

## Linear Constant Current Regulated LED Driver

### DESCRIPTION

The TSCR400 & TSCR402 are High-Side Constant Current Regulator (CCR) for linear LED driving. The device regulates with a preset TSCR400 0.1mA and TSCR402 20mA nominal that can be adjusted with an external resistor up to 65mA. It is designed for driving LEDs in strings and will reduce current at increasing temperatures to self-protect. Operating as a series linear CCR for LED string current control, it can be used in multiple applications, as long as the maximum supply voltage to the device is <40V.

The output current at higher temperatures is the result of the negative temperature coefficient of -0.07%/°C of the LED driver.

### FEATURES

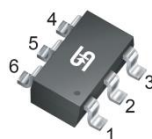
- AEC-Q100 qualified with the following results:
  - Device temperature grade 1: -40°C to 125°C
  - Device HBM ESD classification level H2
  - Device CDM ESD classification level C6
- LED drive current preset:
  - TSCR400CX6: 0.1mA
  - TSCR402CX6: 20mA
- Continuous output current up to 65mA with an external resistor
- Easy paralleling of drivers to increase current
- Supply voltage up to 40V
- Good temperature coefficient vs. output current
- RoHS Compliant
- Halogen-free

### APPLICATION

- Automotive Lighting
- Architectural LED lighting, emergency lighting
- Signage, Advertising, Decorative Lighting
- Retail Lighting in Fridges and Vending Machines



**SOT-26**

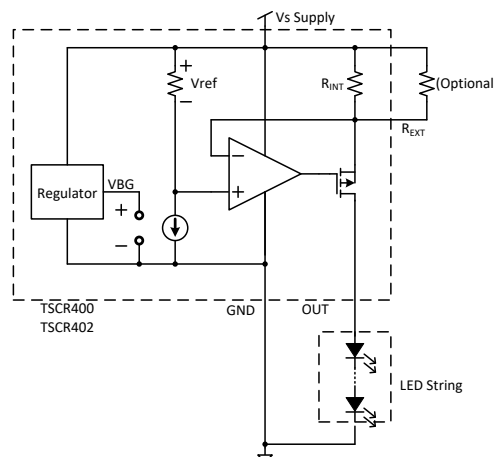


#### Pin Definition:

- |        |                     |
|--------|---------------------|
| 1. GND | 6. R <sub>EXT</sub> |
| 2. OUT | 5. OUT              |
| 3. OUT | 4. V <sub>S</sub>   |

**Notes:** MSL 1 (Moisture Sensitivity Level) per J-STD-020

### TYPICAL APPLICATION CIRCUIT



**ABSOLUTE MAXIMUM RATINGS** ( $T_A = 25^\circ\text{C}$  unless otherwise specified) (Note)

| PARAMETER                                                 | SYMBOL    | LIMIT       | UNIT             |
|-----------------------------------------------------------|-----------|-------------|------------------|
| Supply Voltage                                            | $V_S$     | 40          | V                |
| Output Current                                            | $I_{OUT}$ | 65          | mA               |
| Output Voltage                                            | $V_{OUT}$ | $V_S - 2V$  | V                |
| Reverse voltage between all terminals                     | $V_R$     | 0.5         | V                |
| Total power dissipation @ $T_A = 25^\circ\text{C}$ (Note) | $P_{TOT}$ | 0.83        | W                |
| Junction Temperature Range                                | $T_J$     | -55 to +150 | $^\circ\text{C}$ |
| Storage Temperature Range                                 | $T_{STG}$ | -65 to +150 | $^\circ\text{C}$ |
| ESD Rating (Human Body Mode)                              | HBM       | $\pm 2$     | kV               |
| ESD Rating (Charge Device Model)                          | CDM       | $\pm 1$     | kV               |

**Note:**

Stresses above the maximum values listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.

**THERMAL PERFORMANCE**

| PARAMETER                                | SYMBOL          | TYP | UNIT               |
|------------------------------------------|-----------------|-----|--------------------|
| Thermal Resistance - Junction to Ambient | $R_{\theta JA}$ | 150 | $^\circ\text{C/W}$ |
| Thermal Resistance - Junction to Case    | $R_{\theta JC}$ | 70  | $^\circ\text{C/W}$ |
| Thermal Resistance - Junction to Lead    | $R_{\theta JL}$ | 70  | $^\circ\text{C/W}$ |

**Note:**

The thermal data is based on the PCB at natural convection on 1s0p board with 1 copper layer (1 x 70 $\mu\text{m}$  Cu) and with 10mm<sup>2</sup> heatsink area on PCB.

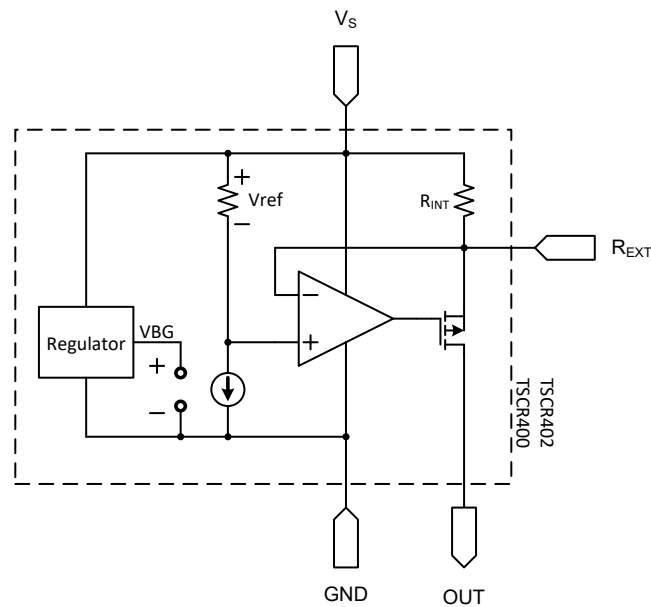
**ELECTRICAL SPECIFICATIONS** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

| PARAMETER                         | CONDITIONS                          | SYMBOL                   | MIN   | TYP   | MAX   | UNIT                |
|-----------------------------------|-------------------------------------|--------------------------|-------|-------|-------|---------------------|
| Break Down Voltage                |                                     | $V_{BR}$                 | 40    | --    | --    | V                   |
| Supply Current                    | TSCR400 $V_S = 3V$                  | $I_S$                    | --    | 40    | --    | $\mu\text{A}$       |
|                                   | TSCR402 $V_S = 10V$                 |                          | --    | 175   | --    | $\mu\text{A}$       |
| Internal Resistor                 | TSCR400 $I_{RINT} = 0.1\text{mA}$   | $R_{INT}$                | 5.2   | 6.5   | 7.8   | k $\Omega$          |
|                                   | TSCR402 $I_{RINT} = 20\text{mA}$    |                          | 38    | 44    | 52    | $\Omega$            |
| Output Current                    | TSCR400 $V_S = 3V$                  | $I_{OUT}$                | 0.075 | 0.1   | 0.125 | mA                  |
|                                   | TSCR402 $V_S = 10V, V_{OUT} = 8.6V$ |                          | 18    | 20    | 22    |                     |
| Voltage Drop ( $V_S - V_{REXT}$ ) | TSCR400 $I_{OUT} = 1\text{mA}$      | $V_{DROP}$               | --    | 0.65  | --    | V                   |
|                                   | TSCR402 $I_{OUT} = 20\text{mA}$     |                          | --    | 0.85  | --    |                     |
| Lowest Sufficient Battery Voltage | TSCR400 $I_{OUT} > 75\mu\text{A}$   | $V_{Smin}$               | --    | 1.6   | --    | V                   |
|                                   | TSCR402 $I_{OUT} > 18\text{mA}$     |                          | --    | 1.4   | --    |                     |
| Output Current vs. Temperature    | TSCR400 $V_S = 3V$                  | $\Delta I_{OUT}/I_{OUT}$ | --    | -0.07 | --    | %/ $^\circ\text{C}$ |
|                                   | TSCR402 $V_S = 10V$                 |                          | --    | -0.07 | --    |                     |
| Output Current vs. Supply Voltage | TSCR400 $V_S = 3V$                  | $\Delta I_{OUT}/I_{OUT}$ | --    | 0.33  | --    | %/ $V$              |
|                                   | TSCR402 $V_S = 10V$                 |                          | --    | 0.33  | --    |                     |

## ORDERING INFORMATION

| ORDERING CODE   | PACKAGE | PACKING            | DEVICE MARKING |
|-----------------|---------|--------------------|----------------|
| TSCR400CX6H RFG | SOT-26  | 3,000pcs / 7" Reel | P1             |
| TSCR402CX6H RFG | SOT-26  | 3,000pcs / 7" Reel | P2             |

## FUNCTION BLOCK



## PIN DESCRIPTION

| PIN NO. | NAME             | FUNCTION                                       |
|---------|------------------|------------------------------------------------|
| 1       | GND              | Power ground                                   |
| 2       | OUT              | Regulated current output                       |
| 3       | OUT              | Regulated current output                       |
| 4       | V <sub>s</sub>   | Supply voltage                                 |
| 5       | OUT              | Regulated current output                       |
| 6       | R <sub>EXT</sub> | External resistor for adjusting output current |

## TSCR400CX6H CHARACTERISTICS CURVES

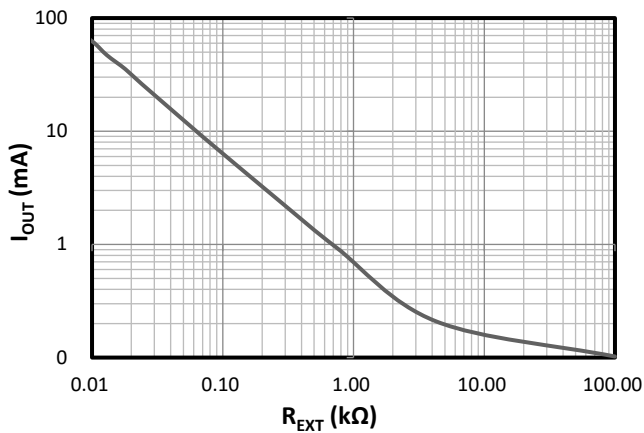


Figure 1.  $I_{OUT}$  vs.  $R_{EXT}$

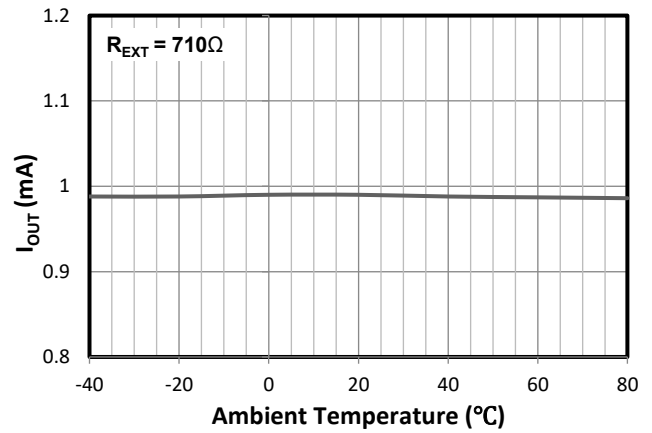


Figure 2.  $I_{OUT}$  vs.  $T_A$  ( $R_{EXT}=710\Omega$ )

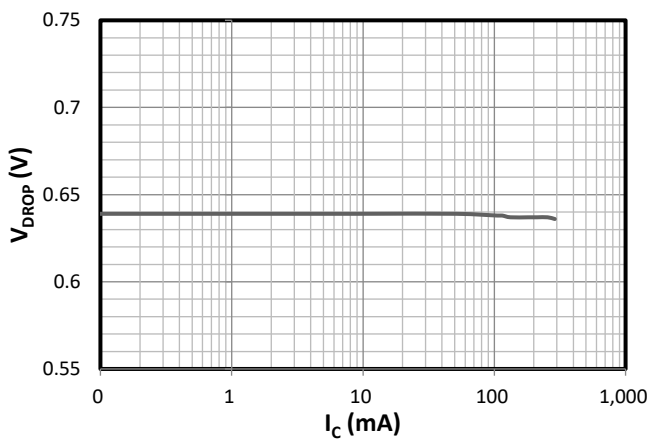


Figure 3.  $V_{DROP}$  vs  $I_C$   
 $V_{DROP} = f(I_C)$  refer to stabilized NPN Transistor

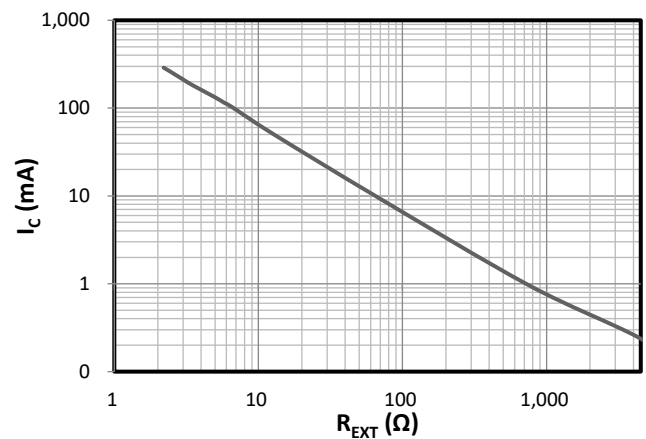


Figure 4.  $I_C$  vs  $R_{EXT}$   
Collector Current  $I_C = f(R_{EXT})$  refer to stabilized NPN Transistor

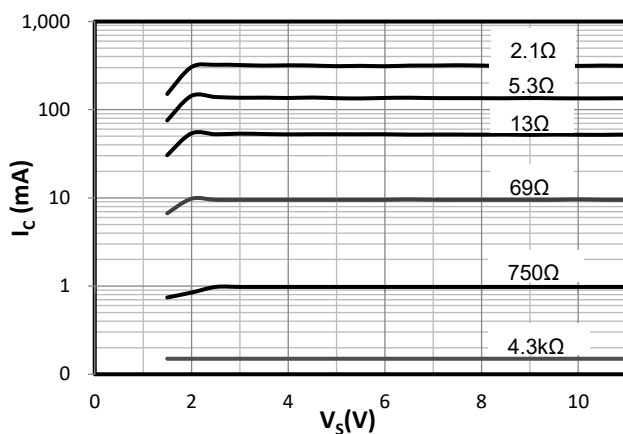


Figure 5.  $I_C$  vs.  $V_S$   
Collector Current  $I_C = f(V_S)$  refer to stabilized NPN Transistor

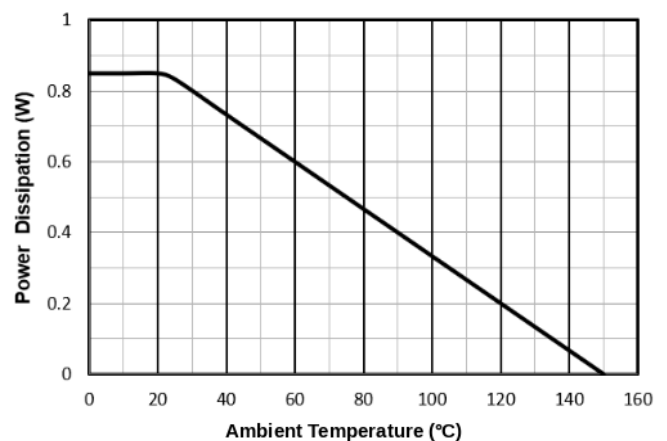
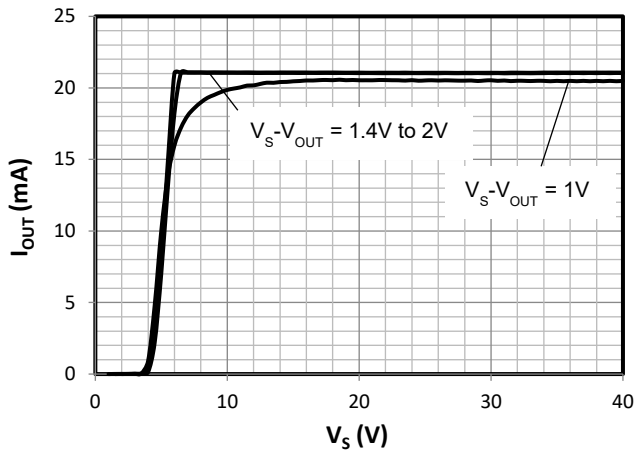
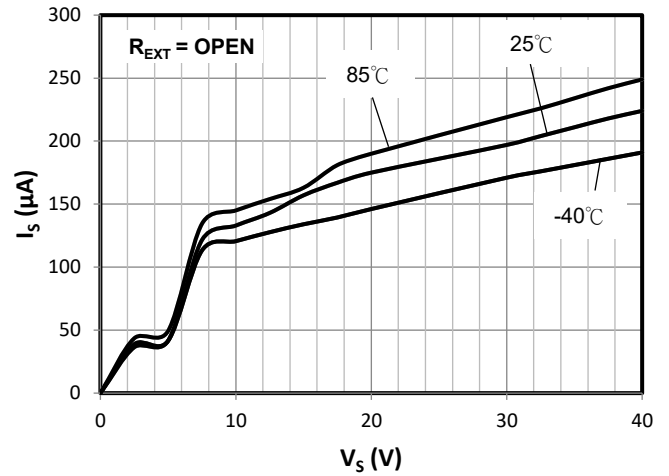


Figure 6.  $P_D$  vs. Ambient Temperature

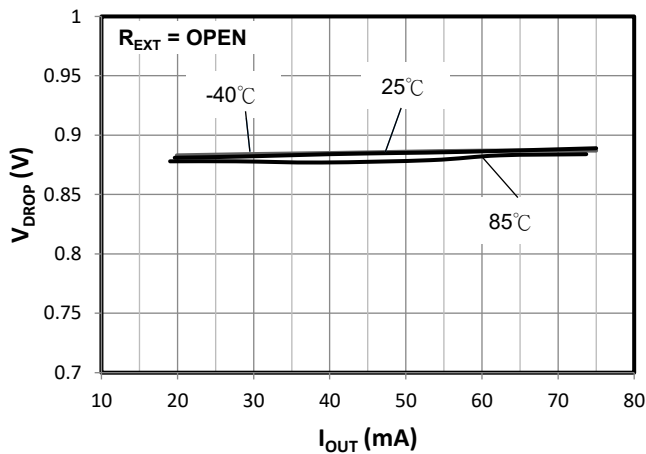
**TSCR402CX6H CHARACTERISTICS CURVES**



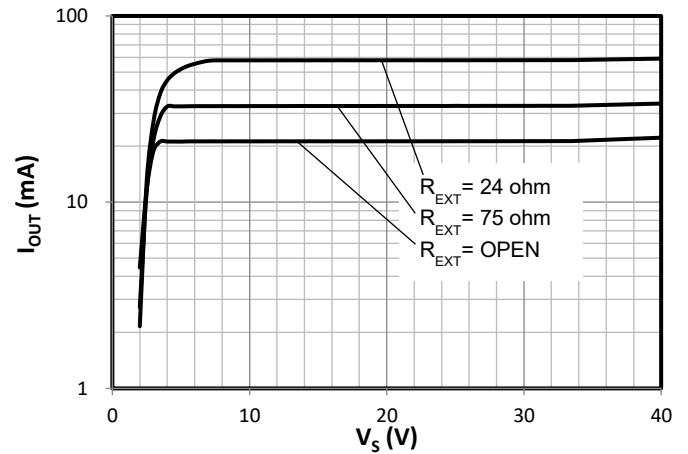
**Figure 7.  $I_{OUT}$  vs.  $V_S$**



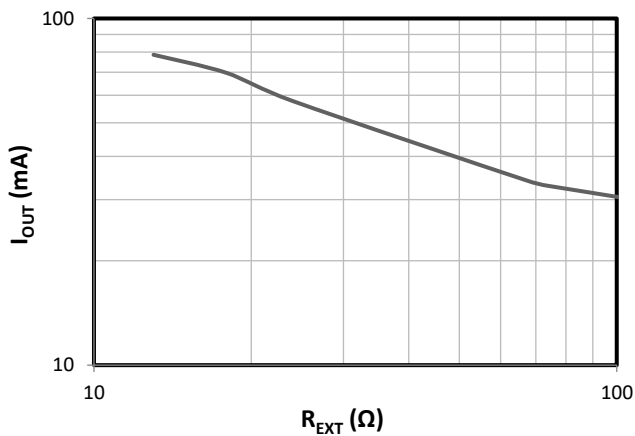
**Figure 8.  $I_S$  vs.  $V_S$  ( $R_{EXT}=OPEN$ )**



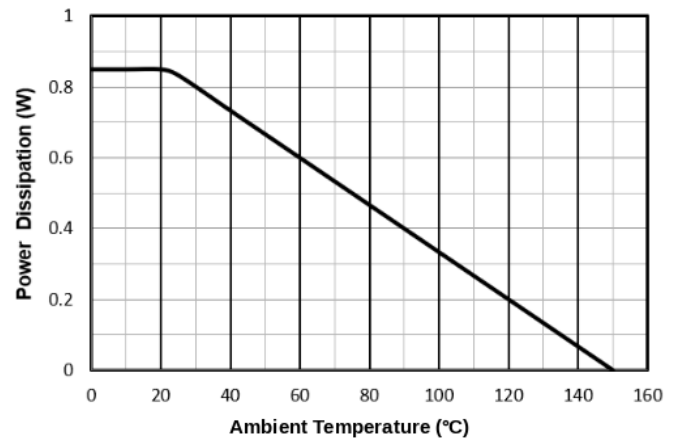
**Figure 9.  $V_{DROP}$  vs.  $I_{OUT}$  ( $R_{EXT}=OPEN$ )**



**Figure 10.  $I_{OUT}$  vs.  $V_S$**



**Figure 11.  $I_{OUT}$  vs.  $R_{EXT}$**



**Figure 12.  $P_D$  vs. Ambient Temperature**

## APPLICATION INFORMATION

The TSCR400 & TSCR402 are designed for driving low current LEDs with typical LED currents of 0.1mA to 65mA. They provide a cost-effective way for driving low current LEDs compared with more complex switching regulator solutions. Furthermore, they reduce the PCB board area of the solution as there is no need for external components like inductors, capacitors and switching diodes

Figure 13 shows circuit diagram for stand-alone application an external resistor  $R_{EXT}$  can be connected to adjust the current. The device comes with an internal resistor ( $R_{INT}$ ) of typically 6.5k $\Omega$  and 44 $\Omega$  which in the absence of an external resistor, sets an LED current of 0.1mA (typical) for TSCR400 and 20mA (typical) for TSCR402. LED current can be increased to a desired value by choosing an appropriate external resistor,  $R_{EXT}$ .

$$R_{EXT} = V_{DROP} / (I_{OUT} - (V_{DROP}/R_{INT}))$$

Figure 14 shows boost mode configuration of LED current can be extended to drive high power LEDs

The  $R_{EXT}$  vs  $I_{LED}$  graphs should be used to select the appropriate resistor. Choosing a low tolerance  $R_{EXT}$  will improve the overall accuracy of the current sense formed by the parallel connection of  $R_{INT}$  and  $R_{EXT}$ .

$$R_{EXT} = V_{DROP} / (I_{LED} - (V_{DROP}/R_{INT}))$$

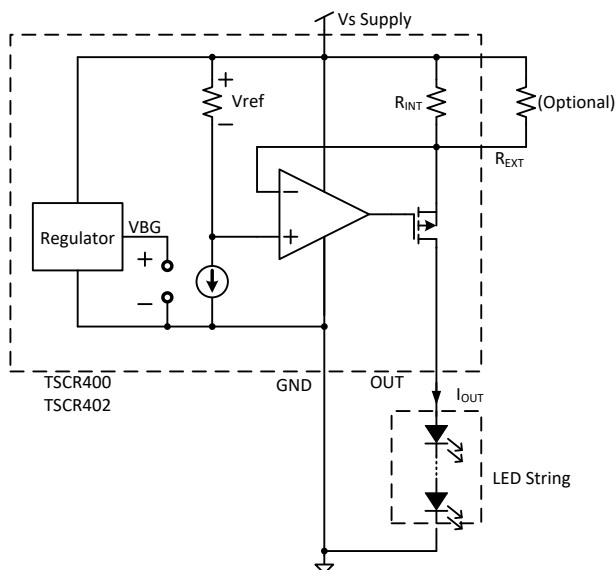
Consideration of the expected linear mode power dissipation must be factored into the design, with respect to the TSCR400 & TSCR402's thermal resistance. The maximum voltage across the device can be calculated by taking the maximum supply voltage and subtracting the voltage across the LED string.

$$V_{DEVICE} = V_S - V_{LED}$$

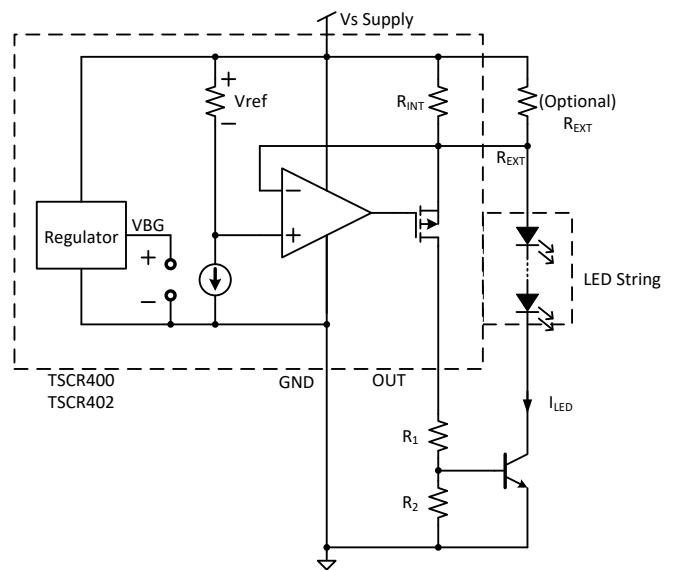
$$P_D = (V_{DEVICE} \times I_{LED}) + (V_S \times I_{GND})$$

As the output current of TSCR400 & TSCR402 increases, it is necessary to provide appropriate thermal relief to the device. The power dissipation supported by the device is dependent upon the PCB board material, the copper area and the ambient temperature. The maximum dissipation the device can handle is given by:

$$P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$$



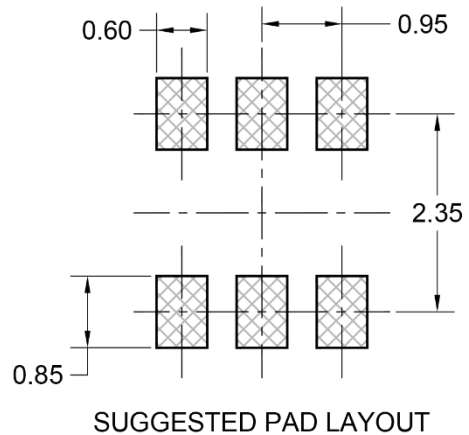
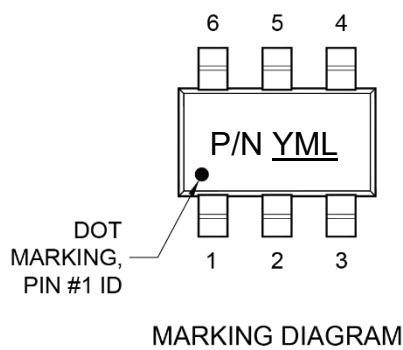
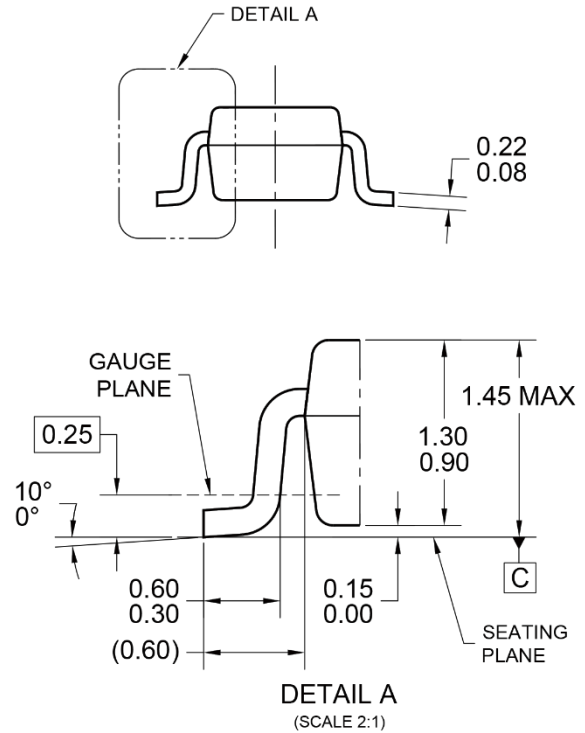
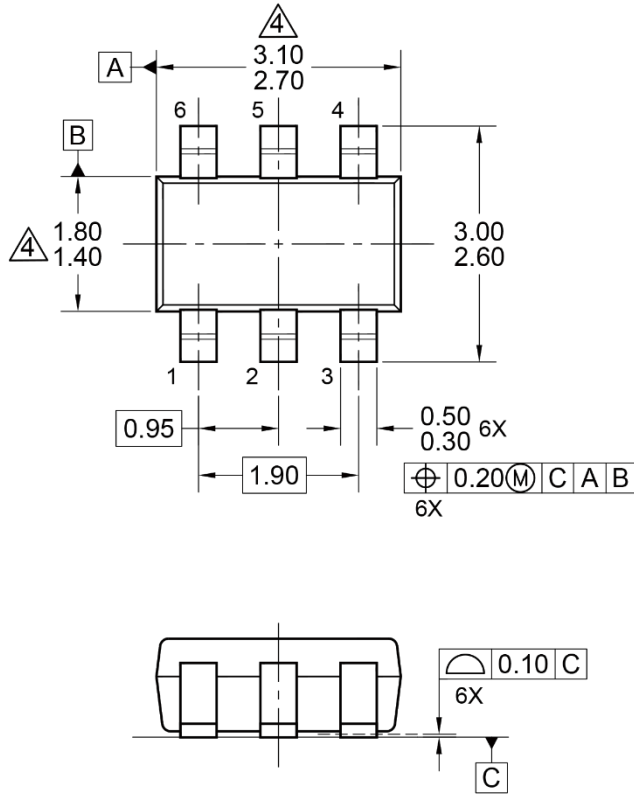
**Figure 13: Application circuit for Stand-alone current source**



**Figure 14: Application Circuit for Boost mode current source with external power transistor**

**PACKAGE OUTLINE DIMENSIONS** (Unit: Millimeters)

**SOT-26**



P/N = Device marking  
Y = Year Code  
M = Month Code for Halogen Free Product  
(O=Jan, P=Feb, Q=Mar, R=Apr, S=May, T=Jun, U=Jul, V=Aug, W=Sep, X=Oct, Y=Nov, Z=Dec)  
L = Lot Code

**NOTES: UNLESS OTHERWISE SPECIFIED**

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
3. PACKAGE OUTLINE REFERENCE: JEDEC MO-178, VARIATION AB.
4. MOLDED PLASTIC BODY DIMENSIONS DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
5. DWG NO. REF: HQ2SD07-SOT26-027 REV A.

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