# BSC71K8181/A

**2-CHANNEL, DUAL INTENSITY, LINEAR CURRENT DRIVER WITH INTEGRATED PWM AND FAULT CONTROL**

## GENERAL DESCRIPTION

The BSC71K8181/A is a low cost two-channel linear constant current regulator for automotive rear tail light applications as well as LED-based digital signage. The LED sink current can be preset at the supplier rated current level for most optimal and reliable operation. The device offers a resistor selectable LED brightness intensity levels “stop” bright (DC mode) and “tail” dim (PWM mode).

The “stop” condition by-passes the PWM engine for the brightest LED intensity, while the “tail” condition reduces the LED brightness by setting the duty cycle of the internally generated PWM signal. The LED sink current level can be selected upto 150mA per Output Channel by a single resistor value at the $R_{EXT}$ pin.

Resistor $R_{DC}$ at the BRIGHT/STOP pin sets the duty cycle of the internal PWM oscillator for reducing the LED brightness intensity when operating in the “tail” condition.

Additionally, the device offers an active low FAULT input/output signal to report device error condition. The FAULT pins of several devices can be tied together to disable all the output stages when a fault condition is detected by any one of the devices.

The high level of functional integration of the BSC71K8181/A device not only reduces the critical external component count, but also allows for a single layer PCB routing for the complete LED Rear Brake Light solution.

The BSC71K8181/A is offered in an industry standard ESOP-8 package.

## FEATURES

- Output current programmable from 10mA to 150mA
- Supply Voltage range from 5V to 42V
- Tail Duty Cycle programmable from 1% to 99%
- Internal linear voltage regulator to minimize power consumption in the device
- Channel to Channel $I_{OUT}$ accuracy of ±5% max.
- Internal PWM logic selects between full brightness and PWM dimming levels
- FAULT status reporting
- LED open/short circuit detection **(BSC71K8181 Only)**
- Input overvoltage protection
- Thermal rollback of output current
- Withstand 50V load dump

## TYPICAL APPLICATIONS

- Rear Combinational Lamp (RCL)
- Center High Mount Stop Light (CHMSL)
- Daytime running lamp
- Fog lamps
- Turn signal
- Digital Display Signage

## PIN CONFIGURATION

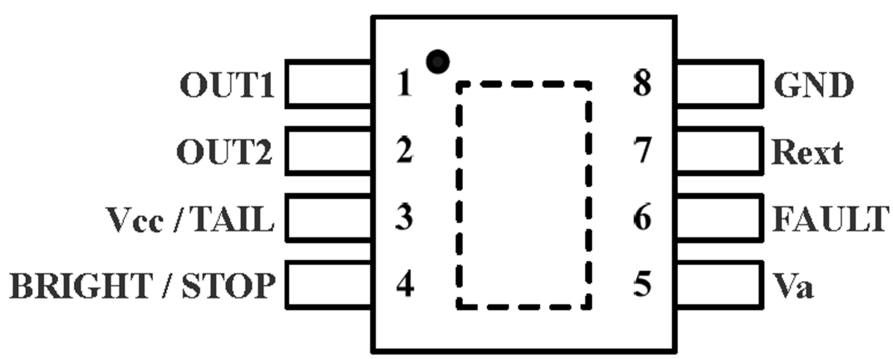
| Package Designator | Pin Configuration (Top View) |
|---|---|
| ESOP - 8 |   |

**Figure 1** Pin Configuration

## PIN DESCRIPTION

| No. | Pin | Description |
|---|---|---|
| 1 | OUT1 | Output current sink channel 1. |
| 2 | OUT2 | Output current sink channel 2. |
| 3 | Vcc / TAIL | Power Input for the IC<br>TAIL light signal for LED Brake Light Application<br>Vcc power input for LED Signage Application |
| 4 | BRIGHT / STOP | Digital logic input for the BRIGHT/STOP signal input. Logic high to select full intensity (by-pass the PWM) and logic low (or floating) to enable the PWM module with the Duty Cycle value selected by the value of the resistor $R_{DC}$ to GND. |
| 5 | Va | Stabilization output voltage reference requiring 1nF capacitor to GND. |
| 6 | FAULT | Open drain fault flag. High impedance status to indicate LED open/short (BSC71K8181 only), STOP pin over current, over voltage, thermal rolloff conditions. Can be tied directly with other BSC71K8181/A to disable all connected devices on case of single device failure. |
| 7 | $R_{EXT}$ | LED Sink Current Value Selection. |
| 8 | GND | Ground connection for the IC. |

### ABSOLUTE MAXIMUM RATINGS[1]

| Parameter | Symbol | Ratings | Unit |
|---|---|---|---|
| Maximum Supply Voltage | Vcc/TAIL | 50 | V |
| Maximum Output Current per Output Channel | $I_{OUT}$ | 180 | mA |
| Maximum Output Voltage | $V_{OUT}$ | 40 | V |
| Maximum Voltage at pin BRIGHT/STOP | $V_{STOP}$ | 50; > $V_{CC}$/TAIL | V |
| Maximum Voltage at pin $V_A$ | $V_A$ | 6 | V |
| Maximum Voltage at pin $R_{EXT}$ | $V_{Rext}$ | 6 | V |
| Maximum Voltage at pin FAULT | $V_{FAULT}$ | 50; < $V_{CC}$/TAIL | V |
| Reverse voltage between all terminals | $V_R$ | 0.5 | V |
| Maximum junction temperature[2] | $T_J$ | 150 | °C |
| ESD (HBM) | ESD | ±2 | kV |

**Note 1:** Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
**Note 2:** Detail information please refers to package thermal de-rating curve on Page 12.

### RECOMMENDED OPERATING CONDITIONS

| Parameter | Symbol | Ratings | Unit |
|---|---|---|---|
| Operating Junction Temperature | $T_J$ | -40…+125 | °C |
| Operating Supply voltage (at $I_{OUT}$≥9mA, $V_{OUT}$>1.5V) | $V_{CC}$/TAIL | 6…42 | V |
| Operating $I_{OUT}$ | $I_{OUT}$ | 10…100 | mA |
| Operating $V_{OUT1}$, $V_{OUT2}$ | $V_{OUT1,2}$ | 1.5…37V; ($V_{CC}$/TAIL - $V_{OUT1,2}$)>3V | V |

### ELECTRICAL CHARACTERISTICS

$R_{EXT}$=4kΩ, $R_{DC}$ = Open. Other Conditions, including Temperature are as noted (Note 3)

| Parameter | Symbol | Conditions | $T_J$, °C | Value Min | Value Typ | Value Max | Unit |
|---|---|---|---|---|---|---|---|
| Current Leakage | $I_{leak}$ | $V_{OUT}$=37V | $T_J$ = -40°C ~+125°C | | | 100 | µA |
| Supply Current | $I_{Vcc/TAIL}$ | $V_{CC}$/TAIL =12V, $V_{OUT1,2}$=1.5V, $R_{ext}$=24k | 25°C | | 3.8 | 4.7 | mA |
| | | | $T_J$ = -40°C ~+125°C | | | 5.2 | |
| Supply Current (Fault Conditions) | $I_{Vcc/TAIL}$ | $V_{CC}$/TAIL =12V, $V_{OUT1,2}$=1.5V, $V_{FLT}$ =0, $R_{ext}$ =4k | $T_J$ = -40°C ~+125°C | | 3.5 | 4.3 | mA |
| Average Output Current | $I_{OUT\_AVG}$ | ($I_{OUT1}$+$I_{OUT2}$)/2; $V_{OUT1,2}$=3V, $V_{CC}$/TAIL =12V, $R_{ext}$ =4k *(Note 1)* | 25°C | 57 | 62 | 67 | mA |
| | | | $T_J$ = -40°C ~+125°C | 54 | | 70 | |
| Voltage Drop ($V_{Rext}$) | $V_{Drop}$ | $V_{CC}$/TAIL=12V, $R_{ext}$ =24k | 25°C | 0.42 | 0.5 | 0.56 | V |
| | | | $T_J$ = -40°C ~+125°C | 0.4 | | 0.58 | |
| $I_{OUT1}$ to $I_{OUT2}$ Accuracy | ($I_{OUT1}$ - $I_{OUT2}$)/ $I_{OUT1}$ | $V_{CC}$/TAIL=12V, $V_{OUT1,2}$=3V, $R_{ext}$ =4k | $T_J$ = -40°C ~+125°C | | ±3 | ±5 | % |
| Duty Cycle | DC | $V_{CC}$/TAIL=12V, $R_{dc}$=50k | 25 °C | 41 | 50 | 59 | % |
| | | | $T_J$ = -40°C ~+125°C | 38 | | 62 | |
| Frequency | $F_{osc}$ | $V_{CC}$/TAIL=12V, $R_{dc}$=50k | 25°C | | 4.5 | | kHz |
| Internal Regulator | $V_A$ | $V_{CC}$/TAIL=12V | $T_J$ = -40°C ~+125°C | 4.05 | 4.27 | 4.5 | V |
| Fault Input Threshold | $V_{FAULT-th}$ | $V_{CC}$/TAIL=12V (at $V_{FAULT}$ =Low Out=OFF; at $V_{FAULT}$ =High Out=ON) | 25°C | 1 | 1.4 | 1.7 | V |
| | | | $T_J$ = -40°C ~+125°C | 0.6 | | 2.0 | |
| Fault Input Current | $I_{FAULT}$ | $V_{CC}$/TAIL=12V, $V_{FAULT}$=0V | 25°C | | -110 | | µA |
| DC Input Threshold High | $V_{STOP-H}$ | $V_{CC}$/TAIL=12V, Duty Cycle=100% | $T_J$ = -40°C ~+125°C | | 3.1 | | V |
| DC Input Threshold Low | $V_{STOP-L}$ | $V_{CC}$/TAIL=12V, Duty Cycle=0% | $T_J$ = -40°C ~+125°C | | 0.9 | | V |

**ELECTRICAL CHARACTERISTICS (CONTINUE)**

$R_{ext}$ =4kΩ, $R_{DC}$ = Open. Other Conditions, including Temperature are as noted (Note 3)

| Parameter | Symbol | Conditions | $T_J$, °C | Value | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | |
| Output Fault Low Voltage | $V_{L\text{-}FAULT}$ | $V_{CC}$/TAIL=12V, open branches LEDs, $I_{FAULT}$=1mA | $T_J$ = -40°C ~+125°C | | 0.2 | 0.4 | V |
| Over Current Protection | $I_{OCP}$ | $V_{CC}$/TAIL=12V | 25°C | 160 | 170 | 190 | mA |
| | | | $T_J$ = -40°C ~+125°C | 105 | | 210 | |
| Fault Short LEDs Threshold[4] | VCC/$TAIL_{SHORT}$ | $V_{OUT1}$-$V_{OUT2}$ *(Note 4)* | 25°C | | ±1.85 | | V |
| | | | $T_J$ = -40°C ~+125°C | ±1.2 | | ±2.5 | |
| Thermo Protection ($T_J$) | TP | $V_{CC}$/TAIL=12V | | | 170 | | °C |
| Thermo Protection Hysteresis | $TP_{HYST}$ | $V_{CC}$/TAIL=12V | | | 35 | | °C |
| Output Current Change versus $V_{CC}$/TAIL | $\Delta I_{OUT}/I_{OUT}$ | $V_{OUT}$ =3V, $V_{CC}$/TAIL=6V…42V | $T_J$ = -40°C ~+125°C | | 0.03 | | %/V |

**Note 3:** All parts are production tested at $T_J$ = 25°C, unless otherwise noted. Other temperature limits are guaranteed by design.

**Note 4:** Short LEDs Fault conditions are determined according to the difference of voltages between pins Out1 and Out2. When this difference exceeds 1.85V resulting in a $V_{FAULT}$="Low". At $T_J$ =+125°C - Vshort~±1.35V, at $T_J$ =-40°C - Vshort~±2.35V. **You must use the same type of LEDs and their number in both branches: OUT1 and OUT2**.

## TYPICAL PERFORMANCE CHARACTERISTICS

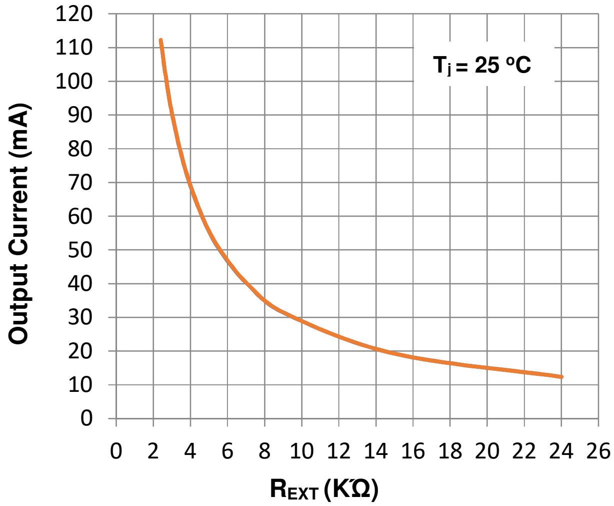



**Figure 2** Output Current vs. $R_{EXT}$

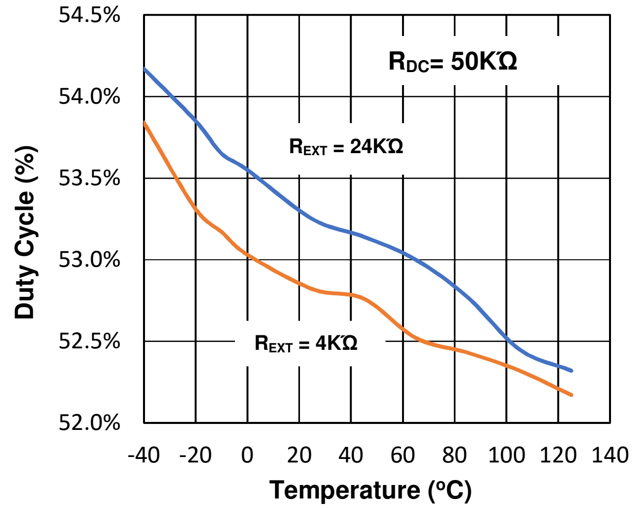



**Figure 3** Duty Cycle vs. Temperature

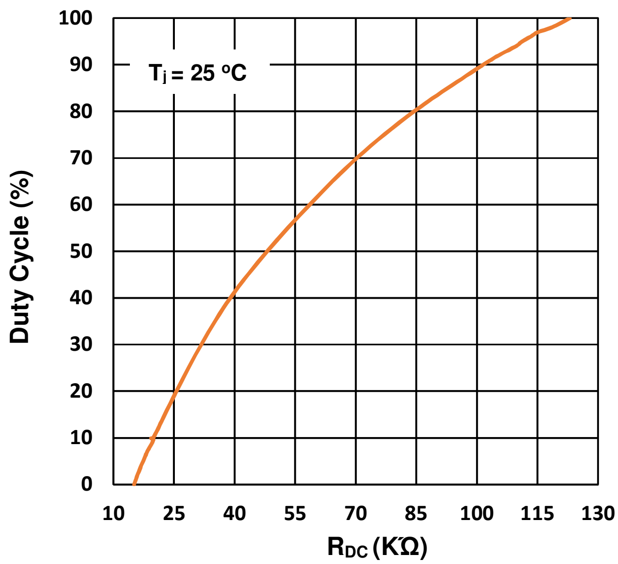



**Figure 4** Duty Cycle vs. $R_{DC}$

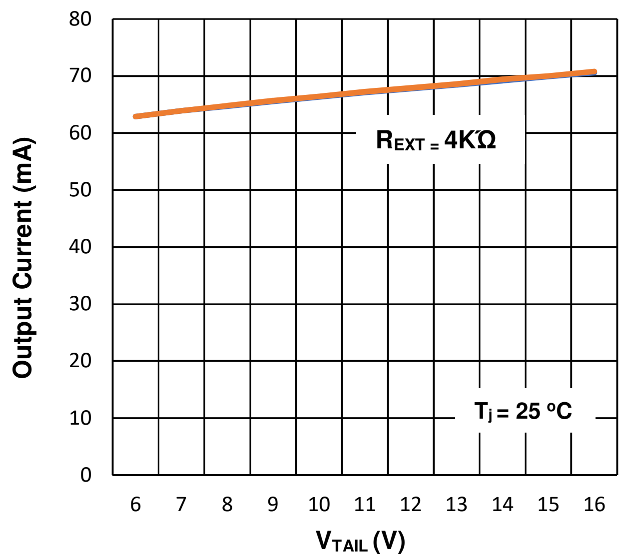



**Figure 5** $I_{OUT}$ vs. $V_{TAIL}$

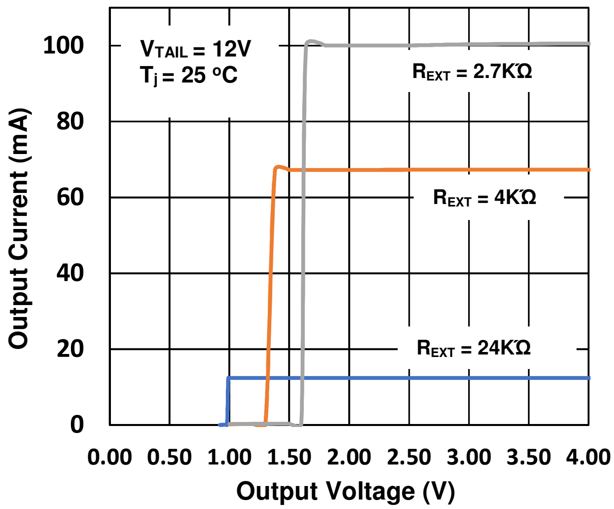



**Figure 6** Output Current vs. Output Voltage

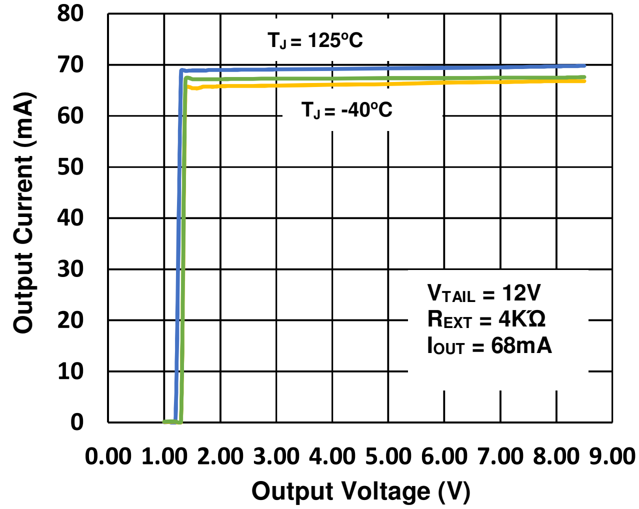



**Figure 7** Output Current vs. Output Voltage

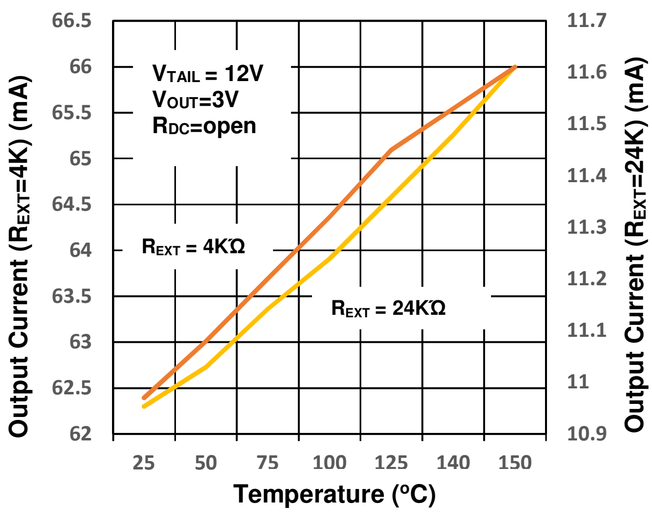
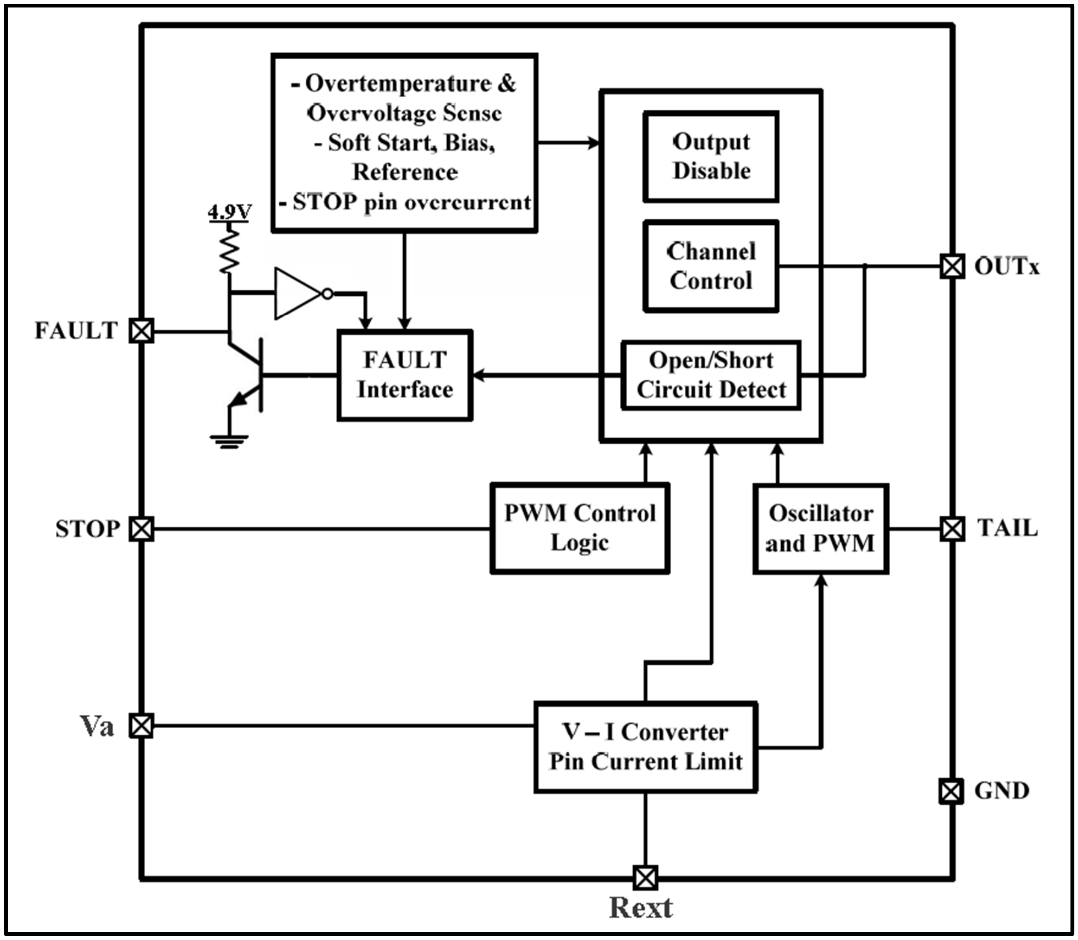



**Figure 8** Output Current vs. $T_J$

**FUNCTIONAL BLOCK DIARGAM FOR BSC71K8181**



## APPLICATION INFORMATION

The BSC71K8181/A is a fully integrated 2-channel linear sink current driver optimized for constant current, dual brightness, lighting applications. This device offers a low-cost single chip solution for Automotive Backlight and Digital Signage markets. The high level of functional integration of the BSC71K8181/A device not only reduces the critical external component count, but also allows for a single layer PCB routing for the complete LED Rear Brake Light solution. Please see Typical Application Circuits on pages 14-15.

An external resistor, $R_{EXT}$, is used to setup the optimal current value for OUT1 and OUT2 channels to drive the LED string. An internal PWM circuit is used to adjust the LED intensity level. An $R_{DC}$ resistor sets up the duty cycle of the PWM to reduce the LED intensity to the desired value. The 'STOP' signal selects between the two brightness levels; when 'STOP' is "high" level, the LED shines brightly (as when the BRAKE pedal is pushed) and when 'STOP' is "low" level, the LED shines less intensely (as when only the night light is turned on).

## PROGRAMMING THE OUTPUT CURRENT

A single programming resistor ($R_{EXT}$) controls the maximum sink current for each LED channel. The programming resistor value may be approximately calculated using the following Equation (1):

$$Iout = \frac{250}{Rext} \qquad (1)$$

Where $I_{OUT}$ is in mA, and $R_{EXT}$ is in kΩ.

Thus, a desired output current of 50mA would require a corresponding external programming resistance of 5kΩ.

## OVER CURRENT PROTECTION

To protect the BSC71K8181/A device against high current surges, over current protection circuitry has been integrated in the design. When the $I_{OUT}$ current on any of the pins reaches or exceeds 170 mA, the FAULT latch will assert, pulling the FAULT signal low.

## PROGRAMMING THE PWM DUTY CYCLE

An external resistor on the STOP pin sets the duty cycle for the PWM circuitry, which, in turn, determines the lower intensity TAIL condition. Resistor value for the Duty Cycle selection can be determined from the chart on Figure 4. Thus, as an example, a 50% duty cycle would require the $R_{DC}$=50kΩ. Internally, PWM circuitry generates a saw-tooth waveform of ~5KHz frequency. The $R_{DC}$ selection will setup a chosen duty cycle at the 5KHz frequency oscillation.

When the STOP signal is asserted, the high voltage level on the STOP pin forces the Duty Cycle to 100% for the BRIGHT (high intensity) operation.

## THERMAL ROLLBACK OF OUTPUT CURRENT

To protect the IC from damage due to high power dissipation, the temperature of the die is monitored. If the die temperature exceeds the thermal shutdown temperature of 170°C (Typ.) then the device will shutdown, and the sink currents will shut off for all channels. The fault register is triggered and FAULT pin will be asserted low after delay time. After a thermal shutdown event, the BSC71K8181/A will not try to restart until its internal temperature has been reduced to less than 135°C (Typ.).

## OPEN LED DETECTION (*BSC71K8181 ONLY*)

Each of the outputs of the BSC71K8181 is monitored for an output voltage of less than 900mV (Typ.). If any of the output voltages drops below this threshold voltage, the fault register is triggered and the FAULT pin is asserted low.

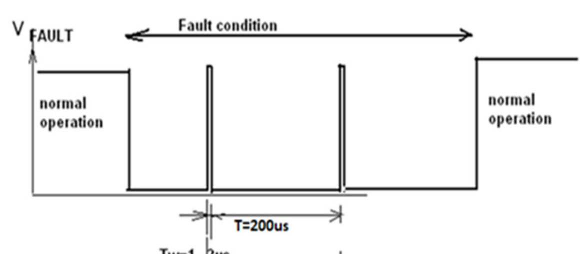
## SHORT LED DETECTION (*BSC71K8181 ONLY*)

Each of the outputs of the BSC71K8181 is monitored for an LED short condition. This condition occurs when any of the system LEDs doesn't incur a voltage drop across it rendering a difference in Vout between the two channels. Short LED Fault condition is triggered when the difference of voltages between pins Out1 and Out2 is greater than ±1.85V. For the Short LED detection to work properly, customer must use identical type of LEDs and their number in both output channels, Out1 and Out2. If in an unlikely situation when the same number of LEDs fail simultaneously in both branches Out1 and Out2, then the Fault condition may not get triggered.

## FAULT OUTPUT OPERATION

The FAULT pin is an open drain structure. When a fault condition occurs, the pin will change from high impedance to pull low state. The FAULT pin is also an input pin. When the voltage of this pin is pulled up to exceed VFAULT_H, all the outputs will be enabled. To shutdown the output, the FAULT pin voltage has to drop lower than VFAULT_L. When multiple BSC71K8181/A devices have their FAULT pins connected together, any FAULT condition on any of the device will act to turn off all the interconnected devices.

Any channel which encounters an open or short LED condition will assert the FAULT pin. However, BSC71K8181/A has an internal monitoring circuitry that constantly checks all the FAULT causing conditions. The FAULT pin will reassert if the fault condition still exists, or, if the fault condition has been cleared, FAULT pin will not re-assert.




The Reset of Fault-Latch by signal clk

### THERMAL CONSIDERATIONS

The thermal resistance is achieved by mounting the BSC71K8181/A on a standard FR4 double-sided printed circuit board (PCB) with a copper area of a few square inches on each side of the board under the BSC71K8181.

Multiple thermal vias, as shown in Figure 9, help to conduct the heat from the exposed pad of the BSC71K8181/A to the copper on each side of the board. The thermal resistance can be further reduced by using a metal substrate or by adding a heatsink.

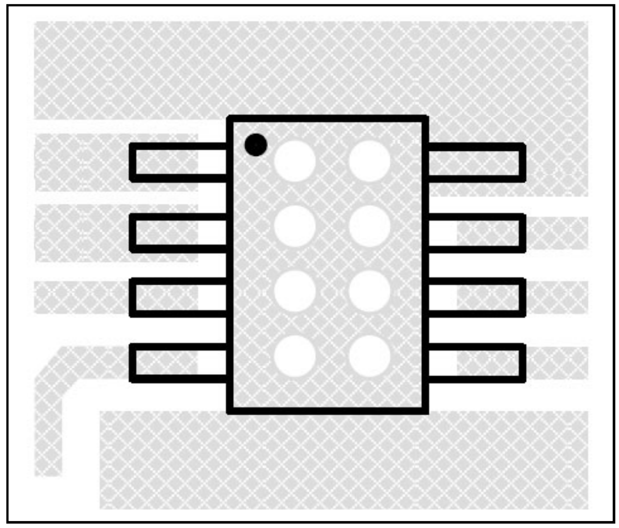
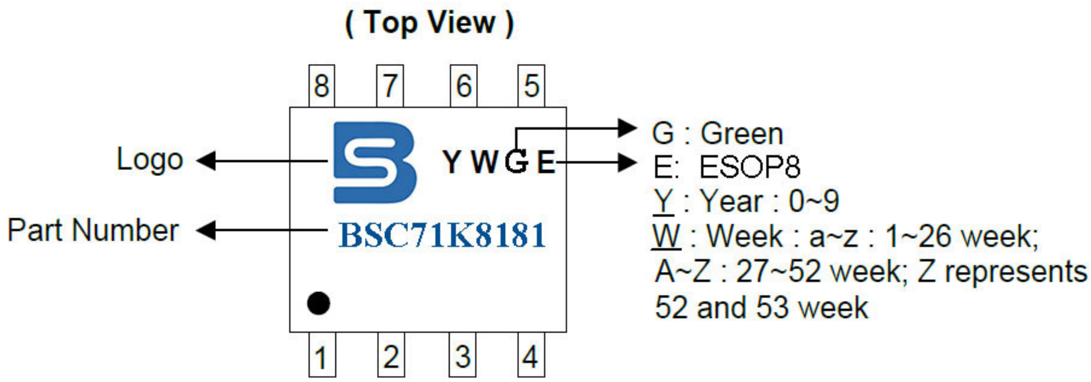


**Figure 9** Board Via Layout For Thermal Dissipation

## DEVICE MARKING



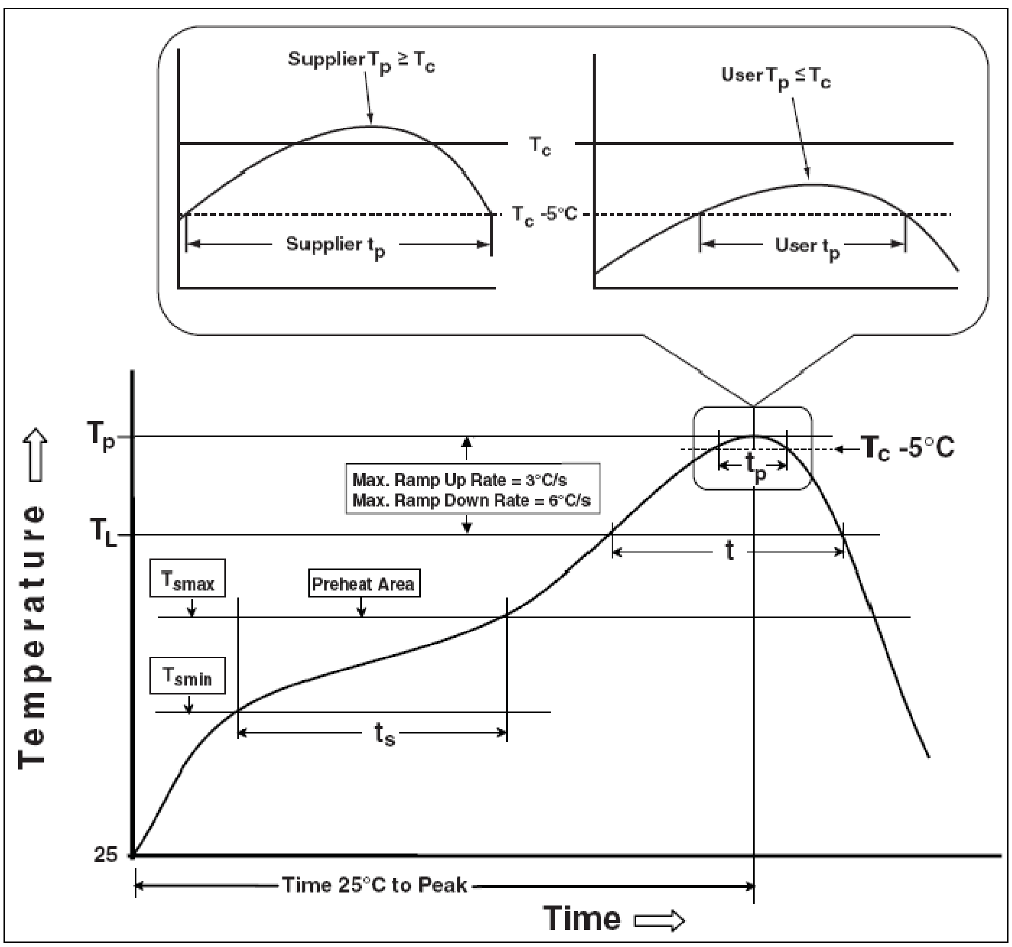

## ORDERING INFORMATION

**Automotive Range: -40°C To +125°C**

| Order Part No. | Package | QTY/Reel |
|---|---|---|
| BSC71K8181-TR | ESOP-8, Lead-free Tape and Reel | 3000 |
| BSC71K818A-TR | ESOP-8, Lead-free Tape and Reel | 3000 |

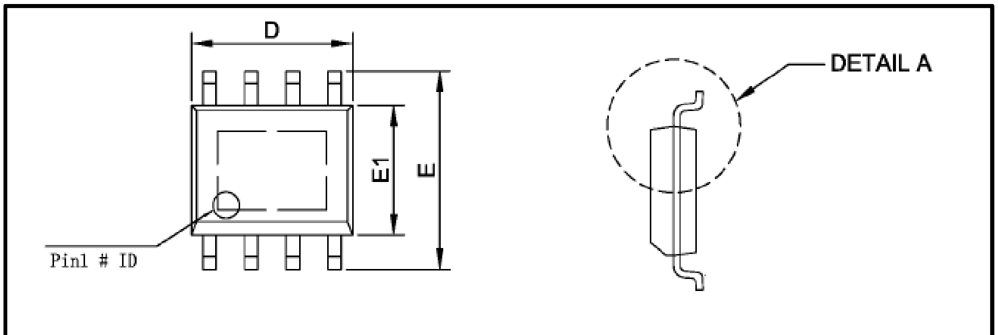
## CLASSIFICATION REFLOW PROFILES

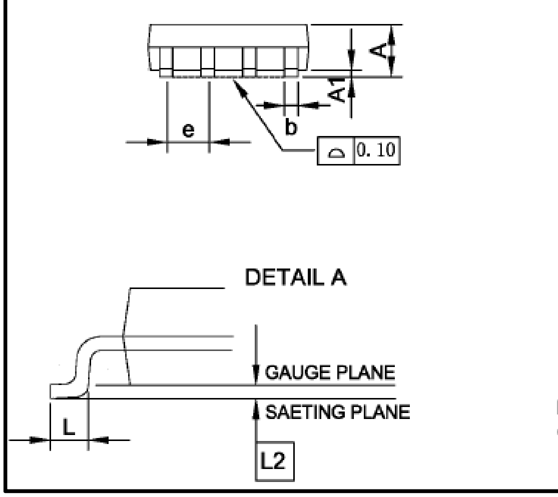
| Profile Feature | Pb-Free Assembly |
|---|---|
| Preheat & Soak<br>Temperature min (Tsmin)<br>Temperature max (Tsmax)<br>Time (Tsmin to Tsmax) (ts) | 150°C<br>200°C<br>60-120 seconds |
| Average ramp-up rate (Tsmax to Tp) | 3°C/second max. |
| Liquidous temperature (TL)<br>Time at liquidous (tL) | 217°C<br>60-150 seconds |
| Peak package body temperature (Tp)* | Max 260°C |
| Time (tp)** within 5°C of the specified classification temperature (Tc) | Max 30 seconds |
| Average ramp-down rate (Tp to Tsmax)<br>Time 25°C to peak temperature | 6°C/second max.<br>8 minutes max. |



## PACKAGE INFORMATION

### ESOP-8



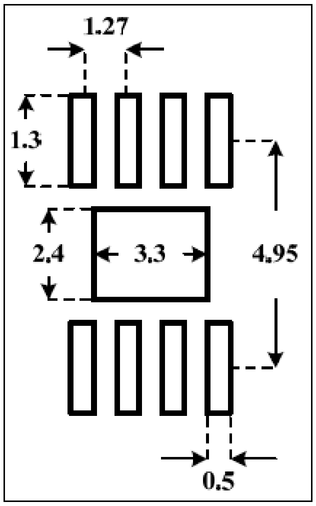

| SYMBOL | MILLIMETER | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| A | – | – | 1.75 |
| A1 | 0.05 | 0.20 | 0.25 |
| E1 | 3.70 | 3.90 | 4.10 |
| E | 5.80 | 6.00 | 6.20 |
| D | 4.70 | 4.90 | 5.10 |
| b | 0.38 | 0.41 | 0.51 |
| e | 1.27BSC | | |
| L | 0.40 | 0.60 | 0.80 |
| L2 | 0.25BSC | | |

NOTES:The shape of body and thermal pad shows different shape among different factories.

## PACKAGE THERMAL DATA

| Package | $\theta_{JC}$ Thermal Resistance Junction-to-Case | $\theta_{JA}$ Thermal Resistance Junction-to-Ambient |
|---|---|---|
| ESOP-8 | 2 | 60°C/W |

**RECOMMENDED LAND PATTERN**




**Note:**

1. Land pattern complies to IPC-7351.
2. All dimensions in MM.
3. This document (including dimensions, notes & specs) is a recommendation based on typical circuit board manufacturing parameters. Since land pattern design depends on many factors unknown (eg. user's board manufacturing specs), user must determine suitability for use.

## TYPICAL APPLICATION CIRCUITS

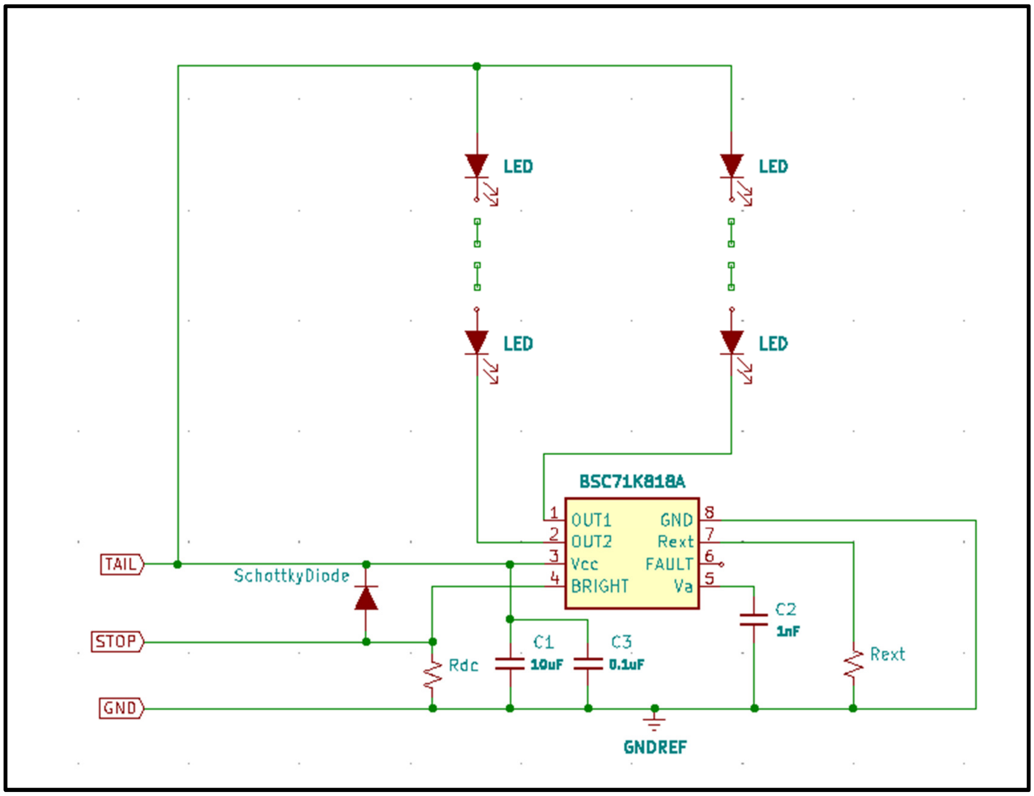



**Figure 10** Typical Application Circuit (Single Device LED Brake Light Operation)

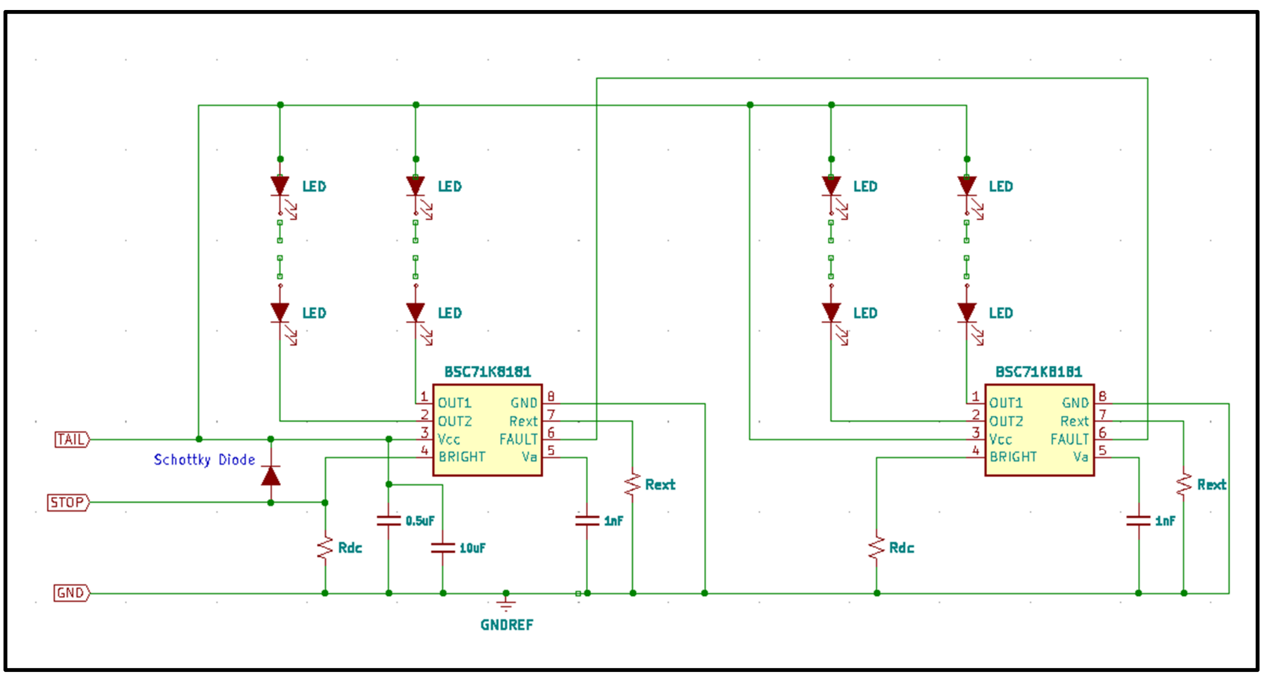



**Figure 11** Typical Application Circuit (Dual Device LED Brake Light Operation with Connected Fault Signal)

## REVISION HISTORY

| Revision | Detail Information | Date |
|---|---|---|
| A | Initial release | 2020.06.01 |
| B | Add 1MΩ Resistor between Out pin and GND in Reference Designs | 2021.02.03 |
| C | Add BSC71K818A without Open and Short LED Detection Option | 2023.01.15 |

## ADDITIONAL REFERENCES AND DOCUMENTS

| DOCUMENT NAME | Description |
|---|---|
| **BSC71K8181_EB Rev B Final** | EVALUATON BOARD FOR BSC71K8181 150mA, DUAL CHANNEL LED DRIVER WITH INTEGRATED PWM AND FAULT DETECTION FOR AUTOMOTIVE REAR TAIL LIGHT |