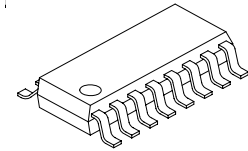



**Macroblock**

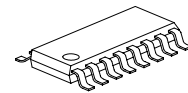
Preliminary Datasheet

**MBI5167**
**8-Channel Constant Current LED Sink Driver**
**Features**

- 8 constant-current output channels
- Constant output current invariant to load voltage change:  
Constant output current range per channel:  
3 - 45mA @  $V_{DD} = 5V$ ;  
3 - 30mA @  $V_{DD} = 3.3V$
- Excellent output current accuracy:  
between channels:  $\pm 3\%$  (max.), and  
between ICs:  $\pm 6\%$  (max.)
- Output current adjusted through an external resistor
- Staggered output delay
- 25MHz clock frequency
- Schmitt trigger input
- 3.3V/ 5V supply voltage
- "Pb-free & Green" Package

**Small Outline Package**


SOP16-150-1.27 Weight : 0.13g

**Shrink SOP**


SSOP16-150-0.64 Weight : 0.07g

Current Accuracy		Conditions
Between Channels	Between ICs	
< $\pm 3\%$	< $\pm 6\%$	$I_{OUT} = 3mA \sim 30mA @ V_{DS} \geq 0.8V; V_{DD} = 3.3V$ $I_{OUT} = 3mA \sim 45mA @ V_{DS} \geq 0.8V; V_{DD} = 5.0V$

**Product Description**

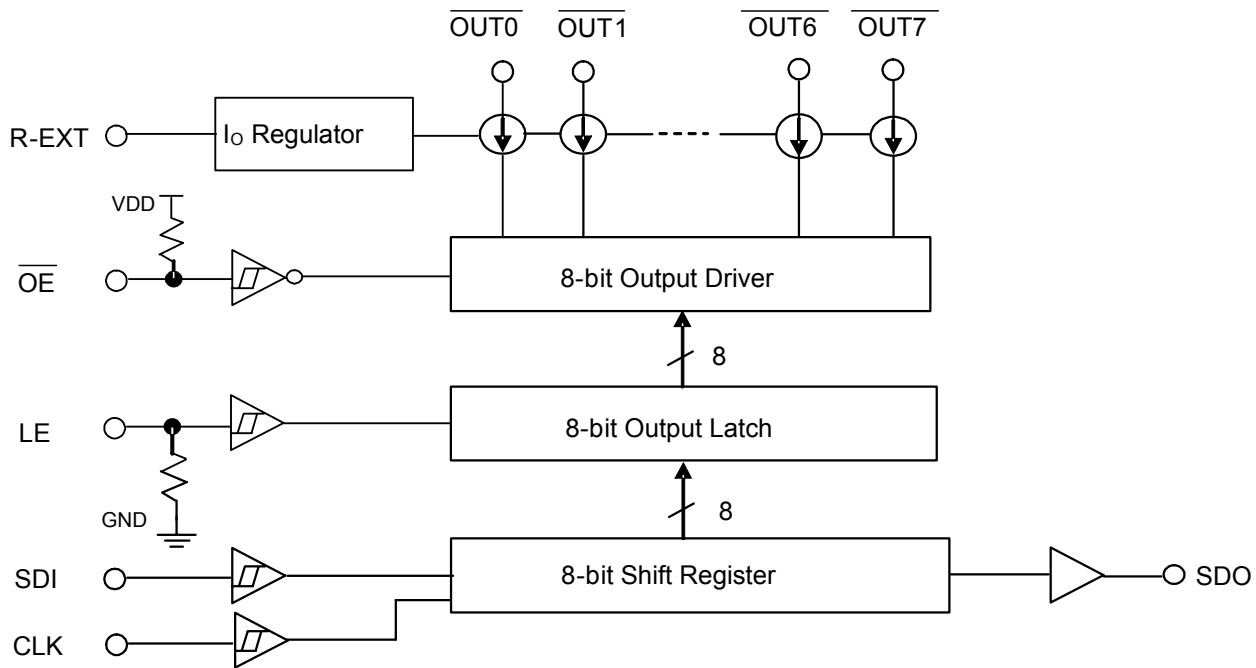
With PrecisionDrive™ technology, MBI5167 is designed for LED displays which require to be operated at low current and to match the luminous intensity of each channel. It provides supply voltage and accepts CMOS logic input at 3.3V and 5.0V to meet the trend of low power consumption. MBI5167 contains a serial buffer and data latches which convert serial input data into parallel output format. At MBI5167 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.

MBI5167 provides users with great flexibility and device performance for LED display applications, e.g. LED panels. It accepts an input voltage range from 3V to 5.5V and maintains a constant current up from 3mA to 45mA determined by an external resistor,  $R_{ext}$ , which gives users flexibility in controlling the light intensity of LEDs. MBI5167 guarantees to endure maximum 17V at the output port. The high clock frequency, 25MHz, also satisfies the system requirements of high volume data transmission.

# MBI5167

# 8-Channel Constant Current LED Sink Driver

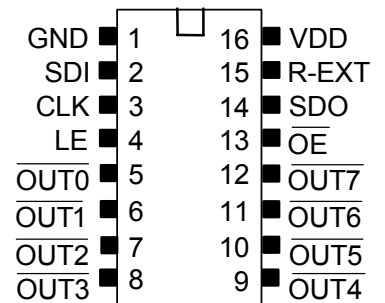
## Block Diagram



## Terminal Description

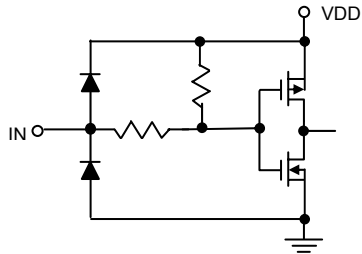
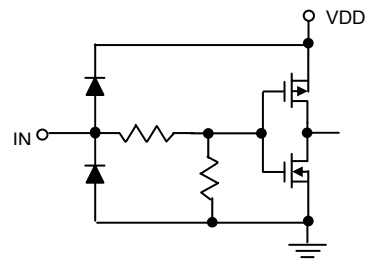
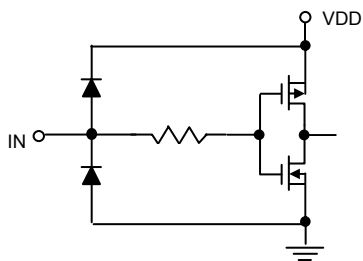
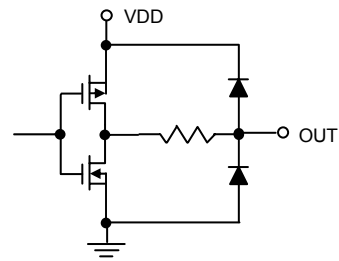
Pin No.	Pin Name	Function
1	GND	Ground terminal for control logic and current sink
2	SDI	Serial-data input to the shift register
3	CLK	Clock input terminal for data shift on rising edge
4	LE	Data strobe input terminal Serial data is transferred to the output latch when LE is high. The data is latched when LE goes low.
5~12	$\overline{\text{OUT0}} \sim \overline{\text{OUT7}}$	Constant current output terminals
13	$\overline{\text{OE}}$	Output enable terminal When $\overline{\text{OE}}$ is active (low), the output is enabled; when $\overline{\text{OE}}$ is inactive (high), the output is turned OFF (blanked).
14	SDO	Serial-data output to the following SDI of next driver IC. SDO signal change on rising edge of CLK.
15	R-EXT	Input terminal used to connect an external resistor for setting up output current for all output channels
16	VDD	3.3V / 5V supply voltage terminal

## Pin Configuration



MBI5167

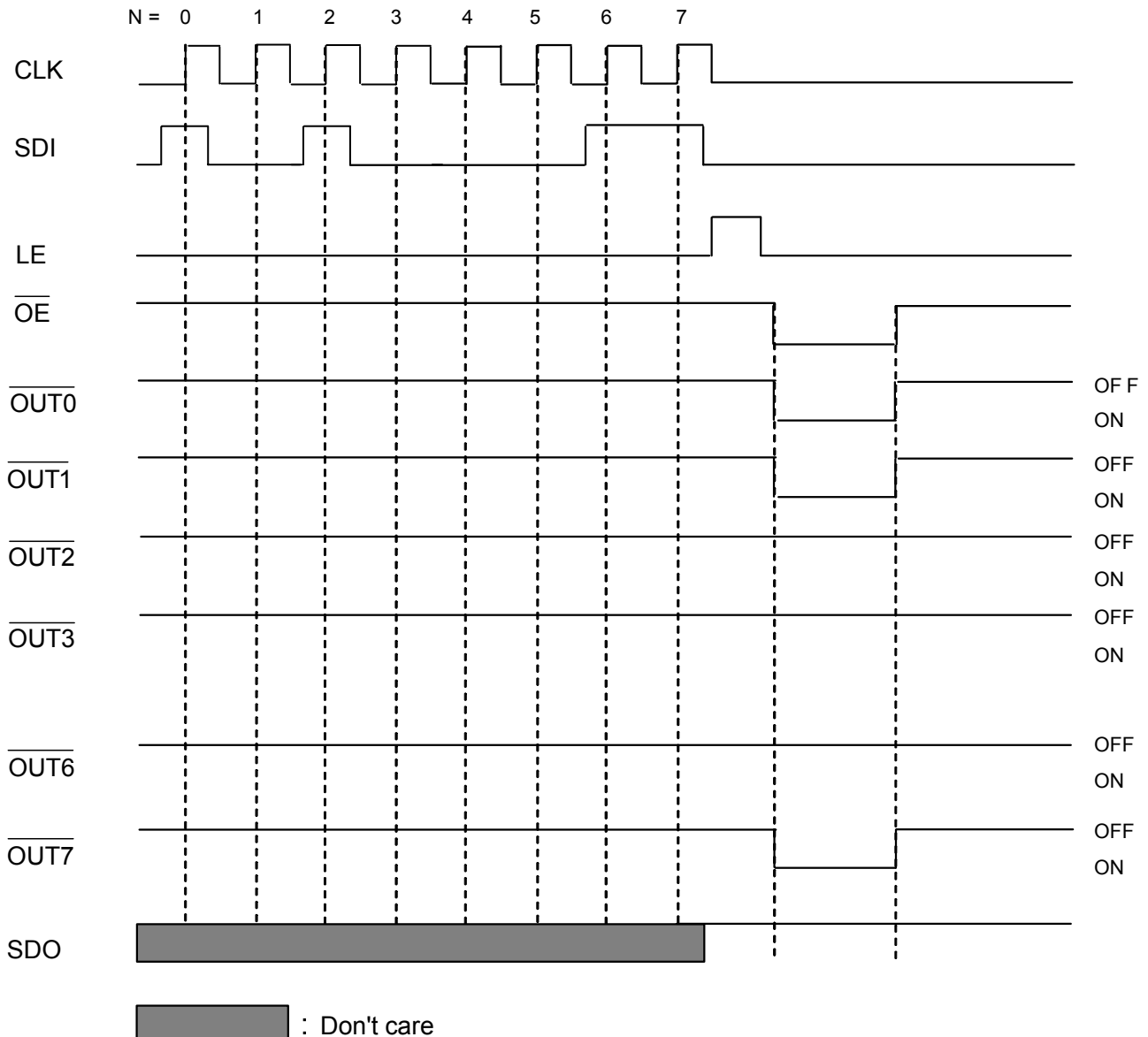
8-Channel Constant Current LED Sink Driver

**Equivalent Circuits of Input and Output Terminals** **$\overline{\text{OE}}$  terminal****LE terminal****CLK, SDI terminal****SDO terminal**

# MBI5167

# 8-Channel Constant Current LED Sink Driver

## Timing Diagram



## Truth Table

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

## MBI5167

## 8-Channel Constant Current LED Sink Driver

**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
Sustaining Voltage at OUT Port		$V_{DS}$	-0.5 ~ +17.0	V
Clock Frequency		$F_{CLK}$	25	MHz
GND Terminal Current		$I_{GND}$	960	mA
Power Dissipation (On 4 Layers PCB, $T_a=25^{\circ}C$ )	GD type	$P_D$	1.57	W
	GP type		1.50	
Thermal Resistance (On 4 Layers PCB, $T_a=25^{\circ}C$ )	GD type	$R_{th(j-a)}$	79.71	$^{\circ}C/W$
	GP type		83.38	
Operating Junction Temperature		$T_{j,max}$	150	$^{\circ}C$
Operating Temperature		$T_{opr}$	-40 ~ +85	$^{\circ}C$
Storage Temperature		$T_{stg}$	-55 ~ +150	$^{\circ}C$

## MBI5167

## 8-Channel Constant Current LED Sink Driver

**Electrical Characteristics ( $V_{DD} = 5.0V$ )**

Characteristics		Symbol	Condition	Min.	Typ.	Max.	Unit
Supply Voltage		$V_{DD}$	-	4.5	5.0	5.5	V
Sustaining Voltage at OUT Ports		$V_{DS}$	$\overline{OUT0} \sim \overline{OUT7}$	-	-	17.0	V
Output Current		$I_{OUT}$	Refer to "Test Circuit for Electrical Characteristics"	3	-	45	mA
		$I_{OH}$	SDO	-	-	-1.0	mA
		$I_{OL}$	SDO	-	-	1.0	mA
Input Voltage	"H" level	$V_{IH}$	$T_a = -40 \sim 85^\circ C$	$0.7 \times V_{DD}$	-	$V_{DD}$	V
	"L" level	$V_{IL}$	$T_a = -40 \sim 85^\circ C$	GND	-	$0.3 \times V_{DD}$	V
Output Leakage Current		$I_{OH}$	$V_{DS} = 17.0V$	-	-	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		$I_{OUT(1)}$	$V_{DS} \geq 0.8V$ $R_{ext} = 1860\Omega$	-	10	-	mA
Current Skew 1		$dI_{OUT(1)}$	$I_{OL} = 10mA$ $V_{DS} \geq 0.8V$ $R_{ext} = 1860\Omega$	-	$\pm 1$	$\pm 3$	%
Output Current 2		$I_{OUT(2)}$	$V_{DS} \geq 0.8V$ $R_{ext} = 744\Omega$	-	25	-	mA
Current Skew 2		$dI_{OUT(2)}$	$I_{OL} = 25mA$ $V_{DS} \geq 0.8V$ $R_{ext} = 744\Omega$	-	$\pm 1$	$\pm 3$	%
Output Current vs. Output Voltage Regulation		$\%/dV_{DS}$	$V_{DS}$ within 1.0V and 3.0V	-	$\pm 0.1$	-	% / V
Output Current vs. Sustaining Voltage Regulation		$\%/dV_{DD}$	$V_{DD}$ within 4.5V and 5.5V	-	$\pm 1$	-	% / V
Pull-up Resistor		$R_{IN(up)}$	$\overline{OE}$	200	370	700	K $\Omega$
Pull-down Resistor		$R_{IN(down)}$	LE	200	370	700	K $\Omega$
Supply Current	"OFF"	$I_{DD(off) 1}$	$R_{ext} = \text{Open}, \overline{OUT0} \sim \overline{OUT7} = \text{Off}$	-	1.5	2.5	mA
		$I_{DD(off) 2}$	$R_{ext} = 1860\Omega, \overline{OUT0} \sim \overline{OUT7} = \text{Off}$	-	3.6	5.0	
		$I_{DD(off) 3}$	$R_{ext} = 744\Omega, \overline{OUT0} \sim \overline{OUT7} = \text{Off}$	-	4.8	6.5	
	"ON"	$I_{DD(on) 1}$	$R_{ext} = 1860\Omega, \overline{OUT0} \sim \overline{OUT7} = \text{On}$	-	5.1	6.5	
		$I_{DD(on) 2}$	$R_{ext} = 744\Omega, \overline{OUT0} \sim \overline{OUT7} = \text{On}$	-	6.3	8.0	

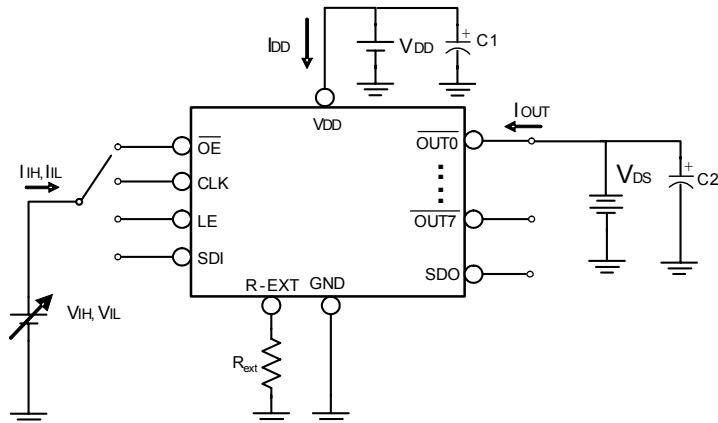
# MBI5167

# 8-Channel Constant Current LED Sink Driver

## Electrical Characteristics ( $V_{DD} = 3.3V$ )

Characteristics		Symbol	Condition	Min.	Typ.	Max.	Unit
Supply Voltage		$V_{DD}$	-	3.0	3.3	4.5	V
Sustaining Voltage at OUT Ports		$V_{DS}$	$\overline{OUT0} \sim \overline{OUT7}$	-	-	17.0	V
Output Current		$I_{OUT}$	Refer to "Test Circuit for Electrical Characteristics"	3	-	30	mA
		$I_{OH}$	SDO	-	-	-1.0	mA
		$I_{OL}$	SDO	-	-	1.0	mA
Input Voltage	"H" level	$V_{IH}$	$T_a = -40 \sim 85^\circ C$	$0.7 \times V_{DD}$	-	$V_{DD}$	V
	"L" level	$V_{IL}$	$T_a = -40 \sim 85^\circ C$	GND	-	$0.3 \times V_{DD}$	V
Output Leakage Current		$I_{OH}$	$V_{DS} = 17.0V$	-	-	0.5	$\mu A$
Output Voltage	SDO	$V_{OL}$	$I_{OL} = +1.0mA$	-	-	0.4	V
		$V_{OH}$	$I_{OH} = -1.0mA$	2.9	-	-	V
Output Current 1		$I_{OUT(1)}$	$V_{DS} \geq 0.8V$ $R_{ext} = 6200\Omega$	-	3	-	mA
Current Skew 1		$dl_{OUT(1)}$	$I_{OL} = 3mA$ $V_{DS} \geq 0.8V$ $R_{ext} = 6200\Omega$	-	$\pm 1$	$\pm 3$	%
Output Current 2		$I_{OUT(2)}$	$V_{DS} \geq 0.8V$ $R_{ext} = 744\Omega$	-	25	-	mA
Current Skew 2		$dl_{OUT(2)}$	$I_{OL} = 25mA$ $V_{DS} \geq 0.8V$ $R_{ext} = 744\Omega$	-	$\pm 1$	$\pm 3$	%
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 3.0V and 3.6V	-	$\pm 1$	-	% / V
Pull-up Resistor		$R_{IN(up)}$	$\overline{OE}$	200	370	700	K $\Omega$
Pull-down Resistor		$R_{IN(down)}$	LE	200	370	700	K $\Omega$
Supply Current	"OFF"	$I_{DD(off) 1}$	$R_{ext} = \text{Open}, \overline{OUT0} \sim \overline{OUT7} = \text{Off}$	-	1.2	2.0	mA
		$I_{DD(off) 2}$	$R_{ext} = 6200\Omega, \overline{OUT0} \sim \overline{OUT7} = \text{Off}$	-	2.3	3.0	
		$I_{DD(off) 3}$	$R_{ext} = 744\Omega, \overline{OUT0} \sim \overline{OUT7} = \text{Off}$	-	4.5	6.0	
	"ON"	$I_{DD(on) 1}$	$R_{ext} = 6200\Omega, \overline{OUT0} \sim \overline{OUT7} = \text{On}$	-	3.5	5.0	
		$I_{DD(on) 2}$	$R_{ext} = 744\Omega, \overline{OUT0} \sim \overline{OUT7} = \text{On}$	-	5.7	7.0	

## Test Circuit for Electrical Characteristics



## MBI5167

## 8-Channel Constant Current LED Sink Driver

**Switching Characteristics ( $V_{DD} = 5.0V$ )**

Characteristics		Symbol	Condition	Min.	Typ.	Max.	Unit
Propagation Delay Time ("L" to "H")	CLK - $\overline{OUT2n}$	$t_{pLH1}$	$V_{DD}=5.0V$ $V_{IH}=V_{DD}$ $V_{IL}=GND$ $R_{ext}=930\Omega$ $V_{LED}=4.5V$ $R_L=162\Omega$ $C_L=10pF$ $C_1=100nF$ $C_2=4.7\mu F$ (Freq.= 500KHz)	-	120*	140	ns
	CLK - $\overline{OUT2n+1}$			-	80	100	ns
	LE - $\overline{OUT2n}$	$t_{pLH2}$		-	120*	140	ns
	LE - $\overline{OUT2n+1}$			-	80	100	ns
	$\overline{OE}$ - $\overline{OUT2n}$	$t_{pLH3}$		-	120*	140	ns
	$\overline{OE}$ - $\overline{OUT2n+1}$			-	80	100	
	CLK - SDO	$t_{pLH4}$		-	25	35	ns
Propagation Delay Time ("H" to "L")	CLK - $\overline{OUT2n}$	$t_{pHL1}$		-	120*	140	ns
	CLK - $\overline{OUT2n+1}$			-	80	100	ns
	LE - $\overline{OUT2n}$	$t_{pHL2}$		-	120*	140	ns
	LE - $\overline{OUT2n+1}$			-	80	100	ns
	$\overline{OE}$ - $\overline{OUT2n}$	$t_{pHL3}$		-	120*	140	ns
	$\overline{OE}$ - $\overline{OUT2n+1}$			-	80	100	
	CLK - SDO	$t_{pHL4}$		-	25	35	ns
Pulse Width	CLK	$t_{w(CLK)}$	20	-	-	ns	
	LE	$t_{w(L)}$	20	-	-	ns	
	$\overline{OE}$	$t_{w(OE)}$	300	-	-	ns	
Hold Time for LE		$t_{h(L)}$	5	-	-	ns	
Setup Time for LE		$t_{su(L)}$	5	-	-	ns	
Maximum CLK Rise Time		$t_r$	-	-	500	ns	
Maximum CLK Fall Time		$t_f$	-	-	500	ns	
SDO Rise Time		$t_{r,SDO}$	-	15	25	ns	
SDO Fall Time		$t_{f,SDO}$	-	15	25	ns	
Output Rise Time of Output Ports		$t_{or}$	-	140	180	ns	
Output Fall Time of Output Ports		$t_{of}$	-	65	90	ns	

\* The delay time of output channels is 40ns between odd number  $\overline{OUT2n+1}$  (e.g. OUT1, OUT3, OUT5, etc.) and even number  $\overline{OUT2n}$  (e.g. OUT2, OUT4, OUT6, etc.). MBI5167 has a built-in staggered circuit to perform delay mechanism, by which the even and odd output ports will be turned on at a different time so that the instant current from the power line will be lowered.

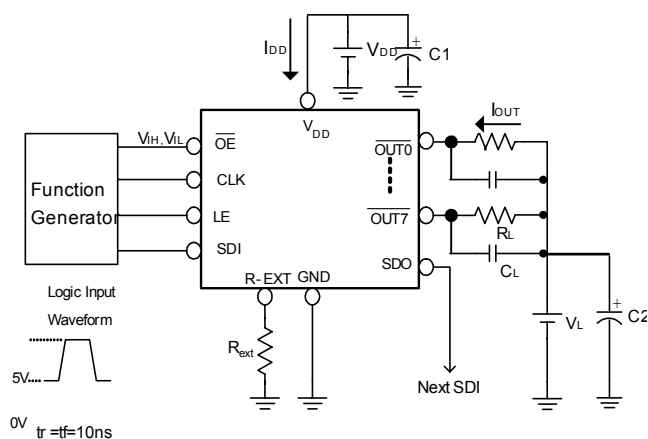


# MBI5167 8-Channel Constant Current LED Sink Driver

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

Characteristics		Symbol	Condition	Min.	Typ.	Max.	Unit
Propagation Delay Time ("L" to "H")	CLK - $\overline{OUT2n}$	$t_{pLH1}$	$V_{DD}=3.3V$ $V_{IH}=V_{DD}$ $V_{IL}=GND$ $R_{ext}=930\Omega$ $V_{LED}=4.5V$ $R_L=162\Omega$ $C_L=10pF$ $C_1=100nF$ $C_2=4.7\mu F$ (Freq.= 500KHz)	-	120*	140	ns
	CLK - $\overline{OUT2n+1}$			-	80	100	ns
	LE - $\overline{OUT2n}$	$t_{pLH2}$		-	120*	140	ns
	LE - $\overline{OUT2n+1}$			-	80	100	ns
	$\overline{OE}$ - $\overline{OUT2n}$	$t_{pLH3}$		-	120*	140	ns
	$\overline{OE}$ - $\overline{OUT2n+1}$			-	80	100	
	CLK - SDO	$t_{pLH4}$		-	25	35	ns
Propagation Delay Time ("H" to "L")	CLK - $\overline{OUT2n}$	$t_{pHL1}$		-	140	160	ns
	CLK - $\overline{OUT2n+1}$			-	100	120	ns
	LE - $\overline{OUT2n}$	$t_{pHL2}$		-	140	160	ns
	LE - $\overline{OUT2n+1}$			-	100	120	ns
	$\overline{OE}$ - $\overline{OUT2n}$	$t_{pHL3}$		-	140	160	ns
	$\overline{OE}$ - $\overline{OUT2n+1}$			-	100	120	
	CLK - SDO	$t_{pHL4}$		-	25	35	ns
Pulse Width	CLK	$t_w(CLK)$	20	-	-	ns	
	LE	$t_w(L)$	20	-	-	ns	
	$\overline{OE}$	$t_w(OE)$	300	-	-	ns	
Hold Time for LE		$t_h(L)$	5	-	-	ns	
Setup Time for LE		$t_{su}(L)$	5	-	-	ns	
Maximum CLK Rise Time		$t_r$	-	-	500	ns	
Maximum CLK Fall Time		$t_f$	-	-	500	ns	
SDO Rise Time		$t_{r,SDO}$	-	15	25	ns	
SDO Fall Time		$t_{f,SDO}$	-	15	25	ns	
Output Rise Time of Output Ports		$t_{or}$	-	150	180	ns	
Output Fall Time of Output Ports		$t_{of}$	-	70	90	ns	

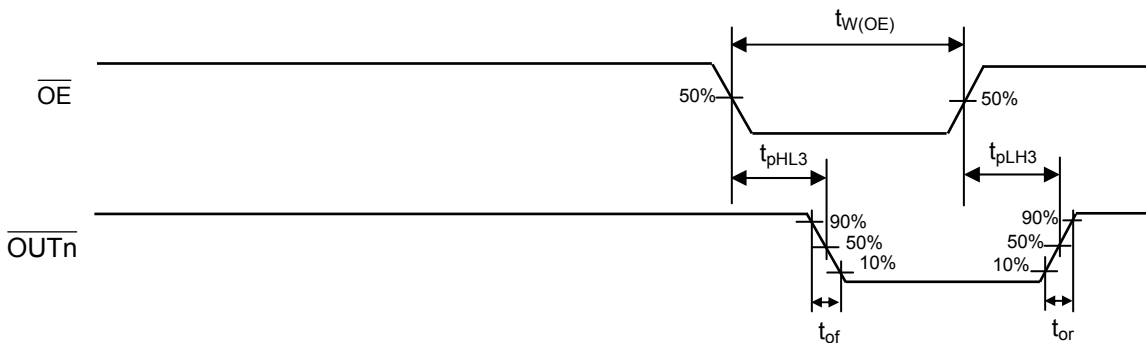
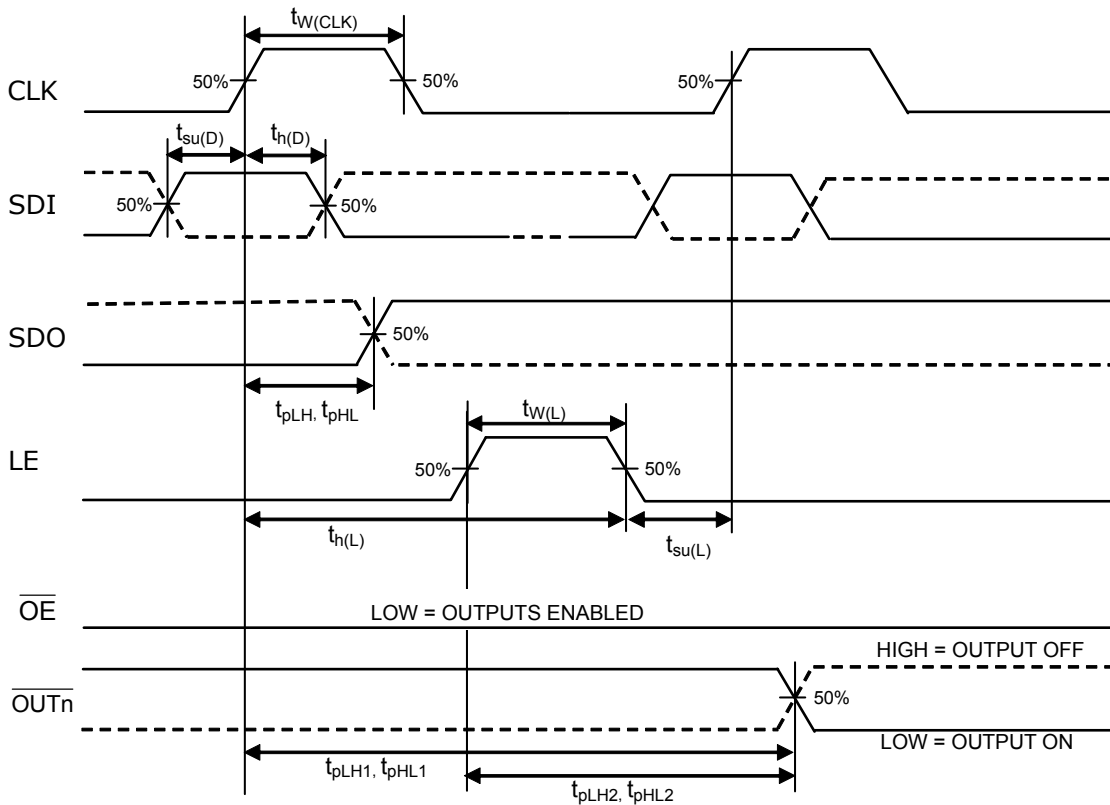
## Test Circuit for Switching Characteristics



# MBI5167

# 8-Channel Constant Current LED Sink Driver

## Timing Waveform



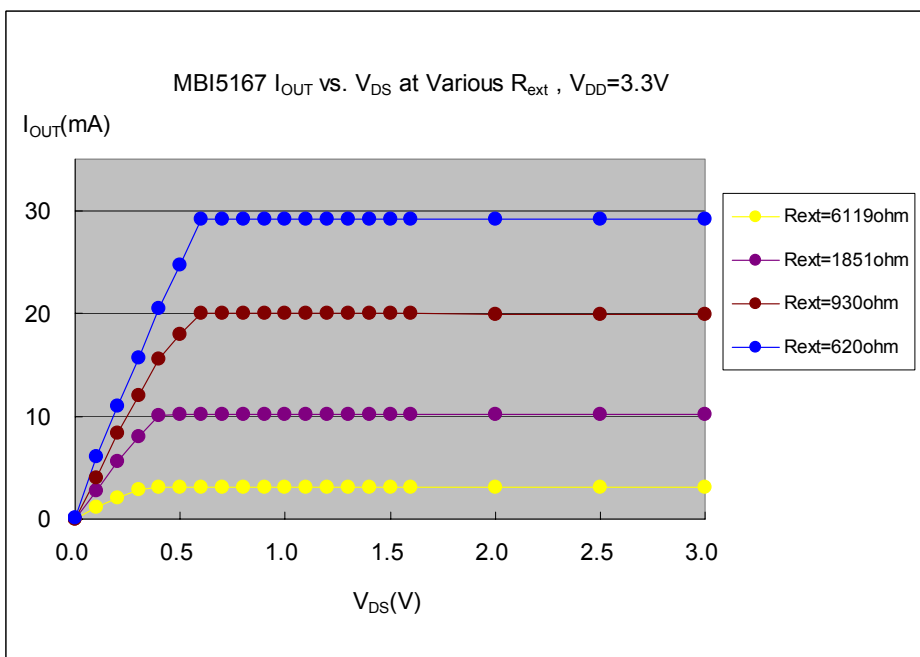
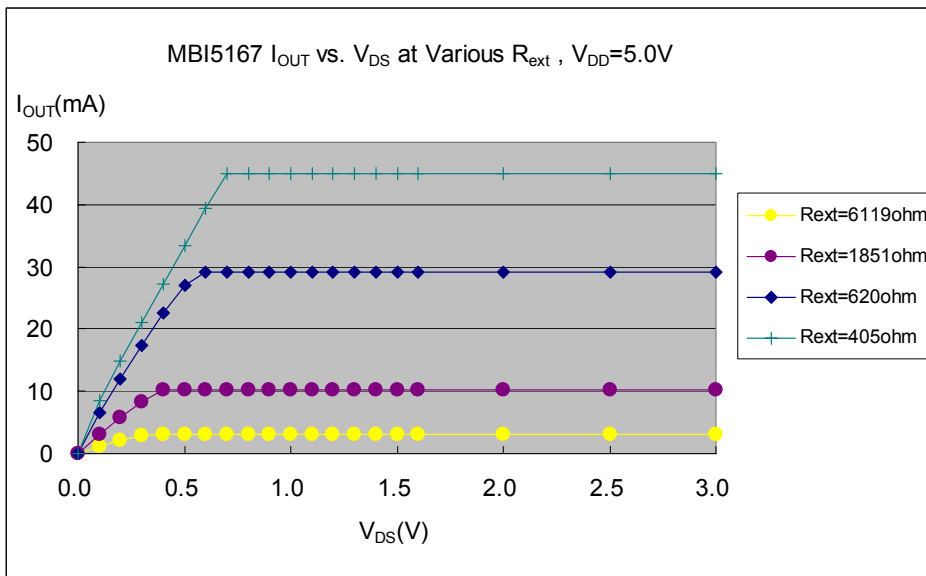
# MBI5167 8-Channel Constant Current LED Sink Driver

## Application Information

### Constant Current

To design LED displays, MBI5167 provides nearly no variation 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 guarantees LED to be performed on the same brightness as user's specification.



# MBI5167

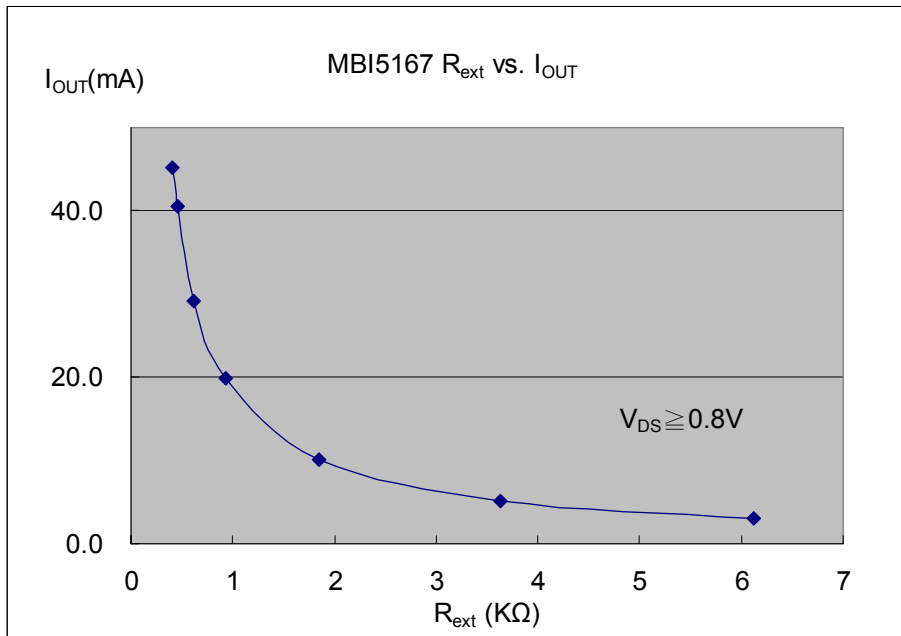
# 8-Channel Constant Current LED Sink Driver

## Setting 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.

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

$$V_{R-EXT} = 1.24V ; I_{OUT} = (V_{R-EXT} / R_{EXT}) \times 15 \text{ within } \pm 3\%$$



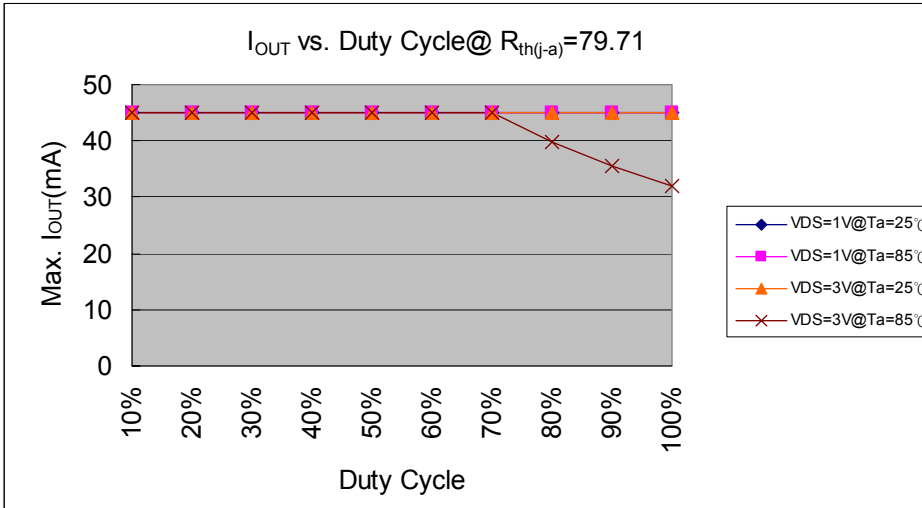
Where  $R_{EXT}$  is the resistance of the external resistor connected to R-EXT terminal and  $V_{R-EXT}$  is the voltage of R-EXT terminal. The magnitude of current (as a function of  $R_{EXT}$ ) is around 3mA at 6200 $\Omega$ , 10mA at 1860 $\Omega$ , and 25mA at 744 $\Omega$ .

# MBI5167 8-Channel Constant Current LED Sink Driver

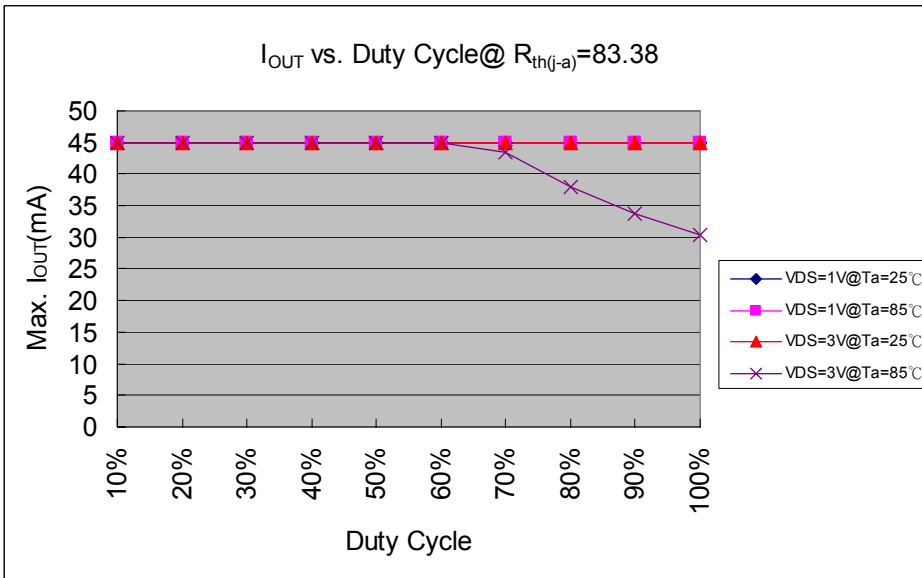
## Package Power Dissipation (PD)

The maximum allowable package power dissipation is determined as  $P_D(max) = (T_{j,max} - T_a) / R_{th(j-a)}$ . 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:

$$I_{OUT} = \{ [(T_j - T_a) / R_{th(j-a)}] - (I_{DD} \times V_{DD}) \} / V_{DS} / Duty / 8, \text{ where } T_j = 150^\circ\text{C}.$$



GD Device Type

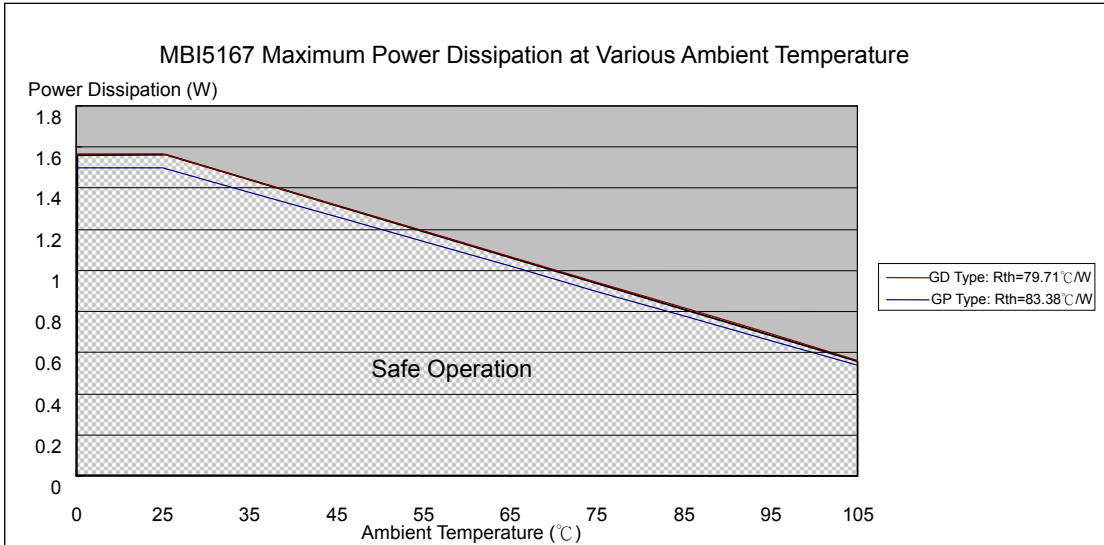


GP Device Type

Condition: V <sub>DD</sub> =5V, I <sub>OUT</sub> = 45mA, 8 Output Channels	
Device Type	R <sub>th(j-a)</sub> (°C/W)
GD	79.71
GP	83.38

# MBI5167 8-Channel Constant Current LED Sink Driver

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



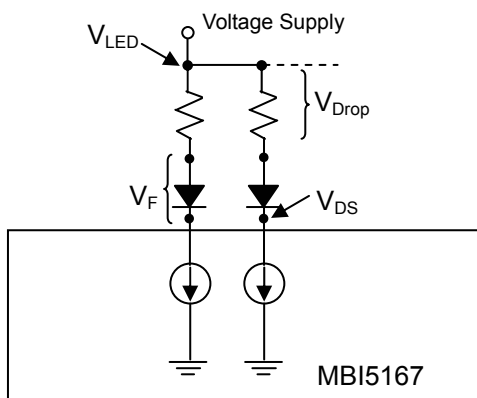
## Load Supply Voltage ( $V_{LED}$ )

MBI5167 is designed to operate with adequate  $V_{DS}$  to achieve constant current.  $V_{DS}$  together with  $I_{OUT}$  should not exceed the package power dissipation limit,  $P_{D(max)}$ .

As in the figure below,  $V_{DS} = V_{LED} - V_F$ , and  $V_{LED}$  is the load supply voltage.  $P_{D(act)}$  will be greater than  $P_{D(max)}$ , if  $V_{DS}$  drops too much voltage on the driver. 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 can be used in the applications as shown in the following figure.



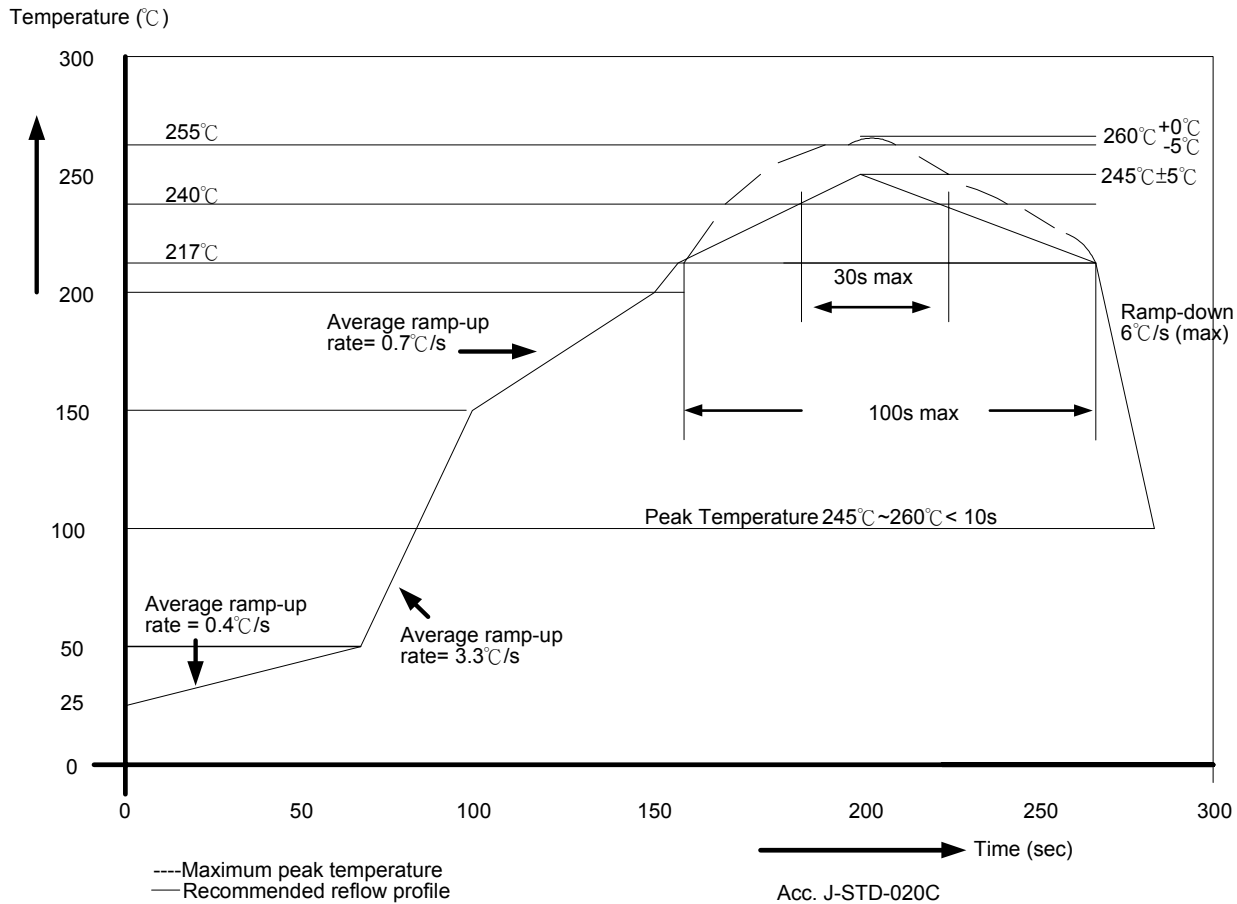
## Switching Noise Reduction

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".

# MBI5167 8-Channel Constant Current LED Sink Driver

## Soldering Process of "Pb-free" Package Plating\*

Macroblock has defined "Pb-Free" 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-020C as shown below.

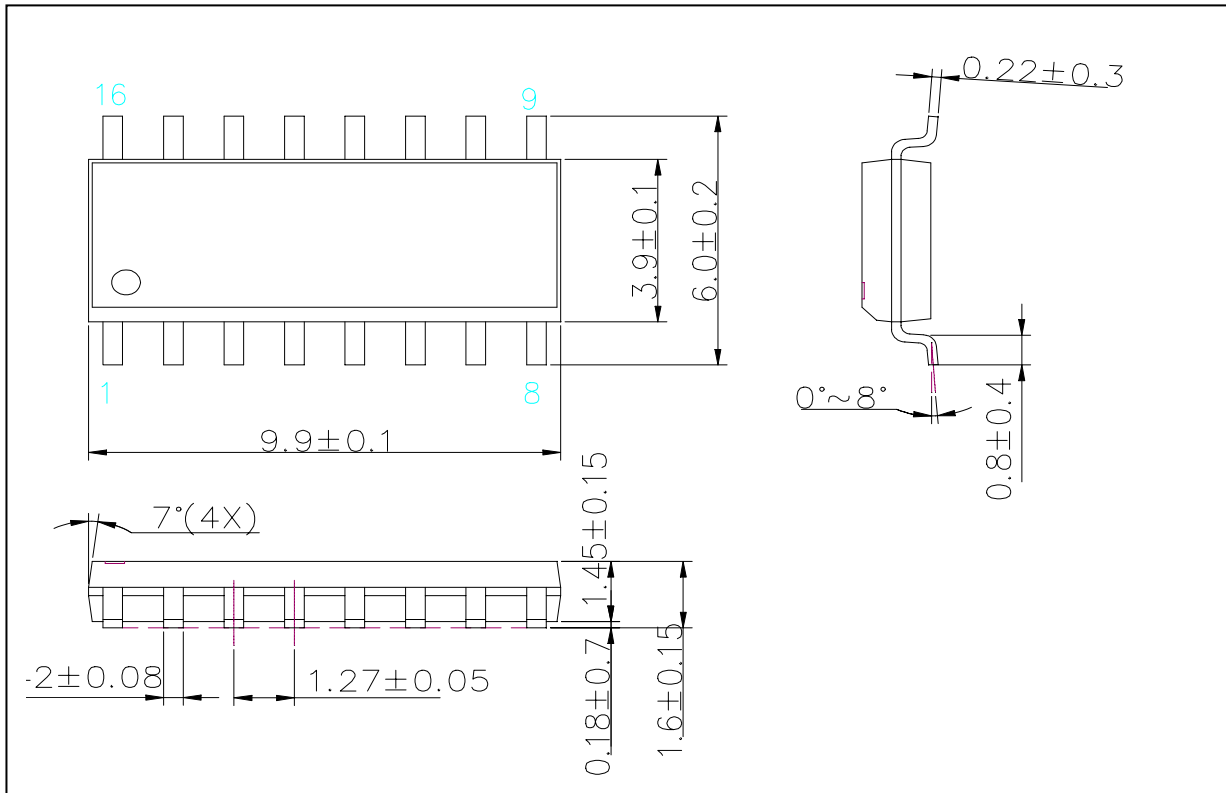


\*Note: For details, please refer to Macroblock's "Policy on Pb-free & Green Package".

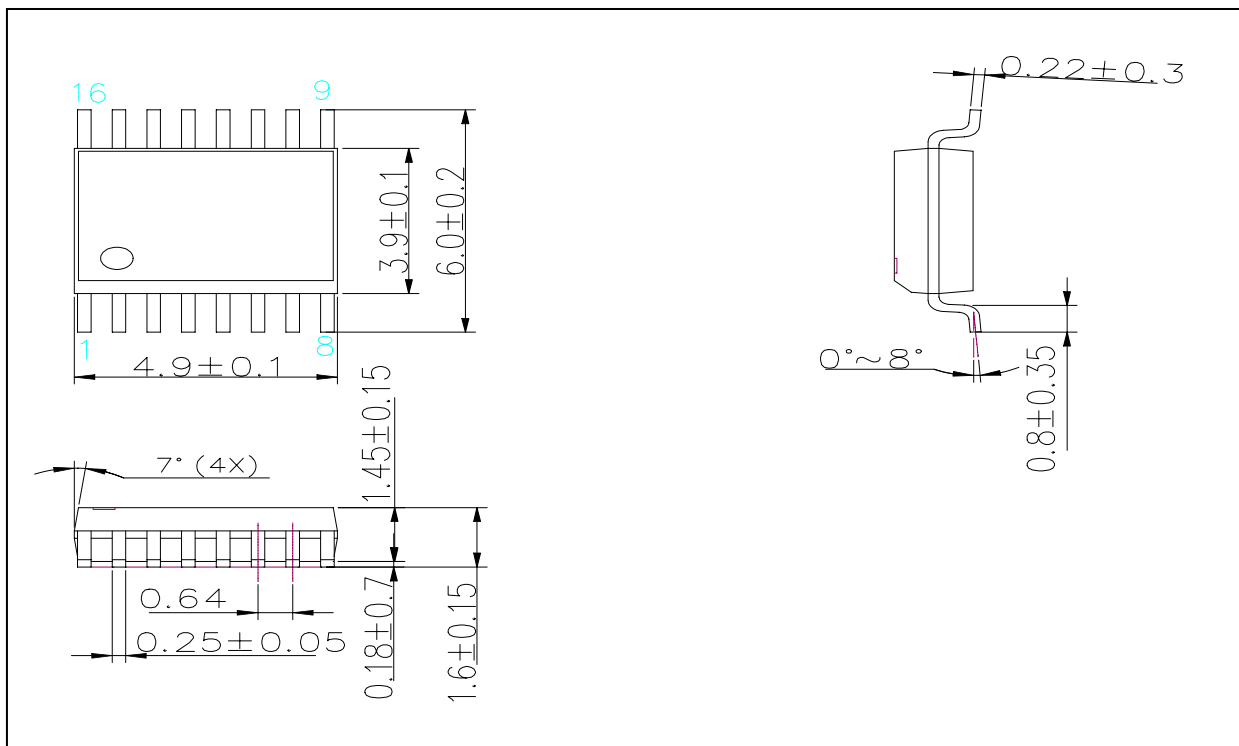
# MBI5167

# 8-Channel Constant Current LED Sink Driver

## Package Outline



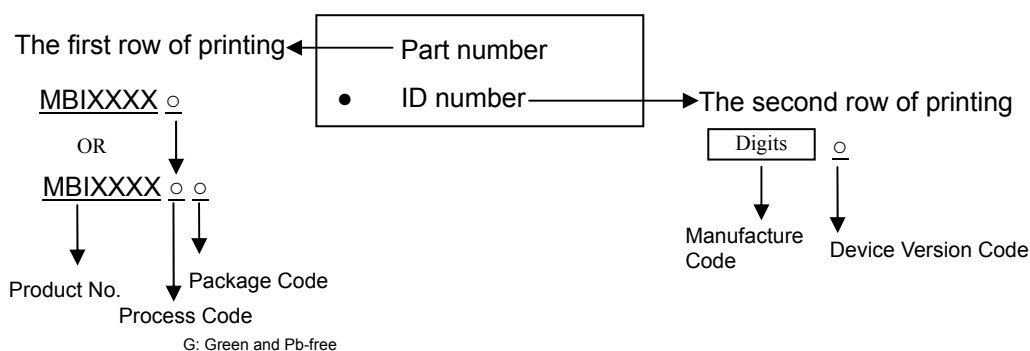
MBI5167GD Outline Drawing



MBI5167GP Outline Drawing

Note: The unit for the outline drawing is mm.



**MBI5167****8-Channel Constant Current LED Sink Driver****Product Top-mark Information****Product Revision History**

Datasheet Version	Device Version Code
V1.00	A
V1.01	B

**Product Ordering Information**

Part Number	Package Type	Weight (g)	Minimum Order Quantity (Pieces per Reel)
MBI5167GD	SOP16-150-1.27	0.13	2,500
MBI5167GP	SSOP16-150-0.64	0.07	2,500

**MBI5167****8-Channel Constant Current LED Sink Driver**

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