# SGM2209
# -24V, -500mA, Low Noise, High PSRR, Negative Output Linear Regulator

## GENERAL DESCRIPTION

The SGM2209 is a low dropout linear regulator that operates from -2.7V to -24V and provides up to -500mA of output current. This high input voltage LDO is a high performance regulator to provide wide output voltage range from -1.2V down to -23V that high performance analog and mixed signal circuits need. The SGM2209 provides high PSRR, low noise and excellent line and load transient responses with a small 2.2μF ceramic output capacitor. These features are very important for noise sensitive circuits.

The SGM2209 is available in fixed output voltage versions and an adjustable version that allows the output voltage to range from -1.2V to ($-V_{IN}$ + $V_{DROP}$) via an external feedback divider.

The SGM2209 regulator output noise is 10.5$\mu V_{RMS}$ at -1.2V output voltage and 16$\mu V_{RMS}$ at -5.0V output voltage. It provides maximum flexibility that the enable logic is capable of interfacing with positive or negative logic levels.

The SGM2209 is available in Green TDFN-2×2-6AL, TDFN-3×3-8L and SOT-23-5 packages. It operates over an operating temperature range of -40℃ to +125℃.

## FEATURES

- **Low Noise:**
  - **10.5$\mu V_{RMS}$ at $V_{OUT}$ = -1.2V**
  - **12$\mu V_{RMS}$ at $V_{OUT}$ = -2.5V**
  - **16$\mu V_{RMS}$ at $V_{OUT}$ = -5.0V**
- **Power Supply Rejection Ratio (PSRR):**
  **-60dB at 10kHz at $V_{OUT}$ = -2.5V**
- **Positive or Negative Enable Logic**
- **Stable with Small 2.2μF Ceramic Output Capacitor**
- **Input Voltage Range: -2.7V to -24V**
- **Maximum Output Current: -500mA**
- **Low Dropout Voltage:**
  **-345mV (TYP) at -500mA Load at $V_{OUT}$ = -3.0V**
- **Output Voltage Accuracy: ±1% at +25℃**
- **Low Quiescent Current:**
  **$I_{GND}$ = -1.2mA (TYP) with -500mA Load**
- **Low Shutdown Current: -1.1μA (TYP)**
- **Adjustable Output from -1.2V to $-V_{IN}$ + $V_{DROP}$**
- **Current-Limit and Thermal Overload Protection**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in Green TDFN-2×2-6AL, TDFN-3×3-8L and SOT-23-5 Packages**

## APPLICATIONS

Regulation to Noise Sensitive Application:
Analog-to-Digital Converter (ADC) and Digital-to-Analog Converter (DAC) Circuits, Precision Amplifiers
Communications and Infrastructure
Medical and Healthcare
Industrial and Instrumentation

## PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---|---|---|---|---|---|
| SGM2209-1.2 | TDFN-2×2-6AL | -40℃ to +125℃ | SGM2209-1.2XTDI6G/TR | MY2<br>XXXX | Tape and Reel, 3000 |
| SGM2209-1.5 | TDFN-2×2-6AL | -40℃ to +125℃ | SGM2209-1.5XTDI6G/TR | MY3<br>XXXX | Tape and Reel, 3000 |
| SGM2209-1.8 | TDFN-2×2-6AL | -40℃ to +125℃ | SGM2209-1.8XTDI6G/TR | CA3<br>XXXX | Tape and Reel, 3000 |
| SGM2209-2.5 | TDFN-2×2-6AL | -40℃ to +125℃ | SGM2209-2.5XTDI6G/TR | MY4<br>XXXX | Tape and Reel, 3000 |
| SGM2209-2.8 | TDFN-2×2-6AL | -40℃ to +125℃ | SGM2209-2.8XTDI6G/TR | CA4<br>XXXX | Tape and Reel, 3000 |
| SGM2209-3.0 | TDFN-2×2-6AL | -40℃ to +125℃ | SGM2209-3.0XTDI6G/TR | CA5<br>XXXX | Tape and Reel, 3000 |
| SGM2209-3.3 | TDFN-2×2-6AL | -40℃ to +125℃ | SGM2209-3.3XTDI6G/TR | CA6<br>XXXX | Tape and Reel, 3000 |
| SGM2209-5.0 | TDFN-2×2-6AL | -40℃ to +125℃ | SGM2209-5.0XTDI6G/TR | MY5<br>XXXX | Tape and Reel, 3000 |
| SGM2209-ADJ | TDFN-2×2-6AL | -40℃ to +125℃ | SGM2209-ADJXTDI6G/TR | MY6<br>XXXX | Tape and Reel, 3000 |
| SGM2209-1.2 | TDFN-3×3-8L | -40℃ to +125℃ | SGM2209-1.2XTDB8G/TR | SGM<br>C9CDB<br>XXXXX | Tape and Reel, 4000 |
| SGM2209-1.5 | TDFN-3×3-8L | -40℃ to +125℃ | SGM2209-1.5XTDB8G/TR | SGM<br>C9DDB<br>XXXXX | Tape and Reel, 4000 |
| SGM2209-1.8 | TDFN-3×3-8L | -40℃ to +125℃ | SGM2209-1.8XTDB8G/TR | SGM<br>C9EDB<br>XXXXX | Tape and Reel, 4000 |
| SGM2209-2.5 | TDFN-3×3-8L | -40℃ to +125℃ | SGM2209-2.5XTDB8G/TR | SGM<br>C9FDB<br>XXXXX | Tape and Reel, 4000 |
| SGM2209-2.8 | TDFN-3×3-8L | -40℃ to +125℃ | SGM2209-2.8XTDB8G/TR | SGM<br>CA0DB<br>XXXXX | Tape and Reel, 4000 |
| SGM2209-3.0 | TDFN-3×3-8L | -40℃ to +125℃ | SGM2209-3.0XTDB8G/TR | SGM<br>CA1DB<br>XXXXX | Tape and Reel, 4000 |
| SGM2209-3.3 | TDFN-3×3-8L | -40℃ to +125℃ | SGM2209-3.3XTDB8G/TR | SGM<br>CA2DB<br>XXXXX | Tape and Reel, 4000 |
| SGM2209-5.0 | TDFN-3×3-8L | -40℃ to +125℃ | SGM2209-5.0XTDB8G/TR | SGM<br>MY0DB<br>XXXXX | Tape and Reel, 4000 |
| SGM2209-ADJ | TDFN-3×3-8L | -40℃ to +125℃ | SGM2209-ADJXTDB8G/TR | SGM<br>MY1DB<br>XXXXX | Tape and Reel, 4000 |

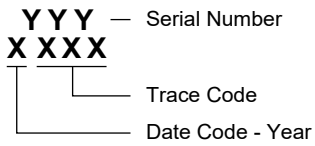
## PACKAGE/ORDERING INFORMATION (continued)

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---|---|---|---|---|---|
| SGM2209-1.2 | SOT-23-5 | -40℃ to +125℃ | SGM2209-1.2XN5G/TR | C9AXX | Tape and Reel, 3000 |
| SGM2209-1.5 | SOT-23-5 | -40℃ to +125℃ | SGM2209-1.5XN5G/TR | C9BXX | Tape and Reel, 3000 |
| SGM2209-1.8 | SOT-23-5 | -40℃ to +125℃ | SGM2209-1.8XN5G/TR | MX9XX | Tape and Reel, 3000 |
| SGM2209-2.5 | SOT-23-5 | -40℃ to +125℃ | SGM2209-2.5XN5G/TR | MXAXX | Tape and Reel, 3000 |
| SGM2209-2.8 | SOT-23-5 | -40℃ to +125℃ | SGM2209-2.8XN5G/TR | MXBXX | Tape and Reel, 3000 |
| SGM2209-3.0 | SOT-23-5 | -40℃ to +125℃ | SGM2209-3.0XN5G/TR | MXCXX | Tape and Reel, 3000 |
| SGM2209-3.3 | SOT-23-5 | -40℃ to +125℃ | SGM2209-3.3XN5G/TR | MXDXX | Tape and Reel, 3000 |
| SGM2209-5.0 | SOT-23-5 | -40℃ to +125℃ | SGM2209-5.0XN5G/TR | MXEXX | Tape and Reel, 3000 |
| SGM2209-ADJ | SOT-23-5 | -40℃ to +125℃ | SGM2209-ADJXN5G/TR | MXFXX | Tape and Reel, 3000 |

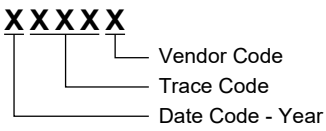
### MARKING INFORMATION

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

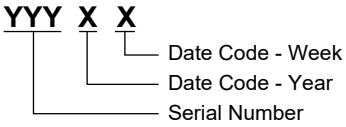
**TDFN-2×2-6AL**




**TDFN-3×3-8L**




**SOT-23-5**




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 to GND ..... +0.3V to -25V
VOUT to GND ..... +0.3V to $V_{IN}$ - 0.3V
EN to GND ..... +5V to $V_{IN}$ - 0.3V
EN to VIN ..... +25V to -0.3V
ADJ to GND ..... +0.3V to $V_{OUT}$
Package Thermal Resistance
TDFN-2×2-6AL, $\theta_{JA}$ ..... 101℃/W
TDFN-2×2-6AL, $\theta_{JB}$ ..... 39℃/W
TDFN-2×2-6AL, $\theta_{JC}$ ..... 83℃/W
TDFN-3×3-8L, $\theta_{JA}$ ..... 70℃/W
TDFN-3×3-8L, $\theta_{JB}$ ..... 25℃/W
TDFN-3×3-8L, $\theta_{JC}$ ..... 47℃/W
SOT-23-5, $\theta_{JA}$ ..... 186℃/W
SOT-23-5, $\theta_{JB}$ ..... 45℃/W
SOT-23-5, $\theta_{JC}$ ..... 74℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM ..... 8000V
CDM ..... 1000V

## RECOMMENDED OPERATING CONDITIONS

Input Voltage Range ..... -2.7V to -24V
Operating Junction Temperature Range ..... -40℃ to +125℃
Input Capacitance, $C_{IN}$ ..... 1.5μF (MIN)
Output Capacitance, $C_{OUT}$ ..... 1.5μF to 10μF

## 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

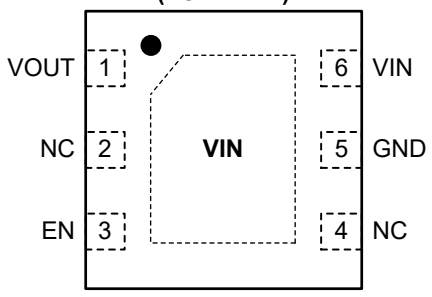
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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.

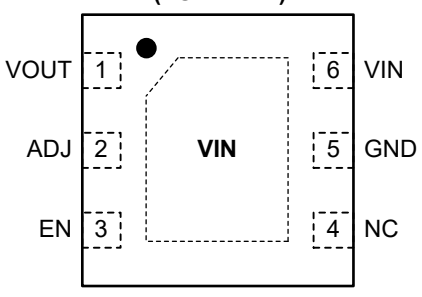
# PIN CONFIGURATIONS

**SGM2209-Fixed Output**
**(TOP VIEW)**




**TDFN-2×2-6AL**

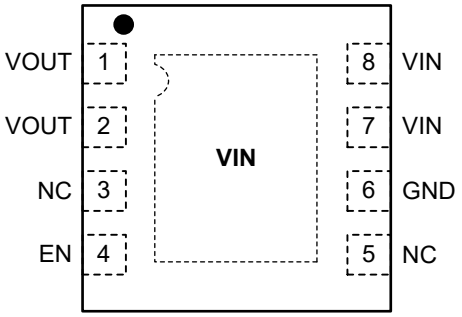
**SGM2209-ADJ**
**(TOP VIEW)**




**TDFN-2×2-6AL**

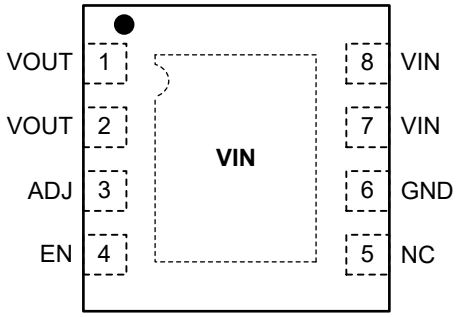
## PIN CONFIGURATIONS (continued)

SGM2209-Fixed Output
(TOP VIEW)



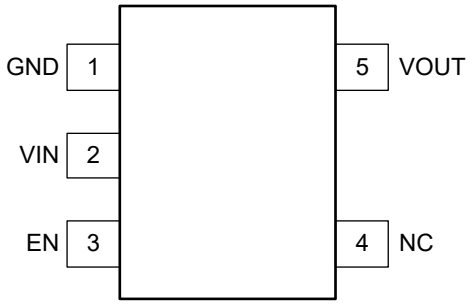

TDFN-3×3-8L

SGM2209-ADJ
(TOP VIEW)



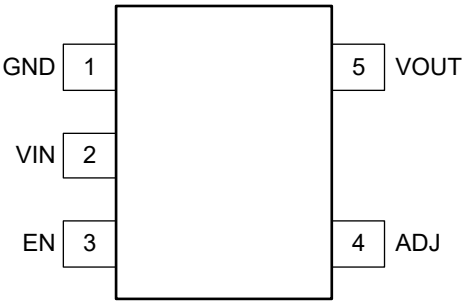

TDFN-3×3-8L

SGM2209-Fixed Output
(TOP VIEW)




SOT-23-5

SGM2209-ADJ
(TOP VIEW)




SOT-23-5

## PIN DESCRIPTION

| PIN | | | NAME | FUNCTION |
|---|---|---|---|---|
| TDFN-2×2-6AL | TDFN-3×3-8L | SOT-23-5 | | |
| 1 | 1, 2 | 5 | VOUT | Regulated Output Voltage. It is recommended to use output capacitor with effective capacitance in the range of 1.5μF to 10μF. The capacitor should be located very close to this pin. |
| 2 | 3 | 4 | NC | Not Connected (fixed voltage version). |
| | | | ADJ | Adjustable Input (adjustable voltage version only). An external resistor divider sets the output voltage. |
| 3 | 4 | 3 | EN | Enable Pin. Driving this pin 2.0V above or below ground to enable the regulator. Driving this pin to ground to turn off the regulator. For automatic startup, connect EN pin to VIN pin. |
| 4 | 5 | – | NC | Not Connected. |
| 5 | 6 | 1 | GND | Ground. |
| 6 | 7, 8 | 2 | VIN | Regulator Input Supply. Bypass VIN pin to GND with a 2.2μF or larger capacitor. The capacitor should be located very close to this pin. Additional capacitance may be required to provide a stable input voltage. |
| Exposed Pad | Exposed Pad | – | VIN | Exposed Pad. The exposed pad on the bottom of the TDFN packages enhances thermal performance and is electrically connected to VIN inside the packages. The exposed pad must be connected to the VIN plane on the board for proper operation. Because this is a negative voltage regulator, VIN is the most negative potential in the circuit. |

## ELECTRICAL CHARACTERISTICS

($V_{IN}$ = ($V_{OUT(NOM)}$ - 0.5V) or -2.7V, whichever is greater, $V_{EN}$ = $V_{IN}$, $I_{OUT}$ = -10mA, $C_{IN}$ = $C_{OUT}$ = 2.2μF, $T_J$ = -40℃ to +125℃, typical values are at $T_J$ = +25℃, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | TEMP | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|
| Input Voltage Range | $V_{IN}$ | $I_{OUT}$ = -250mA | | +25℃ | -2.7 | | -24 | V |
| | | $I_{OUT}$ = -350mA | | +25℃ | -3.0 | | -24 | V |
| | | $I_{OUT}$ = -500mA | | +25℃ | -3.3 | | -24 | V |
| Under-Voltage Lockout Thresholds | $V_{UVLO}$ | $V_{IN}$ falling | | -40℃ to +125℃ | | -2.42 | -2.50 | V |
| | | $V_{IN}$ rising | | -40℃ to +125℃ | -2.24 | -2.33 | | V |
| Operating Supply Current | $I_{GND}$ | $I_{OUT}$ = 0μA | | -40℃ to +125℃ | | -42 | -83 | μA |
| | | $I_{OUT}$ = -500mA | | -40℃ to +125℃ | | -1.2 | -2.1 | mA |
| Shutdown Current | $I_{SHDN}$ | $V_{EN}$ = GND | | -40℃ to +125℃ | | -1.1 | -3.0 | μA |
| | | $V_{EN}$ = GND, $V_{IN}$ = -24V | | -40℃ to +125℃ | | -1.2 | -10 | |
| ADJ Pin Input Bias Current | $I_{ADJ}$ | $V_{ADJ}$ = -1.3V, $V_{IN}$ = -2.7V to -24V | | -40℃ to +125℃ | -3.5 | | 3.5 | nA |
| Output Voltage Accuracy | $V_{OUT}$ | $I_{OUT}$ = -10mA | | +25℃ | -1 | | 1 | % |
| | | $V_{IN}$ = ($V_{OUT(NOM)}$ - 0.5V) to -24V, $I_{OUT}$ = -1mA to -500mA | | -40℃ to +125℃ | -1.5 | | 1.5 | % |
| Feedback Voltage | $V_{ADJ}$ | $I_{OUT}$ = -10mA | | +25℃ | -1.188 | -1.2 | -1.212 | V |
| | | $V_{IN}$ = ($V_{OUT(NOM)}$ - 0.5V) to -24V, $I_{OUT}$ = -1mA to -500mA | | -40℃ to +125℃ | -1.182 | | -1.218 | V |
| Line Regulation | $\frac{\Delta V_{OUT}}{\Delta V_{IN} \times V_{OUT}}$ | $V_{IN}$ = ($V_{OUT(NOM)}$ - 0.5V) to -24V | | -40℃ to +125℃ | | 0.001 | 0.03 | %/V |
| Load Regulation | $\frac{\Delta V_{OUT}}{V_{OUT}}$ | $I_{OUT}$ = -1mA to -500mA | | -40℃ to +125℃ | | 0.03 | 0.8 | % |
| Dropout Voltage (1) | $V_{DROP}$ | $I_{OUT}$ = -250mA | $V_{OUT(NOM)}$ = -2.5V | -40℃ to +125℃ | | -230 | -350 | mV |
| | | | $V_{OUT(NOM)}$ = -3.0V | -40℃ to +125℃ | | -160 | -260 | |
| | | | $V_{OUT(NOM)}$ = -5.0V | -40℃ to +125℃ | | -125 | -220 | |
| | | $I_{OUT}$ = -350mA | $V_{OUT(NOM)}$ = -3.0V | -40℃ to +125℃ | | -230 | -370 | |
| | | | $V_{OUT(NOM)}$ = -5.0V | -40℃ to +125℃ | | -180 | -300 | |
| | | $I_{OUT}$ = -500mA | $V_{OUT(NOM)}$ = -3.0V | -40℃ to +125℃ | | -345 | -550 | |
| | | | $V_{OUT(NOM)}$ = -5.0V | -40℃ to +125℃ | | -260 | -420 | |
| Output Current Limit (2) | $I_{LIM}$ | $V_{IN}$ = MIN($V_{OUT(NOM)}$ - 1V, -4V) | | +25℃ | -0.68 | -1.05 | | A |
| Short Current Limit | $I_{SHORT}$ | $V_{OUT}$ = 0V, $V_{IN}$ = MIN($V_{OUT(NOM)}$ - 1V, -4V) | | +25℃ | | -360 | | mA |
| Output Noise | $e_n$ | 10Hz to 100kHz | $V_{OUT(NOM)}$ = -1.2V | +25℃ | | 10.5 | | $\mu V_{RMS}$ |
| | | | $V_{OUT(NOM)}$ = -2.5V | +25℃ | | 12 | | |
| | | | $V_{OUT(NOM)}$ = -5.0V | +25℃ | | 16 | | |
| | | 10Hz to 100kHz, $V_{OUT(NOM)}$ = -15V, adjustable mode, $C_{NR}$ = open, $R_{NR}$ = open, $R_{FB1}$ = 150kΩ, $R_{FB2}$ = 13kΩ | | +25℃ | | 130 | | |
| | | 10Hz to 100kHz, $V_{OUT(NOM)}$ = -15V, adjustable mode, $C_{NR}$ = 100nF, $R_{NR}$ = 13kΩ, $R_{FB1}$ = 150kΩ, $R_{FB2}$ = 13kΩ | | +25℃ | | 31 | | |

## ELECTRICAL CHARACTERISTICS (continued)

($V_{IN}$ = ($V_{OUT(NOM)}$ - 0.5V) or -2.7V, whichever is greater, $V_{EN}$ = $V_{IN}$, $I_{OUT}$ = -10mA, $C_{IN}$ = $C_{OUT}$ = 2.2μF, $T_J$ = -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 | $V_{IN}$ = $V_{OUT(NOM)}$ - 1V, $\Delta V_{RIPPLE}$ = 0.2$V_{P-P}$, all fixed output voltage options | f = 1kHz | +25℃ | | -75 | | dB |
| | | | f = 10kHz | +25℃ | | -60 | | |
| | | | f = 100kHz | +25℃ | | -42 | | |
| | | $V_{IN}$ = -16V, $V_{OUT(NOM)}$ = -15V, $\Delta V_{RIPPLE}$ = 0.2$V_{P-P}$, adjustable mode, $C_{NR}$ = 100nF, $R_{NR}$ = 13kΩ, $R_{FB1}$ = 150kΩ, $R_{FB2}$ = 13kΩ | f = 1kHz | +25℃ | | -71 | | dB |
| | | | f = 10kHz | +25℃ | | -60 | | |
| | | | f = 100kHz | +25℃ | | -44 | | |
| Start-Up Time (3) | $t_{STR}$ | $V_{OUT(NOM)}$ = -1.2V | | +25℃ | | 210 | | μs |
| | | $V_{OUT(NOM)}$ = -5.0V | | +25℃ | | 540 | | |
| Positive Enable High-Level Voltage | $V_{EN(+HI)}$ | | | -40℃ to +125℃ | 1.22 | | | V |
| Positive Enable Low-Level Voltage | $V_{EN(+LO)}$ | | | -40℃ to +125℃ | | | 0.3 | |
| Negative Enable High-Level Voltage | $V_{EN(-HI)}$ | | | -40℃ to +125℃ | | | -2.0 | V |
| Negative Enable Low-Level Voltage | $V_{EN(-LO)}$ | | | -40℃ to +125℃ | -0.55 | | | |
| EN Positive Input Current | $I_{EN\_P}$ | $V_{EN}$ = 5V, $V_{IN}$ = -19V | | -40℃ to +125℃ | | 0.9 | 3 | μA |
| EN Negative Input Current | $I_{EN\_N}$ | $V_{EN}$ = -24V, $V_{IN}$ = -24V | | -40℃ to +125℃ | | -0.1 | -1 | μA |
| Thermal Shutdown Temperature | $T_{SHDN}$ | | | | | 160 | | ℃ |
| Thermal Shutdown Hysteresis | $\Delta T_{SHDN}$ | | | | | 20 | | ℃ |

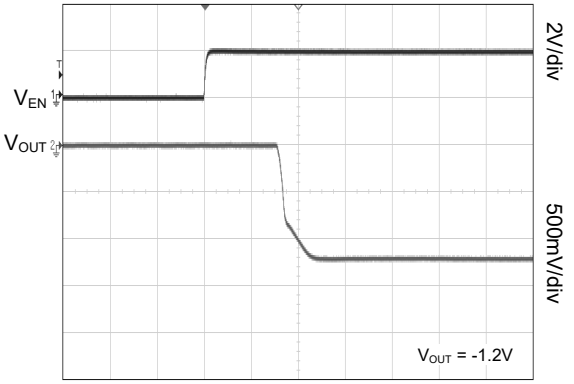
NOTES:

1. Dropout voltage is characterized when $V_{OUT}$ falls 5% below $V_{OUT(NOM)}$.
2. The output current limit is defined as the current at which the output voltage drops to 90% of the nominal value of $V_{OUT}$.
3. The start-up time is defined as the time between the rising edge of EN to $V_{OUT}$ being at 90% of the nominal value.

## TYPICAL PERFORMANCE CHARACTERISTICS

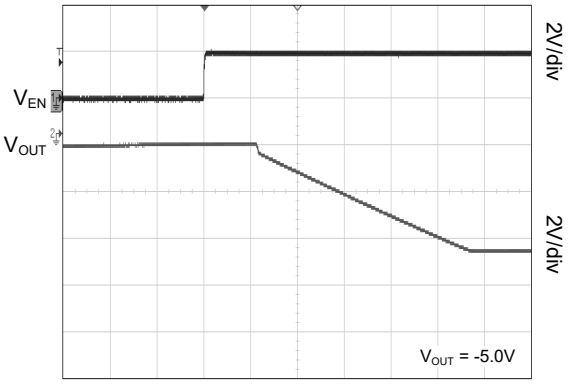
$V_{IN}$ = ($V_{OUT(NOM)}$ - 0.5V) or -2.7V, whichever is greater, $V_{EN}$ = $V_{IN}$, $I_{OUT}$ = -10mA, $C_{IN}$ = $C_{OUT}$ = 2.2μF, $T_J$ = +25℃, unless otherwise noted.

Turn-On with EN Pin



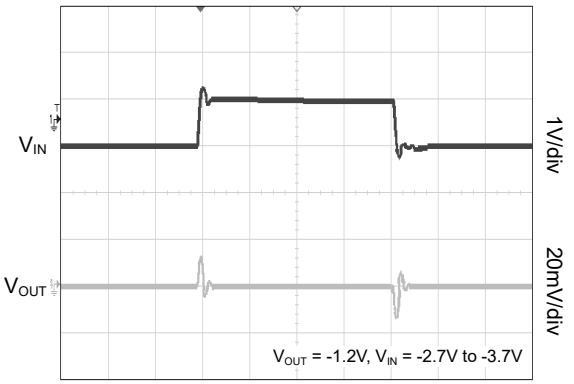

Time (100μs/div)

Turn-On with EN Pin



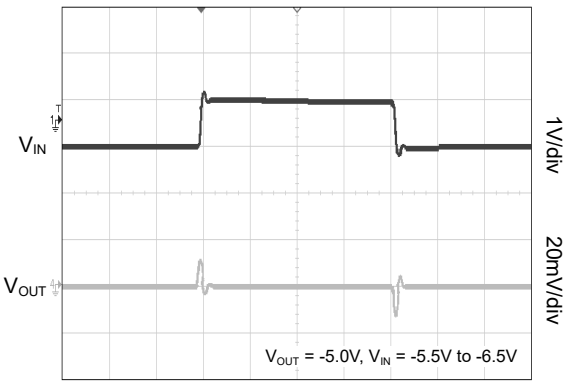

Time (100μs/div)

Line Transient Response



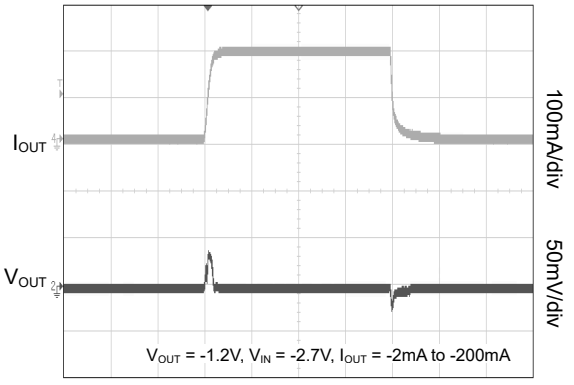

Time (100μs/div)

Line Transient Response



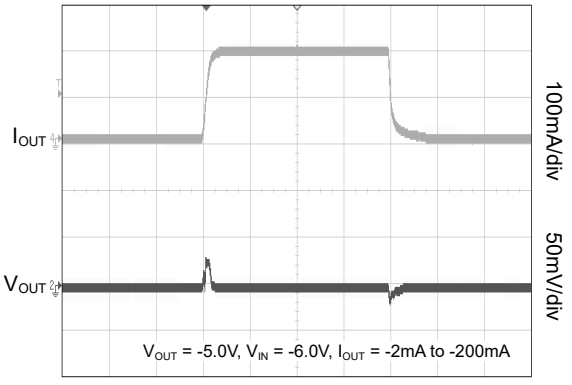

Time (100μs/div)

Load Transient Response




Time (50μs/div)

Load Transient Response

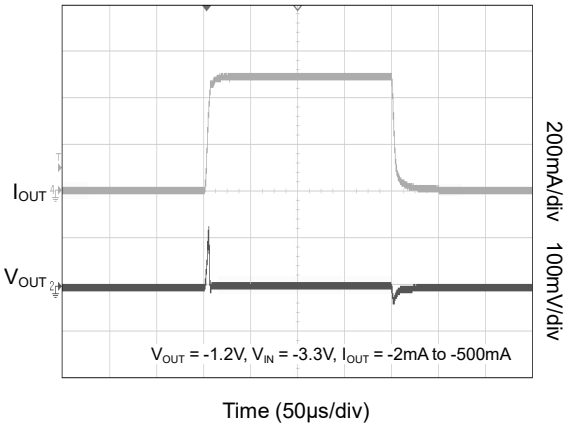



Time (50μs/div)

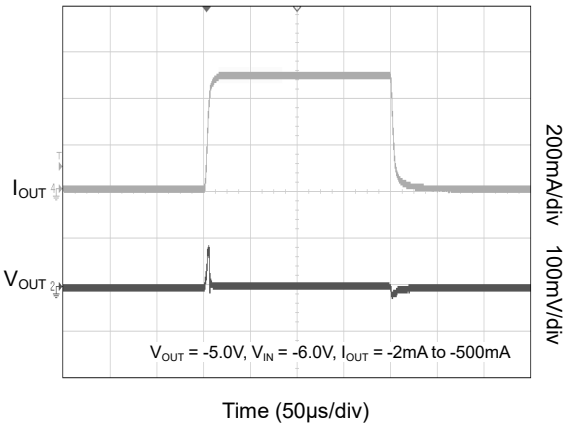
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{IN}$ = ($V_{OUT(NOM)}$ - 0.5V) or -2.7V, whichever is greater, $V_{EN}$ = $V_{IN}$, $I_{OUT}$ = -10mA, $C_{IN}$ = $C_{OUT}$ = 2.2μF, $T_J$ = +25℃, unless otherwise noted.

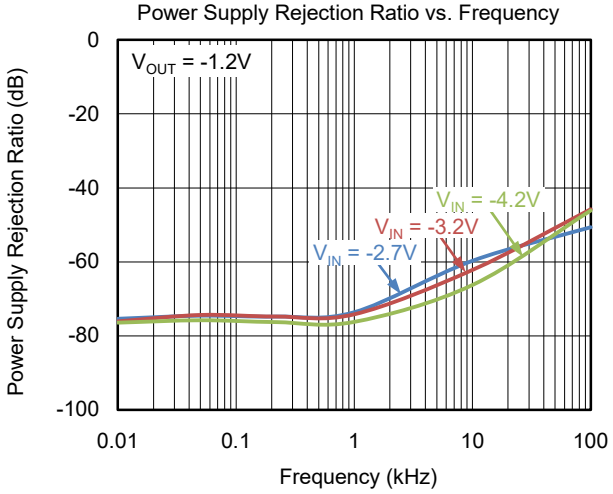
Load Transient Response



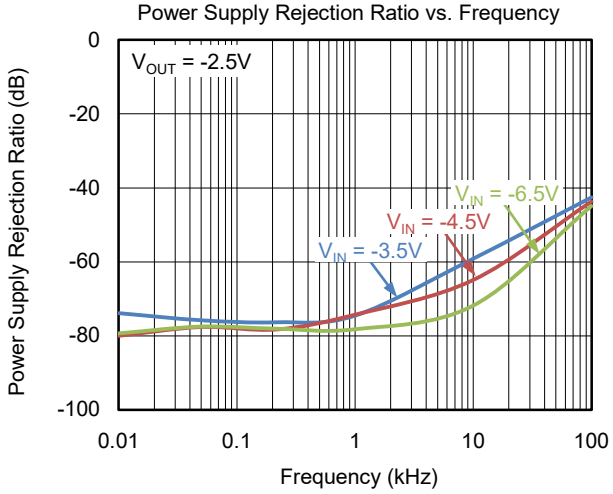

Load Transient Response



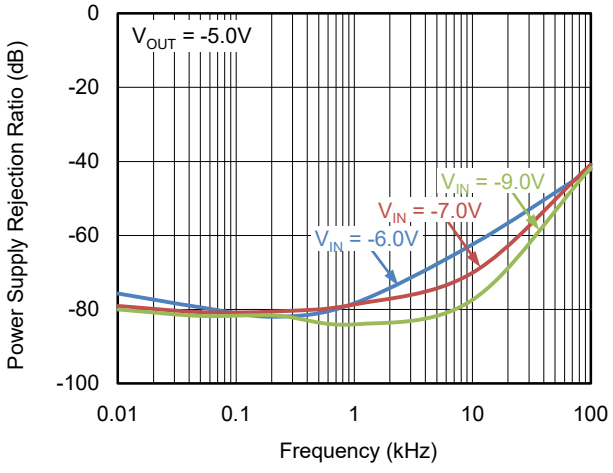

Power Supply Rejection Ratio vs. Frequency



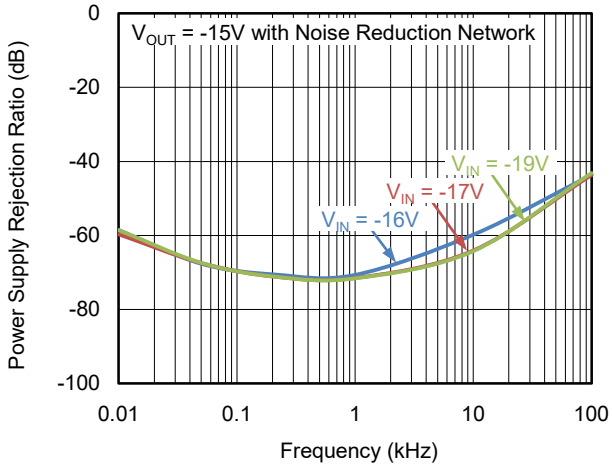

Power Supply Rejection Ratio vs. Frequency




Power Supply Rejection Ratio vs. Frequency



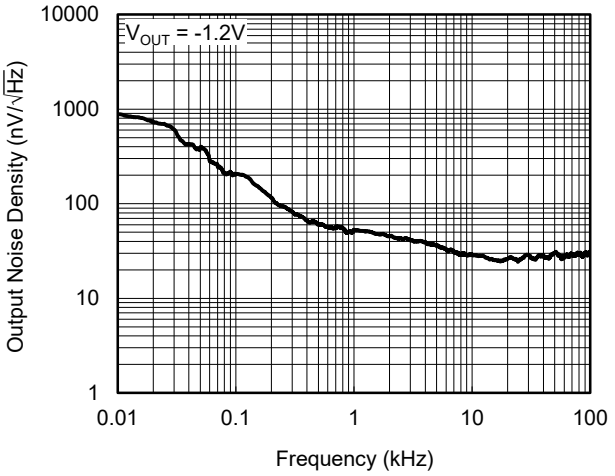

Power Supply Rejection Ratio vs. Frequency



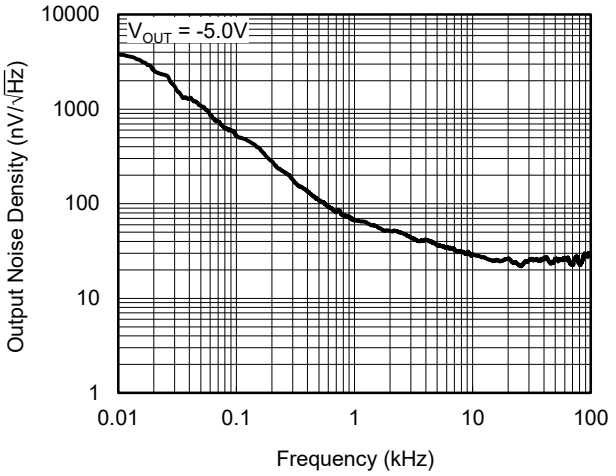
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{IN}$ = ($V_{OUT(NOM)}$ - 0.5V) or -2.7V, whichever is greater, $V_{EN}$ = $V_{IN}$, $I_{OUT}$ = -10mA, $C_{IN}$ = $C_{OUT}$ = 2.2μF, $T_J$ = +25℃, unless otherwise noted.

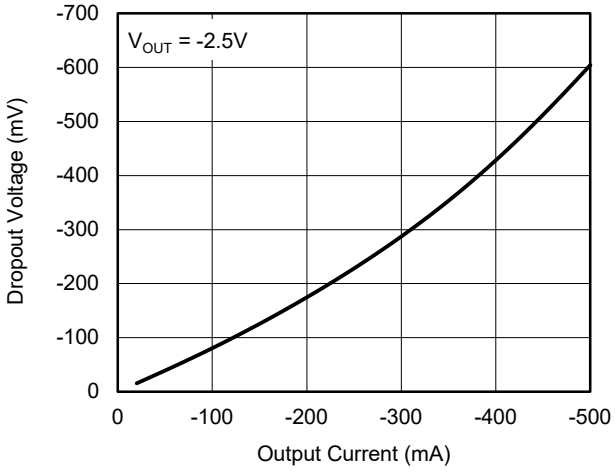
Output Noise Density vs. Frequency



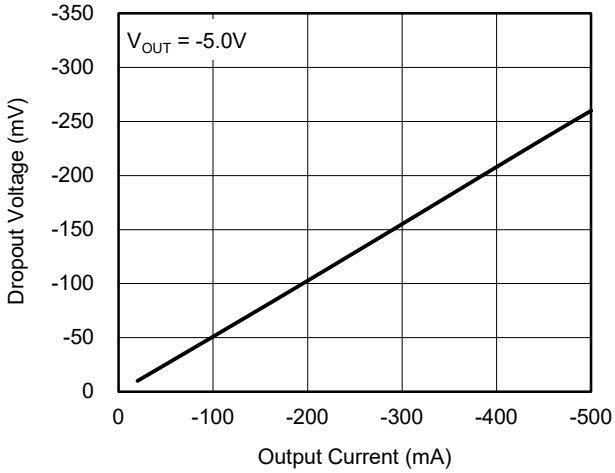

Output Noise Density vs. Frequency



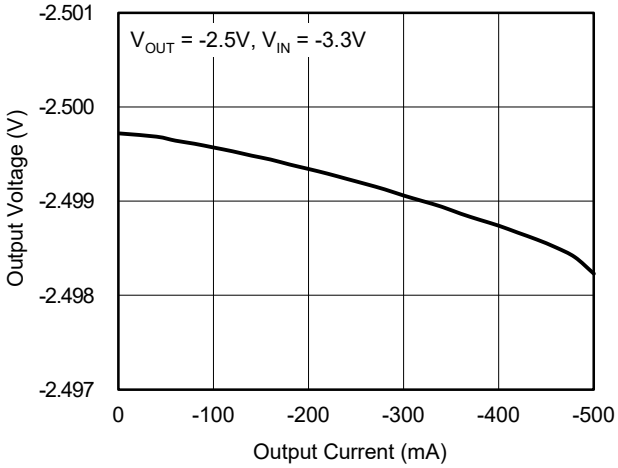

Dropout Voltage vs. Output Current



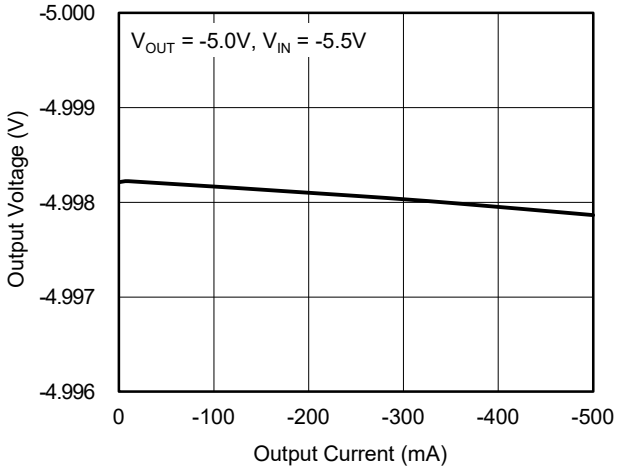

Dropout Voltage vs. Output Current




Output Voltage vs. Output Current



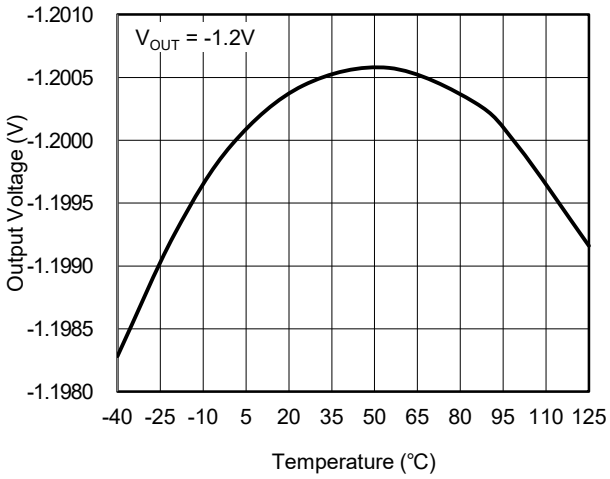

Output Voltage vs. Output Current



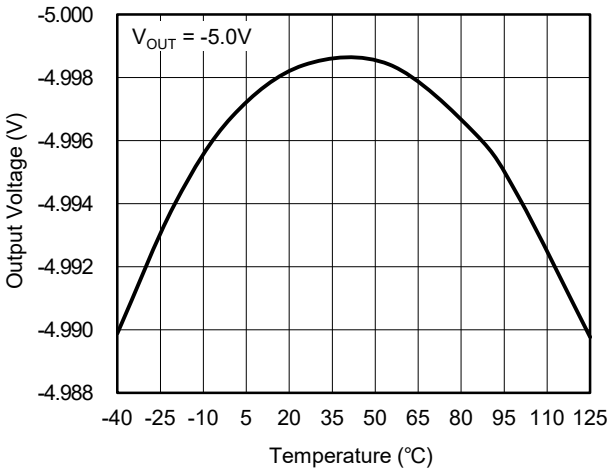
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{IN}$ = ($V_{OUT(NOM)}$ - 0.5V) or -2.7V, whichever is greater, $V_{EN}$ = $V_{IN}$, $I_{OUT}$ = -10mA, $C_{IN}$ = $C_{OUT}$ = 2.2μF, $T_J$ = +25℃, unless otherwise noted.

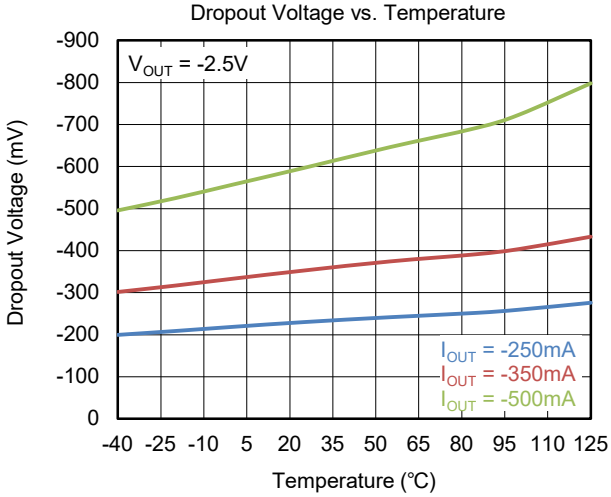
Output Voltage vs. Temperature



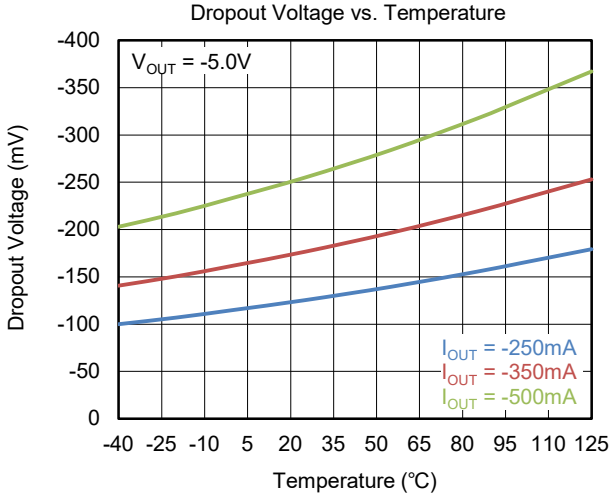

Output Voltage vs. Temperature



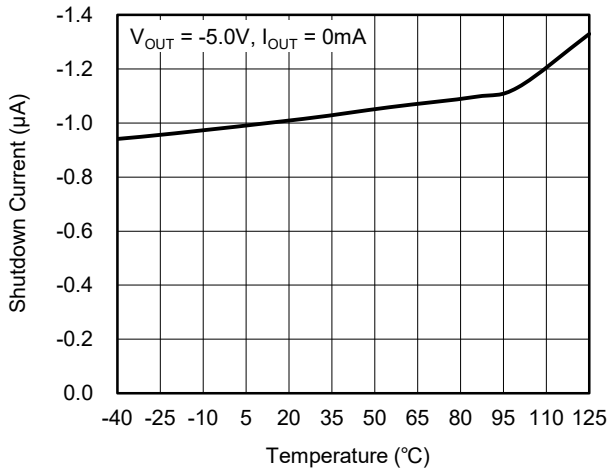

Dropout Voltage vs. Temperature



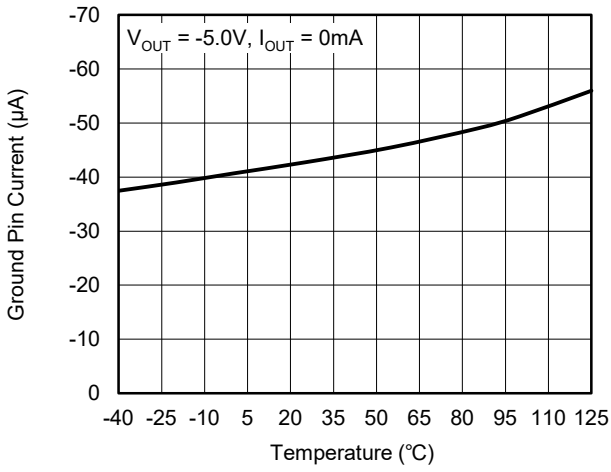

Dropout Voltage vs. Temperature




Shutdown Current vs. Temperature



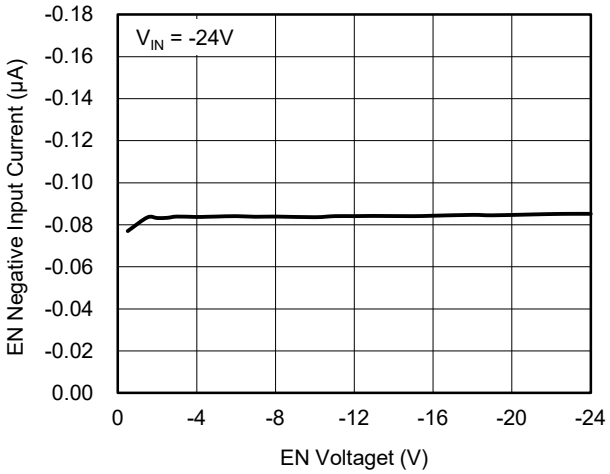

Ground Pin Current vs. Temperature



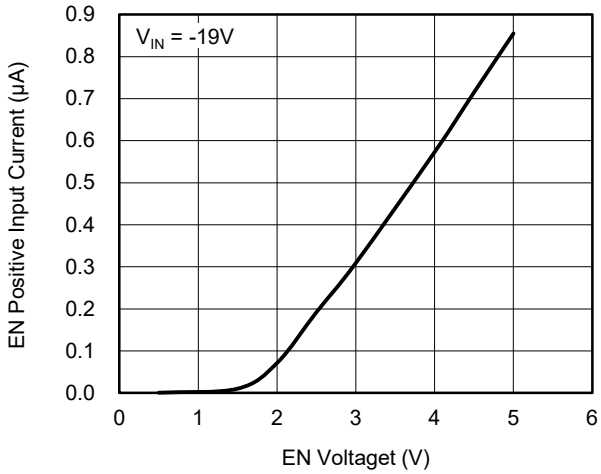
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{IN}$ = ($V_{OUT(NOM)}$ - 0.5V) or -2.7V, whichever is greater, $V_{EN}$ = $V_{IN}$, $I_{OUT}$ = -10mA, $C_{IN}$ = $C_{OUT}$ = 2.2μF, $T_J$ = +25℃, unless otherwise noted.

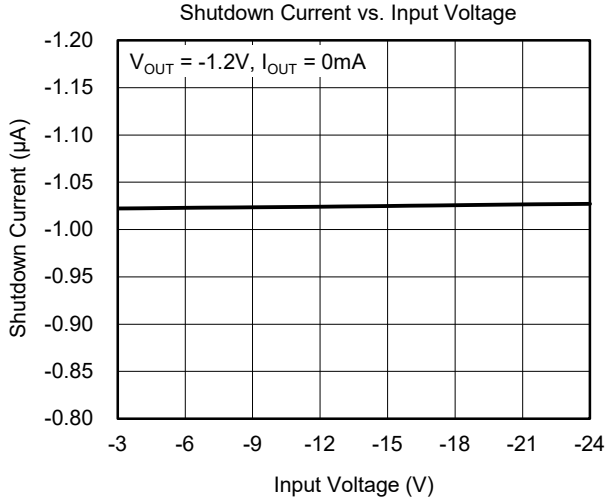
EN Negative Input Current vs. EN Voltage



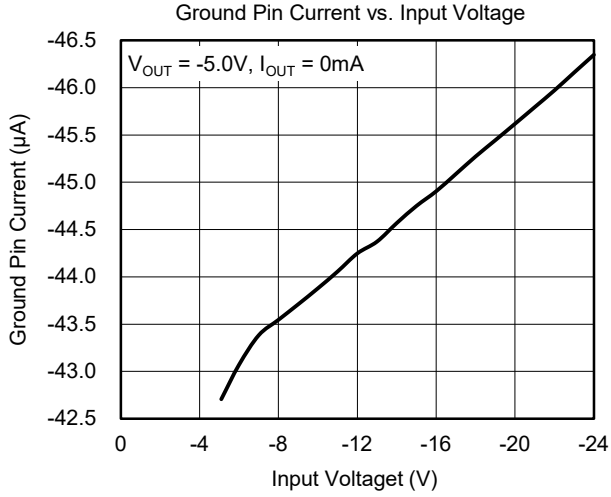

EN Positive Input Current vs. EN Voltage



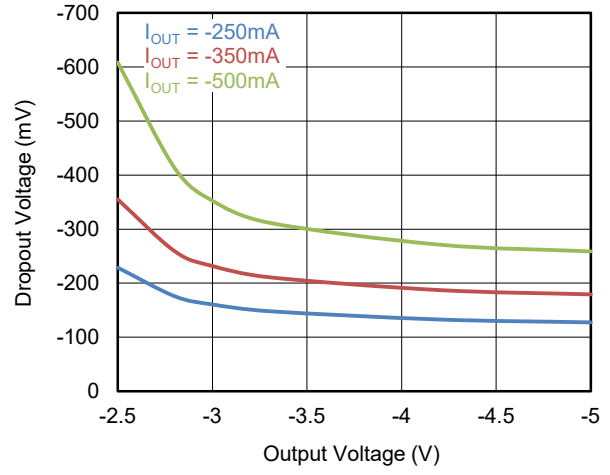

Shutdown Current vs. Input Voltage



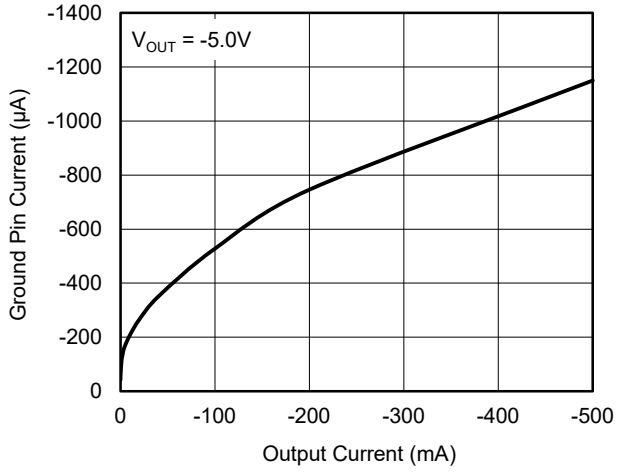

Ground Pin Current vs. Input Voltage




Dropout Voltage vs. Output Voltage




Ground Pin Current vs. Output Current



## TYPICAL APPLICATION CIRCUITS

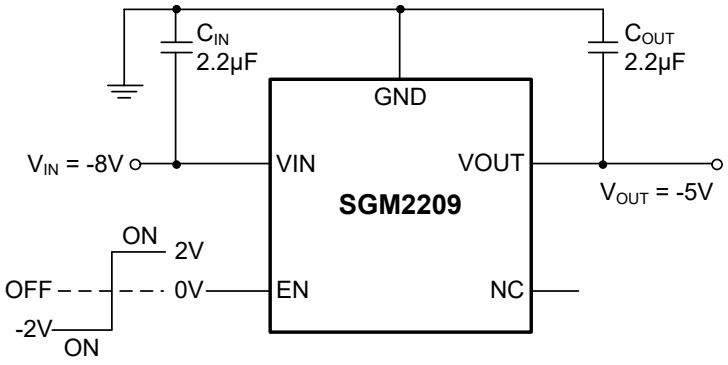



**Figure 1. SGM2209 with Fixed Output Voltage, $V_{OUT}$ = -5.0V**

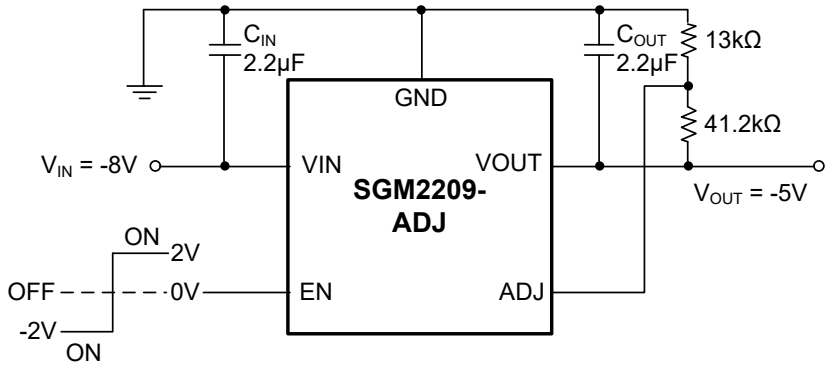



**Figure 2. SGM2209 with Adjustable Output Voltage, $V_{OUT}$ = -5.0V**

## FUNCTIONAL BLOCK DIAGRAM

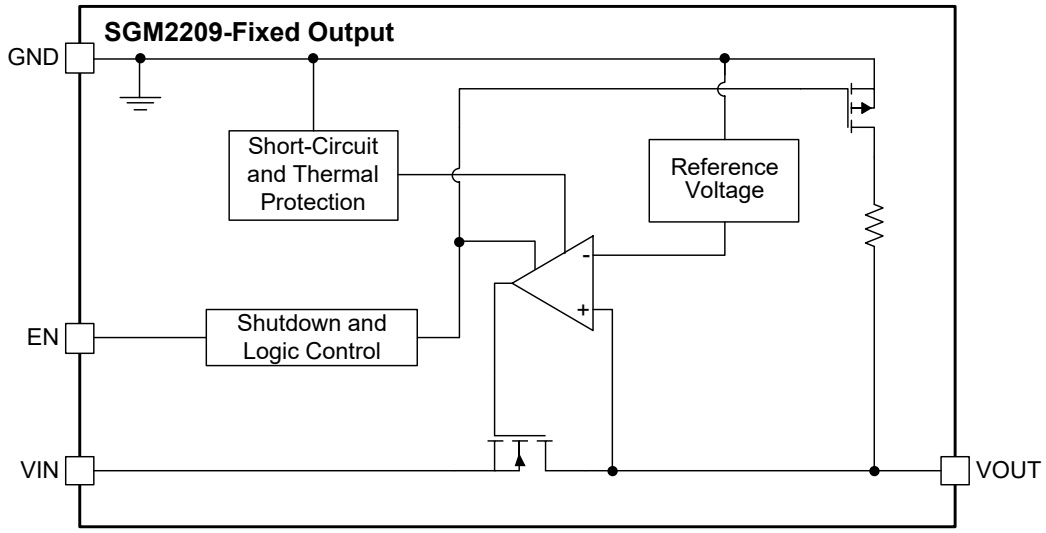



**Figure 3. Fixed Output Voltage Internal Block Diagram**

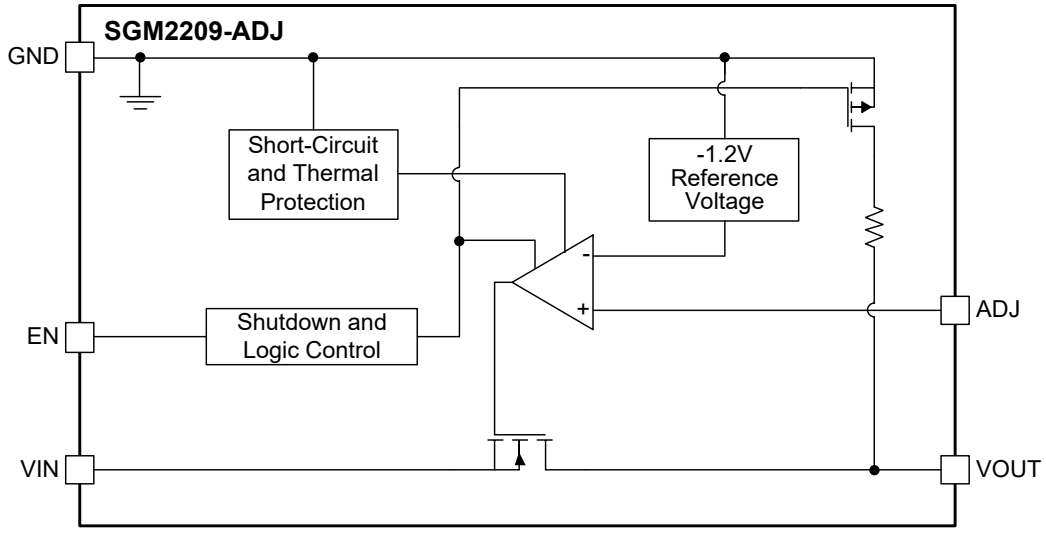



**Figure 4. Adjustable Output Voltage Internal Block Diagram**

# APPLICATION INFORMATION

The SGM2209 is a low quiescent current, low noise and high PSRR LDO linear regulator that operates from -2.7V to -24V and can provide up to -500mA of output current. Because the SGM2209 draws a low quiescent current at full load, the device is an ideal selection for battery-powered portable equipment. The enable logic control function puts the SGM2209 in shutdown mode allowing a total current consumption of -1.1μA (TYP).

The SGM2209 is optimized to use small 2.2μF ceramic capacitors ($C_{IN}$ and $C_{OUT}$) to achieve excellent transient performance.

## Adjustable Mode Operation

The SGM2209 is available in an adjustable version with an output voltage that can be set to between -1.2V and -23V by an external voltage divider. The output voltage can be set according to:

$$V_{OUT} = -1.2V \times (1 + R_{FB1}/R_{FB2})$$

$R_{FB2}$ must be less than 120kΩ to maintain a 10μA minimum load.

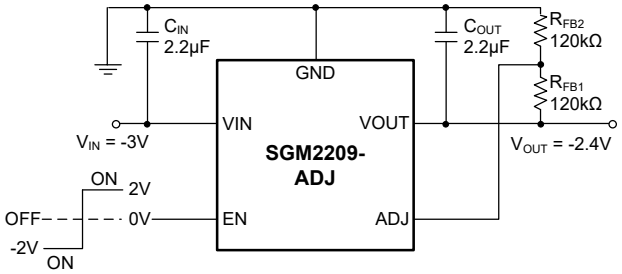



**Figure 5. Setting Adjustable Output Voltage**

## Output Capacitor Selection

The SGM2209 is designed to work with small size ceramic capacitors; however, other types of capacitor also can be used. The ESR of capacitor is the most important parameter to be taken into account, and the ESR of the output capacitor affects the stability of the LDO. A minimum of 2.2μF capacitance with an ESR of 0.2Ω or less is recommended to ensure the stability of the SGM2209. If good load transient is important in application, larger output capacitor can be used.

## Input Bypass Capacitor Selection

In applications, if high source impedance or long input traces are encountered, a 2.2μF capacitor is connected from VIN pin to GND to reduce the circuit sensitivity to PCB layout. A larger input capacitor will be selected if the output capacitor is increased.

## Input and Output Capacitor Properties

Ceramic capacitors are manufactured with a variety of dielectrics and each type of dielectrics them has different behavior over temperature and applied voltage. Capacitors must have an adequate dielectric constant to ensure the minimum capacitance over the necessary temperature range and DC bias conditions. X5R or X7R ceramic capacitors are recommended. Y5V and Z5U ceramic capacitors are not recommended due to their poor temperature and DC bias characteristics.

## Soft-Start

The SGM2209 uses an internal soft-start to limit the inrush current when the device is enabled. The start-up time for the -5.0V option is approximately 540μs from the time the EN active threshold is crossed to when the output reaches 90% of the final value.

## Enable Pin Operation

The EN pin is used to enable and disable the VOUT pin under normal operating conditions. When EN is at ±2.0V with respect to GND, VOUT turns on and when EN is at 0V, VOUT turns off. For automatic startup, EN can be connected to VIN. When the SGM2209 is disabled, a discharge resistor around 200kΩ connects to the VOUT pin, which pulls the VOUT pin up to GND.

The SGM2209 provides a dual polarity enable pin (EN) that turns on the LDO. The enable voltage can be positive or negative with respect to ground.

Figure 6 shows the typical hysteresis of the EN pin. This feature prevents on/off oscillations that can occur due to noise on the EN pin as it passes through the threshold points.

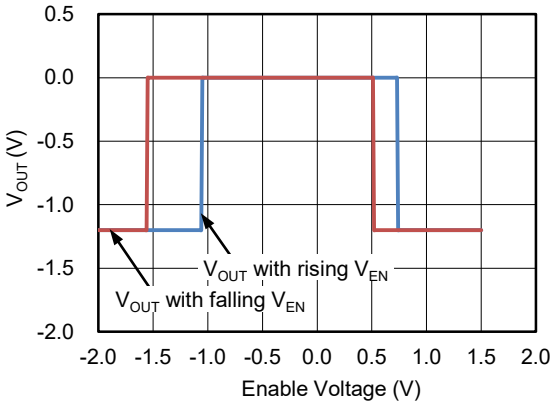



**Figure 6. Typical EN Pin Operation**

# APPLICATION INFORMATION (continued)

## Noise Reduction of the Adjustable SGM2209

The disadvantage of the conventional LDO architecture is that the output voltage noise is proportional to the output voltage. The output noise of adjustable LDO circuit can be modified slightly to levels close to that of the fixed output LDO. The circuit shown in Figure 7 adds two additional components to the output voltage setting resistor divider, $C_{NR}$ and $R_{NR}$ are added in parallel with $R_{FB1}$ to reduce the AC gain of the error amplifier. $R_{NR}$ is chosen to be nearly equal to $R_{FB2}$, this limits the AC gain of the error amplifier to approximately 6dB. The actual gain is the parallel combination of $R_{NR}$ and $R_{FB1}$ divided by $R_{FB2}$. This resistance ensures that the error amplifier always operates at greater than unity gain.

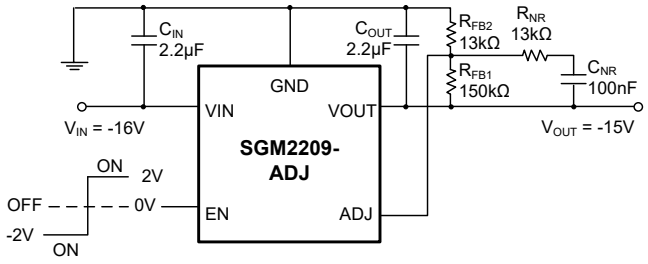



**Figure 7. Noise Reduction Modification to Adjustable LDO**

$C_{NR}$ is chosen by setting the reactance of $C_{NR}$ equal to $R_{FB1}$ - $R_{NR}$ at a frequency between 10Hz and 100Hz. This capacitance sets the frequency where the AC gain of the error amplifier is 3dB down from the DC gain.

## Current-Limit and Thermal Overload Protection

The SGM2209 is protected against damage due to excessive power dissipation by current-limit and thermal overload protection circuits. The SGM2209 is designed to limit current when the output load reaches -1.05A (TYP). When the output load exceeds -1.05A, the output voltage is reduced to maintain a constant current limit. When the output voltage falls to GND, the current limit falls to -360mA.

Under the extreme conditions of high ambient temperature or power dissipation, when the junction temperature is above +160℃, the output is turned off, reducing the output current to 0mA. When the junction temperature falls below +140℃, the output is turned on again and the output current is restored to the nominal value.

For reliable operation, device power dissipation must be externally limited so that the junction temperature do not exceed +125℃.

## PCB Layout Considerations

Place the input capacitor as close as possible to the VIN and GND pins. Place the output capacitor as close as possible to the VOUT and GND pins.

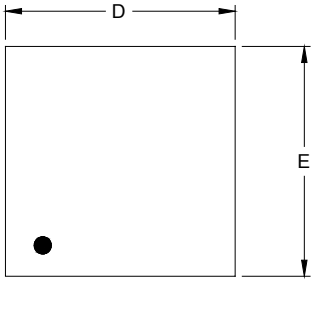
# REVISION HISTORY

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

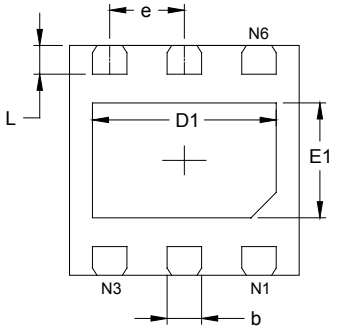
| Changes from Original (JANUARY 2020) to REV.A | Page |
|---|---|
| Changed from product preview to production data | All |

# PACKAGE OUTLINE DIMENSIONS

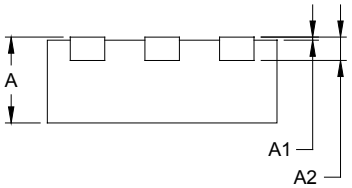
## TDFN-2×2-6AL



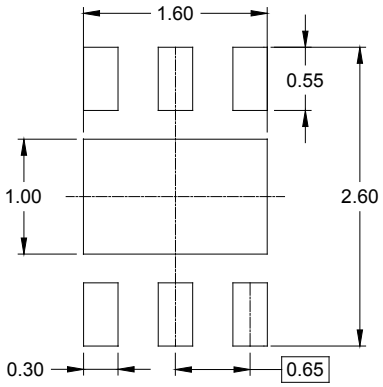

TOP VIEW




BOTTOM VIEW




SIDE VIEW

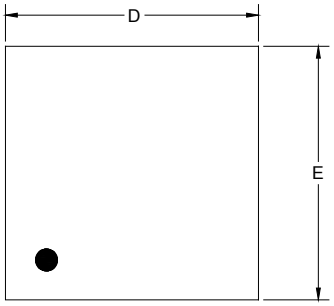



**RECOMMENDED LAND PATTERN** (Unit: mm)

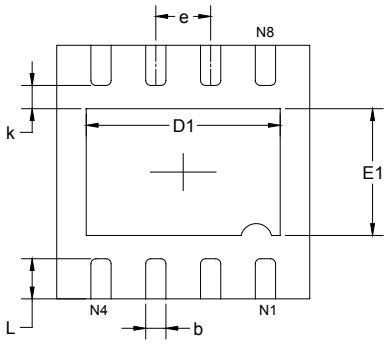
| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.700 | 0.800 | 0.028 | 0.031 |
| A1 | 0.000 | 0.050 | 0.000 | 0.002 |
| A2 | 0.203 REF | | 0.008 REF | |
| D | 1.900 | 2.100 | 0.075 | 0.083 |
| D1 | 1.500 | 1.700 | 0.059 | 0.067 |
| E | 1.900 | 2.100 | 0.075 | 0.083 |
| E1 | 0.900 | 1.100 | 0.035 | 0.043 |
| b | 0.250 | 0.350 | 0.010 | 0.014 |
| e | 0.650 BSC | | 0.026 BSC | |
| L | 0.174 | 0.326 | 0.007 | 0.013 |

# PACKAGE OUTLINE DIMENSIONS

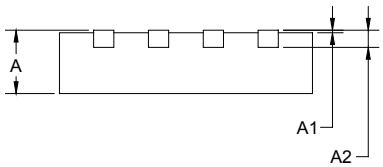
## TDFN-3×3-8L



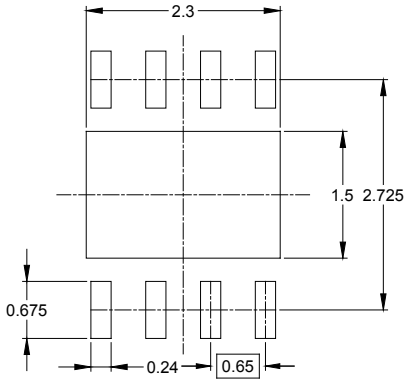

TOP VIEW




BOTTOM VIEW




SIDE VIEW

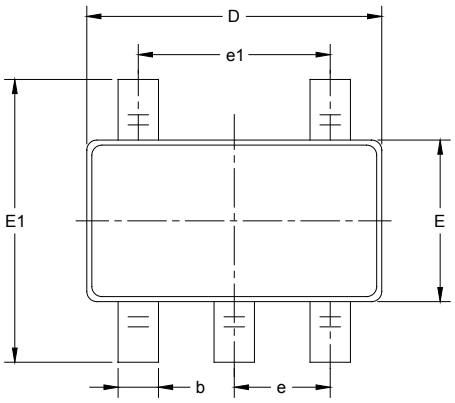


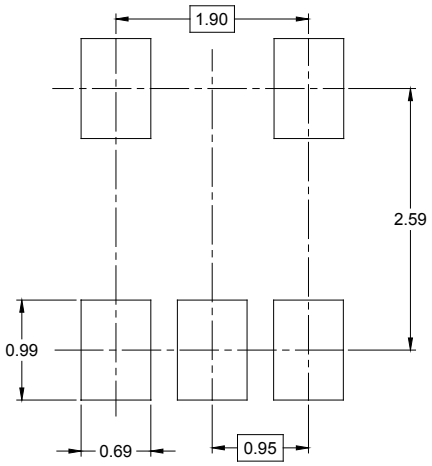

**RECOMMENDED LAND PATTERN** (Unit: mm)

| 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 | 2.900 | 3.100 | 0.114 | 0.122 |
| D1 | 2.200 | 2.400 | 0.087 | 0.094 |
| E | 2.900 | 3.100 | 0.114 | 0.122 |
| E1 | 1.400 | 1.600 | 0.055 | 0.063 |
| k | 0.200 MIN | | 0.008 MIN | |
| b | 0.180 | 0.300 | 0.007 | 0.012 |
| e | 0.650 TYP | | 0.026 TYP | |
| L | 0.375 | 0.575 | 0.015 | 0.023 |

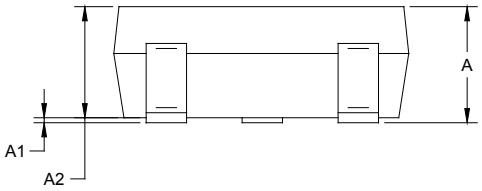
# PACKAGE OUTLINE DIMENSIONS

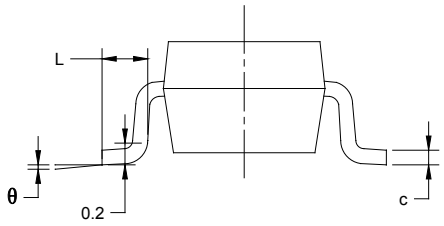
## SOT-23-5




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

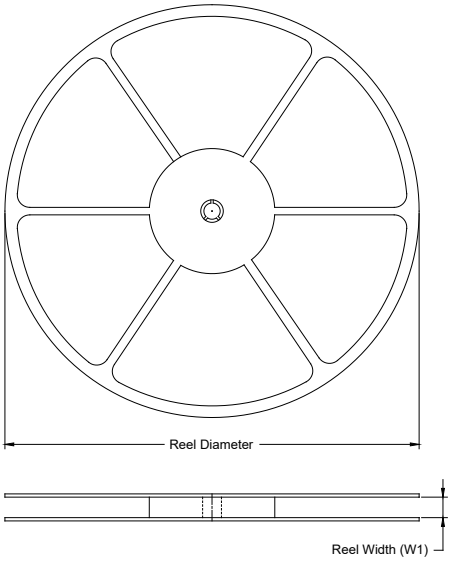


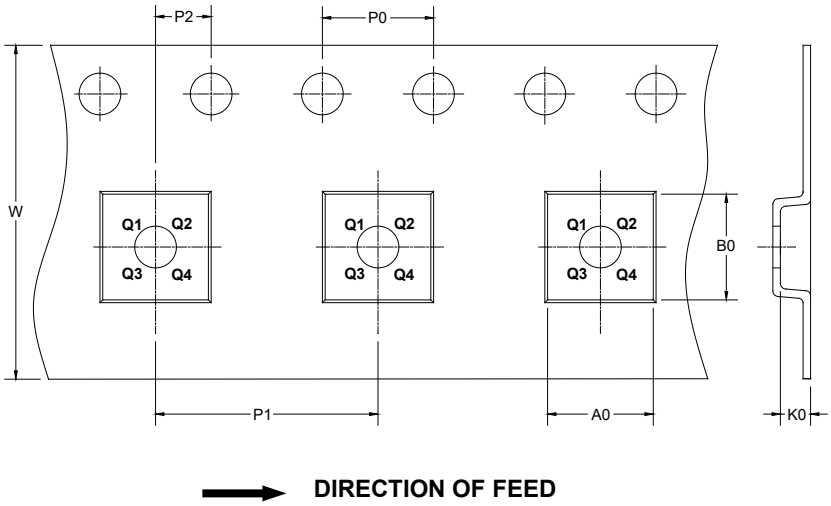

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| D | 2.820 | 3.020 | 0.111 | 0.119 |
| E | 1.500 | 1.700 | 0.059 | 0.067 |
| E1 | 2.650 | 2.950 | 0.104 | 0.116 |
| e | 0.950 BSC | | 0.037 BSC | |
| e1 | 1.900 BSC | | 0.075 BSC | |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0° | 8° | 0° | 8° |

# TAPE AND REEL INFORMATION

### REEL DIMENSIONS




### TAPE DIMENSIONS



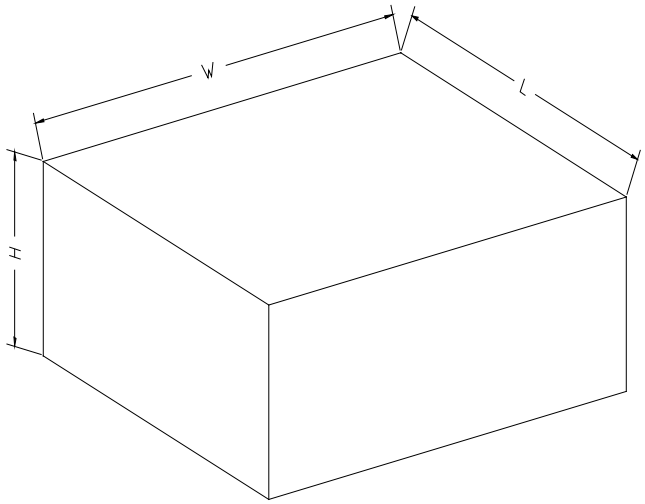

NOTE: The picture is only for reference. Please make the object as the standard.

## 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| TDFN-2×2-6AL | 7″ | 9.5 | 2.30 | 2.30 | 1.10 | 4.0 | 4.0 | 2.0 | 8.0 | Q1 |
| TDFN-3×3-8L | 13″ | 12.4 | 3.35 | 3.35 | 1.13 | 4.0 | 8.0 | 2.0 | 12.0 | Q1 |
| SOT-23-5 | 7″ | 9.5 | 3.20 | 3.20 | 1.40 | 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 |
| 13″ | 386 | 280 | 370 | 5 |

DD0002