SGM2231
-24V, -500mA, Low Noise, High PSRR, Negative Output Linear Regulator

GENERAL DESCRIPTION

The SGM2231 is a low power, low noise, fast transient response and low dropout voltage linear regulator. It provides -500mA output current capability. The operating input voltage range is from -2.7V to -24V. The adjustable output voltage range is from -1.1V to ($-V_{IN}$ + V_{DROP}).

Other features include logic-controlled shutdown mode, short-circuit current limit and thermal shutdown protection. The SGM2231 has automatic discharge function to quickly discharge V_{OUT} in the disabled status.

The SGM2231 is available in a Green UTDFN-2×2-8CL package. It operates over an operating temperature range of -40℃ to +125℃.

APPLICATIONS

Industrial and Medical Equipment
Communications and Infrastructure
Precision Amplifiers
ADC and DAC Circuits

FEATURES

- **Input Voltage Range: -2.7V to -24V**
- **Fixed Outputs of -1.1V, -1.2V, -1.5V, -1.8V, -2.5V, -2.8V, -3.0V, -3.3V and -5.0V**
- **Adjustable Output from -1.1V to ($-V_{IN}$ + V_{DROP})**
- **Output Voltage Accuracy: ±1% at +25℃**
- **-500mA Output Current**
- **Low Quiescent Current:**
  I_{GND} = -47μA (TYP) at No Load
- **Low Dropout Voltage:**
  -230mV (TYP) at -500mA, V_{OUT} = -5.0V
- **Low Noise: 10μV_{RMS} (TYP) at V_{OUT} = -1.1V**
- **Low Shutdown Current: -1.2μA (TYP)**
- **PSRR: -65dB (TYP) at 10kHz, V_{OUT} = -1.1V**
- **Current Limiting and Thermal Protection**
- **Positive or Negative Enable Logic**
- **Stable with Small Case Size Ceramic Capacitors**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in a Green UTDFN-2×2-8CL Package**

TYPICAL APPLICATION

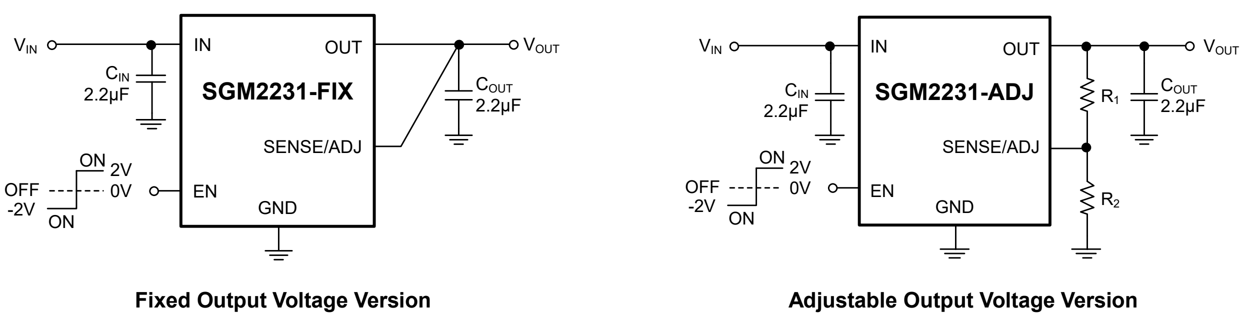


Figure 1. Typical Application Circuits

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM2231-1.1	UTDFN-2×2-8CL	-40℃ to +125℃	SGM2231-1.1XUGN8G/TR	07D XXXX	Tape and Reel, 3000
SGM2231-1.2	UTDFN-2×2-8CL	-40℃ to +125℃	SGM2231-1.2XUGN8G/TR	0X0 XXXX	Tape and Reel, 3000
SGM2231-1.5	UTDFN-2×2-8CL	-40℃ to +125℃	SGM2231-1.5XUGN8G/TR	0X1 XXXX	Tape and Reel, 3000
SGM2231-1.8	UTDFN-2×2-8CL	-40℃ to +125℃	SGM2231-1.8XUGN8G/TR	0X2 XXXX	Tape and Reel, 3000
SGM2231-2.5	UTDFN-2×2-8CL	-40℃ to +125℃	SGM2231-2.5XUGN8G/TR	0OY XXXX	Tape and Reel, 3000
SGM2231-2.8	UTDFN-2×2-8CL	-40℃ to +125℃	SGM2231-2.8XUGN8G/TR	0X3 XXXX	Tape and Reel, 3000
SGM2231-3.0	UTDFN-2×2-8CL	-40℃ to +125℃	SGM2231-3.0XUGN8G/TR	0OZ XXXX	Tape and Reel, 3000
SGM2231-3.3	UTDFN-2×2-8CL	-40℃ to +125℃	SGM2231-3.3XUGN8G/TR	111 XXXX	Tape and Reel, 3000
SGM2231-5.0	UTDFN-2×2-8CL	-40℃ to +125℃	SGM2231-5.0XUGN8G/TR	0P0 XXXX	Tape and Reel, 3000
SGM2231-ADJ	UTDFN-2×2-8CL	-40℃ to +125℃	SGM2231-ADJXUGN8G/TR	05L XXXX	Tape and Reel, 3000

MARKING INFORMATION

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

YYY — Serial Number
XXXX
- Vendor Code
- Trace Code
- Date Code - Year

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 to GND .... +0.3V to -25V
OUT to GND .... +0.3V to (V_{IN} - 0.3V)
EN to GND... +5V to (V_{IN} - 0.3V)
EN to IN .... +25V to -0.3V
SENSE/ADJ to GND.. +0.3V to V_{OUT}
Package Thermal Resistance
UTDFN-2×2-8CL, θ_{JA}... 82℃/W
UTDFN-2×2-8CL, θ_{JB}... 45℃/W
UTDFN-2×2-8CL, $\theta_{JC(TOP)}$ .... 52℃/W
UTDFN-2×2-8CL, $\theta_{JC(BOT)}$ .... 13.7℃/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
Input Effective Capacitance, C_{IN} .... 1.5μF (MIN)
Output Effective Capacitance, C_{OUT}.................1.5μF to 10μF
Operating Junction Temperature Range ...... -40℃ to +125℃

OVERSTRESS CAUTION

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

ESD SENSITIVITY CAUTION

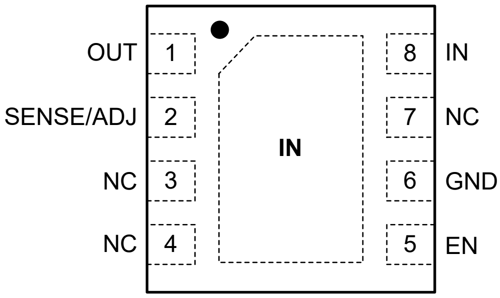
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

DISCLAIMER

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

PIN CONFIGURATION

SGM2231 (TOP VIEW)



UTDFN-2×2-8CL

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 1.5μF to 10μF to ensure stability. This ceramic capacitor should be placed as close as possible to the OUT pin.
2	SENSE/ADJ	Sense or Adjust Input Pin. For fixed output voltage version, this pin is connected to load or the OUT pin directly. For adjustable output voltage version, this pin is connected to the midpoint of an external resistor divider to set the output voltage lower than the fixed output voltage (-1.1V).
3, 4, 7	NC	Not Connected.
5	EN	Enable Pin. Drive EN 2.0V above or below ground to turn on the regulator. Drive EN to ground to turn off the regulator. Connect the EN pin to the IN pin when using automatic startup.
6	GND	Ground.
8	IN	Input Voltage Supply Pin. It is recommended to use a 2.2μF or larger ceramic capacitor from the IN pin to ground to get good power supply decoupling. This ceramic capacitor should be placed as close as possible to the IN pin.
Exposed Pad	IN	Exposed Pad. Connect the exposed pad at the bottom of the package to the internal IN for maximum thermal performance. In normal use, connect the exposed pad to the IN on the board, which is the most negative potential in the negative voltage regulating circuit.

FUNCTIONAL BLOCK DIAGRAM

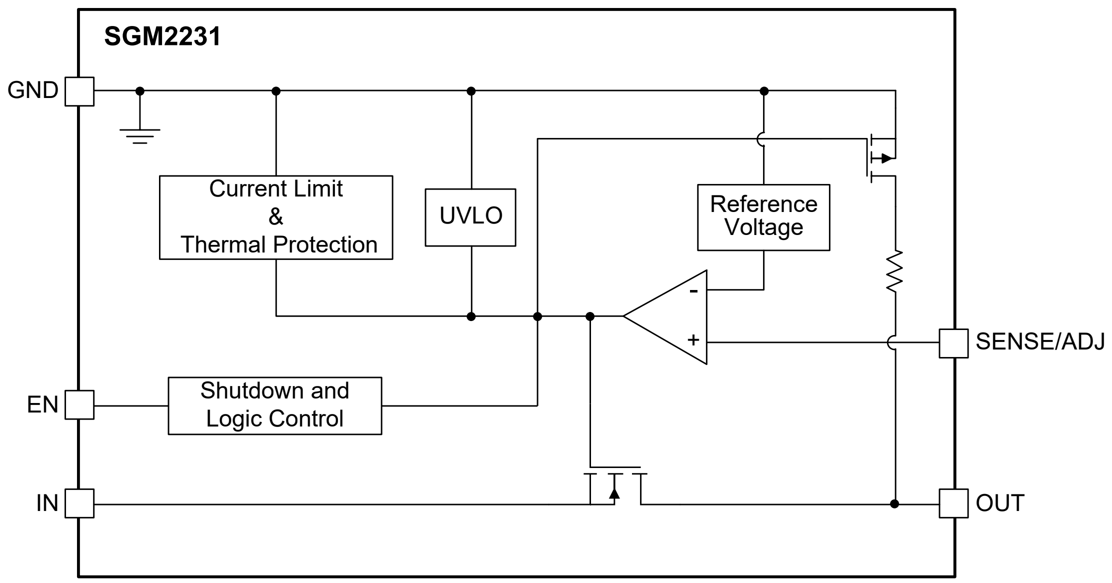


Figure 2. Internal Block Diagram

ELECTRICAL CHARACTERISTICS

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

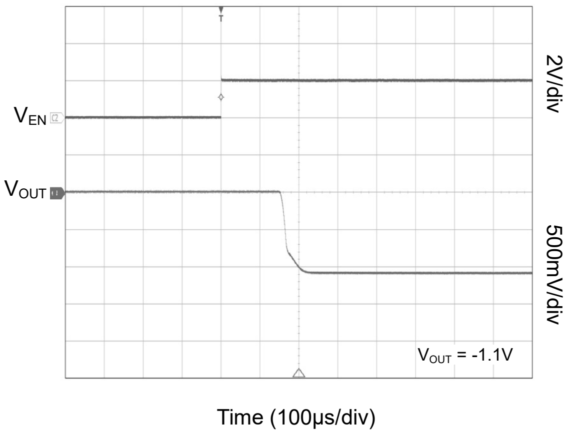
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}	I_{OUT} = -250mA, T_J = +25℃		-2.7		-24	V
		I_{OUT} = -350mA, T_J = +25℃		-3.0		-24	V
		I_{OUT} = -500mA, T_J = +25℃		-3.3		-24	V
Under-Voltage Lockout Thresholds	V_{UVLO}	V_{IN} falling			-2.42	-2.50	V
		V_{IN} rising		-2.24	-2.33		V
Output Voltage Accuracy	V_{OUT}	I_{OUT} = -10mA, T_J = +25℃		-1		1	%
		V_{IN} = ($V_{OUT(NOM)}$ - 0.5V) to -24V, I_{OUT} = -1mA to -500mA, T_J = -40℃ to +125℃		-1.5		1.5	%
Feedback Voltage	V_{ADJ}	I_{OUT} = -10mA, T_J = +25℃		-1.089	-1.1	-1.111	V
		V_{IN} = ($V_{OUT(NOM)}$ - 0.5V) to -24V, I_{OUT} = -1mA to -500mA, T_J = -40℃ to +125℃		-1.083		-1.117	V
ADJ Pin Input Bias Current	I_{ADJ}	V_{IN} = -2.7V to -24V, V_{ADJ} = -1.3V		-3.5		3.5	nA
Line Regulation	$\frac{\Delta V_{OUT}}{\Delta V_{IN} \times V_{OUT}}$	V_{IN} = ($V_{OUT(NOM)}$ - 0.5V) to -24V			0.002	0.03	%/V
Load Regulation	$\frac{\Delta V_{OUT}}{V_{OUT}}$	I_{OUT} = -1mA to -500mA			0.03	0.8	%
Dropout Voltage [1]	V_{DROP}	I_{OUT} = -250mA	$V_{OUT(NOM)}$ = -2.5V		-200	-350	mV
			$V_{OUT(NOM)}$ = -3.0V		-140	-260	
			$V_{OUT(NOM)}$ = -5.0V		-110	-220	
		I_{OUT} = -350mA	$V_{OUT(NOM)}$ = -3.0V		-210	-370	
			$V_{OUT(NOM)}$ = -5.0V		-160	-300	
		I_{OUT} = -500mA	$V_{OUT(NOM)}$ = -3.0V		-310	-550	
			$V_{OUT(NOM)}$ = -5.0V		-230	-420	
Output Current Limit [2]	I_{LIMIT}	V_{IN} = MIN($V_{OUT(NOM)}$ - 1V, -4V)		-0.52	-1.2		A
Short-Circuit Current	I_{SHORT}	V_{IN} = -5.5V, V_{OUT} = 0V			-410		mA
Operating Supply Current	I_{GND}	I_{OUT} = 0μA			-47	-83	μA
		I_{OUT} = -500mA			-1.4	-2.1	mA
Shutdown Current	I_{SHDN}	V_{EN} = GND			-1.2	-3.0	μA
		V_{IN} = -24V, V_{EN} = GND			-1.4	-10	
Positive Enable High-Level Voltage	$V_{EN(+HI)}$			1.22			V
Positive Enable Low-Level Voltage	$V_{EN(+LO)}$					0.3	
Negative Enable High-Level Voltage	$V_{EN(-HI)}$					-2.0	V
Negative Enable Low-Level Voltage	$V_{EN(-LO)}$			-0.55			
EN Positive Input Current	I_{EN_P}	V_{IN} = -19V, V_{EN} = 5V			1	3	μA
EN Negative Input Current	I_{EN_N}	V_{IN} = -24V, V_{EN} = -24V			-0.1	-1	μA
Start-Up Time	t_{STR}	From assertion of V_{EN} to V_{OUT} = 90% × $V_{OUT(NOM)}$, V_{OUT} = -1.1V			210		μs
Power Supply Rejection Ratio	PSRR	V_{IN} = -2.7V, V_{OUT} = -1.1V, ΔV_{RIPPLE} = 0.2V_{P-P}	f = 1kHz		-75		dB
			f = 10kHz		-65		
			f = 100kHz		-54		
Output Voltage Noise	e_n	V_{OUT} = -1.1V, f = 10Hz to 100kHz			10		$μV_{RMS}$
Thermal Shutdown Temperature	T_{SHDN}				160		℃
Thermal Shutdown Hysteresis	ΔT_{SHDN}				20		℃

NOTES:
1. The dropout voltage is defined as the difference between V_{IN} and V_{OUT} when V_{OUT} falls to 95% × $V_{OUT(NOM)}$.
2. Output current limit has the function of current foldback protection and refers to the current at which V_{OUT} falls to 90% × $V_{OUT(NOM)}$.

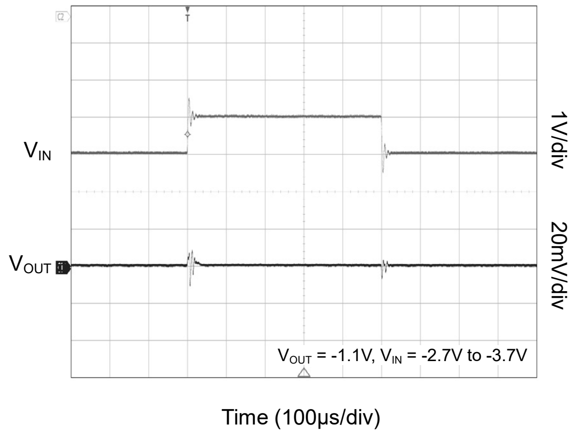
TYPICAL PERFORMANCE CHARACTERISTICS

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

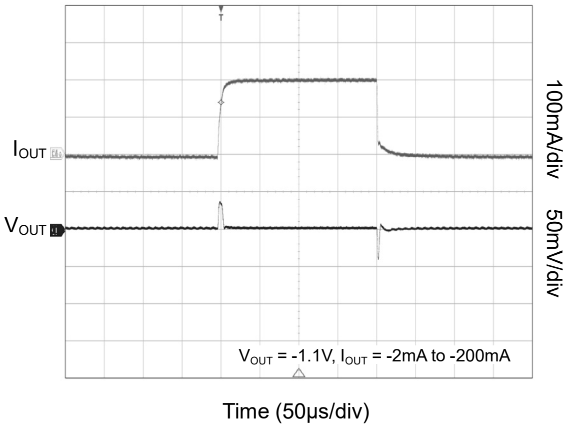
Turn-On with EN Pin



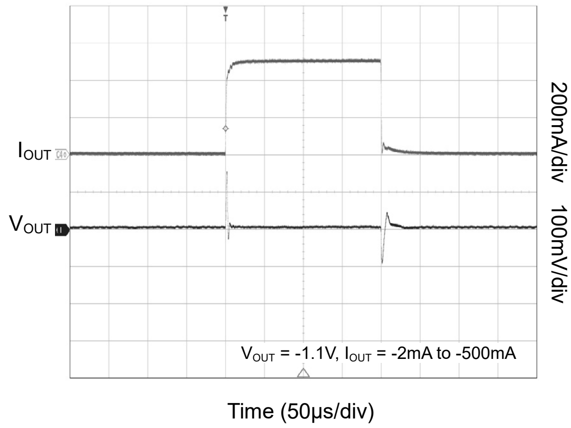
Line Transient Response



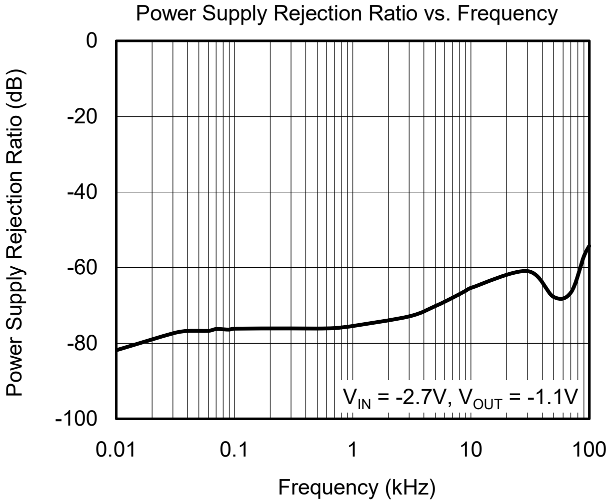
Load Transient Response



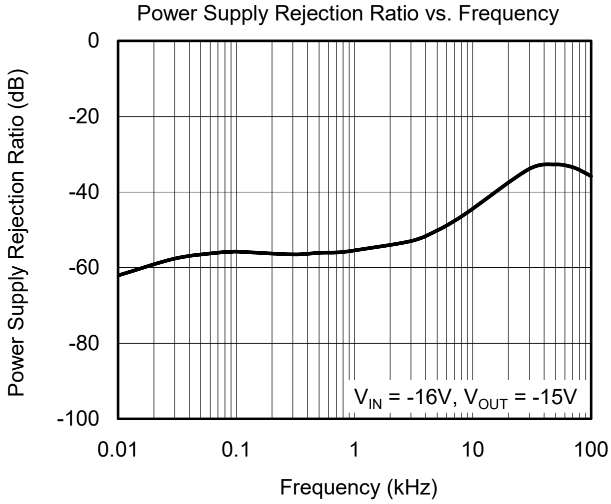
Load Transient Response



Power Supply Rejection Ratio vs. Frequency

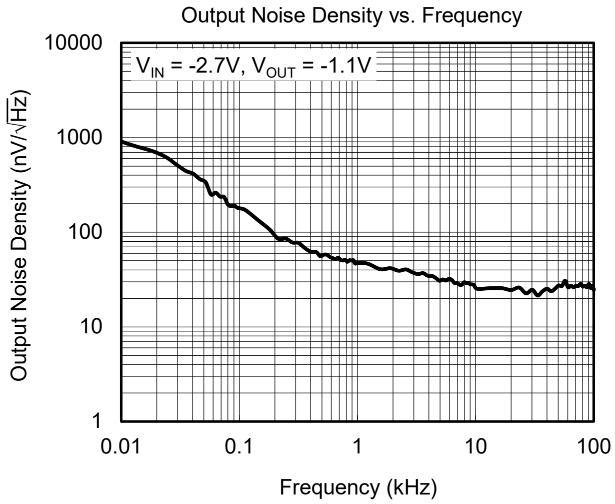


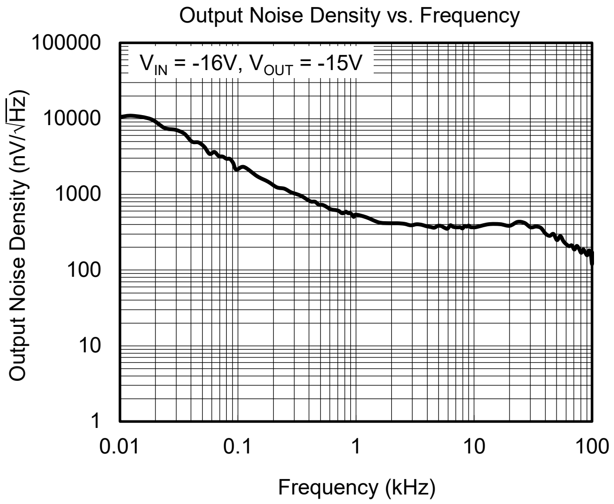
Power Supply Rejection Ratio vs. Frequency

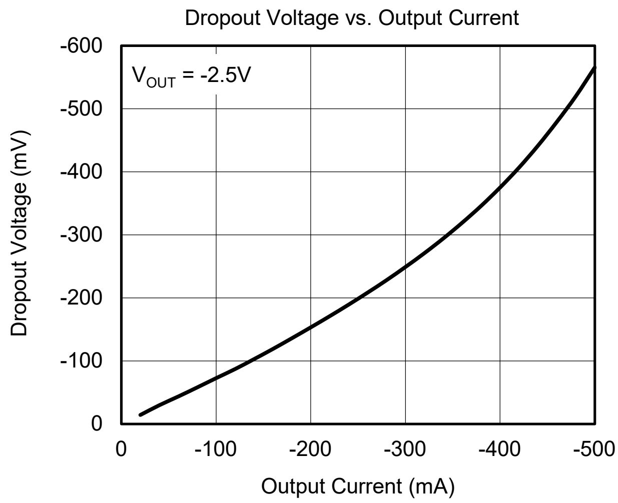


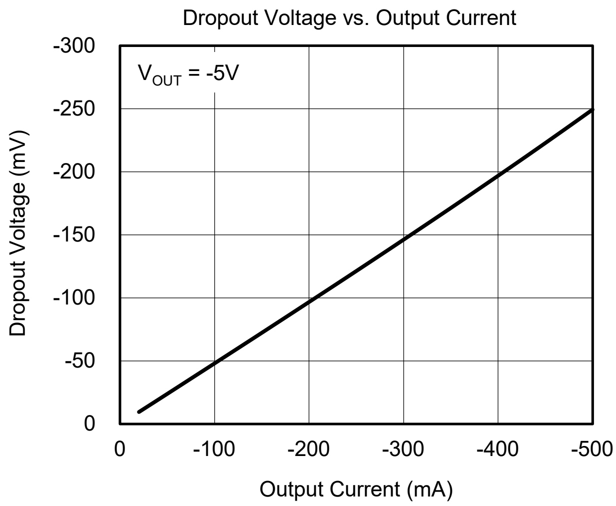
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

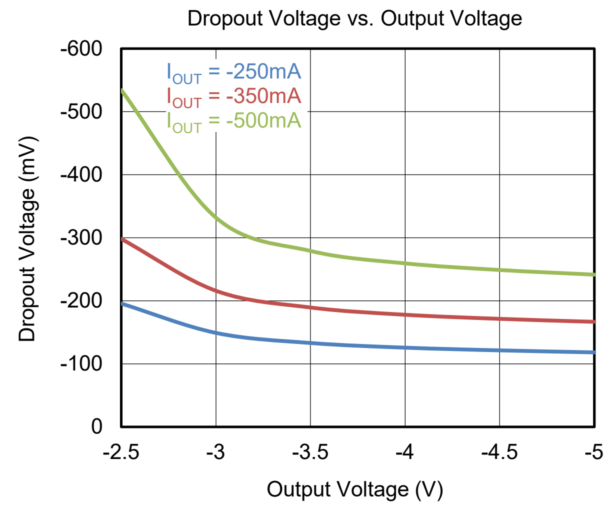
T_J = +25°C, V_{IN} = ($V_{OUT(NOM)}$ - 0.5V) or -2.7V (whichever is greater), V_{EN} = V_{IN}, I_{OUT} = -10mA, C_{IN} = 2.2μF and C_{OUT} = 2.2μF, unless otherwise noted.

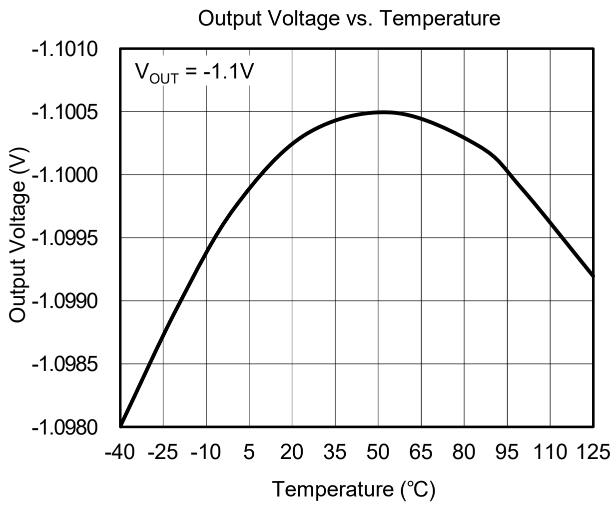






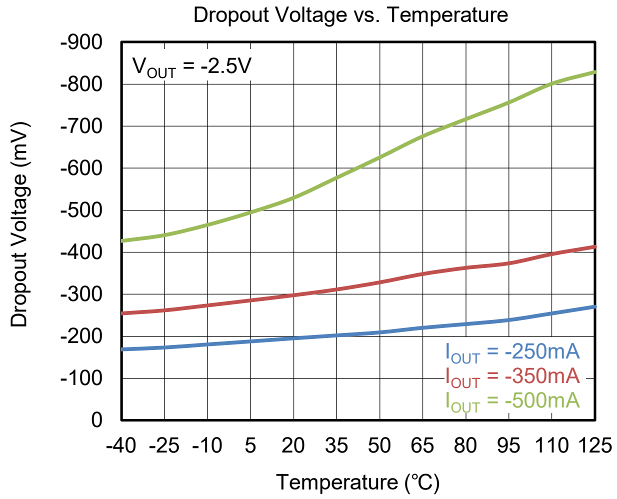


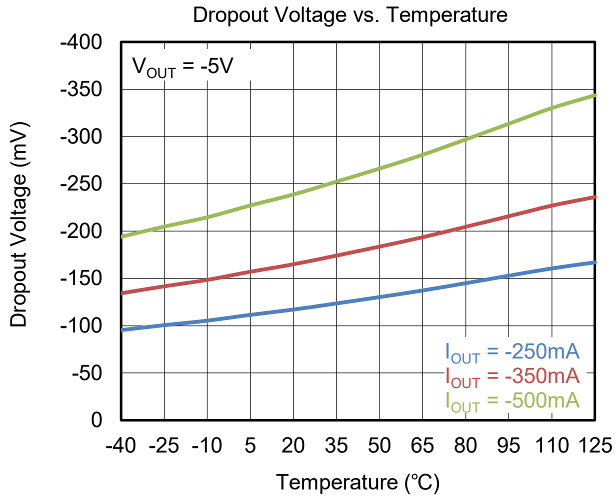


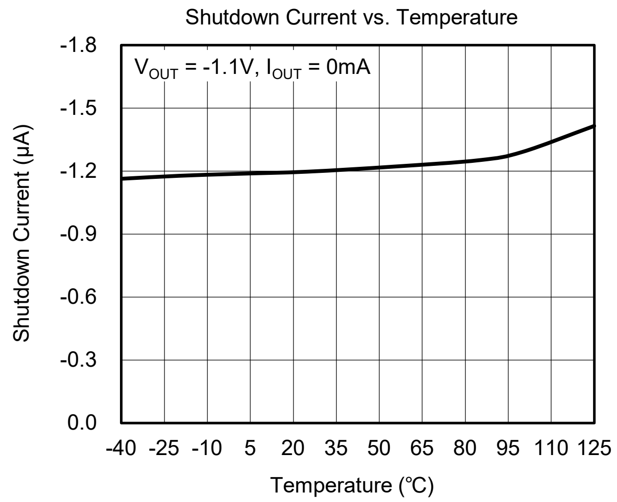


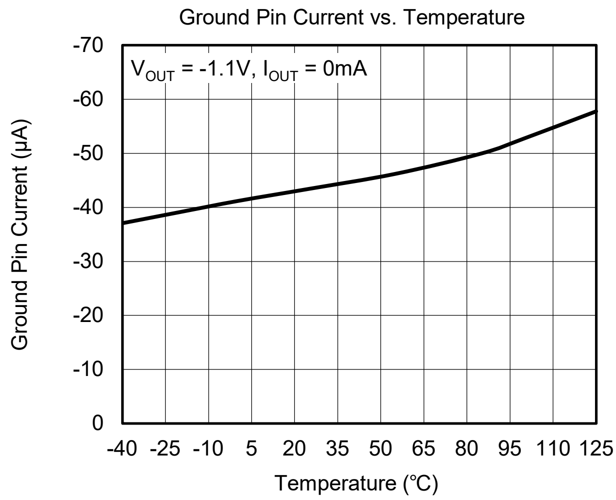
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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









APPLICATION INFORMATION

The SGM2231 is a low quiescent current, low noise and low dropout LDO and provides -500mA 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 SGM2231 useful in a variety of applications. The SGM2231 provides the protection functions for output overload, output short-circuit condition and overheating.

The SGM2231 provides an EN pin as an external chip enable control to enable/disable the device. When the regulator is in shutdown state, the shutdown current consumes as low as -1.2μA (TYP).

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. A 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 reduce the impact from input trace inductance. Adding more input capacitors is available to restrict the ringing and to keep it below the device absolute maximum ratings.

Output Capacitor Selection (C_{OUT})

The output capacitor should be placed as close as possible to the OUT pin. A 2.2μF or larger X7R or X5R ceramic capacitor is selected to get good dynamic performance. The minimum effective capacitance of C_{OUT} that SGM2231 can remain stable is 1.5μF. 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

For the SGM2231-ADJ, set the output voltage by using a resistor divider as shown in Figure 3. Choose R_2 less than 110kΩ to maintain a 10μA minimum load. Calculate the value for the output voltage using the following equation:

$$V_{OUT} = -1.1V \times (1 + R_1/R_2) \quad (1)$$

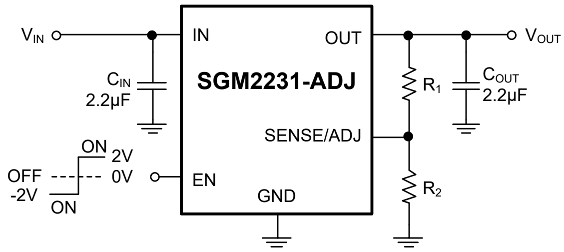


Figure 3. Adjustable Output Voltage Application

Enable Operation

The EN pin of the SGM2231 is used to enable/disable the OUT pin under normal operating conditions. Connect the EN pin to the IN pin when using automatic startup.

When EN is at ±2.0V with respect to GND, the device is in active state. When EN is at 0V, the device is in shutdown state. In this state, a discharge resistor around 200kΩ connects to the OUT pin and pulls the OUT pin up to GND.

The EN pin of the SGM2231 is bipolar, even though the enable voltage can be positive or negative.

The typical hysteresis of the EN pin is shown in Figure 4. This feature is used to prevent on/off oscillations due to noise on the EN pin when it passes the threshold point.

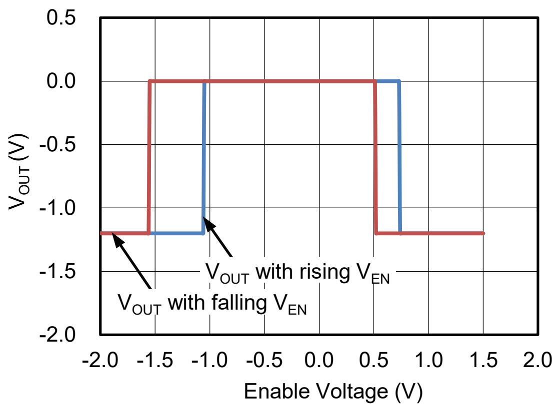


Figure 4. Typical EN Pin Operation

APPLICATION INFORMATION (continued)

Reverse Current Protection

The pass transistor has an inherent body diode which will be forward biased in the case when V_{OUT} < (V_{IN} - 0.3V). If extended reverse voltage operation is anticipated, external limiting might be appropriate.

Output Current Limit and Short-Circuit Protection

When overload events happen, the output current is internally limited to -1.2A (TYP). When the OUT pin is shorted to ground, the short-circuit protection will limit the output current to -410mA (TYP).

Thermal Shutdown

When the die temperature exceeds the threshold value of thermal shutdown, the SGM2231 will be in shutdown state and it will remain in this state until the die temperature decreases to +140℃.

Power Dissipation (P_D)

Power dissipation (P_D) of the SGM2231 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 SGM2231 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:

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

Layout Guidelines

To get good PSRR, low output noise and high transient response performance, the input and output bypass capacitors must be placed as close as possible to the IN pin and OUT pin separately.

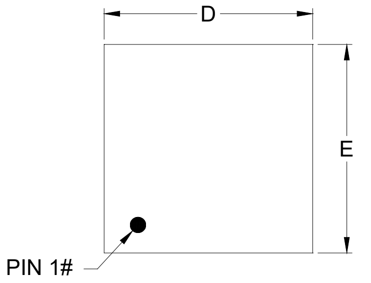
REVISION HISTORY

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

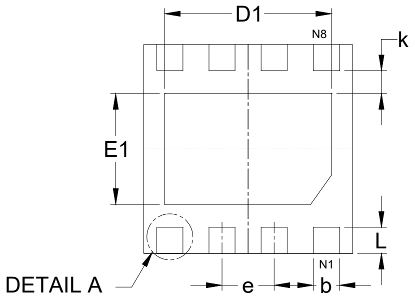
Changes from Original (JANUARY 2024) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

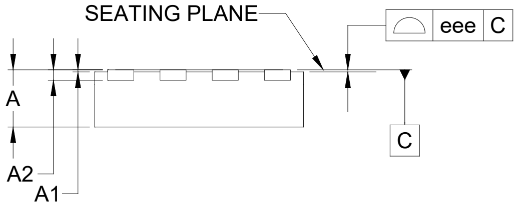
UTDFN-2×2-8CL



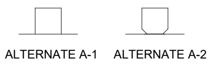
TOP VIEW



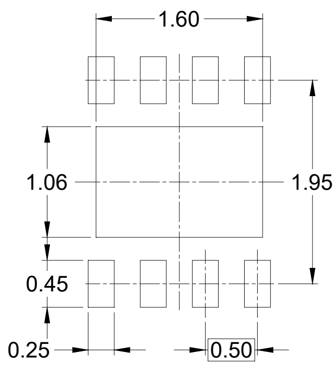
BOTTOM VIEW



SIDE VIEW



DETAIL A
ALTERNATE TERMINAL
CONSTRUCTION



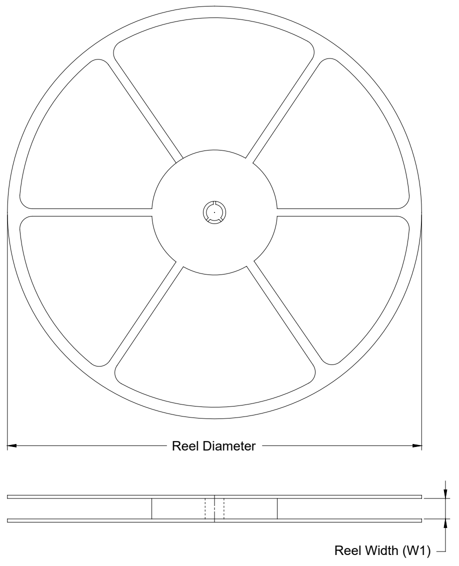
RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	0.500	-	0.600
A1	0.000	-	0.050
A2	0.100 REF		
b	0.200	-	0.300
D	1.900	-	2.100
E	1.900	-	2.100
D1	1.500	-	1.700
E1	0.960	-	1.160
e	0.500 BSC		
k	0.220 REF		
L	0.150	-	0.350
eee	0.050		

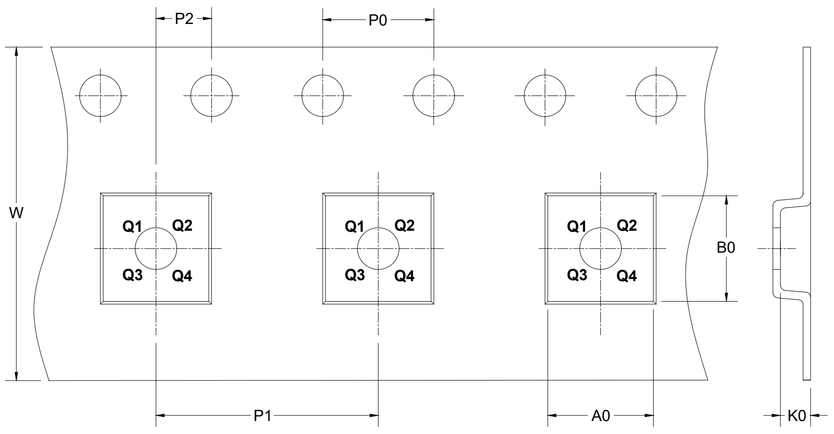
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



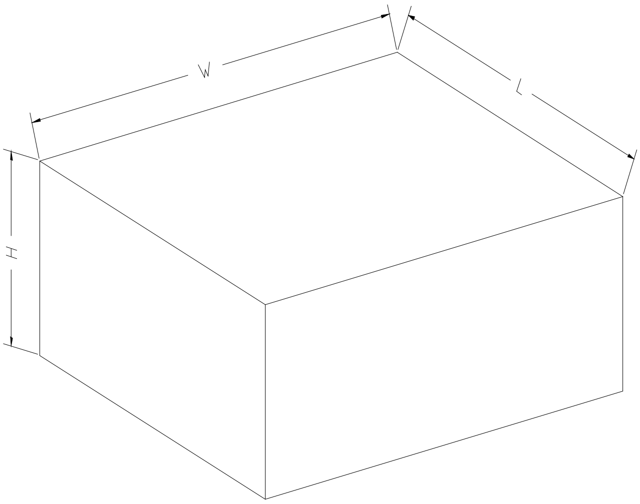
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
UTDFN-2×2-8CL	7"	9.5	2.25	2.25	0.75	4.0	4.0	2.0	8.0	Q2

DD0001

CARTON BOX DIMENSIONS



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

KEY PARAMETER LIST OF CARTON BOX

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

DD0002