2-Channel High Constant Driver with Supply Regulation Feedback

Product Description

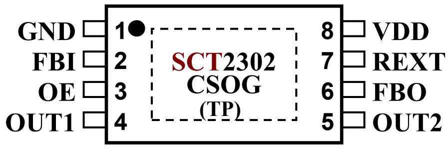
The SCT2302 is a patented logical feedback for automatic supply regulation to minimize the system power consumption. The SCT2302 is a two channels constant current driver for LED lighting. It provides the PWM dimming by sinking constant current from LED clusters with minimum pulse width 20us. The dimming control is performed by connecting the PWM signal from system control unit to OE pin. The full scale current value of each output is set by an external resistor connected to REXT pin. The SCT2302 guarantees to endure maximum DC 24V at each output port. Each output of SCT2302 can sink a constant current up to 480mA. Users can simply shunt the outputs to get higher current driver-ability in lighting high power LED.

The excellent current regulation capability allows SCT2302 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 SCT2302 is equipped with over temperature protection. The two channels IC stops driving the output while junction temperature exceeds 180°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. Furthermore, with feedback input function, the SCT2302 can be operated with cascaded operation for multiple LED drivers system.

Features

- Patented logical feedback for automatic supply regulation
- Cascaded operation for multiple LED drivers is supported
- Power-on open detection to bypass unconnected or broken LED strings
- 2 constant current sinkers with output voltage sustainable to 24V
- Excellent regulation to load, supply voltage and temperature
  Temperature regulation: ±0.01%/°C, load regulation: ±0.1%/V, line regulation: ±0.5%/V
- High current matching accuracy: ±1% between outputs, ±2% between ICs
- Constant output current : 120 – 360/480mA@3.3/5V
- Low dropout voltage 0.5V@240mA, V_{DD}=5V
- Output current is set by a single external resistor
- CMOS Schmitt trigger inputs
- Built-in thermal protection function to prevent damage from over current operation
- Package: SOP8 with thermal pad
- Applications: LED backlight global dimming control, LED lighting, LED lamp

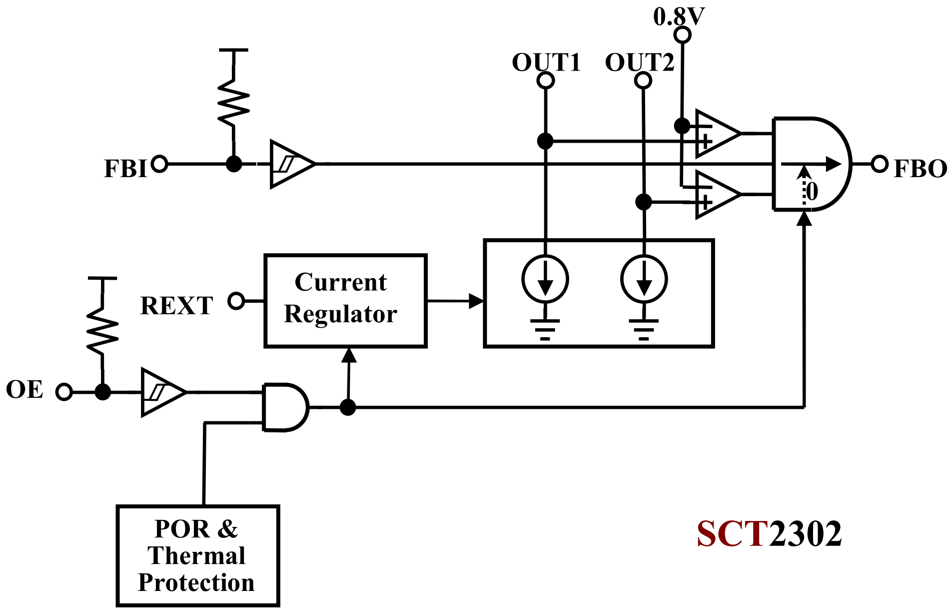
Pin Configurations



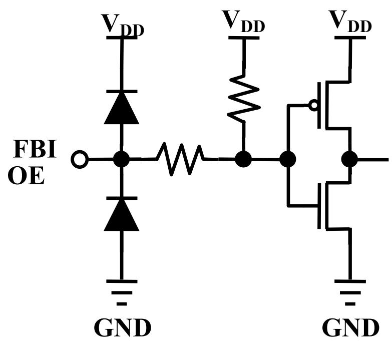
Terminal Description

Pin Name	Pin No.	I/O	Function
GND	1	-	Ground terminal
FBI	2	I	Logical feedback input, comes from FBO of another SCT2302. Refer to p.11, a RC circuit can be employed at first IC to perform the LED open detection. Please leave this pin open if feedback function is not used.
OE	3	I	Global brightness control input. All outputs are enabled when OE is high. When OE is low, all outputs are disabled. It is advised to set OE pulse width larger than 20us.
OUT[1:2]	4-5	O	Open-drain, constant-current outputs.
FBO	6	O	Logical feedback output. FBO is low when ANY of OUT is less than 0.8V, FBO is high when ALL of OUTs are greater than 0.8V. When OE = "0" FBO= FBI, thus the previous FBO information can be carried to next IC.
REXT	7	I/O	Used to connect an external resistor for setting up all output current
VDD	8	-	Supply voltage terminal
GND	TP	-	Thermal pad, please connect TP to ground.

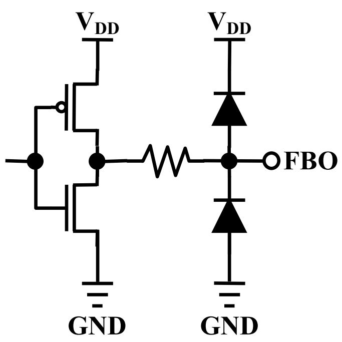
Block Diagram



Equivalent Circuits of Inputs



Equivalent Circuits of Output



Ordering Information

Part	Marking	Package	Unit per reel(pcs)
SCT2302CSOG	SCT2302CSOG	Green SOP8(150mil) with thermal pad	2500

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Maximum Ratings (T_A = 25°C)

Characteristic		Symbol	Rating	Unit
Supply voltage		V_{DD}	7.0	V
Input voltage		V_{IN}	-0.2 ~ V_{DD}+0.2	V
Output current		I_{OUT}	480	mA/Channel
Output voltage	Outputs	V_{OUT}	-0.2 ~ V_{DD}+0.2	V
	OUT1~OUT2		-0.2 ~ 24	V
Total GND terminals current		I_{GND}	1000	mA
Power dissipation	SOP8TP	P_D	2.08	W
Thermal resistance	SOP8TP	$R_{TH(j-a)}$	60	°C /W
Operating junction temperature		$T_{J(max)}$	150	°C
Operating temperature		T_{OPR}	-40~+85	°C
Storage temperature		T_{STG}	-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_A= -40 to 85°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	-	-	24	V
		Output ON	0.8[1]	-	4[2]	V
Output current	I_{OUT}	V_{DD}=3.3/5V, V_{OUT}=0.8V	120	-	300/420	mA
		V_{DD}=3.3/5V, V_{OUT}=1V			360/480[3]	mA
Input voltage	V_{IH}	FBI input signal	0.7V_{DD}	-	V_{DD}	V
	V_{IL}		0	-	0.3V_{DD}	V
	V_{IH}	OE input signals	2.3	-	V_{DD}	V
	V_{IL}		0	-	0.7	V
OE pulse width	$t_{W(OE)}$	V_{DD}=3.3V/5V	20	-	-	us

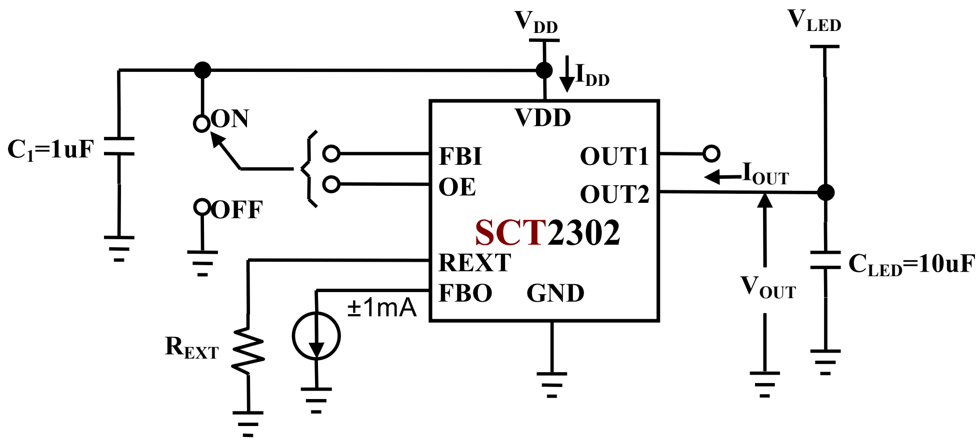
1. If V_{LED} supply voltage is under well regulation, the minimum V_{OUT} on certain output is regulated around 0.8V.
2. The maximum Vout is package thermal limited, user should keep Vout under maximum power dissipation.
3. User can drive higher I_{OUT} with higher V_{OUT} when FBO feedback control is neglected.

Electrical Characteristics (V_{DD}=3.3/5V, T_A=25°C unless otherwise noted)

Characteristic		Symbol	Conditions	Min.	Typ.	Max.	Unit
OE inputs voltage		V_{IH}	-	2.3	-	V_{DD}	V
		V_{IL}	-	0	-	0.7	V
FBI input voltage		V_{IH}	-	$0.7V_{DD}$	-	V_{DD}	V
		V_{IL}	-	0	-	$0.3V_{DD}$	V
FBO output voltage		V_{OH}	V_{DD}=3.3/5V, I_{OH}= -1mA	V_{DD}-0.4	-	-	V
		V_{OL}	V_{DD}=3.3/5V, I_{OL}=+1mA	-	-	0.4	V
Output leakage current		I_{OL}	V_{OUT}=24V	-	-	1	uA
Output current		I_{OUT}	V_{OUT}=1V, R_{EXT}=900Ω	-	190	-	mA
Current bit skew[1]		dI_{OUT1}	V_{OUT}=1V, R_{EXT}=900Ω	-	±1	±2	%
Chip skew[2]		dI_{OUT2}	V_{OUT}=1V, R_{EXT}=900Ω	-	±2	±4	%
Line regulation[3] I_{OUT} vs. V_{DD}		$\%/dV_{DD}$	3V<V_{DD}<5.5V, V_{OUT}>1V, R_{EXT}=900Ω	-	±0.5	±1	%/V
Load regulation[4] I_{OUT} vs. V_{OUT}		$\%/dV_{OUT}$	1V<V_{OUT}<4V, I_{OUT}=190mA, R_{EXT}=900Ω	-	±0.1	±0.5	%/V
Temp. regulation[5] I_{OUT} vs. T_A		$\%/dT_A$	-20°C < T_A < 80°C, I_{OUT}=120mA~420mA,V_{DD}=5V	-	±0.01	-	%/°C
Pull-up resistor		R_{UP}	FBI	-	200	-	KΩ
			OE	-	180	-	KΩ
Thermal shutdown		T_H	Junction temperature	-	180	-	°C
		T_L		-	120	-	°C
Supply current	OFF	$I_{DD(OFF)1}$	V_{DD}=3.3/5V, R_{EXT}=Open, OUT[1:2]=OFF	-	3/4	6	mA
		$I_{DD(OFF)2}$	V_{DD}=3.3/5V, R_{EXT}=900Ω, OUT[1:2]=OFF	-	6/7	9	
	ON	$I_{DD(ON)}$	V_{DD}=3.3/5V, R_{EXT}=900 Ω, OUT[1:2]=ON	-	8/10	12	

1. Bit skew=(I_{OUT}-I_{AVG}) / I_{AVG}, where I_{AVG}=($I_{OUT(max)}$+ $I_{OUT(min)}$)/2
2. Chip skew=(I_{AVG}-I_{CEN}) / I_{CEN}*100(%), where I_{CEN} is the statistics distribution center of output currents.
3. 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} / (5.5V-3V)*100(%/V)
4. Load regulation=[I_{OUT}(V_{OUT}=4V)-I_{OUT}(V_{OUT}=1V)] / {[I_{OUT}(V_{OUT}=4V)+I_{OUT}(V_{OUT}=1V)]/2} / (4V-1V)*100(%/V)
5. Temperature regulation=[I_{OUT}(T_A=80°C)-I_{OUT}(T_A=-20°C)] / {[I_{OUT}(T_A=80°C)+I_{OUT}(T_A=-20°C)]/2} / (80°C+20°C)*100(%/°C)

Test Circuit for Electrical Characteristics

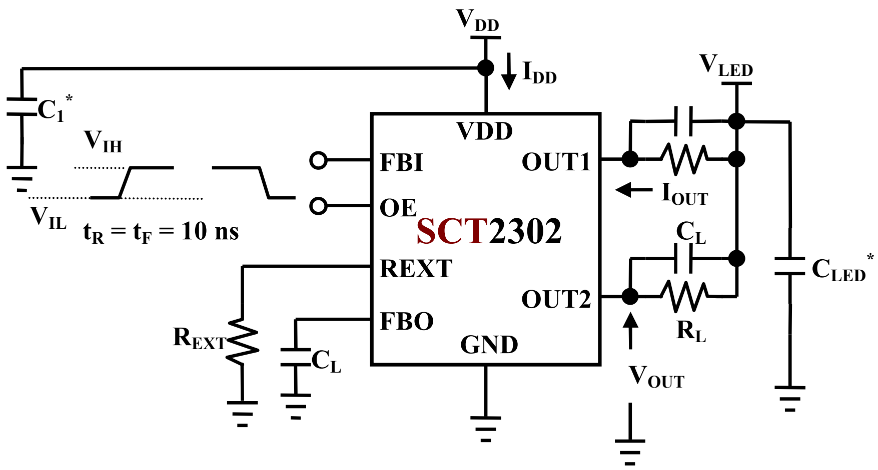


**Place C_1/C_{LED} as close to IC VDD/OUT pin(not supply source) as possible.*

Switching Characteristics (T_A=25°C unless otherwise noted)

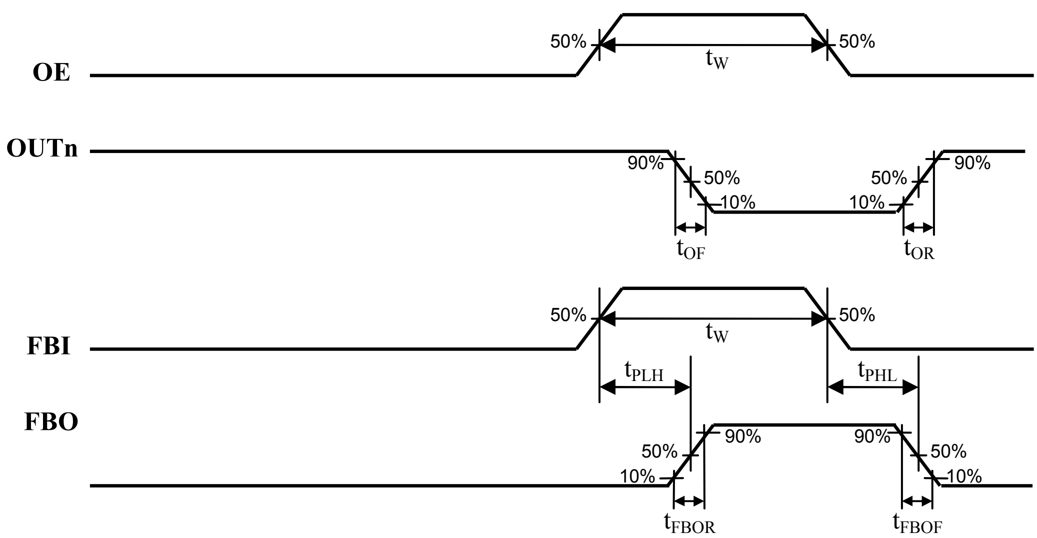
Characteristic		Symbol	Conditions	Min.	Typ.	Max.	Unit
Propagation delay time ("L" to "H")	FBI - FBO	t_{PLH}	V_{DD} = 3.3/5V V_{LED} = 5V V_{IH} = V_{DD} V_{IL}= GND R_{EXT} = 900Ω R_L = 20Ω C_L = 10pF C_1 = 1uF C_{LED} = 100uF		40	-	ns
Propagation delay time ("H" to "L")	FBI - FBO	t_{PHL}		-	40	-	ns
FBO updated freqeuncy		f_{FBO}		-	120/100	-	KHz
FBO output rise time		t_{FBOR}		-	20	-	ns
FBO output fall time		t_{FBOF}		-	20	-	ns
OE Pulse width		t_W		20	-	-	us
Output rise time of I_{OUT}		t_{OR}		-	80	-	ns
Output fall time of I_{OUT}		t_{OF}		-	80	-	ns

Test Circuit for Switching Characteristics



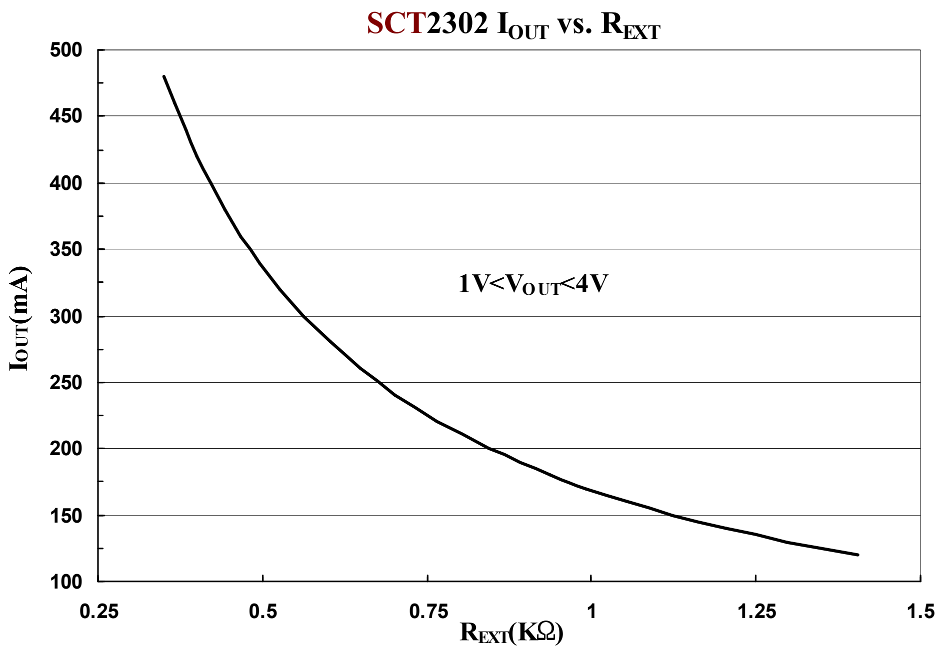
Place C_1/C_{LED} as close to IC VDD/OUT pin(not supply source) as possible.

Timing Waveform



Adjusting Output Current

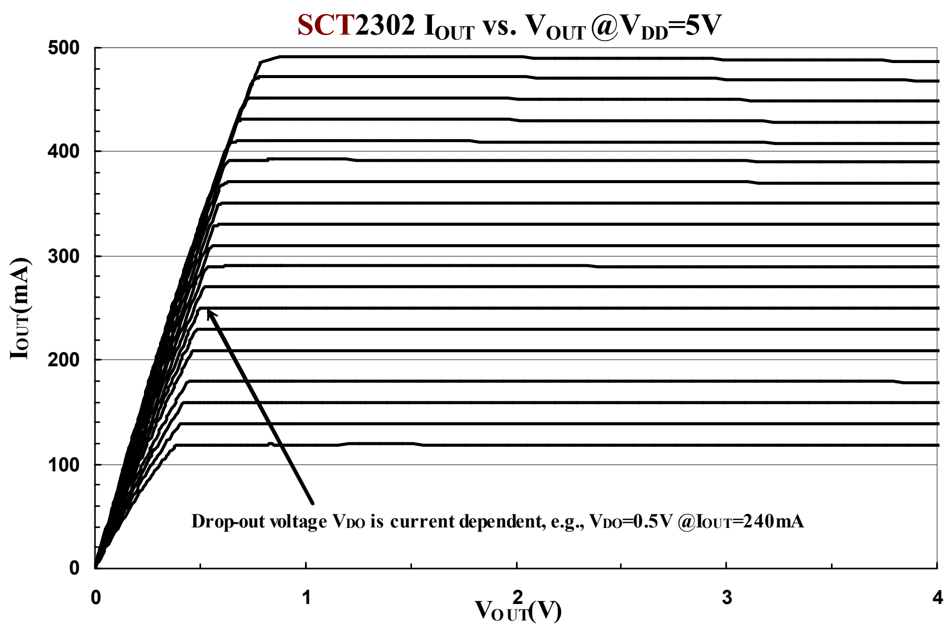
The SCT2302's output current (I_{OUT}) are set by one external resistor at pin REXT. The output current I_{OUT} versus resistance of R_{EXT} is shown as the following figure.

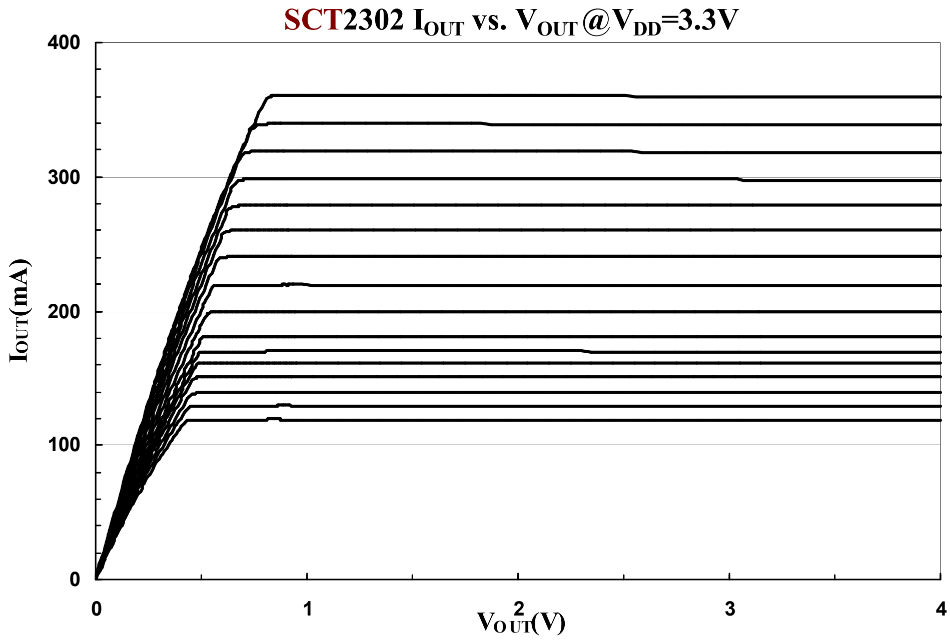


Furthermore, when SCT2302's output voltage is set between 1 Volt and 4 Volt, the output current can be estimated approximately by: $I_{OUT} = 272(630 / R_{EXT})$ (mA) (chip skew < ±4%). Thus the output current is set to be about 190mA at R_{EXT} = 900Ω.

Output Characteristics

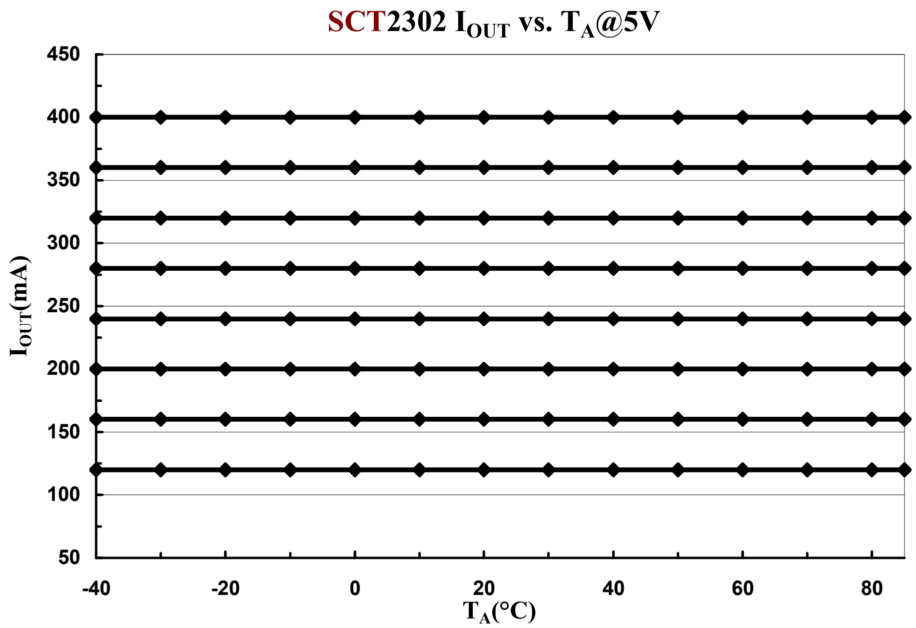
The current characteristic of output curve is flat. The output current can be kept constant regardless of the variations of LED forward voltage when $V_{OUT} > V_{DO}$. The relationship between I_{OUT} and V_{OUT} is shown below. The output voltage should be kept as low as possible to prevent the SCT2302 from being overheated.





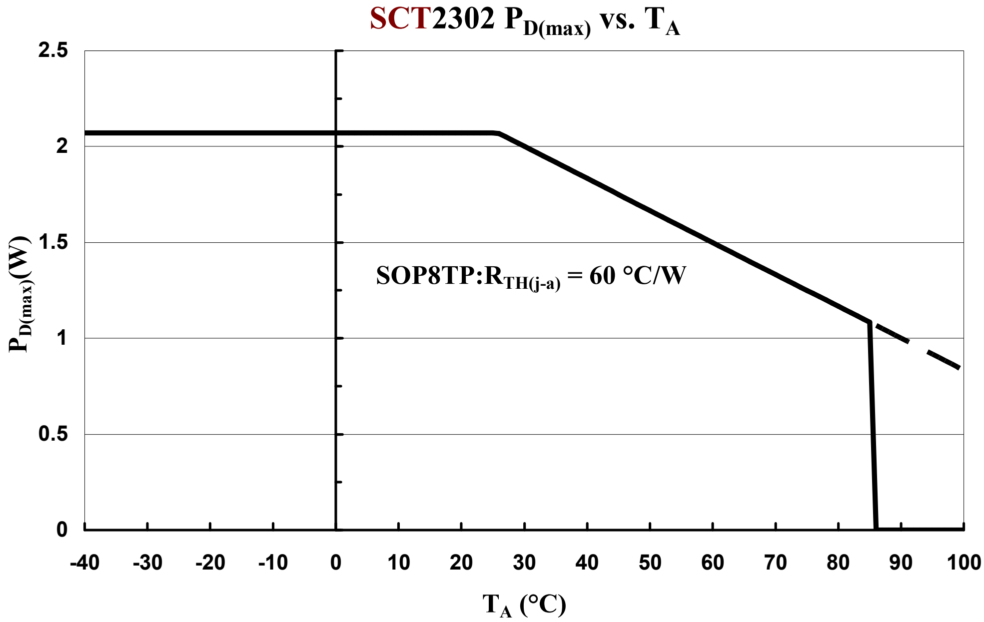
Excellent Temperature Regulation

The constant current driver requires not only the characteristics of supply and load voltage independence, but also temperature invariance. A well thermal stable reference circuit is designed within the SCT2302. Users can get the stable output current over recommended current range I_{OUT}=120mA~420mA with ambient temperature (T_A) widely varying from -40°C to 85°C.



Power Dissipation

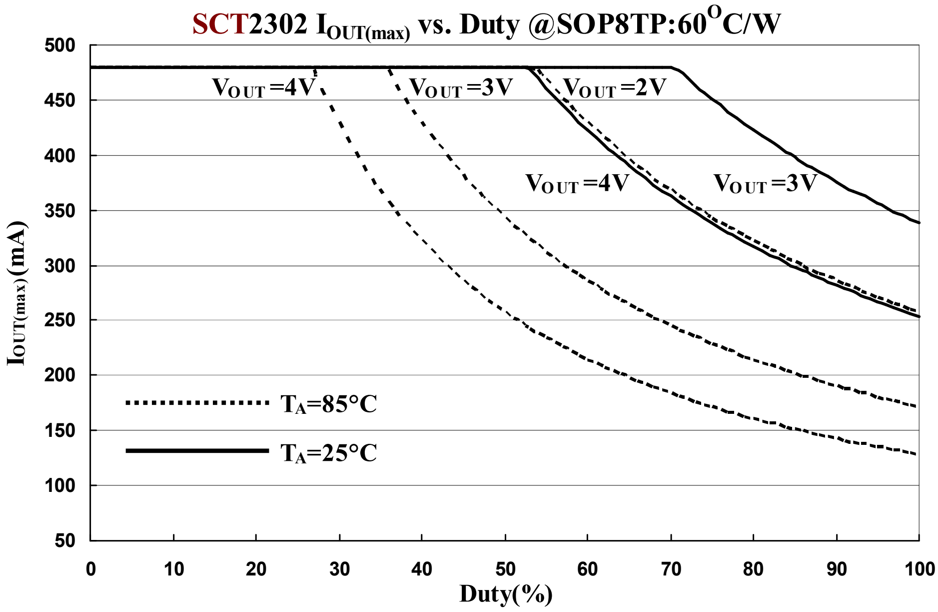
The maximum power dissipation ($P_{D(max)}$) of a semiconductor chip varies with different packages and ambient temperature. It's determined as $P_{D(max)}=(T_{J(max)} - T_A)/R_{TH(j-a)}$ where $T_{J(max)}$: maximum chip junction temperature is usually considered as 150°C, T_A: ambient temperature, $R_{TH(j-a)}$: 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 SCT2302.



Limitation on Maximum Output Current

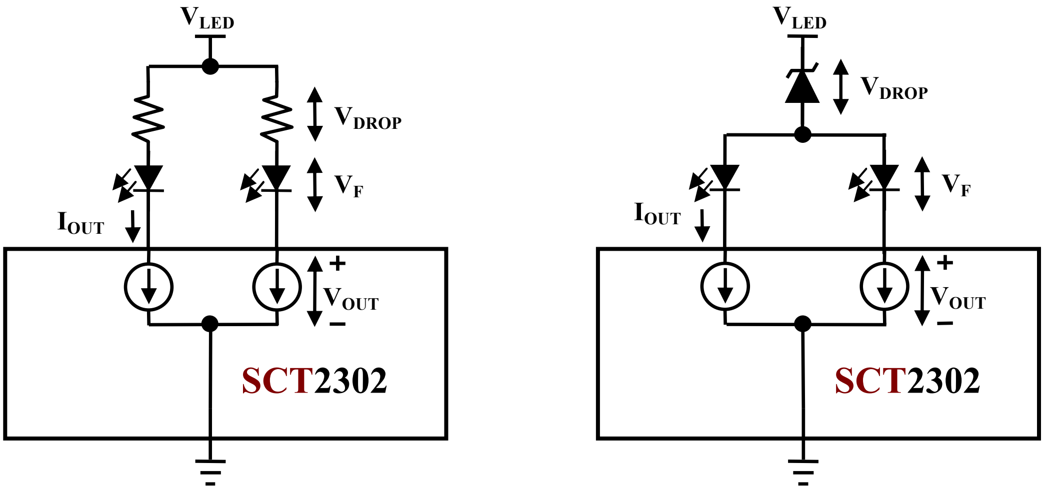
The maximum output current vs. duty cycle is estimated by:

$I_{OUT(max)}=(((T_{J(max)}-T_A)/R_{TH(j-a)})-(V_{DD}*I_{DD}))/V_{OUT}/Duty/N$ where $T_{J(max)}$=150°C, N=2(all ON)



Load Supply Voltage (VLED)

The SCT2302 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 SCT2302. 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

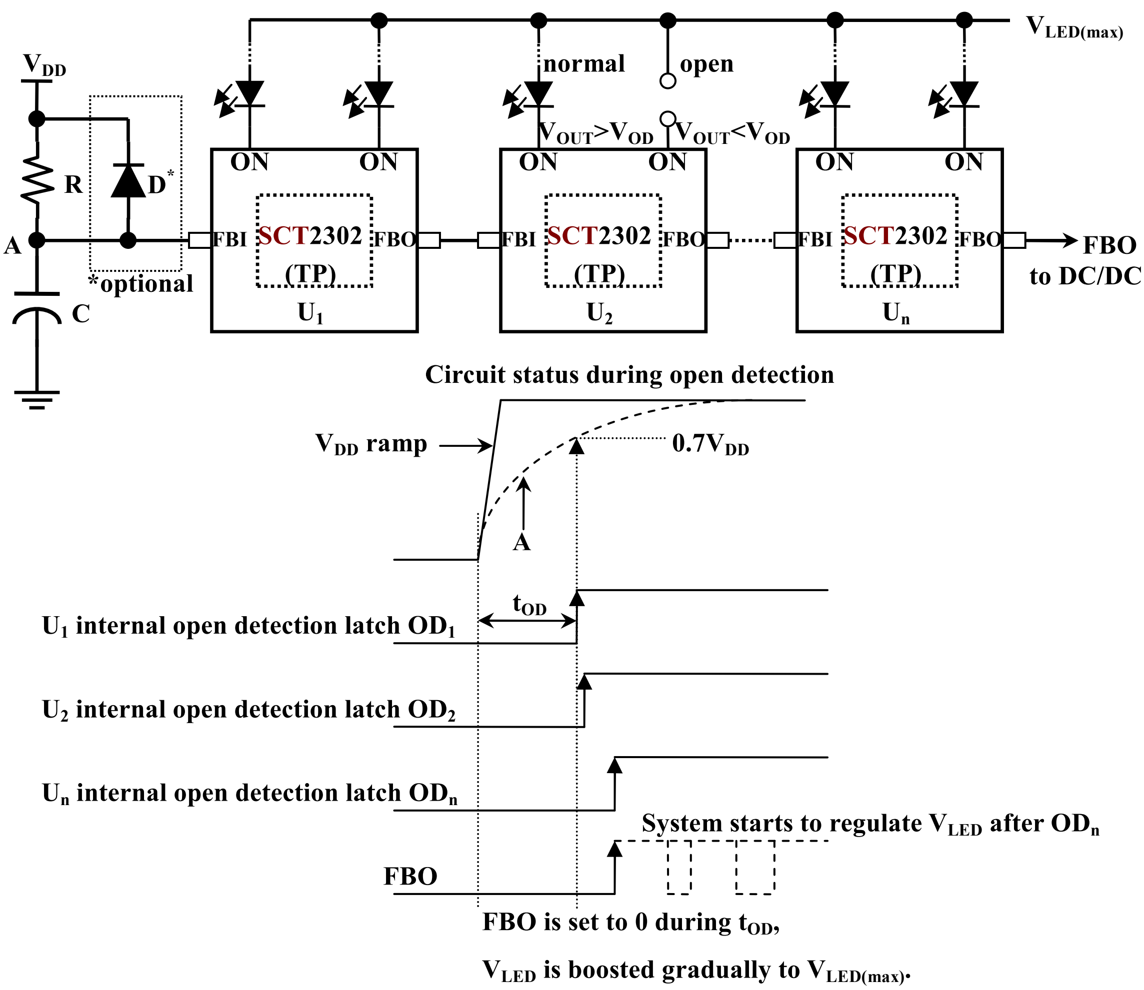
The SCT2302 contains thermal shutdown scheme to prevent damage from being over heated. The internal thermal sensor turns off all outputs when the die temperature exceeds +180°C. The outputs are enabled again when the die temperature drops below +120°C. During the thermal shutdown process, the LEDs look blinking since it is turned OFF then ON periodically.

Power-on Open Detection

To prevent system feedback from abnormal operation when LED strings are not connected to driver, the SCT2302 performs one-time open detection when driver is powered on. User should set sufficient open detection time t_{OD} by applying proper RC delay setting at FBI pin of first IC U1. The scheme of power-on open detection is described as below:

When system is powering on, outputs of each driver are mandatory tuned on and FBO is forced to 0 for a period of time. The time determined by point A is reached to around $0.7V_{DD}$. The V_{LED} should be boosted gradually to $V_{LED(max)}$ if DC/DC is well operated and RC time constant is sufficient. Once the LED string is open, the V_{OUT} is generally less than V_{OD}(~0.3V) with output ON condition. At $t=t_{OD}$, the internal OD1 rising edge of first IC will latch the status of IC1's output port. After IC1 OD (open detection) code is latched, the FBO is transmitted to next IC, then IC2 starts to detect its OD code according to IC2's output status. The same detection is applied to subsequent ICs, until all ICs are performed open detection. The open ports will not be taken into consideration on LED supply regulation.

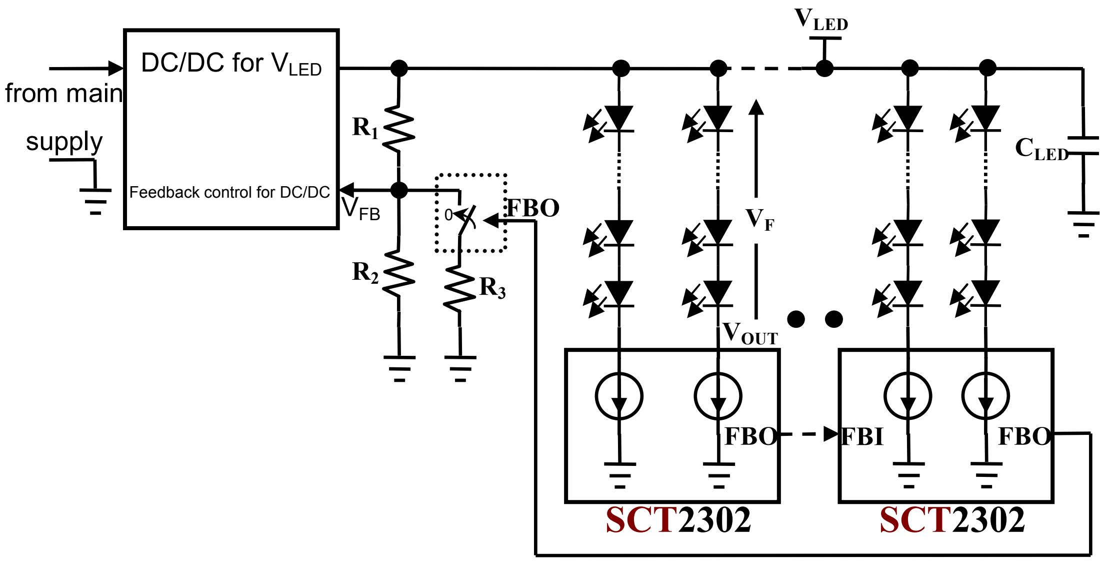
The t_{OD} time must be greater than the time for V_{LED} to reach to $V_{LED(max)}$, yet not too long to induce thermal shutdown happened. As a rule of thumb, RC time constant of around 0.1s with, e.g., R=22K, C=4.7u is usually sufficient for generic DC/DC converter system. Please adapt RC according to your system. Furthermore, an optional fast discharge path by adding a diode to V_{DD} could also be considered.



Typical Application

V_{LED} Supply Regulation Feedback

In order to reduce the total system power dissipation due to LED V_F skew, the SCT2302 incorporates feedback function to detect the minimum V_{OUT}, thus the minimum required supply voltage V_{LED} for the LED strings can be automatically regulated. The concept shown below can be applied to off-the-shelf DC/DC converter or LDO with adjustable output voltage.



Starchips' patented multiple chips logical feedback

The function of this circuit is as follows:

When any of V_{OUT} is less than internal setting voltage 0.8V (the voltage is applicable for most current range), the last cascaded FBO to DC/DC is set to '0'. The turn on switch will decrease the equivalent R2, the VFB is pulled down toward lower voltage. The DC/DC compensates the LED supply voltage by increasing the voltage on V_{LED}. Users should be aware of the regulation loop for stability issue. Otherwise, the LED may flick due to, e.g., larger V_{LED} ripple or noise induced DC/DC entering protection mode which takes time to re-start the control loop. When designing the resistors R_1~R_3, user should consider the V_F skew distribution as well as 0.8V the SCT2302 driver needs:

$V_{LED(min)} = V_{REF}*(1+R_1/R_2)$

$V_{LED(max)} = V_{REF}*(1+R_1/(R_2//R_3))$, where V_{REF} is reference voltage of DC/DC converter.

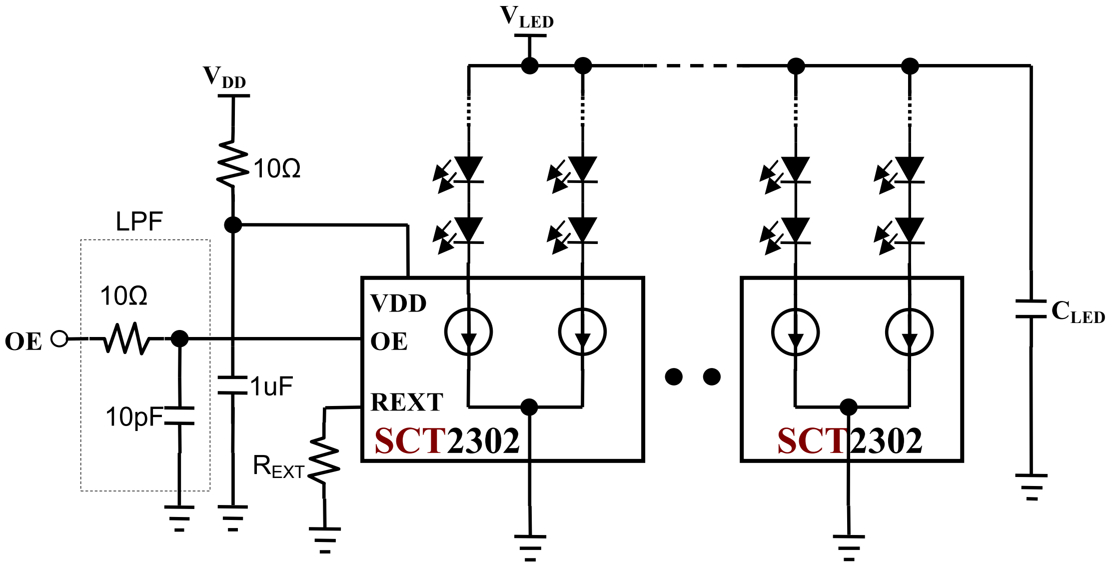
Therefore, the optimum V_{LED} is automatically regulated between $V_{LED(min)}$~$V_{LED(max)}$ according to LED string. Even if the LED strings are broken or some LEDs are shorted, the supply always stays within the limits. Since the total V_F of each LED string is different and all LED strings load are tied to the same supply voltage V_{LED}, thus $V_{OUT(min)}=V_{LED}-V_{F(max)}$ and $V_{OUT(max)}=V_{LED}-V_{F(min)}$. If V_F skew is too large, an over-heated situation occurs, therefore thermal shutdown happens.

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 SCT2302. Locate the capacitor as close to the SCT2302 as possible. The necessary capacitance depends on the LED load current, OE 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 as possible to avoid the noise influence.

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 SCT2302 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

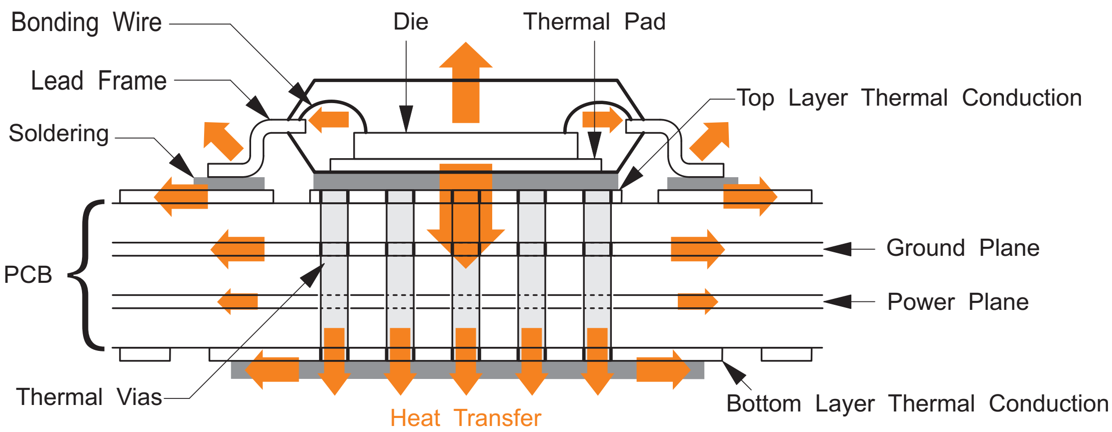
To reduce the EMI radiation from system, an economical solution of RC low pass filter (LPF) is suggested to be used to lower the transient edge of clock input signal, as shown in the figure above. Using at least four layers PCB board with two interior power and ground planes is a good scheme to decrease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

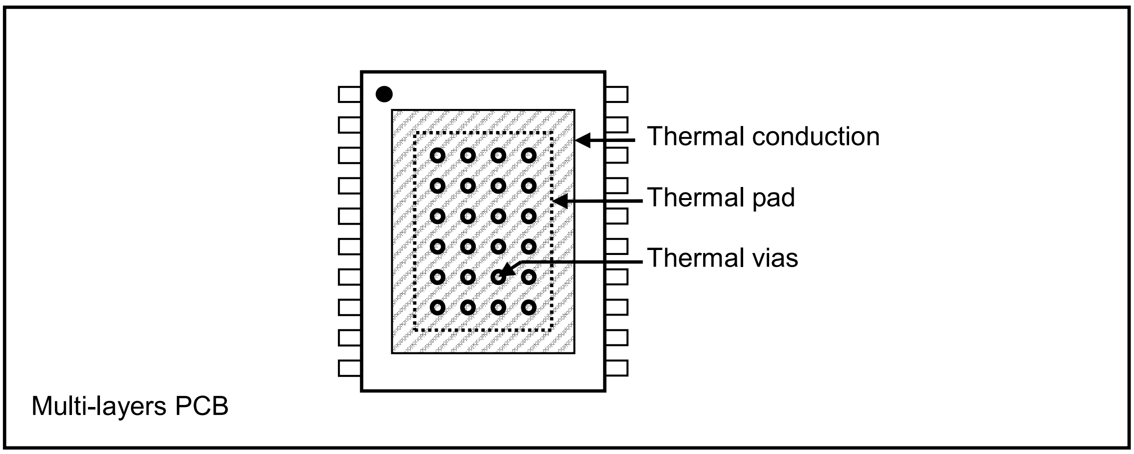
Thermal Pad Consideration

The "thermal pad" (also named as "exposed pad") 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.

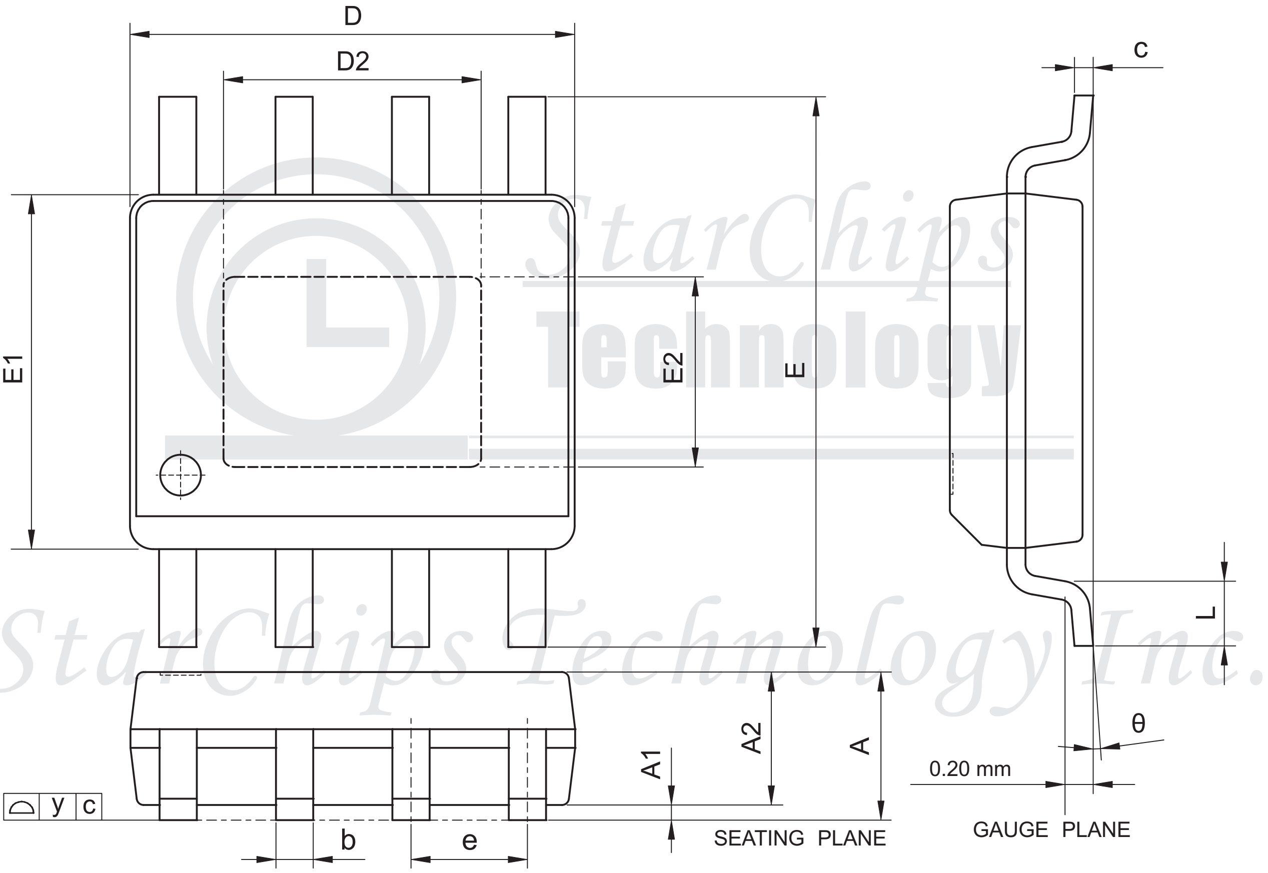
When making the solder paste screen, an opening should be created for the thermal pad. This way the thermal pad can be electrically and thermally connected to the PCB. As the thermal pad is soldered on copper polygon, the chance of inadvertently shorting the thermal pad to traces routed underneath it 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_01	Initial release

Information provided by StarChips Technology is believed to be accurate and reliable. Application circuits shown, if any, are typical examples illustrating the operation of the devices. Starchips can not assume responsibility and any problem raising out of the use of the circuits. Starchips reserves the right to change product specification without prior notice.