



30V STEP-UP CONVERTER LED DRIVER

Features

- No Need for External Schottky Diode
- High Efficiency up to 84%
- Inherently Uniform LED Current
- Output Over-voltage Protection (OVP)
- Fixed 1.2MHz Switching Frequency
- Uses Tiny 1mm Tall Inductor
- Requires Only a small 0.22 μ F Output Capacitor

Applications

- Cellular Phones
- PDA's , Handheld Computers & Terminals
- Digital Cameras
- MP3, MP4, PMP Players
- GPS Receivers
- LCD or OLED Displays Biasing

General Description

The ZD1638 is an inductor-based DC/DC converter designed to drive up to eight white LEDs in series for backlight. Only one feedback resistor is needed to control the LED current and obtain required brightness.

A constant frequency 1.2MHz PWM control scheme is employed in this IC, which means tiny external components can be used. Specifically, 1mm tall inductor and 0.22 μ F output capacitor for a typical application is sufficient. Additionally, the Schottky diode in boost circuit is integrated on chip. ZD1638 also provides a disable function to ease its operation for different systems.

The output over-voltage protection (OVP) is implemented in ZD1638. When any LED is broken or in other abnormal conditions, the output voltage will be clamped, protecting the IC and the LEDs.

The ZD1638 is available in standard SOT-23-6 package.



Ordering Information

Part Number	Temperature Range	Package Type
ZD1638LB6	-40°C to +85°C	6-Pin SOT-23-6
ZD1638EVB	n/a	ZD1638 Eval Board

Please contact the factory for pricing and availability on Tape-on-Reel options

Typical Application

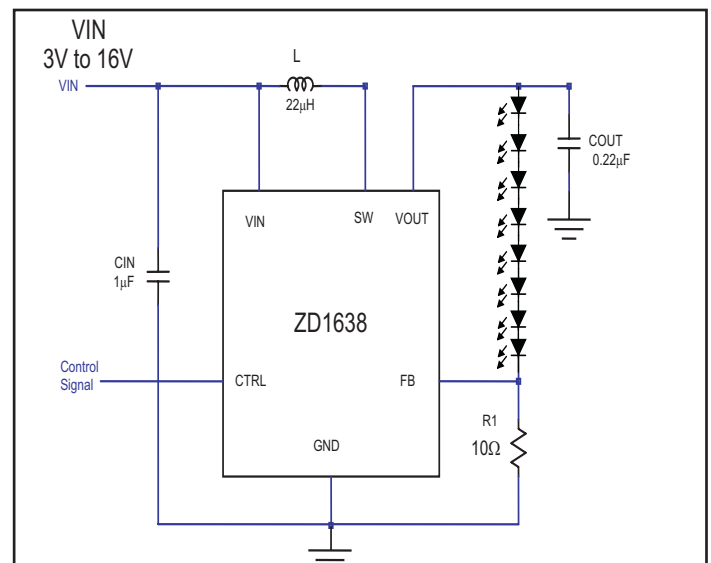
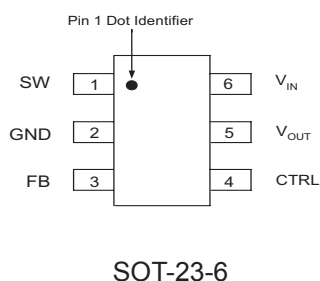


Figure 1. ZD1638 Typical Application

Pin Configuration



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}).....	+20V
SW Voltage.....	+38V
FB Voltage.....	+20V
CTRL Pin Voltage.....	+20V
Extended Commercial	
Operating Temperature.....	-40°C to +85°C
Thermal Resistance (θ_{JA}).....	265°C/W
Maximum Junction Temperature.....	+150°C
Storage Temperature.....	-65°C to +150°C
Lead Temperature (Soldering, 10sec.).....	260°C
ESD (Machine Model).....	250V
ESD (HBM).....	2000V

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 168 hours or stored in an environment at or below 20%RH. If the above conditions cannot be followed, the parts should be baked for 12 hours at 125°C in order to 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 The MSL of this product is 3.

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Electrical Characteristics

$T_A = +25^\circ\text{C}$, $V_{IN} = 3.0\text{V}$, CTRL= 3.0V; unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Operating Voltage	VIN		2.5		16	V
Feedback Voltage (Note 2)	VFB	IOUT=20mA, 4 LEDs, TA=-40°C to 85°C	188	200	212	mV
FB Pin Bias Current	IFB			35	100	nA
Quiescent Current	IQ	VFB=VIN, no switching	1.5	2.5	3.2	mA
Shutdown Quiescent Current	ISHDN	VCTRL=0V	2	4	6	μA
Switching Frequency	f		0.9	1.2	1.5	MHz
Maximum Duty Cycle	DMAX		90	93		%
Switch Current Limit (Note 3)	ILIMIT	D=40%		550		mA
	ILIMIT	D=80%		550		mA
Switch VCE Saturation Voltage	VCESAT	ISW=250mA		360		mV
Switch Leakage Current		VSW=5V		0.01	5	μA
CTRL Pin Voltage	VCTRL	High	1.8		16	V
		low			0.5	
CTRL Pin Bias Current	ICTRL			100		μA
OVP Voltage	VOV			30		V
Schottky Forward Drop	VDROP	ID=150mA		0.7		V
Schottky Leakage Current		VR(reverse voltage)=23V		0.1	4	μA
		VR(reverse voltage)=27V			150	μA
Soft Start Time	t			300		μS
Thermal Resistance (Junction to Case)	θJC	SOT-23-6		60		°C/W

Note 2: The bold type specifications at full temperature range are guaranteed by design.

Note 3: The switch current limit is related to the duty cycle.

Block Diagram

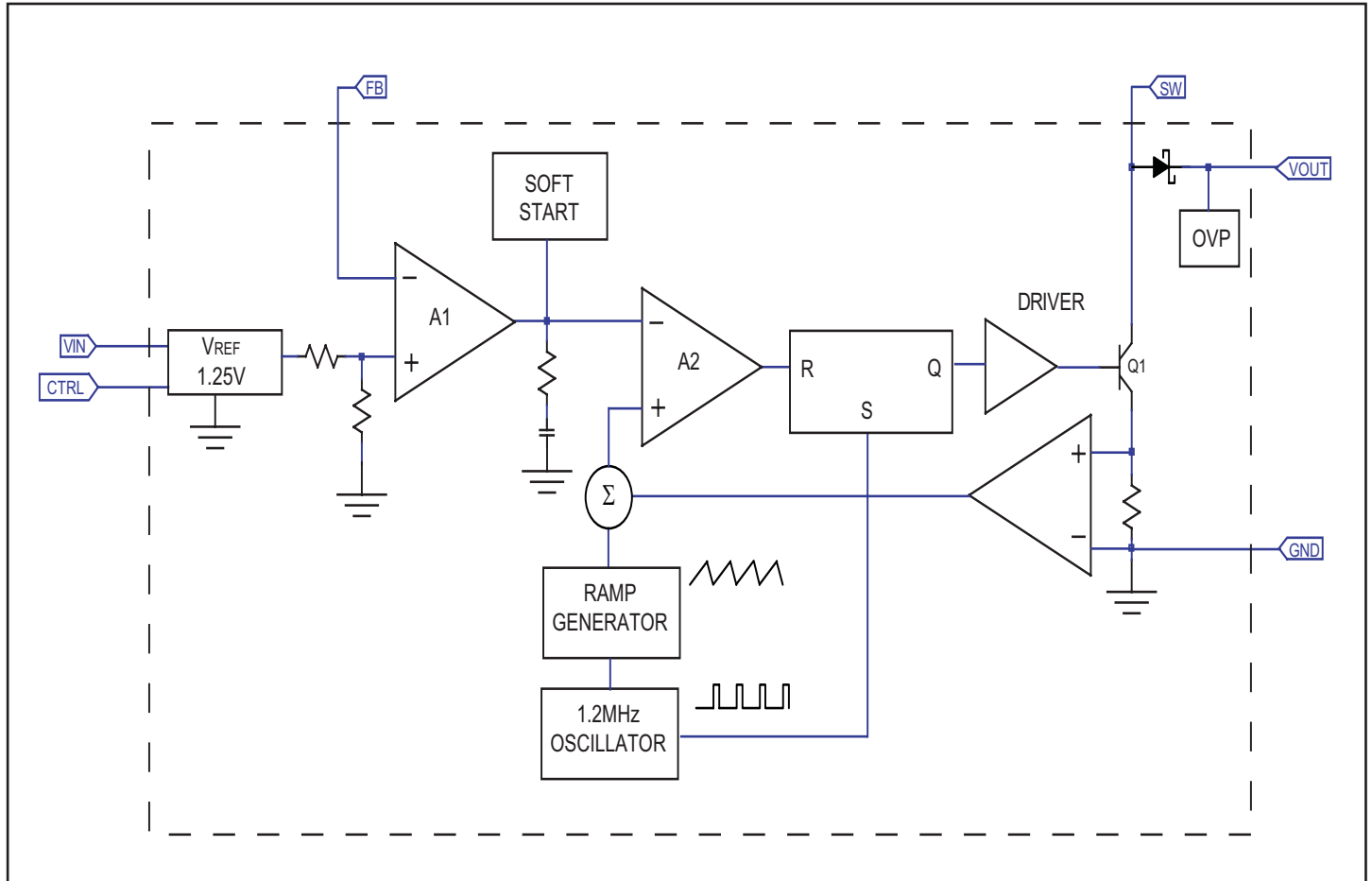


Fig.2. ZD1638 Block Diagram

Pin Description

Pin Number	Pin Name	Function
1	SW	Switch pin. Connect external inductor
2	GND	Ground
3	FB	Voltage feedback pin. Reference voltage is 200mV
4	CTRL	Shutdown and dimming pin. Connect to 1.8V or higher to enable device; Connect to 0.5V or less to disable device; Connect to a PWM signal to achieve LEDs brightness dimming
5	V _{OUT}	Output pin. Connect to the cathode of internal Schottky diode
6	V _{IN}	Input supply pin. Must be connected to a local bypass capacitor

Circuit Description

APPLICATION INFORMATION

Operation

The ZD1638 is a boost DC-DC converter which uses a constant frequency, current mode control scheme to provide excellent line and load regulation. Operation can be best understood by referring to the Figure 2.

At the start of each oscillator cycle, the SR latch is set and switch Q1 turns on. The switch current will increase linearly. The voltage on sense resistor is proportional to the switch current. The output of the current sense amplifier is added to a stabilizing ramp and the result is fed into the non-inversion input of the PWM comparator A2. When this voltage exceeds the output voltage level of the error amplifier A1, the SR latch is reset and the switch is turned off.

It is clear that the voltage level at inversion input of A2 sets the peak current level to keep the output in regulation. This voltage level is the output signal of error amplifier A1, and is the amplified signal of the voltage difference between feedback voltage and reference voltage of 200mV. So, a constant output current can be provided by this operation mode.

Constant LED Current Control

Refer to Figure 1, the LED current is controlled by the feedback resistor R1. LEDs' current accuracy is determined by the regulator's feedback threshold accuracy and is independent of the LED's forward voltage variation. So the precise resistors are preferred. The resistance of R1 is in inverse proportion to the LED current since the feedback reference is fixed at 200mV. The relation for R1 and LED current can be expressed as below:

$$R_1 = \frac{200mV}{I_{LED}}$$

Over Voltage Protection

The ZD1638 has an internal open-circuit protection circuit. When the LEDs are disconnected from circuit or fail open, the output voltage is clamped. The ZD1638 will switch at a low frequency, and minimize input current.

Soft Start

The ZD1638 has an internal soft start circuit to limit the in-rush current during startup. The time of startup is controlled by internal soft start capacitor. Please refer to Figure 3.

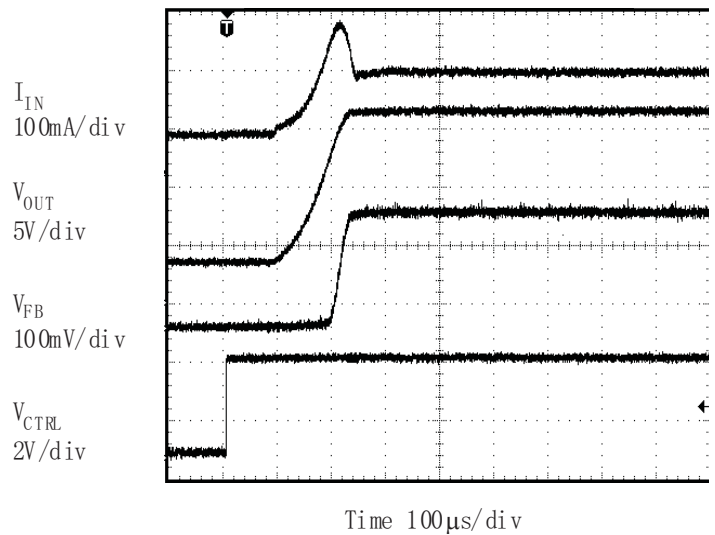


Fig.3. Soft Start Waveform ($V_{IN}=3.6V$, 5 LEDs, $I_{LED}=20mA$)

Circuit Description

Dimming Control

Two typical types of dimming control circuit are present as below. First, controlling CTRL Pin voltage to change operation state is a good choice. Second, changing the feedback voltage to get appropriate duty and luminous intensity is also useful.

(1) Adding a Control Signal to CTRL Pin Adding a PWM Signal to CTRL pin directly. The ZD1638 is turned on or off by the PWM signal when it is applied on the CTRL pin. The typical frequency of this PWM signal can be up to 2kHz. Please refer to Figure 4.

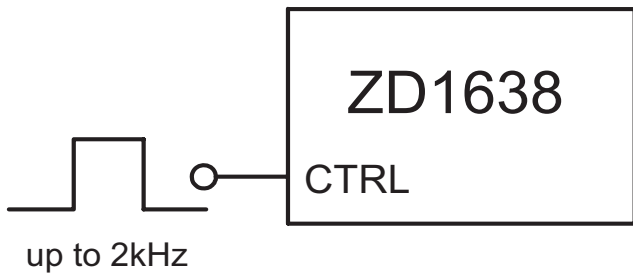


Fig.4. PWM dimming using the CTRL pin

(2) Changing the Effective Feedback Voltage There are three methods to change the effective feedback voltage.

Initially, adding a constant DC voltage through a resistor divider to FB pin can control the dimming. Changing the DC voltage or resistor between the FB Pin and the DC voltage can get appropriate luminous intensity. Comparing with differenet kinds of PWM signal control, this method features a stable output voltage and LED current. Please refer Figure 5.

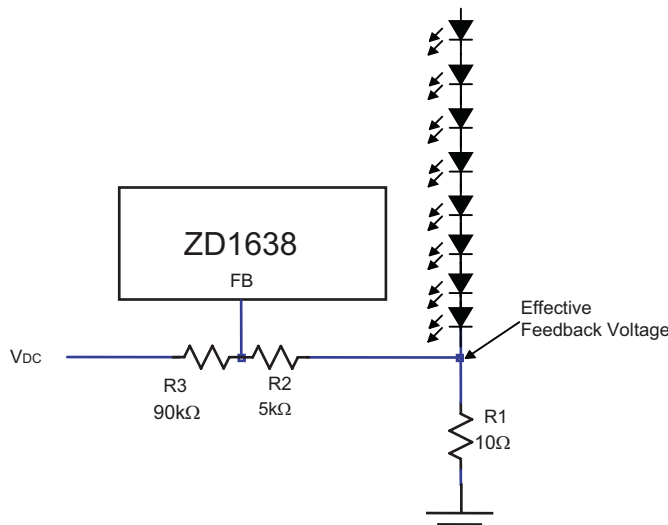


Fig.5. Dimming Control Using DC Voltage

Second, using a filtered PWM signal can do it. The filtered PWM signal can be considered as a varying and adjustable DC voltage.

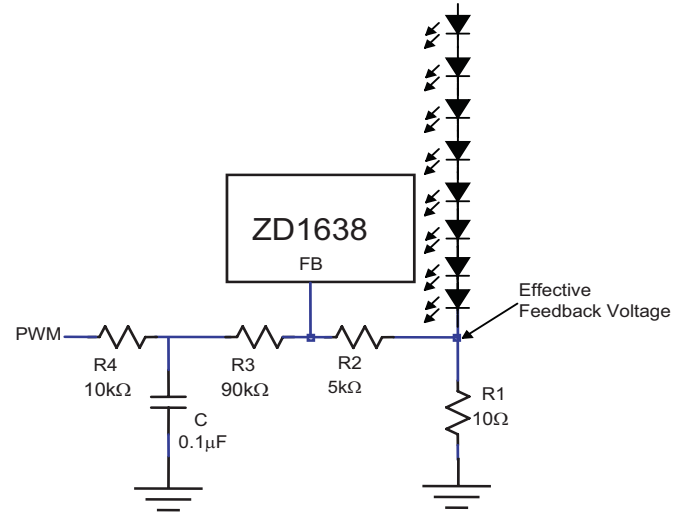


Fig.6. Dimming Control Using Filtered PWM Signal

Third, using a logic signal to change the feedback voltage. For example, the FB pin is connected to the GND through a MOSFET and a resistor. And this MOSFET is controlled a logic signal. The luminous intensity of LEDs will be changed when the MOSFET turns on or off.

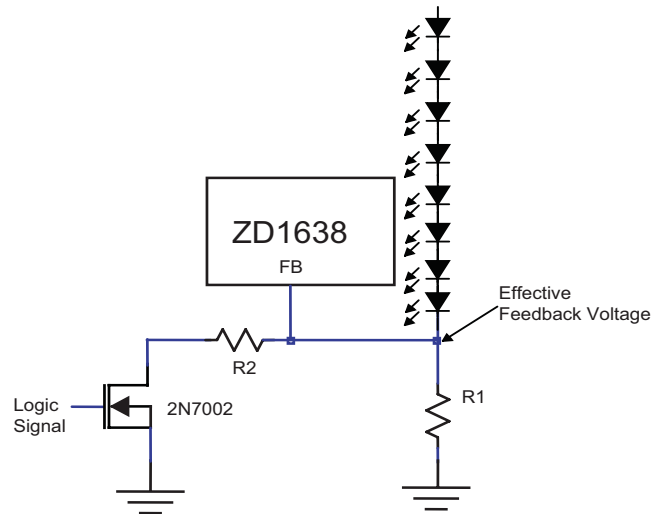


Fig.7. Dimming Control Using Logic Signal

Typical Performance Characteristics

WLED forward voltage (V_F) is 3.45V at $I_F=20\text{mA}$

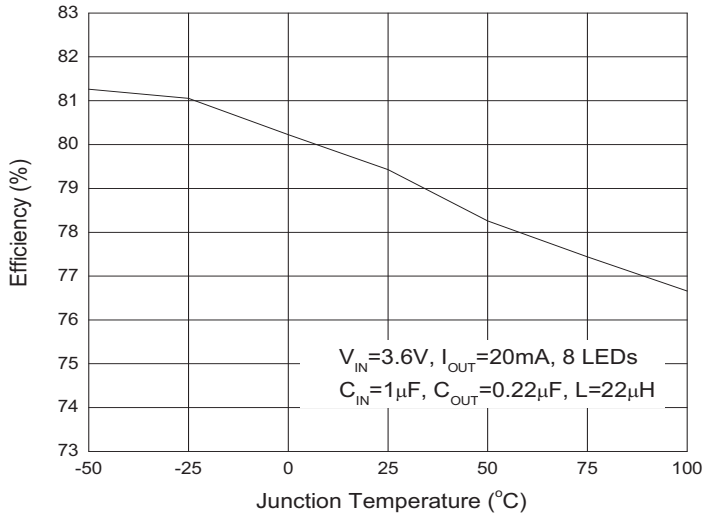


Fig.8. Efficiency vs. Junction Temperature

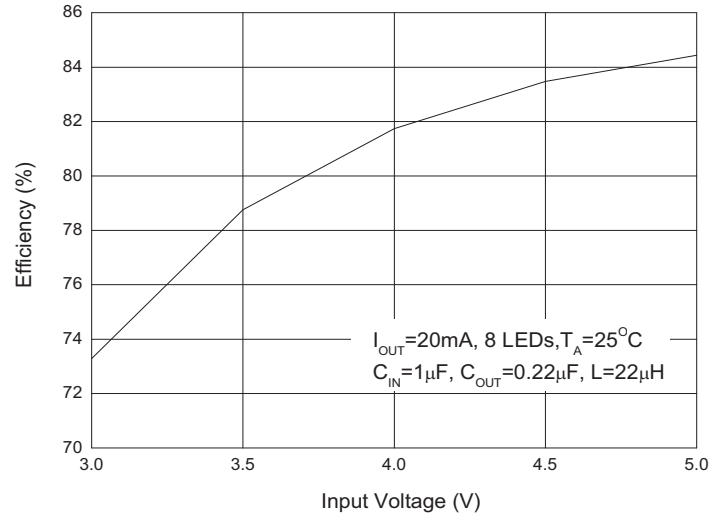


Fig.9. Efficiency vs. Input Voltage

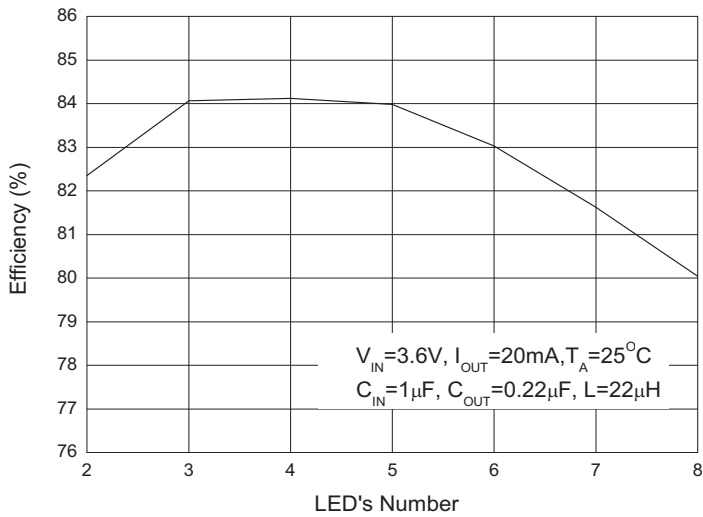


Fig.10. Efficiency vs. LED's Number

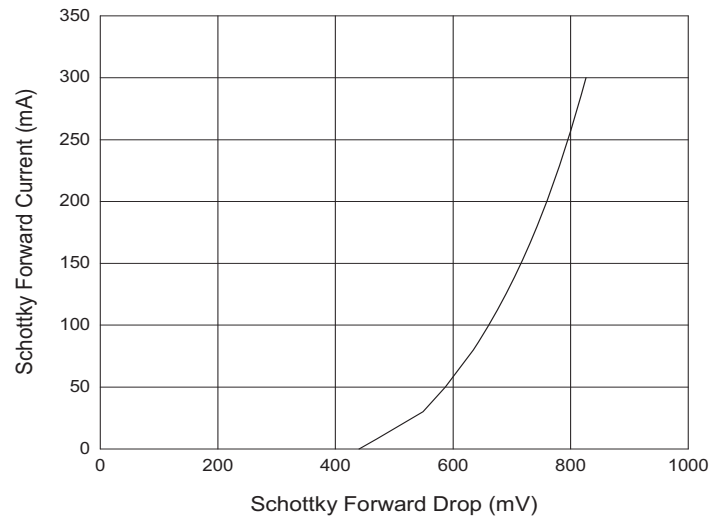


Fig.11. Schottky Forward Current vs. Schottky Forward Drop

Typical Performance Characteristics

WLED forward voltage (V_F) is 3.45V at $I_F=20\text{mA}$

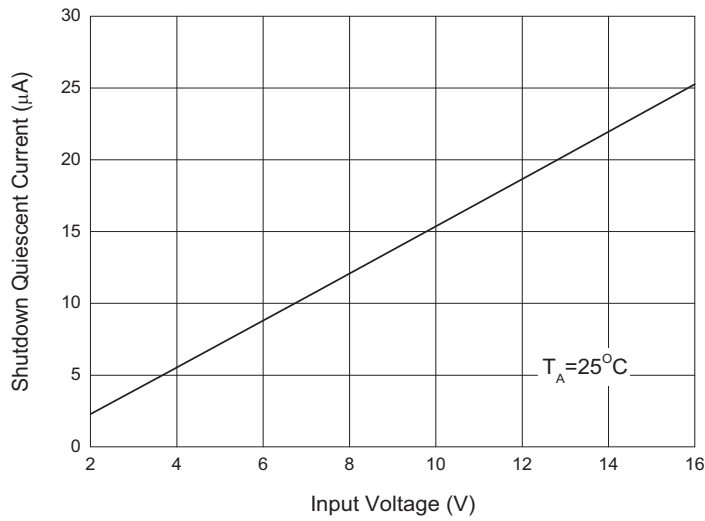


Fig. 12. Shutdown Quiescent Current vs. Input Voltage

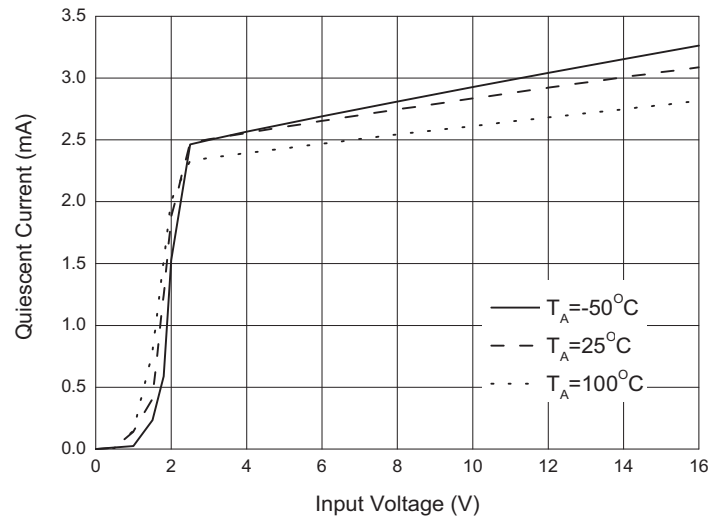


Fig. 13. Quiescent Current vs. Input Voltage

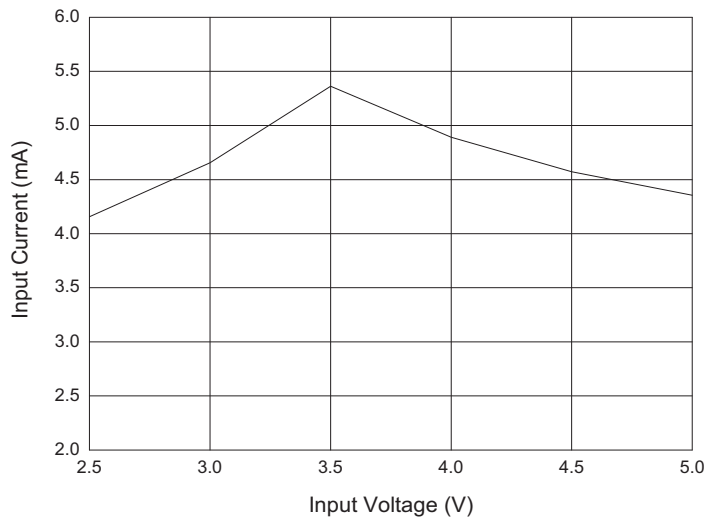


Fig. 14. Input Current in Output Open Circuit vs. Input Voltage

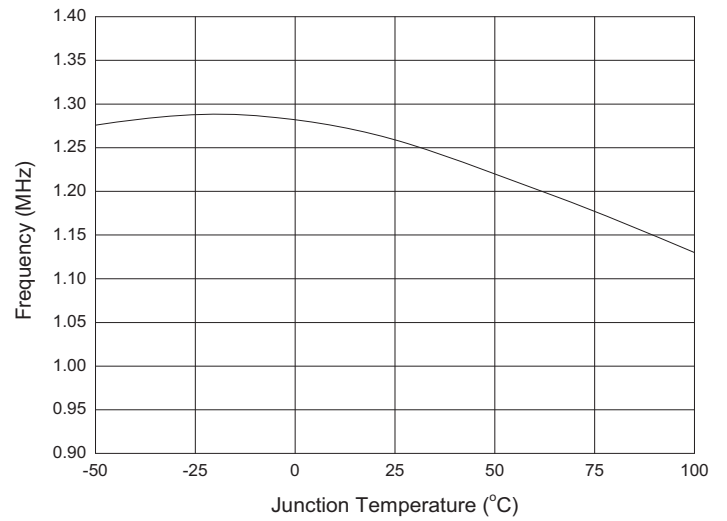


Fig. 15. Frequency vs. Junction Temperature

Typical Performance Characteristics

WLED forward voltage (V_F) is 3.45V at $I_F=20\text{mA}$

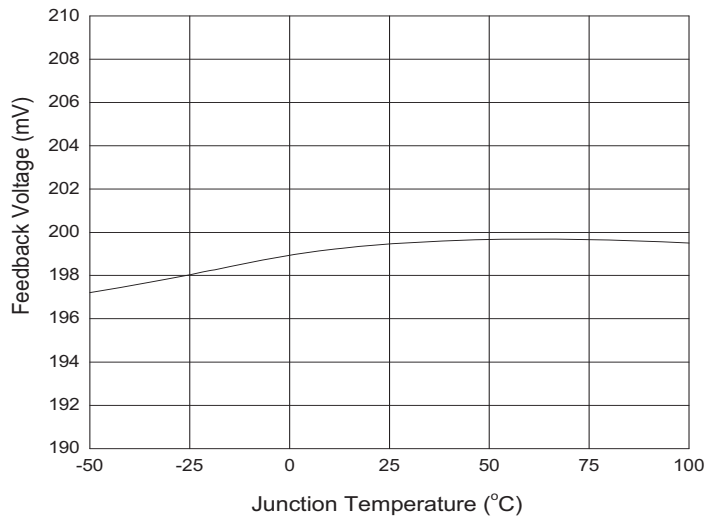


Fig. 16. Feedback Voltage vs. Junction Temperature

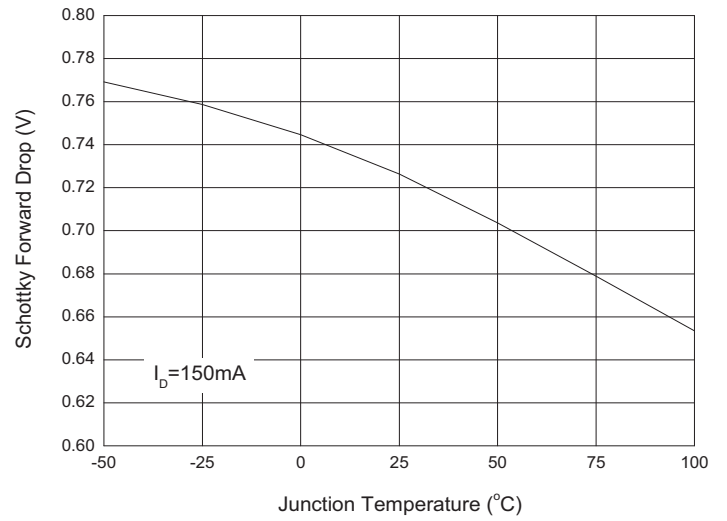


Fig. 17. Schottky Forward Drop vs. Junction Temperature

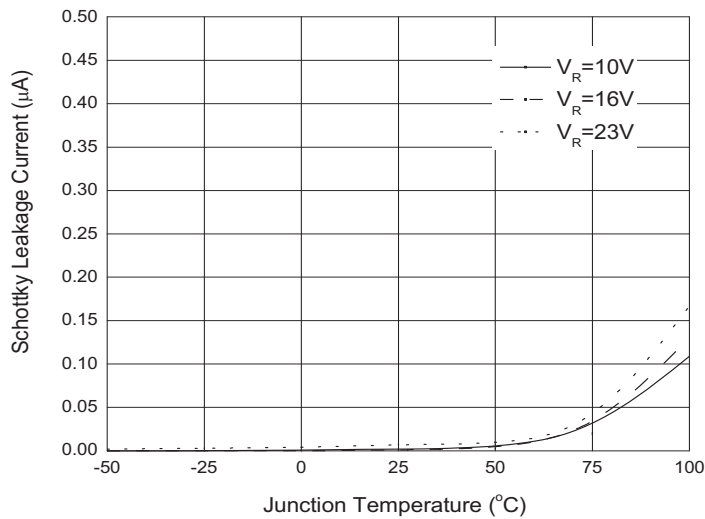


Fig. 18. Schottky Leakage Current vs. Junction Temperature

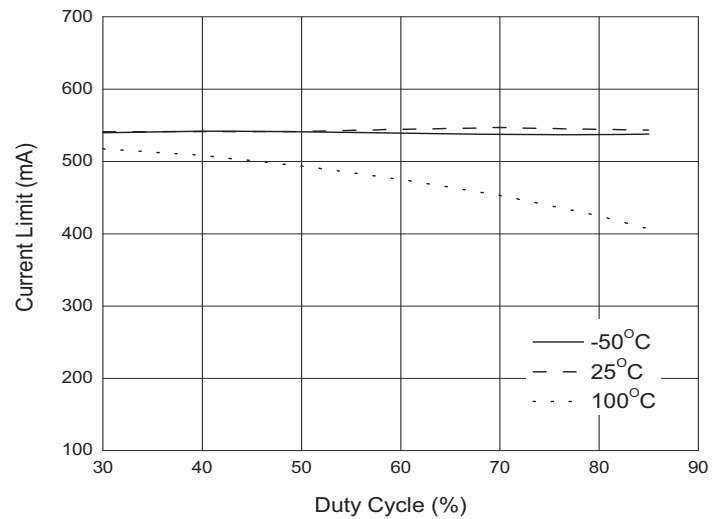


Fig. 19. Current Limit vs. Duty Cycle

Typical Performance Characteristics

WLED forward voltage (V_F) is 3.45V at $I_F=20\text{mA}$

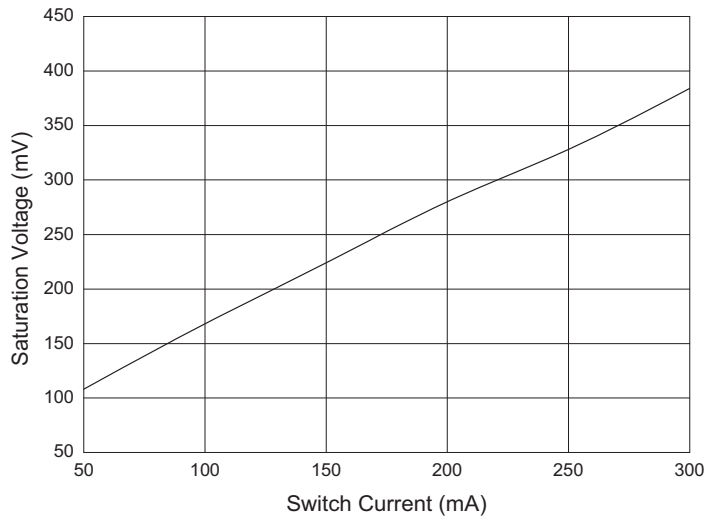


Fig.20. Saturation Voltage vs. Switch Current

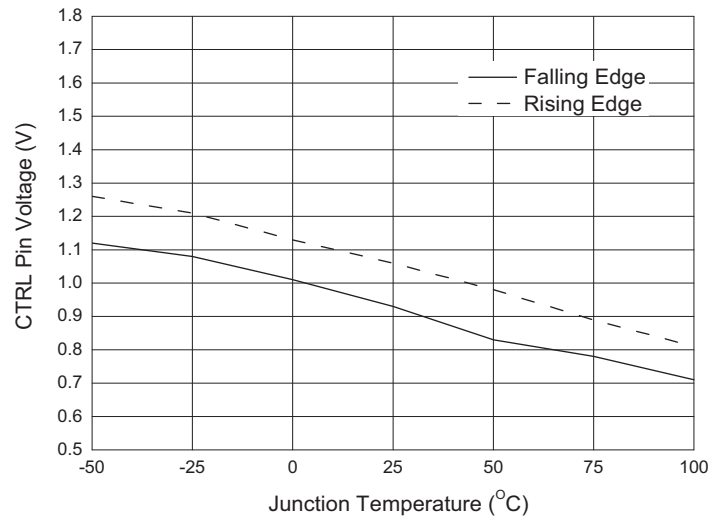
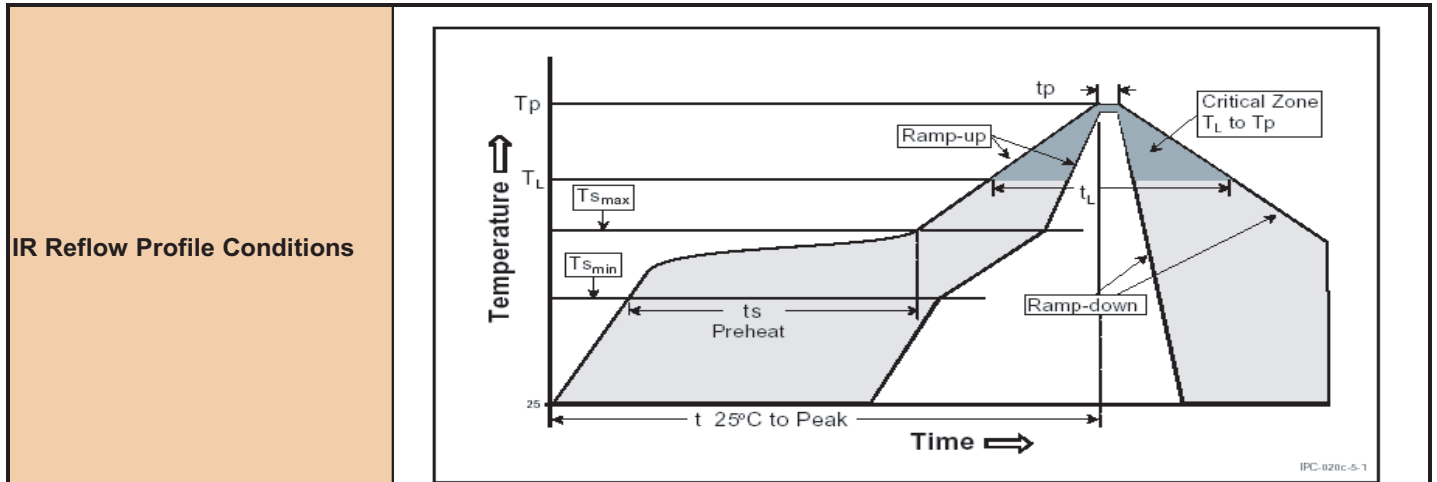


Fig.21. CTRL Pin Voltage vs. Junction Temperature

Green Package SMD IR Reflow Profile Information



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})	100°C	150°C
- Temperature Max (T_{Smax})	150°C	200°C
- Time (T_{Smin} to t_{Smax})	60~120 seconds	60~180 seconds
Time maintained above:		
- Temperature (T_L)	183°C	217°C
- Time (t_L)	60~150 seconds	60~150 seconds
Peak/Classification Temperature (T_P)	235°C+5/-0°C	260°C~265°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 :

- ALL DIMENSIONS ARE IN MILLIMETERS.
- DIMENSION D DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.20MM PER SIDE.
- DIMENSION E1 DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.20MM PER SIDE.
- 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.
- THE SECTION B-B APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.08MM AND 0.15MM FROM THE LEAD TIP.
- LEAD FRAME MATERIAL : EFTEC-64T 1/2H OR H.

SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	-	-	1.450	-	-	0.057
A1	0.000	-	0.100	0.000	-	0.004
A2	0.900	-	1.300	0.035	-	0.051
b	0.300	-	0.400	0.012	-	0.016
b1	-	-	-	-	-	-
c	0.100	-	0.200	0.004	-	0.008
c1	-	-	-	-	-	-
D	2.820	-	3.020	0.111	-	0.119
E	2.650	-	2.950	0.104	-	0.116
E1	1.500	-	1.700	0.059	-	0.067
L	0.300	-	0.600	0.012	-	0.024
L1	0.700			0.028		
e	0.950			0.037		
e1	1.800	-	2.000	0.071	-	0.079
θ	0°	5°	10°	0°	5°	10°
θ1	3°	5°	7°	3°	5°	7°
θ2	6°	8°	10°	6°	8°	10°

CUSTOMER : ZYWYN CORPORATION

APPROVED BY: [Signature] **DATE:** 01/28/2000

DRAW BY: Hui Chen

CHECK BY: Bill Wang

APPROVAL: Paul Lau

APPROVAL: Barry Chen

TITLE: SOT-26 PACKAGE OUTLINE DRAWING (FOR JEDEC)

DWG. NO.: PO-SOT-006 **REV.:** 2

UNIT: mm **SCALE:** 20/1 **SHEET:** 1 OF 1

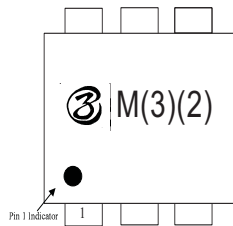
User feed direction →

Dimensions shown include: 1.75 ± 0.10, φ 1.55 ± 0.05, 4.00 ± 0.10, 2.00 ± 0.05, 0.249 ± 0.019, 3.50 ± 0.05, φ 1.00 ± 0.25, 4.00 ± 0.10, 8.00 ± 0.10, 9° MAX, 3.23 ± 0.10, 1.37 ± 0.10, 3.17 ± 0.10, 9° MAX.

Lead Count	Package	Tape And Reel					
		Width/mm	Pitch/mm	Reel Size	Standard Packing Quantity per Reel	Minimum Packing Quantity per inner box	Minimum Order Quantity per outer box
6	SOT-23-6	8+0.3/-0.1	4+/-0.1	7"	3000	15000	60000

Part Marking Information

TOPSIDE MARK INSTRUCTIONS:



Line 1: Zywyn Logo, Zywyn's Part Identification Code "M",
 Zywyn's Part Identification Code "(3)(2)"
 where (3) is a 2-character Lot # code
 (2) is a 1-character date-code
 MES is Zywyn's Engineering Sample.

Refer to Zywyn's WLED Part Marking Table for details.

BOTTOMSIDE MARK INSTRUCTIONS:



No bottom-side marking.

(For SOT-23-6 Package)

Zywyn Corporation

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