8-Output, 8-bit PWM LED Driver with Global Brightness Control

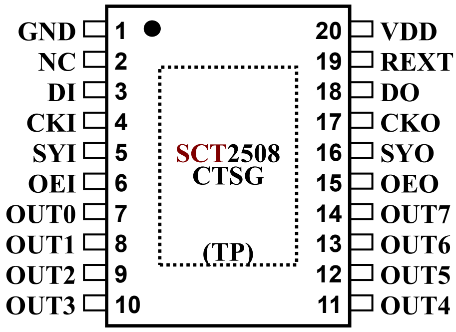
Product Description

The SCT2508 is a patented SPI+™ interface design for simplicity of backlight local dimming control. It's an 8-bit constant current sink driver incorporating shift registers and data latches for SPI interface. The patented design is employee to instantly real-time updated dot luminance data without waiting subsequent data are fully filled in display frame. The maximum current value of all 8 outputs is determined by an external resistor and is adjustable with the OEI signal. Besides, the output current value can be individually controlled with 256 steps. In application of LCD backlight, the SCT2508s can be daisy chained to drive LED blocks with local dimming function in sequence of scanning images. A synchronous signal (SYNC) initiated from controller is used to identify a frame start. The SCT2508 receiving the SYNC signal from the SYI pin has the right to download the PWM data bytes. Once the 8 PWM data are placed into the 8 data latches, the output currents are changed and the SYNC signal is passed to the next SCT2508 via the SYO pin. Thus the brightness of each LED block is adjusted in proper status and LEDs are lit according to the luminance of each block's image.

Features

- Patented SPI+™ interface for simplicity of local dimming control
- Real-time dot correction of luminance
- Backlight local dimming controller available
- Daisy chained SPI interface by SYI and SYO
- 5 MHz built in PWM clock, 8 individual 8-bit PWM controlled outputs
- 8 robust constant current sinker with LED power-supply voltage up to 24V
- Excellent regulation to load, supply voltage and temperature
  Temperature regulation: ±0.005%/°C,
  Load regulation: ±0.1%/V
  Line regulation: ±0.5%/V
- High current matching accuracy: ±1% between outputs, ±2% between ICs
- Fine grayscale response with 120ns PWM pulse width
- Buffered outputs to regenerate input signals for cascaded operation
- Output current is set by a single external resistor and OEI programmable outputs
- Constant output current : 3 – 30/45mA@3.3/5V
- Low dropout voltage 0.5V@20mA, V_{DD}=5V
- CMOS Schmitt trigger inputs
- Built-in power on reset(POR) circuit forces all the outputs ON while power on
- Built-in thermal protection function to prevent damage from over current operation
- Package: TSSOP20
- Applications: Local dimming LED backlight

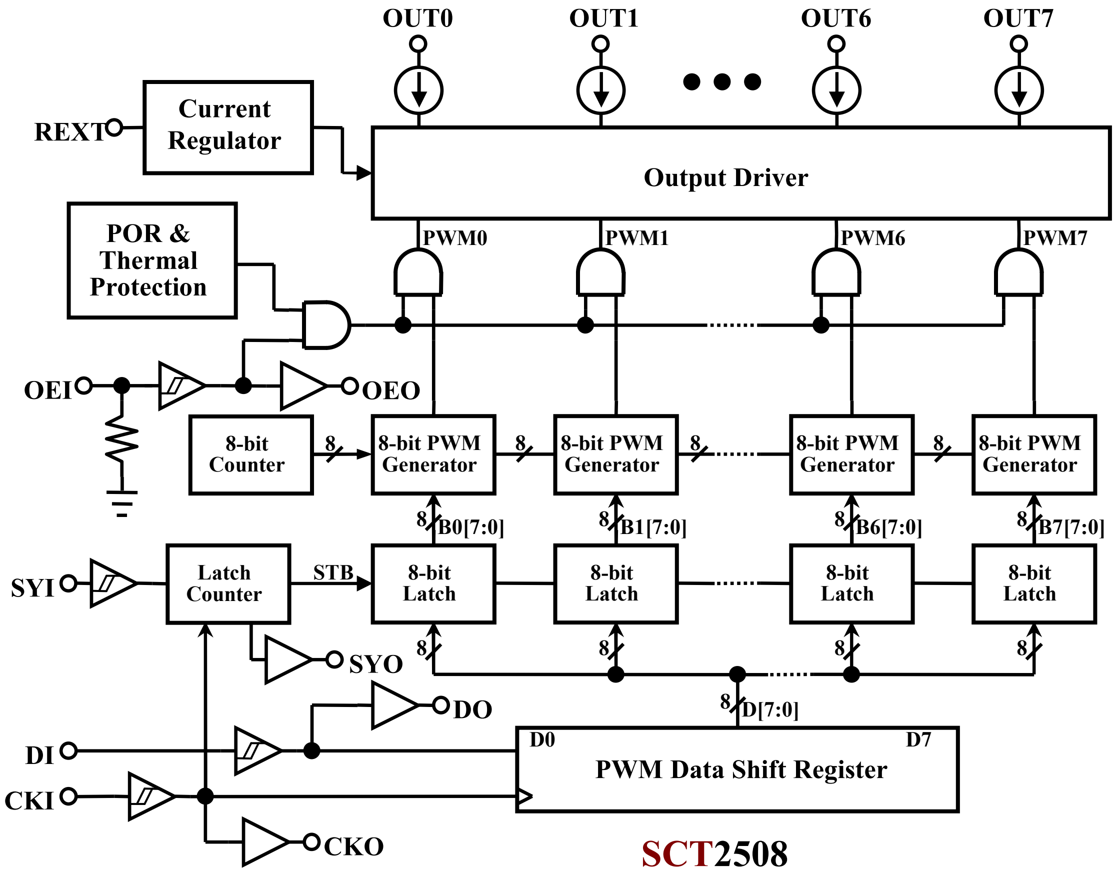
Pin Configurations



Terminal Description

Pin Name	Pin No.	I/O	Function
GND	1	-	Ground terminal
NC	2	-	No connection
DI	3	I	Serial input of data shift register.
CKI	4	I	Clock input of shift register, data is sampled at the rising edge of CLK.
SYI	5	I	Synchronous signal, daisy chain input terminal. When power on, the default status of SYI is low. Only the rising edge of SYI causes the SCT2508 begin to latch data byte form 8-bit shift register.
OEI	6	I	Global brightness control input. All outputs are enabled when OEI is high. When OEI is high, all outputs are turned on or off by their PWM data that starts the built-in 8-bit PWM function. When OEI is low, all outputs are disabled.
OUT[0:7]	7-14	O	Open-drain, constant-current outputs.
OEO	15	O	Buffered output of OEI
SYO	16	O	Synchronous signal, daisy chain output terminal.
CKO	17	O	Buffered output of CKI
DO	18	O	Buffered output of DI
REXT	19	I/O	Used to connect an external resistor for setting up all output current
VDD	20	-	Supply voltage terminal
TP	-	-	Thermal pad, no connection(Connecting it to ground is suggested)

Block Diagram

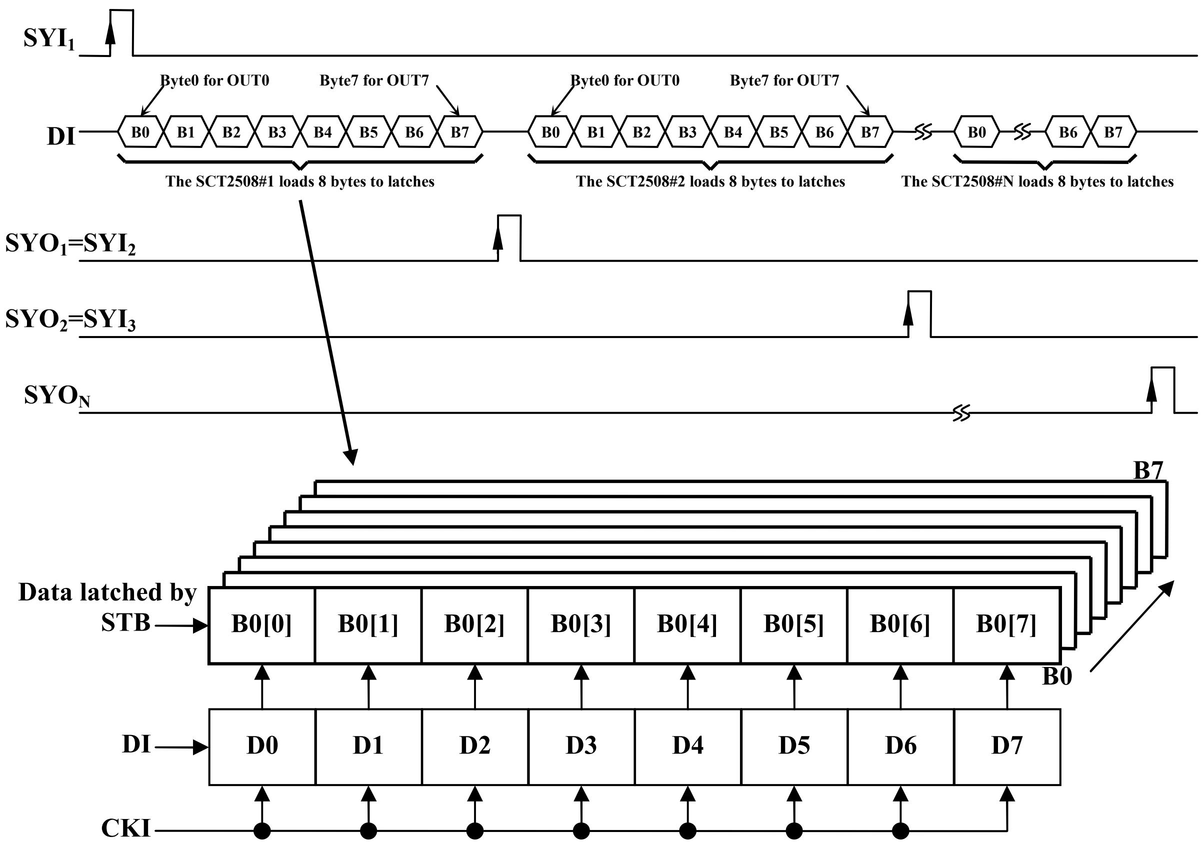


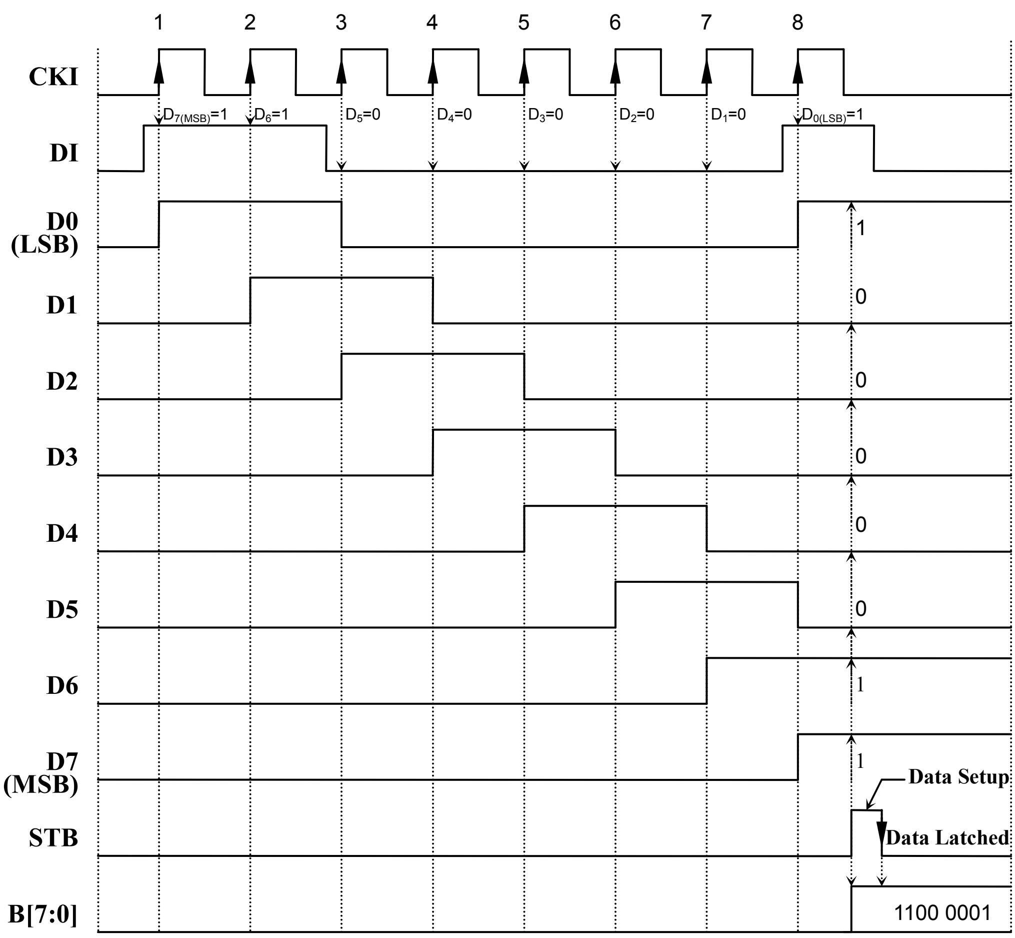
Truth Table

CKI	DI		D[0:7] of Register	B0[7:0]	B1[7:0]	B2[7:0]	B3[7:0]	..B7[7:0]
8*↑	D_{0X}	D_{07-00}	$D_{00}D_{01}D_{02}D_{03}D_{04}D_{05}D_{06}D_{07}$	D_{07-00}	NC	NC	NC	NC
↑	D_{1X}	D_{17}	$D_{17}D_{00}D_{01}D_{02}D_{03}D_{04}D_{05}D_{06}$	NC*	NC	NC	NC	NC
↑		D_{16}	$D_{16}D_{17}D_{00}D_{01}D_{02}D_{03}D_{04}D_{05}$	NC	NC	NC	NC	NC
↑		D_{15}	$D_{15}D_{16}D_{17}D_{00}D_{01}D_{02}D_{03}D_{04}$	NC	NC	NC	NC	NC
↑		D_{14}	$D_{14}D_{15}D_{16}D_{17}D_{00}D_{01}D_{02}D_{03}$	NC	NC	NC	NC	NC
↑		D_{13}	$D_{13}D_{14}D_{15}D_{16}D_{17}D_{00}D_{01}D_{02}$	NC	NC	NC	NC	NC
↑		D_{12}	$D_{12}D_{13}D_{14}D_{15}D_{16}D_{17}D_{00}D_{01}$	NC	NC	NC	NC	NC
↑		D_{11}	$D_{11}D_{12}D_{13}D_{14}D_{15}D_{16}D_{17}D_{00}$	NC	NC	NC	NC	NC
↑		D_{10}	$D_{10}D_{11}D_{12}D_{13}D_{14}D_{15}D_{16}D_{17}$	NC	D_{17-10}	NC	NC	NC
↑	D_{2X}	D_{27}	$D_{27}D_{10}D_{11}D_{12}D_{13}D_{14}D_{15}D_{16}$	NC	NC	NC	NC	NC
↑		D_{26}	$D_{26}D_{27}D_{10}D_{11}D_{12}D_{13}D_{14}D_{15}$	NC	NC	NC	NC	NC
↑		D_{25}	$D_{25}D_{26}D_{27}D_{10}D_{11}D_{12}D_{13}D_{14}$	NC	NC	NC	NC	NC
↑		D_{24}	$D_{24}D_{25}D_{26}D_{27}D_{10}D_{11}D_{12}D_{13}$	NC	NC	NC	NC	NC
↑		D_{23}	$D_{23}D_{24}D_{25}D_{26}D_{27}D_{10}D_{11}D_{12}$	NC	NC	NC	NC	NC
↑		D_{22}	$D_{22}D_{23}D_{24}D_{25}D_{26}D_{27}D_{10}D_{11}$	NC	NC	NC	NC	NC
↑		D_{21}	$D_{21}D_{22}D_{23}D_{24}D_{25}D_{26}D_{27}D_{00}$	NC	NC	NC	NC	NC
↑		D_{20}	$D_{20}D_{21}D_{22}D_{23}D_{24}D_{25}D_{26}D_{27}$	NC	NC	D_{27-20}	NC	NC
8*↑	D_{3X}	D_{37-30}	$D_{30}D_{31}D_{32}D_{33}D_{34}D_{35}D_{36}D_{26}$	NC	NC	NC	D_{37-30}	NC
..8*↑	..D_{7X}	..D_{77-70}	$D_{70}D_{71}D_{72}D_{73}D_{74}D_{75}D_{76}D_{77}$	NC	NC	NC	NC	D_{77-70}
↓	D_X		$D_{70}D_{71}D_{72}D_{73}D_{74}D_{75}D_{76}D_{77}$	NC	NC	NC	NC	NC

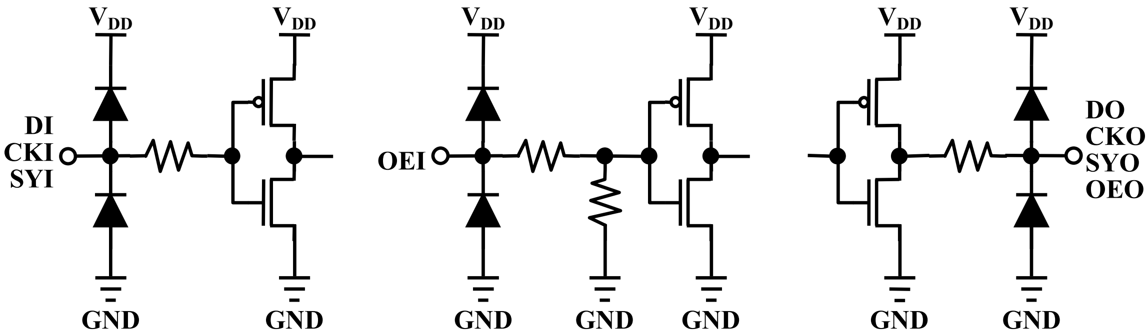
*NC: No Change, D_{1X} e.g D_{17}/D_{10} means the MSB/LSB of byte1 data.

Timing Diagram





Equivalent Circuits of Inputs/Outpus



Ordering Information

Part	Marking	Package	Unit per reel(pcs)
SCT2508CTSG	SCT2508CTSG	Green TSSOP20 with Thermal pad	2500

StarChips Technology, Inc.

4F, No.5, Technology Rd., Science-Based Industrial Park, Hsin-Chu, Taiwan, R.O.C.

Tel : +886-3-577-5767 Ext.555,

Fax: +886-3-577-6575,

E-mail : service@starchips.com.tw

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}	60	mA/Channel
Output voltage	Outputs	V_{OUT}	-0.2 ~ V_{DD}+0.2	V
	OUT0~OUT7		-0.2 ~ 24	V
Total GND terminals current		I_{GND}	480	mA
Power dissipation	TSSOP20	P_D	1.39	W
Thermal resistance	TSSOP20	$R_{TH(j-a)}$	90	°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)

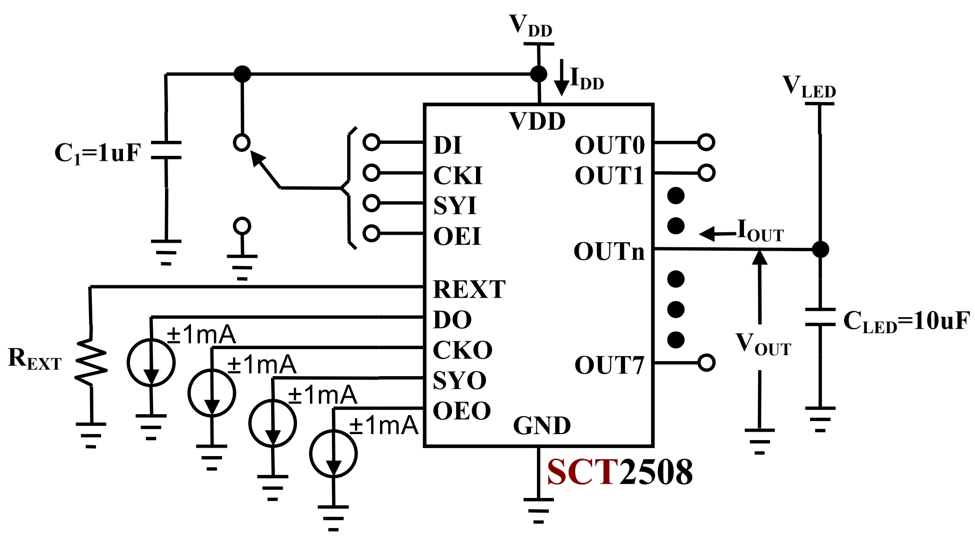
Characteristic	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply voltage	V_{DD}	-	3	-	5.5	V
Output voltage	V_{OUT}	Output OFF	-	-	24	V
		Output ON	-	1	4	V
Output current	I_{OUT}	V_{DD}=3.3/5V	5	-	30/45	mA
Input voltage	V_{IH}	Input signals	0.7V_{DD}	-	V_{DD}	V
	V_{IL}	Input signals	0	-	0.3V_{DD}	V
OEI pulse width	$t_{W(OEI)}$	V_{DD}=3.3V/5V	120	-	-	ns

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

Characteristic		Symbol	Conditions	Min.	Typ.	Max.	Unit
Digital input voltage (DI/CKI/SYI/OEI)		V_{IH}	-	$0.7V_{DD}$	-	V_{DD}	V
		V_{IL}	-	0	-	$0.3V_{DD}$	V
Digital output voltage (DO/CKO/SYO/OEO)		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	-	-	0.5	uA
Output current		I_{OUT}	V_{OUT}=1V, R_{EXT}=900Ω	-	21	-	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}=21mA, 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}=5mA~45mA, V_{DD}=5V	-	±0.005	-	%/°C
Pull-down resistor		R_{DOWN}	OEI	-	500	-	KΩ
Thermal shutdown		T_H	Junction temperature	-	160	-	°C
		T_L		-	110	-	°C
Supply current	OFF	$I_{DD(OFF)1}$	V_{DD}=3.3/5V, R_{EXT}=Open, OUT[0:7]=OFF	-	3	4	mA
		$I_{DD(OFF)2}$	V_{DD}=3.3/5V, R_{EXT}=900Ω, OUT[0:7]=ON	-	6	8	mA
	ON	$I_{DD(ON)}$	V_{DD}=3.3/5V, R_{EXT}=900 Ω, OUT[0:7]=ON	-	8/9	11	mA

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

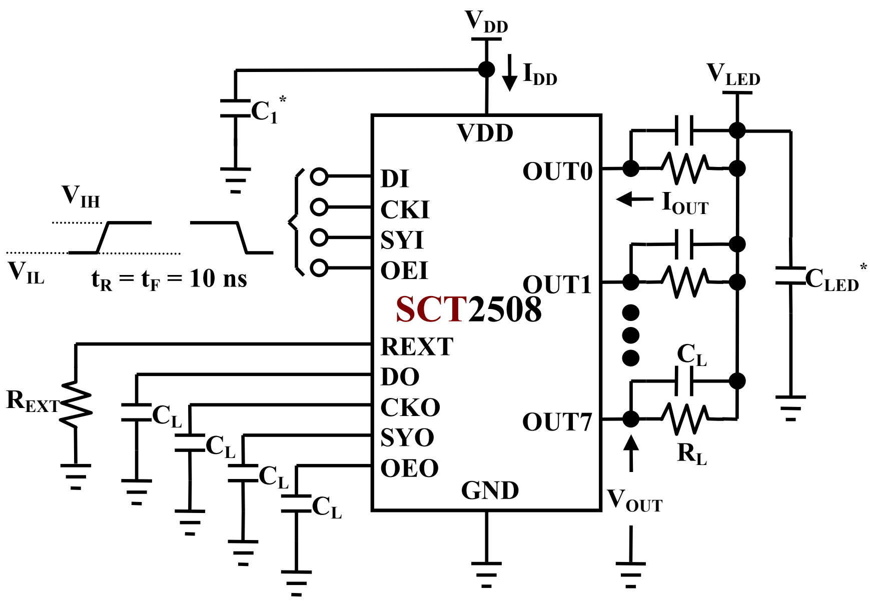


Switching Characteristics (T_A=25°C unless otherwise noted)

Characteristic		Symbol	Conditions	Min.	Typ.	Max.	Unit
Propagation delay time ("L" to "H")	CKI - SYO	t_{PLH}	V_{DD} = 3.3/5V, V_{LED} = 5V, V_{IH} = V_{DD}, V_{IL}= GND, R_{EXT} = 900Ω, R_L = 180Ω, C_L = 10pF, C_1 = 1uF, C_{LED} = 100uF	-	15/10	20	ns
	CKI - CKO	t_{PLH1}		-	15/10	20	
	DI – DO	t_{PLH2}		-	15/10	20	ns
	OEI - OEO	t_{PLH3}		-	15/10	20	ns
Propagation delay time ("H" to "L")	CKI - CKO	t_{PHL1}		-	15/10	20	ns
	DI - DO	t_{PHL2}		-	15/10	20	ns
	OEI - OEO	t_{PHL3}		-	15/10	20	ns
Pulse width	CKI	$t_{W(CKI)}$		30/25	-	-	ns
	DI	$t_{W(DI)}$		15	-	-	ns
	SYI	$t_{W(SYI)}$		15	-	-	ns
	OEI	$t_{W(OEI)}$		120	-	-	ns
	SYO	$t_{W(SYO)}$		100	-	-	ns
Setup time for DI		$t_{S(DI)}$		5	-	-	ns
Hold time for DI		$t_{H(DI)}$		10	-	-	ns
Setup time for SYI		$t_{S(SYI)}$		20	-	-	ns
Output rise time (DO/CKO/SYO/OEO)		t_{OR}		-	20	-	ns
Output fall time (DO/CKO/SYO/OEO)		t_{OF}		-	20	-	ns
Maximum CKI rise time[1]		t_R		-	-	5	us
Maximum CKI fall time		t_F		-	-	5	us
Delay between bytes		t_D	$D_X – D_{X+1}$	25	-	-	ns
PWM Clock Frequency		f_{OSC}	-	-	7/5	-	MHz

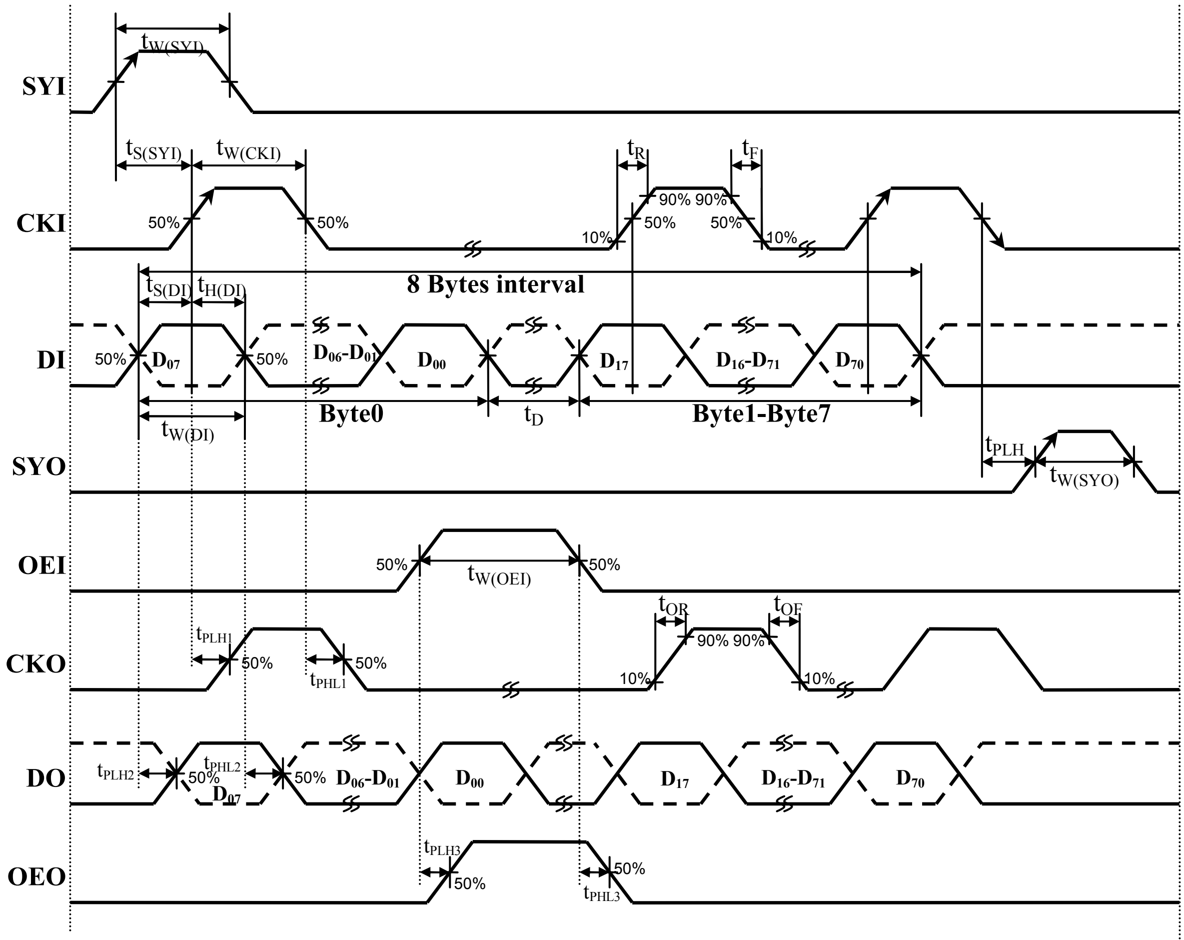
1. It may not be possible to achieve the timing required for data transfer between two cascaded drivers if t_R/t_F is large.

Test Circuit for Switching Characteristics



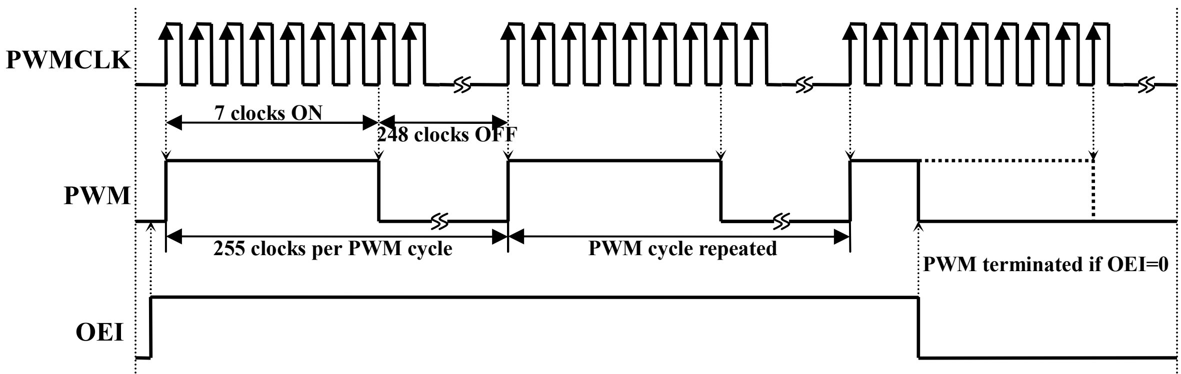
*Place C_1/C_{LED} more close to IC VDD/OUT pin(not supply source) as possible.

Timing Waveform



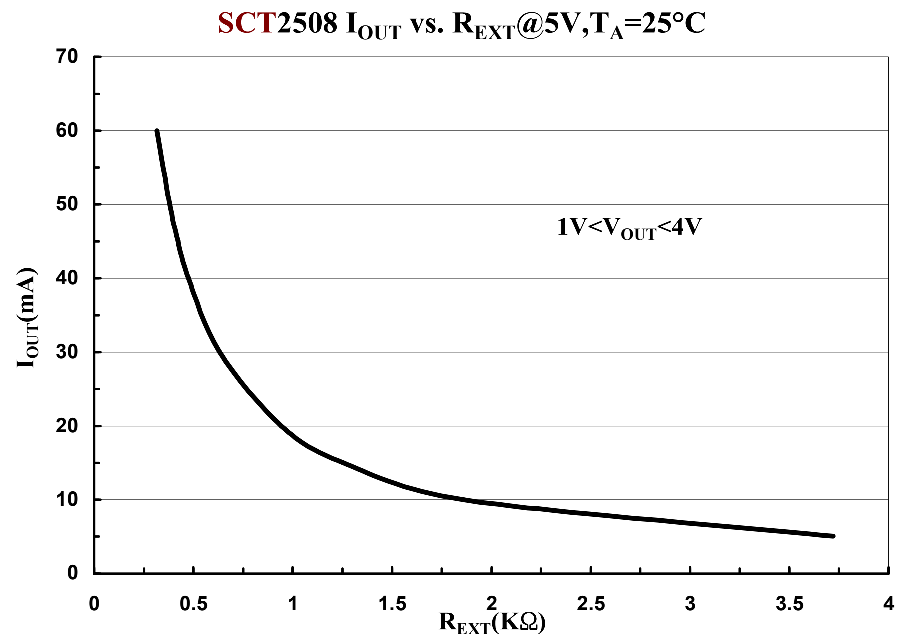
8-bit PWM

PWM luminance data code D = (D7, D6, D5, D4, D3, D2, D1, D0) determines duty of the output turn-on pulse = $(D7*2^7+D6*2^6+D5*2^5+D4*2^4+D3*2^3+D2*2^2+D1*2^1+D0*2^0)/255$. For example when D = $00000111_B = 7_D$, the output will be turn on for a time interval by counting 8-bit counter from binary code 0000_B to 0110_B (D-1) through internal PWM clock PWMCLK. That is, when OEI is active, the output will turn on for 7 PWM clocks of total 255 clock cycles over and over. Such a turn-on status will be lasted until the 8-bit latch loads with new luminance data code. When D = 0/255 the output will be fully turn off/on without PWM functionality. The output of SCT2508 is initialized to be ON. This makes the LED backlight source automatically lit-up even if controller doesn't issue any signals to the SCT2508.



Adjusting Output Current

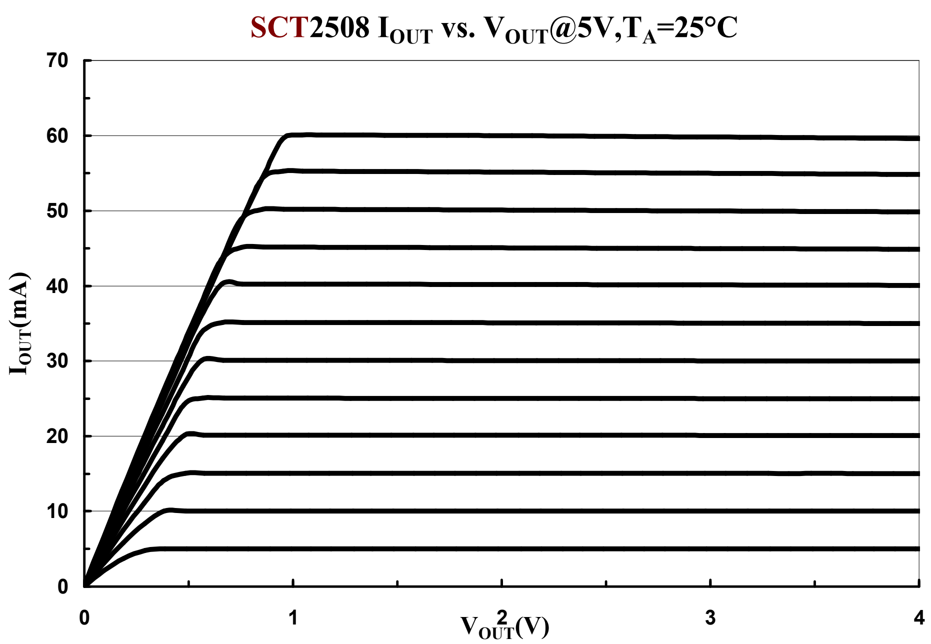
The SCT2508's output current (I_{OUT}) are set by one external resistor at pin REXT. The output current I_{OUT} versus resistance of R_{EXT} is shown as the following figure.

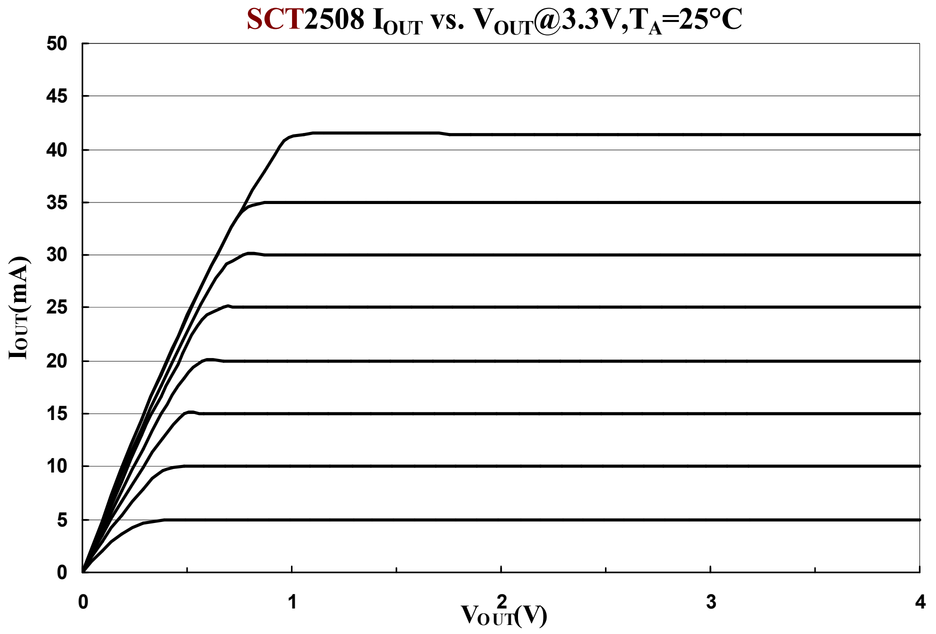


Furthermore, when SCT2508's output voltage is set between 1 Volt and 4 Volt, the output current can be estimated approximately by: $I_{OUT} = 30(630 / R_{EXT})$ (mA) (chip skew < ±4%). Thus the output current are set about 21mA at R_{EXT} = 900Ω.

Output Characteristics

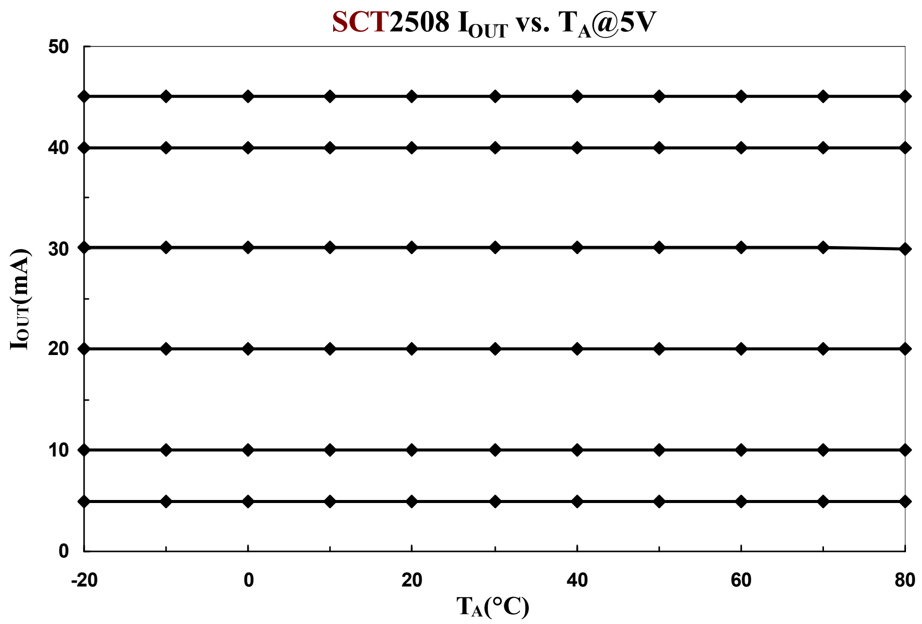
The current characteristic of output curve is flat. The output current can be kept constant regardless of the variations of LED forward voltage when V_{OUT} > 1V. The relationship between I_{OUT} and V_{OUT} is shown below.





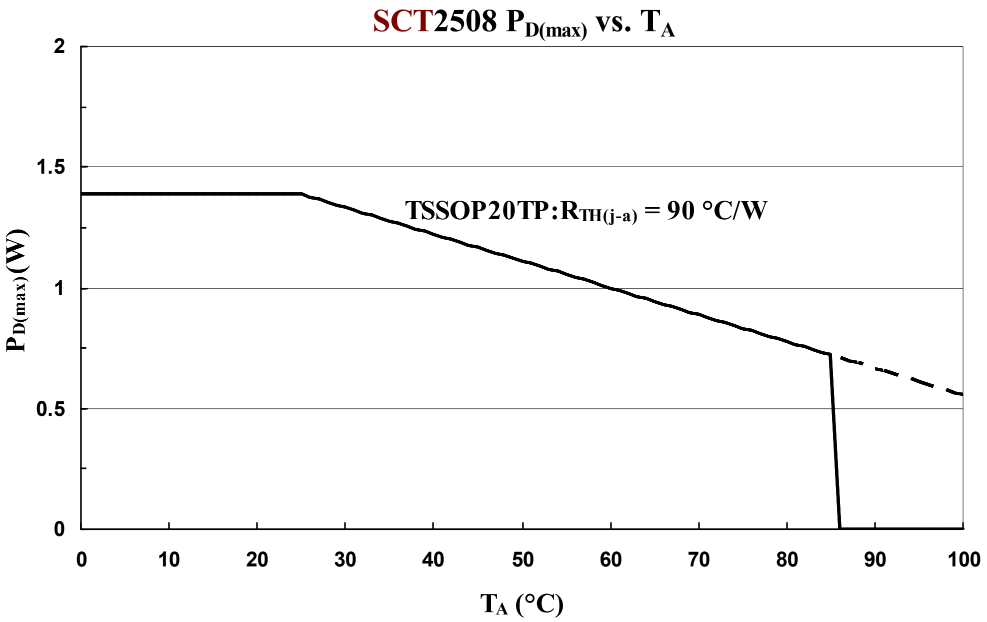
Excellent Temperature Regulation

The constant current driver does not only require the characteristics of supply and load voltage independence, but also temperature invariance. A well thermal stable reference circuit is designed within the SCT2508. Users can get the stable output current over recommended current range I_{OUT}=5mA~45mA when ambient temperature (T_A) widely varies from -20°C to 80°C.



Power Dissipation

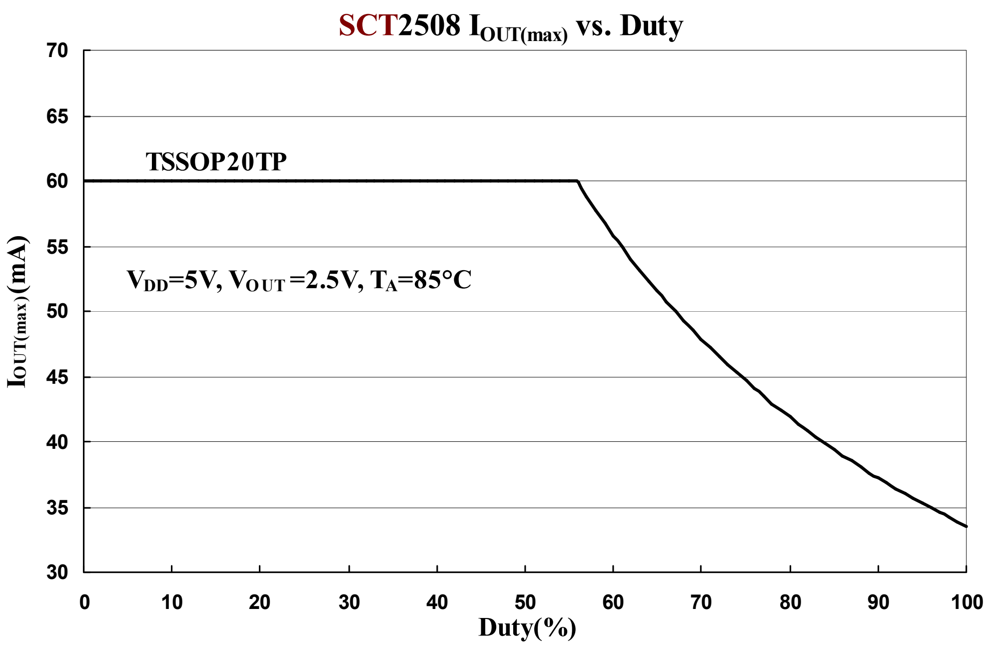
The maximum power dissipation ($P_{D(max)}$) of a semiconductor chip varies with different packages and ambient temperature. It's determined as $P_{D(max)}=(T_{J(max)}-T_A)/R_{TH(j-a)}$ where $T_{J(max)}$: maximum chip junction temperature is usually considered as 150°C, T_A: ambient temperature, $R_{TH(j-a)}$: thermal resistance. Since P=IV, for sink larger I_{OUT}, users had better add proper voltage reducers on output to reduce the heat generated from the SCT2508.



Limitation on Maximum Output Current

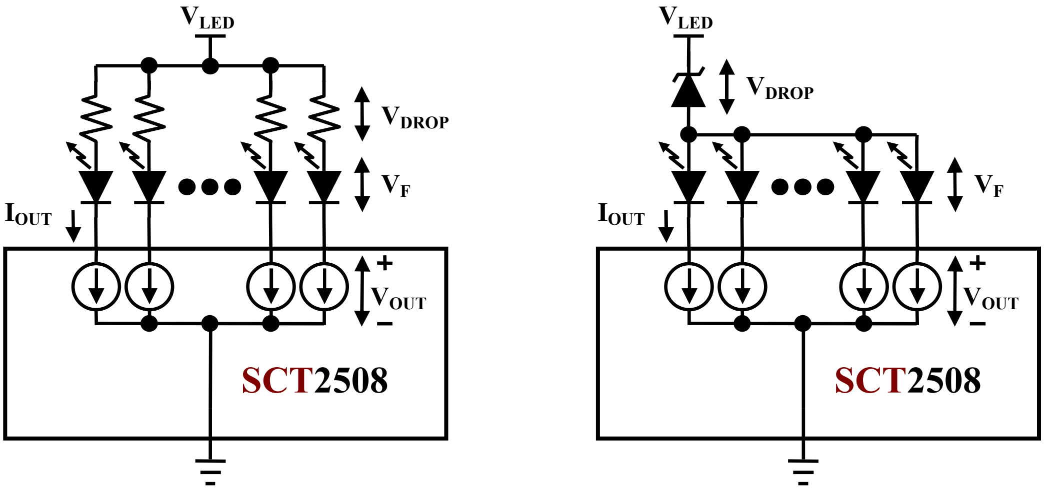
The maximum output current vs. duty cycle is estimated by:

$I_{OUT(max)}=(((T_{J(max)}-T_A)/R_{TH(j-a)})-(V_{DD}*I_{DD}))/V_{OUT}/Duty/N$ where $T_{J(max)}$=150°C, N=8(all ON)



Load Supply Voltage (VLED)

The SCT2508 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 SCT2508. 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 $V_{OUT}=V_{LED}-V_{DROP}-V_F$.

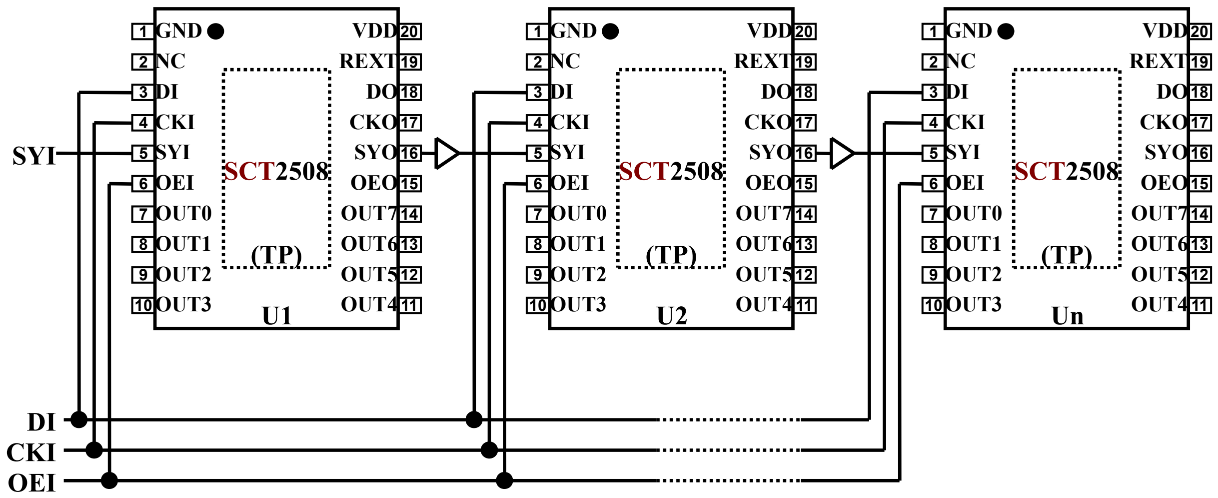


Over Temperature Shutdown

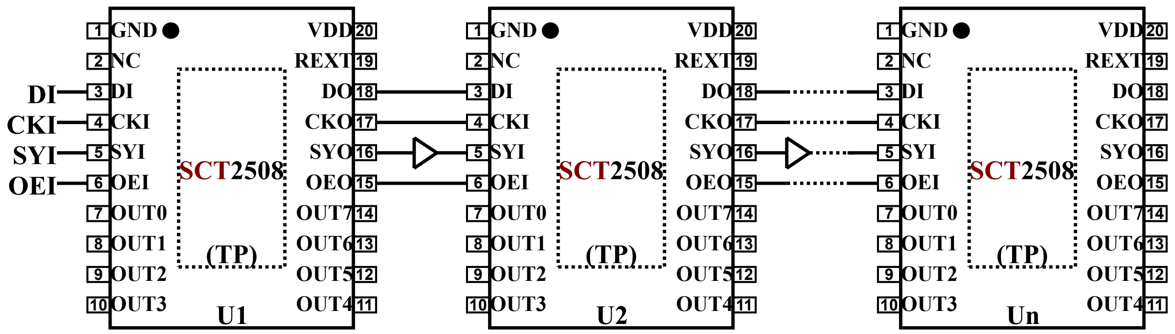
The SCT2508 contains thermal shutdown scheme to prevent damage from over heated. The internal thermal sensor turns off all outputs when the die temperature exceeds +160°C. The outputs are enabled again when the die temperature drops below +110°C. During the thermal shutdown process, the LEDs look blinking since it is turned OFF then ON periodically.

Typical Application Circuits

Individual PWM - Daisy Chain

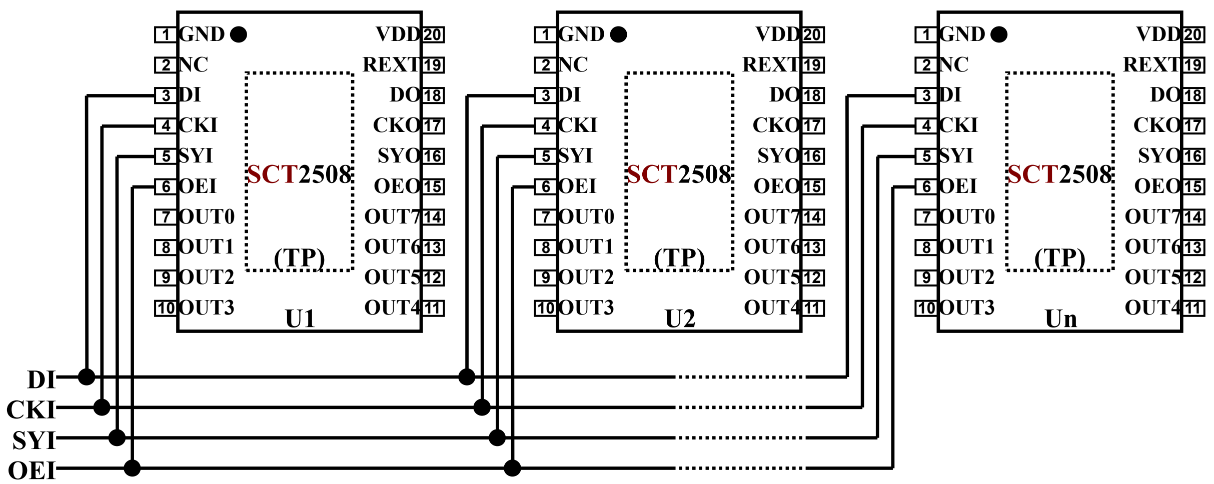


Individual PWM - Cascaded



Users may need to add delay circuits e.g. simple LPF RC or buffer on SYO pin if timing required can not be meet during cascaded operation.

Global PWM

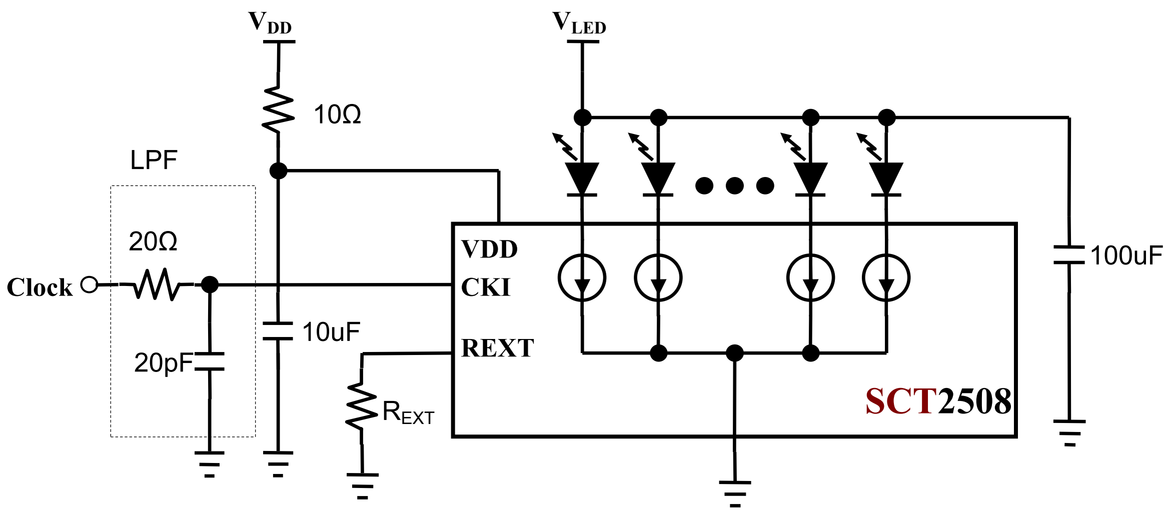


PCB Design Considerations

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 SCT2508. Locate the capacitor as close to the SCT2508 as possible. The necessary capacitance depends on the LED load current, PWM switching frequency, and serial-in data speed. 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 SCT2508 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 larger capacitor e.g. 100uF beside the LED are strongly recommended.

EMI Reduction

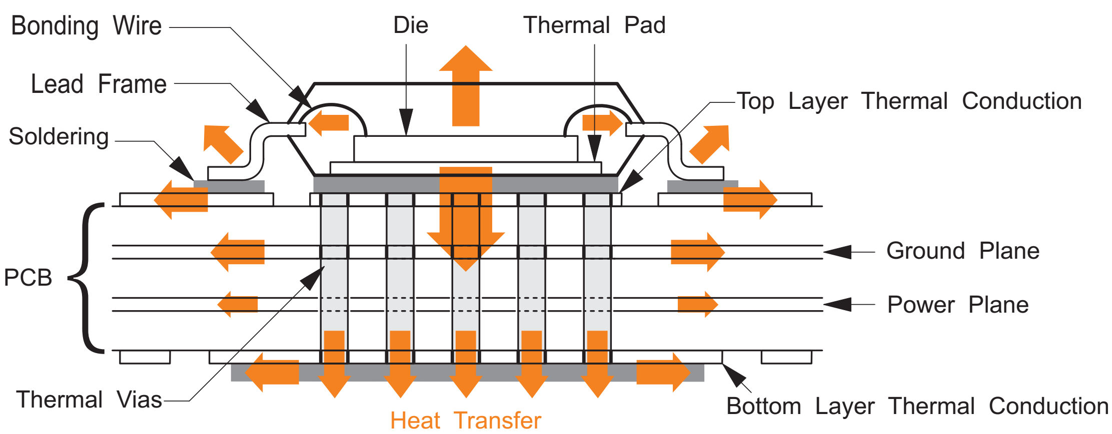
To reduce the EMI radiation from system, an economic solution RC low pass filter (LPF) is suggested to be used to lower the transient edge of clock input signal, as shown in the figure above. Using at least four layers PCB board with two interior power and ground planes is a good scheme to decrease the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

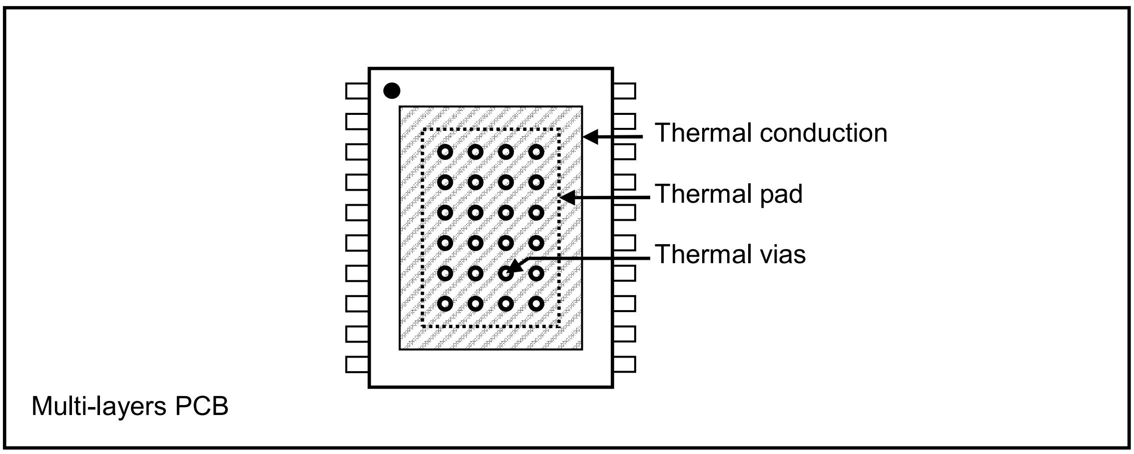
Thermal Pad Consideration

The “thermal pad” (also named as “exposed pad”) TSSOPTP package beneath used to increase the heat dissipation capability is floating (NC), NOT wire-bonded to ground terminal (Pin 1). User should be aware of this electrical connection when designing the PCB board, and make provisions for its use. In most of application, the NC thermal pad thermal is strongly electrically connected to ground plane or conduction. This makes the IC operated with more stable condition.

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.

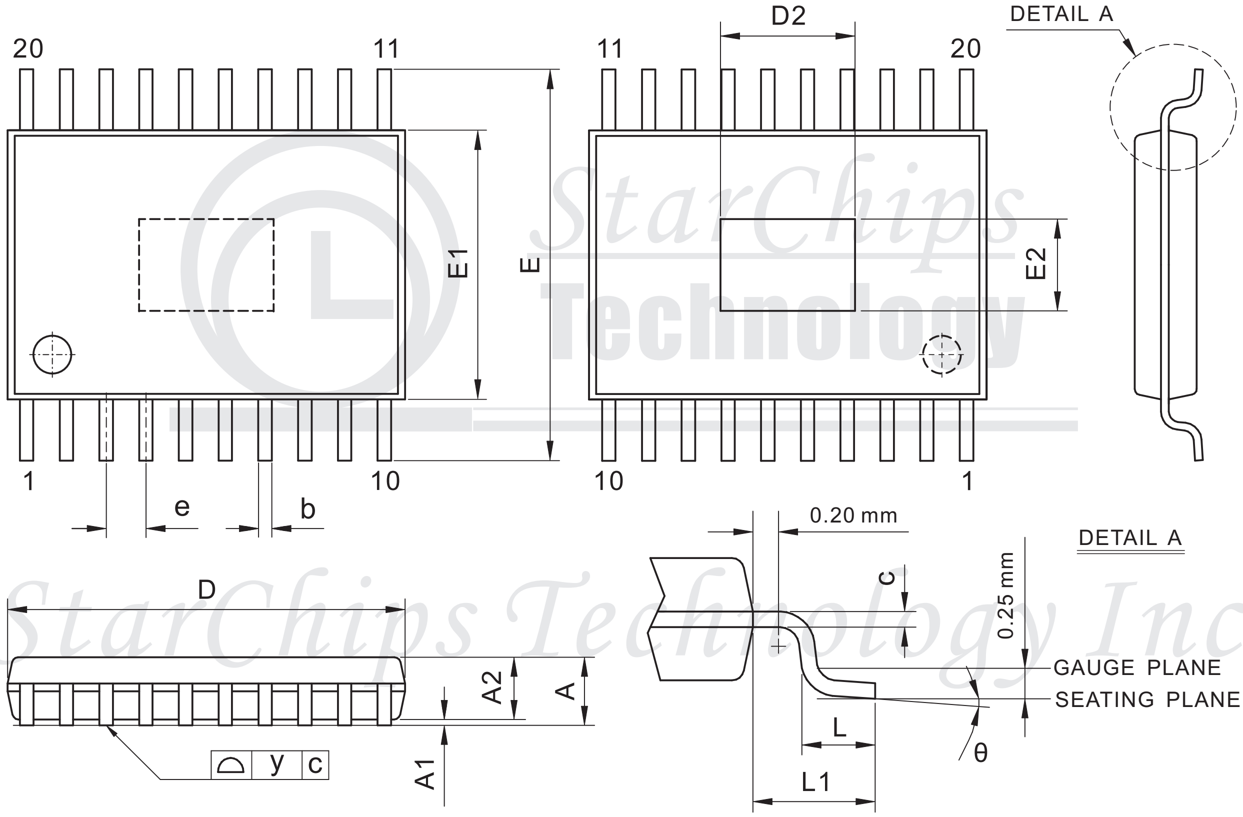
When making the solder paste screen, an opening should be created for the thermal pad. This way the thermal pad can be electrically and thermally connected to the PCB. As the thermal pad is soldered on copper polygon, the chance of inadvertently shorting the thermal pad to traces routed underneath it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





Package Dimension

TSSOP20TP(check up-to-date version)



Symbol	Dimension (mm)			Dimension (mil)		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.20	-	-	47.2
A1	0.05	-	0.15	2.0	-	6.0
A2	0.80	0.90	1.05	31.0	35.0	41.0
b	0.19	-	0.30	7.0	-	12.0
c	0.09	-	0.20	4.0	-	8.0
D	6.40	6.50	6.60	252.0	255.9	259.8
E1	4.30	4.40	4.50	169.0	173.0	177.0
E	6.40 BSC			252.0 BSC		
e	0.65 BSC			26.0 BSC		
L1	1.00 REF			39.0 REF		
L	0.45	0.60	0.75	18.0	24.0	30.0
y	-	-	0.10	-	-	4.0
θ	0°	-	8°	0°	-	8°
D2	-	3.81	-	-	150.0	-
E2	-	3.00	-	-	118.1	-

Revision History (check up-to-date version)

Data Sheet Version	Remark
V01_01	New Release