# SGM3770
# PWM Control Linear Dimming LED Driver with 1:500 Twinkle Free Dynamic Range

## GENERAL DESCRIPTION

The SGM3770 is a 2A synchronous step-down LED driver with 28V maximum input voltage. The integrated power MOSFETs and fixed 790kHz switching frequency provide high efficiency and extremely small solution size. The SGM3770 uses peak-current-mode control and full internal compensation to regulate the LED current with high accuracy over a wide range of operation conditions.

The SGM3770 implements analog diming method. It accepts an external PWM dimming input and changes the internal reference voltage proportional to the duty cycle of the PWM signal. During normal operation, the precise internal 100mV reference voltage allows the device to achieve 1:500 twinkle free dimming current range. The recommended PWM dimming frequency is in the range from 5kHz to100kHz.

The SGM3770 implements full protections, including the cycle-by-cycle current limit, LED+ short to GND, LED short, LED open, FB short to GND, VIN_OVP and thermal shutdown protection.

The SGM3770 is available in Green TDFN-2×2-6EL and TSOT-23-6 packages. It operates over a wide junction temperature range of -40℃ to +125℃.

## FEATURES

- **1:500 Twinkle Free Dimming**
- **Wide Input Range up to 28V**
- **2A LED Driving Capability**
- **Low $R_{DSON}$ for Internal MOSFETs**
  **High-side/Low-side: 96mΩ/60mΩ (TYP)**
- **Fixed 790kHz Switching Frequency**
- **Forced Pulse Width Modulation Mode (FPWM)**
- **Output Discharge in Turn-Off**
- **Cycle-by-Cycle Current Limit**
- **Output Short-Circuit Protection**
- **LED Short and Open Protection**
- **Input Over-Voltage Protection**
- **+155℃ Die Temperature Thermal Shutdown**
- **Available in Green TDFN-2×2-6EL and TSOT-23-6 Packages**

## APPLICATIONS

Lighting
Indicator Driving

## TYPICAL APPLICATION

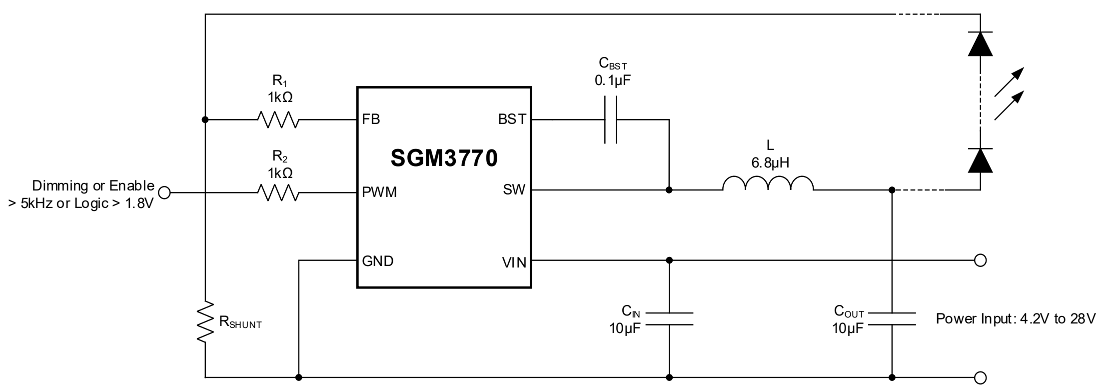



**Figure 1. Typical Application Circuit**

## PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---|---|---|---|---|---|
| SGM3770 | TDFN-2×2-6EL | -40℃ to +125℃ | SGM3770XTGE6G/TR | 3770<br>XXXX | Tape and Reel, 3000 |
| | TSOT-23-6 | -40℃ to +125℃ | SGM3770XTN6G/TR | MEKXX | Tape and Reel, 3000 |

### MARKING INFORMATION

NOTE: XX = Date Code. XXXX = Date Code, Trace Code and Vendor Code.

TDFN-2×2-6EL

X X X X
- Vendor Code
- Trace Code
- Date Code - Year

TSOT-23-6

YYY X X
- Date Code - Week
- Date Code - Year
- Serial Number

Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

## ABSOLUTE MAXIMUM RATINGS

VIN, SW .......... -0.3V to 30V
VIN (100μs Transient Pulse) .......... 36V
SW Spike over Plateau .......... -2V and +4V, 40ns
BST to SW Voltage .......... -0.3V to 6V
FB, PWM .......... -0.3V to 24V
Package Thermal Resistance
TDFN-2×2-6EL, $\theta_{JA}$ .......... 119℃/W
TDFN-2×2-6EL, $\theta_{JC}$ .......... 26℃/W
TSOT-23-6, $\theta_{JA}$ .......... 107℃/W
TSOT-23-6, $\theta_{JC}$ .......... 45℃/W
Junction Temperature .......... +150℃
Storage Temperature Range .......... -65℃ to +150℃
Lead Temperature (Soldering, 10s) .......... +260℃
ESD Susceptibility
HBM .......... 2500V
CDM .......... 2000V

## RECOMMENDED OPERATING CONDITIONS

Input Voltage, $V_{IN}$ .......... 4.2V to 28V
Maximum LED Current .......... 2A
Operating Junction Temperature Range .......... -40℃ to +125℃

## OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

## ESD SENSITIVITY CAUTION

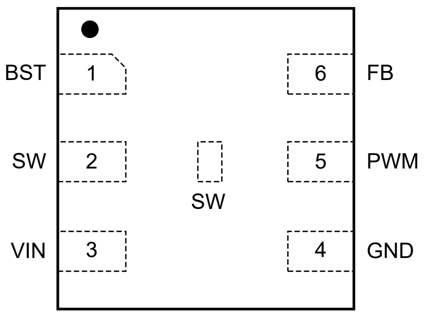
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

## DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

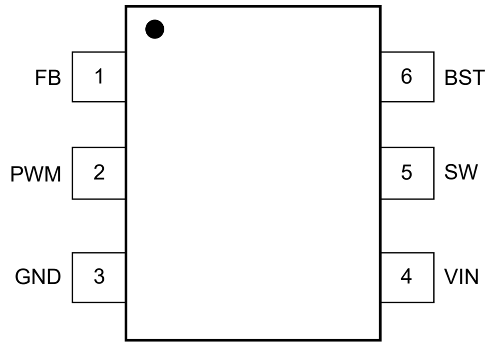
## PIN CONFIGURATIONS

(TOP VIEW)




TDFN-2×2-6EL

(TOP VIEW)




TSOT-23-6

## PIN DESCRIPTION

| PIN | | NAME | I/O | FUNCTION |
|---|---|---|---|---|
| TSOT-23-6 | TDFN-2×2-6EL | | | |
| 1 | 6 | FB | AI | Current Sensing Input. Connect it to the shunt resistor sample end. An inserted serial resistor about 1kΩ in the connection to shunt resistor is suggested if the wiring to LED string may induce large electric surge in application. |
| 2 | 5 | PWM | AI | Dimming and Enable Control Input. Feed continuous PWM train into this pin to keep this chip operation and control the LED current in proportional to the PWM duty cycle. Shut down the chip operation if no pulse is seen in more than 0.4ms. |
| 3 | 4 | GND | P | Ground and Current Sensing Shunt Zero Reference Point. Placing the shunt resistor close to this pin is recommended for less ground difference interference induction. |
| 4 | 3 | VIN | P | Power Input. |
| 5 | 2 | SW | P | Switching Node of the Internal Power Chopper. Connect this pin to the external Inductor. |
| 6 | 1 | BST | AI | Bootstrap Input. Connect it to the SW pin through a capacitor. |
| — | Exposed Pad | SW | — | It should be soldered to the SW pin. |

NOTE: P: power supply, AI: analog input.

# ELECTRICAL CHARACTERISTICS

($V_{IN}$ = 12V, $T_J$ = +25℃, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **Input Supply** | | | | | | | |
| Input Voltage Range | $V_{IN}$ | | | 4.2 | | 28.0 | V |
| Input Under-Voltage Lockout Threshold | $V_{UVLO}$ | $V_{IN}$ rising | | | 3.8 | 4.05 | V |
| Input Under-Voltage Lockout Hysteresis | $V_{UVLO\_HYS}$ | $V_{IN}$ falling | | | 260 | | mV |
| Input Over-Voltage Protection Threshold | $V_{OVP}$ | | | 29.9 | 31.2 | 32.6 | V |
| Input Over-Voltage Protection Hysteresis | $V_{OVP\_HYS}$ | | | | 2.9 | | V |
| Shutdown Current | $I_{SHDN}$ | | | | 6.0 | 7.5 | μA |
| Quiescent Current | $I_Q$ | | | | 1.3 | 1.5 | mA |
| **Feedback** | | | | | | | |
| Feedback Voltage Accuracy | $V_{FB}$ | $f_{PWM}$ = 5kHz | For 100% PWM | 98.00 | 100.19 | 103.90 | mV |
| | | | For 5% PWM | 5.50 | 6.00 | 6.70 | |
| | | | For 1% PWM | 1.60 | 1.94 | 2.30 | |
| The Shunt Resistor Sample End Voltage | $V_{LED-}$ | $f_{PWM}$ = 5kHz, $R_1$ = 1kΩ | For 100% PWM | 97.00 | 99.28 | 102.90 | mV |
| | | | For 5% PWM | 4.40 | 5.00 | 5.60 | |
| | | | For 1% PWM | 0.60 | 1.02 | 1.40 | |
| | | | For 2‰ PWM | | 0.25 | | |
| **Switching** | | | | | | | |
| Switching Frequency | $f_{SW}$ | | | 590 | 790 | 1000 | kHz |
| Minimum ON Time | $t_{ON\_MIN}$ | | | | 104 | | ns |
| Max Duty Cycle | $D_{MAX}$ | | | | 95 | | % |
| **BST Voltage** | | | | | | | |
| Bias Voltage for High-side FET Driver | $V_{BST\_SW}$ | | | | 5 | | V |
| **Integrated Power Switches** | | | | | | | |
| High-side FET On-Resistance | $R_{DSON\_H}$ | | | | 96 | 110 | mΩ |
| Low-side FET On-Resistance | $R_{DSON\_L}$ | | | | 60 | 71 | mΩ |
| High-side FET Peak Current Limit | $I_{MAX\_H}$ | | | 2.9 | 3.3 | 3.6 | A |
| Low-side FET Valley Current Limit | $I_{MAX\_L}$ | | | 2.1 | 2.6 | 3.2 | A |
| Negative Low-side FET Current Limit | $I_{MAX\_L\_H}$ | | | | -1.5 | | A |
| **Dimming** | | | | | | | |
| Dimming ON Threshold | $V_{DIM\_ON}$ | | | | | 1.2 | V |
| Dimming OFF Threshold | $V_{DIM\_OFF}$ | | | 0.6 | | | V |
| Power Blank Time (1) | $t_{BLK}$ | Not accept PWM control and force the PWM input pull-down internally during this blank time. | | | 0.5 | | ms |
| PWM Pulse Duration (1) | $t_{MIN}$ | | | | 50 | | ns |
| **Soft-Start** | | | | | | | |
| Soft-Start Time | $t_{SS}$ | | | | 0.6 | | ms |
| **Thermal Shutdown** | | | | | | | |
| Thermal Shutdown Threshold | $T_{SD}$ | | | | 155 | | ℃ |
| Thermal Shutdown Hysteresis | $T_{HYS}$ | | | | 50 | | ℃ |

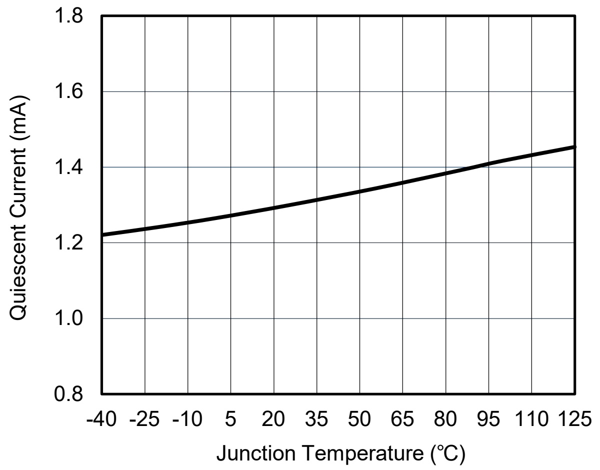
NOTE:

1. Guaranteed by design.

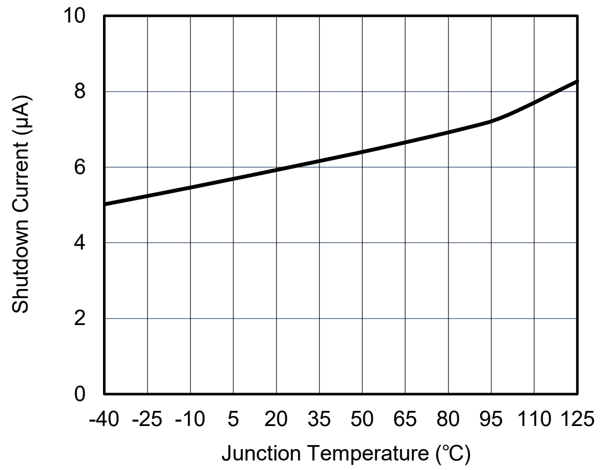
# TYPICAL PERFORMANCE CHARACTERISTICS

$V_{IN}$ = 12V, $R_{SHUNT}$ = 50mΩ, unless otherwise noted.

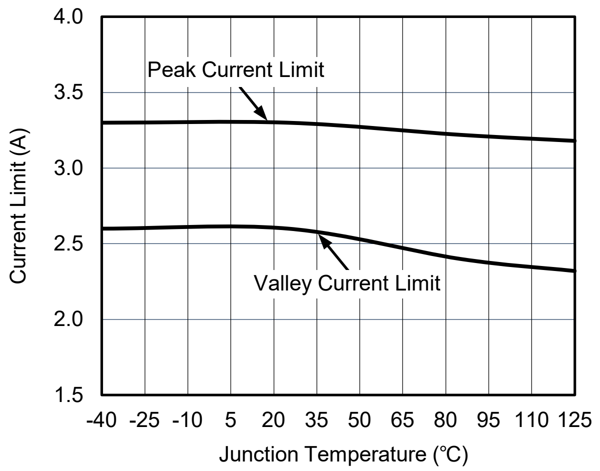
Quiescent Current vs. Junction Temperature



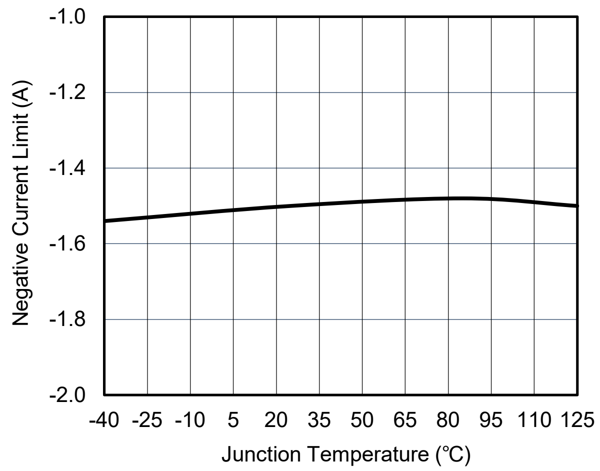

Shutdown Current vs. Junction Temperature



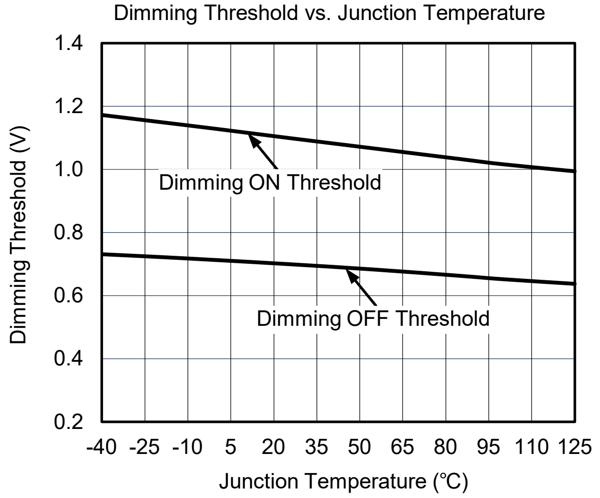

Current Limit vs. Junction Temperature



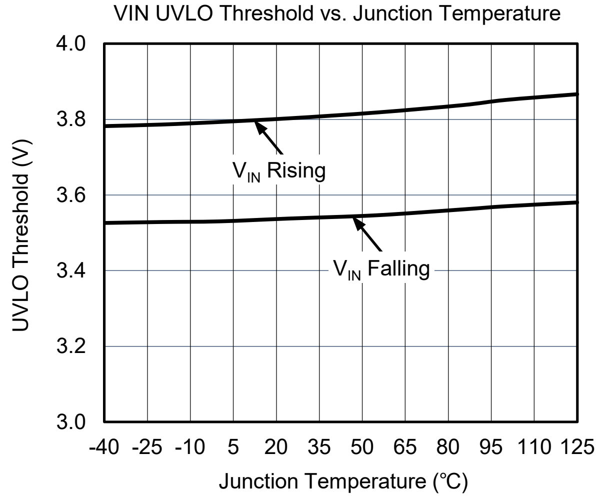

Negative Current Limit vs. Junction Temperature




Dimming Threshold vs. Junction Temperature



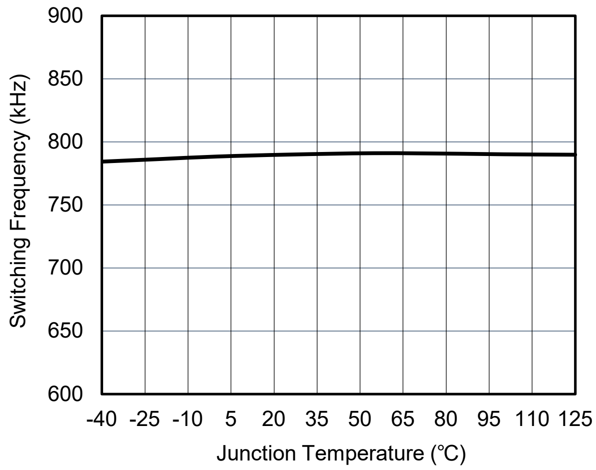

VIN UVLO Threshold vs. Junction Temperature



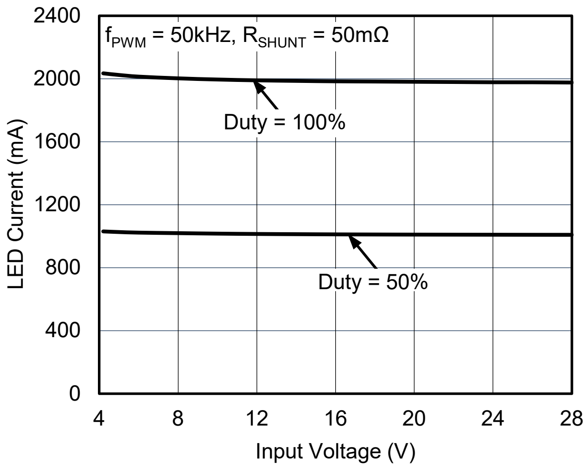
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{IN}$ = 12V, $R_{SHUNT}$ = 50mΩ, unless otherwise noted.

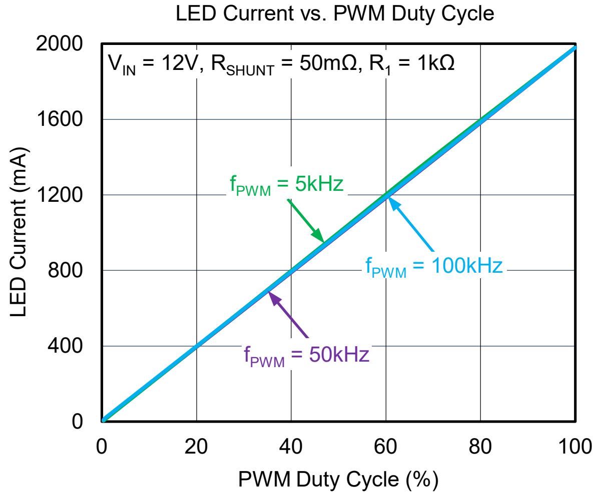
Switching Frequency vs. Junction Temperature



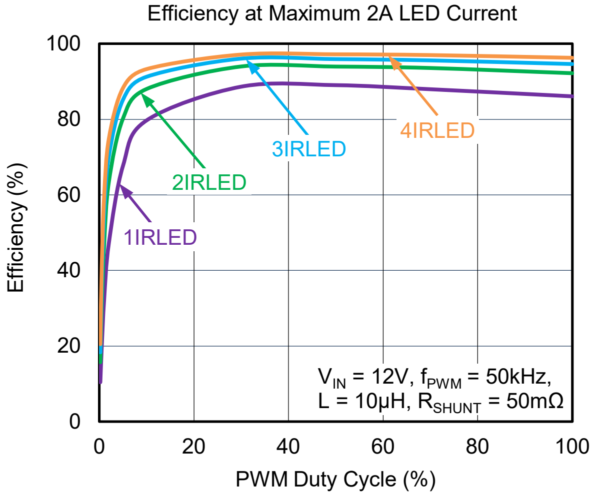

LED Current vs. Input Voltage



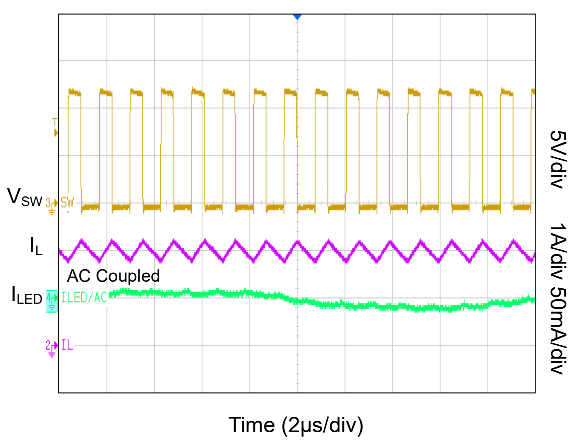

LED Current vs. PWM Duty Cycle



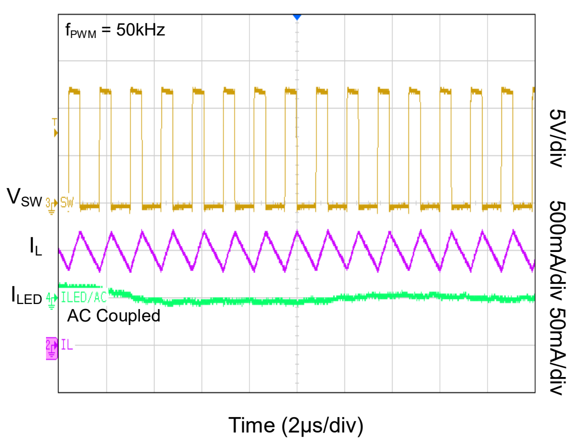

Efficiency at Maximum 2A LED Current




Steady State at 100% Duty Cycle



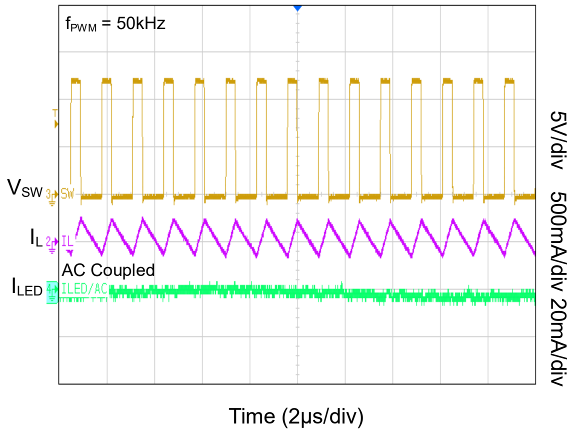

Steady State at 50% Duty Cycle



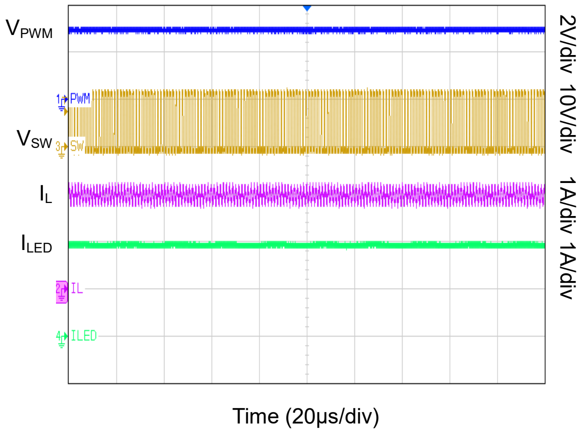
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{IN}$ = 12V, $R_{SHUNT}$ = 50mΩ, unless otherwise noted.

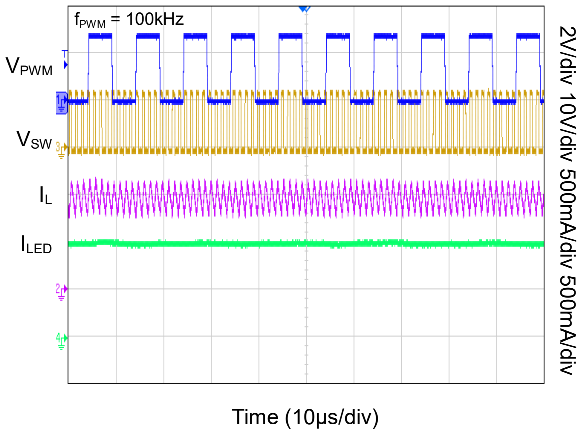
Steady State at 1% Duty Cycle



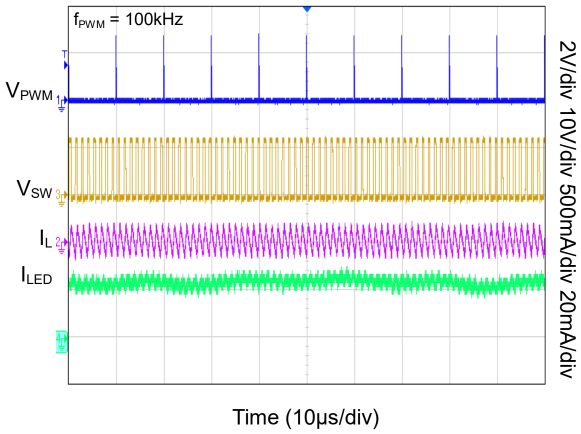

LED Current at 100% Duty Cycle



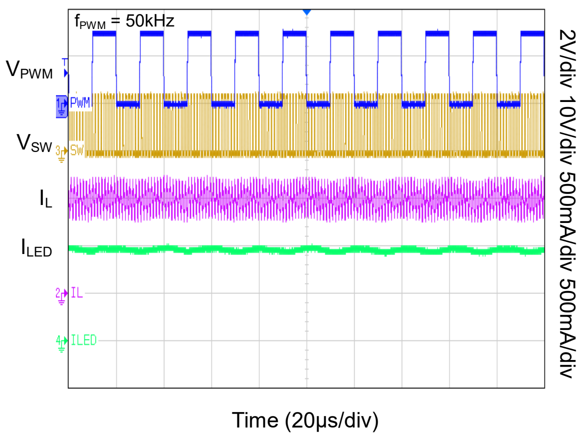

LED Current at 50% Duty Cycle



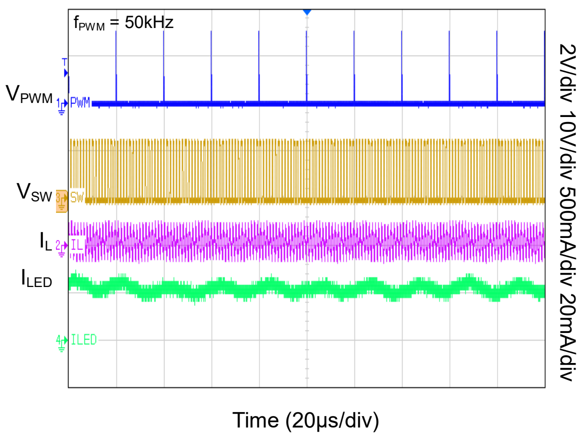

LED Current at 1% Duty Cycle




LED Current at 50% Duty Cycle



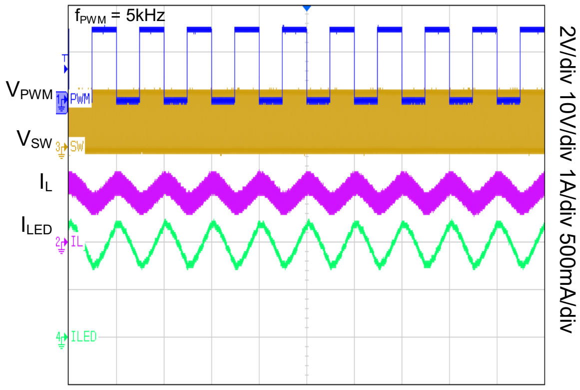

LED Current at 1% Duty Cycle



## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

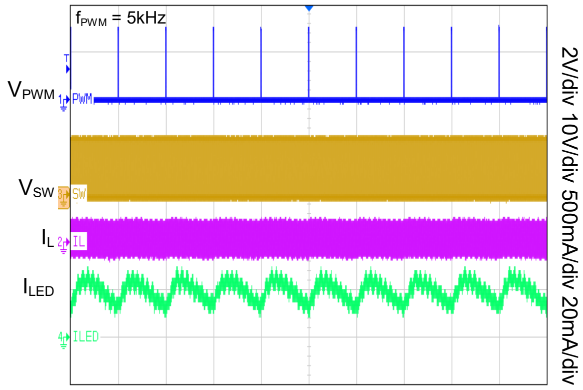
$V_{IN}$ = 12V, $R_{SHUNT}$ = 50mΩ, unless otherwise noted.

LED Current at 50% Duty Cycle



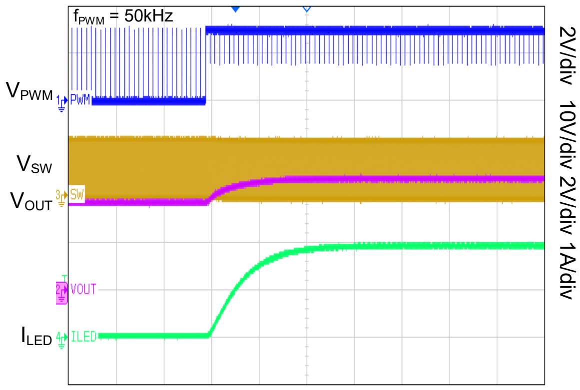

Time (200μs/div)

LED Current at 1% Duty Cycle



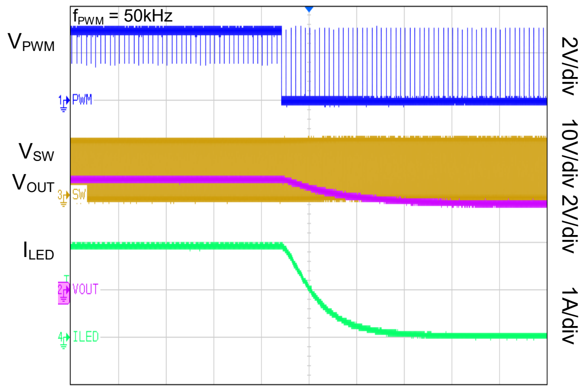

Time (200μs/div)

LED Current Transient from 1% to 100% Duty Cycle



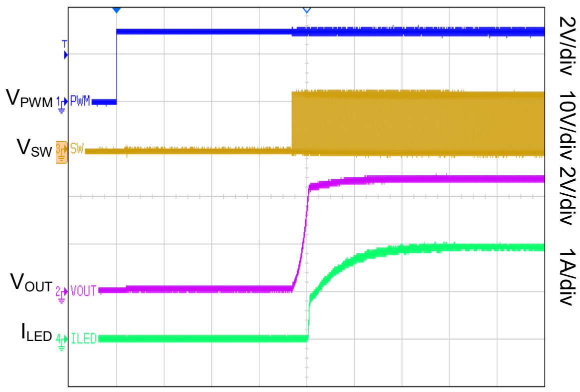

Time (200μs/div)

LED Current Transient from 100% to 1% Duty Cycle



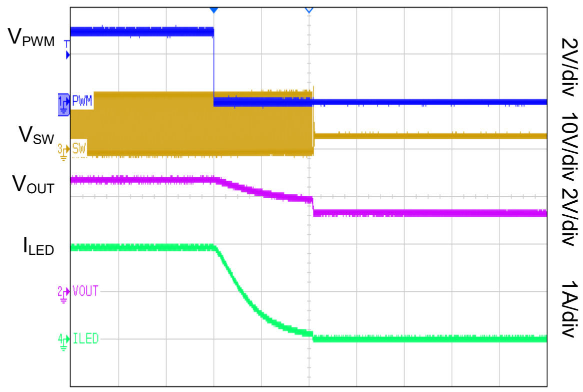

Time (200μs/div)

PWM Startup at 100% Duty Cycle




Time (200μs/div)

PWM Shutdown at 100% Duty Cycle

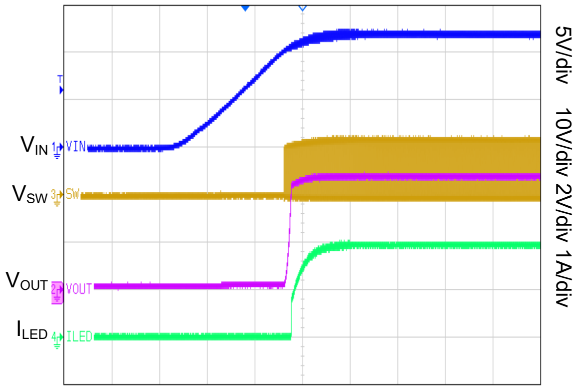



Time (200μs/div)

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

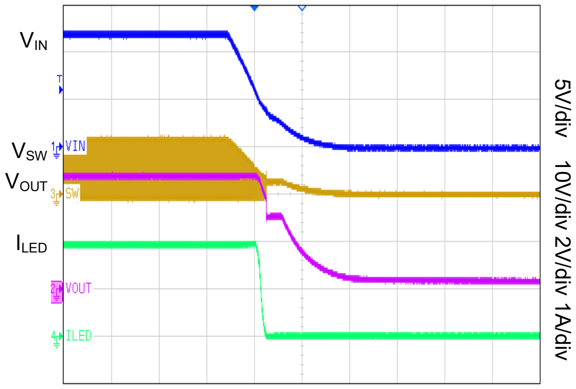
$V_{IN}$ = 12V, $R_{SHUNT}$ = 50mΩ, unless otherwise noted.

VIN Startup at 100% Duty Cycle




Time (500μs/div)

VIN Shutdown at 100% Duty Cycle




Time (10ms/div)

## FUNCTIONAL BLOCK DIAGRAM

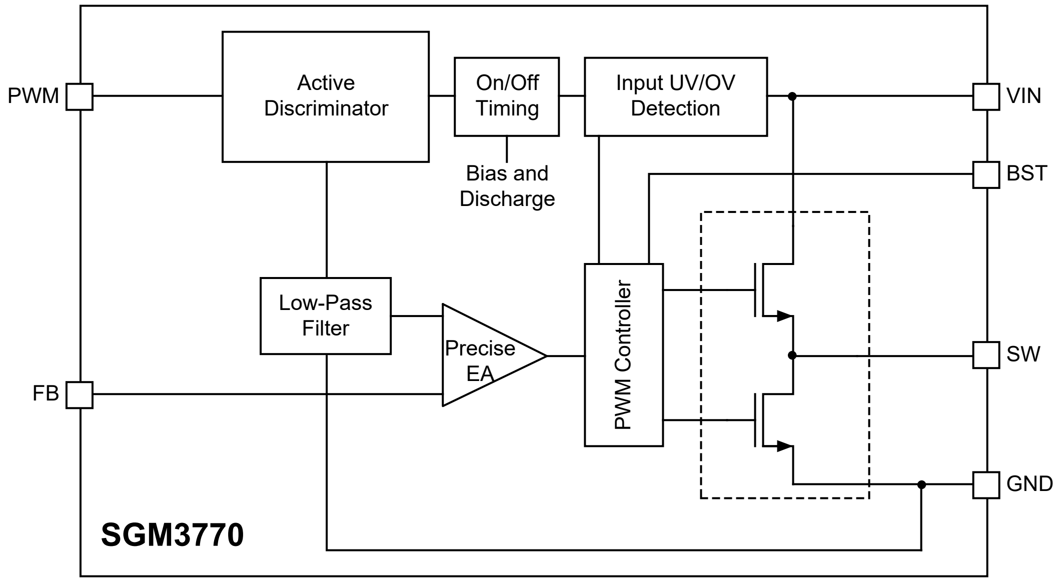



**Figure 2. Functional Block Diagram**

# DETAILED DESCRIPTION

The SGM3770 is a 2A synchronous step-down LED driver. It uses peak-current-mode control and full internal compensation to regulate the LED current with high accuracy for LED lighting. The SGM3770 also provides a comprehensive set of protection features such as cycle-by-cycle current limit, output short-circuit protection, LED short protection, LED open protection, input over-voltage protection, and thermal shutdown.

## Peak-Current-Mode Control

The SGM3770 uses peak-current-mode control to regulate the output current. The output current is sensed by the external feedback resistor $R_{SHUNT}$ and amplified by the internal error amplifier (EA). During each switching on cycle, the internally measured high-side N-MOSFET (HS) switch current ($I_{HS\_SENSE}$) is compared to the EA output voltage ($V_{EAO}$). The slope compensation ramp is deducted from the EA output to avoid sub-harmonic oscillations and the result is compared to the HS current. When the peak value of $V_{HS\_SENSE}$ reaches $V_{EAO}$, the HS switch is turned off and the low-side N-MOSFET (LS) switch is turned on after a short dead time. The LS remains on until next clock cycle coming or negative current limit is triggered. The switching frequency is internally set to 790kHz.

## Under-Voltage Lockout

The SGM3770 implements internal under-voltage lockout (UVLO) circuitry to control the device on or off. When the $V_{IN}$ voltage goes above the UVLO threshold (3.8V, TYP), the SGM3770 internal control circuit is enabled. The UVLO threshold has internal 260mV (TYP) hysteresis.

## Enable and Dimming

To achieve the dimming, apply a digital signal on the PWM pin and the LED current is in proportional to the PWM duty cycle. The amplitude of this PWM signal must be higher than 1.2V for high level and less than 0.6V for low level. And the PWM minimum on time of high level must be larger than 50ns. The recommended PWM frequency is in the range from 5kHz to 100kHz. The device can be shut down if no PWM pulse is seen in more than 0.4ms. More detailed description can be found in APPLICATION INFORMATION section.

## Bootstrap Voltage

The gate driver of the HS switch requires a voltage higher than $V_{IN}$ that is present on its drain. A bootstrap voltage regulator is integrated to provide this voltage which is powered by bootstrapping through a small ceramic capacitor $C_{BST}$ placed between the BST and SW pins. $C_{BST}$ is charged in each cycle when the LS switch is turned on ($V_{SW}$ ≈ 0V) and discharges to the boot regulator when the HS switch is turned on ($V_{SW}$ ≈ $V_{IN}$). A 0.1μF ceramic capacitor with 16V or higher rated voltage is recommended.

## Soft-Start

SGM3770 implements internal soft-start mechanism to control the LED current rise up slew rate. The internal soft-start time is 0.6ms (TYP).

## Output Discharge

SGM3770 implements internal discharge mechanism to discharge output voltage when one of the following 3 events happens: UVLO, PWM off, and thermal shutdown.

## Over-Current Protection (OCP)

Cycle-by-cycle current limits for both peak and valley currents are included in the SGM3770. If the OCP persists, it may trigger the thermal shutdown.

During each switching on cycle, the internally measured HS switch current ($I_{HS\_SENSE}$) is compared to the EA output voltage ($V_{EAO}$). To avoid overstress at OCP condition, the EA output is clamped to a fixed maximum threshold ($I_{MAX\_H}$) to limit the current. When the $I_{HS\_SENSE}$ reaches $I_{MAX\_H}$, the HS switch is turned off and the LS switch is turned on. At the end of each clock cycle, if the LS switch current ($I_{LS\_SENSE}$) is higher than the valley current limit ($I_{MAX\_L}$), the LS switch remains on until the current falls below $I_{MAX\_L}$.

For SGM3770, the inductor current can go negative at light load or discharge conditions. If the $I_{LS\_SENSE}$ exceeds the LS negative current limit ($I_{MAX\_L\_N}$), the LS switch is turned off until the next cycle to protect the LS switch from large currents.

## DETAILED DESCRIPTION (continued)

### LED+ and GND Short-Circuit Protection

When LED+ is shorted to GND, the $V_{FB}$ is much lower than internal $V_{REF}$, and internal $V_{EAO}$ is up to its high clamp value. Then the HS switch peak current limit and LS switch valley current limit are triggered. The cycle-by-cycle current limit protection works until the short condition is released or thermal shutdown is triggered.

### LED+ and LED- Short-Circuit Protection

When LED+ and LED- are shorted, the $V_{FB}$ is higher than internal $V_{REF}$, both HS switch and LS switch are turned off. When the $V_{FB}$ drops below $V_{REF}$, the HS switch and LS switch are turned on. If the short between LED+ and LED- persists, $V_{FB}$ is higher than $V_{REF}$, then HS switch and LS switch are turned off again. The SGM3770 repeats these actions until the short condition is removed.

### LED Open Load Protection

When LED load is open, the $V_{FB}$ is much lower than internal $V_{REF}$, and internal $V_{EAO}$ is up to its high clamp value. The output voltage is close to input voltage and the HS switch current slew rate is slow. Due to the slow slew rate and the high clamp $V_{EAO}$, SGM3770 works at max duty cycle in this condition.

### FB and GND Short-Circuit Protection

When FB is shorted to GND, the $V_{FB}$ is lower than internal $V_{REF}$, and internal $V_{EAO}$ is up to its high clamp value. Then the cycle-by-cycle current limit protection is triggered until the short condition is released or thermal shutdown.

### Input Over-Voltage Protection

If the input has an inrush voltage above $V_{OVP}$ (31.2V, TYP), the SGM3770 stops switching immediately to protect the HS and LS switch on/off under the overstress condition. When the input voltage falls below 28.3V, the device recovers to normal switching.

NOTE: The VIN_OVP function just protects the device damage from large inrush input voltage. During normal operation, the SGM3770 can support up to 28V input voltage. The steady state operation under 28V < $V_{IN}$ < 31.2V range may cause the device damage.

### Thermal Shutdown

When the device junction temperature exceeds +155℃ (TYP), the SGM3770 shuts down to protect device from damaging due to overheating. The SGM3770 recovers to normal operation when the junction temperature falls below 105℃ (TYP).

# APPLICATION INFORMATION

## PWM Dimming

For the brightness dimming control of the SGM3770, the IC provides typically 100mV feedback voltage when the PWM pin is pulled constantly high. However, PWM pin allows a digital signal to reduce this regulation voltage by changing the PWM duty cycle to achieve LED brightness dimming control. The relationship between the PWM duty cycle and FB voltage can be calculated as following equation.

$$V_{FB} = Duty \times 99mV + 1mV \quad (1)$$

where

Duty = duty cycle of the PWM signal.

From Equation 1, the $V_{FB}$ is always above 1mV even at extremely small duty cycle. For SGM3770, FB pin has about 1μA leakage current. In application, 1kΩ resistor between FB pin and LED- is recommended to get lower LED current at extremely small duty cycle. The relationship between the PWM duty cycle and LED- voltage can be calculated as following equation.

$$V_{LED-} = V_{FB} - 1k\Omega \times 1\mu A = Duty \times 99mV \quad (2)$$

The $V_{LED-}$ vs. PWM duty cycle curve is shown in Figure 3. The PWM frequency is recommended in the range from 5kHz to 100kHz, and the minimum PWM duty cycle is 0.2% for twinkle free dimming.

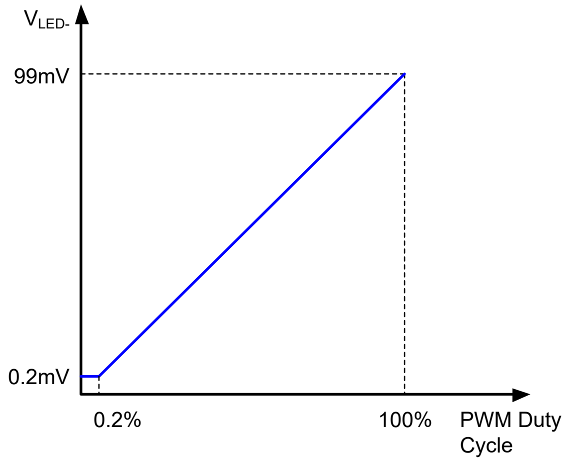



**Figure 3. SGM3770 Dimming Curve at $R_1$ = 1kΩ**

## Input Capacitor Selection

For SGM3770, a high quality input capacitor (X5R, X7R or better) is required to reduce the surge current drawn from the input supply and the switching noise from the device. For most applications, it is recommended to use a 10μF input capacitor and an additional 0.1μF capacitor from VIN to GND to provide additional high-frequency filtering, and place them as close to the device as possible. The input capacitor voltage rating must be greater than the maximum input voltage.

## Inductor Selection

For Inductor selection, three main parameters that need to be concerned are inductance, saturation current and rated current. Larger inductance is a good choice for smaller inductor current ripple. However, it leads to higher cost and larger volume. The saturation current rating should exceed the peak current limit of the device, especially for high LED current application. The DCR is also an important factor for efficiency. If high efficiency is a critical requirement, a low DCR inductor should be selected.

To select the inductor, use Equation 3, 4 and 5 to calculate the inductance, inductor current ripple ($\Delta I_L$) and inductor peak current ($I_{PEAK}$) respectively, where K is the ratio of $\Delta I_L$ to the LED current ($I_{LED}$). The recommended range of K is between 0.2 and 0.4.

$$L = \frac{(V_{IN\_MAX} - V_{OUT}) \times V_{OUT}}{V_{IN\_MAX} \times K \times I_{LED} \times f_{SW}} \quad (3)$$

$$\Delta I_L = \frac{(V_{IN\_MAX} - V_{OUT}) \times V_{OUT}}{V_{IN\_MAX} \times L \times f_{SW}} \quad (4)$$

$$I_{PEAK} = I_{LED} + \frac{\Delta I_L}{2} \quad (5)$$

For the design with $V_{IN}$ = 12V, $I_{LED}$ = 2A, $V_{OUT}$ = 5V parameters, and by choosing K = 0.3, the calculated inductance will be 6.15μH. A 6.8μH or 10μH standard inductor is recommended for this application.

## Output Capacitor Selection

The output capacitor is required to reduce the high frequency ripple current through the LED string. Use Equation 6 and 7 to calculate the required minimum effective output capacitance.

$$Z_{COUT} = \frac{(R_{LED} + R_{SHUNT}) \times \Delta I_{LED}}{\Delta I_L - \Delta I_{LED}} \quad (6)$$

$$C_{OUT} = \frac{1}{2\pi \times f_{SW} \times Z_{COUT}} \quad (7)$$

where

$R_{LED}$ = the total dynamic resistance of the LED string, which can be referenced to the LED's datasheet.

$\Delta I_{LED}$ = the acceptable LED ripple current.

## APPLICATION INFORMATION (continued)

An output capacitor larger than the calculation result can be chosen due to the derating effect of applied DC voltage. For most applications, a 10μF output capacitor (X5R, X7R or better) with enough voltage rating is recommended.

### LED Maximum Current Setting

The LED maximum current, $I_{MAX}$, is determined by the feedback resistor ($R_{SHUNT}$ in Figure 1). The feedback voltage is internally set at 100mV when the PWM duty cycle = 100%. Then the LED maximum current is programmed according to the following equation.

$$I_{MAX} = 100mV / R_{SHUNT} \quad (8)$$

The LED maximum current is up to 2A, which means the minimum $R_{SHUNT}$ is 50mΩ. For accurate LED current settings, the sense resistors with 1% precision are recommended, and the power rating with enough margins should be concerned.

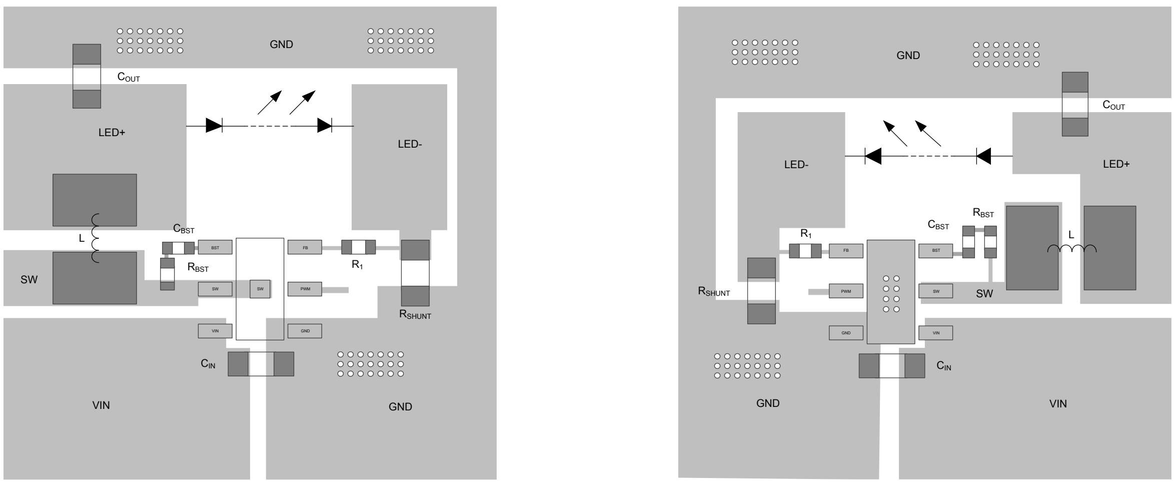
### Bootstrap Capacitor Selection

A 0.1μF ceramic capacitor (X5R or X7R) with 16V or higher rated voltage is recommended between BST and SW pins for supplying the internal HS switch gate drive voltage.

### PCB Layout Considerations

Figure 4 shows an example of SGM3770 PCB layout. The following PCB layout design guidelines are recommended:

- The input capacitors must be placed as close as possible to the VIN pin and the GND pin of the device.
- Minimize the feedback trace length and keep it away from the noisy nodes (SW).
- The SW trace must be kept as short as possible to reduce radiated noise and EMI.
- Creating sufficiently wide VIN and GND plane area to reduce trace impedance. The wide traces have an additional advantage of providing excellent heat dissipation.
- The thermal vias can be used to connect the top layer to the bottom layer for good heat dissipation.




TDFN-2×2-6EL TSOT-23-6

**Figure 4. Layout Example**

## REVISION HISTORY

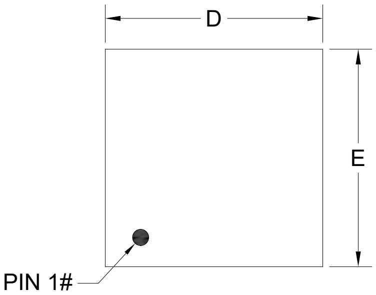
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| DECEMBER 2023 – REV.A to REV.A.1 | Page |
|---|---|
| Changed General Description section | 1 |
| Changed Electrical Characteristics section | 4 |
| Added Typical Performance Characteristics section | 6, 7 |
| Changed Detailed Description section | 11 |
| Changed Application Information section | 13 |

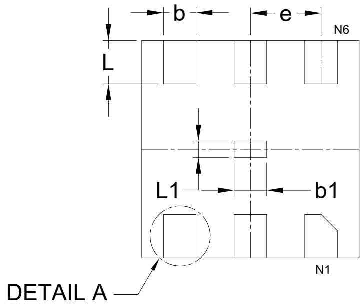
| Changes from Original (MAY 2023) to REV.A | Page |
|---|---|
| Changed from product preview to production data | All |

# PACKAGE OUTLINE DIMENSIONS

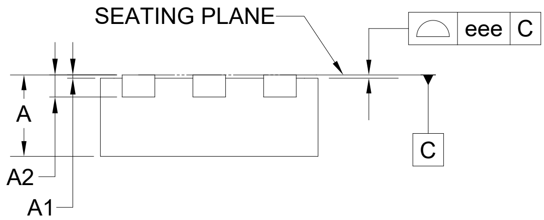
## TDFN-2×2-6EL



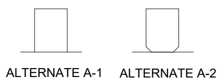

**TOP VIEW**



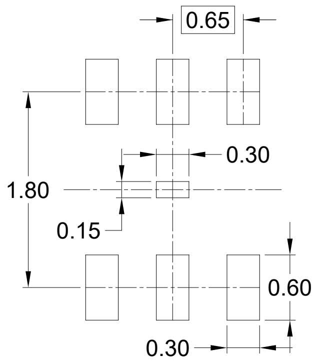

**BOTTOM VIEW**




**SIDE VIEW**




**DETAIL A**
ALTERNATE TERMINAL CONSTRUCTION



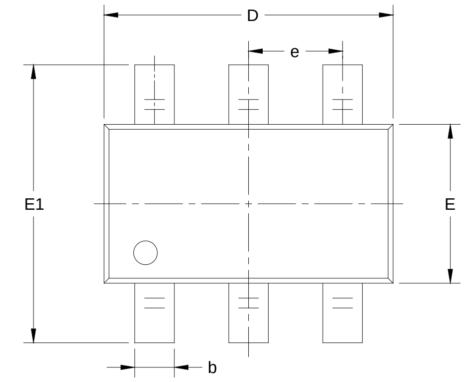

**RECOMMENDED LAND PATTERN** (Unit: mm)

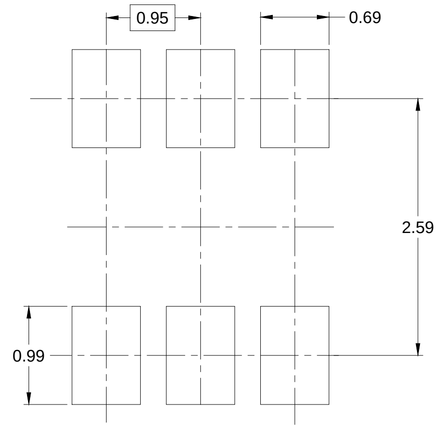
| Symbol | Dimensions In Millimeters | | |
|---|---|---|---|
| | MIN | MOD | MAX |
| A | 0.700 | - | 0.800 |
| A1 | 0.000 | - | 0.100 |
| A2 | 0.203 REF | | |
| b | 0.250 | - | 0.350 |
| b1 | 0.300 REF | | |
| D | 1.900 | - | 2.100 |
| E | 1.900 | - | 2.100 |
| e | 0.650 BSC | | |
| L | 0.300 | - | 0.500 |
| L1 | 0.150 REF | | |
| eee | 0.080 | | |

NOTE: This drawing is subject to change without notice.

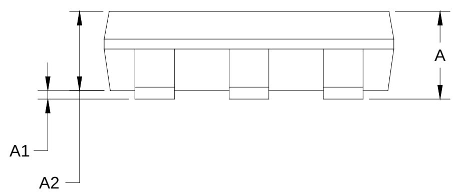
# PACKAGE OUTLINE DIMENSIONS

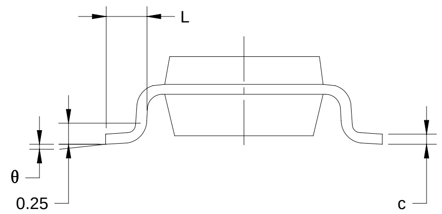
## TSOT-23-6




**RECOMMENDED LAND PATTERN** (Unit: mm)



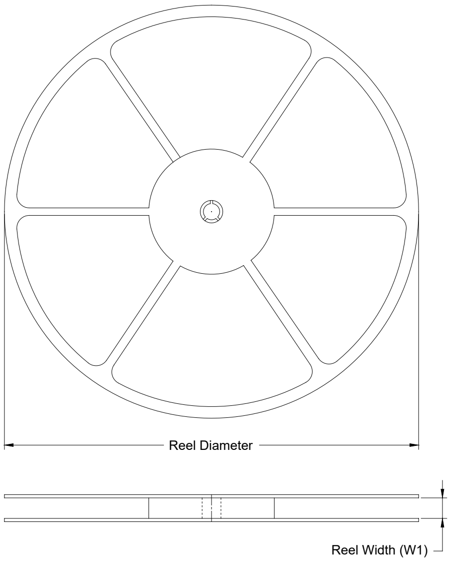

| Symbol | Dimensions In Millimeters | | |
|---|---|---|---|
| | MIN | MOD | MAX |
| A | - | - | 1.100 |
| A1 | 0.000 | - | 0.100 |
| A2 | 0.700 | - | 1.000 |
| b | 0.300 | - | 0.500 |
| c | 0.080 | - | 0.200 |
| D | 2.820 | - | 3.050 |
| E | 1.550 | - | 1.700 |
| E1 | 2.650 | - | 2.950 |
| e | 0.950 BSC | | |
| L | 0.300 | - | 0.600 |
| θ | 0° | - | 8° |

NOTES:

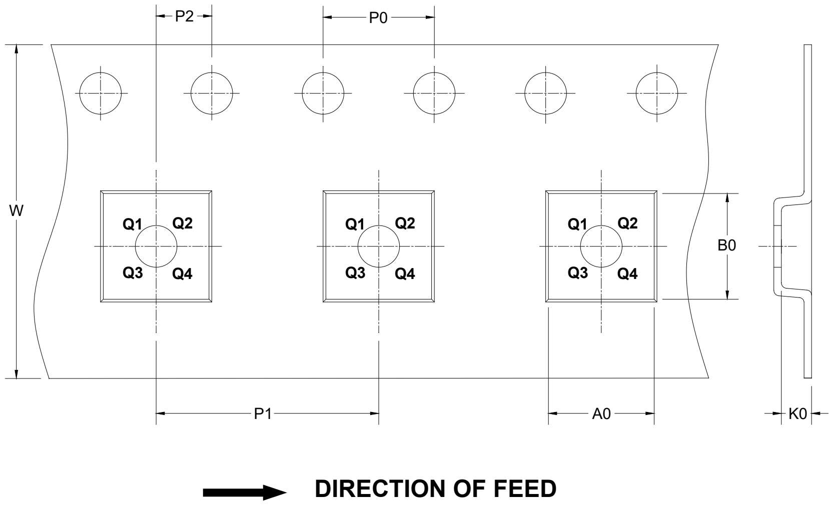
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

# TAPE AND REEL INFORMATION

## REEL DIMENSIONS




## TAPE DIMENSIONS



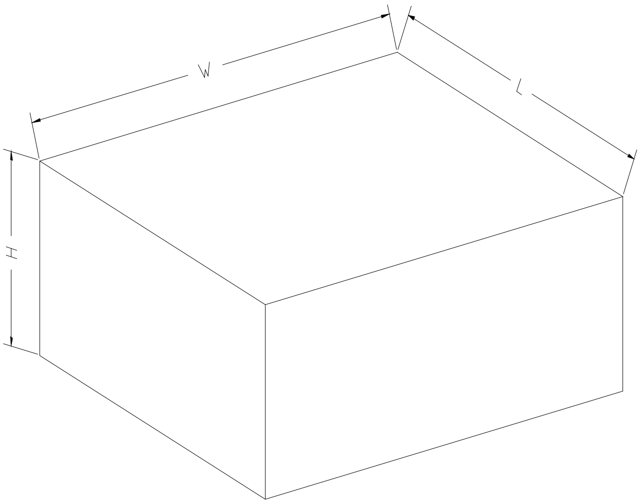

NOTE: The picture is only for reference. Please make the object as the standard.

## KEY PARAMETER LIST OF TAPE AND REEL

| Package Type | Reel Diameter | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P0 (mm) | P1 (mm) | P2 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|
| TDFN-2×2-6EL | 7" | 9.5 | 2.30 | 2.30 | 1.00 | 4.0 | 4.0 | 2.0 | 8.0 | Q1 |
| TSOT-23-6 | 7" | 9.5 | 3.20 | 3.10 | 1.10 | 4.0 | 4.0 | 2.0 | 8.0 | Q3 |

DD0001

## CARTON BOX DIMENSIONS




NOTE: The picture is only for reference. Please make the object as the standard.

## KEY PARAMETER LIST OF CARTON BOX

| Reel Type | Length (mm) | Width (mm) | Height (mm) | Pizza/Carton |
|---|---|---|---|---|
| 7″ (Option) | 368 | 227 | 224 | 8 |
| 7″ | 442 | 410 | 224 | 18 |

DD0002