

### Description

The GM1937 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 output capacitor can be as small as 0.22 $\mu$ F, saving space versus alternative solutions. A low 95mV feedback voltage minimizes power loss for better

### 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 0.22 F Output Capacitor
- ◆ Low profile TSOT package

### Application

Cellular Phones

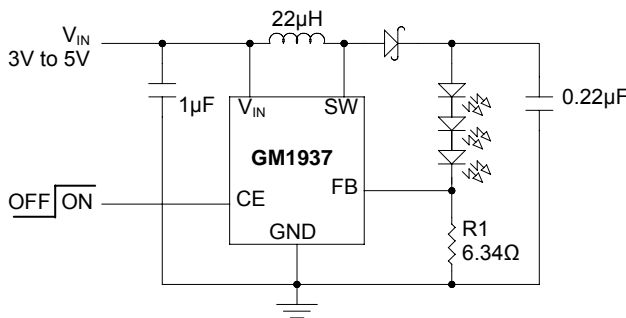
PDA, Handheld Computers

Digital Cameras

MPS3 Players

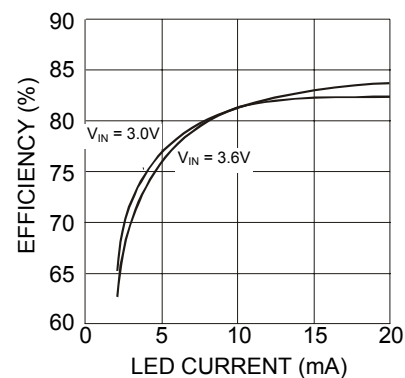
GPS Receivers

### Typical Application Circuits



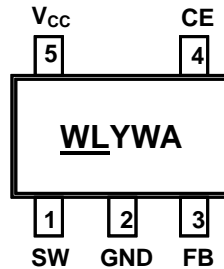
**Figure 1**

Li-Ion Powered Driver for Three White LEDs



### Marking Information and Pin Configurations (Top View)

SOT25



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

### Pin Descriptions

Pin Number	Pin Name	Pin Function
1	SW	Switch Pin, (Minimize trace area at this pin to reduce EMI.)
2	GND	Ground
3	FB	Feedback Pin. Reference voltage is 95 mV. (Calculate resistor value according to the formula $R_{FB}=95 \text{ mV} / I_{LED}$ .)
4	CE	Shutdown Pin (Connect to 1.5 V or higher to enable device; 0.4 V or less to disable device)
5	V <sub>CC</sub>	Input Supply Pin. (Must be locally bypassed)

### Order Information

Ordering Number	Package	Shipping
GM1937ST25RG	SOT-25	3,000 Units/Tape and Reel

### Absolute Maximum Ratings

PARAMETER	SYMBOL	RATINGS	UNITS
Input Voltage	$V_{IN}$	10	V
SW Voltage		36	V
FB Voltage		10	V
CE Voltage		10	V
Continuous Total Power Dissipation	SOT-25 $P_D$	300	mW
Operating Ambient Temperature	$T_A$	- 40 to 85	
Storage Temperature	$T_{stg}$	- 65 to 150	
Lead Temperature (Soldering, 10 sec)		+ 300	

### Block Diagram

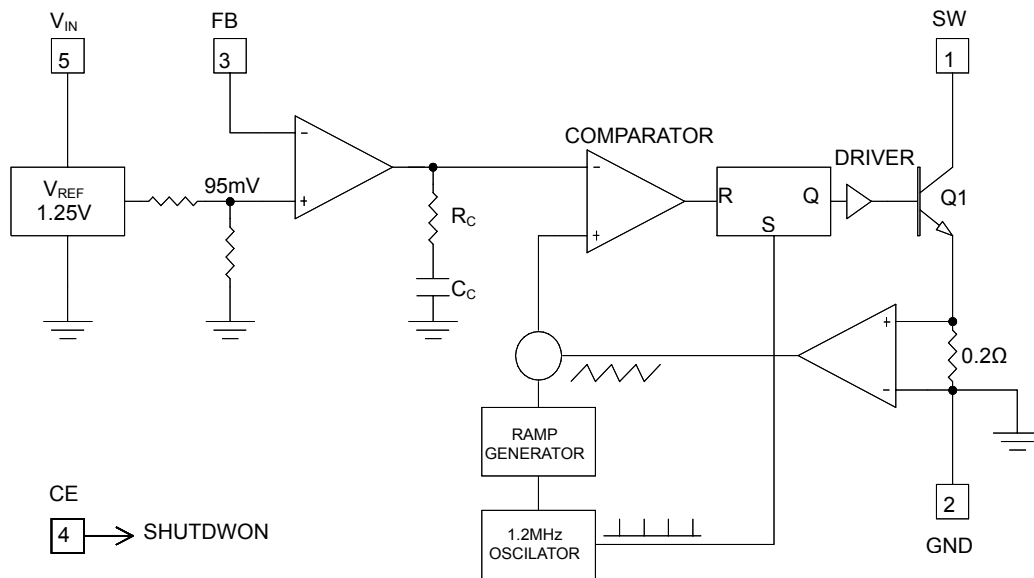


Figure 2

### Electrical Characteristics ( $T_A = 25^\circ\text{C}$ , $V_{CC} = 3\text{V}$ , $V_{CE} = 3\text{V}$ , unless otherwise noted)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Feedback Voltage	$V_{FB}$	$I_{SW} = 100\text{mA}$ , Duty Cycle = 66%	86	95	104	mV
FB Pin Bias Current	$I_{FB}$		10	45	100	nA
Supply Current	$I_{CC(ON)}$			1.9	2.5	mA
	$I_{CC(OFF)}$	$V_{CE} = 0\text{V}$		0.1	1.0	$\mu\text{A}$
Switching Frequency	$f_{SW}$		0.8	1.2	1.6	MHz
Maximum Duty Cycle	$D_{MAX}$		85	90		%
Switch Current Limit	$I_{SW}$			320		mA
Switch $V_{CESAT}$	$V_{SAT}$	$I_{SW} = 250\text{mA}$		350		mV
Switch Leakage current	$I_{LEAK}$	$V_{SW} = 5\text{V}$		0.00 1	5	$\mu\text{A}$
CE Voltage High			1.5			V
CE Voltage Low					0.4	V
CE Pin Bias Current	$I_{CE}$			65		$\mu\text{A}$

### Application Information

#### Operation

GM1937 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

GM 1937 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 GM1937 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 ( $\Omega$ )	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 GM1937 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 1 $\mu$ F input capacitor and a 0.22 $\mu$ F output capacitor are sufficient for most GM1937 applications.

### Application Information – Cont'd

#### Diode Selection

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for GM1937 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 LT1937K. A Schottky diode rated at 100mA to 200mA is sufficient for most GM1937 applications. Some recommended Schottky diodes are listed in Table 2.

**Table 2. Recommended Schottky 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. R1 Resistor Value Selection**

$I_{LED}$ (mA)	R1 ( $\Omega$ )
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 GM1937 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 than 0.1mA.

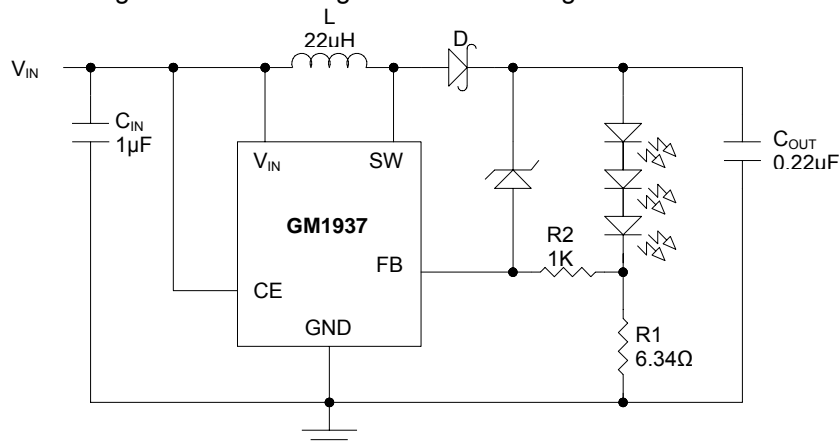


Figure 3. LED Driver with Open-Circuit Protection

## Application Information – Cont'd

### 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 GM1937 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 GM1937 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.

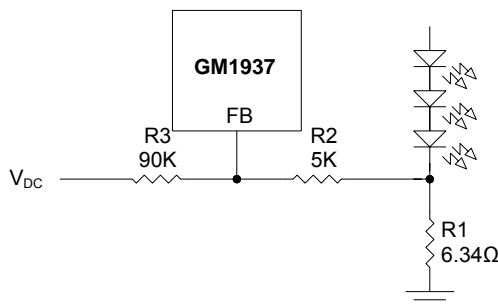


Figure 4. Dimming Control Using a DC Voltage

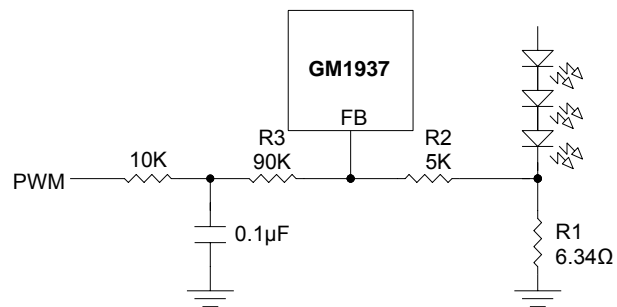


Figure 5. Dimming Control Using a Filtered PWM Signal

#### 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.

#### 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). 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

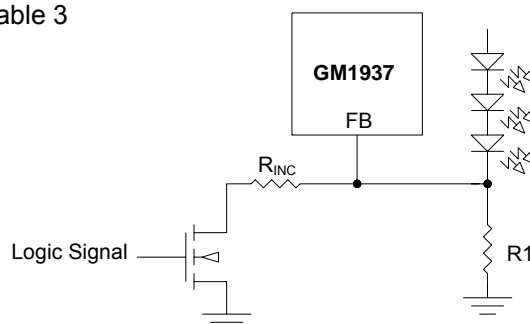
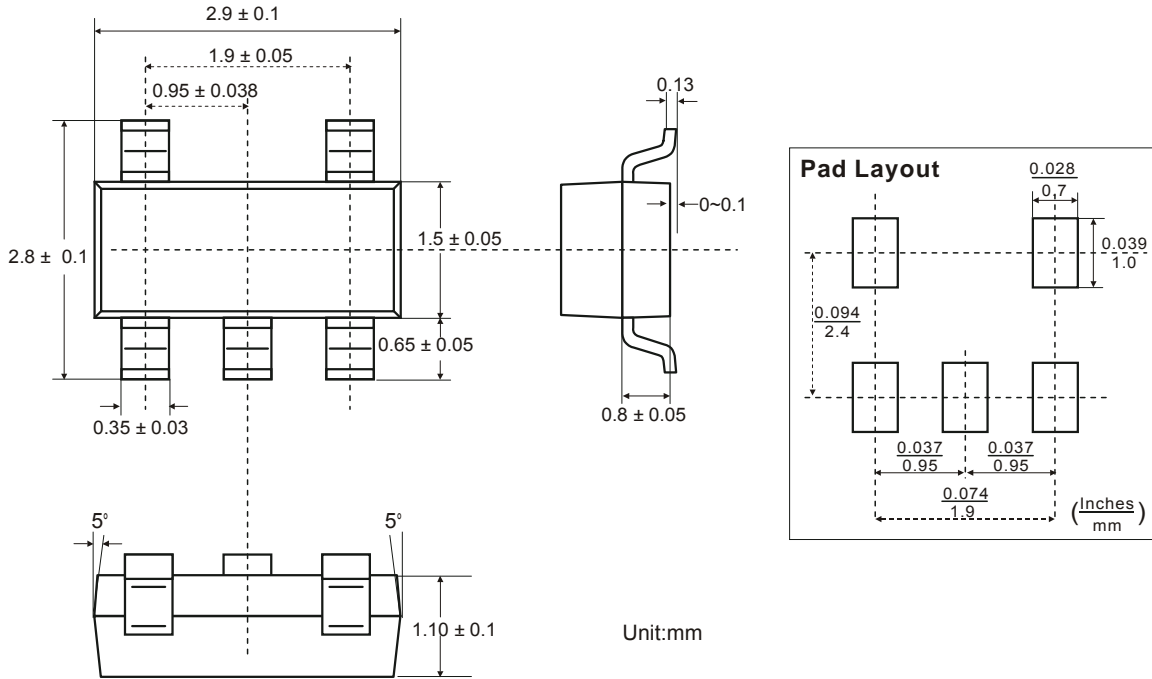


Figure 6. Dimming Control Using a Logic Signal

## Package Outline Dimensions – SOT 25





### Ordering Number

**GM 1937 ST25 R G**

APM Gamma Micro	Circuit Type	Package Type  ST25: SOT 25	Shipping Type  R: Tape & Reel	Blank: Pb-free G:Green
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Note:

**Pb-free products:**

- ◆ RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- ◆ Suitable for use in SnPb or Pb-free soldering processes with 100% matte tin (Sn) plating.

**Green products:**

- ◆ Lead-free (RoHS compliant)
- ◆ Halogen free(Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight)