基于ZD832的通用AC输入无变压器AC-DC恒流LED驱动器

摘　要：ZD832是一种用于驱动白光或RGB串联LED串的高压无变压器AC-DC恒流驱动器IC。它利用85～125VAC或180～240VAC的通用输入电压操作，产生一个可达30mA的可编程恒定输出电流，能为所有形式因数的LED灯和照明系统驱动直达117个串联LED(@V_F=1.8V)。

关键词：ZD832；LED驱动器；通用AC输入；无变压器；可调光；过温度/过电压保护

Universal AC Input Transformer-Free AC-DC Constant-Current LED Driver Based on ZD832

ZHU Dawei

(Beijing Zhi-Qianli Science & Trading Co., Ltd, Beijing 100029, China)

Abstract: The ZD832 is a high voltage, Transformer-Free ("no transformer") AC-DC constant-current driver IC for driving white or RGB LEDs in series. It operates under an universal input voltage of 85～125VAC or 180～240VAC, generates a up to 30mA programmable constant output current and it is able to drive up to 117 LEDs (@V_F=1.8V) for all form-factored LED lamps and lighting systems.

Keywords: ZD832; LED Driver; Universal AC Input; Transformer Free; Dimmable; Over-temperature/Over-voltage Protection

中图分类号: TM923.34,TM46　　**文献标识码**: B　　**文章编号**: 0219-2713(2010)01-0024-04

0 引言

目前LED分DC LED 和AC LED两类。AC LED是韩国首尔半导体在前几年发明的，它不需要驱动电路，可像电灯泡一样，直接由110V/220V的工频电源来驱动。目前被广为应用的LED是DC LED，需用DC电源供电。如果使用工频电源为DC LED供电，必须经其进行AC-DC转换。AC-DC转换方案有数种，但无论是哪一种转换方案，都需使用工频或高频变压器和桥式整流器，有的还要使用一个电感器，并且整个驱动电路比较复杂，使用元件较多。

Zywyn公司推出ZD832全球通用AC输入AC-DC恒流LED驱动器IC，在应用中无需外加变压器、桥式整流器和电感器，元件总量仅为6～10个，则可以驱动几十个乃至100多个串联在一起的LED(@30mA)，输出功率可达8W左右。

1 关于ZD832的一般介绍

1）内部结构

收稿日期：2009-10-10

ZD832芯片集成了桥式整流器、线性控制结构体系以及功率MOSFET和保护电路，从而消除了在应用时外部变压器、电感器和桥式整流二极管的需要。

2）封装及引脚功能

ZD832采用符合欧盟RoHS指令的20引脚热增强的裸露TSSOP无铅“绿色”封装，引脚排列如图1所示，各引脚功能见表1.

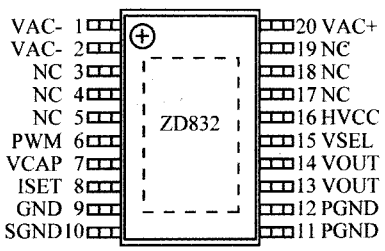

图1 ZD832引脚排列

表1 ZD832引脚功能

引脚号	引脚名称	引脚功能
1，2	VAC−	高压AC输入。当输入为85～125VAC时，引脚VSEL连接HVCC；当输入为180～240VAC时，引脚VSEL悬空
20	VAC+	
6	PWM	LED亮度控制端，PWM或逻辑高/低电平输入
7	VCAP	内部稳压器输出，从该引脚到SGND连接一个1μF/16V的退耦电容
8	ISET	从该端到PGND连接一个电阻设置LED电流
9	GND	基片地，必须连接到SGND(引脚10)
10	SGND	信号地，所有小信号元件的地连接到该端
11，12	PGND	电源和功率级地
13，14	VOUT	LED驱动器MOSFET漏极输出
15	VSEL	85～125VAC(该端连接HVCC)或180～240VAC(该端开路0的AC输入选择端
16	HVCC	经整流的DC电压输出，同时(在VAC+和VAC−无输入时)又是DC电压输入端
3，4，15，17，18，19	NC	空脚

3）主要特点

(1)芯片集成了桥式整流器、线性结构体系和功率开关管，在应用时无需外加桥式整流器、变压器、电感器和功率MOSFET，使外加元件减少到5～9个。

(2)在引脚VAC+和VAC−上的AC输入可通过引脚VSEL选择。若VSEL连接HVCC，AC输入为85～125V；若VSEL引脚悬空，AC输入则为180～240V。

(3)当在引脚VAC+和VAC−没有AC输入时，一个85～340V的DC电压可以从引脚HVCC输入。在此情况下，从引脚HVCC到PGND应当连接一个1μF/250V的电容。

(4)LED电流从3mA到30mA，可以通过引脚ISET上的接地电阻R_{SET}(73～733kΩ)来编程，计算公式为I_{LED}=2200V/R_{SET}。

(5)能够驱动近百个正向压降U_F=3.1～3.3V、I_{LED}=15～30mA的串联在一起的LED。若U_F=1.8V，可以驱动多达117个相串联的LED。

(6)提供PWM调光和模拟电压调光控制。在引脚PWM施加一个50HZ～5kHZ的PWM信号，可以实现数字PWM调光。引脚PWM同时提供开、关功能。当引脚PWM为逻辑低电平(“0”)时，IC进入关闭模式；当引脚PWM为逻辑高电平(“1”)时，IC则完全导通。

如果通过一个电阻R_{SET}在引脚ISET施加一个0～1.25V的DC电压，可以实现模拟电压调光，如图2所示。随电压增加，LED电流将减少，亮度则变暗。

(7)提供过温度和过电压保护。

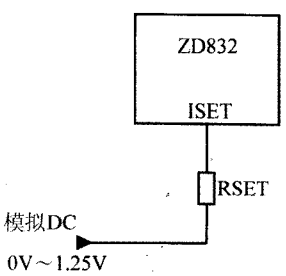

图2 用模拟电压调光

2 基于ZD832的LED串驱动电路

1）220V(±2%)输入驱动78个串联LED电路

220V(±2%)AC输入驱动78个正向电压U_F=3.3V(@30mA)的串联在一起的LED电路如

图3所示。串接在引脚VAC+(也可以是VAC-)上的1kΩ/0.5W的NTC热敏电阻，用于限制启动时因对输出电容C_{OUT}充电而产生的浪涌电流。由于LED电流I_{LED}=30mA，电流限制电阻值则为：R_{SET}=2200V/30mA=73kΩ。

ZD832引脚U_{OUT}上的电压U_{OUT}范围为3～30V，通常将其设定在7～20V的范围之内。如果U_{OUT}值较大，通常要连接一个限制电阻R_{EXT}，以保护内部的功率开关管。如果引脚HVCC上的电压为U_{HVCC}，串联LED的数量为N，则：

$$R_{EXT}=(U_{HVCC}-N\cdot U_F-U_{OUT})/I_{LED}$$

在220VAC(±2%)输入时，在IC引脚HVCC上的平均DC电压是279V，若选择U_{OUT}=13V，可得：R_{EXT}=(279V-78·3.3V-13V)/30mA=287Ω

选择R_{EXT}=270Ω。

R_{EXT}的额定功率根据公式

$P_{REXT}=(I_{LED})^2\cdot R_{EXT}$计算，即

$P_{REXT}=(30mA)^2\cdot 270\Omega=0.243W$，选择0.5W。

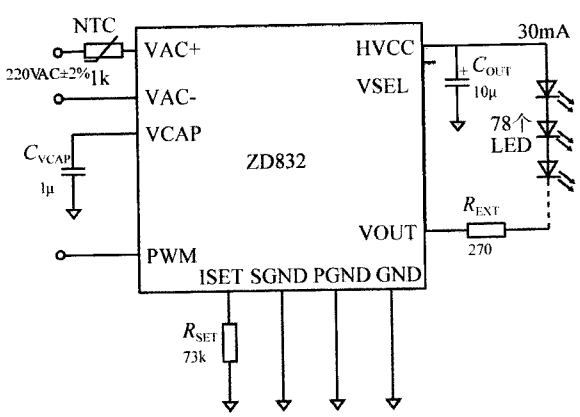

图3 220V_{AC}输入驱动78个串联LED电路

2) 220VAC(±2%)输入驱动40个串联LED电路

图4为输入电压为220VAC(±2%)带电容降压驱动40个串连在一起的LED电路。由于LED的正向电压U_F=3.3V，LED串的总电压降为40·3.3V=132V。如果在ZD832输入端(VAC-)不串接RC电路将220VAC输入降压，引脚HVCC上的输出电压达279V，如此高的电压来驱动40个3.3V(@30mA)串联在一起的LED是不适宜的。在引脚VAC-上串联一个1.5μF/250V的降压电容C_{AC}后，实际输入到IC引脚VAC+与VAC-上的AC电压变为110V，因此引脚VSEL应当连接到HVCC。引脚HVCC上的平均输出电压约为150VAC，引脚U_{OUT}上的电压为150V-132V=18V，因此在引脚U_{OUT}上可以不加限制电阻。与电容C_{AC}并联在一起的R_{AC}为泄放电阻，在关断电源后为C_{AC}放电提供通路。

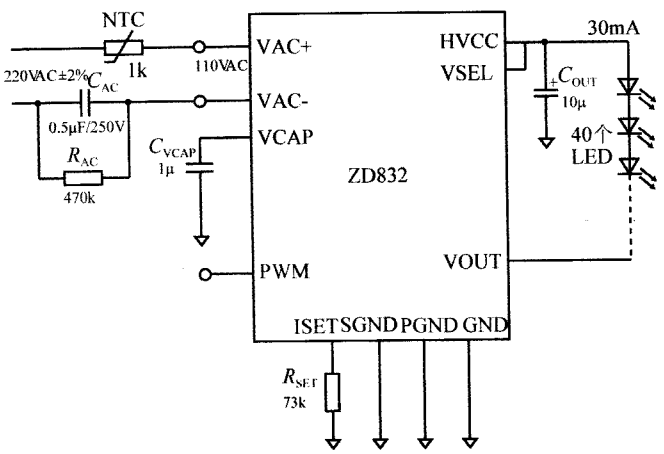

图4 220VAC输入带电容降压驱动40个LED电路

3) 180～240VAC输入驱动两串相并联的LED电路

AC输入电压范围为180～240V、驱动两串相并联的LED电路如图5所示。单颗LED的U_F=3.15V(@15mA)，每串含45个LED，两串LED总计90个。

由于45个LED的总电压降仅为3.15V·45=141.75V，当ZD832的AC输入为180～240V时，必须先利用一个1.5μF/250V的电容C_{AC}降压，再施加到IC的两个输入端VAC+和VAC-。为防止在输出上产生电压波动，加入了由150V的齐纳二极管、R_1和晶体管VT组成的稳压电路。在IC引脚HVCC上的输出电压是160～220VDC，稳压器输出电压U_O为150～160VDC，IC引脚U_{OUT}上的电压$U_{OUT}\leqslant$160V-141.75V=18.25V，故无需外加限制电阻R_{EXT}，驱动电路中的输出总电流为30mA(±6%)，接近于恒流。齐纳二极管选用

BZG03-C150-TR(150V/3W)，晶体管VT选择BV_{CEO}=300～350V、I_{CM}=1A的器件，如2N3439、NTE157和NTE396。

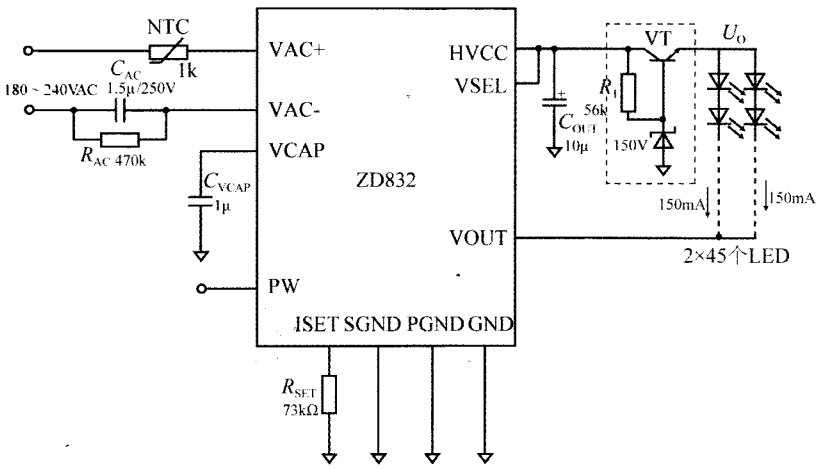

图5　180～240VAC输入驱动2串相并联的LED电路

4）ZD832的并联应用

两个ZD832相并联输出8W驱动66个3.16V(@40mA)串联在一起的LED电路如图6所示。AC输入电压范围是200～240V，由于R_{SET}=110kΩ，每个ZD832输出电流为20mA，两个ZD832并联后输出总电流为40mA.

3　结束语

ZD832无需外加变压器，电感器和桥式整流器，仅需几个元件，在85～240V的AC输入下可以驱动8W左右的LED串，并且还能提供PWM或模拟调光及过热/过电压保护。在低功率LED照明应用中，ZD832被业界认为是一种首选驱动器IC。

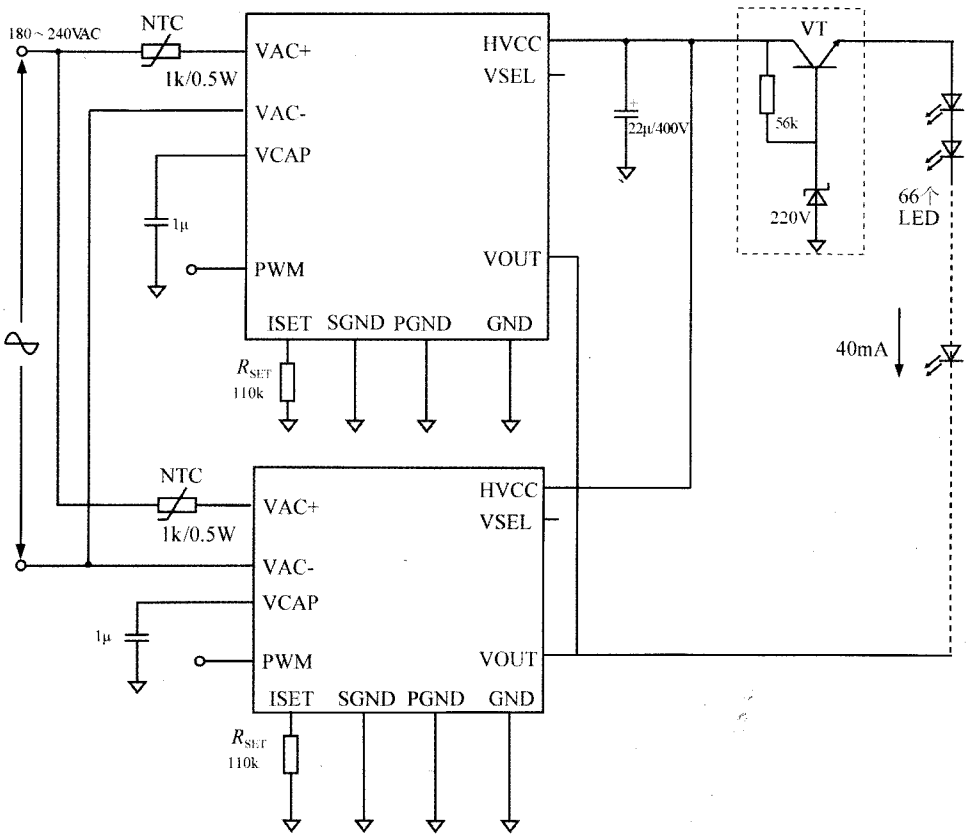

图6　两个ZD832相并联输出8W驱动66个3.16V串联LED电路

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[2] Zywyn Corporation . ZD832EVB Evaluation Board Manual . Application Note AN019 . 2008.3(www.zywyn.com)

HV9910、HV9910B和HV9931：LED专用PWM控制器

HV9910、HV9910B和HV9931都是Supertex公司专门为LED采用市电供电而开发的PWM控制器，其中HV9910、HV9910B在国内的应用比较广泛，HV9910B是HV9910的改进增强型版本，引脚完全兼容，所需外围元件少，输入电压的适应范围宽，可以直接适应全球市电电压而无需更改外围元件，突出特点是集成了为自身供电的高压线性稳压器，无需外部低压电源，支持线性调光（调恒流电流）和PWM（脉宽调制）方式调光。HV9931则集成了APFC（有源功率因数校正）控制功能，自适应全球市电电压范围，不需要电解电容，可以兼顾效率、EMI和电路板体积的要求，支持PWM方式调光，比较适合目前的节能和环保潮流。

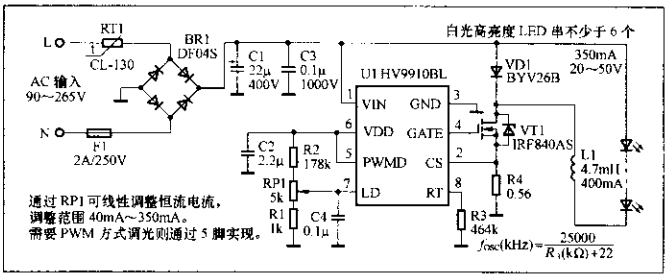


图1 HV9910BL参考设计电路

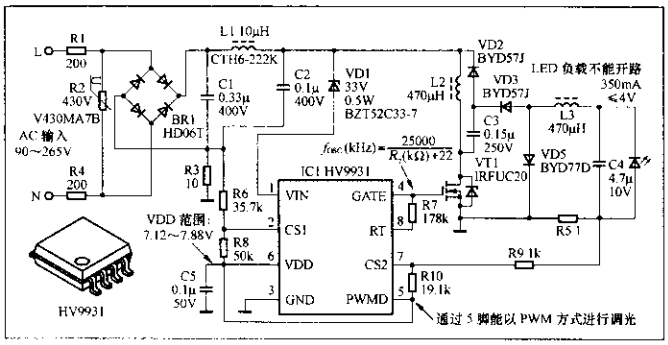


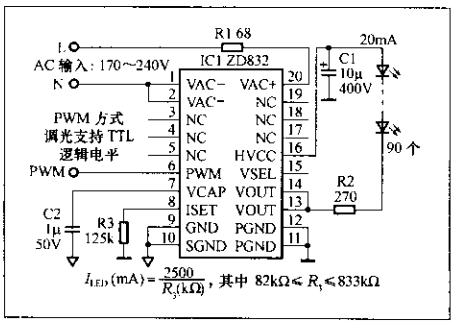
图2 HV9931参考设计电路

图1是HV9910BL的参考设计电路，字母后缀“L”表示扁平SO-8封装，图中的IRF840AS也是采用扁平的DPAK封装。

HV9931采用单级APFC方式，图2是HV9931的参考设计电路，可以驱动一个1W的LED。

ZD832：高压恒流源

ZD832是Zywyn公司的产品，之所以称之为高压恒流源，是因为它并非采用开关方式工作，可以理解为一个高压供电（133V或者312V）的恒流控制电路，内部集成了整流桥，高压滤波电容需要外接，直接以AC方式供电，无需变压器或者电感，以线性方式工作，EMI问题可以忽略，思路非常有特色。



以线性方式工作的ZD832

附图是ZD832用于220V市电规格的典型应用电路原理图，交流输入电压范围170V~240V，用于110V/115V市电规格时，需要将ZD832的15、16脚直接相连，交流输入电压范围85V~170V。图1所示电路的电流输出范围是3mA~30mA，所以只能适用20mA规格的HB LED，输出电流由外围电阻设定，计算公式如附图所示。

ZD832支持两种方式的调光，一种是线性方式，R3不用，将一个0~1.25V的直流电平加至8脚，通过调整恒流电流的大小进行调光。另一种方式是以PWM方式调光，PWM信号频率50Hz~5kHz，占空比10%~90%，同时也支持TTL电平进行关断控制，不使用调光功能时，该脚悬空即可。

按照图1元件规格，16脚输出的直流电压范围是240V~340V，R2是外部限流电阻，不用R2，可以驱动94个HB LED，VOUT（13、14）是内部VMOS开漏输出端，可耐受电压7V~100V，因此不能使VOUT端子承受的直流电压超过100V，即串联的LED不能太少。按极限值计算，HVCC（16脚）为340V，串联的LED最少为71个。ZD832的交流输入端能承受的最大交流电流，不能大于30mA，R1兼有保险丝的作用，需要采用可熔型阻燃电阻，推荐的取值范围是47Ω~82Ω，功率0.25W。ZD832采用的是带增强散热焊盘的TTSOP20封装，所有空脚（NC）必须悬空，不能与电路有电气联系。附图电路除了LED外，所有器件可以安装于20.5mm × 15.5mm见方的单面PCB上，组件高度由高压电解电容C1决定。

News Release

ZYWYN CORPORATION

FOR IMMEDIATE RELEASE

Corporate Headquarters
David Lee
VP, Marketing
408/733-3225
dlee@zywyn.com

ZYWYN ANNOUNCES

Universal TransformerFree™ AC-DC Constant Current LED Driver

SUNNYVALE, Calif., May 18, 2007 - Zywyn Corporation today introduced ZD832, the universal TransformerFree™ AC-DC constant current LED driver for the industrial lighting and display lighting market.

The ZD832 is a high voltage, AC-DC constant current driver for driving a string of white or RGB LEDs in series without the use of external transformer and no bridge rectifier. It operates from a direct input voltage of 85VAC to 170VAC or 170VAC to 240VAC off the AC mains and generates a programmable constant output current of up to 30mA by a single resistor.

"In addition to its earlier ZD831 successor, the ZD832 eliminates the need for an external inductor, transformer and rectifying diode bridge - making it very simple to use with only a few external passive components," said Raymond Chow, Zywyn CEO. "By using proprietary high-voltage process with patent-pending design, we have integrated the AC/DC bridge rectifier and linear voltage regulator on a single silicon successfully, allowing us to open up new methodologies in dealing with off-line AC-DC applications. More of such breakthrough related products will be evolved in the near future."

The ZD832 also features digital PWM and analog dimming control with over-temperature protection and over-voltage limiting functions. With high voltage isolation supported by the robust proprietary processing technology, there is no EMI generation and it does not require any additional EMI filtering circuits.

Samples & Availability

The ZD832 is available in a thermally enhanced 20-pin exposed TSSOP green package. Pricing for the ZD832LEY is US$1.88 each in 1K quantities. Samples and evaluation boards (ZD832EVB) are available from stock and can be requested through Zywyn sales representatives. Lead-time for production quantities is about 8 to 10 weeks ARO.

About Zywyn

Zywyn Corporation is a privately held high voltage analog semiconductor supplier, focusing on power conversion and control for the display and lighting industry, as well as in the datacom interface communication market. Zywyn products and corporate information are available at www.zywyn.com.

Zywyn

Advance Product Information
ZD832

Universal TransformerFree™ AC-DC Constant Current LED Driver

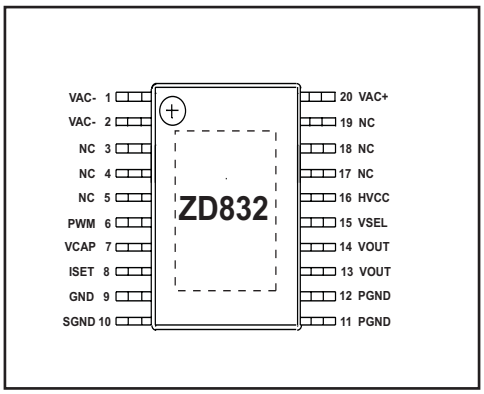
Features

- AC to DC Constant Current Driver
- No Transformer, No External Bridge Rectifier
- Universal Input Voltage Range of 85VAC to 170VAC or 170VAC to 240VAC
- Programmable up to 30mA Constant Output Current
- PWM or Analog Dimming Control
- Over-Temperature Protection
- Over-Voltage Limiting on Internal Power Transistor
- High Voltage Static Circuit Design With No EMI
- Thermally Enhanced 20-Lead Exposed TSSOP Green Package

Applications

- Offline LED Lamps and Fixtures
- LCD Panel Display Backlighting
- Avionics Displays
- Decorative Lighting
- Industrial Lighting

Pin Configuration



20-Pin Exposed TSSOP

WARNING! This is a high voltage application circuit where Galvanic Isolation is not provided. Dangerous voltages are present when connected to the AC line. It is the responsibility of the engineer employing the ZD832 to ensure adequate safeguards are put in place to protect the end user from electrical hazardous shock.

General Description

The ZD832 is a high voltage, TransformerFree™ AC-DC constant current driver for driving a string of white or RGB LEDs in series. It operates from an universal input voltage of 85VAC to 170VAC, or 170VAC to 240VAC and generates a programmable constant output current. The high operating voltage of ZD832, along with its linear control architecture eliminates the need for an external inductor, transformer and rectifying diode bridge. The output current level is set by a single resistor and can be set as high as 30mA. Dimming control can be accomplished by using pulse-width modulation signal with varying duty cycle on the PWM pin or by applying an analog DC voltage on the ISET pin. Thermal and over-voltage circuitry protects the internal power transistors from excessive power dissipation.

The ZD832 is available in a thermally enhanced 20-pin exposed TSSOP green package.

Ordering Information

Part Number	Temperature Range	Package Type
ZD832LEY	–40°C to +85°C	20-EP TSSOP
ZD832EVB	n/a	Evaluation Board

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

Typical Application

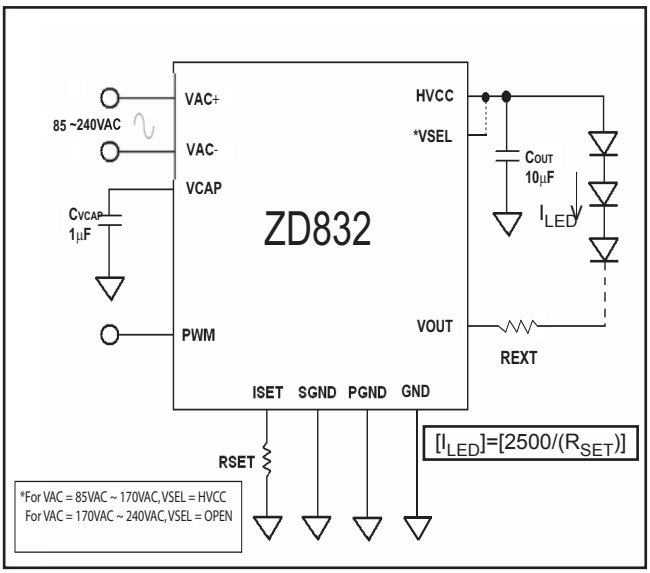


Figure 1. ZD832 driving a string of LEDs in series at a pre-setted constant current

World Class Universal TransformerFree™ AC-DC Constant Current LED Driver

....In The Smallest Footprint

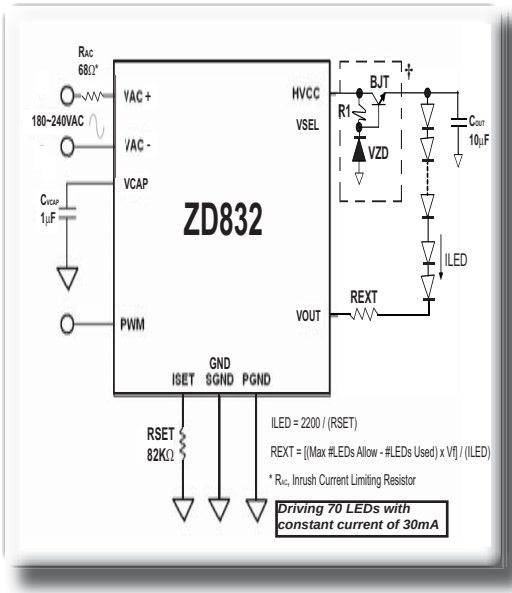
For All Form-Factored LED Lamps And Lighting Systems

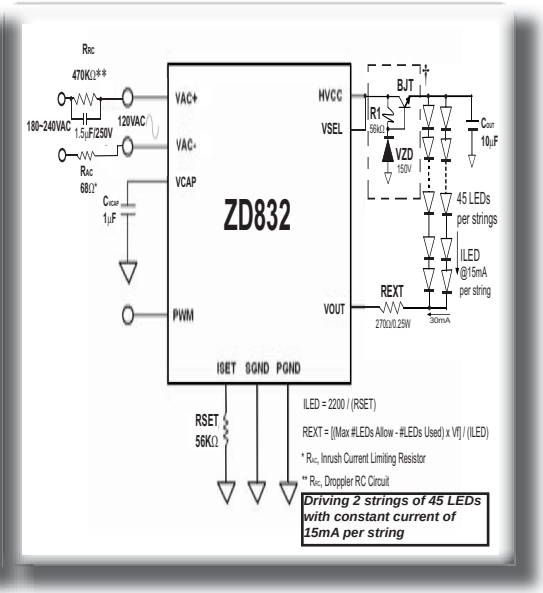
- No Transformer, No Bridge Rectifier
- 85VAC To 240VAC Input Voltage Range
- Programmable 30mA Constant Output Current
- Drives Up To 117 LEDs Per String#
- Digital PWM Or Analog Voltage Dimming Control
- Over-Temperature/Voltage Protection
- Very Minimum External Components
- Complete Static Design With No EMI
- Thermally Enhanced 20-Pin Exposed TSSOP RoHS Green Package

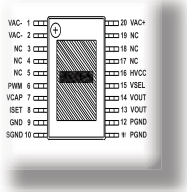
ZD832 Display Driver

ZYWYN CORPORATION
www.zywyn.com

Typical Applications







Ordering Information

Part Number	Temperature Range	Package Type
ZD832LEY	–40°C to +85°C	20-EP TSSOP
ZD832EVB	n/a	Evaluation Board

Pin Description

Pin Number	Pin Name	Pin Function
1, 2	VAC-	High Voltage AC Input, from 85~170VAC (VSEL=HVCC), or 170~240VAC (VSEL=OPEN)
20	VAC+	High Voltage AC Input, from 85~170VAC (VSEL=HVCC), or 170~240VAC (VSEL=OPEN)
6	PWM	LED Dimming Control Pin. PWM signal with duty cycle or logic high/low input.
7	VCAP	Internal Regulator Output. Bypass this pin with a 1µF capacitor to SGND.
8	ISET	Output Current Level Resistor Input. Connecting a resistor RSET from this pin to ground sets the output current of the LED driver.
9	GND	Substrate Ground. Must be connected to SGND (Pin# 10).
10	SGND	Signal Ground. Connects all small signal components to this ground.
11, 12	PGND	Power Ground. Connects high voltage decoupling capacitor to this ground.
13, 14	VOUT	LED Driver Open-Drain Output. Constant current sinking output rated for 100V.
15	VSEL	VSEL=OPEN when the device is to operate for 220VAC input. VSEL=HVCC (connects to HVCC pin) when the device is to operate for 110VAC input.
16	HVCC	High Voltage Rectified DC Output. Connects a 10µF decoupling capacitor from this pin to PGND. The power rating (V_{DC}) of the capacitor depends on the input VAC voltage.
3, 4, 5, 17, 18, 19	NC	No Connect Pins. Must be left open and unconnected.

Assuming Vf of LEDs is at 1.8V at constant current over the supply voltage range of 180VAC~240VAC.
† Optional circuit to maintain ILED at constant current of ± 6% throughout the supply voltage range of 180VAC~240VAC.

0807

ZD832 Display Driver

ZYWYN CORPORATION
www.zywyn.com

Zywyn

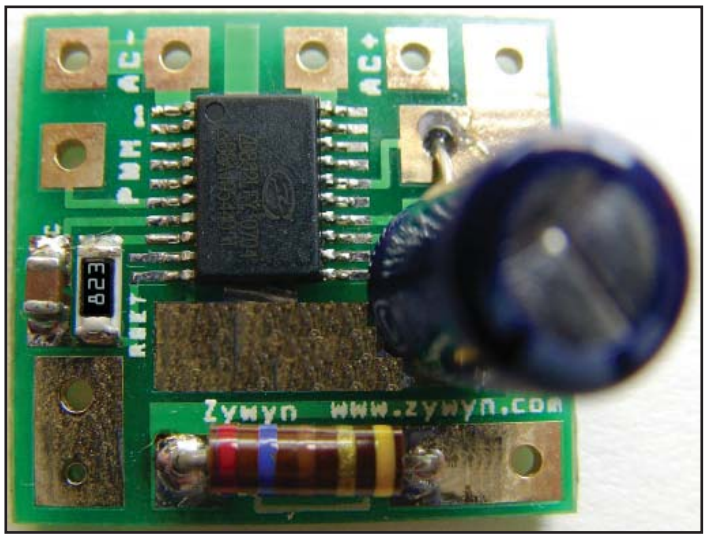
Application Note AN019

ZD832EVB Evaluation Board Manual

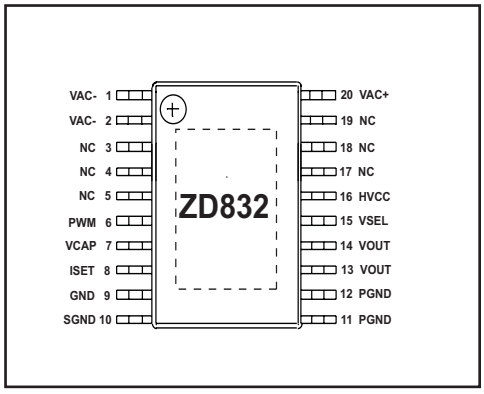
General Description

The ZD832 is a high voltage, TransformerFree™ AC-DC constant current driver for driving a string of white or RGB LEDs in series. It operates from an universal input voltage of 85VAC to 170VAC, or 170VAC to 240VAC and generates a programmable constant output current. The high operating voltage of ZD832, along with its linear control architecture eliminates the need for an external inductor, transformer and rectifying diode bridge. The output current level is set by a single resistor and can be set as high as 30mA. Dimming control can be accomplished by using pulse-width modulation signal with varying duty cycle on the PWM pin or by applying an analog DC voltage on the ISET pin. Thermal and over-voltage circuitry protects the internal power transistors from excessive power dissipation. The ZD832EVB is configured for 240VAC application using 96 LEDs (details in the Typical Applications section) operation by default settings from factory.

The ZD832 is available in a thermally enhanced 20-pin exposed TSSOP green package.



Pin Configuration



20-Pin Exposed TSSOP

WARNING! This is a high voltage application circuit where Galvanic Isolation is not provided. Dangerous voltages are present when connected to the AC line. It is the responsibility of the engineer employing the ZD832EVB to ensure adequate safeguards are put in place to protect the end user from electrical hazardous shock. Do not connect the ZD832 circuit ground with earth grounded devices such as scopes and power supplies.

Typical Application

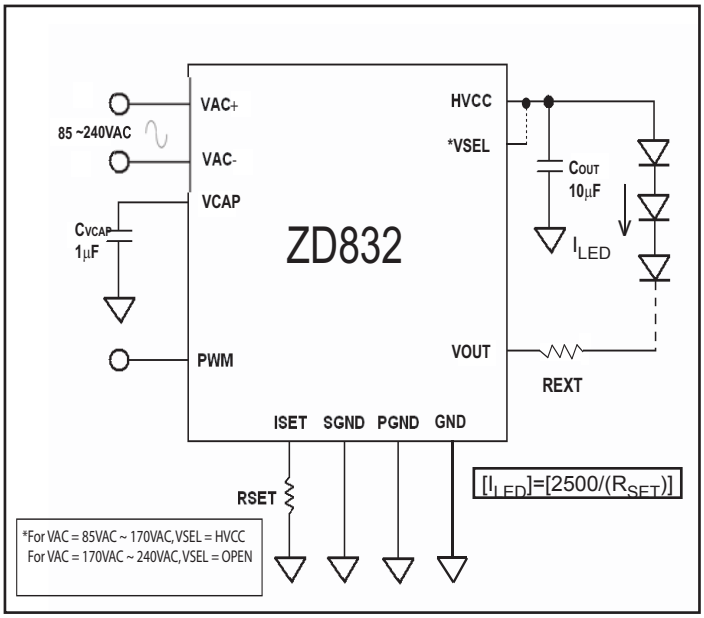


Figure 1. ZD832 driving a string of LEDs in series at a presetted constant current

Ordering Information

Part Number	Temperature Range	Package Type
ZD832LEY	–40°C to +85°C	20-EP TSSOP
ZD832EVB	n/a	Evaluation Board

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

Electrical Characteristics

T_A = +25°C, VAC+ & VAC- = 110VAC (VSEL = HVCC) or 240VAC (VSEL = OPEN), SGND = PGND = 0V, C_{OUT} to PGND = 10µF (rated at 350V), C_{VCAP} to SGND = 1µF (rated at 10V), PWM = 5V; unless otherwise noted.

Parameter	Condition	Min	Typ	Max	Units
AC Input Voltage, VAC+ & VAC-	VSEL = HVCC VSEL = OPEN	85 170		240 240	V_{AC} V_{AC}
High Voltage, HVCC DC Input applied to HVCC DC Output from HVCC	VSEL = HVCC un-connected VAC+ & VAC-, I_{LED}=5mA, VOUT=5V connected VAC+ & VAC-, I_{LED}=5mA, VOUT=5V	 120 120		 240 240	 V V
High Voltage, HVCC DC Input applied to HVCC DC Output from HVCC	VSEL = OPEN un-connected VAC+ & VAC-, I_{LED}=5mA, VOUT=5V connected VAC+ & VAC-, I_{LED}=5mA, VOUT=5V	 240 240		 340 340	 V V
Supply Current, I_{VAC} Quiescent Current	R_{SET}=125kΩ, PWM=5V, un-connected VOUT		2	5	mA
LED Output Current Range, I_{LED}		3		30	mA
Output Current, I_{LED}	R_{SET}=125KΩ; $[I_{LED}]=[2500/(R_{SET})]$ VOUT=5V to 10V VOUT=3V to 30V	 18.6 17	 20 20	 21.4 23	 mA mA
Output Leakage Current, $I_{LED-Leakage}$	PWM=0V, VOUT=5V		20	100	µA
PWM Signal Pin Input Voltage High Input Voltage Low Input Leakage Current	 PWM=0V or 5V	 2.0 	 0.2 1	 10	 V V µA
ISET Pin Regulated ISET Voltage, V_{ISET}		 1.1	 1.25	 1.3	 V

Pin Description

Pin Number	Pin Name	Pin Function
1, 2	VAC-	High Voltage AC Input, from 85~240V_{AC}.
20	VAC+	High Voltage AC Input, from 85~240V_{AC}.
6	PWM	LED Control Pin, Pulse-width Modulated or logic high/low Input.
7	VCAP	Internal Regulator Output. Bypass this pin with a 1µF capacitor to SGND.
8	ISET	LED Current Setting Pin. Connect RSET from ISET to PGND to set the LED current.
9	GND	Substrate Ground. Must be connected to SGND (Pin #10)
10	SGND	Signal Ground. Connects all small signal components to this ground.
11, 12	PGND	Power Ground. Connects high voltage decoupling capacitor to this ground.
13, 14	VOUT	LED Driver open-drain Output. Constant current sinking outputs rated for 100V.
15	VSEL	VSEL = OPEN when the device is to operate for 240V_{AC} input. VSEL=HVCC (connect to HVCC pin) when the device is to operate for 110V_{AC} input.
16	HVCC	High Voltage Rectified DC Output from VAC+ & VAC-. Bypass HVCC with at least 10µF to PGND.
3, 4, 5, 9, 17, 18, 19	NC	No Connect Pins. Must be left open and unconnected.

Output Operation Description

High Voltage Rectified DC Output (HVCC)

A typical range of $85V_{DC}$ to $340V_{DC}$ can be sourced from the HVCC pin and is dependent on the AC input voltage at VAC+ and VAC-. A 10µF decoupling capacitor, C_{OUT}, is connected from the HVCC pin to PGND is used to reduce the rectified ripples at the output. The power rating (V_{DC}) of the capacitor depends on the input VAC voltage, but should typically be rated at 400V. Please refer to the following figures for expected HVCC values using different COUT at various output current, ILED.

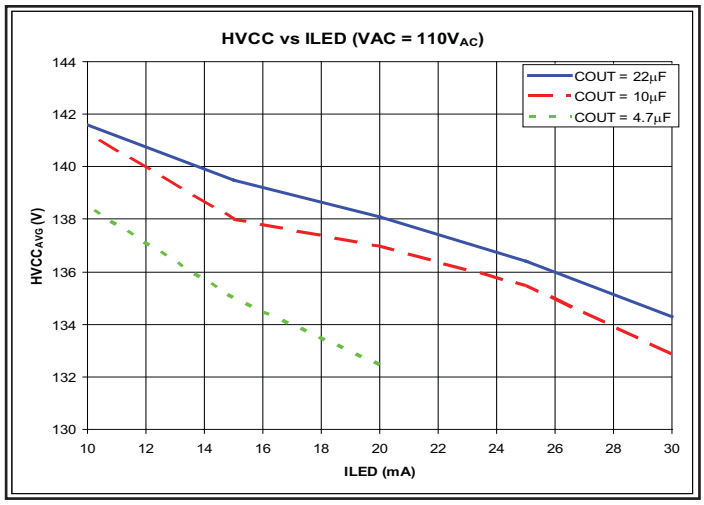


Figure 2. Expected Values of HVCC with VAC = $110V_{AC}$

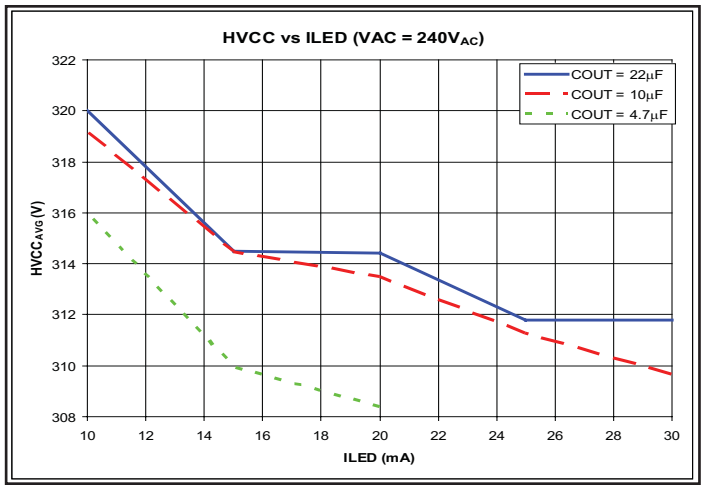


Figure 3. Expected Values of HVCC with VAC = $240V_{AC}$

Input Operation Description

AC Input Voltage (VAC+, VAC-)

An AC voltage power source, with a typical range of $85V_{AC}$ to $240V_{AC}$, can be applied directly to the VAC+ and VAC- pins of the ZD832 to drive a string of LEDs. The input voltage power source should be able to provide a 1.5A load current. The ZD832EVB demo board is capable of providing a constant current for the string of LEDs over this input voltage ranges of $85V_{AC}$ to $240V_{AC}$.

Note: The ZD832EVB evaluation board is not protected from output open/short circuit conditions. Potential damage to the Demo Board may occur if the output load is not properly connected.

High Voltage DC Input (HVCC)

A typical range of $85V_{DC}$ to $340V_{DC}$ can be applied to the HVCC pin to drive the LED string directly without connecting the VAC+ and VAC-. A small 1µF decoupling capacitor from the HVCC pin to PGND is used to reduce possible ripples. The power rating (V_{DC}) of the capacitor depends on the input voltage at HVCC, but should typically be rated at 250V.

LED Dimming

PWM Dimming

The output string of series LEDs can be dimmed by applying an input pulse-width modulated signal (50Hz to 5kHz) to the PWM pin. This allows for a wide range of dimming gradient. The dimming is proportional to the PWM duty cycle, which can range from 10% to 90%. The device is in shutdown mode when PWM is at LOGIC LOW "0" state, and is fully-on when PWM is at a LOGIC HIGH "1" state.

Input Operation Description cont.

Analog Voltage Dimming

To allow for LED current amplitude adjustment as well as linear dimming, ISET can be connected to an analog voltage through a resistor, RSET, where RSET is in the range of 833KΩ ≥ RSET ≥ 83KΩ. The ISET pin is typically regulated at 1.25V.

As shown in Figure 4, when the DC voltage is set at 0V for example, the I_{LED} current is positioned at its default value which is calculated from the equation,

$$[I_{LED}]=[2500/(RSET)]$$

Increasing the DC voltage from 0V to 1.25V will dim the LEDs in linear proportion with decreased in the I_{LED} current. Setting the DC voltage at midpoint upon device power-up can control the dimming up and down function.

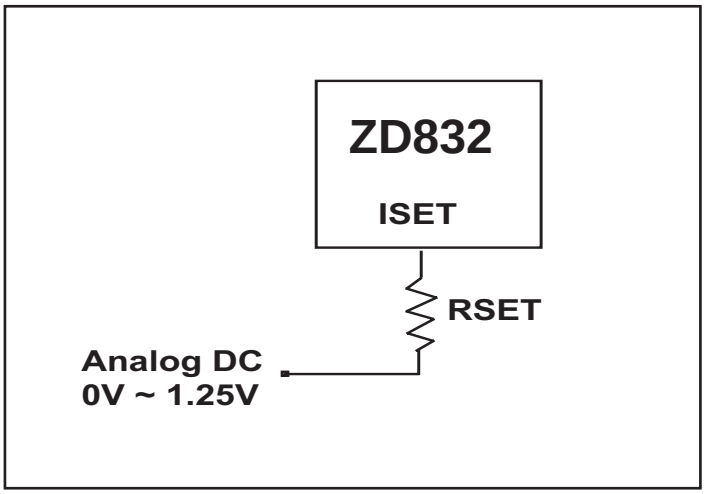


Figure 4. Analog dimming using analog DC voltage.

Note: The ZD832EVB circuit is not isolated from AC mains. Connecting external devices or equipments to the ZD832 input pins without the use of proper isolations, such as opto-isolators, can be hazardous and may cause equipment damages. Do not connect the ZD832 circuit ground with earth grounded devices such as scopes and power supplies.

Voltage Select (VSEL)

The ZD832 can be operated from two banks of AC voltage range inputs; 85VAC~170VAC or 170VAC ~240VAC. To operate for 85VAC~170VAC, the VSEL (pin #15) must be connected to the HVCC (pin #16). To operate for 170VAC~240VAC, VSEL (pin #15) must be left OPEN.

Circuit Description

The Limiting Resistor R_{EXT}

To protect excessive power dissipation on the internal power transistor, an external resistor R_{EXT} may be required to maintain the V_{OUT} within the range of 3V and 30V. The formula for the limiting resistor R_{EXT} should be used to calculate the resistor value in series with the LEDs as follows,

$$R_{EXT} = (HVCC - n \cdot V_f - V_{OUT})/I_{LED}$$

where,

HVCC = Average High Voltage Rectified DC. Please refer to Figure 2 and Figure 3 for expected values.
n = Number of LEDs connected in series.
V_f = Forward bias voltage of a single LED at specified I_{LED} level.
V_{OUT} = Average dropout voltage at VOUT pin, recommended to be set at 7V for calculations.
I_{LED} = Regulated average LED current, ranges from 3mA to 30mA.

Use the following formula to make sure R_{EXT} has adequate power rating tolerance:

$$P_{REXT} = (I_{LED})^2 \cdot R_{EXT}$$

where
P_{REXT} = Power dissipated by R_{EXT}

Several design examples are shown in table below for reference, assuming the V_f of the LED is 3.2V at I_{LED}=30mA and C_{OUT} = 10μF.

VAC Input Voltage	$HVCC_{AVG}$ (V)	# of LEDs	Calculated V_{OUT}	R_{EXT} (Ω)	Power Rating (W)
110 VAC	133	39	7.0	Not required	N/A
110 VAC	133	36	8.0	270	0.5
240 VAC	312	94	7.0	Not required	N/A
240VAC	312	90	7.0	270	0.5

Table 1 Design Examples.

Selecting External Component RSET to Set I_{LED} Current

The ZD832 uses an external resistor, RSET, to set the constant LED current, I_{LED}. I_{LED} is determined by the formula:

$$[I_{LED}]=[2500/(RSET)]$$

with a minimum value of RSET ≥ 82KΩ, which sets the I_{LED} to 30mA, and a maximum value of RSET ≤ 833KΩ, which sets the minimum I_{LED} to 3mA (Refer to Figure 5). The maximum allowable capacitance at the ISET pin is 50pF.

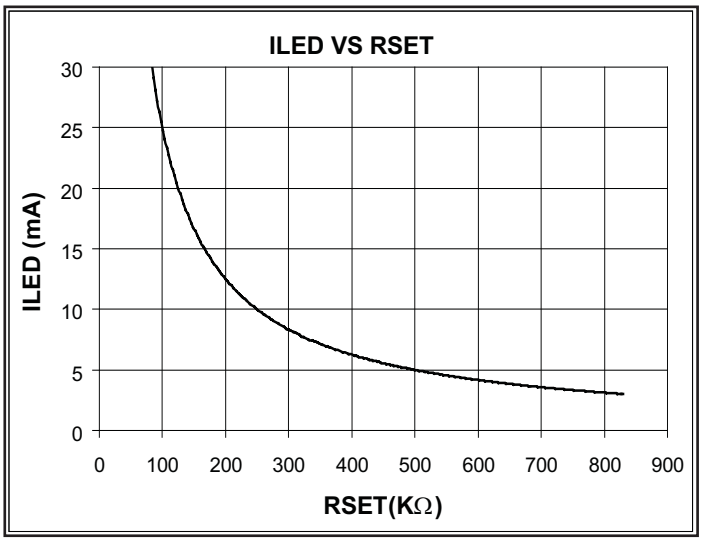


Figure 5 ILED vs RSET

Typical Application Circuit

The ZD832EVB Evaluation Board is populated for operations 94 LEDs and 40 LEDs with a 240VAC input. Both circuit boards are wired for driving a constant output current of about 30mA using a RSET of 82kΩ. as the default value configuration at factory. A jumper is connected at the VCAP pin and can be connected to the PWM to enable the device. If PWM dimming control is required, disconnect the jumper.

Application circuit using 90 LEDs

An input voltage of 240V_{AC} can be applied to VAC+ and VAC- pin. The average output at HVCC will be about 312V and the limiting REXT is set at 270Ω (See Table 1), assuming 90 LEDs in series with V_f of 3.2V are being used. VSEL is left open for this application. Figure 6 shows the typical circuit.

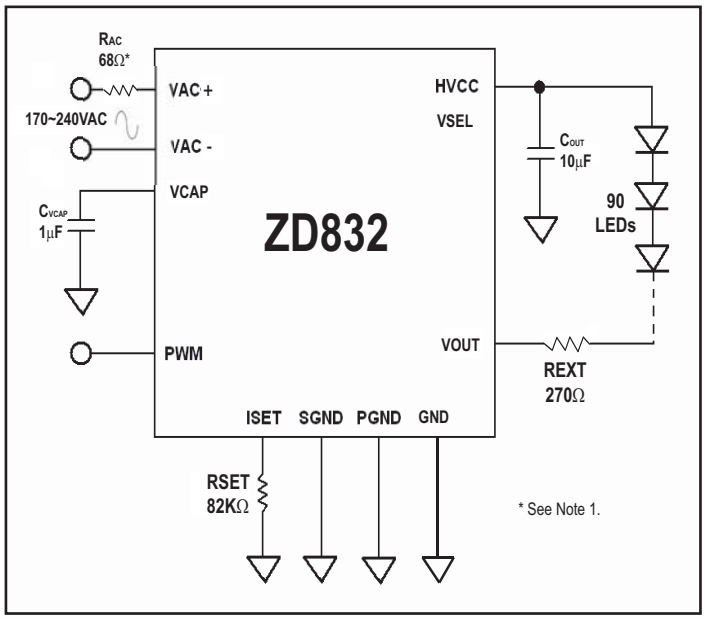


Figure 6. ZD832 driving a string of 94 LEDs in series with constant current of 30mA.

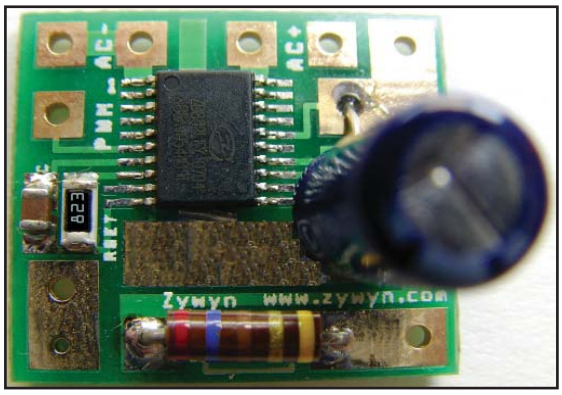


Figure 7. ZD832EVB evaluation board configured for 240V_{AC} operation.

Application circuit using 40 LEDs

An input voltage of 240V_{AC} can be stepped down by using an external RC circuit to about 110V_{AC} across VAC+ and VAC-. The average output at HVCC will be about 150V and the limiting REXT is set at 270Ω (See Table 1), assuming 40 LEDs in series with V_f of 3.2V are being used. VSEL is connected to HVCC for this application. Figure 8 shows the typical circuit

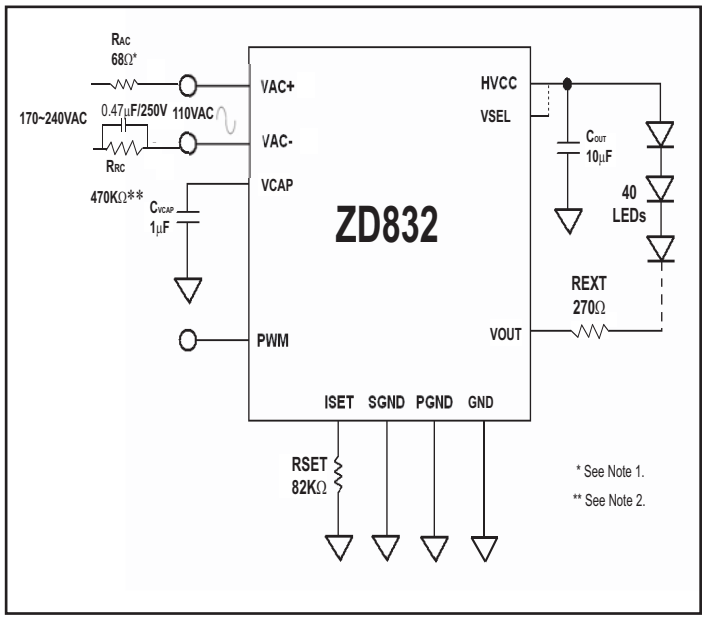


Figure 8. ZD832 driving a string of 40 LEDs in series with constant current of 30mA.

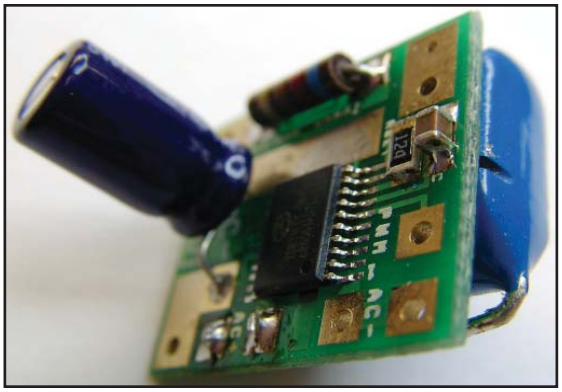


Figure 9. ZD832EVB evaluation board configured for 240V_{AC} operation.

Note: The ZD832EVB evaluation board is not protected from output open/short circuit conditions. Potential damage to the Demo Board may occur if the output load is not properly connected. The ZD832EVB circuit is not isolated from AC mains. Connecting external devices or equipments to the ZD832 input pins without the use of proper isolations, such as opto-isolators, can be hazardous and may cause equipment damages. Do not connect the ZD832 circuit ground with earth grounded

Application Note

Operation for VAC from 85V to 170V

An input voltage of $110V_{AC}$ can be applied to VAC+ and VAC-. The output at HVCC is rectified at $156V_{DC}$ (110V •√2) and the limiting REXT is set be 220Ω, assuming 30 LEDs in series with V_f of 3.2V are being used. Figure 10 shows the typical circuit with VSEL connected to HVCC.

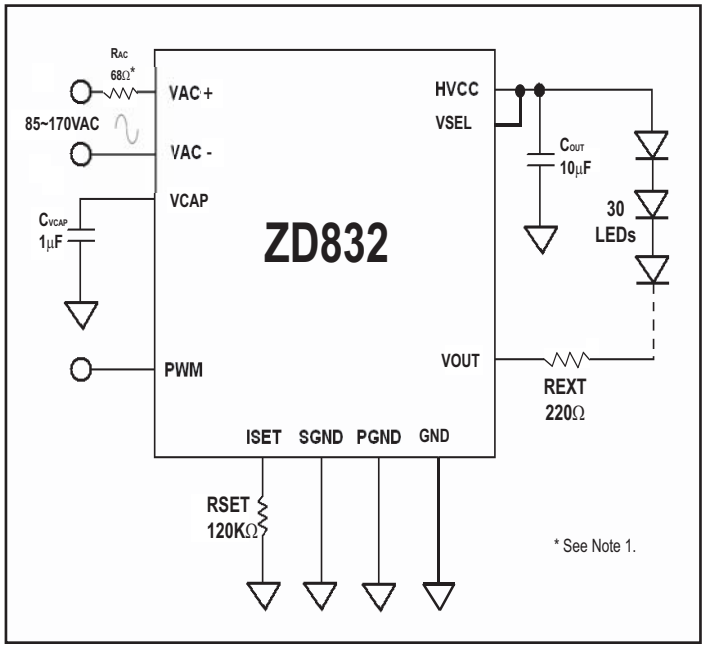


Figure 10. Driving the ZD832 from a power source of $85V_{AC}$ to $170V_{AC}$ with 20mA output current.

* Note 1. A non-flammable metal-film resistor, R_{AC}, should be used to limit inrush current spikes during start-up and transient voltage induced in the AC-power line by incidental lightning strike. In normal operations, the AC current does not exceed $30mA_{RMS}$, and a 47Ω-82Ω, 0.25W reistor provides sufficient current limiting.

Application circuit with parallel ZD832

The ZD832 can be used in parallel with another ZD832 to achieve an ILED current of 60mA through and LED string. See Figure 11 for reference.

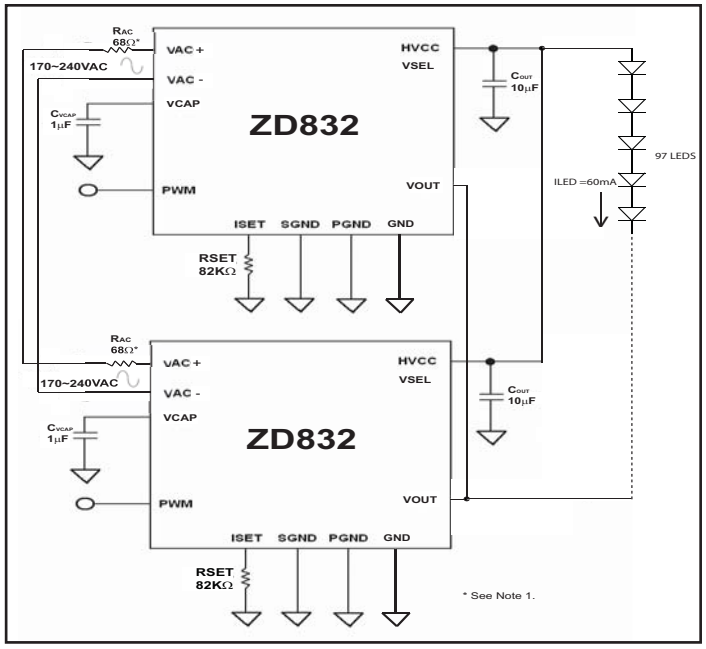


Figure 11. Driving parallel ZD832s from a power source of $170V_{AC}$ to $240V_{AC}$ with 60mA output current.

Components Selection

Capacitor Selection

The small size of ceramic capacitors makes them ideal- for ZD832 applications. X5R and X7R types retain their capacitance over wider voltage and temperature ranges and are recommended over Y5V or Z5U types. A 10μF filtering output capacitor and a 1μF input capacitor are sufficient for the most ZD832 applications.

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

Table 1. Recommended Ceramic Capacitor Manufacturers

ZD832EVB Bill of Material (BOM) Listing

For 90 LEDs Application

Item	Quantity	Location	Part
1	1	VCAP	1μF/16VDC
2	1	HVCC	10μF/400VDC
3	1	RSET	Variable
4	1	R_{EXT}	Variable
5	1	U1	ZD832LEY
6	90-97	HVCC	LEDs
7	1	VAC	68Ω*/0.25W

For 40 LEDs Application

Item	Quantity	Location	Part
1	1	VCAP	1μF/16VDC
2	1	HVCC	10μF/400VDC
3	1	RSET	Variable
4	1	R_{EXT}	Variable
5	1	U1	ZD832LEY
6	30 ~ 50	HVCC	LEDs
7	1	VAC	68Ω*/0.25W
8	1	VAC	0.47μF/250VDC
9	1	VAC	470kΩ**/0.25W

* Note 1. A non-flammable metal-film resistor, R_{AC}, should be used to limit inrush current spikes during start-up and transient voltage induced in the AC-power line by incidental lightning strike. In normal operations, the AC current does not exceed $30mA_{RMS}$, and a 47Ω-82Ω, 0.25W reistor provides sufficient current limiting.

** Note 2. R_{RC} should be in the range of 390KΩ~680KΩ, 0.25W when used in the external RC circuit.

Evaluation Board Information

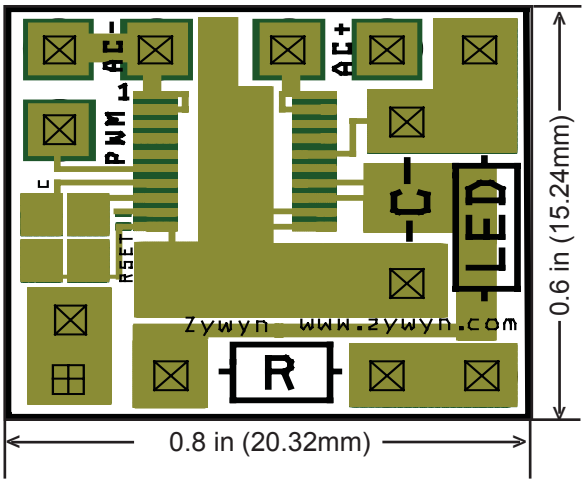


Figure 8. ZD832EVB Single-Layer Evaluation Board
Component Side Layout

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