SGM2238xQ
Automotive, 40V, 300mA, Low Quiescent Current and Low Dropout Voltage Linear Regulator

GENERAL DESCRIPTION

The SGM2238xQ is a high voltage, low quiescent current and low dropout voltage linear regulator. It is capable of supplying 300mA output current with typical dropout voltage of 410mV. The operating input voltage range is from 3V to 40V. The fixed output voltage range is from 1.8V to 12V and the adjustable output voltage range is from 1.25V to 24V.

Other features include logic-controlled shutdown mode, short-circuit current limit and thermal shutdown protection. The SGM2238xQ has automatic discharge function to quickly discharge V_{OUT} in the disabled status.

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

The SGM2238xQ is available in a Green SOIC-8 (Exposed Pad) package. It operates over an operating temperature range of -40℃ to +125℃.

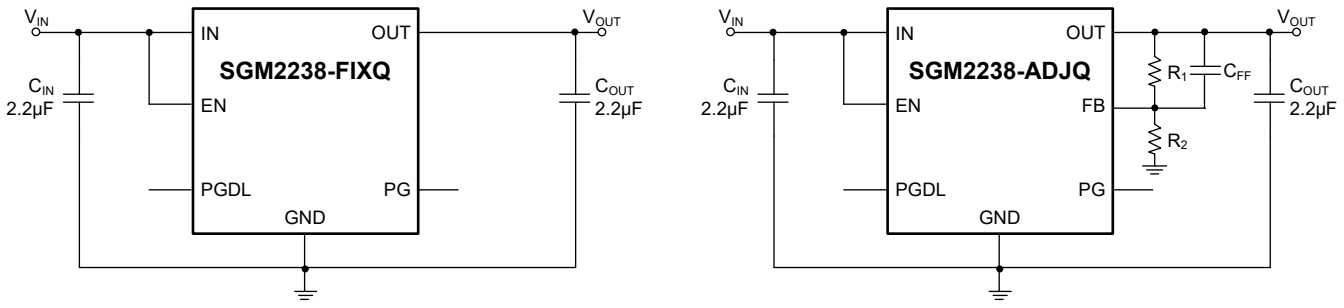
FEATURES

- **AEC-Q100 Qualified for Automotive Applications**
  Device Temperature Grade 1
  T_A = -40℃ to +125℃
- **Operating Input Voltage Range: 3V to 40V**
- **Enable Pin Accept Voltages Higher than the Supply Voltage and up to 40V**
- **Fixed Output from 1.8V to 12V**
- **Adjustable Output from 1.25V to 24V**
- **300mA Output Current**
- **Low Quiescent Current: 3.3μA (TYP)**
- **Low Dropout Voltage:**
  410mV (TYP) at 300mA, V_{OUT} = 5V
- **Current Limiting and Thermal Protection**
- **Support Power-Good Indicator Function**
- **With Output Automatic Discharge**
- **Stable with Small Case Size Ceramic Capacitors**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in a Green SOIC-8 (Exposed Pad) Package**

APPLICATIONS

Automotive
Battery-Powered Equipment
Ultra-Low Power System
Medical Equipment
Industrial Equipment

TYPICAL APPLICATION



Fixed Output Voltage Version

Adjustable Output Voltage Version

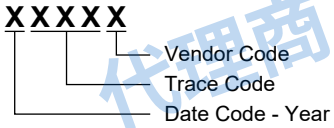
Figure 1. Typical Application Circuits

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM2238-1.8Q	SOIC-8 (Exposed Pad)	-40℃ to +125℃ (T_A)	SGM2238-1.8QPS8G/TR	1DZPS8 XXXXX	Tape and Reel, 4000
SGM2238-2.5Q	SOIC-8 (Exposed Pad)	-40℃ to +125℃ (T_A)	SGM2238-2.5QPS8G/TR	1E0PS8 XXXXX	Tape and Reel, 4000
SGM2238-3.0Q	SOIC-8 (Exposed Pad)	-40℃ to +125℃ (T_A)	SGM2238-3.0QPS8G/TR	1E1PS8 XXXXX	Tape and Reel, 4000
SGM2238-3.3Q	SOIC-8 (Exposed Pad)	-40℃ to +125℃ (T_A)	SGM2238-3.3QPS8G/TR	160PS8 XXXXX	Tape and Reel, 4000
SGM2238-3.6Q	SOIC-8 (Exposed Pad)	-40℃ to +125℃ (T_A)	SGM2238-3.6QPS8G/TR	1E2PS8 XXXXX	Tape and Reel, 4000
SGM2238-4.2Q	SOIC-8 (Exposed Pad)	-40℃ to +125℃ (T_A)	SGM2238-4.2QPS8G/TR	1E3PS8 XXXXX	Tape and Reel, 4000
SGM2238-5.0Q	SOIC-8 (Exposed Pad)	-40℃ to +125℃ (T_A)	SGM2238-5.0QPS8G/TR	15ZPS8 XXXXX	Tape and Reel, 4000
SGM2238-8.0Q	SOIC-8 (Exposed Pad)	-40℃ to +125℃ (T_A)	SGM2238-8.0QPS8G/TR	1E4PS8 XXXXX	Tape and Reel, 4000
SGM2238-9.0Q	SOIC-8 (Exposed Pad)	-40℃ to +125℃ (T_A)	SGM2238-9.0QPS8G/TR	1E5PS8 XXXXX	Tape and Reel, 4000
SGM2238-12Q	SOIC-8 (Exposed Pad)	-40℃ to +125℃ (T_A)	SGM2238-12QPS8G/TR	161PS8 XXXXX	Tape and Reel, 4000
SGM2238-ADJQ	SOIC-8 (Exposed Pad)	-40℃ to +125℃ (T_A)	SGM2238-ADJQPS8G/TR	162PS8 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

IN, EN to GND ..... -0.3V to 45V
OUT, FB to GND ..... -0.3V to 45V
PG to GND ..... -0.3V to 45V
PGDL to GND ..... -0.3V to 6V
Package Thermal Resistance
SOIC-8 (Exposed Pad), θ_{JA} ..... 40℃/W
SOIC-8 (Exposed Pad), θ_{JB} ..... 16.7℃/W
SOIC-8 (Exposed Pad), $\theta_{JC(TOP)}$ ..... 55.9℃/W
SOIC-8 (Exposed Pad), $\theta_{JC(BOT)}$ ..... 6℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃

RECOMMENDED OPERATING CONDITIONS

Supply Voltage Range, V_{IN} ..... 3V to 40V
Enable Input Voltage Range, V_{EN} ..... 3V to 40V
Input Effective Capacitance, C_{IN} ..... 1μF (MIN)
Output Effective Capacitance, C_{OUT} ..... 1μF to 100μF
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

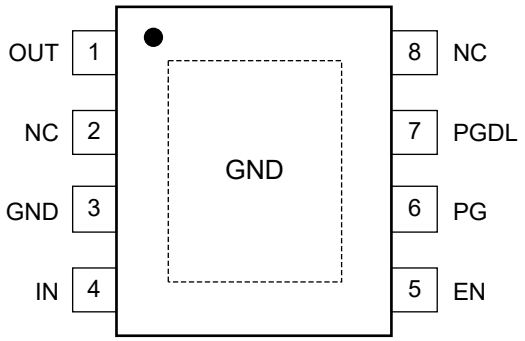
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

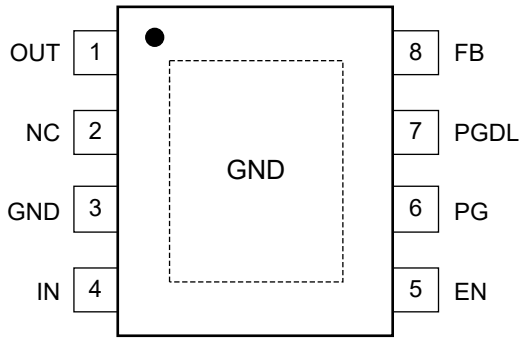
PIN CONFIGURATIONS

SGM2238-FIXQ (TOP VIEW)



SOIC-8 (Exposed Pad)

SGM2238-ADJQ (TOP VIEW)



SOIC-8 (Exposed Pad)

PIN DESCRIPTION

PIN	NAME	FUNCTION
1	OUT	Regulator Output Pin. It is recommended to use a ceramic capacitor with effective capacitance in the range of 1μF to 100μF to ensure stability. This ceramic capacitor should be placed as close as possible to OUT pin.
2	NC	No Connection.
3	GND	Ground.
4	IN	Input Supply Voltage Pin. It is recommended to use a 2.2μF or larger ceramic capacitor from IN pin to ground to get good power supply decoupling. This ceramic capacitor should be placed as close as possible to IN pin.
5	EN	Enable Pin. Drive EN high to turn on the regulator. Drive EN low to turn off the regulator.
6	PG	Power-Good Indicator Output Pin. An open-drain, active-high output that indicates the status of V_{OUT}. When the output voltage reaches $V_{PG(TH,RISING)}$ of the target, the PG pin goes into a high-impedance state.
7	PGDL	Power-Good Delay Pin. Keep this pin floating when it is not in use.
8	NC	No Connection (Fixed Version Only).
	FB	Feedback Voltage Input Pin (adjustable voltage version only). Connect this pin to the midpoint of an external resistor divider to adjust the output voltage. Place the resistors as close as possible to this pin.
Exposed Pad	GND	Exposed Pad. Connect it to GND internally. Connect it to a large ground plane to maximize thermal performance. This pad is not an electrical connection point.

FUNCTIONAL BLOCK DIAGRAMS

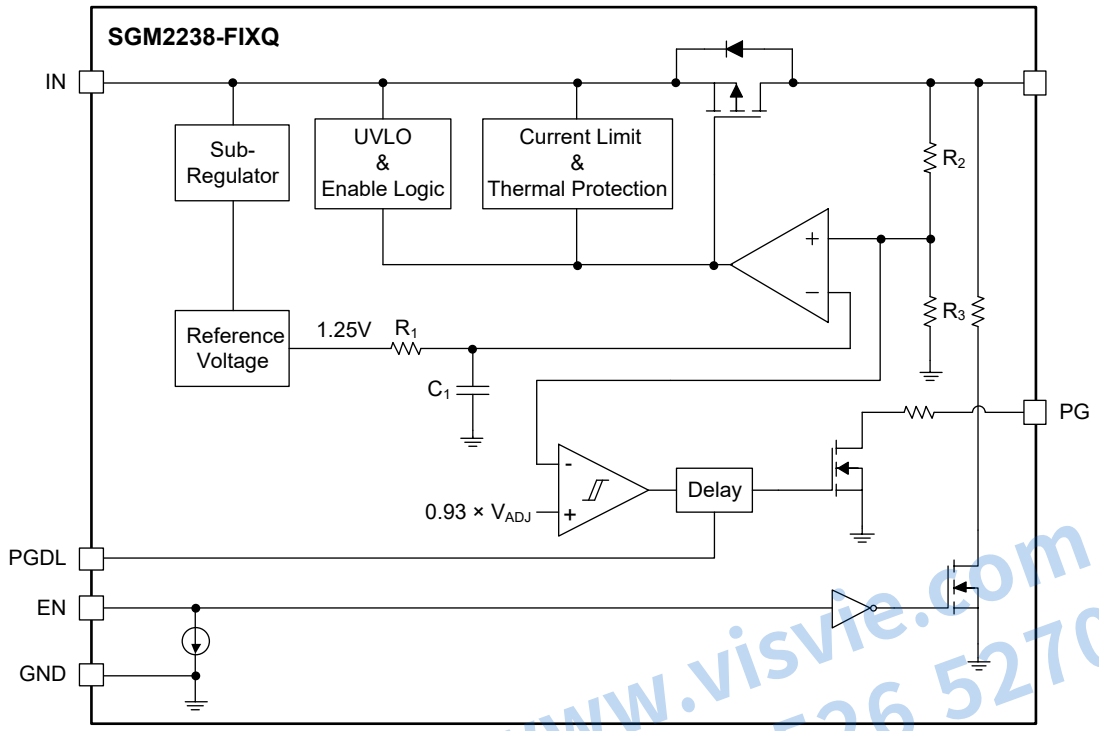


Figure 2. Block Diagram of Fixed Output Version

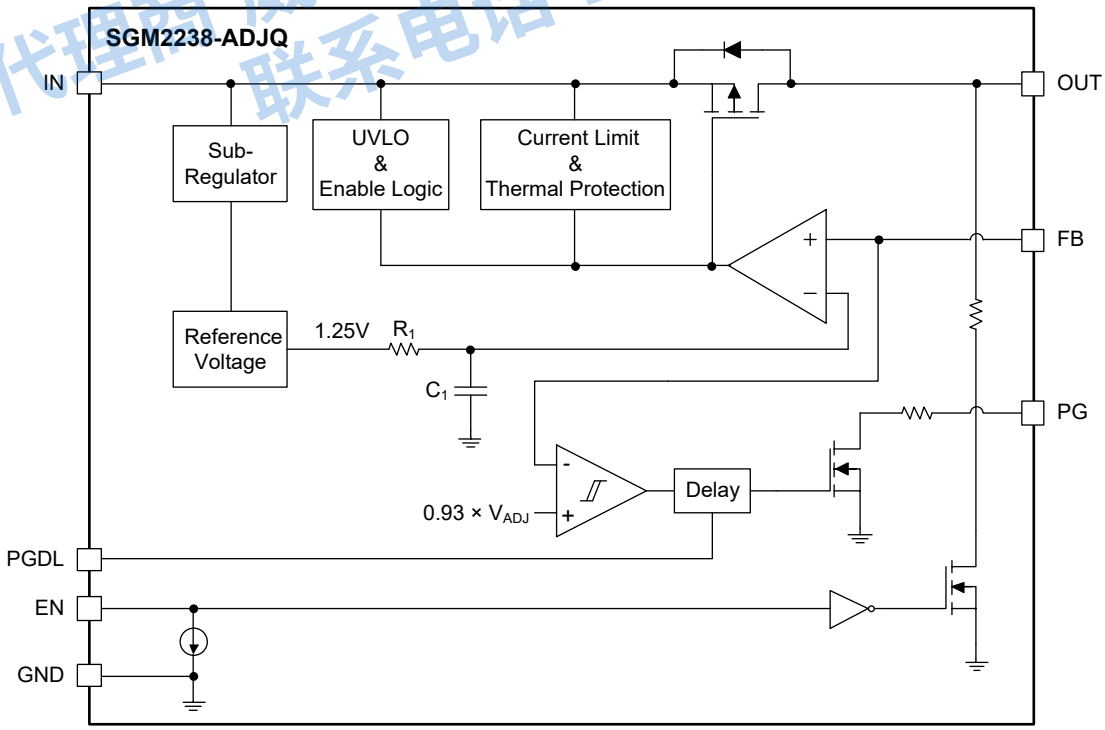


Figure 3. Block Diagram of Adjustable Output Version

ELECTRICAL CHARACTERISTICS

(V_{IN} = ($V_{OUT(NOM)}$ + 1.5V) or 3V(whichever is greater), C_{IN} = 2.2μF, C_{OUT} = 2.2μF, T_J = -40℃ to +125℃ (1), typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITION		MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}			3		40	V
Output Voltage Accuracy	V_{OUT}	V_{IN} = ($V_{OUT(NOM)}$ + 1.5V) to 40V, I_{OUT} = 1mA	T_J = +25℃	TBD		TBD	%
			T_J = -40℃ to +125℃	TBD		TBD	
Feedback Voltage	V_{ADJ}	V_{IN} = ($V_{OUT(NOM)}$ + 1.5V) to 40V, I_{OUT} = 1mA	T_J = +25℃	TBD	1.25	TBD	V
			T_J = -40℃ to +125℃				
FB Pin Input Current	I_{ADJ}				0.2		nA
Under-Voltage Lockout	V_{UVLO}	V_{IN} rising			2.06		V
Line Regulation	V_{LNR}	V_{IN} = ($V_{OUT(NOM)}$ + 1.5V) to 40V, I_{OUT} = 1mA			0.04		mV
Load Regulation	V_{LDR}	I_{OUT} = 1mA to 300mA			0.45		mV
Dropout Voltage	V_{DROP}	V_{OUT} = 95% × $V_{OUT(NOM)}$, $V_{OUT(NOM)}$ = 5V	I_{OUT} = 150mA		200		mV
			I_{OUT} = 300mA		410		
Output Current Limit	I_{LIMIT}	V_{IN} = $V_{OUT(NOM)}$ + 3V, V_{OUT} = 90% × $V_{OUT(NOM)}$			1.03		A
Output Short-Circuit Current	I_{SHORT}	V_{IN} = $V_{OUT(NOM)}$ + 3V, V_{OUT} = 0V			430		mA
Ground Pin Current	I_{GND}	I_{OUT} = 0mA			3.3		μA
		I_{OUT} = 1mA			6.3		
		I_{OUT} = 30mA			38		
		I_{OUT} = 300mA			112		
Shutdown Supply Current	I_{SHDN}	V_{EN} = 0V, V_{IN} = 3V to 40V			0.3		μA
EN Pin High-level Input Voltage	V_{IH}	V_{IN} = 3V to 40V, T_J = +25℃		1.5		40	V
EN Pin Low-level Input Voltage	V_{IL}	V_{IN} = 3V to 40V, T_J = +25℃		0		0.3	V
EN Pin Input Current	I_{EN}	V_{EN} = 0V, V_{IN} = 40V			0.7		nA
		V_{EN} = 40V, V_{IN} = 40V			73		
Output Discharge Resistance	R_{DIS}	V_{EN} = 0V			220		Ω
Turn-On Time	t_{ON}	From assertion of V_{EN} to V_{OUT} = 90% × $V_{OUT(NOM)}$			1.1		ms
PG High Threshold	PG_{HTH}	V_{OUT} rising			93		%V_{ADJ}
PG Low Threshold	PG_{LTH}	V_{OUT} falling			87		%V_{ADJ}
PG Trip Hysteresis	PG_{HYS}				6		%V_{ADJ}
PG Pin Low-Level Output Voltage	$V_{PG(LO)}$	I_{SINK} = 1mA			0.1		V
PG Pin Leakage Current	$I_{PG(LKG)}$	V_{PG} = 5V			0.3		nA
PGDL Charging Current	I_{DLY}	V_{PGDL} = 1V			5.3		μA
PGDL Rising Threshold	V_{HDLY}	I_{OUT} = 1mA			1.5		V
PGDL Falling Threshold	V_{LDLY}	I_{OUT} = 1mA			0.34		V
PG Delay Time	t_{PGD}	C_{PGDL} = 47nF, the time from V_{OUT} × 93% to V_{PGDL} × 90%			14		ms
PG Reaction Time	t_{PGR}	C_{PGDL} = 47nF, the time from V_{OUT} × 87% to V_{PGDL} × 10%			0.69		μs
Power Supply Rejection Ratio	PSRR	V_{IN} = 6.5V, V_{OUT} = 5V, C_{OUT} = 10μF, I_{OUT} = 10mA	f = 100Hz		70		dB
			f = 1kHz		48		
			f = 100kHz		47		
		V_{IN} = 13.5V, V_{OUT} = 5V, C_{OUT} = 10μF, I_{OUT} = 10mA	f = 100Hz		72		dB
			f = 1kHz		53		
			f = 100kHz		54		
Thermal Shutdown Temperature	T_{SHDN}				175		℃
Thermal Shutdown Hysteresis	ΔT_{SHDN}				40		℃

NOTE:

1. Tested under pulse load conditions, so $T_J \approx T_A$.

APPLICATION INFORMATION

The SGM2238xQ is a high voltage, low quiescent current and low dropout LDO and provides 300mA output current. These features make the device a reliable solution to solve many challenging problems in the generation of clean and accurate power supply. The high performance also makes the SGM2238xQ useful in a variety of applications. The SGM2238xQ provides protection functions for output overload, output short-circuit condition and overheating.

Input Capacitor Selection (C_{IN})

The input decoupling capacitor should be placed as close as possible to the IN pin to ensure the device stability. 2.2μF or larger X7R or X5R ceramic capacitor is selected to get good dynamic performance.

When V_{IN} is required to provide large current instantaneously, a large effective input capacitor is required. Multiple input capacitors can limit the input tracking inductance. Adding more input capacitors is available to restrict the ringing and to keep it below the device absolute maximum ratings. For C_{OUT} with larger capacitance, it is recommended to choose the larger capacitance C_{IN}.

Output Capacitor Selection (C_{OUT})

The output capacitor should be placed as close as possible to the OUT pin. 2.2μF or larger X7R or X5R ceramic capacitor is selected to get good dynamic performance. The minimum effective capacitance of C_{OUT} that SGM2238xQ can remain stable is 1μF. For ceramic capacitor, temperature, DC bias and package size will change the effective capacitance, so enough margin of C_{OUT} must be considered in design. Additionally, C_{OUT} with larger capacitance and lower ESR will help increase the high frequency PSRR and improve the load transient response.

Adjustable Regulator

The output voltage of the SGM2238-ADJQ can be adjusted from 1.25V to 24V. The FB pin will be connected to two external resistors as shown in Figure 4. The output voltage is determined by the following equation:

$$V_{OUT} = V_{ADJ} \times \left(1 + \frac{R_1}{R_2}\right) \quad (1)$$

where:

V_{OUT} is output voltage and V_{ADJ} is the internal voltage reference, V_{ADJ} = 1.25V. R_1 and R_2 can be calculated for any output voltage range using equation 1. Choose R_2 = 1MΩ to maintain a 1.25μA minimum load.

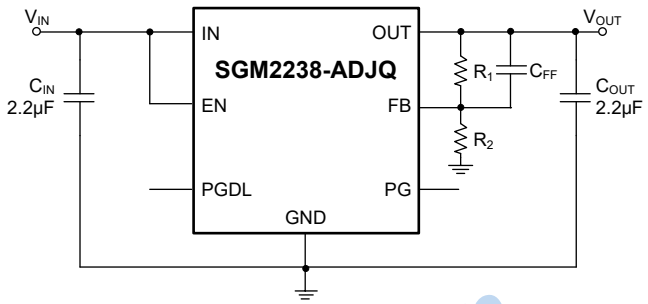


Figure 4. Adjustable Output Voltage Application

Enable Operation

The SGM2238xQ uses the EN pin to enable/disable the device and to deactivate/activate the output automatic discharge function.

When the EN pin voltage is lower than 0.3V, the device is in shutdown state. There is no current flowing from IN to OUT pins. In this state, the automatic discharge transistor is active to discharge the output voltage through a 220Ω (TYP) resistor and the PG output is pulled down.

When the EN pin voltage is higher than 1.5V, the device is in active state. The output voltage is regulated to the expected value and the automatic discharge transistor is turned off.

Under-Voltage Lockout (UVLO)

The UVLO circuit monitors the input voltage to prevent the device from turning on before V_{IN} rises above the V_{UVLO} threshold. The UVLO circuit responds quickly to glitches on the IN pin and attempts to disable the output of the device if any of these rails collapses. The local input capacitance prevents severe brownouts in most applications.

APPLICATION INFORMATION (continued)

Power-Good Function

The SGM2238xQ features PG function for monitoring the feedback voltage, so as to reflect the state of the output voltage. When the output voltage is lower than PG_{LTH}, the PG pin open-drain engages and pulls the PG pin close to GND. When the output voltage is higher than PG_{HTH}, the PG pin is indicated as high impedance. Connecting the PG pin to an external power supply via a pull-up resistor enables any downstream device to receive a power-good valid logic signal for sequencing. The resistance of the pull-up resistor is recommended to be 100kΩ.

The PG output is pulled down when the SGM2238xQ is in one of the following states, including disabled, thermal shutdown and UVLO.

Reverse Current Protection

The PMOS power transistor has an inherent body diode. This body diode will be forward biased when $V_{OUT} > V_{IN}$. When $V_{OUT} > V_{IN}$, the reverse current flowing from the OUT pin to the IN pin will damage the SGM2238xQ. If $V_{OUT} > V_{IN}$ event would happen in system, one external Schottky diode will be added between OUT pin and IN pin in circuit design to protect the SGM2238xQ.

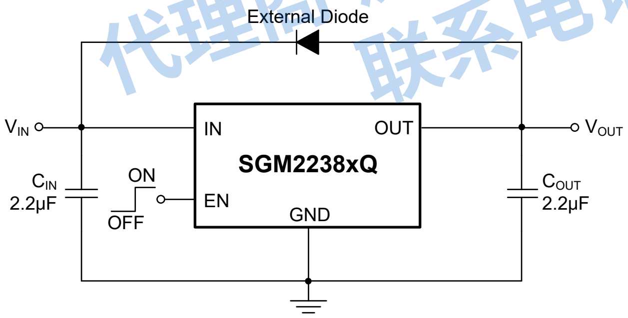


Figure 5. Reverse Protection Reference Design

Output Current Limit and Short-Circuit Protection

When overload events happen, the output current is internally limited to 1.03A (TYP). When the OUT pin is shorted to ground, the short-circuit protection will limit the output current to 430mA (TYP).

Thermal Shutdown

When the die temperature exceeds the threshold value of thermal shutdown, the SGM2238xQ will be in shutdown state and it will remain in this state until the die temperature decreases to +135℃. When the device enters thermal shutdown, the PG output is pulled low.

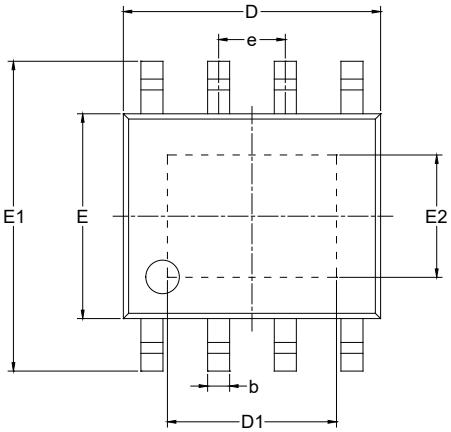
Power Dissipation (P_D)

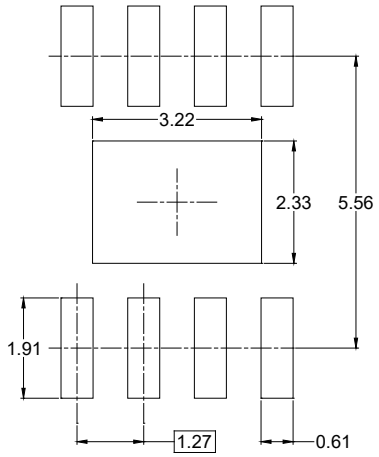
Power dissipation (P_D) of the SGM2238xQ can be calculated by the equation $P_D = (V_{IN} - V_{OUT}) \times I_{OUT}$. The maximum allowable power dissipation ($P_{D(MAX)}$) of the SGM2238xQ is affected by many factors, including the difference between junction temperature and ambient temperature ($T_{J(MAX)} - T_A$), package thermal resistance from the junction to the ambient environment (θ_{JA}), the rate of ambient airflow and PCB layout. $P_{D(MAX)}$ can be approximated by the following equation:

$$P_{D(MAX)} = (T_{J(MAX)} - T_A)/\theta_{JA} \quad (2)$$

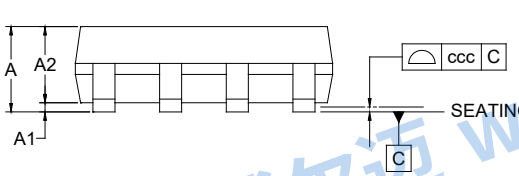
PACKAGE OUTLINE DIMENSIONS

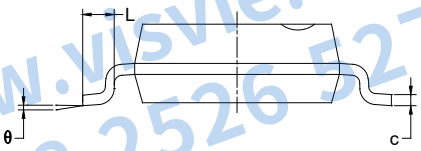
SOIC-8 (Exposed Pad)





RECOMMENDED LAND PATTERN (Unit: mm)



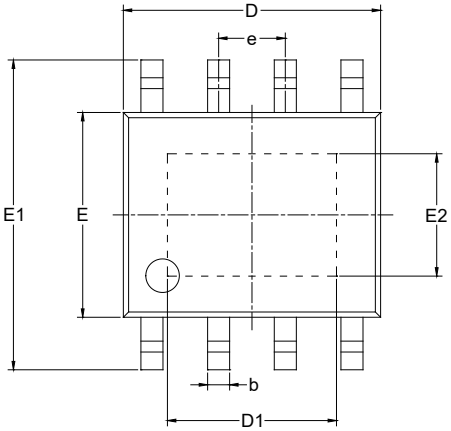


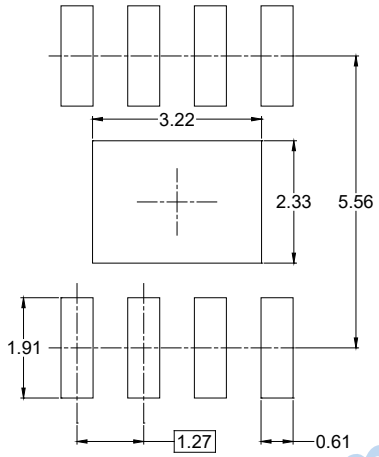
Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A			1.700
A1	0.000	-	0.150
A2	1.250	-	1.650
b	0.330	-	0.510
c	0.170	-	0.250
D	4.700	-	5.100
D1	3.020	-	3.420
E	3.800	-	4.000
E1	5.800	-	6.200
E2	2.130	-	2.530
e	1.27 BSC		
L	0.400	-	1.270
θ	0°	-	8°
ccc	0.100		

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 MS-012.

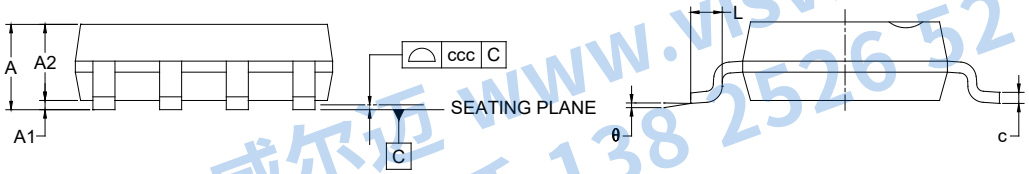
PACKAGE OUTLINE DIMENSIONS

SOIC-8 (Exposed Pad)





RECOMMENDED LAND PATTERN (Unit: mm)



Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
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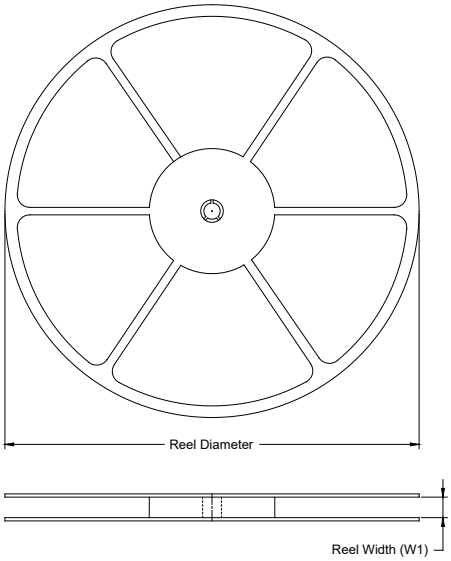
A1	0.000	-	0.150
A2	1.250	-	1.650
b	0.330	-	0.510
c	0.170	-	0.250
D	4.700	-	5.100
D1	3.020	-	3.420
E	3.800	-	4.000
E1	5.800	-	6.200
E2	2.130	-	2.530
e	1.27 BSC		
L	0.400	-	1.270
θ	0°	-	8°
ccc	0.100		

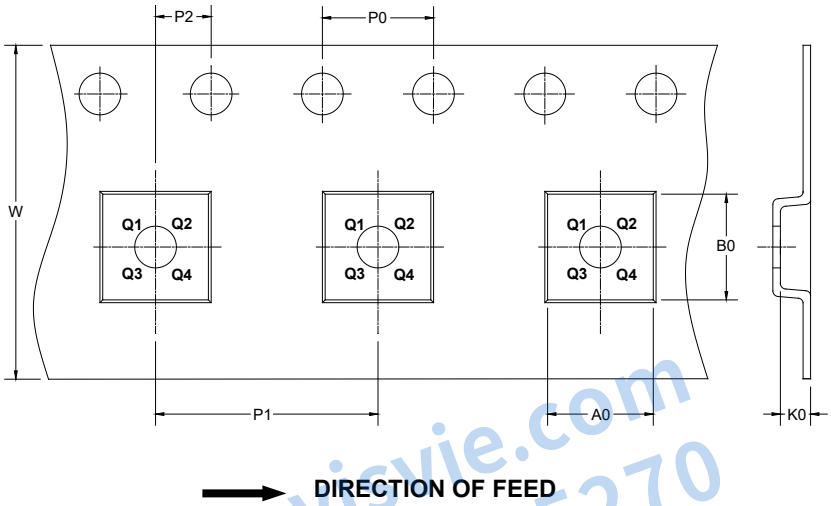
NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MS-012.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



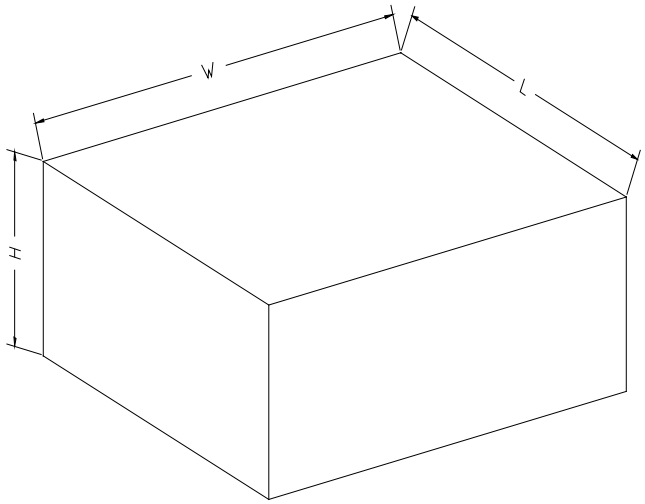
NOTE: The picture is only for reference. Please make the object as the standard.

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
SOIC-8 (Exposed Pad)	13"	12.4	6.40	5.40	2.10	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