IT1412
16-bit Constant Current LED Sink Driver

INNOCHIP

General Description

IT1412 is designed for LED displays. IT1412 contains a serial buffer and data latches which convert serial input data into parallel output format. At IT1412 output stage, sixteen regulated current ports are designed to provide uniform and constant current sinks for driving LEDs within a large range of V_F variations.

IT1412 provides users with great flexibility and device performance while using IT1412 in their system design for LED display applications. Users may adjust the output current from 5mA to 45mA through an external resistor, R_{ext}, which gives users flexibility in controlling the light intensity of LEDs. IT1412 guarantees to endure maximum 17V at the output port. The high clock frequency, 25MHz, also satisfies the system requirements of high volume data transmission.

Features

- **16 constant-current output channels**
- **Constant output current invariant to load voltage change:**
  $3{\sim}45mA@V_{DD}=5V$,
  $3{\sim}30mA@V_{DD}=3.3V$
- **Excellent channel output current accuracy:**
  between channels: $<\pm1.5\%$(typ.)/$<\pm2.5\%$(max.);
  between ICs: $<\pm2\%$(typ.)/$<\pm3.5\%$(max.)
- **Output current adjusted with an external resistor**
- **Fast response of output current,**
  $\overline{OE}$ (min.): 50ns
- **25MHz clock frequency**
- **Maximum output terminal voltage: 17V**
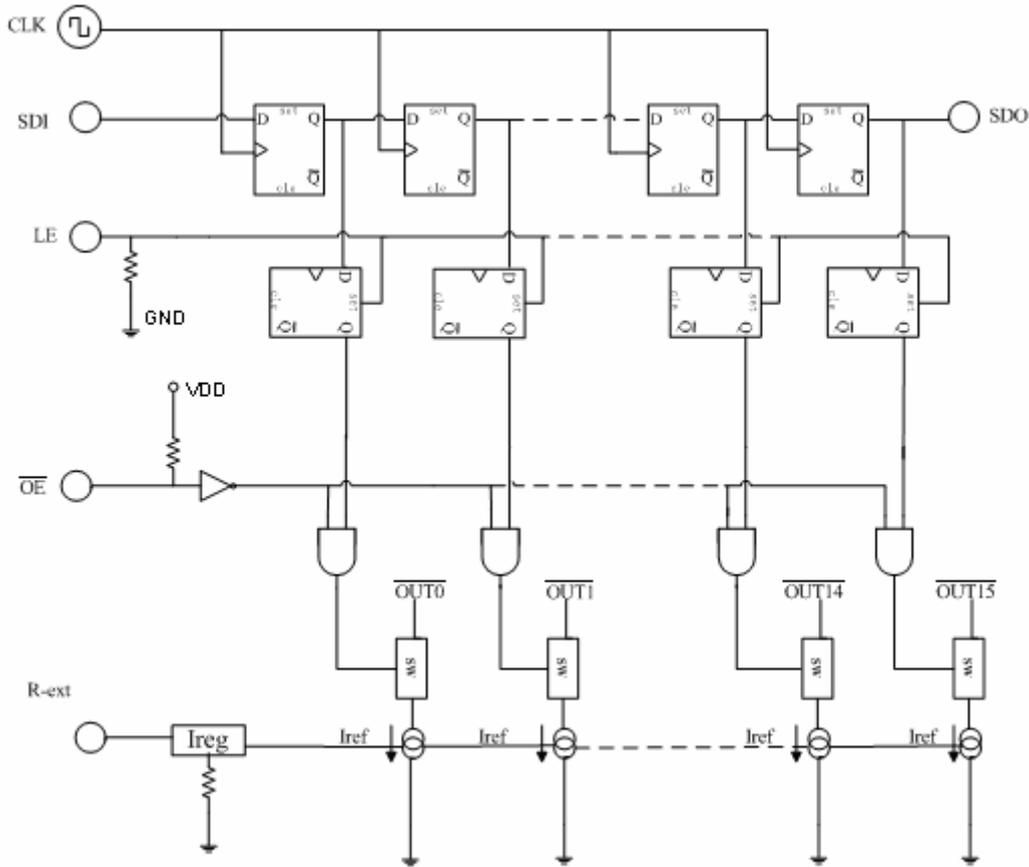- **$3V{\sim}5.5V$ Supply Voltage**

Pin Configurations
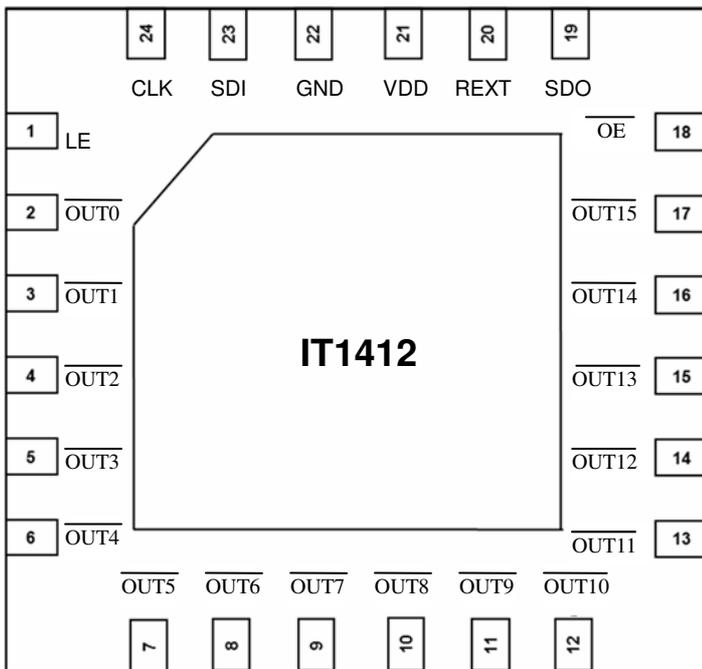

QFN-24(4mm x 4mm TOP VIEW)
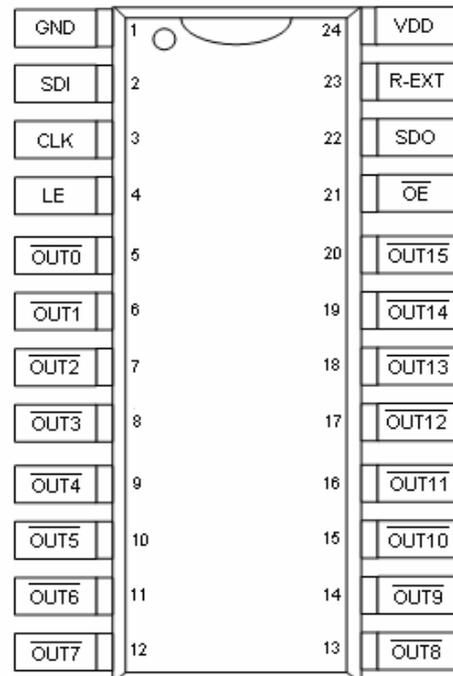


SSOP-24(0.635mm pitch)
(TOP VIEW)

Block Diagram

Pin Description

Pin		I/O	Description
NO.	Name		
1	GND		Ground pin
2	SDI	I	Serial input data for data shift register
3	CLK	I	Clock input for data shift on rising edge
4	LE	I	Serial data is transferred to output latch when LE is high. The data is latched when LE goes low.
5~20	$\overline{OUT0} \sim \overline{OUT15}$	O	Constant current output terminals
21	$\overline{OE}$	I	Output enable, low active
22	SDO	O	Serial data output to the following next driver IC
23	R-EXT	I	Input terminal used to connect an external resistor for setting output current for all channels
24	V_{DD}	I	Voltage supply input

Equivalent Circuits of Inputs and Outputs
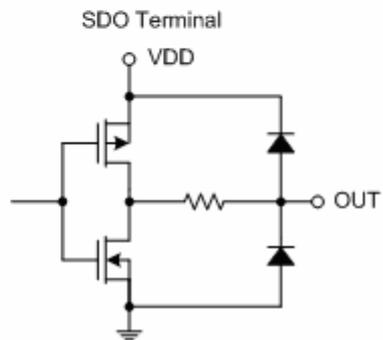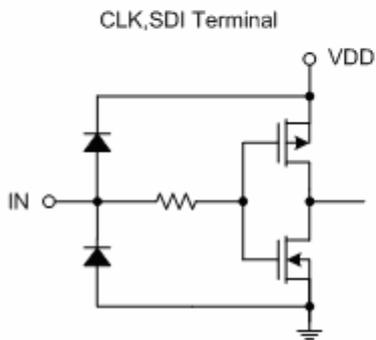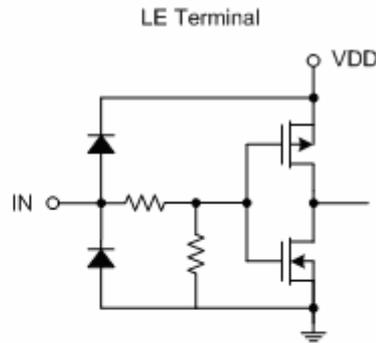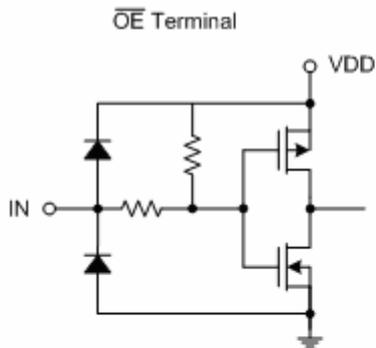
Timing Diagram
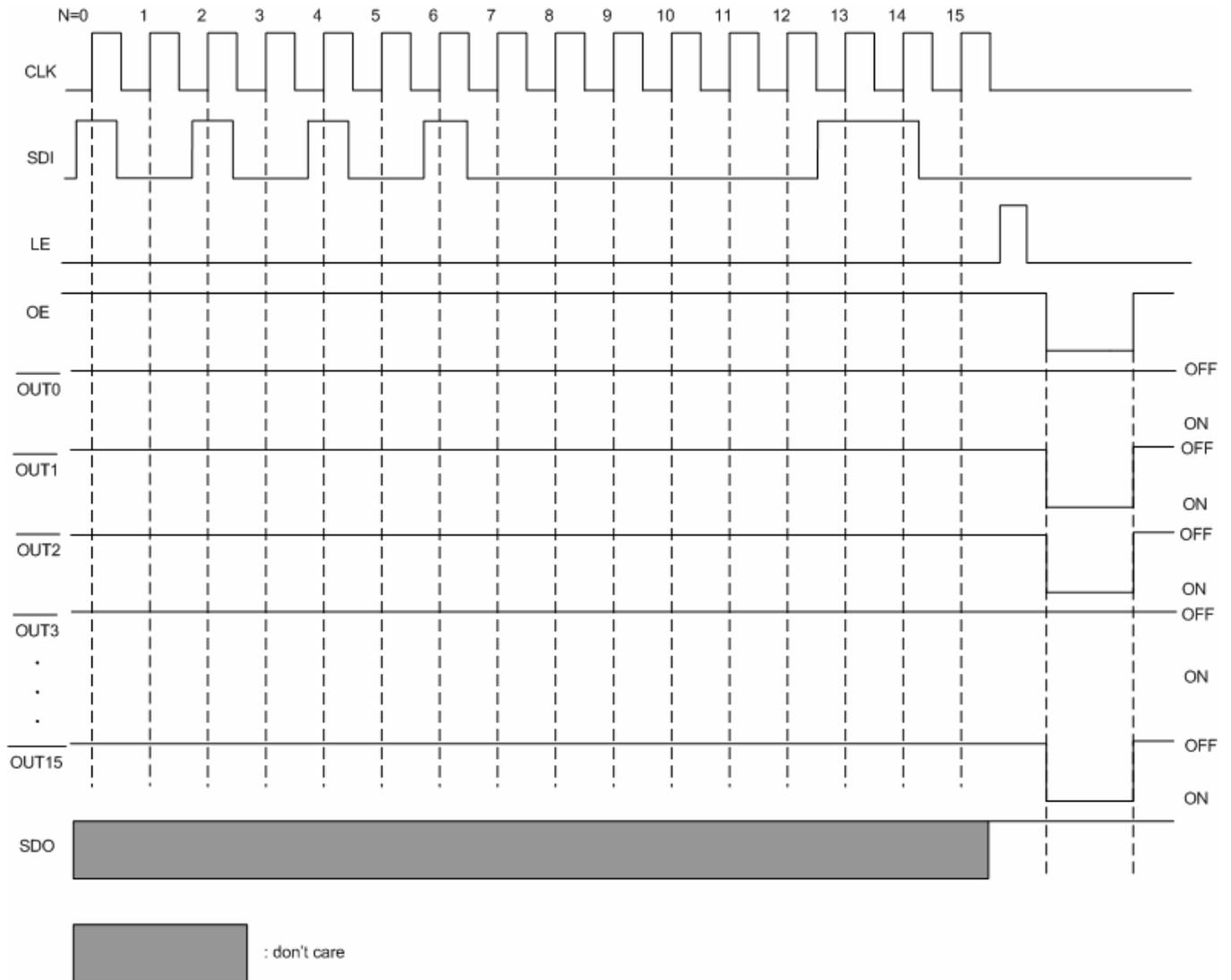
Truth Table

CLK	LE	$\overline{OE}$	SDI	$\overline{OUT_0}...\overline{OUT_7}...\overline{OUT_{15}}$	SDO
⌐	H	L	D_n	$\overline{D_n}...\overline{D_{n-7}}...\overline{D_{n-15}}$	D_{n-15}
⌐	L	L	D_{n+1}	No Change	D_{n-14}
⌐	H	L	D_{n+2}	$\overline{D_{n+2}}...\overline{D_{n-5}}...\overline{D_{n-13}}$	D_{n-13}
⌐_	X	L	D_{n+3}	$\overline{D_{n+2}}...\overline{D_{n-5}}...\overline{D_{n-13}}$	D_{n-13}
⌐_	X	H	D_{n+3}	Off	D_{n-13}

Absolute Maximum Ratings

Characteristic		Symbol	Rating	Unit
Supply Voltage		V_{DD}	7	**V**
Input Voltage		V_{IN}	-0.2~VDD+0.2	**V**
Output Current		I_{OUT}	+45	**mA/ch**
Output Voltage		V_{OUT}	17	**V**
Clock Frequency		F_{CLK}	+25	**MHz**
GND Terminal Current		I_{GND}	720	**mA**
Power Dissipation	SOP24-300	P_D	1.8	**W**
	SSOP24-150		1.4	
Thermal Resistance	SOP24-300	$R_{th(j-a)}$	52	**°C/W**
	SSOP24-150		64	
Operation Temperature		Topr	-40~+85	**°C**
Storage Temperature		Tstg	-55~+150	**°C**
Minimum ESD Rating		HBM	2	**KV**
		MM	200	**V**

1.Stress beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

2. Device is ESD sensitive. Handling precaution recommended. The Human Body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin.
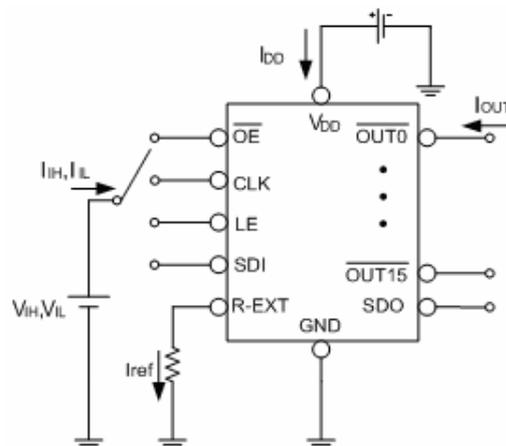
Electrical Characteristics (V_{DD}=5V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage Range	V_{DD}	-	4.5	5	5.5	**V**
Output Voltage	V_{OUT}	-	-	-	17	**V**
Output Current	I_{OUT}	DC Output Channel	5	-	45	**mA**
		SDO=high	-	-	-1	
		SDO=low	-	-	1	
Input Voltage	V_{iH}	T_a=-40°C ~85°C	0.7V_{DD}	-	V_{DD}	**V**
	V_{iL}	T_a=-40°C ~85°C	0	-	0.3V_{DD}	
Output Voltage(SDO)	V_{OH}	I_{OH}=-1.0mA	4.6	-	-	**V**
	V_{OL}	I_{OL}=1.0mA	-	-	0.4	
Output Leakage Current	I_{OH}	V_{OUT}=17.0V	-	-	1	**μA**
Output Current1	I_{OUT1}	V_{DS}=1V, R_{EXT}=1240Ω	-	15	-	**mA**
Current Skew	dI_{OUT1}	I_{OUT}=40mA	-	-	±1.5	**%**
Output Current2	I_{OUT2}	V_{DS}=1V, R_{EXT}=620Ω	-	30	-	**mA**
Current Skew	dI_{OUT2}	I_{OUT}=20mA	-	-	±1.5	**%**
Output Current vs. Output Voltage Regulation	%/dV_{DS}	V_{DS} within 1.0V and 3.0V	-	±0.1	-	**%/V**
Output Current vs. Supply Voltage Regulation	%/dV_{DD}	V_{DD} within 4.5V and 5.5V	-	±1	-	**%/V**
Pull-up Resistor	R_{IN}(up)	$\overline{OE}$	-	500	-	**KΩ**
Pull-down Resistor	R_{IN}(dn)	LE	-	500	-	**KΩ**
Supply Current (OFF)	I_{DD}(off)1	R_{EXT}=OPEN,$\overline{OUT0}$~$\overline{OUT15}$=OFF	-	5.7	-	**mA**
	I_{DD}(off)2	R_{EXT}=1240Ω,$\overline{OUT0}$~$\overline{OUT15}$=OFF	-	7.9	-	
	I_{DD}(off)3	R_{EXT}=620Ω,$\overline{OUT0}$~$\overline{OUT15}$=OFF	-	10.2	-	
Supply Current (ON)	I_{DD}(on)1	R_{EXT}=1240Ω,$\overline{OUT0}$~$\overline{OUT15}$=ON	-	8.3	-	
	I_{DD}(on)2	R_{EXT}=620Ω, $\overline{OUT0}$~$\overline{OUT15}$=ON	-	10.6	-	

16-bit Constant Current LED Sink Driver

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Electrical Characteristics (V$_{DD}$=3.3V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage Range	V$_{DD}$	-	3.0	3.3	3.6	**V**
Output Voltage	V$_{OUT}$	-	-	-	17	**V**
Output Current	I$_{OUT}$	DC Output Channel	3	-	30	**mA**
		SDO=high	-	-	-1	
		SDO=low	-	-	1	
Input Voltage	V$_{iH}$	T$_a$=-40°C ~85°C	0.7V$_{DD}$	-	V$_{DD}$	**V**
	V$_{iL}$	T$_a$=-40°C ~85°C	0	-	0.3V$_{DD}$	
Output Voltage(SDO)	V$_{OH}$	I$_{OH}$=-1.0mA	2.9	-	-	**V**
	V$_{OL}$	I$_{OL}$=1.0mA	-	-	0.4	
Output Leakage Current	I$_{OH}$	V$_{OUT}$=17.0V	-	-	0.5	**µA**
Output Current1	I$_{OUT1}$	V$_{DS}$=1V, R$_{EXT}$=1860Ω	-	10	-	**mA**
Current Skew	dI$_{OUT1}$	I$_{OUT}$=10mA	-	-	±1.8	**%**
Output Current2	I$_{OUT2}$	V$_{DS}$=1V, R$_{EXT}$=744Ω	-	25	-	**mA**
Current Skew	dI$_{OUT2}$	I$_{OUT}$=25mA	-	-	±1.5	**%**
Output Current vs. Output Voltage Regulation	%/dV$_{DS}$	V$_{DS}$ within 1.0V and 3.0V	-	±0.1	-	**%/V**
Output Current vs. Supply Voltage Regulation	%/dV$_{DD}$	V$_{DD}$ within 3.0V and 3.6V	-	±1	-	**%/V**
Pull-up Resistor	R$_{IN}$(up)	$\overline{OE}$	-	500	-	**KΩ**
Pull-down Resistor	R$_{IN}$(dn)	LE	-	500	-	**KΩ**
Supply Current (OFF)	I$_{DD}$(off)1	R$_{EXT}$=OPEN, $\overline{OUT0}$~$\overline{OUT15}$ =OFF	-	5.5	-	**mA**
	I$_{DD}$(off)2	R$_{EXT}$=1860Ω, $\overline{OUT0}$~$\overline{OUT15}$ =OFF	-	7	-	
	I$_{DD}$(off)3	R$_{EXT}$=744Ω, $\overline{OUT0}$~$\overline{OUT15}$ =OFF	-	9.2	-	
Supply Current (ON)	I$_{DD}$(on)1	R$_{EXT}$=1860Ω, $\overline{OUT0}$~$\overline{OUT15}$ =ON	-	7.2	-	
	I$_{DD}$(on)2	R$_{EXT}$=744Ω, $\overline{OUT0}$~$\overline{OUT15}$ =ON	-	9.4	-	

Test Circuit for Electrical Characteristics

Switching Characteristics (V_{DD}=5V)

| Characteristic		Symbol	Condition	Values			Unit
				Min.	Typ.	Max.	
Propagation Delay ("L" to "H")	$CLK - \overline{OUTn}$	t_{pLH1}	V_{DD}=5.0V V_{IH}= V_{DD} V_{IL}=GND R_{ext}=910Ω V_L=2.0V R_L=52Ω C_L=10pF	-	20	-	**nS**
	$LE - \overline{OUTn}$	t_{pLH2}		-	10	-	**nS**
	$\overline{OE} - \overline{OUTn}$	t_{pLH3}		-	10	-	**nS**
	$CLK - SDO$	t_{pLH}		-	21	-	**nS**
Propagation Delay ("H" to "L")	$CLK - \overline{OUTn}$	t_{pHL1}		-	45	-	**nS**
	$LE - \overline{OUTn}$	t_{pHL2}		-	35	-	**nS**
	$OEB - \overline{OUTn}$	t_{pHL3}		-	35	-	**nS**
	$CLK - SDO$	t_{pHL}		-	21	-	**nS**
Pulse Width	CLK	$t_{w(CLK)}$		20	-	-	**nS**
	LE	$t_{w(LE)}$		20		-	**nS**
	$\overline{OE}$	$t_{w(OE)}$		50	-	-	**nS**
Hold time for LE		$t_{h(LE)}$		5	-	-	**nS**
Setup time for LE		$t_{su(LE)}$		5	-	-	**nS**
Output Rise Time		t_{or}		-	15	-	**nS**
Output Fall Time		t_{of}		-	35	-	**nS**
Maximum CLK rise time		t_r[**]		-	-	500	**nS**
Maximum CLK fall time		t_f[**]		-	-	500	**nS**

※If the devices are connected in cascade and t_r or t_f is large, it may be critical to achieve the timing required for data transfer between two cascaded devices.

## Switching Characteristics (V_{DD}=3.3V)

Characteristic		Symbol	Condition	Values			Unit
				Min.	Typ.	Max.	
Propagation Delay ("L" to "H")	$CLK - \overline{OUTn}$	t_{pLH1}	V_{DD}=3.3V V_{IH}= V_{DD} V_{IL}=GND R_{ext}=910Ω V_L=2.0V R_L=52Ω C_L=10pF	-	25	-	nS
	$LE - \overline{OUTn}$	t_{pLH2}		-	15	-	nS
	$\overline{OE} - \overline{OUTn}$	t_{pLH3}		-	15	-	nS
	$CLK - SDO$	t_{pLH}		-	35	-	nS
Propagation Delay ("H" to "L")	$CLK - \overline{OUTn}$	t_{pHL1}		-	50	-	nS
	$LE - \overline{OUTn}$	t_{pHL2}		-	40	-	nS
	$OEB - \overline{OUTn}$	t_{pHL3}		-	40	-	nS
	$CLK - SDO$	t_{pHL}		-	35	-	nS
Pulse Width	CLK	$t_{w(CLK)}$		20	-	-	nS
	LE	$t_{w(LE)}$		20	-	-	nS
	$\overline{OE}$	$t_{w(OE)}$		50	-	-	nS
Hold time for LE		$t_{h(LE)}$		5	-	-	nS
Setup time for LE		$t_{su(LE)}$		5	-	-	nS
Output Rise Time of Vout (turn off)		t_{or}		-	20	-	nS
Output Fall Time of Vout (turn on)		t_{of}		-	37	-	nS
Maximum CLK rise time		t_r^{**}		-	-	500	nS
Maximum CLK fall time		t_f^{**}		-	-	500	nS

※If the devices are connected in cascade and t_r or t_f is large, it may be critical to achieve the timing required for data transfer between two cascaded devices.

Test Circuit for Switching Characteristics
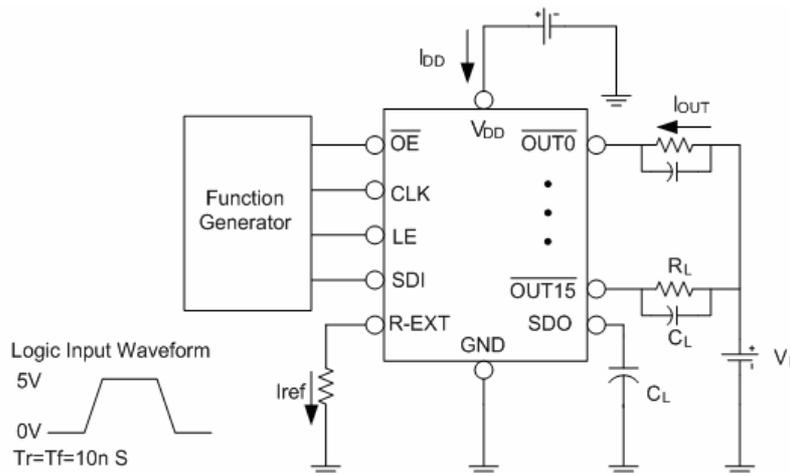
Timing Waveform
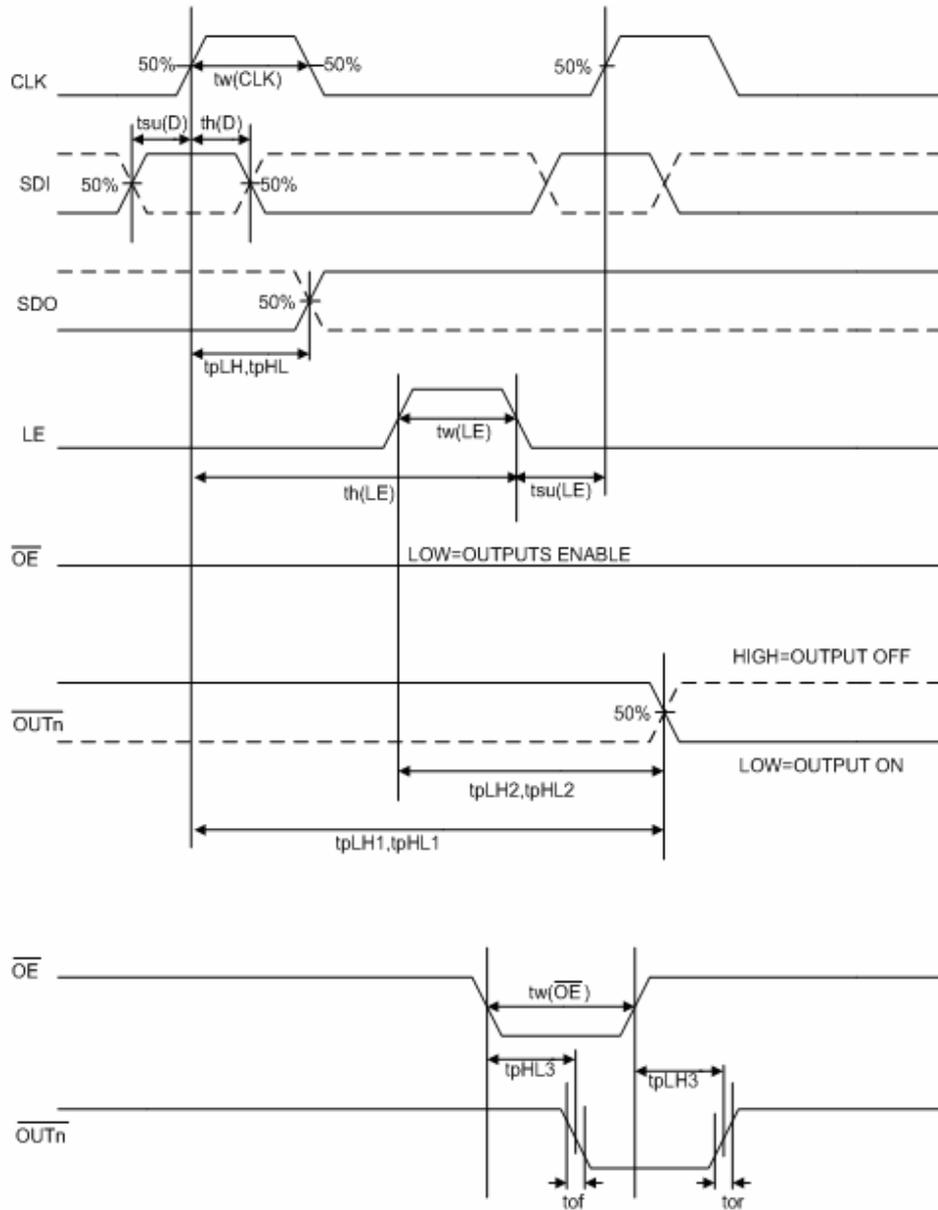
Application Information

Constant Current

To design LED displays, IT1412 provides nearly no variations in current from channel to channel and from IC to IC. This can be achieved by:

1) The maximum current variation between channels is less than ±2.5%, and that between ICs is less than ±3.5%.

2) In addition, the current characteristic of output stage is flat and users can refer to the figure as shown below. The output current can be kept constant regardless of the variations of LED forward voltage(Vf). This performs as a perfection of load regulation.
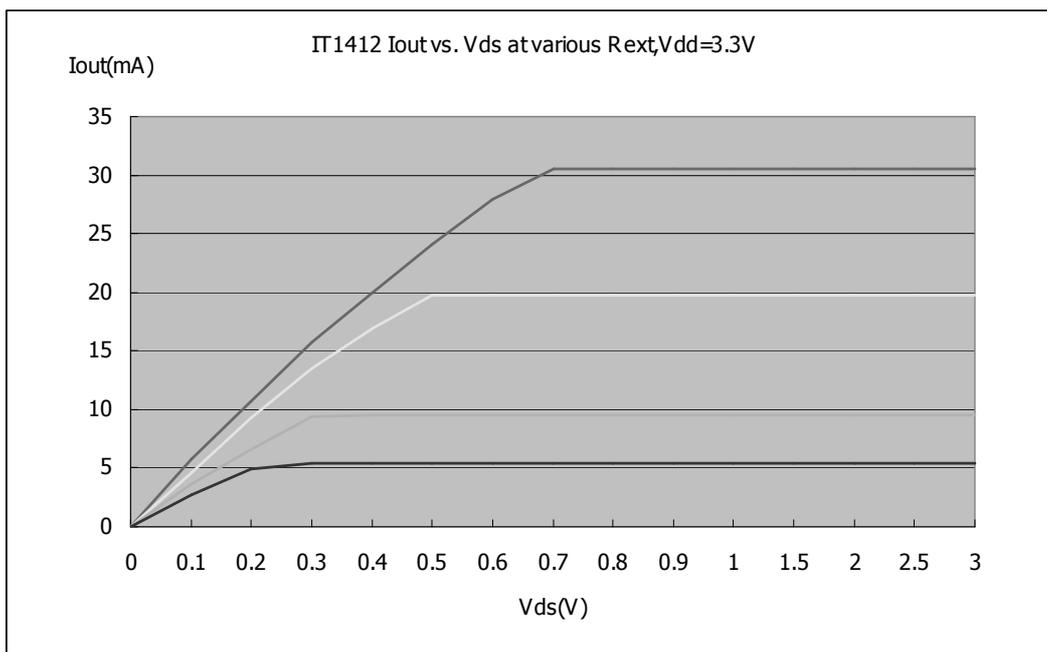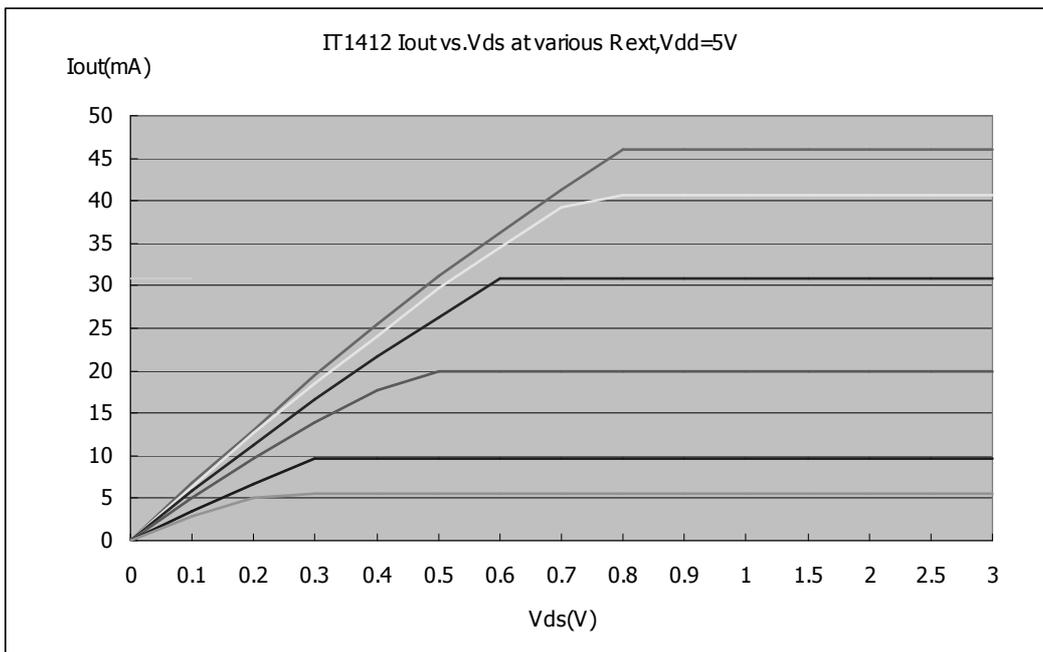
Adjusting Output Current

The output current of each channel (I_{OUT}) is set by an external resistor, R_{ext}. The relationship between I_{OUT} and R_{ext} is shown in the following figure.

IT1412 R ext vs. Iout

$V_{DS}=1.0V$
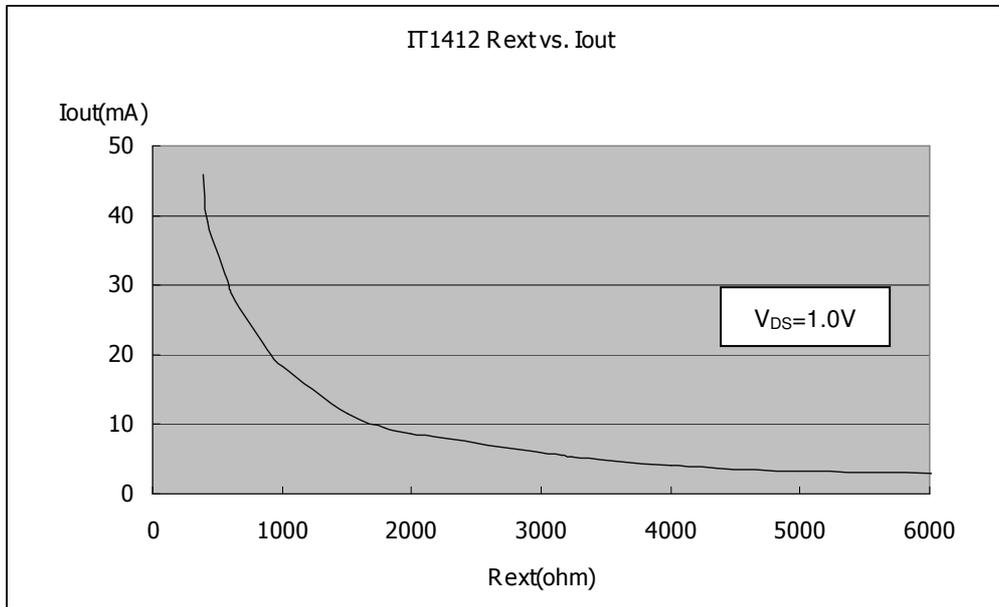
Resistance of the external resistor, Rext, in Ω

Also, the output current in milliamps can be calculated from the equation:

I_{OUT} is $(1.24/R_{ext})\times15$, approximately,

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

The magnitude of current (as a function of R_{ext}) is around 45mA at 420Ω and 20mA at 910Ω.
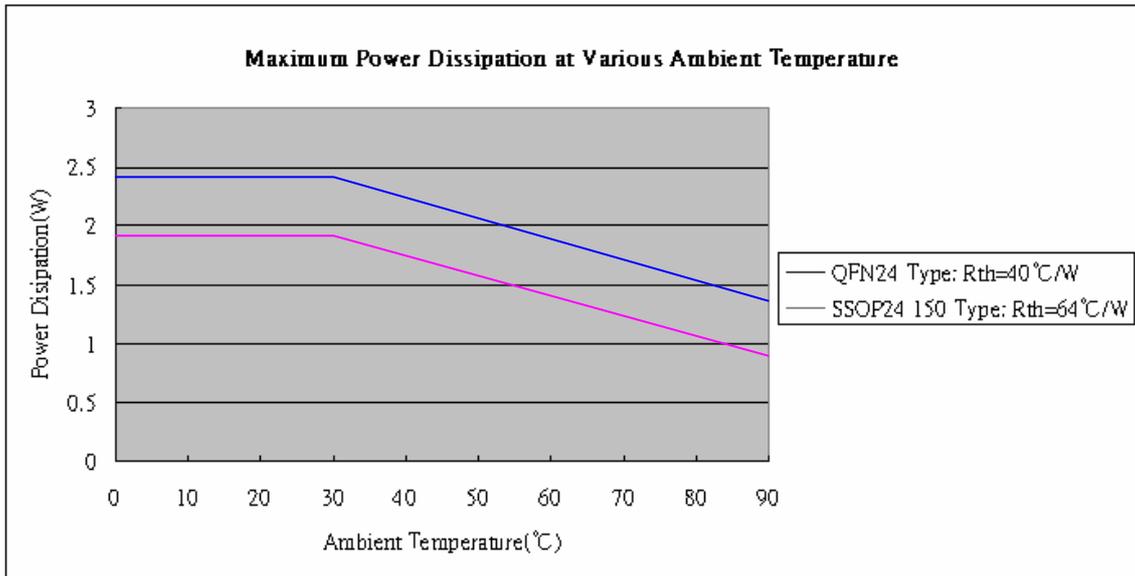
Package Power Dissipation(P_D)

This maximum allowable package power dissipation is determined as $P_D(max)=(T_j-T_a)/ R_{th(j-a)}$. When 16 output channels are turned on simultaneously, the actual package power dissipation is

$P_D(act)=(I_{DD}\times V_{DD})+(I_{OUT}\times Duty\times V_{Ds}\times16)$. Therefore, to keep $P_D(act) \leq P_D(max)$, the allowable maximum output current as a function of duty cycle is:

$I_{OUT}=\{[(T_j-T_a)/ R_{th(j-a)}]-(I_{DD}\times V_{DD})\}/ V_{Ds}/Duty/16$, where $T_j=150^oC$.

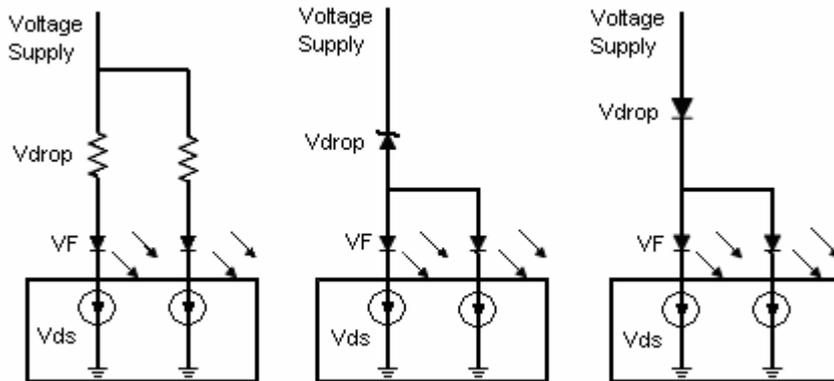| Condition: Iout=50mA, V_{DS}=1V, 16 output channels	
Device Type	$R_{th(j-a)}$(℃/W)
QFN24	40
SSOP24-150	64

The maximum power dissipation, $P_D(max)=(Tj-Ta)/R_{th(j-a)}$, decreases as the ambient temperature increases.

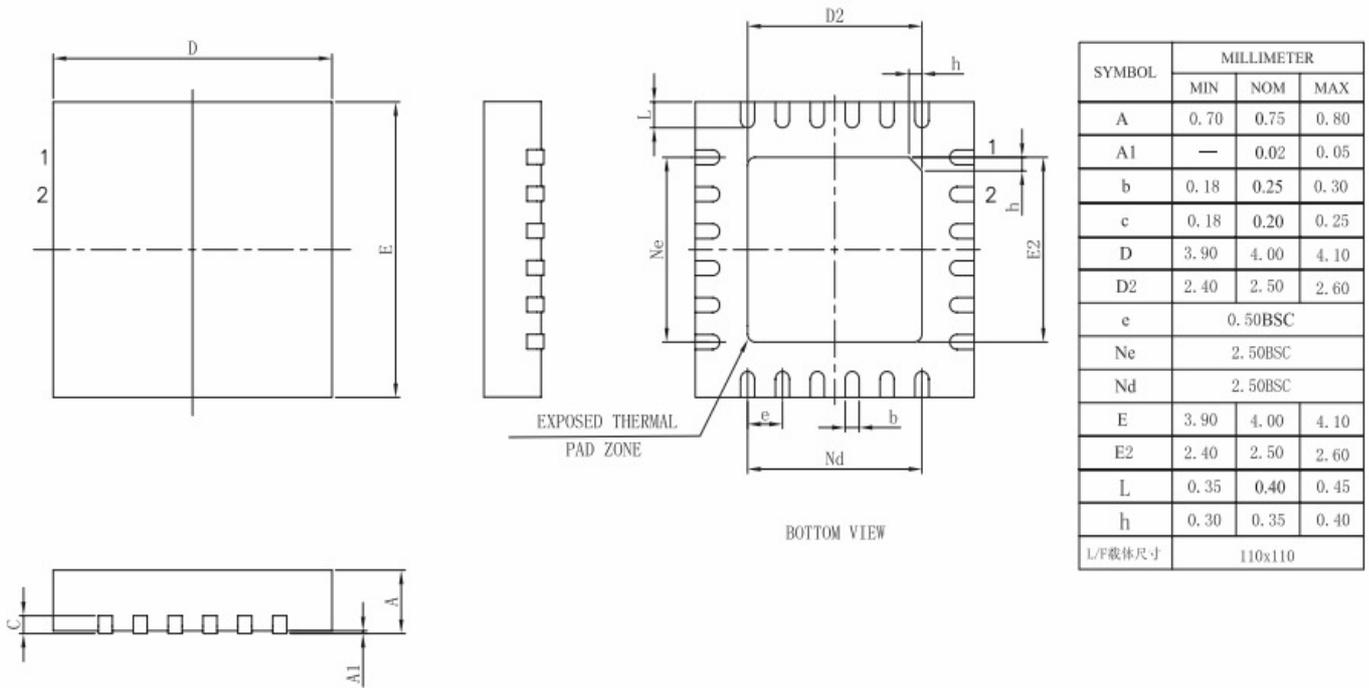Maximum Power Dissipation at Various Ambient Temperature

Load Supply Voltage(VLED)

This device is operating with the VDS of 1.0V to 1.2V with LED forward voltage(VF) of 1.2V to 4.0V. If VDS be higher enough to make package power dissipation increased. It is recommended to use lowest load supply voltage or to set any serials dropping voltage as following figures.
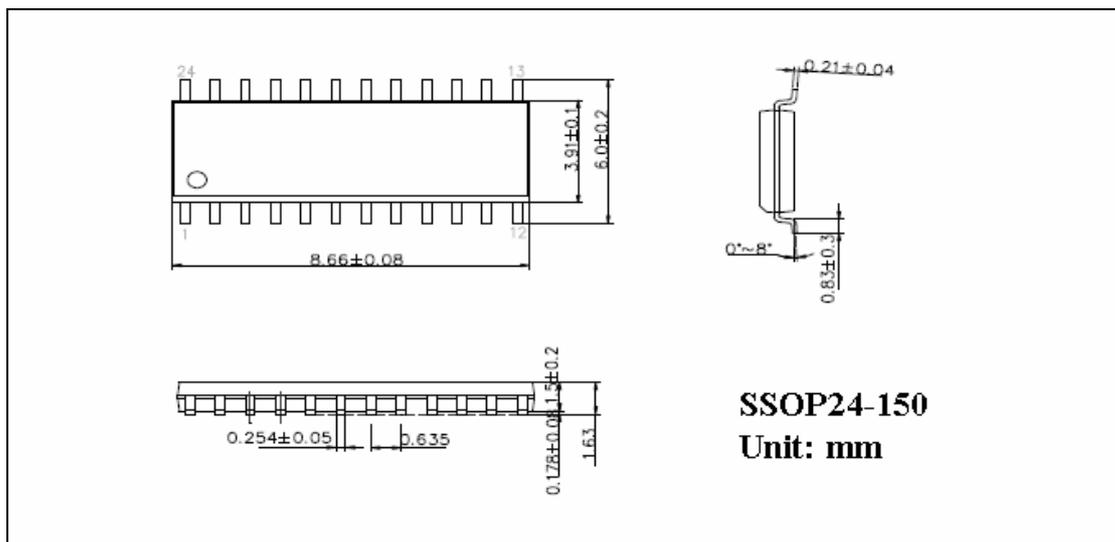
VDS=VLED-VF-VDROP

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## IT1412(QFN24/ 4mm x 4mm with pin pitch 0.5mm) Outline Drawing

EXPOSED THERMAL
PAD ZONE

BOTTOM VIEW

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	—	0.02	0.05
b	0.18	0.25	0.30
c	0.18	0.20	0.25
D	3.90	4.00	4.10
D2	2.40	2.50	2.60
e	0.50BSC		
Ne	2.50BSC		
Nd	2.50BSC		
E	3.90	4.00	4.10
E2	2.40	2.50	2.60
L	0.35	0.40	0.45
h	0.30	0.35	0.40
L/F载体尺寸	110x110		

IT1412(SSOP24-150 with pin pitch 0.635mm) Outline Drawing

SSOP24-150
Unit: mm

Soldering Temperature Suggestion for RoHS materials(JEDEC J-STD-020C)

Temperature($^{\circ}$C)

Time(sec)
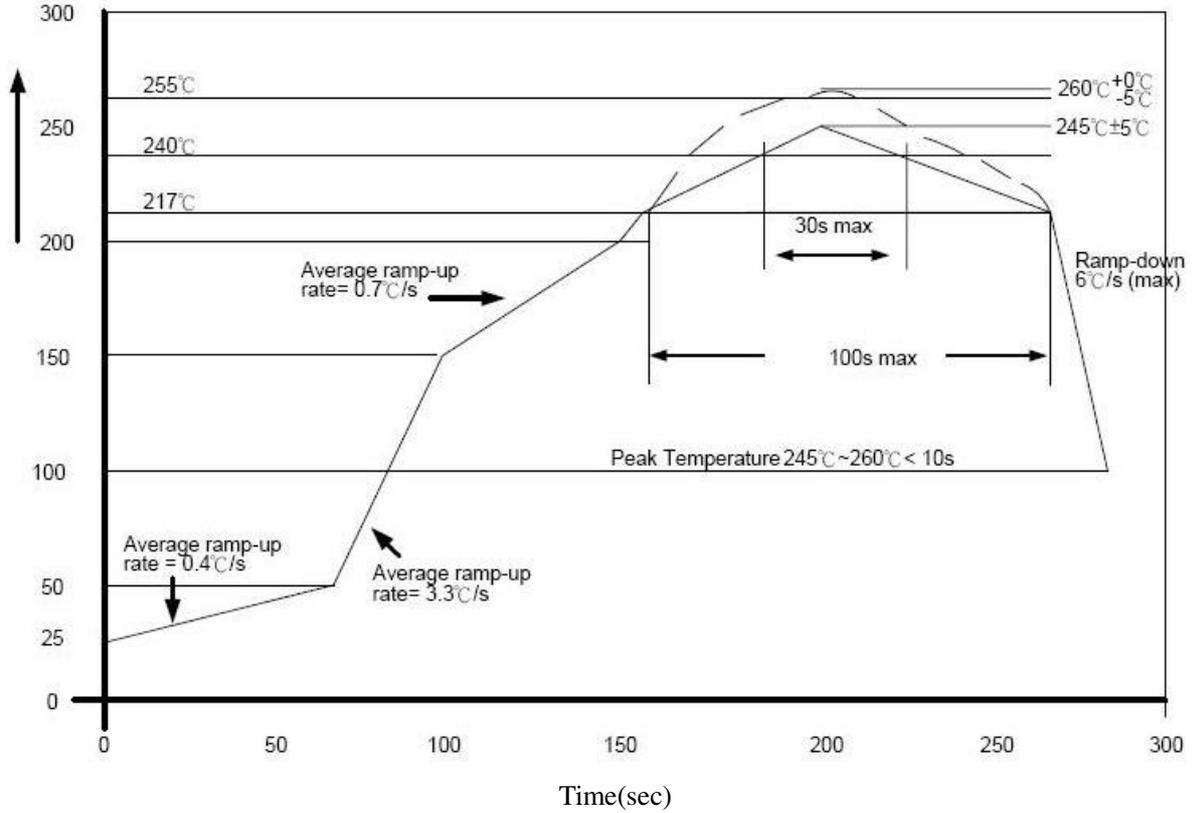
———: Recommended Reflow Profile

------: Maximum Peak Temperature