

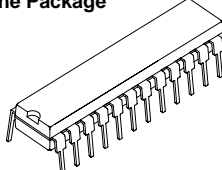


# 16-bit Constant Current LED Sink Driver

## Features

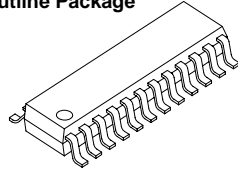
- 16 constant-current output channels
- Constant output current invariant to load voltage change
- Excellent output current accuracy:  
between channels:  $<\pm 3\%$  (max.), and  
between ICs:  $<\pm 6\%$  (max.)
- Output current adjusted through an external resistor
- Constant output current range: 5-90 mA
- Fast response of output current,  $\overline{OE}$  (min.): 200 ns
- 25MHz clock frequency
- Schmitt trigger input
- 5V supply voltage
- Optional for "Pb-free & Green" Package

**Dual In-Line Package**



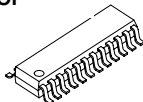
CN: P-DIP24-300-2.54  
GN: P-DIP24-300-2.54  
CNS: SP-DIP24-300-1.78  
GNS: SP-DIP24-300-1.78

**Small Outline Package**



CD: SOP24-300-1.27  
GD: SOP24-300-1.27  
CF: SOP24-300-1.00  
GF: SOP24-300-1.00

**Shrink SOP**



CP\CPA: SSOP24-150-0.64  
GP\GPA: SSOP24-150-0.64

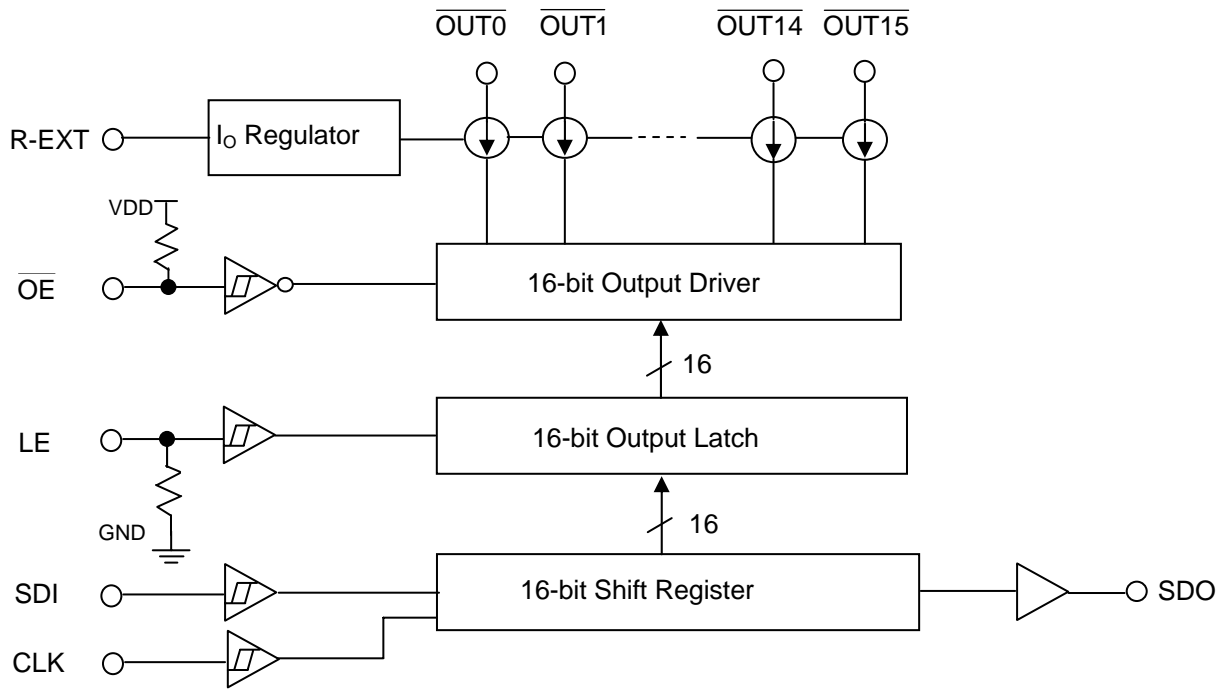
| Current Accuracy |             | Conditions                        |
|------------------|-------------|-----------------------------------|
| Between Channels | Between ICs |                                   |
| $< \pm 3\%$      | $< \pm 6\%$ | $I_{OUT} = 10 \sim 60 \text{ mA}$ |

## Product Description

MBI5026 is designed for LED displays. As an enhancement of its predecessor, MBI5016, MBI5026 exploits PrecisionDrive™ technology to enhance its output characteristics. MBI5026 contains a serial buffer and data latches which convert serial input data into parallel output format. At MBI5026 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.

MBI5026 provides users with great flexibility and device performance while using MBI5026 in their system design for LED display applications, e.g. LED panels. Users may adjust the output current from 5 mA to 90 mA through an external resistor,  $R_{ext}$ , which gives users flexibility in controlling the light intensity of LEDs. MBI5026 guarantees to endure maximum 17V at the output port. The high clock frequency, 25 MHz, also satisfies the system requirements of high volume data transmission.

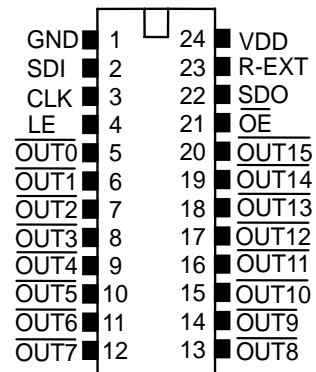
Block Diagram



Terminal Description

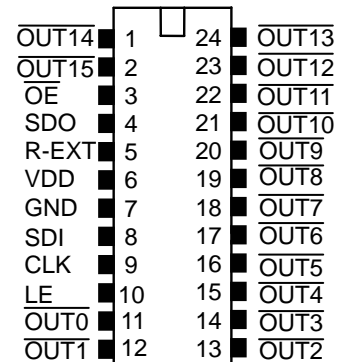
| Pin Name  | Function   |
|---|--|
| GND   | Ground terminal for control logic and current sink   |
| SDI   | Serial-data input to the shift register  |
| CLK   | Clock input terminal for data shift on rising edge   |
| LE  | Data strobe input terminal<br>Serial data is transferred to the output latch when LE is high. The data is latched when LE goes low.  |
| $\overline{\text{OUT0}} \sim \overline{\text{OUT15}}$ | Constant current output terminals  |
| $\overline{\text{OE}}$                                | Output enable terminal<br>When $\overline{\text{OE}}$ (active) low, the output drivers are enabled; when $\overline{\text{OE}}$ high, all output drivers are turned OFF (blanked). |
| SDO   | Serial-data output to the following SDI of next driver IC  |
| R-EXT   | Input terminal used to connect an external resistor for setting up output current for all output channels  |
| VDD   | 5V supply voltage terminal   |

Pin Configuration



MBI5026CN\ICNS\ICD\ICFCPI

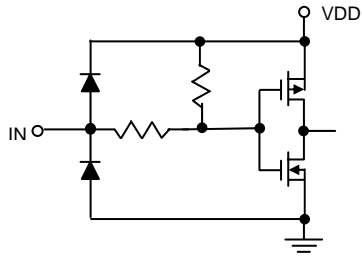
GN\GNS\GD\GF\GP



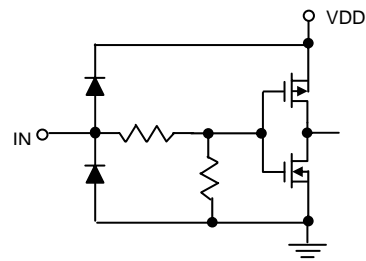
MBI5026CPA\GPA

Equivalent Circuits of Inputs and Outputs

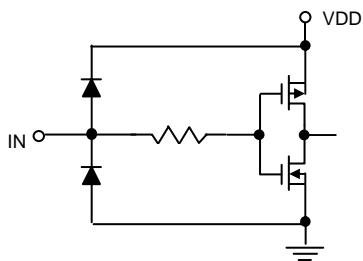
**$\overline{OE}$  terminal**



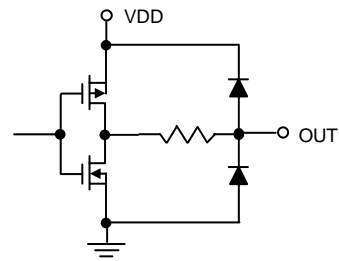
**LE terminal**



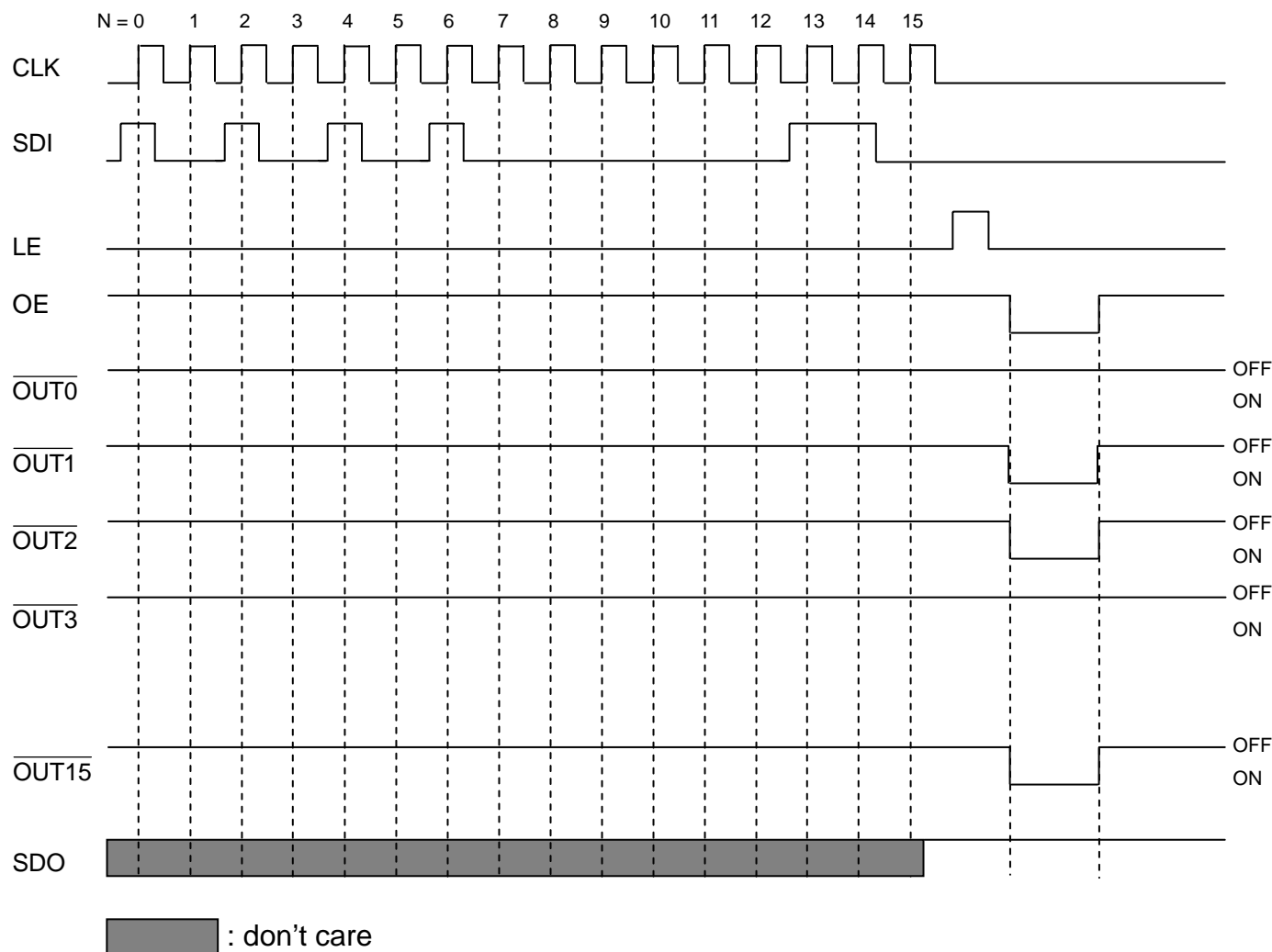
**CLK, SDI terminal**



**SDO terminal**



Timing Diagram



Truth Table

| CLK          | LE | $\overline{\text{OE}}$ | SDI       | $\overline{\text{OUT0}} \dots \overline{\text{OUT7}} \dots \overline{\text{OUT15}}$ | SDO        |
|--------------|----|------------------------|-----------|---|------------|
| $\uparrow$   | H  | L                      | $D_n$     | $\overline{D_n} \dots \overline{D_{n-7}} \dots \overline{D_{n-15}}$                 | $D_{n-15}$ |
| $\uparrow$   | L  | L                      | $D_{n+1}$ | No Change   | $D_{n-14}$ |
| $\uparrow$   | H  | L                      | $D_{n+2}$ | $\overline{D_{n+2}} \dots \overline{D_{n-5}} \dots \overline{D_{n-13}}$             | $D_{n-13}$ |
| $\downarrow$ | X  | L                      | $D_{n+3}$ | $\overline{D_{n+2}} \dots \overline{D_{n-5}} \dots \overline{D_{n-13}}$             | $D_{n-13}$ |
| $\downarrow$ | X  | H                      | $D_{n+3}$ | Off   | $D_{n-13}$ |

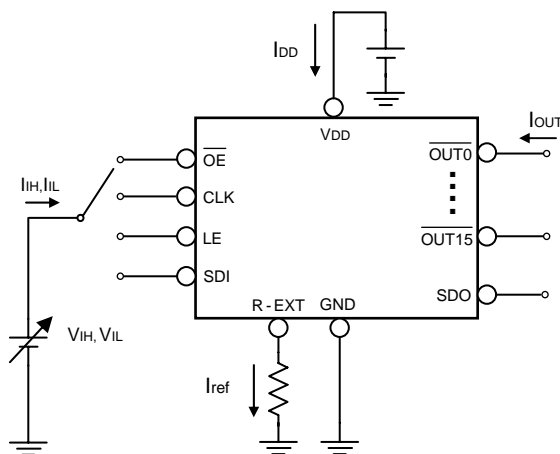
Maximum Ratings

| Characteristic  |     |     | Symbol        | Rating               |       | Unit               |
|---|-----|-----|---------------|----------------------|-------|--------------------|
| Supply Voltage  |     |     | $V_{DD}$      | 0~7.0                |       | V                  |
| Input Voltage   |     |     | $V_{IN}$      | -0.4~ $V_{DD} + 0.4$ |       | V                  |
| Output Current  |     |     | $I_{OUT}$     | +90                  |       | mA                 |
| Output Voltage  |     |     | $V_{DS}$      | -0.5~+17.0           |       | V                  |
| Clock Frequency   |     |     | $F_{CLK}$     | 25                   |       | MHz                |
| GND Terminal Current                                    |     |     | $I_{GND}$     | 1440                 |       | mA                 |
| Power Dissipation<br>(On PCB, $T_a=25^\circ\text{C}$ )  | CN  | GN  | $P_D$         | 1.80                 | 2.00  | W                  |
|   | CNS | GNS |               | 1.50                 | 1.61  |                    |
|   | CD  | GD  |               | 2.01                 | 2.19  |                    |
|   | CF  | GF  |               | 1.69                 | 1.91  |                    |
|   | CP  | GP  |               | 1.38                 | 1.46  |                    |
|   | CPA | GPA |               | 1.38                 | 1.46  |                    |
| Thermal Resistance<br>(On PCB, $T_a=25^\circ\text{C}$ ) | CN  | GN  | $R_{th(j-a)}$ | 55.52                | 49.9  | $^\circ\text{C/W}$ |
|   | CNS | GNS |               | 66.74                | 62.28 |                    |
|   | CD  | GD  |               | 49.81                | 45.69 |                    |
|   | CF  | GF  |               | 59.01                | 52.38 |                    |
|   | CP  | GP  |               | 72.43                | 68.48 |                    |
|   | CPA | GPA |               | 72.43                | 68.48 |                    |
| Operating Temperature                                   |     |     | $T_{opr}$     | -40~+85              |       | $^\circ\text{C}$   |
| Storage Temperature                                     |     |     | $T_{stg}$     | -55~+150             |       | $^\circ\text{C}$   |

Electrical Characteristics

| Characteristic                               |           | Symbol          | Condition   | Min.                   | Typ.      | Max.               | Unit       |    |
|--|-----------|-----------------|---|------------------------|-----------|--------------------|------------|----|
| Supply Voltage                               |           | $V_{DD}$        | -   | 4.5                    | 5.0       | 5.5                | V          |    |
| Output Voltage                               |           | $V_{DS}$        | $\overline{OUT0} \sim \overline{OUT15}$                                     | -                      | -         | 17.0               | V          |    |
| Output Current                               |           | $I_{OUT}$       | DC Test Circuit   | 5                      | -         | 90                 | mA         |    |
|  |           | $I_{OH}$        | SDO   | -                      | -         | -1.0               | mA         |    |
|  |           | $I_{OL}$        | SDO   | -                      | -         | 1.0                | mA         |    |
| Input Voltage                                | "H" level | $V_{IH}$        | $T_a = -40 \sim 85^\circ C$   | $0.8 \cdot V_{DD}$     | -         | $V_{DD}$           | V          |    |
|  | "L" level | $V_{IL}$        | $T_a = -40 \sim 85^\circ C$   | GND                    | -         | $0.3 \cdot V_{DD}$ | V          |    |
| Output Leakage Current                       |           | $I_{OH}$        | $V_{OH} = 17.0V$  | -                      | -         | 0.5                | $\mu A$    |    |
| Output Voltage                               | SDO       | $V_{OL}$        | $I_{OL} = +1.0mA$   | -                      | -         | 0.4                | V          |    |
|  |           | $V_{OH}$        | $I_{OH} = -1.0mA$   | 4.6                    | -         | -                  | V          |    |
| Output Current 1                             |           | $I_{OUT1}$      | $V_{DS} = 0.6V$   | $R_{ext} = 720 \Omega$ | -         | 26.25              | -          | mA |
| Current Skew                                 |           | $dI_{OUT1}$     | $I_{OL} = 26.25mA$<br>$V_{DS} = 0.6V$                                       | $R_{ext} = 720 \Omega$ | -         | $\pm 1$            | $\pm 3$    | %  |
| Output Current 2                             |           | $I_{OUT2}$      | $V_{DS} = 0.8V$   | $R_{ext} = 360 \Omega$ | -         | 52.5               | -          | mA |
| Current Skew                                 |           | $dI_{OUT2}$     | $I_{OL} = 52.5mA$<br>$V_{DS} = 0.8V$  | $R_{ext} = 360 \Omega$ | -         | $\pm 1$            | $\pm 3$    | %  |
| Output Current vs. Output Voltage Regulation |           | $\% / dV_{DS}$  | $V_{DS}$ within 1.0V and 3.0V   | -                      | $\pm 0.1$ | -                  | $\% / V$   |    |
| Output Current vs. Supply Voltage Regulation |           | $\% / dV_{DD}$  | $V_{DD}$ within 4.5V and 5.5V   | -                      | $\pm 1$   | -                  | $\% / V$   |    |
| Pull-up Resistor                             |           | $R_{IN(up)}$    | $\overline{OE}$   | 250                    | 500       | 800                | K $\Omega$ |    |
| Pull-down Resistor                           |           | $R_{IN(down)}$  | LE  | 250                    | 500       | 800                | K $\Omega$ |    |
| Supply Current                               | "OFF"     | $I_{DD(off) 1}$ | $R_{ext} = \text{Open}, \overline{OUT0} \sim \overline{OUT15} = \text{Off}$ | -                      | 6         | 6.8                | mA         |    |
|  |           | $I_{DD(off) 2}$ | $R_{ext} = 720 \Omega, \overline{OUT0} \sim \overline{OUT15} = \text{Off}$  | -                      | 8.8       | 9.6                |            |    |
|  |           | $I_{DD(off) 3}$ | $R_{ext} = 360 \Omega, \overline{OUT0} \sim \overline{OUT15} = \text{Off}$  | -                      | 12.4      | 13.2               |            |    |
|  | "ON"      | $I_{DD(on) 1}$  | $R_{ext} = 720 \Omega, \overline{OUT0} \sim \overline{OUT15} = \text{On}$   | -                      | 8.8       | 10.8               |            |    |
|  |           | $I_{DD(on) 2}$  | $R_{ext} = 360 \Omega, \overline{OUT0} \sim \overline{OUT15} = \text{On}$   | -                      | 12.3      | 15.3               |            |    |

Test Circuit for Electrical Characteristics

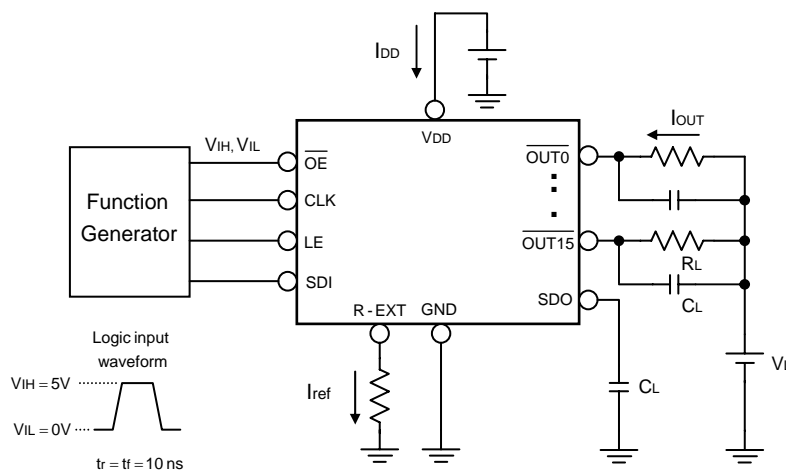


Switching Characteristics

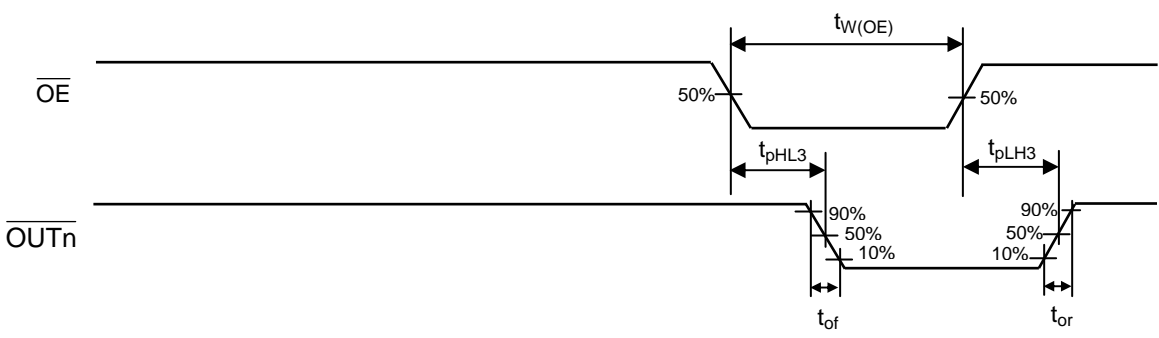
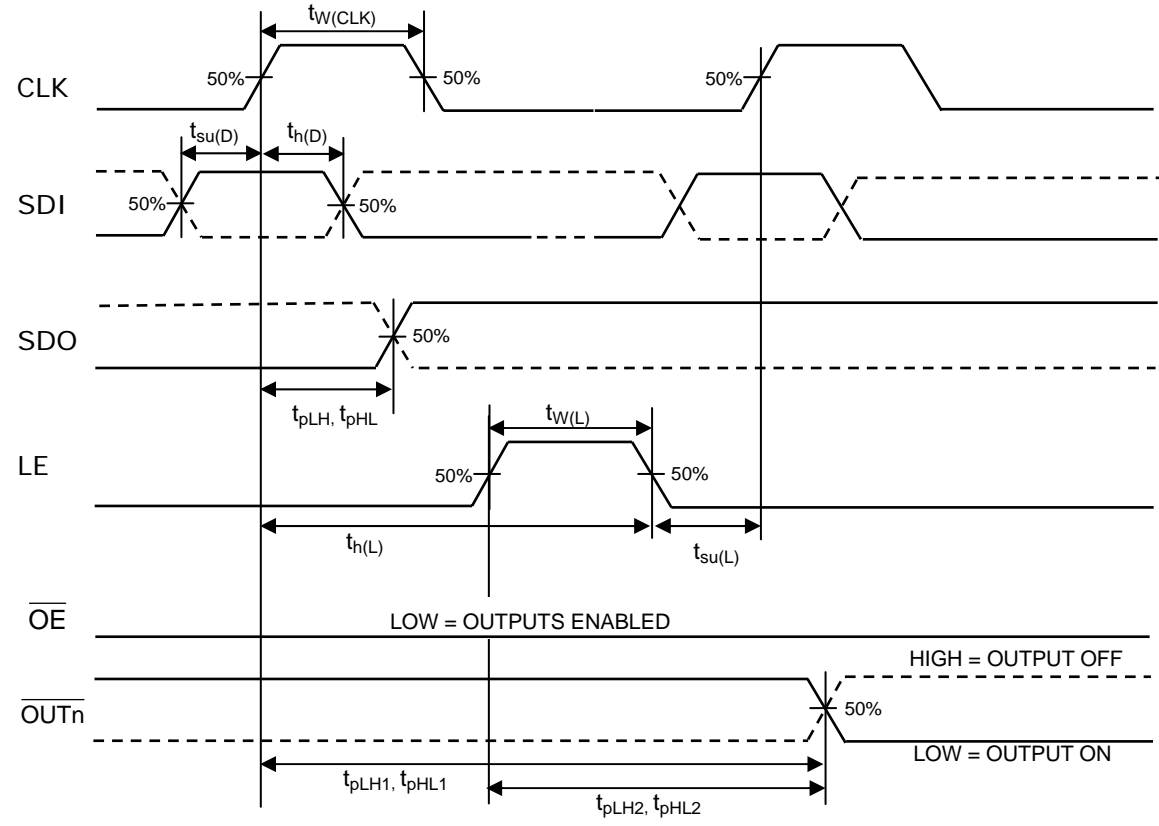
| Characteristic                      |   | Symbol            | Condition   | Min. | Typ. | Max. | Unit |
|-------------------------------------|---|-------------------|---|------|------|------|------|
| Propagation Delay Time ("L" to "H") | CLK - $\overline{\text{OUTn}}$                    | $t_{pLH1}$        | $V_{DD}=5.0\text{ V}$<br>$V_{DS}=0.8\text{ V}$<br>$V_{IH}=V_{DD}$<br>$V_{IL}=\text{GND}$<br>$R_{ext}=300\ \Omega$<br>$V_L=4.0\text{ V}$<br>$R_L=52\ \Omega$<br>$C_L=10\text{ pF}$ | -    | 100  | 150  | ns   |
|                                     | LE - $\overline{\text{OUTn}}$                     | $t_{pLH2}$        |   | -    | 100  | 150  | ns   |
|                                     | $\overline{\text{OE}}$ - $\overline{\text{OUTn}}$ | $t_{pLH3}$        |   | -    | 50   | 150  | ns   |
|                                     | CLK - SDO   | $t_{pLH}$         |   | 15   | 20   | -    | ns   |
| Propagation Delay Time ("H" to "L") | CLK - $\overline{\text{OUTn}}$                    | $t_{pHL1}$        |   | -    | 50   | 100  | ns   |
|                                     | LE - $\overline{\text{OUTn}}$                     | $t_{pHL2}$        |   | -    | 50   | 100  | ns   |
|                                     | $\overline{\text{OE}}$ - $\overline{\text{OUTn}}$ | $t_{pHL3}$        |   | -    | 20   | 100  | ns   |
|                                     | CLK - SDO   | $t_{pHL}$         |   | 15   | 20   | -    | ns   |
| Pulse Width                         | CLK   | $t_w(\text{CLK})$ |   | 20   | -    | -    | ns   |
|                                     | LE  | $t_w(\text{L})$   |   | 20   | -    | -    | ns   |
|                                     | $\overline{\text{OE}}$                            | $t_w(\text{OE})$  |   | 200  | -    | -    | ns   |
| Hold Time for LE                    | $t_h(\text{L})$                                   | 5                 |   | -    | -    | ns   |      |
| Setup Time for LE                   | $t_{su}(\text{L})$                                | 5                 |   | -    | -    | ns   |      |
| Hold Time for SDI                   | $t_h(\text{D})$                                   | 10                |   | -    | -    | ns   |      |
| Setup Time for SDI                  | $t_{su}(\text{D})$                                | 5                 |   | -    | -    | ns   |      |
| Clock Frequency                     | $F_{\text{CLK}}$                                  | Cascade Operation |   | -    | -    | 25.0 | MHz  |
| Maximum CLK Rise Time               | $t_r^{**}$  |                   | -   | -    | 500  | ns   |      |
| Maximum CLK Fall Time               | $t_f^{**}$  |                   | -   | -    | 500  | ns   |      |
| Output Rise Time of Vout (turn off) | $t_{or}$  |                   | -   | 70   | 200  | ns   |      |
| Output Fall Time of Vout (turn on)  | $t_{of}$  |                   | -   | 40   | 120  | 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



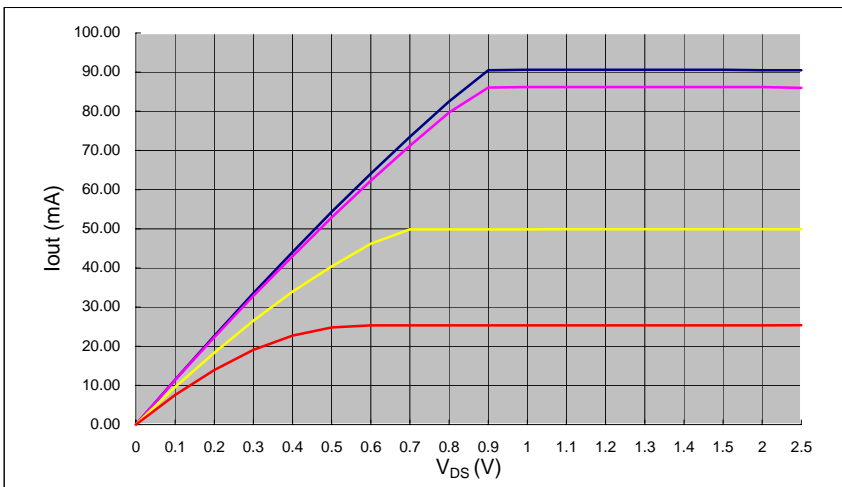


Application Information

**Constant Current**

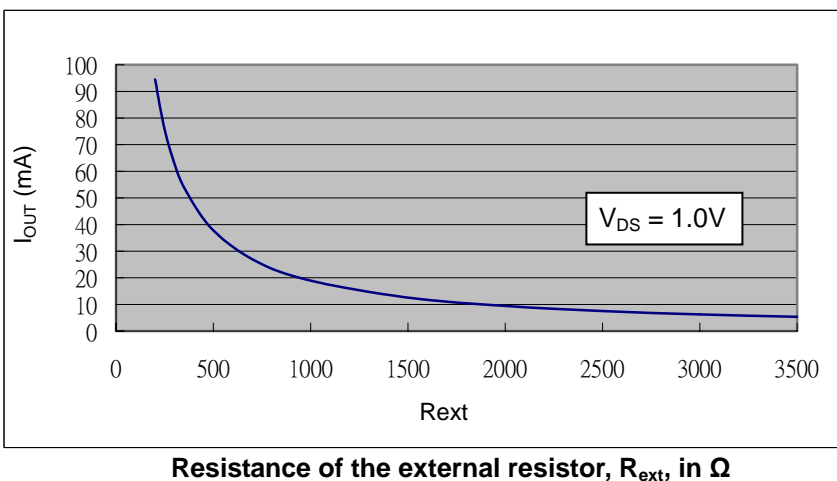
In LED display application, MBI5026 provides nearly no variations in current from channel to channel and from IC to IC. This can be achieved by:

- 1) The maximum current variation between channels is less than  $\pm 3\%$ , and that between ICs is less than  $\pm 6\%$ .
- 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 voltages ( $V_F$ ). 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.



Resistance of the external resistor,  $R_{ext}$ , in  $\Omega$

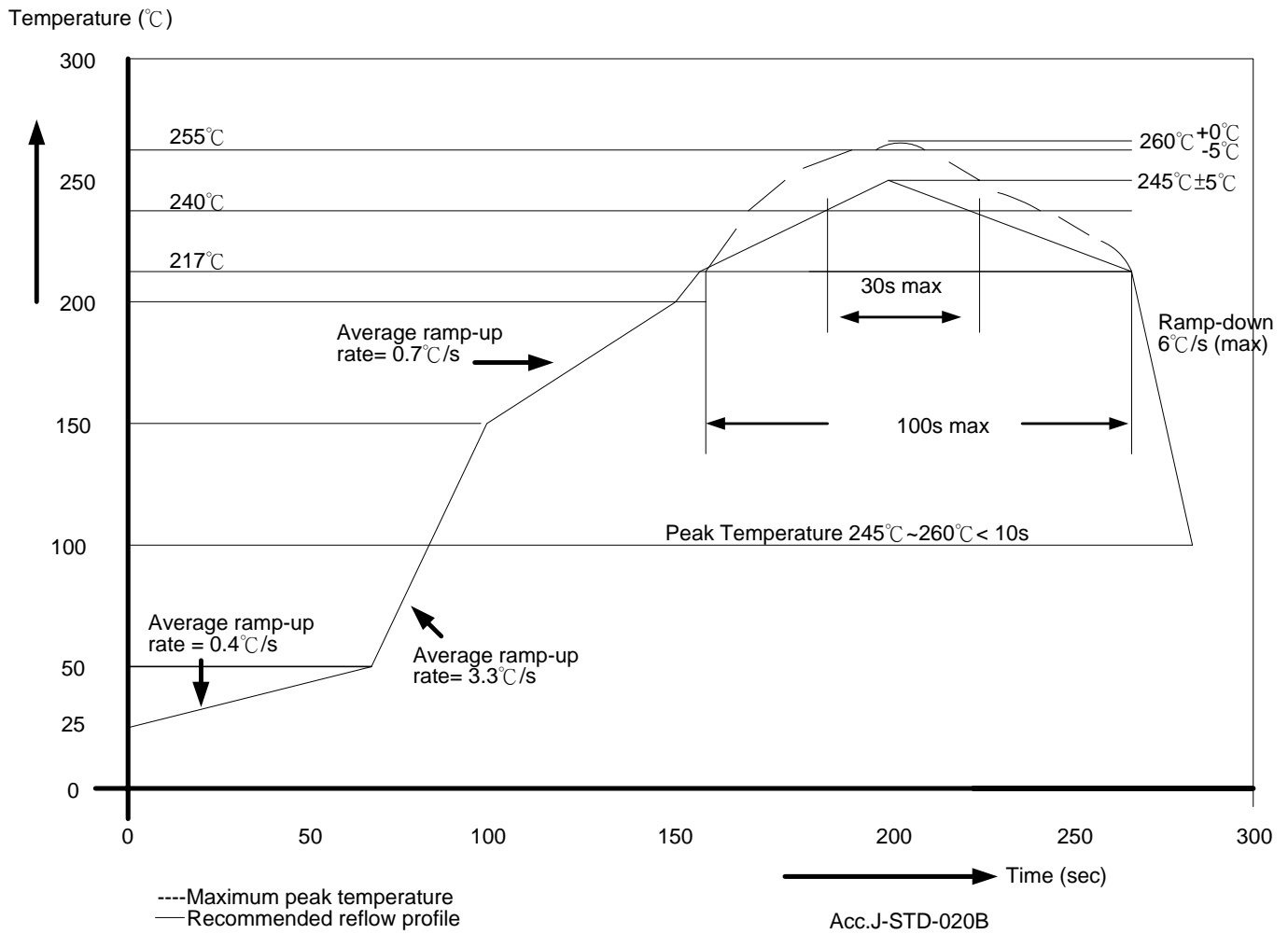
Also, the output current can be calculated from the equation:

$$V_{R-EXT} = 1.26V ; I_{OUT} = (V_{R-EXT} / R_{ext}) \times 15$$

where  $R_{ext}$  is the resistance of the external resistor connected to R-EXT terminal and  $V_{R-EXT}$  is the voltage of R-EXT terminal. The magnitude of current (as a function of  $R_{ext}$ ) is around 52.5mA at 360 $\Omega$  and 26.25mA at 720 $\Omega$ .

**Soldering Process of “Pb-free & Green” Package Plating\***

Macroblock has defines "Pb-Free & Green" to mean semiconductor products that are compatible with the current RoHS requirements and selected **100% pure tin (Sn)** to provide forward and backward compatibility with both the current industry-standard SnPb-based soldering processes and higher-temperature Pb-free processes. Pure tin is widely accepted by customers and suppliers of electronic devices in Europe, Asia and the US as the lead-free surface finish of choice to replace tin-lead. Also, it is backward compatible to standard 215°C to 240°C reflow processes which adopt tin/lead (SnPb) solder paste. However, in the whole Pb-free soldering processes and materials, 100% pure tin (Sn), will all require up to 260°C for proper soldering on boards, referring to J-STD-020B as shown below.



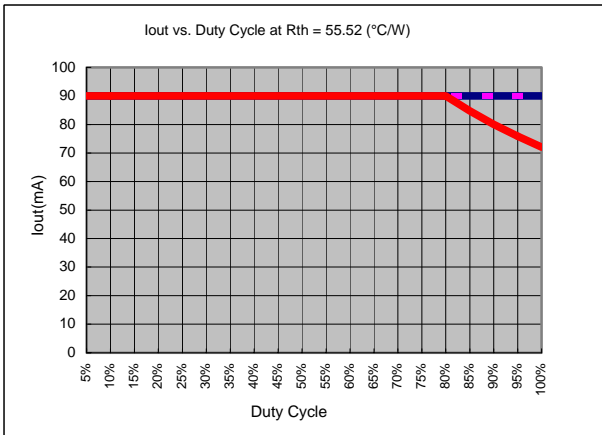
\*Note1: For details, please refer to Macroblock’s “Policy on Pb-free & Green Package”.

Package Power Dissipation ( $P_D$ )

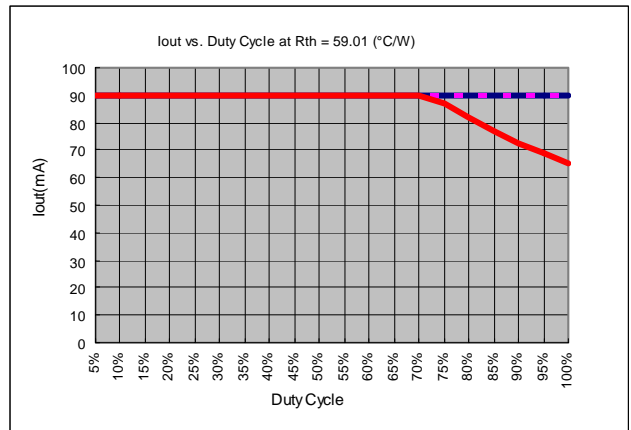
The maximum allowable package power dissipation is determined as  $P_{D(max)} = (T_j - T_a) / R_{th(j-a)}$ . When 16 output channels are turned on simultaneously, the actual package power dissipation is  $P_{D(act)} = (I_{DD} \times V_{DD}) + (I_{OUT} \times Duty \times V_{DS} \times 16)$ . Therefore, to keep  $P_{D(act)} \leq P_{D(max)}$ , the allowable maximum output current as a function of duty cycle is:

$$I_{OUT} = \{ [(T_j - T_a) / R_{th(j-a)}] - (I_{DD} \times V_{DD}) \} / V_{DS} / Duty / 16,$$

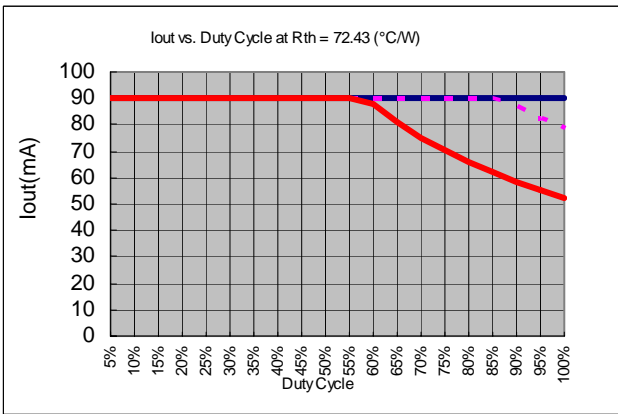
where  $T_j = 150^\circ\text{C}$ .



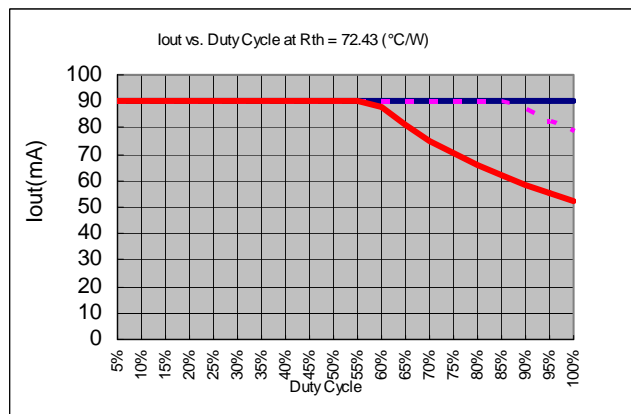
CN\GN type package



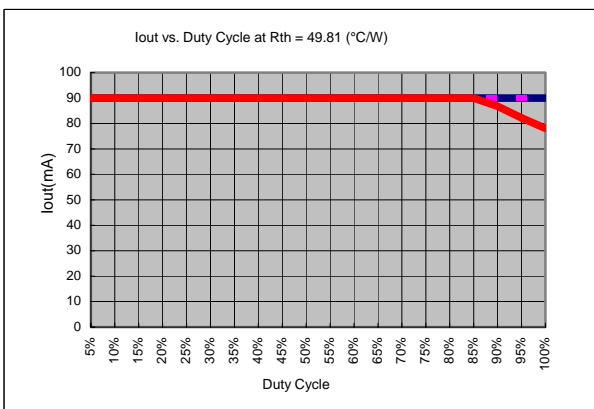
CF\GF type package



CNS\GNS type package



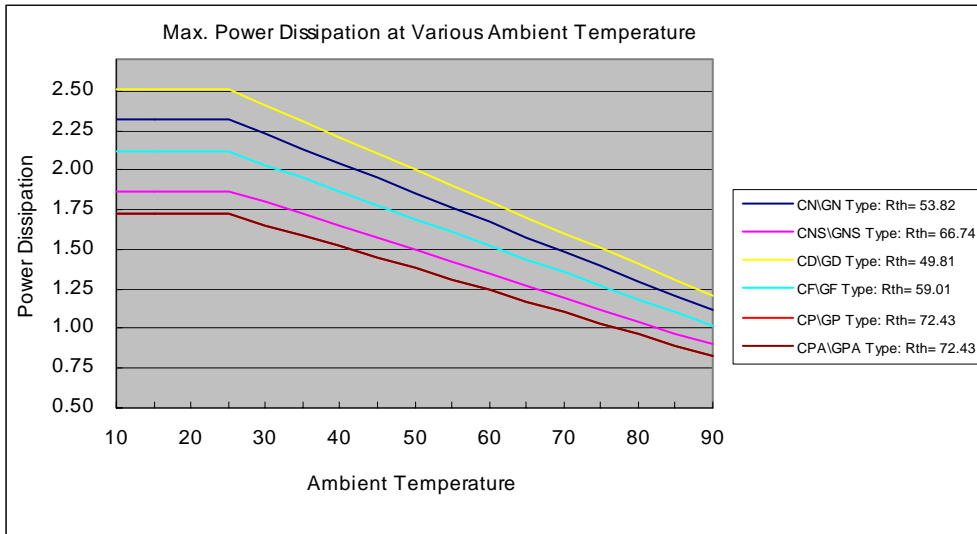
CP\CPA\GP\GPA type package



CD\GD type package

| Condition : $I_{out} = 90\text{mA}$ , $V_{DS} = 1.0\text{V}$ , 16 output channels active |        |                                    | Note |
|--|--------|------------------------------------|------|
| Device Type  |        | $R_{th(j-a)} (^{\circ}\text{C/W})$ |      |
| CN   | GN     | 55.52    49.90                     |      |
| CNS  | GNS    | 66.74    62.28                     |      |
| CD   | GD     | 49.81    45.69                     |      |
| CF   | GF     | 59.01    52.38                     |      |
| CP\CPA   | GP\GPA | 72.43    68.48                     |      |

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

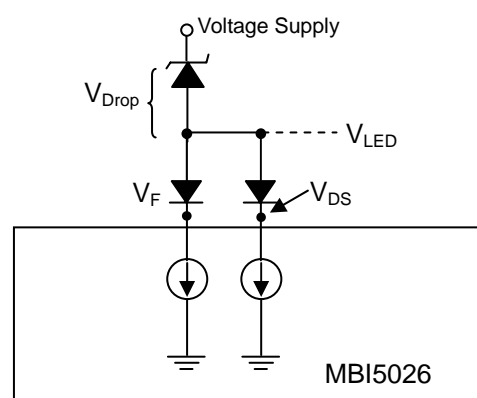
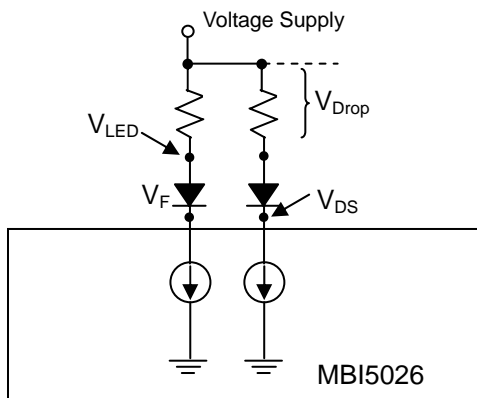


### Load Supply Voltage ( $V_{LED}$ )

MBI5026 are designed to operate with  $V_{DS}$  ranging from 0.4V to 1.0V considering the package power dissipating limits.  $V_{DS}$  may be higher enough to make  $P_{D(act)} > P_{D(max)}$  when  $V_{LED} = 5V$  and  $V_{DS} = V_{LED} - V_F$ , in which  $V_{LED}$  is the load supply voltage. In this case, it is recommended to use the lowest possible supply voltage or to set an external voltage reducer,  $V_{DROP}$ .

A voltage reducer lets  $V_{DS} = (V_{LED} - V_F) - V_{DROP}$ .

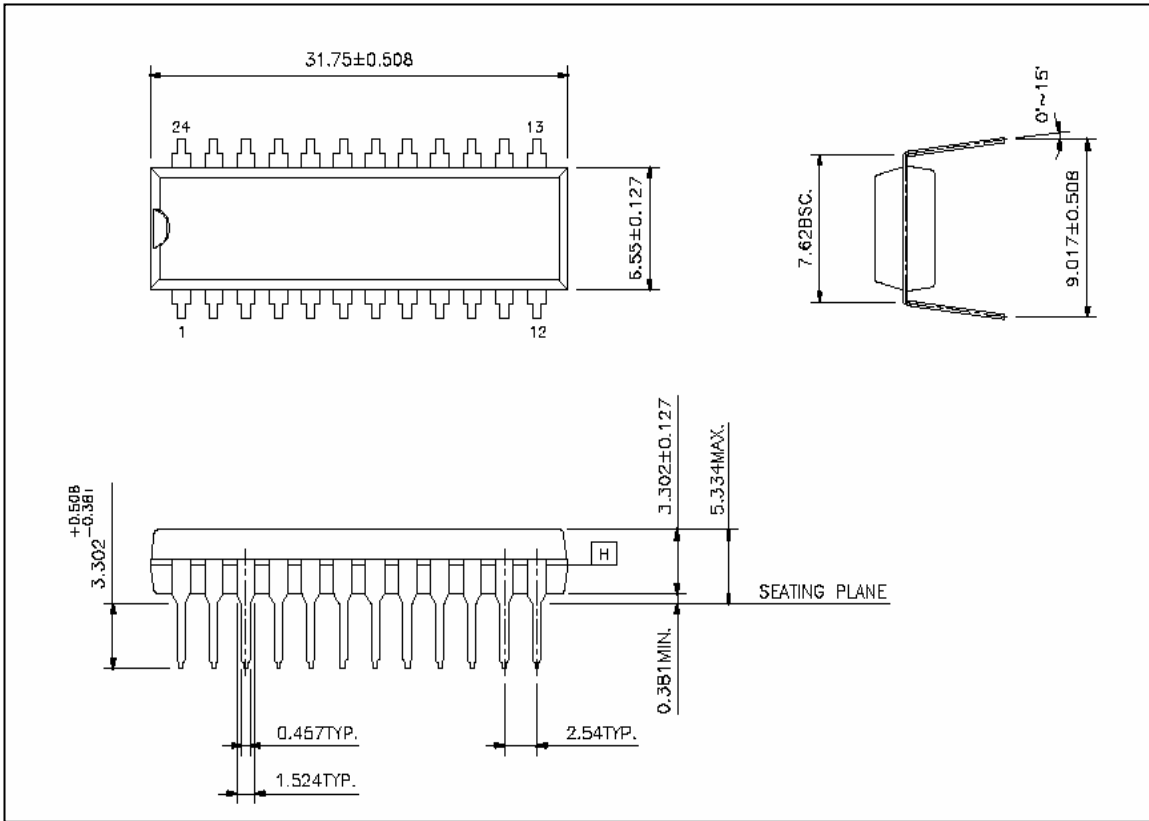
Resistors or Zener diode can be used in the applications as shown in the following figures.



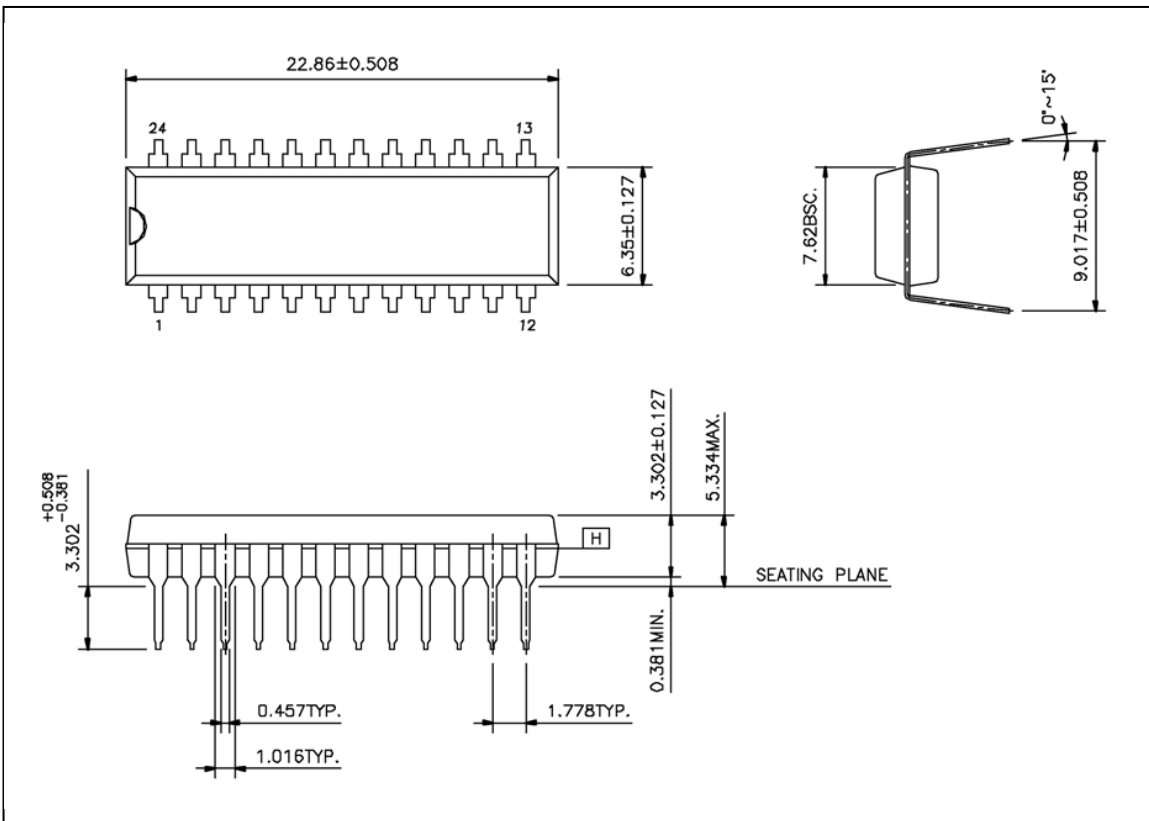
### Switching Noise Reduction

LED driver ICs are frequently used in switch-mode applications which always behave with switching noise due to the parasitic inductance on PCB. To eliminate switching noise, refer to "Application Note for 8-bit and 16-bit LED Drivers- Overshoot".

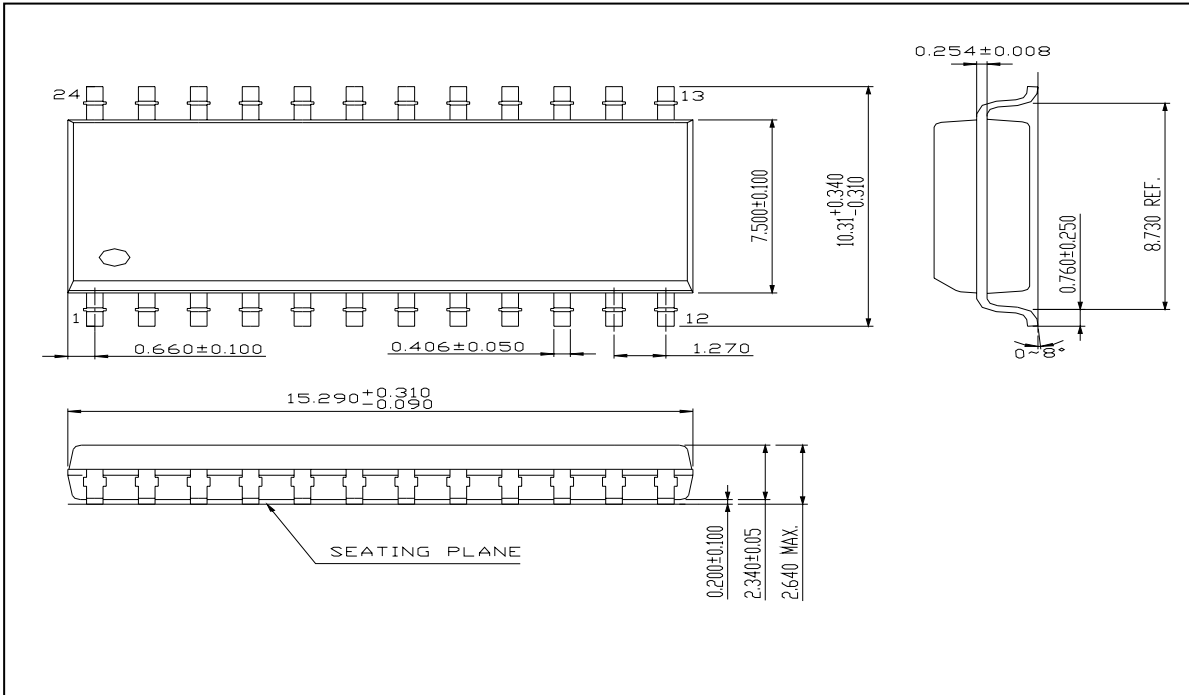
Package Outline



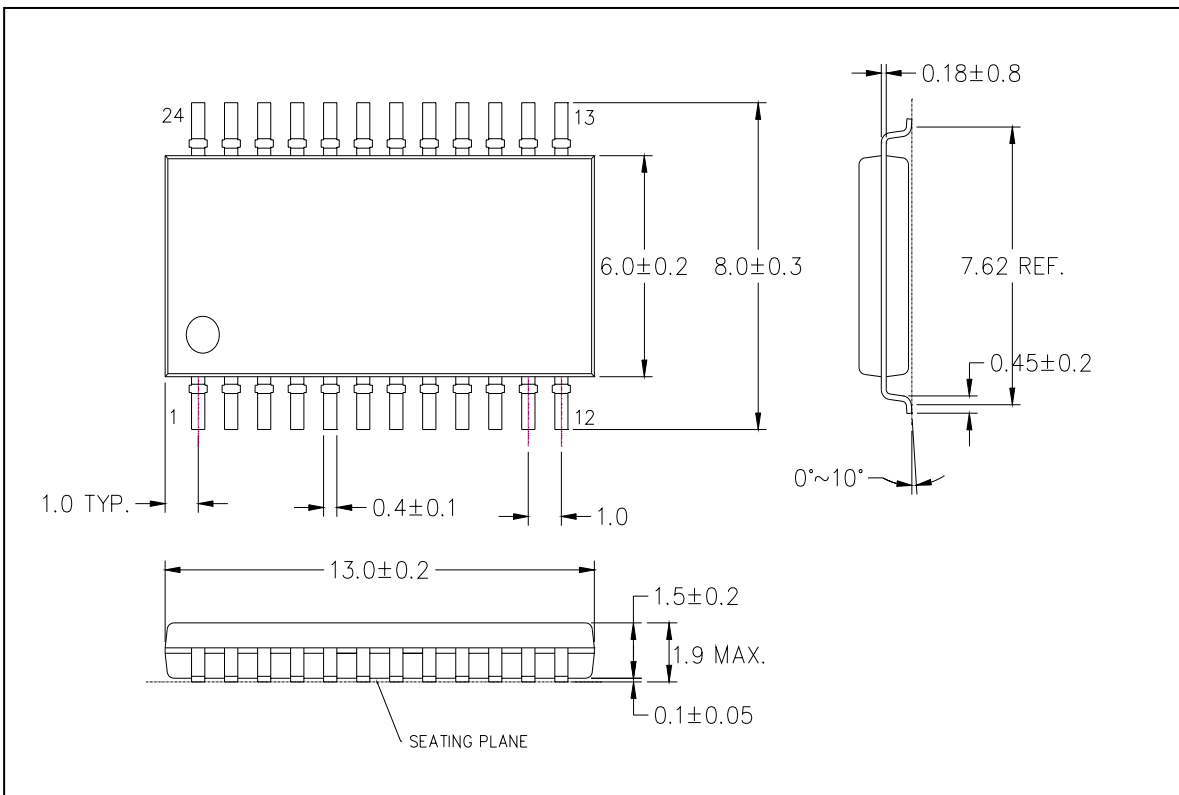
MBI5026CN\GN Outline Drawing



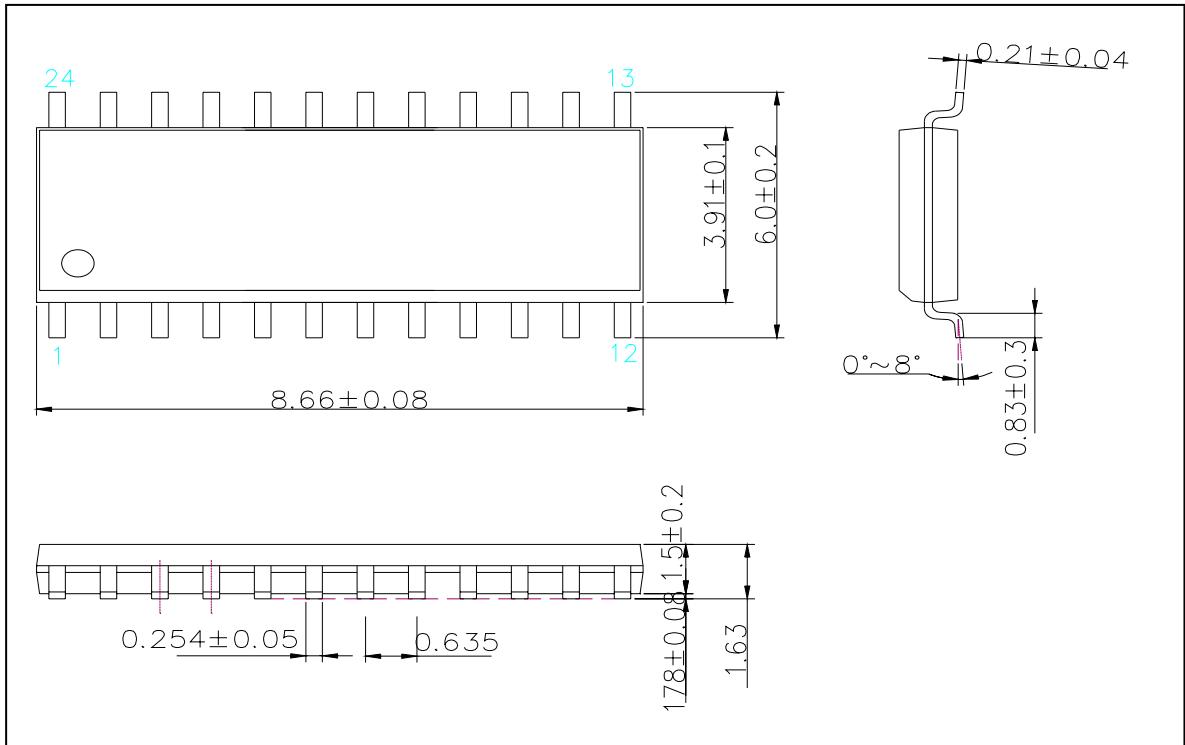
MBI5026CNS\GNS Outline Drawing



MBI5026CD\GD Outline Drawing



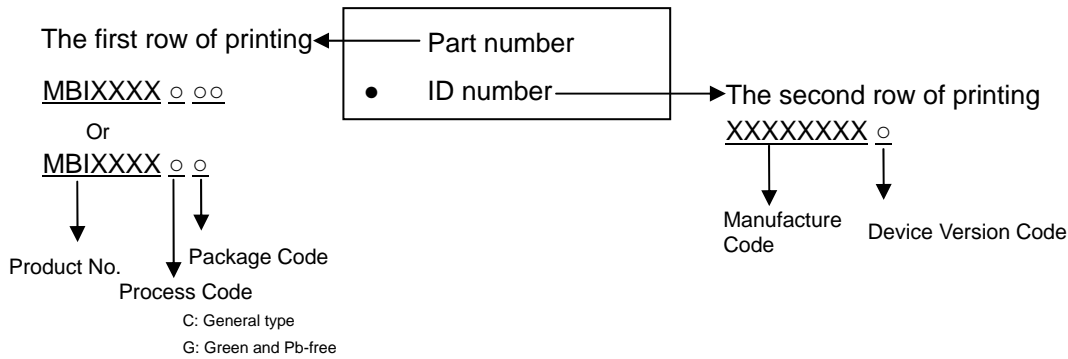
MBI5026CF\GF Outline Drawing



MBI5026CP\CPA\GP\GPA Outline Drawing

Note: The unit for the outline drawing is mm.

**Product Top-mark Information**



**Product Revision History**

| Datasheet version | Device version code |
|-------------------|---------------------|
| VA.00             | Not defined         |
| VA.01             | A                   |
| VA.02             | A                   |

**Product Ordering Information**

| Part Number | Package Type      | Weight (g) |
|-------------|-------------------|------------|
| MBI5026CN   | P-DIP24-300-2.54  | 1.628      |
| MBI5026CNS  | SP-DIP24-300-1.78 | 1.11       |
| MBI5026CD   | SOP24-300-1.27    | 0.617      |
| MBI5026CF   | SOP24-300-1.00    | 0.28       |
| MBI5026CP   | SSOP24-150-0.64   | 0.11       |
| MBI5026CPA  | SSOP24-150-0.64   | 0.11       |

| Part Number | "Pb-free & Green" Package Type | Weight (g) |
|-------------|--------------------------------|------------|
| MBI5026GN   | P-DIP24-300-2.54               | 1.628      |
| MBI5026GNS  | SP-DIP24-300-1.78              | 1.11       |
| MBI5026GD   | SOP24-300-1.27                 | 0.617      |
| MBI5026GF   | SOP24-300-1.00                 | 0.28       |
| MBI5026GP   | SSOP24-150-0.64                | 0.11       |
| MBI5026GPA  | SSOP24-150-0.64                | 0.11       |

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