SGM8605-1
1.2mA, 12.5MHz, Rail-to-Rail I/O CMOS Operational Amplifier

GENERAL DESCRIPTION

The SGM8605-1 (single with shutdown) is a low noise, low voltage and low power operational amplifier, that can be designed into a wide range of applications. The SGM8605-1 has a high gain-bandwidth product of 12.5MHz, a slew rate of 8.5V/μs, and a quiescent current of 1.2mA at 5V. The SGM8605-1 has a power-down disable feature that reduces the supply current to less than 1μA.

The SGM8605-1 is designed to provide optimal performance in low voltage and low noise systems. It provides rail-to-rail output swing into heavy loads. The input common mode voltage range includes ground, and the maximum input offset voltage is 4.5mV for SGM8605-1. The operating supply range is from 2.1V to 5.5V.

SGM8605-1 is available in a Green UTDFN-1.45×1-6L package. It is specified over the extended industrial temperature range (-40℃ to +125℃).

FEATURES

- **Rail-to-Rail Input and Output**
- **Input Offset Voltage: 0.9mV (TYP)**
- **High Gain-Bandwidth Product: 12.5MHz**
- **High Slew Rate: 8.5V/μs**
- **Settling Time to 0.1% with 2V Step: 0.21μs**
- **Overload Recovery Time: 0.6μs**
- **Supply Voltage Range: 2.1V to 5.5V**
- **Input Common Mode Voltage Range:**
  -0.1V to 5.6V with V_S = 5.5V
- **Low Power: 1.2mA Typical Supply Current**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in a Green UTDFN-1.45×1-6L Package**

APPLICATIONS

Sensors
Audio
Active Filters
A/D Converters
Communications
Test Equipment
Cellular and Cordless Phones
Laptops and PDAs
Photodiode Amplification
Battery-Powered Instrumentation

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8605-1	UTDFN-1.45×1-6L	-40℃ to +125℃	SGM8605-1XUDL6G/TR	78X	Tape and Reel, 5000

MARKING INFORMATION

NOTE: X = Date Code.

YY X

Date Code - Year

Serial Number

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

Supply Voltage, $+V_S$ to $-V_S$ 6V
Input Common Mode Voltage Range ....
.... $(-V_S)$ - 0.3V to $(+V_S)$ + 0.3V
Junction Temperature ....+150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s) ....+260℃
ESD Susceptibility
HBM 8000V
MM 400V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range ....2.1V to 5.5V
Operating 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

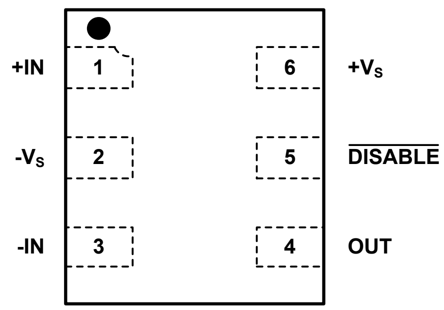
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

(TOP VIEW)



UTDFN-1.45×1-6L

ELECTRICAL CHARACTERISTICS

(At V_S = +5V, T_A = +25℃, V_{CM} = +V_S/2, R_L = 600Ω, unless otherwise noted.)

PARAMETER	CONDITIONS	SGM8605-1				
		TYP	MIN/MAX OVER TEMPERATURE			
		+25℃	+25℃	-40℃ to +125℃	UNITS	MIN/MAX
Input Characteristics						
Input Offset Voltage (V_{OS})		0.9	4.5	4.8	mV	MAX
Input Bias Current (I_B)		2			pA	TYP
Input Offset Current (I_{OS})		3			pA	TYP
Input Common Mode Voltage Range (V_{CM})	V_S = 5.5V	-0.1 to 5.6			V	TYP
Common Mode Rejection Ratio (CMRR)	V_S = 5.5V, V_{CM} = -0.1V to 4V	79	68	65	dB	MIN
	V_S = 5.5V, V_{CM} = -0.1V to 5.6V	75	60	58	dB	MIN
Open-Loop Voltage Gain (A_{OL})	R_L = 600Ω, V_{OUT} = 0.15V to 4.85V	88	80	67	dB	MIN
	R_L = 10kΩ, V_{OUT} = 0.05V to 4.95V	100	96	75	dB	MIN
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta T$)		2			μV/℃	TYP
Output Characteristics						
Output Voltage Swing from Rail	R_L = 600Ω	74	96	123	mV	TYP
	R_L = 10kΩ	6	13	19	mV	TYP
Output Current (I_{OUT})		78	59	50	mA	MIN
Closed-Loop Output Impedance	f = 1MHz, G = +1	8.5			Ω	TYP
Power-Down Disable						
Turn-On Time		1			μs	TYP
Turn-Off Time		0.2			μs	TYP
$\overline{\text{DISABLE}}$ Voltage-Off			0.8		V	MAX
$\overline{\text{DISABLE}}$ Voltage-On			2		V	MIN
Power Supply						
Operating Voltage Range			2.1	2.1	V	MIN
			5.5	5.5	V	MAX
Power Supply Rejection Ratio (PSRR)	V_S = 2.1V to 5.5V, V_{CM} = (-V_S) + 0.5V	75	67	61	dB	MIN
Quiescent Current (I_Q)	I_{OUT} = 0	1.2	1.5	1.9	mA	MAX
Supply Current when Disabled		0.5	8	10	μA	MAX
Dynamic Performance						
Gain-Bandwidth Product (GBP)	R_L = 600Ω	12.5			MHz	TYP
Phase Margin (φ_O)		65			degrees	TYP
Slew Rate (SR)	G = +1, 2V output step	8.5			V/μs	TYP
Settling Time to 0.1% (t_S)	G = +1, 2V output step	0.21			μs	TYP
Overload Recovery Time	V_{IN} × G = V_S	0.6			μs	TYP
Noise Performance						
Input Voltage Noise Density (e_n)	f = 1kHz	12			nV/$\sqrt{Hz}$	TYP
	f = 10kHz	8			nV/$\sqrt{Hz}$	TYP

ELECTRICAL CHARACTERISTICS (continued)

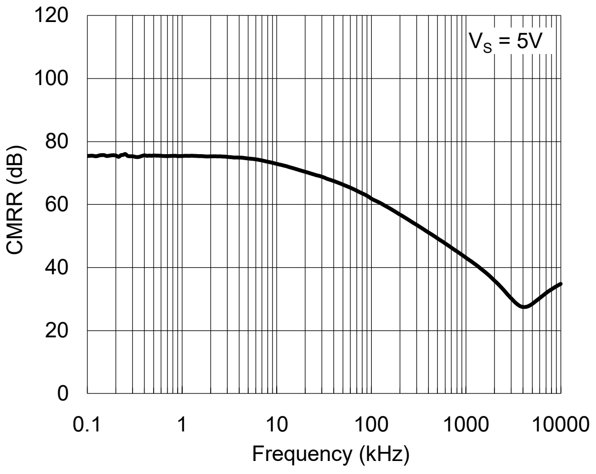
(At V_S = +2.1V, T_A = +25℃, V_{CM} = +V_S/2, R_L = 600Ω, unless otherwise noted.)

PARAMETER	CONDITIONS	SGM8605-1				
		TYP	MIN/MAX OVER TEMPERATURE			
		+25℃	+25℃	-40℃ to +125℃	UNITS	MIN/MAX
Input Characteristics						
Input Offset Voltage (V_{OS})		0.8	4.7	4.9	mV	MAX
Input Bias Current (I_B)		2			pA	TYP
Input Offset Current (I_{OS})		3			pA	TYP
Input Common Mode Voltage Range (V_{CM})	V_S = 2.1V	-0.1 to 2.2			V	TYP
Common Mode Rejection Ratio (CMRR)	V_S = 2.1V, V_{CM} = -0.1V to 0.6V	70	60	50	dB	MIN
	V_S = 2.1V, V_{CM} = -0.1V to 2.2V	70	54	49	dB	MIN
Open-Loop Voltage Gain (A_{OL})	R_L = 600Ω, V_{OUT} = 0.15V to 1.95V	87	81	64	dB	MIN
	R_L = 10kΩ, V_{OUT} = 0.05V to 2.05V	97	90	72	dB	MIN
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta T$)		2			μV/℃	TYP
Output Characteristics						
Output Voltage Swing from Rail	R_L = 600Ω	38	58	70	mV	TYP
	R_L = 10kΩ	5	9	11	mV	TYP
Output Current (I_{OUT})		28	20	15	mA	MIN
Power-Down Disable						
Turn-On Time		7.4			μs	TYP
Turn-Off Time		0.4			μs	TYP
$\overline{\text{DISABLE}}$ Voltage-Off			0.4		V	MAX
$\overline{\text{DISABLE}}$ Voltage-On			1.8		V	MIN
Power Supply						
Quiescent Current (I_Q)	I_{OUT} = 0	1.3	1.55	1.9	mA	MAX
Supply Current when Disabled		0.5	4	6	μA	MAX
Dynamic Performance						
Gain-Bandwidth Product (GBP)	R_L = 600Ω	12.5			MHz	TYP
Phase Margin (φ_O)		60			degrees	TYP
Slew Rate (SR)	G = +1, 1V output step	8.9			V/μs	TYP
Settling Time to 0.1% (t_S)	G = +1, 1V output step	0.24			μs	TYP
Overload Recovery Time	V_{IN} × G = V_S	0.53			μs	TYP
Noise Performance						
Input Voltage Noise Density (e_n)	f = 1kHz	12.5			nV/$\sqrt{\text{Hz}}$	TYP
	f = 10kHz	9			nV/$\sqrt{\text{Hz}}$	TYP

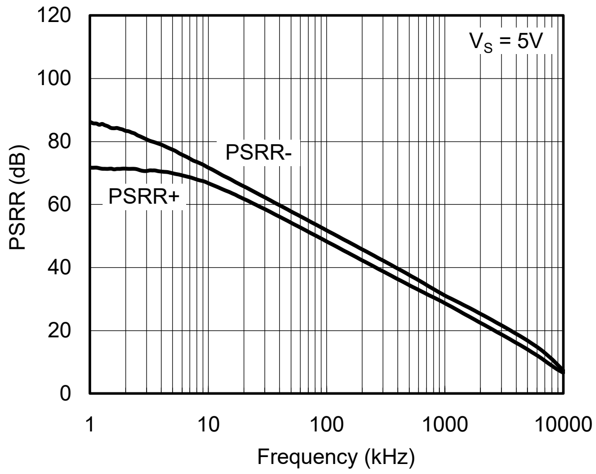
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_{CM} = V_S/2, R_L = 600Ω, unless otherwise noted.

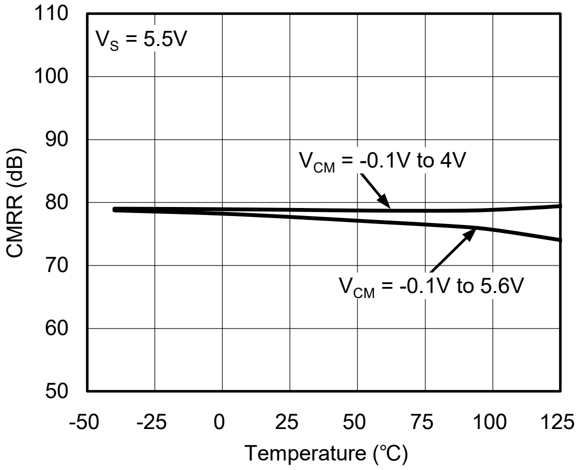
CMRR vs. Frequency



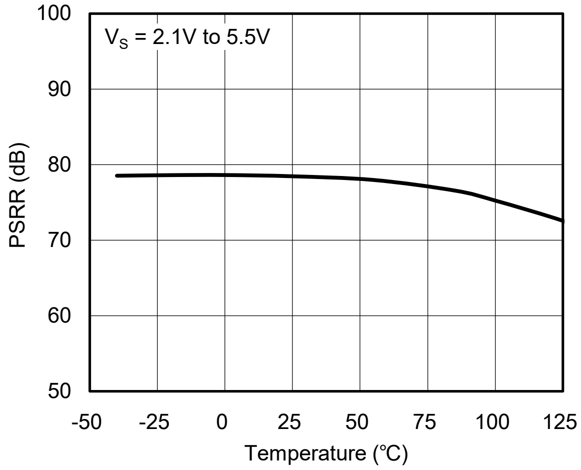
PSRR vs. Frequency



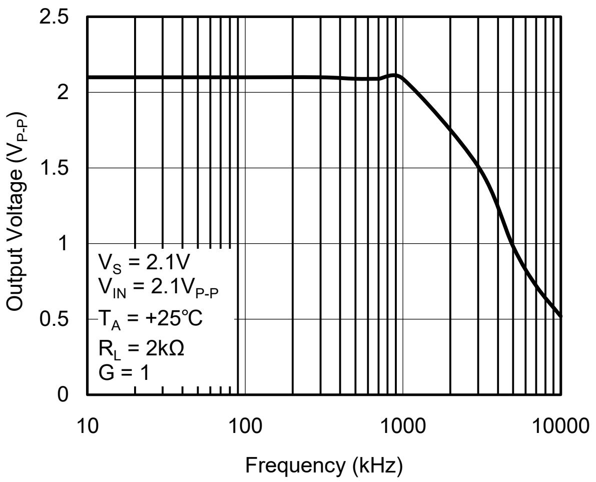
CMRR vs. Temperature



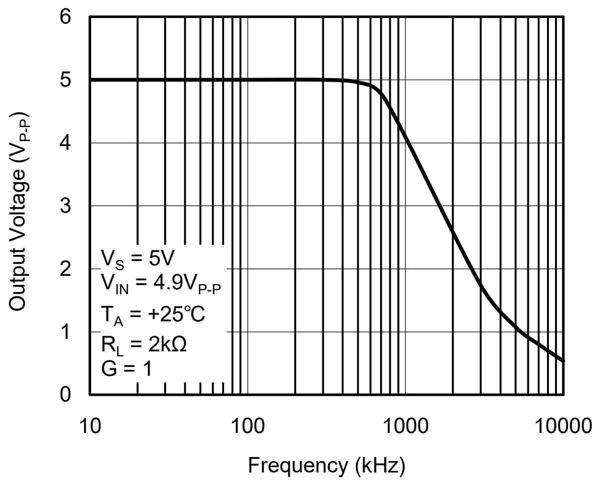
PSRR vs. Temperature



Closed-Loop Output Voltage Swing



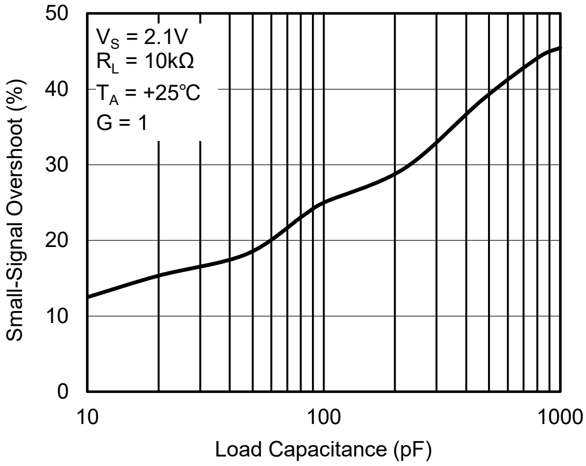
Closed-Loop Output Voltage Swing



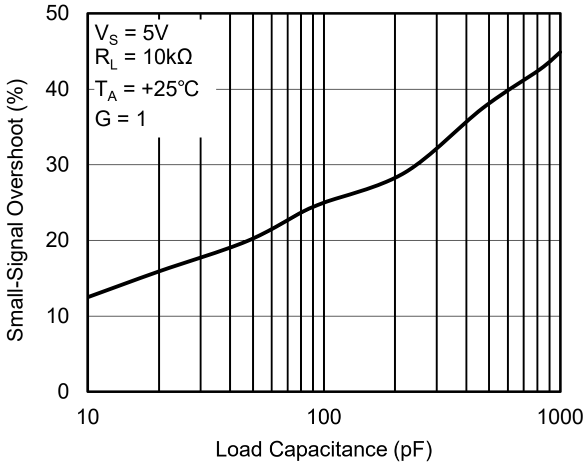
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_{CM} = V_S/2, R_L = 600Ω, unless otherwise noted.

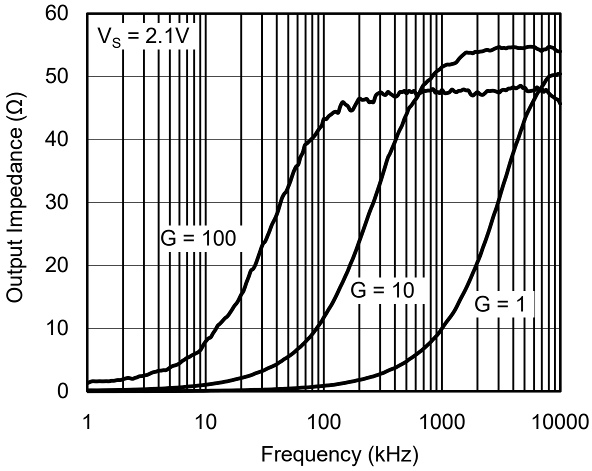
Small-Signal Overshoot vs. Load Capacitance



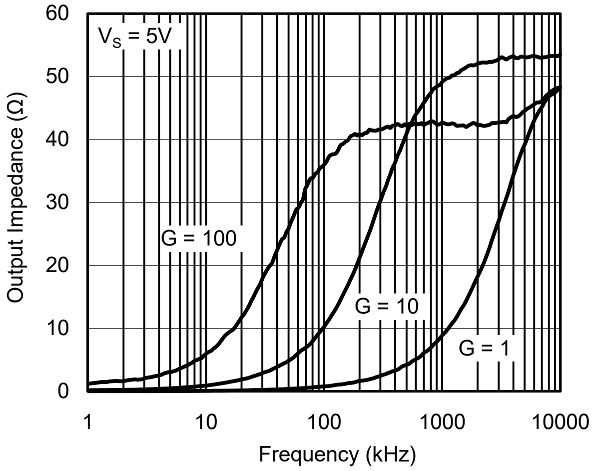
Small-Signal Overshoot vs. Load Capacitance



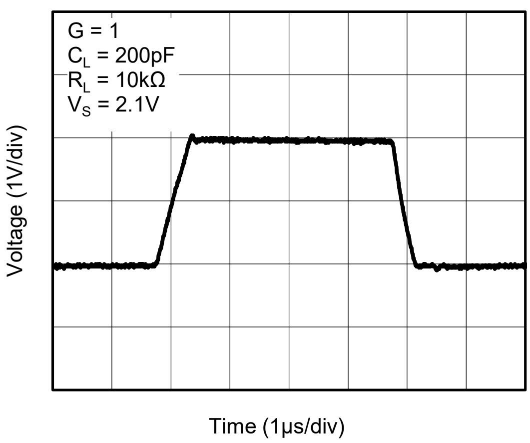
Output Impedance vs. Frequency



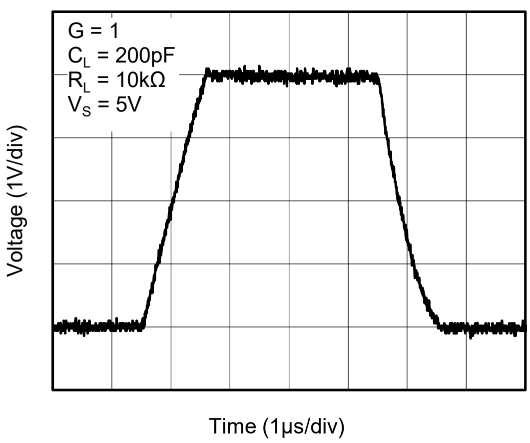
Output Impedance vs. Frequency



Large-Signal Step Response

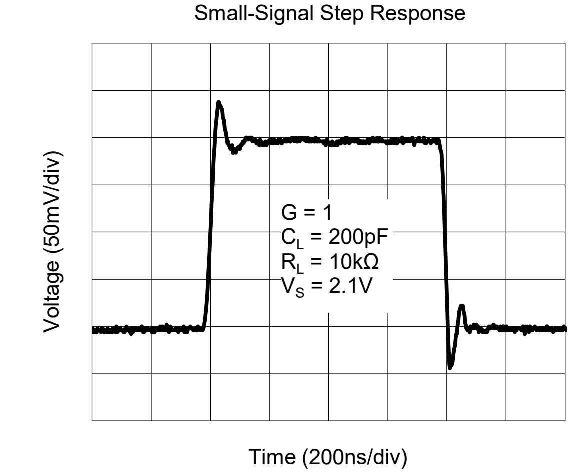


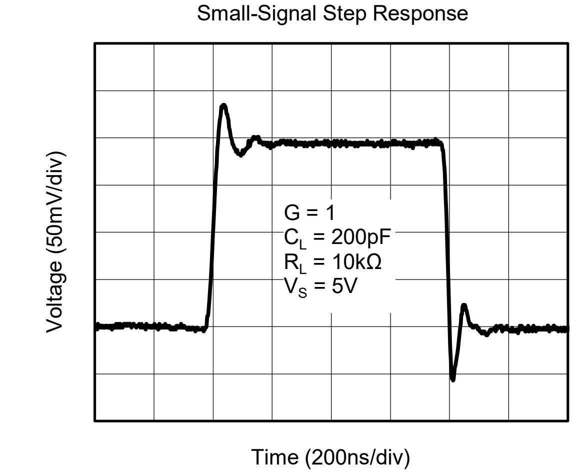
Large-Signal Step Response

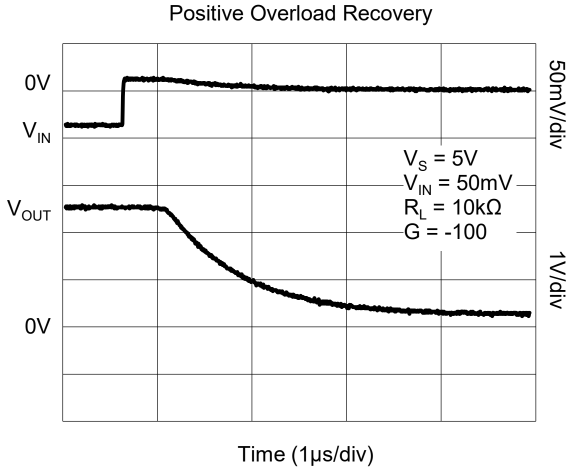


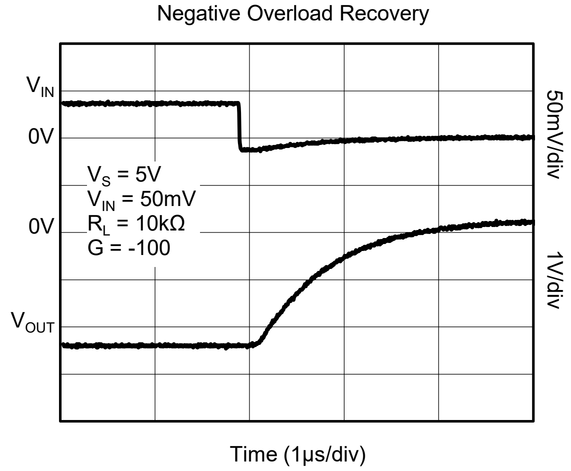
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

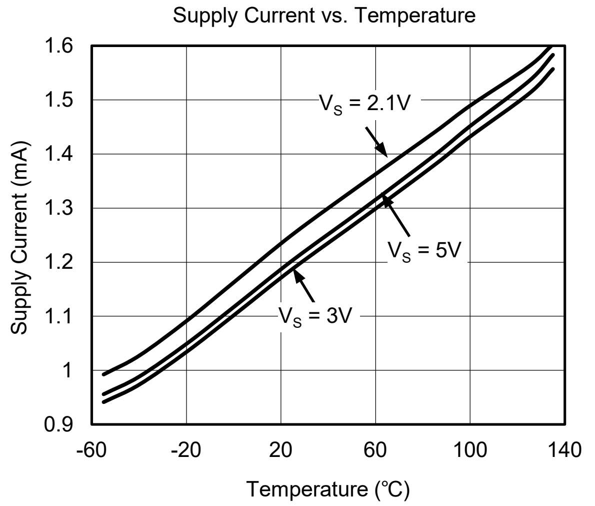
At T_A = +25℃, V_{CM} = V_S/2, R_L = 600Ω, unless otherwise noted.

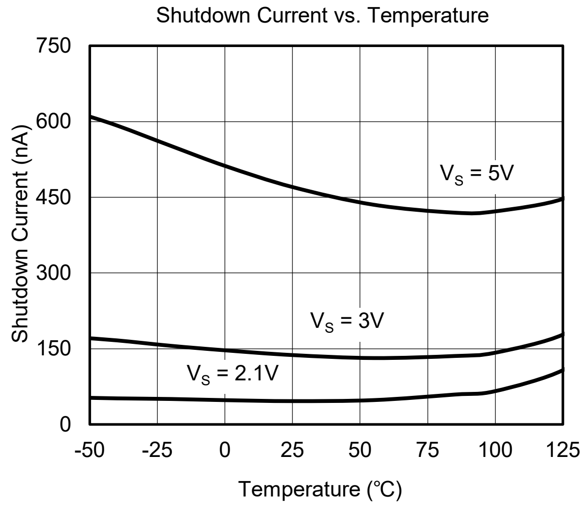








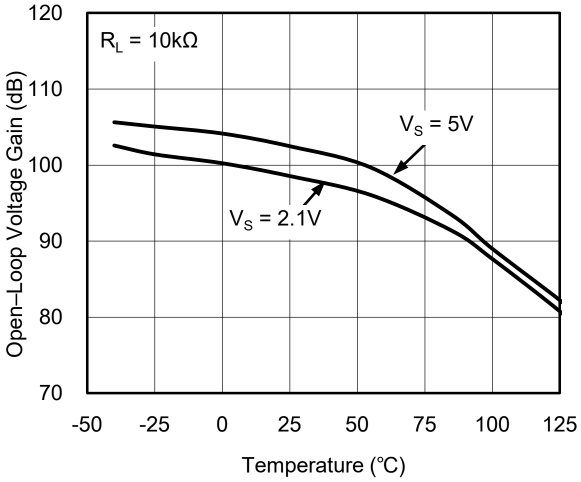




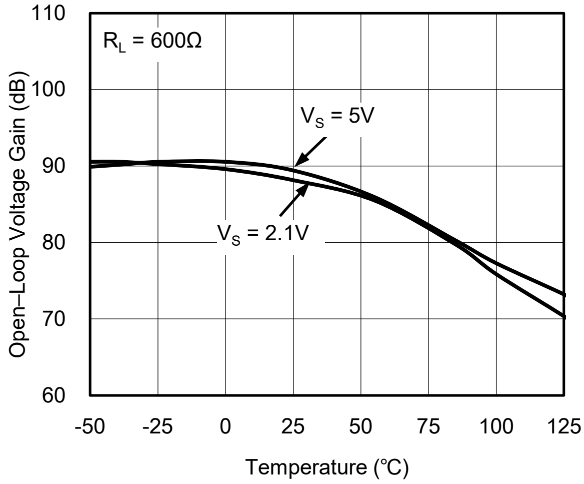
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_{CM} = V_S/2, R_L = 600Ω, unless otherwise noted.

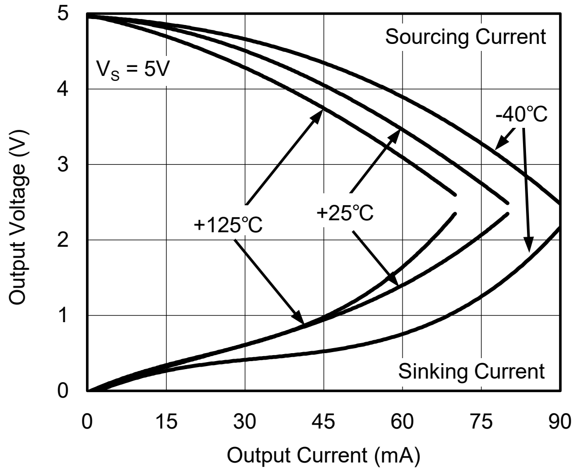
Open-Loop Voltage Gain vs. Temperature



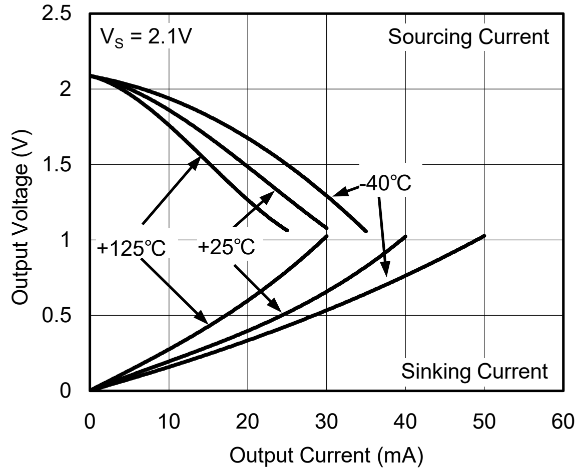
Open-Loop Voltage Gain vs. Temperature



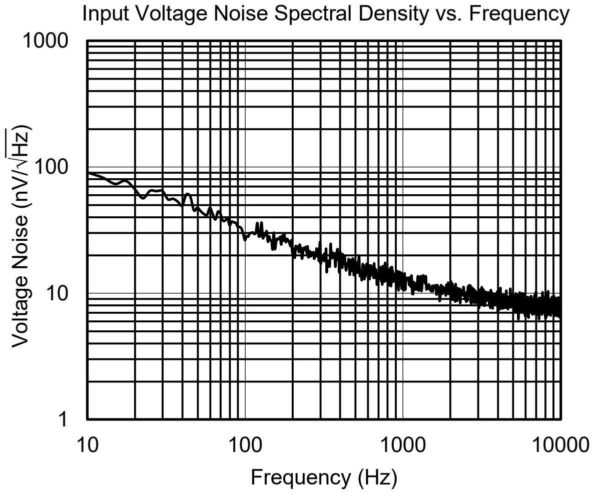
Output Voltage Swing vs. Output Current



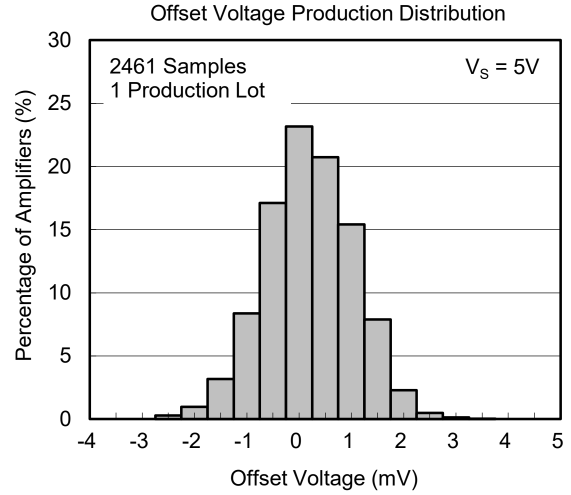
Output Voltage Swing vs. Output Current



Input Voltage Noise Spectral Density vs. Frequency



Offset Voltage Production Distribution



APPLICATION INFORMATION

Driving Capacitive Loads

The SGM8605-1 can directly drive 4700pF in unity-gain without oscillation. The unity-gain follower (buffer) is the most sensitive configuration to capacitive loading. Direct capacitive loading reduces the phase margin of amplifiers and this results in ringing or even oscillation. Applications that require greater capacitive driving capability should use an isolation resistor between the output and the capacitive load like the circuit in Figure 1. The isolation resistor R_{ISO} and the load capacitor C_L form a zero to increase stability. The bigger the R_{ISO} resistor value, the more stable V_{OUT} will be. Note that this method results in a loss of gain accuracy because R_{ISO} forms a voltage divider with the R_{LOAD}.

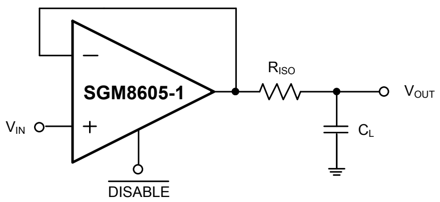


Figure 1. Indirectly Driving Heavy Capacitive Load

An improved circuit is shown in Figure 2. It provides DC accuracy as well as AC stability. R_F provides the DC accuracy by connecting the inverting input with the output. C_F and R_{ISO} serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving phase margin in the overall feedback loop.

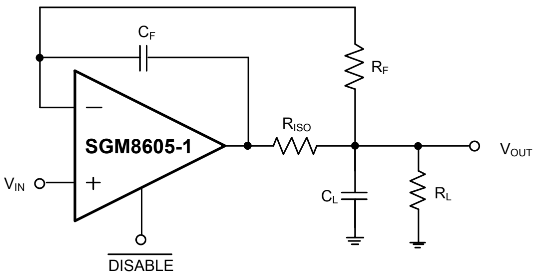


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

For non-buffer configuration, there are two other ways to increase the phase margin: (a) by increasing the amplifier's closed-loop gain or (b) by placing a capacitor in parallel with the feedback resistor to counteract the parasitic capacitance associated with inverting node.

Power Supply Bypassing and Layout

The SGM8605-1 operates from either a single 2.1V to 5.5V supply or dual ±1.05V to ±2.75V supplies. For single-supply operation, bypass the power supply $+V_S$ with a 0.1μF ceramic capacitor which should be placed close to the $+V_S$ pin. For dual-supply operation, both the $+V_S$ and the $-V_S$ supplies should be bypassed to ground with separate 0.1μF ceramic capacitors. 2.2μF tantalum capacitor can be added for better performance.

Good PC board layout techniques optimize performance by decreasing the amount of stray capacitance at the operational amplifier's inputs and output. To decrease stray capacitance, minimize trace lengths and widths by placing external components as close to the device as possible. Use surface-mount components whenever possible.

For the operational amplifier, soldering the part to the board directly is strongly recommended. Try to keep the high frequency current loop area small to minimize the EMI (electromagnetic interference).

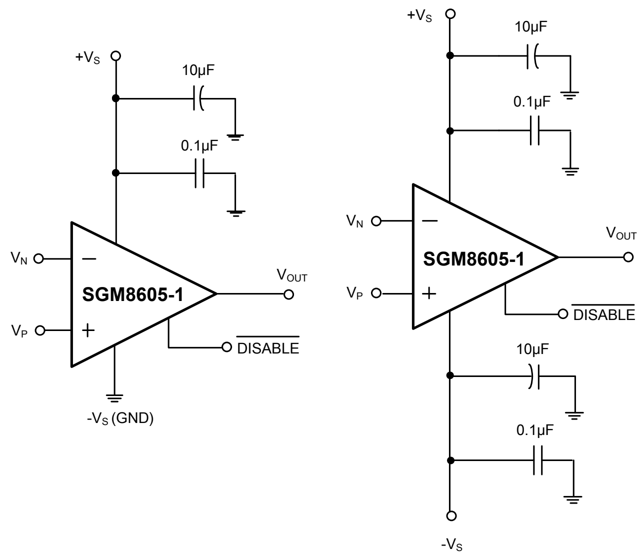


Figure 3. Amplifier with Bypass Capacitors

Grounding

A ground plane layer is important for SGM8605-1 circuit design. The length of the current path in an inductive ground return will create an unwanted voltage noise. Broad ground plane areas will reduce the parasitic inductance.

APPLICATION INFORMATION

Input-to-Output Coupling

To minimize capacitive coupling, the input and output signal traces should not be in parallel. This helps reduce unwanted positive feedback.

Differential Amplifier

The circuit shown in Figure 4 performs the difference function. If the resistor ratios are equal ($R_4/R_3 = R_2/R_1$), then $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$.

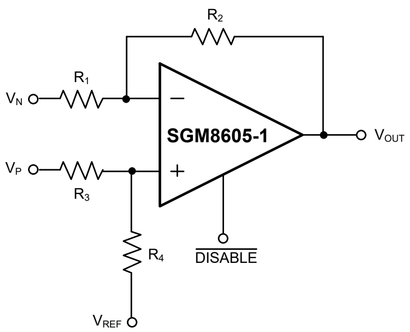


Figure 4. Differential Amplifier

Instrumentation Amplifier

The circuit in Figure 5 performs the same function as that in Figure 4 but with a high input impedance.

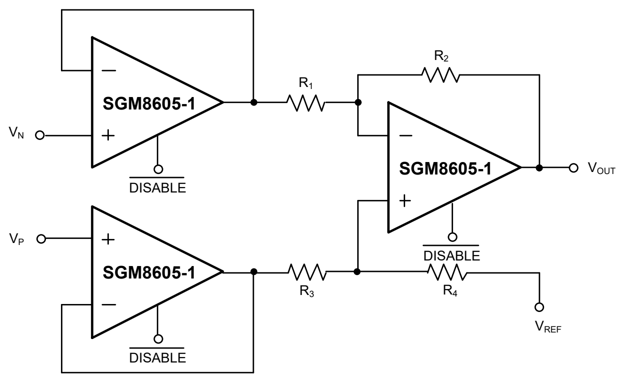


Figure 5. Instrumentation Amplifier

Active Low-Pass Filter

The low-pass filter shown in Figure 6 has a DC gain of ($-R_2/R_1$) and the -3dB corner frequency is $1/2\pi R_2C$. Make sure the filter bandwidth is within the bandwidth of the amplifier. Feedback resistors with large values can couple with parasitic capacitance and cause undesired effects such as ringing or oscillation in high-speed amplifiers. Keep resistor values as low as possible and consistent with output loading consideration.

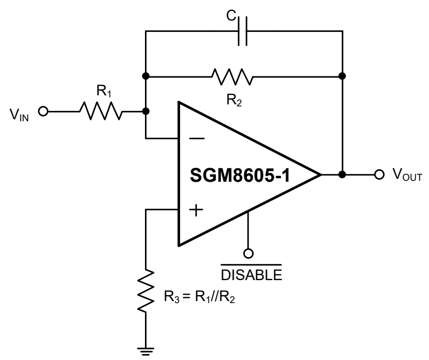


Figure 6. Active Low-Pass Filter

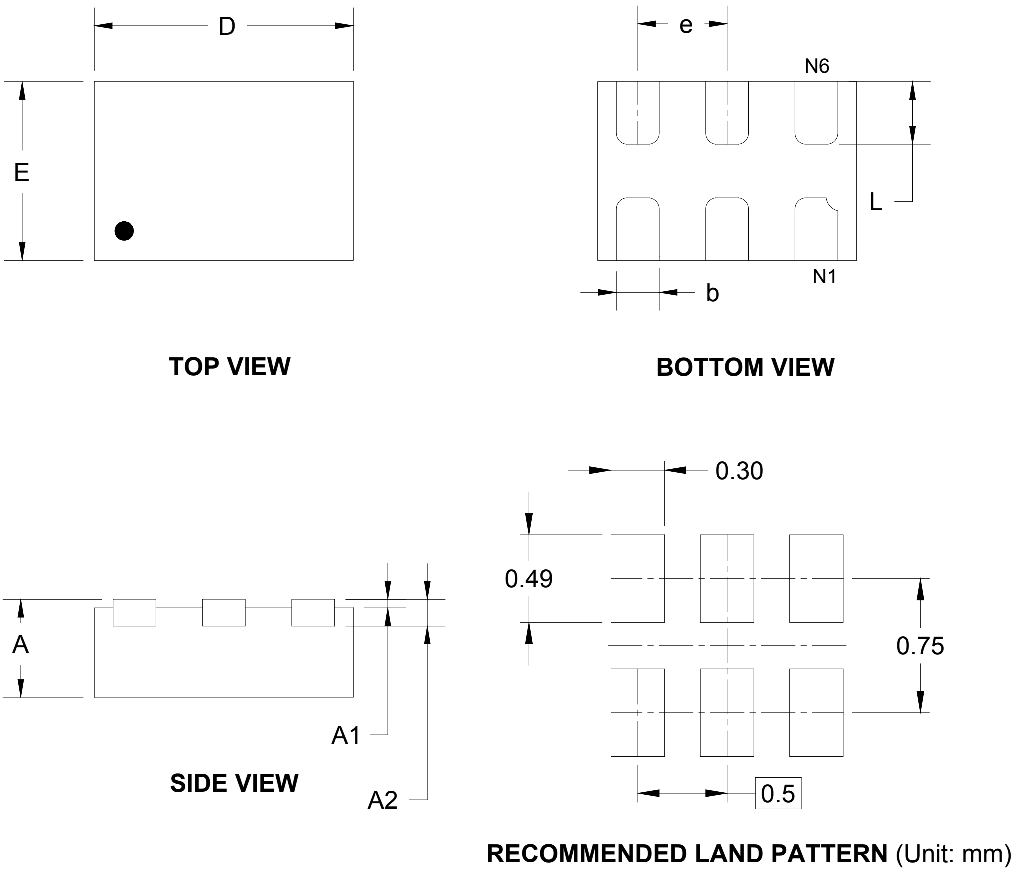
REVISION HISTORY

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

Changes from Original (MARCH 2016) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

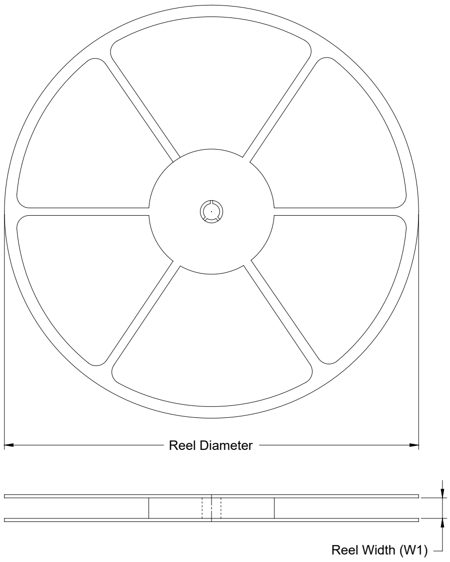
UTDFN-1.45×1-6L



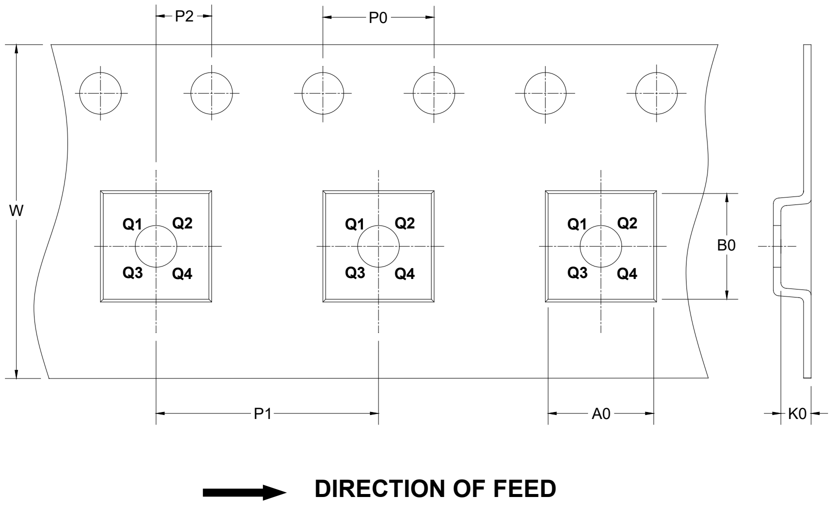
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.450	0.550	0.018	0.022
A1	0.000	0.050	0.000	0.002
A2	0.150 REF		0.006 REF	
D	1.374	1.526	0.054	0.060
E	0.924	1.076	0.036	0.042
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.274	0.426	0.011	0.017

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



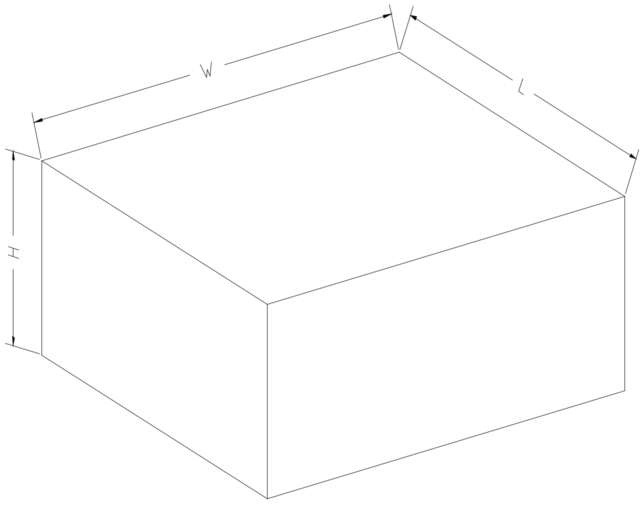
NOTE: The picture is only for reference. Please make the object as the standard.

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-1.45×1-6L	7″	9.5	1.15	1.60	0.75	4.0	4.0	2.0	8.0	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
7″ (Option)	368	227	224	8
7″	442	410	224	18

DD0002