3-Bit Constant-Current LED Driver

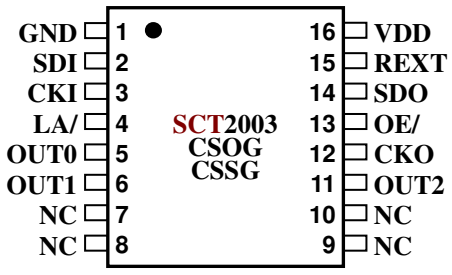
Product Description

The constant current SCT2003 serial-interfaced LED driver sinks 3 LED clusters to keep excellent uniform intensity of LED displays. In applications, an external resistor is used to set the full-scale constant output current from 5mA up to 45mA. The SCT2003 guarantees each output endures maximum 17V DC voltage stress. The built-in shift registers and data latches make the SCT2003 the effective solution in driving LED display. The output enable function gates all 3 outputs on and off, and it is fast enough to be used as PWM input for LED intensity control. The SCT2003 works very well in high volume data transmission system which aims to control the LED RGB cluster application, since the serial data input and replica clock output rate of the SCT2003 can stably reached up to 25MHz.

Features

- 3 constant-current outputs rate at 17V
- Constant current range: 5 – 45mA@5V, 5 – 30mA@3.3V
- Excellent current regulation to load, supply voltage and temperature
- ±2%(max) current matching between outputs
- ±5%(max) current matching between ICs
- Fast output current control: Minimum PWM pulse width = 200ns
- All output currents are programmed together using a single external resistor
- Schmitt triggered inputs available
- High serial data transfer rate: 25MHz
- Operating supply voltage range of 3.3V to 5V
- Low standby/operating supply current
- Built-in power on reset and thermal protection function
- Replica clock for long distance cascade operation
- Package: SOP16 and SSOP16
- Applications: LED RGB clusters, Billboard, Message board, Scoreboard.

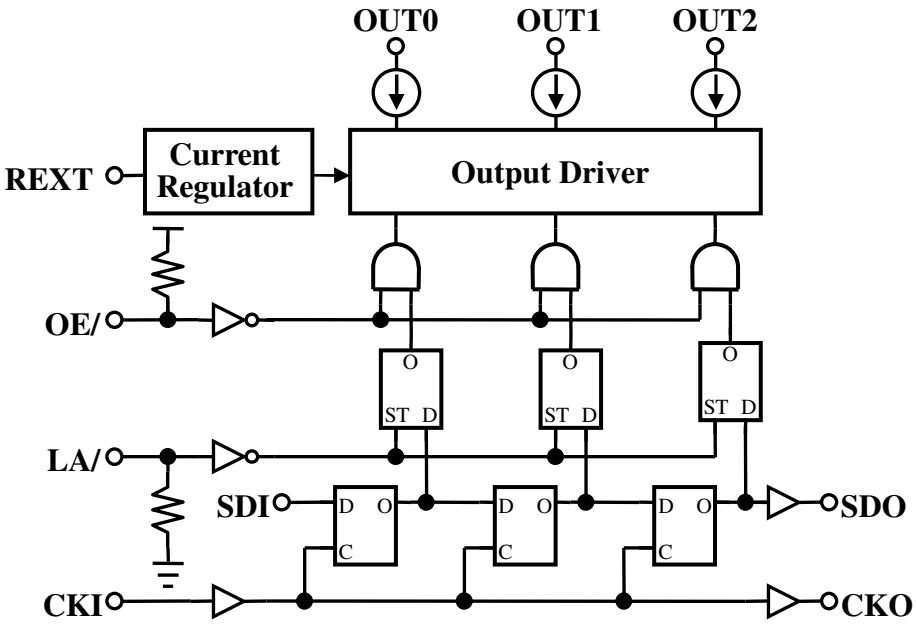
Pin Configurations



Terminal Description

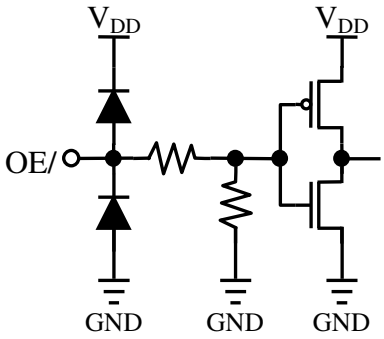
Pin No.	Pin Name	Function
1	GND	Ground terminal
2	SDI	Serial input of data shift register
3	CKI	Clock input of shift register, data is sampled at the rising edge of CKI.
4	LA/	Input terminal of data strobe. Data is latched when LA/ is low. And data on shift register goes through when LA/ is high.
5,6,11	OUT[0:2]	Open-drain, constant-current outputs
7-10	NC	No Connection
12	CKO	Replica clock for cascade operation
13	OE/	Output enable signal. Output is enabled when OE/ is forced to low.
14	SDO	Output terminal of serial-data output to the SDI of next SCT2003.
15	REXT	Connected an external resistor for setting up all output current
16	VDD	Supply voltage terminal

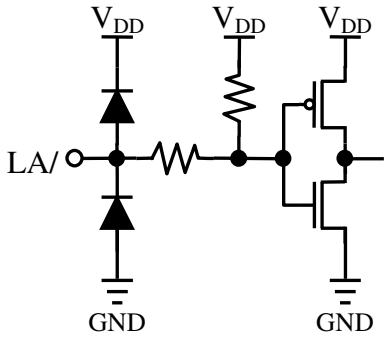
Block Diagram



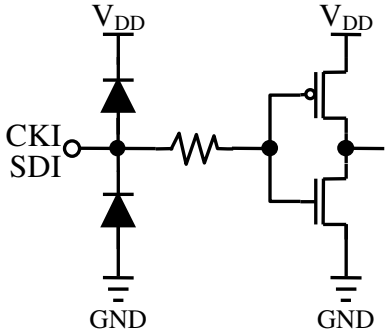
SCT2003

Equivalent Circuits of Inputs (1)

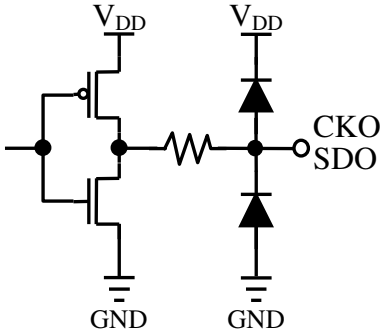




Equivalent Circuits of Inputs (2)



Equivalent Circuits of Output



Ordering Information

Part	Package	Unit per reel(pcs)
SCT2003CSOG	Green SOP16	2500
SCT2003CSSG	Green SSOP16	2500

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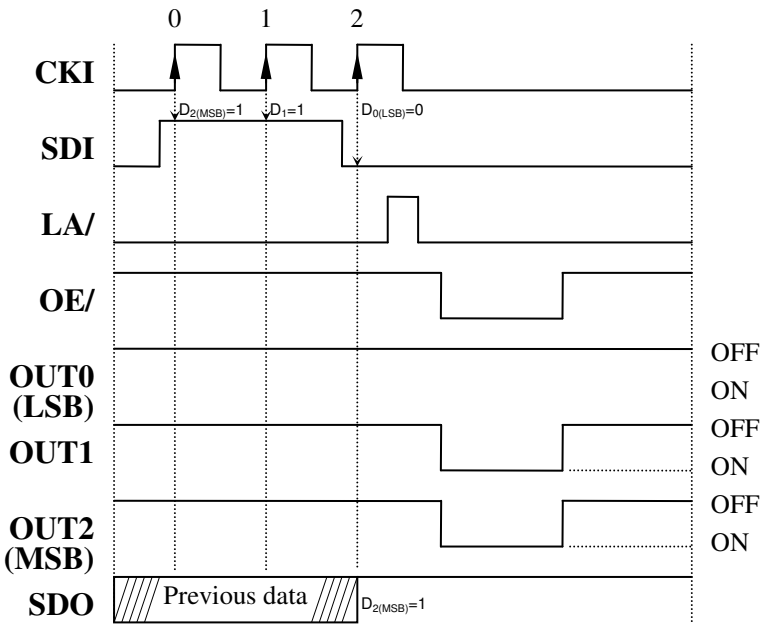
Truth Table

CKI	LA/	OE/	SDI	OUT0 OUT1 OUT2	SDO
↑	H	L	Dn	Dn Dn-1 Dn-2	Dn-2
↑	L	L	Dn+1	No change	Dn-1
↑	H	L	Dn+2	Dn+2 Dn+1 Dn	Dn
↓	X	L	Dn+3	Dn+2 Dn+1 Dn	Dn
↓	X	H	Dn+3	Off	Dn

Timing Diagram



Maximum Ratings (T_A = 25℃)

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		V_{OUT}	-0.2 ~ 17.0	V
Total GND terminal current		I_{GND}	200	mA
Power dissipation (Free Air)	SOP16	P_D	1.13	W
	SSOP16		1.08	
Thermal resistance (Free Air)	SOP16	$R_{TH(j-a)}$	111	℃ /W
	SSOP16		116	
Operating temperature		T_{OPR}	-40~+85	℃
Storage temperature		T_{STG}	-55~+150	℃

Recommended Operating Conditions (T_A= -40 to 85℃ 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
Output voltage	V_{OUT}	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
OE/ pulse width	t_W	V_{DD}=3.3V/5V	200	-	-	ns

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

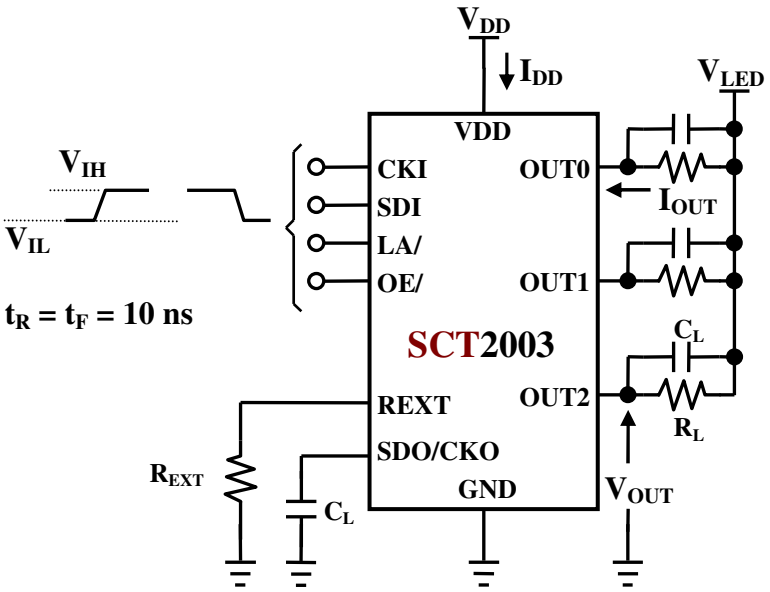
Characteristic		Symbol	Conditions	Min.	Typ.	Max.	Unit
Input voltage		V_{IH}	-	0.7V_{DD}	-	V_{DD}	V
		V_{IL}	-	0	-	0.3V_{DD}	V
SDO/CKO output voltage		V_{OH}	V_{DD}=3.3/5V, I_{OH}= -1mA	V_{DD}-0.4	-	-	V
		V_{OL}	V_{DD}=3.3/5V, I_{OL}=+1mA	-	-	0.4	V
Output leakage current		I_{OL}	V_{OUT}=17V	-	-	0.5	uA
Output current		I_{OUT}	V_{OUT}=1V, R_{EXT}=900Ω	-	21	-	mA
Current bit skew*		dI_{OUT1}	V_{OUT}=1V, R_{EXT}=900Ω	-	±1	±2	%
Chip skew		dI_{OUT2}	V_{OUT}=1V, R_{EXT}=900Ω	-	±3	±5	%
Line regulation I_{OUT} vs. V_{DD}		%/dV_{DD}	3V<V_{DD}<5.5V, V_{OUT}>1V, R_{EXT}=900Ω	-	-	±1	%/V
Load regulation I_{OUT} vs. V_{OUT}		%/dV_{OUT}	1V<V_{OUT}<4V, R_{EXT}=900Ω, V_{DD}=3.3-5V	-	-	±1	%/V
Pull-up Resistor		R_{UP}	OE/	-	500	-	KΩ
Pull-down Resistor		R_{DOWN}	LA/	-	500	-	KΩ
Thermal Shutdown		T_H	Junction Temp.	-	160	-	℃
		T_L		-	110	-	℃
Supply Current	OFF	$I_{DD(OFF)1}$	V_{DD}=3.3/5V, R_{EXT}=Open, OUT[0:2]=OFF	-	2	3	mA
		$I_{DD(OFF)2}$	V_{DD}=3.3/5V, R_{EXT}=900Ω, OUT[0:2]=ON	-	5	7	
	ON	$I_{DD(ON)}$	V_{DD}=3.3/5V, R_{EXT}=900 Ω, OUT[0:2]=ON	-	6	8	

* Skew=(I_{OUT}-I_{AVG})/I_{AVG}, where I_{AVG}=(I_{max}+ I_{min})/2

Switching Characteristics (T_A=25℃ unless otherwise noted)

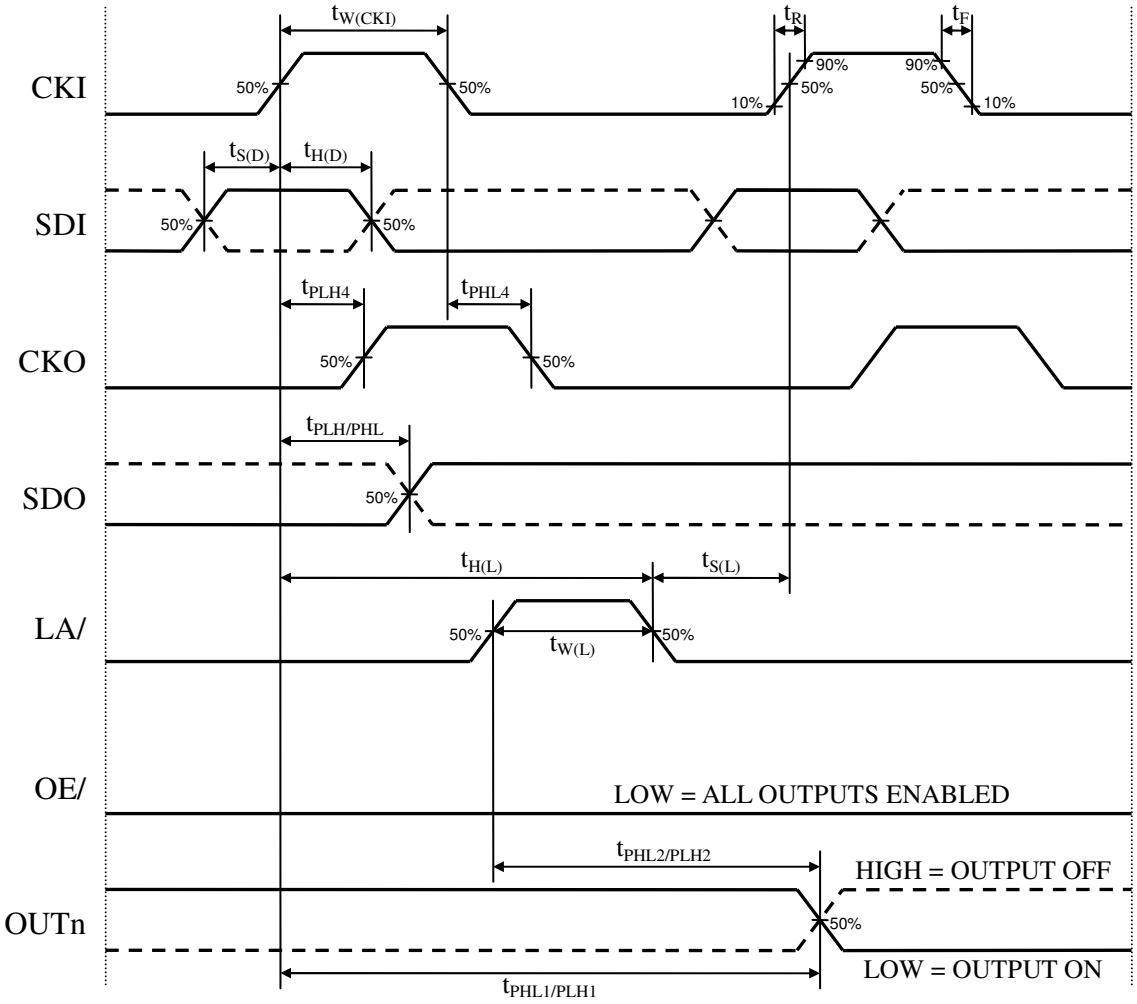
Characteristic		Symbol	Conditions	Min.	Typ.	Max.	Unit
Propagation delay time (“L” to “H”)	CKI - OUTn	t_{PLH1}	V_{DD} = 3.3/5V V_{LED} = 5V V_{IH} = V_{DD} V_{IL}= GND R_{EXT} = 900Ω R_L = 180Ω C_L = 10pF	-	80	100	ns
	LA/ - OUTn	t_{PLH2}		-	80	100	ns
	OE/ - OUTn	t_{PLH3}		-	80	100	ns
	CKI - CKO	t_{PLH4}		-	15	30	ns
	CKI - SDO	t_{PLH}		-	20	40	ns
Propagation delay time (“H” to “L”)	CKI - OUTn	t_{PHL1}		-	80	100	ns
	LA/ - OUTn	t_{PHL2}		-	80	100	ns
	OE/ - OUTn	t_{PHL3}		-	80	100	ns
	CKI - CKO	t_{PHL4}		-	15	30	ns
	CKI - SDO	t_{PHL}		-	20	40	ns
Pulse width	CKI	$t_{W(CKI)}$		20	-	-	ns
	LA/	$t_{W(L)}$		20	-	-	ns
	OE/	$t_{W(OE)}$		200	-	-	ns
Hold time for LA/		$t_{H(L)}$		5	-	-	ns
Setup time for LA/		$t_{S(L)}$		5	-	-	ns
Output rise time of I_{OUT}		t_{OR}		-	80	100	ns
Output fall time of I_{OUT}		t_{OF}		-	80	100	ns
Slow CKI rise time		t_R	Cascade	-	-	500	ns
Slow CKI fall time		t_F		-	-	500	ns

Test Circuit for Switching Characteristics

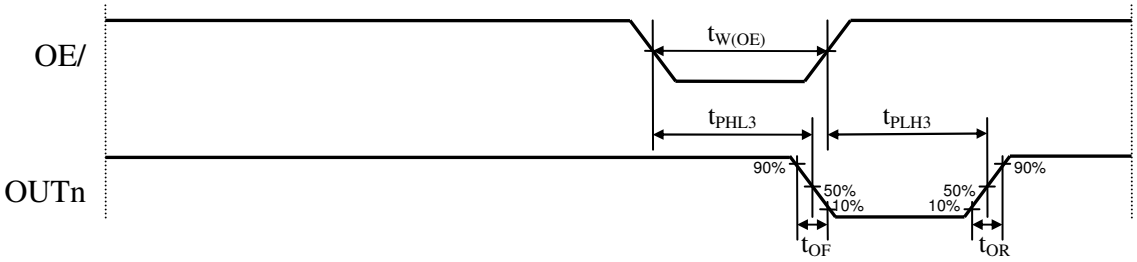


Timing Waveform

LA/ Control Output

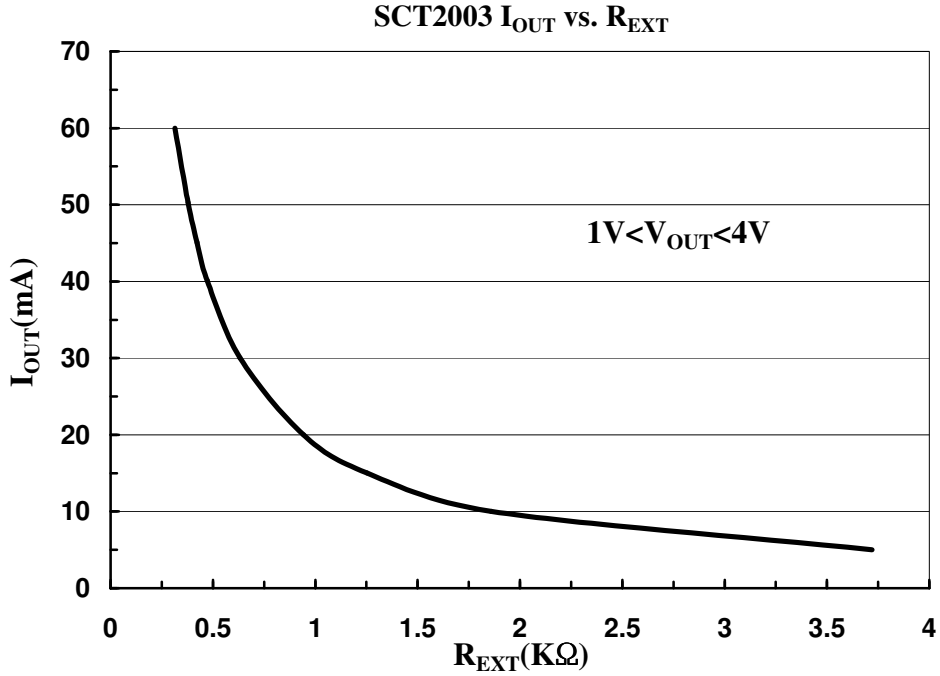


OE/ Control Output



Adjusting Output Current

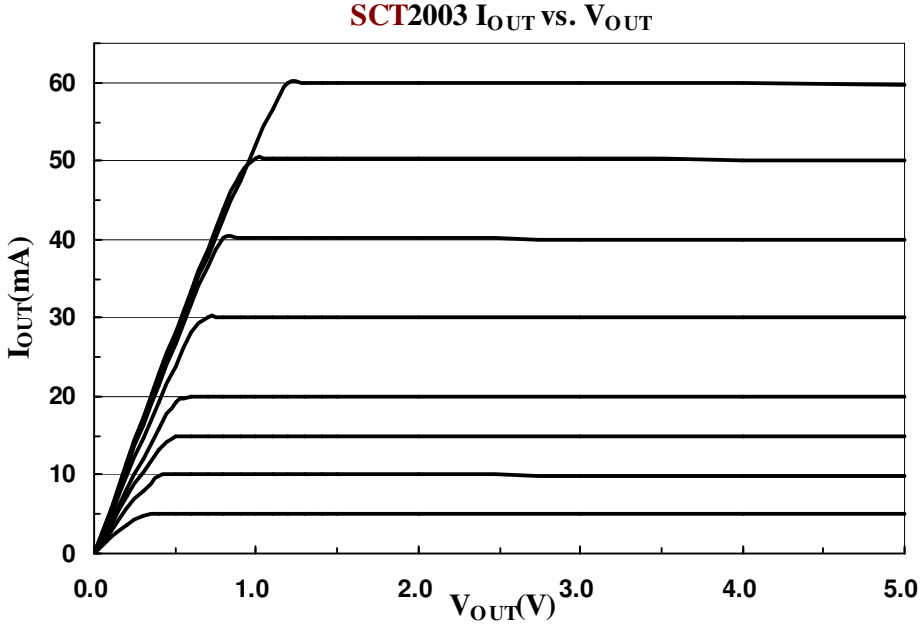
All SCT2003's output currents (I_{OUT}) are set by one external resistor at pin REXT. The output current I_{OUT} versus resistance of R_{EXT} is shown as the following figure.



Furthermore, when SCT2003's output voltage is set between 1V and 4 V, the output current I_{OUT} can be estimated by the formula: I_{OUT} = 30(630 / R_{EXT}) (mA) (Chip skew±5%), Thus the output currents are set about 21mA at R_{EXT} = 900Ω.

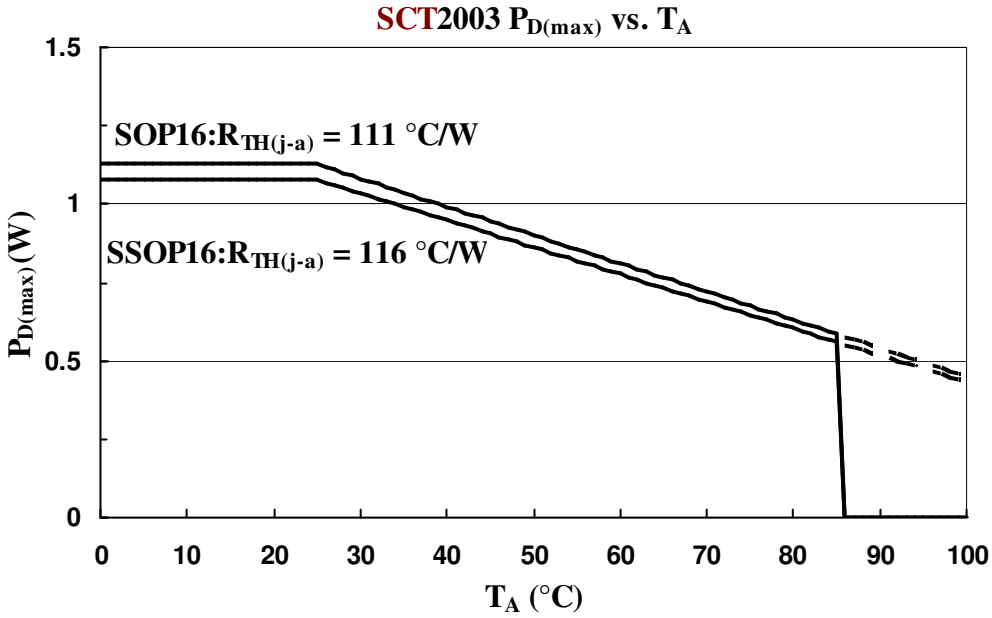
Output Characteristics

The current characteristic of output stage is flat. The output current remains constant regardless of the variations of LED forward voltage when V_{OUT} > 1V. The relationship between I_{OUT} and V_{OUT} is shown as below:



Maximum Power Dissipation

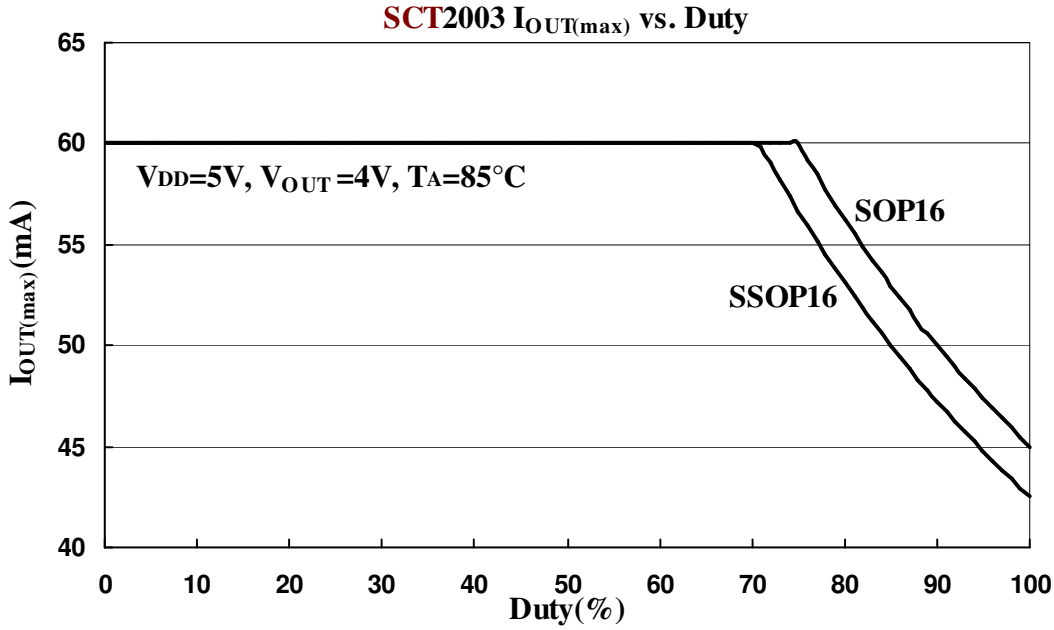
The maximum power dissipation ($P_{D(max)}$) of a semiconductor chip varied to different package and ambient temperature. It's determined by $P_{D(max)}=(T_{J(max)} - T_A)/R_{TH(j-a)}$ where $T_{J(max)}$: maximum chip junction temperature usually considered as 150℃, T_A: ambient temperature, $R_{TH(j-a)}$: thermal resistance of the package. The relationship between $P_{D(max)}$ and T_A is shown as the below figure:



Limitation on Maximum Output Current

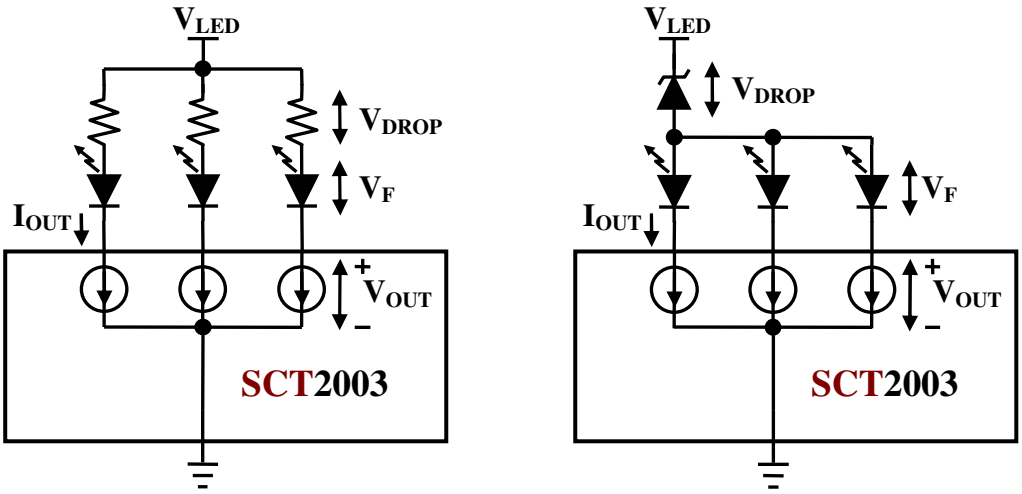
The maximum output current vs. duty cycle is estimated by:

$I_{OUT(max)}=(((T_{J(max)}-T_A)/R_{TH(j-a)})-(V_{DD}*I_{DD}))/V_{OUT}/Duty/N$ where $T_{J(max)}$=150℃, N=3(all ON)



Load Supply Voltage (VLED)

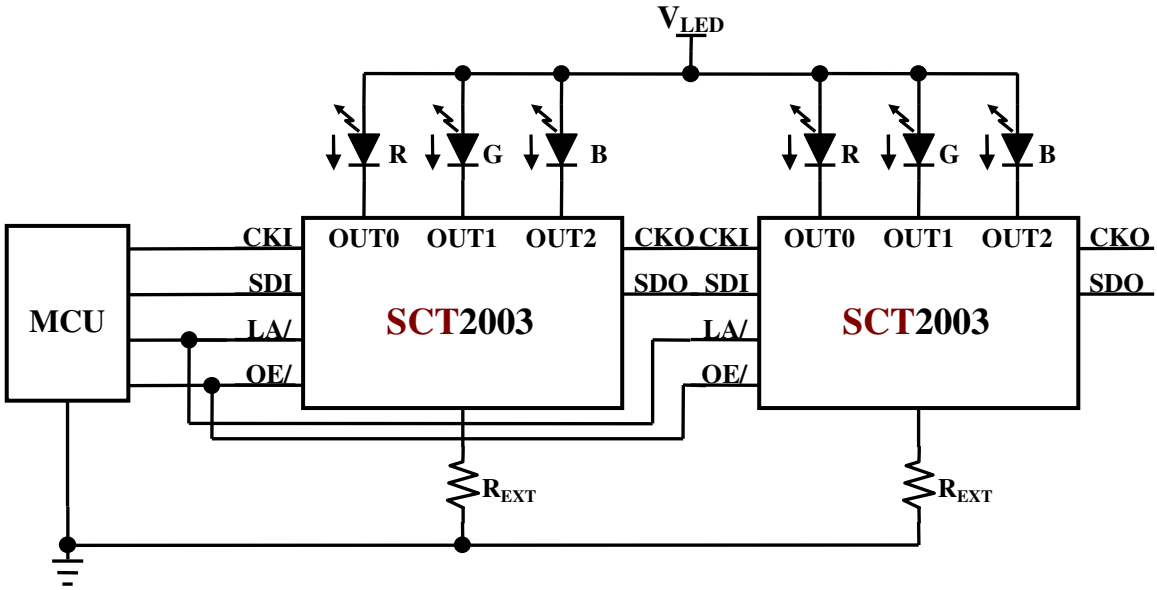
The SCT2003 can be operated very well when V_{OUT} ranging from 1V to 4V. It is recommended to use the lowest possible supply voltage or set a voltage reducer to reduce the V_{OUT} voltage, at the same time reduce the power dissipation of the SCT2003. The diagram instructions shown below are to lower 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 SCT2003 contains thermal shutdown scheme to prevent damage from over heated. The internal thermal sensor turns off all outputs when the die temperature exceeds ~ +160℃. The outputs are enabled again when the die temperature drops below ~ +110℃.

Typical Application Circuits

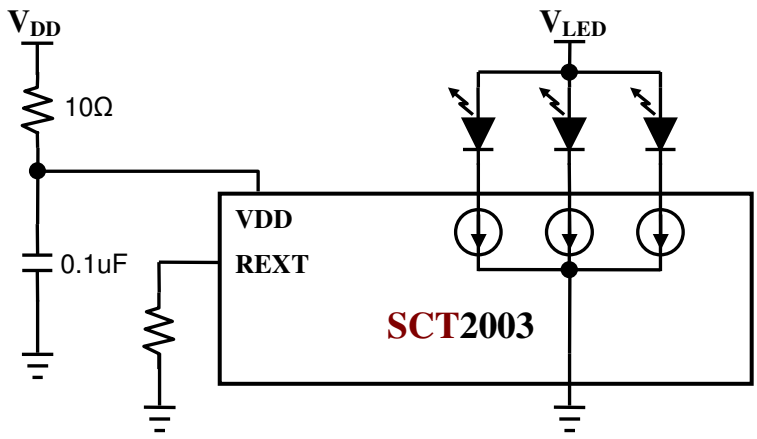


PCB Design Considerations

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

Decoupling Capacitor

Place a decoupling capacitor e.g. 0.1uF between VDD and GND pins of SCT2003. Locate the capacitor as close to the SCT2003 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})

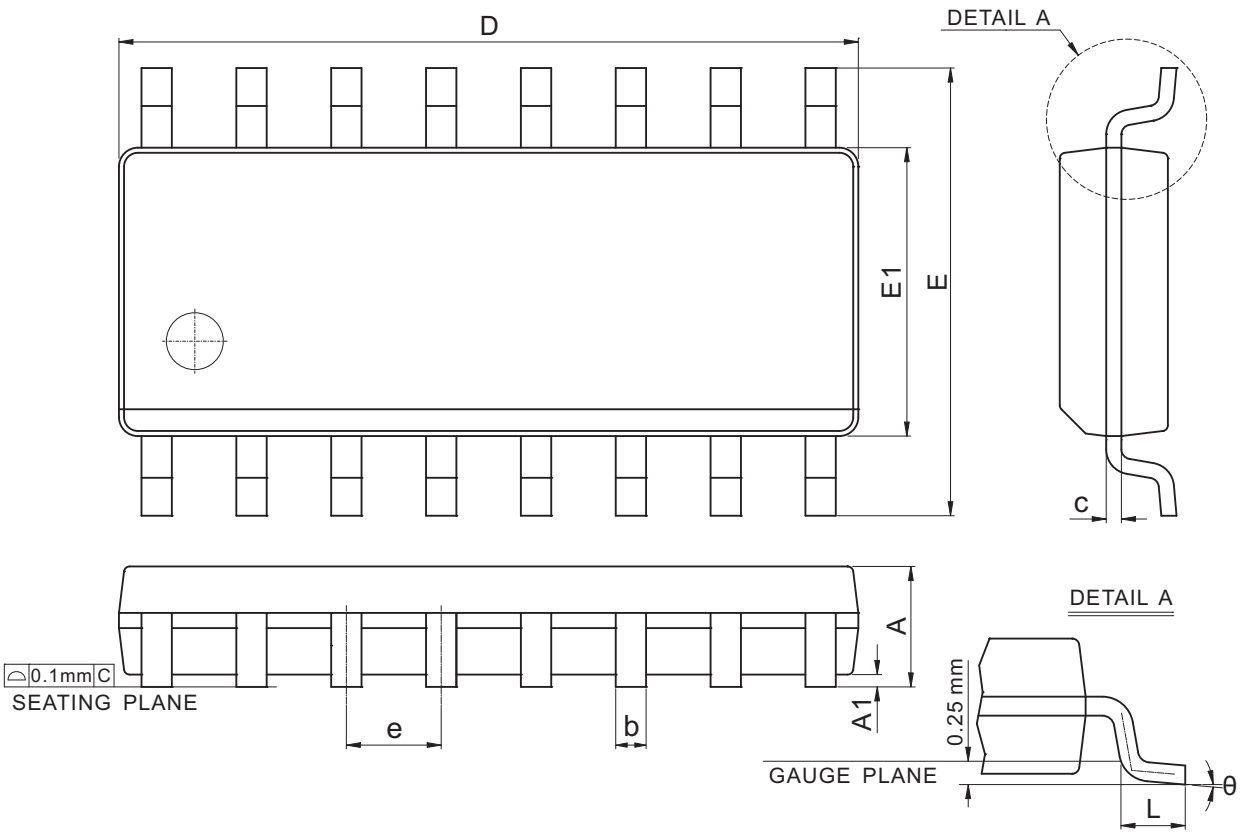
Locate the external resistor as close to the REXT pin as possible to avoid noise.

Power and Ground

Maximizing the width and minimizing the length of VDD and GND trace improve the efficiency and lower ground bouncing by reducing both power and ground parasitic resistance and inductance. A small value of resistor e.g. 10Ω series in power input of the SCT2003 in conjunction with decoupling capacitor shunting the ICs is recommended. Separating and feeding the LED power from another stable supply terminal V_{LED} is strongly recommended.

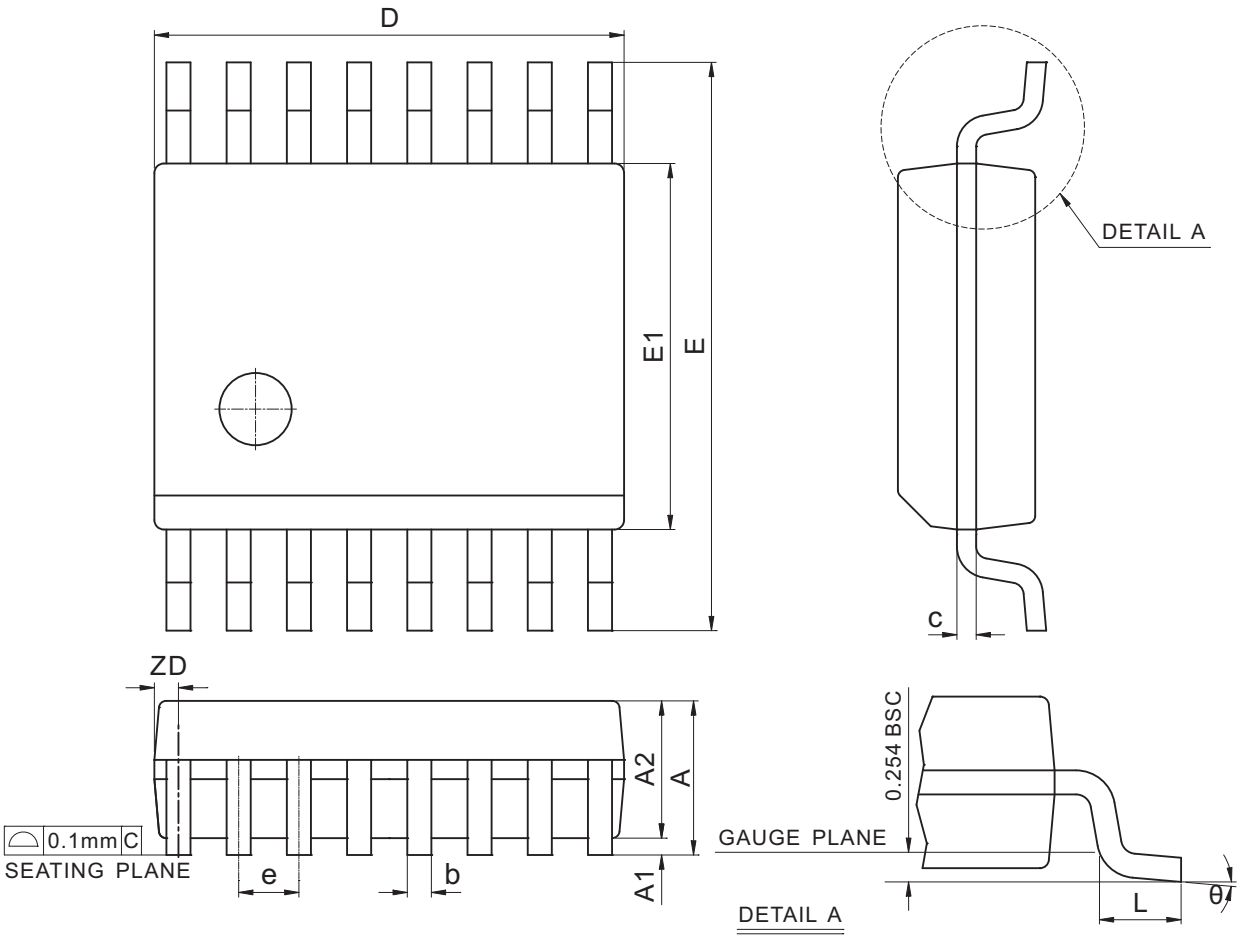
Package Dimension

SOP16



Symbol	Dimension (mm)			Dimension (mil)		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.35	-	1.75	53.1	-	68.9
A1	0.1	-	0.25	3.9	-	9.8
b	0.33	-	0.51	13.0	-	20.1
c	0.19	-	0.25	7.5	-	9.8
D	9.8	-	10	385.8	-	393.7
E	5.8	-	6.2	228.3	-	244.1
E1	3.8	-	4	149.6	-	157.5
e	1.27 BSC			50.0 BSC		
L	0.4	-	1.27	15.7	-	50.0
θ	0°	-	8°	0°	-	8°

SSOP16



Symbol	Dimension (mm)			Dimension (mil)		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.35	1.63	1.75	53.1	64.2	68.9
A1	0.1	0.15	0.25	3.9	5.9	9.8
A2	-	-	1.5	-	-	59.1
b	0.2	-	0.3	7.9	-	11.8
c	0.18	-	0.25	7.1	-	9.8
D	4.8	4.9	5	189.0	192.9	196.9
E	5.79	5.99	6.2	228.0	235.8	244.1
E1	3.81	3.91	3.99	150.0	153.9	157.1
e		0.635 BSC			25.0 BSC	
L	0.41	0.635	1.27	16.1	25.0	50.0
ZD		0.229 REF			9.0 REF	
θ	0°	-	8°	0°	-	8°

Revision History (check up-to-date version)

Data Sheet Version	Remark
V01_01	New 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.

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