SGM2208
3A, Low Noise, Adjustable Output with Single Resistor and Low Dropout Regulator

GENERAL DESCRIPTION

The SGM2208 is a 3A output current, low noise and low dropout linear regulator whose output voltage is adjusted with a single resistor and the lowest output voltage can be true zero. The SGM2208 can be easily paralleled to increase output current or spread heat on surface mounted boards. The SGM2208 can be widely used in many applications, such as precision large current source and voltage follower, laser diode power supply requiring high current, adjustability to zero and no heat sink.

By using a reference current through a single resistor, the output voltage is programmed to any level. The SGM2208 has the capability to supply a wide output voltage range. The SGM2208 is stable with ceramic capacitors and a 10μF of capacitance on the output that is always used for large output current applications. The SGM2208 also has internal protection functions, such as current limiting and thermal protection.

The SGM2208 is available in Green TSSOP-16 (Exposed Pad), TDFN-3×3-12L and TO-263-5B packages. It operates over an operating temperature range of -40℃ to +125℃.

FEATURES

- **Power Input Voltage Range (Relative to OUT): 0V to 24V**
- **Bias Supply Voltage Range (Relative to OUT): 2.7V to 25V**
- **Single Resistor Programs Output Voltage**
- **SET Pin Current: 50μA (TYP)**
- **Output Adjustable to 0V**
- **Low Output Noise: 32μV_{RMS} (10Hz to 100kHz)**
- **Low Dropout Voltage: 155mV (TYP) at 3A**
- **Current Limit with Foldback**
- **Over-Temperature Protection**
- **Outputs May be Paralleled for Higher Current and Heat Spreading**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in Green TSSOP-16 (Exposed Pad), TDFN-3×3-12L and TO-263-5B Packages**

APPLICATIONS

High-Efficiency Post-Regulator for Switching Supplies
High Current All Surface Mount Power Supplies
High-Efficiency Linear Low Voltage Supplies
Low Parts Count Variable Voltage Supplies
Low Output Voltage Power Supplies

TYPICAL APPLICATION

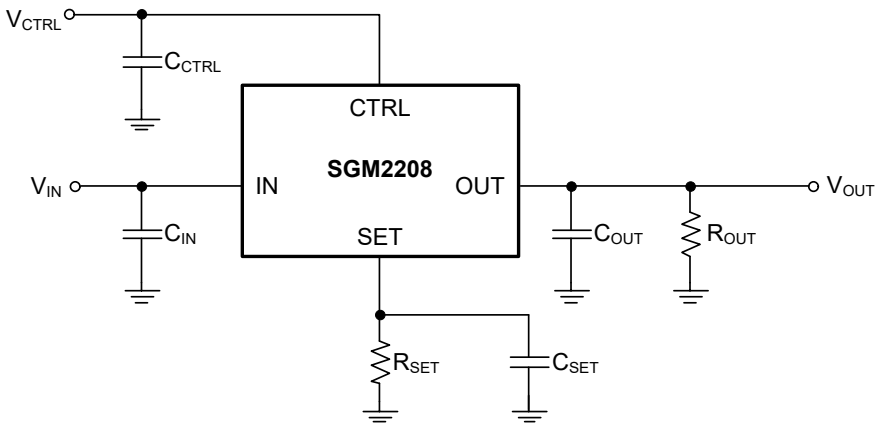


Figure 1. Typical Application Circuit

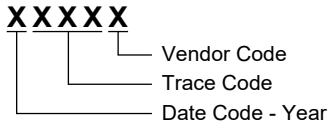
PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM2208	TSSOP-16 (Exposed Pad)	-40℃ to +125℃	SGM2208XPTS16G/TR	SGM2208 XPTS16 XXXXX	Tape and Reel, 4000
	TDFN-3×3-12L	-40℃ to +125℃	SGM2208XTDF12G/TR	SGM 2208DF XXXXX	Tape and Reel, 4000
	TO-263-5B	-40℃ to +125℃	SGM2208XO5G/TR	SGM2208 XO5 XXXXX	Tape and Reel, 800

MARKING INFORMATION

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

TSSOP-16 (Exposed Pad)/TDFN-3×3-12L/TO-263-5B



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

CTRL to OUT ..... ±28V
IN to OUT ..... -0.3V to 28V
SET to OUT ..... ±15V
SET Pin Current ..... ±25mA
Package Thermal Resistance
TSSOP-16 (Exposed Pad), θ_{JA} ..... 39℃/W
TSSOP-16 (Exposed Pad), θ_{JB} ..... 16℃/W
TSSOP-16 (Exposed Pad), θ_{JC} ..... 46℃/W
TDFN-3×3-12L, θ_{JA} ..... 62℃/W
TDFN-3×3-12L, θ_{JB} ..... 27℃/W
TDFN-3×3-12L, θ_{JC} ..... 41℃/W
TO-263-5B, θ_{JA} ..... 29℃/W
TO-263-5B, θ_{JB} ..... 9℃/W
TO-263-5B, θ_{JC} ..... 32℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 3000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Operating Junction Temperature Range ..... -40℃ to +125℃
Input Capacitance, C_{IN} ..... 10μF (MIN)
Output Capacitance, C_{OUT} ..... 10μF to 100μF
CTRL Capacitance, C_{CTRL} ..... 2.2μF (MIN)

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

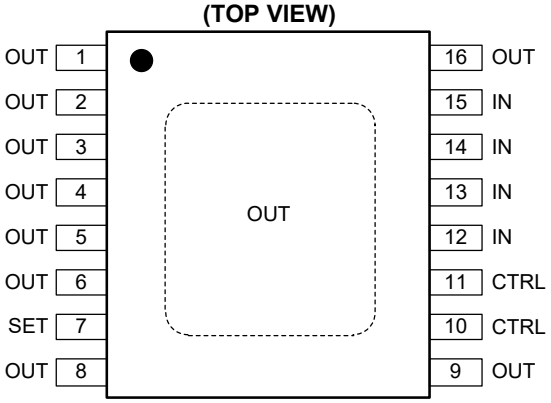
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

DISCLAIMER

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

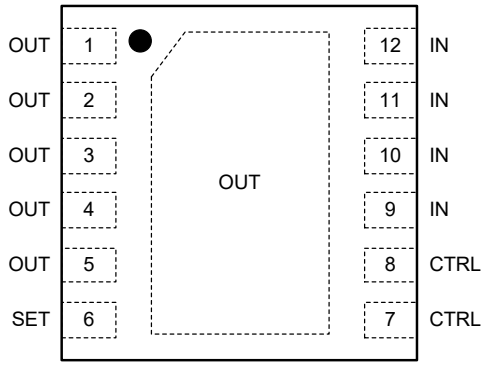
PIN CONFIGURATIONS

(TOP VIEW)



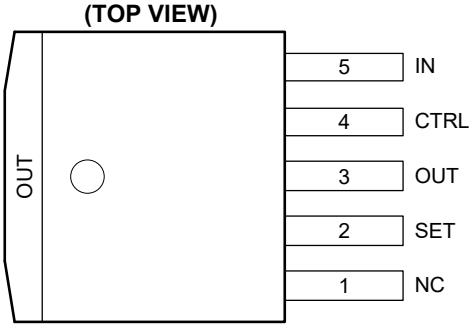
TSSOP-16 (Exposed Pad)

(TOP VIEW)



TDFN-3×3-12L

(TOP VIEW)



TO-263-5B

PIN DESCRIPTION

PIN			NAME	FUNCTION
TSSOP-16 (Exposed Pad)	TDFN-3×3-12L	TO-263-5B		
1-6, 8, 9, 16	1-5	3	OUT	Regulated Output Voltage Pin. It is recommended to use output capacitor with effective capacitance in the range of 10μF to 100μF. There must be a minimum load current of 1mA.
7	6	2	SET	Set Point Pin. This pin is the non-inverting input to the error amplifier and the regulation set point. A fixed current of 50μA flows out of this pin through a single external resistor, which programs the output voltage of the device.
10, 11	7, 8	4	CTRL	Bias Supply Pin. This is the supply pin for the control circuitry of the device. Minimum CTRL capacitance is 2.2μF.
12-15	9-12	5	IN	Power Input Pin. The output load current is supplied through this pin. Minimum IN capacitance is 10μF.
–	–	1	NC	No Connection.
Exposed Pad	Exposed Pad	–	OUT	Regulated Output Voltage Pin. The exposed pad on the bottom of the package enhances thermal performance. It is recommended that the exposed pad connect to the OUT plane on the board.

ELECTRICAL CHARACTERISTICS

(V_{IN} = $V_{OUT(NOM)}$ + 0.5V, V_{CTRL} = $V_{OUT(NOM)}$ + 2.7V, I_{OUT} = 1mA, C_{IN} = C_{OUT} = 10μF, C_{CTRL} = 2.2μF and C_{SET} = 0.1μF, T_J = -40℃ to +125℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		TEMP	MIN	TYP	MAX	UNITS
Bias Supply Voltage Range	V_{CTRL}	Relative to OUT		-40℃ to +125℃	2.7		25	V
Power Input Voltage Range	V_{IN}	Relative to OUT		-40℃ to +125℃	V_{DROP}		24	V
SET Pin Current	I_{SET}	V_{IN} = 0.5V to 24V, V_{CTRL} = 2.7V to 25V, I_{OUT} = 1mA to 3A		+25℃	49.5	50	50.5	μA
				-40℃ to +125℃	49		51	
Output Offset Voltage (V_{OUT} - V_{SET})	V_{OS}	V_{IN} = 0.5V to 24V, V_{CTRL} = 2.7V to 25V		+25℃	-5		5	mV
				-40℃ to +125℃	-5.5		5.5	
Load Regulation (1)	ΔI_{SET}	I_{OUT} = 1mA to 3A		+25℃	-30	2	30	nA
				-40℃ to +125℃	-50		50	
	ΔV_{OS}	I_{OUT} = 1mA to 3A	TSSOP-16 (Exposed Pad)	+25℃	-1	-0.2		mV
				-40℃ to +125℃	-1.6			
			TDFN-3×3-12L	+25℃	-1	-0.2		
				-40℃ to +125℃	-1.6			
			TO-263-5B	+25℃	-1.6	-0.7		
				-40℃ to +125℃	-2.1			
V_{IN} Line Regulation	$\frac{\Delta I_{SET}}{\Delta V_{IN}}$	V_{IN} = 0.5V to 24V		+25℃		0.1	1	nA/V
				-40℃ to +125℃			12	
	$\frac{\Delta V_{OS}}{\Delta V_{IN}}$	V_{IN} = 0.5V to 24V		+25℃		0.001	0.015	mV/V
				-40℃ to +125℃			0.02	
V_{CTRL} Line Regulation	$\frac{\Delta I_{SET}}{\Delta V_{CTRL}}$	V_{CTRL} = 2.7V to 25V		+25℃		0.1	1	nA/V
				-40℃ to +125℃			12	
	$\frac{\Delta V_{OS}}{\Delta V_{CTRL}}$	V_{CTRL} = 2.7V to 25V		+25℃		0.001	0.015	mV/V
				-40℃ to +125℃			0.02	
Minimum Load Current (2)		V_{IN} = 0.5V to 24V, V_{CTRL} = 2.7V to 25V		+25℃		330	430	μA
				-40℃ to +125℃			490	
V_{IN} Dropout Voltage (3)	V_{DROP}	I_{OUT} = 3A	TSSOP-16 (Exposed Pad)	+25℃		155	210	mV
				-40℃ to +125℃			280	
			TDFN-3×3-12L	+25℃		155	210	
				-40℃ to +125℃			280	
			TO-263-5B	+25℃		245	300	
				-40℃ to +125℃			400	
CTRL Pin Current	I_{CTRL}	I_{OUT} = 1mA		+25℃		310	410	μA
				-40℃ to +125℃			470	
		I_{OUT} = 3A		+25℃		820	1040	
				-40℃ to +125℃			1110	
Output Current Limit (4)	I_{LIM}	V_{IN} = 1V, V_{SET} = 0V, V_{OUT} = -0.1V		+25℃	5.3	8		A
Error Amplifier RMS Output Noise		I_{OUT} = 500mA, f = 10Hz to 100kHz		+25℃		32		$μV_{RMS}$
Reference Current RMS Output Noise		I_{OUT} = 500mA, f = 10Hz to 100kHz		+25℃		1		nA_{RMS}

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = $V_{OUT(NOM)}$ + 0.5V, V_{CTRL} = $V_{OUT(NOM)}$ + 2.7V, I_{OUT} = 1mA, C_{IN} = C_{OUT} = 10μF, C_{CTRL} = 2.2μF and C_{SET} = 0.1μF, T_J = -40℃ to +125℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		TEMP	MIN	TYP	MAX	UNITS
Power Supply Rejection Ratio	PSRR	V_{CTRL} + V_{IN} to V_{OUT}, V_{CTRL} = V_{IN} = 3V, I_{OUT} = 100mA	f = 120Hz	+25℃		80		dB
			f = 10kHz	+25℃		47		
			f = 1MHz	+25℃		43		
		V_{CTRL} to V_{OUT}, V_{CTRL} = 3V, I_{OUT} = 100mA	f = 120Hz	+25℃		88		dB
			f = 10kHz	+25℃		63		
			f = 1MHz	+25℃		87		
		V_{IN} to V_{OUT}, V_{IN} = 1V, I_{OUT} = 100mA	f = 120Hz	+25℃		70		dB
			f = 10kHz	+25℃		40		
			f = 1MHz	+25℃		37		
Thermal Shutdown Temperature	T_{SHDN}					160		℃
Thermal Shutdown Hysteresis	ΔT_{SHDN}					20		℃

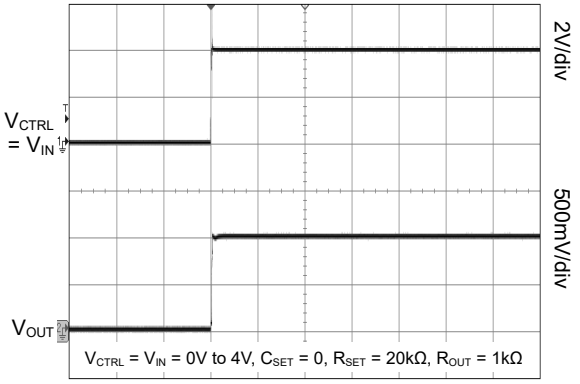
NOTES:

1. Load regulation is Kelvin sensed at the package.
2. Minimum load current is equivalent to the quiescent current of the part. Since all quiescent and drive current is delivered to the output of the part, the minimum load current is the minimum current required to maintain regulation.
3. The dropout voltage is defined as V_{IN} - V_{OUT}, when V_{OS} = 50mV.
4. Current limit includes foldback protection circuitry. Current limit decreases at higher input-to-output differential voltages.

TYPICAL PERFORMANCE CHARACTERISTICS

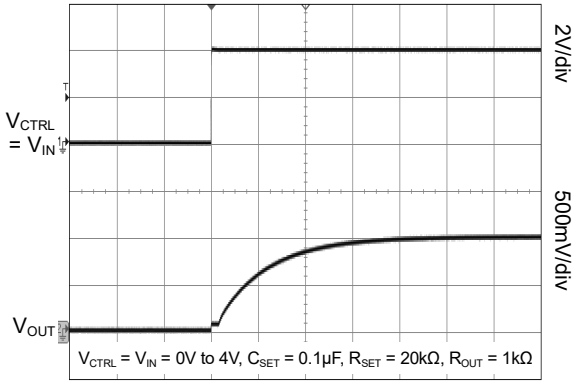
T_J = +25℃, V_{IN} = $V_{OUT(NOM)}$ + 0.5V, V_{CTRL} = $V_{OUT(NOM)}$ + 2.7V, I_{OUT} = 1mA, C_{IN} = C_{OUT} = 10μF, C_{CTRL} = 2.2μF and C_{SET} = 0.1μF, unless otherwise noted.

Turn-On Response



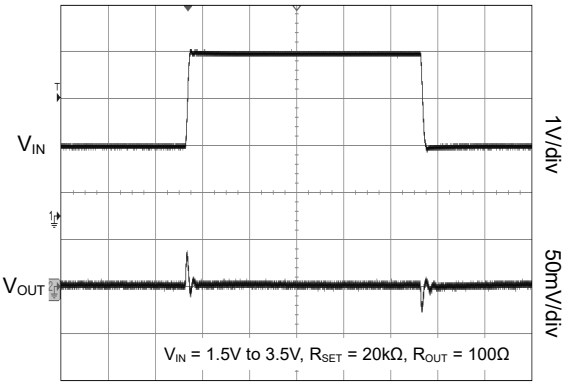
Time (2ms/div)

Turn-On Response



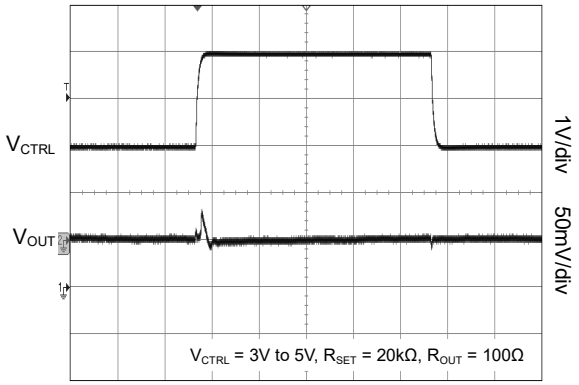
Time (2ms/div)

V_{IN} Line Transient Response



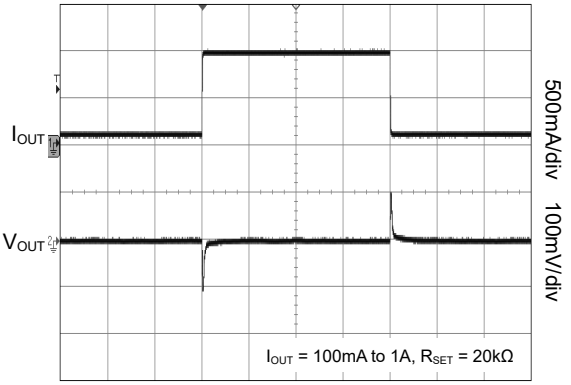
Time (200μs/div)

V_{CTRL} Line Transient Response



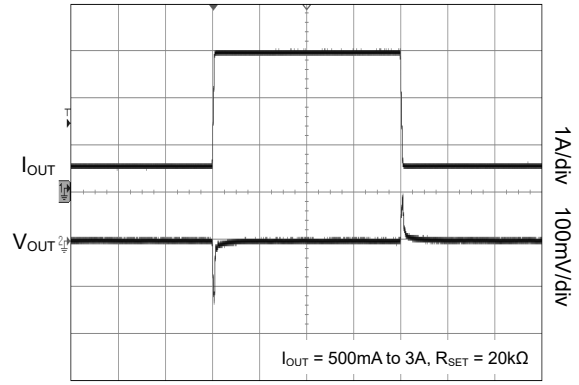
Time (200μs/div)

Load Transient Response



Time (500μs/div)

Load Transient Response

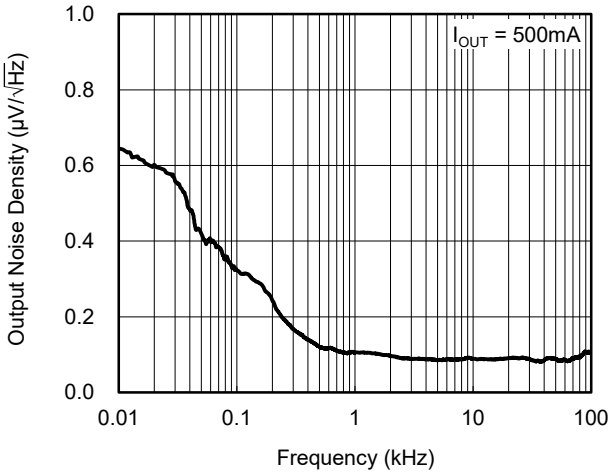


Time (500μs/div)

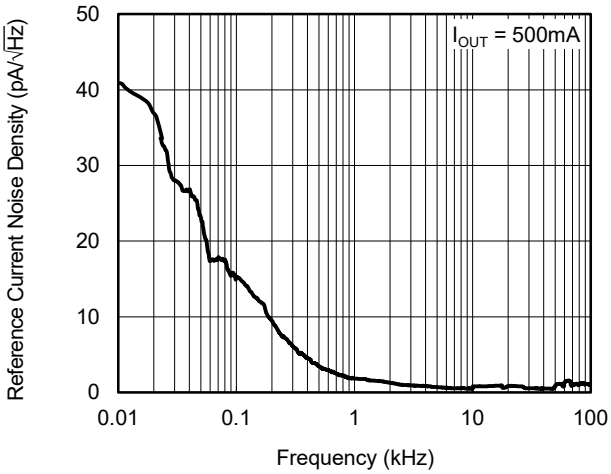
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_J = +25℃, V_{IN} = $V_{OUT(NOM)}$ + 0.5V, V_{CTRL} = $V_{OUT(NOM)}$ + 2.7V, I_{OUT} = 1mA, C_{IN} = C_{OUT} = 10μF, C_{CTRL} = 2.2μF and C_{SET} = 0.1μF, unless otherwise noted.

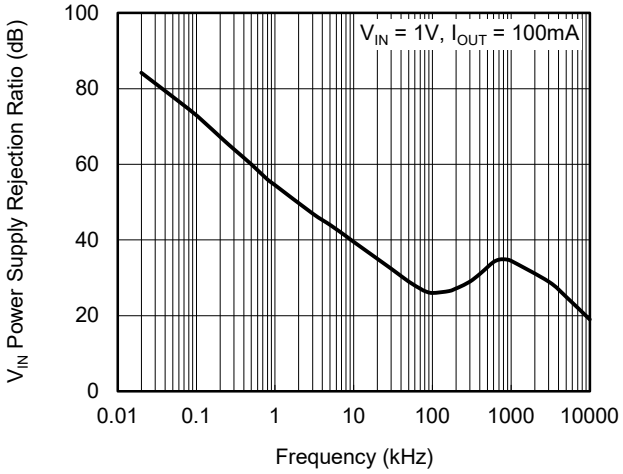
Output Noise Density vs. Frequency



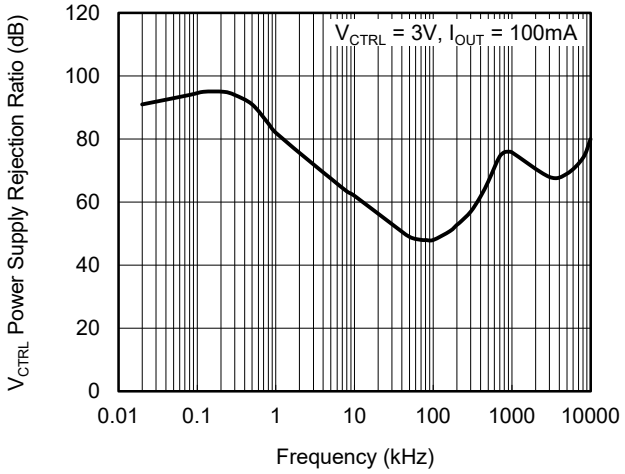
Reference Current Noise Density vs. Frequency



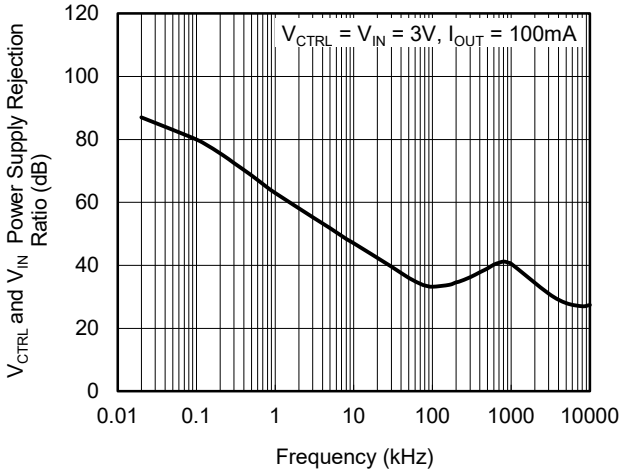
V_{IN} Power Supply Rejection Ratio vs. Frequency



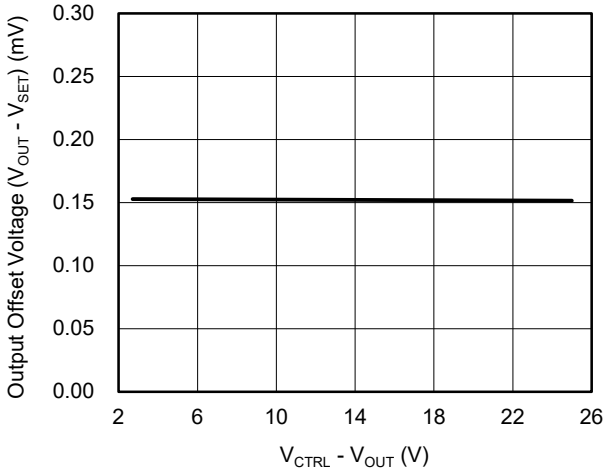
V_{CTRL} Power Supply Rejection Ratio vs. Frequency



V_{CTRL} and V_{IN} Power Supply Rejection Ratio vs. Frequency



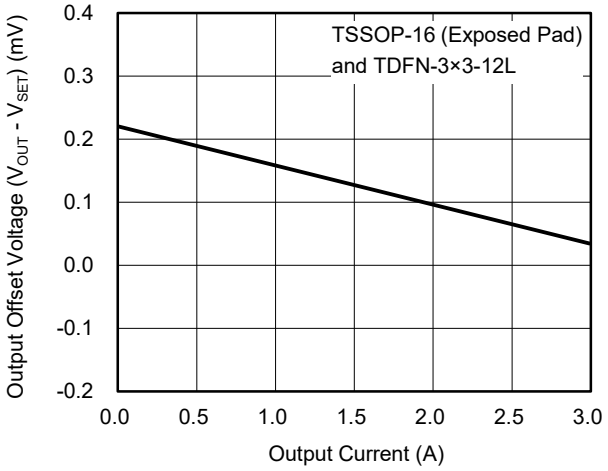
Output Offset Voltage (V_{OUT} - V_{SET}) vs. (V_{CTRL} - V_{OUT})



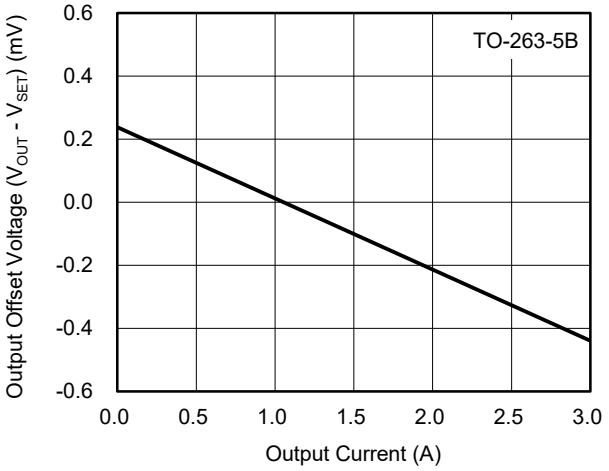
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_J = +25℃, V_{IN} = $V_{OUT(NOM)}$ + 0.5V, V_{CTRL} = $V_{OUT(NOM)}$ + 2.7V, I_{OUT} = 1mA, C_{IN} = C_{OUT} = 10μF, C_{CTRL} = 2.2μF and C_{SET} = 0.1μF, unless otherwise noted.

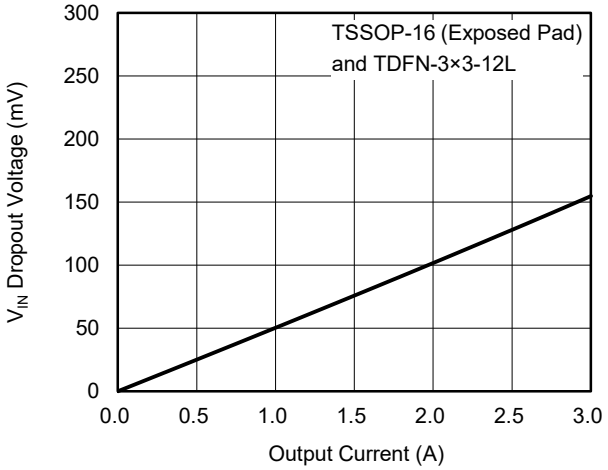
Output Offset Voltage (V_{OUT} - V_{SET}) vs. Output Current



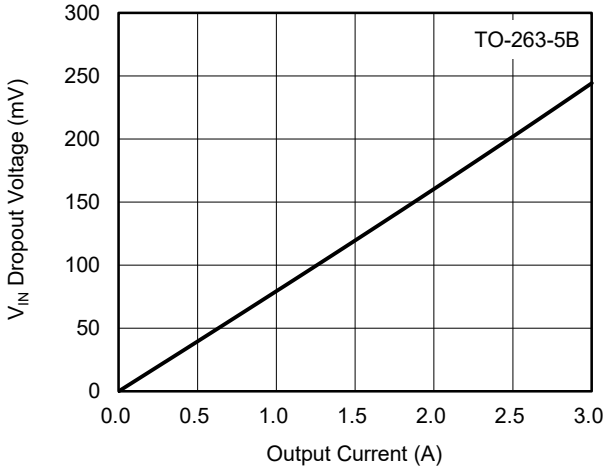
Output Offset Voltage (V_{OUT} - V_{SET}) vs. Output Current



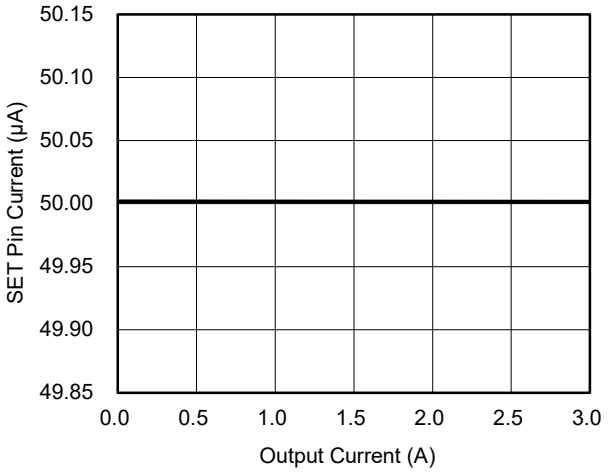
V_{IN} Dropout Voltage vs. Output Current



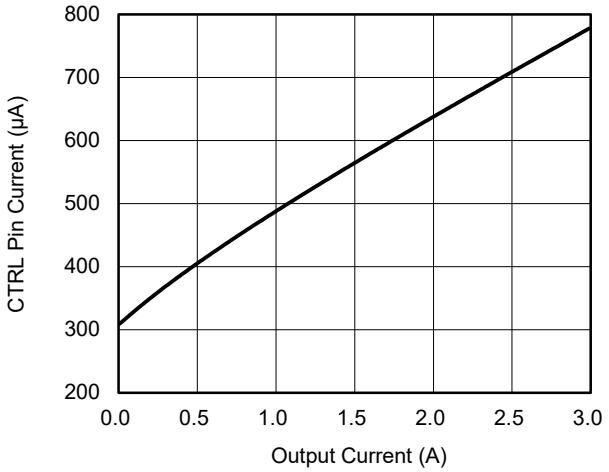
V_{IN} Dropout Voltage vs. Output Current



SET Pin Current vs. Output Current



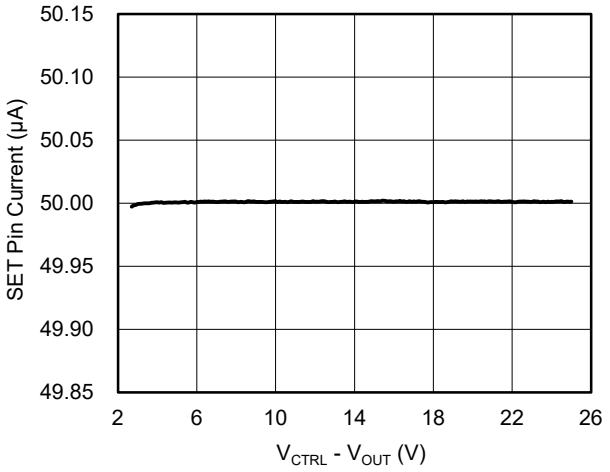
CTRL Pin Current vs. Output Current



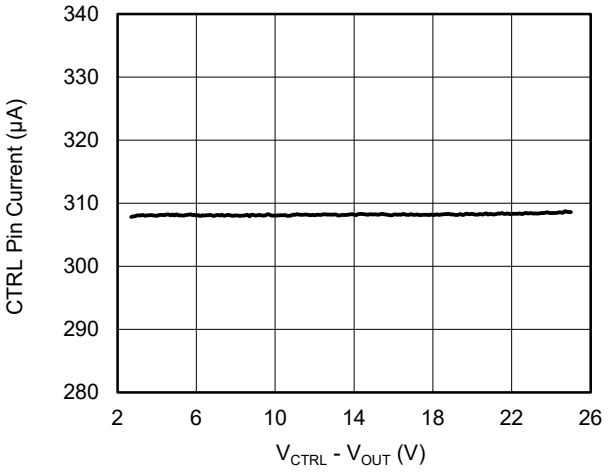
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_J = +25℃, V_{IN} = $V_{OUT(NOM)}$ + 0.5V, V_{CTRL} = $V_{OUT(NOM)}$ + 2.7V, I_{OUT} = 1mA, C_{IN} = C_{OUT} = 10μF, C_{CTRL} = 2.2μF and C_{SET} = 0.1μF, unless otherwise noted.

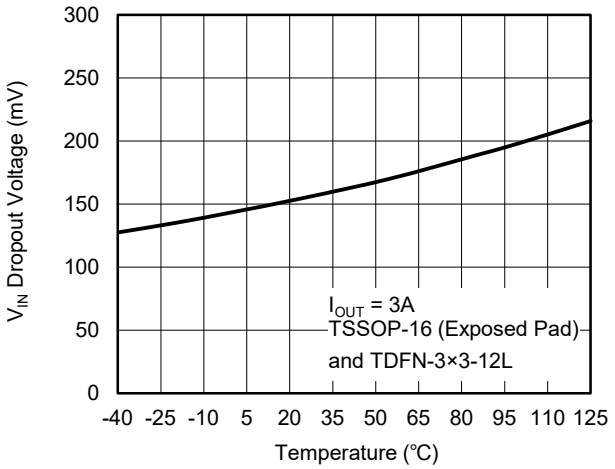
SET Pin Current vs. (V_{CTRL} - V_{OUT})



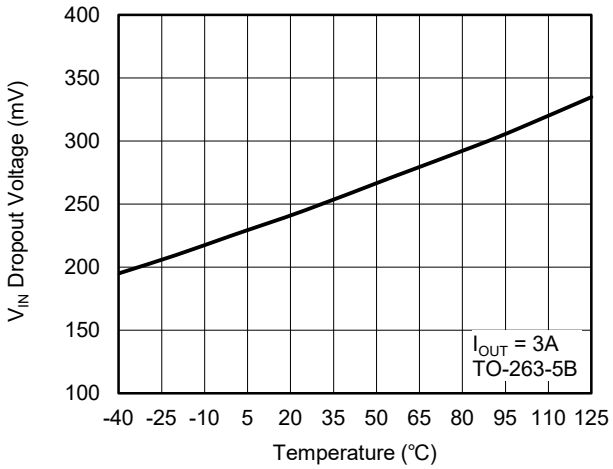
CTRL Pin Current vs. (V_{CTRL} - V_{OUT})



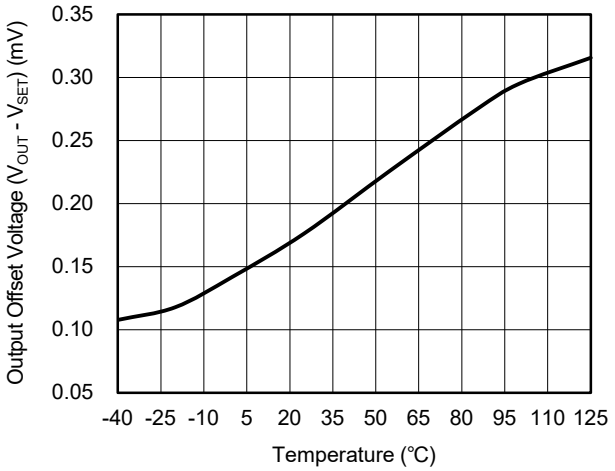
V_{IN} Dropout Voltage vs. Temperature



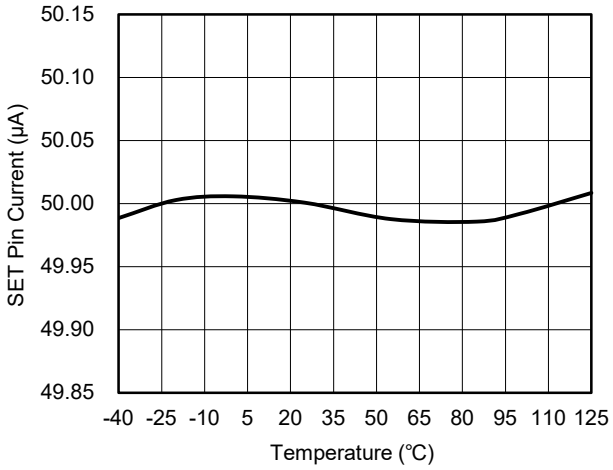
V_{IN} Dropout Voltage vs. Temperature



Output Offset Voltage (V_{OUT} - V_{SET}) vs. Temperature



SET Pin Current vs. Temperature



FUNCTIONAL BLOCK DIAGRAM

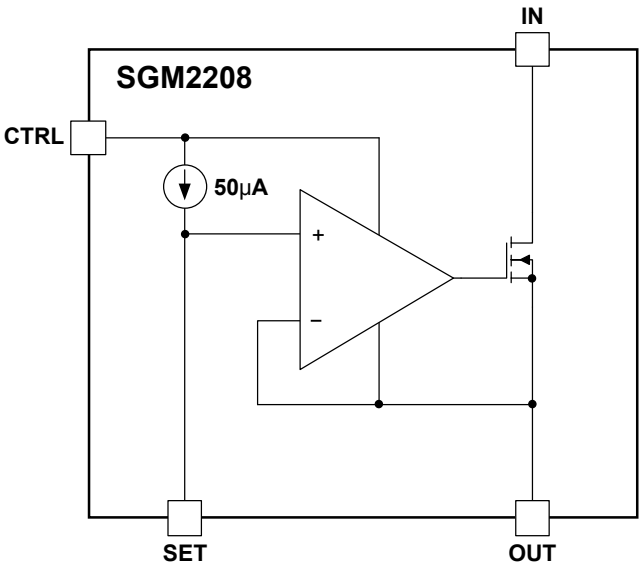


Figure 2. Block Diagram

APPLICATION INFORMATION

The SGM2208 regulator is easy to use. Internal protection circuitry includes current limiting and thermal limiting.

The SGM2208's output voltage can be adjusted down to zero with a single resistor. This feature makes the SGM2208 fit well in applications requiring multiple rails and it handles power supply for modern low voltage digital IC and supports parallel operation and thermal management without heat sinks.

The SGM2208 has the drain of the output N type power MOSFET connected to a separate pin and two supplies can be used to power the SGM2208 to reduce power dissipation: a higher voltage supply for the control circuitry and a lower voltage supply for the drain. This increases efficiency and reduces dissipation. The dropout voltage from IN pin to OUT pin is typically only 155mV.

Setting the Output Voltage

The SGM2208 sources a 50μA reference current that flows out of the SET pin. Connecting a resistor R_{SET} from SET pin to ground generates a reference voltage for the error amplifier (see Figure 3). The reference voltage is equal to 50μA × $R_{SET,}$ and then any output voltage can be generated.

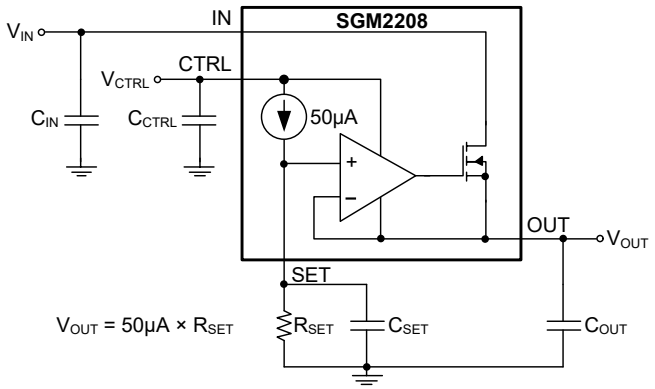


Figure 3. Basic Adjustable Regulator

Regulation of the output voltage requires a minimum load current of 1mA. With the lower level current used to generate the reference voltage, leakage current to or from the SET pin can create errors in the reference and output voltage.

In order to improve the transient performance, a 0.1μF capacitor is paralleled with the resistor R_{SET}. This 0.1μF bypass capacitor reduces system noise as well, but start-up time is proportional to the time constant of R_{SET} × 0.1μF.

APPLICATION INFORMATION (continued)

Input and Output Capacitors

Typical minimum input capacitance is 10μF for IN and 2.2μF for CTRL and low ESR ceramic capacitors work well for input power supply decoupling. The capacitors must be placed close to the SGM2208 and the circuit is located in close proximity to the power source. Higher values of input capacitance may be necessary to maintain stability depending on the application.

The SGM2208 is designed to be stable with low ESR ceramic capacitors. A minimum output capacitance of 10μF is required to prevent oscillations. Larger values of output capacitance decrease peak deviations and provide improved transient response for larger load current changes.

Paralleling Devices

Multiple SGM2208s can be paralleled to support higher output current as shown in Figure 4. Connect the individual SET pins together and tie the individual IN pins together. Connect the outputs in common using small pieces of PC trace as ballast resistors (R_B) to improve the equal current sharing between the paralleled SGM2208s.

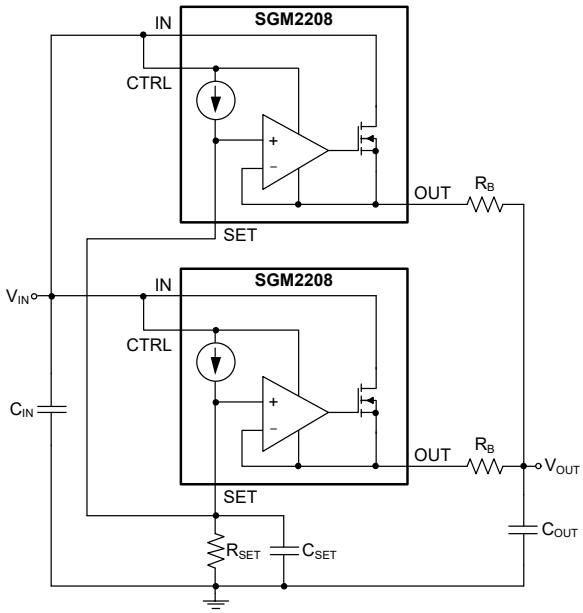


Figure 4. Parallel Devices

Thermal Considerations

The SGM2208's internal thermal limiting circuitry protects itself under overload conditions. For continuous normal load conditions, do not exceed the +125℃ maximum junction temperature. Carefully thermal design is required to reduce the thermal resistance from junction-to-ambient, this includes (but is not limited to) junction-to-case, case-to-heat sink interface, heat sink resistance or circuit board-to-ambient as the application dictates. Consider all additional, adjacent heat generating sources in proximity on the PCB.

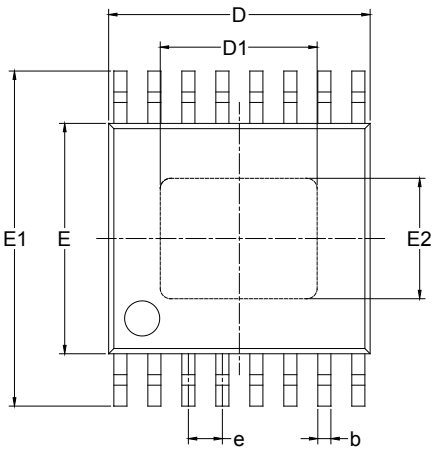
REVISION HISTORY

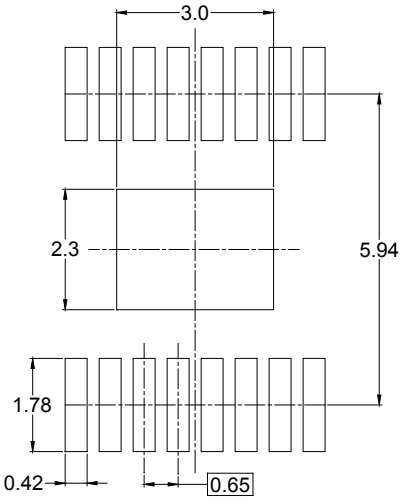
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (DECEMBER 2019) to REV.A	Page
Changed from product preview to production data	All

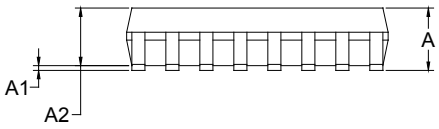
PACKAGE OUTLINE DIMENSIONS

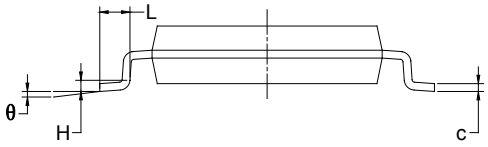
TSSOP-16 (Exposed Pad)





RECOMMENDED LAND PATTERN (Unit: mm)

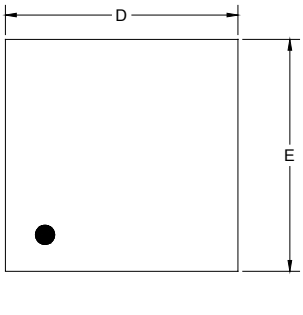




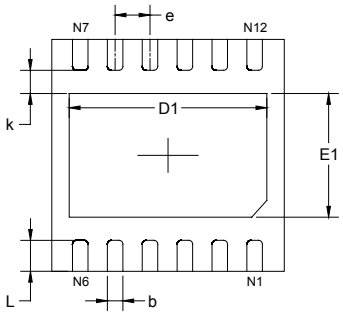
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.100		0.043
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.900	5.100	0.193	0.201
D1	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
E2	2.200	2.400	0.087	0.094
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.02	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

PACKAGE OUTLINE DIMENSIONS

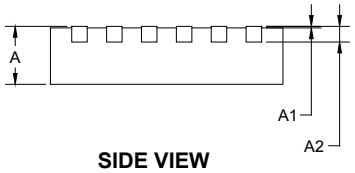
TDFN-3×3-12L



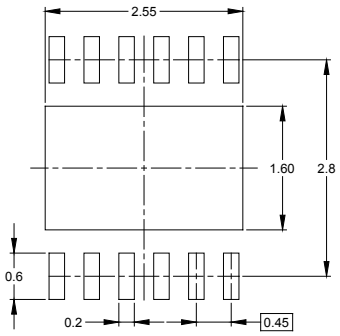
TOP VIEW



BOTTOM VIEW



SIDE VIEW

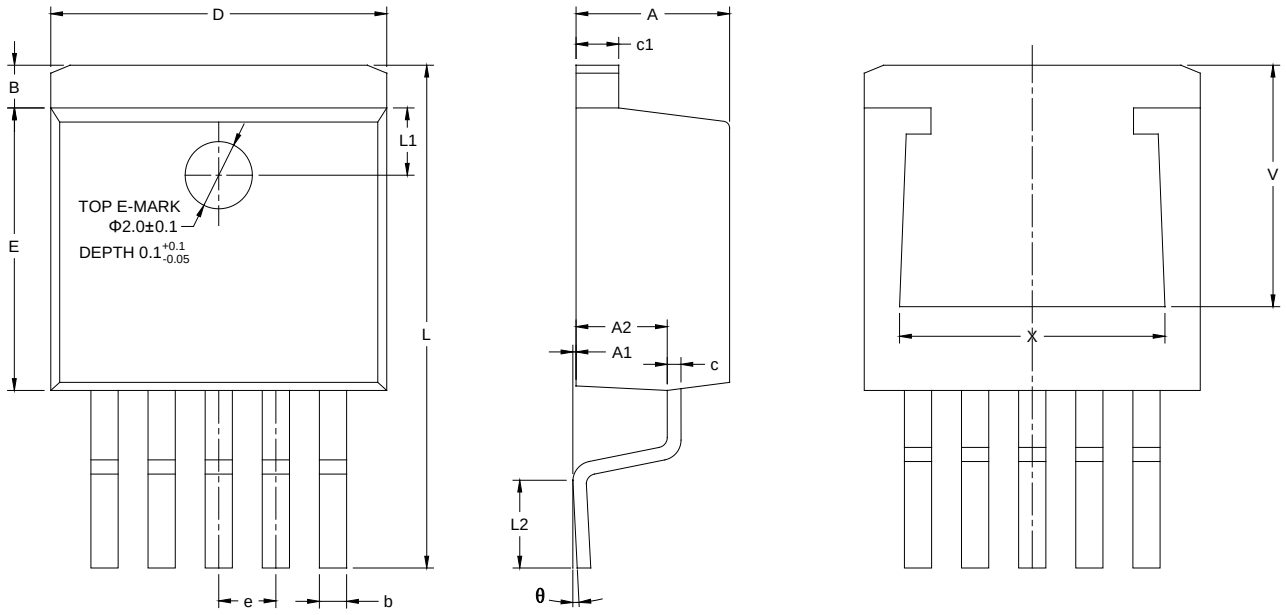


RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.924	3.076	0.115	0.121
D1	2.450	2.650	0.096	0.104
E	2.924	3.076	0.115	0.121
E1	1.500	1.700	0.059	0.067
k	0.200 MIN		0.008 MIN	
b	0.150	0.250	0.006	0.010
e	0.450 TYP		0.018 TYP	
L	0.324	0.476	0.013	0.019

PACKAGE OUTLINE DIMENSIONS

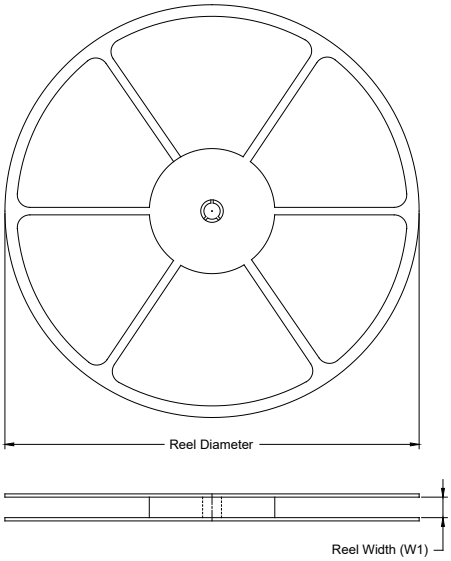
TO-263-5B



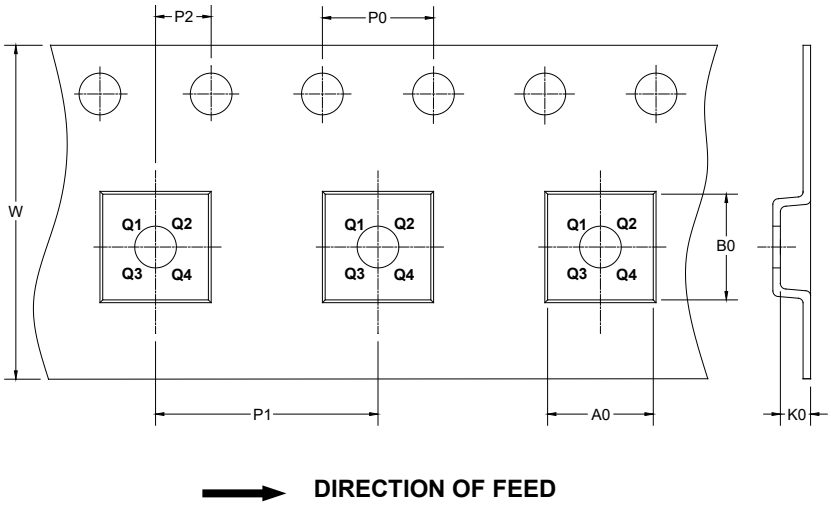
Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	4.40	4.57	4.70
A1	0	0.10	0.25
A2	2.59	2.69	2.79
b	0.77	-	0.90
c	0.34	-	0.47
c1	1.22	-	1.32
e	1.70 BSC		
D	10.06	10.16	10.26
E	9.05	9.15	9.25
B	1.17	1.27	1.40
V	6.86	-	7.50
X	7.50	-	8.30
L	14.70	15.10	15.50
L1	2.00 REF		
L2	2.00	2.30	2.60
θ	0°	-	8°

TAPE AND REEL INFORMATION

REEL DIMENSIONS

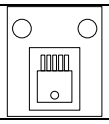


TAPE DIMENSIONS



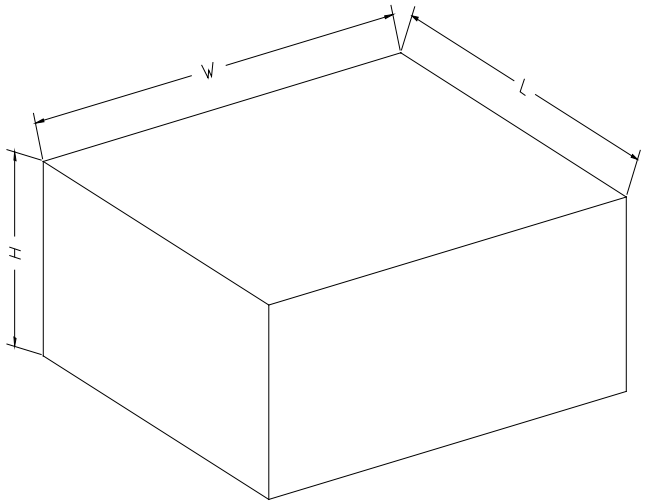
NOTE: The picture is only for reference. Please make the object as the standard.

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	6.90	5.60	1.20	4.0	8.0	2.0	12.0	Q1
TDFN-3×3-12L	13″	12.4	3.30	3.30	1.10	4.0	8.0	2.0	12.0	Q1
TO-263-5B	13″	24.4	10.80	16.30	5.11	4.0	16.0	2.0	24.0	

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