

# DIO8221B

## Controller for Adaptive 100/120Hz Current Ripple Removing Circuit

### Features

- Controller for adaptive 100/120Hz current ripple remover
- Built-in zener diode for input voltage clamping
- VG output voltage high to 10V
- Programmable amplitude of LED current ripple
- Programmable maximum cathode voltage of LED
- Programmable maximum LED current
- Short protection
- Over temperature protection
- SOT23-6 Package

### Applications

- LED lighting

### Descriptions

DIO8221B is a controller for driving external NMOSFET to remove the 100/120Hz LED current ripple on AC/DC power by a capacitor between VC and GND.

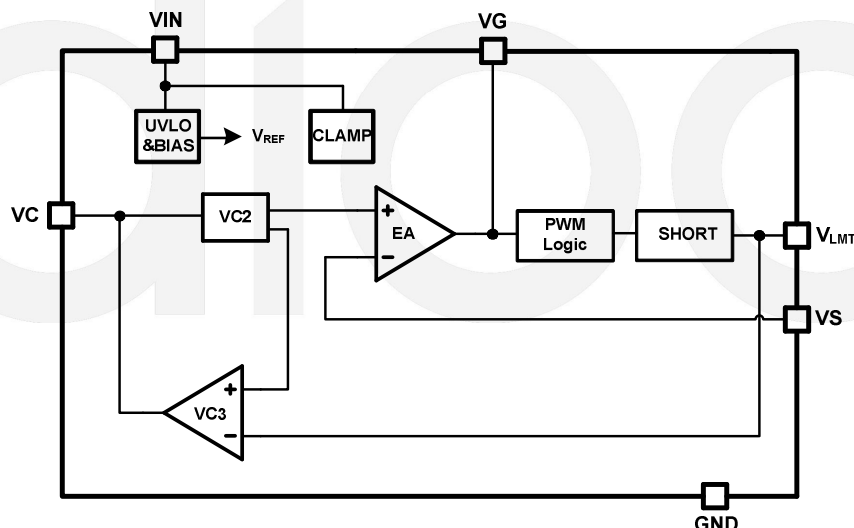
The adaptive technology of DIO8221B ensures minimum power dissipation on NMOSFET while removing LED current ripple.

DIO8221B clamps the input voltage on VIN pin by 37V. DIO8221B allows user to setup maximum LED current, which keeps NMOSFET damaged when LED short or hot-plug.

By sensing the drain voltage of NMOSFET via a resistor between the drain and V<sub>LMT</sub> pin, DIO8221B allows user to setup the maximum cathode voltage of LED string, which could help limit the power dissipation on chip.

DIO8221B provides two kinds of protection function: it shuts down NMOSFET when LED is shorted and recovers after 40ms. DIO8221B provides over thermal protection. When the OTP is triggered, the function of current ripple removing is shielded and MOSFET is ON.

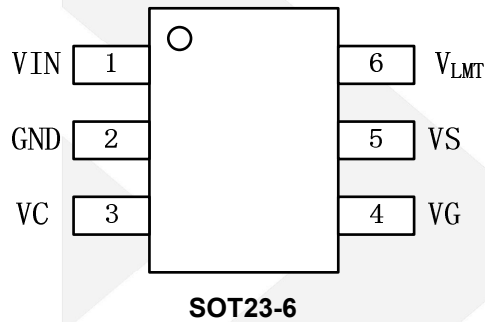
### Block Diagram



## Ordering Information

Order Part Number	Top Marking		T <sub>A</sub>	Package	
DIO8221BCST6	W21B	Green	-40 to 125°C	SOT23-6	Tape & Reel, 3000

## Pin Assignments



**Figure 1 Pin Assignment (Top View)**

## Pin Definitions

Pin Name	Description
VIN	Power Supply
GND	Power Ground
VC	LED Current Ripple Programming
VG	NMOSFET GATE driving voltage output
VS	LED Current sensing input
V <sub>LMT</sub>	LED Voltage limit and short protection Programming



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### 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 maximum rating conditions for extended periods may affect device reliability.

Parameter	Rating	Unit
VIN clamp voltage	37	V
VG	20	V
VS, VC, VLMT	-0.3 to 5	V
Junction Temperature	150	°C
Lead Temperature	260	°C
Storage Temperature	-65 to 150	°C
Thermal Resistance / $\theta_{JA}$	170	°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
Junction Temperature ( $T_J$ )	125	°C





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### Electrical Characteristics

T<sub>A</sub> = 25°C, V<sub>IN</sub> = 12V, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V <sub>IN_CLP</sub>	VIN clamp voltage			37		V
I <sub>IN</sub>	VIN operation current	5V<V <sub>IN</sub> <38V	0.21	0.24	0.3	mA
V <sub>THULVO</sub>	VIN startup voltage threshold			16		V
V <sub>HYSUVLO</sub>	VIN startup voltage hysteresis			5		V
V <sub>VG</sub>	Maximum VG output voltage		6.5	8	9	V
I <sub>VCST</sub>	VC startup current	VC short to GND when startup	0.9	1.1	1.3	mA
V <sub>VLMT</sub>	VLMT reference voltage		1.95	2	2.05	V
V <sub>D_CLP</sub>	NMOSFET drain voltage limit	Drain voltage of NMOSFET When voltage limit is triggered. R <sub>LIMIT</sub> =100K.	3.5	4	4.5	V
V <sub>TH_SHORT</sub>	Short protection threshold	Drain voltage of NMOSFET When short is triggered. R <sub>LIMIT</sub> =100K.	5.5	6	7	V
T <sub>SPD</sub>	Short protection delay time			70		μs
T <sub>SPH</sub>	Short protection hold time			40		ms
V <sub>VS</sub>	VS voltage limit				0.15	V

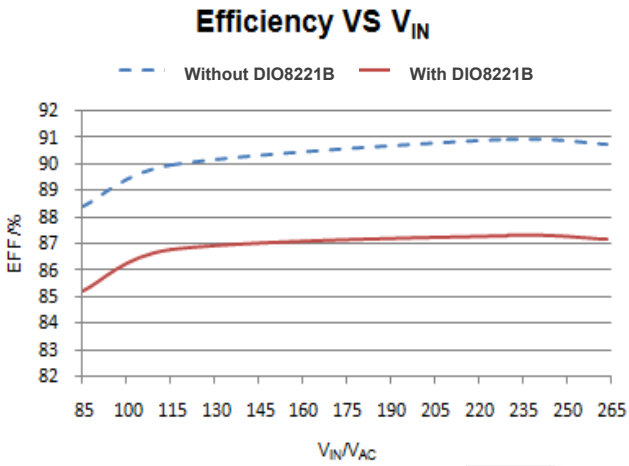
Specifications subject to change without notice.



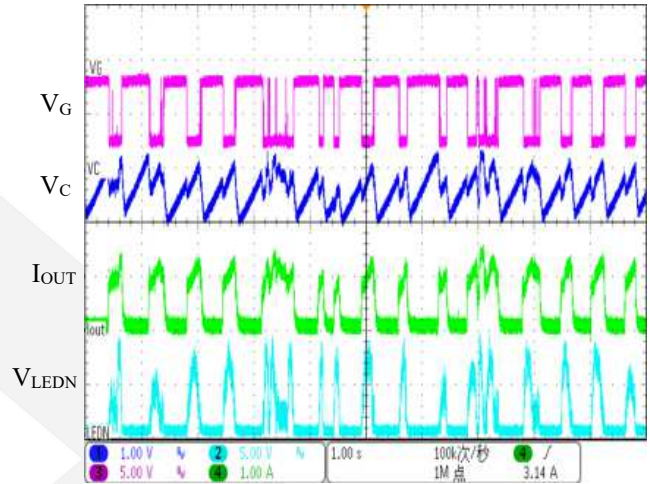
## Typical System Characteristics

$V_{IN}=85V\sim 264V_{AC}$ ,  $V_{OUT}=36V$ ,  $I_{OUT}=1A$ ,  $C_{OUT}=470\mu F/50V*4$ ,  $T_A = 25^\circ C$

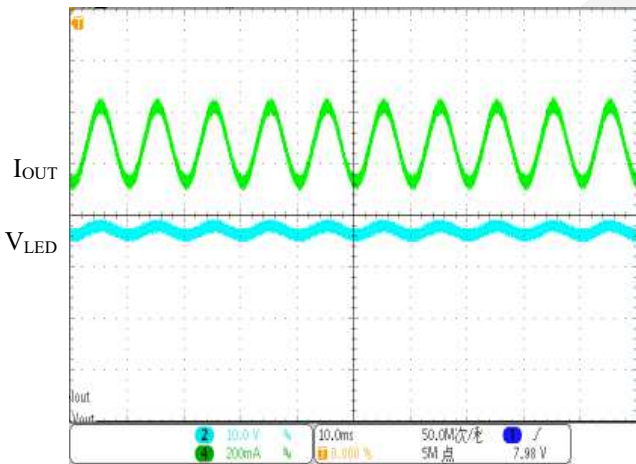
### Efficiency Comparison with vs. without DIO8221B



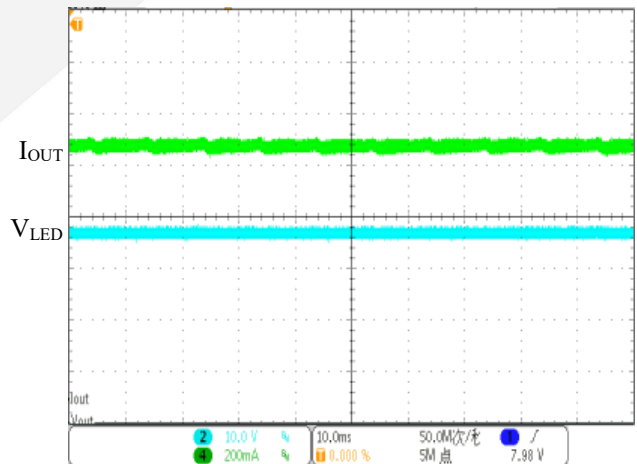
### Line Input arcing test



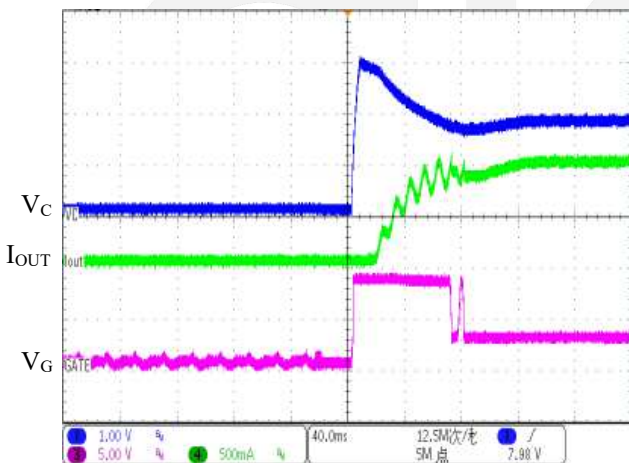
### Current Ripple without DIO8221B



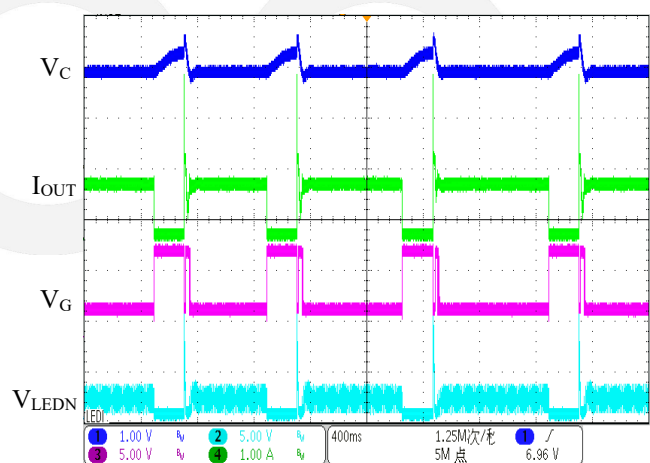
### Current Ripple with DIO8221B



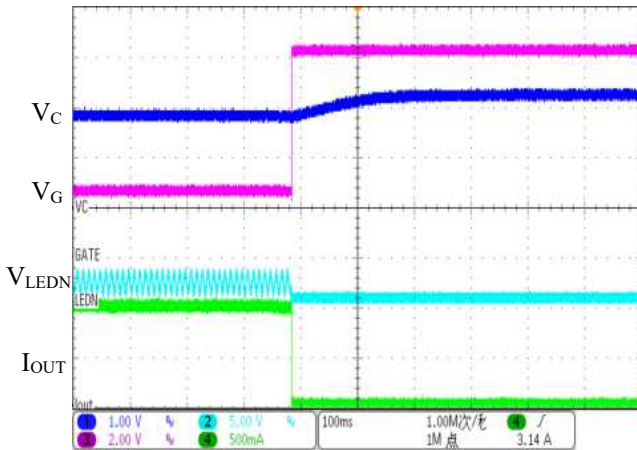
### Power ON



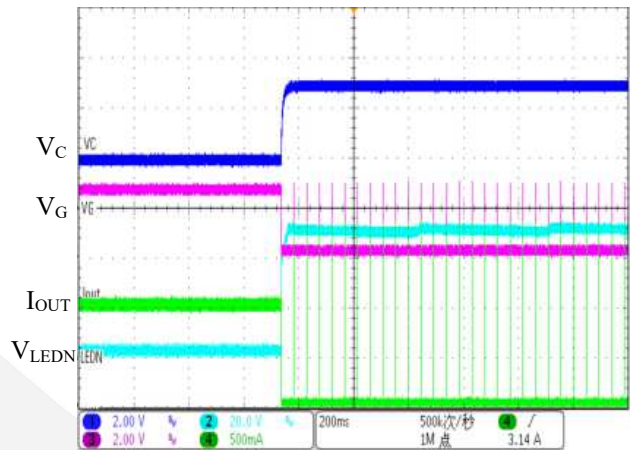
### LED Hot plug test



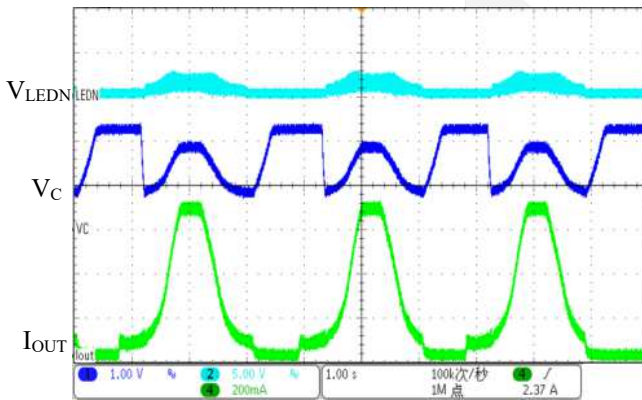
**LED Open Protection test**



**LED Short Protection test**



**Dimming application test**



## Functional Description

### Theory of Operation:

The LED string and DIO8221B are both supplied by an AC/DC current source. The drain of external NMOSFET is connected to the cathode of LED string. A sensing resistor  $R_{CS}$  is connected between the source of NMOSFET and GND. The gate is connected to the VG of DIO8221B.

DIO8221B drives NMOSFET to transfer the LED current ripple to voltage ripple on NMOSFET, and ensures the constant voltage across LED string and the current flow through LED string. The scalable adaptive function of DIO8221B 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  $V_C$  and GND is a integration capacitor. DIO8221B transform the voltage on  $C_C$  to a reference voltage. The current regulator regulates the voltage on  $R_{CS}$  equal to the reference voltage.

The relationship between the voltage on  $C_C$  and  $R_{CS}$  is shown as following:

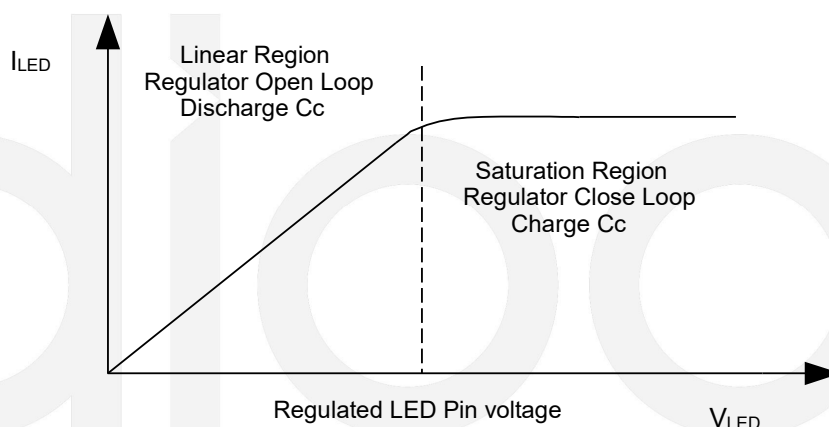
$$V_{CS} = I_{LED} * R_{SENSE} = V_{VC} / 10$$

$C_C$  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:

DIO8221B control the voltage on  $C_C$  by monitoring the operation state of external NMOSFET. The efficiency of system is relatively low when NMOSFET is working in the saturation region. DIO8221B 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.

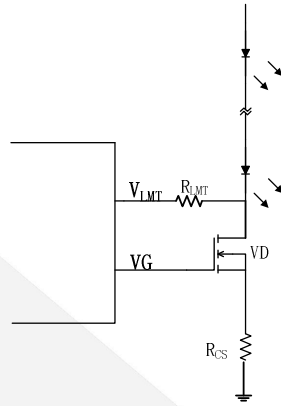
Conversely, when NMOSFET is working in the linear region, LED current regulation loop is open. DIO8221B detects it and discharges  $C_C$  to reduce the  $V_{VC}$  and  $I_{LED}$ , then the output voltage of power supply is raised, and the LED current regulation loop is close.



### Drain Voltage of NMOSFET Limit:

The voltage ripple on the drain of NMOSFET maybe very large when the current ripple is removed, which would bring large power dissipation on chip. The resistor between the drain of NMOSFET and  $V_{LMT}$  pin can setup the limit value of drain voltage of NMOSFET.





The limit threshold is calculated as below:

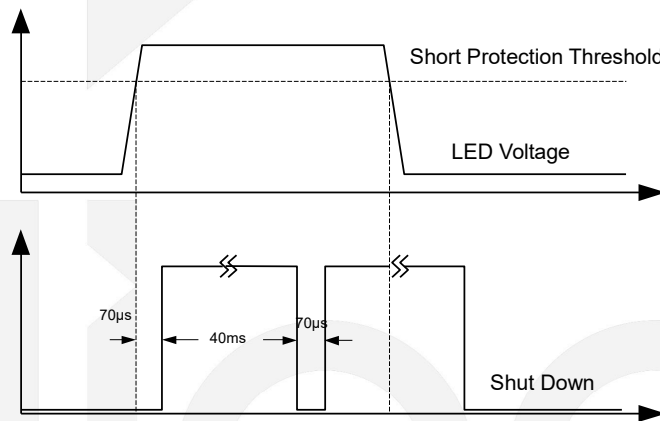
$$V_{LMT} = 2V + R_{LMT} * 20\mu A$$

### LED Current Limit:

The voltage of VS pin is limited to 0.15V internally. So the current limitation is  $0.15V/R_{CS}$ . Current limit can protect the chip when LED is short connected or HOT-PLUG. The function of current limit is higher priority than drain voltage limit. It means that the voltage on drain of NMOSFET is not limited when LED current exceed current limit threshold.

### LED Short Protection:

DIO8221B detect short by  $R_{LMT}$ . When the drain voltage of NMOSFET exceeds the short protection threshold and the state holds for more than  $70\mu s$ , DIO8221B considers the LED string is short connected, and shut down the external MOSFET. The short state is reset after 40ms.



The short protection threshold is calculated as below:

$$V_{THSCP} = 2V + R_{LMT} * 40\mu A$$

### Over Thermal Protection:

DIO8221B monitors operation temperature. When the temperature is higher than  $135^{\circ}C$ , the function of current ripple removing is shielded and MOSFET is ON.

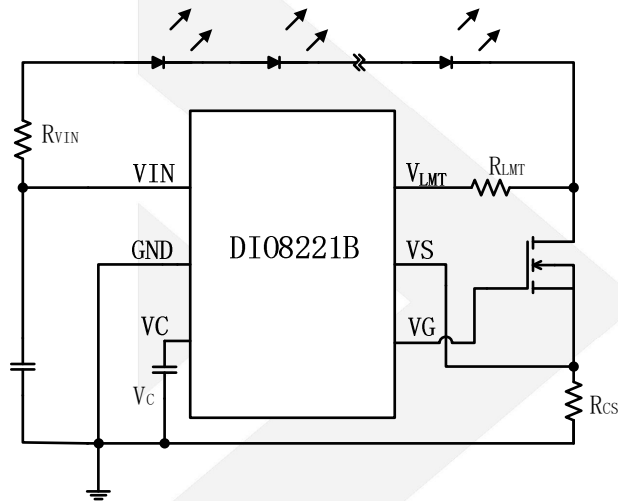


## PCB Design Guideline:

1. The bypass capacitor of VIN should be placed as close as possible to the VIN pin and GND pin of IC.
2. DIO8221B 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 note

### DIO8221B design guide:



1. Because of the 37V zener integrated and the 16V VIN start threshold, the value of  $R_{VIN}$  may satisfy the following conditions:

$$R_{VIN} < \frac{V_F - 16V}{0.5mA}$$

$V_F$ : the voltage of LED.

2. The maximum voltage of VS pin is 0.15V in order to limit the maximum output current especially in the short circuit condition. The value of  $R_{CS}$  can be calculated as below:

$$R_{CS} < \frac{0.15V}{I_{LED}}$$

$I_{LED}$ : the output current of the pre-driver.

Recommend the DIO8221 VS voltage range of 0.08~0.12V typical. In order to ensure nothing will be damaged, the value of VS must be less than 0.15V. Low VS voltage will increase short circuit power consumption. High VS voltage will reduce the system efficiency.

3. When the voltage of LED- reaches  $V_{SCP}$  which is set by the  $R_{LMT}$ , DIO8221B turns off the MOSFET. In order to ensure nothing will be damaged in the short circuit condition, the value of  $R_{LMT}$  must satisfy the following conditions:

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

$$V_{SCP} < V_{INSTART} = R_{VIN} * 0.5mA + 16V$$

$$V_{SCP} = 2V + 40\mu A * R_{LMT}$$



## DIO8221B

$V_{OVP}$ : the output voltage when the pre-driver is open.

$V_{SCP}$ : the threshold of DIO8221B short circuit protection.

$V_{INSTART}$ : the output voltage of the pre-driver when the  $V_{IN}$  of DIO8221B is 16V.

4. The value of the capacitor between VC and GND can determine the final amplitude of the current ripple. It 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. In normal condition,  $1\mu F$  or  $2.2\mu F$  is relatively reasonable.
5. To ensure DIO8221B work properly, the  $R_{DS(ON)}$  of MOSFET must be less than  $3R_s$ . The MOSFET will endure a large power shorting the output on the moment, so the appropriate package and  $R_{DS(ON)}$  of the MOSFET is necessary.
6. When short the LED, there is an overshoot on the drain of the MOSFET. The breakdown voltage of the MOSFET must be higher than  $V_{OVP}$ . A diode connected to LED+&LED- can reduce the overshoot when short.

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