



## Single Channel High Power Constant Current Driver

### Product Description

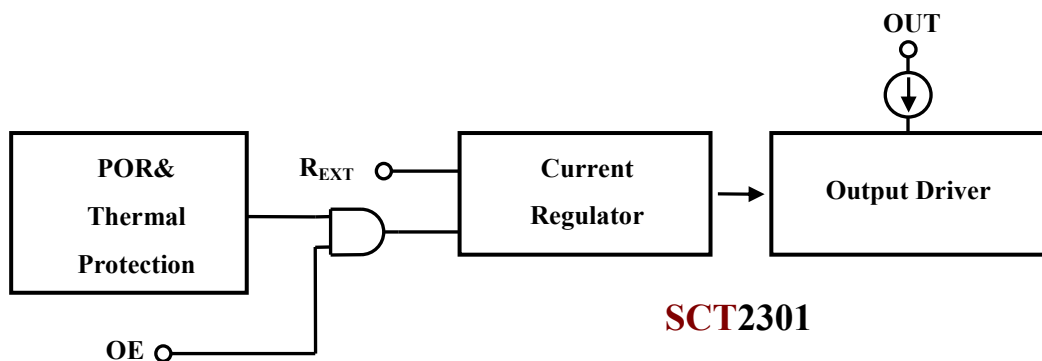
The SCT2301 is a single channel constant current driver best for the high power LED lighting and lamp application. It provides the PWM control effect by sinking constant current from high power LED clusters with minimum pulse width 200ns. The PWM control is performed by connecting the PWM signal from system control unit to OE pin of the SCT2301. The full scale current value of output is set by an external resistor connected to REXT pin. The SCT2301 guarantees to endure maximum DC 24V at output port. The output of SCT2301 can sink a constant current up to 720mA.

The excellent current regulation capability allows SCT2301 easily to 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 SCT2301 is equipped with over temperature protection. The single channel IC stops driving the output while sensing its junction temperature exceeding 160°C the higher limit and the output will be reactivated while the junction temperature is below 110°C. The exposed pad on IC provides significant power dissipation. This provides lower thermal impedance from the IC to the ambient air, thus IC can be operated more safely. In conclusion, the driver system is protected from damage of overheated.

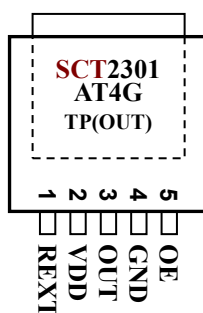
### Features

- ◆ LED power supply voltage up to 24V
- ◆ Constant current range: 80 to 480/720mA@3.3/5V
- ◆ Excellent regulation to load, supply voltage and temperature
  - Temperature regulation:  $\pm 0.005\%/^{\circ}\text{C}$
  - Load regulation:  $\pm 0.5\%/V$
  - Line regulation:  $\pm 1\%/V$
- ◆ Maximum operating switching frequency 5MHz
- ◆ Minimum PWM pulse width 200ns
- ◆ Current matching between ICs:  $\pm 2\%$
- ◆ Dropout voltage 0.6/1V@360/720mA,  $V_{DD}=5V$
- ◆ Two steps current ramp to lower switching noise
- ◆ Output current is adjusted through one external resistor
- ◆ Built-in power on reset and thermal protection
- ◆ Supply voltage range 3.3V to 5V
- ◆ Dimming control with Schmitt triggered input
- ◆ Package: TO-252-5L
- ◆ Application: LED lighting, LED lamp

**Block Diagram**



**Pin Configuration**

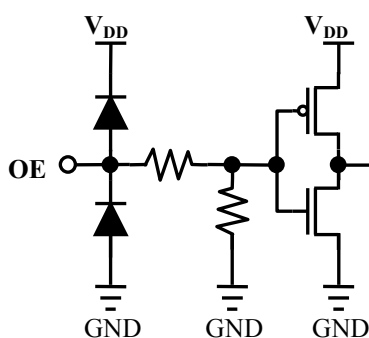


Note: Thermal pad (TP) is connected to pin 3(OUT) of TO-252.

**Terminal Description**

Pin No.	Pin Name	Function
1	REXT	Input terminal connected to an external resistor for setting up output current
2	VDD	Supply voltage terminal
3(TP)	OUT	Output terminal with constant current(thermal pad included)
4	GND	Ground terminal
5	OE	Input terminal of output enable signal. Output is enabled when OE is high.

**Equivalent Circuits of Inputs**



**Ordering information**

Part	Marking	Package	Unit per reel(pcs)
SCT2301AT4G	SCT2301AT4G	Green TO-252-5L	2500

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

Characteristic		Symbol	Rating	Unit
Supply voltage		$V_{DD}$	7	V
Input voltage		$V_{IN}$	-0.2 to $V_{DD}+0.2$	V
Output current		$I_{OUT}$	750	mA/Channel
Output voltage		$V_{OUT}$	24	V
Total GND terminals current		$I_{GND}$	800	mA
Power dissipation	TO-252	$P_D$	2.5	W
Thermal resistance	TO-252	$R_{TH(j-a)}$	50	$^\circ\text{C}/\text{W}$
Operating junction temperature		$T_{J(max)}$	150	$^\circ\text{C}$
Operating temperature		$T_{OPR}$	-40 to +85	$^\circ\text{C}$
Storage temperature		$T_{STG}$	-55 to +150	$^\circ\text{C}$

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** ( $T_A = -40$  to  $85^\circ\text{C}$  unless otherwise noted)

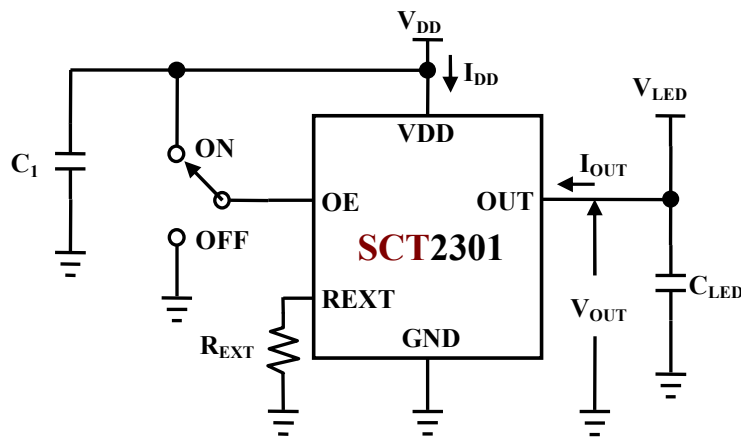
Characteristic	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply voltage	$V_{DD}$	-	3	-	5.5	V
Output voltage	$V_{OUT}$	Output OFF	-	-	17	V
		$I_{OUT}=360/720\text{mA}$ , $V_{DD}=5\text{V}$	-	0.8/1.2	4/2	V
Output current	$I_{OUT}$	$V_{DD}=3.3/5\text{V}$	80	-	480/720	mA
Input voltage	$V_{IH}$	-	$0.7V_{DD}$	-	$V_{DD}$	V
	$V_{IL}$	-	0	-	$0.3V_{DD}$	V
OE pulse width	$t_w$	$V_{DD}=3.3$ to $5\text{V}$	200	-	-	ns

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

Characteristic	Symbol	Test 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	$I_{OL}$	$V_{OUT} = 24V$	-	-	1	$\mu A$	
Output current	$I_{OUT}$	$V_{OUT}=1V$   $R_{EXT}=900\Omega$	-	336	-	mA	
Current chip skew <sup>1</sup>	$dI_{OUT2}$	$V_{OUT}=1V$   $R_{EXT}=900\Omega$	-	$\pm 2$	$\pm 4$	%	
Line regulation <sup>2</sup> $I_{OUT}$ vs. $V_{DD}$	$\%/dV_{DD}$	$3V < V_{DD} < 5.5V$ $R_{EXT}=900\Omega, V_{OUT} > 1V$	-	-	$\pm 1$	$\%/V$	
Load regulation <sup>3</sup> $I_{OUT}$ vs. $V_{OUT}$	$\%/dV_{OUT}$	$1V < V_{OUT} < 4V$ , $R_{EXT}=900\Omega, V_{DD}=3.3-5V$	-	-	$\pm 0.5$	$\%/V$	
Temp. regulation <sup>4</sup> $I_{OUT}$ vs. $T_A$	$\%/dT_A$	$-20^{\circ}C < T_A < 80^{\circ}C$ , $I_{OUT}=100mA\sim 720mA, V_{DD}=5V$	-	$\pm 0.005$	-	$\%/^{\circ}C$	
Current variation $I_{OUT}$ vs. $T_A$	$dI_{OUT3}$	$-20^{\circ}C < T_A < 80^{\circ}C$ , $R_{EXT}=900\Omega, V_{OUT}>1V, V_{DD}=5V$	-	0.2	-	mA	
Pull-down resistor	$R_{DOWN}$	OE	-	500	-	K $\Omega$	
Thermal shutdown	$T_H$	Junction Temperature	-	160	-	$^{\circ}C$	
	$T_L$		-	110	-	$^{\circ}C$	
Supply current	OFF	$I_{DD(OFF)1}$	$R_{EXT} = Open, OUT=OFF$	-	3	5	mA
		$I_{DD(OFF)2}$	$R_{EXT} = 900\Omega, OUT=OFF$	-	6	8	
	ON	$I_{DD(ON)}$	$R_{EXT} = 900\Omega, OUT=ON$	-	8	10	

1. Chip skew= $(I_{OUT}-I_{CEN})/I_{CEN} \times 100(\%)$ ,  $I_{CEN}$  is the statistics distribution center of output currents.
2. Line regulation= $[I_{OUT}(V_{DD}=5.5V)-I_{OUT}(V_{DD}=3V)]/(5.5V-3V) \times 100(\%/V)$
3. Load regulation= $[I_{OUT}(V_{OUT}=4V)-I_{OUT}(V_{OUT}=1V)]/(4V-1V) \times 100(\%/V)$
4. Temperature regulation= $[I_{OUT}(T_A=80^{\circ}C)-I_{OUT}(T_A=-20^{\circ}C)]/(80^{\circ}C+20^{\circ}C) \times 100(\%/^{\circ}C)$

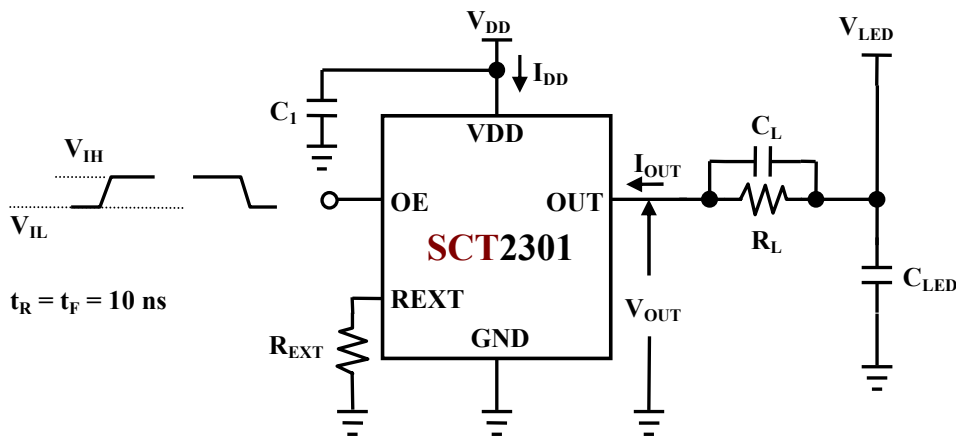
**Test Circuit for Electrical Characteristics**



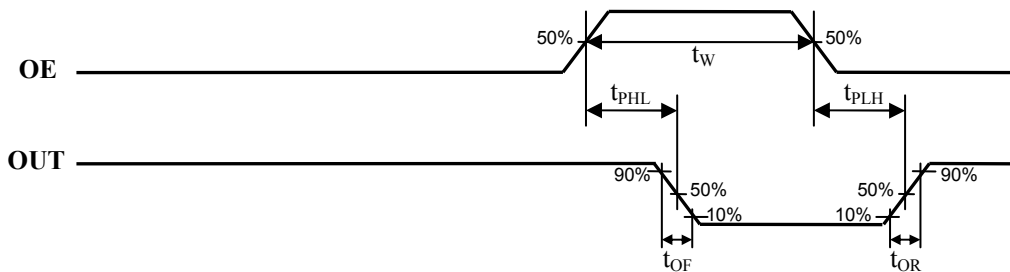
**Switching Characteristics** ( $V_{DD}=3.3/5V$ ,  $T_A=25^{\circ}C$  unless otherwise noted)

Characteristic	Symbol	Condition	Min.	Typ.	Max.	Unit	
Propagation delay time ("L" to "H")	OE - OUTn	$t_{PLH}$	$V_{DD} = 3.3/5V$ $V_{LED} = 5V$ $V_{IH} = V_{DD}$ $V_{IL} = GND$ $R_{EXT} = 900\Omega$ $R_L = 12\Omega$ $C_L = 10pF$ $C_1 = 10uF$ $C_{LED} = 470uF$	-	60	100	ns
Propagation delay time ("H" to "L")	OE - OUTn	$t_{PHL}$		-	60	100	ns
Pulse width	OE	$t_w$		200	-	-	ns
Output rise time of $I_{OUT}$		$t_{OR}$		-	80	100	ns
Output fall time of $I_{OUT}$		$t_{OF}$		-	60	100	ns

**Test Circuit for Switching Characteristics**

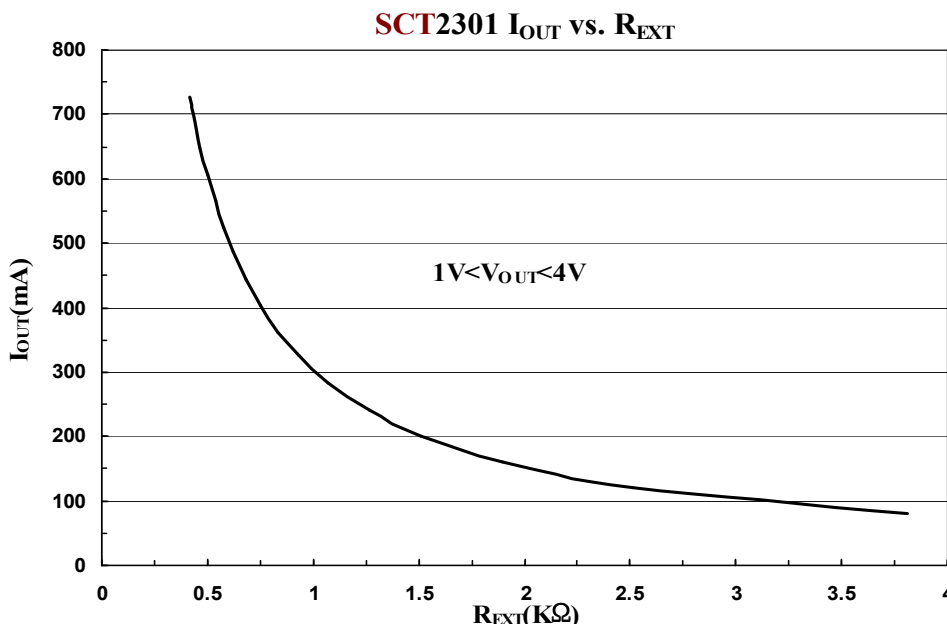


**Timing Waveform**



## Adjusting Output Current

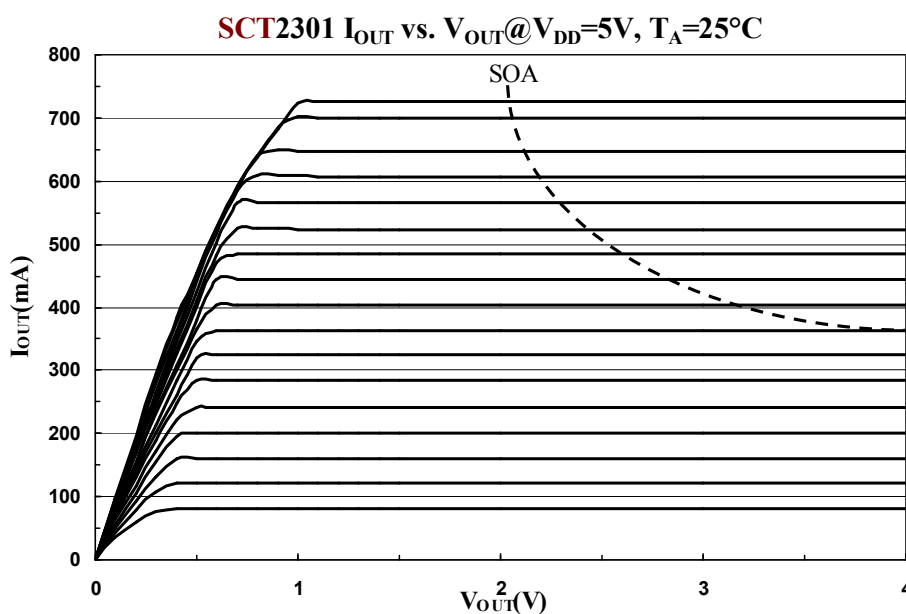
The SCT2301's output current ( $I_{OUT}$ ) are set by one external resistor at pin REXT. The output current  $I_{OUT}$  versus resistance of  $R_{EXT}$  is shown as the following figure.



Furthermore, when SCT2301's output voltage is set between 1 Volt and 4 Volt, the output current can be estimated approximately by:  $I_{OUT} = 480(630 / R_{EXT})$  (mA) (chip skew  $< \pm 4\%$ ). Thus the output current are set about 336mA at  $R_{EXT} = 900\Omega$ .

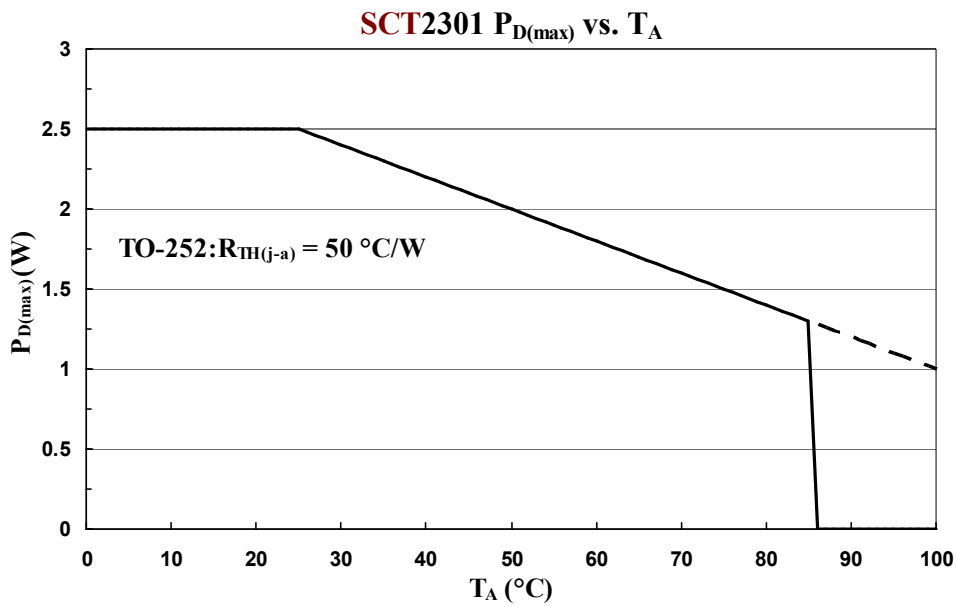
## Output Characteristics

The current characteristic of output curve is flat. The output current can be kept constant regardless of the variations of LED forward voltage when  $V_{OUT} > 1V$ . The relationship between  $I_{OUT}$  and  $V_{OUT}$  is shown below. To prevent the SCT2301 from thermal shutdown due to an improper heat dissipation scheme, the  $V_{OUT}$  of IC should not exceed the boundary of SOA (Safe Operating Area).



### 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 sink larger  $I_{OUT}$ , users had better add proper voltage reducers on output to reduce the heat generated from the SCT2301.

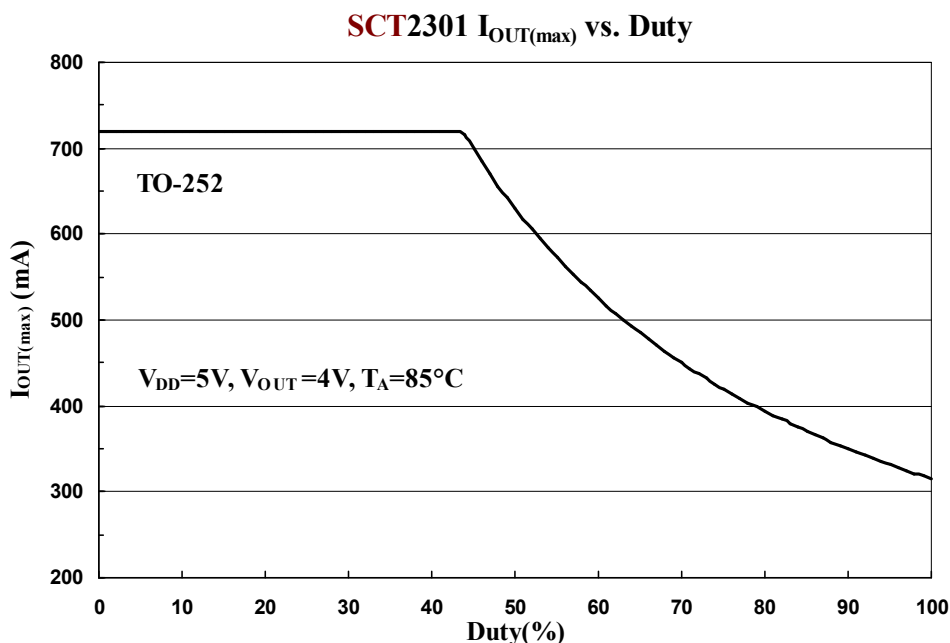


### Limitation on Maximum Output Current

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

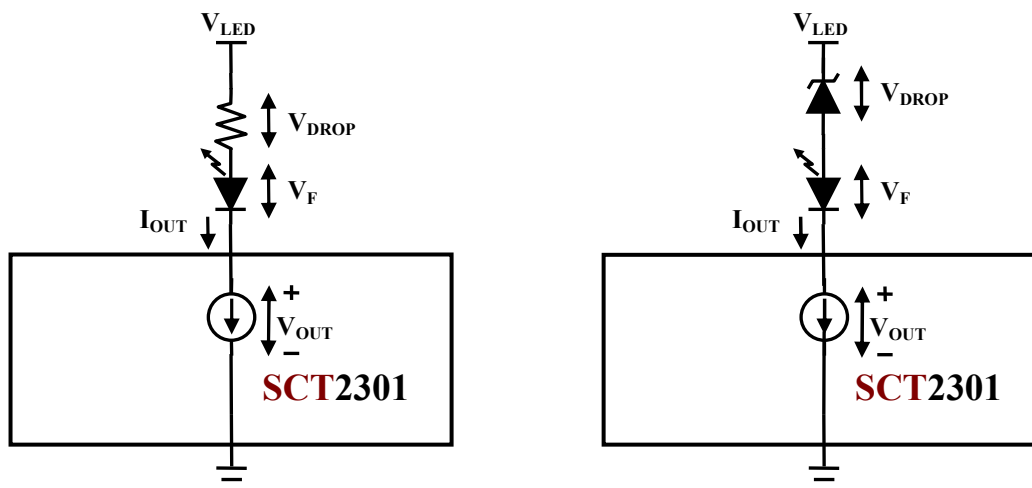
$$I_{OUT(max)} = (((T_{J(max)} - T_A) / R_{TH(j-a)}) - (V_{DD} * I_{DD})) / V_{OUT} / \text{Duty}$$

where  $T_{J(max)} = 150^\circ\text{C}$ .



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

The SCT2301 can be operated very well when  $V_{OUT}$  ranges from 1V to 4V. 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 SCT2301. This can prevent the IC from malfunction with thermal shutdown situation. Follow the diagram instructions shown below to lower down the output voltage. This can be done by adding additional resistor or zener diode, thus  $V_{OUT} = V_{LED} - V_{DROP} - V_F$ .



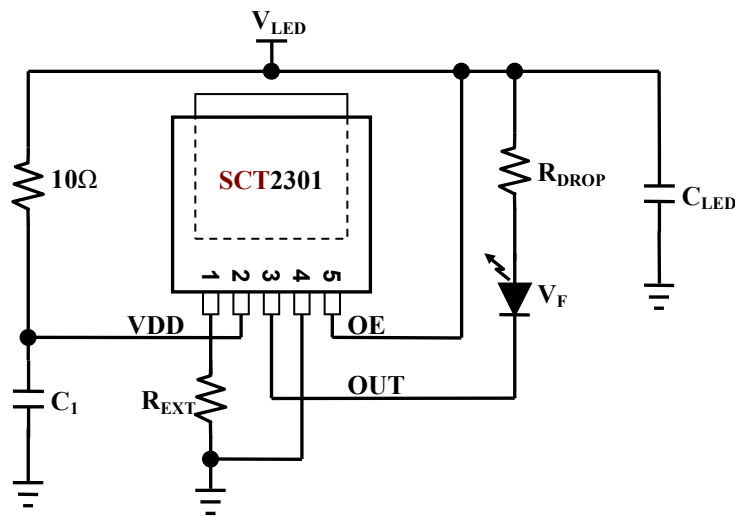
## Over Temperature Shutdown

The SCT2301 contains thermal shutdown scheme to prevent damage from over heated. 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:

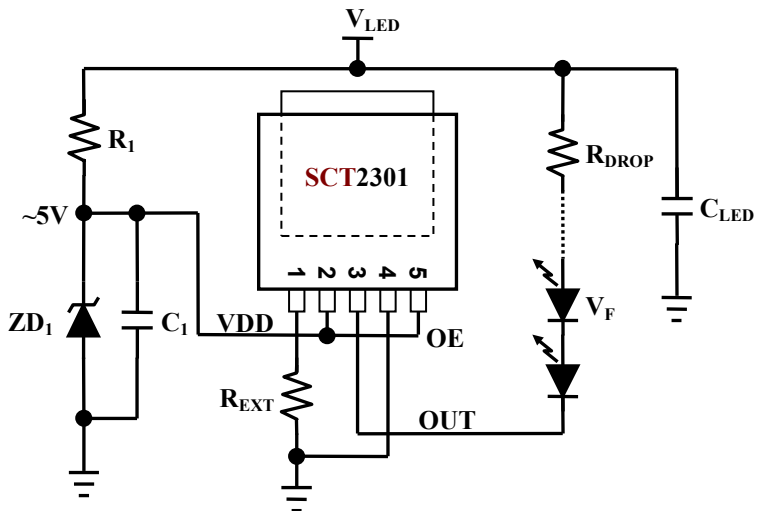
$I_{DD}$  is  $R_{EXT}$  dependent, the higher

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

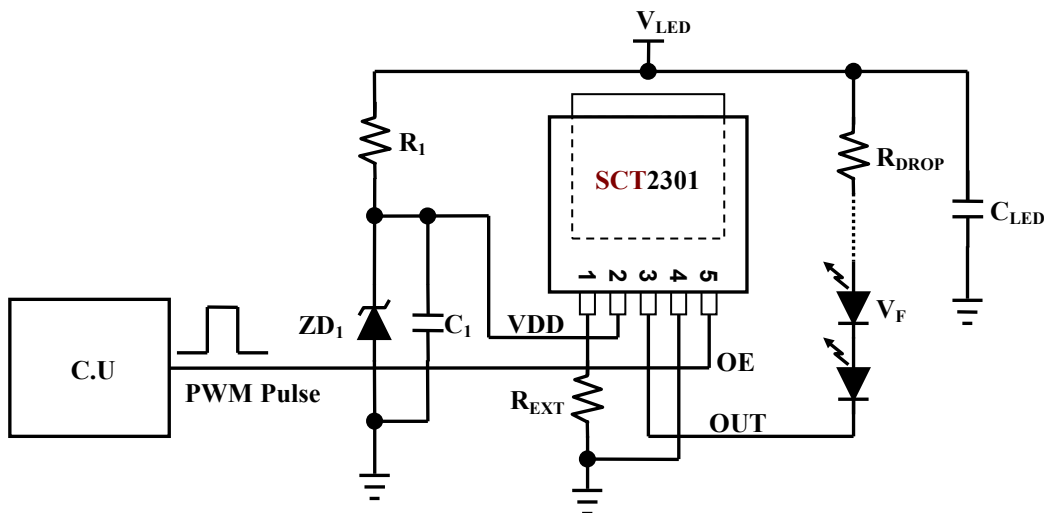
$$R_{DROP} = (V_{LED} - n * V_F - V_{DO}) / I_{OUT}$$

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

$C_1=10\mu F$ ,  $C_{LED}=470\mu F$



**(3) Lighting with dimming control**

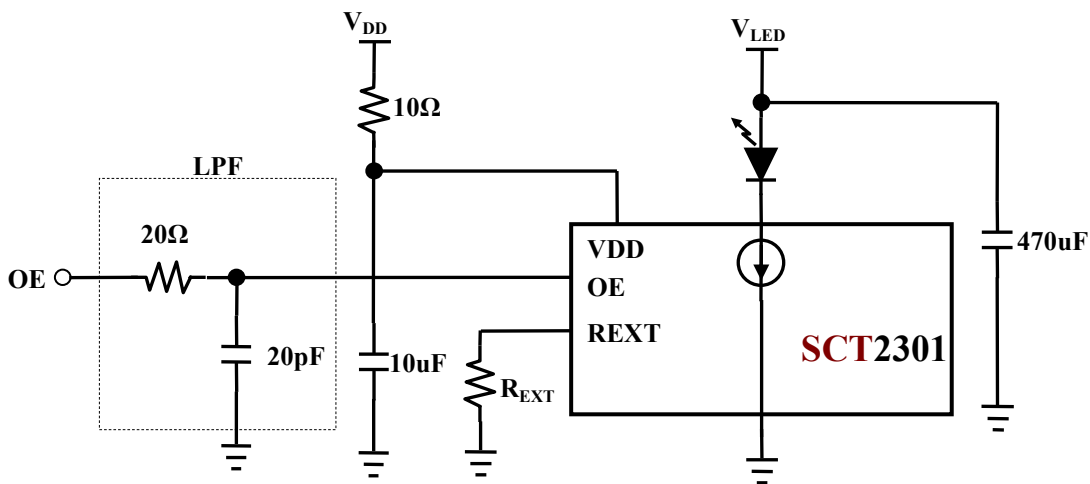


**PCB Design Considerations**

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

**Decoupling Capacitor**

Place a decoupling capacitor e.g. 10uF between VDD and GND pins of the SCT2301. Locate the capacitor as close to the SCT2301 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<sub>EXT</sub>)**

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 series in power input of the SCT2301 in conjunction with decoupling capacitor shunting the IC is recommended. Separating and feeding the LED power from another stable supply terminal V<sub>LED</sub>, furthermore adding a larger capacitor e.g. 470uF beside the LED are strongly recommended.

**EMI Reduction**

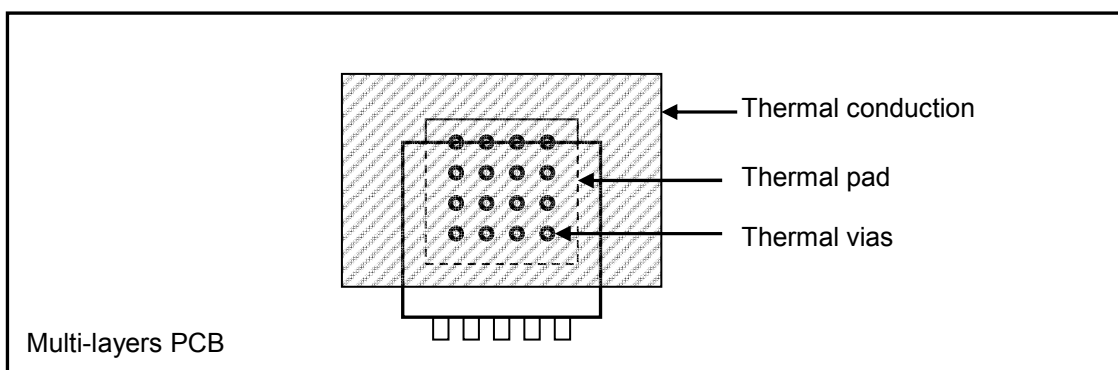
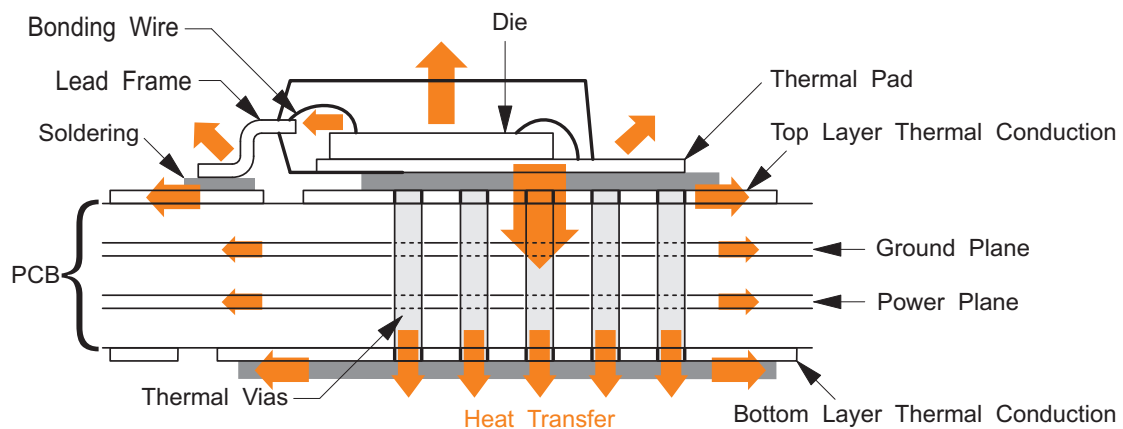
To reduce the EMI radiation from system, an economic solution RC low pass filter (LPF) is suggested to be used to lower the transient edge of OE input signal, as shown in the figure above. Using at least four layers PCB board with two interior power and ground planes is a good scheme to decrease the 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”) package beneath is connected to pin 3 of TO-252 through package lead frame internally. Pin 3 is wire-bonded to output current terminal OUT not GND pin. User should be aware of this electrical connection when designing the PCB board, and make provisions for its use. Please DO NOT connect the ground plane (with ground potential) to the SCT2301 thermal pad, otherwise the OUT pin will be grounded.

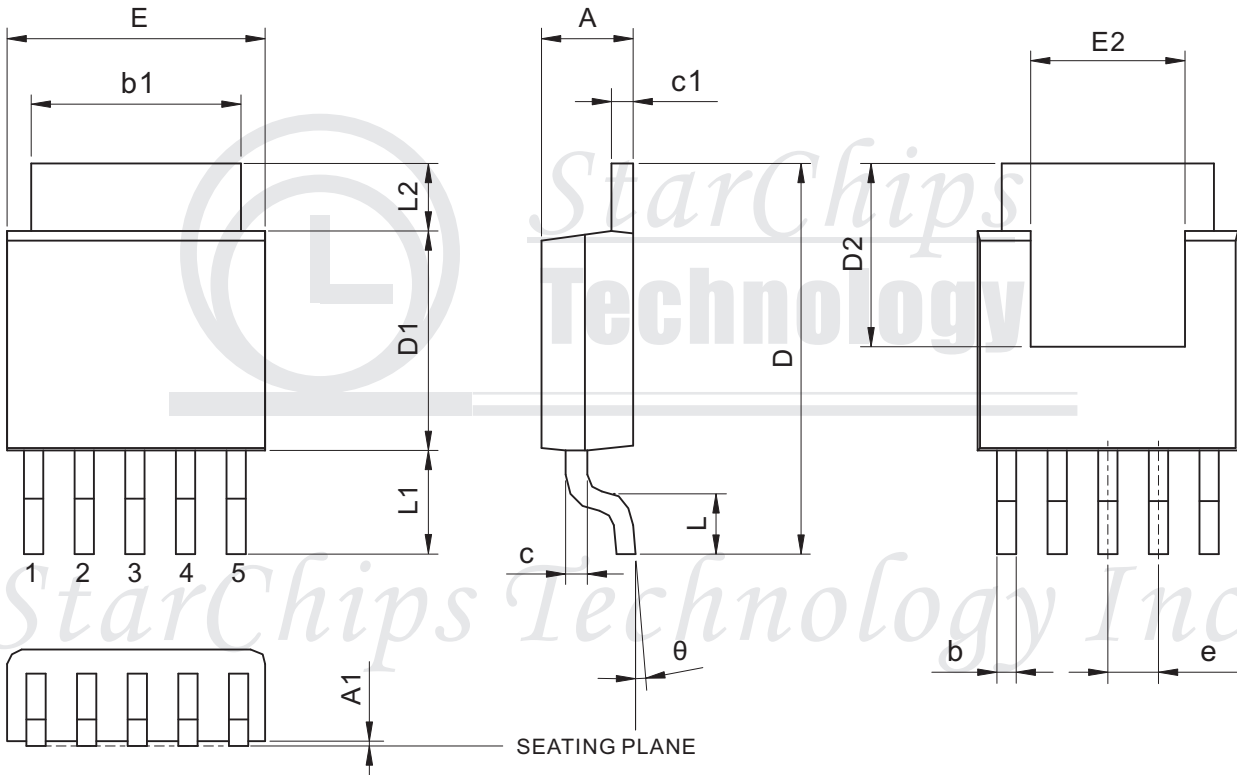
In general, the heat generated from an IC is conducted to the PCB then radiates to the ambient. Thermal pad specifically increases the maximum power dissipation capability of the IC packages. To provide lower thermal resistance from the IC to the ambient air, PCB designers should layout larger thermal conduction areas on top layer (component side) and bottom layer (solder side) 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**

**TO-252-5L** ([check up-to-date version](#))



Symbol	Dimension (mm)			Dimension (mil)		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	2.18	-	2.39	86.0	-	94.0
A1	0.00	-	0.13	0.0	-	5.0
b	0.51 TYP			20.0 TYP		
b1	5.21	-	5.46	205.0	-	215.0
c	0.46	-	0.58	18.0	-	23.0
c1	0.46	-	0.58	18.0	-	23.0
D	9.40	-	10.41	370.0	-	410.0
D1	5.33	-	5.59	210.0	-	220.0
D2	4.57	-	-	180.0	-	-
E	6.35	-	6.73	250.0	-	265.0
E2	3.81	-	-	150.0	-	-
e	1.27 BSC			50.0 BSC		
L	1.40	-	1.78	55.0	-	70.0
L1	2.67 REF			105.0 REF		
L2	1.52	-	2.03	60.0	-	80.0
θ	0°	-	4°	0°	-	4°

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

Data Sheet Version	Remark
V01_02	Updated

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