LED lighting Output Current Ripple Suppressor for Dimmable LED Constant Current System

REV. 00

General Description

The LD6802/J is an output current ripple suppressor for LED lighting. It supports easy use at output terminal with isolation or non-isolation active PFC architecture with constant current.

The LD6802/J is easy to achieve current ripple limitation with minimum output capacitance and built-in adjustable over voltage protection / multi-level over current protection and internal clamp zener diode can be used at wide range LED voltage application. The device is the SOT-26 package to minimize the PCB size well as component counts.

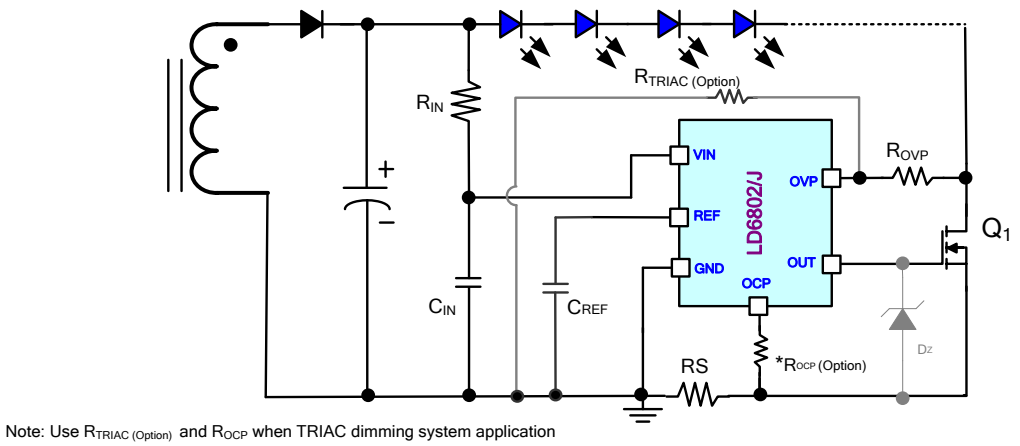
Features

- Controller for adaptive 100Hz/120Hz current ripple remover
- Built-in clamping circuit for input voltage clamping
- 6V drive voltage for MOSFET control
- Programmable amplitude of LED current ripple
- Programmable maximum cathode voltage of LED
- Programmable maximum LED current
- Support wide output current variation
- Lamp short or open circuit protection
- Built-in internal over temperature protection
- SOT-26 Package

Applications

- LED Driver Application for Non-Ripple Current
- Analog Dimming LED power (Include TRIAC dimming system)

Typical Application

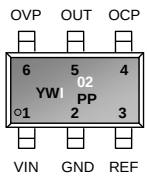


Note: Use $R_{TRIAC\ (Option)}$ and R_{OCP} when TRIAC dimming system application

Figure.1 Reference Circuit Design

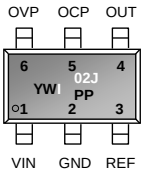
Pin Configuration

SOT-26 (TOP VIEW)



Y : Year code (D: 2004, E: 2005…..)
W : Week code
PP : Production code
I02 : LD6802

SOT-26 (TOP VIEW)



Y : Year code (D: 2004, E: 2005…..)
W : Week code
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I02J : LD6802J

Ordering Information

Part number	Package	Top Mark	Shipping
LD6802 GL	SOT-26	YWI/02/PP	3000 /tape & reel
LD6802J GL	SOT-26	YWI/02J/PP	3000 /tape & reel

The LD6802/J is ROHS compliant/green packaged.

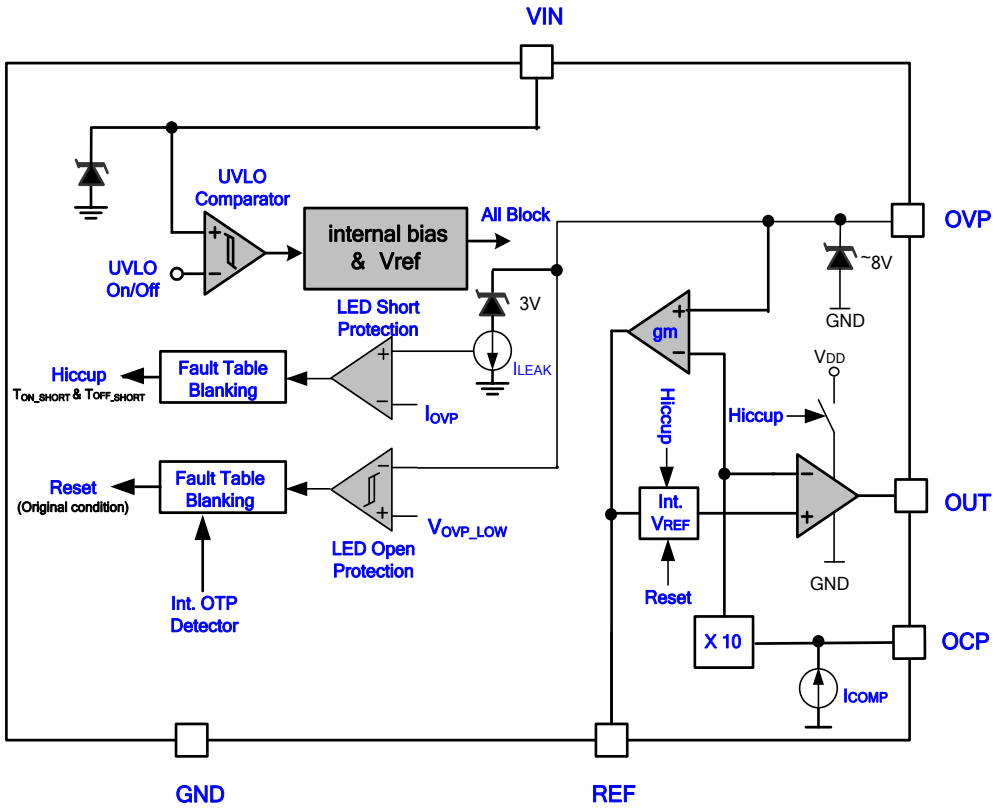
Protection Mode

Part number	Open LED Protection	Short LED Protection	Internal OTP
LD6802/JGL	Auto-recovery OUT pin is High	Auto-recovery Hiccup 250μs/250ms	Auto-recovery OUT pin is High

Pin Descriptions

LD6802 Pin No.	LD6802J Pin No.	NAME	FUNCTION
1	1	VIN	Power Supply for the device. Internal Zener Clamp for wide range LED light bar voltage. Connecting a R_{IN} to supply voltage source for current limit and a capacitor to GND for filter out noise
2	2	GND	Ground
3	3	REF	LED Reference Voltage, It's essential to connect REF pin with a ceramic capacitor to filter the 100/120Hz ripple.
4	5	OCP	LED current feedback and maximum LED current limit and source compensation current for low dimming operation.
5	4	OUT	This pin connects the MOSFET gate to regulate LED current ripple.
6	6	OVP	Over voltage Protection for Short LED protection

Block Diagram



Absolute Maximum Ratings

VIN	-0.3V ~ 33V
VIN Shunt Regulation Pull–down Current	3mA
OVP	-0.3V ~ 8V
VIN Shunt Regulation Pull–down Current	1.5mA
OCP, OUT	-0.3V ~ 16V
REF	-0.3V ~ 6V
Maximum Junction Temperature	150°C
Storage Temperature Range	-65°C ~ 150°C
Package Thermal Resistance (SOT-26, θ_{JA})	200°C/W
Power Dissipation (SOT-26, Tj=125ºC, Ta=85°C)	200mW
Lead temperature (Soldering, 10sec)	260°C
ESD Voltage Protection, Human Body Model	2.5KV
ESD Voltage Protection, Machine Model	250 V

Caution:

Stress exceeding maximum ratings may damage the device. Maximum ratings are stress ratings only. Functional operation above the recommended operating conditions is not implied. Extended exposure to stress above recommended operating conditions may affect device reliability.

Recommended Operating Conditions

Item	Min.	Max.	Unit
Operating Junction Temperature Note3,Note5	-40	125	°C
VIN Operation Range	9	30	V
VIN Operation Current	0.5	2.5	mA
VIN pin Filter Capacitor to GND	1	4.7	μF
REF pin Capacitor to GND	0.47	1.5	μF
OCP pin Filter Resistance (*R_{OCP})	-	1	kΩ
OVP pin Resistance to GND(*R_{TRIAC})	750	1500	kΩ
Zener Diode Voltage (D_Z) between gate and source of NMOS	5.6	7.5	V

Note：

1) Exceeding these ratings may damage the device.
2) This product guarantees robust performance from -20°C to 105°C ambit temperature. The junction temperature range specification is assured by design, characterization and correlation with statistical process controls.
3) When operation at harsh environment condition, as temperature and humidity or climate change …etc . Please pay attention to impedance variation between pin to pin or ground to avoid ripple remover closing loop and being failure.
4) When use dimmable power system by 0-10V or TRIAC dimmer, please consider *R_{REF}, *C_{REF}, *R_{OCP} design parameters.
5) When operation temperature is lower than -25°C, please pay attention to the temperature coefficient of capacitance and ESR diversification of output aluminum electrolytic capacitors.

Electrical Characteristics

(V_{IN}=15V, T_A = 25°C unless otherwise specified.)

PARAMETER	CONDITIONS	SYMBOL	MIN	TYP	MAX	UNITS
Supply Voltage (VIN Pin)						
Shunt Regulator Voltage	*; When shunt regulation pull-down current is ~2mA	V_{IN_CLAMP}	29.0	30.5	32.0	V
Shunt Regulator Pull-Down Current	V_{IN} = 33V, RIN=1KΩ	I_{IN_SINK}		2	3	mA
Operating Current	10V≦VIN≦27V; C_{OUT}=3000pF	I_{VIN}		350		μA
UVLO(OFF)		V_{UV_OFF}	4.5	5.5	6.5	V
UVLO(ON)		V_{UV_ON}	6.5	7.5	8.5	V
Gate Drive Output (OUT Pin)						
Maximum Output voltage		V_{OUT}	5.0	6.0	7.5	V
GM	*; V_{OVP}=0~3V	G.M		6		μA/V
CURRENT SENSE (OCP Pin)						
Over Current Limited Threshold Voltage	After V_{CC} ≧ V_{UV_ON}	V_{OCP_LIM}	0.27	0.32	0.37	V
Blanking time	*	T_{OCP_LIM}		100		ns
Recover Delay time	*; V_{OUT} is Low Level	T_{OCP}		250		μs
LED Reference Voltage to LED Current rate	Ratio is V_{REF}/ V_{OCP}	K	9.5	10	10.5	-
Maximum Output Current	When V_{REF} ≦ 0.1V	I_{COMP_MAX}		15		μA
Enable Output Current by REF Voltage	Increase source current beginning level ; ICOMP ≧ 0.1uA	V_{COMP_L}	1.40	1.55	1.70	V
REFERENCE FILTER (REF Pin)						
REF Regulation Operation Voltage	Normal operation mode	V_{REF_CLAMP}	2.10	2.25	2.40	V
REF Max. Clamp Voltage	*	V_{REF_MAX}	2.40		3.2	V
Internal REF Voltage before IC start up (Pre-charging)	*; When VCC < V_{UV_ON} -1.5V	V_{REF_INT}		1.40		V
Internal REF Voltage when Open LED Protection is trigged	When OVP pin is pull to GND	V_{REF_OPEN}	0.85	1.00	1.15	V
Internal REF Voltage when Short LED Protection is trigged	Here is de-bounce ~8μs	V_{REF_SHORT}	1.8	2.0	2.3	V

(V_{IN}=15V, T_A = 25°C unless otherwise specified.)

PARAMETER	CONDITIONS	SYMBOL	MIN	TYP	MAX	UNITS
Over Voltage Protection (OVP pin)						
Drain voltage of NMOSFET Threshold	When R_{OVP}=100Kohm	V_{OVP_DRAIN}	5.0	6.0	7.0	V
Short LED Protection Sink Current		I_{OVP}	25	30	35	μA
Short LED Protection Delay Time	*	T_{ON_SHORT}	120	280	480	μs
Short LED Protection Reset Time	*	T_{OFF_SHORT}	120	280	480	ms
LED Open Protection Threshold Voltage		V_{OVP_LOW}	2	8	15	mV
LED Open Protection Recovery Voltage	*	V_{OVP_HIGH}		2		mV
LED Open Protection Trigger De-bounce	*	T_{OVP_LOW}		40		ms
Internal Over Temperature Protection						
OTP Trip level	*	OTP		140		°C
OTP Hysteresis	*	△OTP		30		°C

*: Guaranteed by Design.

Typical Performance Characteristics

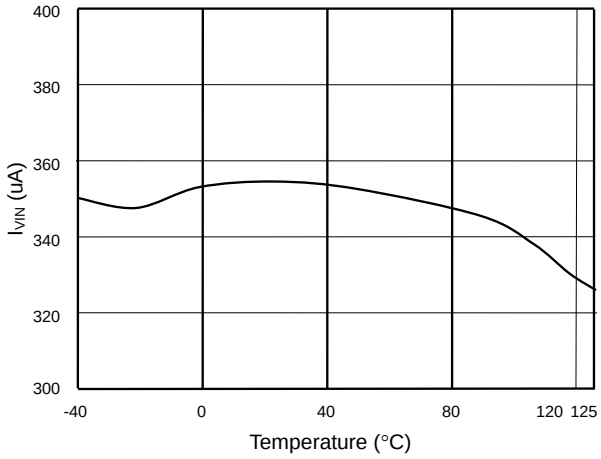


Fig. 2 I_{VIN} vs. Temperature

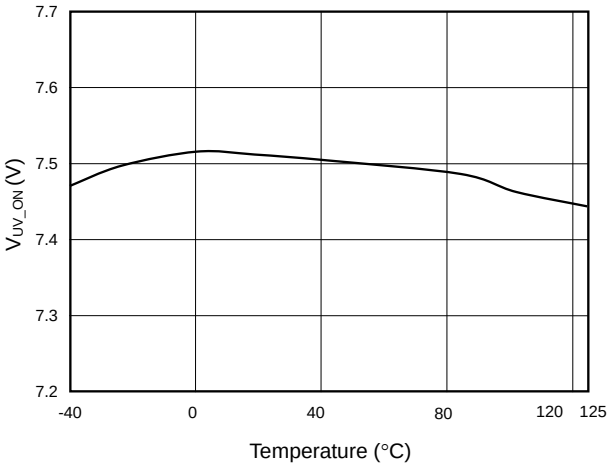


Fig. 3 V_{UV_ON} vs. Temperature

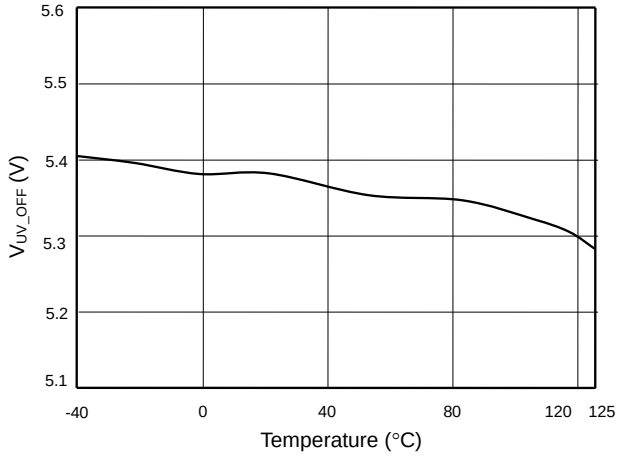


Fig. 4 V_{UV_OFF} vs. Temperature

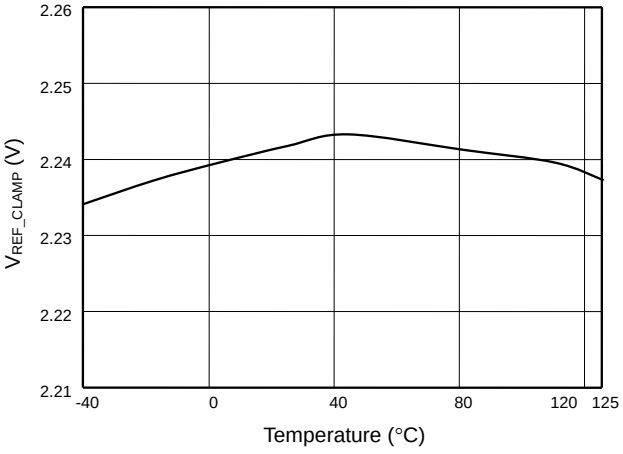


Fig. 5 V_{REF_CLAMP} vs. Temperature

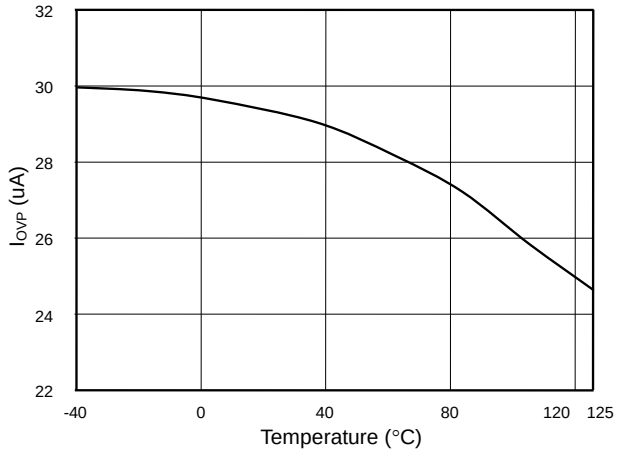


Fig. 6 I_{OVP} vs. Temperature

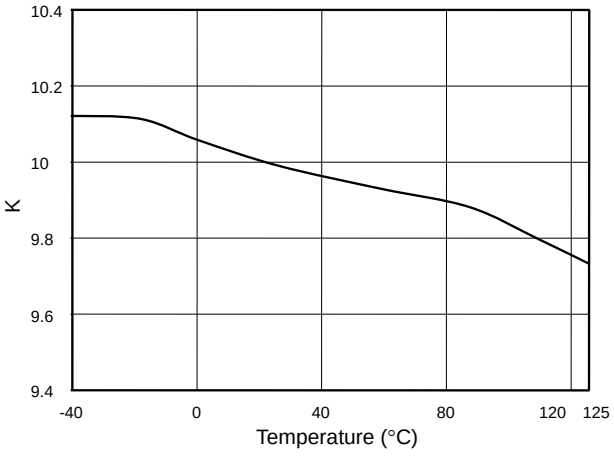


Fig. 7 K vs. Temperature

Application Information

Basic Description

LD6802/J is an external MOSFET controller for LED lighting current ripple eliminated. The REF pin connection a filter capacitor to GND to suppressor the 100/120Hz LED current ripple. In the start-up process, the LD6802/J charges the REF capacitor quickly to avoid LED voltage overshoot this time. And the device provide adjustable short LED string protection, LED string open protection and programmable over current limiting.

Theory of Operation

The LED light bar and LD6802/J are both supplied by an AC/DC current source. The drain of external MOSFET is connected to the cathode of LED light bar. A sensing resistor R_{OCP} is connected between the source of MOSFET and GND. The gate is connected to the OUT pin of LD6802/J.

The LD6802/J detects the OVP pin and OCP pin voltage to adjust C_{REF} Voltage and control the external MOSFET operate in linear/saturation region. When external MOSFET working in the saturation region, the LED current ripple transfer to LED voltage on MOSFET. If the drain Voltage of external MOSFET break away saturation region, the LED current ripple suppressor will invalid naturally.

Reference Voltage to LED Current Ratio and LED Current Limit

The V_{REF} is regulation the LED current to limit threshold. The V_{REF} operation voltage is limited to 2.25V around on REF pin. So that the LED limit current threshold voltage is

$$V_{REF} \cong K \times (I_{LED} \times R_S)$$

The suggestion for normal LED operation current is 50%~60% of LED limit current threshold (Normally, V_{REF} is 1.0~1.5V). It avoids the larger LED peak current to trigger over current limit protection on OCP pin (V_{OCP_LIM} ≅ 0.30V) or produce MOSFET over current issue as short output circuit. Then setting REF pin voltage must be higher than output ripple voltage for real LED lamp. The equation is

$$V_{REF\_CLAMP} > V_{REF} \geqq (V_{LED,P-P} \div 2) + (R_{ON\_MOS} \text{ X } I_{LED,MEAN})$$

Where $V_{LED,P-P}$ is a ripple voltage of LED lamp between output terminal to ground, R_{ON_MOS} is turn on resistance of MOSFET, $I_{LED,MEAN}$ is an average current of LED lamp.

LED String Open Protection

When OVP pin voltage is under about V_{OVP_LOW} and T_{OVP_LOW} de-bounce time, the LD6802/J will go to LED open protection stage. This time OUT pin and V_{REF} voltage keep 1.0V until the LED string replies connection. If OVP pin voltage is higher than 30mV around, the LD6802/J will be into saturation region and enable ripple remover function.

LED String Short Protection

If OVP pin voltage is larger than 3V in the condition of IOVP ≧ 30μA and continuous T_{ON_SHORT}, the LD6802/J will change REF limit voltage to 1.0V and turn off MOSFET until T_{OFF_SHORT}. Then, the overvoltage protection state is reset. The programmed overvoltage protection is calculated as below:

$$V_{OVP\_TH} = 3V \text{ x } [(R_{TRIAC}+R_{OVP})/R_{TRIAC}] + (R_{OVP} \times 30\mu A)$$

Where V_{OVP_TH} is drain voltage of MOSFET. If LED short abnormal test result is fail, it probably damages RS or MOS. The suggested solution is to add a 6.8V zener diode between gate and source pin of MOSFET.

LED Current Limit

The voltage of OCP pin is limited to 0.3V internally. So the current of MOSFET limitation is 0.30V/R_{OCP}. Current limit can protect the FET and current resistor 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 MOSFET is not limited when LED current exceed current limit threshold.

Shunt Regulation Voltage and Current on VIN Pin

The LD6802/J support wide range LED light bar application that integrated zener diode (V_{IN_CLAMP} ~30V) which is about 2.5 mA sink current and V_{UV_ON} is to 7.5V.

So the value of R_{IN} that is connected between V_{LED} and V_{IN} of LD6802/J, we can be calculated as below:

$$R_{IN} \leqq (V_{LED\_MIN} - V_{UV\_ON}) \div 0.5mA$$

and $$R_{IN} \geqq (V_{LED\_OPEN} - V_{IN\_CLAMP}) \div 3.0mA$$

Where V_{LED} is a terminal voltage of LED lamp or auxiliary wire

Internal Thermal protection

Thermal protection limits total power dissipation in this device. When the junction temperature reaches ~140°C approximately, the LD6802/J will turn on the MOSFET completely until the IC's junction temperature cools down approximately ~40°C.

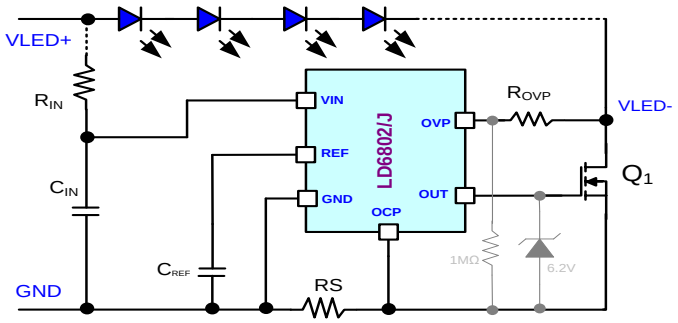
PCB Design Guideline

1. The bypass capacitor of V_{IN} should be placed as close as possible to the V_{IN} and GND pin of LD6802/J.
2. The filter capacitor of C_{REF} should be placed as close as possible to the REF and GND pin of LD6802/J.
3. LD6802/J Controller should be placed near to the external MOSFET.
4. To consider temperature requirement, we need add PCB pad or heat sink be to fit system specification.
5. The area of LED current loop should be as small as possible.
6. When LED has a short circuit condition, please check MOS's stress (ID, BVDSS , VGS ..ect) are enough.

LD6802/J design guide

Example:

System Parameter	Specification	System Parameter	Specification
V_{LED+}	30~60Vdc	I_{LED}	700mA+/-5%
V_{LED+_OVP}	72Vdc	I_{LED_RIPPLE}	< 10%
V_{LED+_P-P}	~2.0V	Rds,on	50mΩ



1. Base on the 30V zener integrated and the 7.5V VIN start threshold, the value of RVIN may satisfy the following conditions:

$$\frac{72V-30V}{3.0mA} < R_{IN} \leq \frac{30V-7.5V}{0.5mA}$$

So, R_{IN} is recommend to 15kΩ~40KΩ. And C_{IN} value is recommend 0.1μF~1μF

2. The maximum voltage of REF pin is ~2.25V in order to limit the maximum output current especially in the short circuit condition. The value of R_{OCP} can be calculated as below:

$$(2.25V \times 0.8) \geqq V_{REF} \geqq (2.0V \div 2) + [(R_{ON\_MOS} \times I_{LED}) \times K] = 1.35$$

$$\text{So } V_{REF} \fallingdotseq 1.0\sim1.5V$$

So, R_{OCP} is recommend to 0.14Ω~0.21Ω.

3. When the voltage of LED- reaches V_{OVP} which is set by the R_{OVP}, LD6802/J pulls down the VIN then turns off the MOSFET. In order to ensure nothing will be damaged in the short circuit condition, the value of R_{OVP} must satisfy the following conditions:

$$(V_{LED\_MAX} - V_{UV\_ON})/3 < V_{OVP_{TH}} < (V_{LED\_MIN} - V_{UV\_ON})/2$$

$$V_{OVP\_TH} = 3V + (30\mu A \times R_{OVP})$$

As this example , R_{OVP} is recommend to 250k~470kΩ.

4. The value of the capacitor between V_{REF} 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, 0.47μF to 1.5μF on REF pin is relatively reasonable.

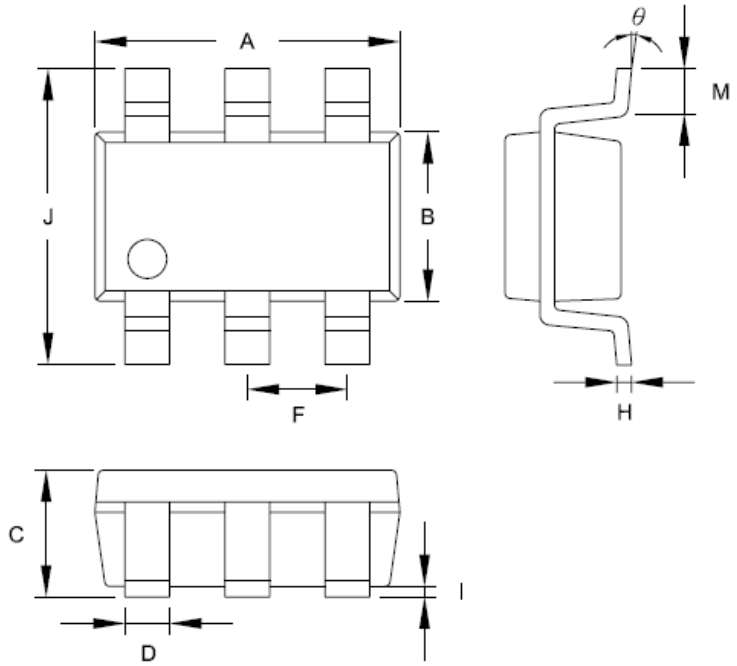
5. To ensure LD6802/J work properly, the R_{DS_ON} of MOSFET must be less than 250mΩ at V_{GS} = 5V. The MOSFET will endure a large power shorting the output on the moment, so the appropriate package and R_{DS_ON} of the MOSFET is necessary. Our suggestion is the below table.

I_{LED} (mA)	Vth(V) of MOSFET	R_{DS_ON} (mΩ) of MOSFET at Vth=7.5V	BVDSS(V) of MOSFET
≧ 350	2~4	< 250	1.2 x Open Circuit Clamp Voltage (V_{LED_OPEN})
350 < I_{LED} ≦ 500		< 200	
500 < I_{LED} ≦ 1000		< 100	
1000 < I_{LED} ≦ 1500		< 50	

6. When short the LED lamp, 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.

Package Information

SOT-26



Symbol	Dimension in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	2.692	3.099	0.106	0.122
B	1.397	1.803	0.055	0.071
C	-------	1.450	-------	0.057
D	0.300	0.500	0.012	0.020
F	0.95 TYP		0.037 TYP	
H	0.080	0.254	0.003	0.010
I	0.050	0.150	0.002	0.006
J	2.600	3.000	0.102	0.118
M	0.300	0.600	0.012	0.024
Θ	0°	10°	0°	10°

Revision History

REV.	Date	Change Notice
00	09/03/2019	Original specification

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