



## 4-Channel Constant Current Driver

### Product Description

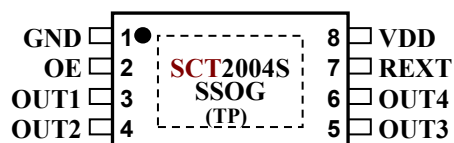
The SCT2004S is a four channels constant current driver best for LED lighting. It provides the PWM control effect by sinking constant current from LED clusters with minimum pulse width 200ns. The PWM control is performed by connecting the PWM signal from system control unit to OE pin of the SCT2004S. The full scale current value of each output is set by an external resistor connected to REXT pin.

The SCT2004S guarantees to endure maximum DC 24V at each output port. Each output of SCT2004S can sink a constant current up to 180mA. Users can simply shunt the outputs to get higher current driver-ability, especially in the case of high power LED lighting.

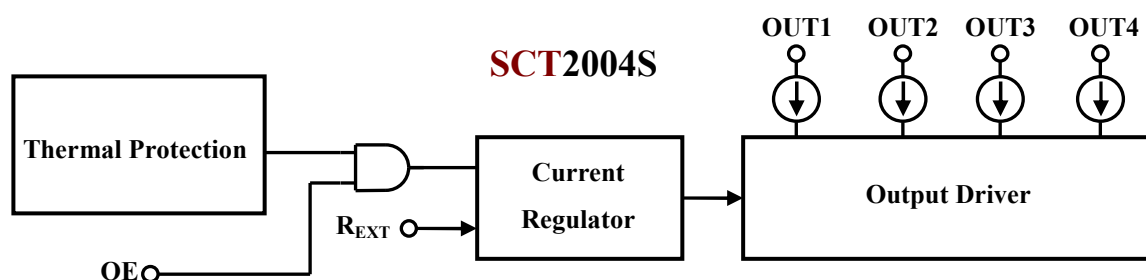
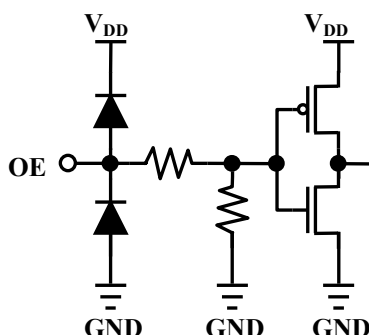
The excellent current regulation capability allows SCT2004S easily drive each output current to a constant stable output nearly without affected by power supply of LED, loading due to variant  $V_F$  of LEDs and operating temperature. The SCT2004S is equipped with over temperature protection. The four channels IC stops driving the output while junction temperature exceeds 160°C the high limit and the output will be reactivated while the junction temperature is below 110°C the low limit. In conclusion, the driver system is protected from damage of overheated.

### Features

- ◆ Four constant-current outputs rate at 24V
- ◆ Constant current range: 20 – 120/180mA@3.3/5V
- ◆ Excellent regulation to load, supply voltage and temperature
- ◆ Minimum PWM pulse width 200ns
- ◆  $\pm 2\%$ (typ) current matching between outputs
- ◆  $\pm 4\%$ (typ) current matching between ICs
- ◆ Dropout output 0.6V@80mA,  $V_{DD}=5V$
- ◆ All output current are adjusted through one external resistor
- ◆ Built-in thermal protection
- ◆ Supply voltage range 3.3 to 5V
- ◆ Dimming control with Schmitt triggered input
- ◆ Package: SOP8 with heat sink pad
- ◆ Application: LED backlight, LED lighting, LED lamp

**Pin Configuration****Terminal Description**

| Pin Name | Pin No. | I/O | Function   |
|----------|---------|-----|--|
| GND      | 1       | -   | Ground terminal  |
| OE       | 2       | I   | Input terminal of output enable signal. Output is enabled when OE is high.         |
| OUT1~4   | 3~6     | O   | Output terminals with constant current   |
| REXT     | 7       | I/O | Input terminal connected to an external resistor for setting up all output current |
| VDD      | 8       | -   | Supply voltage terminal  |
| TP       | -       | -   | Thermal pad, please connect TP to ground.  |

**Block Diagram****Equivalent Circuits of Inputs**

## Ordering information

| Part        | Marking     | Package                             | Unit per reel(pcs) |
|-------------|-------------|-------------------------------------|--------------------|
| SCT2004SSOG | SCT2004SSOG | Green SOP8(150mil) with thermal pad | 2500               |

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## Maximum Ratings (T<sub>A</sub> = 25°C)

| Characteristic              | Symbol                         | Rating                      | Unit       |
|-----------------------------|--------------------------------|-----------------------------|------------|
| Supply voltage              | V <sub>DD</sub>                | 7                           | V          |
| Input voltage               | V <sub>IN</sub>                | -0.2 ~ V <sub>DD</sub> +0.2 | V          |
| Output current              | I <sub>OUT</sub>               | 200                         | mA/Channel |
| Output voltage              | V <sub>OUT</sub>               | 24                          | V          |
| Total GND terminals current | I <sub>GND</sub>               | 800                         | mA         |
| Power dissipation           | SOP8TP<br>P <sub>D</sub>       | 2.08                        | W          |
| Thermal resistance          | SOP8TP<br>R <sub>TH(j-a)</sub> | 60                          | °C /W      |
| Operating temperature       | T <sub>OPR</sub>               | -40~+85                     | °C         |
| Storage temperature         | T <sub>STG</sub>               | -55~+150                    | °C         |

The absolute maximum ratings are a set of ratings not to be exceeded. Stresses beyond those listed under "Maximum Ratings" may cause the device breakdown, deterioration even permanent damage. Exposure to the maximum rating conditions for extended periods may affect device reliability.

## Recommended Operating Conditions (T<sub>A</sub>=-40 to 85°C unless otherwise noted)

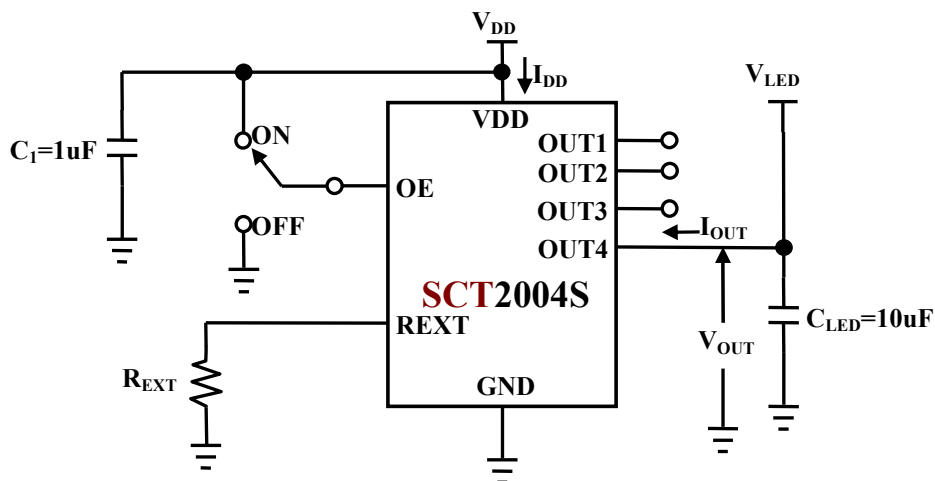
| Characteristic | Symbol           | Conditions              | Min.               | Typ.           | Max.               | Unit |
|----------------|------------------|-------------------------|--------------------|----------------|--------------------|------|
| Supply voltage | V <sub>DD</sub>  | -                       | 3                  | -              | 5.5                | V    |
| Output voltage | V <sub>OUT</sub> | Output OFF              | -                  | -              | 24                 | V    |
|                |                  | Output ON               | -                  | 1 <sup>1</sup> | 4 <sup>2</sup>     | V    |
| Output current | I <sub>OUT</sub> | V <sub>DD</sub> =3.3-5V | 20                 | -              | 120/180            | mA   |
| Input voltage  | V <sub>IH</sub>  | -                       | 0.7V <sub>DD</sub> | -              | V <sub>DD</sub>    | V    |
|                | V <sub>IL</sub>  | -                       | 0                  | -              | 0.3V <sub>DD</sub> | V    |
| OE pulse width | t <sub>w</sub>   | V <sub>DD</sub> =3.3-5V | 200                | -              | -                  | ns   |

- The output current keep constant in range of 20-180mA if V<sub>OUT</sub>=1V.  
However, user can minimize V<sub>OUT</sub> to reduce power dissipation according to used current, e.g., set V<sub>OUT</sub> to 0.6V if I<sub>OUT</sub>=80mA.
- The maximum Vout is package thermal limited, user should keep Vout under maximum power dissipation.

**Electrical Characteristics** ( $V_{DD}=3.3/5V$ ,  $T_A=25^{\circ}C$  unless otherwise noted)

| Characteristic  | Symbol        | Conditions   | Min.        | Typ.      | Max.        | Unit        |
|---|---------------|--|-------------|-----------|-------------|-------------|
| Input voltage   | $V_{IH}$      | -  | $0.7V_{DD}$ | -         | $V_{DD}$    | V           |
|   | $V_{IL}$      | -  | 0           | -         | $0.3V_{DD}$ | V           |
| Output leakage current                                  | $I_{OL}$      | $V_{OUT} = 24V$  | -           | -         | 0.5         | $\mu A$     |
| Output current  | $I_{OUT}$     | $V_{OUT}=1V$ $R_{EXT}=900\Omega$   | -           | 84        | -           | mA          |
| Current channel skew <sup>1</sup>                       | $dI_{OUT1}$   | $V_{OUT}=1V$ $R_{EXT}=900\Omega$   | -           | $\pm 2$   | $\pm 3$     | %           |
| Current chip skew <sup>2</sup>                          | $dI_{OUT2}$   | $V_{OUT}=1V$ $R_{EXT}=900\Omega$   | -           | $\pm 4$   | $\pm 6$     | %           |
| Line regulation<br>$I_{OUT}$ vs. $V_{DD}$ <sup>3</sup>  | $\%/dV_{DD}$  | $3V < V_{DD} < 5.5V$<br>$R_{EXT}=900\Omega$ , $V_{OUT} > 1V$             | -           | $\pm 0.5$ | $\pm 1$     | %/V         |
| Load regulation<br>$I_{OUT}$ vs. $V_{OUT}$ <sup>4</sup> | $\%/dV_{OUT}$ | $1V < V_{OUT} < 4V$ , $R_{EXT}=900\Omega$ ,<br>$V_{DD}=3.3-5V$           | -           | $\pm 0.5$ | $\pm 1$     | %/V         |
| Pull-down resistor                                      | $R_{DOWN}$    | OE   | -           | 400       | -           | K $\Omega$  |
| Thermal shutdown  | $T_H$         | Junction Temperature   | -           | 160       | -           | $^{\circ}C$ |
|   | $T_L$         |  | -           | 110       | -           | $^{\circ}C$ |
| Supply current  | OFF           | $I_{DD(OFF)1}$ $R_{EXT} = \text{Open}$ , $OUT_1 \sim OUT_4 = \text{OFF}$ | -           | 3         | 5           | mA          |
|   |               | $I_{DD(OFF)2}$ $R_{EXT} = 900\Omega$ , $OUT_1 \sim OUT_4 = \text{OFF}$   | -           | 6         | 8           |             |
|   | ON            | $I_{DD(ON)}$ $R_{EXT} = 900\Omega$ , $OUT_1 \sim OUT_4 = \text{ON}$      | -           | 8         | 10          |             |

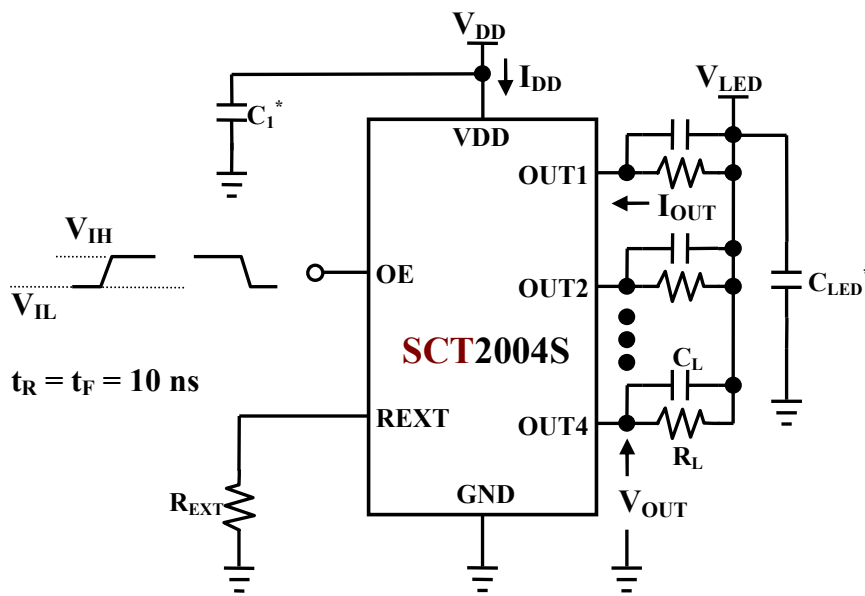
- Channel skew= $(I_{OUT}-I_{AVG})/I_{AVG}$ , where  $I_{AVG}=(I_{OUT(max)}+I_{OUT(min)})/2$
- Chip skew= $(I_{AVG}-I_{CEN})/I_{CEN} \times 100(\%)$ , where  $I_{CEN}$  is the statistics distribution center of output currents.
- Line regulation= $[I_{OUT}(V_{DD}=5.5V)-I_{OUT}(V_{DD}=3V)] / \{ [I_{OUT}(V_{DD}=5.5V)+I_{OUT}(V_{DD}=3V)]/2 \} \times (5.5V-3V) \times 100(\%/V)$
- Load regulation= $[I_{OUT}(V_{OUT}=4V)-I_{OUT}(V_{OUT}=1V)] / \{ [I_{OUT}(V_{OUT}=4V)+I_{OUT}(V_{OUT}=1V)]/2 \} \times (4V-1V) \times 100(\%/V)$

**Test Circuit for Electrical Characteristics**

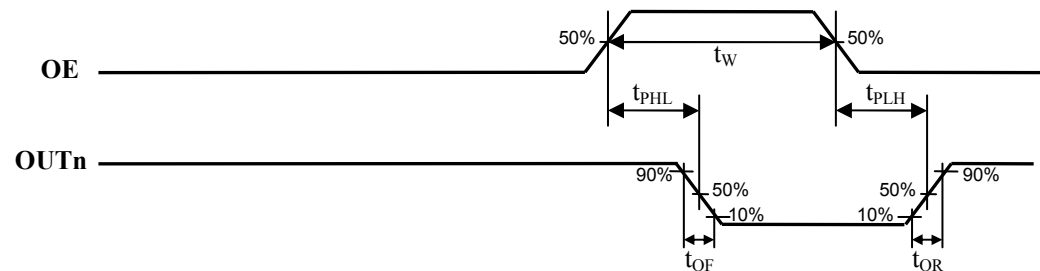
Switching Characteristics (V<sub>DD</sub>=3.3/5V, T<sub>A</sub>=25°C unless otherwise noted)

| Characteristic                       |           | Symbol           | Condition  | Min. | Typ. | Max. | Unit |
|--------------------------------------|-----------|------------------|--|------|------|------|------|
| Propagation delay time ("L" to "H")  | OE - OUTn | t <sub>PLH</sub> | V <sub>DD</sub> = 3.3/5V<br>V <sub>LED</sub> = 5V<br>V <sub>IH</sub> = V <sub>DD</sub><br>V <sub>IL</sub> = GND<br>R <sub>EXT</sub> = 900Ω<br>R <sub>L</sub> = 47Ω<br>C <sub>L</sub> = 10pF<br>C <sub>1</sub> = 1uF<br>C <sub>LED</sub> = 10uF | -    | 120  | -    | ns   |
| Propagation delay time ("H" to "L")  | OE - OUTn | t <sub>PHL</sub> |  | -    | 120  | -    | ns   |
| Pulse width                          | OE        | t <sub>w</sub>   |  | 200  | -    | -    | ns   |
| Output rise time of I <sub>OUT</sub> |           | t <sub>OR</sub>  |  | -    | 120  | -    | ns   |
| Output fall time of I <sub>OUT</sub> |           | t <sub>OF</sub>  |  | -    | 120  | -    | ns   |

Test Circuit for Switching Characteristics

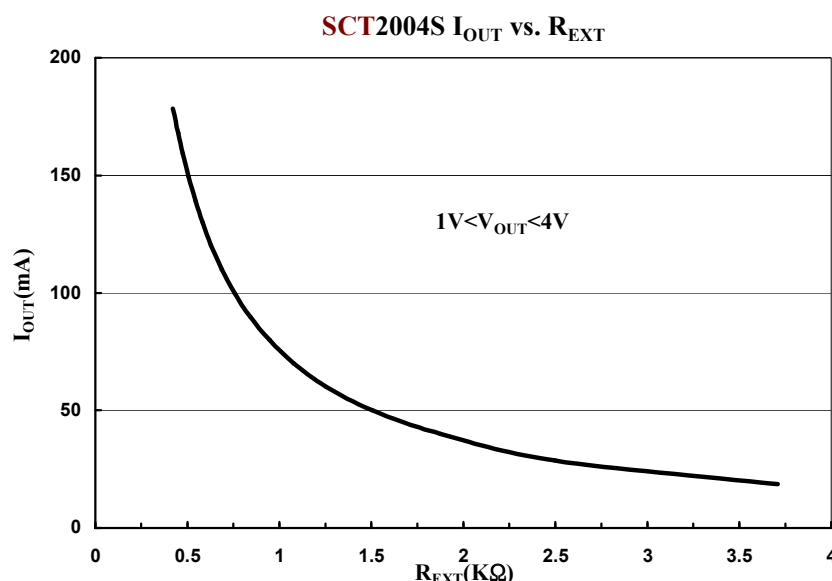


Timing Waveform



## Adjusting Output Current

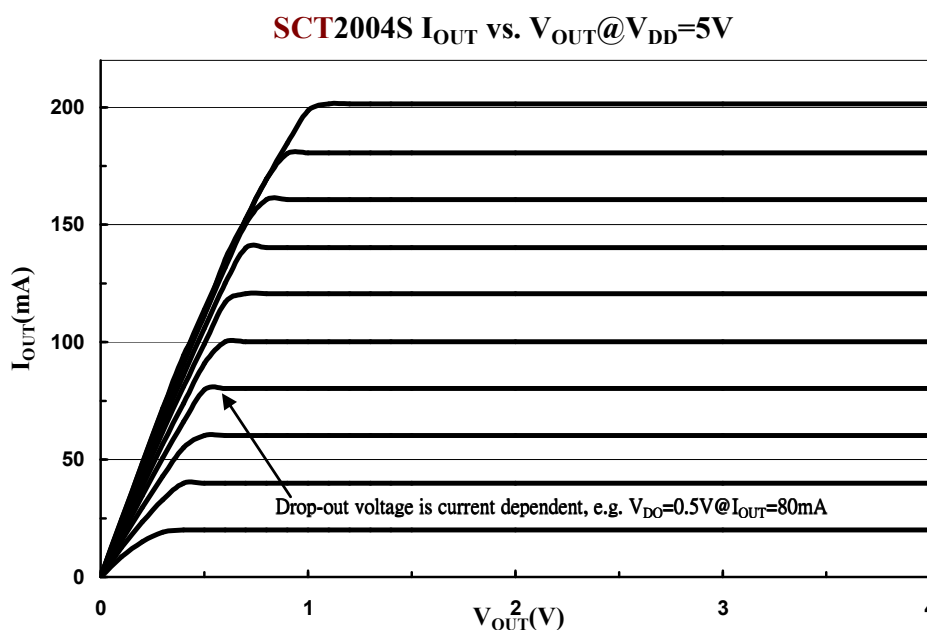
All SCT2004S's output current ( $I_{OUT}$ ) are set by one external resistor at pin REXT. The output current  $I_{OUT}$  versus resistance of  $R_{EXT}$  is shown as the following figure.

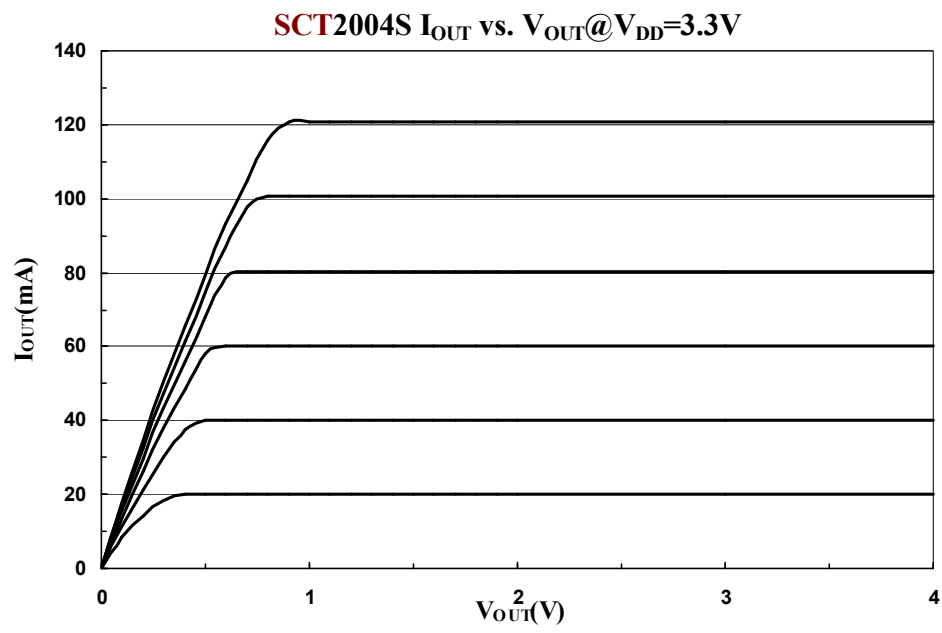


According to SCT2004S' I-V curve, the output voltage should be larger than 1V to get 180 mA constant current. By applying proper output voltage, the SCT2004S' output current set by an external resistor is approximate to:  $I_{OUT} = 120(630 / R_{EXT})$  (mA) (chip skew <  $\pm 6\%$ ). Thus the output current is set to be about 84mA at  $R_{EXT} = 900\Omega$ .

## Output Characteristics

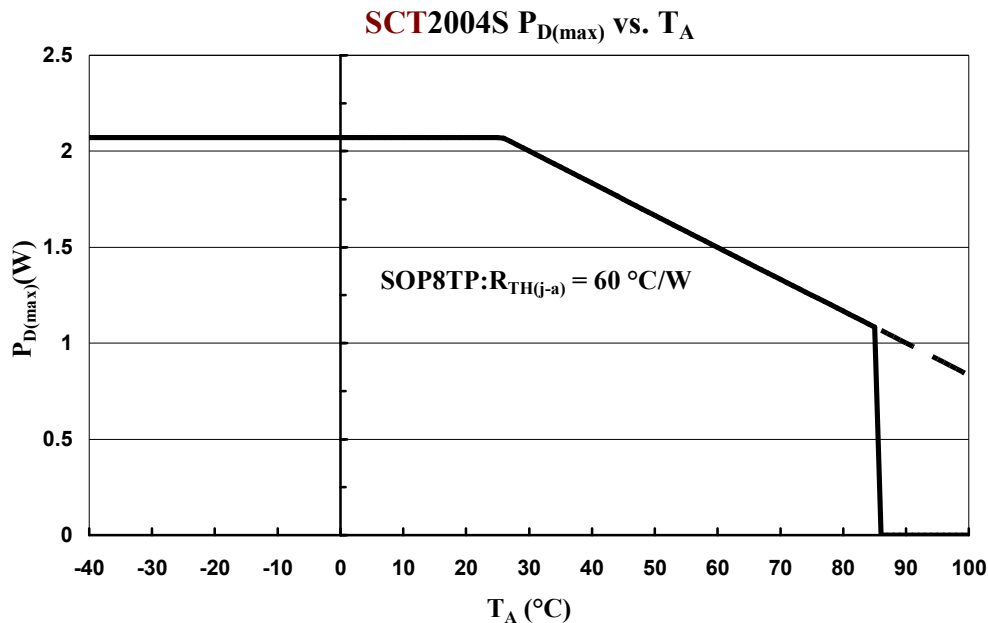
The current characteristic of output curve is flat. The output current can be kept constant regardless of the variations of LED forward voltage when  $V_{OUT} > V_{DO}$  (drop-out voltage). The relationship between  $I_{OUT}$  and  $V_{OUT}$  is shown below. The output voltage should be kept as low as possible to prevent the SCT2004S from being overheated.





## Maximum Power Dissipation

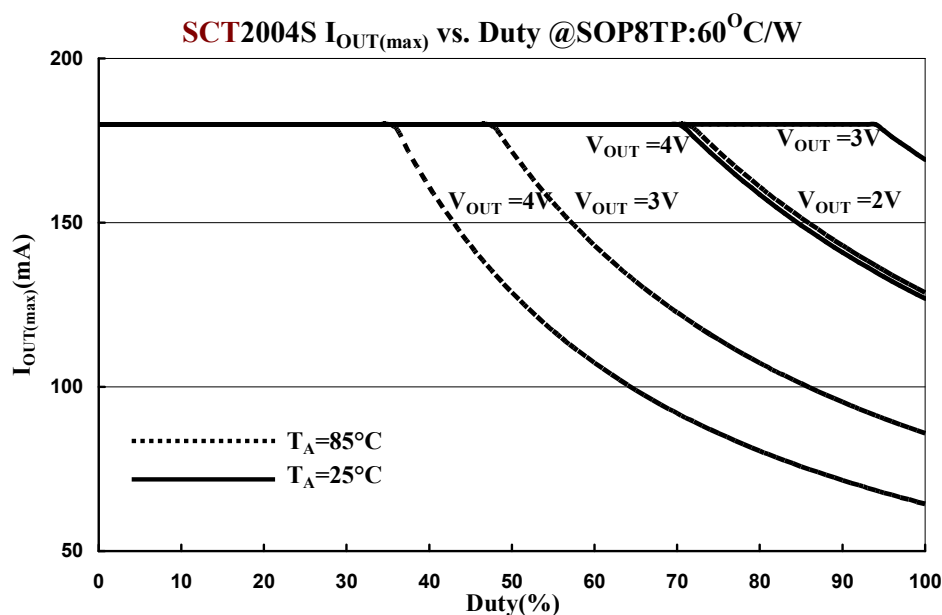
The maximum power dissipation ( $P_{D(max)}$ ) of a semiconductor chip varies with different packages and ambient temperature. It's determined as  $P_{D(max)} = (T_{J(max)} - T_A) / R_{TH(j-a)}$  where  $T_{J(max)}$ : maximum chip junction temperature is usually considered as 150°C,  $T_A$ : ambient temperature,  $R_{TH(j-a)}$ : thermal resistance. Since  $P=IV$ , for sinking larger  $I_{OUT}$ , users had better add proper voltage reducers on outputs to reduce the heat generated from the SCT2004S.



## Limitation on Maximum Output Current

The maximum output current vs. duty cycle is estimated by:

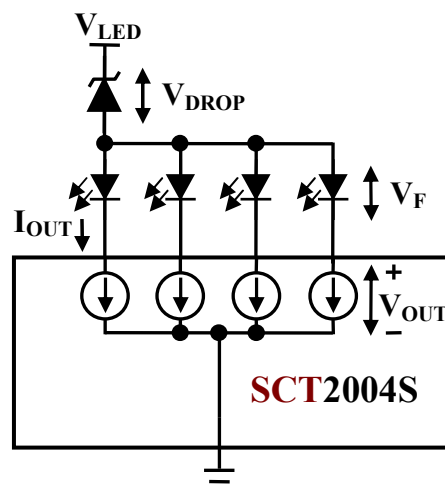
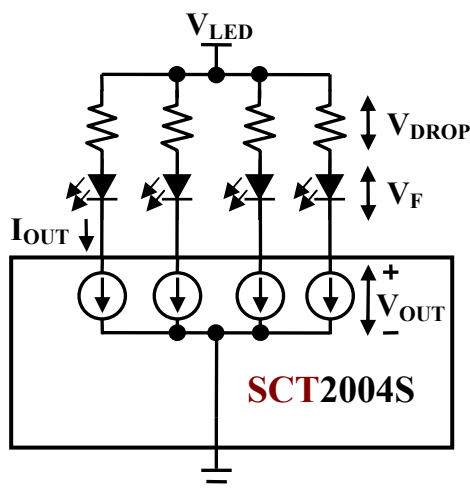
$$I_{OUT(max)} = (((T_{J(max)} - T_A) / R_{TH(j-a)}) - (V_{DD} * I_{DD})) / V_{OUT} / \text{Duty} / N, \text{ where } T_{J(max)} = 150^\circ C, N=4(\text{all ON})$$





## Load Supply Voltage ( $V_{LED}$ )

The SCT2004S can be operated very well when  $V_{OUT}$  ranges from 1V to 4V. However, it is recommended to use the lowest possible supply voltage or set a voltage reducer to reduce the  $V_{OUT}$  voltage, at the same time reduce the power dissipation of the SCT2004S. Follow the diagram instructions shown below to lower down the output voltage. This can be done by adding additional resistor or zener diode, thus  $V_{OUT} = V_{LED} - V_{DROP} - V_F$ .

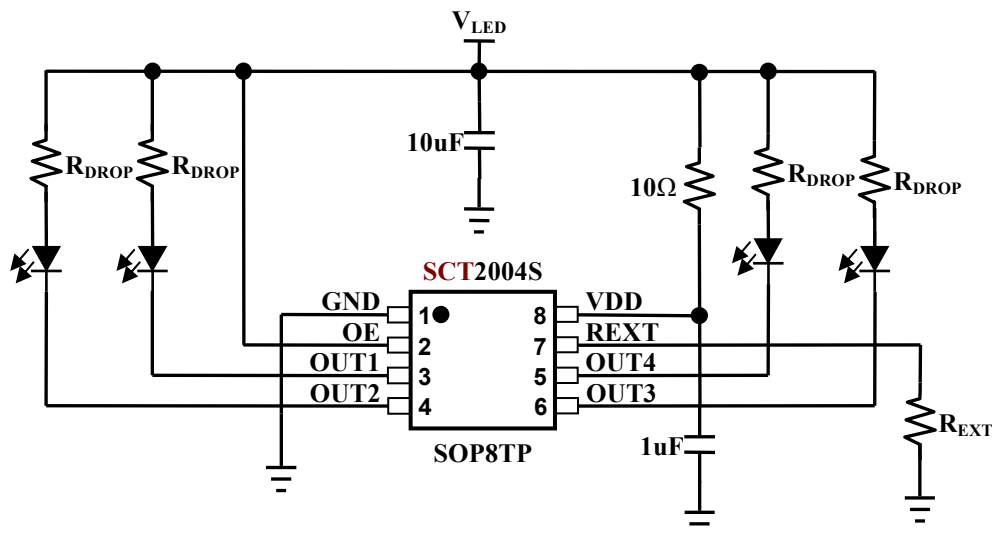


## Over Temperature Shutdown

The SCT2004S contains thermal shutdown scheme to prevent damage from over-heating. The internal thermal sensor turns off all outputs when the die temperature exceeds  $+160^{\circ}\text{C}$ . The outputs are enabled again when the die temperature drops below  $+110^{\circ}\text{C}$ . During the thermal shutdown process, the LEDs look blinking since it is turned OFF then ON periodically.

## Typical Application Circuits

### (1) Lighting with recommended $V_{LED}=3.3/5V$



### (2) Lighting with $V_{LED} > 5V$ , e.g. $V_{LED}=12V/24V$

Components suggestion:

$$R_1 = (V_{LED} - V_Z) / (I_{DD} + I_Z)$$

If  $V_{LED}=24V$ ,  $V_Z=5.1V$ ,  $I_Z=1mA$

$R_{EXT}=900\Omega$ ,  $I_{DD(max)}=10mA$ , then

$R_1 \sim 1.7K$  is obtained. Beware that:

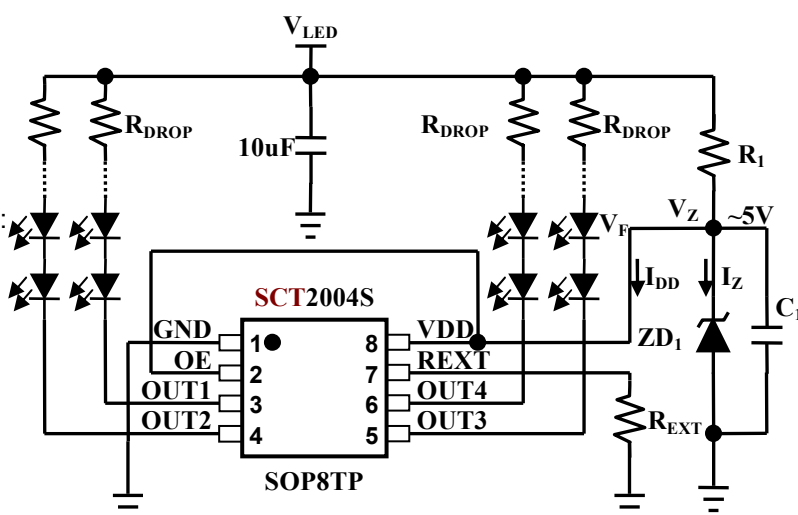
$I_{DD}$  is  $R_{EXT}$  dependent, the higher

$R_{EXT}$  the lower  $I_{DD}$ , vice versa.

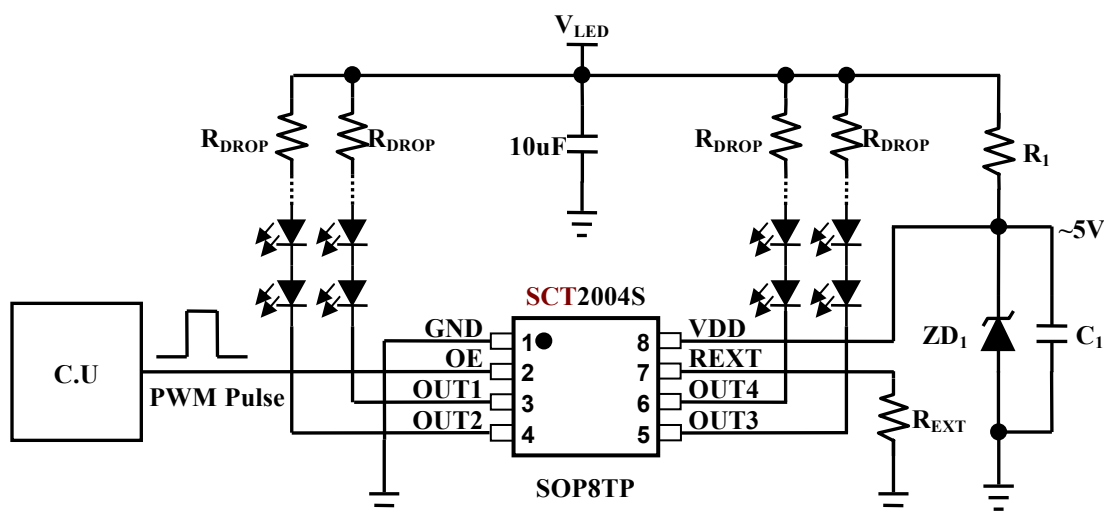
$$R_{DROP} = (V_{LED} - n \cdot V_F - V_{DO}) / I_{OUT}$$

$V_{DO}$  is the drop-out voltage of intended output current.

$$C_1 = 1\mu F$$



### (3) Lighting with dimming control

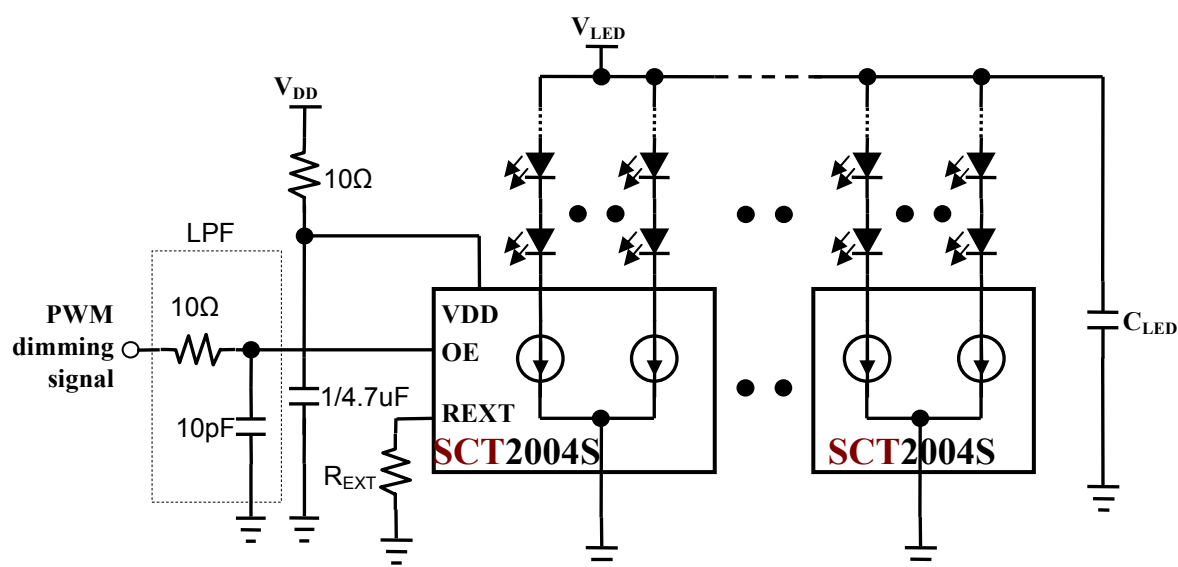


## PCB Design Considerations

Use the following general guide-line when designing printed circuit boards (PCB) :

### Decoupling Capacitor

Place a decoupling capacitor e.g. 1uF between VDD and GND pins of the SCT2004S. Locate the capacitor as close to the SCT2004S as possible. The necessary capacitance depends on the LED load current and dimming frequency. Inadequate VDD decoupling can cause timing problems, and very noisy LED supplies can affect LED current regulation.



### External Resistor ( $R_{EXT}$ )

Locate the external resistor as close to the REXT pin in as possible to avoid noise.

### Power and Ground

Maximizing the width and minimizing the length of VDD and GND trace improves efficiency and ground bouncing by effect of reducing both power and ground parasitic resistance and inductance. A small value of resistor, e.g., 10Ω (higher if  $I_{OUT}$  is larger) series in power input of the SCT2004S in conjunction with decoupling capacitor shunting the IC is recommended. Separating and feeding the LED power from another stable supply terminal  $V_{LED}$ , furthermore adding a capacitor  $C_{LED}$  greater than 10uF beside the LED are recommended. Please adapt  $C_{LED}$  according to total system current consumption.

### EMI Reduction

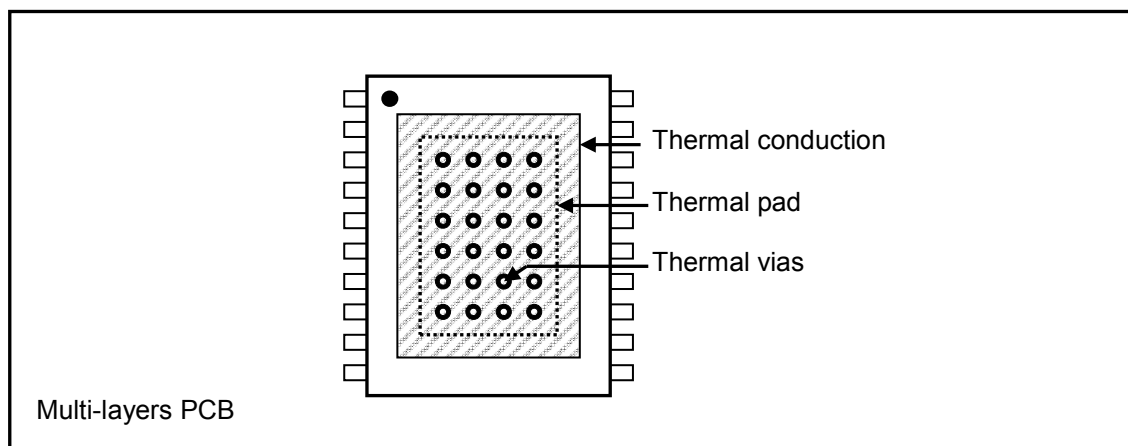
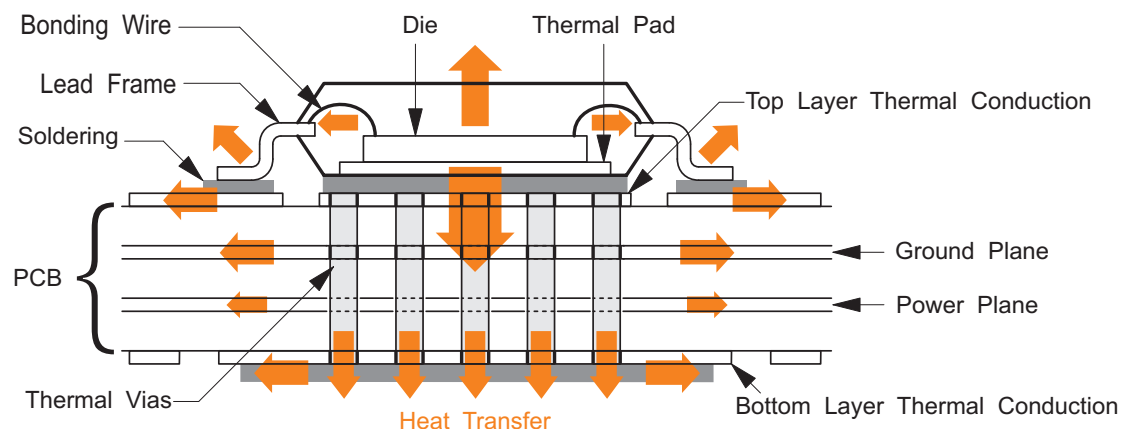
To reduce the EMI radiation from system, an economical solution of RC low pass filter (LPF) is suggested to be used to lower the transient edge of PWM dimming signal OE, as shown in the figure above. Using at least four layers PCB board with two interior power and ground planes is a good scheme to decrease the signal current path which is the source of radiation emission. As a result, EMI radiation can be decreased.

## Thermal Pad Consideration

The “thermal pad” (also named as “exposed pad”) SOP8 package beneath is NOT directly wired to ground terminal (pin1) internally. User should be aware of this electrical connection when designing the PCB board. In most application, connecting the thermal pad to system ground is strongly suggested.

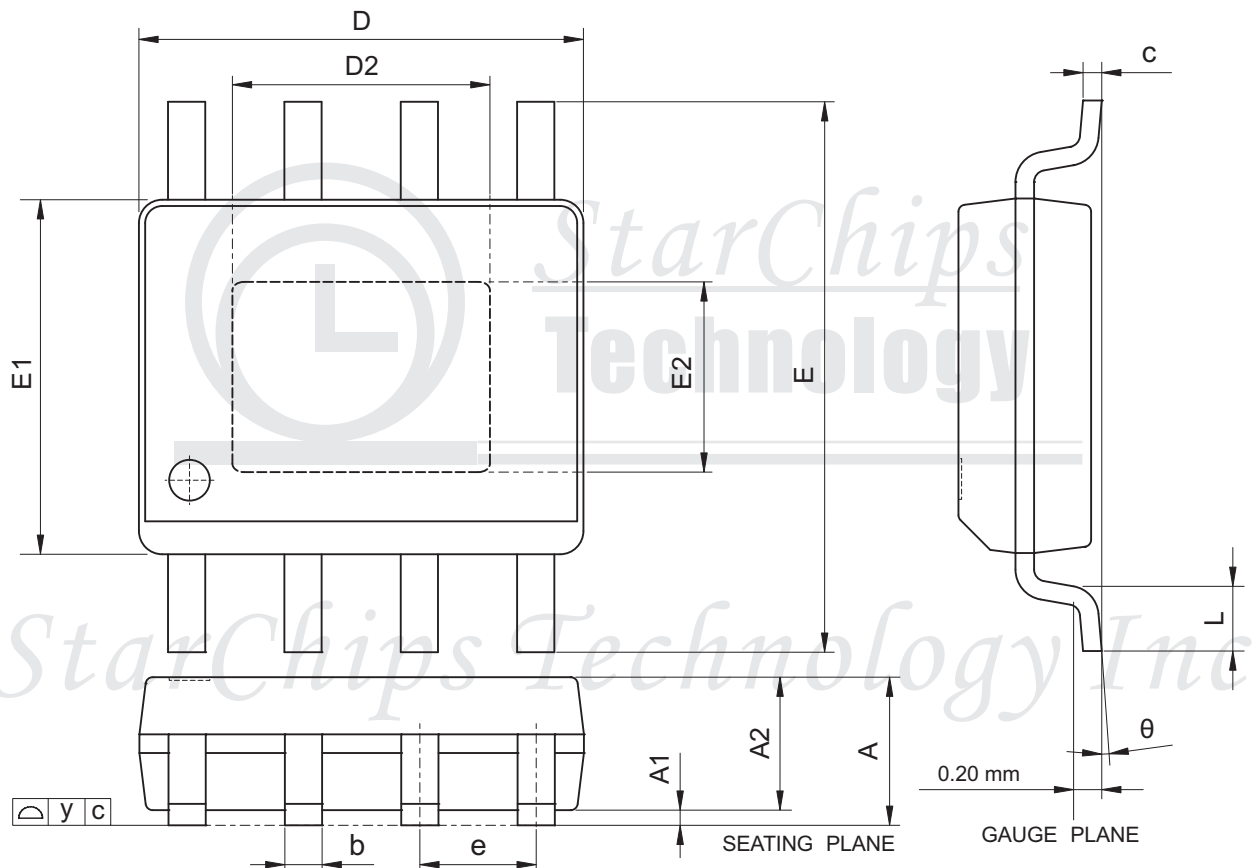
In general, the heat generated from an IC is conducted to the PCB then radiates to the ambient. Thermal pad specifically increases the maximum power dissipation capability of the IC packages. To provide lower thermal resistance from the IC to the ambient air, PCB designers should layout larger thermal conduction areas on top layer (component side) and bottom layer as well as thermal vias, the more the better. In addition, connecting thermal via to the ground plane also increases thermal conduction areas, this improves the heat transfer efficiency at the same time greatly dissipates heat generated from the package. Furthermore, coating solder on bottom layer and selecting e.g. 2 oz. copper which will increase the total thickness of thermal conduction is an alternative.

When making the solder paste screen, an opening should be created for the thermal pad. This way the thermal pad can be electrically and thermally connected to the PCB. As the thermal pad is soldered on copper polygon, the chance of inadvertently shorting the thermal pad to traces routed underneath it could be eliminated.



## Package Dimension

SOP8TP([check up-to-date version](#))



| Symbol | Dimension (mm) |      |      | Dimension (mil) |       |       |
|--------|----------------|------|------|-----------------|-------|-------|
|        | Min.           | Nom. | Max. | Min.            | Nom.  | Max.  |
| A      | 1.40           | 1.50 | 1.60 | 55.1            | 59.1  | 63.0  |
| A1     | 0.00           | -    | 0.10 | 0.0             | -     | 3.9   |
| A2     | -              | 1.45 | -    | -               | 57.1  | -     |
| b      | 0.33           | -    | 0.51 | 13.0            | -     | 20.1  |
| c      | 0.19           | -    | 0.25 | 7.5             | -     | 9.8   |
| D      | 4.80           | -    | 5.00 | 189.0           | -     | 196.9 |
| E      | 5.80           | 6.00 | 6.20 | 228.3           | 236.2 | 244.1 |
| E1     | 3.80           | 3.90 | 4.00 | 149.6           | 153.5 | 157.5 |
| D2     | -              | 3.30 | -    | -               | 130.0 | -     |
| E2     | -              | 2.40 | -    | -               | 95.0  | -     |
| e      | -              | 1.27 | -    | -               | 50.0  | -     |
| L      | 0.40           | -    | 1.27 | 15.7            | -     | 50.0  |
| y      | -              | -    | 0.10 | -               | -     | 3.9   |
| θ      | 0°             | -    | 8°   | 0°              | -     | 8°    |

## Revision History([check up-to-date version](#))

| Data Sheet Version | Remark                            |
|--------------------|-----------------------------------|
| V01_03             | Switching characteristics updated |

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