DIO8232
Adaptive 100/120Hz Current Ripple Remover
Max LED Current ≤1A

Features

- **Wide input voltage range from 10V up to 60V**
- **Internal 60V power MOSFET**
- **Adaptive 100/120Hz current ripple remover for dimmable LED luminaries with wide input current range from 0.1A up to 1A**
- **LED voltage low to 0.4V when LED current is 1A**
- **Multiple protection features:**
    - ◇ **Reliable LED voltage limit**
    - ◇ **Reliable LED current limit**
    - ◇ **Reliable Short LED Protection (SLP)**
    - ◇ **Hot-plug protection**
    - ◇ **Over Temperature Protection (OTP)**
- **TO252-5 package**

Applications

- **LED lighting**

Descriptions

DIO8232 is designed to eliminate the 100/120Hz current ripple on AC/DC power for LED driver, especially single stage LED driver.
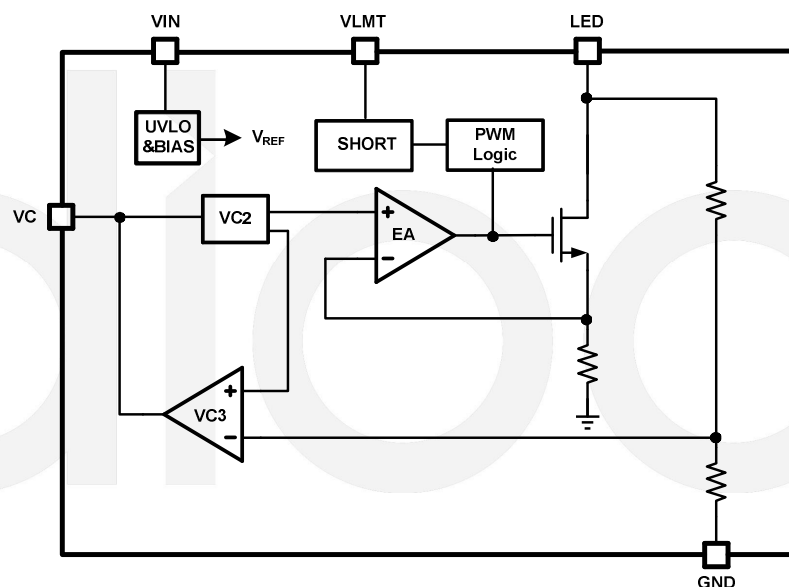
Reliable LED voltage limit function could achieve trade-off between current ripple ratio and power dissipation on chip. DIO8232 provides short protection and hot-plug protection. Reliable LED current limit function sets the maximum LED current at 1.5A.

DIO8232 provides over thermal protection. When the OTP is trigged, the internal MOSFET shuts down until the temperature decreases to 120℃
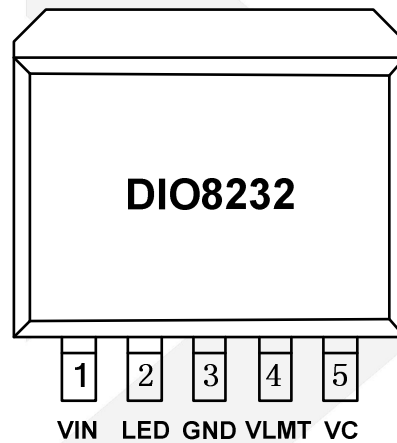
Block Diagram

Ordering Information

Order Part Number	Top Marking		T$_A$		Package	
DIO8232TA5	DIO8232	Green	-40 to +150°C		TO252-5	Tape & Reel, 2500

Pin Assignments

TO252-5
Figure 1 Pin Assignment (Top View)

Pin Definitions

Pin Name	Description
VIN	Power Supply voltage input
LED	Connect to Cathode of LED string
GND	Ground
VLMT	Adjustable LED Short Protection Threshold
VC	Adjustable LED Current Ripple. By connecting a capacitor between VC to GND to regulate the current ripple.

Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Rating" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maxim rating conditions for extended periods may affect device reliability.

Parameter	Rating	Unit
VIN	60	V
LED	-0.3 to 60	V
VC, VLMT	-0.3 to 6	V
Junction Temperature	150	°C
Lead Temperature	260	°C
Storage Temperature	-65 to +150	°C
Thermal Resistance / θ_{JA}	45	°C/W

Recommend Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended Operating conditions are specified to ensure optimal performance to the datasheet specifications. DIOO does not Recommend exceeding them or designing to Absolute Maximum Ratings.

Parameter	Rating	Unit
VIN	10 to 55	V
LED	<60	V
Maximum Junction Temperature (T_J)	150	°C

Electrical Characteristics

T_A = 25°C, VIN = 12V, C_C=1µF, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN_ON}	V_{IN} Power On Voltage Threshold			10		V
V_{IN_OFF}	V_{IN} Power Off Voltage Threshold			6		V
I_{IN_OP}	V_{IN} Operation Current	I_{LED}=700mA		0.25		mA
V_{LED_LIMIT}	LED Voltage Limit Threshold	LED voltage when voltage limit is trigged	5.4	6	6.6	V
V_{TH_SHORT}	LED Short Protection Threshold	VLMT voltage when LED short protection is trigged	1.8	2	2.2	V
T_{SP}	LED Short Protection Delay Time			60		µs
T_{SH}	LED Short Protection Hold Time			10		ms
V_{LED_MIN}	Min LED Pin Voltage when operation	I_{LED}=700mA		0.40		V
I_{LIMIT}	LED Current Limit			1.5		A
T_{SD}	Thermal Shutdown Threshold		125	140		°C
T_{HYST}	Thermal Shutdown Hysteresis			25		°C

Adaptive 100/120Hz Current Ripple Remover, Max Input Current ≤ 1A

Typical System Characteristics

VIN=85V~264Vac, V_{OUT}=42V, I_{OUT}=700mA, C_{OUT}=470µF/63V*3, TA=25℃.

Efficiency Comparison

- - ◆ - - Without DIO8232   —■— With DIO8232
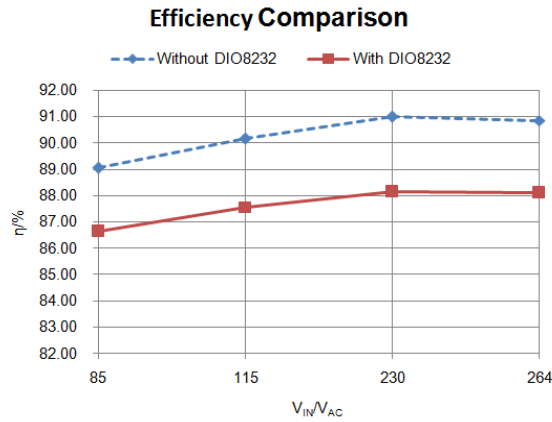
Current Ripple without DIO8232

I_{LED}: 200mA/div V_{LED}: 10V/div
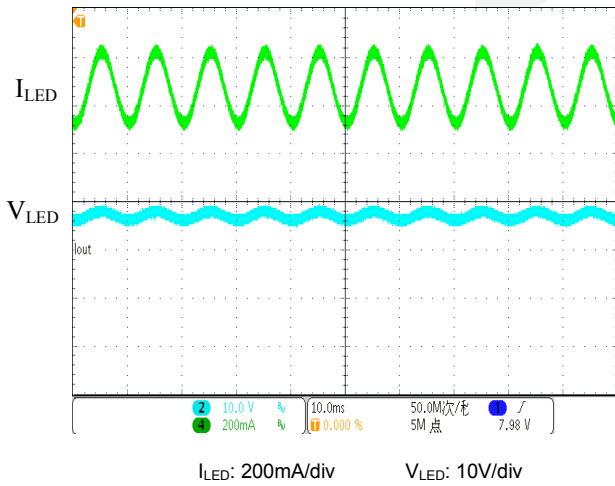
Current Ripple with DIO8232

I_{LED}: 200mA/div V_{LED}: 10V/div

Power ON

V_C: 1V/div V_{LEDN}: 2V/div

I_{LED}: 200mA/div V_{LED}: 20V/div

AC Input ON/OFF

V_C: 2V/div V_{LEDN}: 1V/div

I_{LED}: 200mA/div V_{LED}: 20V/div

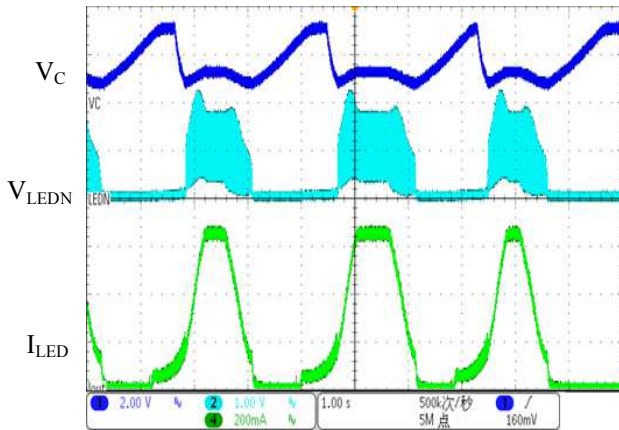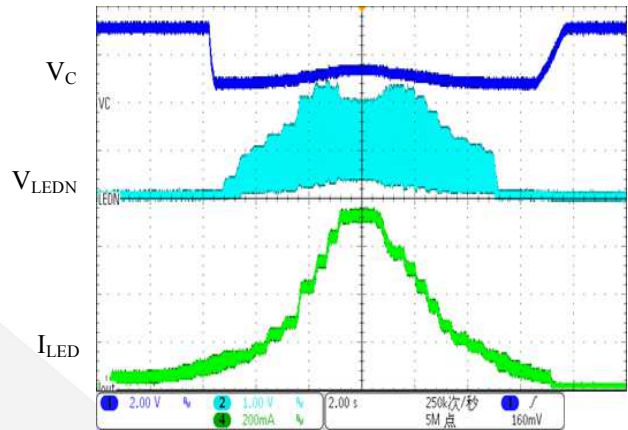**Adaptive 100/120Hz Current Ripple Remover, Max Input Current ≤ 1A**
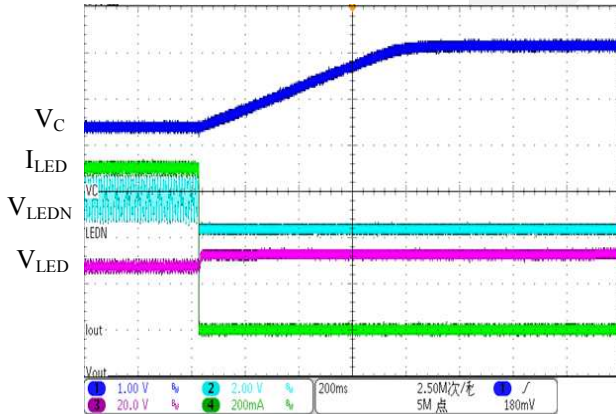
DIO8232
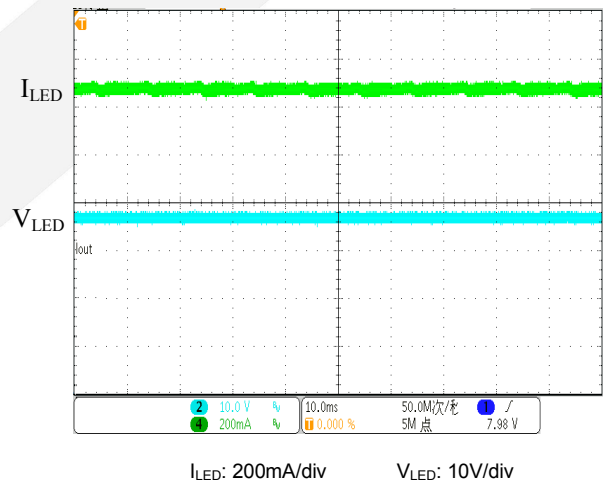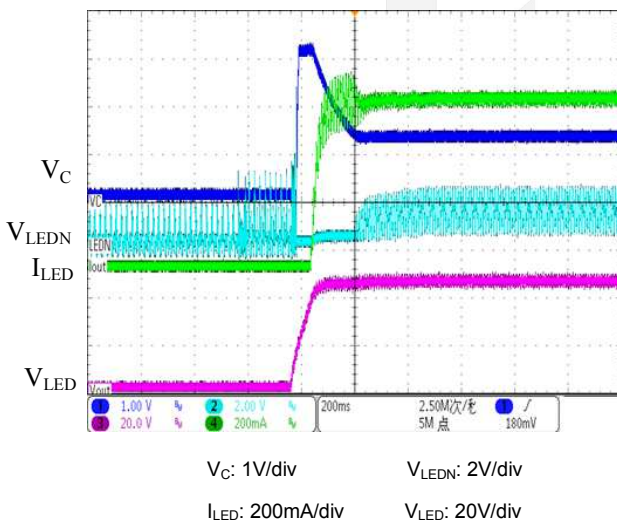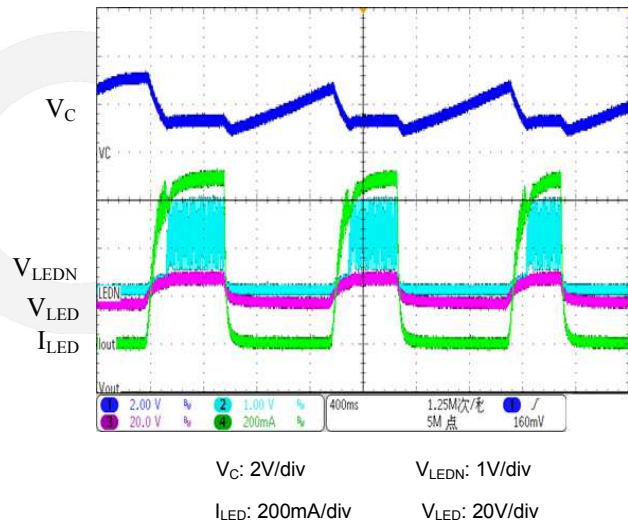
Fast dimming application test

V_C: 2V/div   V_LEDN: 1V/div
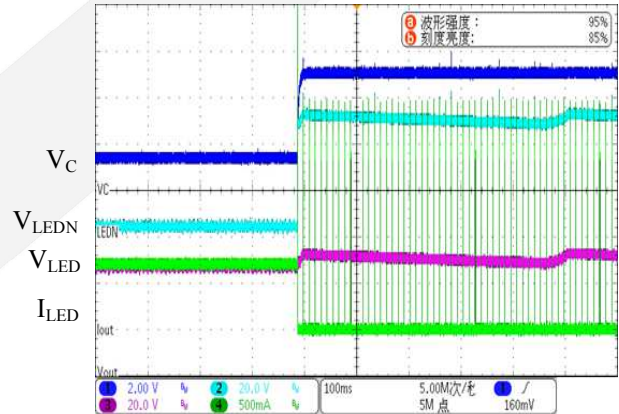
I_LED: 200mA/div

Slow dimming application test

V_C: 2V/div   V_LEDN: 1V/div

I_LED: 200mA/div

LED Open Protection test

V_C: 1V/div   V_LEDN: 2V/div

I_LED: 200mA/div   V_LED: 20V/div

LED Short Protection test

V_C: 2V/div   V_LEDN: 20V/div

I_LED: 500mA/div   V_LED: 20V/div

Application Information

Theory of Operation

DIO8232 is a secondary side LED current ripple remover which is designed for single stage LED driver, supplied by an AC/DC current source with the LED string. The LED pin is connected to the cathode of LED string. DIO8232 transfers the LED current ripple to voltage ripple on chip, and ensures the constant voltage across LED string and the current flow through LED string.

The scalable adaptive function of DIO8232 can regulate the cathode voltage of LED string to minimum to improve the efficiency of the system.

Current Ripple Removing

The capacitor C_C between VC and GND is an integration capacitor. DIO8232 transform the voltage on C_C to a reference voltage. The current regulator regulates LED current via negative feedback control.

The relationship between the voltage on C_C and LED current is shown as following:

$$I_{LED} = V_{VC} * 800(mA)$$

C_C should be large enough in order to remove the current ripple of the LED string. However, too large capacitor may slow down the dynamic response.

Adaptive Regulation

DIO8232 control the voltage on C_C by monitoring the operation state of built-in NMOSFET. The efficiency of system is relatively low when NMOSFET always work in the saturation region. DIO8232 detects it and charges C_C to raise the V_{VC} and I_{LED}, then the output voltage of power supply is reduced, and the voltage drop on NMOSFET decreases.

Conversely, when NMOSFET is working in the linear region, LED current regulation loop is open. DIO8232 detects it and discharges C_C to reduce the V_{VC} and I_{LED}, then the output voltage of power supply is raised, and the LED current regulation loop is close.

LED Pin Voltage Limit

The voltage ripple on LED pin is very large when the current ripple is removed, which would bring large power dissipation on chip. DIO8232 limit the voltage on LED pin as 6V internally. When the voltage on LED pin reaches 6V, the current ripple removing function is blocked.

LED Current Limit

The current of LED is limited to 1.5A internally. The current limitation can protect the chip when LED is short connected or HOT-PLUG.

The function of current limit is higher priority than LED Pin voltage limit. It means that the voltage on LED Pin is limited when LED current exceed 1.5A.

LED Short Protection

The resistor divider connected between LED and GND can setup the Short protection threshold. When the voltage input to V_{LMT} Pin is exceed 2V and the state holds for more than 60µs, DIO8232 considers the LED string is short connected, and shut down the internal MOSFET.

The shut down state is latched for 10ms hold time. After 10ms, the short state is reset, and the MOSFET restart.
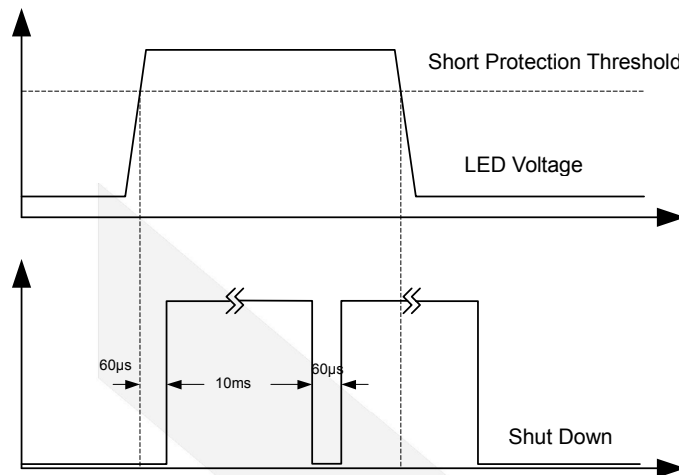
The short protection threshold is calculated as below:

$$V_{TH\_VLMT} = 2V * (R_1 + R_2) / R_2$$
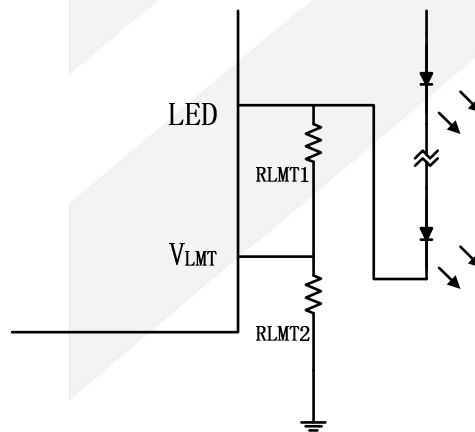
Open and HOT-PLUG Protection

When DIO8232 detects that LED current is lower than 50mA, and the state holds for more than 60µs, DIO8232 considers the LED string is open connected, and shuts down the internal MOSFET. The shut down state is latched for 0.5ms hold time. The MOSFET restart after 0.5ms.

If the LED string is connected suddenly during MOSFET restart, the open state is reset, internal MOSFET is turned on and the LED current is limited at 1.5A.

Over Thermal Protection

DIO8232 monitors operation temperature. When the temperature is higher than 150℃, the internal MOSFET is shut down until the temperature drop to 130℃.

PCB Design Guideline

1.   The bypass capacitor of VIN should be placed as close as possible to the VIN pin and GND pin of IC.

2.   DIO8232 should be placed far away from the power devices such as MOSFET and SBD.

3.   The area of LED current loop should be as small as possible.

Application Information

1. Design considerations:

a) The maximum voltage rating of LED pin is 60V, so the overvoltage threshold of the pre-driver must be lower than 60V in order to protect the chip in LED short condition.

b) A LED string should be used to test the characteristics of DIO8232 including open and short circuit test.

2. The recommended operating current of DIO8232 is 0.8A (max 1A). The power loss and temperature rise of the chip depend on the amplitude of the output current ripple and the final amplitude required.

3. Based on the power factor correction of the pre-driver, the law of energy conservation and reasonable temperature rise of the DIO8232 the output capacitance of the pre-driver can be approximately calculated as follows:

P_{IN}:   Input power

P_{OUT}:   Output power

P_D: Power loss of DIO8232

I_{LED}:   LED current

U: Output voltage

V_{MIN}:   the minimum LED pin voltage

$\triangle U$:   Peak to peak output voltage ripple

V_{LED-}:   LED- pin voltage

T: Line cycle

η: Efficiency of the system

a) The power factor correction of the pre-driver and law of conservation of energy:
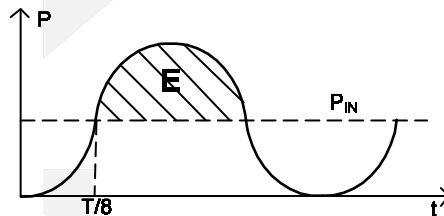
$$P_{IN} = (P_{OUT} + P_D)/\eta \qquad (1)$$

$$E = 2\left[P_{IN} * \frac{T}{8} - \int_0^{T/8} P_{IN}(1 - \cos 2\omega t)dt \right] \qquad (2)$$

b) The energy formula of capacitance:

$$E = \frac{1}{2} * C\left[(U + \frac{\Delta U}{2})^2 - (U - \frac{\Delta U}{2})^2 \right] \qquad (3)$$

c) The reasonable temperature rise of the DIO8232:
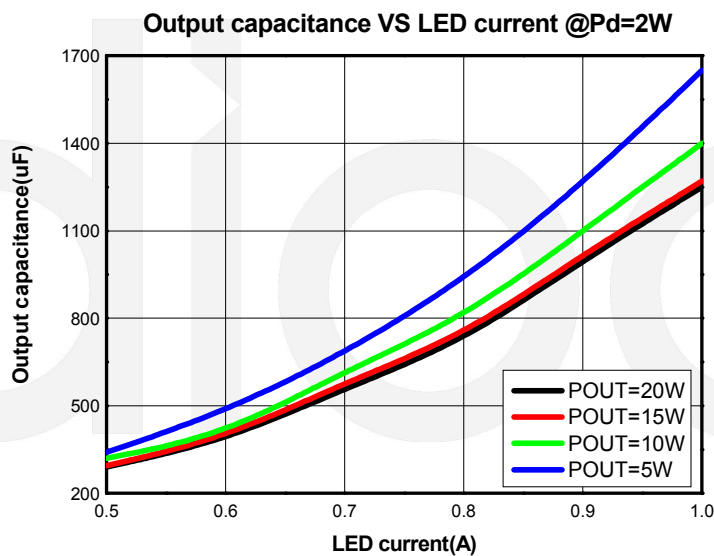
$$V_{MIN} = I_{LED} * R_{DSON} \qquad (4)$$

$$P_D \approx I_{LED} * V_{LED-} \approx I_{LED} * \left(\frac{\Delta U}{2} + V_{MIN} \right) \qquad (5)$$

$$C = \frac{P_{OUT} + P_D}{2*\pi*f*\eta*P_{OUT}*\Delta U} * I_{LED} \qquad (6)$$

d) The smaller output power, the larger capacitance is needed as it can be seen in the equation above.

e) For example:

   i.   Given: P_D=1W (Equivalent to 40℃ temperature rise); η=0.85; f=1/T=50Hz.
        Then the result shows in the following figure:

Output capacitance VS LED current @Pd=1W
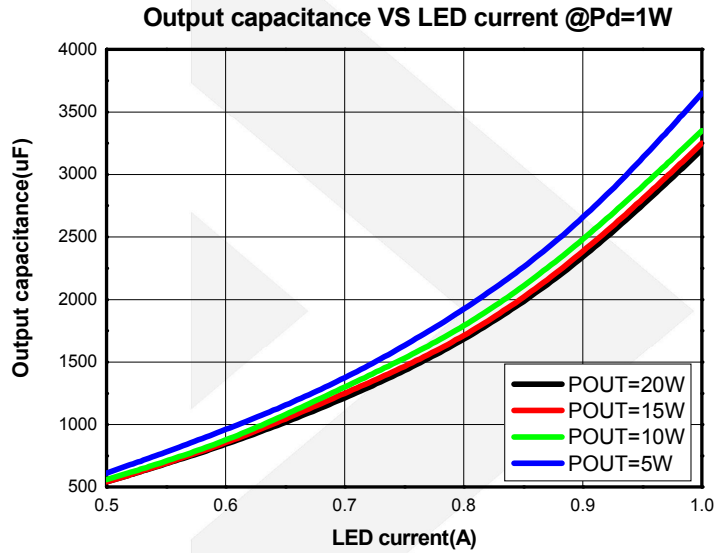
   ii. Given: P_D=2W(Equivalent to 80℃ temperature rise); η=0.85; f=1/T=50Hz.
        Then the result shows in the below:

Output capacitance VS LED current @Pd=2W

4. DIO8232 allows user to setup the SCP voltage via resistor divider. When the V_{VLMT} is higher than 2V, DIO8232 shuts down the MOSFET internal and recoveries when V_{VLMT} is lower than 2V. Also, the SCP voltage must meet the following condition:

$$V_{OVP} - V_F < V_{SCP} < V_F$$

$$V_{SCP} < V_{INSTART} = I_Q * R_{VIN} + V_{INRISING}$$

R_{VIN}: the resister between anode of the input and the VIN pin.

$V_{INRISING}$: VIN Start Up Voltage Threshold.

5. The capacitance between VC and GND determines the final current ripple. It should be large enough to remove the LED current ripple. However, too large capacitor may slow down the dynamic response. 1µF or 2.2µF is recommended.
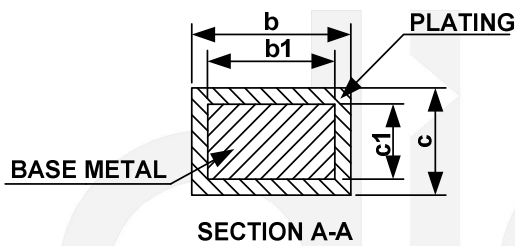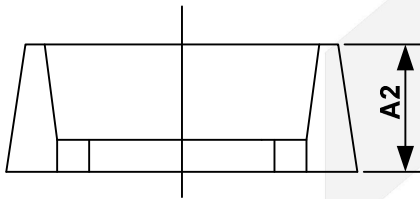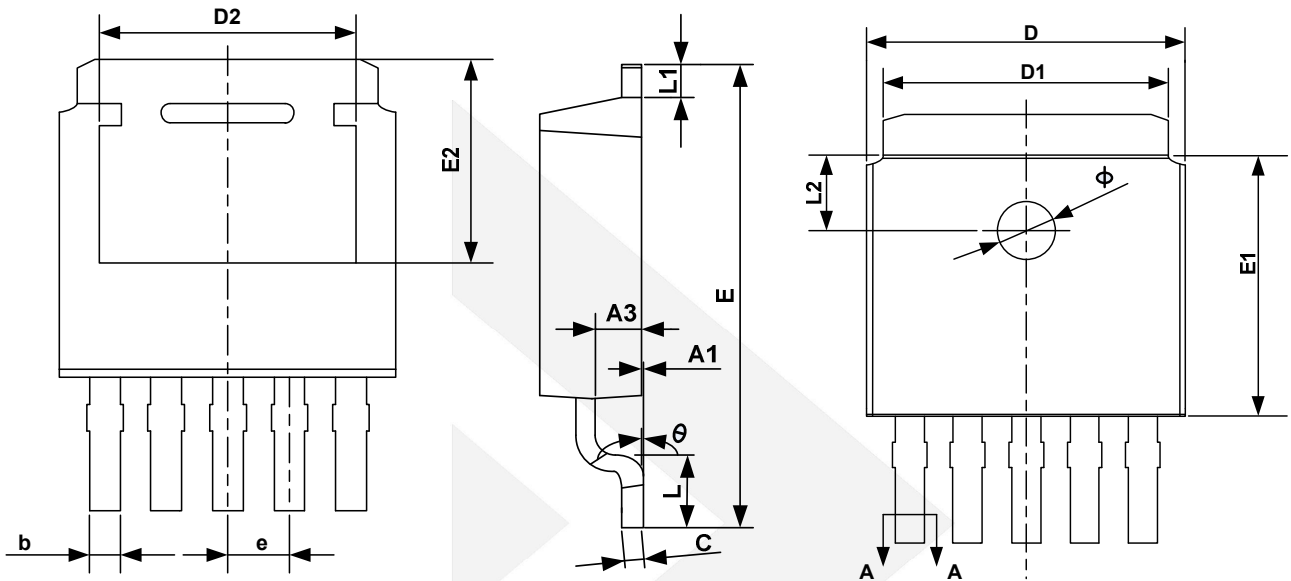
Application Reference
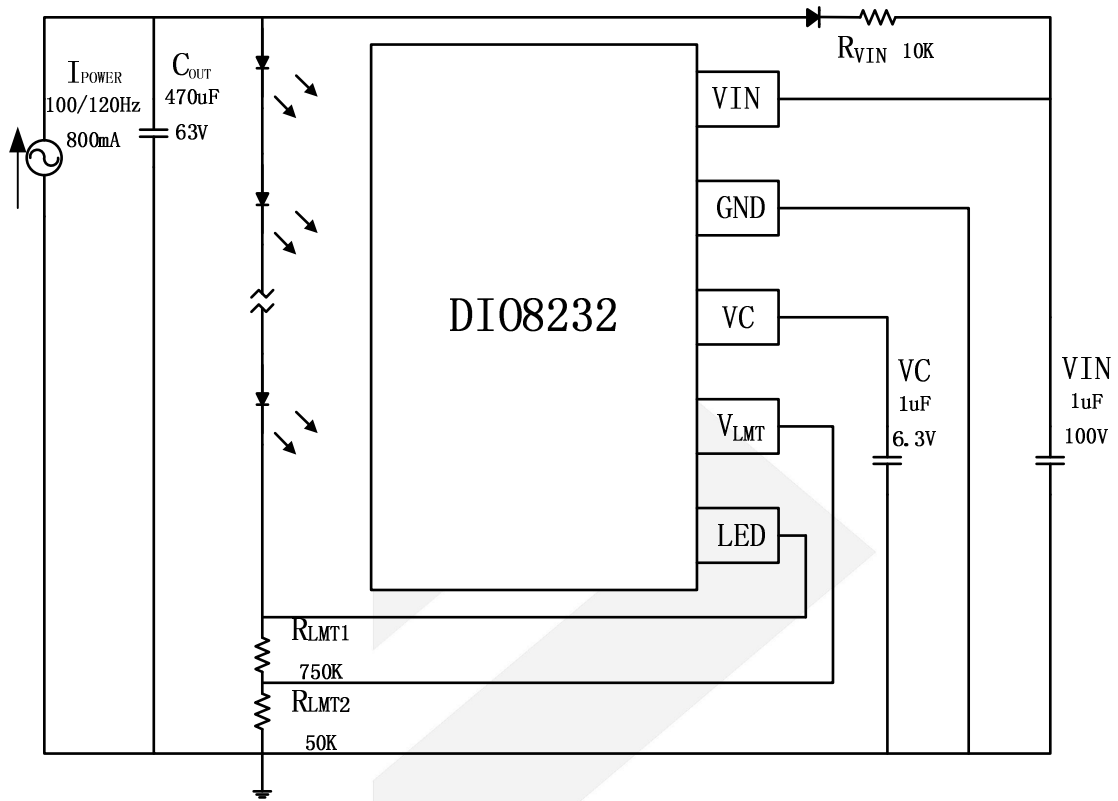
Physical Dimensions: TO252-5

COMMON DIMENSIONS (UNITS OF MEASURE=MILLIMETER)			
Symbol	MIN	NOM	MAX
A1	0.00	-	0.10
A2	2.20	2.30	2.40
A3	1.02	1.07	1.12
b	0.55	-	0.64
b1	0.54	0.56	0.59
c	0.49	-	0.56
c1	0.48	0.51	0.52
D	6.50	6.60	6.70
D1	5.33 REF.		
D2	4.83 REF.		
E	9.90	10.10	10.30
E1	6.00	6.10	6.20
E2	5.30REF		
e	1.27 BSC		
L	1.40	1.50	1.60
L1	1.02 REF		
L2	1.70	1.80	1.90
Θ	0	-	8°
Φ	1.20X0.1±0.05 DP		

CONTACT US

Dioo is a professional design and sales corporation for high-quality and performance analog semiconductors. The company focuses on industry markets, such as, cell phone, handheld products, laptop, and medical equipment and so on. Dioo's product families include analog signal processing and amplifying, LED drivers and charger IC. Go to http://www.dioo.com for a complete list of Dioo product families.

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