Zywyn

Application Note AN013

ZD1637EVB Evaluation Board Manual

General Description

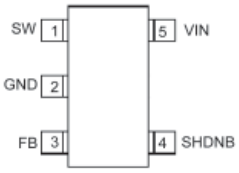
The ZD1637EVB demonstration board is populated to show the function of the ZD1637 as a high power, constant frequency, current mode PWM, inductor based, step-up DC/DC boost converter IC especially designed to drive multiple white LEDs in series. The LED current is regulated in this converter design so that all LEDs can obtain predictable constant current, matched luminous intensity and chromaticity. LED current accuracy is determined and controlled by the regulator's feedback threshold and is independent of the LED's forward-bias voltage variation.

The ZD1637EVB is a standard boost demo circuit with switches and all controlling logic circuits integrated in the ZD1637 device. Apart from the LEDs, only five external components are required in the application of the demo circuit which include the bypass capacitor, the boost inductor, the boost schottky diode, a current sensing resistor and an output integrating capacitor. The converter design operates at high frequency of 1.5MHz so that a small, low profile 1mm tall inductor and small value output capacitor of 1μF can be used for space saving application circuitry. Figure 1 shows a typical demo board circuit schematics.

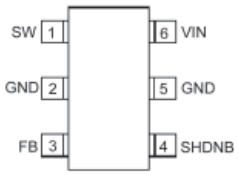
The demo board can be powered from 2.6V to 16V at the VIN tap. The LEDs current can be controlled by the feedback resistor (R1). The feedback voltage reference (FB tap) is set as 1.25V by default on the demo board by using a 63.4Ω (R2) and 6 LEDs in series in place of R1. The LEDs current can be calculated using the equation I_{LED}=(1.25V)/(R2). Dimming control of the LEDs can be achieved with external extended control circuitry. The ZD1637 device can be put into low quiescent shutdown mode by bringing the SHDN tap to the GND tap.

The ZD1637EVB is designed to fit demonstration of the ZD1637 in all packages, namely for 5-pin SOT-23 (SOT25) and the 6-pin SC70 Green Packages.

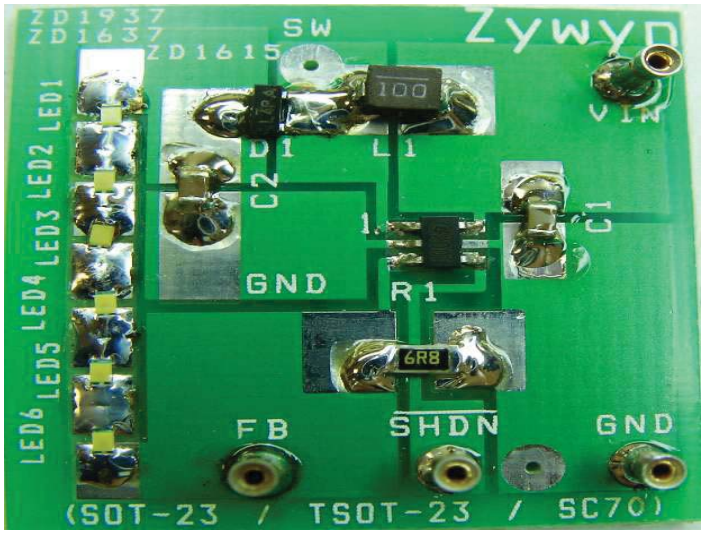
ZD1637 Pin Configuration



SOT-23



SC-70



PCB Circuit Schematics

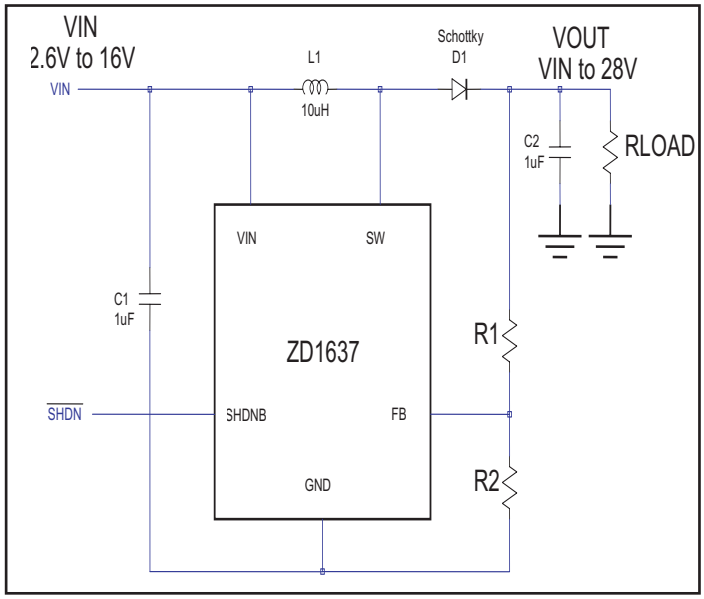


Figure 1. Typical Demo Circuit Driver for Four White LEDs

Product Ordering Information

Part Number	Temperature Range	Package Type (All Green)
ZD1637LB5	-40°C to +85°C	5-Pin SOT-23 (or SOT-25)
ZD1637LEBC6	-40°C to +85°C	6-Pin SC70
ZD1637EVB	n/a	Evaluation Board For SOT25, TSOT25 and SC70 Packages

Electrical Characteristics Of The ZD1637

T_A = +25°C, V_{IN} = 3V, $\overline{SHDN}$ = 3V; unless otherwise noted.

Parameter	Condition	Min	Typ	Max	Units
Min Operating Voltage		2.6			V
Max Operating Voltage				16	V
Feedback Voltage	V_{IN}=5V, V_{OUT}=24V, I_{OUT}=30mA	1.17	1.25	1.33	V
FB Pin Bias Current	V_{FB}=1.25V	10	45	100	nA
Supply Current	$\overline{FB}$=V_{IN} $\overline{SHDN}$ = 0V, V_{FB}=0V		2.5 0.1	3.5 1.0	mA µA
Switching Frequency		1.1	1.5	1.9	MHz
Maximum Duty Cycle		85	90		%
Switch Current Limit			500		mA
Switch Vds	I_{SW} = 250mA		300		mV
Switch Leakage Current	V_{SW} = 5V		0.01	5	µA
$\overline{SHDN}$ Voltage High (ON)		1.5			V
$\overline{SHDN}$ Voltage Low (OFF)				0.4	V
$\overline{SHDN}$ Pin Bias Current			50		µA
V_{OUT} Adjustable Output Voltage		VIN		28	V
Over-Voltage Protection (OVP) Threshold		26	29	32	V
Soft-Start Timing	$\overline{SHDN}$=3V		550		µs

Input Operation Description

Input Voltage Setting

A DC voltage power source is needed to drive the LEDs load. In this application, a typical 3V to 5V DC is the input voltage power source and it should be able to provide a 1.5A load current. The ZD1637EVB demo board is capable of providing a constant current for the string of LEDs over this input voltage range (VIN) of 3V to 5V.

Input Under Voltage

If the ZD1637EVB is operated at an input voltage as low as 2.5V or with a single battery device, the demo application circuit will still work and functional. The lower the input voltage is, the longer will be the standby time. In general, lowering the input voltage will not cause damage to the demo circuit.

Application of DC Power

Since this application circuit is meant for driving a string of LEDs for backlight function with constant current, it is not recommended to use this circuit to flash the LEDs string that could be harmful to the naked human eyes. Upon power-up, the current flow through the string of LEDs shall be ramping up, with a positive slope until it hits its steady state.

Removal of DC Power

The physical profile of the LED current decaying at power-down is not specified in the ZD1637 datasheet specification. However, dimming control can be applied by using external circuitry on the SHDN pin such as a PWM pulse to control the period of lighting and dimming function appropriately.

Low Quiescent Current

To operate with lower power dissipation, the quiescent current of the ZD1637 is controlled at a 1.0μA max range when SHDN is held at low (0V). This will help to prolong battery life of the power source and increase the standby time.

Noise

The high frequency switching inductor will generate slight noise. It is highly recommended to avoid this noise from RFI or EMI signals and it must be properly controlled in the system circuit.

Typical Applications Examples

Using ZD1637 for LCD Panel Display Bias

The ZD1637 can be used as a biasing IC circuit to drive a large LCD panel display. A typical recommended circuit is shown in figure 13 when Vout=24V, Iout=30mA at Vin=5V. In this application, R1=91KΩ, R2=5.1KΩ and L=10μH is being used. The bill of material listing of this circuit is shown below for reference:

L=10μH, Sumida Coil CDRH5D28R-100NC
(or L=22μH, Sumida Coil CDRH5D28R-220NC)
D1=1N5819, Schottky Diode
C1=C2=1.0μF/X5R/1206, 35V, Tayo Yuden GMK-316BJ105KL
R1=91KΩ, 5%
R2=5.1KΩ, 5%

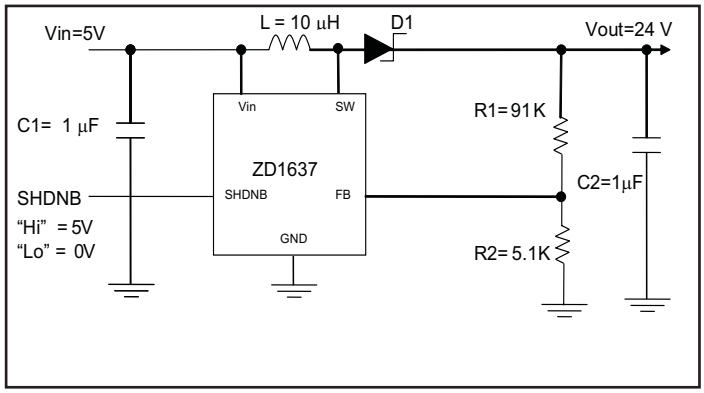


Fig.2. Recommended circuit for LCD Display Bias

The ZD1637 has an adjustable output voltage which can be determined by the equation:

$$V_{OUT} = VFB\left(1+\frac{R1}{R2}\right)$$

where VFB = 1.25V typical, with minimum of 1.17V and maximum of 1.33V

The following table (Table 1.) gives suggested value for various outpu voltages.

V_{OUT} (V)	R1 (Ω)	R2 (Ω)
5	100K	33K
12	100K	11.6K
18	100K	7.5K
21	100K	6.4K
24	91K	5.1K
28	100K	4.7K

Table 1.. R1 and R2 values for V_{OUT}.

Using ZD1637 to drive 6 to 8 LEDs

The ZD1637 can be used as a LED driver to drive 6 to 8 LEDs in series. A typical application circuit is shown in figure 14. The R1 and R2 sets the FB pin voltage maintaining at 1.25 typical for current regulation over the input supply voltage range of 2.6V to 4.2V with a inductor L of 22μH.

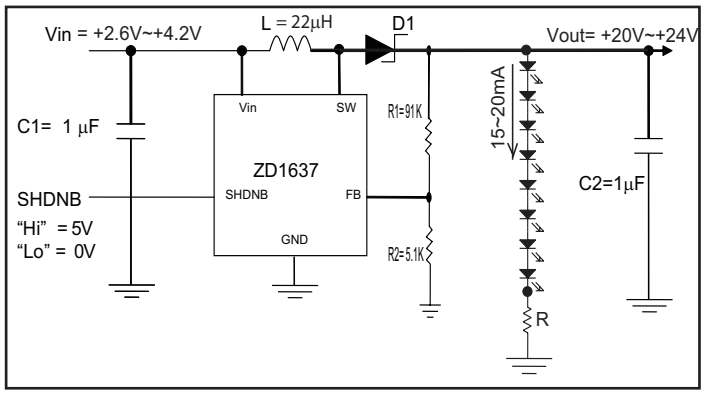


Fig.3. Recommended circuit for driving 6 to 8 LEDs

Using ZD1637 for Main-LCD Display and Sub/Keypad Backlighting

The ZD1637 can also be used as a LED driver to drive a main LCD display (with 3 to 4 LEDs in series of 15 to 20mA LED current) and a group of sub/keypad strings (about 3 LEDs per string of 5 to 7mA LED current) backlighting function. A typical application circuit is shown in figure 15. The R1 and R2 sets the FB pin voltage maintaining at 1.25 typical for current regulation over the input supply voltage range of 2.6V to 4.2V with a inductor L of 22μH. R3 sets the main display LED backlighting current and R4 sets the sub/keypad backlighting current.

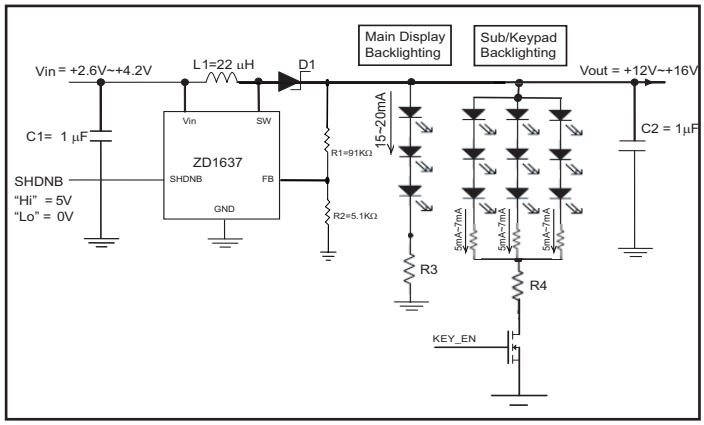


Fig.4. Recommended circuit for driving a main LCD display and a sub/keypad backlighting

Output Operation Description

Output Noise And Ripple

To maintain a constant current output, the output ripple should be kept as minimum as possible or less than 100mV after the demo circuit is powered up. A filter cap (C2) of 1μF can be used.

Efficiency

The efficiency of the demo circuit can be achieved at 80% for a 20mA LED current and about 85% for a 15mA LED current.

Output Protection

Open-Cicuit Protection

The demo circuit will go into shutdown and latch off mode when the output of the ZD1637 device is opened (no LED is connected in the string). This should not cause any damage to the demo board.

Over-Voltage Protection

The ZD1637 has a built-in over-voltage protection (OVP) circuitry with internal thermal shutdown capability to prevent the device from over-voltage or an open-circuit condition at the output. The typical OVP threshold is set at 29V. The output voltage should not exceed 38V at any case to avoid damaging the LEDs when the LEDs are either disconnected from the circuit, the LEDs are open/short, or the feedback resistor (R1) is shorted.

Components Selection

Inductor Selection

For most ZD1637 applications, a 22μH inductor is recommended. The inductor should have low core losses at 1.5MHz and low copper wire resistance (DCR), even though small size and high efficiency are major concerns. Table 2 lists some inductors that meet these requirements.

Part Number	DCR (Ω)	Current Rating (mA)	Manufacturer
LEM2520-220	5.5	125	Taiyo Yuden www.t-yuden.com
LB2012B220M	1.7	75	Taiyo Yuden www.t-yuden.com
CDRH3D16-220	0.53	350	Sumida www.sumida.com
ELJPC220KF	4.0	160	Panasonic www.panasonic.com
LQH3C220	0.71	250	Murata www.murata.com

Table 2. Recommended Inductors

Capacitor Selection

The small size of ceramic capacitors makes them ideal- for ZD1637 applications. X5R and X7R types retain their capacitance over wider voltage and temperature ranges and are recommended over Y5V or Z5U types. A 1uF filtering output capacitor and a 1uF input capacitor are sufficient for most ZD1637 applications.

AVX	www.avxcorp.com
Kemet	www.kemet.com
Murata	www.murata.com
Taiyo Yuden	www.t-yuden.com

Table 3. Recommended Ceramic Capacitor Manufacturers

Diode Selection

Schottky diodes are the ideal choice for ZD1637 applications because of their fast reverse recovery and low forward voltage drop.

The diode capacitance (C_T or C_D) represents the switching loss and the forward voltage drop represents the conduction losses in the diode. Both forward voltage drop and diode capacitance need to be considered in diode selection. Lower forward voltage drop and higher diode capacitance are usually found in Schottky diodes with higher current ratings and can cause significant switching losses at the 1.5MHz switching frequency of the ZD1637. For most ZD1637 applications, a Schottky diode rated at 100mA to 200mA is sufficient. Table 4 lists some recommended Schottky diodes.

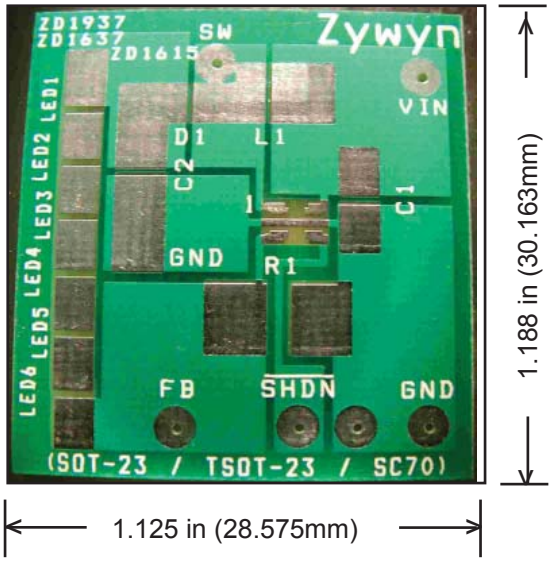
Part Number	Forward Current (mA)	Voltage Drop(V)	Diode Capacitance (pF)	Manufacturer
CMDSH-3	100	0.58 at 100mA	7.0 at 10V	Central www.centralsemi.com
CMDSH2-3	200	0.49 at 200mA	15 at 10V	Central www.centralsemi.com
BAT54	200	0.53 at 100mA	10 at 25V	Zetex www.zetex.com

Table 4. Recommended Schottky Diodes

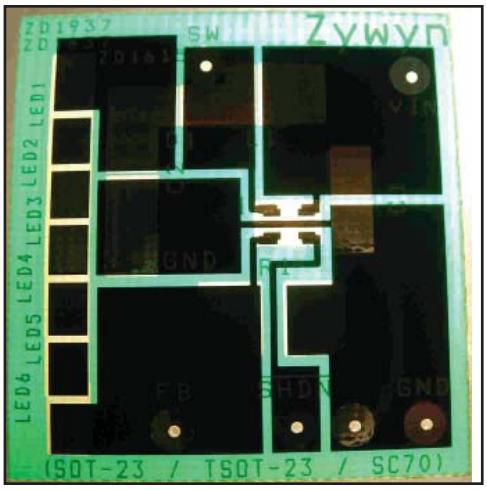
ZD1637EVB Bill Of Material (BOM) Listing

Item	Quantity	Location	Part
1	1	C1	1μF
2	1	C2	1μF
3	1	D1	1N5819
4	1	L1	22μH
5	1	R1	Variable
6	1	R2	Variable
7	6	U1	ZD1637

PCB Demo Board Dimensions And Layout



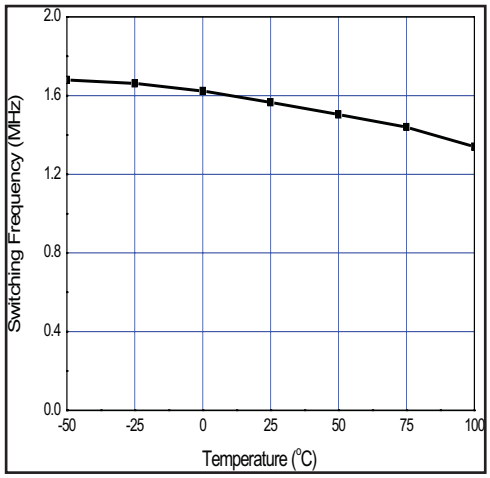
PCB Layout - Component Side



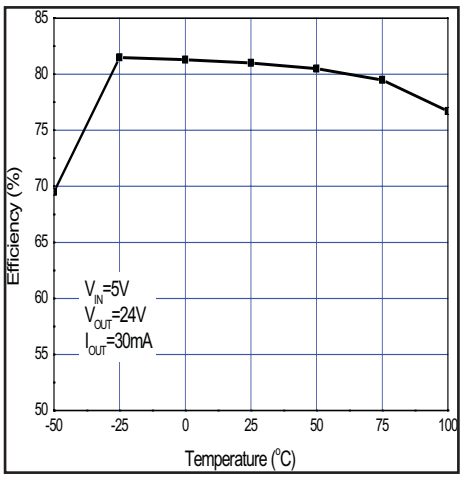
PCB Layout - Negative Side

Typical Switching Performance Characteristics

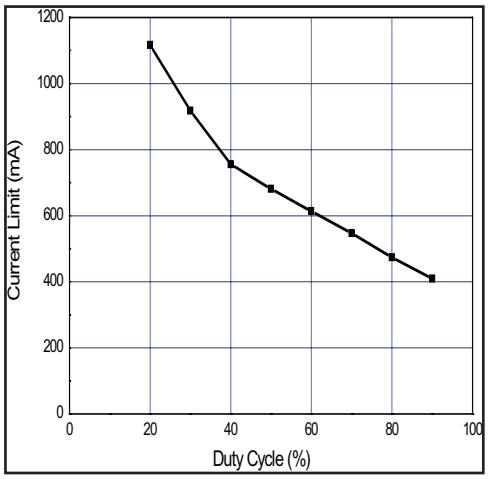
Switching Frequency

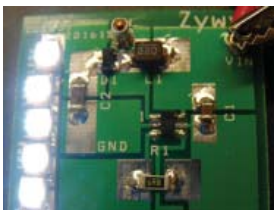


Efficiency



Switching Current Limit





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