BLOCK DIAGRAM

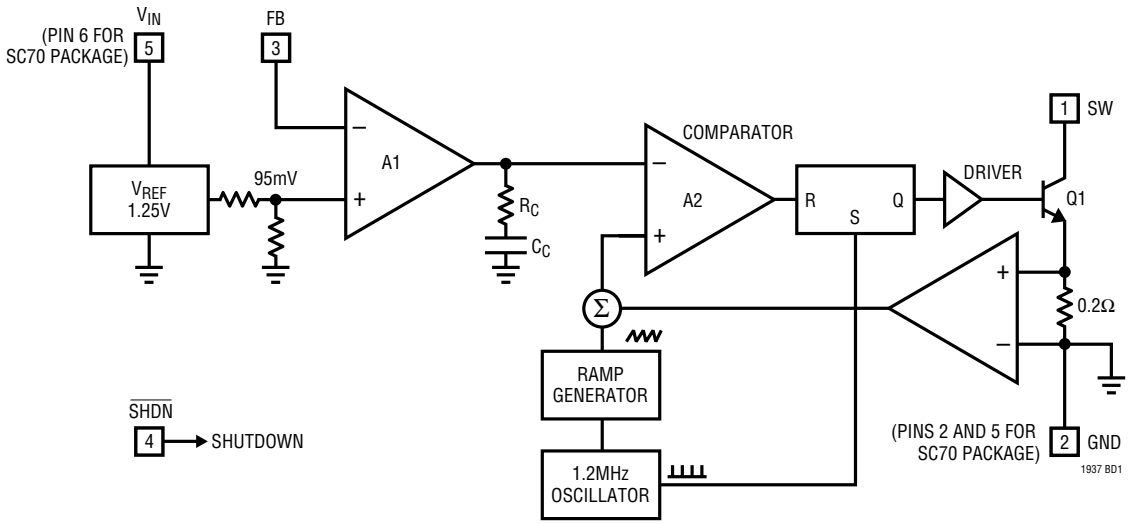

Figure 2. LT1937 Block Diagram

OPERATION

The LT1937 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 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

The LT1937 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. The photo in Figure 3 details circuit operation driving three white LEDs at a 4mA load. Peak inductor current is less than 50mA and the regulator operates in discontinuous mode, meaning the inductor current reaches zero during the discharge phase. After the inductor current reaches zero, the switch pin exhibits ringing due to the LC tank circuit formed by the inductor in combination with switch and diode capacitance. This ringing is not harmful; far less spectral energy is contained in the ringing than in the switch transitions. The ringing can be damped by application of a 300Ω resistor across the inductor, although this will degrade efficiency.

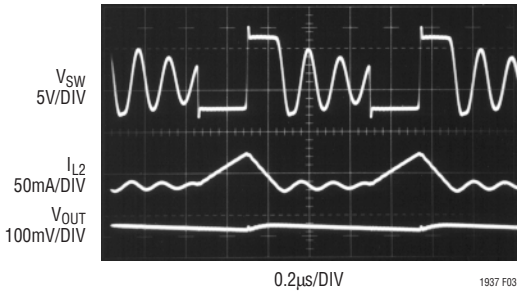

Figure 3. Switching Waveforms at I_{LED} = 4mA, V_{IN} = 3.6V

APPLICATIONS INFORMATION

Inductor Selection

A 22µH inductor is recommended for most LT1937 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. The efficiency comparison of different inductors is shown in Figure 4.

Table 1. Recommended Inductors

PART NUMBER	DCR (Ω)	CURRENT RATING (mA)	MANUFACTURER
LQH3C220	0.71	250	Murata 814-237-1431 www.murata.com
ELJPC220KF	4.0	160	Panasonic 714-373-7334 www.panasonic.com
CDRH3D16-220	0.53	350	Sumida 847-956-0666 www.Sumida.com
LB2012B220M	1.7	75	Taiyo Yuden 408-573-4150 www.t-yuden.com
LEM2520-220	5.5	125	Taiyo Yuden 408-573-4150 www.t-yuden.com

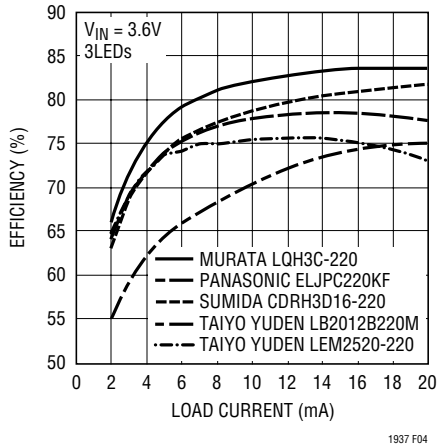

Figure 4. Efficiency Comparison of Different Inductors

Capacitor Selection

The small size of ceramic capacitors makes them ideal for LT1937 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 LT1937 applications.

Table 2. Recommended Ceramic Capacitor Manufacturers

MANUFACTURER	PHONE	URL
Taiyo Yuden	408-573-4150	www.t-yuden.com
AVX	843-448-9411	www.avxcorp.com
Murata	814-237-1431	www.murata.com
Kemet	408-986-0424	www.kemet.com

Diode Selection

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for LT1937 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 LT1937. A Schottky diode rated at 100mA to 200mA is sufficient for most LT1937 applications. Some recommended Schottky diodes are listed in Table 3.

Table 3. 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 631-435-1110 www.centralsemi.com
CMDSH2-3	200	0.49 at 200mA	15 at 10V	Central 631-435-1110 www.centralsemi.com
BAT54	200	0.53 at 100mA	10 at 25V	Zetex 631-543-7100 www.zetex.com

APPLICATIONS INFORMATION

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.

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

Table 4. R1 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 LT1937 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 5). 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.

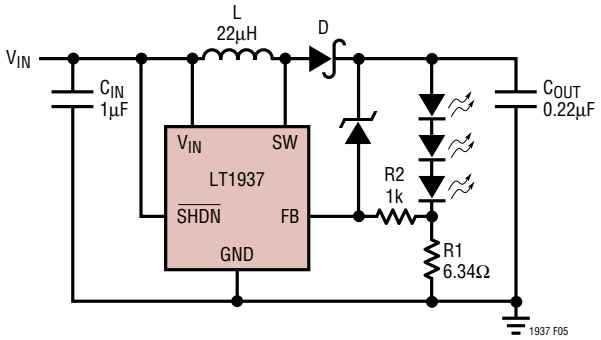

Figure 5. LED Driver with Open-Circuit Protection

Dimming Control

There are four different types of dimming control circuits:

1. Using a PWM Signal to $\overline{SHDN}$ Pin

With the PWM signal applied to the $\overline{SHDN}$ pin, the LT1937 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 LT1937 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 $\overline{SHDN}$ voltage high. The switching waveforms of the $\overline{SHDN}$ pin PWM control are shown in Figures 6a and 6b.

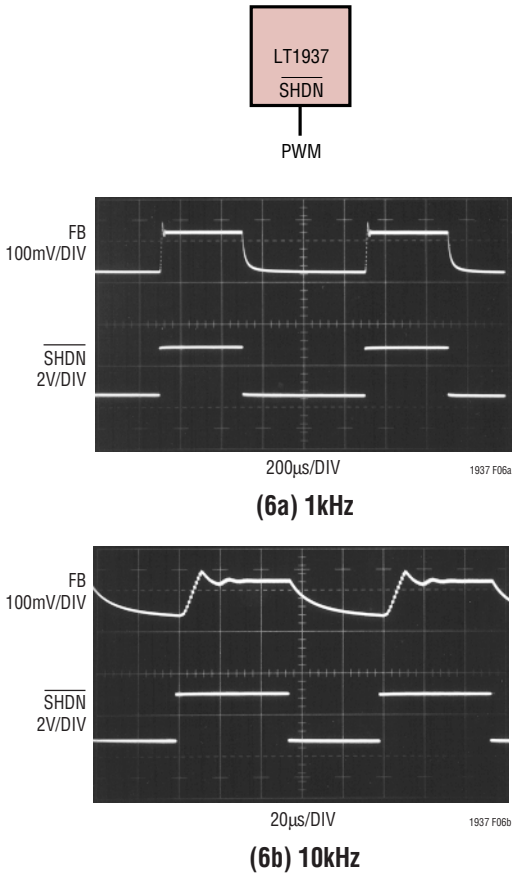

Figure 6. PWM Dimming Control Using the $\overline{SHDN}$ Pin