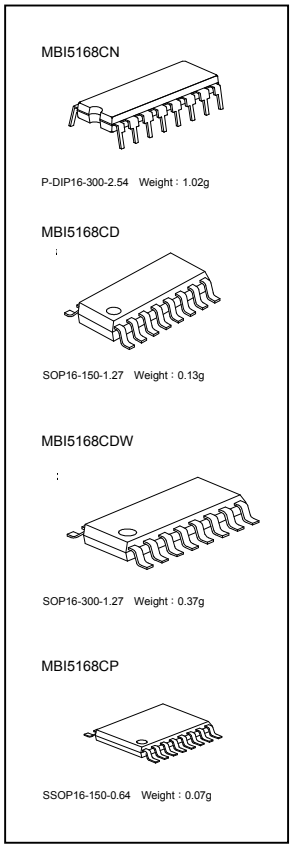
# 8-bit Constant Current LED Sink Driver

## Features

- 8 constant-current output channels
- Constant output current invariant to load voltage change
- Excellent output current accuracy:
  between channels: < ±3% (max.), and
  between ICs: < ±6% (max.)
- Output current adjusted through an external resistor
- Constant output current range: 5 -120 mA
- Fast response of output current,
  $\overline{OE}$ (min.): 200 ns @$I_{out}$ < 60mA
  $\overline{OE}$ (min.): 400 ns @$I_{out}$ = 60~100mA
- 25MHz clock frequency
- Schmitt trigger input
- 5V supply voltage




| Current Accuracy | | Conditions |
|---|---|---|
| Between Channels | Between ICs | |
| < ±3% | < ±6% | $I_{OUT}$ = 10 ~ 100 mA, $V_{DS}$ = 0.8V |

## Product Description

MBI5168 is designed for LED display applications. As an enhancement of its predecessor, MBI5001, MBI5168 exploits PrecisionDrive™ technology to enhance its output characteristics. MBI5168 contains a serial buffer and data latches, which convert serial input data into parallel output format. At MBI5168 output stage, eight regulated current ports are designed to provide uniform and constant current sinks for driving LEDs within a large range of Vf variations.

MBI5168 provides users with great flexibility and device performance while using MBI5168 in their system design for LED display applications, e.g. LED panels. Users may adjust the output current from 5 mA to 120 mA through an external resistor $R_{ext}$, which gives users flexibility in controlling the light intensity of LEDs. MBI5168 guarantees to endure maximum 17V at the output ports. The high clock frequency up to 25 MHz also satisfies the system requirements of high volume data transmission.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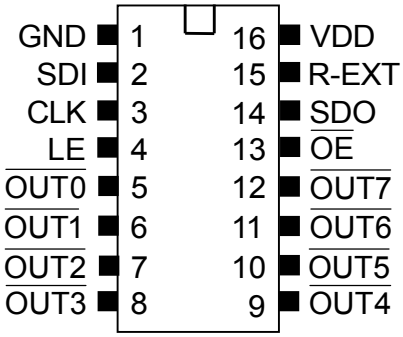
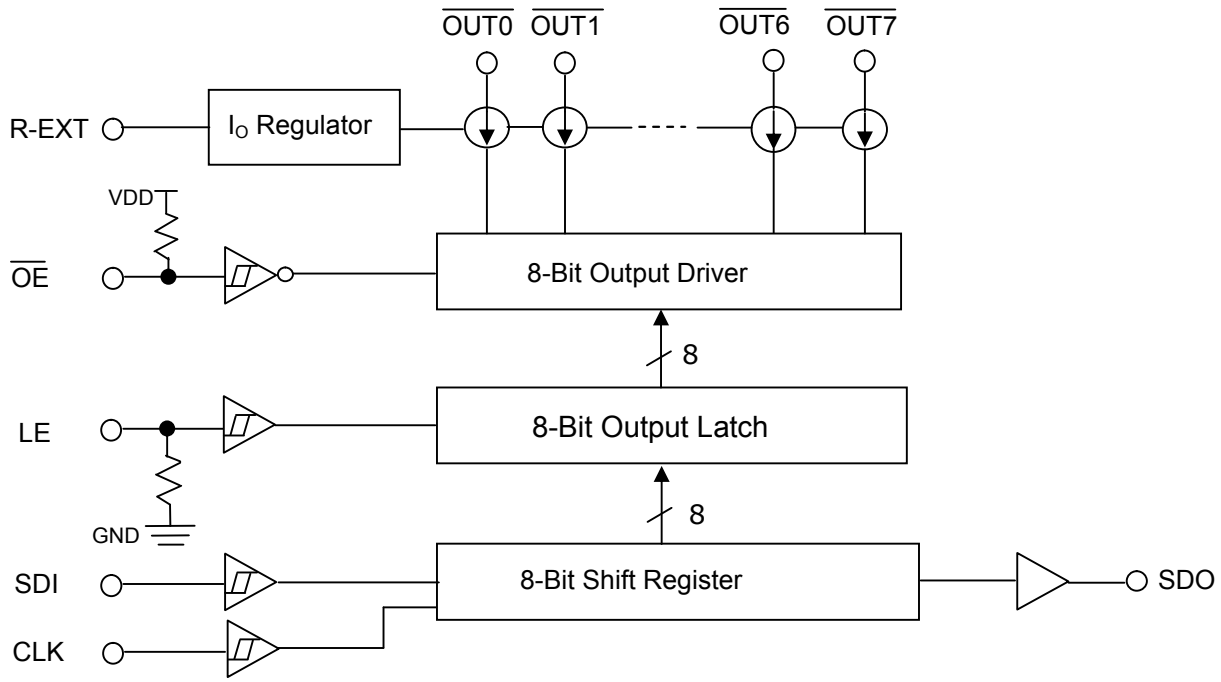
## Terminal Description

| Pin No. | Pin Name | Function |
|---|---|---|
| 1 | GND | Ground terminal for control logic and current sinks |
| 2 | SDI | Serial-data input to the shift register |
| 3 | CLK | Clock input terminal for data shift on rising edge |
| 4 | LE | Data strobe input terminal<br>Serial data is transferred to the respective latch when LE is high. The data is latched when LE goes low. |
| 5-12 | $\overline{OUT0}$ ~ $\overline{OUT7}$ | Constant current output terminals |
| 13 | $\overline{OE}$ | Output enable terminal<br>When (active) low, the output drivers are enabled; when high, all output drivers are turned OFF (blanked). |
| 14 | SDO | Serial-data output to the following SDI of next driver IC |
| 15 | R-EXT | Input terminal used to connect an external resistor for setting up output current for all output channels |
| 16 | VDD | 5V supply voltage terminal |

## Pin Description

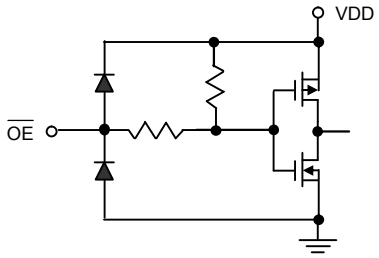



## Block Diagram

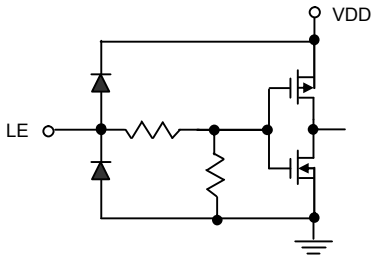


## Equivalent Circuits of Inputs and Outputs

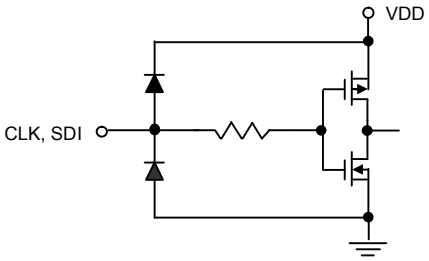
**$\overline{OE}$ terminal**



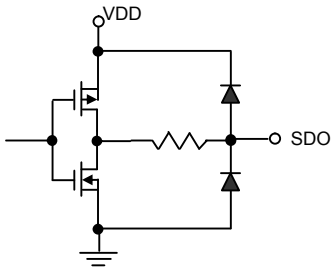

**LE terminal**



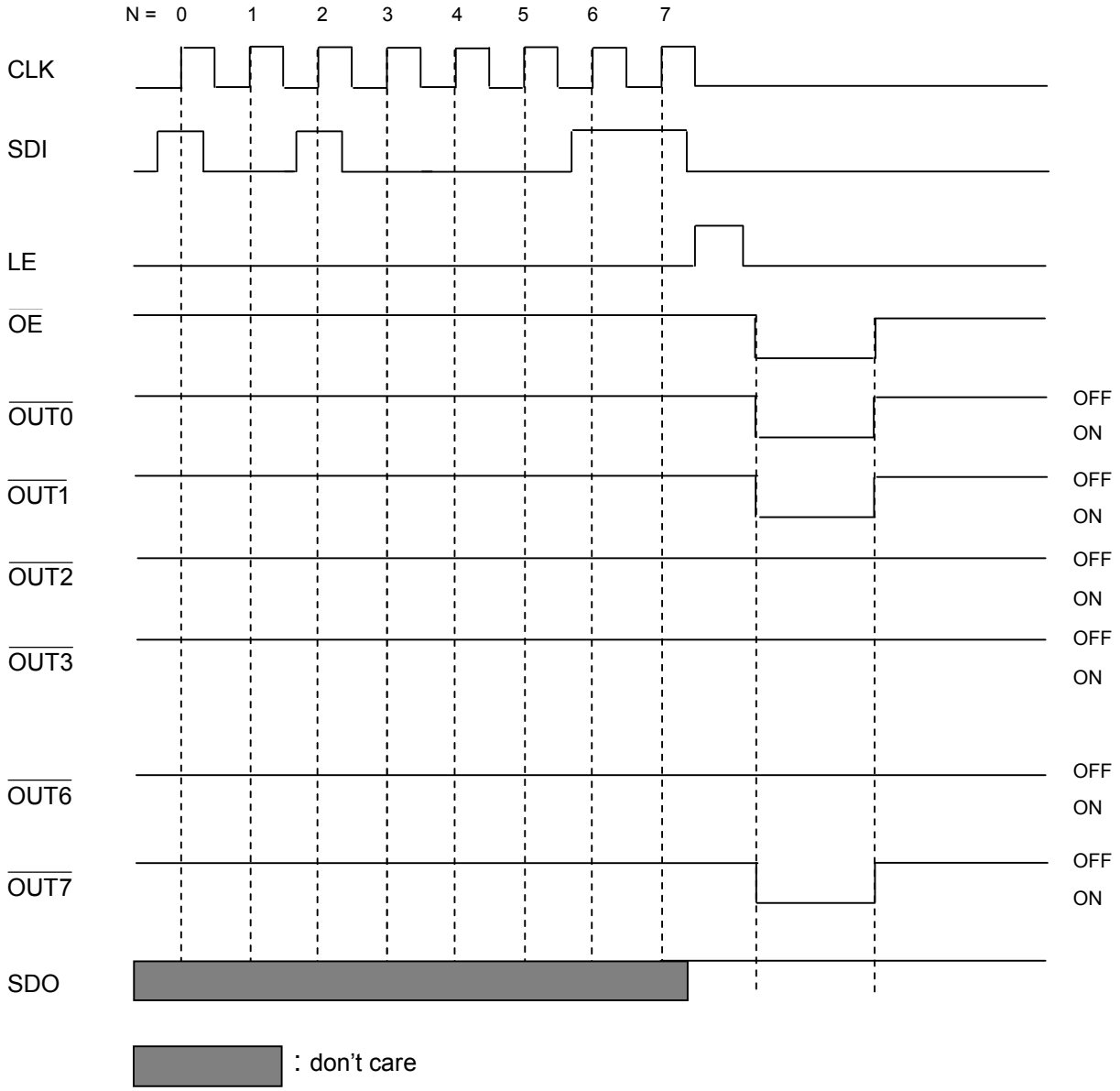

**CLK, SDI terminal**




**SDO terminal**



## Timing Diagram



## Truth Table

| CLK | LE | $\overline{OE}$ | SDI | $\overline{OUT0}$ … $\overline{OUT5}$ … $\overline{OUT7}$ | SDO |
|---|---|---|---|---|---|
| ↑ | H | L | $D_n$ | $\overline{D_n}$ ….. $\overline{D_{n-5}}$ …. $\overline{D_{n-7}}$ | $D_{n-7}$ |
| ↑ | L | L | $D_{n+1}$ | No Change | $D_{n-6}$ |
| ↑ | H | L | $D_{n+2}$ | $\overline{D_{n+2}}$ …. $\overline{D_{n-3}}$ …. $\overline{D_{n-5}}$ | $D_{n-5}$ |
| ↓ | X | L | $D_{n+3}$ | $\overline{D_{n+2}}$ …. $\overline{D_{n-3}}$ …. $\overline{D_{n-5}}$ | $D_{n-5}$ |
| ↓ | X | H | $D_{n+3}$ | Off | $D_{n-5}$ |

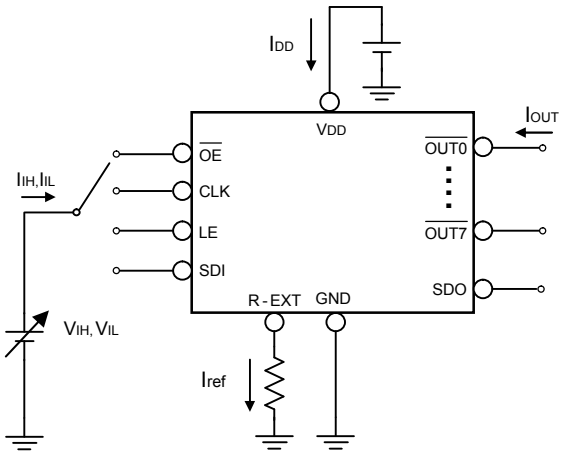
## Maximum Ratings

| 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 | | $I_{OUT}$ | +120 | mA |
| Output Voltage | | $V_{DS}$ | -0.5 ~ +20.0 | V |
| Clock Frequency | | $F_{CLK}$ | 25 | MHz |
| GND Terminal Current | | $I_{GND}$ | 1000 | mA |
| Power Dissipation (On PCB, Ta=25°C) | CN – type | $P_D$ | 2.03 | W |
| | CD – type | | 1.46 | |
| | CDW – type | | 2.03 | |
| | CP – type | | 1.32 | |
| Thermal Resistance (On PCB, Ta=25°C) | CN – type | $R_{th(j-a)}$ | 61.65 | °C/W |
| | CD – type | | 85.82 | |
| | CDW – type | | 61.63 | |
| | CP – type | | 94.91 | |
| Operating Temperature | | $T_{opr}$ | -40 ~ +85 | °C |
| Storage Temperature | | $T_{stg}$ | -55 ~ +150 | °C |

## Electrical Characteristics

| Characteristic | | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|
| Supply Voltage | | $V_{DD}$ | - | | 4.5 | 5.0 | 5.5 | V |
| Output Voltage | | $V_{DS}$ | $\overline{OUT0}$ ~ $\overline{OUT7}$ | | - | - | 17.0 | V |
| Output Current | | $I_{OUT}$ | Test Circuit for Electrical Characteristics | | 5 | - | 120 | mA |
| | | $I_{OH}$ | SDO | | - | - | -1.0 | mA |
| | | $I_{OL}$ | SDO | | - | - | 1.0 | mA |
| Input Voltage | "H" level | $V_{IH}$ | Ta = -40~85ºC | | 0.8$V_{DD}$ | - | $V_{DD}$ | V |
| | "L" level | $V_{IL}$ | Ta = -40~85ºC | | GND | - | 0.3$V_{DD}$ | V |
| Output Leakage Current | | | $V_{OH}$ = 17.0V and channel off | | - | - | 0.5 | μA |
| Output Voltage | SDO | $V_{OL}$ | $I_{OL}$ = +1.0mA | | - | - | 0.4 | V |
| | | $V_{OH}$ | $I_{OH}$ = -1.0mA | | 4.6 | - | - | V |
| Output Current 1 | | $I_{OUT1}$ | $V_{DS}$ = 0.5V | $R_{ext}$ = 744 Ω | - | 25.26 | - | mA |
| Current Skew (between channels) | | $dI_{OUT1}$ | $I_{OUT}$ = 25.26mA<br>$V_{DS} \geq$ 0.5V | $R_{ext}$ = 744 Ω | - | ±1 | ±3 | % |
| Output Current 2 | | $I_{OUT2}$ | $V_{DS}$ = 0.6V | $R_{ext}$ = 372 Ω | - | 50.52 | - | mA |
| Current Skew (between channels) | | $dI_{OUT2}$ | $I_{OUT}$ = 50.52mA<br>$V_{DS} \geq$ 0.6V | $R_{ext}$ = 372 Ω | - | ±1 | ±3 | % |
| Output Current 3 | | $I_{OUT3}$ | $V_{DS}$ = 0.8V | $R_{ext}$ = 186 Ω | - | 101.0 | - | mA |
| Current Skew (between channels) | | $dI_{OUT3}$ | $I_{OUT}$ = 101.0mA<br>$V_{DS} \geq$ 0.8V | $R_{ext}$ = 186 Ω | - | ±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) | $\overline{OE}$ | | 250 | 500 | 800 | KΩ |
| Pull-down Resistor | | $R_{IN}$(down) | LE | | 250 | 500 | 800 | KΩ |
| Supply Current | "OFF" | $I_{DD}$(off) 1 | $R_{ext}$ = Open, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off | | - | 3.25 | - | mA |
| | | $I_{DD}$(off) 2 | $R_{ext}$ = 744 Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off | | - | 5 | - | |
| | | $I_{DD}$(off) 3 | $R_{ext}$ = 372 Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off | | - | 6.8 | - | |
| | | $I_{DD}$(off) 4 | $R_{ext}$ = 186 Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off | | - | 10.5 | - | |
| | "ON" | $I_{DD}$(on) 1 | $R_{ext}$ = 744 Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = On | | - | 5 | - | |
| | | $I_{DD}$(on) 2 | $R_{ext}$ = 372 Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = On | | - | 6.8 | - | |
| | | $I_{DD}$(on) 3 | $R_{ext}$ = 186 Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = On | | | 10.5 | | |

## Test Circuit for Electrical Characteristics

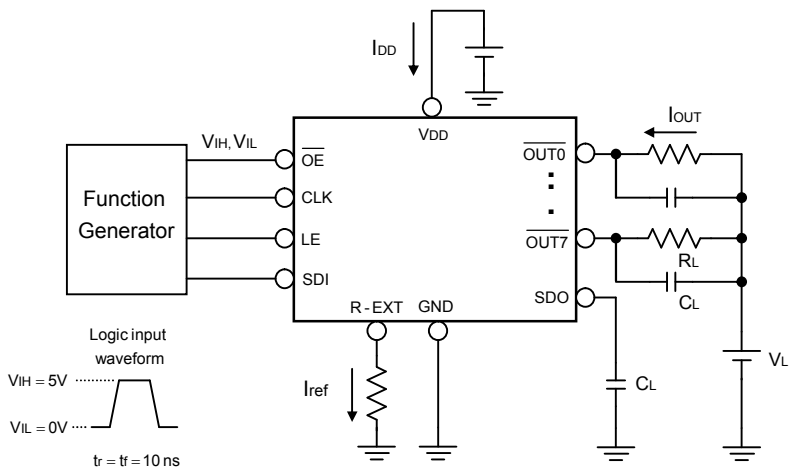


## Switching Characteristics

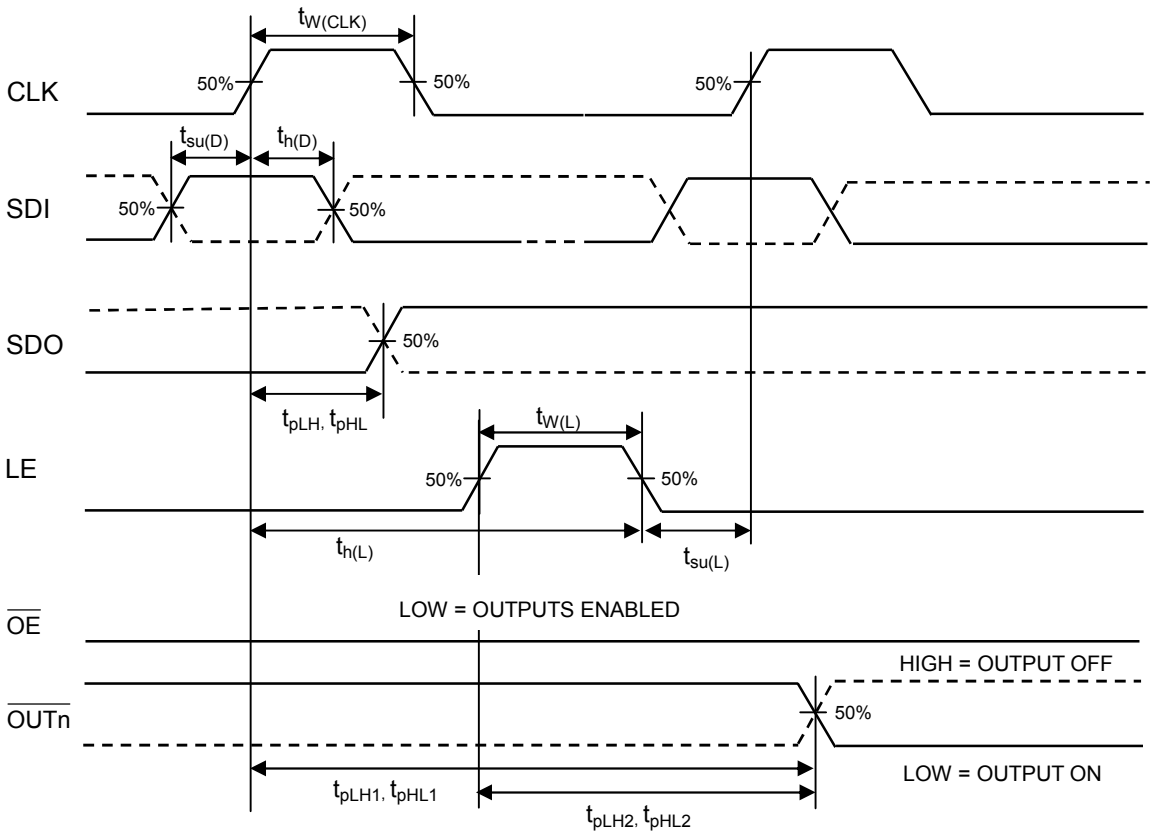
| Characteristic | | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Propagation Delay Time (“L” to “H”) | CLK - $\overline{OUTn}$ | $t_{pLH1}$ | Test Circuit for Switching Characteristics<br>$V_{DD}$ = 5.0 V<br>$V_{DS}$ = 0.8 V<br>$V_{IH}$ = $V_{DD}$<br>$V_{IL}$ = GND<br>$R_{ext}$ = 372 Ω<br>$V_L$ = 4.0 V<br>$R_L$ = 64 Ω<br>$C_L$ = 10 pF | - | 50 | 100 | ns |
| | LE - $\overline{OUTn}$ | $t_{pLH2}$ | | - | 50 | 100 | ns |
| | $\overline{OE}$ - $\overline{OUTn}$ | $t_{pLH3}$ | | - | 20 | 100 | ns |
| | CLK - SDO | $t_{pLH}$ | | 15 | 20 | - | ns |
| Propagation Delay Time (“H” to “L”) | CLK - $\overline{OUTn}$ | $t_{pHL1}$ | | - | 100 | 150 | ns |
| | LE - $\overline{OUTn}$ | $t_{pHL2}$ | | - | 100 | 150 | ns |
| | $\overline{OE}$ - $\overline{OUTn}$ | $t_{pHL3}$ | | - | 50 | 150 | ns |
| | CLK - SDO | $t_{pHL}$ | | 15 | 20 | - | ns |
| Pulse Width | CLK | $t_{w(CLK)}$ | | 20 | - | - | ns |
| | LE | $t_{w(L)}$ | | 20 | - | - | ns |
| | $\overline{OE}$ (@$I_{out}$ < 60mA) | $t_{w(OE)}$ | | 200 | - | - | ns |
| Hold Time for LE | | $t_{h(L)}$ | | 10 | - | - | ns |
| Setup Time for LE | | $t_{su(L)}$ | | 5 | - | - | ns |
| Hold Time for SDI | | $t_{h(D)}$ | | 10 | - | - | ns |
| Setup Time for SDI | | $t_{su(D)}$ | | 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) | | $t_{or}$ | | - | 40 | 120 | ns |
| Output Fall Time of Vout (turn on) | | $t_{of}$ | | - | 70 | 200 | ns |
| Clock Frequency | | $F_{CLK}$ | Cascade Operation | - | - | 25.0 | MHz |

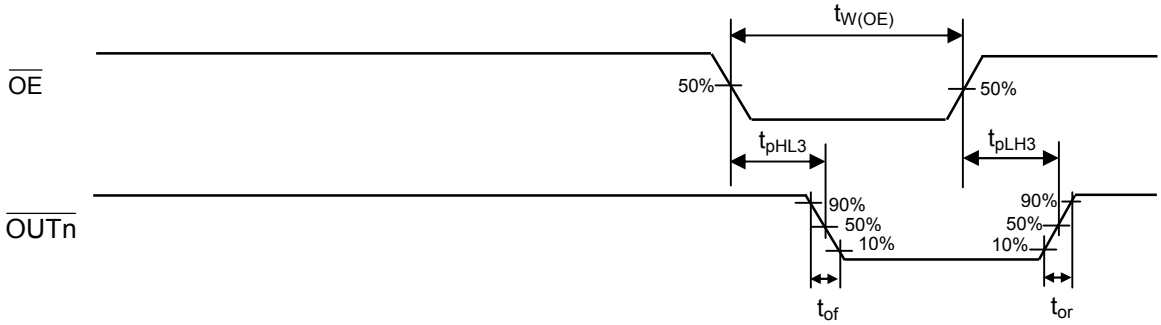
**If the devices are connected in cascade and $t_r$ or $t_f$ is large, it may be critical to achieve the timing required for data transfer between two cascaded devices.

## Test Circuit for Switching Characteristics



## Timing Waveform



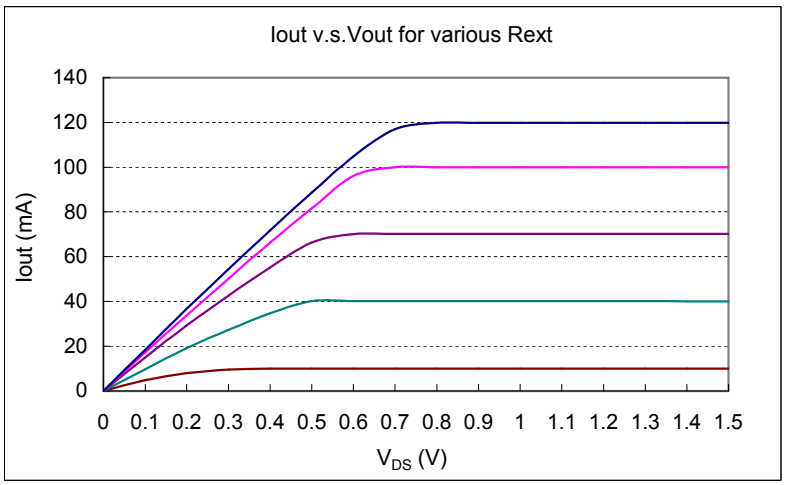
# Application Information

## Constant Current

In LED display application, MBI5168 provides nearly no variations in current from channel to channel and from IC to IC. This can be achieved by:

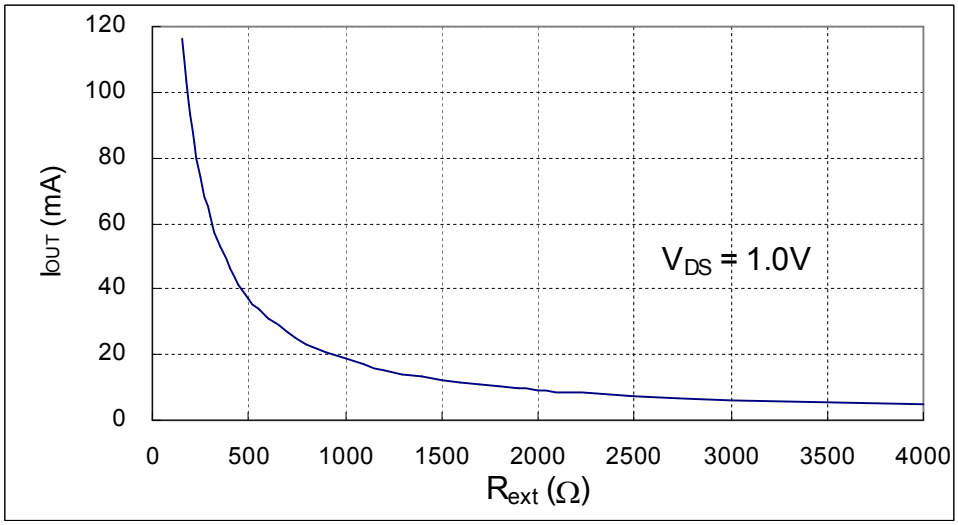
1) While $I_{OUT} \leqq$ 100mA, the maximum current variation between channels is less than ±3%, and that between ICs is less than ±6%.

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 (Vf).



## 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 output current can be calculated from the equation:

$V_{R\text{-}EXT}$ = 1.253Volt

$I_{ref} = V_{rext} / R_{ext}$ if another end of the external resistor $R_{ext}$ is connected to ground.

$I_{OUT} = I_{ref} \times 15 = 1.253\text{Volt} / R_{ext} \times 15$.

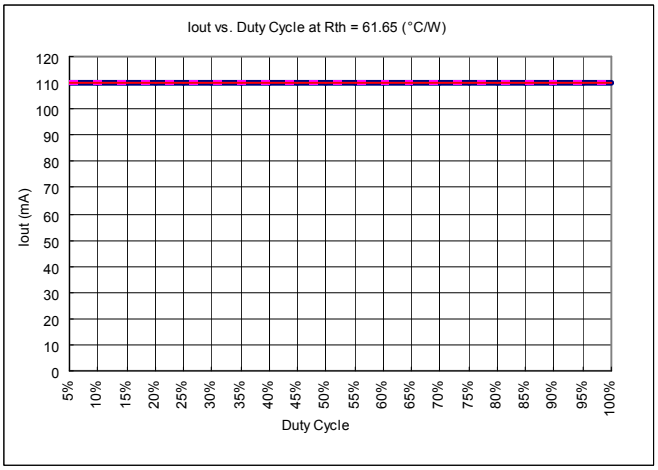
where $R_{ext}$ is the resistance of the external resistor connected to R-EXT terminal and $V_{R\text{-}EXT}$ is the voltage of R-EXT terminal. The magnitude of current (as a function of $R_{ext}$) is around 50.52mA at 372Ω and 25.26mA at 744Ω.

## Package Power Dissipation ($P_D$)

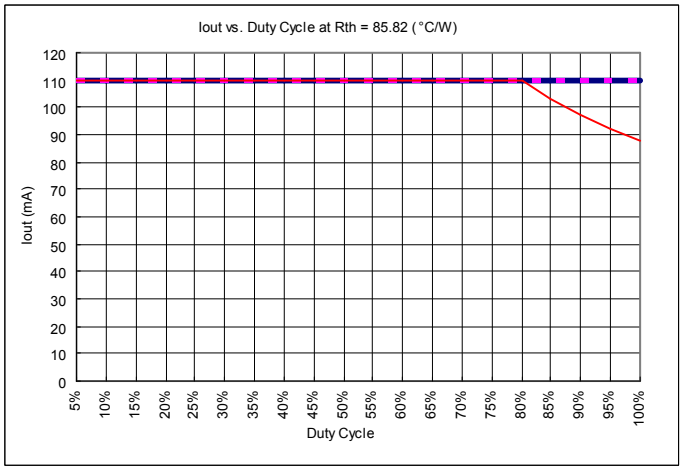
The maximum allowable package power dissipation is determined as $P_D(max) = (Tj – Ta) / R_{th(j-a)}$. When 8 output channels are turned on simultaneously, the actual package power dissipation is $P_D(act) = (I_{DD} \times V_{DD}) + (I_{OUT} \times Duty \times V_{DS} \times 8)$. Therefore, to keep $P_D(act) \leq P_D(max)$, the allowable maximum output current as a function of duty cycle is:

$I_{OUT} = \{ [ (Tj – Ta) / R_{th(j-a)} ] – (I_{DD} \times V_{DD}) \} / V_{DS} / Duty / 8,$

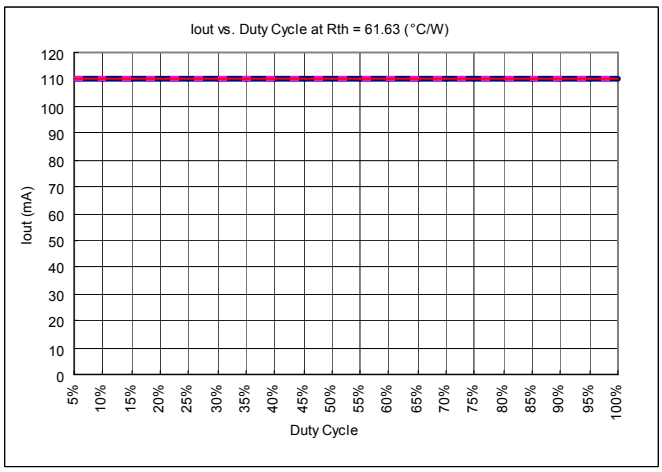
where Tj = 150°C.



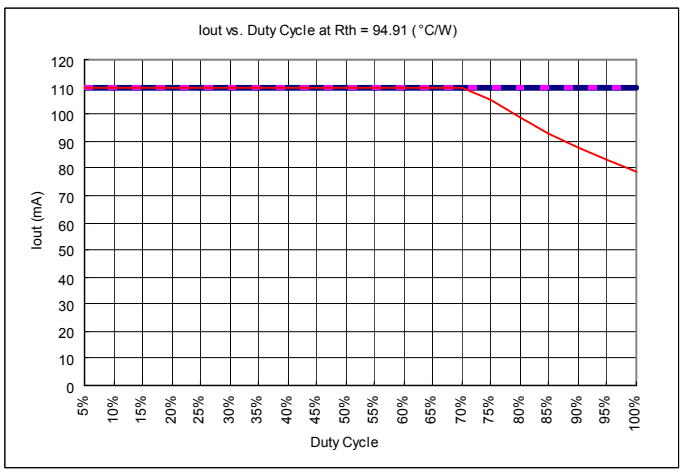

CN Device Type




CD Device Type



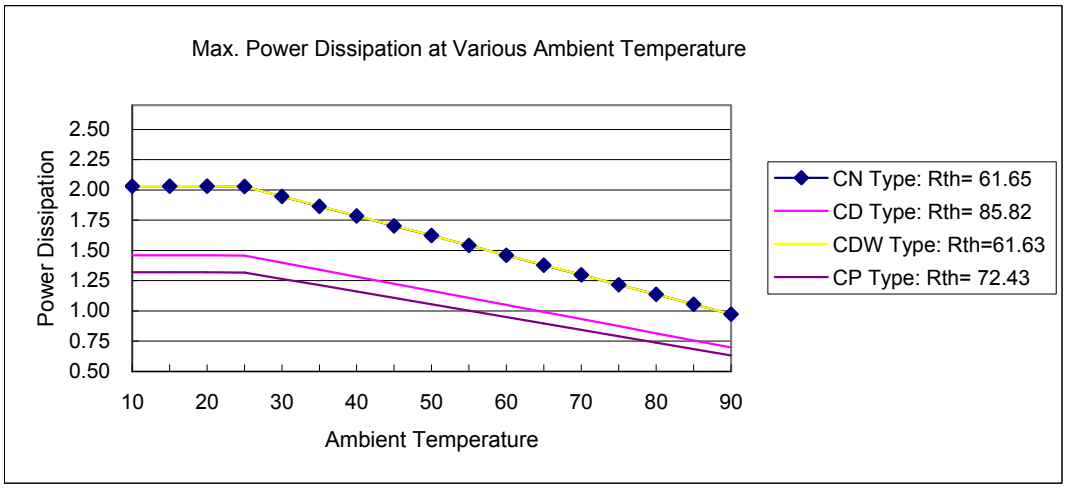

CDW Device Type




CP Device Type

| **Condition :** $V_{DS}$ = 1.0V，8 output channels active，Ta is listed in the below legends. | | |
|---|---|---|
| Device Type | $R_{th(j-a)}$(°C/W) | Note |
| CN | 61.65 | 25℃<br>55℃<br>85℃ |
| CD | 85.82 | |
| CDW | 61.63 | |
| CP | 94.91 | |

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

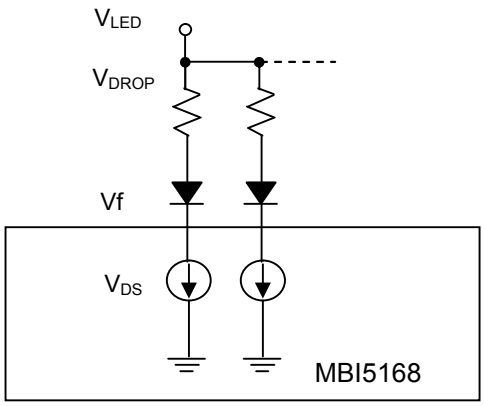


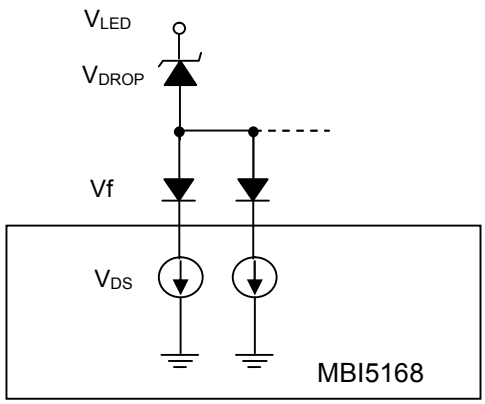

## Load Supply Voltage ($V_{LED}$)

MBI5168 are designed to operate with $V_{DS}$ ranging from 0.4V to 1.0V considering the package power dissipating limits. $V_{DS}$ may be so high as to make $P_{D(act)} > P_{D(max)}$ under higher $V_{LED}$, for instance, than 5V, where $V_{DS} = V_{LED} – Vf$ and $V_{LED}$ 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, $V_{DROP}$.

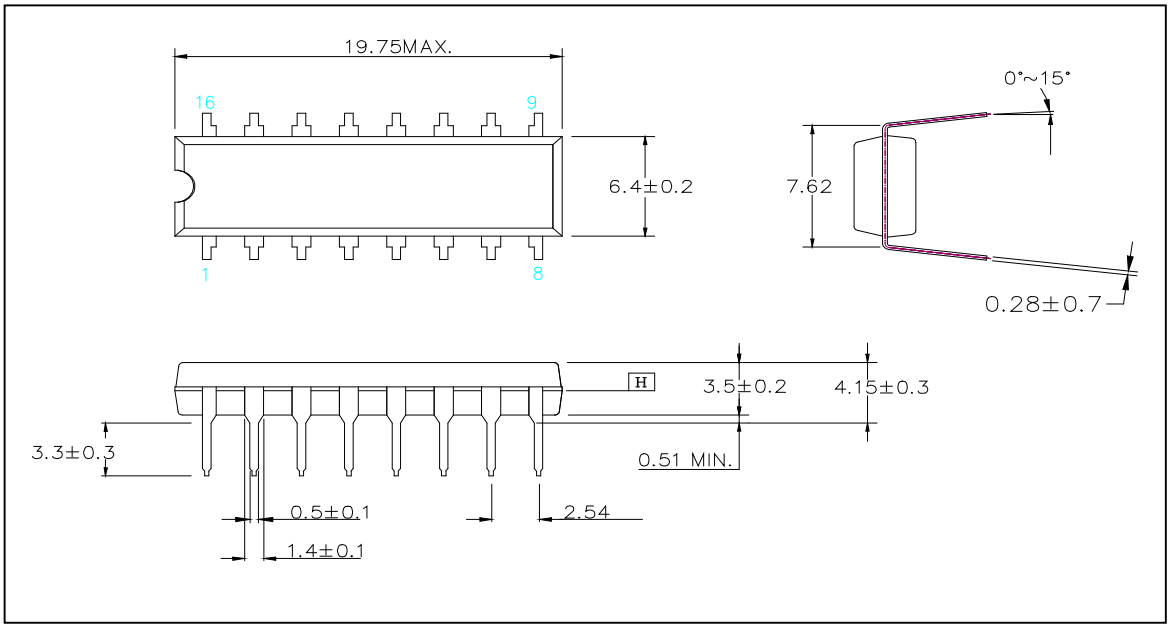
A voltage reducer lets $V_{DS} = (V_{LED} – Vf) – V_{DROP}$.

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

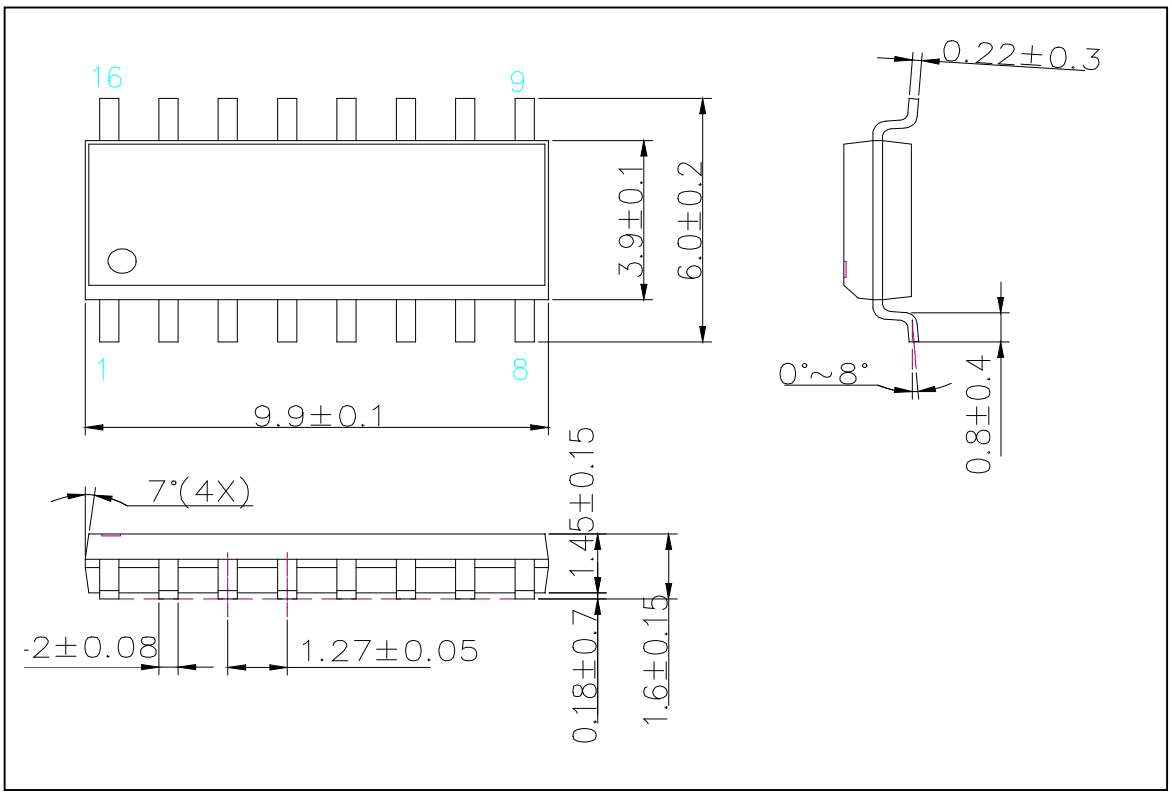


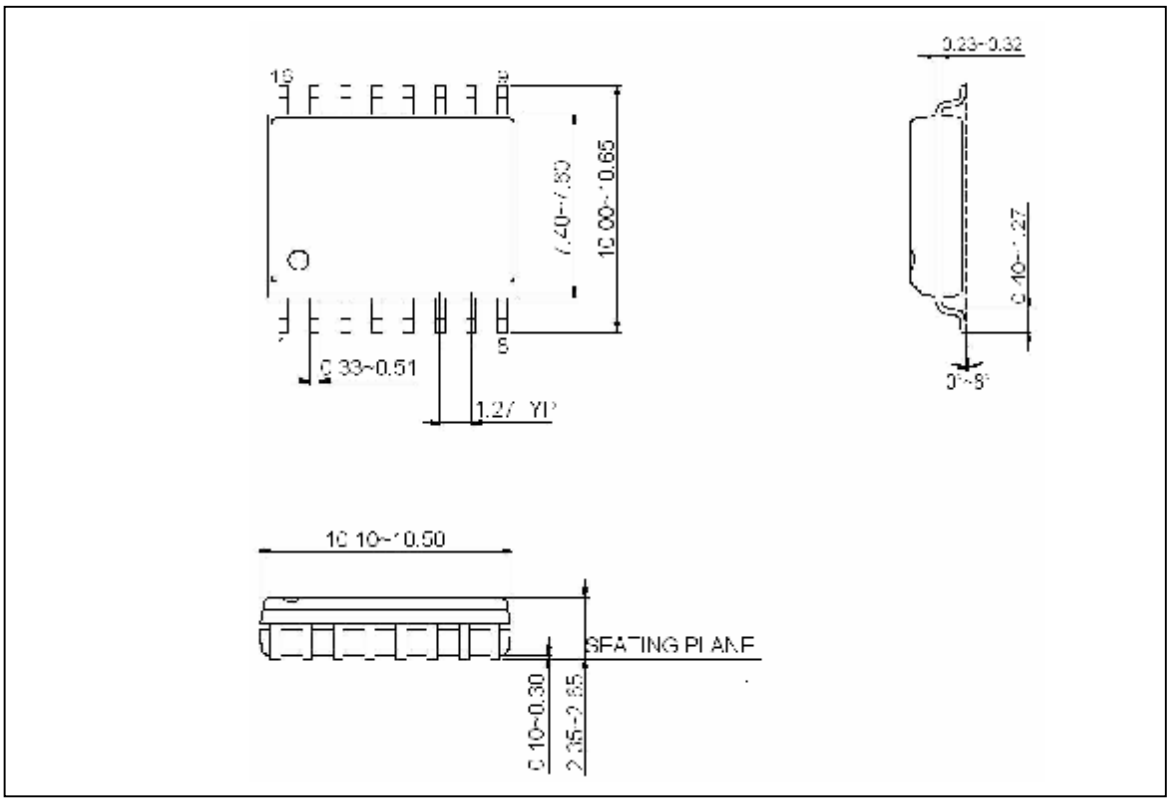
## Outline Drawings



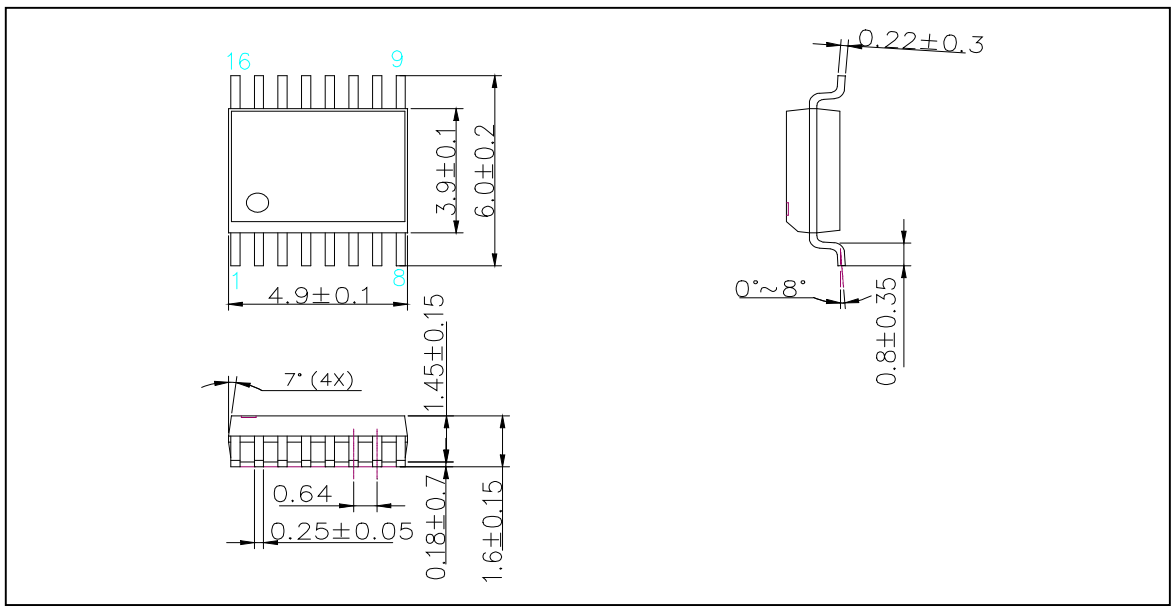

MBI5168CN Outline Drawing




MBI5168CD Outline Drawing




MBI5168CDW Outline Drawing




MBI5168CP Outline Drawing

## MBI5168 Package Information

| Device Type | Package Type | Weight(g) |
|---|---|---|
| CN | P-DIP16-300-2.54 | 1.02 |
| CD | SOP16-150-1.27 | 0.13 |
| CDW | SOP16-300-1.27 | 0.37 |
| CP | SSOP16-150-0.64 | 0.07 |

Note: The unit for the outline drawing is mm.