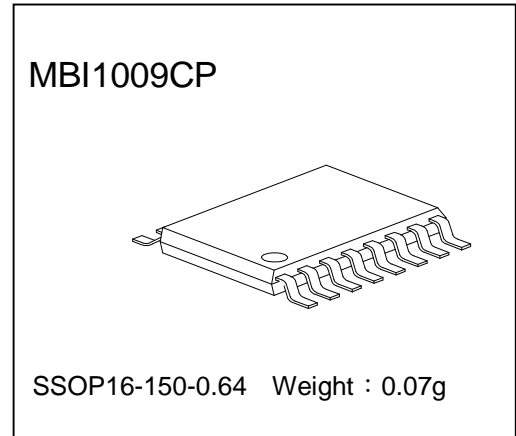


3-Channel RGB LED Lamp Driver

Features

- I 3 output channels for RGB LED lamps
- I Output current invariant to load voltage change
- I Programmable output current for each channel
- I Built-in brightness control
- I Constant output current range: 5 - 40mA
- I Output current accuracy:
between channels: $<\pm 5\%$ (max.), and
between ICs: $<\pm 12\%$ (max.)
- I 3 ~ 5.5V supply voltage



Applications

- I Multi-color (Color-variable) LED backlight for portable devices
- I Keypad backlighting
- I Push-button backlighting

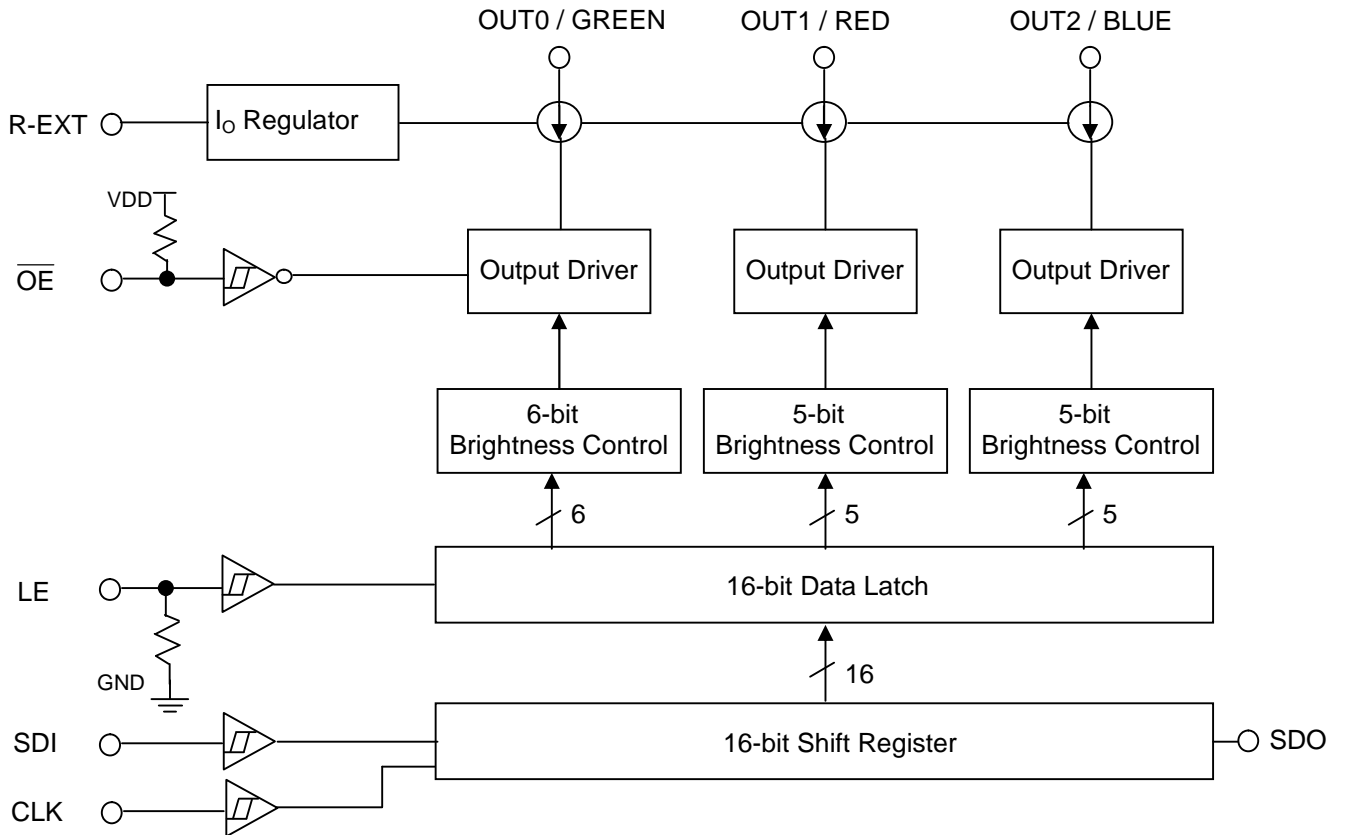
General Description

MBI1009 is a 3-channel current sink driver for RGB LED lamps. It is easy to be designed in applications that need mixing RGB light sources for multi-color output. MBI1009 contains a serial buffer and data latches which convert serial input data into parallel output format. At MBI1009 output stage, three regulated current ports are designed to provide uniform and constant current sinks for driving LEDs within a large range of V_f variations. The output current is determined by an external resistor and the brightness control code, both set by users.

MBI1009 provides users with great flexibility and device performance. Users may adjust the output current from 5 mA to 40 mA, which gives users flexibility in controlling the light intensity of LEDs. MBI1009 guarantees to endure maximum 17V at the output port.

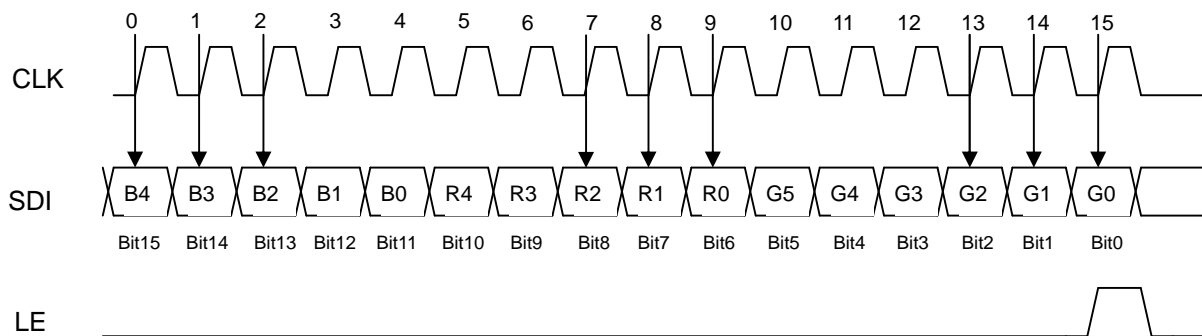
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Block Diagram



Note: To let users understand how to use MBI1009, we assume OUT0 is GREEN output, OUT1 and OUT2 respectively for RED and BLUE. The applications of MBI1009 would not be limited to what has been shown in this example.

Timing Diagram



Brightness Control Code

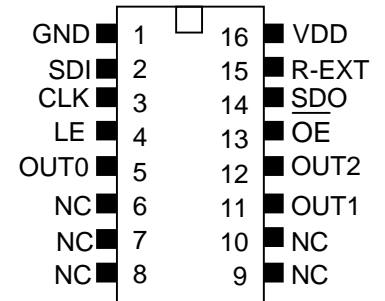
Bit Definition of 16-Bit Brightness Control Code																
	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8	Bit 9	Bit 10	Bit 11	Bit 12	Bit 13	Bit 14	Bit 15
Meaning	G0	G1	G2	G3	G4	G5	R0	R1	R2	R3	R4	B0	B1	B2	B3	B4
	G _{GREEN}					G _{RED}					G _{BLUE}					
Default Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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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 Serial data is transferred to the respective latch when LE is high. The data is latched when LE goes low.
5	OUT0	Constant current output terminal
6-10	NC	-
11	OUT1	Constant current output terminal
12	OUT2	Constant current output terminal
13	\overline{OE}	Output enable terminal 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	Supply voltage terminal

Pin Description



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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}	+60	mA
Output Voltage	V_{DS}	-0.5 ~ +17.0	V
Clock Frequency	F_{CLK}	20	MHz
Operating Temperature	T_{opr}	-40 ~ +85	°C
Storage Temperature	T_{stg}	-55 ~ +150	°C

Electrical Characteristics ($T_a = 25^\circ\text{C}$, $V_{DD} = 5\text{V}$, unless otherwise noted)

Characteristics	Symbol	Condition	Min.	Typ.	Max.	Unit	
Supply Voltage	V_{DD}	-	3.0	5.0	5.5	V	
Output Voltage	V_{DS}	OUT0, OUT1, OUT2 terminals	-	-	17.0	V	
Output Current	I_{OUT}	DC Test Circuit	5	-	40	mA	
Input Voltage	"H" level	V_{IH}	$T_a = -40\sim 85^\circ\text{C}$	$0.8V_{DD}$	-	$V_{DD}+0.3$	V
	"L" level	V_{IL}	$T_a = -40\sim 85^\circ\text{C}$	-0.3	-	$0.3V_{DD}$	V
Output Leakage Current	I_{OH}	$V_{OH} = 17.0\text{V}$	-	-	10	μA	
OUT0 / GREEN Current	$I_{OUT,GREEN}$	$V_{DS} = 1.0\text{V}$, $R_{ext} = 3.6\text{K}\Omega$ $G_{GREEN} = (G0,G1,G2,G3,G4,G5) = (1,1,1,1,1,0)$	-	26.25	-	mA	
OUT1 / RED Current	$I_{OUT,RED}$	$V_{DS} = 1.0\text{V}$, $R_{ext} = 3.6\text{K}\Omega$ $G_{RED} = (R0,R1,R2,R3,R4) = (1,1,1,1,1)$	-	26.25	-	mA	
OUT2 / BLUE Current	$I_{OUT,BLUE}$	$V_{DS} = 1.0\text{V}$, $R_{ext} = 3.6\text{K}\Omega$ $G_{BLUE} = (B0,B1,B2,B3,B4) = (1,1,1,1,1)$	-	26.25	-	mA	
Current Skew	ΔI_{OUT}	$I_{OUT} = 26.25\text{mA}$ $V_{DS} = 1.0\text{V}$	$R_{ext} = 3.6\text{K}\Omega$	-	± 1	± 5	%
Output Current Variation vs. Supply Voltage Variation	-	V_{DD} within 2.7V and 3.3V, $R_{ext} = 3.6\text{K}\Omega$	-	± 15	-	%	
		V_{DD} within 4.5V and 5.5V $R_{ext} = 3.6\text{K}\Omega$	-	± 3	-		
Pull-up Resistor	$R_{IN(up)}$	\overline{OE}	250	500	800	$\text{K}\Omega$	
Pull-down Resistor	$R_{IN(down)}$	LE	250	500	800	$\text{K}\Omega$	
Supply Current	"OUT Off"	$I_{DD(off) 1}$	$R_{ext} = 3.6\text{K}\Omega$, OUT0/OUT1/OUT2 = Off, $V_{DD} = 3.3\text{V}$	-	3.0	6.0	mA
	"OUT On"	$I_{DD(on) 1}$	$R_{ext} = 3.6\text{K}\Omega$, OUT0/OUT1/OUT2 = On, $V_{DD} = 3.3\text{V}$	-	3.0	6.0	
	"OUT Off"	$I_{DD(off) 1}$	$R_{ext} = 3.6\text{K}\Omega$, OUT0/OUT1/OUT2 = Off, $V_{DD} = 5\text{V}$	-	8.0	12.0	
	"OUT On"	$I_{DD(on) 1}$	$R_{ext} = 3.6\text{K}\Omega$, OUT0/OUT1/OUT2 = On, $V_{DD} = 5\text{V}$	-	8.0	15.0	

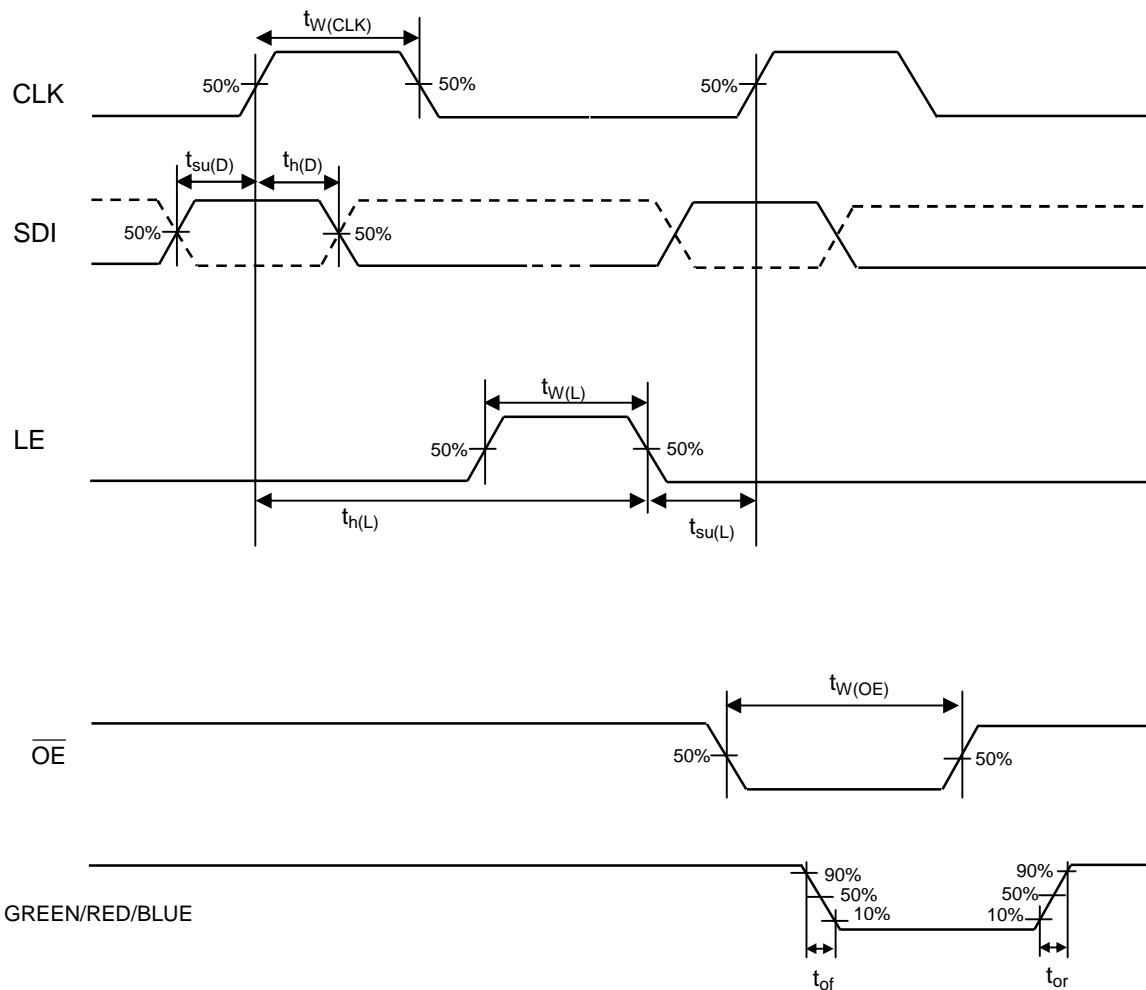
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Switching Characteristics

(Ta = 25°C, V_{DD} = 3.3V ~ 5V, unless otherwise noted)

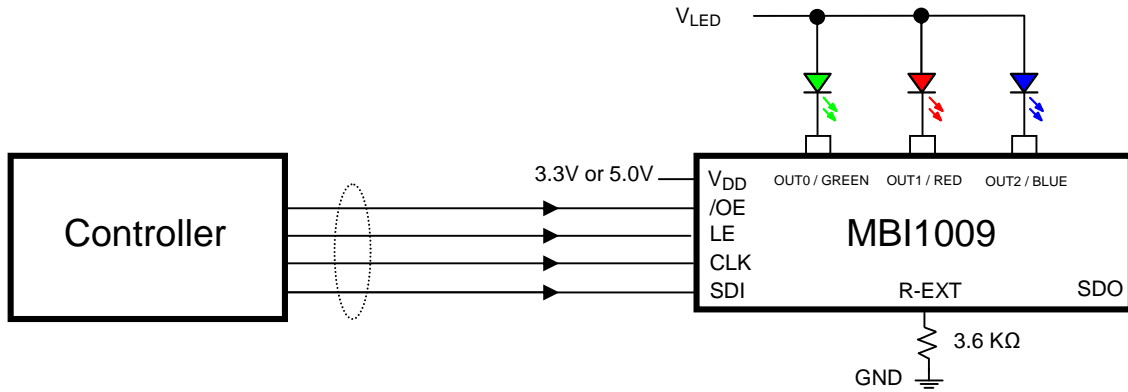
Characteristics	Symbol	Min.	Typ.	Max.	Unit	
Pulse Width	CLK	t _{w(CLK)}	25	-	-	ns
	LE	t _{w(L)}	25	-	-	ns
	\overline{OE}	t _{w(OE)}	1000	-	-	ns
Hold Time for LE	t _{h(L)}	20	-	-	ns	
Setup Time for LE	t _{su(L)}	20	-	-	ns	
Hold Time for SDI	t _{h(D)}	15	-	-	ns	
Setup Time for SDI	t _{su(D)}	20	-	-	ns	
Clock Frequency	F _{CLK}	-	-	20	MHz	
Output Rise Time (turn off)	t _{or}	-	200	400	ns	
Output Fall Time (turn on)	t _{of}	-	200	400	ns	

Timing Waveform



Application Information

Typical Application Circuit



Current Setting for GREEN, RED, and BLUE Output Ports

The output currents of OUT0 / GREEN, OUT1 / RED, and OUT2 / BLUE are determined by an external resistor and the 16-bit Brightness Control Code, both set by users.

That is:

$$I_{OUT, GREEN} = G_{GREEN} \times I (R_{EXT});$$

$$I_{OUT, RED} = G_{RED} \times I (R_{EXT});$$

$$I_{OUT, BLUE} = G_{BLUE} \times I (R_{EXT});$$

where $I (R_{EXT})$ is the reference current set by the external resistor R_{EXT}

and G_{GREEN} , G_{RED} , G_{BLUE} are current gains for output channels OUT0 / GREEN, OUT1 / RED, and OUT2 / BLUE , respectively.

$I (R_{EXT})$ ($T_a = 25^{\circ}C, V_{DD} = 3.3V$) – A reference table

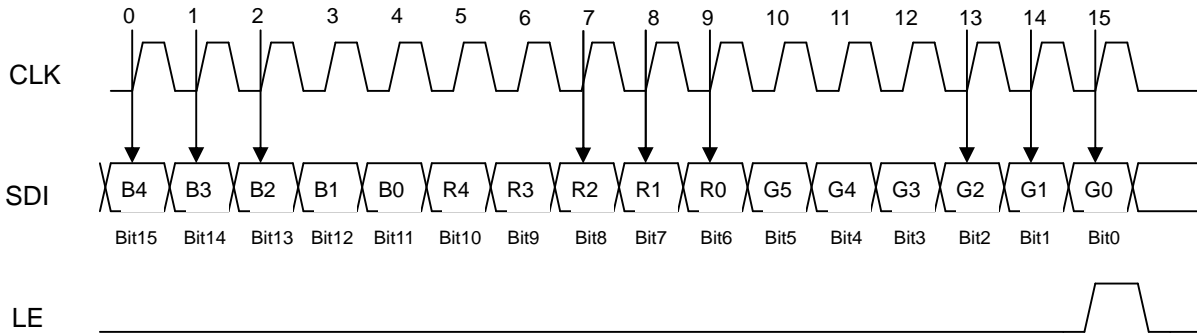
R _{EXT}	I (R _{EXT}) in mA									
	V _{out} = 0.1V	V _{out} = 0.2V	V _{out} = 0.3V	V _{out} = 0.4V	V _{out} = 0.5V	V _{out} = 0.6V	V _{out} = 0.7V	V _{out} = 0.8V	V _{out} = 0.9V	V _{out} = 1.0V
4571Ω	3.05	4.01	4.19	4.26	4.26	4.26	4.26	4.26	4.26	4.26
3600Ω	3.64	5.07	5.4	5.52	5.52	5.52	5.52	5.52	5.52	5.52
2952Ω	4.14	6.08	6.62	6.80	6.80	6.80	6.80	6.80	6.80	6.80

$I (R_{EXT})$ ($T_a = 25^{\circ}C, V_{DD} = 5V$) – A reference table

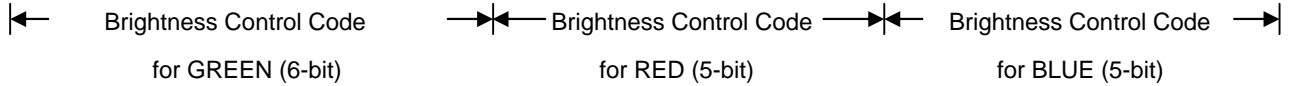
R _{EXT}	I (R _{EXT}) in mA									
	V _{out} = 0.1V	V _{out} = 0.2V	V _{out} = 0.3V	V _{out} = 0.4V	V _{out} = 0.5V	V _{out} = 0.6V	V _{out} = 0.7V	V _{out} = 0.8V	V _{out} = 0.9V	V _{out} = 1.0V
4571Ω	2.86	3.65	3.79	3.84	3.84	3.84	3.84	3.84	3.84	3.84
3600Ω	3.40	4.57	4.81	4.88	4.88	4.88	4.88	4.88	4.88	4.88
2952Ω	3.89	5.45	5.84	5.94	5.94	5.94	5.94	5.94	5.94	5.94

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Current Gain and Brightness Control Code



Bit Definition of 16-Bit Brightness Control Code																
	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8	Bit 9	Bit 10	Bit 11	Bit 12	Bit 13	Bit 14	Bit 15
Meaning	G0	G1	G2	G3	G4	G5	R0	R1	R2	R3	R4	B0	B1	B2	B3	B4
	G _{GREEN}					G _{RED}					G _{BLUE}					
Default Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



G _{GREEN}	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5
	G0	G1	G2	G3	G4	G5
0	0	0	0	0	0	0
1	1	0	0	0	0	0
2	1	1	0	0	0	0
3	1	1	1	0	0	0
4	1	1	1	1	0	0
5	1	1	1	1	1	0
6	1	1	1	1	1	1

G _{RED}	Bit 6	Bit 7	Bit 8	Bit 9	Bit 10
	R0	R1	R2	R3	R4
0	0	0	0	0	0
1	1	0	0	0	0
2	1	1	0	0	0
3	1	1	1	0	0
4	1	1	1	1	0
5	1	1	1	1	1

G _{BLUE}	Bit 11	Bit 12	Bit 13	Bit 14	Bit 15
	B0	B1	B2	B3	B4
0	0	0	0	0	0
1	1	0	0	0	0
2	1	1	0	0	0
3	1	1	1	0	0
4	1	1	1	1	0
5	1	1	1	1	1

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An Example

Setting $R_{ext} = 4571\Omega$, $V_{out} = 1.0V$ for OUT0 / GREEN, OUT1 / RED, and OUT2 / BLUE , then $I (R_{ext}) = 4mA$

If the 16-bit Configuration Code is {111111, 00000, 11110},

$$I_{OUT, GREEN} = G_{GREEN} \times I (R_{ext}) = 6 \times 4mA = 24mA ;$$

$$I_{OUT, RED} = G_{RED} \times I (R_{ext}) = 0 \times 4mA = 0mA ;$$

$$I_{OUT, BLUE} = G_{BLUE} \times I (R_{ext}) = 4 \times 4mA = 16mA ;$$

The mixing multi-color is determined by $I_{OUT, GREEN} = 24mA$, $I_{OUT, RED} = 0mA$, and $I_{OUT, BLUE} = 16mA$.

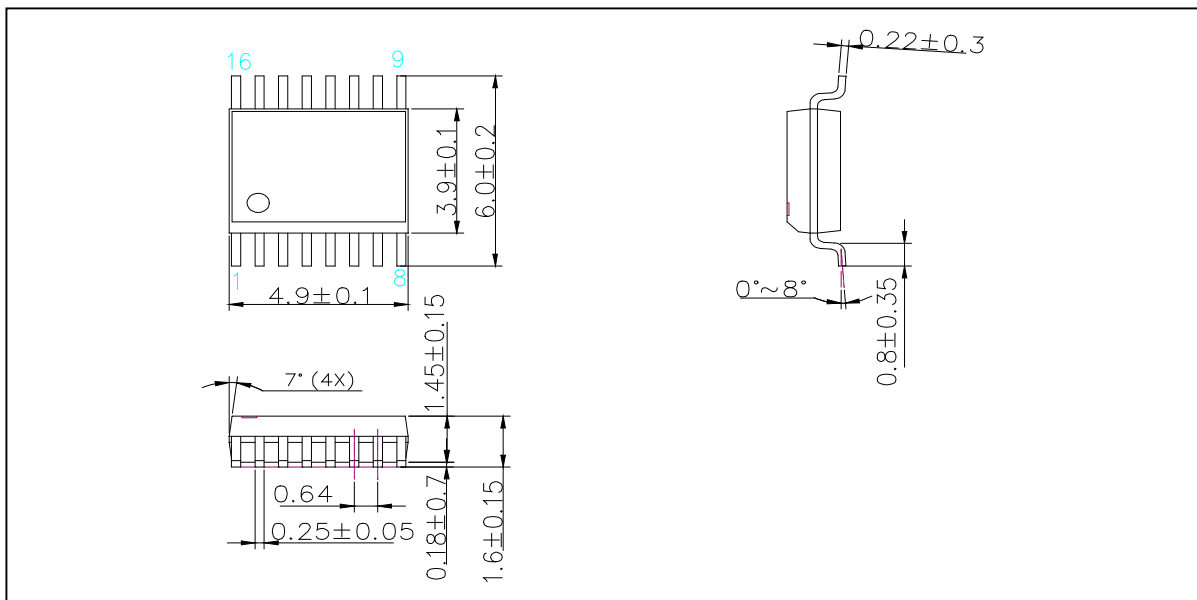
Assuming Luminous Intensity (mcd) of R/G/B LEDs are the same and $I (R_{ext}) = 4mA$, we may ideally let

$$G_{GREEN} + G_{RED} + G_{BLUE} = C \text{ (Constant value) to get a stable brightness.}$$

For instance, while $C = 10$, that is $G_{GREEN} + G_{RED} + G_{BLUE} = 10$, MBI1009 can easily give system designers a wide range of color and brightness control in portable electronic devices.

$(G_{GREEN}, G_{RED}, G_{BLUE})$	(0, 6, 4)	(0, 5, 5)					
Total 26 color Combinations	(1, 6, 3)	(1, 5, 4)	(1, 4, 5)				
	(2, 6, 2)	(2, 5, 3)	(2, 4, 4)	(2, 3, 5)			
	(3, 6, 1)	(3, 5, 2)	(3, 4, 3)	(3, 3, 4)	(3, 2, 5)		
	(4, 6, 0)	(4, 5, 1)	(4, 4, 2)	(4, 3, 3)	(4, 2, 4)	(4, 1, 5)	
		(5, 5, 0)	(5, 4, 1)	(5, 3, 2)	(5, 2, 3)	(5, 1, 4)	(5, 0, 5)

Package Outline



MBI1009CP Outline Drawing

MBI1009 Package Information

Device Type	Package Type	Weight (g)
CP	SSOP16-150-0.64	0.07

Note: The unit for the outline drawings is mm.