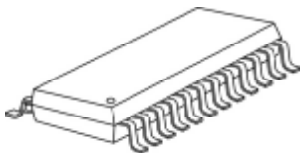
Features

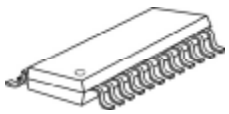
- 16 constant-current output channels
- Constant output current invariant to load voltage change:
  Constant output current range:
  3-45mA@V_{DD}=5V;
  3-30mA@V_{DD}=3.3V
- Excellent output current accuracy:
  between channels: ±1.5% (typ.) and ±2.5% (max.)
  between ICs: ±1.5% (typ.) and ±3% (max.)
- Output current adjusted through an external resistor
- Fast response of output current, $\overline{OE}$ (min.): 70ns with good uniformity between output channels
- Staggered delay of output
- 25MHz clock frequency
- Schmitt trigger input
- 3.3V/ 5V supply voltage
- "Pb-free & Green" Package

Small Outline Package



GF: SOP24L-300-1.00

Shrink SOP



GP/GPA: SSOP24L-150-0.64

Current Accuracy		Conditions
Between Channels	Between ICs	
<±2%	<±3%	I_{OUT}=25mA@V_{DS}=0.7V
<±2.5%	<±3%	I_{OUT}=3mA~30mA@V_{DS}=0.7V; V_{DD}=3.3V I_{OUT}=3mA~45mA@V_{DS}=0.7V; V_{DD}=5.0V

Product Description

With PrecisionDrive™ technology, MBI5024 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. MBI5024 contains a serial buffer and data latches which convert serial input data into parallel output format. At MBI5024 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.

MBI5024 provides users with great flexibility and device performance while using MBI5024 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 3mA to 45mA determined by an external resistor, R_{ext}, which gives users flexibility in controlling the light intensity of LEDs. MBI5024 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.

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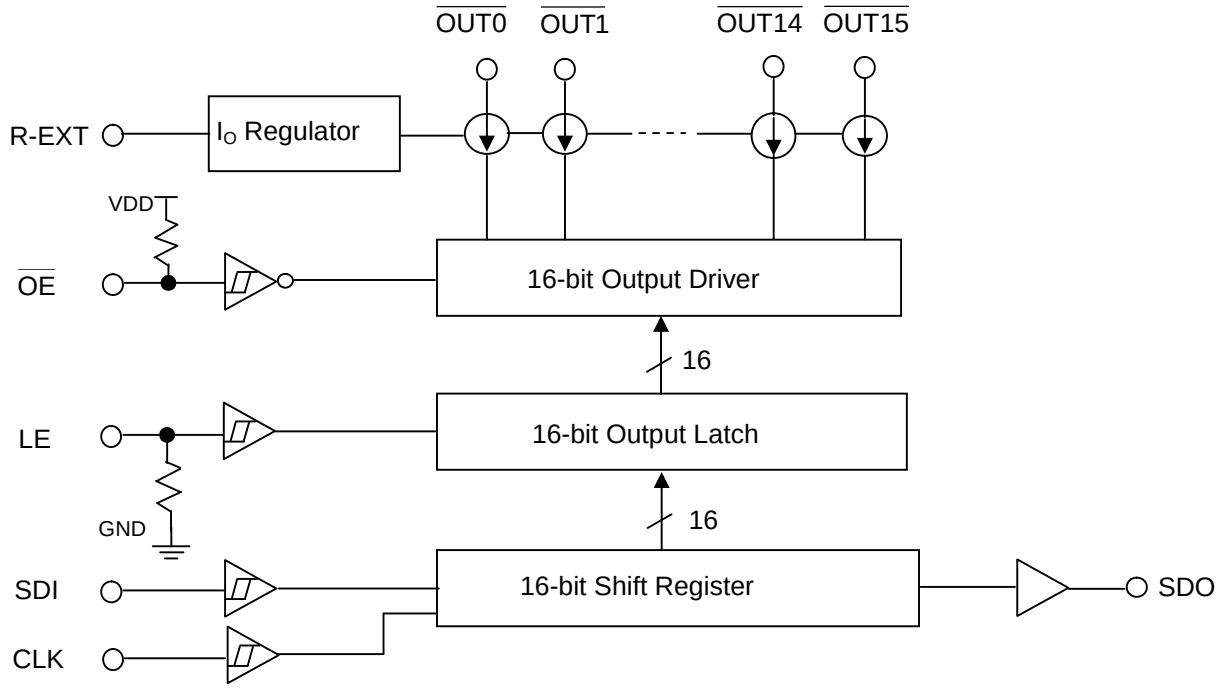
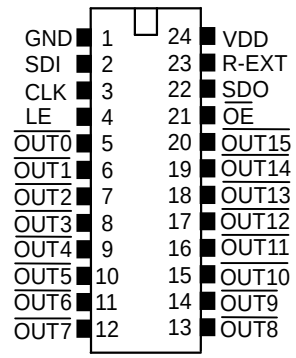
Block Diagram



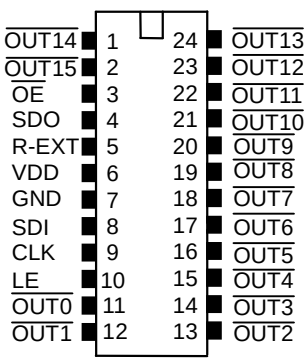
Terminal Description

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.
5~20	$\overline{OUT0}$ ~ $\overline{OUT15}$	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



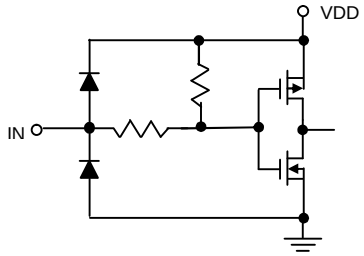
MBI5024 GF\GP



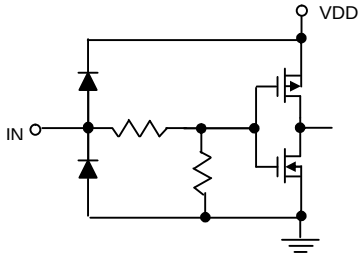
MBI5024 GPA

Equivalent Circuits of Inputs and Outputs

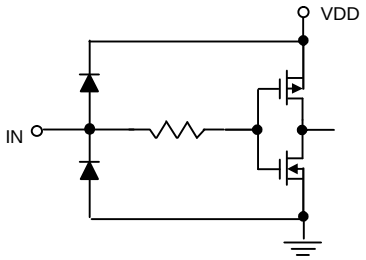
$\overline{OE}$ terminal



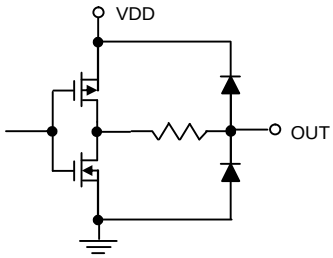
LE terminal



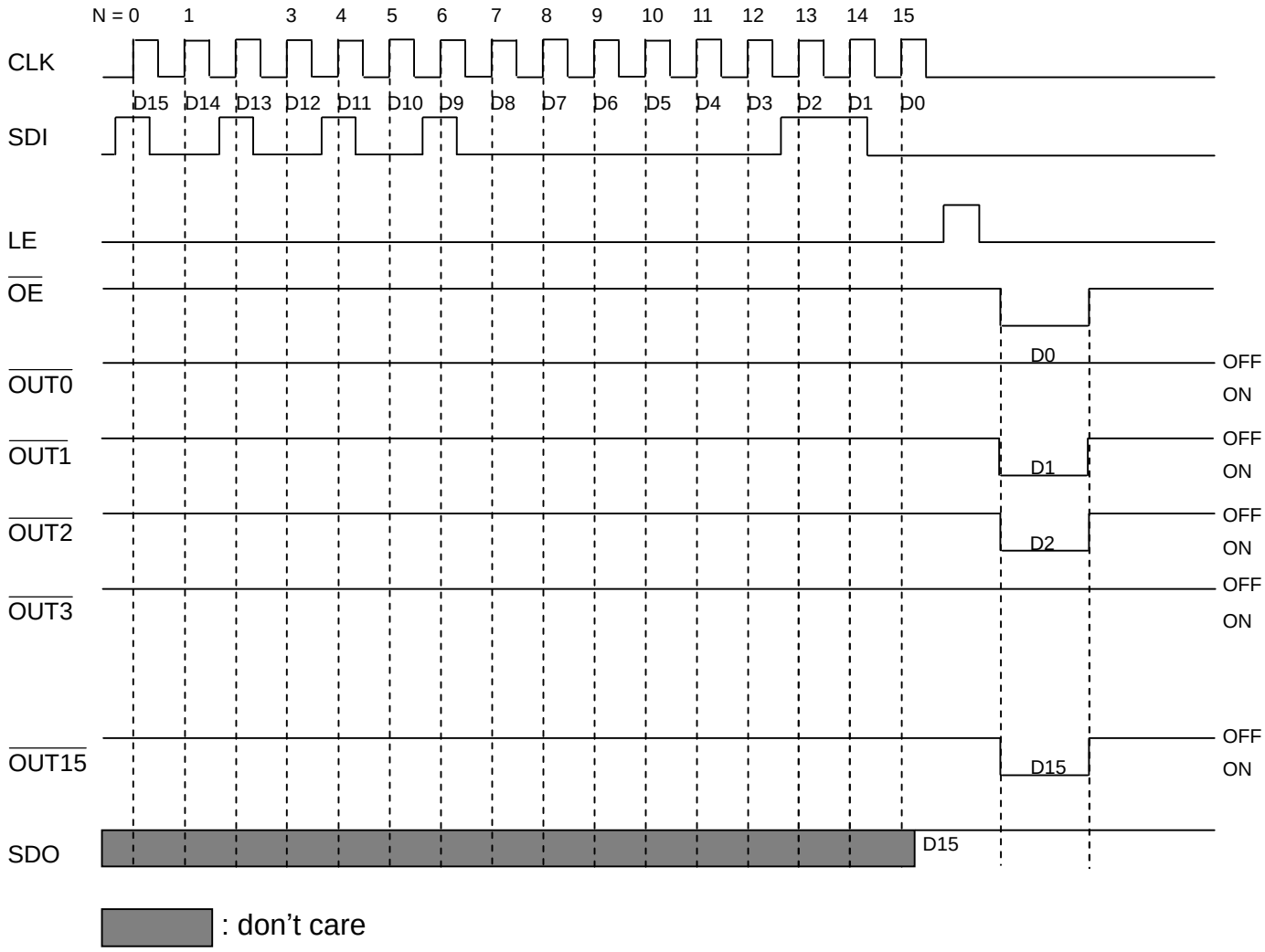
CLK, SDI terminal



SDO terminal



Timing Diagram



Truth Table

CLK	LE	$\overline{OE}$	SDI	$\overline{OUT0}$ ... $\overline{OUT7}$ ... $\overline{OUT15}$	SDO
↑	H	L	D_n	$\overline{D_n}$ ..... $\overline{D_{n-7}}$ .... $\overline{D_{n-15}}$	D_{n-15}
↑	L	L	D_{n+1}	No Change	D_{n-14}
↑	H	L	D_{n+2}	$\overline{D_{n+2}}$ .... $\overline{D_{n-5}}$ .... $\overline{D_{n-13}}$	D_{n-13}
↓	X	L	D_{n+3}	$\overline{D_{n+2}}$ .... $\overline{D_{n-5}}$ .... $\overline{D_{n-13}}$	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
GND Terminal Current		I_{GND}	+1000	mA
Power Dissipation (On PCB, Ta=25°C)	GF–type	P_D	2.35	W
	GP–type		1.76	
	GPA–type		1.76	
Thermal Resistance (On PCB, Ta=25°C)	GF–type	$R_{th(j-a)}$	53.28	°C/W
	GP–type		70.90	
	GPA–type		70.90	
Operating Temperature		T_{opr}	-40~+85	°C
Storage Temperature		T_{stg}	-55~+150	°C

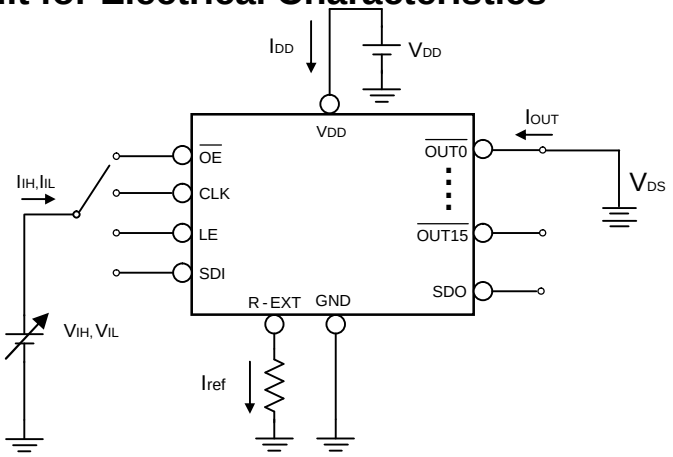
Electrical Characteristics (V_{DD}= 5.0V)

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}=6000 Ω	-	3.1	-	mA
Current Skew		dI_{OUT1}	I_{OL}=3.1mA V_{DS}=1.0V	R_{ext}=6000 Ω	-	±1.5	±2.5	%
Output Current 2		I_{OUT2}	V_{DS}=1.0V	R_{ext}=720 Ω	-	25.8	-	mA
Current Skew		dI_{OUT2}	I_{OL}=25.8mA V_{DS}=1.0V	R_{ext}=720 Ω	-	±1.5	±2.0	%
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}=6000 Ω	-	3.1	-	mA
Current Skew		dI_{OUT1}	I_{OL}=3.1mA V_{DS}=1.0V	R_{ext}=6000 Ω	-	±1.5	±2.5	%
Output Current 2		I_{OUT2}	V_{DS}=1.0V	R_{ext}=720 Ω	-	25.8	-	mA
Current Skew		dI_{OUT2}	I_{OL}=25.8mA V_{DS}=1.0V	R_{ext}=720 Ω	-	±1.5	±2.0	%
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		-	-	±1.0	%/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		-	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)

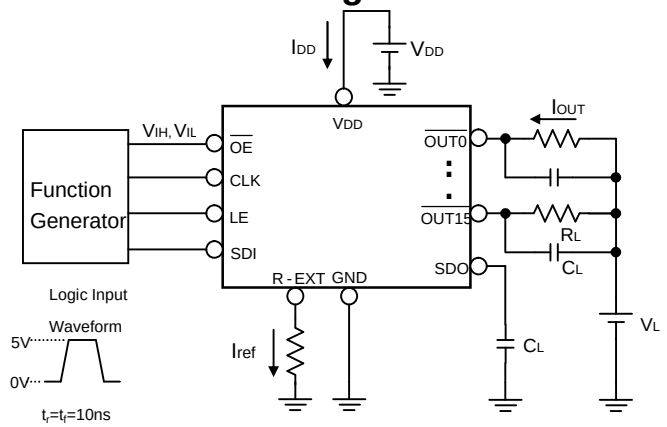
Characteristics		Symbol	Condition	Min.	Typ.	Max.	Unit
Propagation Delay Time (“L” to “H”)	CLK-$\overline{OUT2n}$	t_{pLH1}	V_{DD}=5.0 V V_{DS}=1.0 V V_{IH}=V_{DD} V_{IL}=GND R_{ext}=930 Ω V_L=4.5 V R_L=162 Ω C_L=10 pF	-	50	70	ns
	CLK-$\overline{OUT2n+1}$			-	35	55	ns
	LE-$\overline{OUT2n}$	t_{pLH2}		-	50	70	ns
	LE-$\overline{OUT2n+1}$			-	35	55	ns
	$\overline{OE}$-$\overline{OUT2n}$	t_{pLH3}		-	50	70	ns
	$\overline{OE}$-$\overline{OUT2n+1}$			-	35	55	ns
	CLK-SDO	t_{pLH}		-	20	40	ns
Propagation Delay Time (“H” to “L”)	CLK-$\overline{OUT2n}$	t_{pHL1}		-	90	110	ns
	CLK-$\overline{OUT2n+1}$			-	75	95	ns
	LE-$\overline{OUT2n}$	t_{pHL2}		-	90	110	ns
	LE-$\overline{OUT2n+1}$			-	75	95	ns
	$\overline{OE}$-$\overline{OUT2n}$	t_{pHL3}		-	90	110	ns
	$\overline{OE}$-$\overline{OUT2n+1}$			-	75	95	ns
	CLK-SDO	t_{pHL}		-	20	40	ns
Pulse Width	CLK	$t_{w(CLK)}$		20	-	-	ns
	LE	$t_{w(L)}$		20	-	-	ns
	$\overline{OE}$	$t_{w(OE)}$		70	100	-	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}		-	40	-	ns
Output Fall Time of Output Ports		t_{of}		-	55	-	ns

* Among output channels exist 15ns delay time between odd number $\overline{OUT2n+1}$ (e.g.:Bit1/Bit3/Bit5…)and even number $\overline{OUT2n}$ (ex: Bit0/Bit2/Bit4…). MBI5024 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.

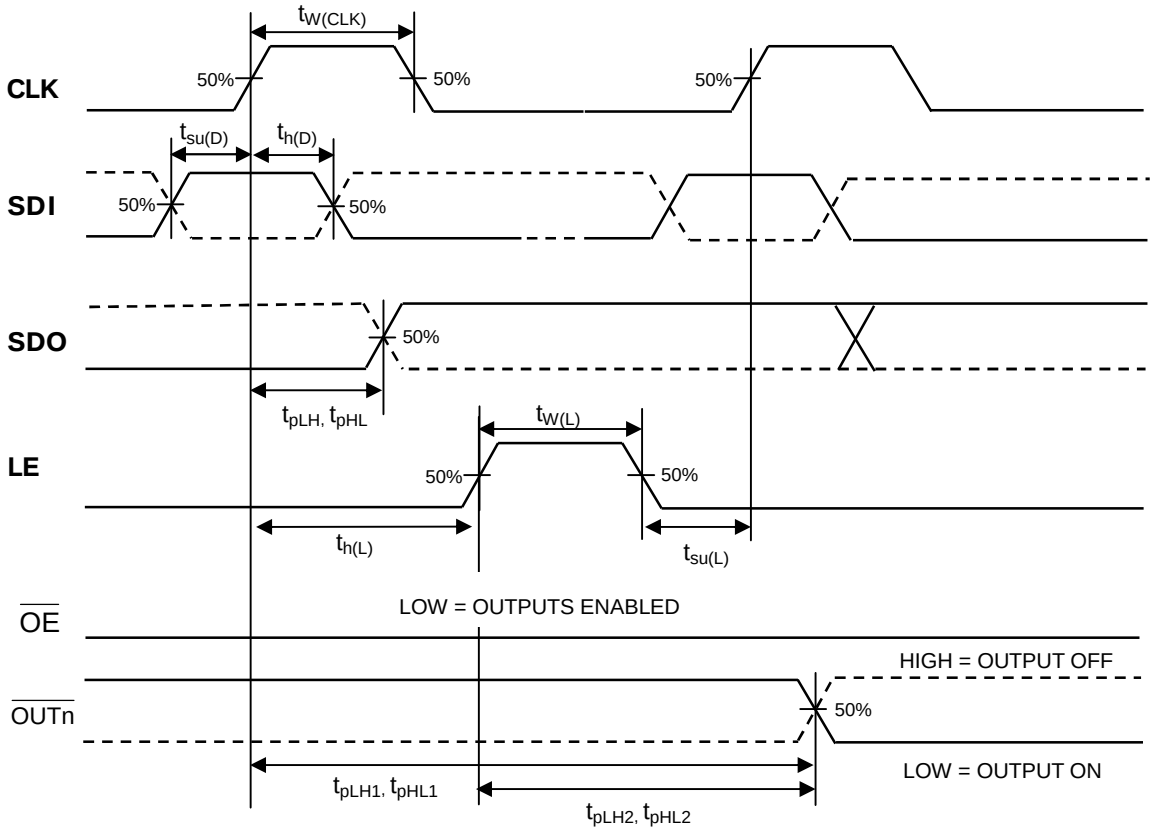
Switching Characteristics (V_{DD}= 3.3V)

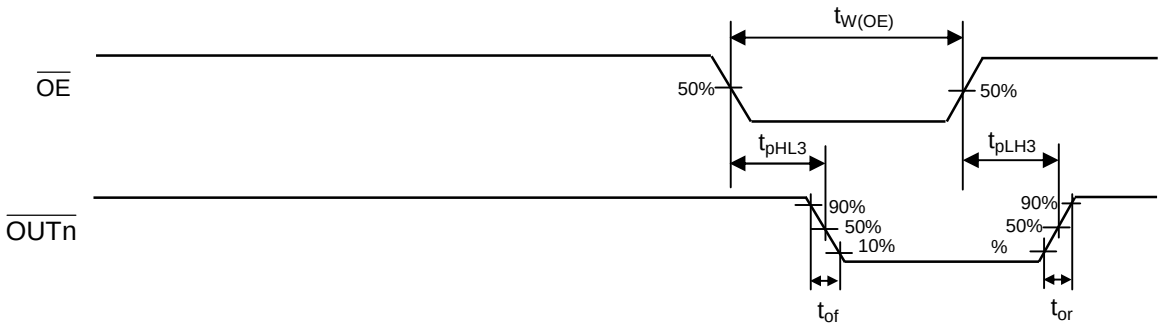
Characteristics		Symbol	Condition	Min.	Typ.	Max.	Unit
Propagation Delay Time (“L” to “H”)	CLK-$\overline{OUT2n}$	t_{pLH1}	V_{DD}=3.3 V V_{DS}=1.0 V V_{IH}=V_{DD} V_{IL}=GND R_{ext}=930 Ω V_L=4.5 V R_L=162 Ω C_L=10 pF	-	50	70	ns
	CLK-$\overline{OUT2n+1}$			-	35	55	ns
	LE-$\overline{OUT2n}$	t_{pLH2}		-	50	70	ns
	LE-$\overline{OUT2n+1}$			-	35	55	ns
	$\overline{OE}$-$\overline{OUT2n}$	t_{pLH3}		-	50	70	ns
	$\overline{OE}$-$\overline{OUT2n+1}$			-	35	55	ns
	CLK-SDO	t_{pLH}		-	20	40	ns
Propagation Delay Time (“H” to “L”)	CLK-$\overline{OUT2n}$	t_{pHL1}		-	115	135	ns
	CLK-$\overline{OUT2n+1}$			-	100	120	ns
	LE-$\overline{OUT2n}$	t_{pHL2}		-	115	135	ns
	LE-$\overline{OUT2n+1}$			-	100	120	ns
	$\overline{OE}$-$\overline{OUT2n}$	t_{pHL3}		-	105	125	ns
	$\overline{OE}$-$\overline{OUT2n+1}$			-	90	110	ns
	CLK-SDO	t_{pHL}		-	20	40	ns
Pulse Width	CLK	$t_{w(CLK)}$		20	-	-	ns
	LE	$t_{w(L)}$		20	-	-	ns
	$\overline{OE}$	$t_{w(OE)}$		100	130	-	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}		-	40	-	ns
Output Fall Time of Output Ports		t_{of}		-	60	-	ns

Test Circuit for Switching Characteristics



Timing Waveform





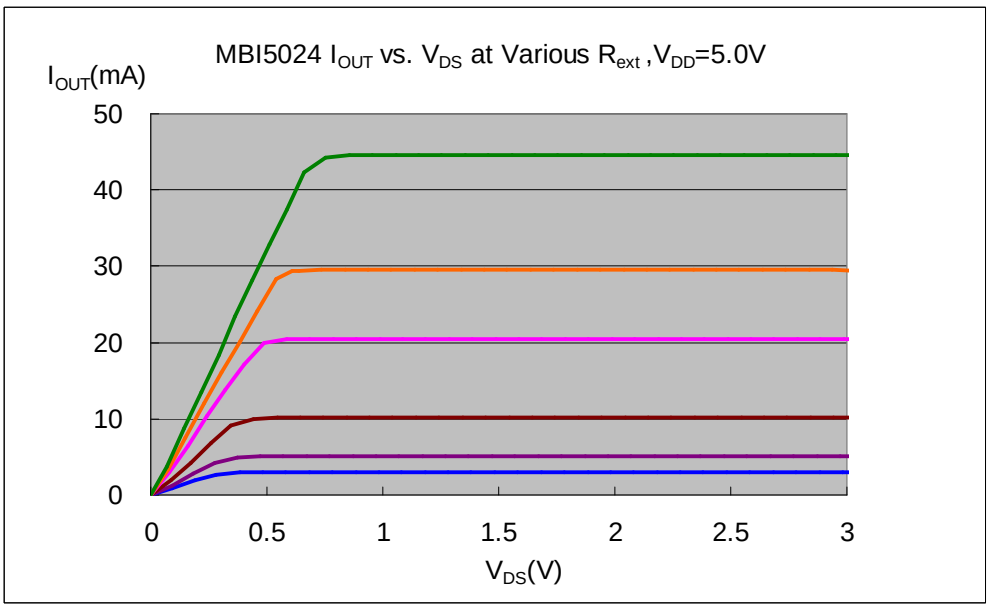
Application Information

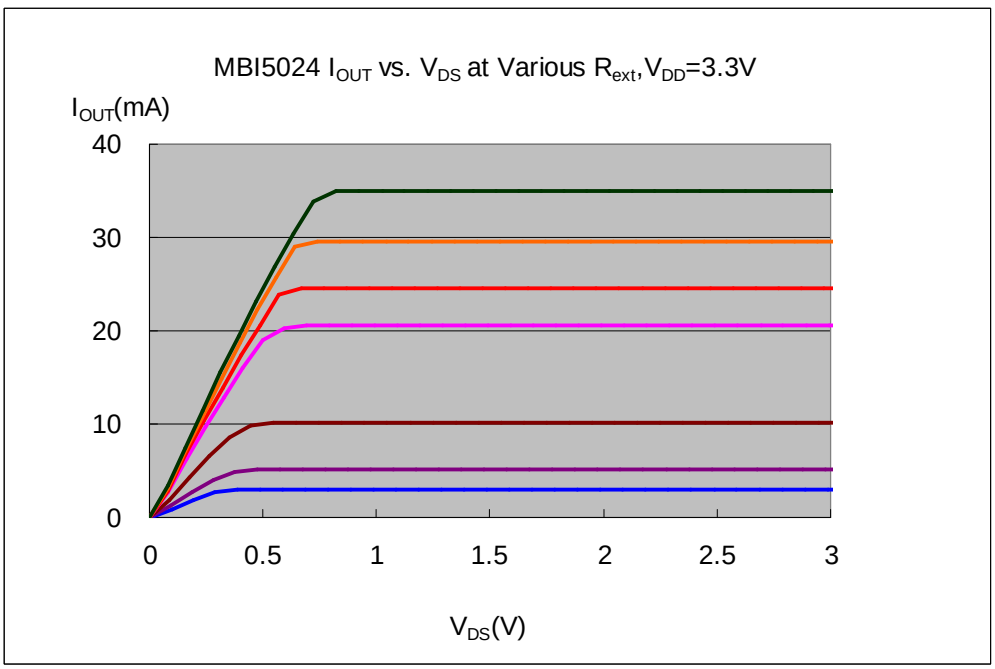
Constant Current

To design LED displays, MBI5024 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 ±2.5%, and that between ICs is less than ±3%.

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.



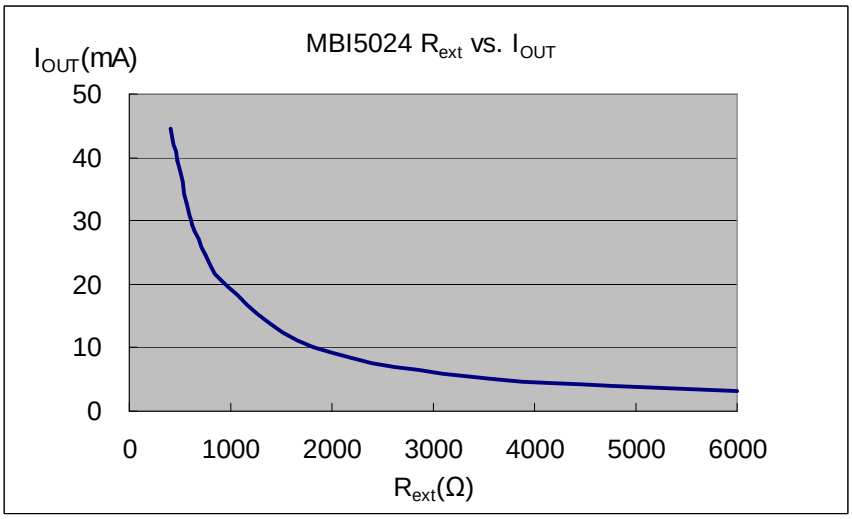


Adjusting Output Current

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:

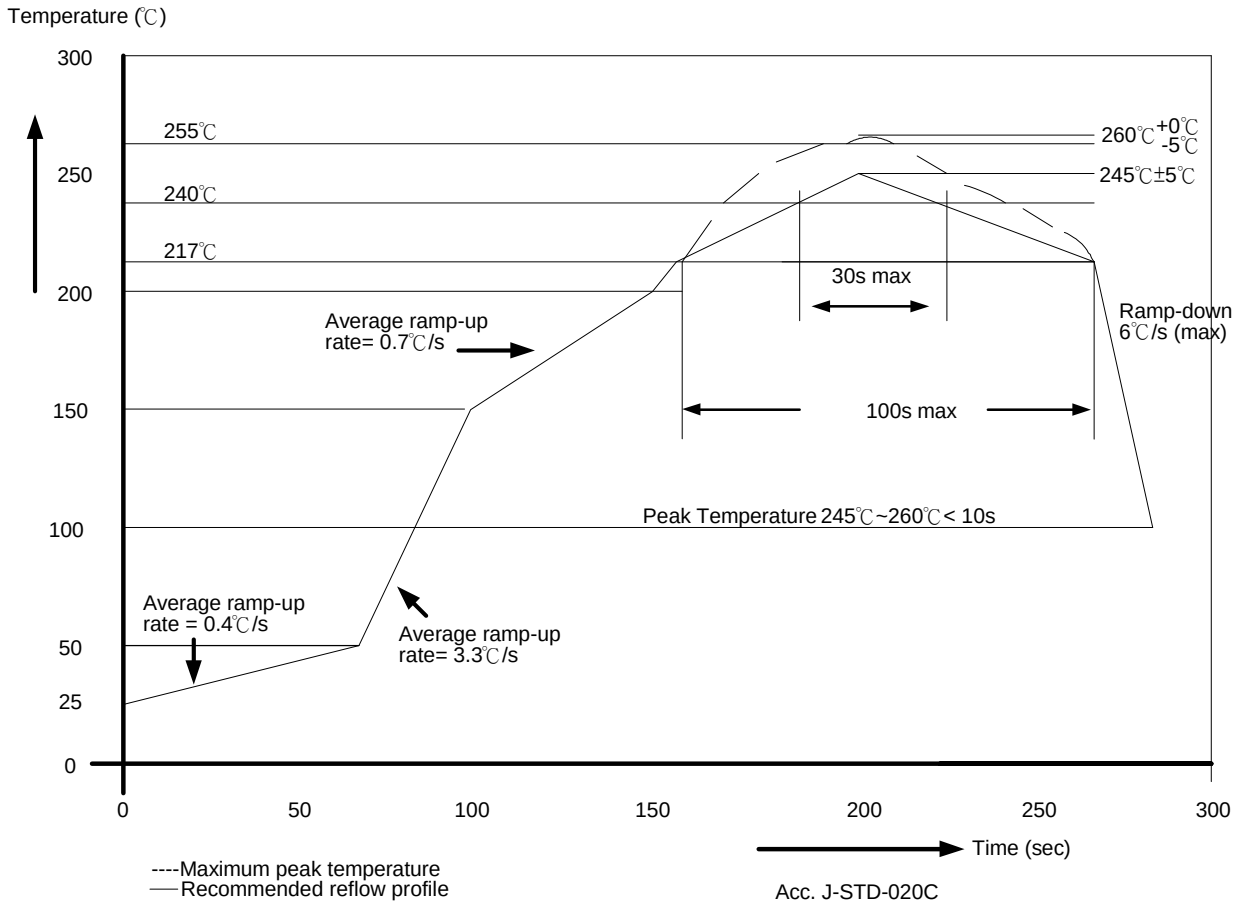
$V_{R\text{-}EXT}$=1.24V；$I_{OUT}=V_{R\text{-}EXT}$ *(1/Rext)x15; $R_{ext}=(V_{R\text{-}EXT}/I_{OUT})$x15



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 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.

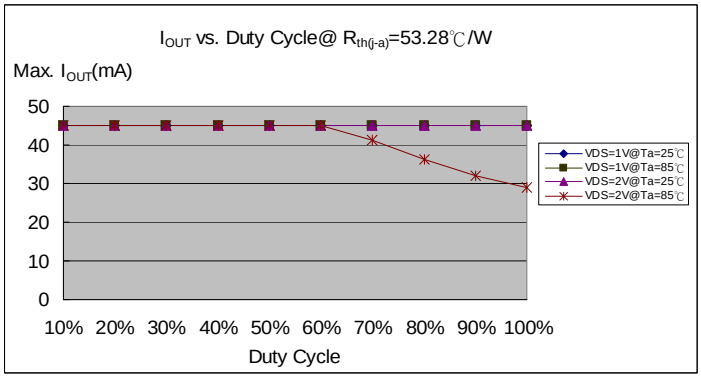


*Note1: For details, please refer to Macroblock’s “Policy on Pb-free & Green Package”.

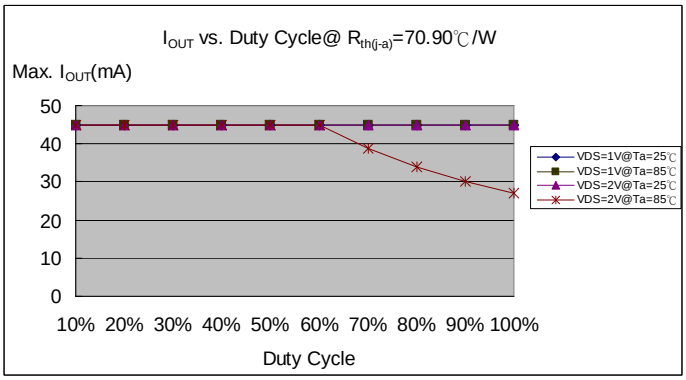
Package Power Dissipation (PD)

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 $P_D(act)=(I_{DD}xV_{DD})+(I_{OUT}xDutyxV_{DS}x16)$. Therefore, to keep $P_D(act)\leq P_D(max)$, the allowable maximum output current as a function of duty cycle is:

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



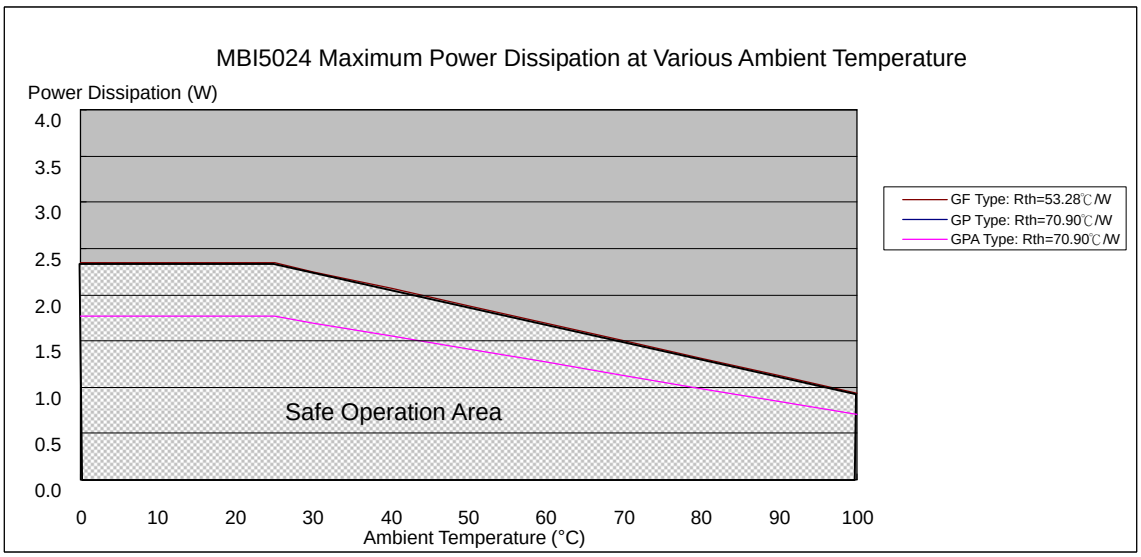
MBI5024GF



MBI5024GP/GPA

Condition: I_{OUT}=50mA, 16 output channels	
Device Type	$R_{th(j-a)}$ (°C/W)
GF	53.28
GP/GPA	70.90

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

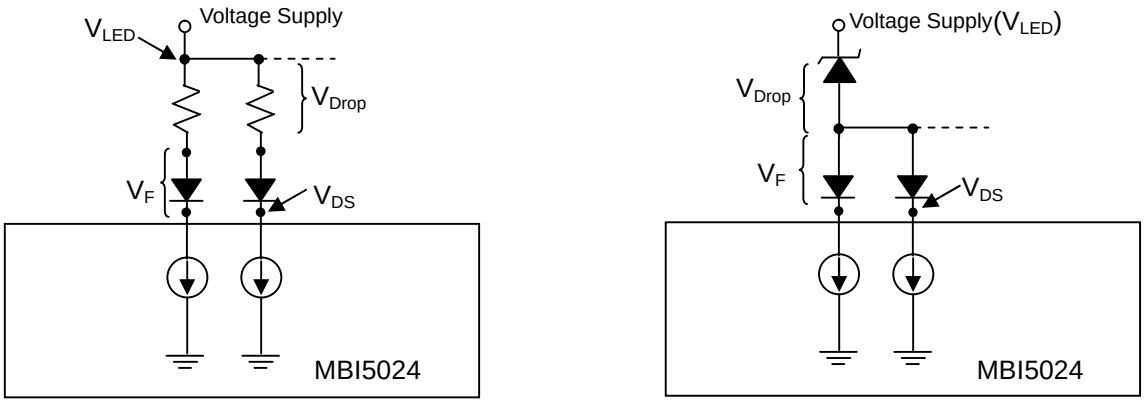


Load Supply Voltage (V_{LED})

MBI5024 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 $V_{DS}=(V_{LED}-V_F)-V_{DROP}$.

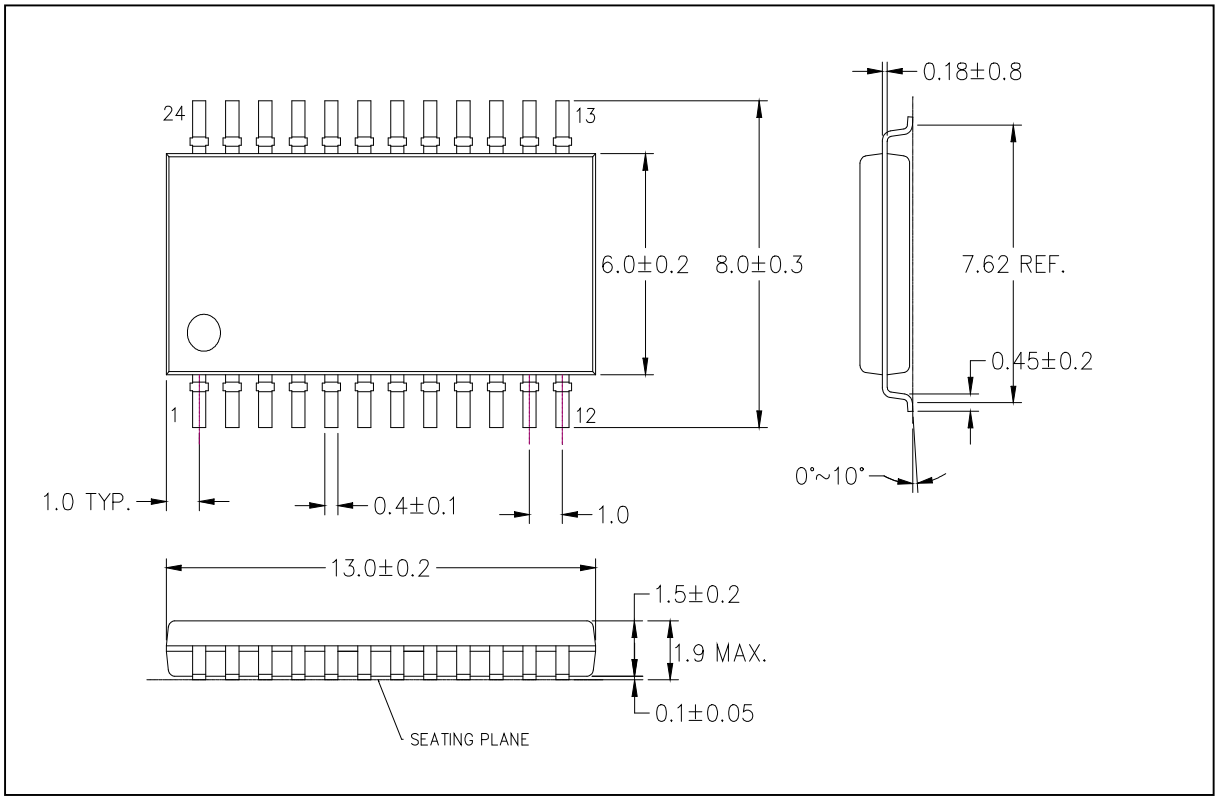
Resistors or Zener diode can be used in the applications as shown in the following figures.



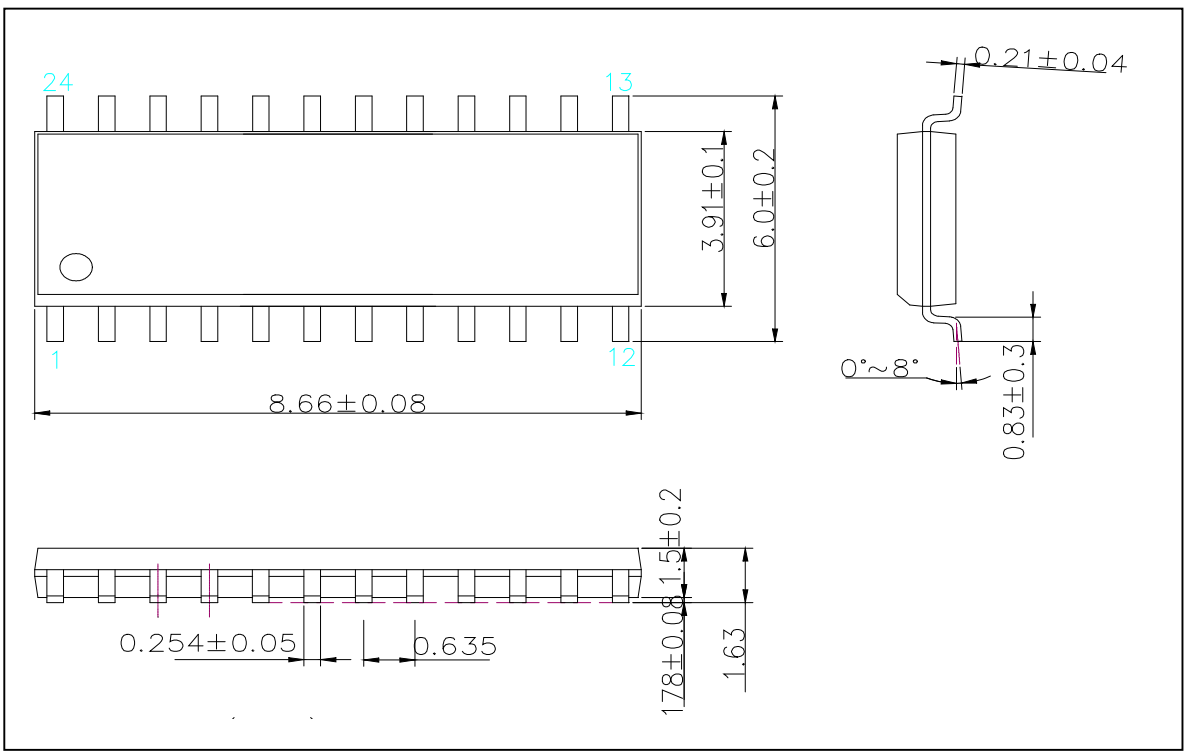
Switching Noise Reduction

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



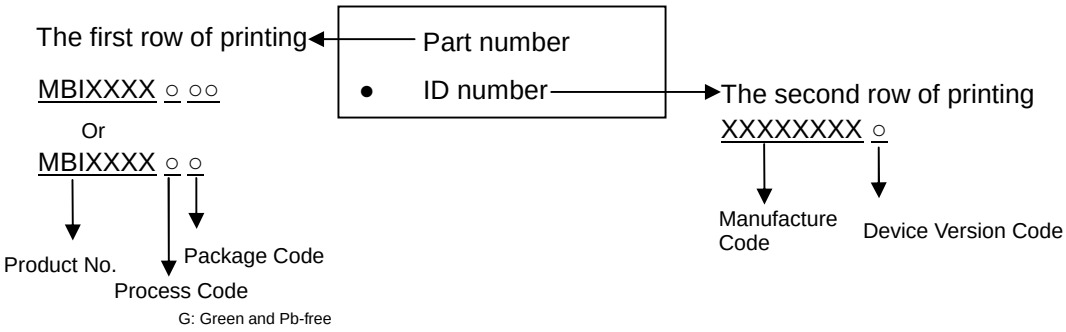
MBI5024GF Outline Drawing



MBI5024GP \ GPA Outline Drawing

Note: The unit for the outline drawing is mm.

Product Top-mark Information



Product Revision History

Datasheet version	Device version code
Refer to the Official Datasheet "MBI5024 Datasheet- VA.02-CN"	B

*MBI5024 is ONLY sold in China. This English document is an unofficial supplement of MBI5024 Datasheet-VA.02-CN. For any change of MBI5024 in the future, Macroblock will only make changes on the official MBI5024 Datasheet.

Product Ordering Information

Part Number	"Pb-free & Green" Package Type	Weight (g)
MBI5024GF	SOP24L-300-1.00	0.28
MBI5024GP	SSOP24L-150-0.64	0.11
MBI5024GPA	SSOP24L-150-0.64	0.11

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