

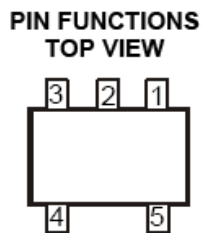
Features

- Inherently Matched LED Current
- High Efficiency: 84% Typical
- Drives Up to Four LEDs from a 3.2V Supply
- Drives Up to Six LEDs from a 5V Supply
- 36V Rugged Bipolar Switch
- Fast 1.2MHz Switching Frequency
- Uses Tiny 1mm Tall Inductors
- Requires Only 0.22μF Output Capacitor

Applications

- Cellular Phones
- PDAs, Handheld Computers
- Digital Cameras
- MP3 Players
- GPS Receivers

Package Pin Out



General Description

The LD6101 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 0.22μF, saving space versus alternative solutions. A low 95mV feedback voltage minimizes power loss for better efficiency.

Ordering Information

| Part No. | Package | Packing Options | |
|----------|---------|-----------------|------------------|
| | | Tube (TU) | Tape & Reel (TR) |
| LD6101 | SOT23-5 | LD6101L2-TU | LD6101L2-TR |

- Package material default is "Green" package.

Product Marking

| | |
|--------------------|--|
| LD8888 SSSSS... | ◇ Line 1 – "LD" is a fixed character 8888: product name |
| ● | ◇ Line 2 – SSSSS...: lot number |

Absolute Maximum Ratings

| Parameter | Maximum | Unit |
|--------------------------------------|------------|------|
| Input Voltage (VIN) | 10 | V |
| SW Voltage | 36 | V |
| FB Voltage | 10 | V |
| $\overline{\text{SHDN}}$ Voltage | 10 | V |
| Operating Temperature Range | -40 to 85 | °C |
| Maximum Junction Temperature | 125 | °C |
| Storage Temperature Range | -65 to 150 | °C |
| Lead Temperature (Soldering, 10 sec) | 300 | °C |

The values beyond the boundaries of absolute maximum rating may cause the damage to the device. Functional operation in this context is not implied. Continuous use of the device at the absolute rating level might influence device reliability. All voltages have their reference to device ground.

Electrical Characteristics

T_A = 25°C, V_{IN} = 3V, V_{SHDN} = 3V, unless otherwise noted.

| Parameter | 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 | mA |
| FB Pin Bias Current | | 10 | 45 | 100 | nA |
| Supply Current | | – | 1.9 | 2.5 | mA |
| | $\overline{\text{SHDN}}$ = 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} | | – | 350 | – | mV |
| Switch Leakage Current | V _{sw} = 5V | – | 0.01 | 5 | μA |
| $\overline{\text{SHDN}}$ Voltage High | | 1.5 | – | – | V |
| $\overline{\text{SHDN}}$ Voltage Low | | – | – | 0.4 | V |
| $\overline{\text{SHDN}}$ Pin Bias Current | | – | 65 | – | μA |

Pin Description

| Name | Description |
|--------------------------|---|
| SW | Switch Pin. (Minimize trace area at this pin to reduce EMI.) |
| GND | Ground Pin. Connect directly to local ground plane. |
| FB | Feedback Pin. Reference voltage is 95 mV. (Calculate resistor value according to the formula: RFB=95 mV / ILED.) |
| $\overline{\text{SHDN}}$ | Shutdown Pin. (Connect to 1.5 V or higher to enable device; 0.4 V or less to disable device.) |
| VIN | Input Supply Pin. (Must be locally bypassed.) |

Block Diagram

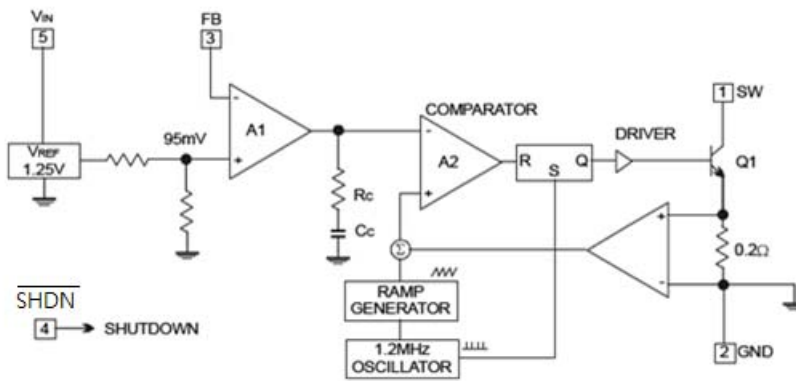


Figure 1. BLOCK DIAGRAM LD6101

Typical Application Circuit

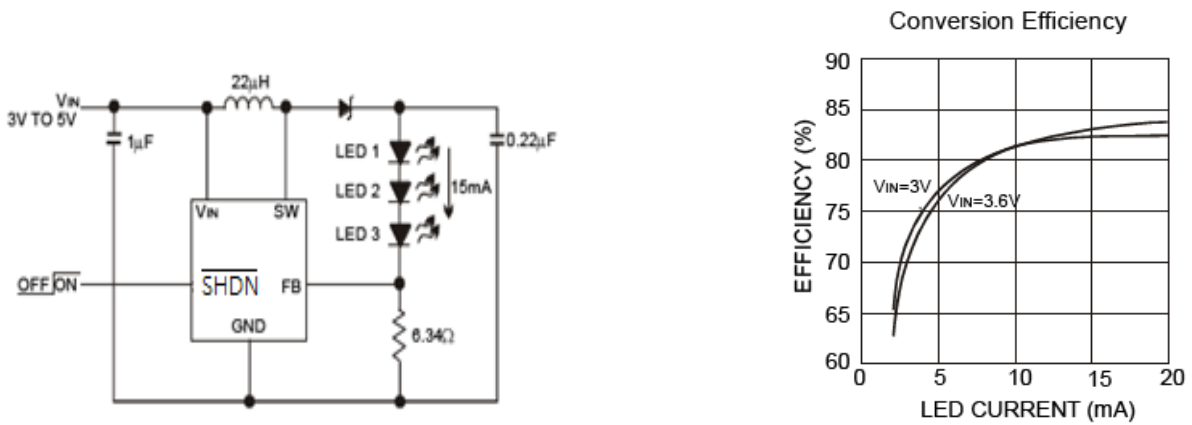


Figure 2. Li-Ion Powered Driver for Three White LEDs

OPERATION

The LD6101 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 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

The LD6101 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 22mH inductor is recommended for most LD6101 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 |
| ELJPC220KF | 4.0 | 160 | Panasonic |
| CDRH3D16-220 | 0.53 | 350 | Sumida |
| LB2012B220M | 1.7 | 75 | Taiyo Yuden |
| LEM2520-220 | 5.5 | 125 | Taiyo Yuden |

Capacitor Selection

The small size of ceramic capacitors makes them ideal for LD6101 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 LD6101 applications. Recommended Ceramic Capacitor Manufacturers: Taiyo Yuden, AVX, Murata, Kemet.

Diode Selection Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for LD6101 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 LD6101. A Schottky diode rated at 100mA to 200mA is sufficient for most LD6101 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 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 |

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 3 for R1 selection are shown below. $R1 = 95mV/I_{LED}$

Table 3. R1 Resistor Value Selection ILED (mA) R1(Ω)

| 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 LD6101 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.

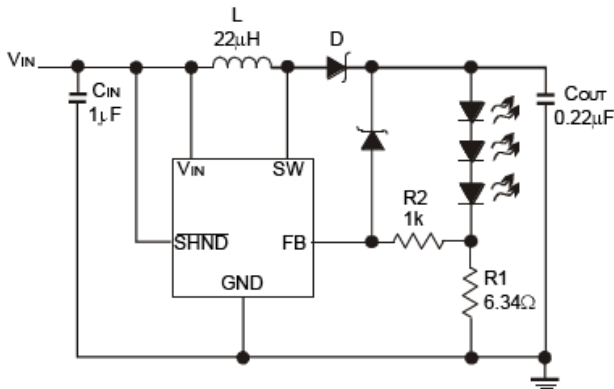


Figure 3. LED Driver with Open-Circuit Protection

Dimming Control

There are some different types of dimming control circuits:

1. Using a PWM Signal to SHDN Pin With the PWM signal applied to the SHDN pin, the LD6101 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 LD6101 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 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.

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.

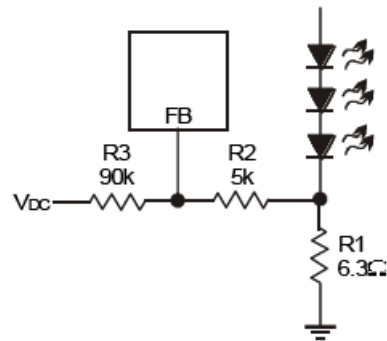


Figure 4. Dimming Control Using a DC Voltage

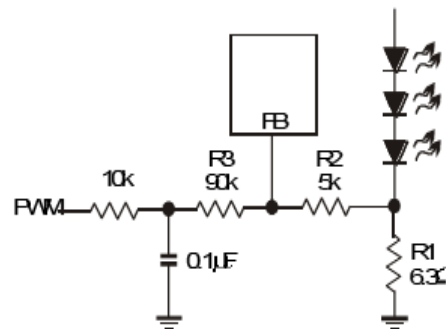
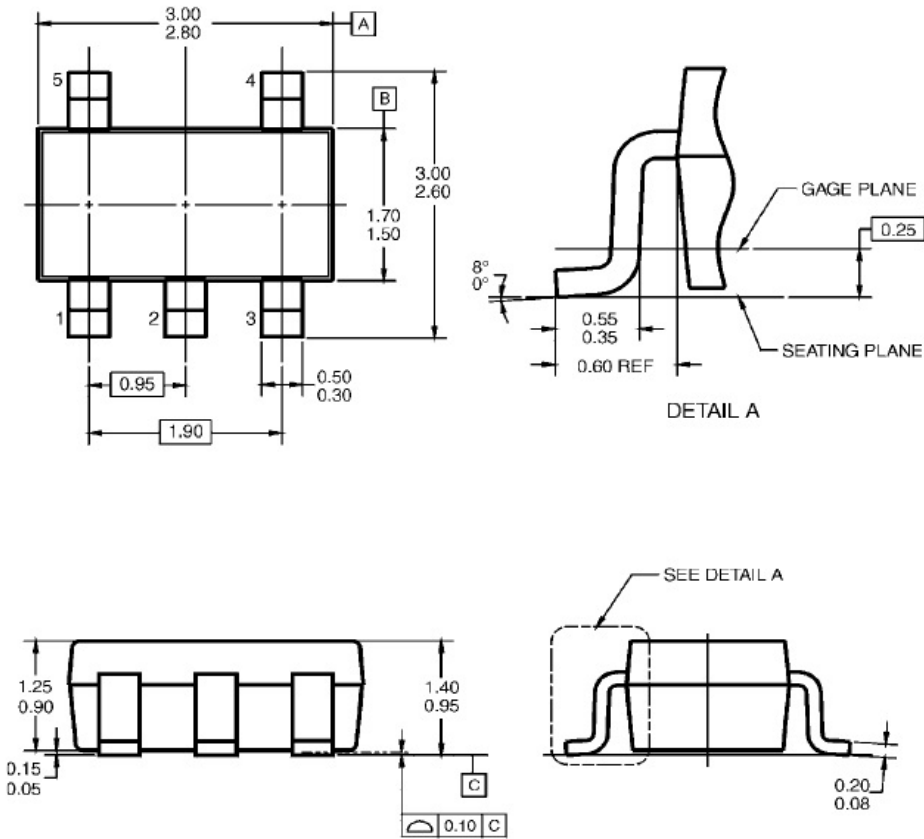


Figure 5. Dimming Control Using a Filtered PWM Signal

Package Outline
SOT23-5:



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