Application Note AN025

ZD810EVB Manual

General Description

ZD810

The ZD810 is a dimmable current-mode constant current LED driver IC. It drives an external MOSFET to accurately regulate the current in the LED string. The MOSFET can be sized for all types of LEDs including Power and HB LEDs beyond 1W. Its robust 450V rating makes it universally applicable to systems powered directly from Mains sources or from popular PFC sources. Its low voltage rating of 8V makes is suitable as well for low/medium voltage sources. The internal linear regulator generates 7.5V at the Vdd pin, which is also made available for external use, thus saving the cost of an external regulator.

ZD810EVB Evaluation Board Factory Default Settings

The ZD810EVB is an offline, high current LED driver demoboard configured to drive a maximum of 40V output from the LED string with a maximum ILED current of 1.5A. The ILED current can be dimmed by adjusting the on-board potentiometer from 350mA ~1.5A. PWM dimming can also be achieved by using an isolated PWM signal on the PWMD pin. The ZD810EVB operates at a voltage supply of 90VAC ~ 265VAC.

NOTE: MOV1 is not included on the EVB but is recommended and depends on the AC input voltage (see BOM list).

Typical Application

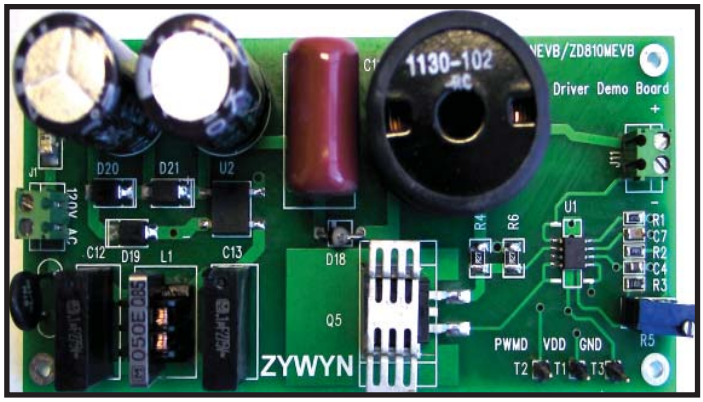


Figure 1. Default Setting of ZD810EVB

Ordering Information

Part Number	Temperature Range	Package Type
ZD810LEN	–40°C to +85°C	8-Pin nSOIC
ZD810NEVB	n/a	For 8-pin nSOIC
ZD810E27EVB	n/a	For 8-pin nSOIC

Please contact the factory for pricing and availabiliy on Tape-on-Reel option.

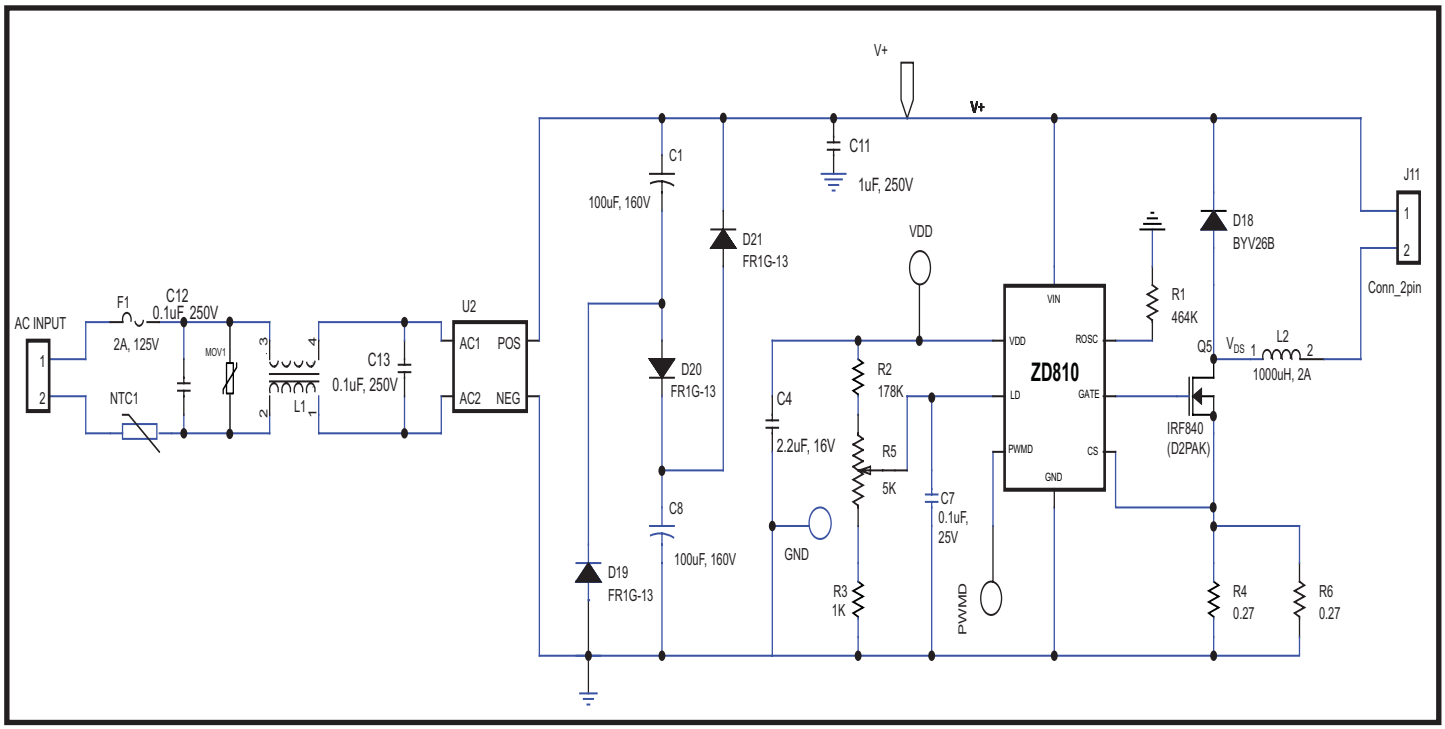


Figure 2. Typical Application of ZD810EVB

Board Connections

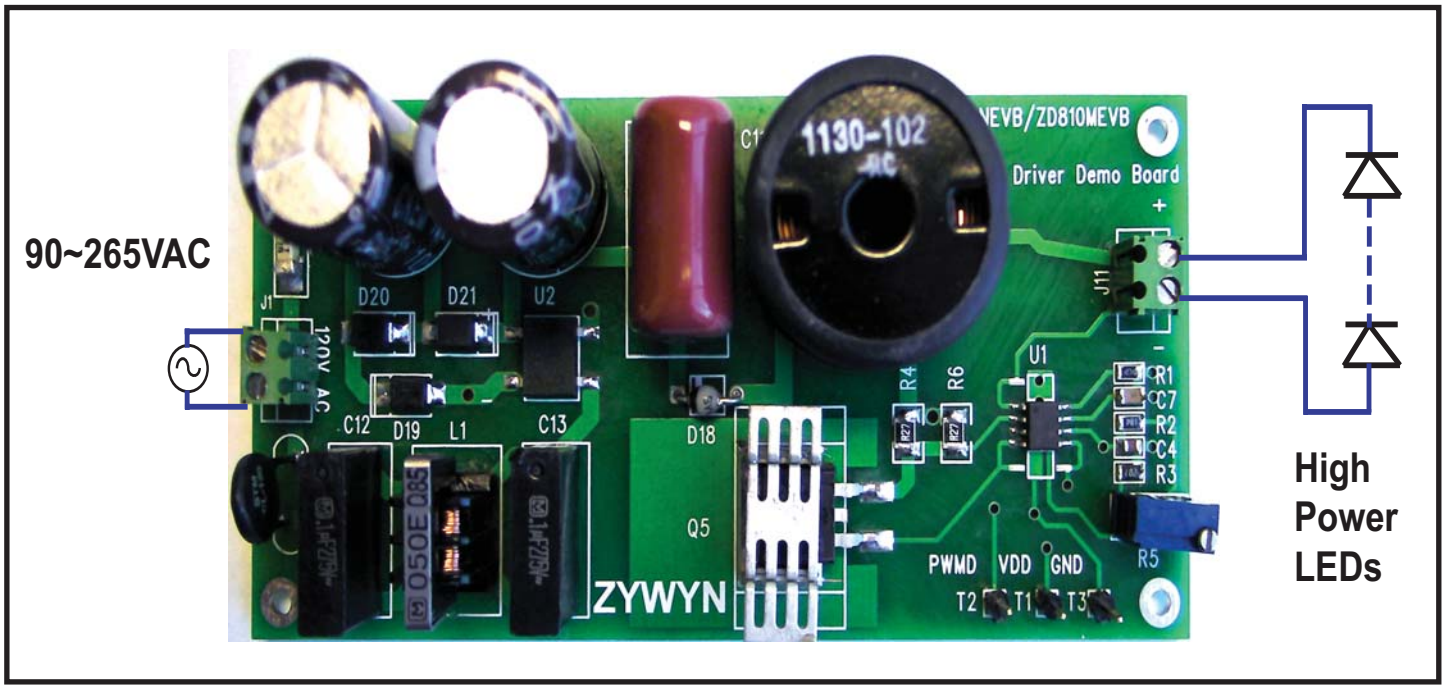


Figure 3. Input and Output Connections of the ZD810EVB

ZD810EVB Operation Description

AC INPUT

An input terminal block, J1, on the ZD810EVB is used to connect a 90~265VAC line voltage.

WARNING: THE ZD810EVB IS NOT ISOLATED FROM THE LINE VOLTAGE. DO NOT CONNECT EARTH GROUNDED MEASURING INSTRUMENTS TO THE THE ZD810EVB. ALL MEASURING INSTRUMENTS MUST BE ISOLATED (FLOATING GROUND OR BATTERY OPERATED).

OUTPUT

An output terminal block, J11, on the ZD810EVB is used to connect the LED string. The ZD810EVB allows an output voltage of 10~40V driving the LED string with ILED current set by the sensing resistors, R4 and R6, and the trim pot R5.

VDD

This is the internally regulated voltage of the ZD810, which is typically 7.5V. This pin can be used to drive external circuitry (SEE DATASHEET).

GND

This is the circuit ground for the ZD810.

PWMD

This is the PWMD pin of the ZD810. It can be used as an enable/disable pin or as a PWM dimming pin.

A 50Hz ~ 1kHz PWM signal with respect to GND can be applied to this pin for PWM dimming. The duty cycle (0~100%) of the PWM determines the percentage of the ILED current

If PWM dimming is not desired, connect this pin to VDD to enable the ZD810 for 100% of the set ILED.

WARNING: THE PWM SIGNAL MUST BE ISOLATED FROM THE AC INPUT VOLTAGE.

LINEAR DIMMING

The ZD810EVB also allows for linear dimming using the the on-board 5kΩ potentiometer, R5, connected to the LD pin. When the LD pin is less than 250mV, the LD pin can be used to linearly adjust the LED brightness. With the external resistor divider, R2 and R3, connected to the VDD pin and the potentiometer, the ILED current can be dimmed linearly from 350mA ~ 1.5A.

Designing applications using the ZD810 with constant switching frequency

Step 1 Switching Frequency and R1

The switching frequency determines the value and size of the inductor and input capacitor of the application. The higher the frequency, the smaller the size. The higher the input voltage range, the lower the frequency should be to avoid capacitive losses.

For a 100VAC ~ 130VAC application, f_{OSC}=100kHz can be used.

For a 200VAC ~ 250VAC application, f_{OSC}=20~50kHz can be used.

The oscillating resistor, R1 can be solved with the following equation:

$$t_{OSC}(\mu s) = \frac{R_1(k\Omega) + 22}{25} \quad (1)$$

Step 2 Diode bridge and Thermistor

The diode bridge rectifier depends on the maximum AC input voltage used in the application and varies from country to country. A 50% safety margin is used to determine the maximum voltage rating on the diode bridge rectifier in equation (2).

$$V_{BRIDGE} = 1.5 \cdot (\sqrt{2} \cdot V_{INMAX,AC}) \quad (2)$$

$$I_{BRIDGE} = \frac{V_{OUT,MAX} \cdot I_{OUT,MAX}}{V_{INMIN,DC} \cdot \eta} \quad (3)$$

$V_{INMAX,AC}$ = the maximum rated AC input voltage

$V_{OUT,MAX}$ = the maximum output voltage desired in the application

$I_{OUT,MAX}$ = the maximum output current desired in the application

$V_{INMIN,DC}$ = the minimum rectified DC input voltage needed to drive the application. This voltage must be 2 times the maximum output voltage to avoid sub-harmonics when the duty cycle is greater than 50%

η = efficiency (assuming 90%).

A thermistor in series with the diode bridge will limit the inrush current caused by the capacitor during start-up.

$$R_{COLD} = \frac{V_{BRIDGE}}{5 \cdot I_{BRIDGE}} \quad (4)$$

Step 3 Input capacitors

$$C1 \geq \frac{V_{OUT,MAX} \cdot I_{OUT,MAX}}{\left(2 \cdot V_{MIN,AC}^2 - V_{MIN,DC}^2\right) \cdot \eta \cdot freq} \quad (5)$$

$$V_{MAX,CAP} \geq \sqrt{2} \cdot V_{MAX,AC} \quad (6)$$

$V_{INMAX,AC}$ = the maximum rated AC input voltage

$V_{OUT,MAX}$ = the maximum output voltage desired in the application

$I_{OUT,MAX}$ = the maximum output current desired in the application

$V_{INMIN,DC}$ = the minimum rectified DC input voltage needed to drive the application. This voltage must be 2 times the maximum output voltage to avoid sub-harmonics when the duty cycle is greater than 50%

freq = the AC line frequency and depends on country

η = efficiency (assuming 90%).

Step 4 Inductor

The inductor depends on the ripple current and a +/- 15% ripple is used for the equation below (30% total).

$$L1 = \frac{V_{O,MAX} \cdot \left(1 - \frac{V_{O,MAX}}{\sqrt{2} \cdot V_{AC,NOM}}\right)}{0.3 \cdot I_{O,MAX} \cdot f_{OSC}} \quad (7)$$

Choose a peak current rating for the inductor that is greater than the equation:

$$I_P = I_{O,MAX} \cdot 1.15 \quad (8)$$

Step 5 MOSFET and Switching diode

The maximum voltage that will be applied on the MOSFET will be equal to the maximum input voltage. The current through the MOSFET depends on the maximum duty cycle, which is 50%. Again for safety, the voltage on the MOSFET is multiplied by 1.5 and the current through the MOSFET is multiplied by 3 in the following equations. The MOSFET

$$V_{FET} = 1.5 \cdot (\sqrt{2} \cdot V_{MAX,AC}) \quad (9)$$

$$I_{FET} = 3 \cdot I_{OUT,MAX} \cdot \sqrt{0.5} \quad (10)$$

The maximum voltage that will be applied on the diode is the same as the MOSFET

$$V_{DIODE} = V_{FET} \tag{11}$$

$$I_{DIODE} = 0.5 \cdot I_{OUT,MAX} \tag{12}$$

Step 6 Sense resistor

The sense resistor is given in the datasheet by the equation

$$R_{CS} = \frac{0.25V(or\ V_{LD})}{1.15 \cdot ILED(A)} \tag{13}$$

Step 7 Optional High Frequency Capacitor

A good option to absorb the high frequency ripple is to use a multi-layer ceramic capacitor in parallel with C1.

$$C = \frac{I_{O,MAX} \cdot 25}{f_{OSC} \cdot 0.05 \cdot V_{MIN,DC}} \tag{14}$$

DC Applications

For a DC application, skip Step 2 and equations (5) and (6) and use equation (14) as the input capacitor. Equation (7) can be changed to:

$$L1 = \frac{V_{O,MAX} \cdot \left(1 - \frac{V_{O,MAX}}{V_{IN,DC}}\right)}{0.3 \cdot I_{O,MAX} \cdot f_{OSC}} \tag{15}$$

ZD810EVB EXAMPLE

The equations above are used to determine components for the ZD810EVB. The ZD810EVB operates at a voltage supply of 90VAC ~ 265VAC.

NOTE: Due to size and availability of components, a 15% safety margin is used for the 220VAC application.

ZD810EVB Bill of Material (BOM) Listing

Item	Quantity	Location	Description
1	2	J1, J11	Terminal Block
2	2	C1, C8	100μF, 200V electrolytic capacitor
3	1	C4	2.2μF, 16V SMD 0805 ceramic capacitor
4	1	C7	0.1μF, 25V SMD 0805 ceramic capacitor
5	1	C11	1μF, 400V metallized polypropylene capacitor
6	2	C12, C13	0.1μF, 275V metallized polyester capacitor
7	1	D18	400V, 1.5A fast - soft recovery diode
8	3	D19, D20, D21	400V, 1A SMB fast recovery diode
9	1	F1	Slow Blo SMD 250V, 2A fuse
10	1	L1	Low profile common mode choke
11	1	L2	1000μH, 2A inductor
12	1	NTC1	NTC inrush current limiter
13	1	Q5	500V, 8A D2PAK MOS-FET
14	1	R1	464kΩ, 1/8W 0805 SMD resistor
15	1	R2	178kΩ, 1/8W 0805 SMD resistor
16	1	R3	1kΩ, 1/8W 0805 SMD resistor
17	2	R4, R6	0.27Ω, 1/4W 1210 SMD resistor
18	1	R5	Top adjust 5kΩ trim pot
19	1	U1	Universal LED driver
20	1	U2	400V, 1.5A, DF-S, single phase diode bridge
21	1	-	D2PAK heat sink
22	1	MOV1 (Optional)	ERZ-V05D221(110VAC) or ERZ-V05D431(220VAC)

ZD810E27EVB for 5W E27 LED Lamp

The equations above are used to determine components for the ZD810E27EVB. The ZD810E27EVB operates at a voltage supply of 90VAC ~ 265VAC and is ideal for 5W LED light output on an E27/GU10 light bulb or equivalent platforms.

ZD810E27EVB Bill of Material (BOM) Listing

Item	Quantity	Location	Part	Outline
1	1	U1	ZD810	SOP-8
2	1	DB1	B6S	SMT
3	1	C1	10μF/400V	DIP
4	1	C2	2.2μF/16V	1206
5	2	CO	0.1μf/500V	1812
6	1	Q1	MOSFET,EMD06N60F	TO-220, LEADED
7	1	L1	3.3mH/400mA	12X16 LEADED
8	1	F1	SCK08082MSY	LEADED
9	1	R1	440kΩ, 1%	0805
10	1	R2A	1.4Ω, 1%	1206
11	1	R2B	1.4Ω, 1%	1206
12	1	D2	600V/2A, SFM28	SMT
13	1	Z1	ZMM55C43 zener diode 43V, 0.5W	SOD-80,SMT
14	1	R2	3.3kΩ, 5%	1206
15	1	MOV1 (Optional)	ERZ-V05D221(110VAC) or ERZ-V05D431(220VAC)	LEADED

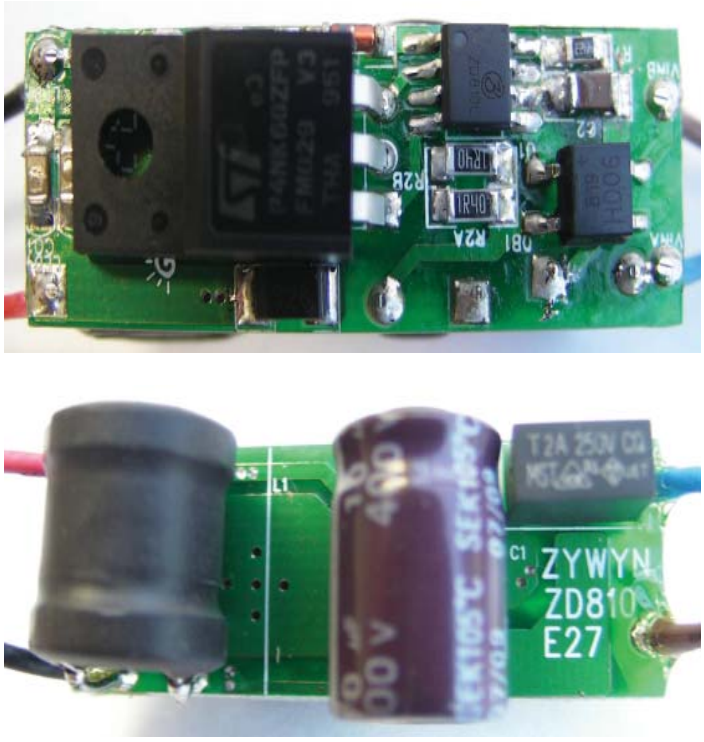


Figure 4 and 5 ZD810E27EVB top and bottom view.

Figure 6 E27 form factor light bulb with ZD810E27EVB inside

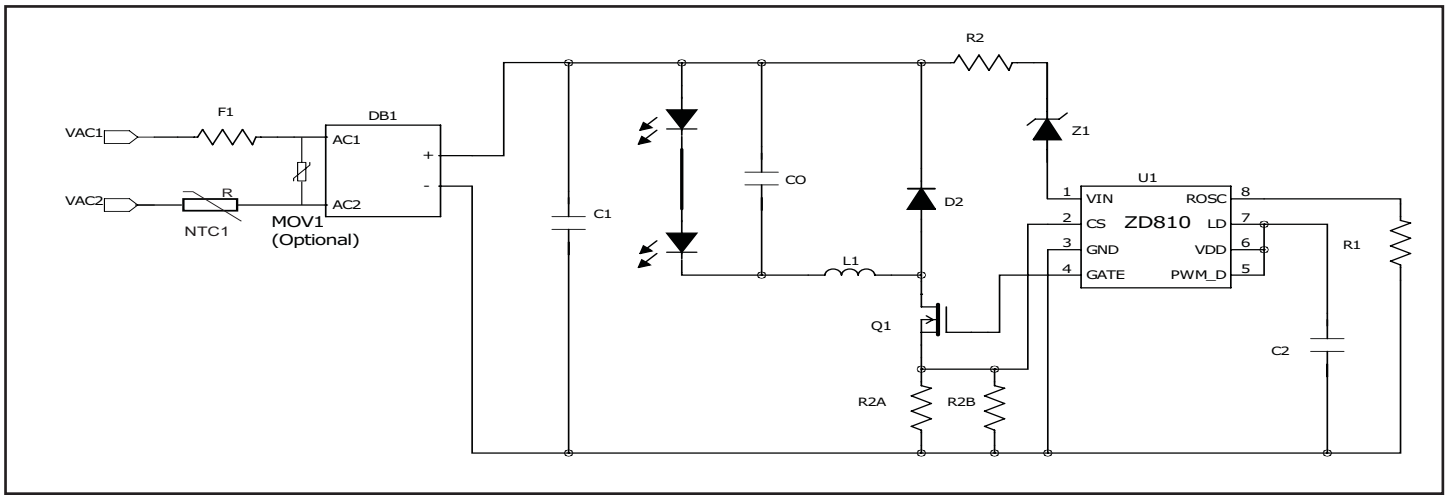
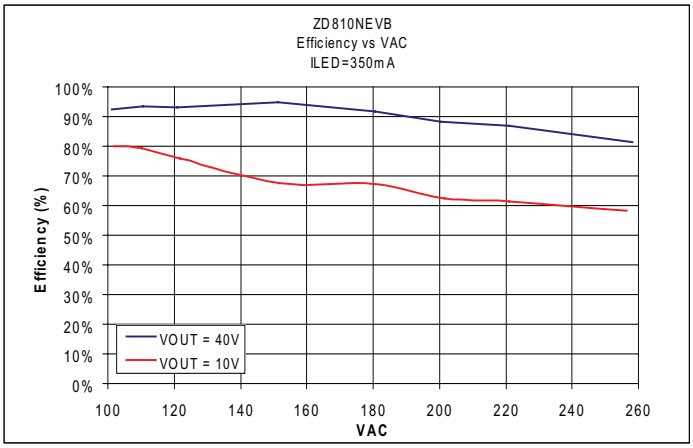
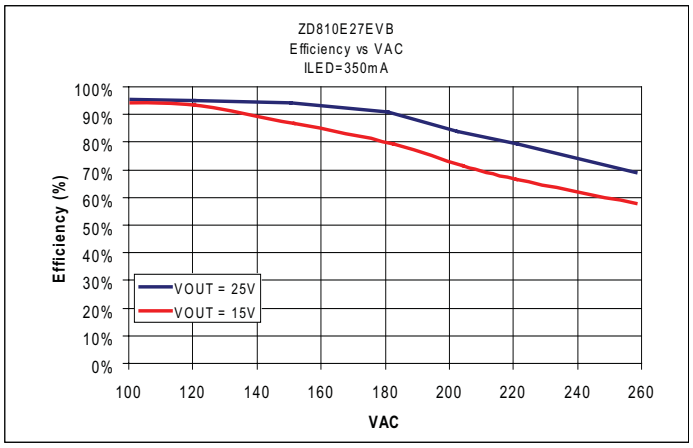
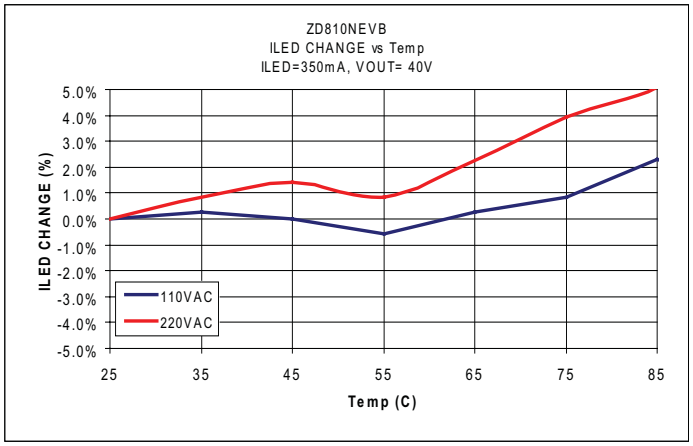


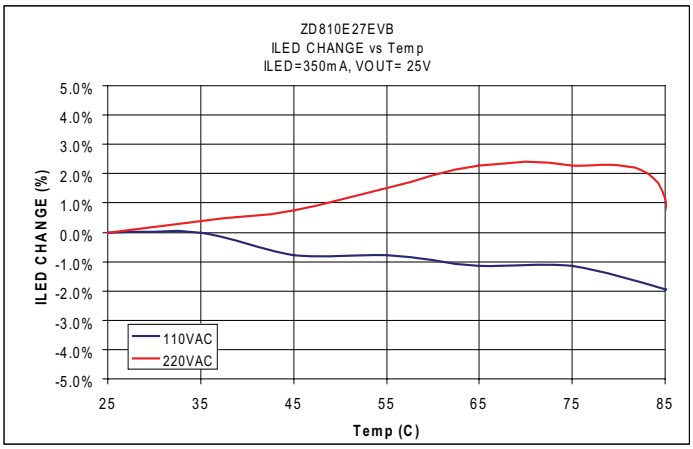
Figure 7. Typical Application of ZD810E27EVB

Typical Performance

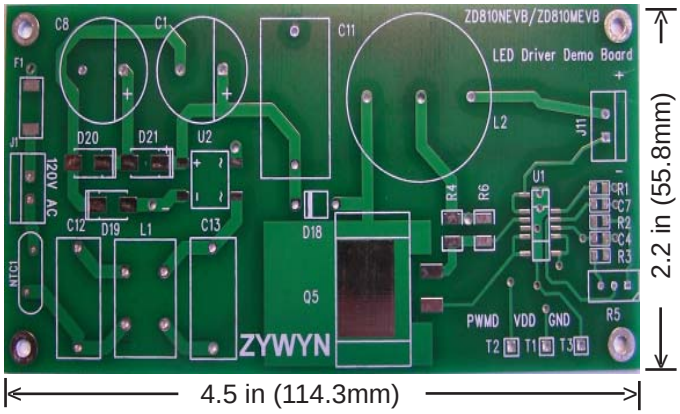








Evaluation Board Information



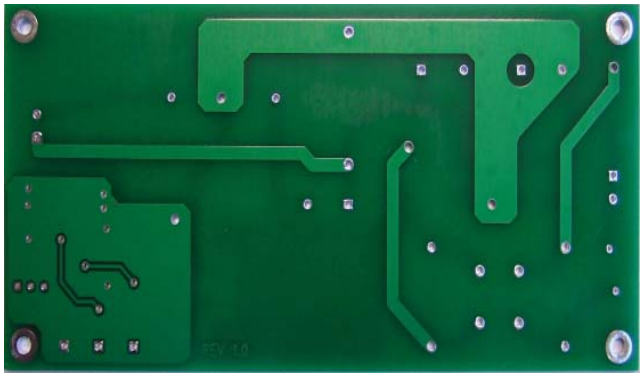


Figure 8 and 9 ZD810EVB top and bottom view.

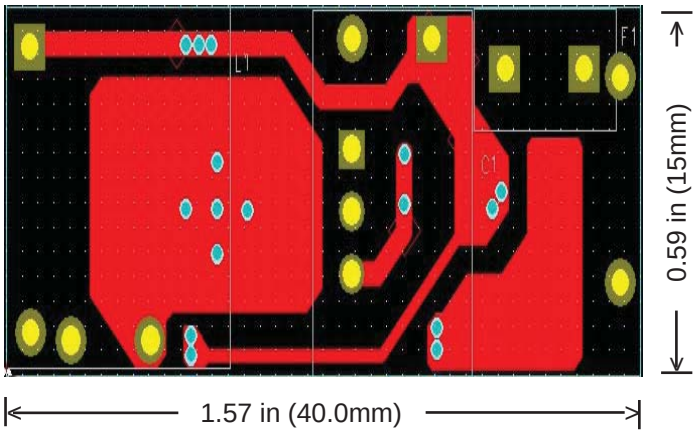


Figure 10 ZD810E27EVB Top Layout

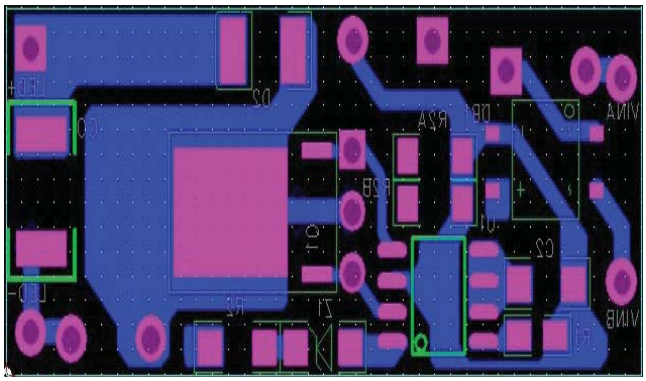


Figure 11 ZD810E27EVB Bottom Layout

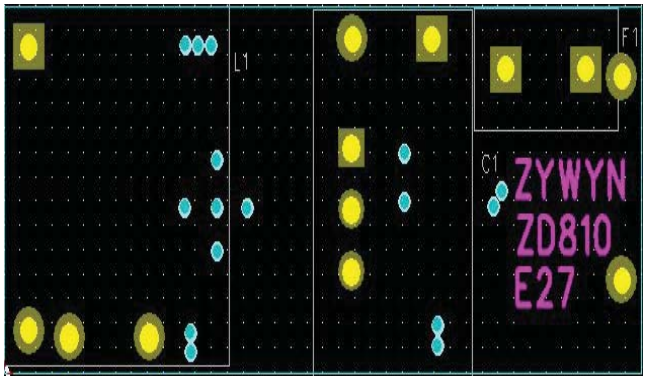


Figure 12 ZD810E27EVB Silkscreen Layout

Zywyn Corporation
Headquarters and Sales Office
1270 Oakmead Parkway, Suite 201 • Sunnyvale, CA 94085 • Tel: (408) 733-3225 • Fax: (408) 733-3206
Email: sales@zywyn.com • www.zywyn.com

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