

1. Features

- 16 channels constant current output.
- Constant output current is to set up external resistor.
 $I_{out} = 5mA \sim 90mA$
Constant current output voltage : $V_o = 17V(Max)$
- Excellent output current accuracy :
between outputs : $\pm 1\%(typ)$
between devices : $\pm 3\%(typ)$
- Control data method : serial-in, parallel out.
- Data transfer frequency : $f_{max} = 25MHz$
- Operating voltage range : $V_{dd} = 4.5 \sim 5.5V$
- Operating temperature range : $T_{op} = -40 \sim 85^{\circ}C$
- 20ns delay of output to lower bouncing noise.
- Schmitt trigger input.
- Pb free Package : LSD9016-X24T SSOP24-150 - 0.64
 LSD9016-X24S SOP24L- 300 - 1.0
 LSD9016-X24W SOP24 - 375- 1.27

2. Description

The LSD9016 is a constant current LED driver for lighting application.

It has sixteen regulated current ports to provide uniform and constant current sink for driving LEDs within a large range of V_f variations.

A user may adjust the output current from 5mA to 90mA through an external resistor and can control LED brightness via OEB input, too.

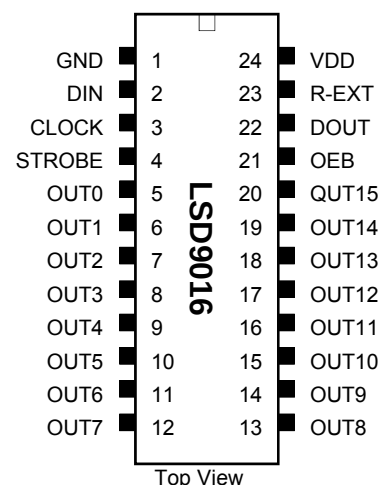
The duty cycle of OEB can decide the brightness intensity from 0% to 100%.

3. Application

- Automotive interior LED lighting driver.
- Decoration lighting.
- Traffic sign
- Video wall
- A signboard

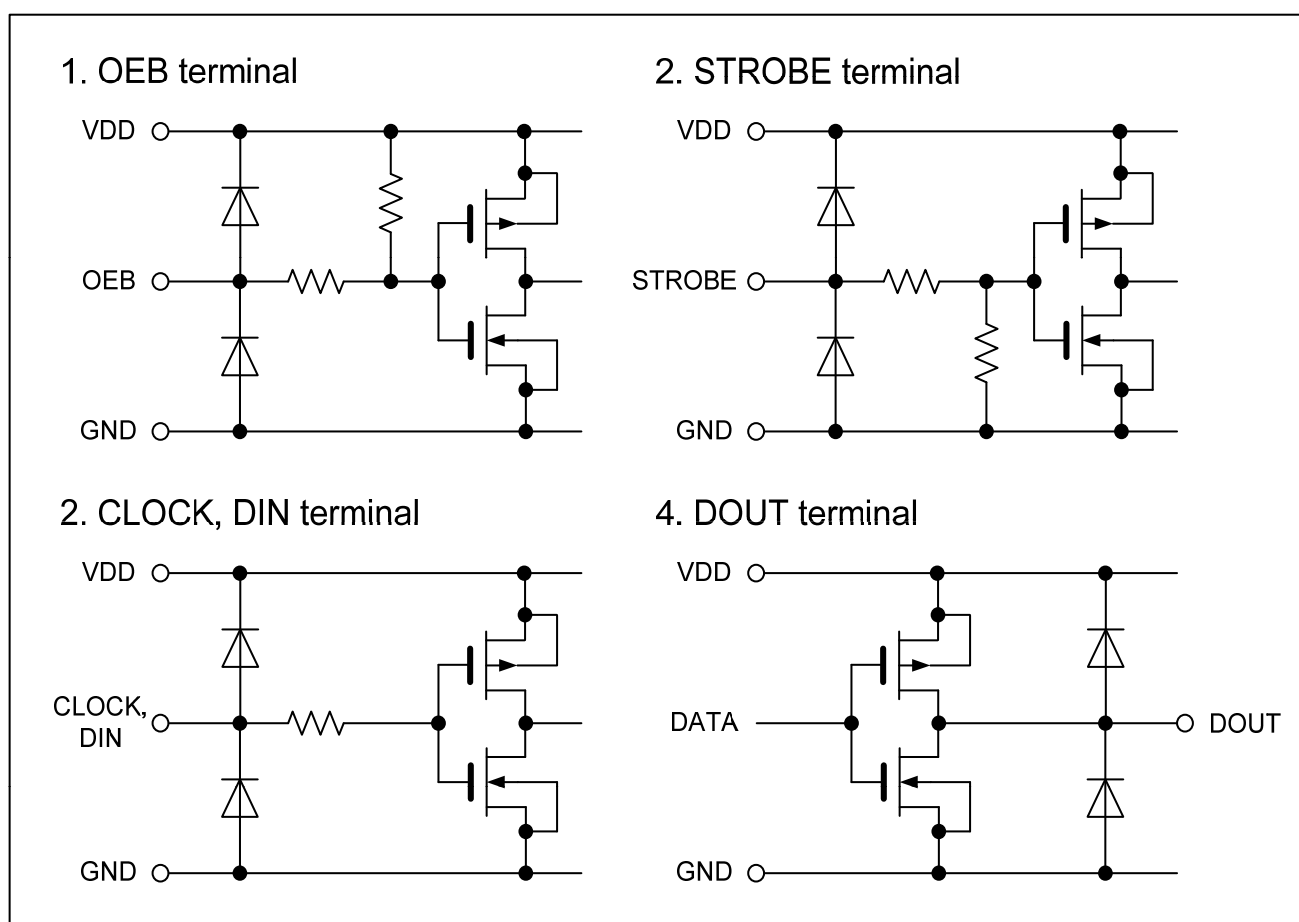
4. Pin Description

PIN NO	PAD NAME	DESCRIPTION
1	GND	GND terminal for logic and current sink.
2	DIN	Serial data input terminal for Internal shift register.
3	CLOCK	Clock input terminal for internal shift register. Serial data is captured at rising edge of this input.
4	STROBE	Data strobe terminal for internal data latch.
24	VDD	Power supply terminal(4.5V ~ 5.5V)
5~20	OUTn	Output terminal for External LED.
21	OEB	Output enable input terminal. OUTn pin outputs when this input at "L" level
22	DOUT	Serial data output terminal for external device.
23	R-EXT	Input terminal for external RESISTER The resister which connects between R-EXT and GND sets a output current on OUTn terminal.

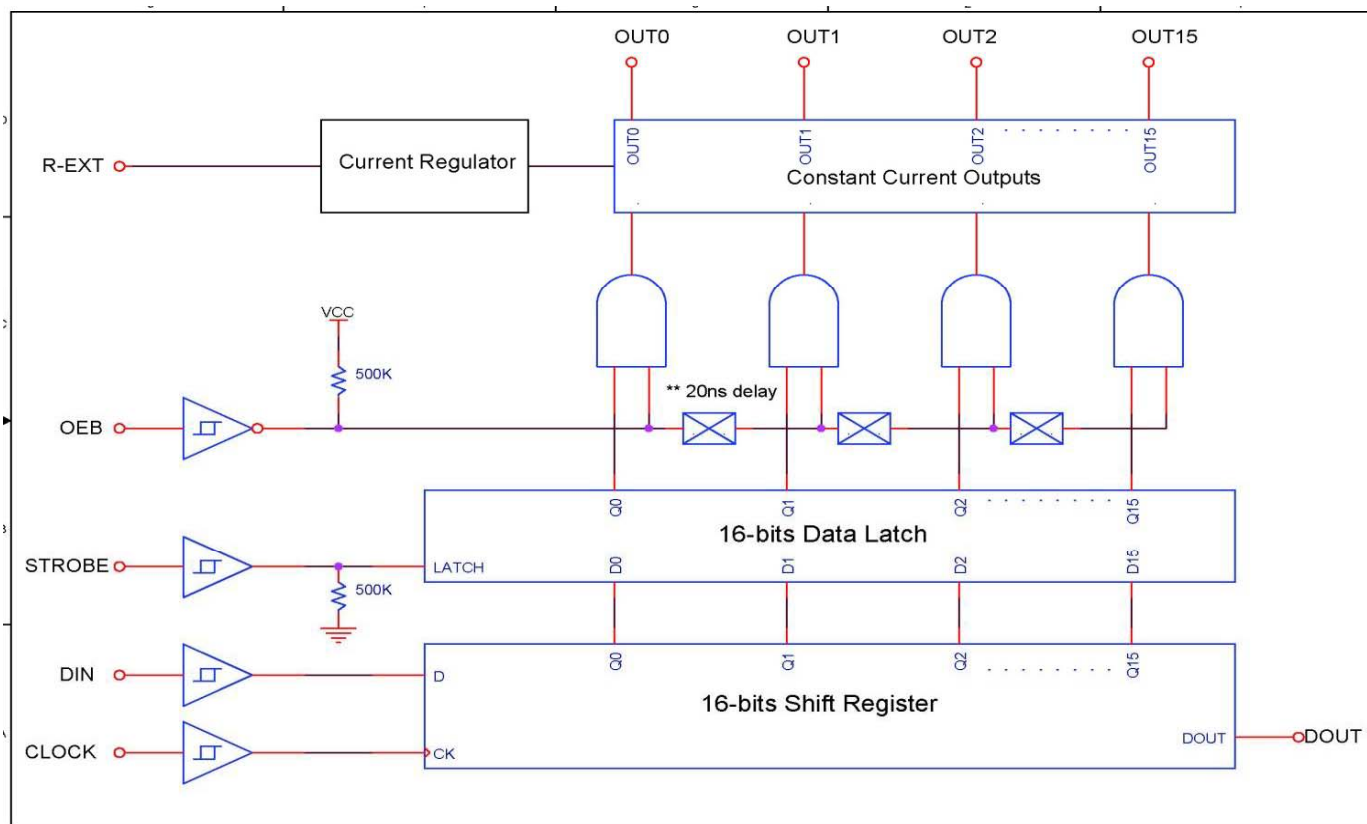


SSOP24-150-0.64
SOP24L -300-1.0
SOP24 - 375-1.27

5. Equivalent Circuit of input and output



6. Block Diagram



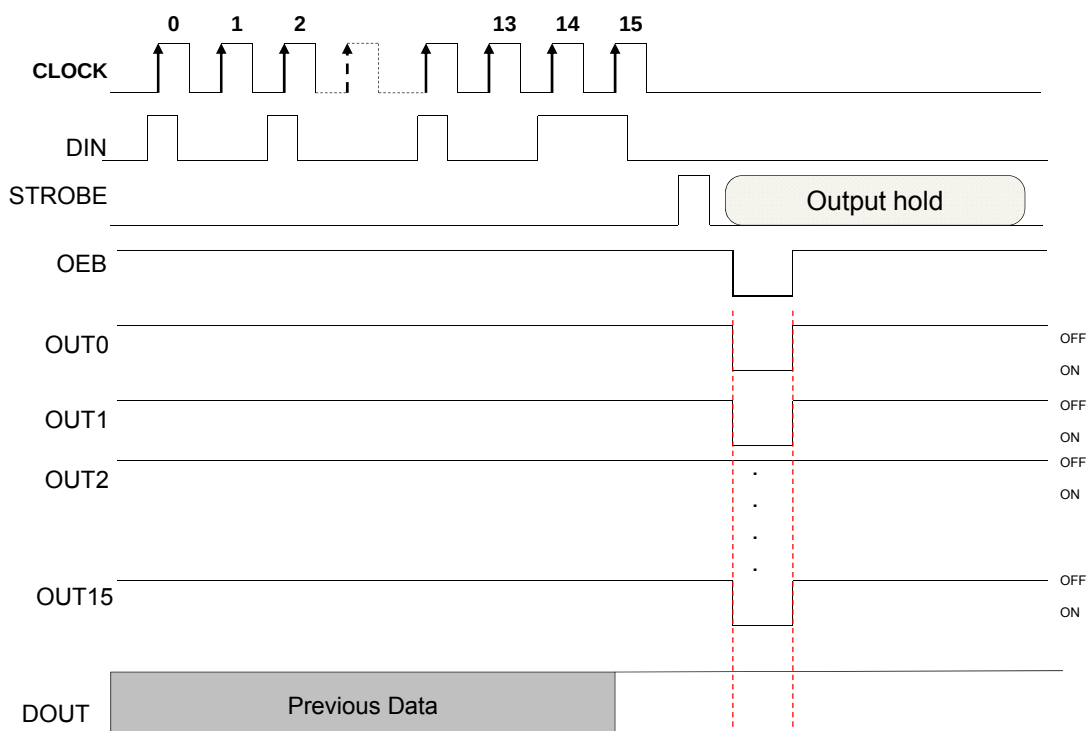
**** 20ns delay**

This is designed for high speed switching between outputs and is intended to have the effect of reducing switching noise when all outputs are ON or OFF at the same time. There is a switching time delay (20 ns typ.) between adjacent outputs.

< Truth Table >

CLOCK	STROBE	OEB	DIN	OUT0~15	DOUT
↑	H	L	D _n	D _n D _{n-1} D _{n-14} D _{n-15}	D _{n-15}
↑	L	L	D _{n+1}	No Change	D _{n-14}
↑	H	L	D _{n+2}	D _{n+2} D _{n+1} D _{n-12} D _{n-13}	D _{n-13}
↓	X	L	D _{n+3}	D _{n+2} D _{n+1} D _{n-12} D _{n-13}	D _{n-13}
↓	X	H	D _{n+3}	All output s are off	D _{n-13}

7. Timing Diagram



STROBE are level sensitive (not edge triggered).

STROBE = "H" level, become transparent STROBE ="L" level hold data

OEB = "H" level , all ouput are off. DOUT is to change on the rising edge of clock..

8. Electrical Characteristics

8-1. Absolute Maximum Ratings(Ta = 25℃)

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	V _{DD}	0 ~ 6	V
Output Voltage	V _{OUT}	-0.3 ~ 17	V
Input Voltage	V _{IN}	-0.4 ~ V _{DD} + 0.4	V
Output Current	I _{out}	90	mA
Clock Frequency	F _{CK}	25	MHz
GND Terminal Current	I _{GND}	1440	mA
Power Dissipation (2 Layer PCB, Ta = 25℃)	P _D	1.56(X24W)/1.31(X24S) / 1.136(X24T)	W
Thermal resistance (2 Layer PCB, Ta = 25℃)	R _{TH}	LSD9016-X24W = 80	℃ /W
		LSD9016-X24S = 95	
		LSD9016-X24T = 110	
Operating Temperature	T _{OP}	-40 ~ 85	℃
Storage Temperature	T _{ST}	-55 ~ 150	℃

8-2. Recommended Operating Ratings(Ta = 25℃)

PARAMETER	SYMBOL	Condition	MIN	TYP	MAX	UNIT
Supply Voltage	VDD	-	3.5		5.5	V
Output Voltage when LED off	VOUT(OFF)	-	-	-	17	V
Output Voltage when LED on	VOUT(ON)	-	0.7	-	4	V
High level logic Input Voltage	VIH	-	2.0		Vdd	V
Low level logic Input Voltage	VIL	-	GND		0.8	V
High level DOUT output current	IOH	-			-1	mA
Low level DOUT output current	IOL	-			1	mA
Output Current LSD9016-X24S	Iout	-	5		90	mA
Output Current LSD9016-X24T	Iout	-	5		50	mA
Operating Temperature	TOP	-			-40 ~ 85	℃
Storage Temperature	TST	-			-55 ~ 150	℃
STROBE Pulse Width	twSTROBE	Vdd = 4.5~5.5V	50	-	-	ns
CLOCK Pulse Width	twCLOCK		20	-	-	ns
OEB Pulse Width	twOEB		100	-	-	ns
DIN Setup Time	tsDIN		5	-	-	ns
DIN Hold Time	thDIN		10	-	-	ns
STROBE Setup Time	tsSTROBE		50	-	-	ns
STROBE Hold Time	thSTROBE		50	-	-	ns
CLOCK Frequency	FCK	Cascade Operation	-	-	25	MHz

8-3. DC Characteristics

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
High level logic output voltage	V_{OH}	DOUT $I_{OH} = -1\text{mA}$	$V_{DD} - 0.4$	-	-	V
Low level logic output voltage	V_{OL}	DOUT $I_{OL} = 1\text{mA}$	-	-	0.4	V
High level logic input current	I_{IH}	OEB, DIN, CLOCK $V_{IN} = V_{DD}$	-	-	1	μA
Low level logic input current	I_{IL}	STROBE, DIN, CLOCK $V_{IN} = \text{GND}$	-	-	-1	μA
Power supply current	I_{DD1}	$V_{out} = 16\text{V}$, No R_{EXT} , CLOCK = Low, OEB = High	-	0.1	0.5	mA
	I_{DD2}	$R_{EXT} = 1.56\text{k}\Omega$, All output off.	-	-	7.0	mA
	I_{DD3}	$R_{EXT} = 500\Omega$, All output off.	-	-	14.0	mA
	I_{DD4}	$R_{EXT} = 1.56\text{k}\Omega$, All output on.	-	-	7.0	mA
	I_{DD5}	$R_{EXT} = 500\Omega$, All output on.	-	-	14.0	mA
Constant current output	I_{O1}	$V_{DD} = 5.0\text{V}$, $V_{out} = 1.5\text{V}$, $R_{EXT} = 1.56\text{k}\Omega$	11.28	12.0	12.72	mA
	I_{O2}	$V_{DD} = 5.0\text{V}$, $V_{out} = 1.5\text{V}$, $R_{EXT} = 500\Omega$	34.78	37.0	39.22	mA
Output off leak current	I_{OK}	$V_{out} = 1.0\text{V}$, $R_{EXT} = 1.56\text{k}\Omega$, All output off.	-	-	0.5	μA
Constant current error	ΔI_O	OUT0 to OUT15 $V_{DD} = 5.0\text{V}$, $V_{out} = 1.5\text{V}$, $R_{EXT} = 1.56\text{k}\Omega$	-	± 1	± 3	%
Constant current power supply voltage regulation	$\%V_{DD}$	OUT0 to OUT15 $V_{DD} = 4.5\sim 5.5\text{V}$, $V_{out} = 1.5\text{V}$, $R_{EXT} = 1.56\text{k}\Omega$	-	± 1	± 4	$\%/V$
Constant current output voltage regulation	$\%V_{out}$	OUT0 to OUT15 $V_{DD} = 5.0\text{V}$, $V_{out} = 1.0\sim 3.0\text{V}$, $R_{EXT} = 1.56\text{k}\Omega$		± 1	± 4	$\%/V$
Pull-up resistor	R_{UP}	OEB	250	500	800	$\text{k}\Omega$
Pull-down resistor	R_{DOWN}	STROBE	250	500	800	$\text{k}\Omega$

8-4. AC Characteristics (Unless otherwise specified, Ta = 25 °C VDD = 5V)

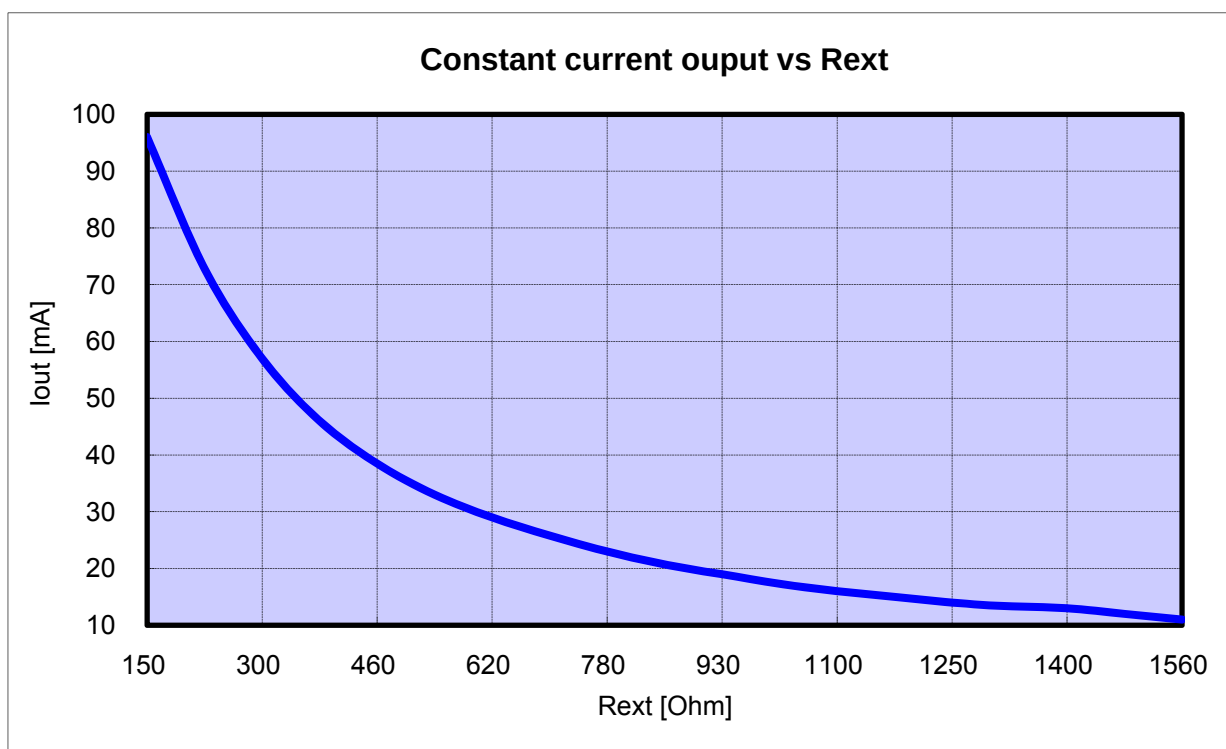
PARAMETER		SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Propagation Delay time	CLOCK-OUT0	tpLH1	STROBE = "H", OEB = "L"	-	25	100	ns
	STROBE-OUT0	tpLH2	OEB = "L"	-	25	100	
	OEB – OUT0	tpLH3	STROBE = "H"	-	25	100	
	CLOCK - DOUT	tpLH	-		20	-	
	CLOCK -OUT0	tpHL1	STROBE = "H", OEB = "L"	-	50	100	
	STROBE-OUT0	tpHL2	OEB = "L"	-	50	100	
	OEB – OUT0	tpHL3	STROBE = "H"	-	50	100	
	CLOCK –DOUT	tpHL	-		20	-	
Output rise time		tor	10 to 90% of voltage wave form	-	30	150	ns
Output fall time		tof	90 to 10% of voltage wave form	-	70	150	ns
Output delay time		tDLY(on)	OUTn – OUT(n+1) Between adjacent outputs	-	20	-	ns
Output delay time		tDLY(off)	OUTn – OUT(n+1) Between adjacent outputs	-	20	-	ns

9. Application Information

< Constant Current >

To keep supply constant current, LSD9016 provides minimum variation in current from channel to channel and chip to chip. The maximum current skew in each channel is less than 3% and less than 6% between ICs

where, $T_a = 25^{\circ}\text{C}$ $V_{out} = 1.5\text{V}$ $V_{dd} = 5\text{V}$ $R_{ext} = 1.56\text{k}$



- Conditions : $V_{out}=1.5\text{V}$, $V_{dd}=5.0\text{V}$, $T_a=25^{\circ}\text{C}$
- This data is provided for reference only.

< Adjusting Output Current >

All output CURRENT of LSD9016(I_{out}) are setting by one external resistor at pin R-EXT. The relative curve between I_{out} and resistance R-EXT is shown as the above figure and under table I_{out} vs R_{EXT} .

Also, the output current can be calculated from as below equation approximately.

$$I_{out} \approx V_{ref} / R_{EXT} * 14.8 \quad (I_{out} < 60\text{mA}) \quad \text{where , } V_{ref} = 1.22\text{V}$$

$$I_{out} \approx V_{ref} / R_{EXT} * 13.2 \quad (I_{out} \geq 60\text{mA})$$

where R_{ext} in Ω is resistance of the external resistor connected to R-EXT terminal.

< Table " I_{out} vs R_{EXT} " >

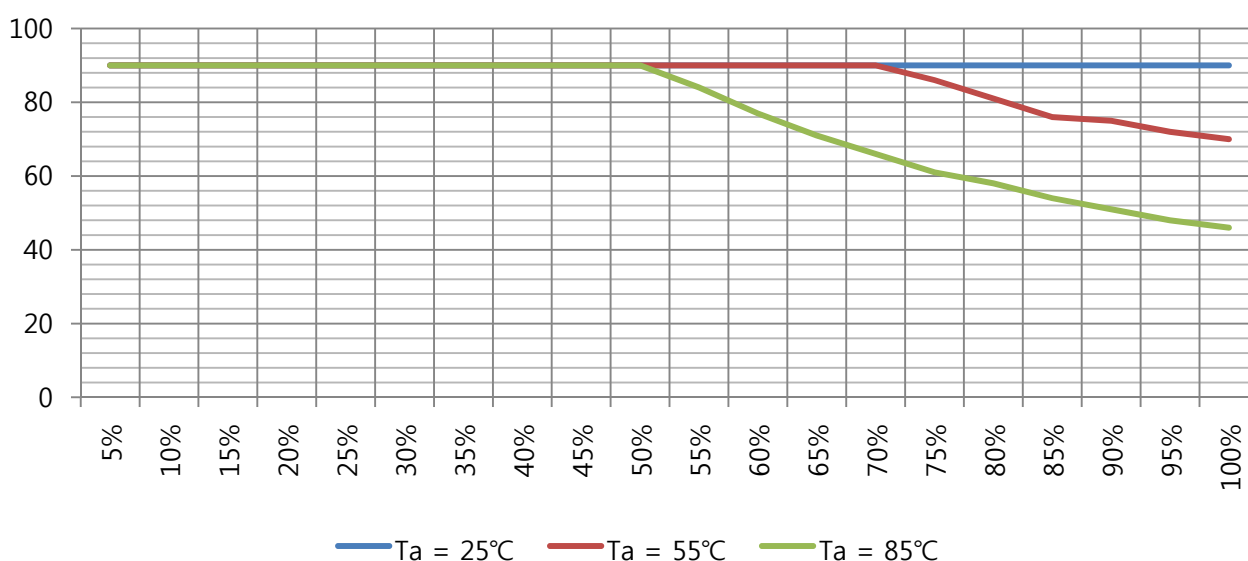
$I_{out} \text{ (mA)}$	$R_{EXT} \text{ (}\Omega\text{)}$	$I_{out} \text{ (mA)}$	$R_{EXT} \text{ (}\Omega\text{)}$
20	900	60	300
30	600	70	240
40	450	80	200
50	360	90	180

< Package Power Dissipation(Pd) >

The maximum allowable package power dissipation is determined as $P_d(max) = (T_j - T_a) / R_{th}$
 When 16 output channels are turn on simultaneously, the operating package power dissipation is $P_d(op) = (I_{dd} \times V_{dd}) + (I_{out} \times \text{duty} \times V_{out} \times 16)$ therefore, to keep $P_d(op) \leq P_d(max)$ nomally the allowable maximum output current "I out" is determinated
 $I_{out} = \{ [(T_j - T_a) / R_{th}] - (I_{dd} \times V_{dd}) \} / V_{out} / \text{duty} / 16,$
 Where, the T_j of LSD9016 is 150 °C

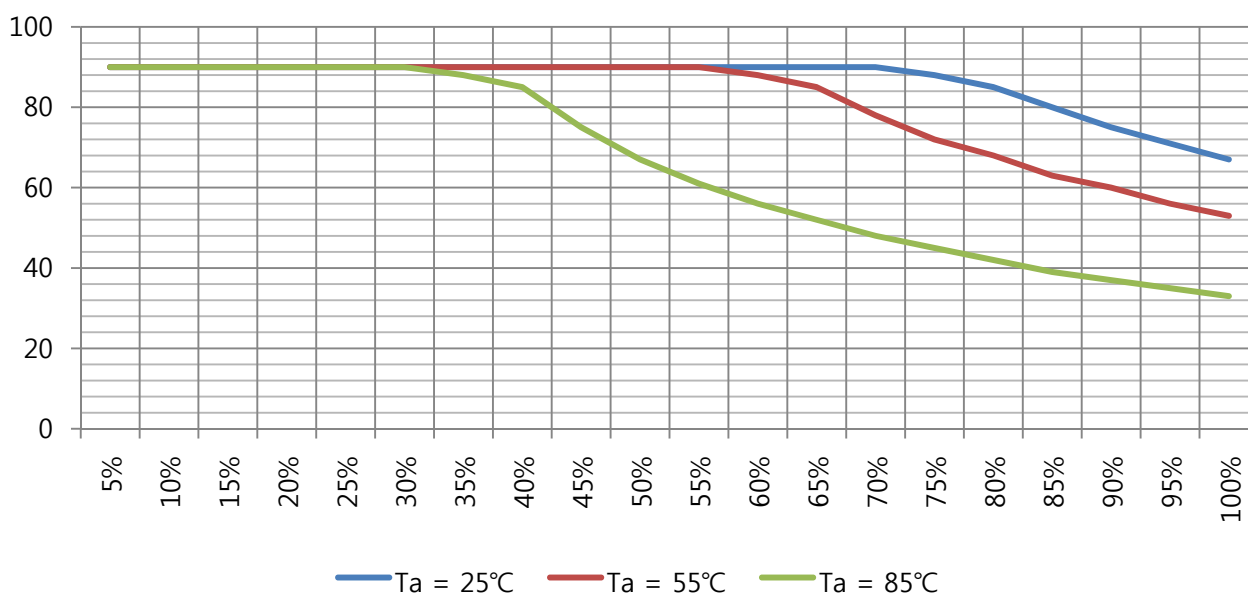
(A1) $I_{out} = 90\text{mA}$ $V_{out} = 1.0\text{V}$ 16 channel outputs

For SOP24L type package, the thermal resistance is $R_{th} = 95(^{\circ}\text{C}/\text{W})$



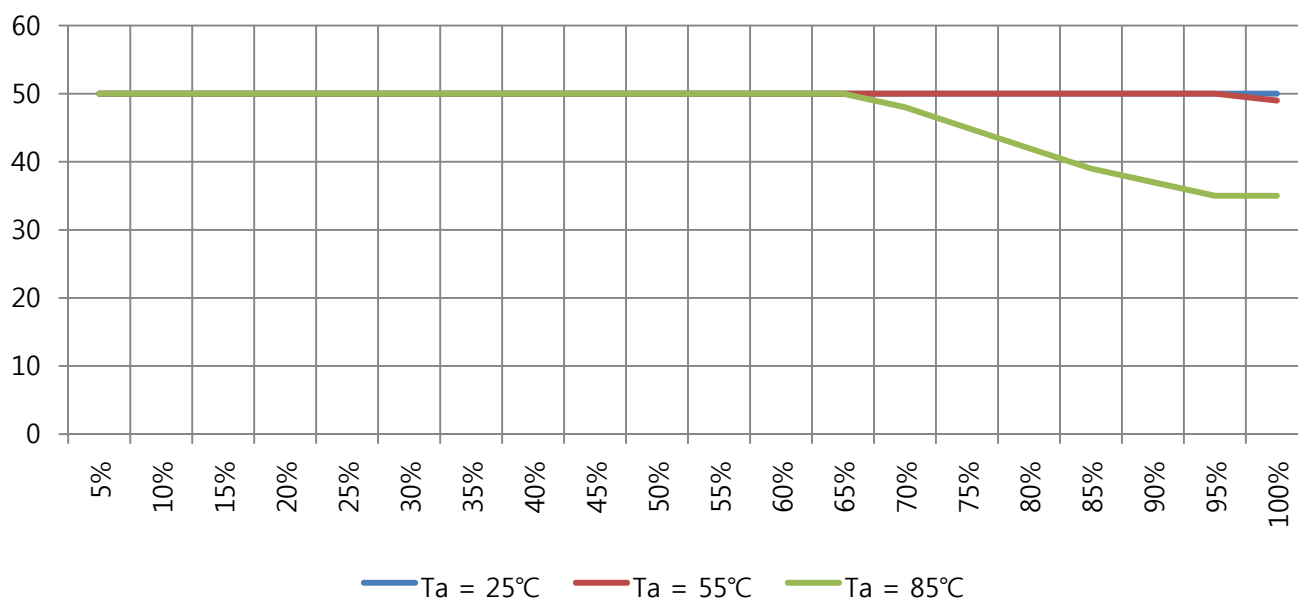
(A2) $I_{out} = 90\text{mA}$ $V_{out} = 1.0\text{V}$ 16 channel outputs

For SSOP24 type package, the thermal resistance is $R_{th} = 110(^{\circ}\text{C}/\text{W})$



(A2) $I_{out} = 50\text{mA}$ $V_{out} = 1.0\text{V}$ 16 channel outputs

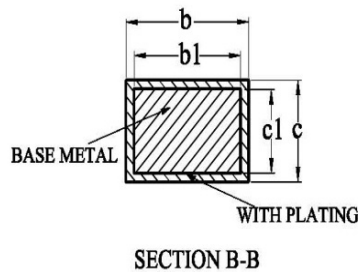
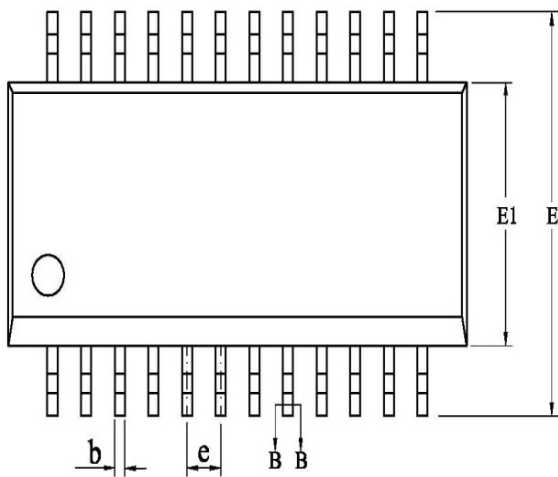
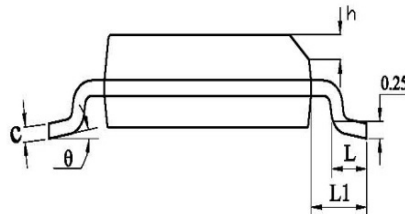
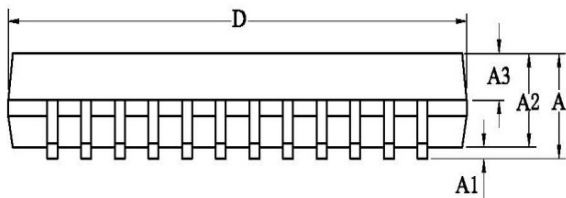
For SSOP24 type package, the thermal resistance is $R_{th} = 110(^{\circ}\text{C}/\text{W})$



Due to above curve, when SSOP24 type package in operating $I_{out(max)} = 50\text{mA}$ LSD9016-X24T is advised to choice duty cycle, around 65%.
It should be sure to operate more safety.

10. Package Dimension

SSOP24



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	--	--	1.75
A1	0.10	--	0.25
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.23	--	0.33
b1	0.22	0.25	0.28
c	0.21	--	0.25
c1	0.19	0.20	0.21
D	8.45	8.65	8.85
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	0.635BSC		
h	0.25	--	0.50
L	0.50	--	0.80
L1	1.05BSC		
θ	0	--	8°
L/P载体尺寸 (mil)	96×140		

Revision History

	Date	Description
REV 0.0	2009/3/20	First Edition (Preliminary)
REV 0.1	2009/4/20	"7-4 Constant Current Output Characteristics" is added.
	2009/4/30	"810.Package dimension " is added.
REV0.2	2009/6/30	SSOP Package is added and SOP Package elimination.
	2009/7/1	Contents of Temp sensor elimination.
REV1.0	2009/8/14	9. Application imformation is added 8-4 AC Characteristics is added
REV1.2	2009/10/25	8-4 AC Characteristics is Changed.
REV1.3	2009/11/16	8-2 Recommended Operating Ratings is Changed.
REV1.4	2009/12/28	10. Package dimension is added "SOP24-375-1.27"