

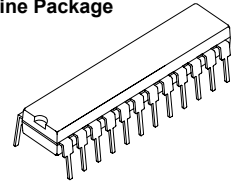


16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

Features

- Open-/Short-Circuit Detection Mode to detect individual LED errors
- 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



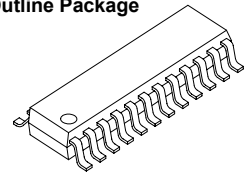
CN: P-DIP24-300-2.54

GN: P-DIP24-300-2.54

CNS: SP-DIP24-300-1.78

GNS: SP-DIP24-300-1.78

Small Outline Package



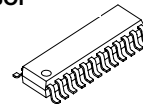
CD: SOP24-300-1.27

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 | |
| $< \pm 3\%$ | $< \pm 6\%$ | $I_{OUT} = 10 \sim 60 \text{ mA}$ |

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

Product Description

MBI5027 succeeds MBI5026 and is designed for LED displays with Open-/Short-circuit Detection extension. MBI5027 exploits PrecisionDrive™ technology to enhance its output characteristics. MBI5027 contains a 16-bit shift register and data latches, which convert serial input data into parallel output format. At MBI5027 output stage, sixteen regulated current ports are designed to provide uniform and constant current sinks for driving LEDs within a wide range of V_F variations.

While MBI5027 is used in their system design for LED display applications, e.g. LED panels, it provides users with great flexibility and device performance. 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. MBI5027 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.

MBI5027 exploits the idea of Share-I-O™ technology to extend its performance ; in addition, MBI5027 is backward compatible with MBI5026 in both electrical characteristics and package aspect. With Share-I-O™ technology, users can let MBI5027 enter a special function mode, an Open-/Short-circuit Detection mode. In an Open-/Short-circuit Detection mode, users can set a specific sequence of signals on LE(ED1), \overline{OE} (ED2) and CLK input pins. For Short-Circuit Detection mode, however, in addition to the previous steps, users need bias insufficiently LED loads, this step that can make sure to distinguish LED loads with normal current from ones with short error. In Open-/Short-circuit Detection mode, MBI5027 detects the status of individual LED connected to MBI5027. The status will be saved in the built-in shift register. Then, a system controller may read, through SDO pin, the error status from the register to know whether LEDs are properly lit or not. By setting another sequence of signals on LE(ED1), \overline{OE} (ED2) and CLK input pins, MBI5027 may resume to a Normal mode and perform as MBI5026. In **Application Information**, users can get detailed ideas about how MBI5027 works in the Open-/Short-circuit Detection mode.

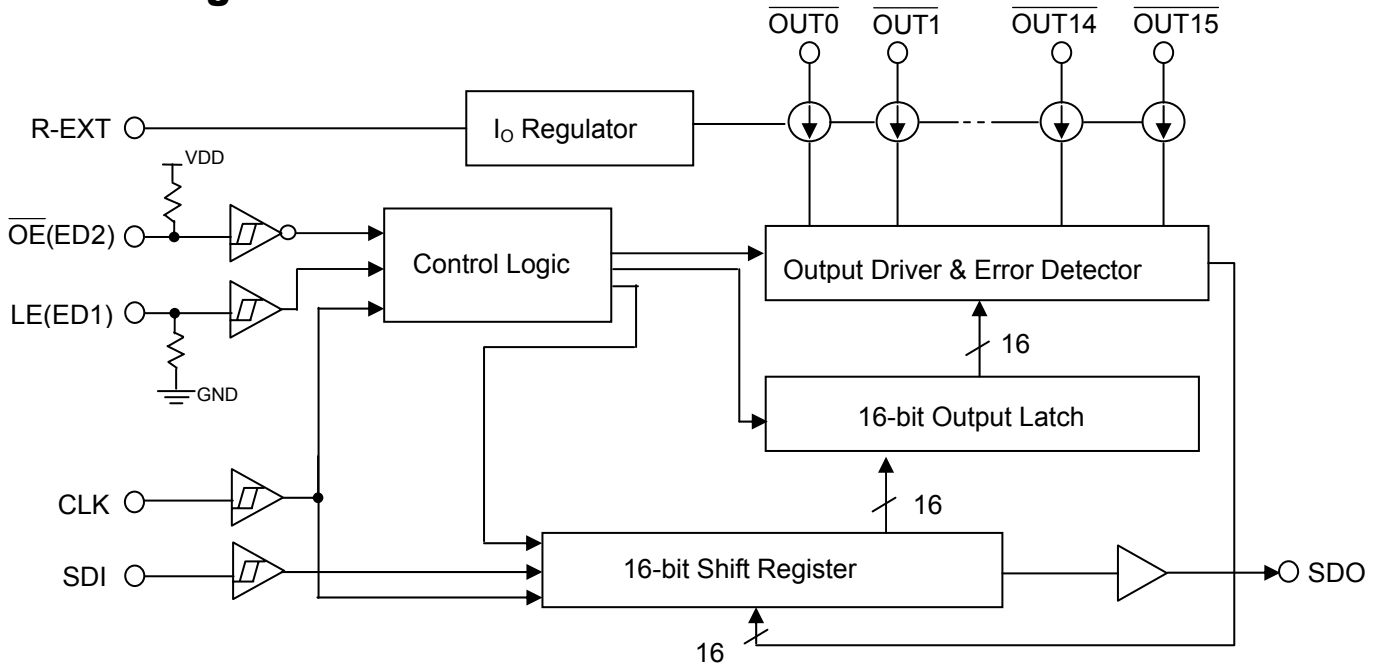
By means of the Share-I-O™ technique, an additionally effective function, Open-/Short-circuit Detection, can be added to LED drivers, MBI5027, without any extra pins. Thus, MBI5027 could be a drop-in replacement of MBI5026. The printed circuit board originally designed for MBI5026 may be also applicable for MBI5027.

For MBI5027, Pin LE and \overline{OE} can respectively offer two functions:

| Device Type | Pin Name | Function description |
|------------------------------------|----------|----------------------------------|
| CN\CNS\CD\CF\CP GN\GNS\GD\GF\GP | Pin4 | LE + Error Detection |
| CPA GPA | Pin10 | LE + Error Detection |
| CN\CNS\CD\CF\CP GN\GNS\GD\GF\GP | Pin21 | \overline{OE} +Error Detection |
| CPA GPA | Pin3 | \overline{OE} +Error Detection |

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

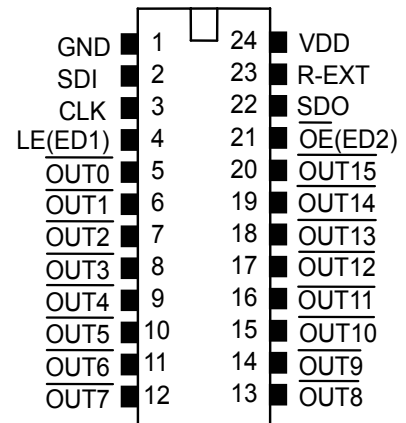
Block Diagram



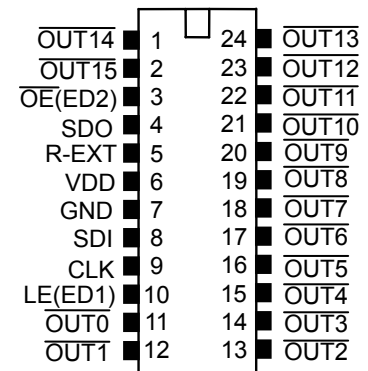
Terminal Description

| 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(ED1) | Data strobe input terminal Serial data is transferred to the respective latch when LE(ED1) is high. The data is latched when LE(ED1) goes low. Also, a control signal input for an Open-/Short-circuit Detection mode (See Timing Diagram) |
| OUT0 ~ OUT15 | Constant current output terminals |
| OE (ED2) | Output enable terminal When OE (ED2)(active) low, the output drivers are enabled; when OE (ED2) high, all output drivers are turned OFF (blanked). Also, a control signal input for an Open-/Short-circuit Detection mode (See Timing Diagram) |
| 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 all output current |
| VDD | 5V supply voltage terminal |

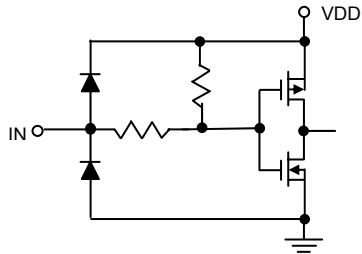
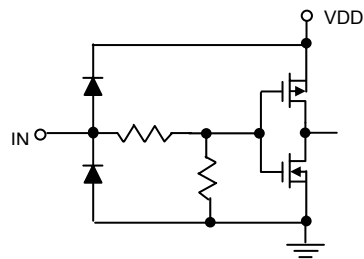
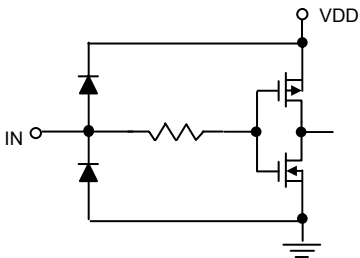
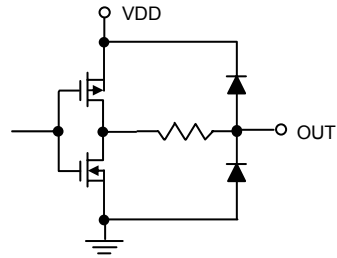
Pin Configuration



MBI5027 CN\CNS\CD\CF\CP\GN\GNS\GD\GF\GP



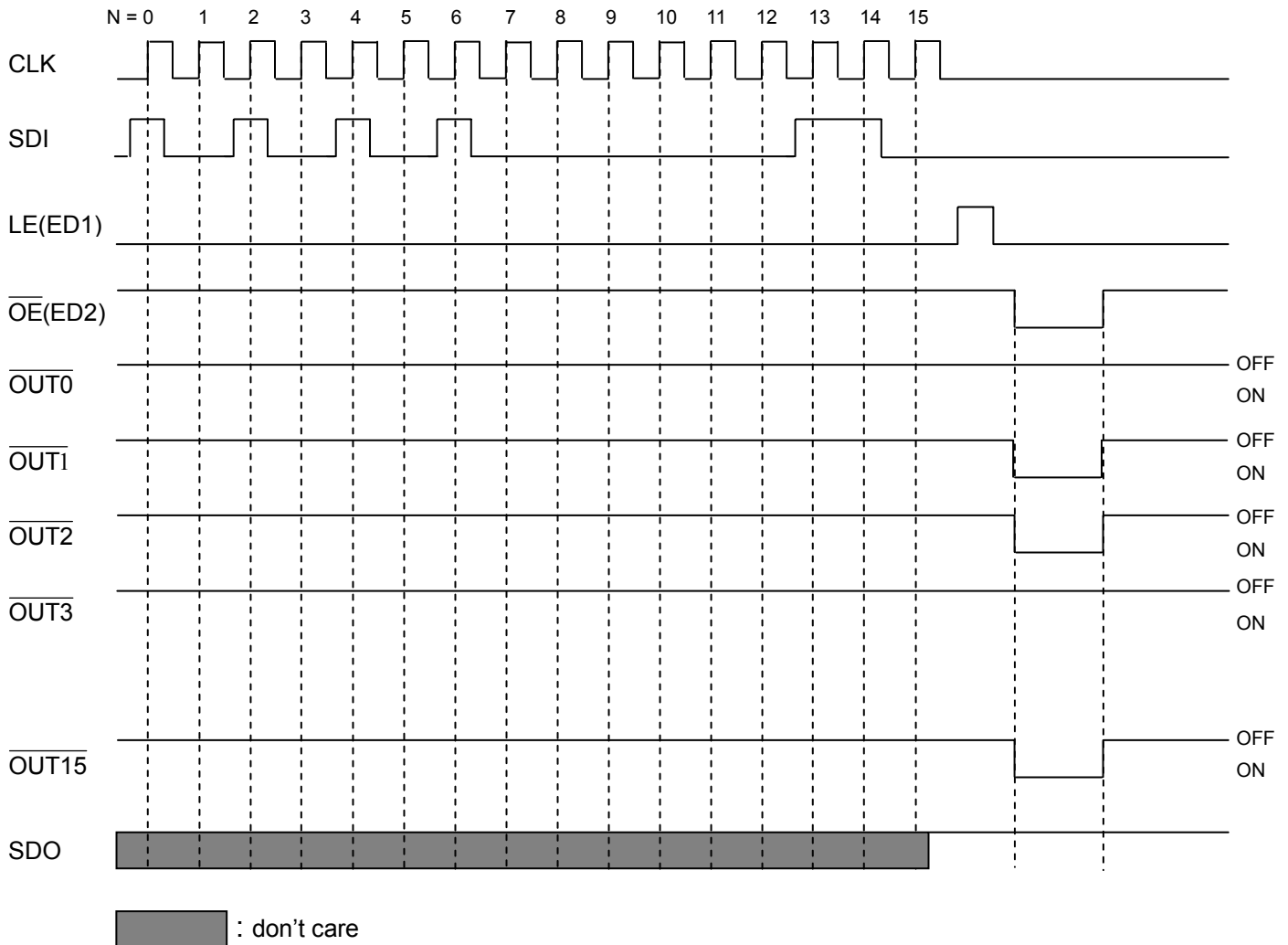
MBI5027 CPA\GPA

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection**Equivalent Circuits of Inputs and Outputs** **$\overline{\text{OE}}$ (ED2) terminal****LE(ED1) terminal****CLK, SDI terminal****SDO terminal**

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

Timing Diagram

Normal Mode

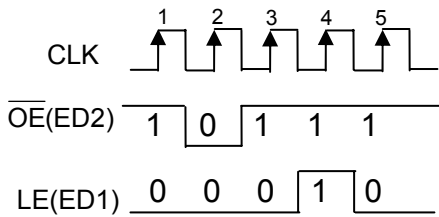


Truth Table (In Normal Mode)

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

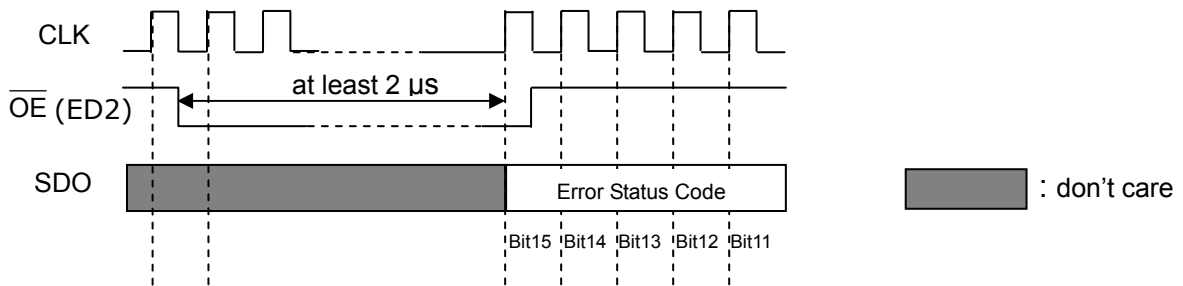
MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

Switching to Open-/Short-Circuit Detection Mode



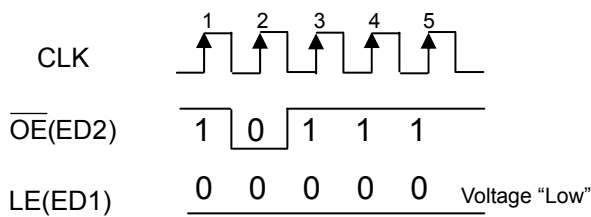
The signal sequence sets MBI5027 to be in the Open-/Short-circuit Detection mode. Here, the LE active pulse would not latch any data.

Reading Error Status Code



When MBI5027 is working under the Open-/Short-circuit Detection mode, the above sequence signals can enable a system controller to read Error Status codes through SDO pin.

Switching to Normal Mode



The signal sequence sets MBI5027 to be in the Normal mode.

Note:

If users want to know the whole process, that is how to enter the Open-/Short-circuit Detection mode, to read Error Status codes and to resume to the Normal mode, please refer to the contents in **Application Information**.

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection**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 (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 (On PCB, $T_a=25^\circ\text{C}$) | CN | GN | $R_{th(j-a)}$ | 53.82 | 49.91 | $^\circ\text{C/W}$ |
| | 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 | | $^\circ\text{C}$ |

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection**Recommended Operating Conditions**

| 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 | V_{IH} | CLK, \overline{OE} (ED2), LE(ED1) and SDI | $0.8 \cdot V_{DD}$ | - | V_{DD} | V |
| | V_{IL} | CLK, \overline{OE} (ED2), LE(ED1) and SDI | GND | - | $0.3 \cdot V_{DD}$ | V |
| LE(ED1) Pulse Width | $t_{w(L)}$ | Normal Mode $V_{DD}=4.5\sim 5.5V$ | 40 | - | - | ns |
| CLK Pulse Width | $t_{w(CLK)}$ | | 20 | - | - | ns |
| \overline{OE} (ED2) Pulse Width | $t_{w(OE)}$ | | 200 | - | - | ns |
| Setup Time for SDI | $t_{su(D)}$ | | 5 | - | - | ns |
| Hold Time for SDI | $t_{h(D)}$ | | 10 | - | - | ns |
| Setup Time for LE(ED1) | $t_{su(L)}$ | | 15 | - | - | ns |
| Hold Time for LE(ED1) | $t_{h(L)}$ | | 15 | - | - | ns |
| \overline{OE} (ED2) Pulse Width | $t_{w(ED2)}$ | Error Detection Mode $V_{DD}=4.5\sim 5.5V$ | 2 | - | - | us |
| CLK Pulse Width | $t_{w(CLK)}$ | | 20 | - | - | ns |
| Setup Time for LE(ED1) | $t_{su(ED1)}$ | | 5 | - | - | ns |
| Hold Time for LE(ED1) | $t_{h(ED1)}$ | | 10 | - | - | ns |
| Setup Time for \overline{OE} (ED2) | $t_{su(ED2)}$ | | 5 | - | - | ns |
| Hold Time for \overline{OE} (ED2) | $t_{h(ED2)}$ | | 10 | - | - | ns |
| Clock Frequency | F_{CLK} | Cascade Operation | - | - | 25 | MHz |

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

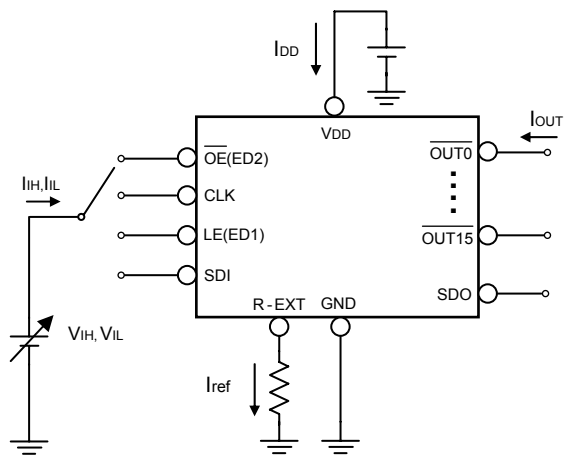
Electrical Characteristics

| 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} | $T_a = -40 \sim 85^\circ\text{C}$ | $0.8 \cdot V_{DD}$ | - | V_{DD} | V |
| | "L" level | V_{IL} | $T_a = -40 \sim 85^\circ\text{C}$ | GND | - | $0.3 \cdot V_{DD}$ | V |
| Output Leakage Current | | I_{OH} | $V_{OH} = 17.0\text{V}$ | - | - | 0.5 | μA |
| Output Voltage | SDO | V_{OL} | $I_{OL} = +1.0\text{mA}$ | - | - | 0.4 | V |
| | | V_{OH} | $I_{OH} = -1.0\text{mA}$ | 4.6 | - | - | V |
| Output Current 1 | | I_{OUT1} | $V_{DS} = 0.6\text{V}$ $R_{ext} = 720 \Omega$ | - | 26.25 | - | mA |
| Current Skew | | dI_{OUT1} | $I_{OL} = 26.25\text{mA}$ $V_{DS} = 0.6\text{V}$ $R_{ext} = 720 \Omega$ | - | ± 1 | ± 3 | % |
| Output Current 2 | | I_{OUT2} | $V_{DS} = 0.8\text{V}$ $R_{ext} = 360 \Omega$ | - | 52.5 | - | mA |
| Current Skew | | dI_{OUT2} | $I_{OL} = 52.5\text{mA}$ $V_{DS} = 0.8\text{V}$ $R_{ext} = 360 \Omega$ | - | ± 1 | ± 3 | % |
| 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} (ED2) | 250 | 500 | 800 | K Ω |
| Pull-down Resistor | | $R_{IN(down)}$ | LE(ED1) | 250 | 500 | 800 | K Ω |
| Open Circuit Error*** Discrimination Voltage | | $V_{DS, Th1}$ | When all output ports sink 20mA simultaneously | 1.0 | - | - | V |
| | | $V_{DS, Th2}$ | When a single output port sinks 20mA | 0.8 | - | - | V |
| | | $V_{DS, Th3}$ | When all output ports sink 50mA simultaneously | 1.2 | - | - | V |
| | | $V_{DS, Th4}$ | When a single output port sinks 50mA | 1.0 | - | - | V |
| 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 | |

*** To effectively detect the open-circuit error occurring at the output port, MBI5027 has a built-in current detection circuit. The current detection circuit will detect the effective current $I_{OUT, effective}$ and compare the effective current $I_{OUT, effective}$ to the target current $I_{OUT, target}$ defined by R_{ext} . If $I_{OUT, effective}$ is less than the target current $I_{OUT, target}$, an error flag(Low) will be asserted and stored into the built-in Shift Register. The minimum voltage requirement for such current detection is $V_{DS, Th1}$, $V_{DS, Th2}$, $V_{DS, Th3}$ and $V_{DS, Th4}$.

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

Test Circuit for Electrical Characteristics



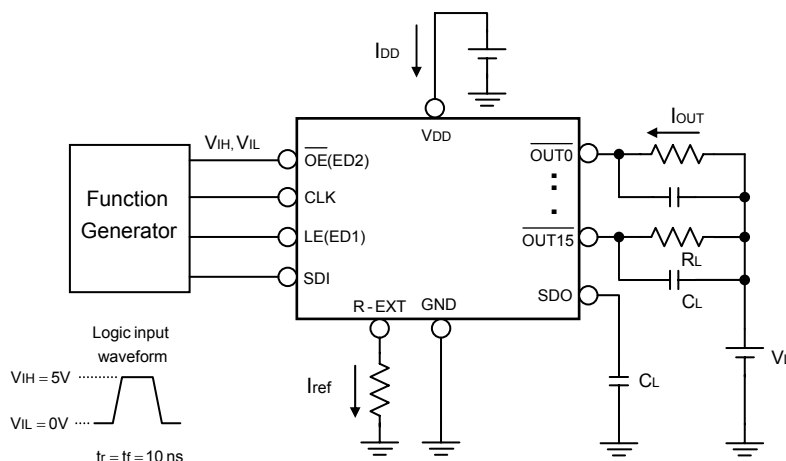
MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

Switching Characteristics

| Characteristic | | Symbol | Condition | Min. | Typ. | Max. | Unit |
|-------------------------------------|---|-------------------|--|------|------|------|------|
| Propagation Delay Time ("L" to "H") | CLK - $\overline{\text{OUTn}}$ | t_{pLH1} | $V_{DD}=5.0\text{ V}$ $V_{DS}=0.8\text{ V}$ $V_{IH}=V_{DD}$ $V_{IL}=GND$ $R_{ext}=300\ \Omega$ $V_L=4.0\text{ V}$ $R_L=52\ \Omega$ $C_L=10\text{ pF}$ | - | 100 | 150 | ns |
| | LE(ED1) - $\overline{\text{OUTn}}$ | t_{pLH2} | | - | 100 | 150 | ns |
| | $\overline{\text{OE}}$ (ED2) - $\overline{\text{OUTn}}$ | 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(ED1) - $\overline{\text{OUTn}}$ | t_{pHL2} | | - | 50 | 100 | ns |
| | $\overline{\text{OE}}$ (ED2) - $\overline{\text{OUTn}}$ | t_{pHL3} | | - | 20 | 100 | ns |
| | CLK - SDO | t_{pHL} | | 15 | 20 | - | ns |
| Pulse Width | CLK | $t_w(\text{CLK})$ | | 20 | - | - | ns |
| | LE(ED1) | $t_w(L)$ | | 20 | - | - | ns |
| | $\overline{\text{OE}}$ (ED2) | $t_w(\text{OE})$ | | 200 | - | - | ns |
| Hold Time for LE(ED1) | | $t_{h(L)}$ | | | 5 | - | - |
| Setup Time for LE(ED1) | | $t_{su(L)}$ | | 5 | - | - | ns |
| 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.

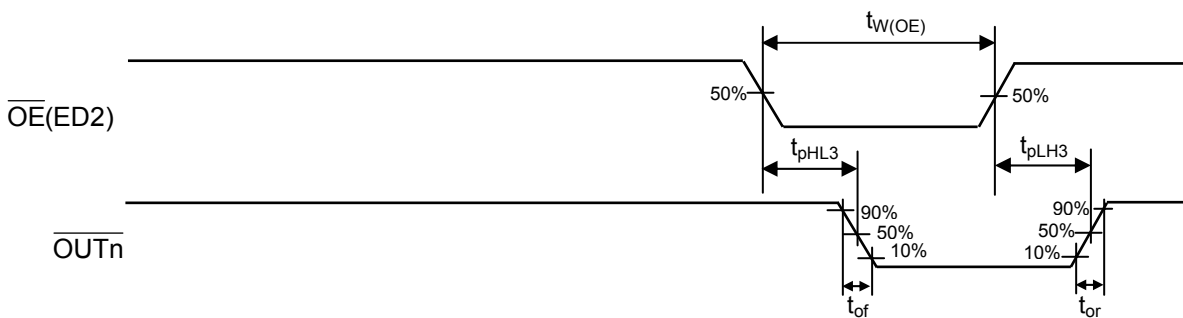
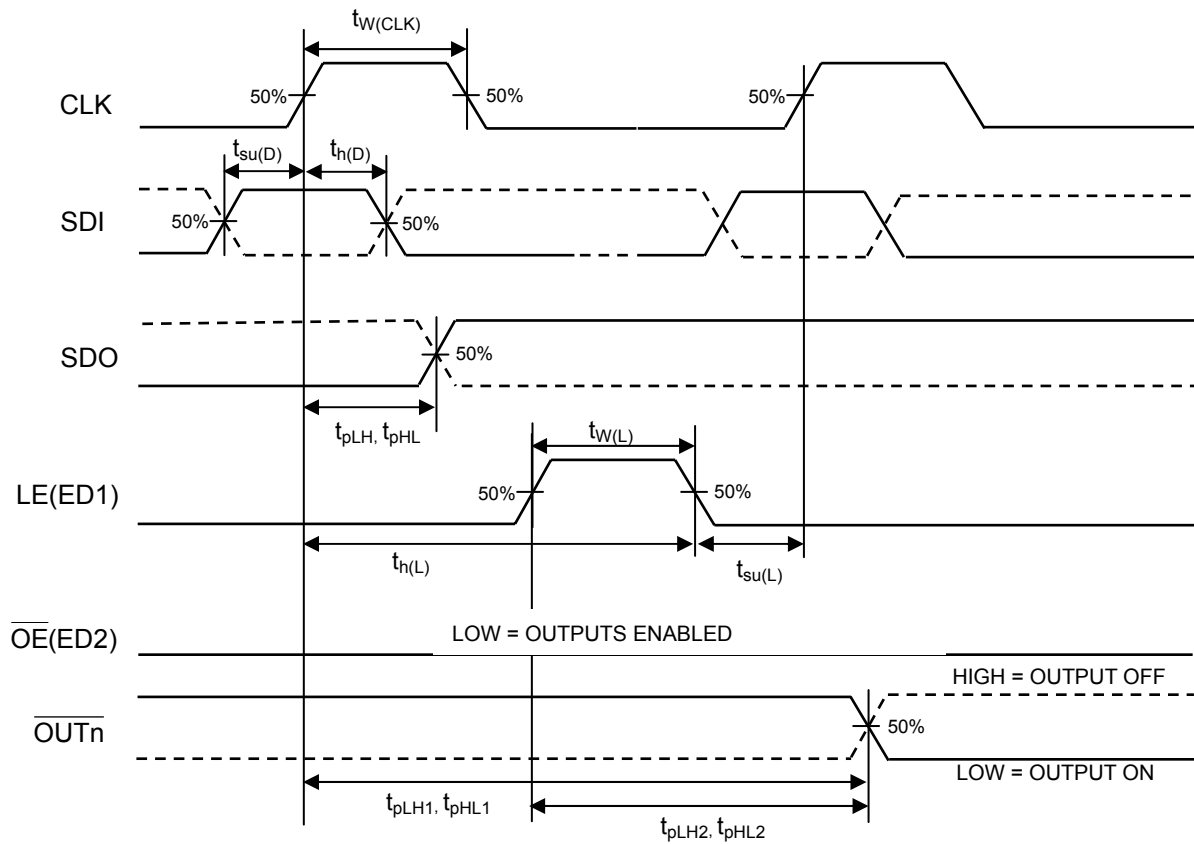
Test Circuit for Switching Characteristics



MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

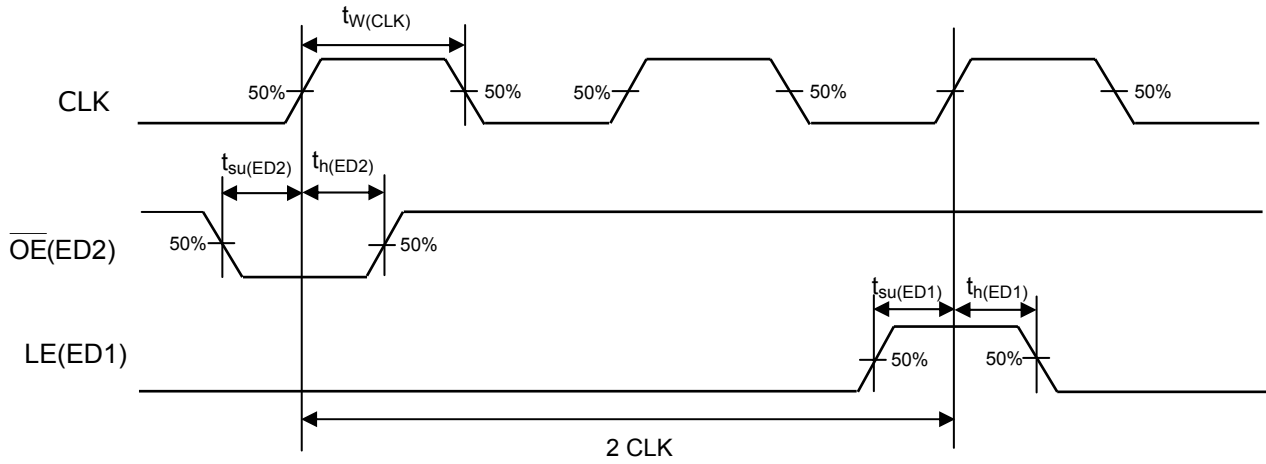
Timing Waveform

Normal Mode

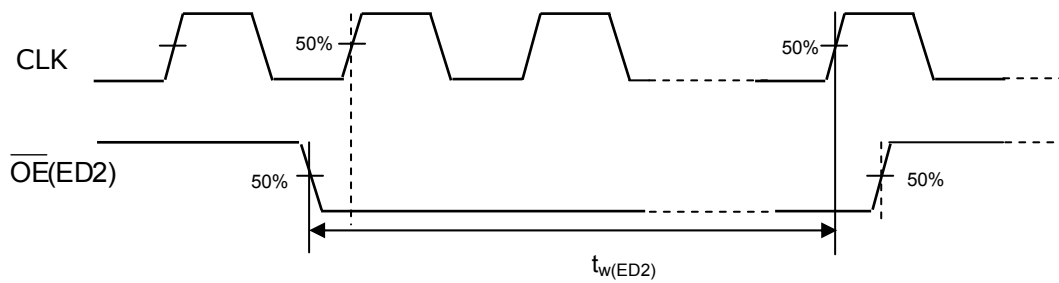


MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

Switching to Open-/Short-circuit Detection Mode



Reading Error Status Code



MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

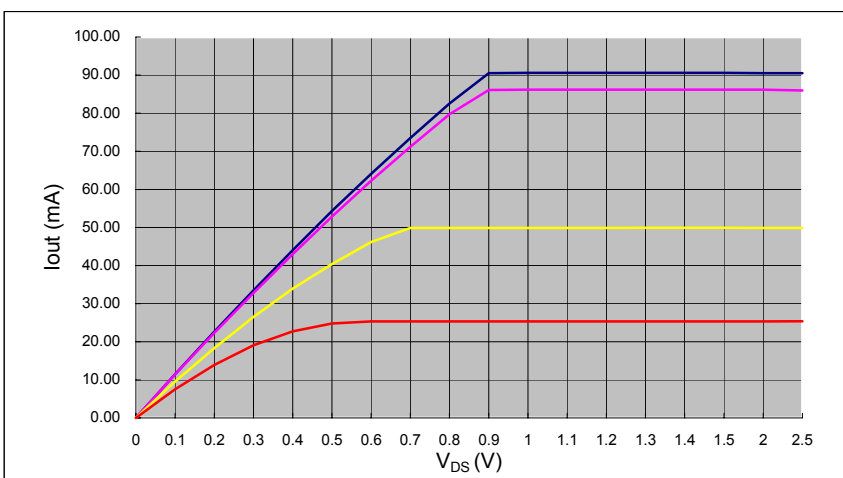
Application Information

Constant Current

In LED display application, MBI5027 provides nearly no variations in current from channel to channel and from IC to IC. This can be achieved by:

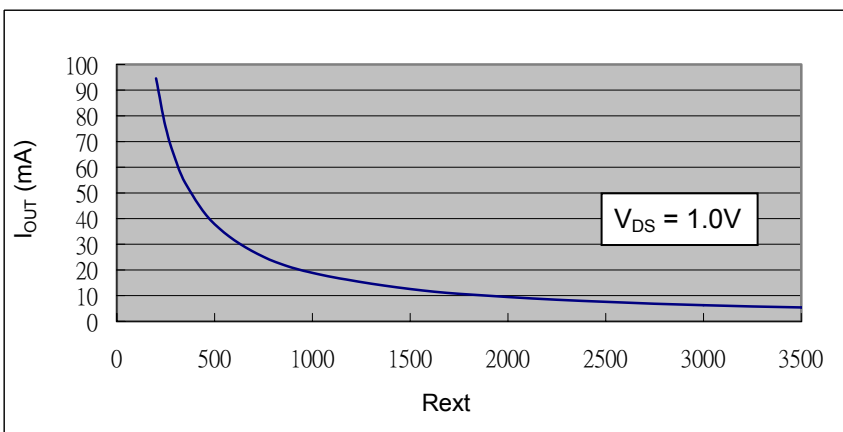
- 1) The maximum current variation between channels is less than ±3% and that between ICs is less than ±6%.
- 2) In addition, the characteristics curve of output stage in the saturation region is flat and users can refer to the figure as shown below. Thus, the output current can be kept constant regardless of the variations of LED forward voltages (V_F).

Note: The mentioned target current $I_{out, target}$ is defined as the output current in the saturation region.



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 Ω

Also, the target output current $I_{out, target}$ can be calculated from the equation:

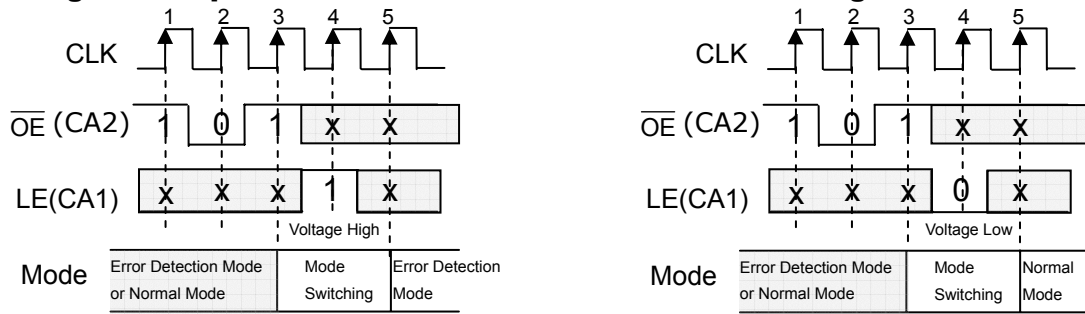
$$V_{R-EXT} = 1.26V ; I_{out, target} = (V_{R-EXT} / R_{ext}) \times 15$$

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 360Ω and 26.25mA at 720Ω.

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

Operation Mode Switching

Switching to the Open/ Short Error Detection Mode Switching to the Normal Mode



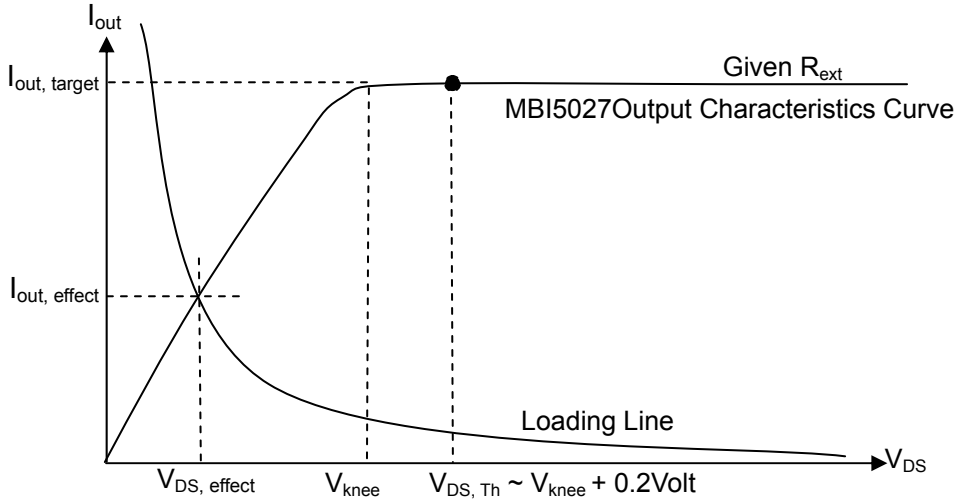
As shown in the above figures, once a short pulse “101” of \overline{OE} (ED2) appears, MBI5027 would go through the mode switching. At the fourth rising edge of CLK, if LE(ED1) is sampled as “Voltage High”, MBI5027 would switch to the Open-/Short-circuit Detection mode; otherwise, it would switch to the Normal Mode. Worthwhile noticing, the signal LE(ED1) between the third and the fifth rising edges of CLK can not latch any data. Its level is just used for determining which mode to switch. However, the short pulse of \overline{OE} (ED2) can still enable the output ports. During mode switching, the serial data can still be transferred through SDI pin and shifted out from SDO pin.

Note:

1. The signals for mode switching could be used for making sure under which mode MBI5027 is working.
2. The aforementioned “1” and “0” are sampled at the rising edge of CLK. The “X” means its level would not affect the result of mode switching.
3. After power-on, the default operation mode is Normal mode.

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

Open-Circuit Detection Principle

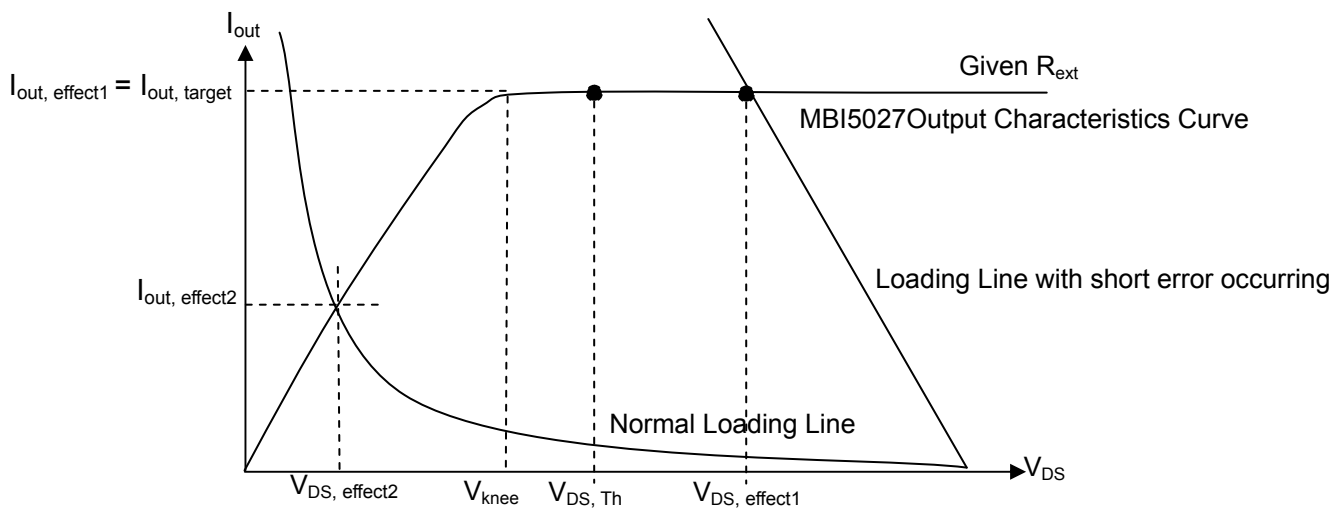


The principle of MBI5027 LED Open-Circuit Detection is based on the fact that the LED loading status is judged by comparing the effective current value ($I_{out, effect}$) of each output port with the target current ($I_{out, target}$) set by R_{ext} . As shown in the above figure, the knee voltage (V_{knee}) is the one between triode region and saturation region. The cross point between the loading line and MBI5027 output characteristics curve is the effective output point ($V_{DS, effect}, I_{out, effect}$). Thus, to detect the status of LED correctly, the output ports of MBI5027 must be enabled. The relationship between the Error Status code and the effective output point is shown below:

| State of Output Port | Condition of Effective Output Point | Detected Open-Circuit Error Status Code | Meaning |
|----------------------|---|---|--------------|
| OFF | $I_{out, effect} = 0$ | "0" | - |
| ON | $I_{out, effect} \leq I_{out, target}$ and $V_{out, effect} < V_{DS, Th}$ | "0" | Open Circuit |
| | $I_{out, effect} = I_{out, target}$ and $V_{out, effect} \geq V_{DS, Th}$ | "1" | Normal |

Note : the threshold voltage $V_{DS, Th}$ is around $V_{knee} + 0.2V$

Short-Circuit Detection Principle



When LED is damaged, a short-circuit error may occur. To effectively detect the short-circuit error, LEDs need insufficiently biasing. The principle of MBI5027 LED Short Circuit Detection is based on the fact that the LED loading status is judged by comparing the effective current value ($I_{out, effect}$) of each output port with the target current ($I_{out, target}$) set by R_{ext} . When normal LED is insufficiently biased, its effective output point would be located at

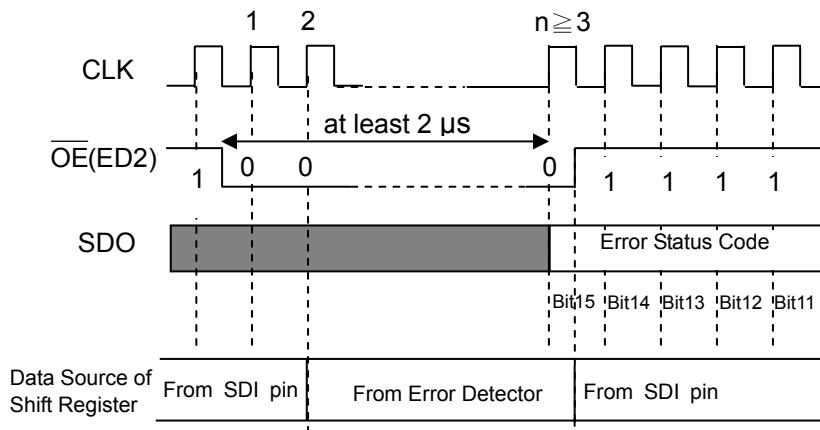
MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

the ramp area of MBI5027 Output Characteristics Curve, compared with LED with a short error falling within the flat zone. The relationship between the Error Status code and the effective output point is shown below:

| State of Output Port | Condition of Effective Output Point | Detected Short-Circuit Error Status Code | Meaning |
|----------------------|---|--|---------------|
| OFF | $I_{out, effect} = 0$ | "0" | - |
| ON | $I_{out, effect} \leq I_{out, target}$ and $V_{out, effect} < V_{DS, Th}$ | "0" | Normal |
| | $I_{out, effect} = I_{out, target}$ and $V_{out, effect} \geq V_{DS, Th}$ | "1" | Short Circuit |

Note : the threshold voltage $V_{DS, Th}$ is around $V_{knee} + 0.2\text{Volt}$

Reading Error Status Code

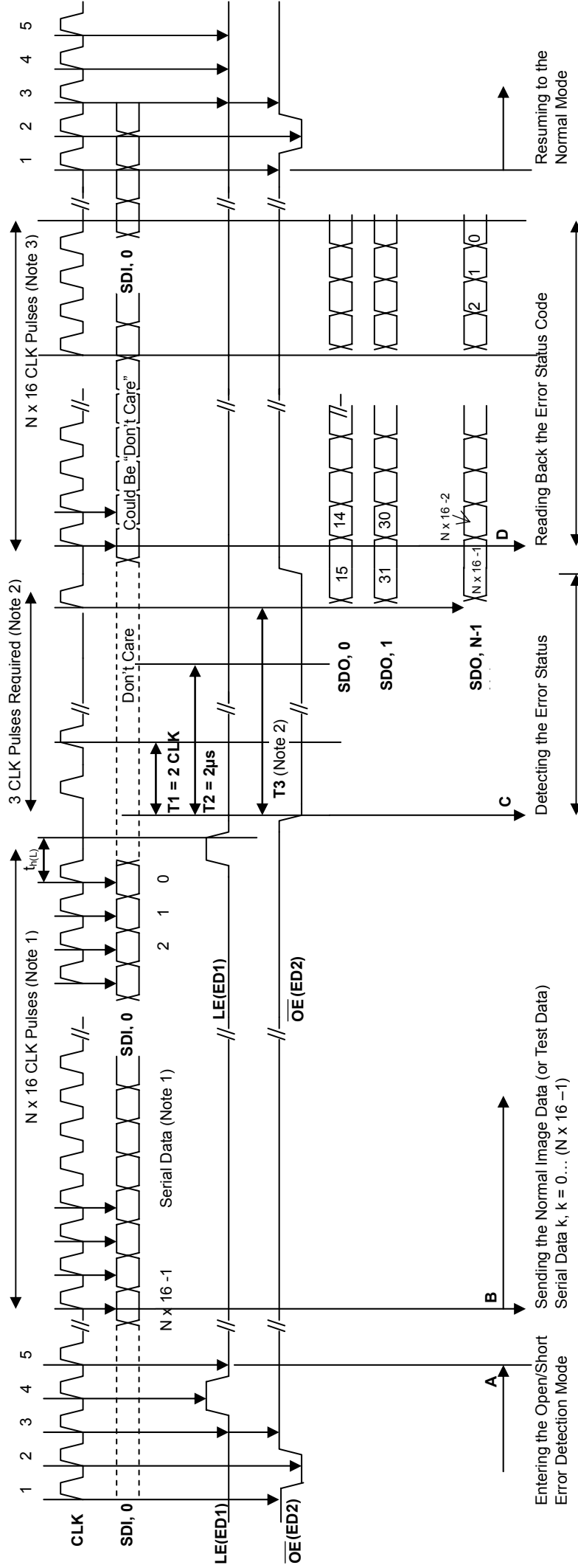
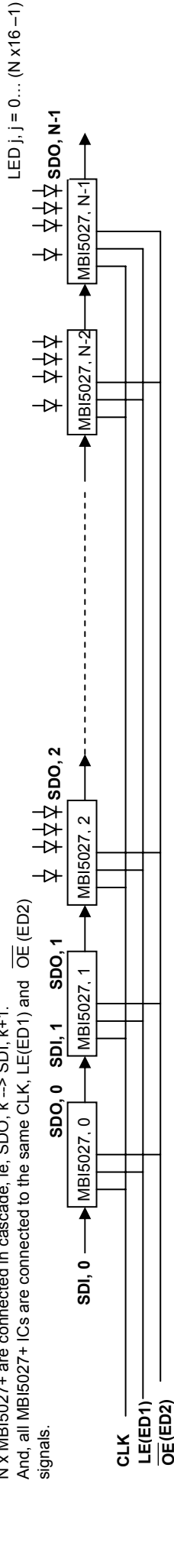


In the Open-/Short-circuit Detection mode, the state of \overline{OE} (ED2) must be switched from "Voltage High" to "Voltage Low". And, then, MBI5027 would execute Open-/Short-circuit Detection as well as enabling output ports to drive current. At least three "0" must be sampled at the "Voltage Low" state of \overline{OE} (ED2) and the last "0" should be at least $2\mu s$ after the falling edge of \overline{OE} (ED2). The occurrence of the last "0" results in the event that MBI5027 saves the detected error status into the built-in shift register. Thus, when \overline{OE} (ED2) is at the voltage low state, the serial data cannot be shifted into MBI5027 through SDI pin. The "0" and "1" shown in the above figure is sampled at the rising edge of each CLK. Before reading the Error Status Code, the state of \overline{OE} (ED2) should be pulled up to "Voltage High" from "Voltage Low", the output ports are closed and the detection is finished. Then, the error status saved in the built-in register would be shifted out through SDO pin bit by bit by sending CLK. At the same time, the serial data is also shifted into MBI5027 through SDI pin. It is worthwhile noticing that as long as \overline{OE} (ED2) is not at the "Voltage Low", the serial data can still be shifted to the shift register through SDI and shifted out through SDO pin. As in Normal Mode, the positive pulse of LE(ED1) can also make the data in the shift register latched to 16-bit Output Latch in Open-/Short-circuit Detection mode.

Timing Chart for Open-/Short-Circuit Detection Mode (An Example)

N x MBI5027+ are connected in cascade, ie, SDO_k --> SDI_{k+1}.

And, all MBI5027+ ICs are connected to the same CLK, LE(ED1) and OE(ED2) signals.



Note 3:

The first rising edge of CLK after the rising edge of OE(ED2) starts shifting the Image Data with LED Error. An LED error will be represented by a "0", to over write the original image data "1". Image Data $k = 0 \dots (N \times 16 - 1)$, = all "1" is suggested. N x 16 CLK pulses shift all N x 16 error results (Error Status Code) via Node SDO, N-1.

Note 2:

T1 = 2 CLK pulses is required to start the error detection. When Short-Circuit Detection is executed, LEDs should be insufficiently biased during this period. T2 = 2 μs is required to obtain the stable error status result. T3 = the third CLK pulses is required before OE(ED2) goes voltage high. The rising edge of CLK writes the error status code back to the MBI5027 built-in shift register.

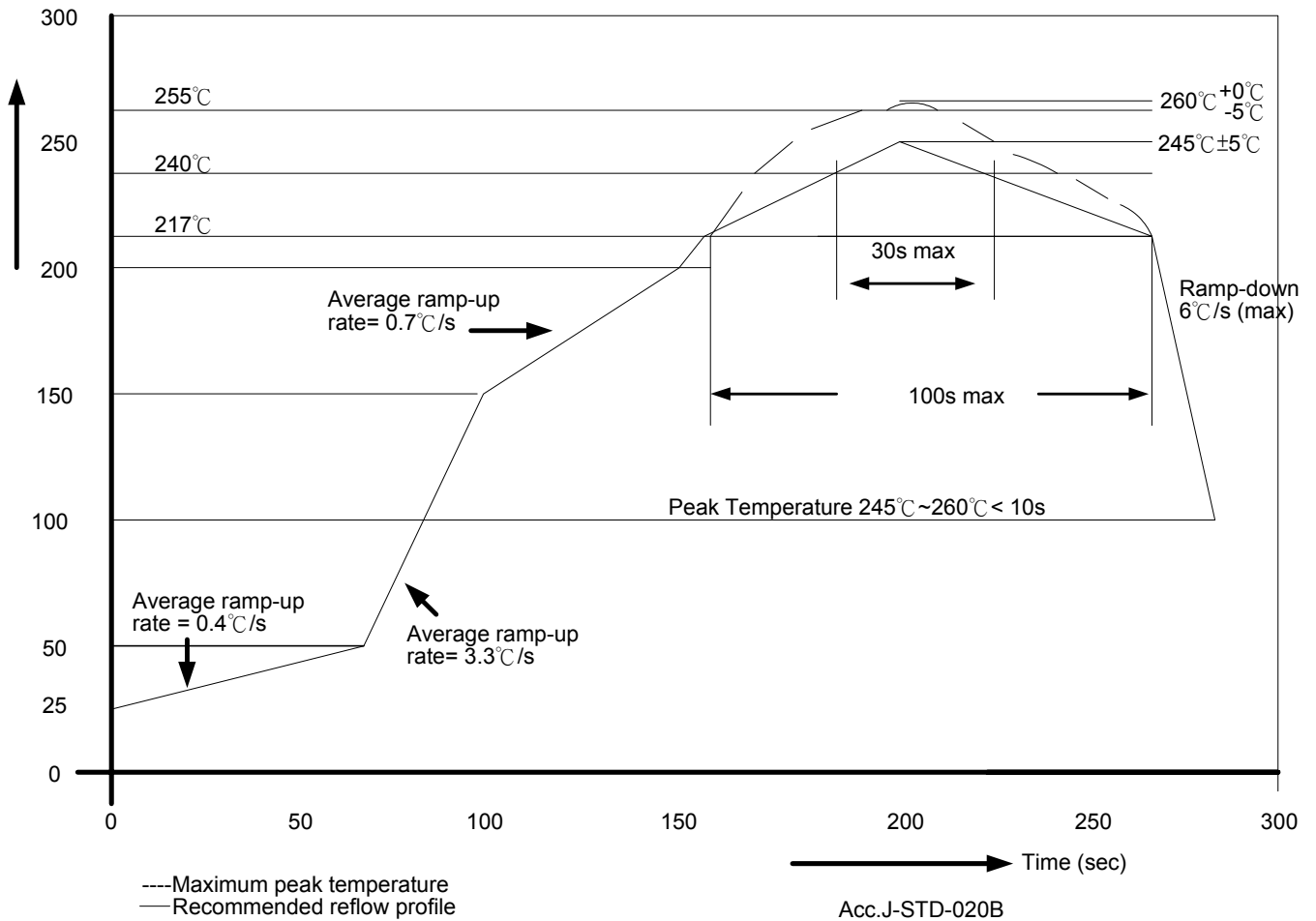
Note 1: N x 16 CLK pulses before the next LE shift the valid image data. N x 16 "1"s are suggested.

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

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.

Temperature (°C)



*Note1: For details, please refer to Macroblock's "Policy on Pb-free & Green Package".

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

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

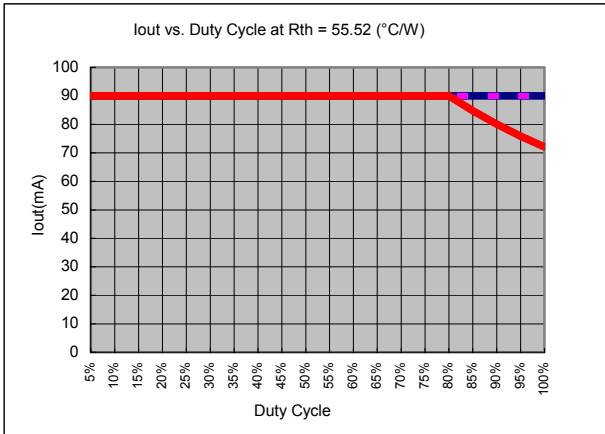
$$P_D(act) = (I_{DD} \times V_{DD}) + (I_{OUT} \times Duty \times V_{DS} \times 16).$$

Therefore, to keep $P_D(act) \leq P_D(max)$,

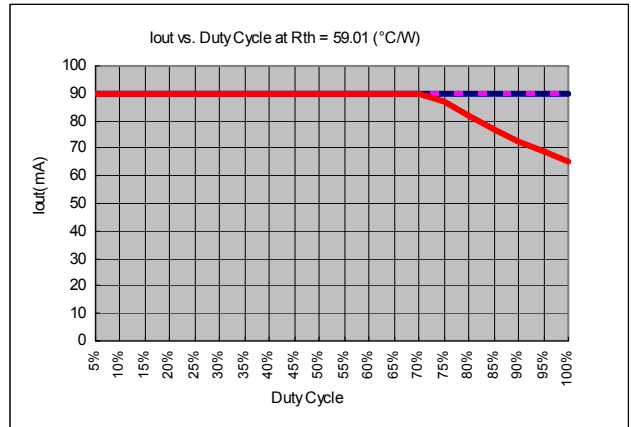
the allowable maximum output current as a function of duty cycle is:

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

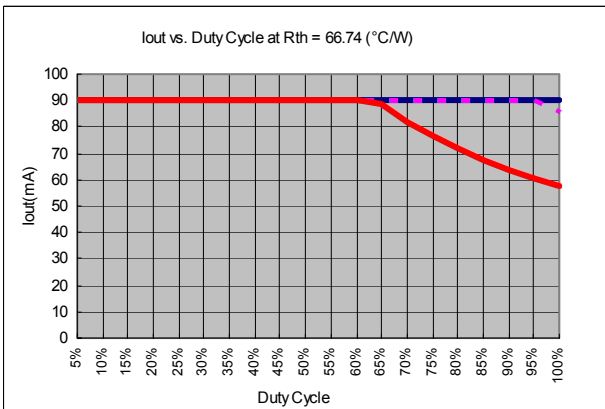
where $T_j = 150^\circ C$.



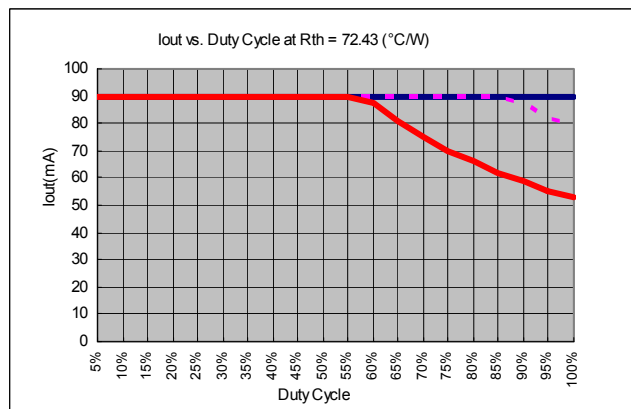
CN\GN type package



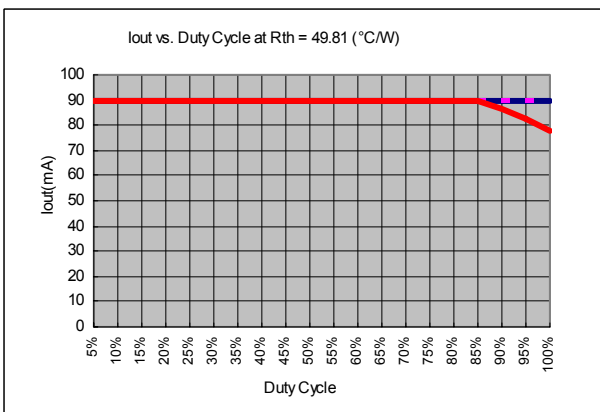
CF\GF type package



CNS\GNS type package



CP\CPA\GP\GPA type package



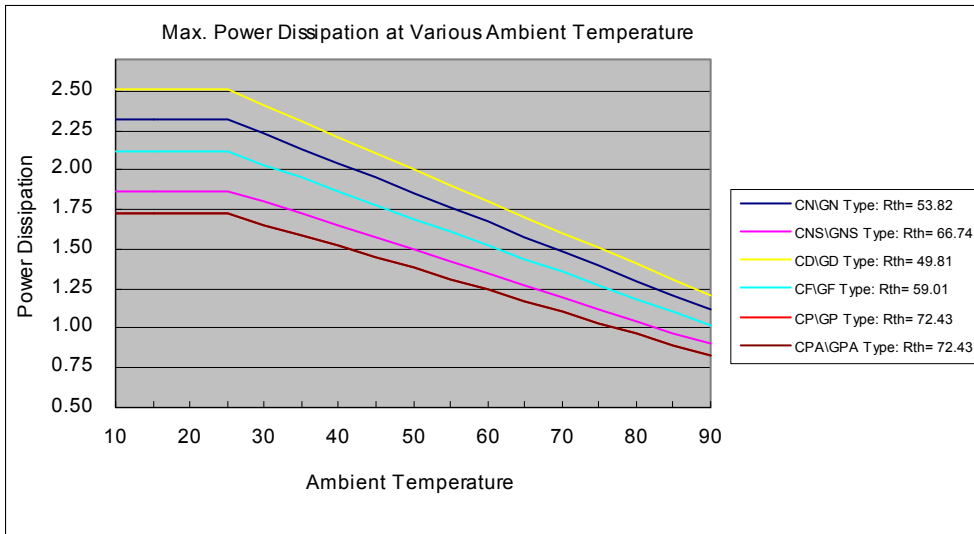
CD\GD type package

Condition : $I_{out} = 90mA$, $V_{DS} = 1.0V$, 16 output channels active

| Device Type | | $R_{th(j-a)} (^{\circ}C/W)$ | | Note |
|-------------|--------|-----------------------------|-------|------|
| 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 | |

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

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

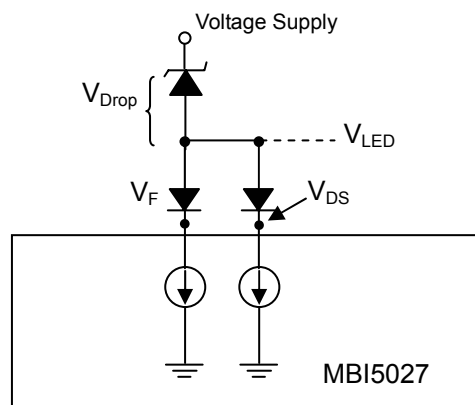
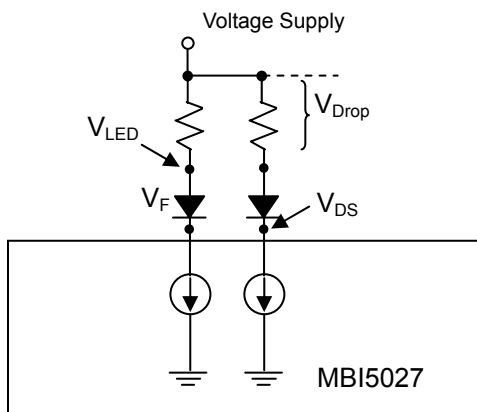


Load Supply Voltage (V_{LED})

MBI5027 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 the following figures.

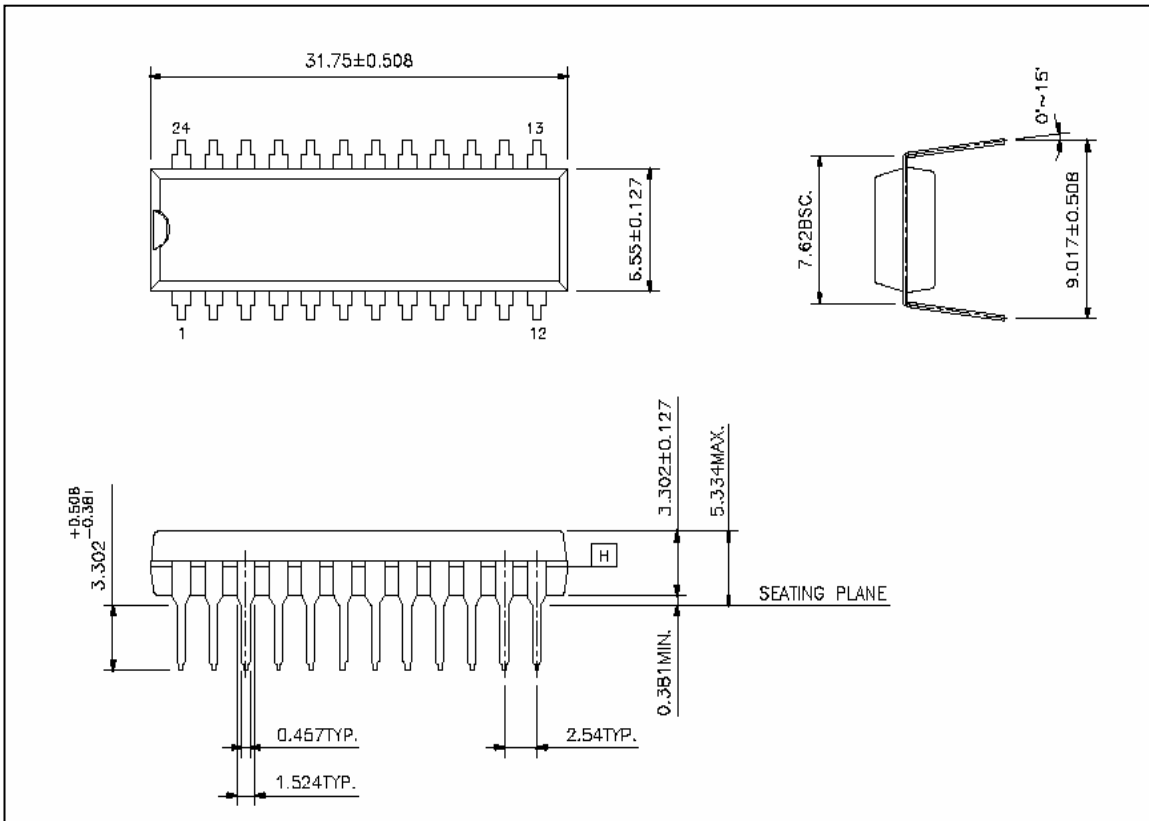


Switching Noise Reduction

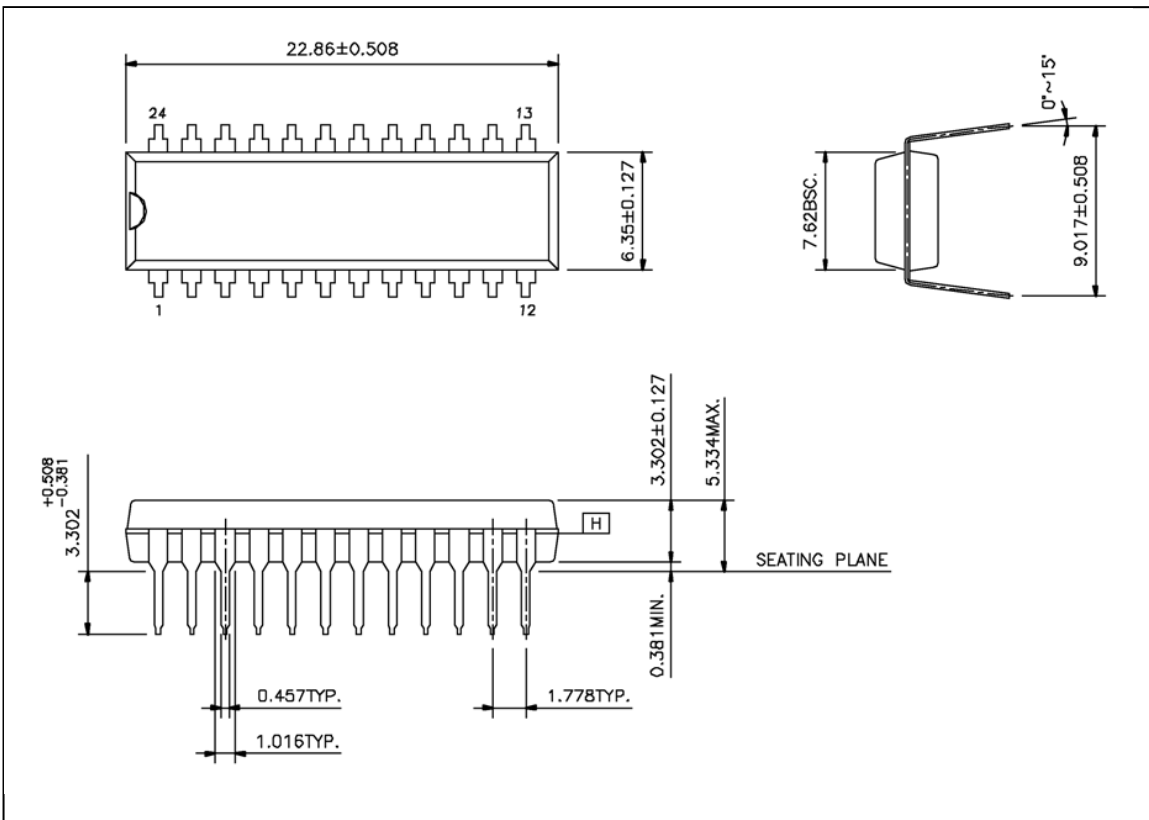
LED Driver ICs are frequently used in switch-mode applications which always behave with switching noise due to the parasitic inductance on PCB. To eliminate switching noise, refer to "Application Note for 8-bit and 16-bit LED Drivers- Overshoot".

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

Package Outline

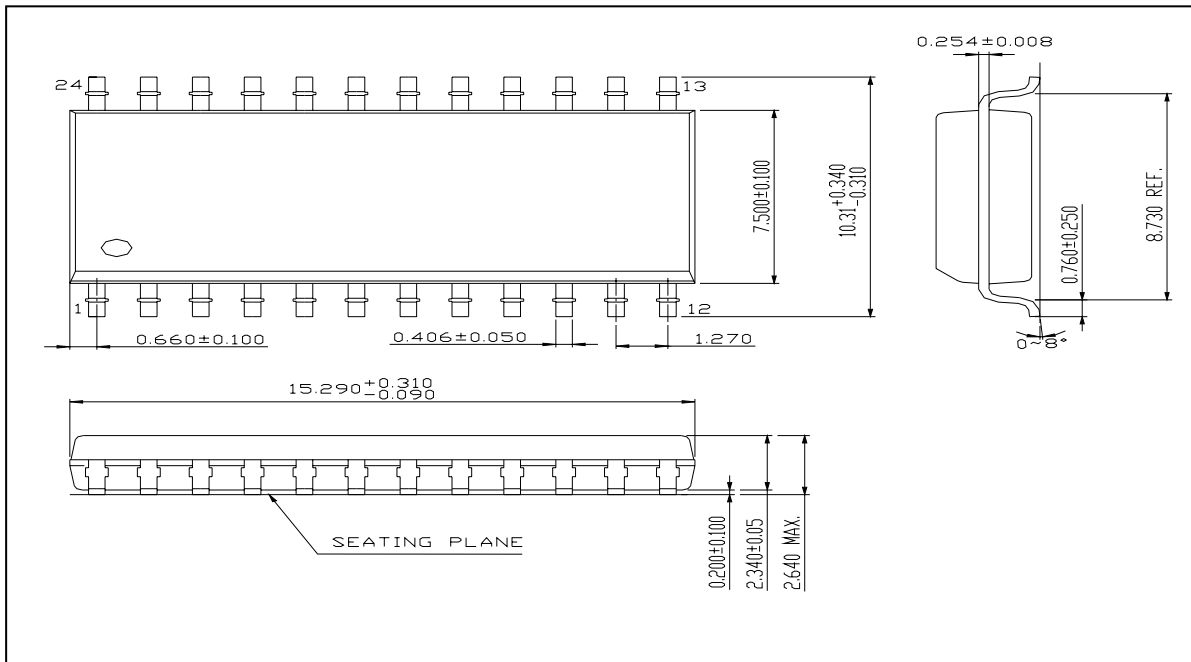


MBI5027CN\GN Outline Drawing

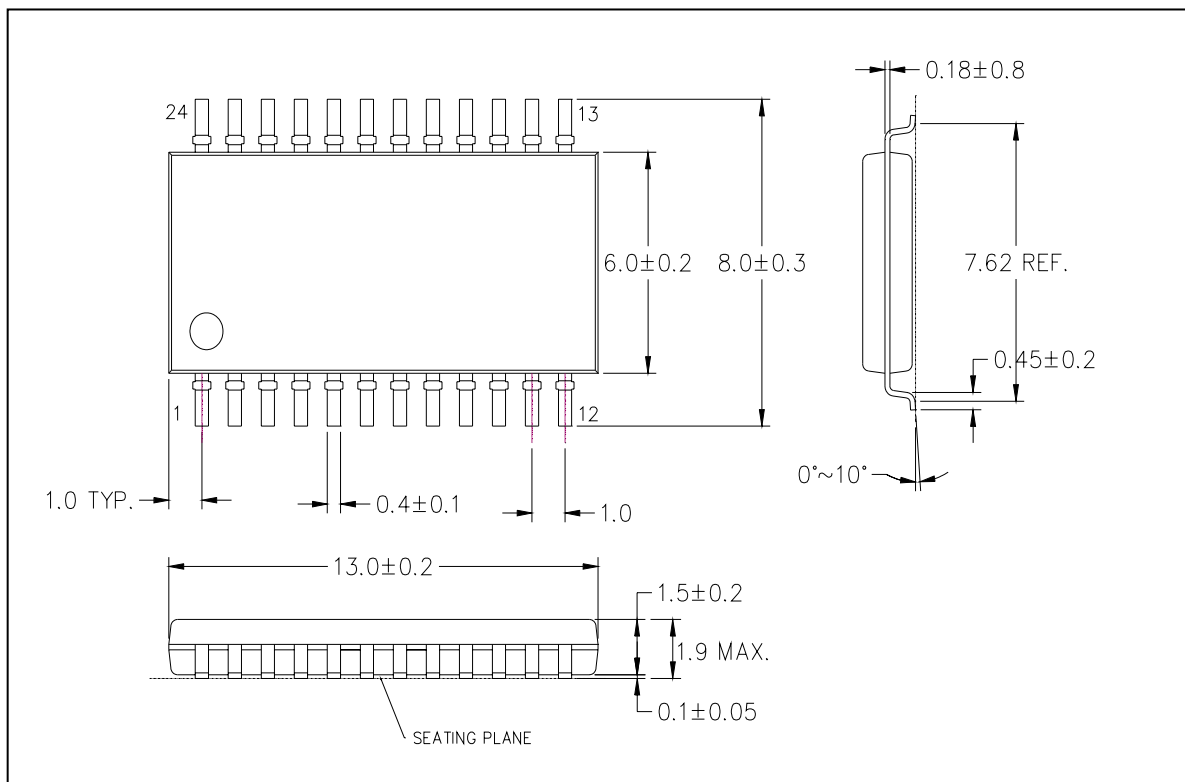


MBI5027CNS\GNS Outline Drawing

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

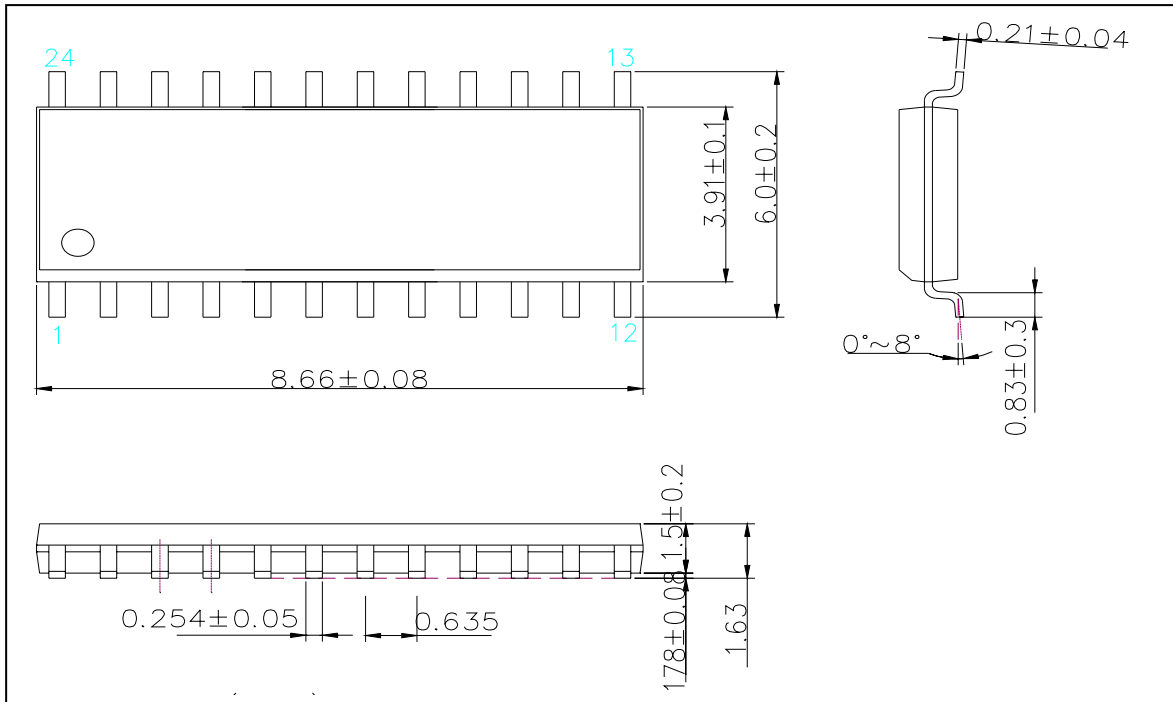


MBI5027CD\GD Outline Drawing



MBI5027CF\GF Outline Drawing

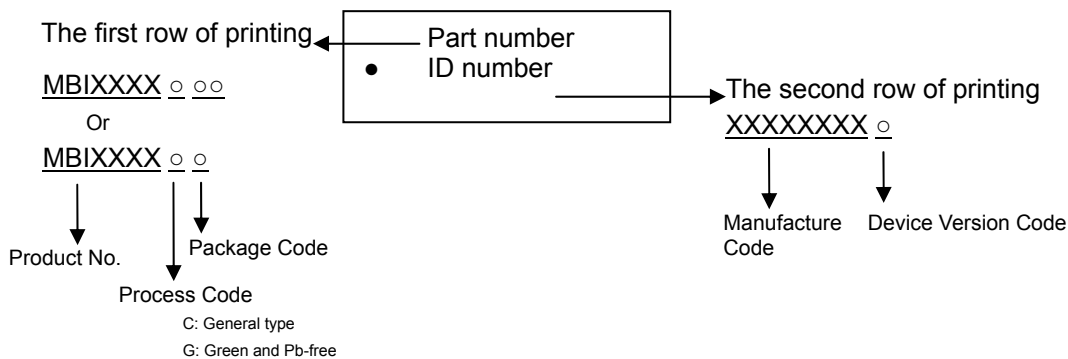
MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection



MBI5027CP\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) |
|-------------|-------------------|------------|
| MBI5027CN | P-DIP24-300-2.54 | 1.628 |
| MBI5027CNS | SP-DIP24-300-1.78 | 1.11 |
| MBI5027CD | SOP24-300-1.27 | 0.617 |
| MBI5027CF | SOP24-300-1.00 | 0.28 |
| MBI5027CP | SSOP24-150-0.64 | 0.11 |
| MBI5027CPA | SSOP24-150-0.64 | 0.11 |

| Part Number | "Pb-free & Green" Package Type | Weight (g) |
|-------------|--------------------------------|------------|
| MBI5027GN | P-DIP24-300-2.54 | 1.628 |
| MBI5027GNS | SP-DIP24-300-1.78 | 1.11 |
| MBI5027GD | SOP24-300-1.27 | 0.617 |
| MBI5027GF | SOP24-300-1.00 | 0.28 |
| MBI5027GP | SSOP24-150-0.64 | 0.11 |
| MBI5027GPA | SSOP24-150-0.64 | 0.11 |

MBI5027 16-Bit Constant Current LED Sink Driver with Open/Short Circuit Detection

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