

# ST2221C

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## ***16-Bit Constant Current LED Drivers***



**SITI**

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## ST2221C

### 16-Bit Constant Current LED Drivers

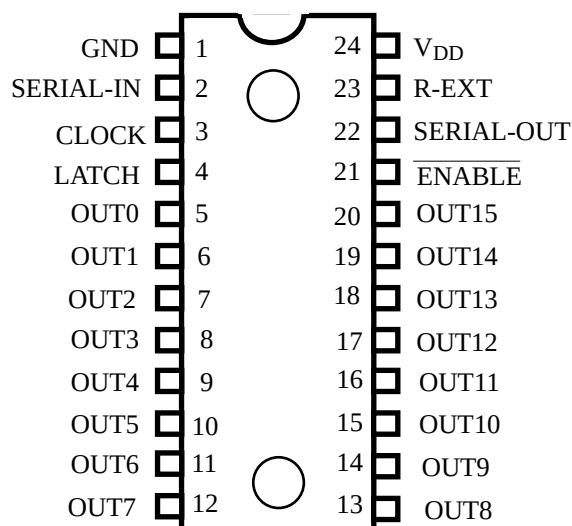
#### General Description

The ST2221C is specifically designed for LED and LED DISPLAY constant current drivers. The value of constant current can be varied using an external resistor ( $I_{out} = 5 \sim 90\text{mA}$ ). The devices include a 16-bit shift registers, latches, and constant current drivers on a single Silicon CMOS chip.

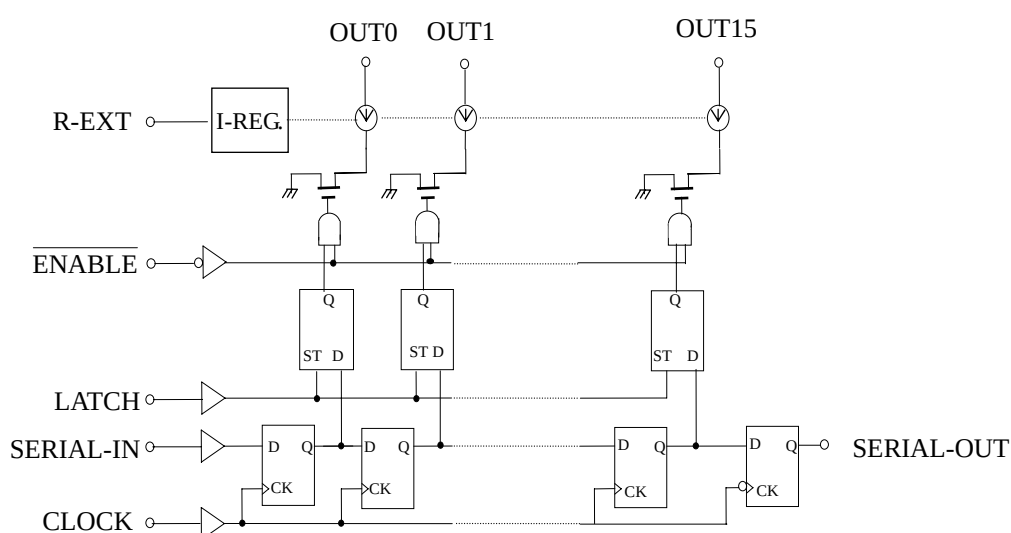
#### Features

- Constant Current Output : Current with one resistor for 5mA to 90mA
- Maximum Clock Frequency : 25MHz (Cascade Operation)
- 5V CMOS Compatible Input
- Package : DIP24 , SOP24, SSOP24
- Constant Current Matching: ( $T_a = 25^\circ\text{C}$  、  $V_{DD} = 5.0\text{V}$ )  
Bit-to-Bit:  $\pm 6.0\%$  、 Chip-to-Chip :  $\pm 10.0\%$  、  
@  $I_{OUT} = 5 \sim 90\text{mA}$

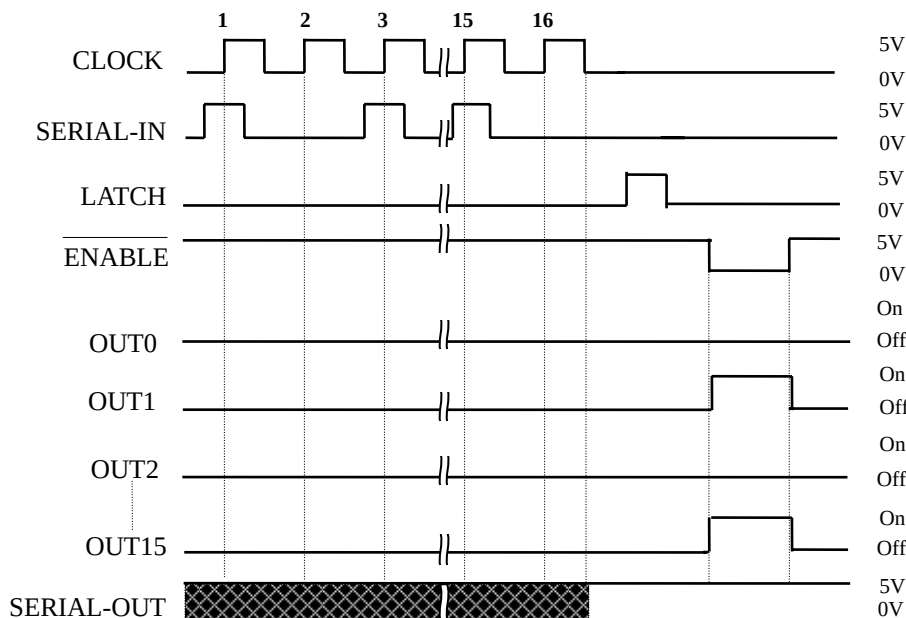
## Pin Connection (Top view)



## Block Diagram



## Timing Diagram



(Note) Latches are level sensitive (not edge triggered).

LATCH-terminal = H level, latches become transparent; LATCH-terminal = L level, latches hold data.

ENABLE-terminal = H level, all outputs (OUT0~15) are off.

An external resistor is connected between R-EXT and GND for setting up the value of constant current.

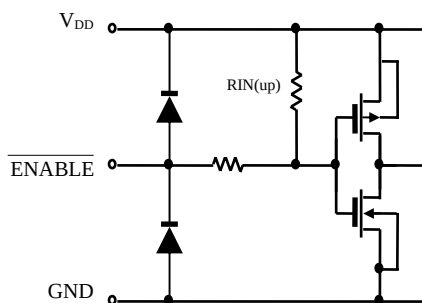
SERIAL-OUT changes state on the falling edges of clock.

## Pin Description

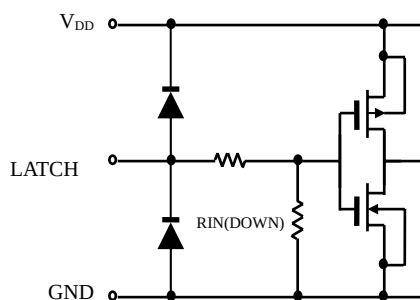
| PIN No. | PIN NAME        | FUNCTION                                     |
|---------|-----------------|----------------------------------------------|
| 1       | GND             | Ground terminal                              |
| 2       | SERIAL-IN       | Input terminal of a data shift register      |
| 3       | CLOCK           | Input terminal of a clock for shift register |
| 4       | LATCH           | Input terminal of data strobe                |
| 5~20    | OUT0~15         | Output terminals                             |
| 21      | <u>ENABLE</u>   | Input terminal of output enable (active low) |
| 22      | SERIAL-OUT      | Output terminal of a data shift register     |
| 23      | R-EXT           | Input terminal of an external resistor       |
| 24      | V <sub>DD</sub> | 5V Supply voltage terminal                   |

## Equivalent Circuit of Inputs and Outputs

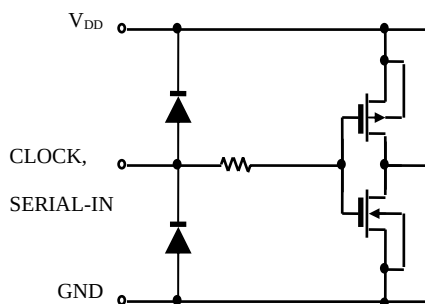
### 1. $\overline{\text{ENABLE}}$ terminal



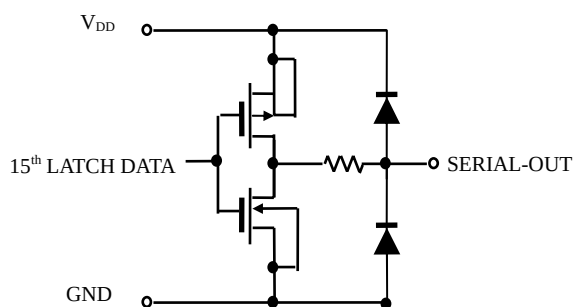
### 2. LATCH terminal



### 3. CLOCK, SERIAL-IN terminal



### 4. SERIAL-OUT terminal



## Maximum Ratings (Ta = 25°C, Tj(max) = 140°C)

| CHARACTERISTIC       | SYMBOL   | RATING                   | UNIT |
|----------------------|----------|--------------------------|------|
| Supply Voltage       | VDD      | 0 ~ 7.0                  | V    |
| Input Voltage        | VIN      | -0.4 ~ VDD+0.4           | V    |
| Output Current       | IOUT     | 90                       | mA   |
| Output Voltage       | VOUT     | -0.5 ~ 9.5               | V    |
| Clock Frequency      | fCLK     | 25                       | MHz  |
| GND Terminal Current | IGND     | 1440                     | mA   |
| Power Dissipation    | PD       | 2.87 (DIP-24 : Ta=25°C)  | W    |
|                      |          | 1.45 (SOP-24 : Ta=25°C)  |      |
|                      |          | 1.27 (SSOP-24 : Ta=25°C) |      |
| Thermal Resistance   | Rth(j-a) | 40.0 (DIP-24)            | °C/W |
|                      |          | 79.2 (SOP-24)            |      |
|                      |          | 90.2 (SSOP-24)           |      |
| Storage Temperature  | Tstg     | -55 ~ 150                | °C   |

## Recommended Operating Condition

| CHARACTERISTIC        | SYMBOL           | CONDITION           | MIN.   | TYP. | MAX.    | UNIT |
|-----------------------|------------------|---------------------|--------|------|---------|------|
| Supply Voltage        | VDD              | —                   | 4.5    | 5.0  | 5.5     | V    |
| Output Voltage        | VOUT             | —                   | —      | —    | 9       | V    |
| Operating temperature | T <sub>OPR</sub> | —                   | -40    | —    | 85      | °C   |
| Output Current        | IO               | OUTn                | 5      | —    | 85      | mA   |
|                       | IOH              | SERIAL-OUT          | —      | —    | 1.0     |      |
|                       | IOL              | SERIAL-OUT          | —      | —    | -1.0    |      |
| Input Voltage         | VIH              | —                   | 0.7VDD | —    | VDD+0.3 | V    |
|                       | VIL              | —                   | -0.3   | —    | 0.3VDD  |      |
| LATCH Pulse Width     | tw LAT           | VDD = 4.5 ~ 5.5 V   | 15     | —    | —       | ns   |
| CLOCK Pulse Width     | tw CLK           |                     | 15     | —    | —       | ns   |
| Set-up Time for DATA  | tsetup(D)        |                     | 20     | —    | —       | ns   |
| Hold Time for DATA    | thold(D)         |                     | 20     | —    | —       | ns   |
| Set-up Time for LATCH | tsetup(L)        |                     | 15     | —    | —       | ns   |
| Clock Frequency       | fCLK             | Cascade operation   | —      | —    | 25      | MHz  |
| Power Dissipation     | PD               | Ta = 85°C (DIP-24)  | —      | —    | 1.37    | W    |
|                       |                  | Ta = 85°C (SOP-24)  | —      | —    | 0.69    |      |
|                       |                  | Ta = 85°C (SSOP-24) | —      | —    | 0.61    |      |



## Electrical Characteristics (VDD = 5.0 V, Ta = 25°C unless otherwise noted)

| CHARACTERISTIC             | SYMBOL    | CONDITION                       | MIN.   | TYP. | MAX.   | UNIT  |
|----------------------------|-----------|---------------------------------|--------|------|--------|-------|
| Input Voltage “H” Level    | VIH       | —                               | 0.7VDD | —    | VDD    | V     |
| Input Voltage “L” Level    | VIL       | —                               | GND    | —    | 0.3VDD |       |
| Output Leakage Current     | IOH       | VOH = 9.5 V                     | —      | —    | 1.0    | uA    |
| Output Voltage ( S - OUT)  | VOL       | IOL = 1.0 mA                    | —      | —    | 0.4    | V     |
|                            | VOH       | IOH = -1.0 mA                   | 4.6    | —    | —      |       |
| Output Current (Bit-Bit)   | IOL1      | VOUT = 0.7±0.25V<br>REXT = 910Ω | —      | 3    | 6      | %     |
|                            | IOL2      | VOUT = 0.7±0.25V<br>REXT = 360Ω | —      | 3    | 6      |       |
| Output Current (Chip-Chip) | IOL3      | VOUT = 0.7V REXT = 910Ω         | —      | 5    | 10     |       |
|                            | IOL4      | VOUT = 0.7V REXT = 360Ω         | —      | 5    | 10     |       |
| Supply Voltage Regulation  | % / VDD   | REXT = 470Ω, Ta = -40 ~ 85°C    | —      | 1.5  | 5.0    | % / V |
| Pull-Up Resistor           | RIN(up)   | —                               | 150    | 300  | 600    | KΩ    |
| Pull-Down Resistor         | RIN(down) | —                               | 100    | 200  | 400    | KΩ    |
| Supply Current “OFF”       | IDD(off)1 | REXT = OPEN, OUT0~7 = off       | —      | 0.3  | 0.6    | mA    |
|                            | IDD(off)2 | REXT = 470Ω, OUT0~7 = off       | 3.9    | 5.5  | 7.7    |       |
|                            | IDD(off)3 | REXT = 250Ω, OUT0~7 = off       | 7.2    | 10.1 | 14.1   |       |
| Supply Current “ON”        | IDD(on)1  | REXT = 470Ω, OUT0~7 = on        | 3.9    | 5.5  | 7.7    |       |
|                            | IDD(on)2  | REXT = 250Ω, OUT0~7 = on        | 7.2    | 10.1 | 14.1   |       |

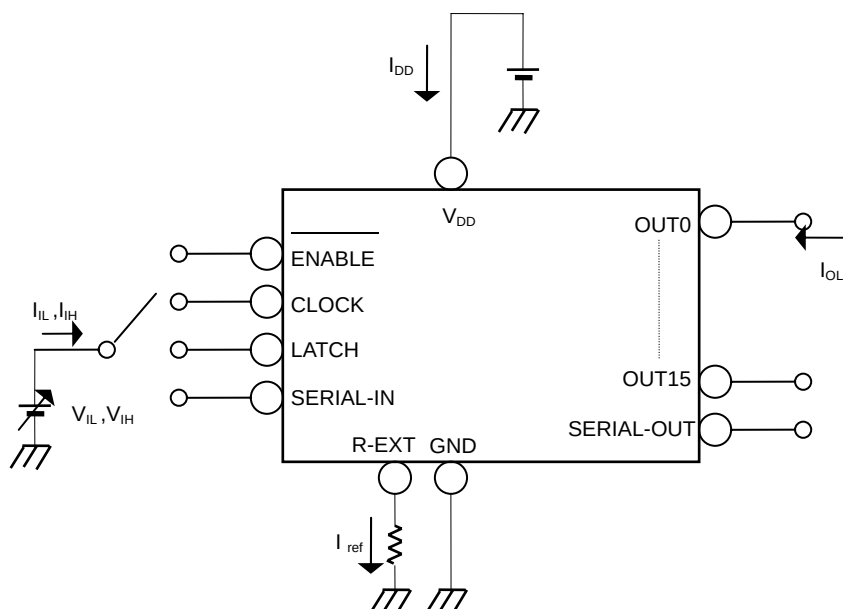
## Switching Characteristics (Ta = 25 °C unless otherwise noted)

| CHARACTERISTIC                      | SYMBOL      | CONDITION                                                                                | MIN. | TYP. | MAX. | UNIT |
|-------------------------------------|-------------|------------------------------------------------------------------------------------------|------|------|------|------|
| Propagation Delay Time (“L” to “H”) | SIN-OUTn    | VDD=5.0V<br>VIH=VDD<br>VIL=GND<br>REXT=470Ω <sup>1</sup><br>VL=3.0V<br>RL=65Ω<br>CL=13pF | —    | 450  | 550  | ns   |
|                                     | LATCH-OUTn  |                                                                                          | —    | 450  | 550  |      |
|                                     | ENABLE-OUTn |                                                                                          | —    | 450  | 550  |      |
|                                     | CLK-SOUT    |                                                                                          | —    | 15   | 20   |      |
| Propagation Delay Time (“H” to “L”) | SIN-OUTn    | VDD=5.0V<br>VIH=VDD<br>VIL=GND<br>REXT=470Ω <sup>1</sup><br>VL=3.0V<br>RL=65Ω<br>CL=13pF | —    | 20   | 40   | ns   |
|                                     | LATCH-OUTn  |                                                                                          | —    | 20   | 40   |      |
|                                     | ENABLE-OUTn |                                                                                          | —    | 20   | 40   |      |
|                                     | CLK-SOUT    |                                                                                          | —    | 15   | 20   |      |
| Output Current Rise Time            | tor         | VDD=5.0V<br>VIH=VDD<br>VIL=GND<br>REXT=470Ω <sup>1</sup><br>VL=3.0V<br>RL=65Ω<br>CL=13pF | —    | 450  | 550  | ns   |
| Output Current Fall Time            | tof         |                                                                                          | —    | 20   | 40   | ns   |

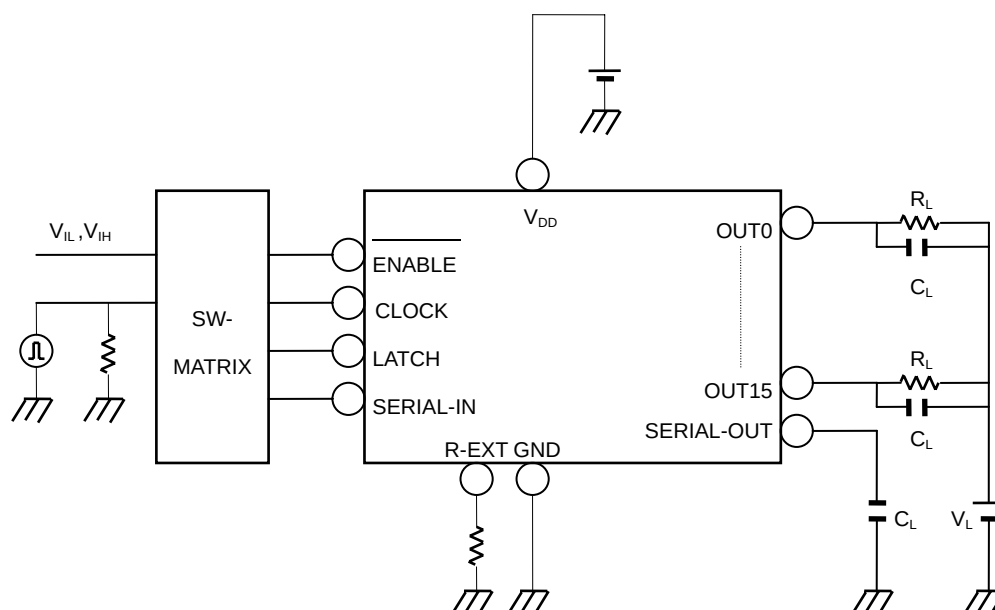
<sup>1</sup> Delay time t<sub>PLH</sub> and Rise Time tor will both increase as the Rext value increased.

## Test Circuit

DC characteristic



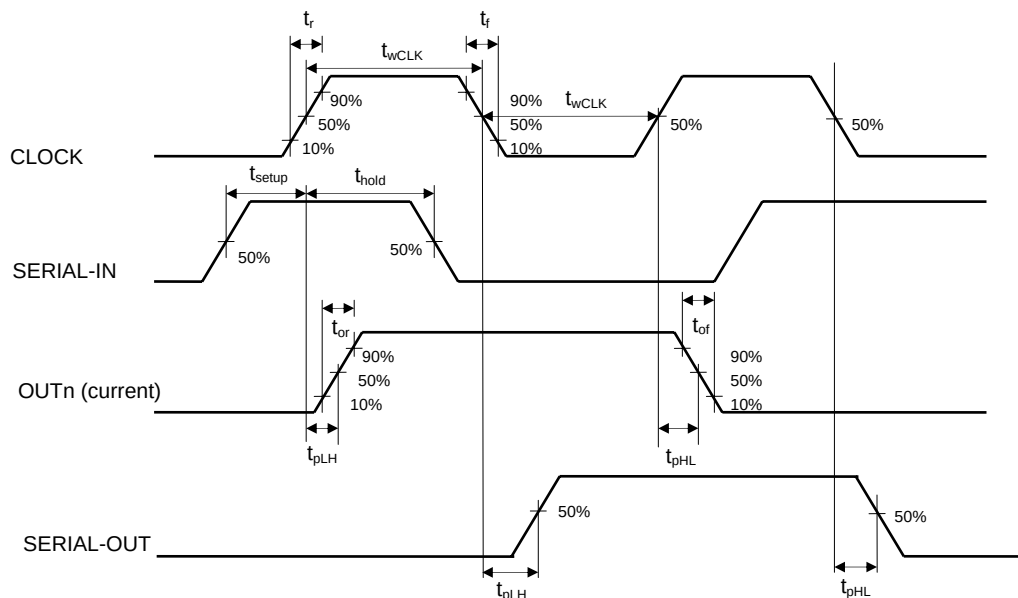
AC characteristic



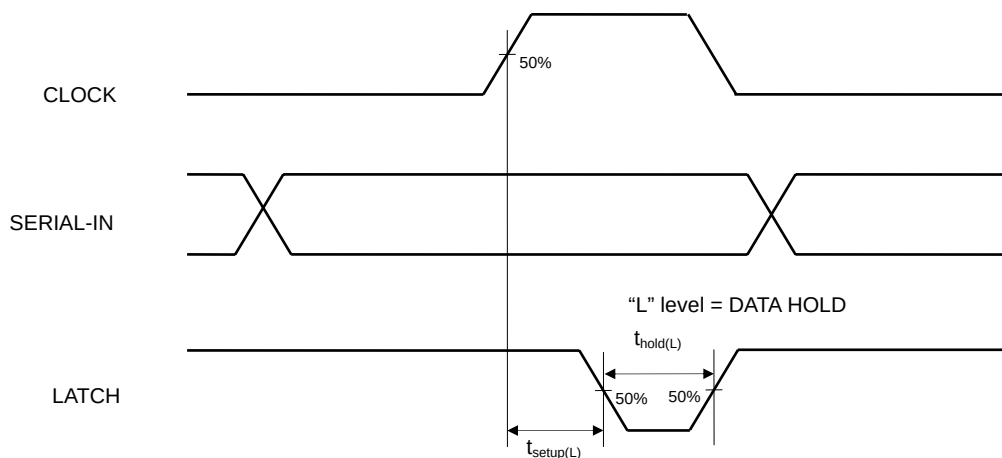


## Timing Diagram

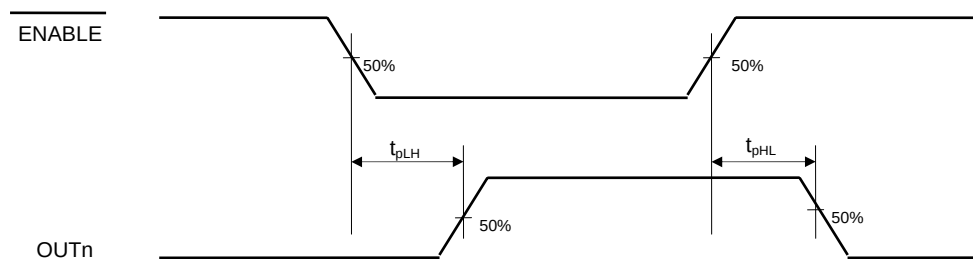
### 1. CLOCK-SERIAL-IN, SERIAL-OUT, OUT<sub>n</sub>

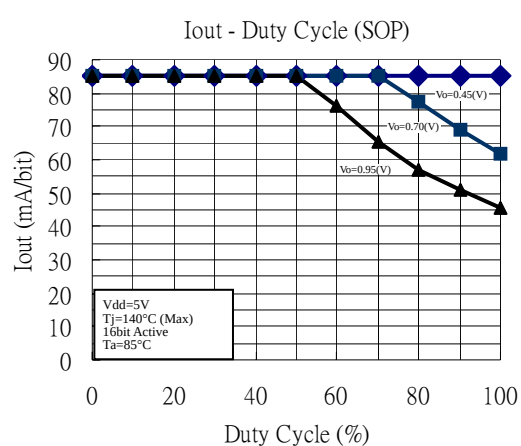
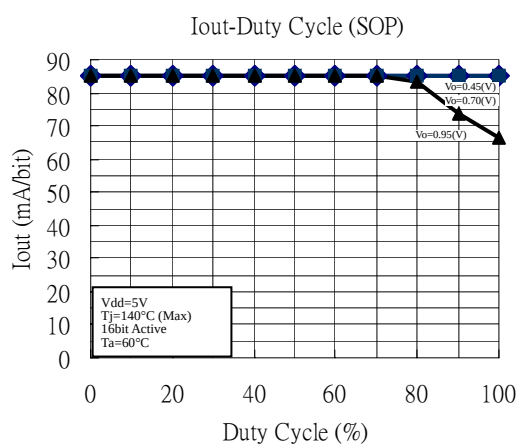
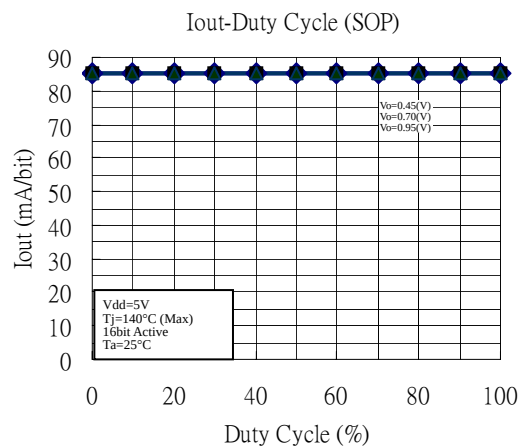
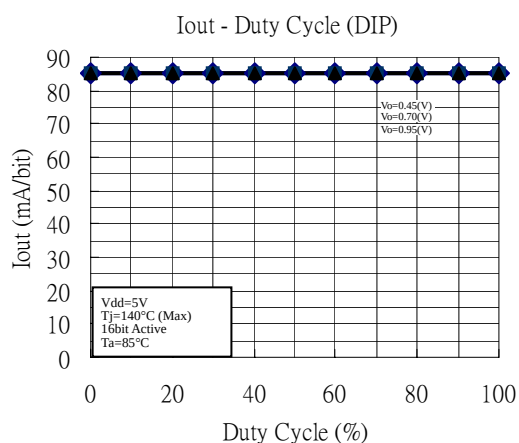
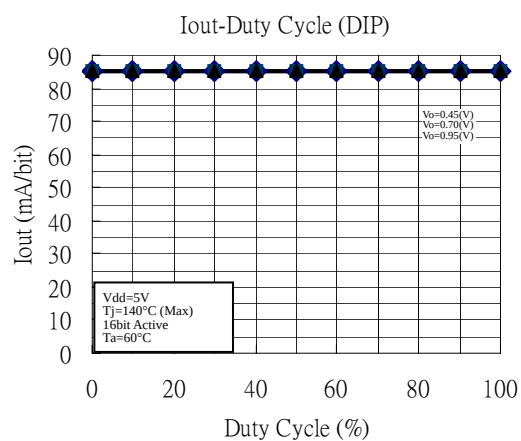
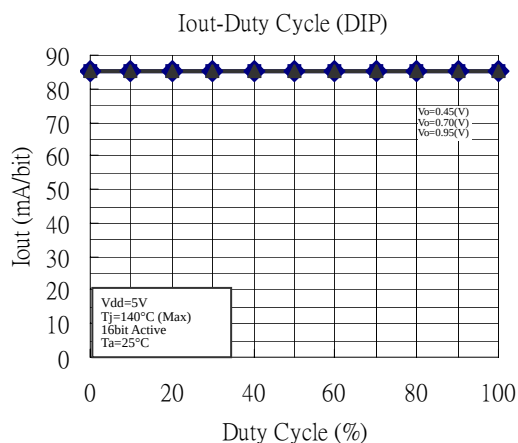


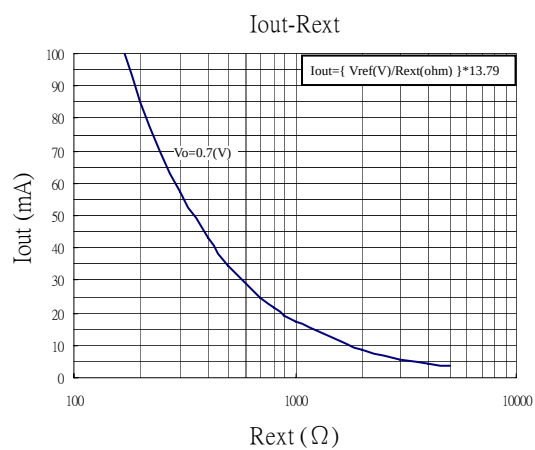
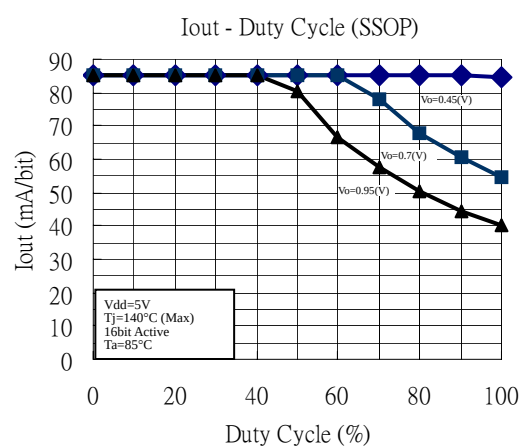
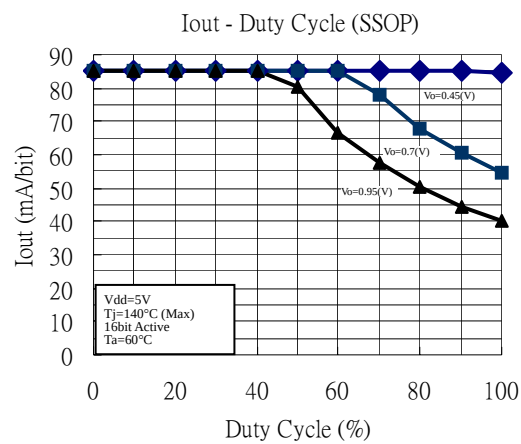
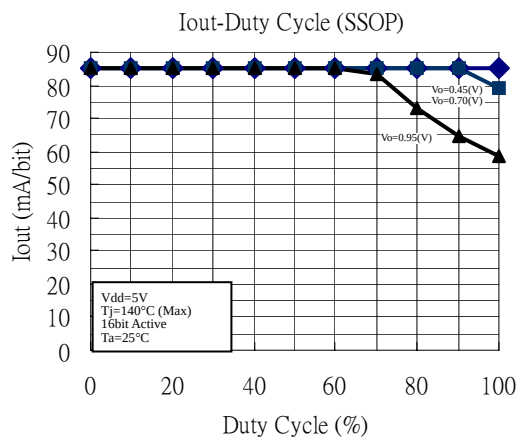
### 2. CLOCK-LATCH

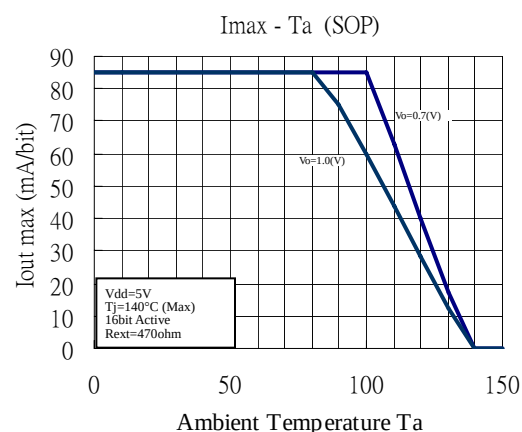
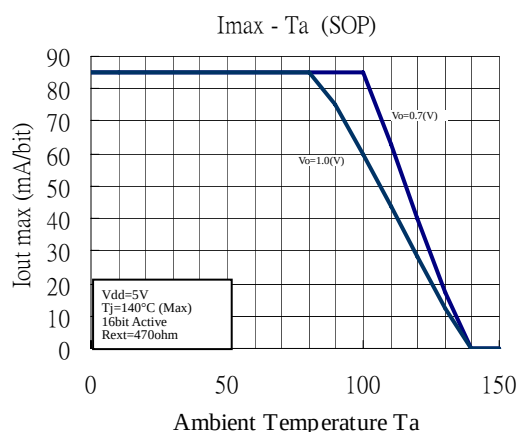
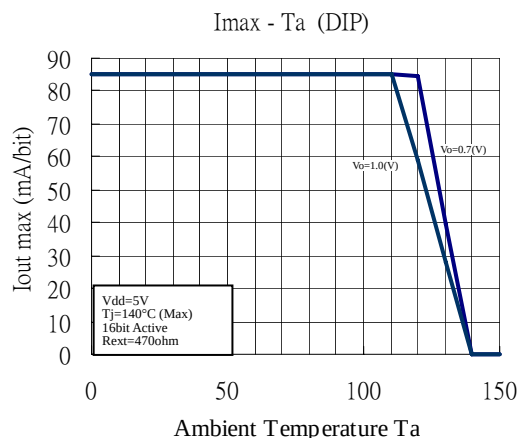
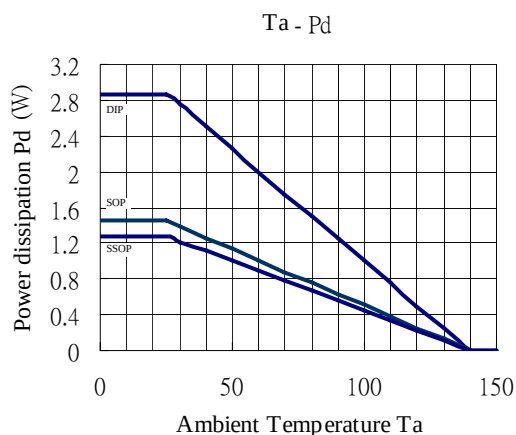


### 3. ENABLE-OUT<sub>n</sub>









#### Note

As the power dissipation of a semiconductor chip is limited its package and ambient temperature, this device requires a maximum output current be calculated for a given operating condition. The maximum allowable power consumption (Pd (max)) of this device is calculated as follows:

$$Pd(max)(Watt) = \frac{(Tj(junction\ temperature)(max) - Ta(ambient\ temperature))(^{\circ}C)}{Rth(^{\circ}C/Watt)}$$

Based on the Pd (max), the maximum allowable current can be calculated as follows:

$$Iout = (Pd - VDD \cdot IDD) / (\# outputs \cdot Vo \cdot Duty)$$

## System Configuration Example

### [1] Output current ( $I_{OUT}$ )

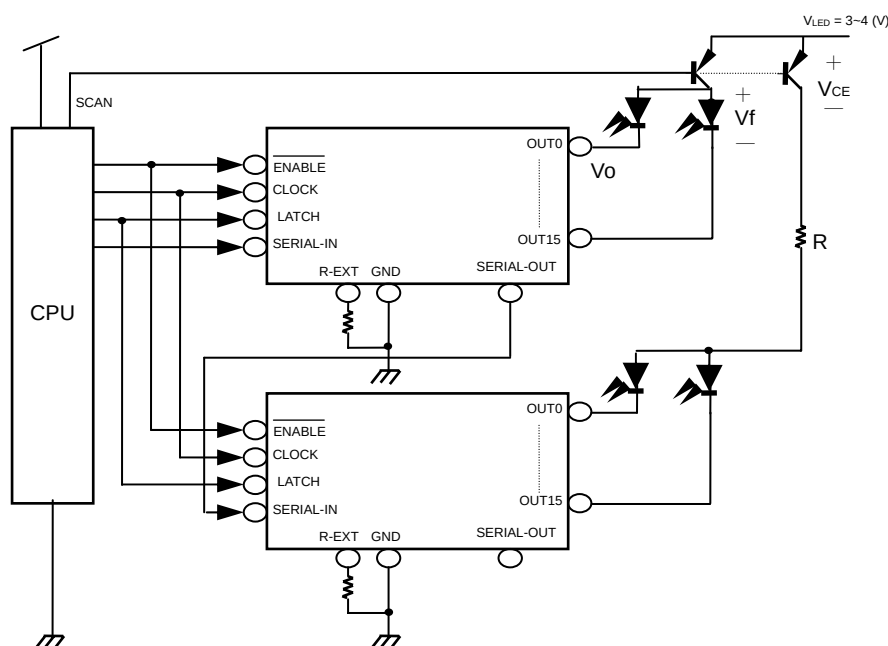
Sink current is set by the external resistor as shown in the figure ( $I_{out}$  vs.  $R_{ext}$ ).

### [2] LED supply voltage ( $V_{LED}$ ) setup

$$V_{LED} = V_{CE} (T_r V_{sat}) + V_f (\text{LED forward voltage}) + V_O (\text{IC supply voltage})$$

To prevent too much power dissipated by the device due to higher  $V_{LED}$ , an additional R can be used to reduce the  $V_{out}$  when the outputs consume current:

$$R = \frac{V_{LED} - V_{CE} - V_f - V_O(\min)}{I_O(\max) * \text{Bit}(\max)}$$



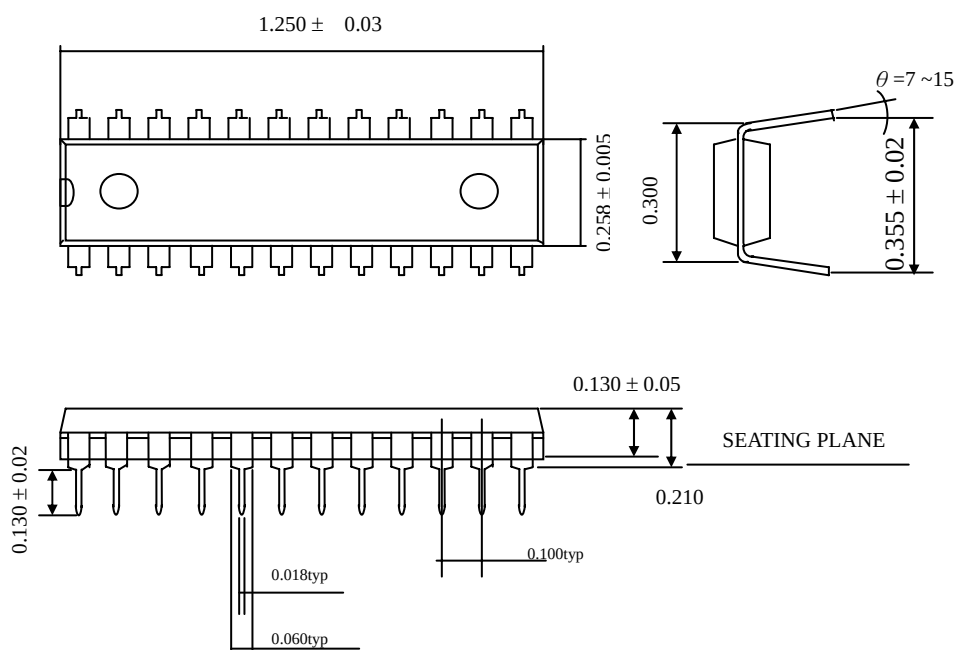
### Note

This device has only one ground pin shared by signal, output sink current, and power ground. It is advisable to pattern the ground layout with minimized inductance such that the switching noise induced by the input signals and the output sink current would not cause chip malfunction. To prevent the drivers' outputs from damage by overshoot stress, it is also advisable not to turn off the drivers and scan transistors simultaneously.

## Package Outline

P-DIP 24

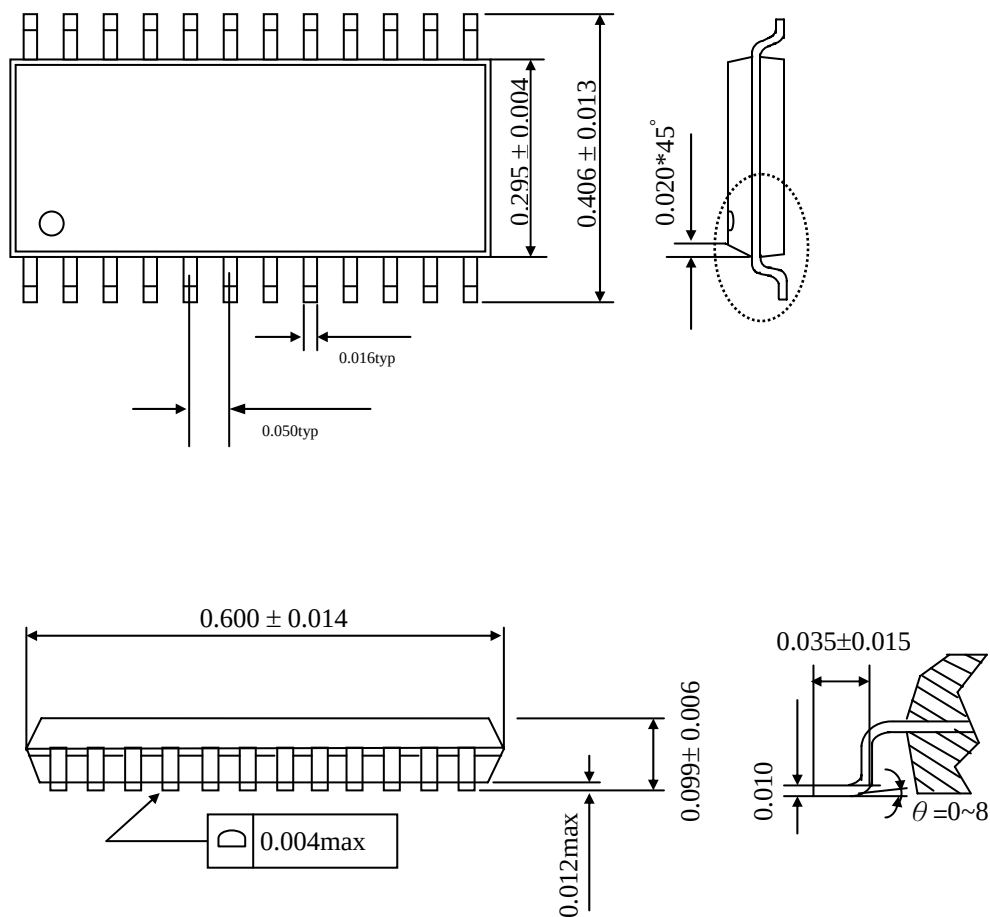
UNIT : INCH



**Package Outline**

SOP24

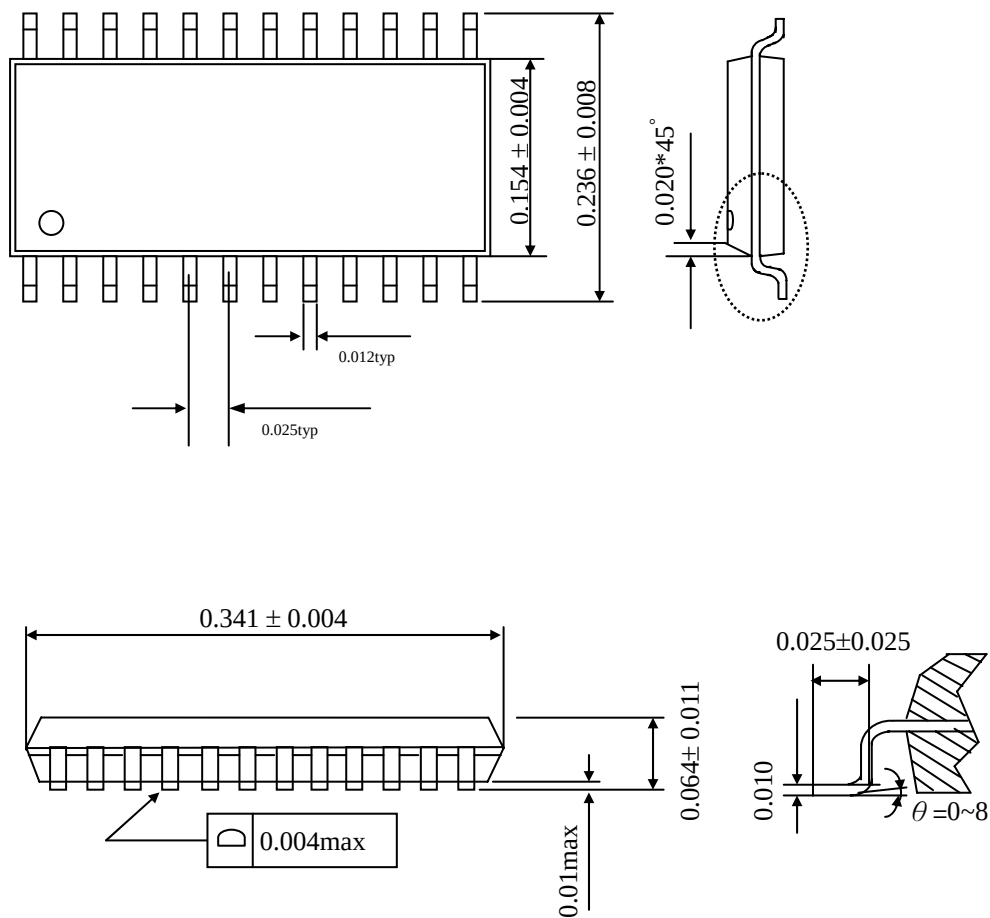
UNIT : INCH



**Package Outline**

SSOP24

UNIT : INCH







The products listed herein are designed for ordinary electronic applications, such as electrical appliances, audio-visual equipment, communications devices and so on. Hence, it is advisable that the devices should not be used in medical instruments, surgical implants, aerospace machinery, nuclear power control systems, disaster/crime-prevention equipment and the like. Misusing those products may directly or indirectly endanger human life, or cause injury and property loss.

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