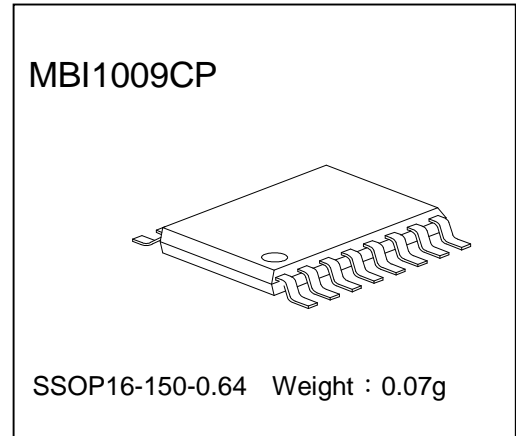


**3-Channel RGB LED Lamp Driver****Features**

- 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**

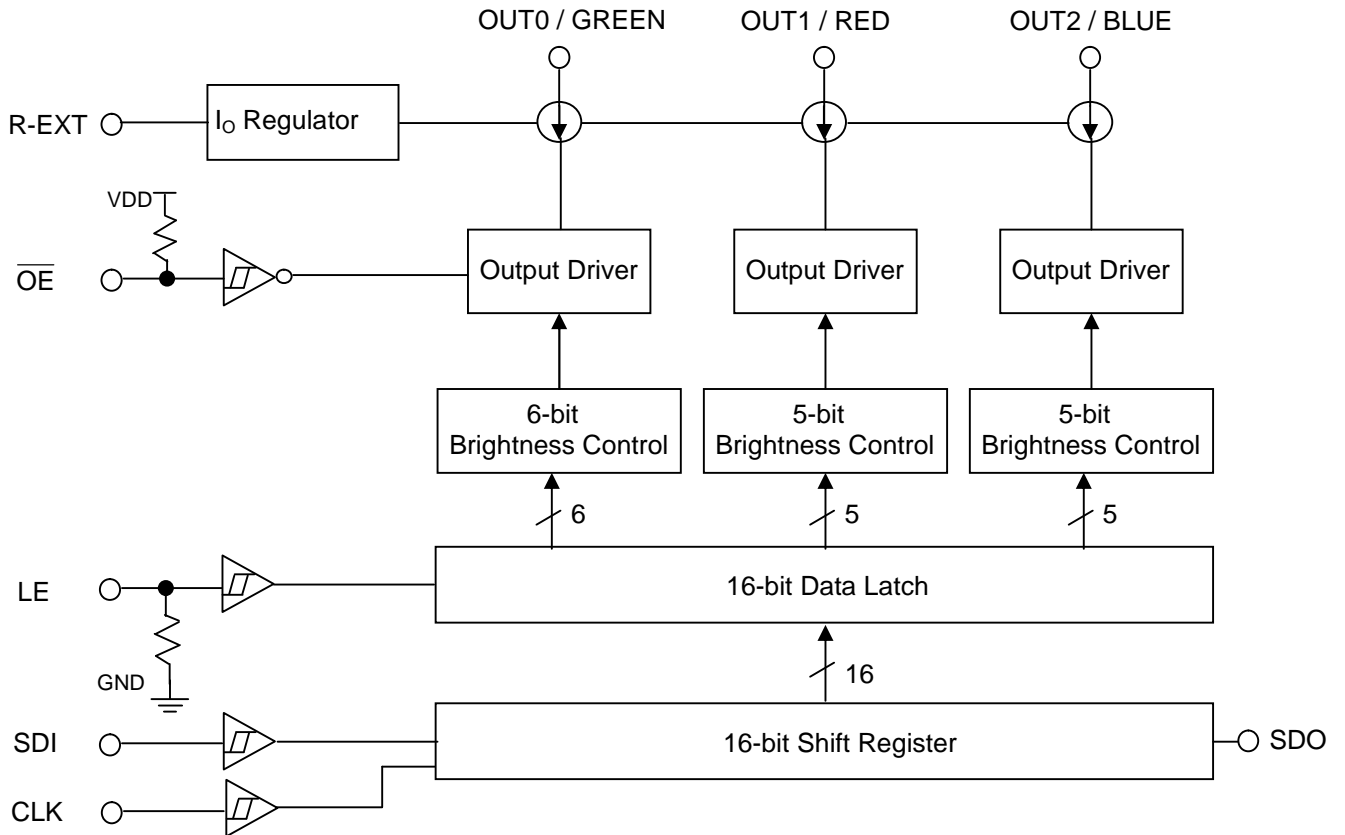
- I Multi-color (Color-variable) LED backlight for portable devices
- I Keypad backlighting
- I Push-button backlighting

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.

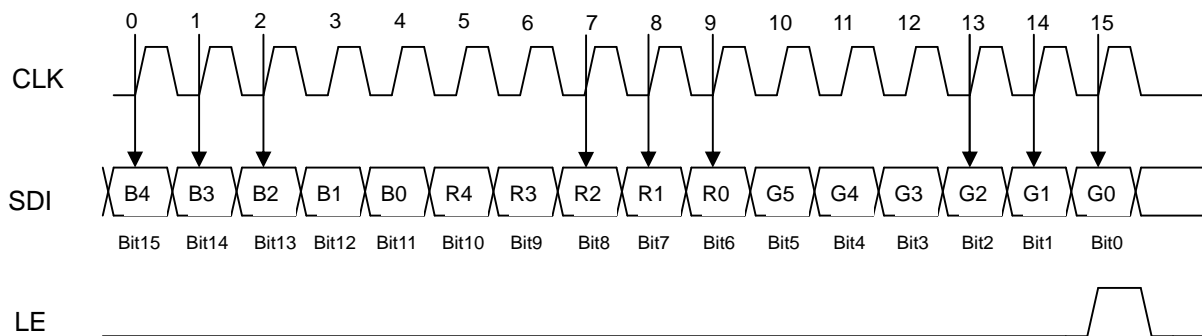
MBI1009 provides users with great flexibility and device performance. Users may adjust the output current from 5 mA to 40 mA, which gives users flexibility in controlling the light intensity of LEDs. MBI1009 guarantees to endure maximum 17V at the output port.

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



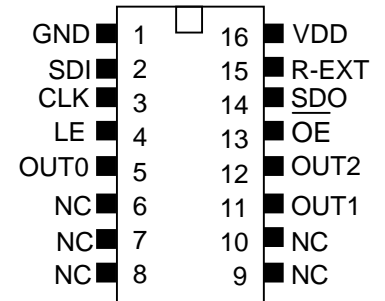
Brightness Control Code

| 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 |

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



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)

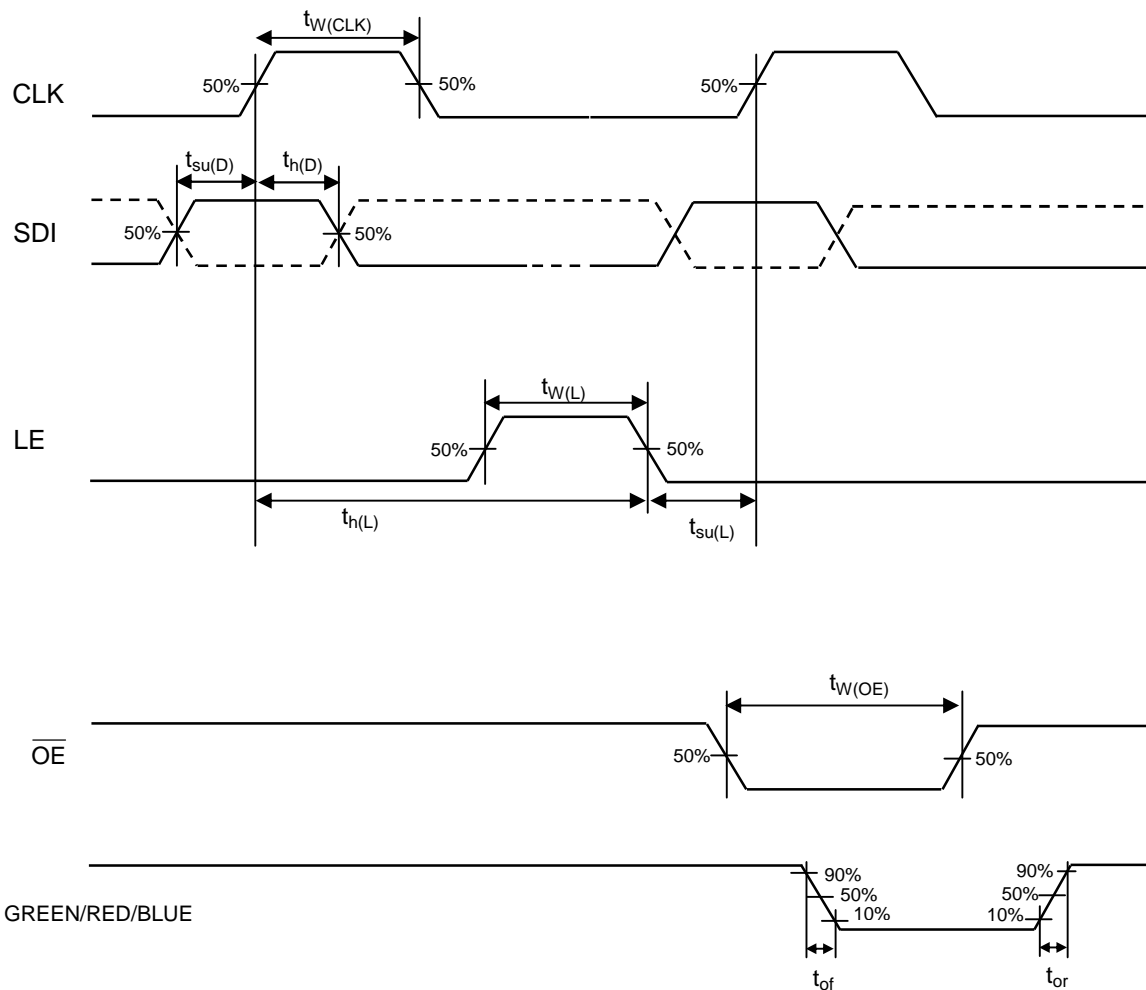
| Characteristics | Symbol | Condition | Min. | Typ. | Max. | Unit | |
|---|------------------|---|--|-------------|---------|------------------|----|
| Supply Voltage | V_{DD} | - | 3.0 | 5.0 | 5.5 | V | |
| Output Voltage | V_{DS} | OUT0, OUT1, OUT2 terminals | - | - | 17.0 | V | |
| Output Current | 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 | |

Switching Characteristics

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

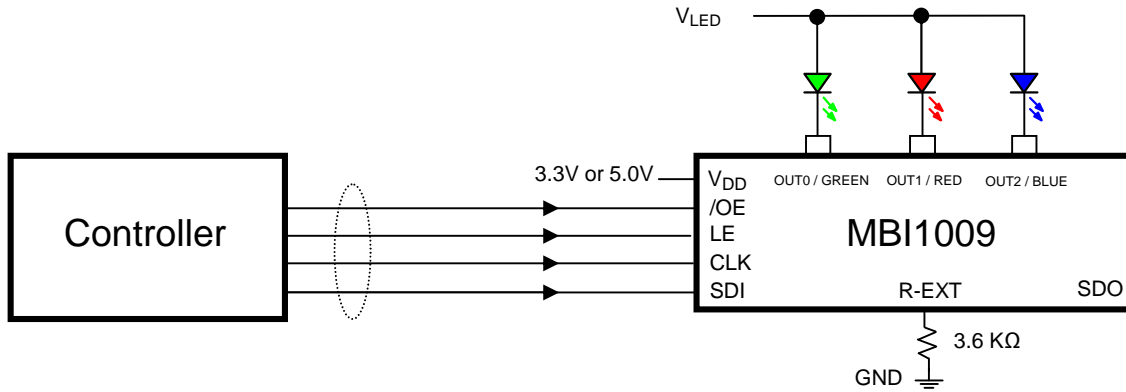
| Characteristics | Symbol | Min. | Typ. | Max. | Unit | |
|-----------------------------|------------------------|---------------------|------|------|------|----|
| Pulse Width | CLK | t _{w(CLK)} | 25 | - | - | ns |
| | LE | t _{w(L)} | 25 | - | - | ns |
| | $\overline{\text{OE}}$ | t _{w(OE)} | 1000 | - | - | 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.

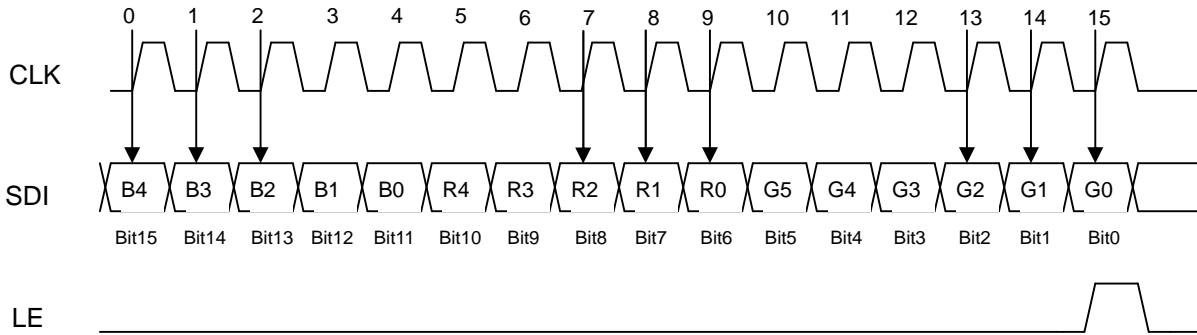
$I (R_{EXT})$ ($T_a = 25^{\circ}C$, $V_{DD} = 3.3V$) – A reference table

| 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 |

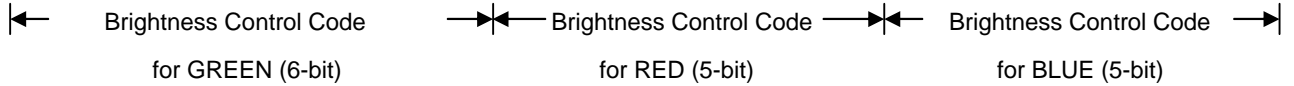
$I (R_{EXT})$ ($T_a = 25^{\circ}C$, $V_{DD} = 5V$) – A reference table

| 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 |

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 |

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 $I_{OUT, BLUE} = 16mA$.

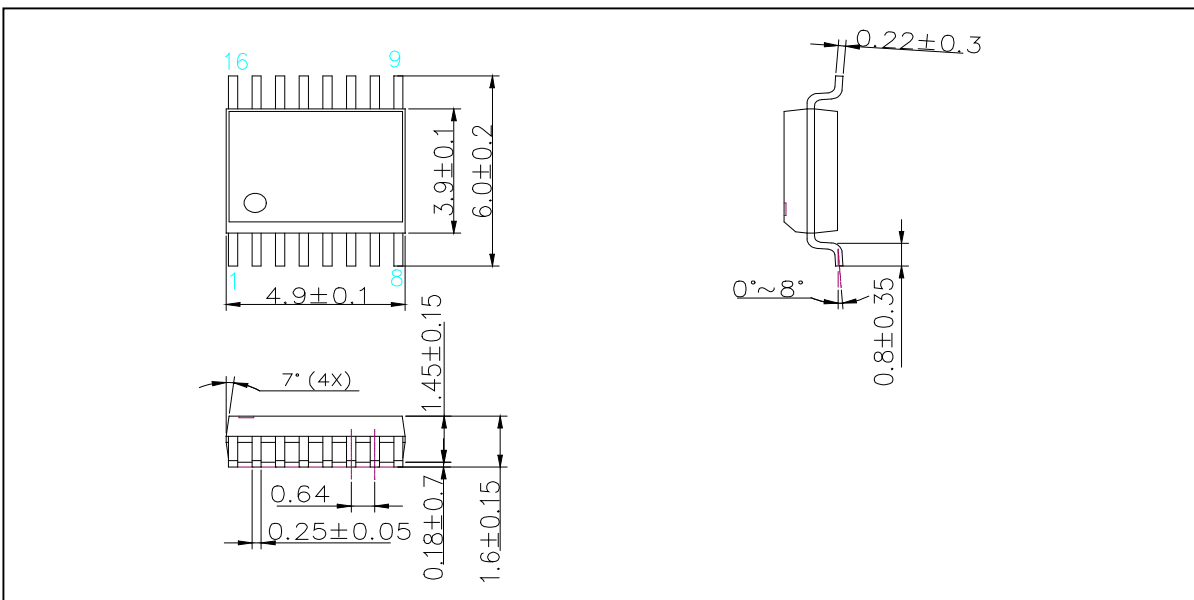
Assuming Luminous Intensity (mcd) of R/G/B LEDs are the same and $I (R_{ext}) = 4mA$, we may ideally let

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

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.