High Efficiency Step-Down LED Driver

Description

The TNL2024SG is a high-efficiency step-down LED driver controller with a wide input voltage range of 6V to 80V. It is designed to operate in continuous current mode.

The TNL2024SG employs a hysteretic control architecture that accurately regulates LED current with a feedback coming from an external high-side current-sense resistor. This control scheme optimizes circuit stabilization and fast response time without loop compensation. Its low 200mV average feedback voltage reduces power loss and improves the converter's efficiency.

The TNL2024SG implements PWM and analog dimming together through the EN/DIM pin. It also Includes thermal overload protection in case of output overload.

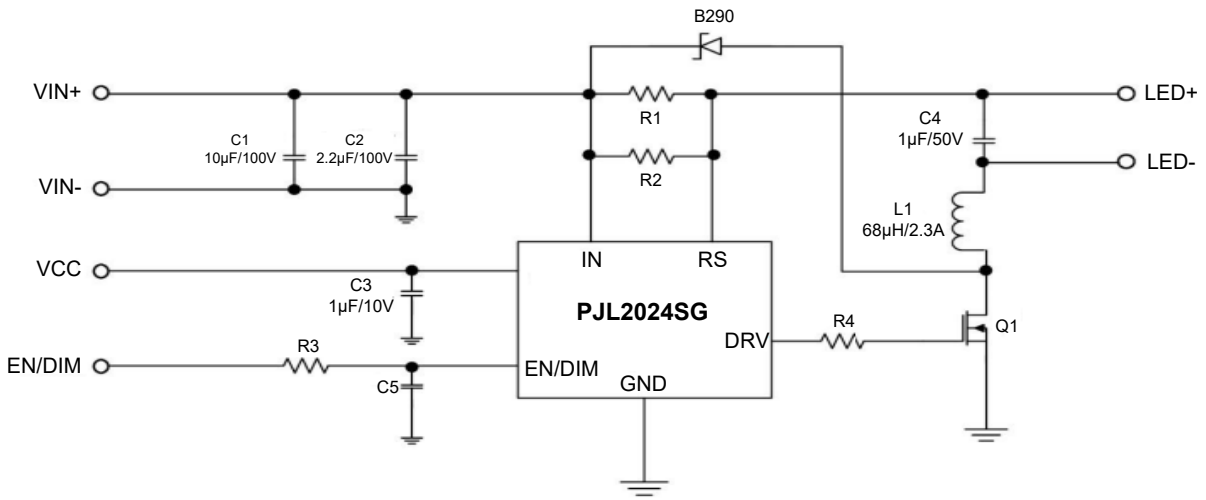
Features

- Wide 6V to 80V Input Range
- High Efficiency (＞95%)
- 2500:1 PWM Dimming Ratio
- Open LED Protection
- Short LED Protection
- Thermal Shutdown
- Hysteresis Control
- Available in SOT-23-6 Package

Applications

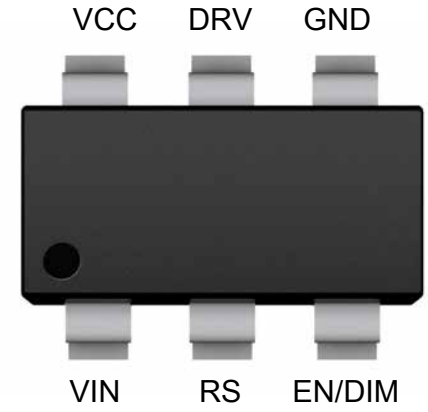
- Automotive/Decorative LED Lighting
- Emergency Lighting
- LED Backlighting
- Low Voltage Halogen Replacement

Typical Application



Pin Function And Descriptions

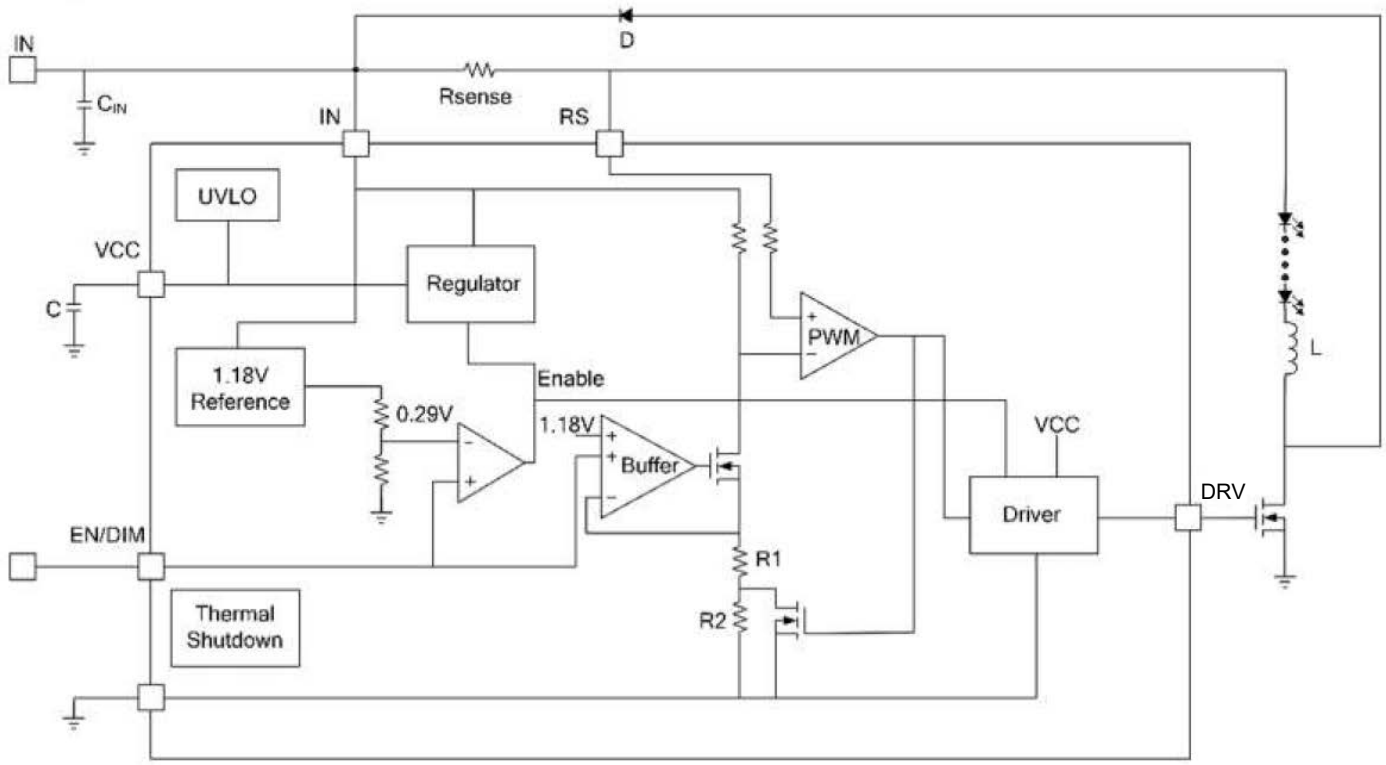
SOT-23-6



Marking Code: 2024

Pin No.	Symbol	Description
1	VIN	Input Supply Pin.Connect a decoupling capacitor from IN pin to GND
2	RS	LED Current Sense Input.Connect a current-sence resistor that programs LED average current to the IN pin
3	EN/DIM	Enable/Dimming Command Input.A voltage greater than 0.3V turns on the chip.To use PWM dimming,apply a square wave signal to this pin.For analog dimming,the EN/DIM pin voltage rises from 0.3V to 2.7V and LED current will change from 20% to 100% of the maximum LED current.
4	GND	Grount
5	DRV	Gate-Driver output.Connect this pin to the gate of the external MOSFET.
6	VCC	Internal Regulator Output.Connect a 1uF decoupling cap from this pin to ground.

Block Diagram



Absolute Maximum Ratings (at T_A = 25°C)[Note1]

Parameter		Value	Unit
VIN to GND		-0.3 ~ +85	V
RS to GND		VIN-0.3 ~ VIN	V
VCC to GND		-0.3 ~ +6	V
EN/DIM to GND		-0.3 ~ +6	V
DRV to GND		-0.3 ~ +6	V
Junction to Ambient Thermal Resistance [Note2]	$R_{\theta JA}$	170	°C/W
Junction to case thermal resistance [Note2]	$R_{\theta JC}$	75	°C/W
Junction Temperature	T_J	150	°C
Lead Temperature	T_L	260	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

Note: 1. Exceeding these ratings may damage the device.
2. Measured on JESD51-7, 4-layer PCB.

Recommended Operating Conditions

Parameter		Value	Unit
Supply Voltage	V_{IN}	+6 ~ +60	V
Operating Junction Temperature	T_{OPR}	-40 ~ +125	°C

Electrical Characteristics

T_J = 25°C. VIN = 12V, unless otherwise noted

Characteristics	Symbol	Conditions	Min.	Typ.	Max.	Units
Input Voltage	VIN		6		80	V
Shutdown supply current	I_{SD}			80	108	uA
Quiescent supply current	I_Q	No Switching		0.3	0.5	mA
VCC Voltage	VCC	VEN/DIM=3.5V	5.5	6		V
Feedback average voltage (with respect to VIN)	V_{IN}-V_{RS}	VEN/DIM=3.5V	194	200	206	mV
Feedback reference voltage hysterisis	V_{FB_HYS}			±30		mV
EN/DIM enable high voltage	V_{EN_HIGH}	VEN Rising		0.29	0.34	V
EN/DIM enable hysterisis	V_{EN_HYS}		20	50	80	mV
EN/DIM pull-up current		Pull up to 5V		2.8		uA
EN/DIM pull-down current		Pull down to GND		25		uA
Min recommended PWM dimming frequency	F_{PWMmin}			0.1		KHz
Max recommended PWM dimming frequency	F_{PWMmax}			20		KHz
Gate driver source resistor	R_{src}			6		Ω
Gate driver sink resistor	R_{sink}			2		Ω
Gate driver high	V_{OH}	IDRV = 10mA	5.5			V
Gate driver low	V_{OL}	IDRV = 10mA			0.5	V
Minimum on time	T_{ON_MIN}			100		ns
Minimum off time	T_{OFF_MIN}			100		ns
Maximum frequency	F_{MAX}			1		MHz
VCC UVLO threshold	V_{UVLOTH}	VCC Rising		5.6		V
VCC UVLO hysteresis	$V_{UVLOHYS}$			0.4		V
Thermal shutdown threshold		Temp Rising		150		℃
Thermal shutdown hysteresis				30		℃

Operation

Steady State

The TNL2024SG is a high-efficiency step-down LED driver controller with hysteresis control that is easily configured for a wide input that ranges from 6V to 80V input. The TNL2024SG uses a high-side current-sense resistor to detect and regulate LED current. The voltage across the current- sense resistor is measured and regulated in the 200mV±30mV range. The internal 1.18V reference voltage provides a 0.3V reference to enable the part. When VEN>0.3V, the output of the comparator goes high and enables the other blocks. The TNL2024SG also provides a 5V pull-up voltage as current reference voltage when EN/DIM pin is float. The inductor current is sensed through the high-side resistor, Rsense. When the switch is on, R2 (see Figure 1 is shorted and inductor current upper-threshold is fixed by R1. When the switch is off, inductor current lower-threshold is fixed by R1 and R2. The ratio of R1 and R2 determines the current hysteresis.

System Soft Start

The voltage on the EN/DIM pin provides the inductor current reference. An external capacitor from the EN/DIM pin to ground provides a soft-start delay. When VIN starts, internal voltage source charges the capacitor from 0V to 5V to fulfill soft-start function.

Dimming Control

The TNL2024SG allows the EN/DIM pin to control both Analog and PWM dimming. Whenever the voltage on DIM is less than 0.25V, the chip turns off. For analog dimming, when the voltage on DIM is from 0.3V to 2.7V, the LED current will change from 20% to 100% of the maximum LED current. If the voltage on EN pin is higher than 2.9V, output LED current will equal the maximum LED current. For PWM dimming, the signal amplitude must exceed 3V. Choose a PWM frequency in range of 100Hz to 20kHz for good dimming linearity.

Applications Information

Setting the LED Current

The LED current is identical and set by the current sense resistor between the IN pin and RS pin.

$$RSENSE=200mV / ILED$$

For RSENSE=0.2Ω, the LED current is set to 1A Selecting the Inductor Lower value of inductance can result in a higher switching frequency, which causes a larger switching loss. Choose a switch frequency between 100kHz to 600kHz for most application. According to switching frequency, inductor value can be estimated as

$$L = \frac{(1-\frac{V_{OUT}}{V_{IN}}) \times V_{OUT}}{0.3 \times I_{LED} \times f_{SW}}$$

For higher efficiency, choose an inductor with a DC resistance as small as possible.

Selecting the Input Capacitor

The input capacitor reduces the surge current drawn from the input supply and the switching noise from the device. Choose a capacitor value between 10uF and 22uF for most applications. The voltage rating should be greater than the input voltage. **U**se a low ESR capacitor for input decoupling.

Selecting the Output Capacitor

For most applications, the output capacitor is not necessary. For applications that require that the peak-to-peak LED ripple current falls below 30% of the average current, add a capacitor across the LEDs. Higher capacitor values will result in proportionally lower ripple. A value of 2.2μF will meet most requirements.

Selecting Soft-Start Capacitor

When selecting a soft-start capacitor, the delay time can be estimated as 0.2ms/nF. For PWM dimming, select C < 2.2nF to eliminate its effect on the average LED current. Dimming Control PJL2024SG provides 1:2500 high-ratio PWM dimming. Apply a 100Hz to 20kHz square waveform to the EN/DIM pin. The average LED current is proportional to PWM duty cycle.

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Thermal Considerations

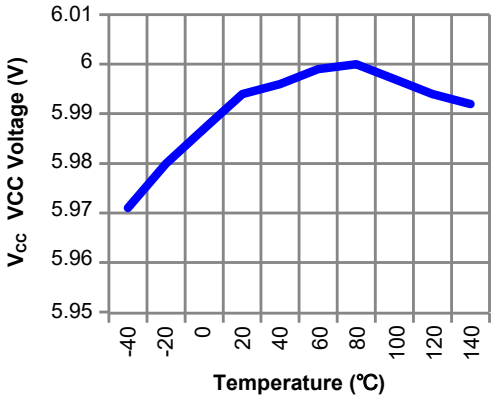
The junction temperature of the IC is monitored internally. If the junction temperature exceeds the threshold value (typically 140°C), the device will reduce output current to avoid system cause to damage.

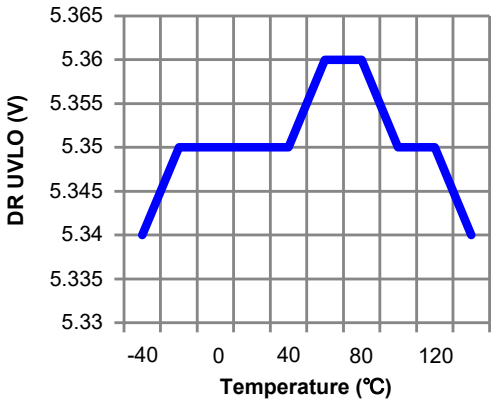
Layout Consideration

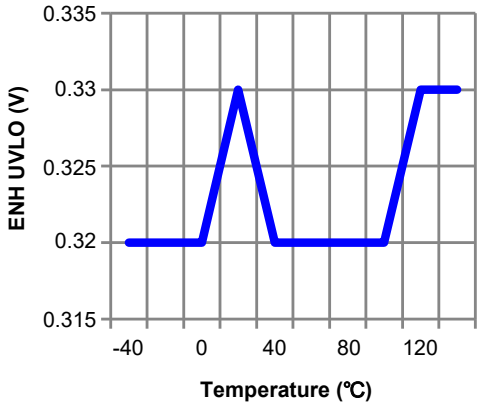
Pay careful attention to the PCB layout and component placement. RSENSE should be placed close to the IN pin and RS pin in order to minimize current sense error. The input loop —including input capacitor, Schottky diode, and MOSFET—should be as short as possible.

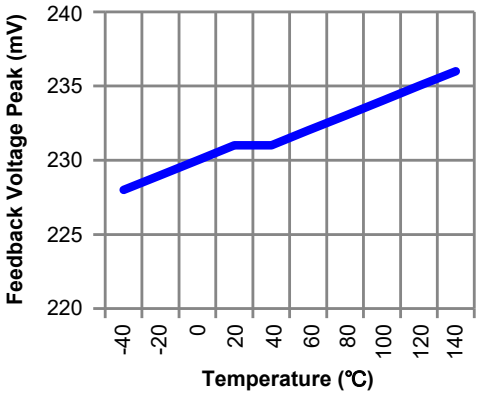
Typical characteristic curve

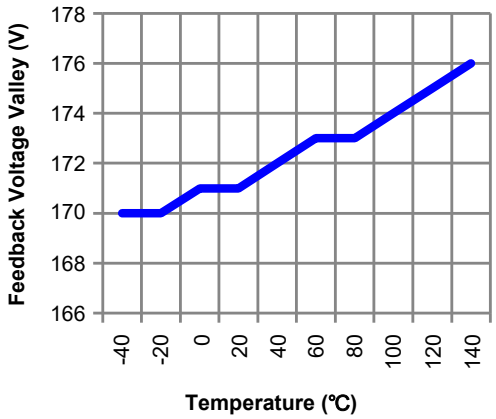
Performance waveforms are tested on the evaluation board of the Design Example section. V_{IN} = 24V, 3LEDs, I_{OUT} = 1A, T_A = 25°C, unless otherwise noted.

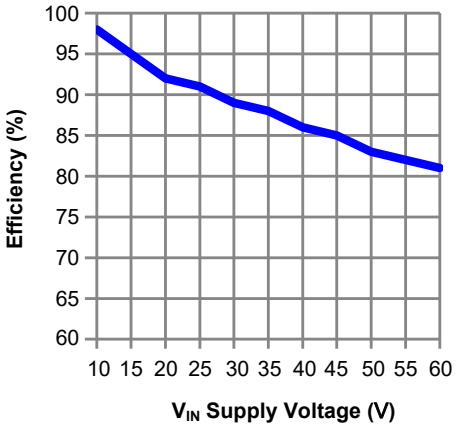












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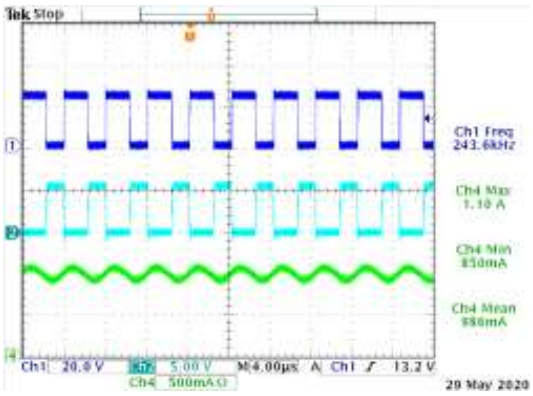
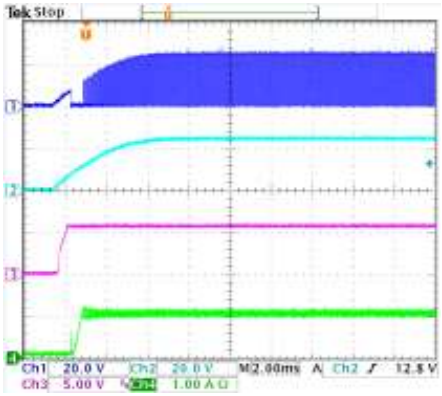
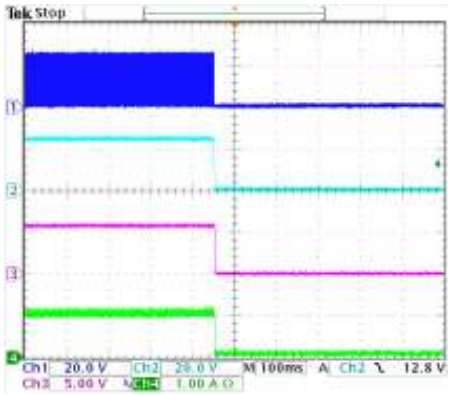


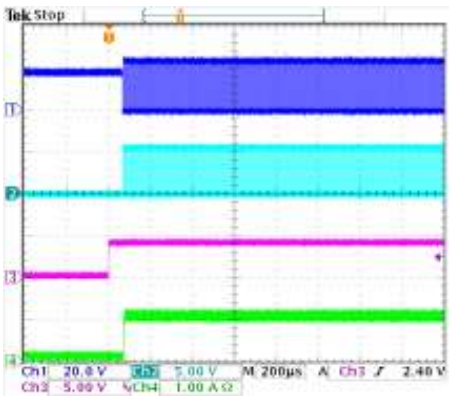
Steady State



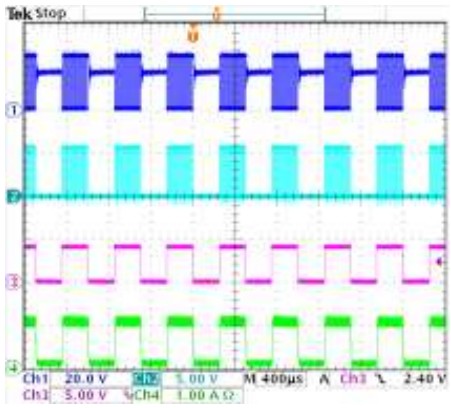
Input Power On



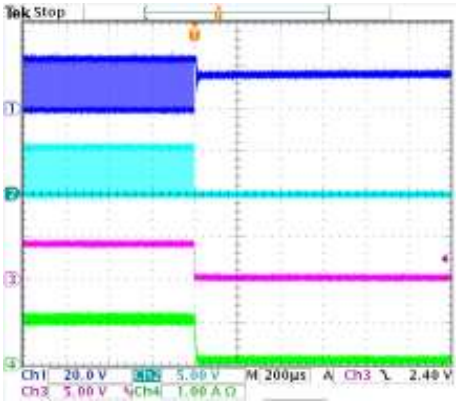
Input Power Off



EN Power On

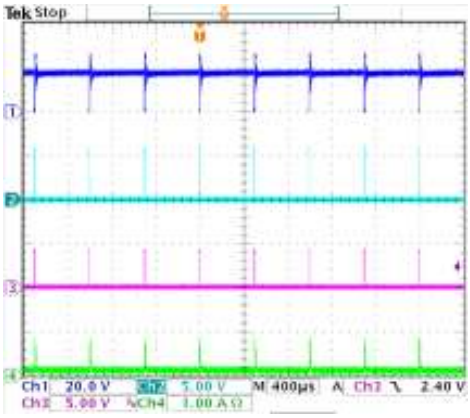


EN Power Off

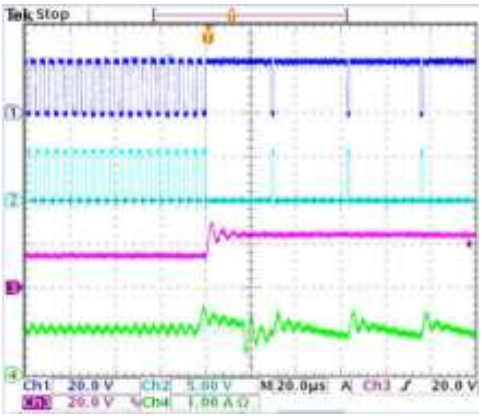


PWM Dimming(2KHz, 50%)

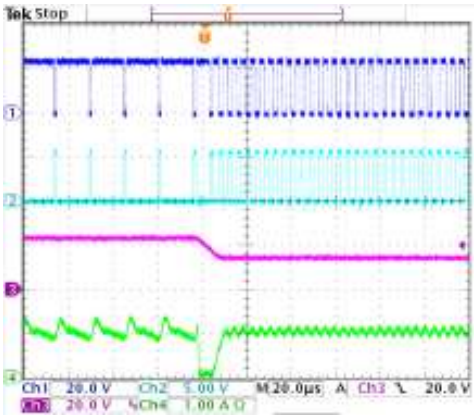
Performance waveforms are tested on the evaluation board of the Design Example section. V_{IN} = 24V, 3LEDs, I_{OUT} = 1A, T_A = 25°C, unless otherwise noted.



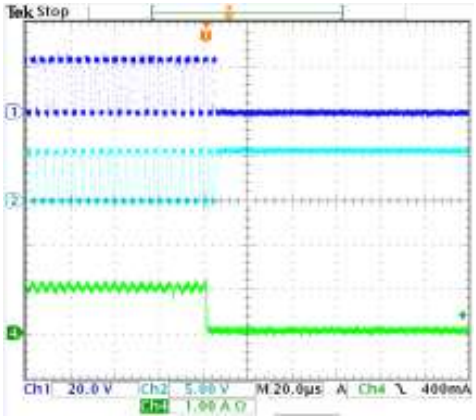
PWM Dimming(2KHz, 1%)



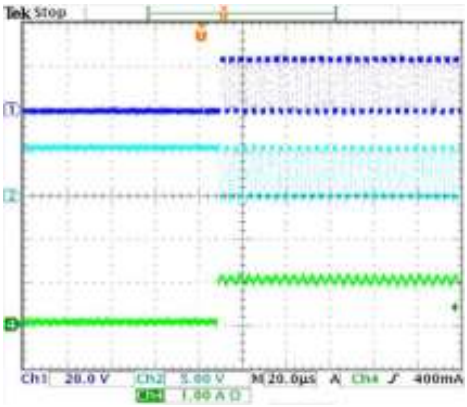
Short LED+ to LED- Protection



Short LED+ to LED- Recovery



ShortOpen LED Load Protection

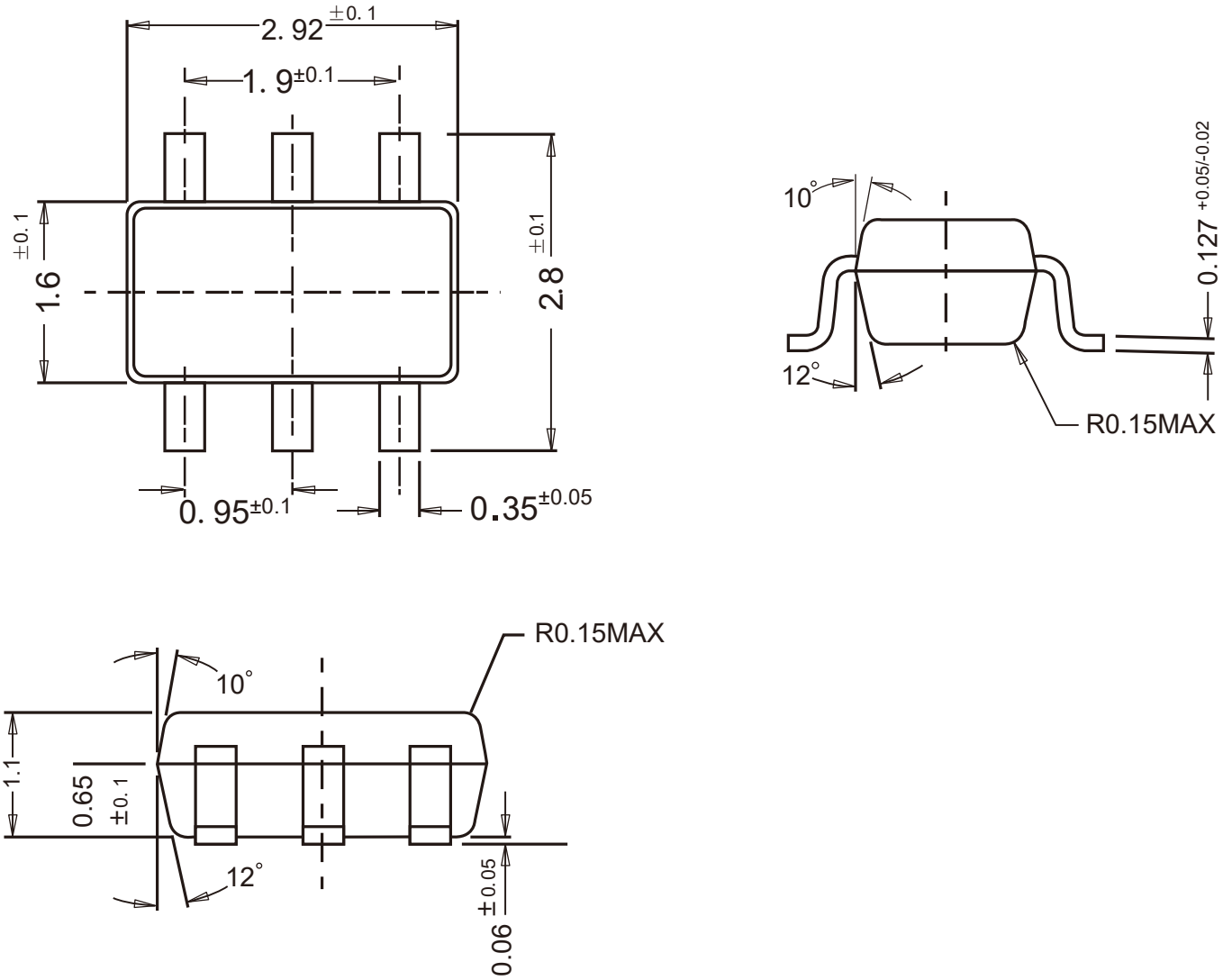


Open LED Load Recovery

Package Outline

SOT-23-6

Dimensions in mm



Ordering Information

Device	Package	Shipping
TNL2024SG	SOT-23-6	3,000PCS/Reel&7inches

Contact Information

TANI website: **http://www.tanisemi.com** Email:tani@tanisemi.com

For additional information, please contact your local Sales Representative.

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