

Parameters Subject to Change Without Notice

### 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
- SOT23-6L Package

### APPLICATIONS

- LED lighting

### DESCRIPTION

JW1221 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 JW1221 ensures minimum power dissipation on NMOSFET while

removing LED current ripple.

JW1221 clamps the input voltage on VIN pin by 30V. Only one resistor is needed when the output voltage of AC/DC power is higher than 31V.

JW1221 allows user to setup maximum LED current by the sensing resistor between the source of NMOSFET and ground, which keeps NMOSFET damaged when LED short connected or hot-plug.

By sensing the drain voltage of NMOSFET via a resistor between the drain and VLMT pin, JW1221 allows user to setup the maximum cathode voltage of LED string, which could help limit the power dissipation on chip.

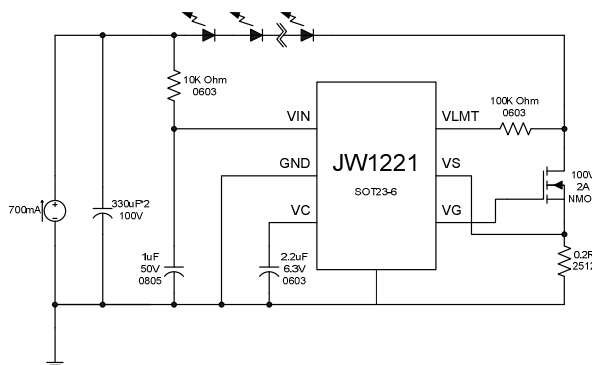
It is considered that LED is shorted when the cathode voltage of LED is higher than short connecting threshold and remains over 60us JW1221 shuts down NMOSFET when LED is shorted and recovers after 13ms.

JW1221 provides over thermal protection. When the temperature of JW1221 exceed 135°C, OTP is trigged. JW1221 shuts down NMOSFET until the temperature decrease to 110°C.

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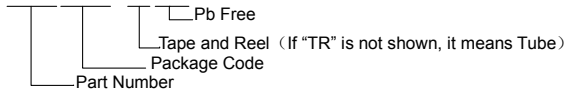
### TYPICAL APPLICATION



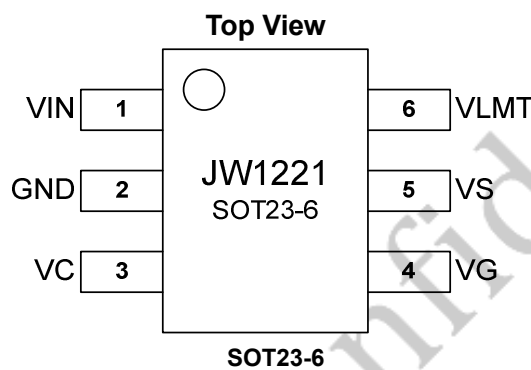
**ORDER INFORMATION**

LEAD FREE FINISH	TAPE AND REEL	PACKAGE	TOP MARKING	JUNCTION TEMPERATURE RANGE
JW1221SOTB #PBF	JW1221SOTB #TRPBF	SOT23-6	1221	- 40 °C to 150 °C

JWXXXXPPPP#TRPBF



**PIN CONFIGURATION**



**ABSOLUTE MAXIMUM RATING<sup>1)</sup>**

VIN clamp voltage.....	31V
VG .....	20V
VS, VC, VLMT .....	-0.3V to 6V
Junction Temperature <sup>2) 3)</sup> .....	150°C
Lead Temperature .....	260 °C
Storage Temperature.....	-65 °C to +150 °C

**RECOMMENDED OPERATING CONDITIONS**

Maximum Junction Temperature (T<sub>J</sub>)..... 150°C

**THERMAL RESISTANCE<sup>4)</sup>**       $\theta_{JA}$        $\theta_{JC}$

SOT23-6L .....

**Note:**

- 1) Exceeding these ratings may damage the device.
- 2) The JW1221 guarantees robust performance from -40°C to 150°C junction temperature. The junction temperature range specification is assured by design, characterization and correlation with statistical process controls.
- 3) The JW1221 includes thermal protection that is intended to protect the device in overload conditions. Thermal protection is active when junction temperature exceeds the maximum operating junction temperature. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.
- 4) Measured on JESD51-7, 2-layer PCB.

**ELECTRICAL CHARACTERISTICS**

*VIN = 12V, TA = 25°C, unless otherwise stated.*

Item	Symbol	Condition	Min.	Typ.	Max.	Units
VIN clamp voltage	V <sub>IN_CLP</sub>		29	31	33	V
VIN operation current	I <sub>IN</sub>	5V<VIN<33V	0.24	0.3	0.58	mA
VIN startup voltage threshold	V <sub>THULVO</sub>		15	16	17	V
VIN startup voltage hysteresis	V <sub>HYSUVLO</sub>			5		V
Maximum VG output voltage	V <sub>VG</sub>		9.5	10	10.5	V
VC startup current	I <sub>VCST</sub>	VC short to GND when startup	0.7	0.8	0.9	mA
VLMT reference voltage	V <sub>VLMT</sub>		1.95	2	2.05	V
NMOSFET drain voltage limit	V <sub>D_CLP</sub>	Drain voltage of NMOSFET when voltage limit is triggered. R <sub>LIMIT</sub> =100K.	3.4	4	4.6	V
SHORT protection threshold	V <sub>TH_SHORT</sub>	Drain voltage of NMOSFET when SHORT is triggered. R <sub>LIMIT</sub> =100K.	5	6	7.5	V
SHORT protection delay time	TSPD			60		us
SHORT protection hold time	TSPH			13		ms
VS voltage limit	V <sub>VS</sub>		0.18	0.2	0.22	V

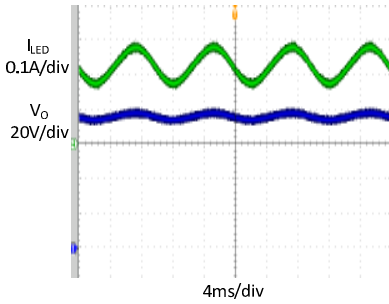
**PIN DESCRIPTION**

SOT23-6L Pin No.	Name	Description
1	VIN	Power Supply
2	GND	Ground
3	VC	LED Current Ripple Programming
4	VG	NMOSFET GATE driving voltage output
5	VS	LED current sensing input
6	VLMT	LED Voltage Limit and SHORT protection Programming

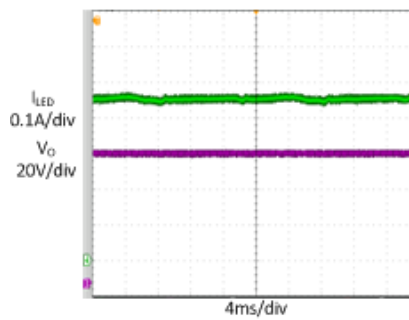
**TYPICAL PERFORMANCE CHARACTERISTICS**

$V_{IN} = 90 \sim 264V_{AC}$ ,  $V_{OUT} = 75V$ ,  $I_{OUT} = 240mA$ ,  $C_{OUT} = 100\mu F / 100V * 2$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted

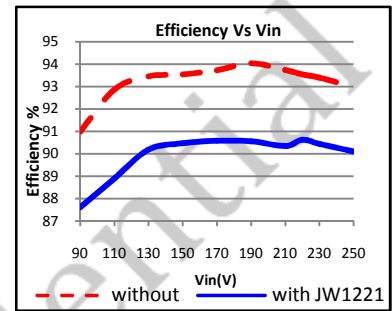
**Pre-driver Output Steady State**



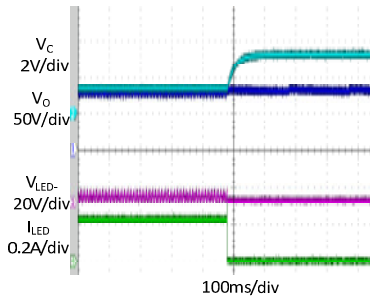
**+JW1221 Output Steady State**



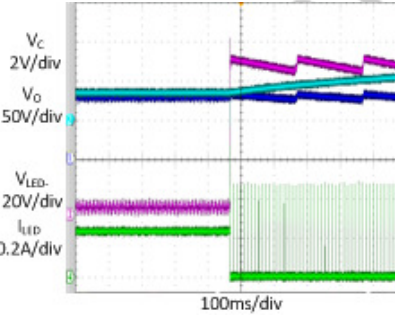
**Efficiency comparison(with and without JW1221)**



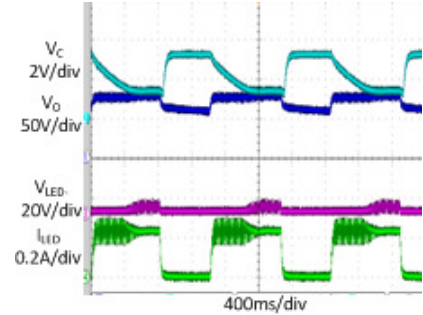
**Open Circuit protection Test**



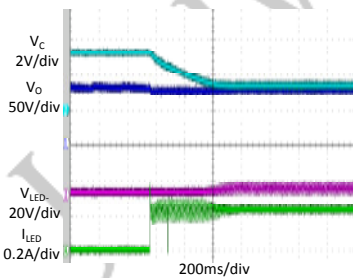
**Short Circuit Protection Test**



**Continuous power on/off test**



**LED Hot plug**



**FUNCTIONAL DESCRIPTION**

JW1221 is a controller for driving external NMOSFET to remove the 100/120Hz LED current ripple on AC/DC power.

**Theory of Operation**

The LED string and JW1221 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  $R_{SENSE}$  is connected between the source of NMOSFET and GND. The gate is connected to the VG of JW1221.

JW1221 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 JW1221 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 a integration capacitor. JW1221 transform the voltage on  $C_C$  to a reference voltage. The current regulator regulates the voltage on  $R_{SENSE}$  equal to the reference voltage. The relationship between the voltage on  $C_C$  and  $R_S$  is shown as following:

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

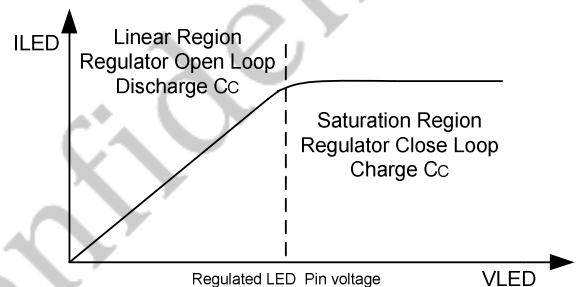
$C_C$  should be large enough in order to remove the current ripple of the LED string. However, too large capacitor may slow down the dynamic response.

**Adaptive Regulation**

JW1221 control the voltage on  $C_C$  by monitoring the operation state of external NMOSFET. The efficiency of system is relatively low when

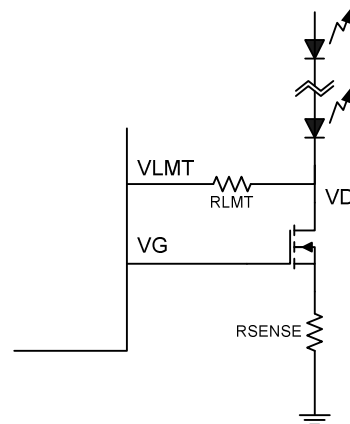
NMOSFET is working in the saturation region. JW1221 detects it and charges  $C_C$  to raise the  $V_{VC}$  and  $I_{LED}$ , then the output voltage of power supply is reduced, and the voltage drop on NMOSFET decreases.

Conversely, when NMOSFET is working in the linear region, LED current regulation loop is open. JW1221 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 NOMSFET and VLMT pin can setup the limit value of drain voltage of NMOSFET.



The limit threshold is calculated as below:

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

**LED Current Limit**

The voltage of VS pin is limited to 0.2V internally. So the current limitation is  $0.2V/R_S$ .

Current limit can protect the chip when LED is short connected or HOT-PLUG.

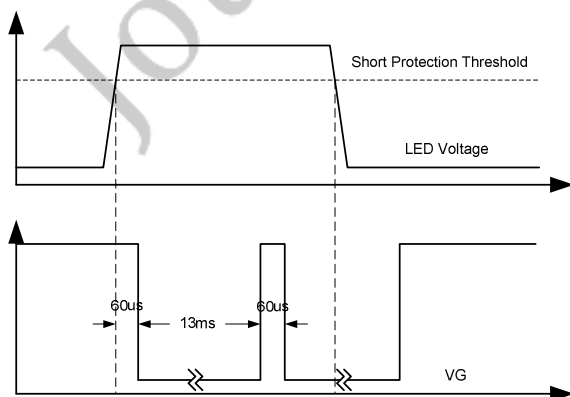
The function of current limit is higher priority than drain voltage limit. It means that the voltage on drain of NMOSFET is not limited when LED current exceed current limit threshold.

**LED Short Protection**

JW1221 detect SHORT by  $R_{\text{LMT}}$ . When the drain voltage of NMOSFET exceeds the SHORT PROTECTION THRESHOLD and the state holds for more than 60us, JW1221 considers the LED string is SHORT connected, and shut down the external MOSFET. The SHORT state is reset after 13ms.

The SHORT PROTECTION THRESHOLD is calculated as:

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



**Over Thermal Protection**

JW1221 monitors operation temperature. When the temperature is higher than 135 °C , the NMOSFET is shut down until the temperature decrease to 115°C.

**PCB Design Guideline**

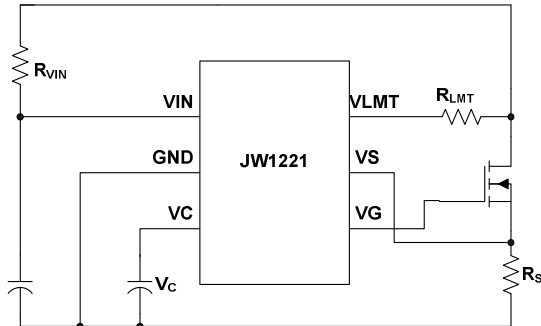
1. The bypass capacitor of VIN should be placed as close as possible to the VIN pin and GND pin of IC.
2. JW1221 should be placed far away from the power devices such as MOSFET and SBD.
3. The area of LED current loop should be as small as possible.

**MOSFET Selection Recommendation**

1. PDD0910, N-Channel MOSFET 100V, 8A, 200mohm, TO252, Potens.
2. FDS86240, N-Channel MOSFET 150V 7.5A 19.8mohm, SO-8, FAIRCHILD.
3. FQD18N20V2, N-Channel MOSFET 200V, 18A, 140mohm, TO252, FAIRCHILD.

**APPLICATION NOTE**

**JW1221 design guide:**



1. Because of the 30V zener integrated and the 16V  $V_{IN}$  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 2V in order to limit the maximum output current especially in the short circuit condition. The value of  $R_S$  can be calculated as below:

$$R_S < \frac{0.2V}{I_{LED}}$$

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

3. When the voltage of LED- reaches  $V_{SCP}$  which is set by the  $R_{LMT}$ , JW1221 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  $R_{LMT}$  must satisfy the following conditions:

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

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

$$V_{SCP} = 2V + 40uA * R_{LMT}$$

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

$V_{SCP}$ : the threshold of JW1221 short circuit protection.

$V_{INSTART}$ : the output voltage of the pre-driver when the VIN of JW1221 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, 1uF or 2.2uF is relatively reasonable.
5. To ensure JW1221 work properly, the  $R_{DSON}$  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  $R_{DSON}$  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.



**REFERENCE DESIGN**

Reference:

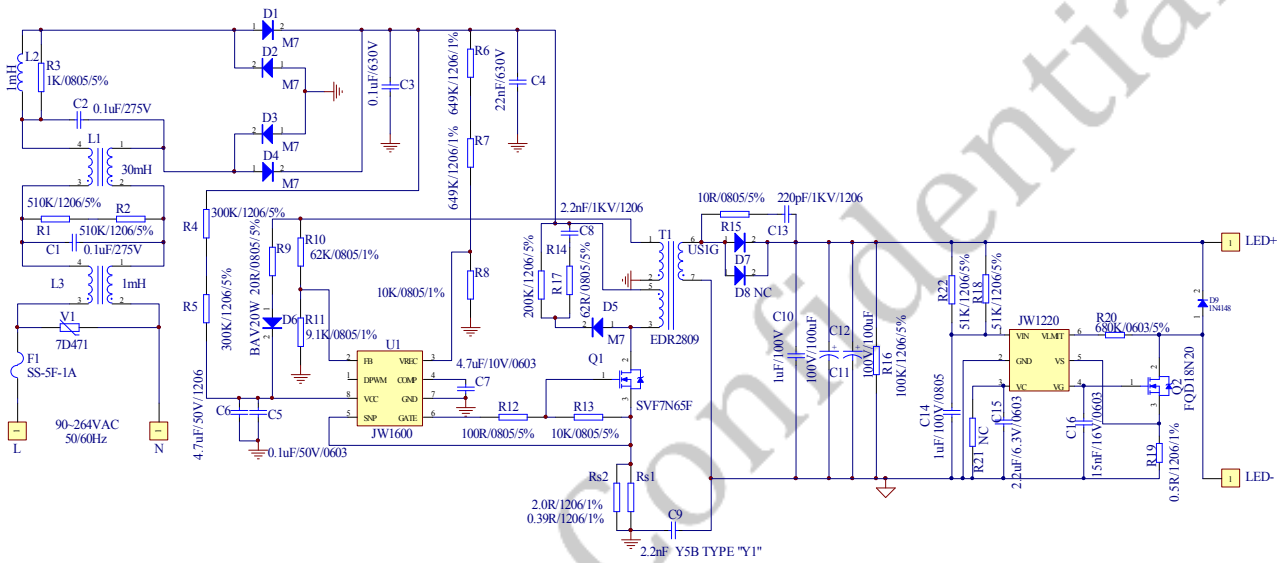
**V<sub>IN</sub>: 90~260VAC**

**V<sub>OUT</sub>: 75V**

**I<sub>OUT</sub>: 240mA**

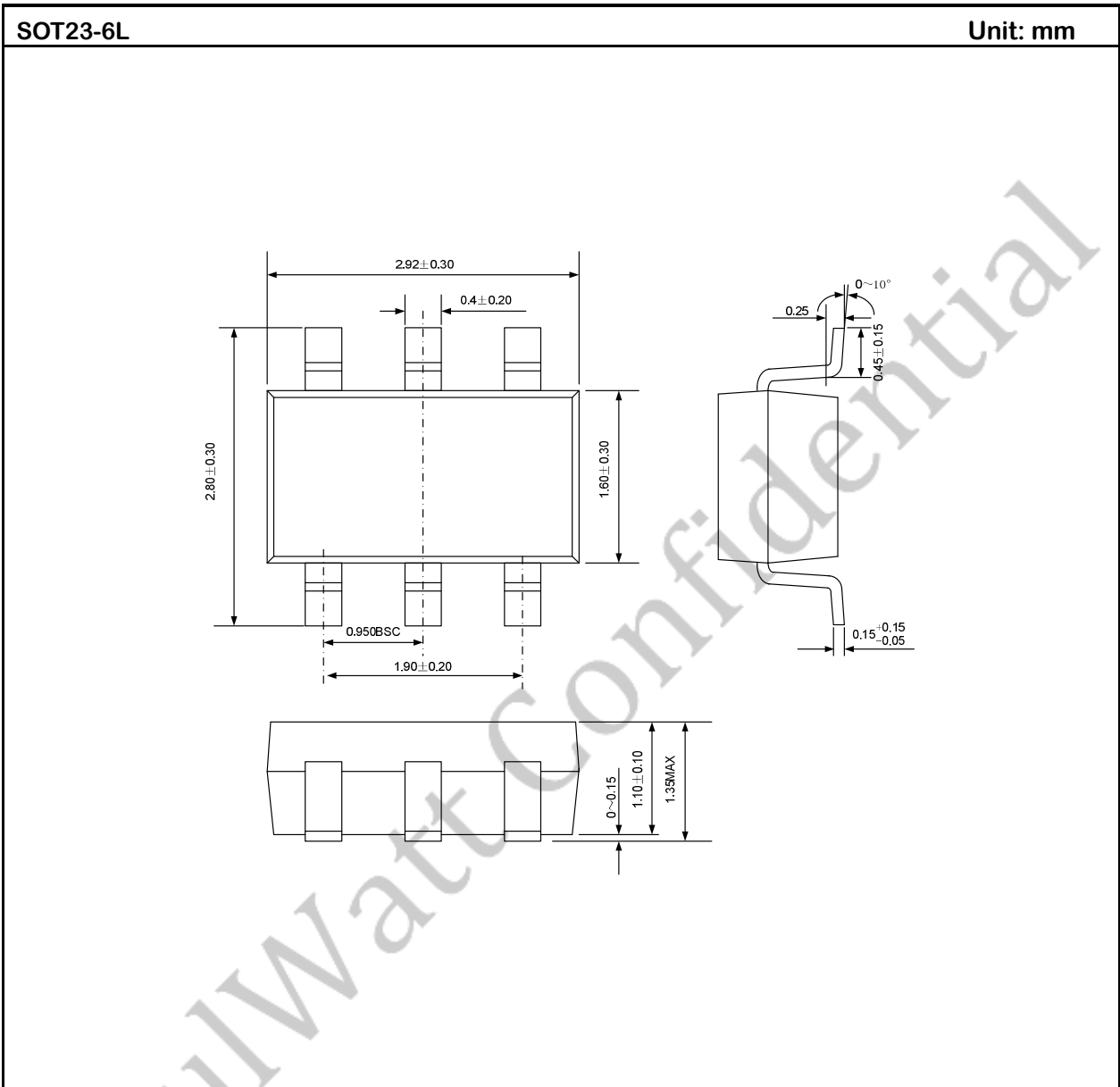
**PF: >0.9**

**Current ripple: <5%**





**PACKAGE OUTLINE**



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