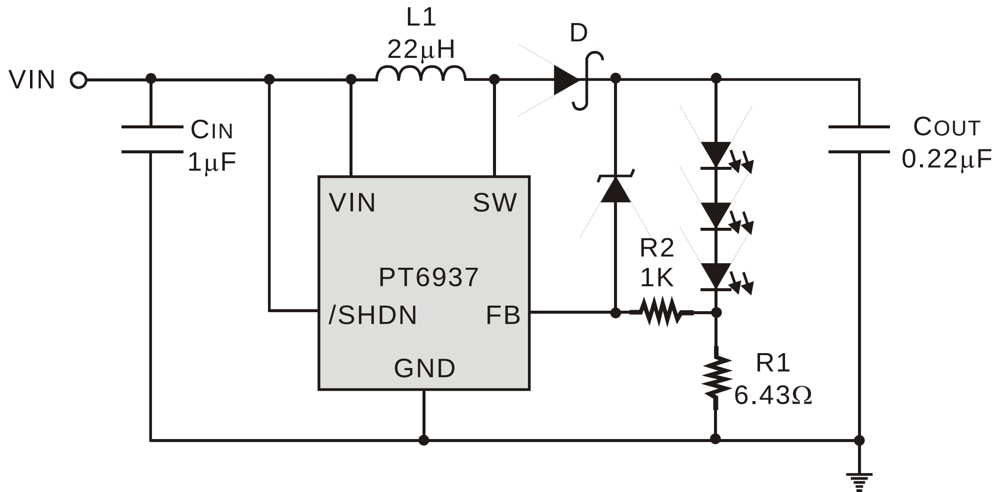

Figure1. LED driver with open-circuit protection

DIMMING CONTROL

There are four different types of dimming control circuits:

USING A PWM SIGNAL TO /SHDN PIN

With the PWM signal applied to the /SHDN pin, the PT6937 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 PT6937 and corresponds to zero LED current; and 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. The switching waveforms of the /SHDN pin PWM control are shown in the Figure 2 as below.

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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 the figure below. 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 5V, the selection of resistors in Figure 3 gives dimming control of LED current from 0mA to 15mA.

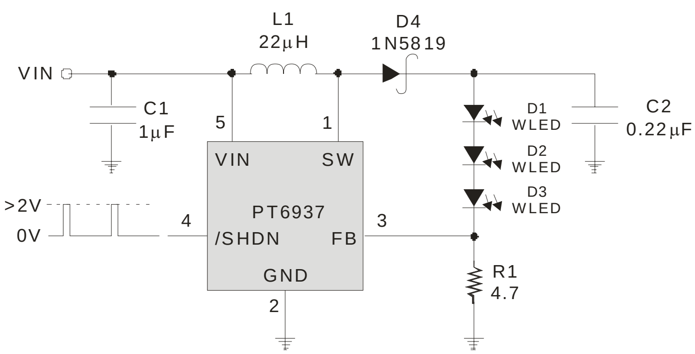


Figure 2. PWM Dimming control Using the /SHDN Pin

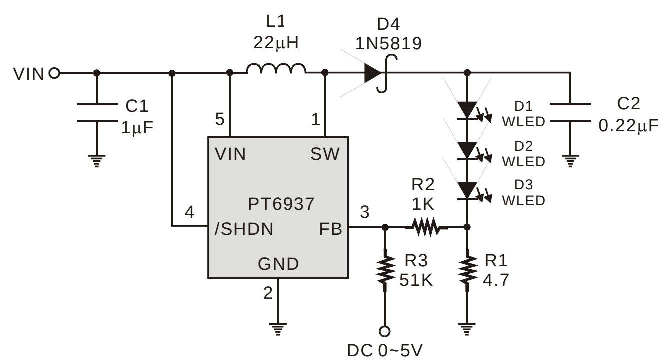


Figure 3. Dimming Control Using DC Voltage

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 4.

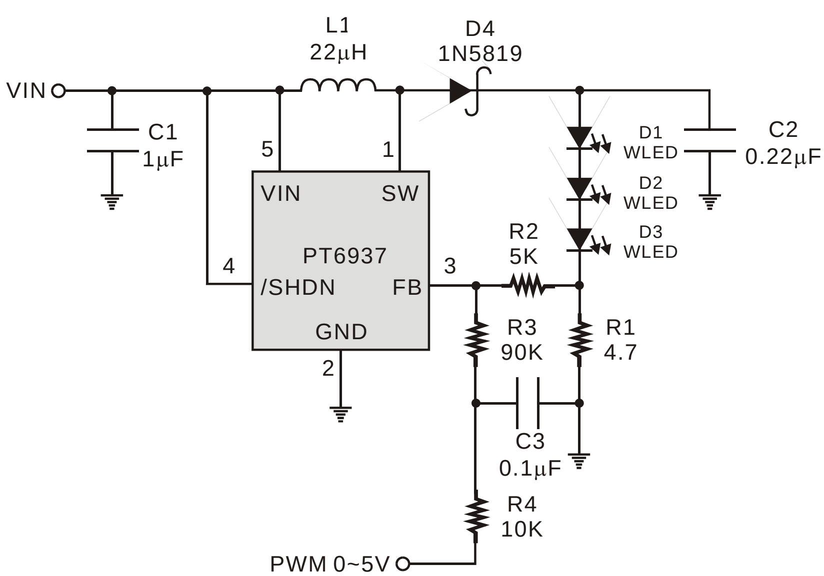
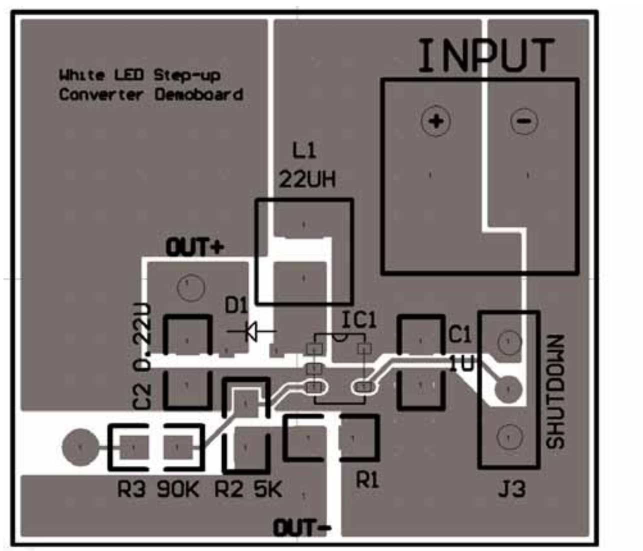


Figure 4. Dimming Control Using Filtered PWM Signal.

BOARD LAYOUT CONSIDERATION

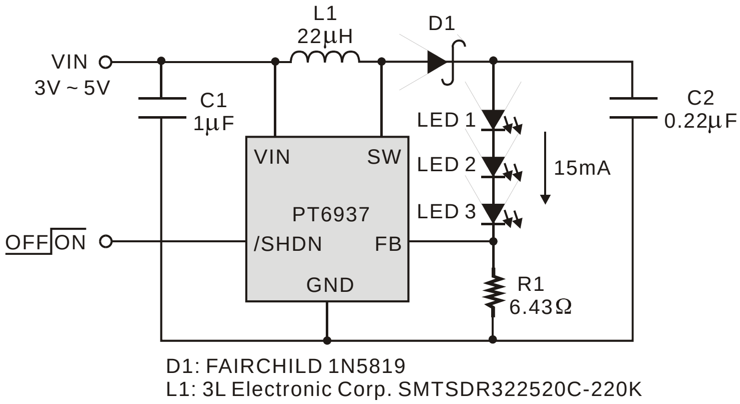
As with all switching regulators, careful attention must be paid to the PCB board layout and component placement. To maximize efficiency, switch rise and fall times are made as short as possible. To prevent electromagnetic interference (EMI) problems, proper layout of the high frequency switching path is essential. The voltage signal of the SW pin has sharp rise and fall edges. Minimize the length and area of all traces connected to the SW pin and always use a ground plane under the switching regulator to minimize inter-plane coupling. In addition, the ground connection for the feedback resistor R1 should be tied directly to the GND pin and not shared with any other component, ensuring a clean, noise-free connection. Recommended component placement is shown in Figure 5

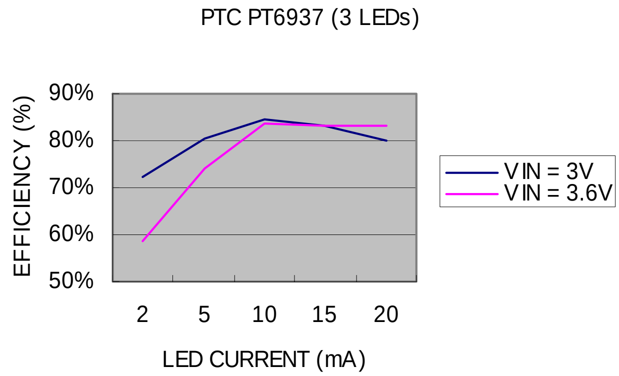


(SOT-23 Package)

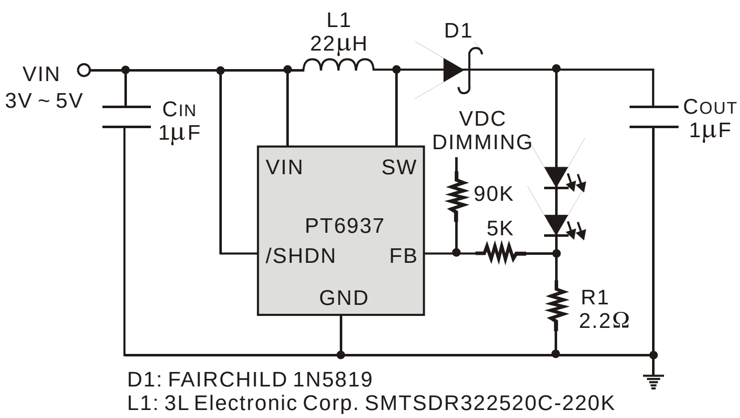
Figure 5. Recommended Component Placements

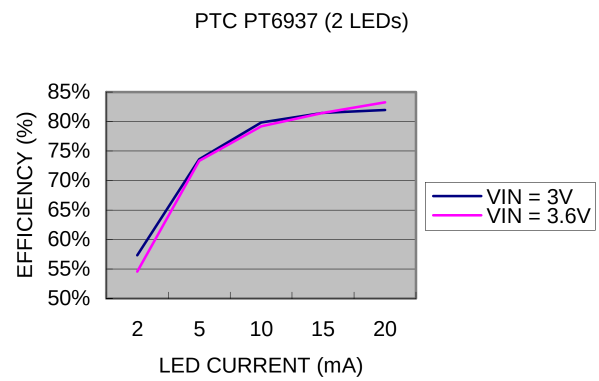
TYPICAL APPLICATIONS



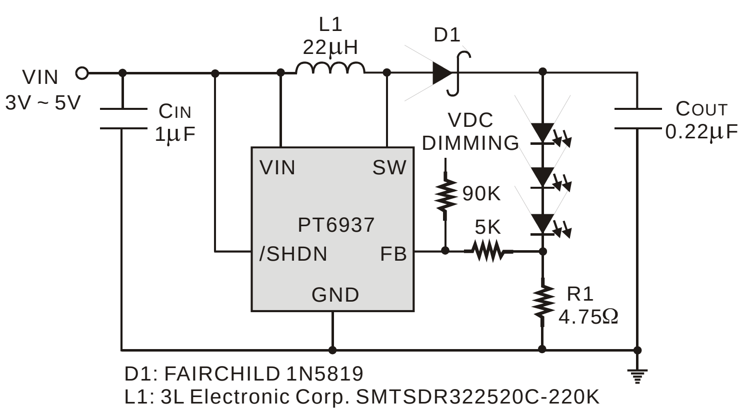


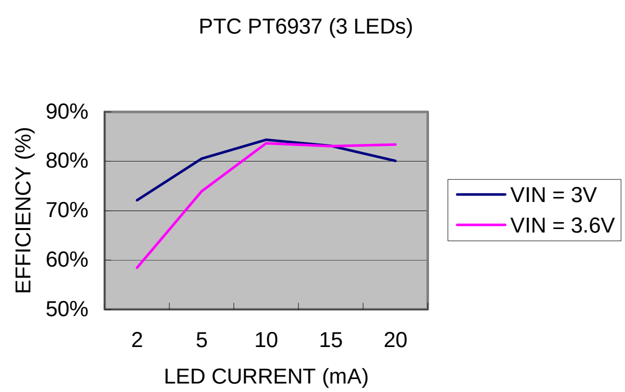
Li-Ion Powered Driver for Three White LEDs





Li-Ion to Two White LEDs





Li-Ion to Three White LEDs

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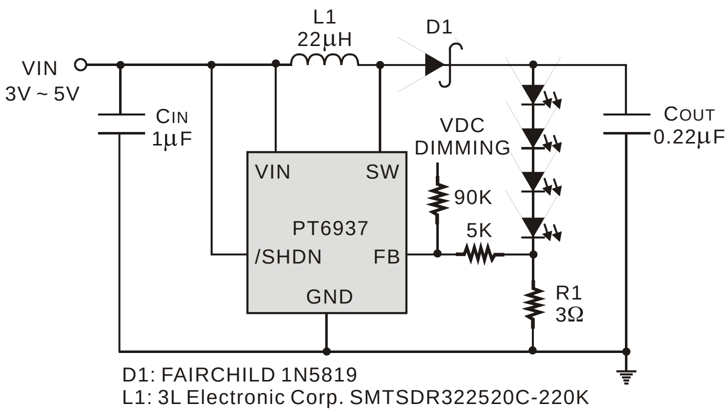
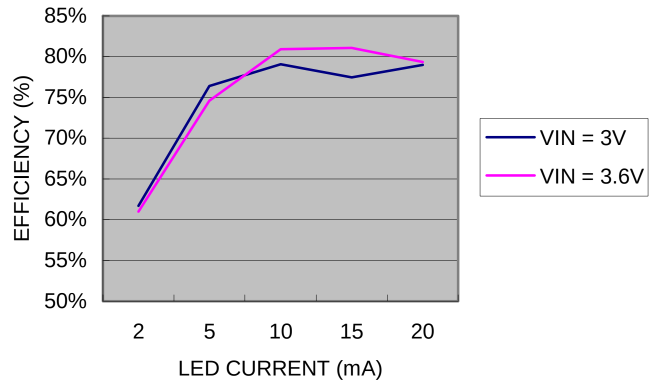
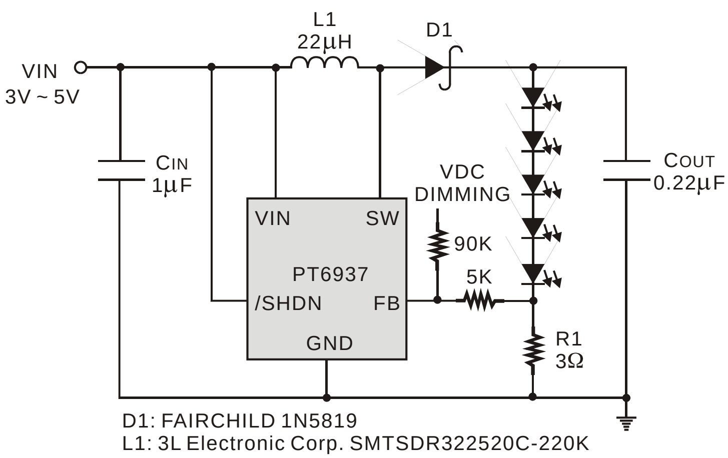
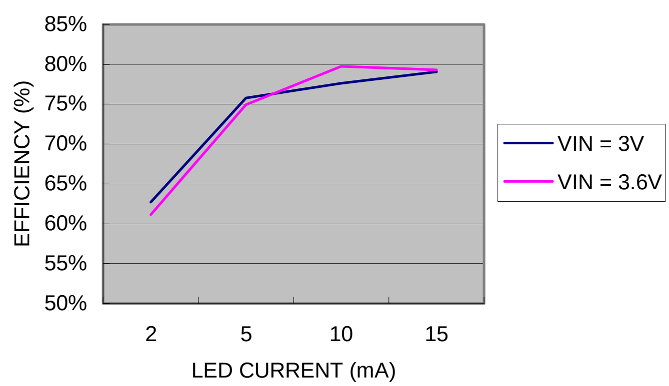


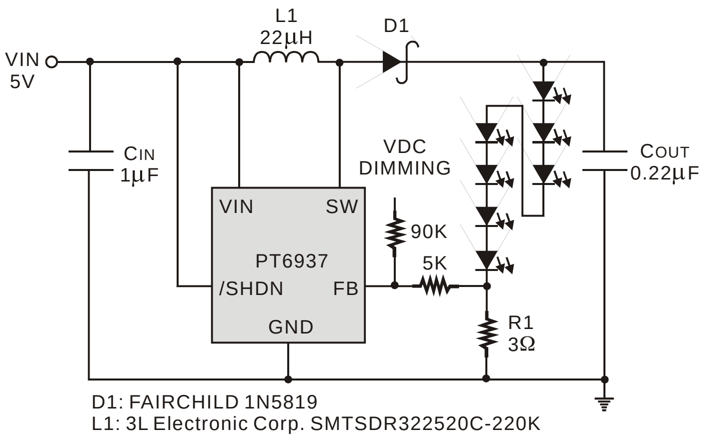


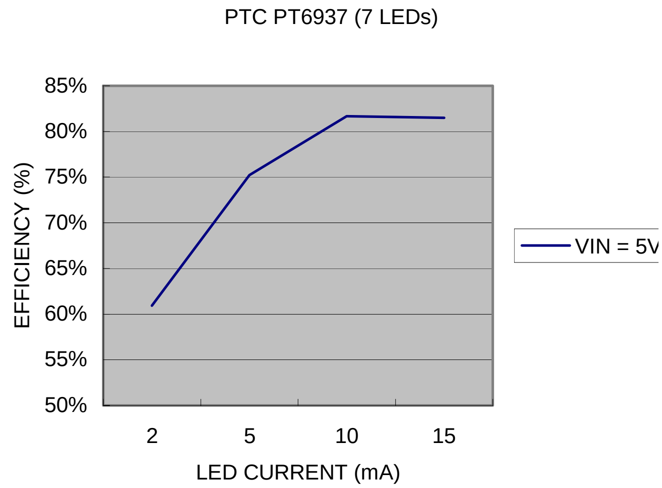
Li-Ion to Four White LEDs





Li-Ion to Five White LEDs





5V to Seven White LEDs

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ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Input voltage	VIN	5	V
SW voltage		33	V
FB voltage		5	V
/SHDN voltage		5	V
Operating temperature	Topr	-40 to +85	℃
Storage temperature	Tstg	-65 to +150	℃
Maximum junction temperature		125	℃
Lead temperature (Soldering, 10 sec.)		300	℃

Note:
Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

ELECTRICAL CHARACTERISTICS

(unless otherwise specified, Ta=25℃, VIN=3V, V /SHDN=3V,.

Parameter	Conditions	Min.	Typ.	Max.	Unit
Minimum operating voltage		2.5			V
Maximum operating voltage				5.5	V
Feedback voltage	ISW=100mA, Duty cycle=66%	86	95	104	mV
FB pin bias current			5	10	nA
Supply current	 /SHDN=0V		0.8 0.1	1.2 1.0	mA µA
Switching frequency		0.8	1.2	1.6	MHz
Maximum duty cycle		84	87	90	%
Switch current limit		300	350	400	mA
Switch VCESAT	ISW=250mA		350	380	mV
Switch leakage current	VSW=30V		0.1	1	µA
/SHDN voltage high		1.3	-	-	V
/SHDN voltage low				0.5	V
/SHDN pin bias current			20	30	µA

Note:
The PT6937 is guaranteed to meet specifications from 0℃ to 70℃. Specifications over the -40℃ to 85℃ operating temperature range are assured by design, characterization and correlation with statistical process controls.

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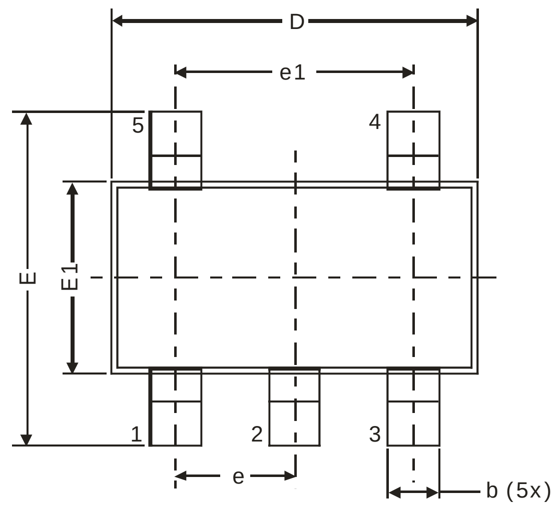
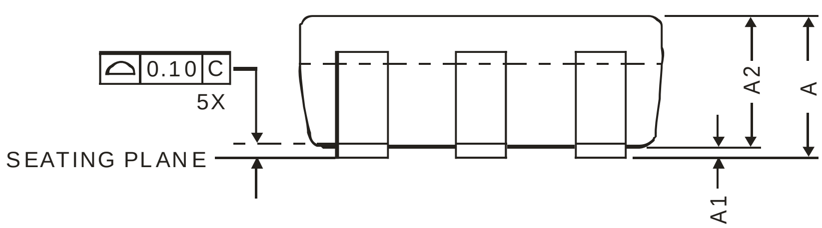
ORDER INFORMATION

Valid Part Number	Package	Top Code
PT6937	5 Pins, SOT	PT6937

PACKAGE INFORMATION

5 PINS, SOT-23





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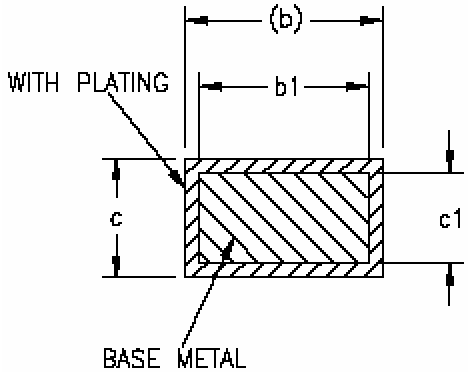
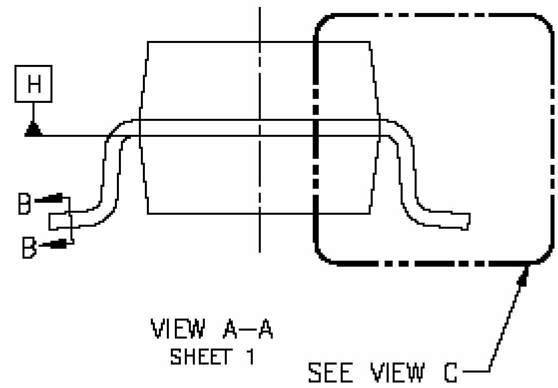
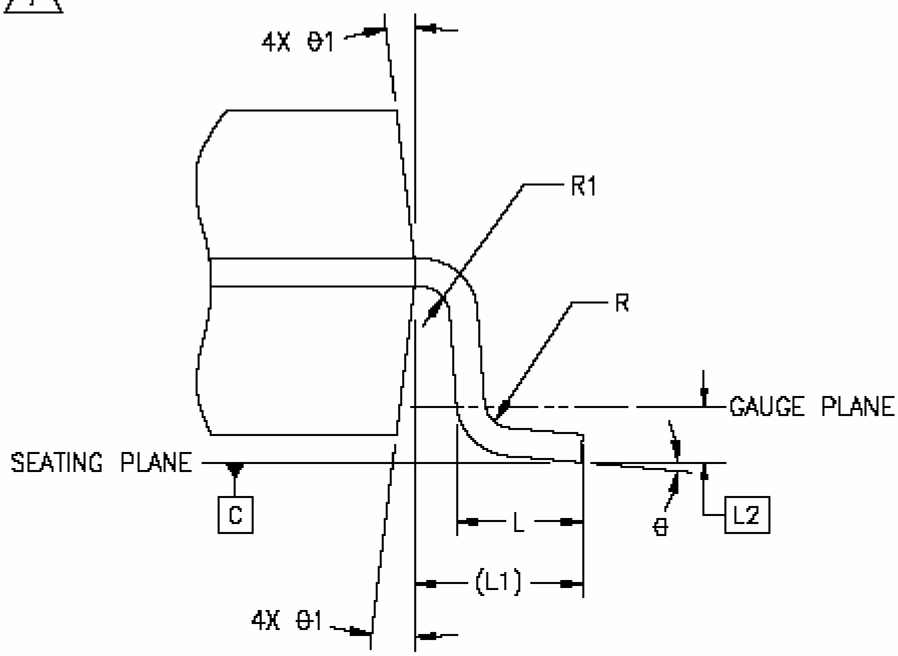
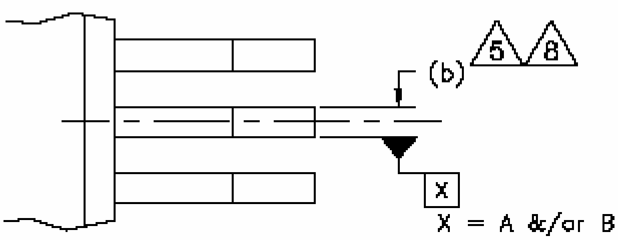


SECTION B-B

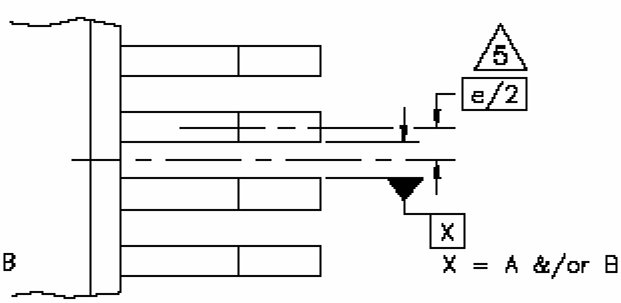




VIEW C



ODD LEAD SIDES
TOPVIEW



EVEN LEAD SIDES
TOPVIEW

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Symbol	Min.	Typ.	Max.
A	-	-	1.45
A1	0	-	0.15
A2	0.90	1.15	1.30
b	0.30	-	0.50
b1	0.30	0.40	0.45
c	0.08	-	0.22
c1	0.08	0.13	0.20
D	2.90 BSC.		
E	2.80 BSC.		
E1	1.60 BSC.		
e	0.95 BSC.		
e1	1.90 BSC.		
L	0.30	0.45	0.60
L1	0.60 REF.		
L2	0.25 BSC.		
R	0.10	-	-
R1	0.10	-	0.25
θ	0°	4°	8°
θ1	5°	10°	15°

Notes:
1. Dimension and tolerancing per ASME Y14.5M-1994.
2. Dimension in Millimeters.
3. Dimension D does not include mold flash, protrusion or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.25mm per end. Dimension E1 does not include interlead flash or protrusion. Interlead flash or protrusion shall not exceed 0.25mm per side. D and E1 dimensions are determined at datum H.
4. 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. D and E1 dimensions are determined at datum H.
5. Datums A & B to be determined at datum H.
6. Package variation “AA” is a 5 lead version of the 6 lead variation “AB” where lead #5 removed from the 6 lead “AB” variation.
7. These dimensions apply to the flat section of the lead between 0.08mm and 0.15mm from the lead tip.
8. Dimension “b” does not include dambar protrusion. Allowable dambar protrusion shall be 0.08mm total in exceed of the “b” dimension at maximum material condition. The dambar cannot be located on the lower radius of the foot. Minimum space between protrusion and an adjacent lead shall not be less than 0.07mm.
9. Details of the pin 1 identifier are optional, but must be located within the zone indicated.
10. Refer to JEDEC MO-178 Variation AA

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