Zywyn

ZD1937

High Efficiency Inductor Based Step-Up Converter for White LEDs

Features

- Drives Up to Four LEDs from a 3.2V Source
- Drives Up to Six LEDs from a 5V Supply
- Series Connected LED Diodes for Inherently Matched Light Output
- High Efficiency, typically 84%
- Internal Thermal Shutdown With Built-In OVP, Over-Voltage Protection Circuit
- 36V Rugged Bipolar Switch
- 1.2MHz Switching Frequency
- Requires Only 0.22mF Output Capacitor
- Uses Low Profile 1mm Tall Inductors
- Low Profile SC70, SOT and ThinSOT Packaging

Applications

- Cellular Phones
- PDA's , Handheld Computers
- Digital Cameras
- MP3 Players
- GPS Receivers
- Battery Powered LCD Display Modules

General Description

The ZD1937 is a constant frequency, current mode PWM, inductor based step-up (boost) converter especially designed to drive multiple white LED's in series. The LED current is regulated in this converter design so that all LED's have the same current and therefore have inherently matched light output. The converter design operates at high frequency (1.2MHz) operation so that a small, low profile inductor can be used as well a small value output integrating capacitor.

The ZD1937 has built-in over-voltage protection (OVP) with internal thermal shutdown ability to prevent device from over-voltage or an open circuit condition at the voltage output.

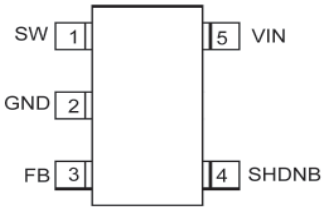
The ZD1937 is available in either a space saving SC70, a SOT25, or ThinSOT25 package for very small board space applications

Ordering Information

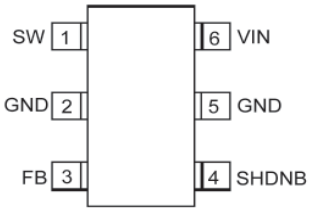
Part Number	Temperature Range	Package Type (All Green)
ZD1937LB5	-40°C to +85°C	5-Pin SOT-23 (or SOT-25)
ZD1937LEB5	-40°C to +85°C	5-Pin TSOT-23 (or TSOT-25)
ZD1937LEBC6	-40°C to +85°C	6-Pin SC70
ZD1937EVB	n/a	Evaluation Board For SOT25, TSOT25 and SC70 Packages

Please contact the factory for pricing and availabiliy on bulk, tube and Tape-on-Reel options.

Pin Configuration



SOT-23/TSOT-23



SC-70

Typical Application

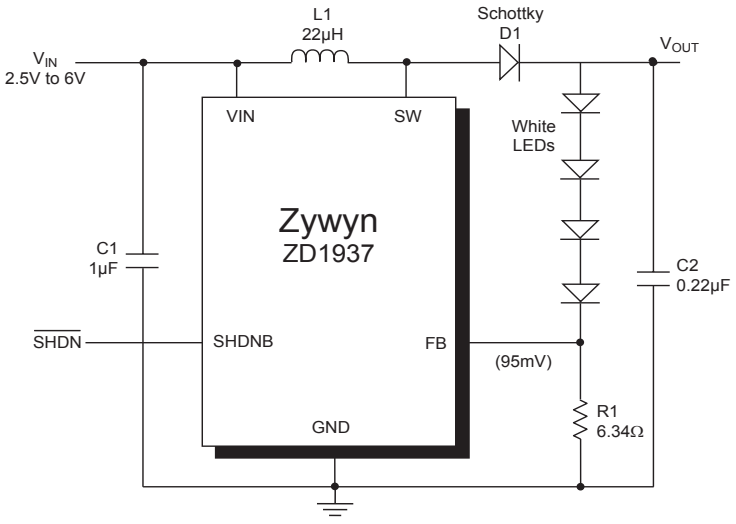


Figure 1. Li-Ion powered Driver for Four White LEDs

Absolute Maximum Ratings

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

Input Voltage, (V_{IN}) ..... +15V
SW Voltage ..... +36V
FB Voltage ..... +10V
SHDNB Voltage ..... +15V
Extended Commercial
Operating Temperature ..... –40°C to +85°C
Maximum Junction Temperature ..... +125°C
Storage Temperature ..... –65°C to +150°C
Lead Temperature (Soldering, 10sec.) ..... 300°C

Power Dissipation Per Package

5-pin SOT-23 (derate 6.67mW/°C above +70°C) ... 460mW
5-pin TSOT-23 (derate 6.10mW/°C above +70°C) 430mW
6-pin SC70 (derate 6.25mW/°C at +70°C) 437mW

Storage Considerations

Storage in a low humidity environment is preferred. Large high density plastic packages are moisture sensitive and should be stored in Dry Vapor Barrier Bags. Prior to usage, the parts should remain bagged and stored below 40°C and 60%RH. If the parts are removed from the bag, they should be used within 48 hours or stored in an environment at or below 20%RH. If the above conditions cannot be followed, the parts should be baked for four hours at 125°C in order remove moisture prior to soldering. Zywyn ships product in Dry Vapor Barrier Bags with a humidity indicator card and desiccant pack. The humidity indicator should be below 30%RH

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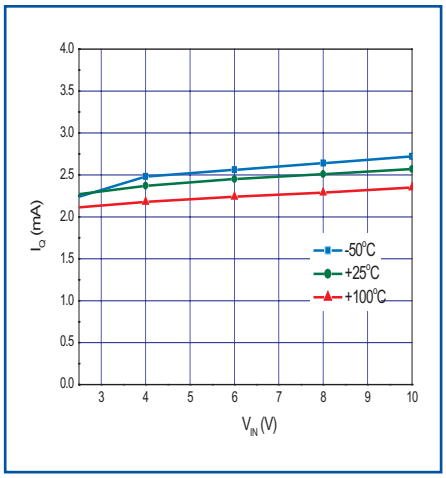
Electrical Characteristics

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

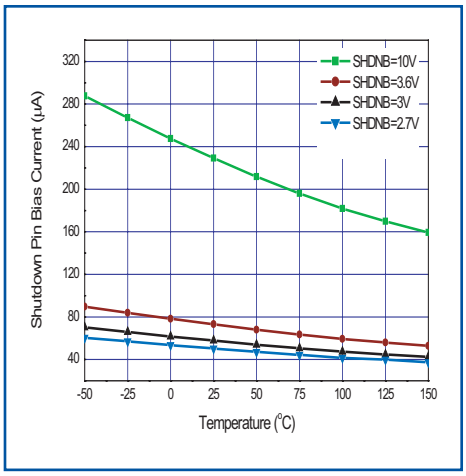
Parameter	Condition	Min	Typ	Max	Units
Min Operating Voltage		2.5			V
Max Operating Voltage				12	V
Feedback Voltage	I_{SW} = 100mA, Duty Cycle = 66%	86	95	104	mV
FB Pin Bias Current	V_{FB} = 95mV		45	100	nA
Supply Current	$\overline{SHDN}$ = 0V		1.9 0.1	2.5 1.0	mA µA
Switching Frequency		0.8	1.2	1.6	MHz
Maximum Duty Cycle		85	90		%
Switch Current Limit			320		mA
Switch Vds	I_{SW} = 250mA		350		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
Over-Voltage Protection (OVP)			29		V

Typical Performance Characteristics

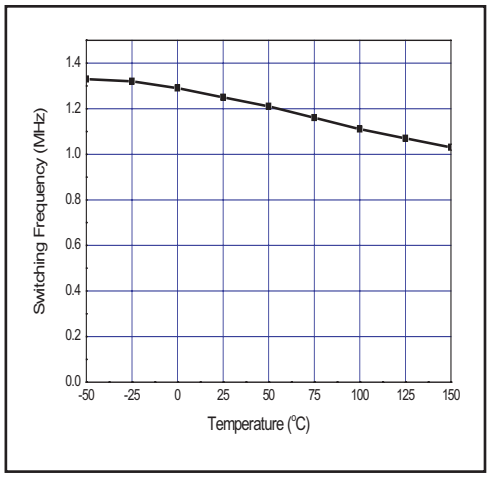
Quiescent Current



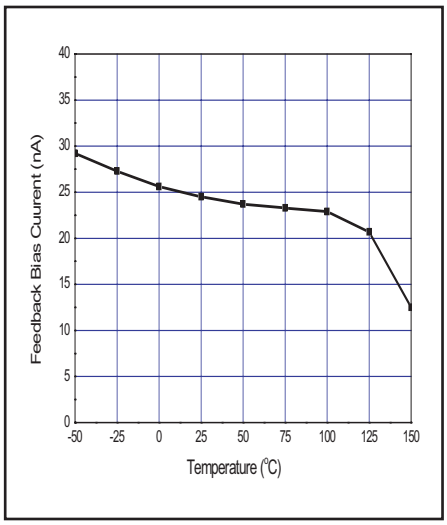
SHDNB Pin Bias Current



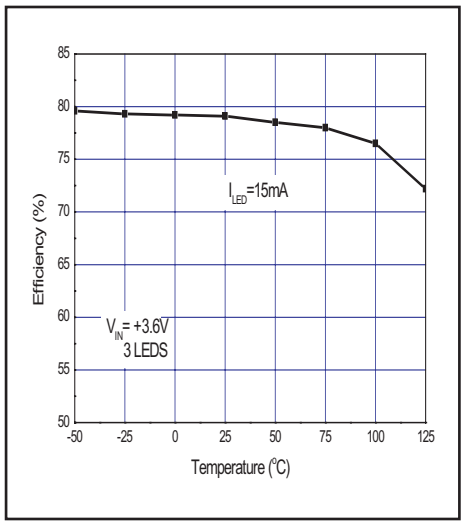
Switching Frequency



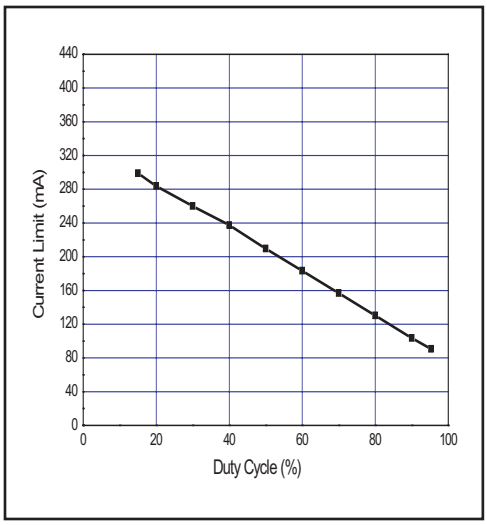
Feedback Bias Current



Efficiency



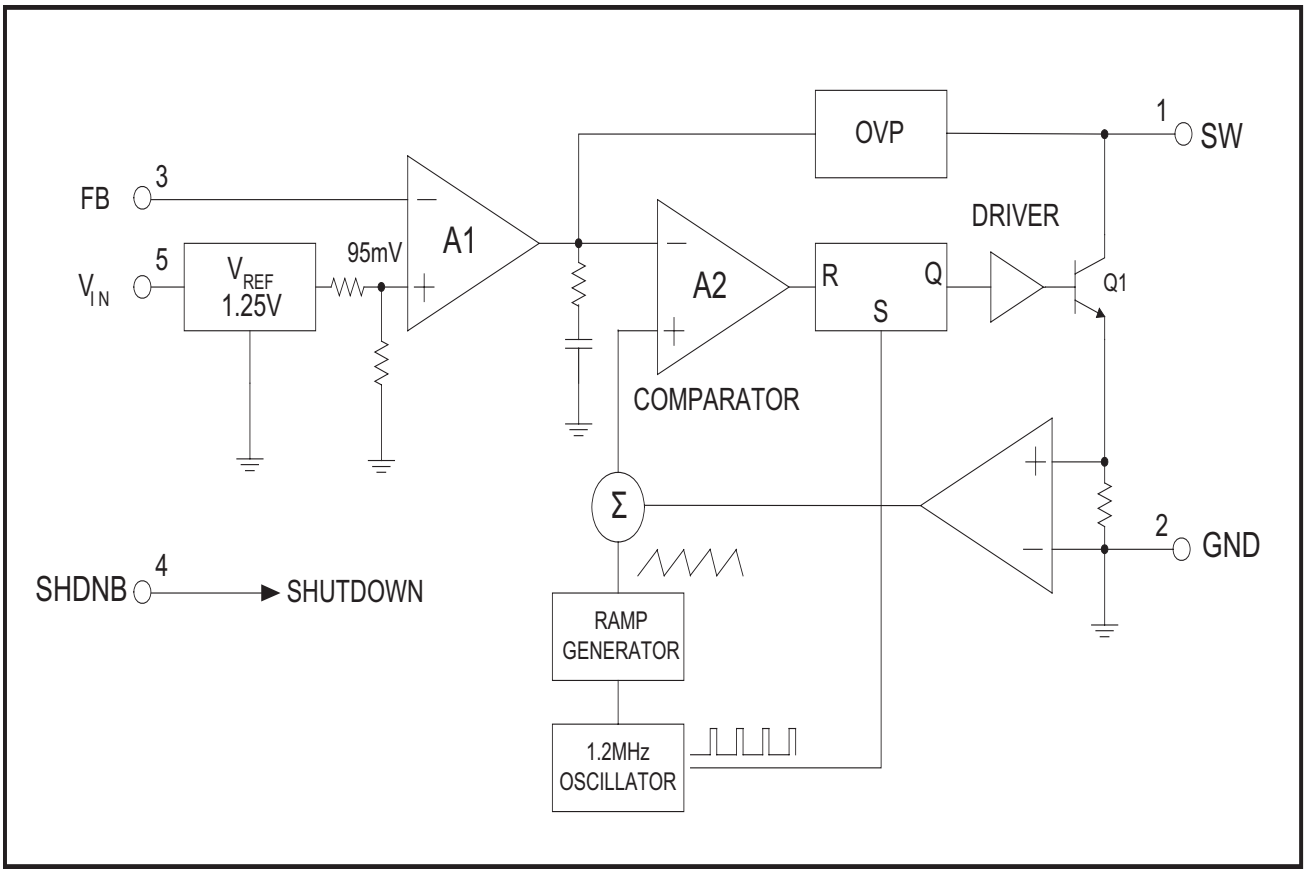
Switching Current Limit



Pin Description

Pin Number	Pin Name	Pin Function
1	SW	Switch Pin. Connect inductor/diode here. The output voltage can go up to 29V but should not exceed this limit. If the voltage on this pin is higher than the over voltage protection threshold (OVP), the device can go into shutdown mode. It can be restarted by a low-to-high sequence on the SHDNB pin or turn off the V_{IN} supply and power back on.
2	GND	Ground Pin. Connect directly to local ground plane.
3	FB	Feedback Pin. Internally servos to 95mV. Connect cathode of lowest LED and resistor here. Calculate the resistor value according to the formula: RFB=0.095/ILED.
4	SHDNB	Shutdown Pin. Connect to 1.5V or higher to enable device (ON), 0.4V or lower to disable device (OFF).
5 (SC70)	GND	Ground Pin. Connect to Pin 2 and to local ground plane.
6 (SC70) 5 (SOT-23/TSOT-23)	V_{IN}	Input Supply Pin. Must be locally by-passed.

Block Diagram



Circuit Description

The ZD1937 provides excellent line and load regulation, by using a constant frequency, current mode control scheme. Each oscillator cycle starts by setting the SR latch, turning on the power switch. The switching current is sensed and converted to a voltage and added to the stabilizing ramp voltage. The resulting voltage is compared to the error between the Feedback and the internal reference voltage. When the switch current offset ramp voltage is higher than the Feedback error voltage the switch turns off. When the Feedback error voltage increases, the switch current increases. When the Feedback error voltage decreases, the switch current decreases.

Minimum Output Current

Regulating three series LEDs, down to 4mA from a 4.2V source is possible, without pulse skipping, by the ZD1937. This is possible with the same external components as specified for 15mA operation. The ZD1937 will begin pulse skipping as the current is reduced further. Although the LED current remains regulated, on average, all the way down to zero current, low frequency ripple will result. In discontinuous mode, the inductor current reaches zero during the discharge phase, while peak inductor current is less than 50mA. Note the low level ringing during the zero current phase. This is caused by the LC tank circuit formed by the inductor, switch and diode capacitance. This ringing contains far less spectral energy than the switching transitions and is not harmful. A 300Ω resistor, across the inductor, will damp the ringing at the expense of decreased efficiency.

Applications Brief

LED Current Control

The feedback resistor (R1 in Figure 1) controls the LED current. The feedback reference is 95mV and the LED current is calculated using I_{LED} = 95mV/R1. Precision resistors are preferred (1% recommended), to achieve accurate LED current. The resistor selection formula is R1 = 95mV/I_{LED} and typical values are shown in Table 1.

ILED (mA)	R1 (Ω)
5	19.1
10	9.53
12	7.87
15	6.34
20	4.75

Table 1. Resistor Value (R1) Selection

Open-Circuit Protection

When the LEDs are disconnected from the circuit or the LEDs fail, an open circuit condition exists. This causes the feedback voltage to drop to zero and the ZD1937 will switch at a high duty cycle, resulting in a high output voltage. This condition may result in the SW pin exceeding its maximum 36V rating. A zener diode can be placed at the output to limit the voltage on the SW pin (Figure 2). The current rating of the zener should be larger than 0.1mA, or else the device will be internally shutdown by the over-voltage protection (OVP) built-in circuity. Reset the device is required by a low-to-high pulse sequence on SHDNB Pin or a power reset on the V_{IN} power supply.

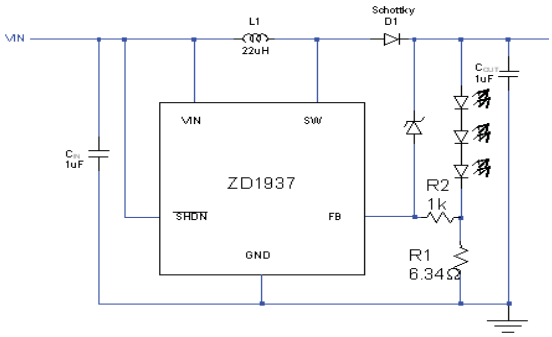


Figure 2. LED Driver with Open-Circuit Protection.

Dimming Control

There are four different types of dimming circuits:

1. Using a DC Voltage

In some applications, a DC voltage is available for adjusting the LED current, see Figure 3. LED current of 0mA to 15mA is provided with a V_{DC} range of 0V to 2V for the values in figure 3.

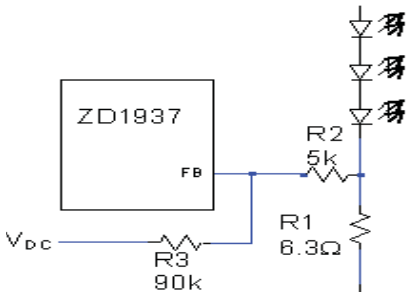


Figure 3. DC Voltage Dimming Control

2. Using a Logic Signal

Adjusting the LED current in discrete steps can be accomplished with a logic signal as shown in Figure 4. The minimum LED current is set by R1, with the NMOS off. R_{INC} controls the amount the LED current increases when the NMOS is turned on. The selection of R1 and R_{INC} follows the formula (1) and Table 1.

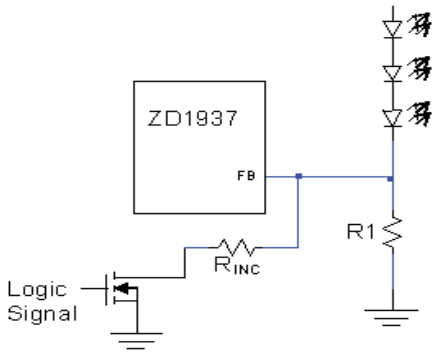


Figure 4. Dimming Control Using a Logic Signal

3. Using a Filtered PWM Signal

This circuit uses a R/C integrator to convert the PWM signal into a DC voltage as shown in Figure 5.

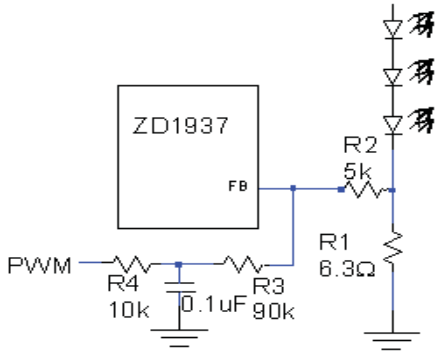


Figure 5. Dimming Control Using a Filtered PWM Signal

4. Using a PWM Signal to SHDNB Pin

The PWM signal turns on and off the ZD1937 when applied to the SHDNB Pin, causing the LEDs to operate at either zero or full current. The PWM duty cycle is proportional to the average LED current. A 100% duty cycle supplies the LED with full current, while a 0% duty cycle turns the LEDs off. The typical frequency range of the PWM signal is 1kHz to 10kHz.The PWM signal must meet the SHDNB Pin logic level requirements.

Applications Brief

Start-up and Inrush Current

To provide the option of minimum start-up delay, no internal soft-start circuit is included in the ZD1937. Inrush current for the ZD1937 is about 200mA, when first turned on, without an external soft-start circuit, as shown in Figure 6. The recommended circuit and waveforms for external soft-start, if desired, are shown in Figure 7. If implementing soft-start and dimming, limit the PWM signal on the SHDNB Pin to below 10kHz or provide the dimming function using the FB Pin as shown in Figures 3, 4 or 5.

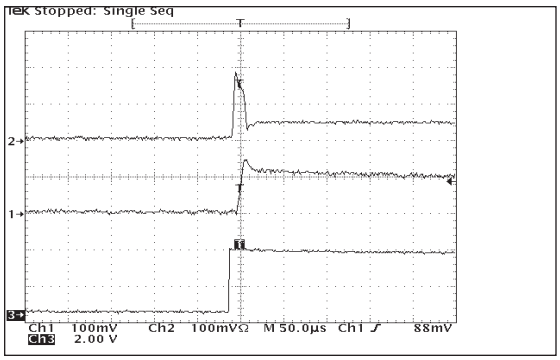


Figure 6. Start-up Waveforms Without External Soft-Start Circuit

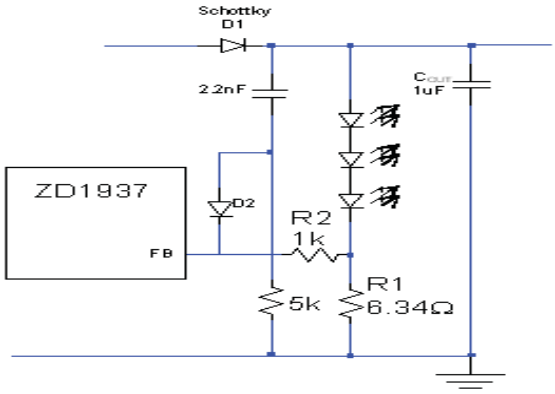


Figure 7a. Recommended Soft-Start-up Circuit

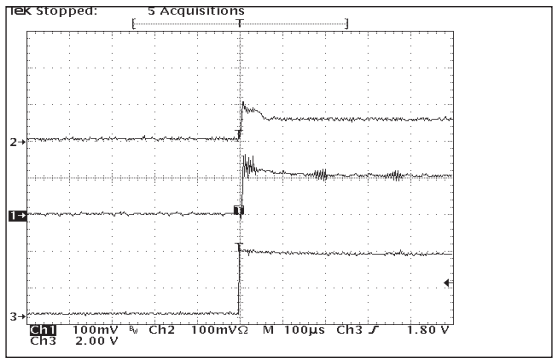
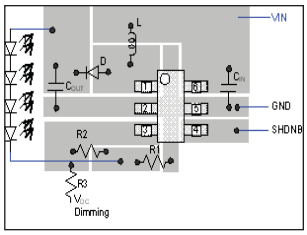


Figure 7b. Soft-Start-up Waveforms.

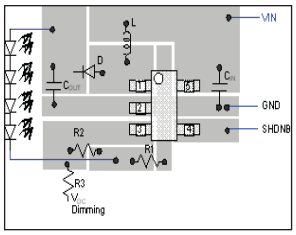
In the figure 6 and 7b waveform, Channel 1 is the Feedback (FB) voltage in 100mV/division. Channel 2 is the supply current in 100mA/division. Channel 3 is the SHDNB in 2V/division.

Board Layout Considerations

The ZD1937 is a switching regulator and therefor careful attention needs to be paid to PCB layout and component placement. Switch rise and fall times are made as short as possible to maximize efficiency. The proper layout of the high frequency switching path is essential to avoid electromagnetic interference (EMI) problems. Minimize the length and area of all traces connected to the SW pin, it requires fast rise and fall times. Always use a ground plane under the ZD1937 to minimize signal coupling. It is important to connect the feedback resistor, R1, directly to the GND pin on the device to ensure a clean, noise-free connection. Figure 8 shows the recommended component placement and figure 9 shows the actual ZD1937EVB evaluation board PCB layout.

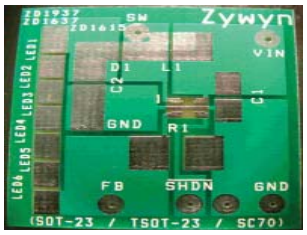


(for SC70 pkg)



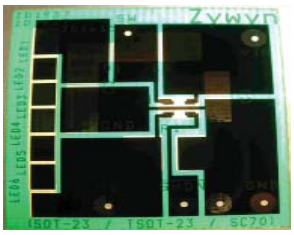
(for SOT-23/TSOT-23 pkg)

Figure 8. Recommended Component Placement



ZD1937EVB PCB Layout

(component side)

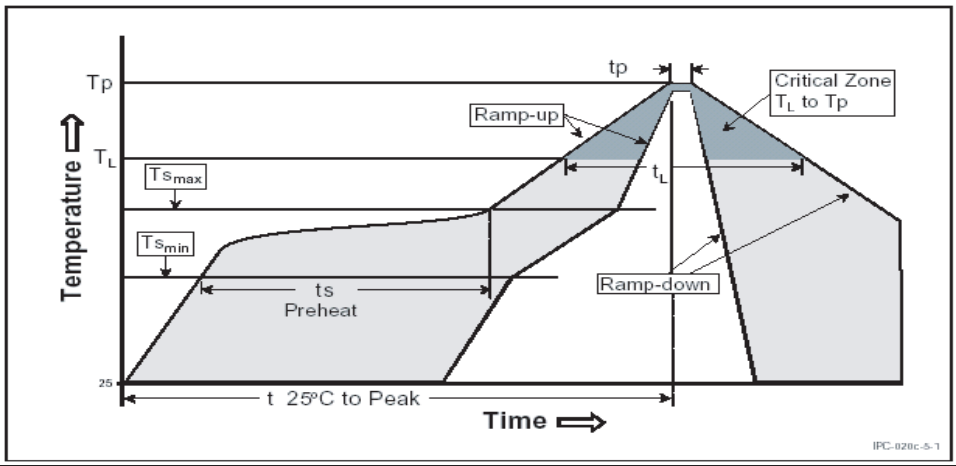


ZD1937EVB PCB Layout

(solder side)

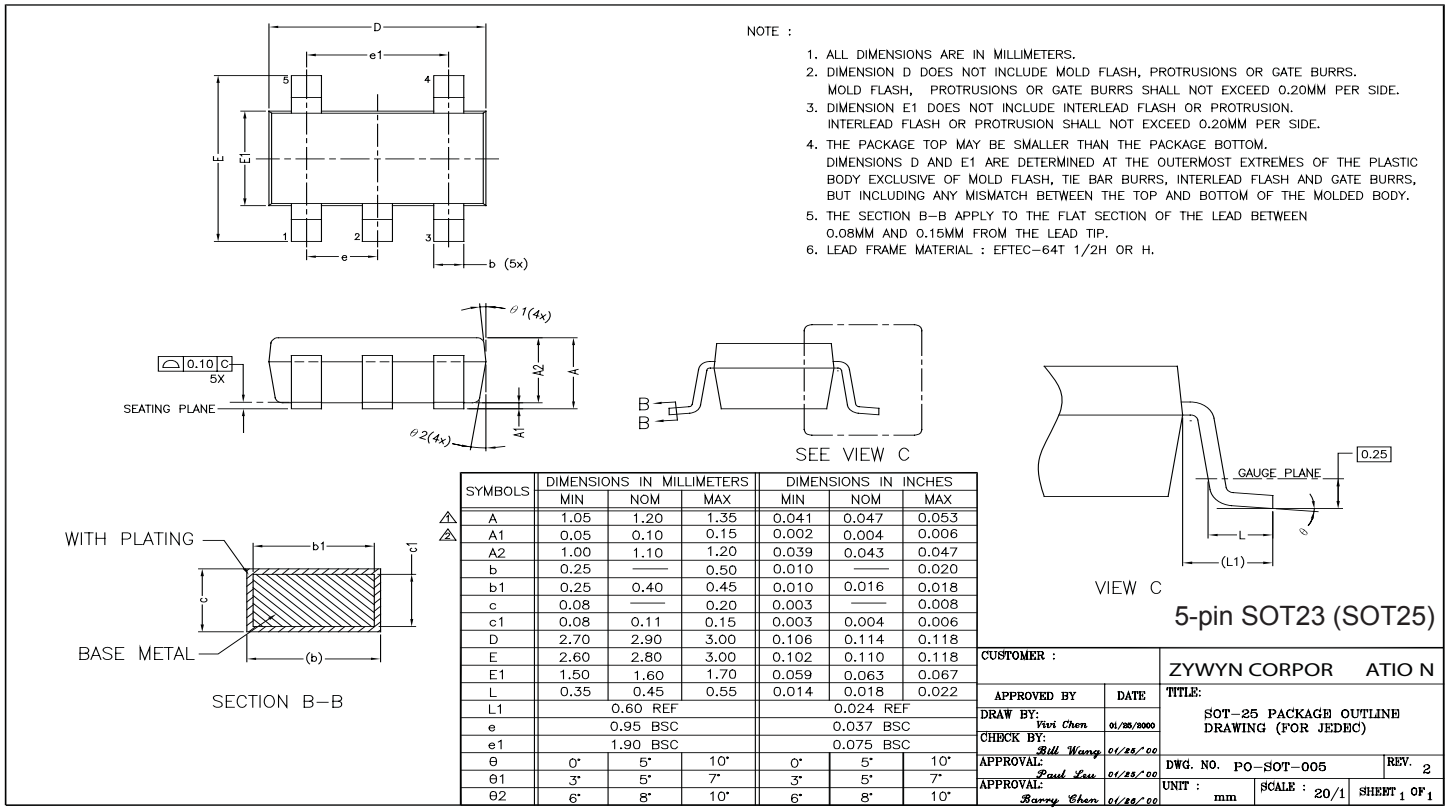
Figure 9. ZD1937EVB Evaluation Board PCB Layout

Green Package SMD IR Reflow Profile Information

IR Reflow Profile Conditions		
Profile Feature	JESD Sn-Pb Eutectic Assembly	**JESD Pb-free Assembly**
Average Ramp-Up Rate (T_{Smax} to T_P)	3°C/seconds max.	**3°C/seconds max.**
Pre-heat **- Temperature Min (T_{Smin})** **- Temperature Max (T_{Smax})** **- Time (T_{Smin} to t_{Smax})**	 100°C 150°C 60~120 seconds	 **150°C** **200°C** **60~180 seconds**
Time maintained above: **- Temperature (T_L)** **- Time (t_L)**	 183°C 60~150 seconds	 **217°C** **60~150 seconds**
Peak/Classification Temperature (T_P)	235°C+5/-0°C	**255°C~260°C**
Time within 5°C of actual Peak Temperature (t_P)	10~30 seconds	**20~40 seconds**
Ramp-Down Rate	6°C/second max.	**6°C/second max.**
Time 25°C to Peak Temperature	6 minutes max.	**8 minutes max.**

Zywyn Green Packages are Pb-free and RoHS compliance.

Package Information



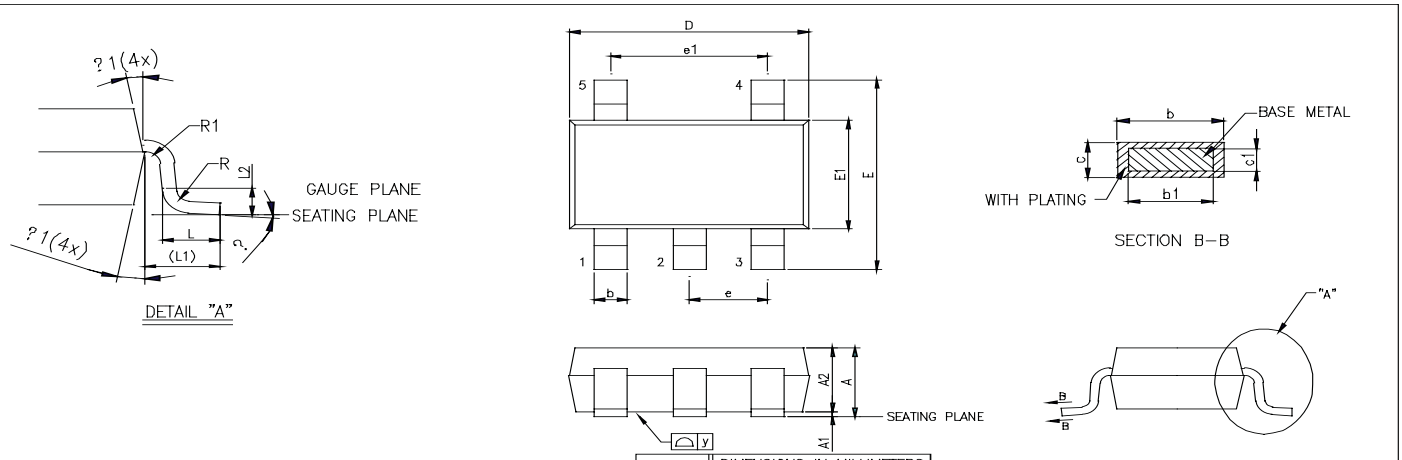
NOTE :

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSION D DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.20MM PER SIDE.
3. DIMENSION E1 DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.20MM PER SIDE.
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, INTERLEAD FLASH AND GATE BURRS, BUT INCLUDING ANY MISMATCH BETWEEN THE TOP AND BOTTOM OF THE MOLDED BODY.
5. THE SECTION B–B APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.08MM AND 0.15MM FROM THE LEAD TIP.
6. LEAD FRAME MATERIAL : EFTEC–64T 1/2H OR H.

SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.05	1.20	1.35	0.041	0.047	0.053
A1	0.05	0.10	0.15	0.002	0.004	0.006
A2	1.00	1.10	1.20	0.039	0.043	0.047
b	0.25	——	0.50	0.010	——	0.020
b1	0.25	0.40	0.45	0.010	0.016	0.018
c	0.08	——	0.20	0.003	——	0.008
c1	0.08	0.11	0.15	0.003	0.004	0.006
D	2.70	2.90	3.00	0.106	0.114	0.118
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
L	0.35	0.45	0.55	0.014	0.018	0.022
L1	0.60 REF			0.024 REF		
e	0.95 BSC			0.037 BSC		
e1	1.90 BSC			0.075 BSC		
θ	0°	5°	10°	0°	5°	10°
θ1	3°	5°	7°	3°	5°	7°
θ2	6°	8°	10°	6°	8°	10°

5-pin SOT23 (SOT25)

CUSTOMER :		ZYWYN CORPOR ATIO N
APPROVED BY	DATE	TITLE: SOT–25 PACKAGE OUTLINE DRAWING (FOR JEDEC)
DRAW BY: Vivi Chen	01/25/2000	
CHECK BY: Bill Wang	01/25/'00	
APPROVAL: Paul Lee	01/25/'00	DWG. NO. PO–SOT–005 REV. 2
APPROVAL: Barry Chen	01/25/'00	UNIT : mm SCALE : 20/1 SHEET 1 OF 1



NOTE :

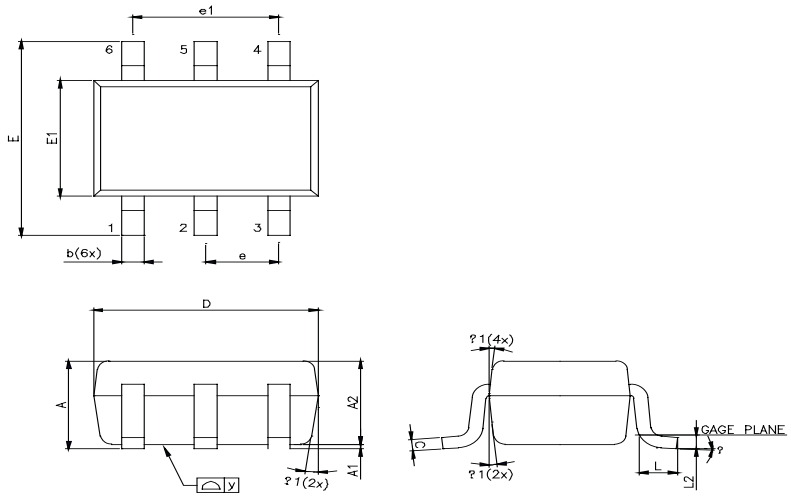
1. DIMENSIONS IN MILLIMETERS.
2. DIMENSION D DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 mm PER END. DIMENSION E1 DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.15 mm PER SIDE.
3. THE PACKAGE TOP MAY BE SMALLER THAN THE PACKAGE BOTTOM. DIMENSIONS D AND E1 ARE DETERMINED AT THE OUTERMOST EXTERMES 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.
4. THESE DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.08 mm AND 0.15 mm FROM THE LEAD TIP.

SYMBOLS	DIMENSIONS IN MILLIMETERS		
	MIN	NOM	MAX
A	——	——	1.10
A1	0	——	0.10
A2	0.70	0.90	1.00
b	0.30	——	0.50
b1	0.30	0.40	0.45
c	0.08	——	0.20
c1	0.08	0.13	0.16
D	——	2.90	——
E	——	2.80	——
E1	——	1.60	——
L	0.30	0.45	0.60
L1	——	0.60	——
L2	——	0.25	——
R	0.10	——	——
R1	0.10	——	0.25
e	——	0.95	——
e1	——	1.90	——
θ	0°	4°	8°
θ1	4°	10°	12°

5-pin TSOT23 (TSOT25)

CUSTOMER :		ZYWYN CORPORATION
APPROVED BY	DATE	TITLE: TSOT–25 PACKAGE OUTLINE DRAWING
DRAW BY: Sandy Sue	08/19/'08	
CHECK BY: Edward Yang	08/19/'08	
APPROVAL: Dennis Liu	08/19/'08	DWG. NO. PO–TSOT–001 REV. 2
APPROVAL: Jack Tu	08/19/'08	UNIT : mm SCALE : 22/1 SHEET 1 OF 1

Package Information



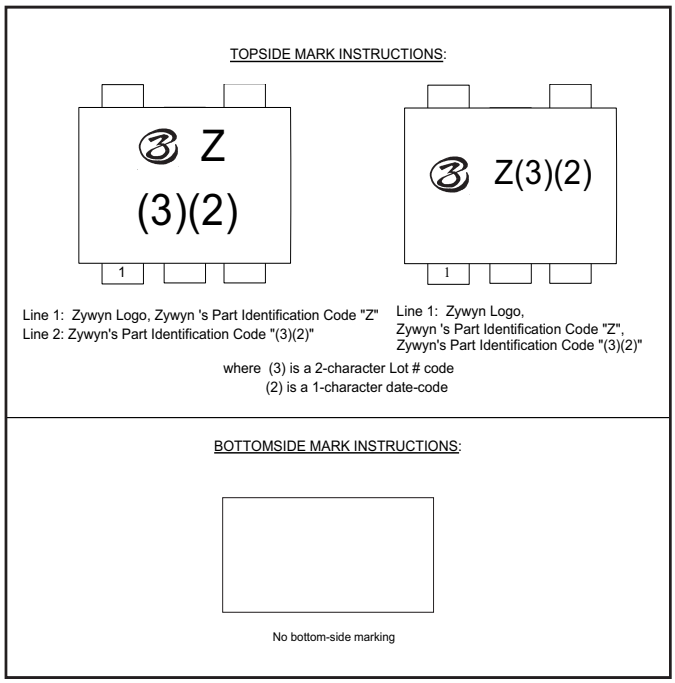
NOTE :
1. CONTROLLING DIMENSION : mm
2. DIMENSION D DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15mm PER SIDE.
3. DIMENSION E1 DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.15mm PER SIDE.

SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	——	——	1.10	——	——	0.043
A1	0.00	——	0.10	0.000	——	0.004
A2	0.70	0.90	1.00	0.028	0.035	0.039
b	0.15	——	0.30	0.006	——	0.012
C	0.08	——	0.22	0.003	——	0.009
D	——	2.00	——	——	0.079	——
E	——	2.10	——	——	0.083	——
E1	——	1.25	——	——	0.049	——
e	——	0.65	——	——	0.026	——
e1	——	1.30	——	——	0.051	——
L	0.26	0.36	0.46	0.010	0.014	0.018
L2	——	0.15	——	——	0.006	——
y	——	——	0.10	——	——	0.004
?	0°	4°	8°	0°	4°	8°
?1	4°	——	12°	4°	——	12°

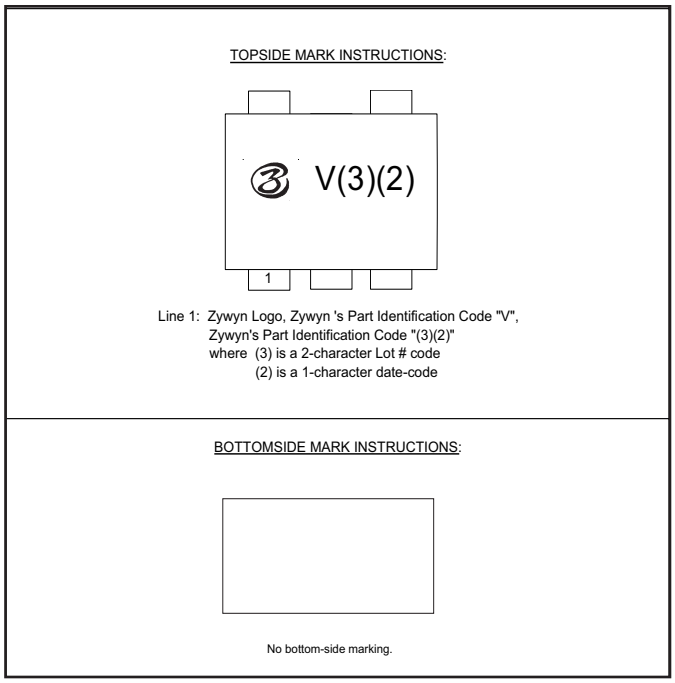
6-pin SC70

CUSTOMER :		ZYWYN CORPORATION
APPROVED BY	DATE	TITLE: SC70 6L PACKAGE OUTLINE DRAWING
DRAW BY: Sandy Fan	03/05/'04	
CHECK BY: Edward Yang	03/05/'04	
APPROVAL: Dennis Liu	03/05/'04	DWG. NO. PO-SC70-001 REV. 1
APPROVAL: Jack Tu	03/05/'04	UNIT : mm SCALE : 30/1 SHEET 1 OF 1

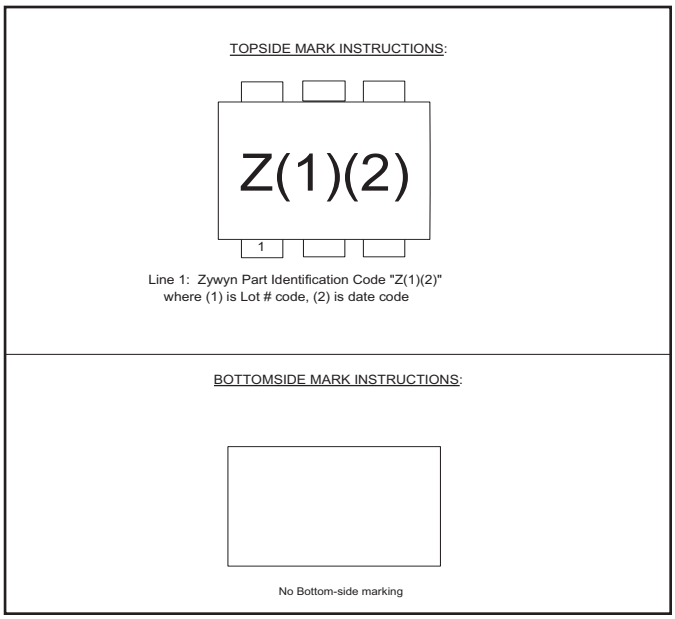
Part Marking Information



(For SOT-23 Package)



(For TSOT-23 Package)



(For SC70 Package)

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