



## 16-bit Serial-In/Parallel-Out Constant-Current LED Driver

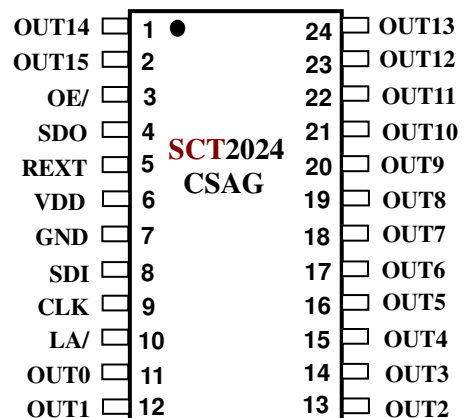
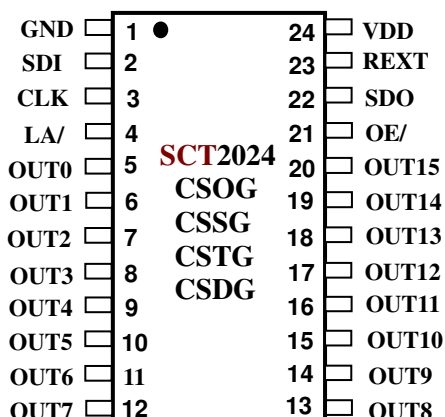
### Product Description

The SCT2024 serial-interfaced LED driver sinks 16 LED clusters with constant current to keep the 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 SCT2024 guarantees each output can endure maximum 17V DC voltage stress. The built-in shift registers and data latches making the SCT2024 effective solution in driving LED display. The output enable function gates all 16 outputs on and off, and is fast enough to be used as PWM input for LED intensity control. Since the serial data input rate can be reached up to 25MHz, the SCT2024 will satisfy system which needs high volume data transmission to control the LED display.

### Features

- ◆ 16 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% Current matching between outputs
- ◆ ±5% Current matching between ICs
- ◆ Fast output current control: Minimum PWM pulse width = 180ns
- ◆ All output current are programmed together using a single external resistor
- ◆ CMOS Schmitt triggered inputs
- ◆ 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
- ◆ Interlaced 30ns delay of output to lower bouncing noise
- ◆ Package: SOP24, SSOP24 and SDIP24
- ◆ Applications: LED Displays, Variable Message Signs, LED Traffic Signs

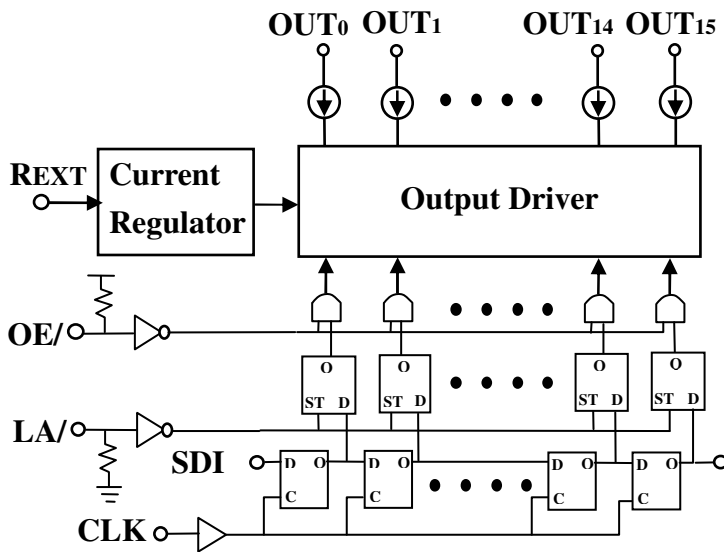
### Pin Configurations



**Terminal Description**

Pin	Name	Function
1	GND	Ground terminal.
2	SDI	Serial input of data shift register.
3	CLK	Clock input of shift register, data is sampled at the rising edge of CLK.
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 -20	OUT[0:15]	Open-drain, constant-current outputs.
21	OE/	Output enable signal. Output is enabled when OE/ is forced to low.
22	SDO	Output terminal of serial-data output to the SDI of next SCT2024.
23	REXT	Used to connect an external resistor for setting up all output current.
24	VDD	Supply voltage terminal.

**Block Diagram**



**Ordering Information**

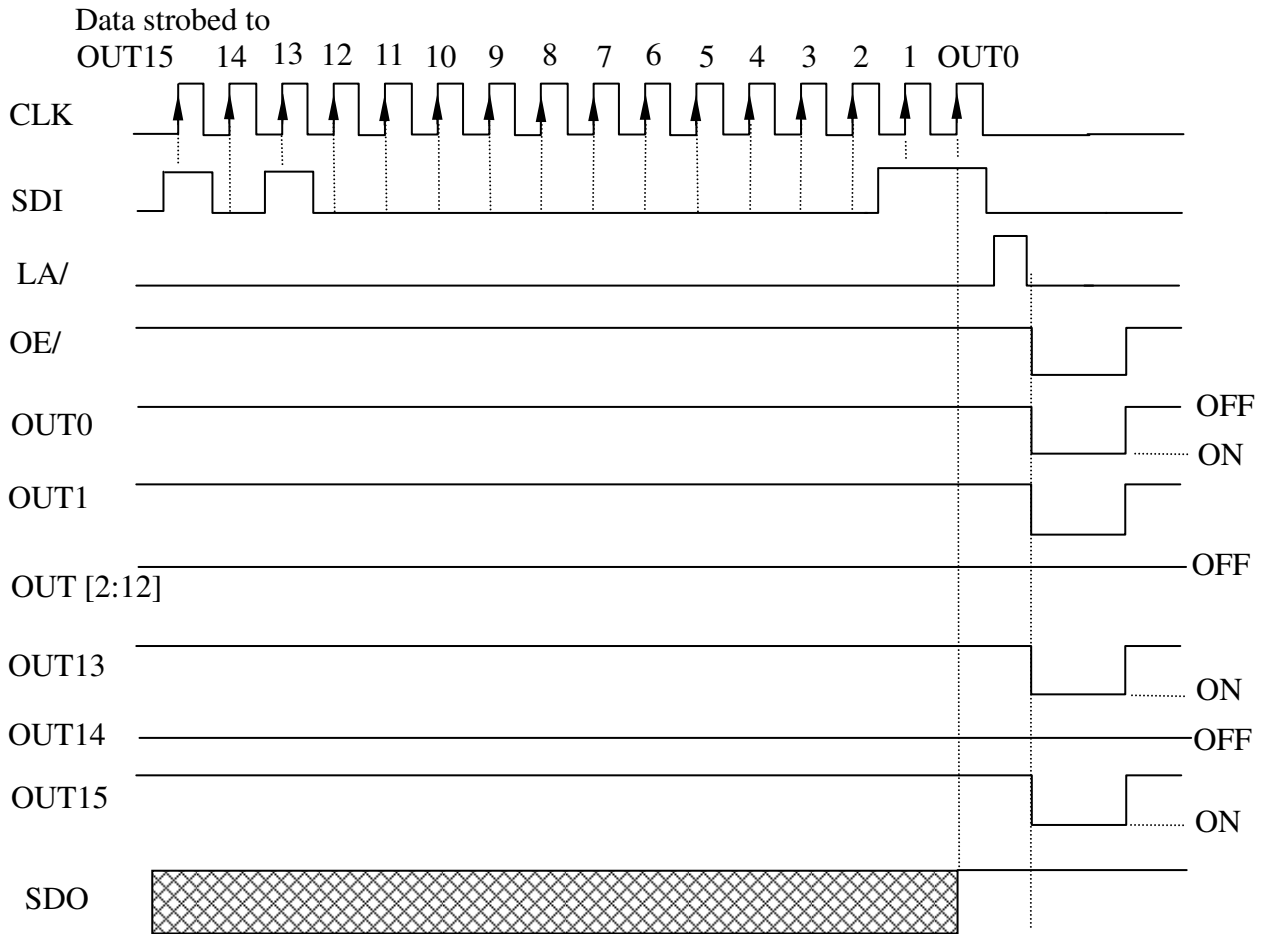
Part	Package
SCT2024CSOG	Pb free SOP24
SCT2024CSSG	Pb free SSOP24
SCT2024CSAG	Pb free SSOP24
SCT2024CSTG	Pb free SSOP24-1.0
SCT2024CSDG	Pb free SDIP24

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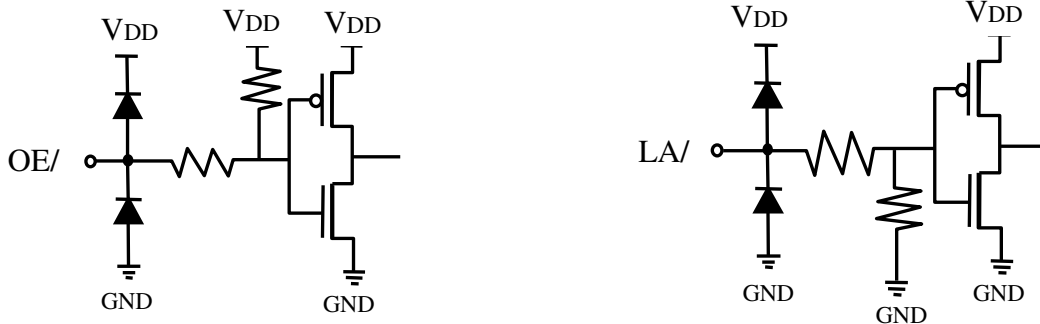
**Truth Table**

CLK	LA/	OE/	SDI	OUT0 ~ OUT15	SDO
↑	H	L	D <sub>n</sub>	D <sub>n</sub> D <sub>n-1</sub> ---- D <sub>n-14</sub> D <sub>n-15</sub>	D <sub>n-15</sub>
↑	L	L	D <sub>n+1</sub>	No change	D <sub>n-14</sub>
↑	H	L	D <sub>n+2</sub>	D <sub>n+2</sub> D <sub>n+1</sub> ---- D <sub>n-12</sub> D <sub>n-13</sub>	D <sub>n-13</sub>
↓	X	L	D <sub>n+3</sub>	D <sub>n+2</sub> D <sub>n+1</sub> ---- D <sub>n-12</sub> D <sub>n-13</sub>	D <sub>n-13</sub>
↓	X	H	D <sub>n+3</sub>	Off	D <sub>n-13</sub>

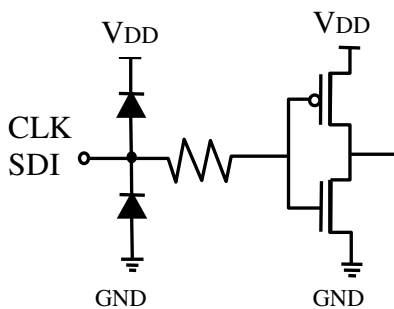
### Timing Diagram



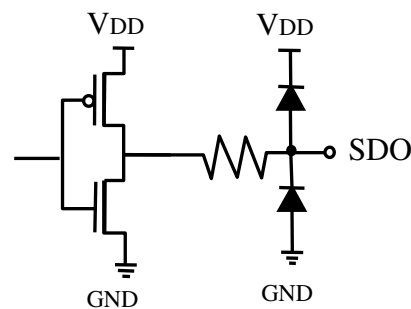
### Equivalent Circuits of Inputs (1)



### Equivalent Circuits of Inputs (2)



### Equivalent Circuits of Output



**Maximum Ratings** (Ta = 25°C)

Characteristic		Symbol	Rating	Unit
Supply Voltage		V <sub>DD</sub>	7.0	V
Input Voltage		V <sub>IN</sub>	-0.2 ~ V <sub>DD</sub> +0.2	V
Output Current		I <sub>OUT</sub>	60	mA/Channel
Output Voltage		V <sub>OUT</sub>	-0.2 ~ 17.0	V
Total GND Terminals Current		I <sub>GND</sub>	960	mA
Power Dissipation	SOP24	P <sub>D</sub>	1.92	W
	SSOP24		1.42	
	SSOP24-1.0		1.74	
	SDIP24		1.95	
Thermal Resistance	SOP24	R <sub>TH(j-a)</sub>	65	°C/W
	SSOP24		88	
	SSOP24-1.0		72	
	SDIP24		64	
Operating Temperature		T <sub>OPR</sub>	-40~+85	°C
Storage Temperature		T <sub>STG</sub>	-55~+150	°C

**Recommended Operating Conditions** (Ta= -40 to 85°C unless otherwise noted)

Characteristic	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply Voltage	V <sub>DD</sub>	-	3	-	5.5	V
Output Voltage	V <sub>OUT</sub>	Output OFF	-	-	17	V
Output Voltage	V <sub>OUT</sub>	Output ON	1	-	4	V
Output Current	I <sub>OUT</sub>	V <sub>DD</sub> =3.3V/5V	5	-	30/45	mA
Input Voltage	V <sub>IH</sub>	Input Signals	0.7V <sub>DD</sub>	-	V <sub>DD</sub>	V
	V <sub>IL</sub>	Input Signals	0	-	0.3V <sub>DD</sub>	V
OE/ Pulse Width	t <sub>w</sub>	V <sub>DD</sub> =3.3V/5V	180	-	-	ns

**Selector Guide**

Part	Number of Outputs	Max Output Current (mA)	Min PWM Pulse Width (ns)	Supply Voltage (V)
SCT2110	8	180	100	5
SCT2167	8	60	180	3.3/5
SCT2210	16	120	50	5
SCT2026	16	90	120	5
SCT2024	16	60	180	3.3/5

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

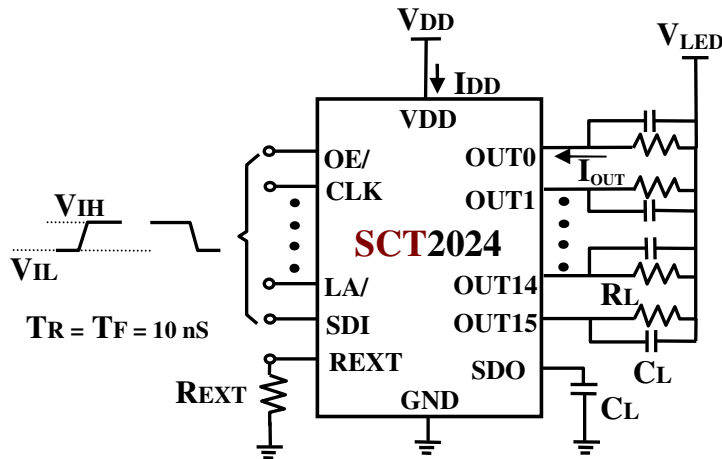
Characteristic	Symbol	Condition	Min.	Typ.	Max.	Unit	
Input Voltage	$V_{IH}$	-	$0.7V_{DD}$	-	$V_{DD}$	V	
	$V_{IL}$	-	0	-	$0.3V_{DD}$	V	
SDO Output Voltage	$V_{OH}$	$V_{DD}=3.3V/5V$ , $I_{OH} = -1mA$	2.9/4.6	-	-	V	
	$V_{OL}$	$V_{DD}=3.3V/5V$ , $I_{OL} = +1mA$	-	-	0.4	V	
Output Leakage Current	$I_{OL}$	$V_{OUT} = 17V$	-	-	1.0	$\mu A$	
Output Current	$I_{OUT}$	$V_{OUT}=1.0V$   $R_{EXT}=900\Omega$	-	20.5	-	mA	
Current Bit Skew*	$dI_{OUT}$	$V_{OUT}=1.0V$   $R_{EXT}=900\Omega$	-	-	$\pm 2$	%	
Chip Skew	$dI_{OUT}$	$V_{OUT}=1.0V$   $R_{EXT}=900\Omega$	-	-	$\pm 5$	%	
$I_{OUT}$ vs. $V_{DD}$ Regulation	$\%/dV_{DD}$	$3V < V_{DD} < 5.5V$ , $V_{OUT} > 1.0V$ , $R_{EXT}=900\Omega$	-	-	$\pm 1$	%/V	
$I_{OUT}$ vs. $V_{OUT}$ Regulation	$\%/dV_{OUT}$	$1V < V_{OUT} < 4V$ $I_{OUT}=20.5mA$ , $R_{EXT}=900\Omega$	-	-	$\pm 0.1$	%/V	
Pull-up Resistor	$R_{up}$	OE/	-	500	-	K $\Omega$	
Pull-down Resistor	$R_{down}$	LA/	-	500	-	K $\Omega$	
Thermal Shutdown	$T_H$	Junction Temp.	-	160	-	$^\circ C$	
	$T_L$		-	110	-	$^\circ C$	
Supply Current	OFF	$I_{DD}(off)1$	$R_{EXT} = Open$ , $V_{DD} = 3.3V/5V$ OUT [0:15]=Off	-	2	3	mA
		$I_{DD}(off)2$	$R_{EXT} = 900\Omega$ , $V_{DD} = 3.3V/5V$ OUT [0:15]=Off	-	5	7	
	ON	$I_{DD}(on)$	$R_{EXT} = 900\Omega$ , $V_{DD} = 3.3V/5V$ OUT [0:15]=On	-	7/8	10	

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

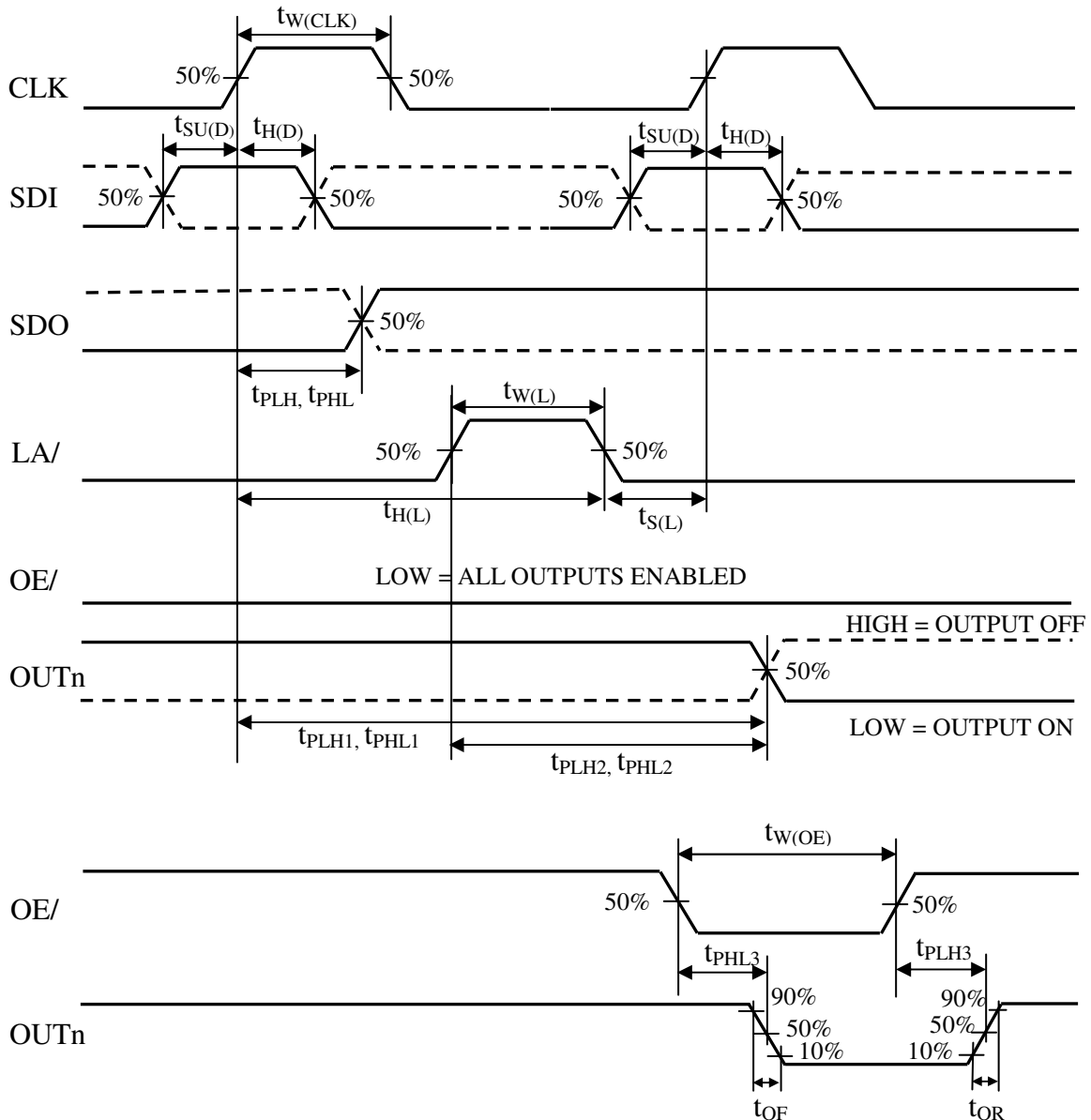
**Switching Characteristics** ( $T_a=25^\circ C$  unless otherwise noted)

Characteristic	Symbol	Condition	Min.	Typ.	Max.	Unit
Propagation Delay Time ("L" to "H")	CLK - OUTn	$t_{PLH1}$	-	80	100	ns
	LA/ - OUTn	$t_{PLH2}$	-	80	100	ns
	OE/ - OUTn	$t_{PLH3}$	-	80	100	ns
	CLK - SDO	$t_{PLH}$	-	20	40	ns
Propagation Delay Time ("H" to "L")	CLK - OUTn	$t_{PHL1}$	-	80	100	ns
	LA/ - OUTn	$t_{PHL2}$	-	80	100	ns
	OE/ - OUTn	$t_{PHL3}$	-	80	100	ns
	CLK - SDO	$t_{PHL}$	-	20	40	ns
Pulse Width	CLK	$t_{W(CLK)}$	20	-	-	ns
	LA/	$t_{W(L)}$	20	-	-	ns
	OE/	$t_{W(OE)}$	180	-	-	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
Output Delay	$t_{DR}$	$OUT_{EVEN} - OUT_{ODD}$	-	30	-	ns
	$t_{DF}$		-	30	-	ns
Slow CLK rise time	$t_R$	Cascade	-	-	500	ns
Slow CLK fall time	$t_F$		-	-	500	ns

**Test Circuit for Switching Characteristics**

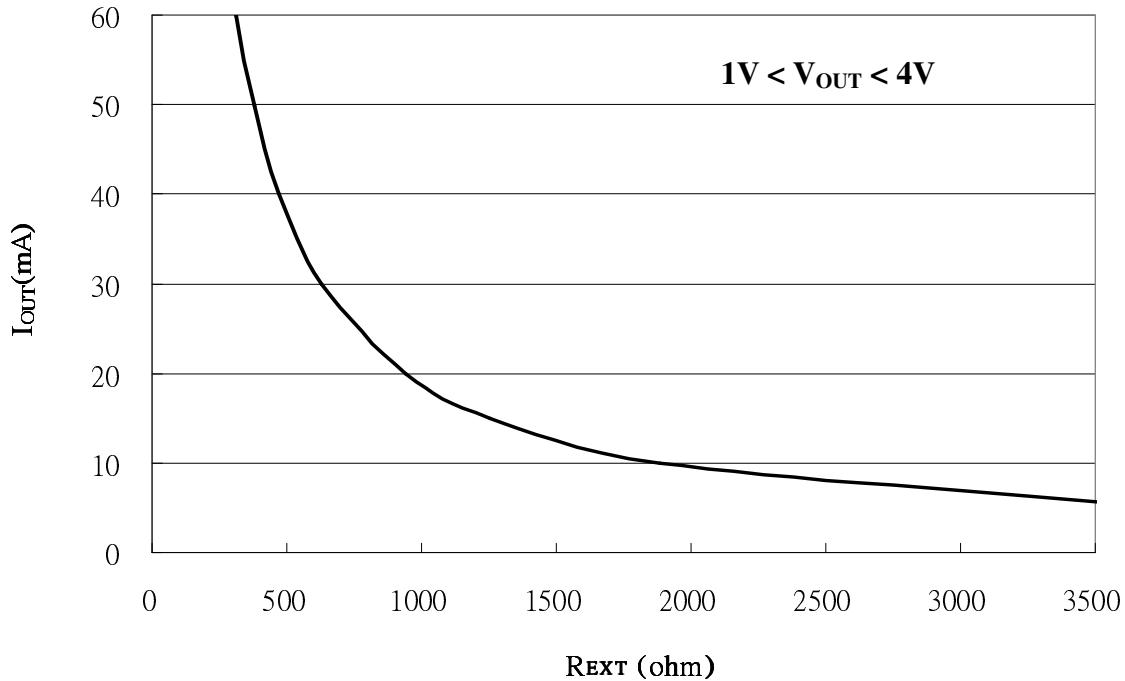


**Timing Waveform**



### Adjusting Output Current

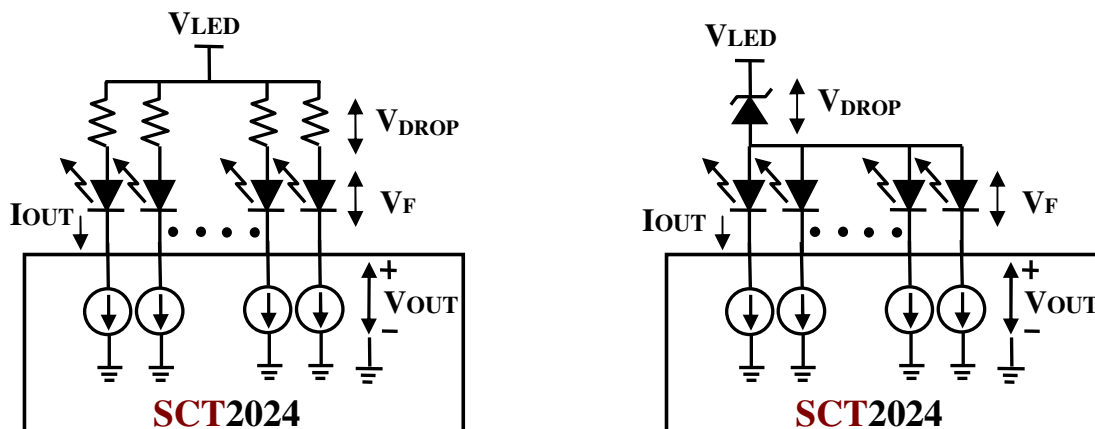
All SCT2024's output current ( $I_{OUT}$ ) are set by one external resistor at pin REXT. The relationship between  $I_{OUT}$  and resistance  $R_{EXT}$  is shown as the following figure.



Also, when SCT2024's output voltage is set between 1 Volt and 4 Volt, the output current  $I_{OUT}$  can be set by the formula:  $I_{OUT} = 30(620 / R_{EXT})$  (mA) (Chip skew  $\pm 5\%$ ). Thus the output currents are all set to 20.5mA by set the reference value  $R_{EXT} = 900\Omega$ .

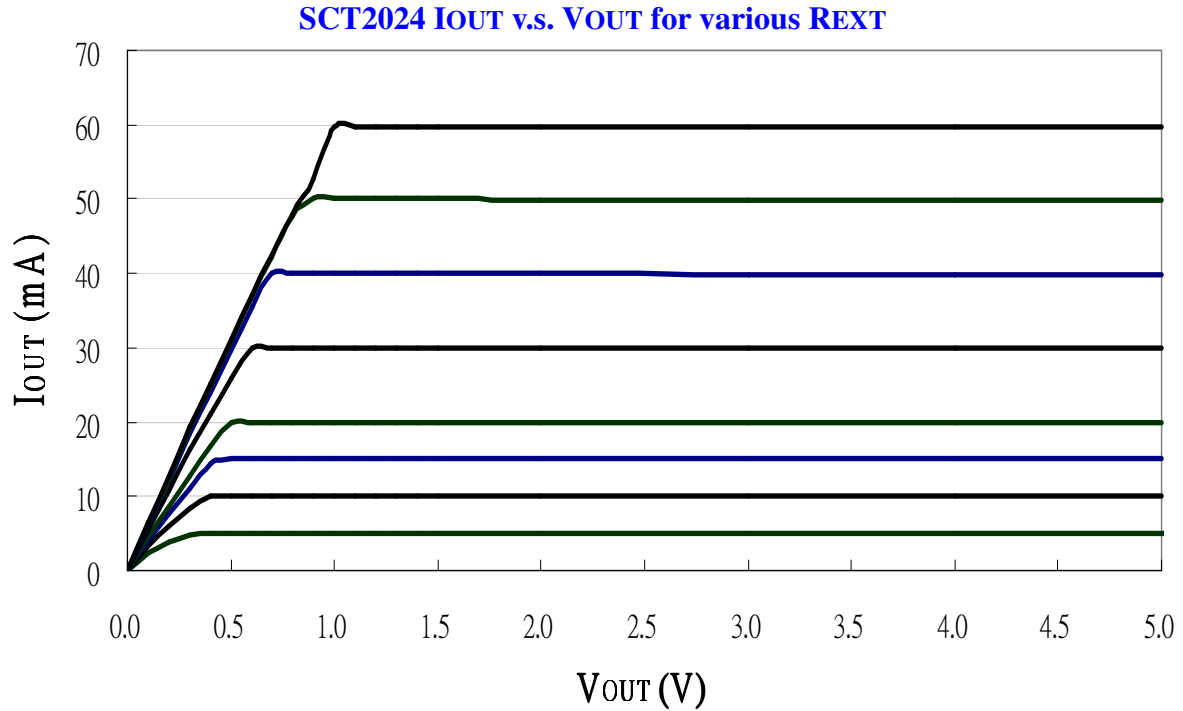
### Load Supply Voltage ( $V_{LED}$ )

SCT2024 can be operated very well when  $V_{OUT}$  ranging from 1V to 4V. So it is recommended to use the lowest possible supply voltage or set a voltage reducer to reduce the  $V_{OUT}$  voltage and then reduce the power dissipation of SCT2024. A voltage reducer lets  $V_{OUT} = V_{LED} - V_{DROP} - V_F$ . Resistors or Zener diode can be used in the applications as shown in the following figures.



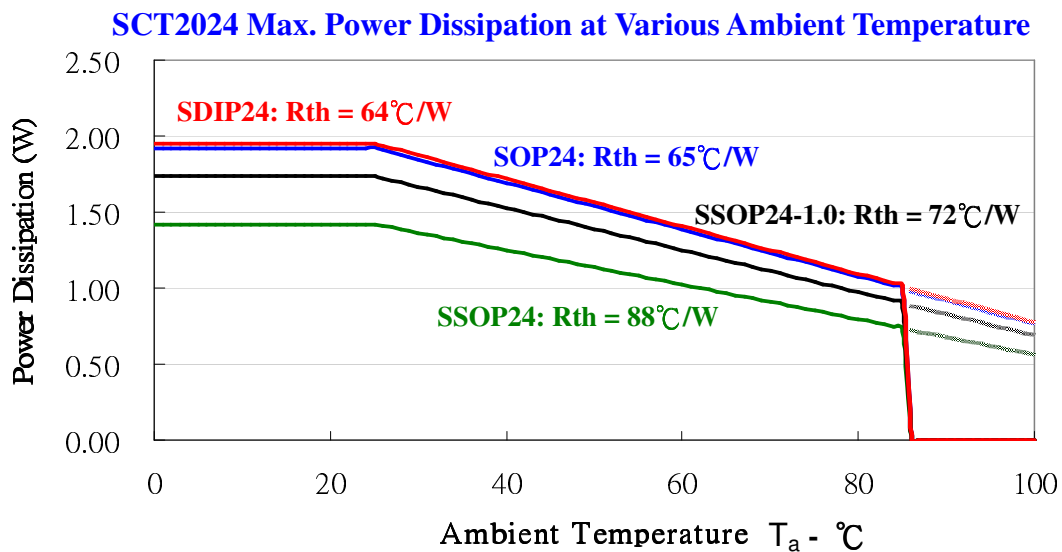
### Output Characteristics

The current characteristic of output stage is flat. The output current can be kept constant regardless of the variations of LED forward voltage when  $V_{OUT} > 1.0V$ . The relationship between  $I_{OUT}$  and  $V_{OUT}$  is shown as below:



### Power Dissipation

The power dissipation ( $P_D$ ) of a semiconductor chip is limited by its package and ambient temperature. The maximum allowable power dissipation  $P_{D(max)}$  is 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  $150^\circ C$ ,  $T_a$ : 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:



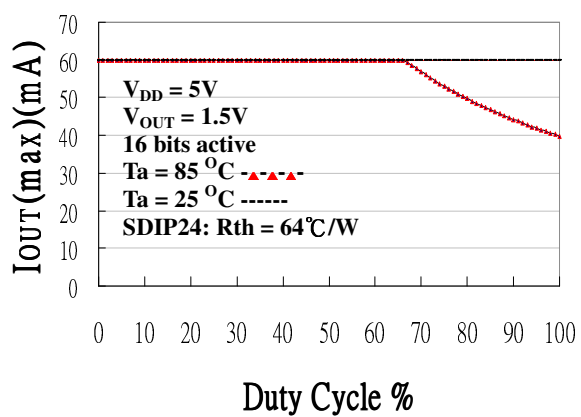
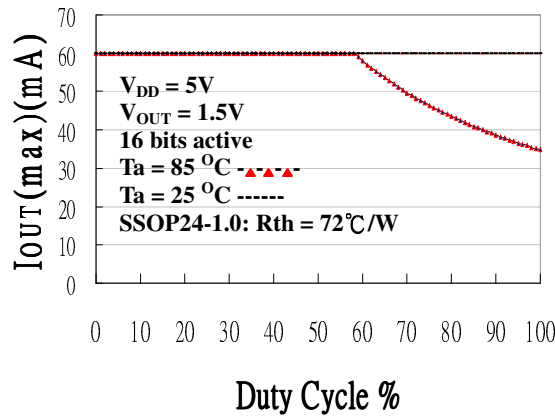
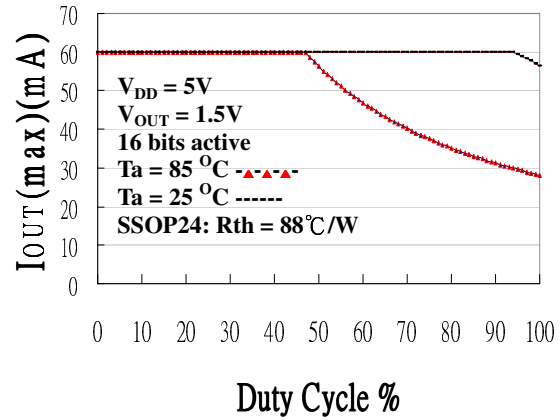
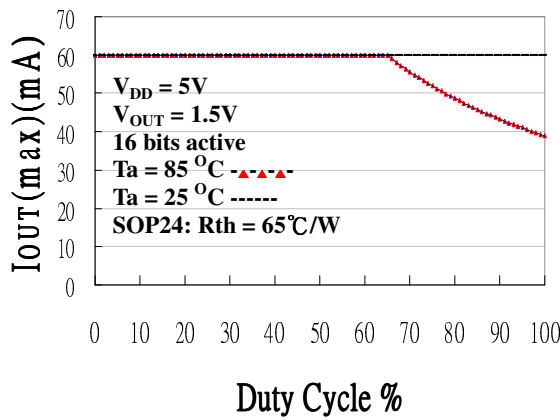


### Limitation on Maximum Output Current

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

$$I_{OUT(max)} = (((T_{j(max)} - T_a) / R_{th(j-a)}) - (V_{DD} * I_{DD})) / V_{OUT} / \text{Duty} / N$$

Where  $T_{j(max)} = 150^\circ\text{C}$ ,  $N = 16$  (all ON)

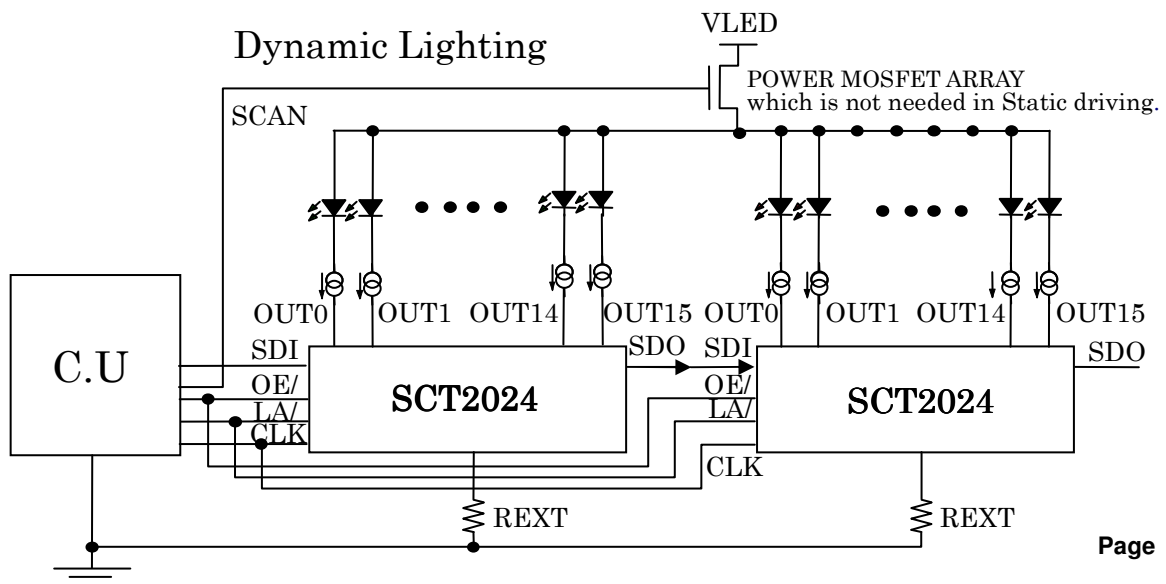


### Over Temperature Shutdown

The SCT2024 contains thermal shutdown scheme to prevent damage from over heat.

The internal thermal sensor turns off all outputs when the die temperature exceeds approximately  $+160^\circ\text{C}$ . The outputs are enabled again when the die temperature drops below approximately  $+110^\circ\text{C}$ .

### Typical Application Circuits

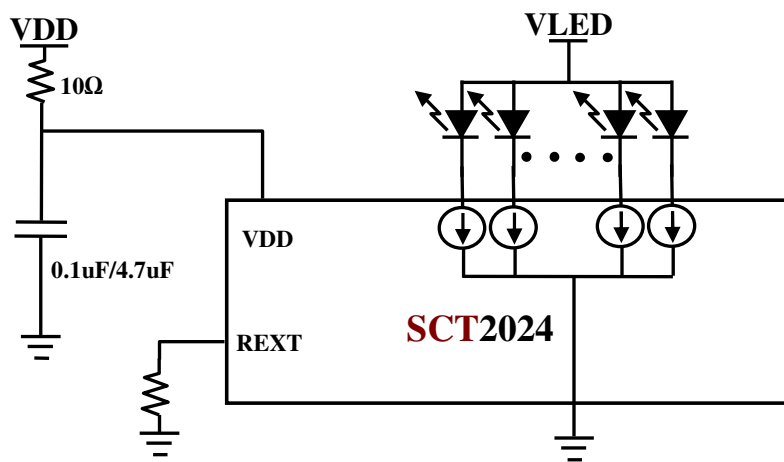


### PCB Design Considerations

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 SCT2024. Locate the capacitor as close to the SCT2024 as possible. This is normally adequate for static LED driving. For dynamic scan or PWM applications, it is necessary to add an additional capacitor of 4.7uF or more to each supply for every SCT2024. 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.

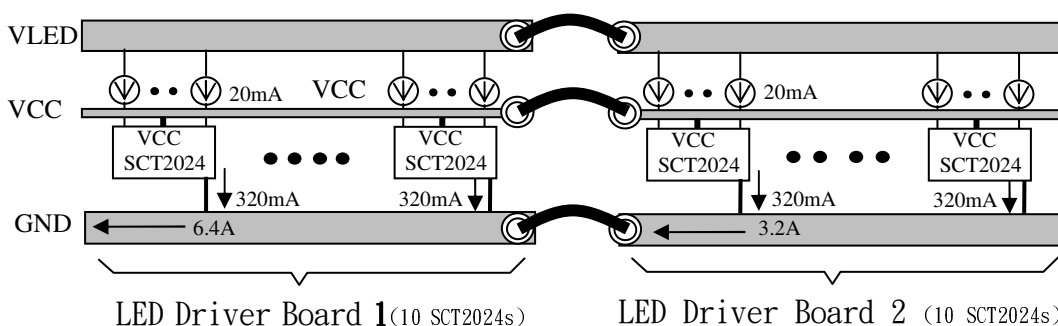


#### External Resistor (REXT)

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

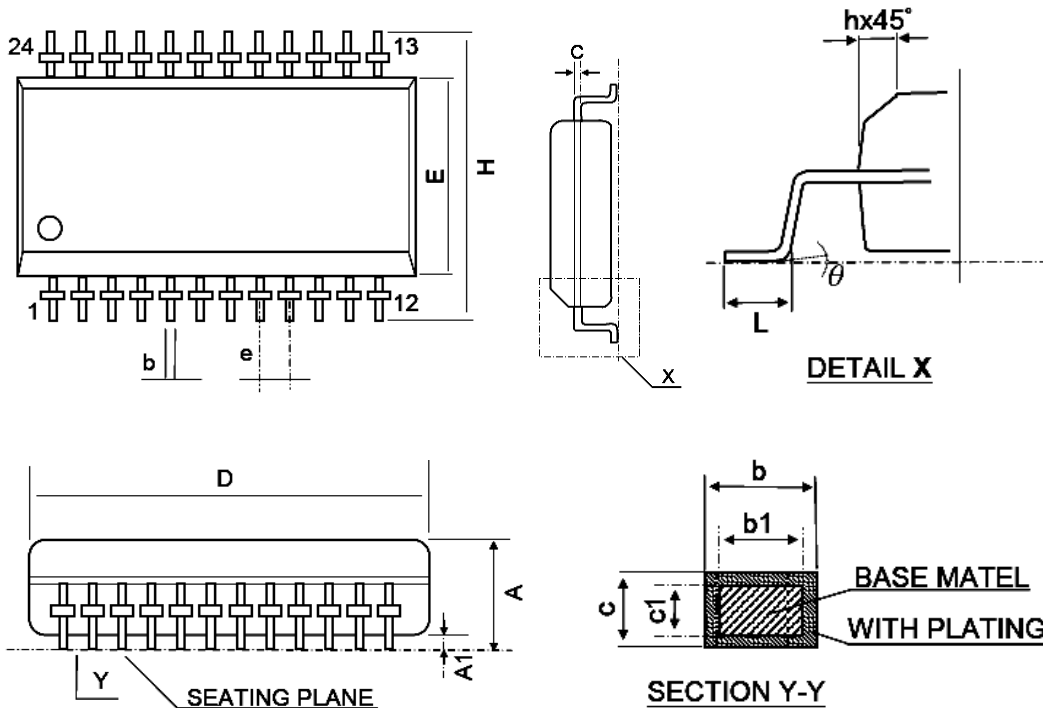
#### Power and Ground

Maximizing the width and minimizing the length of V<sub>DD</sub> and GND trace improve 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 SCT2024 in conjunction with decoupling capacitor shunting the ICs is recommended. Separating and feeding the LED power from another stable supply terminal VLED is strongly recommended.



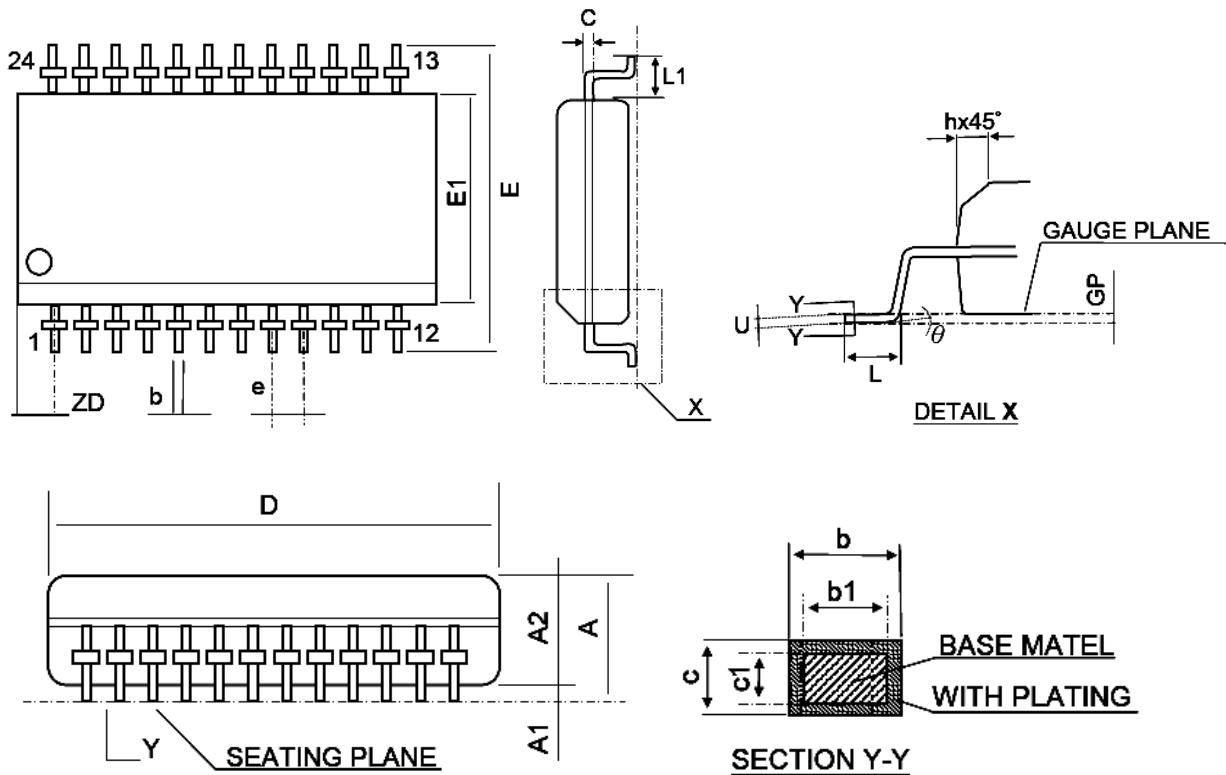
**Package Dimension**

SOP24



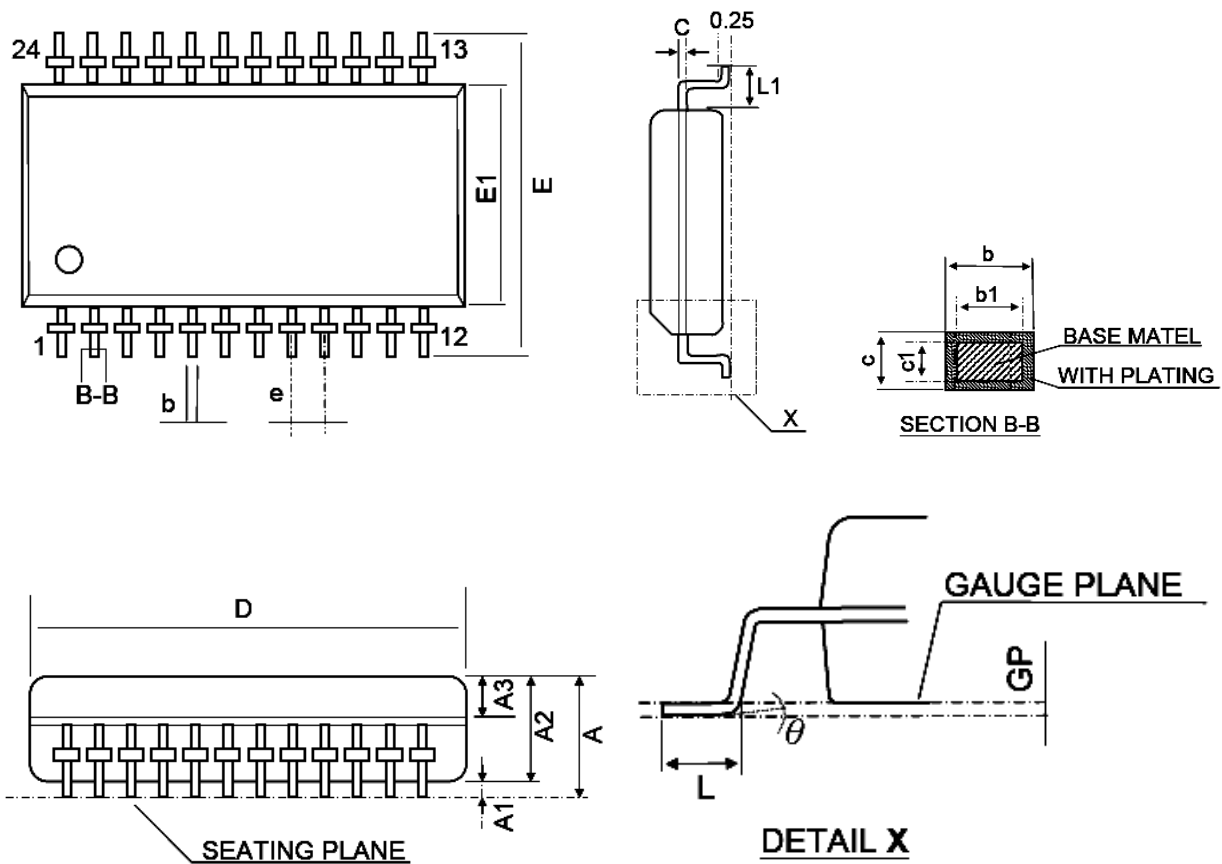
SYMBOL	DIMENSION (mm)			DIMENSION (mil)		
	MIN	NOM	MAX	MIN	NOM	MAX
A	2.36	2.54	2.64	93	100	104
A1	0.10	0.20	0.30	4	8	12
b	0.35	0.406	0.48	14	16	19
b1	0.35		0.46	14		18
c	0.23	0.254	0.31	9	10	12
c1	0.23		0.29	9		11
D	15.20	15.29	15.60	598	602	614
E	7.40	7.50	7.60	291	295	299
e	1.27 BSC			50 BSC		
H	10.00	10.31	10.65	394	406	419
h	0.25	0.66	0.75	10	26	30
L	0.51	0.76	1.02	20	30	40
Y			0.075			3
theta	0°		8°	0°		8°

SSOP24



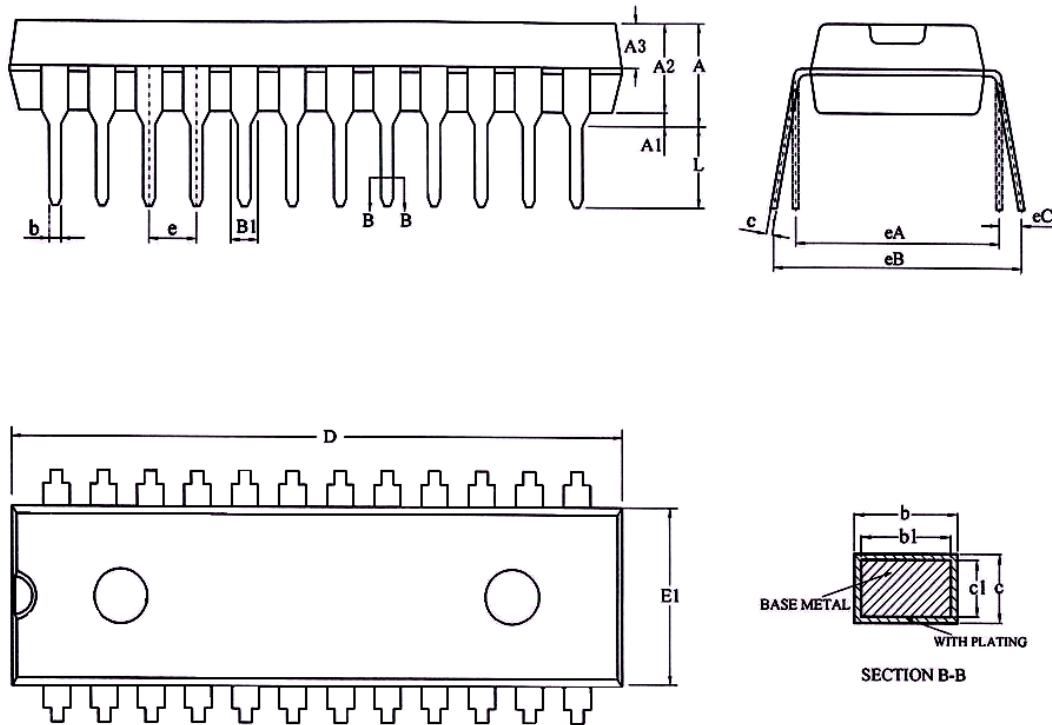
SYMBOL	DIMENSION (mm)			DIMENSION (mil)		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.35	1.60	1.75	53	63	69
A1	0.10	0.15	0.25	4	6	10
A2			1.50			59
b	0.20		0.30	8		12
b1	0.20	0.254	0.28	8	10	11
c	0.18		0.25	7		10
c1	0.18	0.203	0.23	7	8	9
D	8.56	8.66	8.74	337	341	344
E	5.80	6.00	6.20	228	236	244
E1	3.80	3.90	4.00	150	154	157
e	0.635 BSC			25 BSC		
h	0.25	0.42	0.50	10	17	20
L	0.40	0.635	1.27	16	25	50
L1	1.00	1.05	1.10	39	41	43
ZD	0.838 REF			33 REF		
Y			0.10			4
θ	0°		8°	0°		8°

SSOP24-1.0



SYMBOL	DIMENSION (mm)			DIMENSION (mil)		
	MIN	NOM	MAX	MIN	NOM	MAX
A	-	-	2.20	-	-	87
A1	0.10	0.20	0.30	4	8	12
A2	1.60	1.80	2.00	63	71	79
A3	0.62	0.82	0.92	24	32	36
b	0.39	-	0.47	15	-	19
b1	0.38	0.40	0.43	15	16	17
c	0.15	-	0.20	6	-	8
c1	0.14	0.15	0.16	5.5	6	6.5
D	12.80	13.00	13.20	504	512	520
E	7.70	7.90	8.10	303	311	319
E1	5.80	6.00	6.20	228	236	244
e	1.00 BSC			39 BSC		
L	0.35	0.45	0.55	14	18	22
L1	0.95 BSC			37 BSC		
θ	0°	-	8°	0°	-	8°

SDIP24



SYMBOL	DIMENSION (mm)			DIMENSION (mil)		
	MIN	NOM	MAX	MIN	NOM	MAX
A	3.60	3.80	4.00	142	150	157
A1	0.30	-	-	12	-	-
A2	3.10	3.30	3.50	122	130	138
A3	1.42	1.52	1.62	56	60	64
b	0.44	-	0.53	17	-	21
b1	0.43	0.46	0.48	17	18	19
B1	1.00 BSC			39 BSC		
c	0.25	-	0.31	10	-	12
c1	0.24	0.25	0.26	9	10	11
D	22.70	22.90	23.10	894	902	909
E1	6.40	6.60	6.80	252	260	268
e	1.778 BSC			70 BSC		
eA	7.62 BSC			300 BSC		
eB	7.62	-	9.50	300	-	374
eC	0	-	0.94	0	-	37
L	3.00	-	-	118	-	-

**Revision History**

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.