# 30V/1.5A High Brightness Step-Down LED Driver

## ❖ GENERAL DESCRIPTION

The AX2023 is a high-efficiency step-down LED driver controller with a wide input voltage range of 6V to 30V.

The AX2023 employs a continuous conduction mode architecture that accurately regulates LED current with a feedback coming from an external current-sense resistor. This control scheme optimizes circuit stabilization and fast response time without loop compensation. Its low 100mV average feedback voltage reduces power loss and improves the converter's efficiency.

The AX2023 implements PWM and analog dimming together through the DIM pin.

The AX2023 is also Includes thermal regulation protection in case of output overload.

The AX2023 is available in SOT-23-5L package.

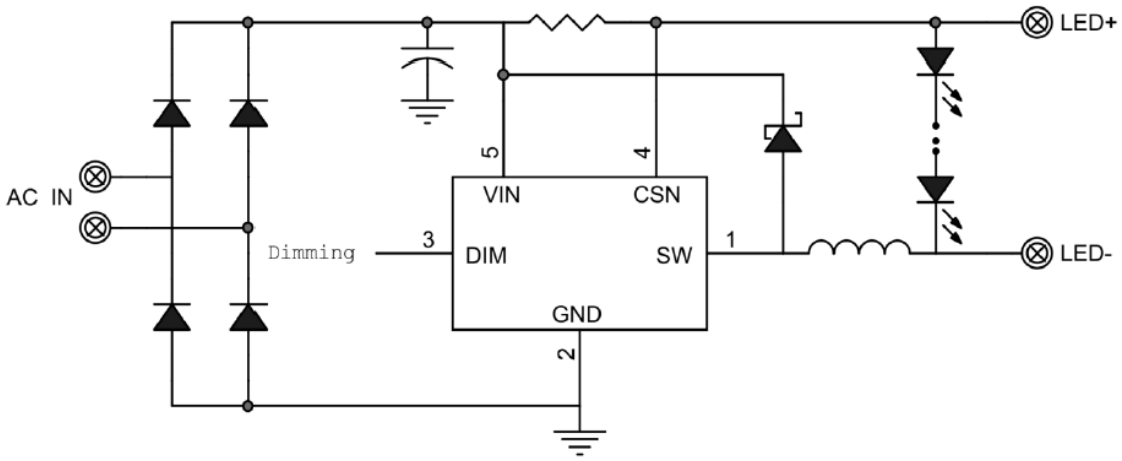
## ❖ FEATURES

- Wide 6V to 30V Input Range
- Able to Drive ≤1.5A LED Load
- ±3% output current accuracy
- Up to 1MHz switching frequency
- High Efficiency
- Analog and PWM Dimming
- Open LED Protection
- No need compensation
- Thermal Regulation
- RoHS and Halogen free compliance.
- Available in SOT23-5 Package

## ❖ APPLICATIONS

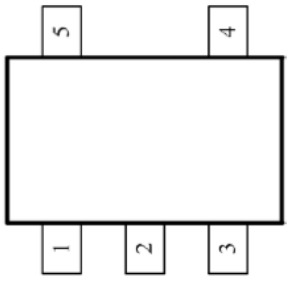
- Low Voltage Halogen Replacement
- DC/DC or AC/DC LED Driver Application
- Automotive/Decorative LED Lighting
- Emergency Lighting
- LED Backlighting

## ❖ TYPICAL APPLICATION




## ❖ PIN ASSIGNMENT

The package of AX2023 is SOT-23-5L; the pin assignment is given by:



## ❖ PIN FUNCTIONS

| Pin | Name | Description |
|---|---|---|
| 1 | SW | Drain of the internal NMOS |
| 2 | GND | Ground |
| 3 | DIM | PWM/Analog Diming Input. Internal week pull up. Drive DIM low to turn off the output |
| 4 | CSN | Connect sensor input reference to VIN for measure output current. |
| 5 | VIN | Power input |

## ❖ ABSOLUTE MAXIMUM RATINGS (1)

VIN, CSN to GND..... -0.3V to +36V

SW to GND..... -0.3 to VIN+0.3V

All Other Pins.....-0.3V to +6.5V

**Continuous Power Dissipation ($T_A$ = 25°C) (2)**

SOT-23-5L..... 0.6W

Junction Temperature..... 125°C

Storage Temperature..... -65°C to +150°C

**Recommended Operating Conditions (3)**

Supply Voltage $V_{IN}$.....6V to 30V

Operating Junction Temp. ($T_J$)..... -40°C to +125°C

| **Thermal Resistance (4)** | **$\theta_{JA}$** | **$\theta_{JC}$** |
|---|---|---|
| SOT-23-5L..... | 250°C/W | 130°C/W |

**Notes:**

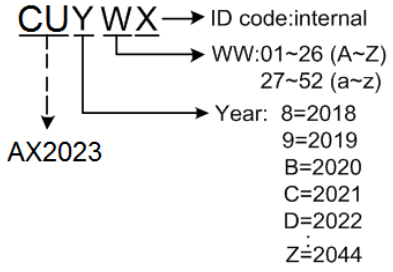
(1)Exceeding these ratings may damage the device.

(2)The maximum allowable power dissipation is a function of the maximum junction temperature $T_J$(MAX), the junction-to-ambient thermal resistance $\theta_{JA}$, and the ambient temperature $T_A$. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_D$(MAX)=($T_J$(MAX)-$T_A$)/ $\theta_{JA}$. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.

(3)The device is not guaranteed to function outside of its operation conditions.

(4)Measured on JESD51-7, 4-layer PCB.

## ❖ ORDER/MARKING INFORMATION

| Order Information | Top Marking |
|---|---|
| AX2023 X X<br>Package Type<br>B:SOT23-5L<br>Packing<br>Blank : Tube<br>A : Taping |  |

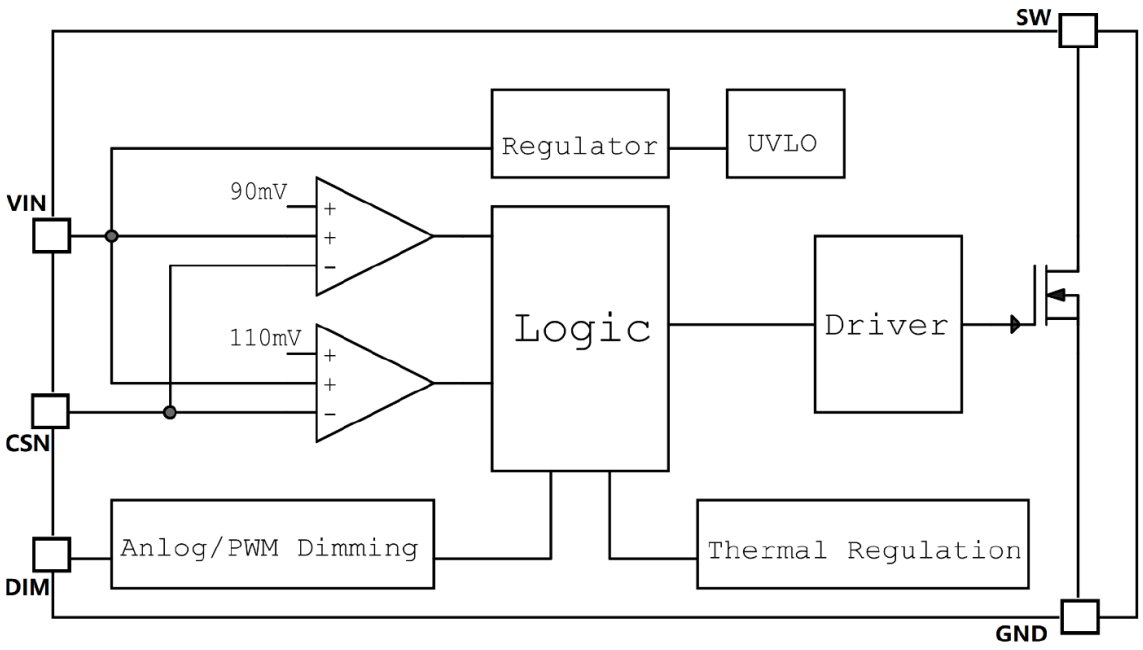
## ❖ ELECTRICAL CHARACTERISTICS

**($V_{IN}$ = 12V, $T_A$ = 25°C, unless otherwise noted.)**

| Parameter | Symbol | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Input voltage | $V_{IN}$ | | 6 | | 30 | V |
| VCC UVLO threshold | $V_{UVLOTH}$ | VCC Rising | | 5.5 | | V |
| VCC UVLO hysteresis | $V_{UVLOHYS}$ | | | 0.5 | | V |
| Quiescent supply current | $I_Q$ | No Switching | | 210 | | μA |
| Current Sense voltage | $V_{CS}$ | | | 100 | | mV |
| Current Sense threshold | $V_{CS\_HY}$ | | | 15 | | % |
| CSN input Current | $I_{CSN}$ | | | 3 | | uA |
| DIM floating voltage | $V_{DIM\_F}$ | | | 3.9 | | V |
| DIM input leakage current | $I_{DIM\_PU}$ | $I_{DIM}$=5V | | 27 | | μA |
| EN/DIM pull-down current | $I_{DIM\_PU}$ | $I_{DI}$M=0V | | -25 | | μA |
| DIM input High | $V_{DIM\_H}$ | | 2.7 | | | V |
| DIM input Low | $V_{DIM\_L}$ | | | | 0.3 | V |
| DIM voltage range | $V_{DIM}$ | $V_{DIM}$ Rising | 0.5 | | 2.5 | V |
| Min recommended pwm dimming frequency | $F_{PWMmin}$ | | | 0.1 | | kHz |
| Max recommended pwm dimming frequency | $F_{PWMmax}$ | | | 20 | | kHz |
| Maximum switch frequency | $F_{MAX}$ | | | 1 | | MHz |
| MOSFET ON resistance | $R_{DSON}$ | | | 390 | | mΩ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Thermal shutdown threshold | $T_{SH}$ | Temp Rising | | 160 | | °C |
| Thermal shutdown hysteresis | $T_{HYS}$ | Guarantee by Designer | | 50 | | °C |

## ❖ FUNCTIONAL BLOCK DIAGRAM




## ❖ FUNCTION DESCRIPTIONS

### Operation

#### Steady State

The AX2023 is a step-down LED-current convertor that is easily configured for a wide input that ranges from 6V to 30V input. The NDP3315SG uses a High-side current-sense resistor to detect and regulate LED current. The average voltage across the current- sense resistor is measured and regulated in the 100mV range.

#### Dimming Control

The AX2023 allows the DIM pin to control both Analog and PWM dimming. Whenever the voltage on DIM is less than 0.3V, the chip turns off. For analog dimming the LED current will change from 0% to 100% of the maximum LED current according to the DIM voltage of 0.5V to 2.5V. If the voltage on DIM pin is higher than 2.5V, output LED current will equal the maximum LED current. For PWM dimming, the signal amplitude must exceed 2.5V. Choose a PWM frequency in range of 100Hz to 20kHz for good dimming linearity.

## ❖ APPLICATION INFORMATION

**Setting the LED Current**

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

$$R_{SENSE}=100mV/I_{LED}$$

For $R_{SENSE}=0.125\Omega$, the LED current is set to 0.8A

**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 500kHz 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 of 100μF for most applications. The voltage rating should be greater than the input voltage. Use a low ESR capacitor for input decoupling.

**Layout Consideration**

Pay careful attention to the PCB layout and component placement. R1 should be placed close to the VIN pin and CSN pin in order to minimize current sense error. The input loop—including input capacitor, Schottky diode, and MOSFET—should be as short as possible.

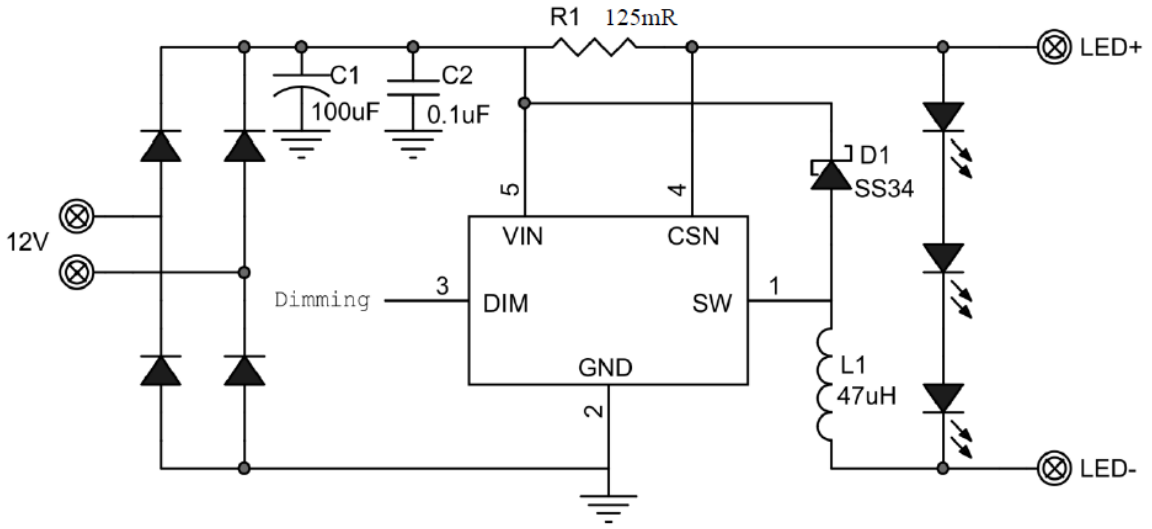
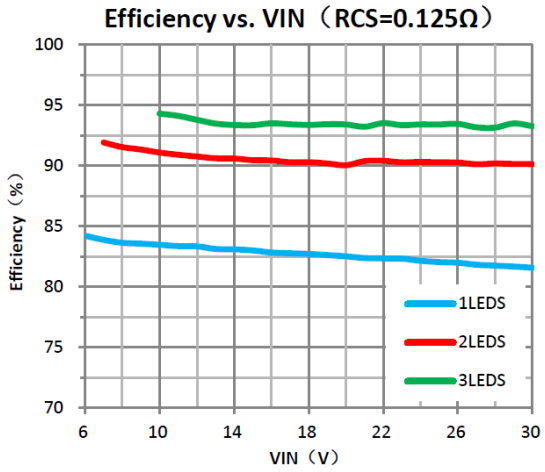
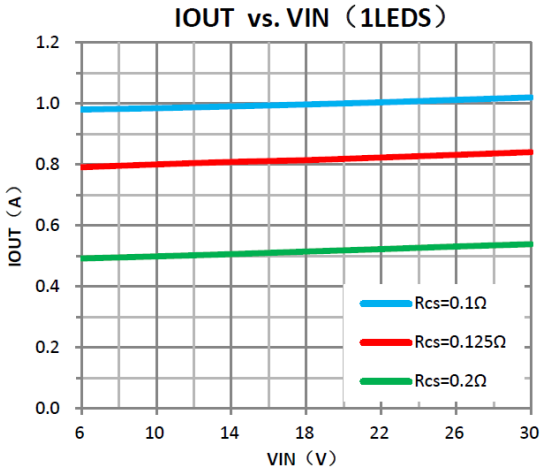
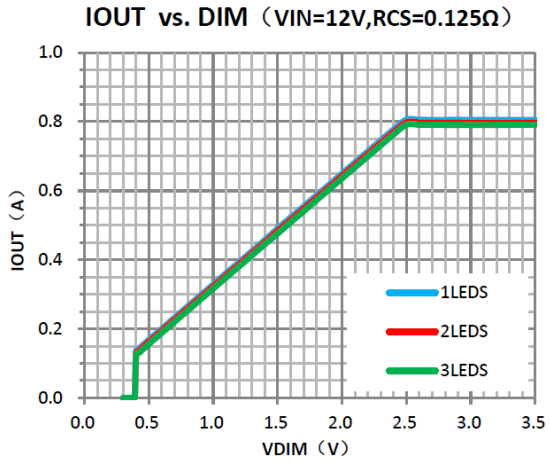


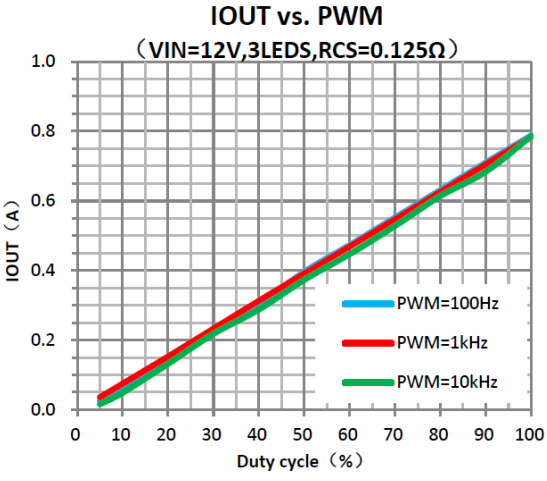

**Figure 2: Application Circuit**

## ❖ TYPICAL PERFORMANCE CURVES



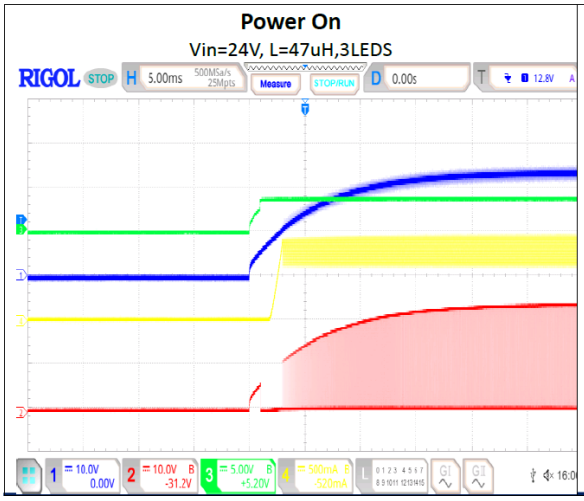



(CH1=Vin, CH2=SW, CH3=Vdim, CH4=Isw)

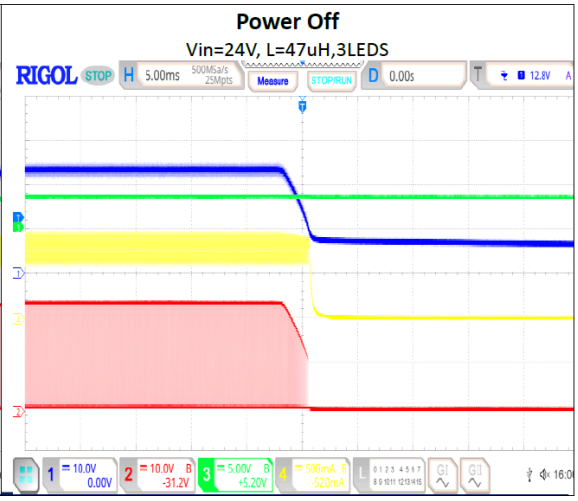
**Power On**

Vin=24V, L=47uH,3LEDS



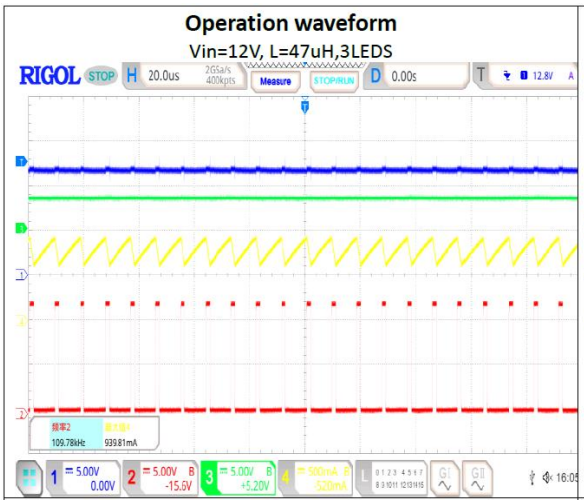
**Power Off**

Vin=24V, L=47uH,3LEDS



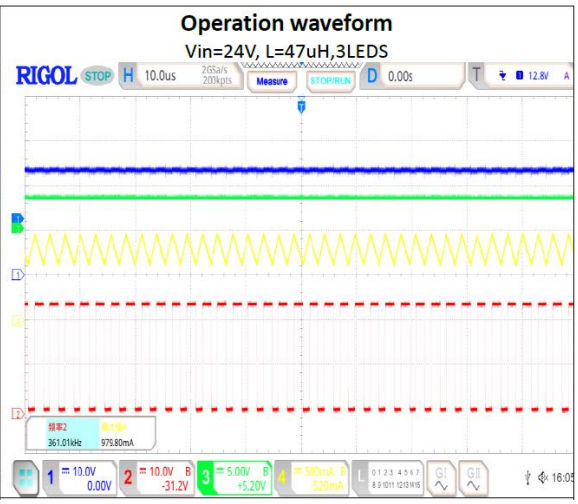
**Operation waveform**

Vin=12V, L=47uH,3LEDS



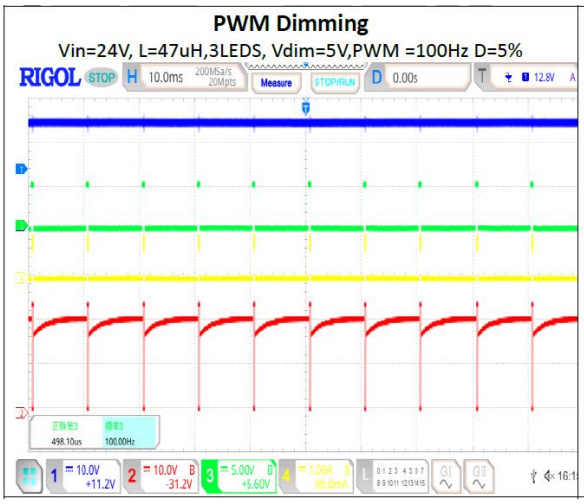
**Operation waveform**

Vin=24V, L=47uH,3LEDS



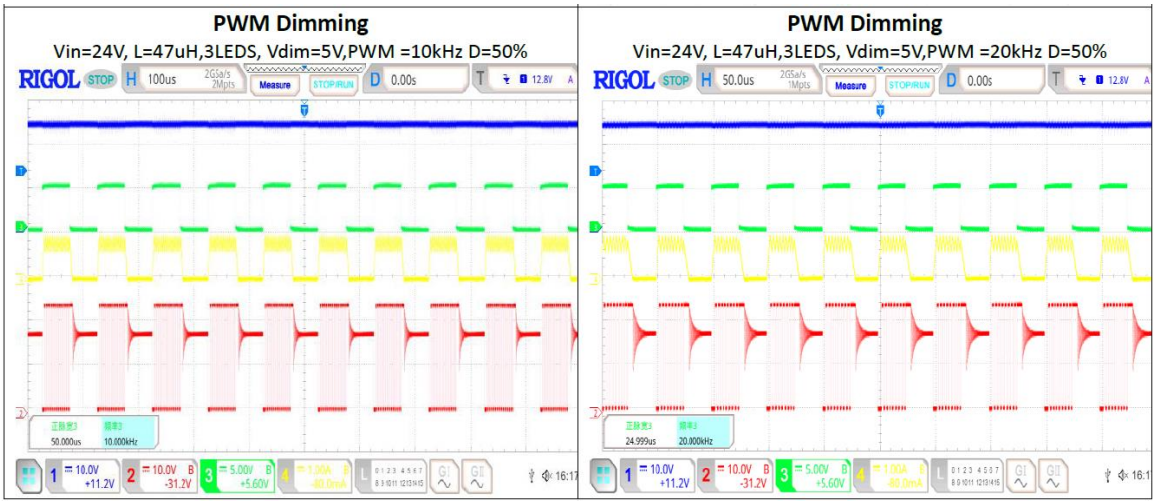
**PWM Dimming**

Vin=24V, L=47uH,3LEDS, Vdim=5V,PWM =100Hz D=5%



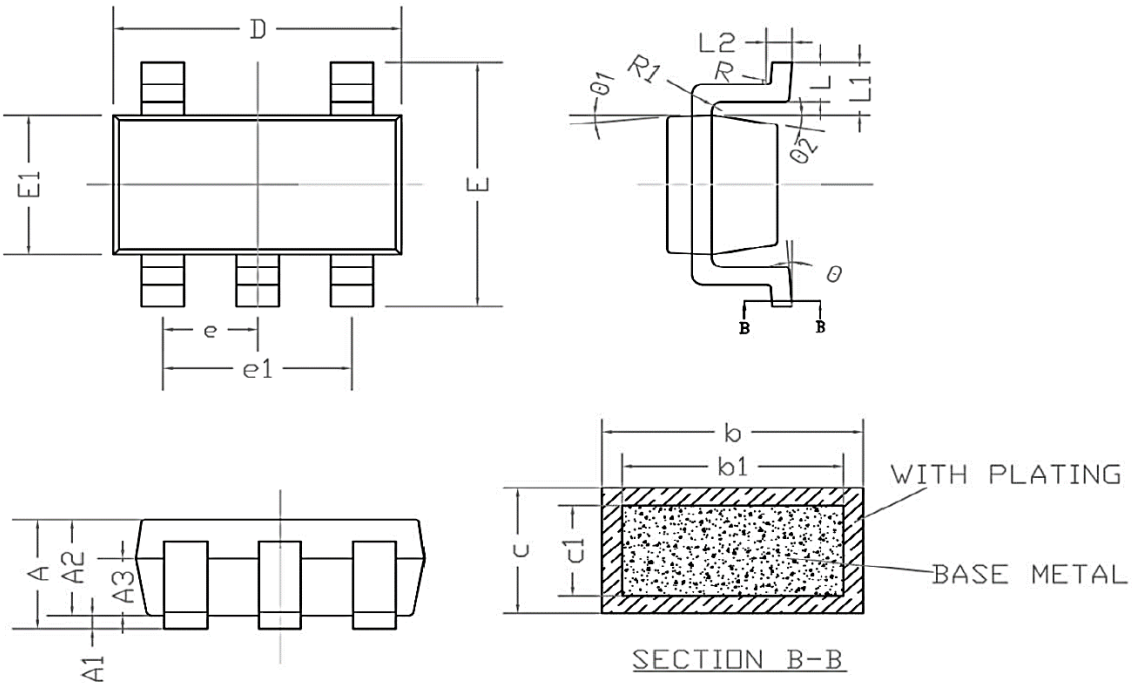
**PWM Dimming**

Vin=24V, L=47uH,3LEDS, Vdim=5V,PWM =100Hz D=95%



## ❖ PACKAGE OUTLINES

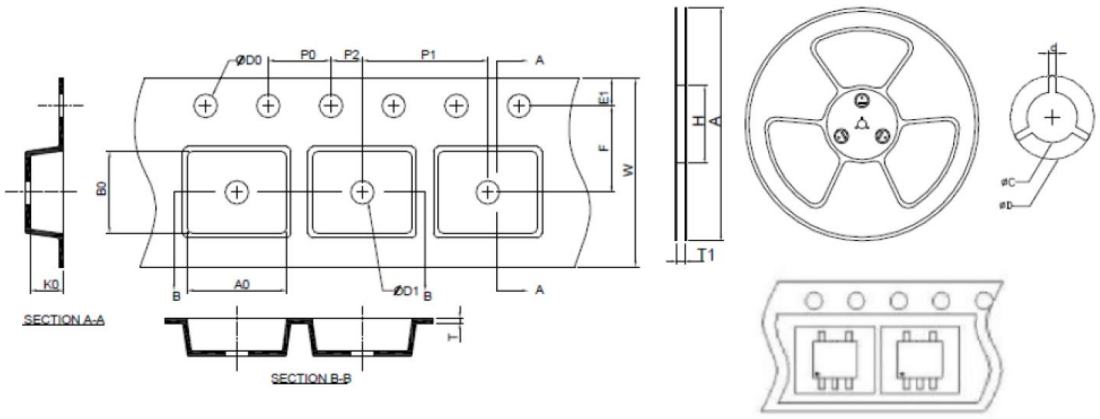
### ❖ SOT-23-5L




| SYMBOL | MILLIMETER | | |
|---|---|---|---|
| | MIN | NOR | MAX |
| A | - | - | 1.25 |
| A1 | 0.04 | - | 0.15 |
| A2 | 1.00 | 1.05 | 1.10 |
| b | 0.36 | 0.4 | 0.5 |
| c | 0.1 | 0.15 | 0.2 |
| c1 | 0.1 | 0.15 | 0.2 |
| D | 2.72 | 2.92 | 3.12 |
| E | 2.60 | 2.80 | 3.0 |
| E1 | 1.40 | 1.60 | 1.80 |
| e | 0.9 | 0.95 | 1.0 |
| e1 | 1.8 | 1.9 | 2.0 |
| L | 0.35 | 0.45 | 0.6 |
| L1 | 0.59 | | |
| L2 | 0.25 | | |
| R | 0.05 | - | |
| R1 | 0.05 | - | 0.2 |
| θ | 0 | - | 8° |
| Θ1 | 3° | 5° | 7° |
| Θ2 | 6° | 10° | 14° |

## ❖ CARRIER TAPE DIMENSION

### SOT-23-5L




| A | H | T1 | C | d | D | W | E1 | F |
|---|---|---|---|---|---|---|---|---|
| 178.0±2.00 | 50 MIN. | 8.4+2.00 -0.00 | 13.0+0.50 -0.20 | 1.5 MIN. | 20.2 MIN. | 8.0±0.30 | 1.75±0.10 | 3.5±0.05 |
| **P0** | **P1** | **P2** | **D0** | **D1** | **T** | **A0** | **B0** | **K0** |
| 4.0±0.10 | 4.0±0.10 | 2.0±0.05 | 1.5+0.10 -0.00 | 1.0 MIN. | 0.6+0.00 -0.40 | 3.20±0.20 | 3.10±0.20 | 1.50±0.20 |

(mm)