SGM3778Q
Automotive 3-Channel Linear LED Driver with Analog and PWM Dimming

GENERAL DESCRIPTION

The SGM3778Q is a 3-channel linear LED driver with a wide 5V to 40V input voltage range.

The device provides both analog diming and PWM dimming methods to modulate LED current independently. Adjusting the REF pin resistor to set the regulated LED current and adjusting the PWMx input to achieve PWM dimming. The individual PWM control input for each channel features more application flexibility.

The SGM3778Q supports 1-to-3 LEDs in each channel with up to 150mA LED current. Paralleling the three outputs can provide up to 450mA LED current.

The SGM3778Q provides full kinds of protections, including short-circuit protection, single-LED short protection, open load protection, short-to-battery protection and thermal shutdown. When a fault occurs, the nFAULT and/or nFAULT_S pin report/s the fault status to MCU.

Besides the thermal shutdown protection, SGM3778Q provides a programmable thermal foldback feature through TEMP pin to reduce power dissipation at high junction temperature.

The device is AEC-Q100 qualified (Automotive Electronics Council (AEC) standard Q100 Grade 1) and it is suitable for automotive applications.

The SGM3778Q is available in a Green TSSOP-16 (Exposed Pad) package.

FEATURES

- **AEC-Q100 Qualified for Automotive Applications**
  Device Temperature Grade 1
  T_A = -40℃ to +125℃
- **5V to 40V Wide Input Voltage Range**
- **3-Channel Linear LED Driver with Analog Dimming and PWM Dimming**
- **Up to 150mA Programmable LED Current for Each Channel**
- **Individual PWM Control for Each Channel**
- **Multiple Channels or Multiple ICs Parallel Application**
- **0.68V (TYP) Dropout Voltage at 150mA**
- **Programmable LED Current Foldback at High Temperature**
- **Fault Indicator for LED Short, Open Load or Thermal Shutdown Event**
- **Separate Fault Indicator for Single-LED Short Event**
- **LED Short-to-GND Protection**
- **LED Open Load Protection**
- **Single-LED Short Protection**
- **Thermal Shutdown Protection**
- **-40℃ to +150℃ Operating Junction Temperature Range**
- **Available in a Green TSSOP-16 (Exposed Pad) Package**

APPLICATIONS

Commercial and Industrial LED Lighting
Automotive LED Lighting:

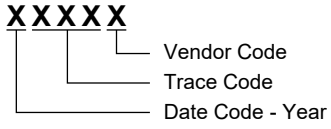
- Stop or Taillight
- Rear Light
- Position Light
- Interior Lighting
- Daytime Running Light
- Fog Light/Signal Light

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM3778Q	TSSOP-16 (Exposed Pad)	-40℃ to +125℃	SGM3778QPTS16G/TR	1IFPTS16 XXXXX	Tape and Reel, 4000

MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace Code and Vendor Code.



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, IOUTx, Unregulated Inputs (1) (2) (3) ..... -0.3V to 45V
PWMx, EN, VSNSx..... -0.3V to 43V
nFAULT, nFAULT_S (1) ..... -0.3V to 22V
Other Pins (1) ..... -0.3V to 6V
Package Thermal Resistance
TSSOP-16 (Exposed Pad), θ_{JA} ..... 35.1℃/W
TSSOP-16 (Exposed Pad), θ_{JB} ..... 15.3℃/W
TSSOP-16 (Exposed Pad), $\theta_{JC\ (TOP)}$ ..... 34.9℃/W
TSSOP-16 (Exposed Pad), $\theta_{JC\ (BOT)}$ ..... 3.2℃/W
Junction Temperature.....+150℃
Storage Temperature Range .....-65℃ to +150℃
Lead Temperature (Soldering, 10s).....+260℃
ESD Susceptibility (4) (5)
HBM.....±4000V
CDM .....±1000V

NOTES:

1. All voltage values are with reference to GND.
2. Absolute maximum voltage 45V for 200ms.
3. V_{IOUTx} must be less than V_{IN} + 0.3V.
4. For human body model (HBM), all pins comply with AEC-Q100-002 specification.
5. For charged device model (CDM), all pins comply with AEC-Q100-011 specification.

RECOMMENDED OPERATING CONDITIONS

VIN.....5V to 40V
PWMx, EN, VSNSx.....0V to 40V
nFAULT, nFAULT_S.....0V to 20V
Others.....0V to 5V
Operating Ambient Temperature Range .....-40℃ to +125℃
Operating Junction Temperature Range .....-40℃ to +150℃

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

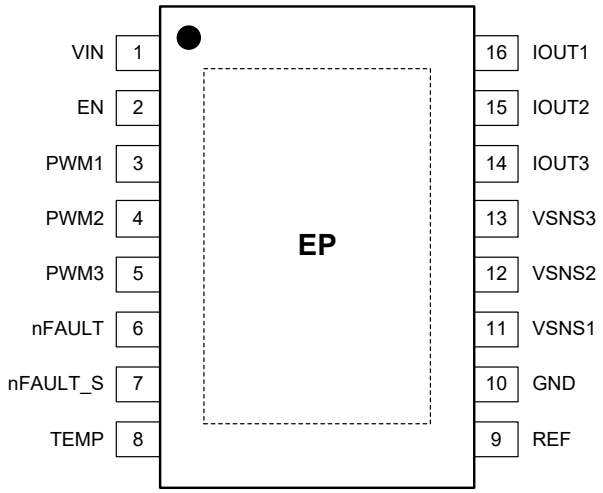
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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 CONFIGURATION

(TOP VIEW)



TSSOP-16 (Exposed Pad)

PIN DESCRIPTION

PIN	NAME	I/O	FUNCTION
1	VIN	—	Power Supply Input. Place at least 1μF input ceramic capacitor close to the VIN pin.
2	EN	I	Enable Pin. IC is enabled when EN is high and disabled when EN is low.
3	PWM1	I	CH1 PWM Control Pin. The CH1 is disabled when PWM1 is floating or connected to GND.
4	PWM2	I	CH2 PWM Control Pin. The CH2 is disabled when PWM2 is floating or connected to GND.
5	PWM3	I	CH3 PWM Control Pin. The CH3 is disabled when PWM3 is floating or connected to GND.
6	nFAULT	I/O	General Fault Indicator. When LED short, LED open load or thermal shutdown happens, the nFAULT pin is internally pulled low.
7	nFAULT_S	I/O	Single-LED Short Fault Indicator. When single-LED short happens, the nFAULT_S pin is internally pulled low.
8	TEMP	I/O	LED Current Foldback Temperature Threshold Program Pin. Connect TEMP pin to GND directly if the current foldback feature is not required.
9	REF	O	Regulated LED Current Setting Pin. Connect a resistor ($800\Omega < R_{REF} < 15k\Omega$) from REF pin to GND to program the regulated LED current.
10	GND	—	Ground.
11	VSNS1	I	CH1 Single-LED Short Detection Pin. Connect VSNS1 to IOUT1 directly if the CH1 single-LED short detection is not required.
12	VSNS2	I	CH2 Single-LED Short Detection Pin. Connect VSNS2 to IOUT2 directly if the CH2 single-LED short detection is not required.
13	VSNS3	I	CH3 Single-LED Short Detection Pin. Connect VSNS3 to IOUT3 directly if the CH3 single-LED short detection is not required.
14	IOUT3	O	CH3 Current Output Pin. Pull PWM3 low to disable the IOUT3.
15	IOUT2	O	CH2 Current Output Pin. Pull PWM2 low to disable the IOUT2.
16	IOUT1	O	CH1 Current Output Pin. Pull PWM1 low to disable the IOUT1.
—	EP	—	Exposed Pad. Connect to GND for better thermal performance.

NOTE: I: input, O: output, I/O = input or output.

TYPICAL APPLICATION

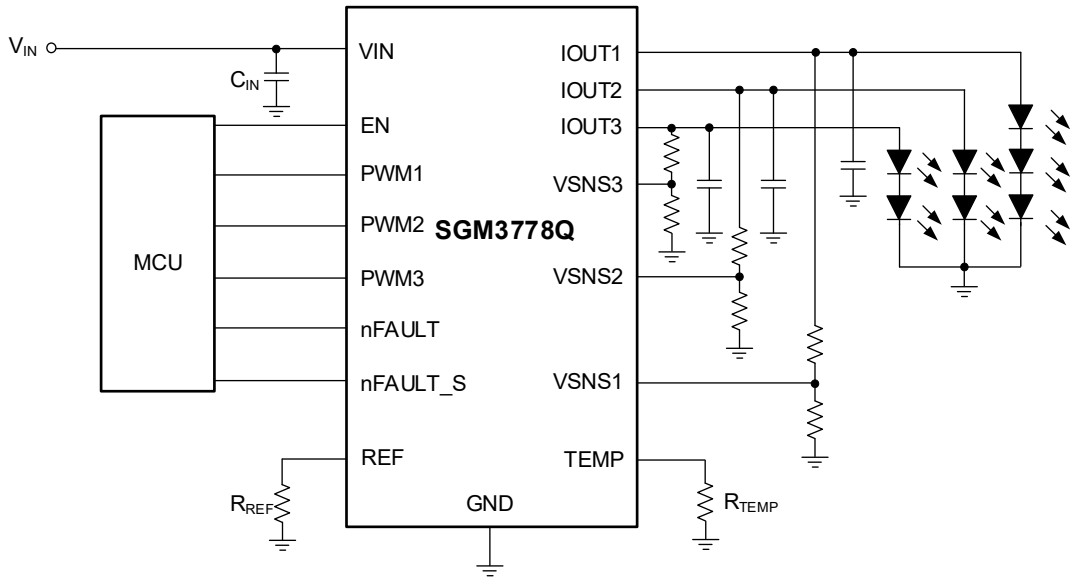


Figure 1. Typical Application Circuit

ELECTRICAL CHARACTERISTICS

(V_{IN} = 14V, T_J = -40℃ to +150℃, all typical values are measured at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage and Current (VIN)						
Input Voltage	V_{IN}		5		40	V
Quiescent Current	I_Q	EN = high, all PWMx = low, nFAULT floating, I_{IOUTx} = 100mA, not including I_{REF}		1.0	1.25	mA
Shutdown Current	I_{SD}	V_{EN} = 0V			10	μA
Shutdown Current in Fault Mode (Device to GND)	I_{FAULT}	PWM = EN = high, nFAULT = low, V_{IN} = 5V to 40V, I = 100mA		0.75	1.00	mA
Shutdown Current in Fault Mode (from V_{IN})					2	
PWMx and EN						
Low-Level Logic Input	V_{EN_IL}	I_{OUTx} disabled			0.7	V
High-Level Logic Input	V_{EN_IH}	I_{OUTx} enabled	2			V
EN Internal Pull-down	I_{EN_PD}	V_{EN} = 0V to 40V	0.35		18	μA
Low-Level Logic Input	V_{IL_PWMx}	I_{OUTx} disabled	1.135	1.195	1.255	V
High-Level Logic Input	V_{IH_PWMx}	I_{OUTx} enabled	1.165	1.225	1.285	V
Hysteresis	V_{HYS_PWM}			30		mV
PWMx Internal Pull-down Current	I_{PWM_PD}	V_{PWMx} = 40V	70	230	400	nA
Current Regulation (I_{OUTx})						
Regulated Output Current Range	I_{IOUTx}	Each channel	10		150	mA
		3-channel in parallel mode	30		450	
Channel Accuracy (1)	$\Delta I_{O\_CHANNEL}$	10mA < I_{IOUTx} ≤ 30mA, V_{IN} = 5V to 20V, channel accuracy = $\frac{I_{IOUTx} - I_{AVG}}{I_{AVG}}$ (2)	-3		3	%
		10mA < I_{IOUTx} ≤ 30mA, V_{IN} = 40V	-4		-4	
		30mA < I_{IOUTx} < 150mA, V_{IN} = 5V to 40V, channel accuracy = $\frac{I_{IOUTx} - I_{AVG}}{I_{AVG}}$ (2)	-1.5		1.5	
Device Accuracy (1)	ΔI_{O_DEVICE}	10mA < I_{IOUTx} < 30mA, V_{IN} = 5V to 20V, device accuracy = $\frac{I_{IOUTx} - I_{SETTING}}{I_{SETTING}}$ (3)	-4		4	%
		30mA ≤ I_{IOUTx} < 150mA, V_{IN} = 5V to 20V, device accuracy = $\frac{I_{IOUTx} - I_{SETTING}}{I_{SETTING}}$ (3)	-2.5		2.5	
Reference Voltage	V_{REF}		1.193	1.223	1.255	V
Ratio of I_{IOUTx} to Reference Current	K_I			100		
Dropout Voltage	V_{DROP}	At 150mA load per channel		0.68	0.94	V
		At 60mA load per channel		0.27	0.4	
Current Rise and Fall Slew Rates (4)	SR	Current rising from 10% to 90% or falling from 90% to 10% at I_{IOUTx} = 60mA	3	9	15	mA/μs
		Current rising from 10% to 90% or falling from 90% to 10% at I_{IOUTx} = 150mA	4	12	20	

NOTES:

1. The MIN/MAX values could cover the full temperature. The final MIN/MAX values need to update when quality test finished.
2. I_{AVG} = (I_{IOUT1} + I_{IOUT2} + I_{IOUT3})/3.
3. I_{SET} is the target current set by R_{REF}.
4. See Figure 2 for the load model for the slew-rate test and delay-time test.

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = 14V, T_J = -40℃ to +150℃, all typical values are measured at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Fault (nFAULT)						
Low-Level Logic Input Voltage	V_{IL}				0.7	V
High-Level Logic Input Voltage	V_{IH}		2			V
Low-Level Logic Output Voltage	V_{OL}	Tested with 500μA external pull-up resistor			0.7	V
High-Level Logic Output Voltage	V_{OH}	Tested with 1μA external pull-down resistor	2			V
Strong Pull-down Current	I_{PD}		500	780	1000	μA
Weak Pull-up Current	I_{PU}		4	8	16	μA
Comparator (VSNSx)						
Internal Comparator Reference (for Short-Circuit Detection)	V_{SNSx}	$V_{IN} > V_{TH}$	1.190	1.219	1.251	V
Leakage Current	I_{LKG}	V_{SNSx} = 3V			500	nA
Voltage at which the Chip Enables the Single-Short Alarm Function	V_{TH}	Single-short detection enabled	8		9	V
V_{TH} Hysteresis				145		mV
Protection						
Open Load Detection Voltage	V_{OLV}	$V_{OLV} = V_{IN} - V_{IOUTx}$	35	105	185	mV
Open Load Detection Hysteresis	V_{OL_HYS}		100	210	300	mV
Short Detection Voltage	V_{SV}		0.846	0.890	0.935	V
Short Detection Hysteresis			310	330	350	mV
Short Detection Deglitch (2)			1	2	3	ms
		During PWM, count the number of continuous cycles when $V_{IOUTx} < V_{SV}$	7		8	Cycles
REF Pin Resistor Open Detection	R_{REF_OPEN}	nFAULT goes low	15	25	55	kΩ
REF Pin Resistor Short Detection	R_{REF_SHORT}	nFAULT goes low	300	475	800	Ω
Thermal Monitor						
Thermal Shutdown	T_{SD}		155	170		℃
Thermal Shutdown Hysteresis	T_{HYS}			15		℃
Thermal Foldback Activation Temperature	T_{TH}	90% of I_{IOUTx} normal (TEMP pin floating)	95	110	125	℃
Minimum Foldback Current	I_{TFC_MIN}		40	50	60	%
Thermal-Foldback-Function Disable Voltage	$V_{T\_DISABLE}$			0	0.2	V

TIMING REQUIREMENTS

PARAMETER	SYMBOL	CONDITIONS	MIN	NOM	MAX	UNITS
Start-up Time	$t_{STARTUP}$	V_{IN} > 5V, I_{IOUTx} = 50%, I_{SET} = 60mA (1)		122		μs
Delay Time between PWM Rising Edge to 10% of I_{IOUTX}	t_{D_ON}	Two LEDs in series, 10kΩ resistor in parallel		19		μs
Delay Time between PWM Falling Edge to 90% of I_{IOUTX}	t_{D_OFF}	Two LEDs in series, 10kΩ resistor in parallel		25		μs
Single-Short Detection Deglitch (2)			1	2	3	ms
		During PWM, count the number of continuous cycles when $V_{SNSx} < 1.24V$	7		8	Cycles
Open Load Detection Deglitch (2)			1	2	3	ms
		During PWM, count the number of continuous cycles when $V_{IN} - V_{IOUTx} < V_{OLV}$	7		8	Cycles
Short Detection Deglitch (2)			1	2	3	ms
		During PWM, count the number of continuous cycles when $V_{IOUTx} < V_{SV}$	7		8	Cycles

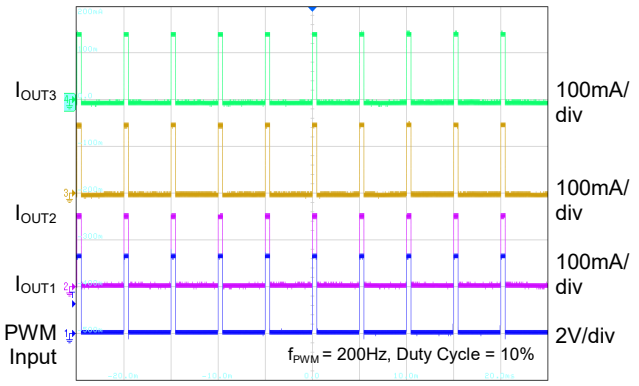
NOTES:

1. Start-up is considered complete when I_{SET} increases to 30mA.
2. Guaranteed by design, not production tested.

TYPICAL PERFORMANCE CHARACTERISTICS

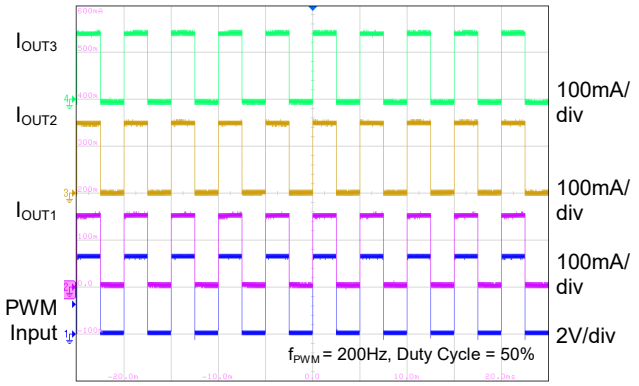
T_A = +25℃, 3 white LEDs in series, unless otherwise noted.

PWM Dimming



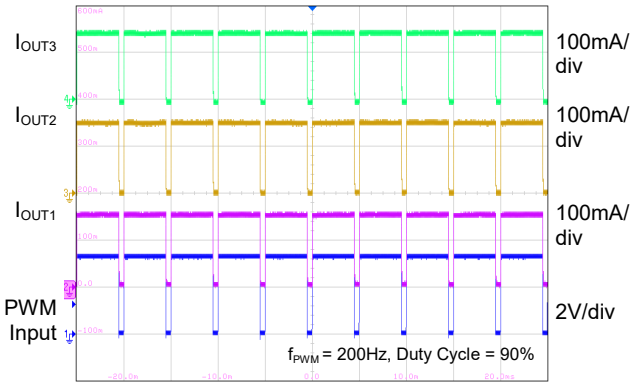
Time (5ms/div)

PWM Dimming



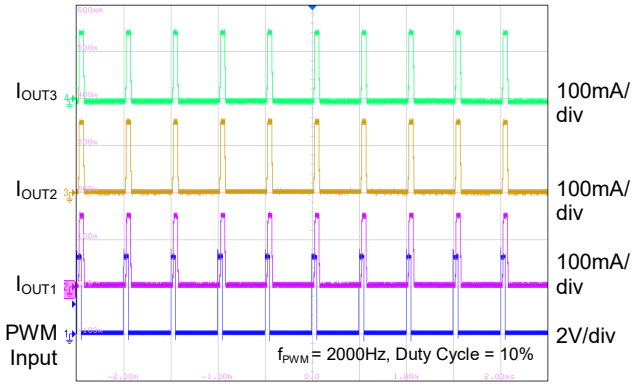
Time (5ms/div)

PWM Dimming



Time (5ms/div)

PWM Dimming

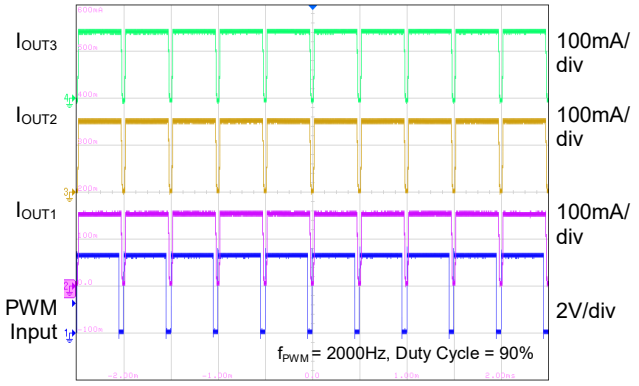


Time (500μs/div)

PWM Dimming

Time (500μs/div)

PWM Dimming

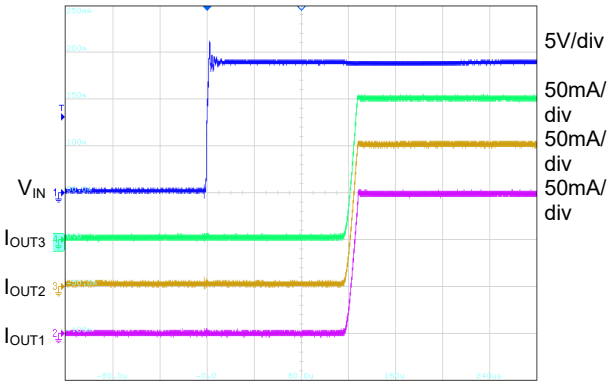


Time (500μs/div)

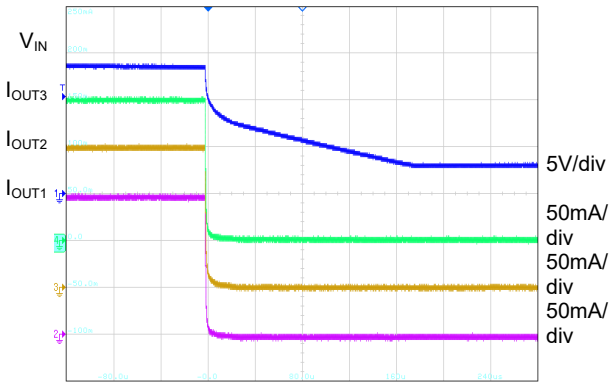
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_A = +25℃, 3 white LEDs in series, unless otherwise noted.

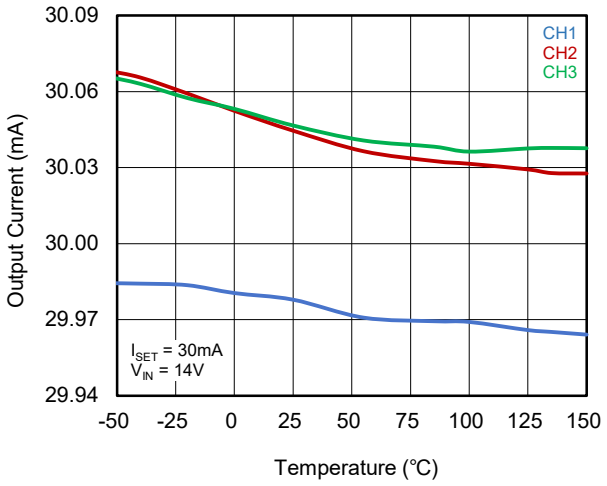
Power Plug-In Waveform



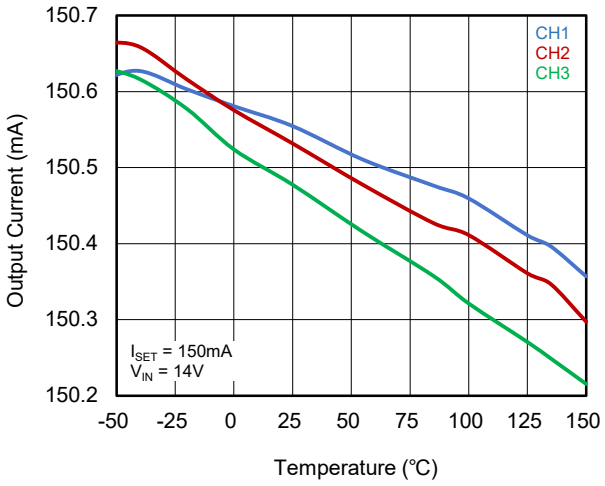
Power Plug-Out Waveform



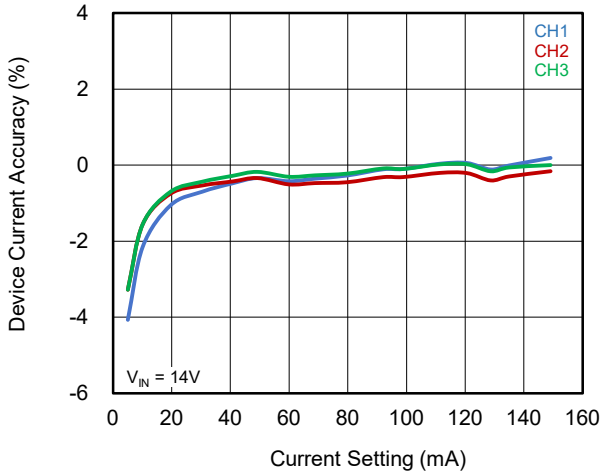
Output Current vs. Temperature



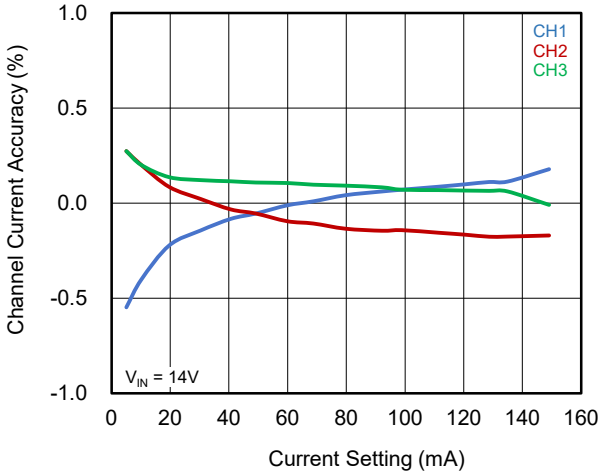
Output Current vs. Temperature



Device Current Accuracy vs. Current Setting



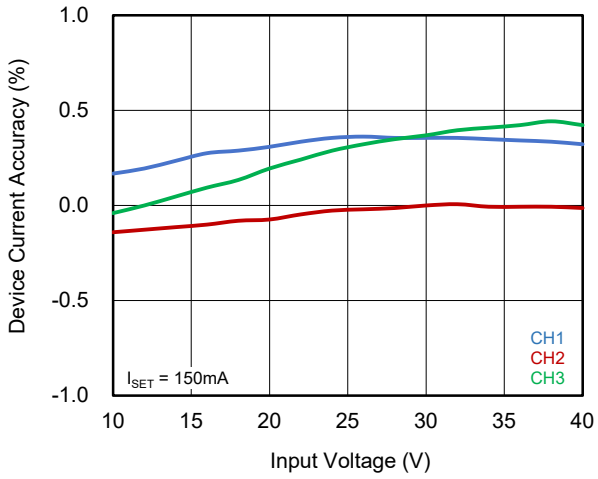
Channel Current Accuracy vs. Current Setting



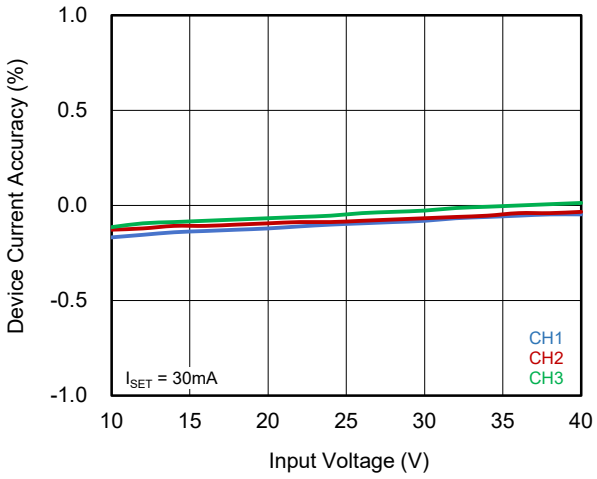
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_A = +25℃, 3 white LEDs in series, unless otherwise noted.

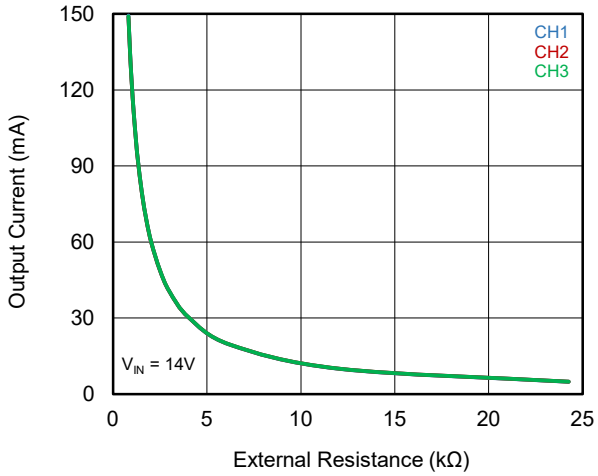
Device Current Accuracy vs. Input Voltage



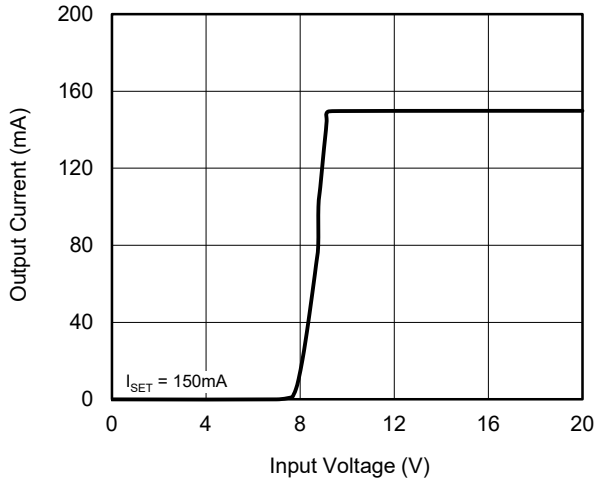
Device Current Accuracy vs. Input Voltage



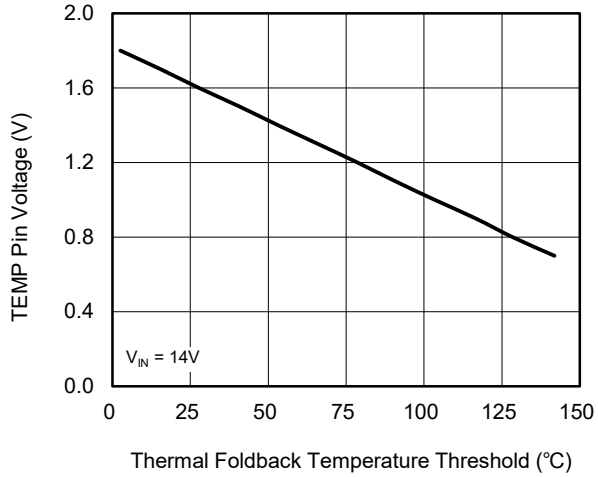
Output Current vs. External Resistance



Output Current vs. Input Voltage



TEMP Pin Voltage vs. Thermal Foldback Temperature Threshold



PARAMETER MEASUREMENT INFORMATION

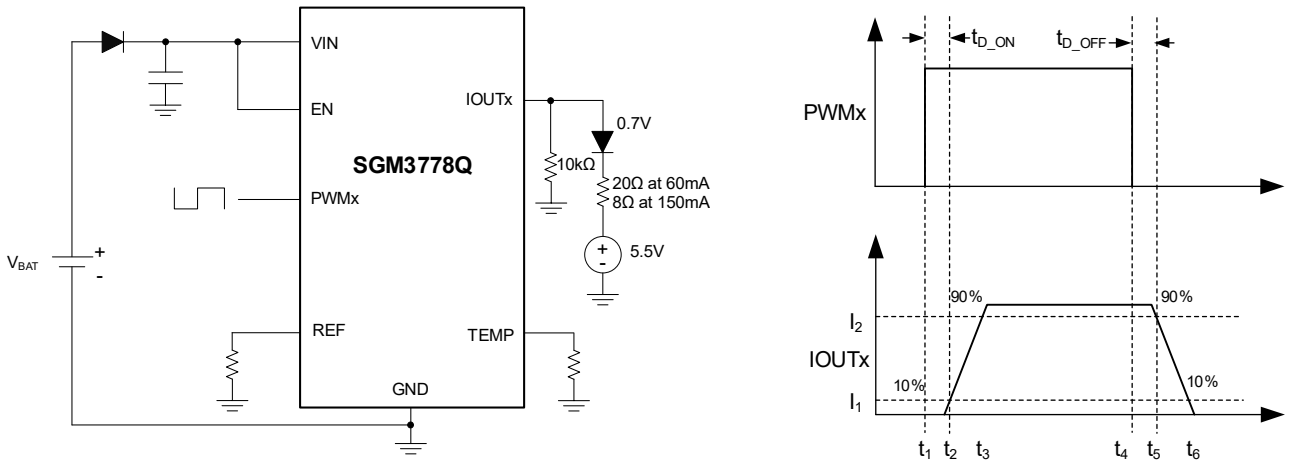


Figure 2. Slew-Rate and Delay-Time Tests Load Model

FUNCTIONAL BLOCK DIAGRAM

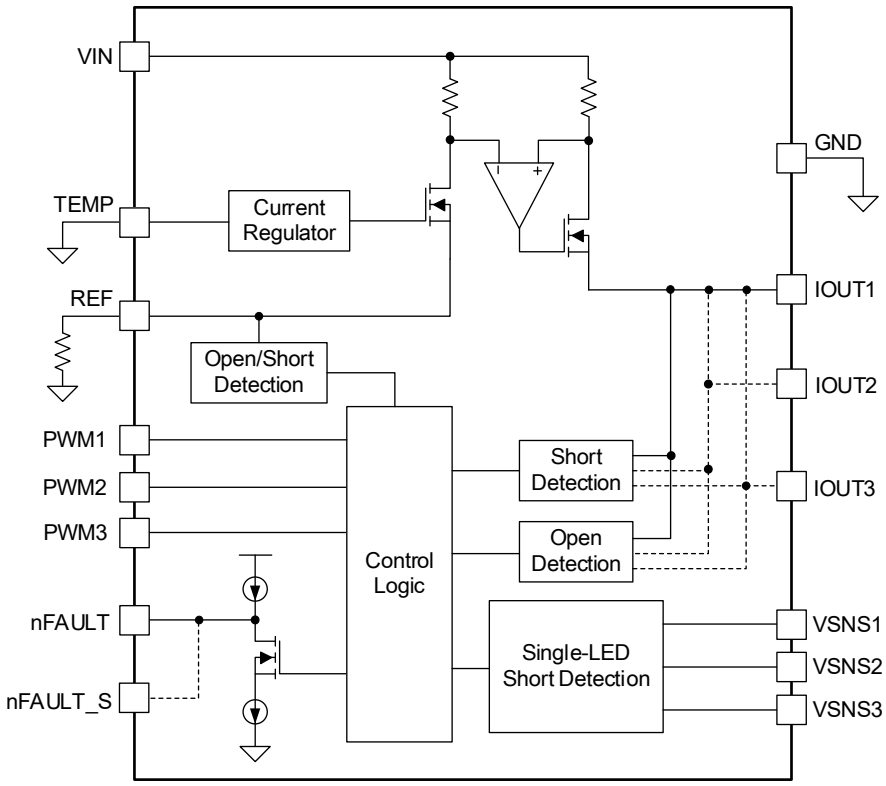


Figure 3. Block Diagram

DETAILED DESCRIPTION

The SGM3778Q is a linear LED driver with 3-channel constant current regulator. It includes three individual PWM dimming controls and can be directly powered by automotive batteries with a wide voltage range. The regulated LED current of each channel can be set by external REF resistor from 10mA to 150mA. The excellent control loop guarantees the current accuracy between each channel, even when the numbers of LED in each channel are different. The individual PWM pins control each channel dimming.

The SGM3778Q provides full protections, including short-circuit protection, single-LED short protection, open load protection, short-to-battery protection, and thermal shutdown. When a fault occurs, the nFAULT and/or nFAULT_S pin report/s the fault status to MCU.

SGM3778Q also has the TEMP pin to program the temperature threshold of LED current foldback.

Constant LED Current Setting

SGM3778Q provides three separate linear current regulators for output current control in each channel. Setting the LED current in each channel via external REF resistor by the equations below:

$$I_{IOUTx} = \frac{V_{REF} \times K_I}{R_{REF}}$$

$$R_{REF} = \frac{V_{REF} \times K_I}{I_{IOUTx}} \quad (1)$$

where, V_{REF} = 1.223V, K_I = 100.

The SGM3778Q allows the REF resistor to change during normal operation. In this case, the regulated LED current changes immediately.

PWM Control

The SGM3778Q has three individual PWM control pins for each channel. When the PWMx pin voltage is higher than V_{IH_PWMx}, the CHx output current is enabled. When the PWMx pin voltage is lower than V_{IL_PWMx}, the CHx output current is disabled. When the PWMx signal frequency is higher than 100Hz, the CHx output average current can be adjusted by the PWMx duty cycle without flicker. It recommends a 200Hz PWM signal with 1% to 100% duty cycle for brightness control.

FAULT Diagnostics

The SGM3778Q has nFAULT and nFAULT_S pins to indicate the fault status. When single-LED short fault occurs, the nFAULT_S is pulled low. When one of the following faults occurs, the nFAULT pin is internally pulled low.

1. LED Short-to-GND
2. LED Open Load
3. LED Short-to-Battery
4. Thermal Shutdown
5. REF Pin Open
6. REF Pin Short

The nFAULT and nFAULT_S pins are open-drain transistors with a default internal pull-up current of 8μA. And the internal pull-down current is 780μA when the fault logic is triggered.

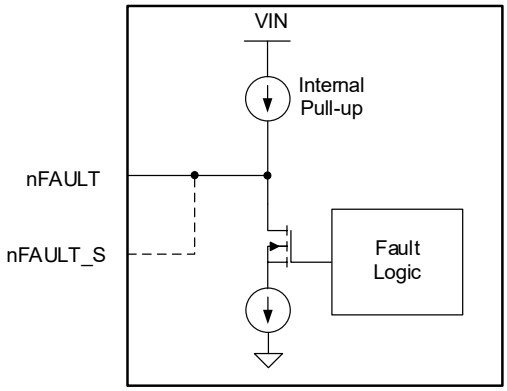


Figure 4. Fault Logic Internal Circuit

The nFAULT input low signal also can shut down the SGM3778Q. This feature can be applied to the fault-line bus connection application, which allows two or more nFAULT pins connected together. When one or more SGM3778Q devices have faults, the nFAULT pin is pulled low respectively, and then the nFAULT low signal will shut down other devices.

DETAILED DESCRIPTION (continued)

LED Short-to-GND Detection

When the V_{IN} and V_{EN} exceed the UVLO threshold, the V_{REF} is set up and SGM3778Q continuously detects V_{IOUTx} when PWMx is high. If V_{IOUTx} < 0.9V is detected, the nFAULT pin is pulled low after 2ms deglitch time, and all other channels are disabled by nFAULT low signal. If the V_{IOUTx} < 0.9V is detected during PWM dimming and the PWMx high period is less than 2ms, the nFAULT pin is pulled low after 8 PWM cycles. In this case, externally pulling nFAULT pin high after all channels disabled cannot enable the channels again, even when the short fault is removed.

Externally pulling nFAULT pin high in advance can avoid other channels being disabled by the nFAULT low signal. Once the nFAULT pin is pulled low and all channels are disabled, the nFAULT pin cannot automatically recover to high even when the short fault is removed, unless toggling EN or power cycle.

Figure 5 and Figure 6 show the LED short-to-GND detection timing diagrams. Note that the channel “a” means a fault channel.

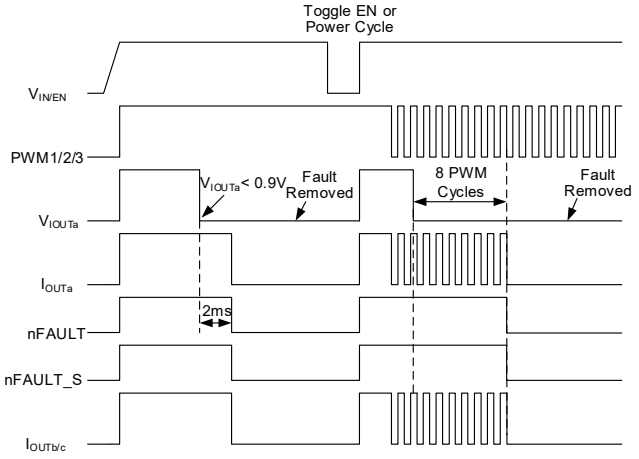


Figure 5. LED Short-to-GND Detection (nFAULT Floating)

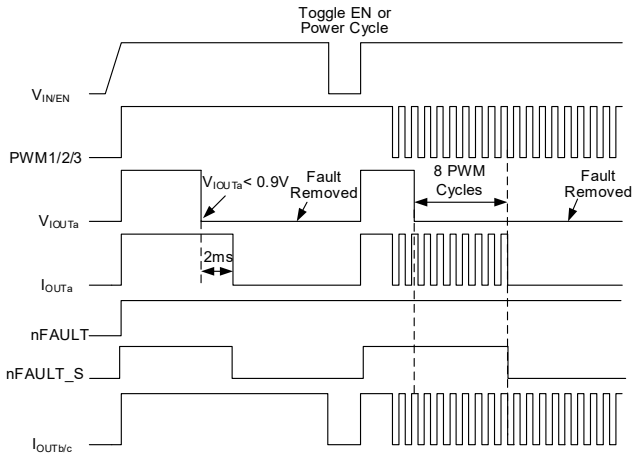


Figure 6. LED Short-to-GND Detection (nFAULT Externally Pulled High)

Single-LED Short Detection

SGM3778Q provides single-LED short detection for each channel by the VSNSx pin when V_{IN} > 9V. When the V_{SNSx} is lower than 1.219V (TYP), the nFAULT_S pin is pulled low to report this failure to MCU after 2ms deglitch time. SGM3778Q continues to enable the output current until MCU takes action to turn off the channels through EN or PWMx pin. If there is no MCU, connecting nFAULT_S pin and nFAULT pin together can disable all channels when single-LED short occurs.

The internally pulled-low nFAULT_S will not automatically recover even when the single-LED short fault is removed, unless toggling EN or power cycle.

Figure 7 shows the different single-LED short conditions.

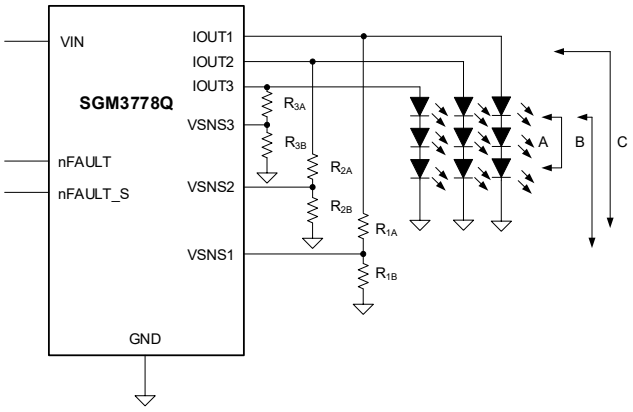


Figure 7. Single-LED Short Conditions

DETAILED DESCRIPTION (continued)

Figure 8 shows the single-LED short detection timing diagram. Note that the channel “a” means fault channel.

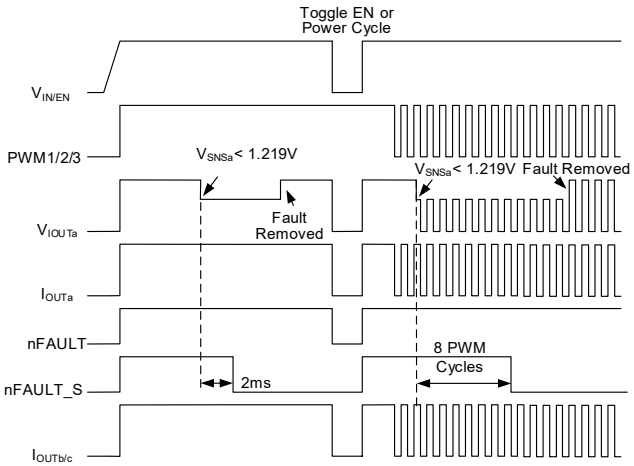


Figure 8. Single-LED Short Detection (nFAULT_S and nFAULT Floating)

Open Load Detection/Short-to-Battery Detection

The SGM3778Q monitors the dropout voltage difference between VIN pin and IOUTx pin for each channel when PWMx is high. When V_{IN} - V_{IOUTx} < 105mV, the nFAULT pin is pulled low after 2ms deglitch time. If the V_{IN} - V_{IOUTx} < 105mV is detected during PWM dimming and the PWMx high period is less than 2ms, the nFAULT pin is pulled low after 8 PWM cycles. The other channels are turned off by nFAULT, and the fault channel keeps on. When the V_{IN} - V_{IOUTx} > 300mV, the nFAULT recovers to high and all channels are enabled. Figure 9 and Figure 10 show the LED open load/short-to-battery detection timing diagrams. Note that the channel “a” means a fault channel.

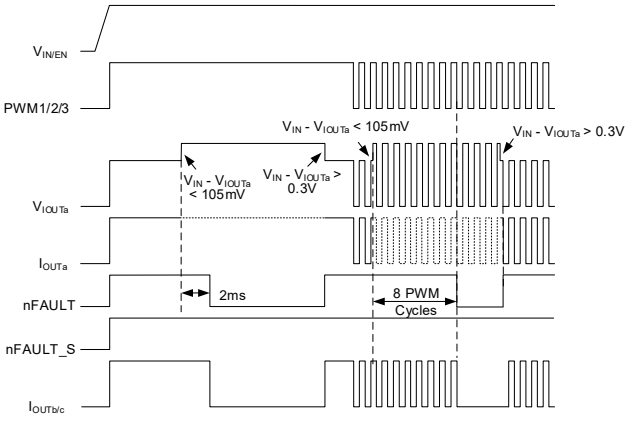


Figure 9. LED Open Load/Short-to-Battery Detection (nFAULT Floating)

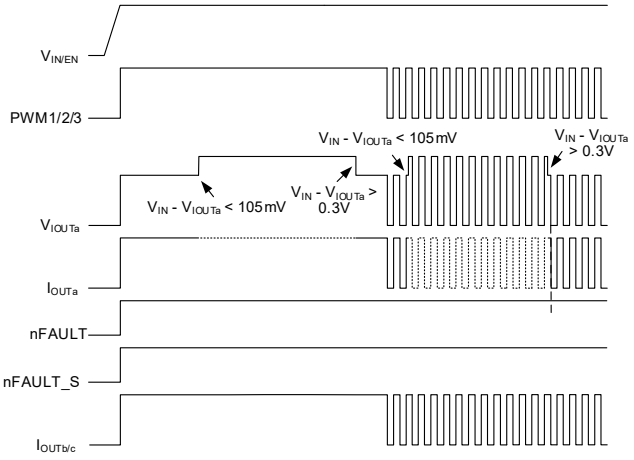


Figure 10. LED Open Load/Short-to-Battery Detection (nFAULT Externally Pulled High)

REF Open/Short Detection

After V_{IN} and V_{EN} exceed the UVLO threshold, the SGM3778Q continuously monitors the resistance of REF pin to GND. It is diagnosed as a REF open fault when R_{REF} > 25kΩ (TYP) and as a REF short fault when R_{REF} < 475Ω (TYP), and then the nFAULT pin is internally pulled low after 40μs deglitch time for both the REF fault events.

DETAILED DESCRIPTION (continued)

Table 1. Fault Table (1) (2)

Failure Mode	Judgment Condition			Diagnostic Output Pins	Action	nFault and nFault_S (3)	Device Reaction	Failure Removed	Self-Clearing
	Detection VIN Voltage	Channel Status	Detection Mechanism						
Short-Circuit: IOUTx Pin Short-to-GND	V_{IN} > 5V	On	V_{IOUTx} < 0.9V	nFAULT	Pulled Low	Externally Pulled High	Failing Strings Turned Off, Other Channels On	Toggle EN, Power Cycle	No
						Floating	All Strings Turned Off	Toggle EN, Power Cycle	
Single-LED Short-Circuit: 1 or Several LED Strings	V_{IN} > 9V	On	V_{SNSx} < 1.219V	nFAULT_S	Pulled Low	Externally Pulled High	All Strings Stay On	Toggle EN, Power Cycle	No
						Floating	All Strings Stay On	Toggle EN, Power Cycle	
Open Load/ Short-to-Battery: 1 or Several LED Strings	V_{IN} > 5V	On	V_{IN} - V_{IOUTx} < 105mV	nFAULT	Pulled Low	Externally Pulled High	All Strings Stay On	V_{IN} - V_{IOUTx} > 300mV	Yes
						Floating	Failing String Stays On, Other Channels Turned Off		
Thermal Shutdown	V_{IN} > 5V	On or Off	Temperature > 170℃	nFAULT	Pulled Low	Externally Pulled High	All Strings Turned Off	Temperature < 155℃	Yes
						Floating			
Thermal Foldback	V_{IN} > 5V	On or Off	Temperature > T_{TH} - 5℃	N/A	None	N/A	All Strings with Reduced Current	Temperature < T_{TH} - 5℃	Yes
REF Resistor Open or Short	V_{IN} > 5V	On or Off	R_{REF} > 25kΩ or R_{REF} < 475Ω	nFAULT	Pulled Low	N/A	All Strings Turned Off	Toggle EN, Power Cycle	No

NOTES:

1. When nFAULT and nFAULT_S pins are tied high externally, the pull-up must be strong enough to cover the internal pull-down.
2. nFAULT_S and nFAULT pins must be connected together to achieve that the single-LED short-circuit can turn off all strings.
3. Pulling nFAULT and nFAULT_S high externally changes the response behavior of the device. If not, the device pulls the pins low according to the failure mode.

DETAILED DESCRIPTION (continued)

Thermal Shutdown and Thermal Foldback

The SGM3778Q device integrates thermal shutdown protection to prevent the device from overheating. When the junction temperature exceeds +170℃, the nFAULT pulls low and all channels are disabled. When the junction temperature falls below +155℃, the nFAULT automatically recovers to high and all channels are reactivated.

Besides, SGM3778Q provides a programmable thermal foldback feature to reduce power dissipation at high junction temperature.

The SGM3778Q reduces the LED regulated current at high junction temperature as shown in Figure 11. The current reduction is from 100% level to 50% level at a typical 2% × I_{SET}/℃ slew rate. The minimum LED regulated current is 50% × I_{SET} before thermal shutdown is triggered.

By mounting the SGM3778Q on the same thermal substrate as the LEDs, this feature can also limit the dissipation of the LEDs.

The thermal foldback temperature threshold (T_{TH}) is defined as the temperature when LED current reduces to 90% of I_{SET}.

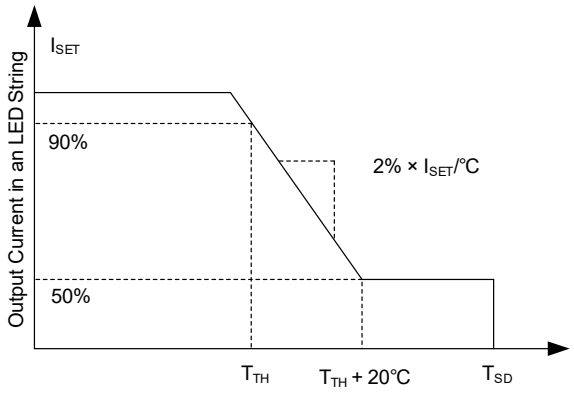


Figure 11. Thermal Foldback

The T_{TH} is programmed by TEMP pin voltage (V_{TEMP}) through the following formula:

$$T_{TH}(℃) = 230.53\text{-}126.58 \times V_{TEMP} \quad (2)$$

When the TEMP pin is floating, V_{TEMP} = 0.96V. When the TEMP pin is connected to the external voltage V_{EXT} via resistor R_{TEMP}, the voltage at the TEMP pin can be calculated using the following formula:

$$V_{TEMP} = \frac{1.92 \times R_{TEMP}(k\Omega) + 9 \times V_{EXT}}{9 + 2 \times R_{TEMP}(k\Omega)} \quad (3)$$

Power Loss Information

The SGM3778Q power dissipation can be calculated by the following formula:

$$P_T = V_{VIN} \times I_{VIN} - n_1 \times V_{LED1} \times I_{LED1} - n_2 \times V_{LED2} \times I_{LED2} - n_3 \times V_{LED3} \times I_{LED3} - V_{REF}^2 / R_{REF} \quad (4)$$

where:

P_T = Total power dissipation of the device.

nx = Number of LEDs for CHx.

V_{LEDx} = Voltage drop across one LED for CHx.

V_{REF} = Reference voltage, typically 1.223V.

I_{LEDx} = Average LED current for CHx.

When the difference between V_{IN} and V_{LEDx} is large, the high total power loss may cause the SGM3778Q to work at thermal foldback operation or trigger the thermal shutdown protection.

APPLICATION INFORMATION

Input and Output Capacitors Selection

It is recommended to put an input capacitor at least 1μF close to the VIN pin, and put output capacitors of 10nF close to the IOUTx pins. While larger capacitors benefit the EMC and ESD, it will take longer to charge the capacitor and may affect PWM dimming performance.

Power Supply Recommendations

The recommended input voltage range of SGM3778Q is from 5V to 40V, which is qualified for automotive electrical power system applications. If the input supply is connected with long wires, more input capacitors close to IC input may be required.

LED Current Setting

Set the LED current for each channel by an external REF resistor through the following equations:

$$I_{IOUTx} = \frac{V_{REF} \times K_I}{R_{REF}}$$
$$R_{REF} = \frac{V_{REF} \times K_I}{I_{IOUTx}} \quad (5)$$

where, V_{REF} = 1.223V, K_I = 100.

The SGM3778Q allows the REF resistor to change during normal operation. In this case, the regulated LED current changes immediately.

It is recommended that the R_{REF} is between 475Ω (TYP) and 25kΩ (TYP) to prevent the device from triggering R_{REF} open or short protection.

VSNSx Resistor Divider Setting

An appropriate resistor divider ratio (K_V) between V_{IOUTx} and V_{SNSx} is essential for single-LED short detection. It should be met with the conditions below:

$$(N-1) \times V_{F\_MAX} < 1.219V \times K_V < N \times V_{F\_MIN}$$
$$K_V = (R_{Xa} + R_{Xb}) / R_{Xb} \quad (6)$$

where, N is the number of LEDs used in CHx. V_{F_MAX} is the maximum forward voltage of the LED used. V_{F_MIN} is the minimum forward voltage of the LED used.

Thermal Foldback Threshold Setting

Pulling up the TEMP pin to external power source (higher than 1V) or pulling it down to GND through different resisters can get different TEMP pin voltages to set the T_{TH}. A larger pull-up resistor can increase the T_{TH}, while a larger pull-down resistor can decrease the T_{TH}.

PWMx Setting

The PWMx pins can be connected to VIN directly or other voltage source higher than V_{IH_PWMx} with a brightness of 100%. When the PWM dimming function is required, it recommends a 200Hz PWM signal with a duty cycle of 1% to 100% for brightness control.

Too low PWM frequency is visible for human eyes, while too high PWM frequency cannot get high dimming accuracy with duty cycle due to the influence of on/off delay time. For most applications, a 100Hz to 1kHz PWMx frequency is recommended.

Layout Guidelines

A good PCB design can optimize the thermal performance of SGM3778Q, which is absolutely critical to its long-term reliability. For best results, please refer to the following guidelines:

1. Maximize the copper area for thermal performance.
2. Put some vias under the SGM3778Q exposed pad to help the heat sink.
3. Put some vias on the copper area to help the heat sink.

Layout Example

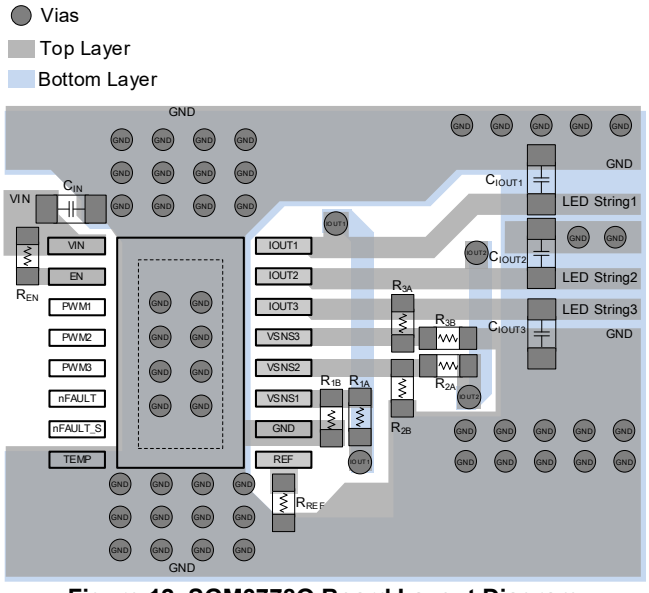


Figure 12. SGM3778Q Board Layout Diagram

APPLICATION INFORMATION (continued)

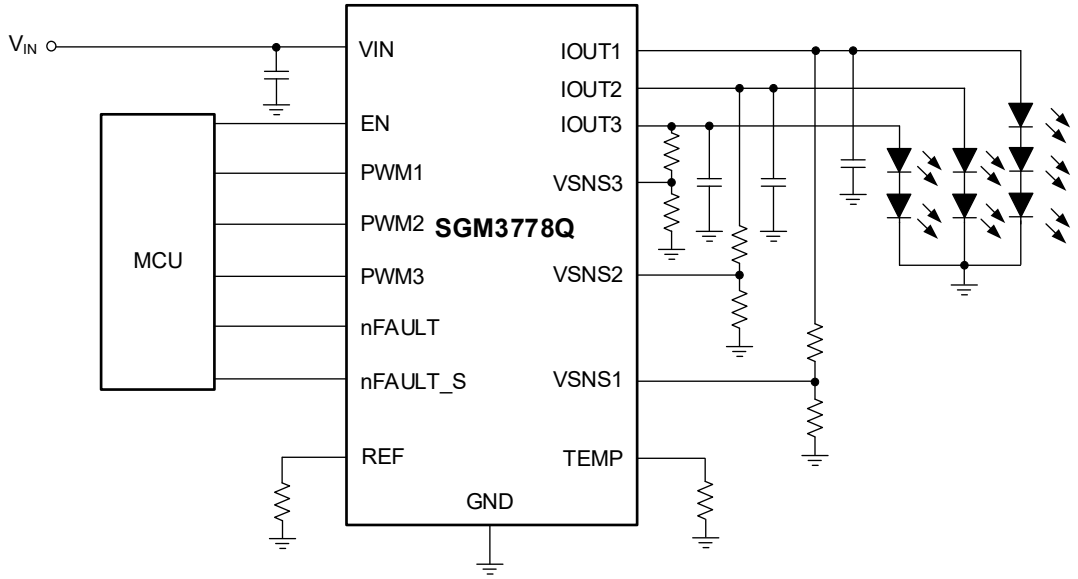


Figure 13. Typical Application Circuit with MCU

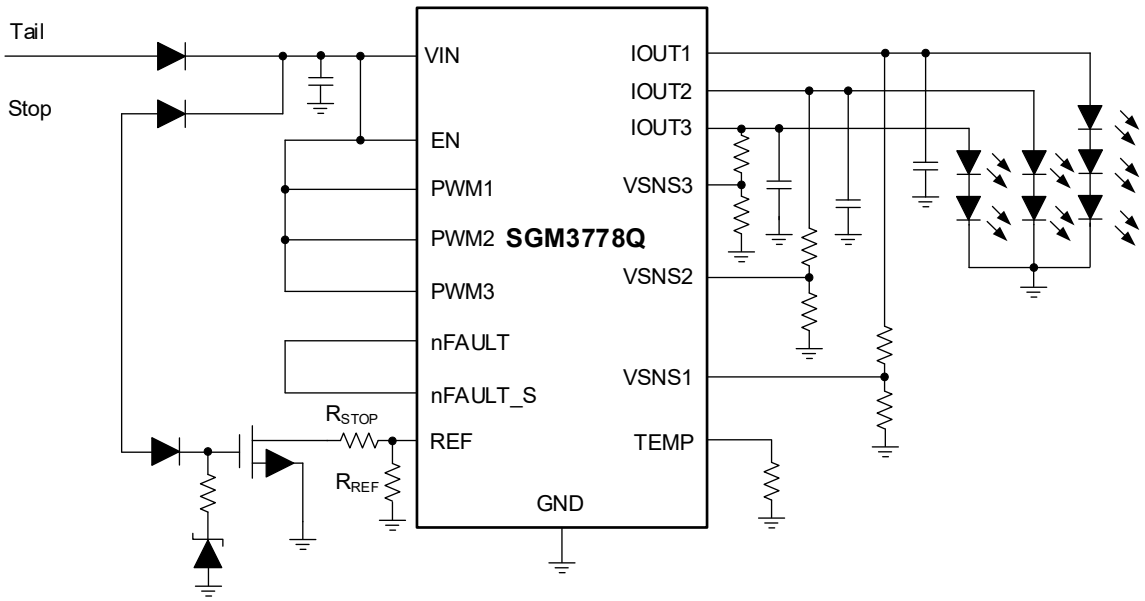


Figure 14. Typical Application Circuit without MCU, Two-Level Brightness Adjustment

APPLICATION INFORMATION (continued)

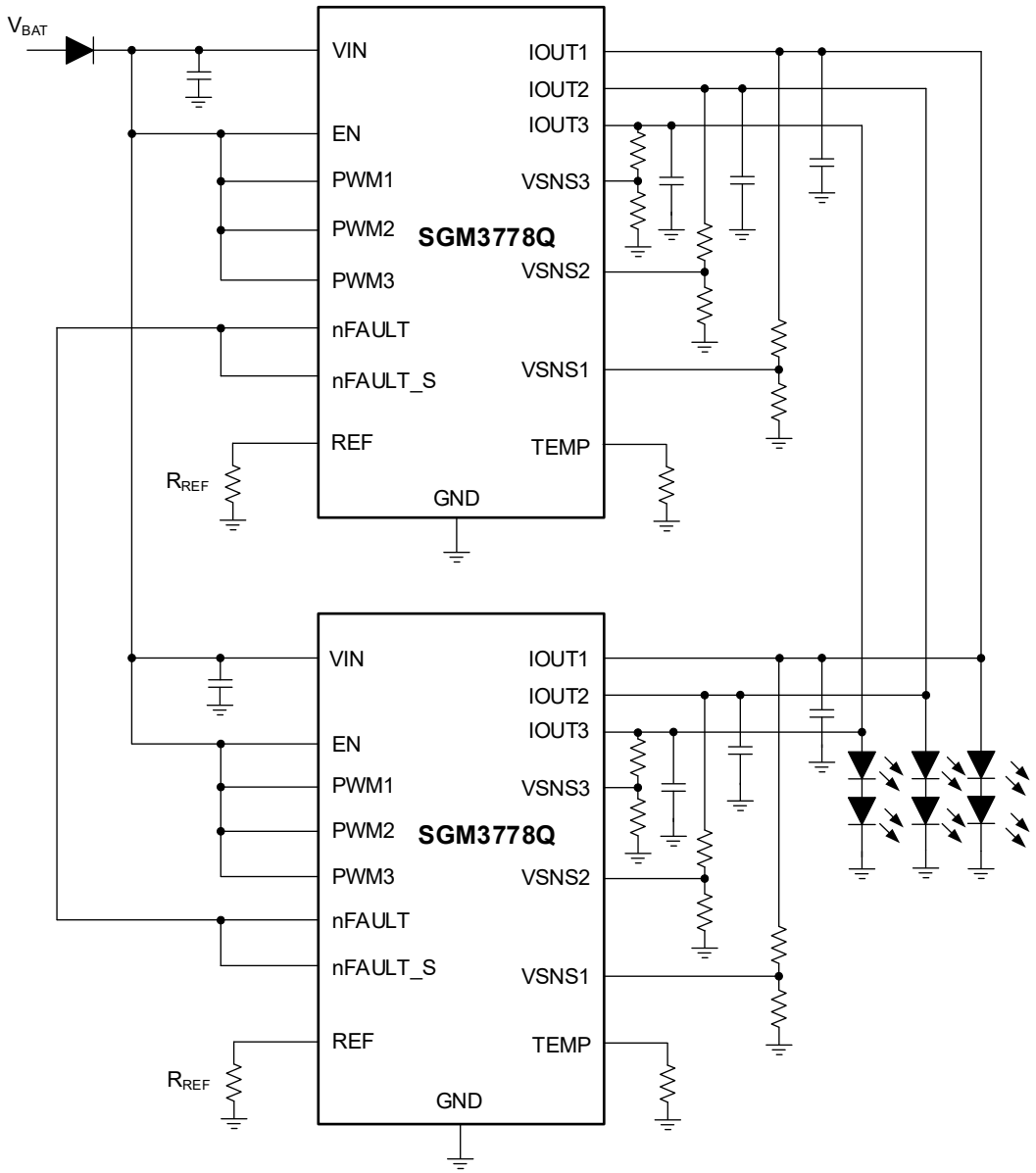


Figure 15. Two SGM3778Q in Parallel for Large Loads Circuit 1

APPLICATION INFORMATION (continued)

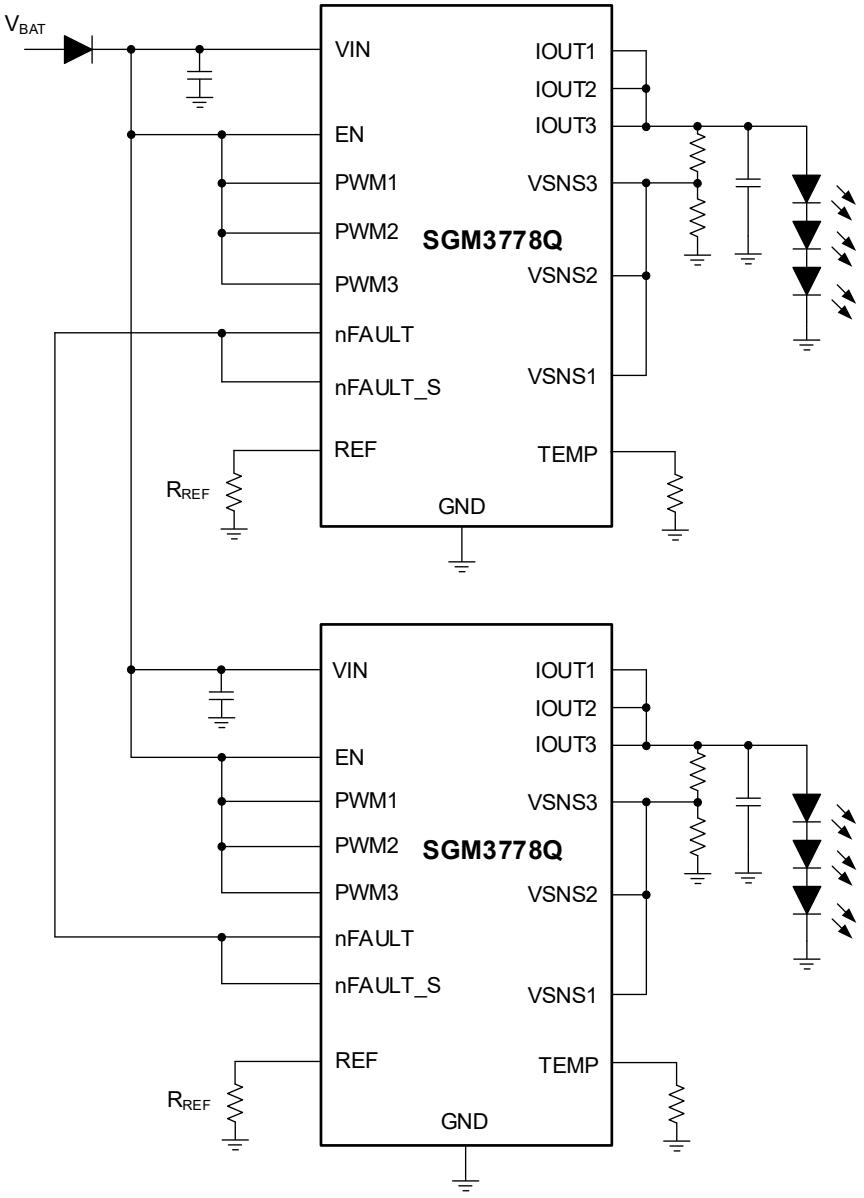


Figure 16. Two SGM3778Q in Parallel for Large Loads Circuit 2

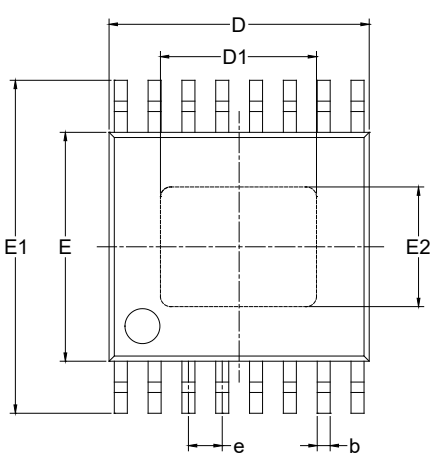
REVISION HISTORY

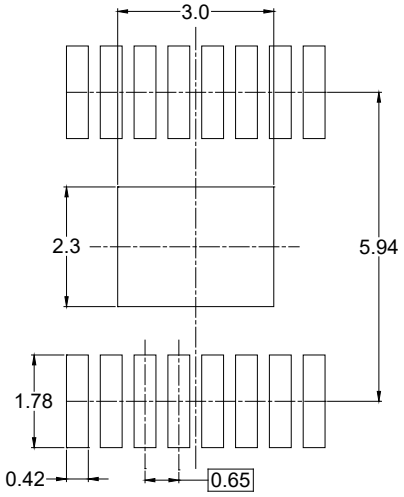
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original to REV.A (AUGUST 2025)	Page
Changed from product preview to production data	All

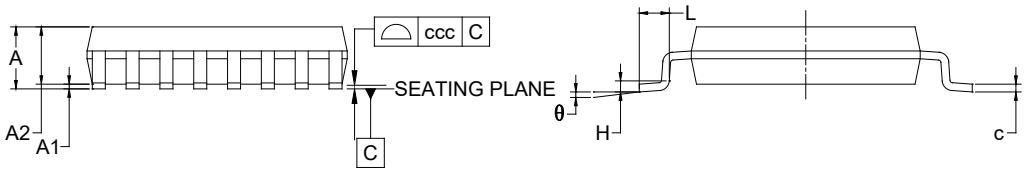
PACKAGE OUTLINE DIMENSIONS

TSSOP-16 (Exposed Pad)





RECOMMENDED LAND PATTERN (Unit: mm)

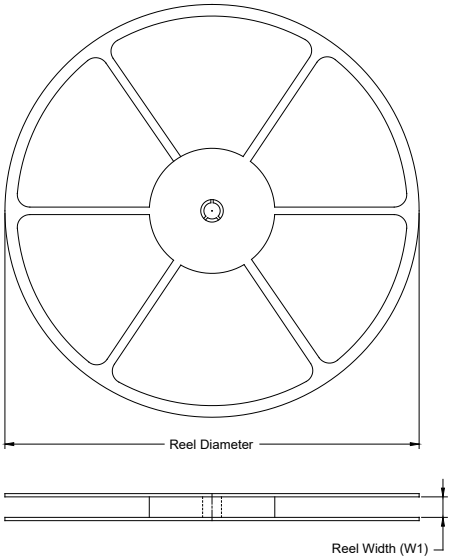


Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	-	-	1.200
A1	0.050	-	0.150
A2	0.800	-	1.050
b	0.190	-	0.300
c	0.090	-	0.200
D	4.860	-	5.100
D1	2.900	-	3.400
E	4.300	-	4.500
E1	6.200	-	6.600
E2	2.200	-	2.980
e	0.650 BSC		
L	0.450	-	0.750
H	0.250 TYP		
θ	0°	-	8°
ccc	0.100		

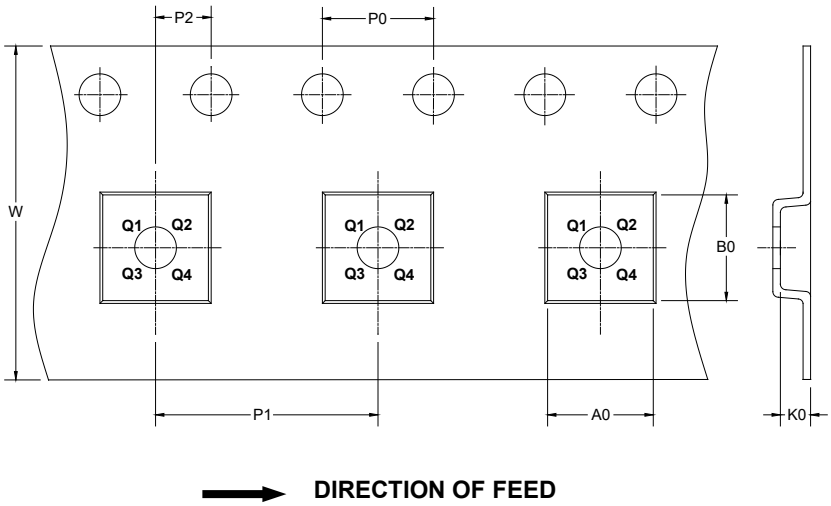
NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions, or gate burrs.
3. Reference JEDEC MO-153.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



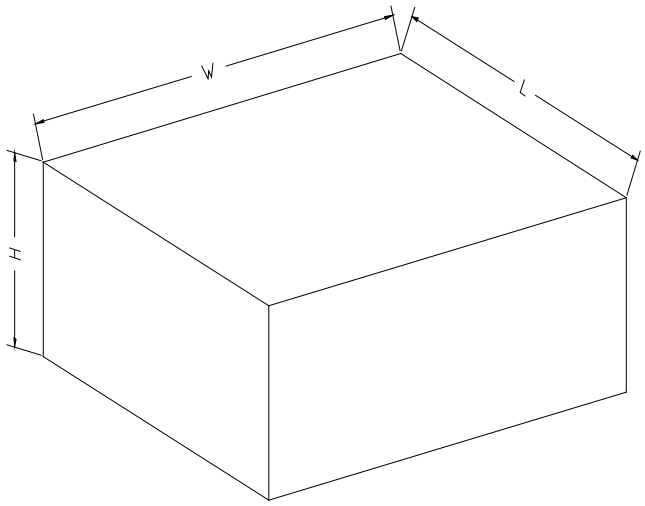
NOTE: The picture is only for reference. Please make the object as the standard.

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
TSSOP-16 (Exposed Pad)	13"	12.4	6.80	5.40	1.50	4.0	8.0	2.0	12.0	Q1

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
13″	386	280	370	5

DD0002