Macroblock

MBI5025

## 16-channel Constant Current LED Sink Driver

Features

- 16 constant-current output channels
- Constant output current invariant to load voltage change:
  Constant output current range:

  3 - 45 mA @ V_{DD}= 5V;

  3 - 30 mA @ V_{DD}= 3.3V

- Excellent output current accuracy:

  between channels: ±3% (max.), and

  between ICs: ±6% (max.)

- Output current adjusted through an external resistor

- Fast response of output current, $\overline{OE}$ (min.): 250 ns @V_{DD}= 5.0V

- Staggered output delay

- 25MHz clock frequency

- Schmitt trigger input

- 3.3V/ 5V supply voltage

- "Pb-free & Green" Package

Small Outline Package

GD: SOP24-300-1.27

GF: SOP24-300-1.00

Shrink SOP

GP: SSOP24-150-0.64
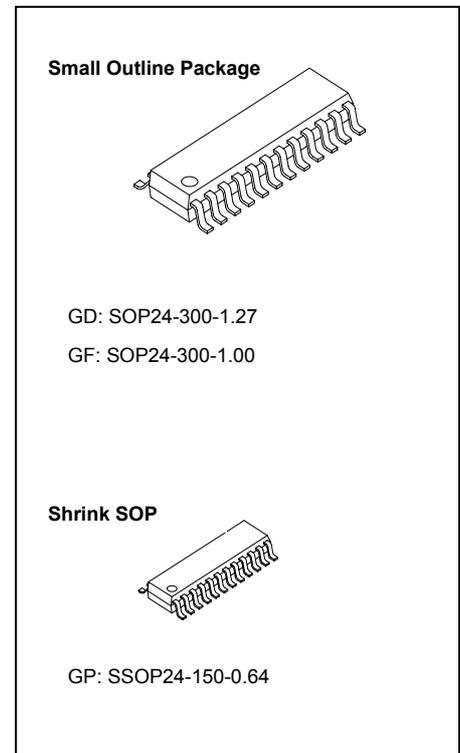
Current Accuracy		Conditions
Between Channels	Between ICs	
< ±3%	< ±6%	I_{OUT}= 3 mA ~ 30 mA @V_{DS}= 0.8V ; V_{DD}= 3.3V I_{OUT}= 3 mA ~ 45 mA @V_{DS}= 0.8V ; V_{DD}= 5.0V

Product Description

With PrecisionDrive™ technology, MBI5025 is designed for LED displays which require to operate 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. MBI5025 contains a serial buffer and data latches which convert serial input data into parallel output format. At MBI5025 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.

MBI5025 provides users with great flexibility and device performance while using MBI5025 in their system design 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 3 mA to 45 mA determined by an external resistor, R_{ext}, which gives users flexibility in controlling the light intensity of LEDs. MBI5025 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.

September 2006, VA.00

Block Diagram
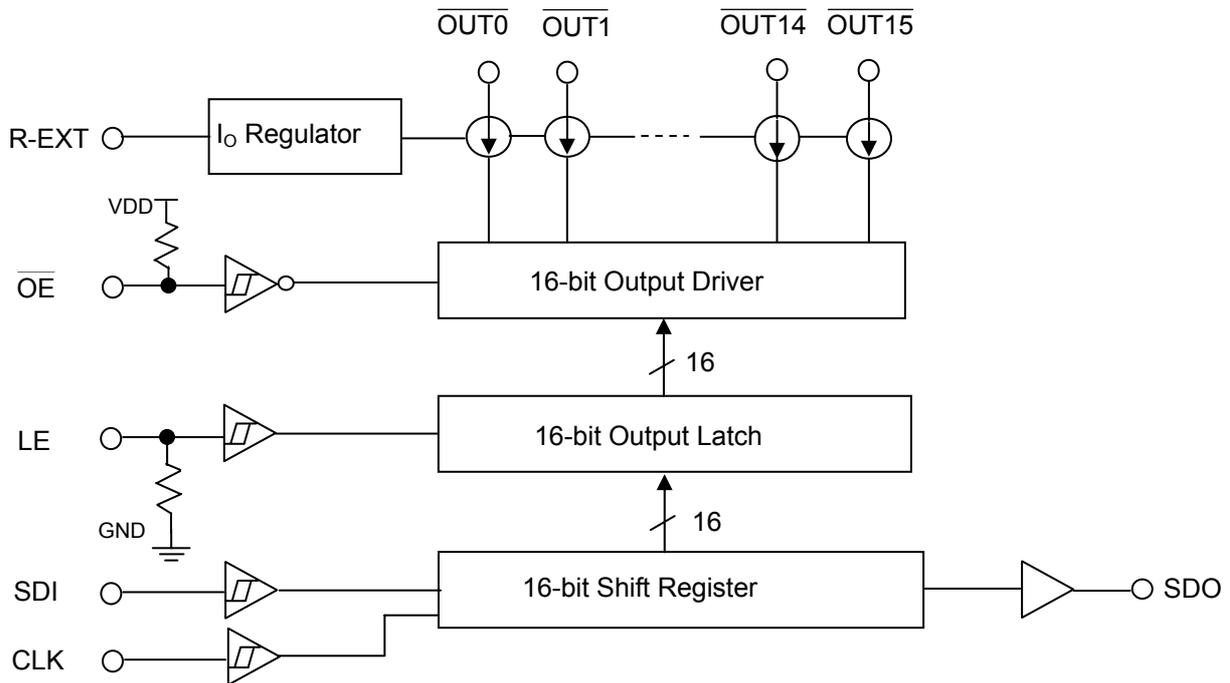
Terminal Description

| 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.
5~20	$\overline{OUT0} \sim \overline{OUT15}$	Constant current output terminals
21	$\overline{OE}$	Output enable terminal When (active) low, the output drivers are enabled; when high, all output drivers are turned OFF (blanked).
22	SDO	Serial-data output to the following SDI of next driver IC. SDO signal change on rising edge of CLK.
23	R-EXT	Input terminal used to connect an external resistor for setting up output current for all output channels
24	VDD	3.3V / 5V supply voltage terminal

## Pin Configuration
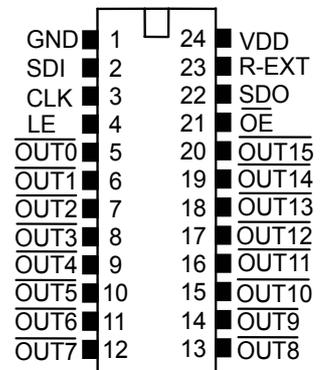
Equivalent Circuits of Inputs and Outputs

$\overline{\text{OE}}$ terminal
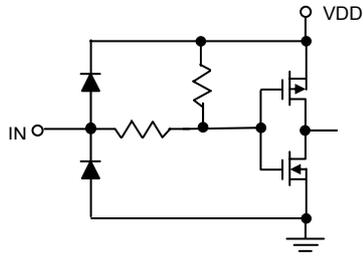
LE terminal
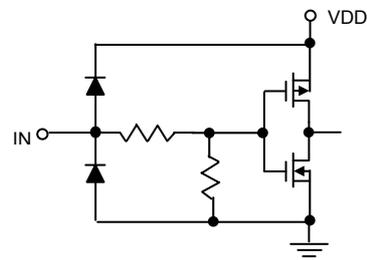
CLK, SDI terminal
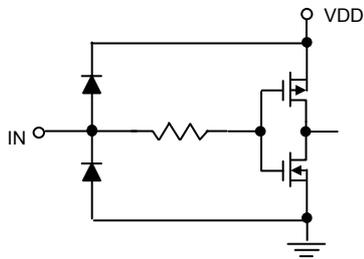
SDO terminal

Timing Diagram

: don't care
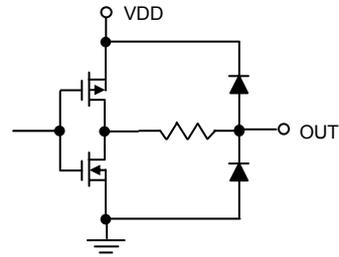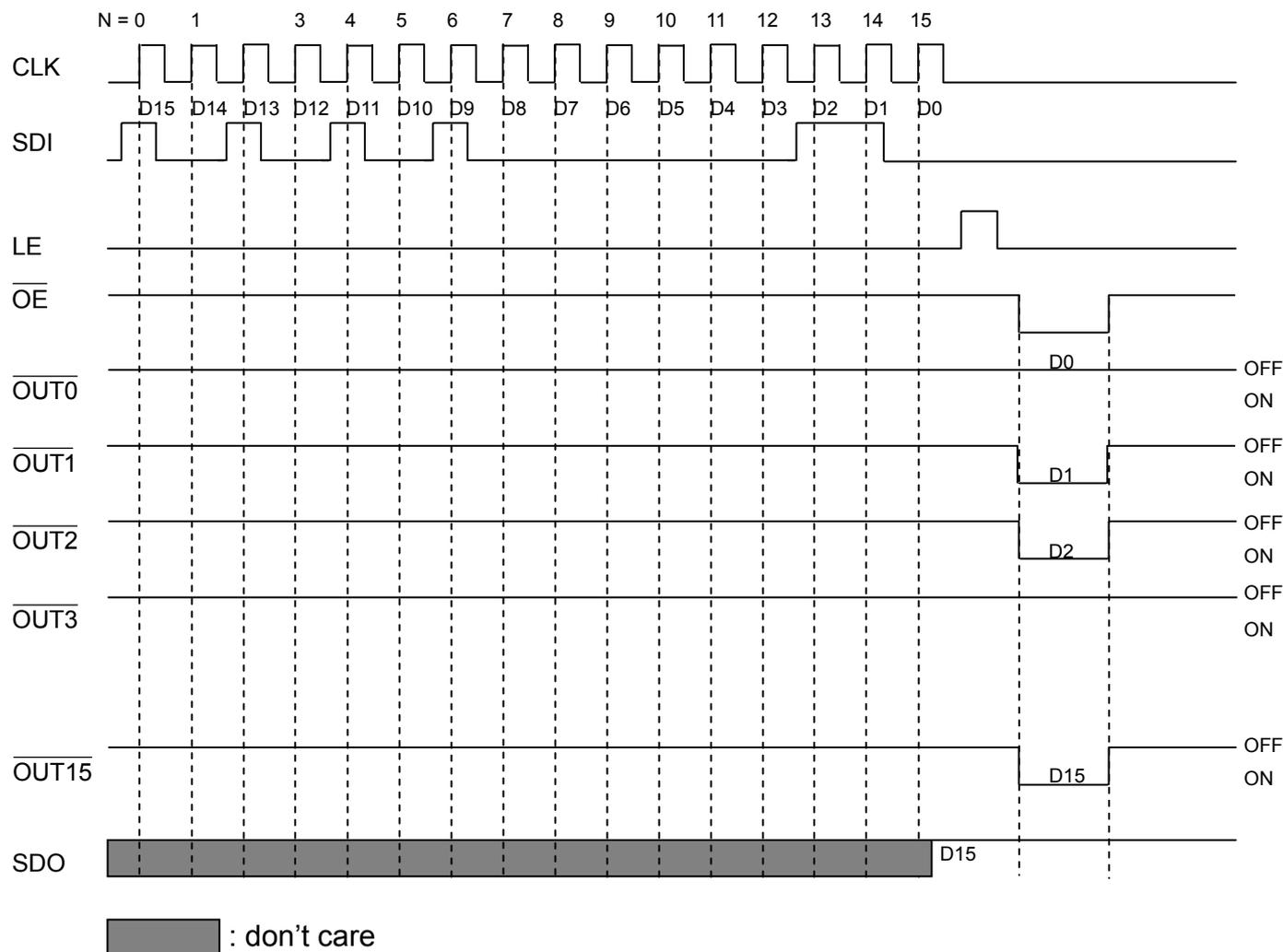
Truth Table

CLK	LE	$\overline{OE}$	SDI	$\overline{OUT0} \dots \overline{OUT\,7} \dots \overline{OUT15}$	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+4}	Off	D_{n-13}

Maximum Ratings

Characteristic		Symbol	Rating	Unit
Supply Voltage		V_{DD}	0 ~ 7.0	V
Input Voltage		V_{IN}	-0.4 ~ V_{DD} + 0.4	V
Output Current		I_{OUT}	+90	mA
Sustaining Voltage at OUT Port		V_{DS}	-0.5 ~ +17.0	V
Clock Frequency		F_{CLK}	25	MHz
GND Terminal Current		I_{GND}	+1000	mA
Power Dissipation (On PCB, Ta=25°C)	GD– type	P_D	2.88	W
	GF – type		1.88	
	GP – type		1.76	
Thermal Resistance (On PCB, Ta=25°C)	GD– type	$R_{th(j-a)}$	46.60	°C/W
	GF – type		66.66	
	GP – type		70.90	
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}	$\overline{OUT0}$ ~ $\overline{OUT15}$		-	-	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}	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		4.6	-	-	V
Output Current 1		I_{OUT1}	V_{DS}= 1.0V	R_{ext}= 1860Ω	-	10	-	mA
Current Skew		dI_{OUT1}	I_{OL} = 10mA V_{DS}= 1.0V	R_{ext}= 1860Ω	-	±1	±3	%
Output Current 2		I_{OUT2}	V_{DS}= 1.0V	R_{ext} = 744Ω	-	25	-	mA
Current Skew		dI_{OUT2}	I_{OL} = 25mA V_{DS}= 1.0V	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 4.5V and 5.5V		-	±1.0	-	% / 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, $\overline{OUT0}$ ~ $\overline{OUT15}$ = Off		-	2.4	5.0	mA
		I_{DD}(off) 2	R_{ext}= 1860Ω, $\overline{OUT0}$ ~ $\overline{OUT15}$ = Off		-	4.3	7.0	
		I_{DD}(off) 3	R_{ext}= 744Ω, $\overline{OUT0}$ ~ $\overline{OUT15}$ = Off		-	5.7	9.0	
	"ON"	I_{DD}(on) 1	R_{ext}= 1860Ω, $\overline{OUT0}$ ~ $\overline{OUT15}$ = On		-	4.6	8.5	
		I_{DD}(on) 2	R_{ext}= 744Ω, $\overline{OUT0}$ ~ $\overline{OUT15}$ = On		-	6.0	9.5	

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}	$\overline{OUT0}$ ~ $\overline{OUT15}$		-	-	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_{OUT1}	V_{DS}= 1.0V	R_{ext}= 6200Ω	-	3	-	mA
Current Skew		dI_{OUT1}	I_{OL}= 3mA V_{DS}= 1.0V	R_{ext}= 6200Ω	-	±1	±3	%
Output Current 2		I_{OUT2}	V_{DS}= 1.0V	R_{ext}= 744Ω	-	25	-	mA
Current Skew		dI_{OUT2}	I_{OL}= 25mA V_{DS}= 1.0V	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 4.5V		-	±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, $\overline{OUT0}$ ~ $\overline{OUT15}$ = Off		-	1.8	5.0	mA
		I_{DD}(off) 2	R_{ext}= 6200Ω, $\overline{OUT0}$ ~ $\overline{OUT15}$ = Off		-	4.0	7.0	
		I_{DD}(off) 3	R_{ext}= 744Ω, $\overline{OUT0}$ ~ $\overline{OUT15}$ = Off		-	5.2	8.5	
	"ON"	I_{DD}(on) 1	R_{ext}= 6200Ω, $\overline{OUT0}$ ~ $\overline{OUT15}$ = On		-	4.5	7.0	
		I_{DD}(on) 2	R_{ext}= 744Ω, $\overline{OUT0}$ ~ $\overline{OUT15}$ = On		-	5.5	8.5	

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}		-	115	135	ns
	CLK - $\overline{OUT2n+1}$			-	80	100	ns
	LE - $\overline{OUT2n}$	t_{pLH2}		-	115	135	ns
	LE - $\overline{OUT2n+1}$			-	80	100	ns
	$\overline{OE}$ - $\overline{OUT2n}$	t_{pLH3}		-	115	135	ns
	$\overline{OE}$ - $\overline{OUT2n+1}$			-	80	100	
	CLK - SDO	t_{pLH4}		-	20	40	ns
Propagation Delay Time ("H" to "L")	CLK - $\overline{OUT2n}$	t_{pHL1}		-	115	135	ns
	CLK - $\overline{OUT2n+1}$			-	80	100	ns
	LE - $\overline{OUT2n}$	t_{pHL2}	V_{DD}=5.0 V V_{DS}=1.0 V V_{IH}=V_{DD} V_{IL}=GND R_{ext}=930 Ω V_L=4.5 V R_L=162 Ω C_L=10 pF	-	115	135	ns
	LE - $\overline{OUT2n+1}$			-	80	100	ns
	$\overline{OE}$ - $\overline{OUT2n}$	t_{pHL3}		-	115	135	
	$\overline{OE}$ - $\overline{OUT2n+1}$			-	80	100	ns
	CLK - SDO	t_{pHL4}		-	20	40	ns
Pulse Width	CLK	$t_{w(CLK)}$		20	-	-	ns
	LE	$t_{w(L)}$		20	-	-	ns
	$\overline{OE}$	$t_{w(OE)}$		250	-	-	ns
Hold Time for LE		$t_{h(L)}$		30		-	ns
Setup Time for LE		$t_{su(L)}$		5		-	ns
Hold Time for SDI		$t_{h(D)}$		5	-	-	ns
Setup Time for SDI		$t_{su(D)}$		3	-	-	ns
Maximum CLK Rise Time		t_r		-	-	500	ns
Maximum CLK Fall Time		t_f		-	-	500	ns
SDO Rise Time		$t_{r,SDO}$			10		ns
SDO Fall Time		$t_{f,SDO}$			10		ns
Output Rise Time of Output Ports		t_{or}		-	160	180	ns
Output Fall Time of Output Ports		t_{of}		-	70	90	ns

* Among output channels exist 35ns delay time between odd number $\overline{OUT2n+1}$ (e.g.:Bit1/Bit3/Bit5…)and even number $\overline{OUT2n}$ (ex: Bit0/Bit2/Bit4…). MBI5025 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}		-	115	135	ns
	CLK - $\overline{OUT2n+1}$			-	80	100	ns
	LE - $\overline{OUT2n}$	t_{pLH2}		-	115	135	ns
	LE - $\overline{OUT2n+1}$			-	80	100	ns
	$\overline{OE}$ - $\overline{OUT2n}$	t_{pLH3}		-	115	135	ns
	$\overline{OE}$ - $\overline{OUT2n+1}$			-	80	100	
	CLK - SDO	t_{pLH4}		-	20	40	ns
Propagation Delay Time ("H" to "L")	CLK - $\overline{OUT2n}$	t_{pHL1}	V_{DD}=3.3 V V_{DS}=1.0 V V_{IH}=V_{DD} V_{IL}=GND R_{ext}=930 Ω V_L=4.5 V R_L=162 Ω C_L=10 pF	-	115	135	ns
	CLK - $\overline{OUT2n+1}$			-	80	100	ns
	LE - $\overline{OUT2n}$	t_{pHL2}		-	115	135	ns
	LE - $\overline{OUT2n+1}$			-	80	100	ns
	$\overline{OE}$ - $\overline{OUT2n}$	t_{pHL3}		-	115	135	ns
	$\overline{OE}$ - $\overline{OUT2n+1}$			-	80	100	
	CLK - SDO	t_{pHL4}		-	20	40	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		$t_{h(L)}$		30	-	-	ns
Setup Time for LE		$t_{su(L)}$		5	-	-	ns
Hold Time for SDI		$t_{h(D)}$		5	-	-	ns
Setup Time for SDI		$t_{su(D)}$		3	-	-	ns
Maximum CLK Rise Time		t_r		-	-	500	ns
Maximum CLK Fall Time		t_f		-	-	500	ns
SDO Rise Time		$t_{r,SDO}$			10		ns
SDO Fall Time		$t_{f,SDO}$			10		ns
Output Rise Time of Output Ports		t_{or}		-	160	180	ns
Output Fall Time of Output Ports		t_{of}		-	70	90	ns

Test Circuit for Switching Characteristics

Timing Waveform

CLK

$t_{W(CLK)}$

50%   50%   50%

SDI

$t_{su(D)}$ $t_{h(D)}$

50%   50%

SDO

50%

t_{pLH}, t_{pHL}

LE

$t_{W(L)}$

50%   50%

$t_{h(L)}$ $t_{su(L)}$

$\overline{OE}$ LOW = OUTPUTS ENABLED

HIGH = OUTPUT OFF

$\overline{OUTn}$ 50%

LOW = OUTPUT ON

t_{pLH1}, t_{pHL1} t_{pLH2}, t_{pHL2}

$\overline{OE}$

$t_{W(OE)}$

50%   50%

t_{pHL3} t_{pLH3}

$\overline{OUTn}$

90%   90%
50%   50%
10%   %

t_{of} t_{or}
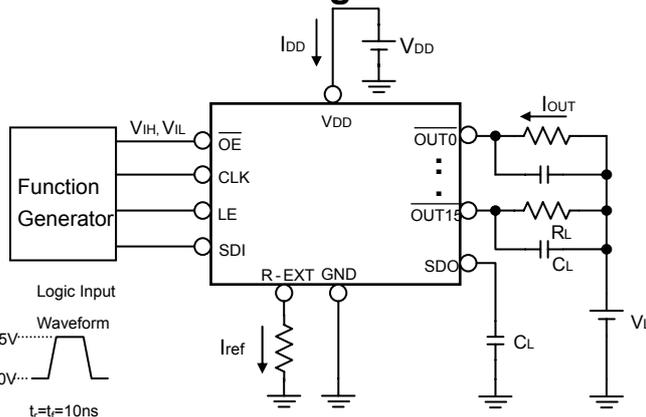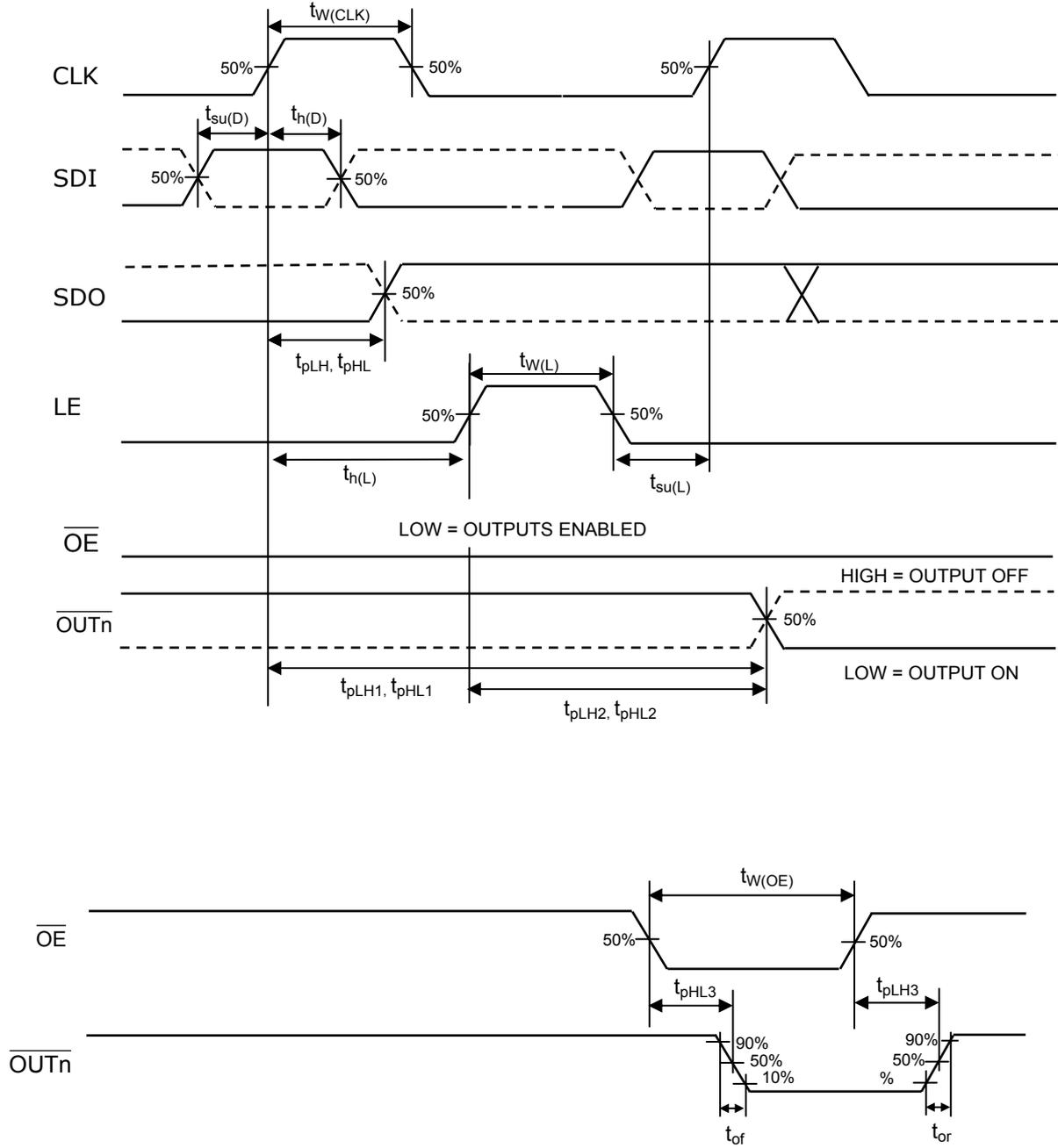
Application Information

Constant Current

To design LED displays, MBI5025 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 current characteristic of output stage is flat and users can refer to the figure as shown below. The output current can be kept constant regardless of the variations of LED forward voltages (V_F). This performs as a perfection of load regulation.

MBI5025 I_{OUT} vs. V_{DS} at Various R_{ext}, V_{DD}=5.0V

MBI5025 I_{OUT} vs. V_{DS} at Various R_{ext}, V_{DD}=3.3V
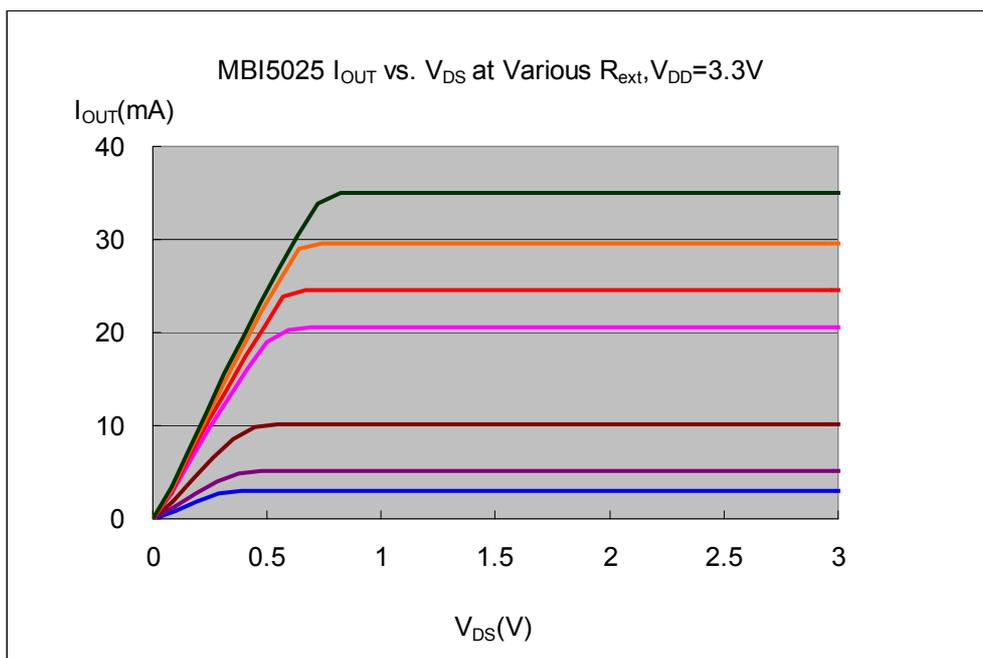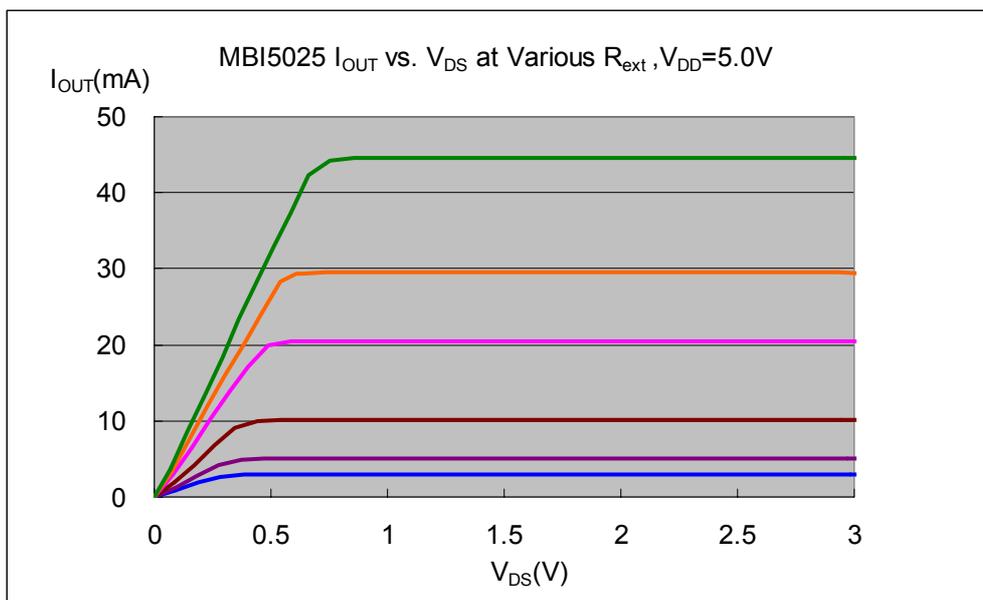
Adjusting Output Current

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.

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

V_{R-EXT} = 1.24V ; I_{OUT} = V_{R-EXT} * (1/Rext) x 15; R_{ext} = (V_{R-EXT} / I_{OUT}) x 15
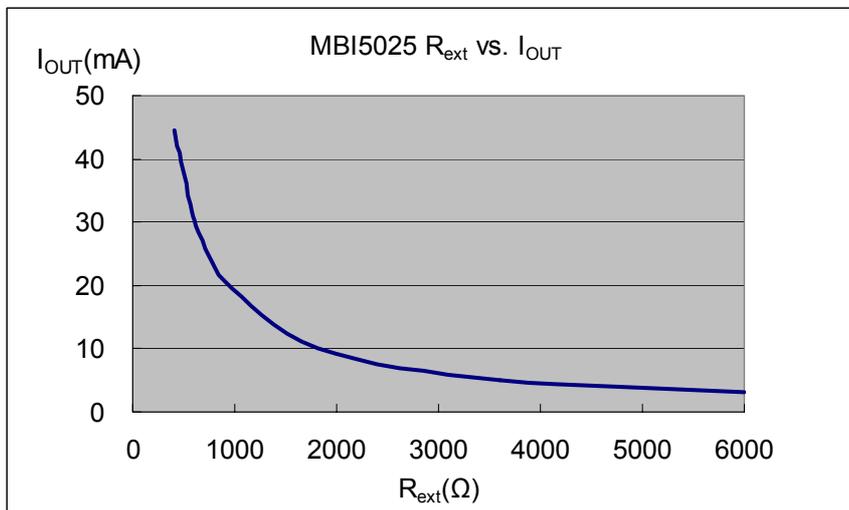
Where R_{ext} is the resistance of the external resistor connected to R-EXT terminal and V_{R-EXT} is the voltage of R-EXT terminal. The magnitude of current (as a function of R_{ext}) is around 25mA at 744Ω and 10mA at 1860Ω.

Soldering Process of "Pb-free & Green" Package*

Macroblock has defined "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 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.

Temperature (℃)


```
300

     255℃                                                260℃ +0℃
                                                               -5℃
250                                                     245℃±5℃
     240℃

     217℃
                                                    30s max
200
          Average ramp-up
          rate= 0.7℃/s                                      Ramp-down
                                                            6℃/s (max)

150                                       100s max

                                    Peak Temperature 245℃~260℃< 10s
100

     Average ramp-up
     rate = 0.4℃/s
 50               Average ramp-up
                  rate= 3.3℃/s
 25

  0
     0      50     100    150    200    250    300
```

Time (sec)

----Maximum peak temperature
——Recommended reflow profile   Acc. J-STD-020C
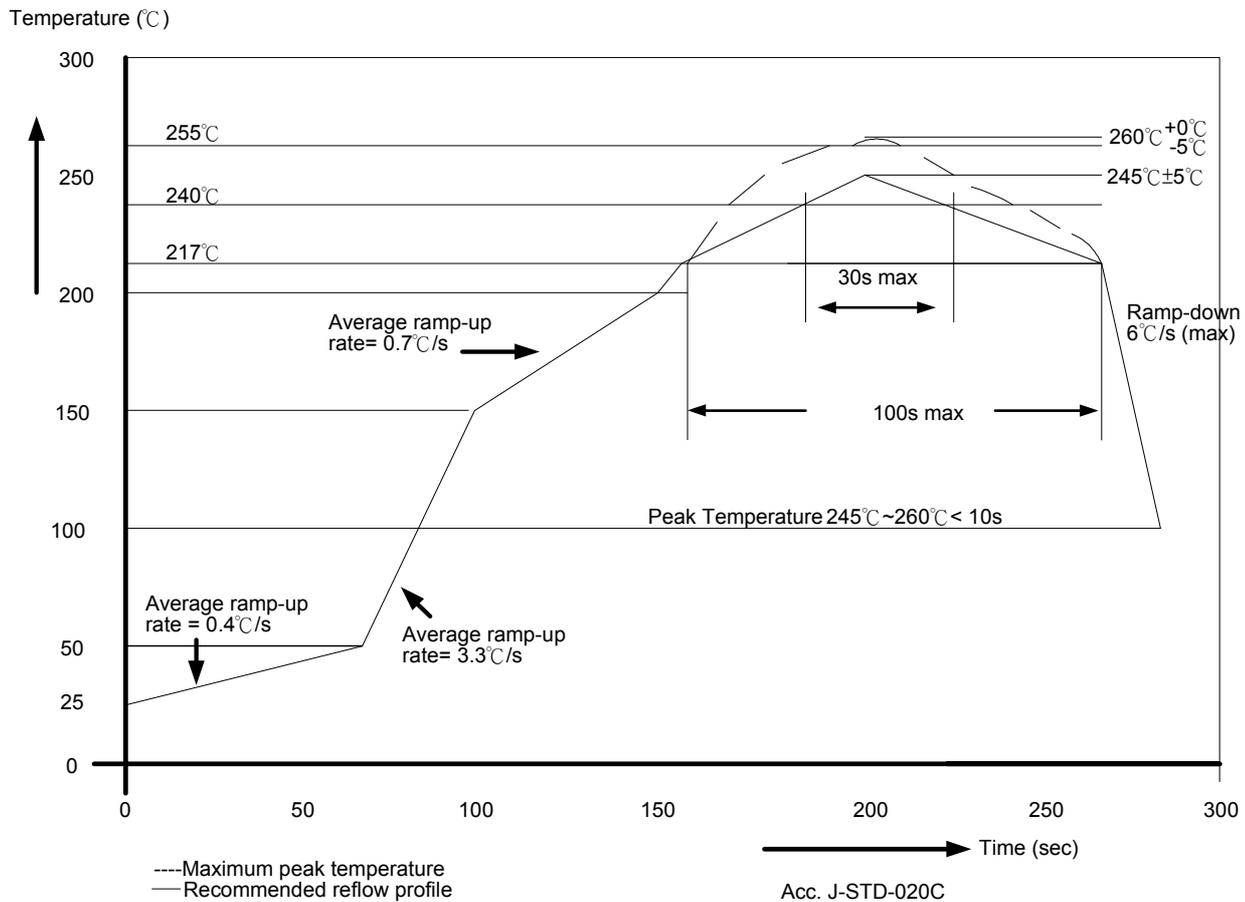
*Note1: For details, please refer to Macroblock's "Policy on Pb-free & Green Package".

Package Power Dissipation (PD)

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

$I_{OUT} = \{ [(Tj - Ta) / R_{th(j-a)}] - (I_{DD} \times V_{DD}) \} / V_{DS} / Duty / 16$, where Tj = 150°C.
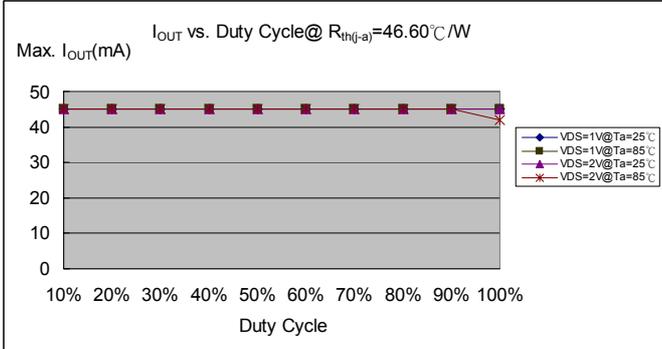
MBI5025GD
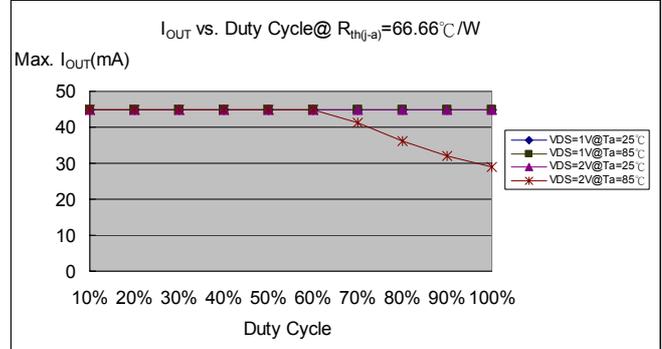
MBI5025GF
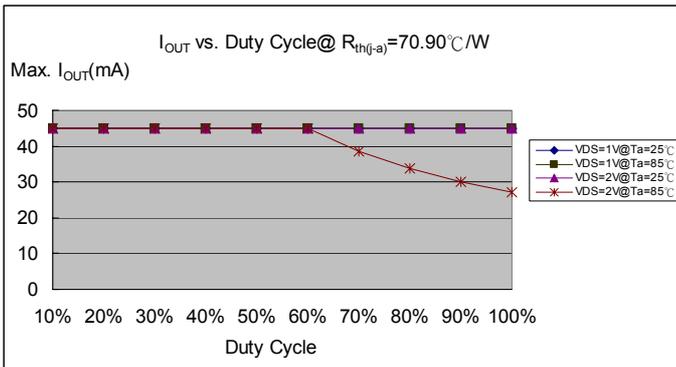
MBI5025GP

Condition: I_{OUT}= 45mA,16 output Channels	
Device Type	$R_{th(j-a)}$(°C/W)
GD	46.60
GF	66.66
GP	70.90

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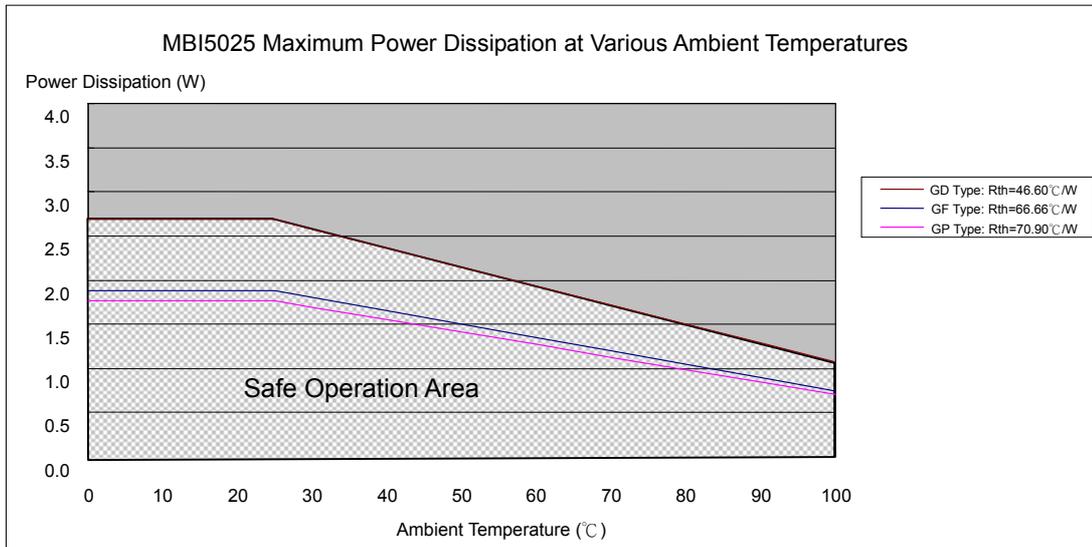
Load Supply Voltage (V_{LED})

MBI5025 are designed to operate with V_{DS} ranging from 0.4V to 0.8V (depending on I_{OUT}=3~45mA) considering the package power dissipating limits. V_{DS} may be higher enough to make $P_{D(act)} > P_{D(max)}$ when V_{LED} = 5V and $V_{DS} = V_{LED} - V_F$, in which V_{LED} is the load supply voltage. In this case, it is recommended to use the lowest possible supply voltage or to set an external voltage reducer, V_{DROP}.

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

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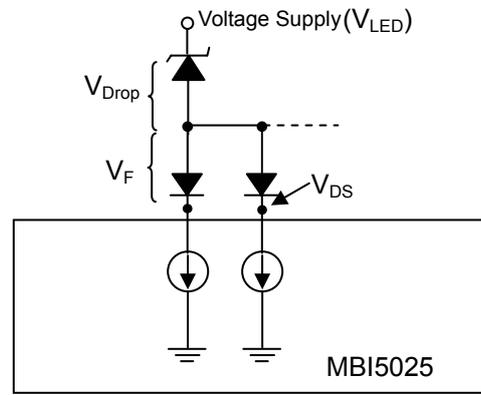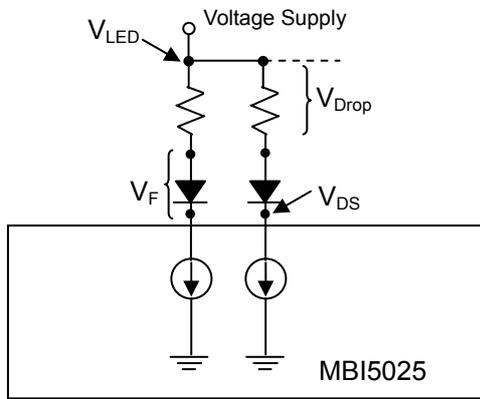

Switching Noise Reduction

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

Package Outline
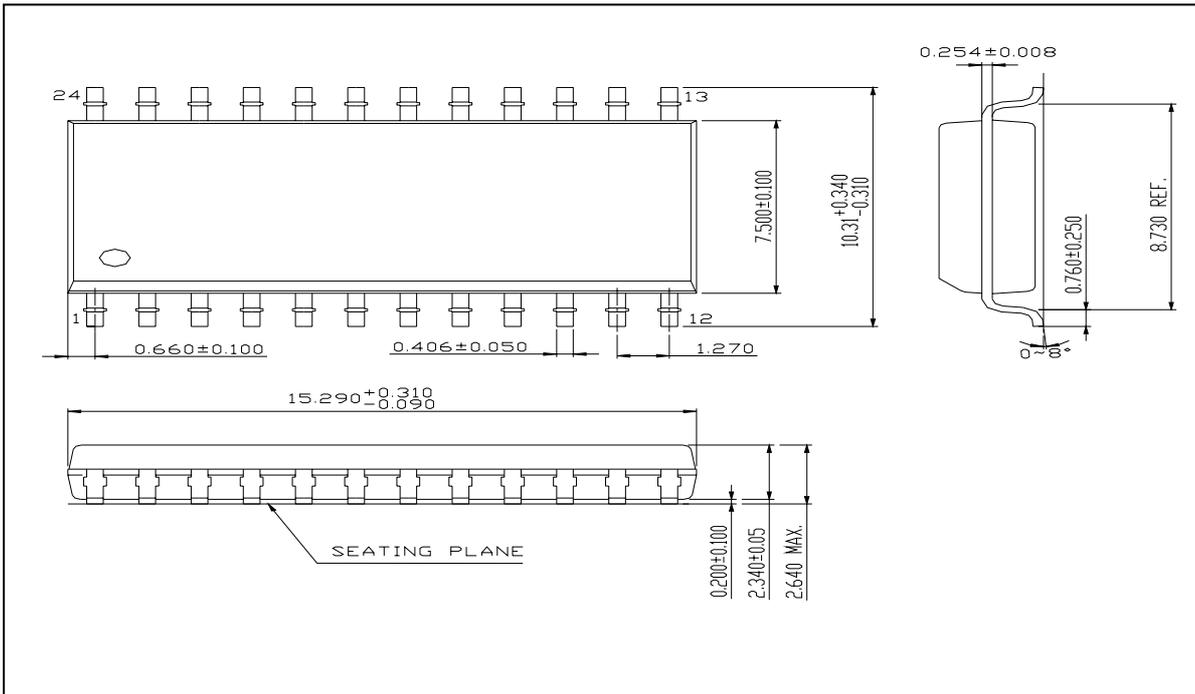
MBI5025GD Outline Drawing
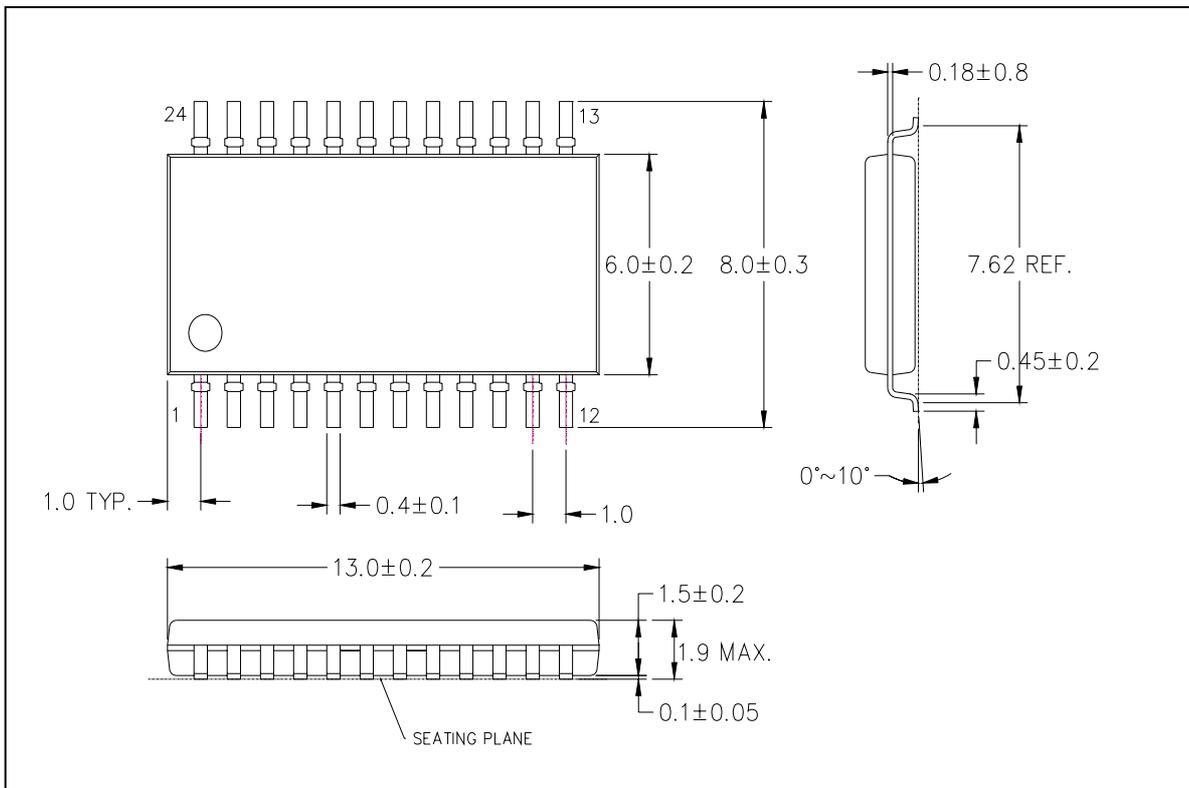
MBI5025GF Outline Drawing
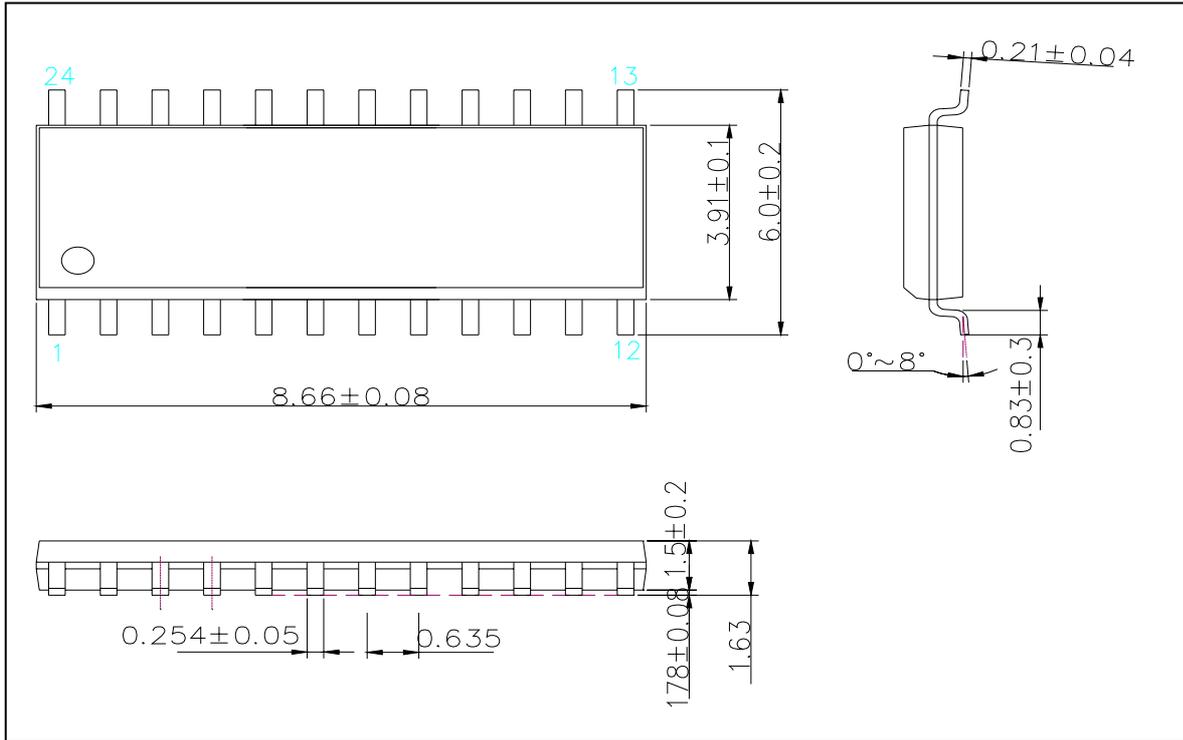
MBI5025GP Outline Drawing

Product Top-mark Information

The first row of printing

MBIXXXX ○ ○○

Or

MBIXXXX ○ ○

Product No.

Package Code

Process Code
G: Green and Pb-free

Part number

● ID number

The second row of printing

XXXXXXXX ○

Manufacture Code

Device Version Code
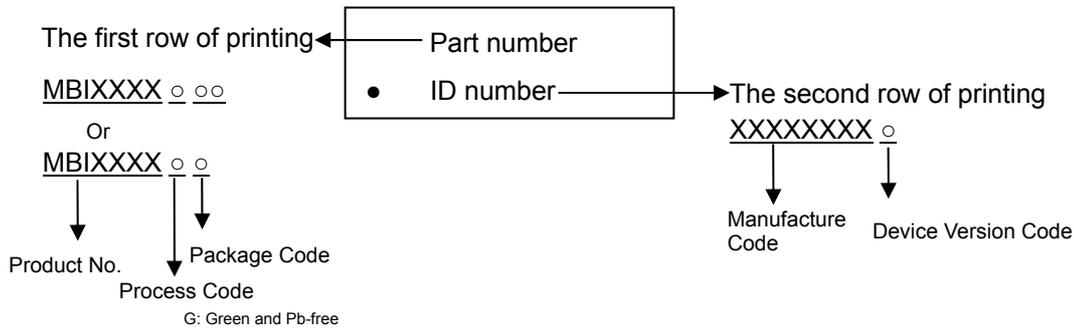
Product Revision History

Datasheet version	Device version code
V1.00	A
VA.00	A

Product Ordering Information

Part Number	"Pb-free & Green" Package Type	Weight (g)
MBI5025GD	SOP24-300-1.27	0.617
MBI5025GF	SOP24-300-1.00	0.28
MBI5025GP	SSOP24-150-0.64	0.11

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