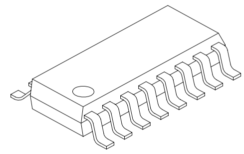
8-Channel Constant Current LED Sink Driver

Features

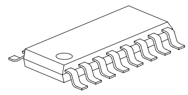
- 8 constant-current output channels
- Constant output current invariant to load voltage change:
  Constant output current range per channel:
  3 - 45mA @ V_{DD}= 5V;
  3 - 30mA @ V_{DD}= 3.3V
- Excellent output current accuracy:
  between channels: ±3% (max.), and
  between ICs: ±6% (max.)
- Output 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	
< ±3%	< ±6%	I_{OUT}= 3mA ~ 30mA @V_{DS}≧0.8V; V_{DD}= 3.3V I_{OUT}= 3mA ~ 45mA @V_{DS}≧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.

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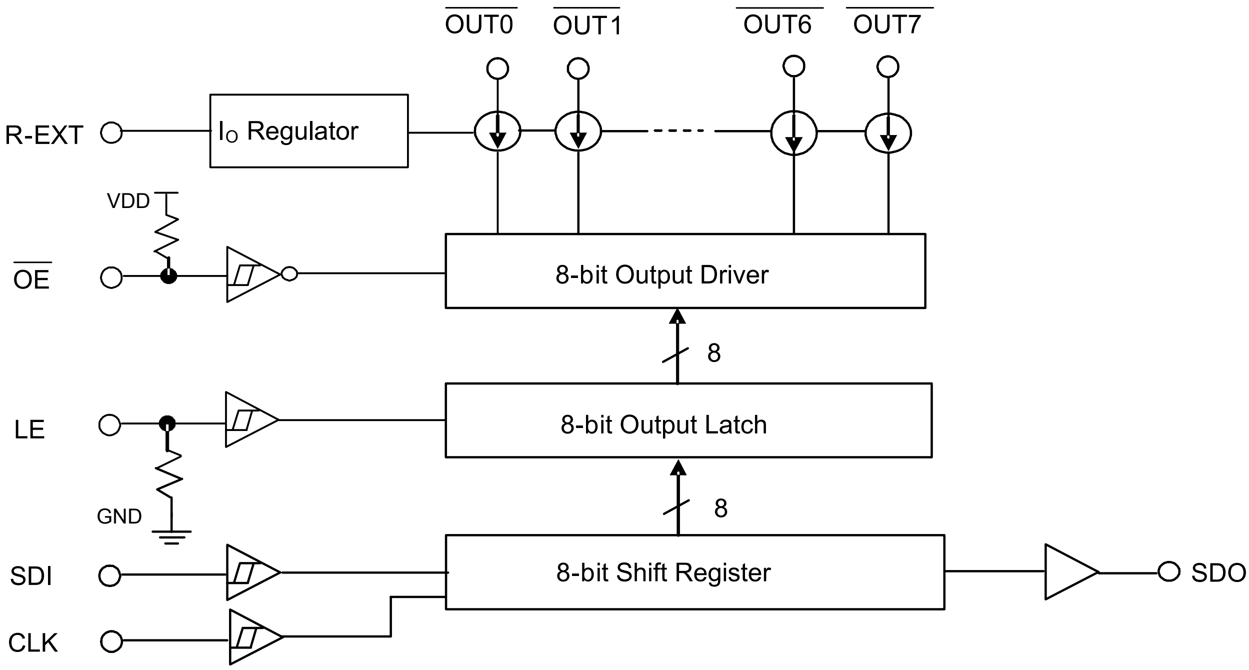
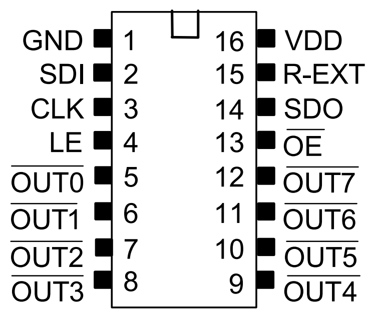
Block Diagram



Terminal Description

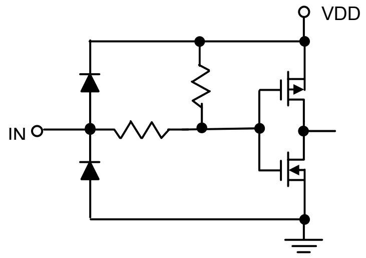
Pin No.	Pin Name	Function
1	GND	Ground terminal for control logic and current sink
2	SDI	Serial-data input to the shift register
3	CLK	Clock input terminal for data shift on rising edge
4	LE	Data strobe input terminal Serial data is transferred to the output latch when LE is high. The data is latched when LE goes low.
5~12	$\overline{\text{OUT0}}$ ~ $\overline{\text{OUT7}}$	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

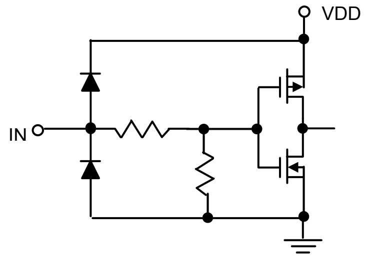


Equivalent Circuits of Input and Output Terminals

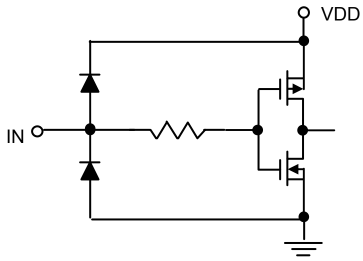
$\overline{\text{OE}}$ terminal



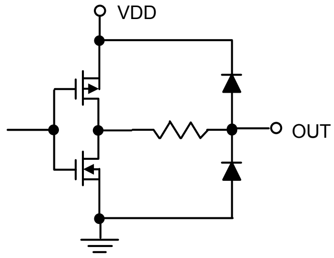
LE terminal



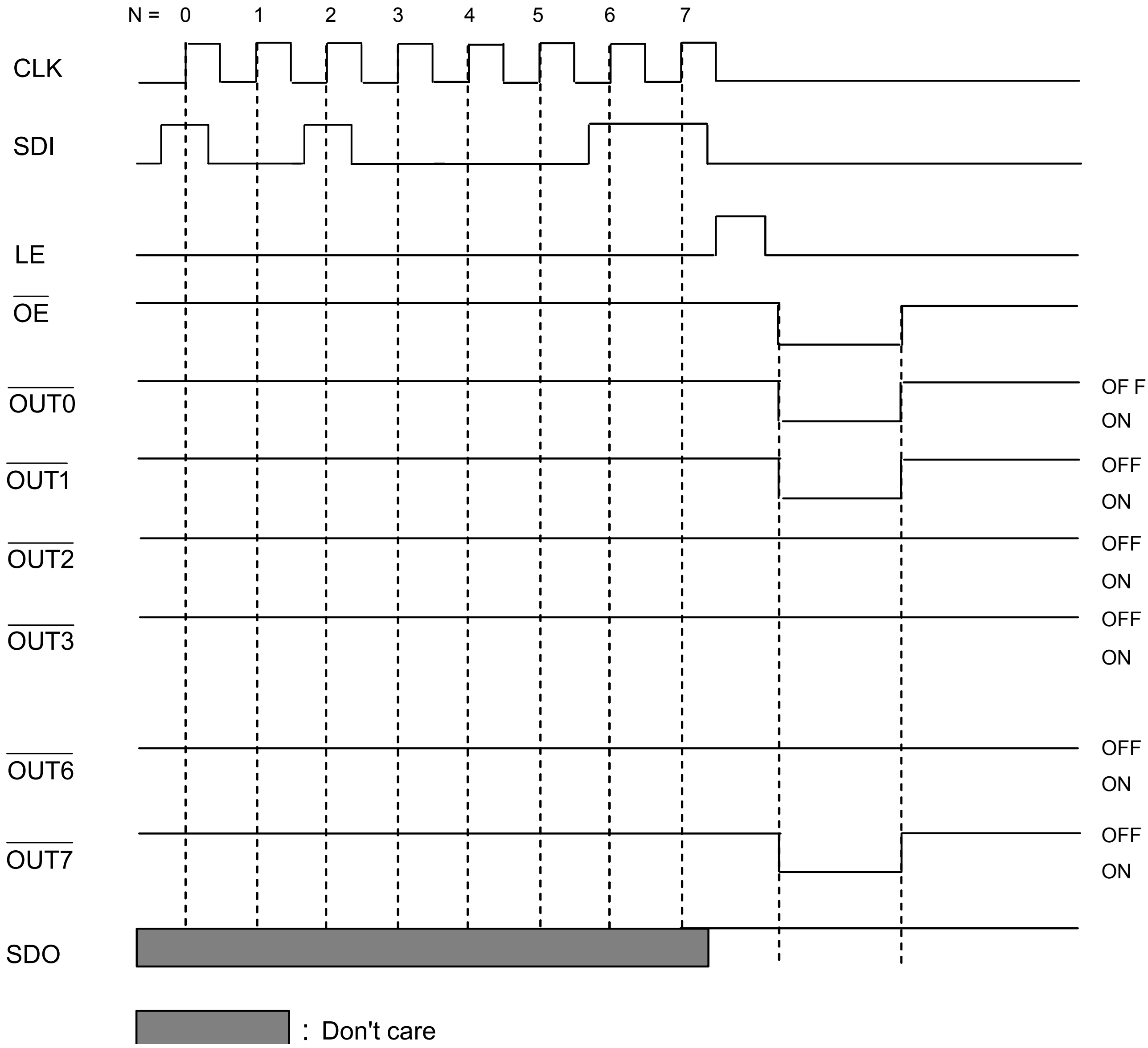
CLK, SDI terminal



SDO terminal



Timing Diagram



Truth Table

CLK	LE	$\overline{OE}$	SDI	$\overline{OUT0}$ … $\overline{OUT5}$ … $\overline{OUT7}$	SDO
↑ (rising edge)	H	L	D_n	$\overline{D_n}$ ….. $\overline{D_{n-5}}$ …. $\overline{D_{n-7}}$	D_{n-7}
↑ (rising edge)	L	L	D_{n+1}	No Change	D_{n-6}
↑ (rising edge)	H	L	D_{n+2}	$\overline{D_{n+2}}$ …. $\overline{D_{n-3}}$ …. $\overline{D_{n-5}}$	D_{n-5}
↓ (falling edge)	X	L	D_{n+3}	$\overline{D_{n+2}}$ …. $\overline{D_{n-3}}$ …. $\overline{D_{n-5}}$	D_{n-5}
↓ (falling edge)	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
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, Ta=25°C)	GD type	P_D	1.57	W
	GP type		1.50	
Thermal Resistance (On 4 Layers PCB, Ta=25°C)	GD type	$R_{th(j-a)}$	79.71	°C/W
	GP type		83.38	
Operating Junction Temperature		$T_{j,max}$	150	°C
Operating Temperature		T_{opr}	-40 ~ +85	°C
Storage Temperature		T_{stg}	-55 ~ +150	°C

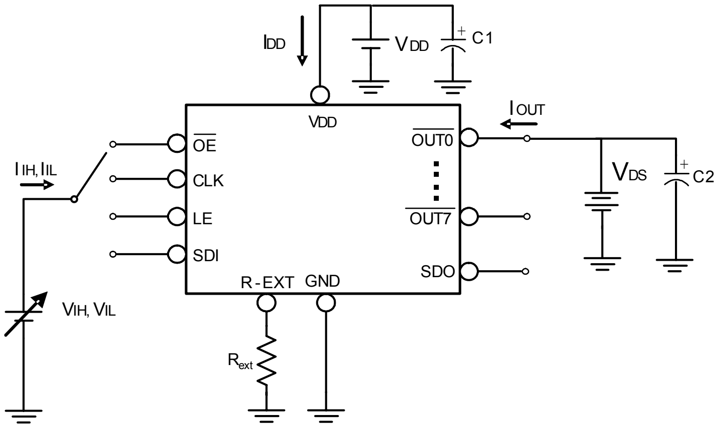
Electrical Characteristics (V_{DD}= 5.0V)

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}	$\overline{OUT0}$ ~ $\overline{OUT7}$		-	-	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 = -40~85ºC		0.7×V_{DD}	-	V_{DD}	V
	"L" level	V_{IL}	T_a = -40~85ºC		GND	-	0.3×V_{DD}	V
Output Leakage Current		I_{OH}	V_{DS}= 17.0V		-	-	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		$I_{OUT(1)}$	V_{DS}≧ 0.8V	R_{ext}= 1860Ω	-	10	-	mA
Current Skew 1		$dI_{OUT(1)}$	I_{OL}= 10mA V_{DS}≧ 0.8V	R_{ext}= 1860Ω	-	±1	±3	%
Output Current 2		$I_{OUT(2)}$	V_{DS}≧ 0.8V	R_{ext}= 744Ω	-	25	-	mA
Current Skew 2		$dI_{OUT(2)}$	I_{OL}= 25mA V_{DS}≧ 0.8V	R_{ext}= 744Ω	-	±1	±3	%
Output Current vs. Output Voltage Regulation		%/dV_{DS}	V_{DS} within 1.0V and 3.0V		-	±0.1	-	% / V
Output Current vs. Sustaining Voltage Regulation		%/dV_{DD}	V_{DD} within 4.5V and 5.5V		-	±1	-	% / V
Pull-up Resistor		R_{IN}(up)	$\overline{OE}$		200	370	700	KΩ
Pull-down Resistor		R_{IN}(down)	LE		200	370	700	KΩ
Supply Current	"OFF"	I_{DD}(off) 1	R_{ext}= Open, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off		-	1.5	2.5	mA
		I_{DD}(off) 2	R_{ext}= 1860Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off		-	3.6	5.0	
		I_{DD}(off) 3	R_{ext}= 744Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off		-	4.8	6.5	
	"ON"	I_{DD}(on) 1	R_{ext}= 1860Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = On		-	5.1	6.5	
		I_{DD}(on) 2	R_{ext}= 744Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = On		-	6.3	8.0	

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}	$\overline{OUT0}$ ~ $\overline{OUT7}$		-	-	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}	Ta = -40~85ºC		0.7×V_{DD}	-	V_{DD}	V
	"L" level	V_{IL}	Ta = -40~85ºC		GND	-	0.3×V_{DD}	V
Output Leakage Current		I_{OH}	V_{DS}= 17.0V		-	-	0.5	μA
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}≧ 0.8V	R_{ext}= 6200Ω	-	3	-	mA
Current Skew 1		$dI_{OUT(1)}$	I_{OL}= 3mA V_{DS}≧ 0.8V	R_{ext}= 6200Ω	-	±1	±3	%
Output Current 2		$I_{OUT(2)}$	V_{DS}≧ 0.8V	R_{ext}= 744Ω	-	25	-	mA
Current Skew 2		$dI_{OUT(2)}$	I_{OL}= 25mA V_{DS}≧ 0.8V	R_{ext}= 744Ω	-	±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 3.0V and 3.6V		-	±1	-	% / V
Pull-up Resistor		R_{IN}(up)	$\overline{OE}$		200	370	700	KΩ
Pull-down Resistor		R_{IN}(down)	LE		200	370	700	KΩ
Supply Current	"OFF"	I_{DD}(off) 1	R_{ext}= Open, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off		-	1.2	2.0	mA
		I_{DD}(off) 2	R_{ext}= 6200Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off		-	2.3	3.0	
		I_{DD}(off) 3	R_{ext}= 744Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off		-	4.5	6.0	
	"ON"	I_{DD}(on) 1	R_{ext}= 6200Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = On		-	3.5	5.0	
		I_{DD}(on) 2	R_{ext}= 744Ω, $\overline{OUT0}$ ~ $\overline{OUT7}$ = On		-	5.7	7.0	

Test Circuit for Electrical Characteristics



Switching Characteristics (V_{DD}= 5.0V)

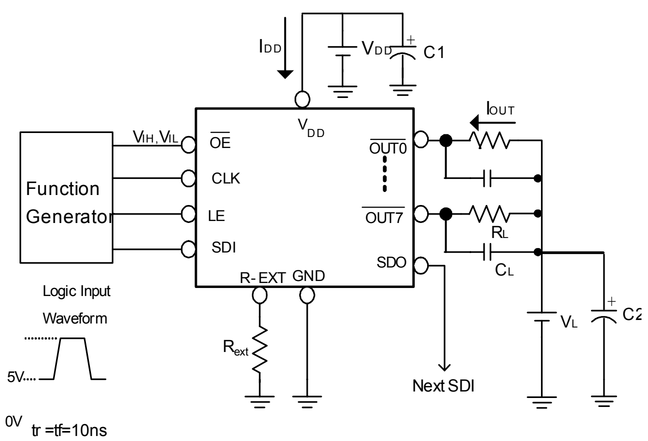
Characteristics		Symbol	Condition	Min.	Typ.	Max.	Unit
Propagation Delay Time ("L" to "H")	CLK - $\overline{OUT2n}$	t_{pLH1}	V_{DD}=5.0V V_{IH}=V_{DD} V_{IL}=GND R_{ext}=930Ω V_{LED}=4.5V R_L=162Ω C_L=10pF C_1=100nF C_2= 4.7uF (Freq.= 500KHz)	-	120*	140	ns
	CLK - $\overline{OUT2n+1}$			-	80	100	ns
	LE - $\overline{OUT2n}$	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.

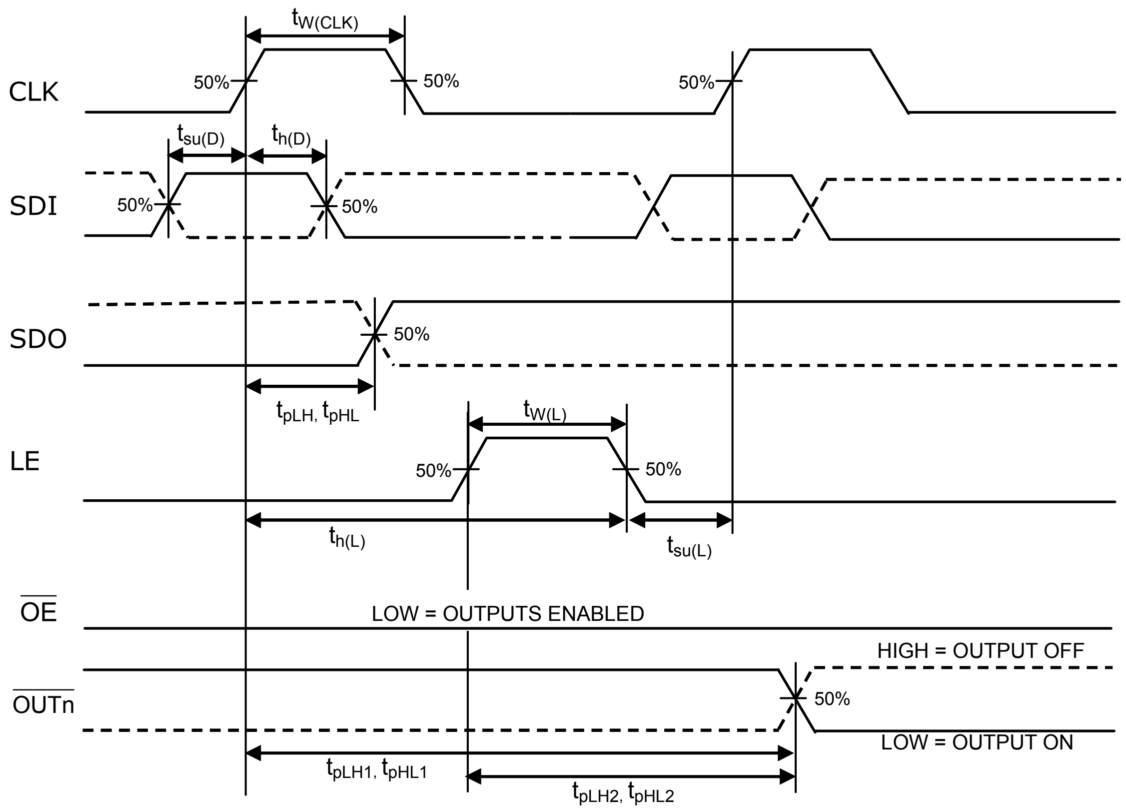
Switching Characteristics (V_{DD}= 3.3V)

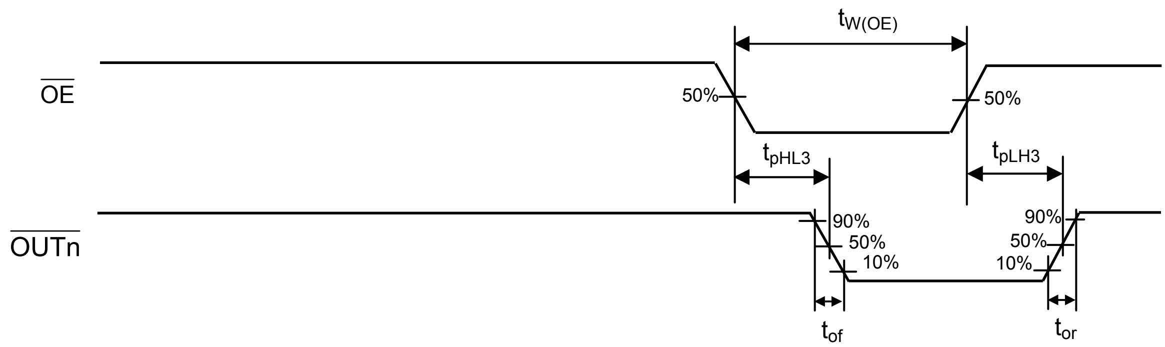
Characteristics		Symbol	Condition	Min.	Typ.	Max.	Unit
Propagation Delay Time ("L" to "H")	CLK - $\overline{OUT2n}$	t_{pLH1}	V_{DD}=3.3V V_{IH}=V_{DD} V_{IL}=GND R_{ext}=930Ω V_{LED}=4.5V R_L=162Ω C_L=10pF C_1=100nF C_2= 4.7uF (Freq.= 500KHz)	-	120*	140	ns
	CLK - $\overline{OUT2n+1}$			-	80	100	ns
	LE - $\overline{OUT2n}$	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



Timing Waveform





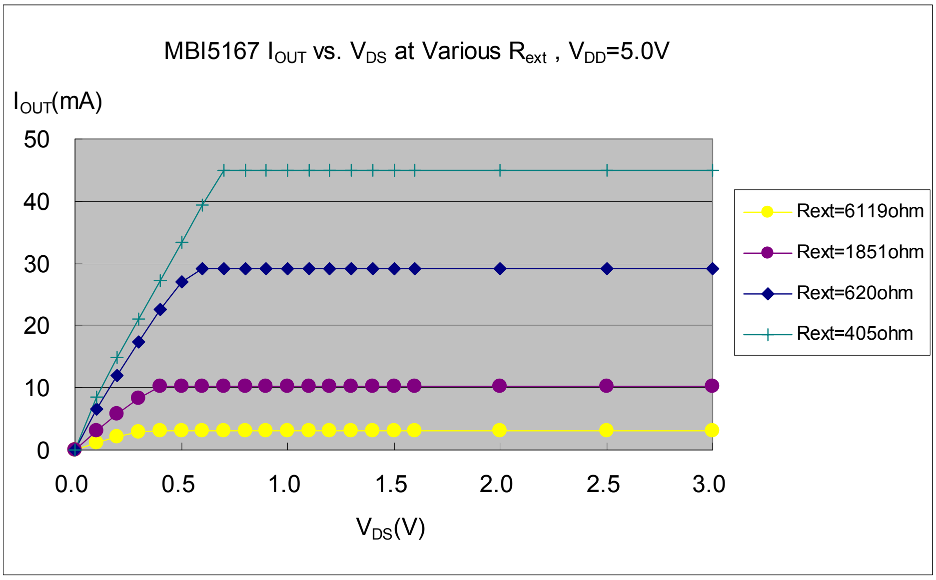
Application Information

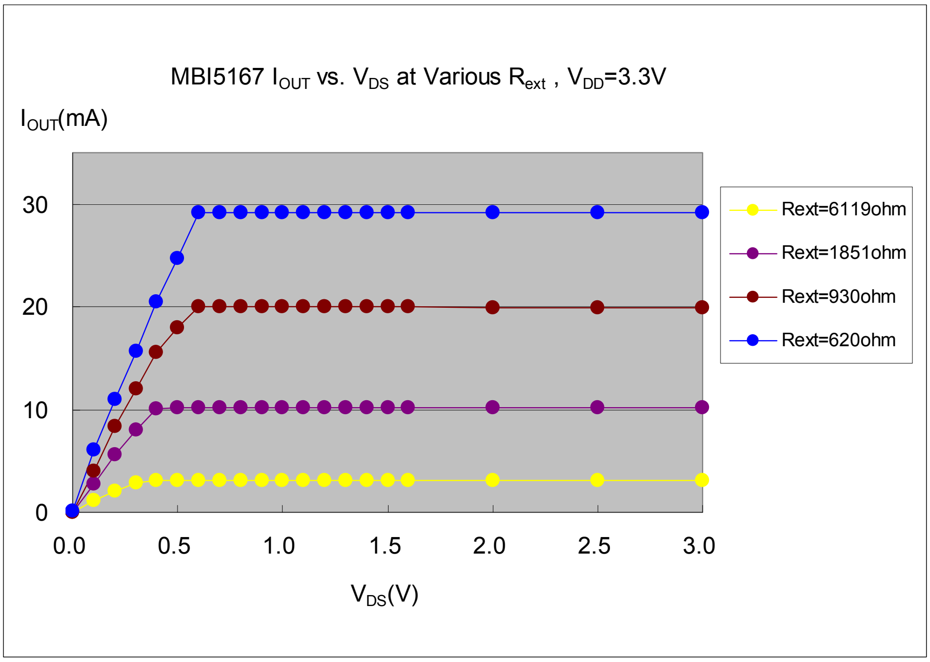
Constant Current

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 ±3%, and that between ICs is less than ±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.



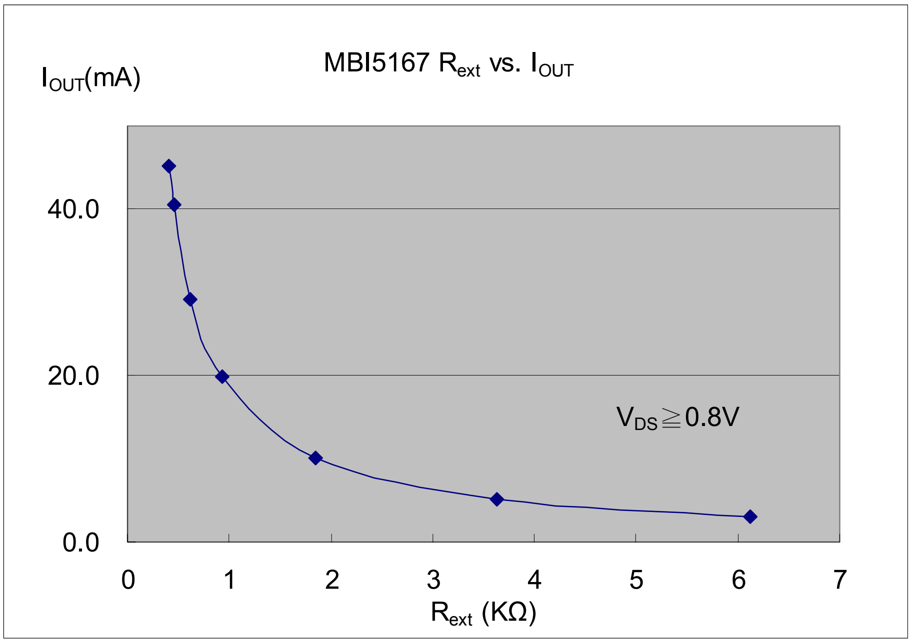


Setting Output Current

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:

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

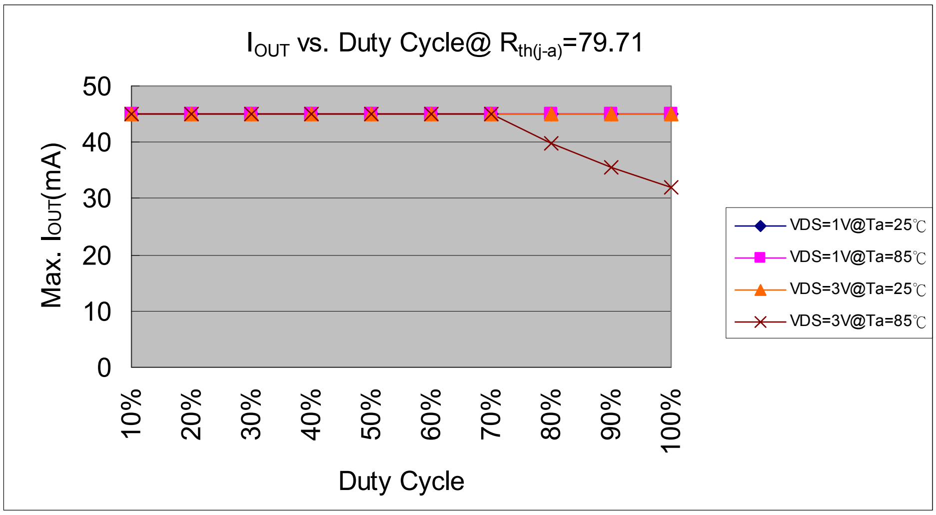


Where R_{ext} is the resistance of the external resistor connected to R-EXT terminal and $V_{R\text{-}EXT}$ is the voltage of R-EXT terminal. The magnitude of current (as a function of R_{ext}) is around 3mA at 6200Ω, 10mA at 1860Ω, and 25mA at 744Ω.

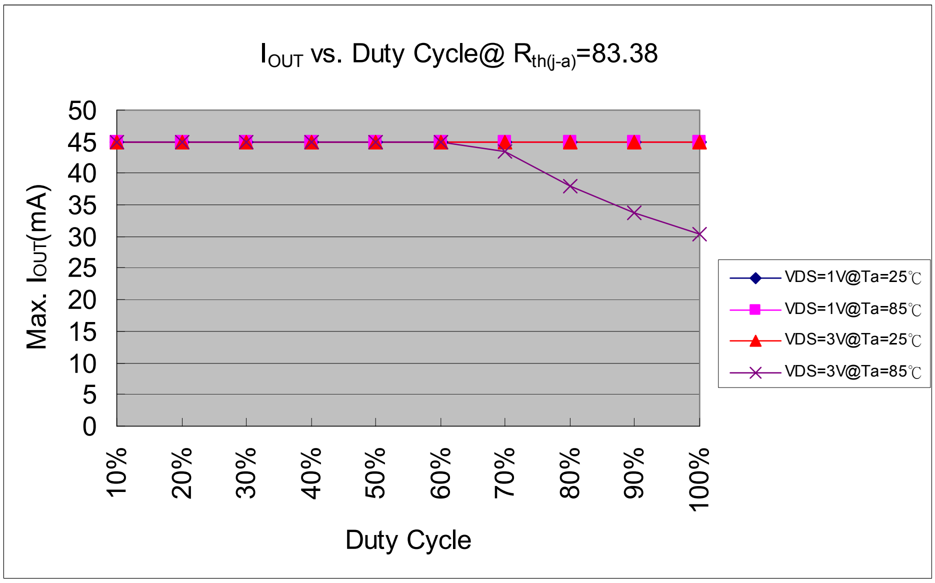
Package Power Dissipation (PD)

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 $P_D(act) \le P_D(max)$, the allowable maximum output current as a function of duty cycle is:

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



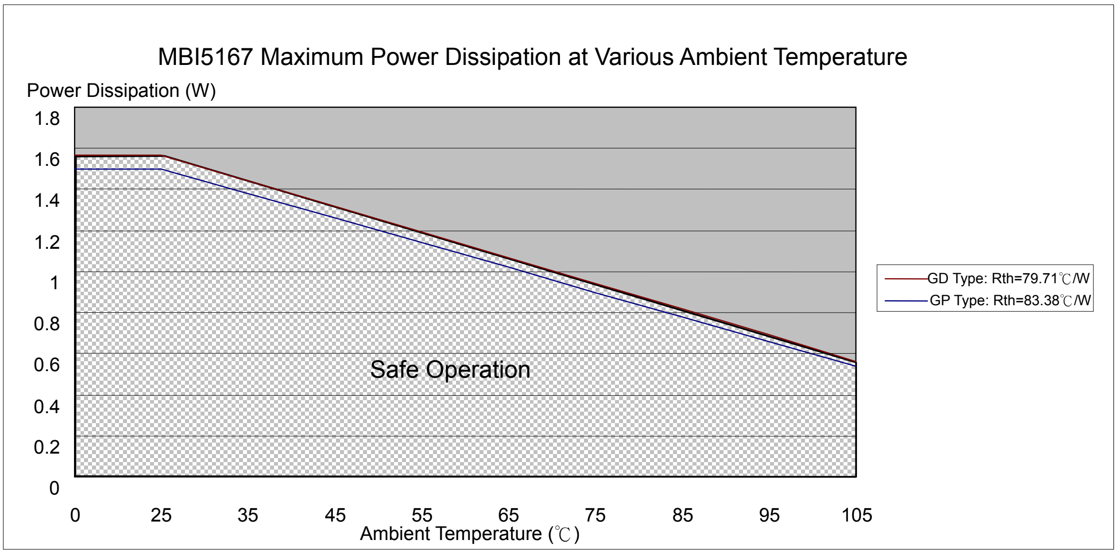
GD Device Type



GP Device Type

Condition: V_{DD}=5V, I_{OUT}= 45mA, 8 Output Channels	
Device Type	$R_{th(j-a)}$ (℃/W)
GD	79.71
GP	83.38

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



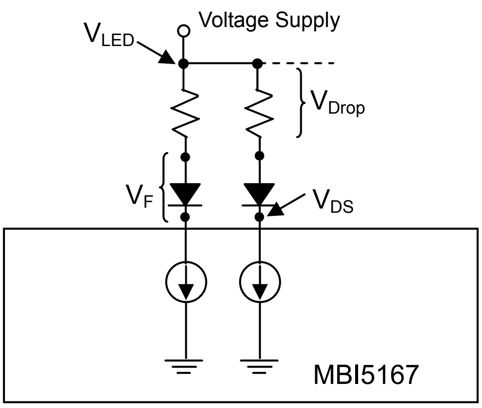
Load Supply Voltage (V_{LED})

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.

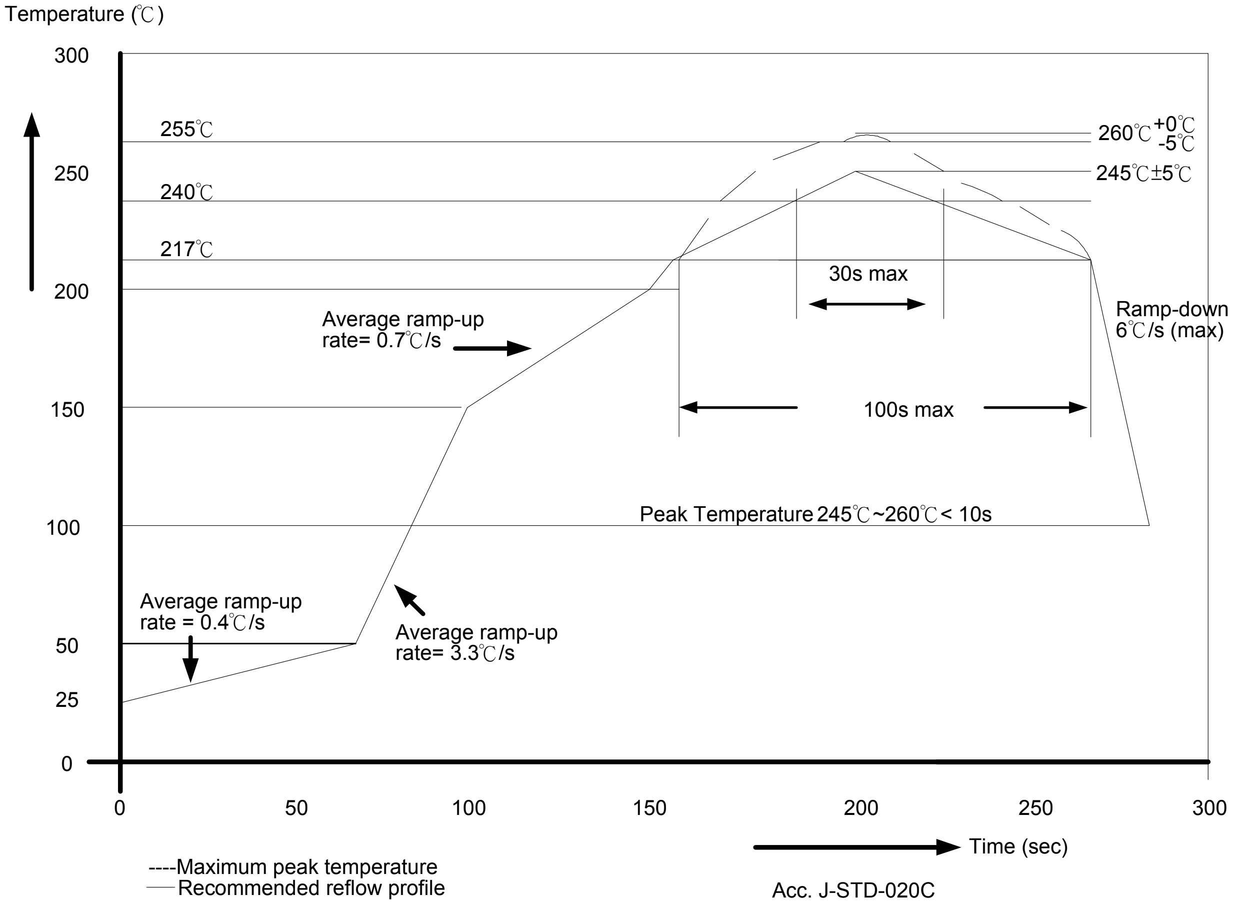


Switching Noise Reduction

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”.

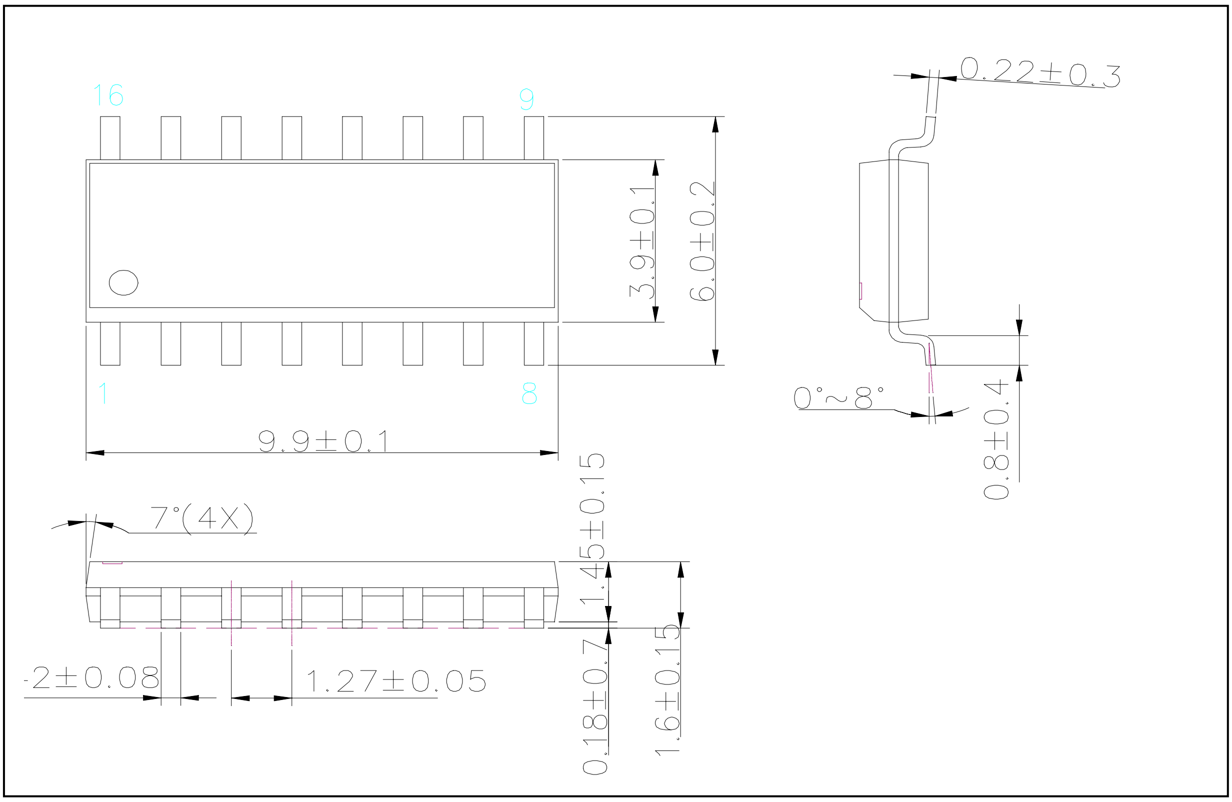
Soldering Process of "Pb-free" Package Plating*

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 215ºC to 240ºC 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.

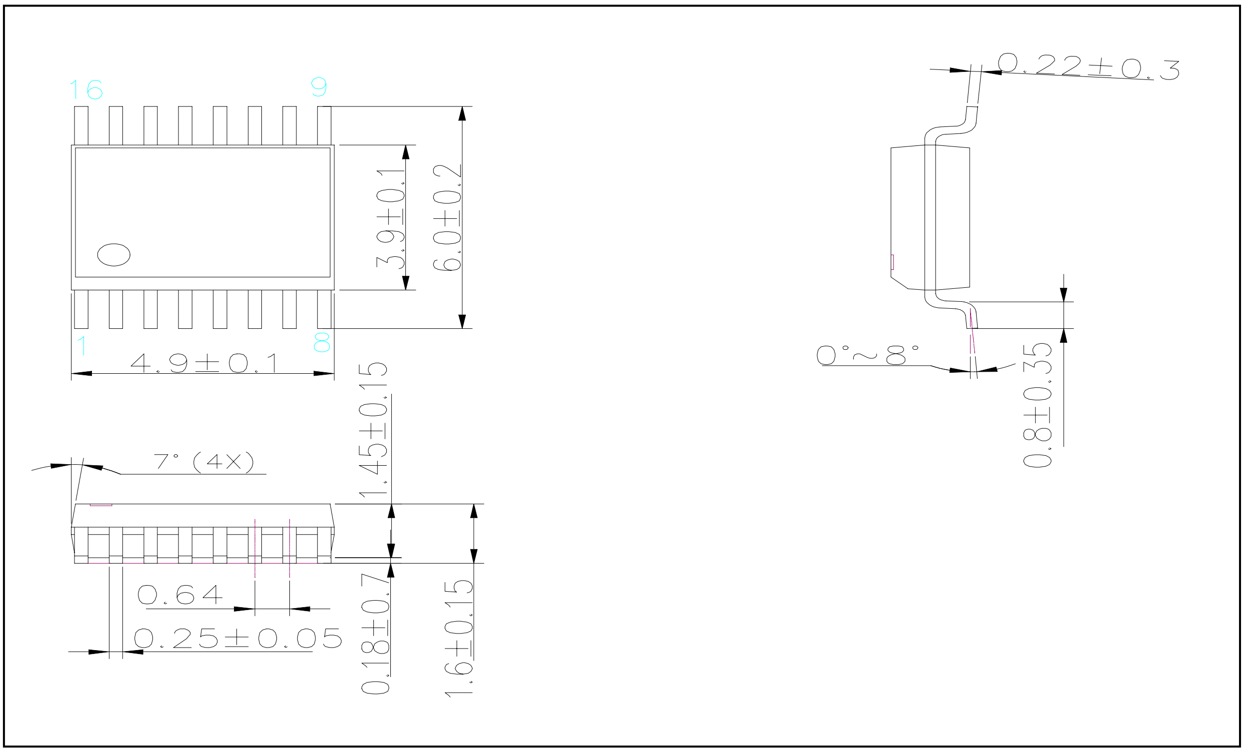


*Note: For details, please refer to Macroblock's "Policy on Pb-free & Green Package".

Package Outline



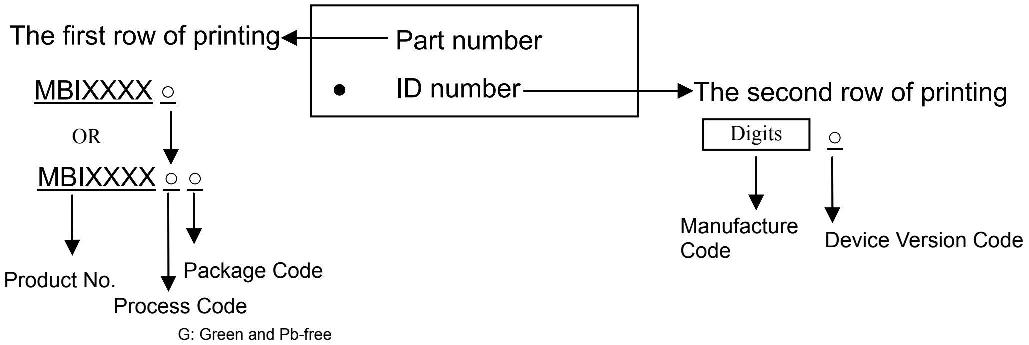
MBI5167GD Outline Drawing



MBI5167GP Outline Drawing

Note: The unit for the outline drawing is mm.

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

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