SGM8603
1.1mA, 11MHz, Low Noise, Rail-to-Rail I/O Tiny Package, CMOS Operational Amplifier

GENERAL DESCRIPTION

The SGM8603 (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 SGM8603 has a high gain-bandwidth product of 11MHz, a slew rate of 8.5V/μs, and a quiescent current of 1.1mA at 5V. The SGM8603 has a power-down disable feature that reduces the supply current to less than 1μA.

The SGM8603 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 4.9mV for SGM8603. The operating supply range is from 2.1V to 5.5V.

The SGM8603 is available in Green TDFN-2×2-6L package. It is specified over the extended industrial temperature range (-40℃ to +125℃).

FEATURES

- **Rail-to-Rail Input and Output**
  1.1mV Typical V_{OS}
- **High Gain-Bandwidth Product: 11MHz**
- **High Slew Rate: 8.5V/μs**
- **Settling Time to 0.1% with 2V Step: 0.21μs**
- **Overload Recovery Time: 0.6μs**
- **Low Noise: 8.5nV/$\sqrt{Hz}$ at 10kHz**
- **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**
  1.1mA Typical Supply Current
  Less than 1μA when Disabled
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in Green TDFN-2×2-6L 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
SGM8603	TDFN-2×2-6L	-40℃ to +125℃	SGM8603XTDI6G/TR	8603 XXXX	Tape and Reel, 3000

NOTE: XXXX = Date Code.

Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, $+V_S$ to $-V_S$ 6V

Input Common Mode Voltage Range

.... $(-V_S)$ - 0.3V to $(+V_S)$ + 0.3V

Storage Temperature Range .... -65℃ to +150℃

Junction Temperature .... 150℃

Lead Temperature (Soldering 10sec) .... 260℃

ESD Susceptibility

HBM 4000V

MM 400V

CDM 1000V

RECOMMENDED OPERATING CONDITIONS

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

Operating Temperature Range .... -40℃ to +125℃

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time.

OVERSTRESS CAUTION

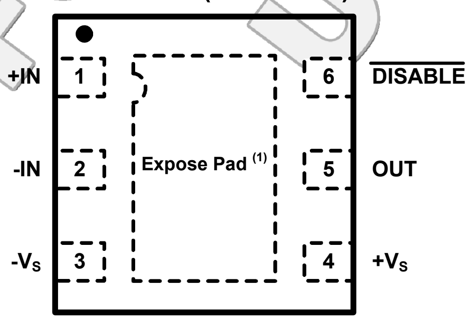
Stresses beyond those listed may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

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.

PIN CONFIGURATION

SGM8603 (TOP VIEW)



TDFN-2×2-6L

NOTE 1: Exposed pad can be connected to $-V_S$ or left floating.

ELECTRICAL CHARACTERISTICS

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

PARAMETER	CONDITIONS	SGM8603 TYP	MIN/MAX OVER TEMPERATURE				
		+25℃	+25℃	-40℃ to 85℃	-40℃ to 125℃	UNITS	MIN/ MAX
INPUT CHARACTERISTICS							
Input Offset Voltage (V_{OS})		1.1	4.9	5.1	5.4	mV	MAX
Input Bias Current (I_B)		1				pA	TYP
Input Offset Current (I_{OS})		1				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	83	67	66	65	dB	MIN
	V_S = 5.5V, V_{CM} = - 0.1V to 5.6V	77	61	60	56	dB	MIN
Open-Loop Voltage Gain (A_{OL})	R_L = 600Ω ,V_O = 0.15V to 4.85V	91	85	73	62	dB	MIN
	R_L = 10kΩ ,V_O = 0.05V to 4.95V	105	97	84	69	dB	MIN
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta_T$)		2.7				μV/℃	TYP
OUTPUT CHARACTERISTICS							
Output Voltage Swing from Rail	R_L = 600Ω	78	102	123	144	mV	MAX
	R_L = 10kΩ	7	12	14	20	mV	MAX
Output Current (I_{OUT})		64	52	25	19	mA	MIN
Closed-Loop Output Impedance	f = 1MHz, G = 1	8.5				Ω	TYP
POWER-DOWN DISABLE							
Turn-On Time		1.1				μs	TYP
Turn-Off Time		0.3				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	2.1	V	MIN
			5.5	5.5	5.5	V	MAX
Power Supply Rejection Ratio (PSRR)	V_s = +2.1V to +5.5V, V_{CM} = (-V_S) + 0.5V	80	68	67	64	dB	MIN
Quiescent Current (I_Q)	I_{OUT} = 0	1.1	1.4	1.6	1.75	mA	MAX
Supply Current when Disabled		0.5	8	9	10	μA	MAX
DYNAMIC PERFORMANCE							
Gain-Bandwidth Product (GBP)	R_L = 10kΩ	11				MHz	TYP
Phase Margin (φ_O)		62				°	TYP
Full Power Bandwidth (BW_P)	< 1% distortion	400				kHz	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} × Gain = V_S	0.6				μs	TYP
NOISE PERFORMANCE							
Voltage Noise Density (e_n)	f = 1kHz	12.5				nV/$\sqrt{Hz}$	TYP
	f = 10kHz	8.5				nV/$\sqrt{Hz}$	TYP

ELECTRICAL CHARACTERISTICS

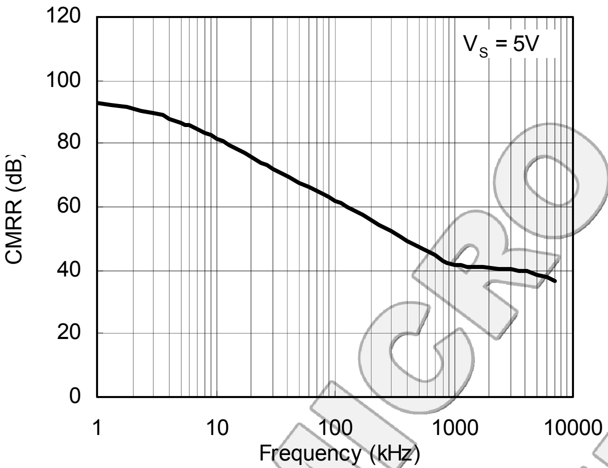
(At T_A = +25℃, V_S = +2.1V, V_{CM} = V_S/2, R_L = 600Ω, unless otherwise noted.)

PARAMETER	CONDITIONS	SGM8603					
		TYP	MIN/MAX OVER TEMPERATURE				
		+25℃	+25℃	-40℃ to 85℃	-40℃ to 125℃	UNITS	MIN/ MAX
INPUT CHARACTERISTICS							
Input Offset Voltage (V_{OS})		1	5.2	5.5	5.6	mV	MAX
Input Bias Current (I_B)		1				pA	TYP
Input Offset Current (I_{OS})		1				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	77	60	59	51	dB	MIN
	V_S = 2.1V, V_{CM} = - 0.1V to 2.2V	70	55	53	49	dB	MIN
Open-Loop Voltage Gain (A_{OL})	R_L = 600Ω ,V_O = 0.15V to 1.95V	88	78	68	58	dB	MIN
	R_L = 10kΩ ,V_O = 0.05V to 2.05V	100	89	82	67	dB	MIN
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta_T$)		2.9				μV/℃	TYP
OUTPUT CHARACTERISTICS							
Output Voltage Swing from Rail	R_L = 600Ω	38	50	59	66	mV	MAX
	R_L = 10kΩ	4	9	11	12	mV	MAX
Output Current (I_{OUT})		28	23	17	14	mA	MIN
Closed-Loop Output Impedance	f = 1MHz, G = 1	9.3				Ω	TYP
POWER-DOWN DISABLE							
Turn-On Time		7.7				μs	TYP
Turn-Off Time		0.5				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	1.1	1.4	1.6	1.75	mA	MAX
Supply Current when Disabled		0.5	8	9	10	μA	MAX
DYNAMIC PERFORMANCE							
Gain-Bandwidth Product (GBP)	R_L = 10kΩ	11.5				MHz	TYP
Phase Margin (φ_O)		59				°	TYP
Full Power Bandwidth (BW_P)	< 1% distortion	400				kHz	TYP
Slew Rate (SR)	G = 1, 2V output step	8				V/μs	TYP
Settling Time to 0.1% (t_S)	G = 1, 2V output step	0.23				μs	TYP
Overload Recovery Time	V_{IN} × Gain = V_S	1				μs	TYP
NOISE PERFORMANCE							
Voltage Noise Density (e_n)	f = 1kHz	15				$nV/\sqrt{Hz}$	TYP
	f = 10kHz	9				$nV/\sqrt{Hz}$	TYP

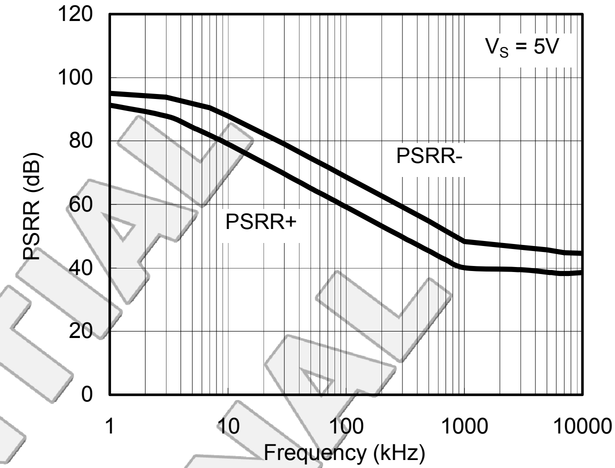
TYPICAL PERFORMANCE CHARACTERISTICS

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

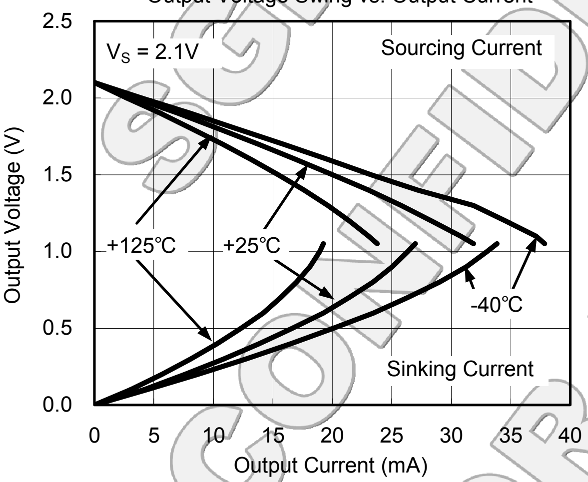
CMRR vs. Frequency



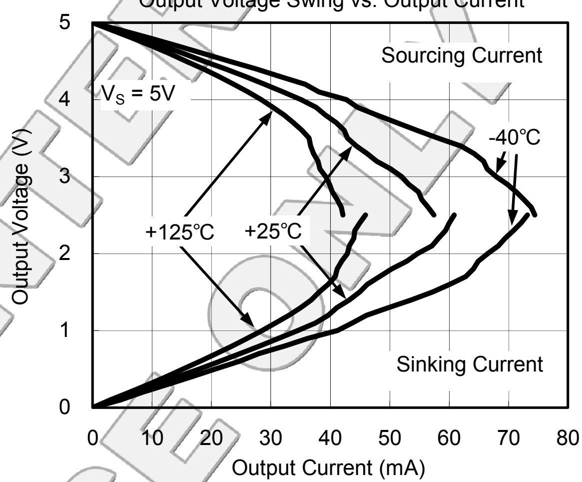
PSRR vs. Frequency



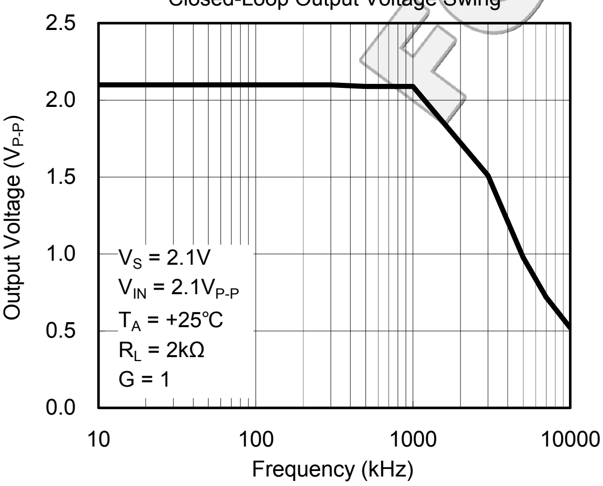
Output Voltage Swing vs. Output Current



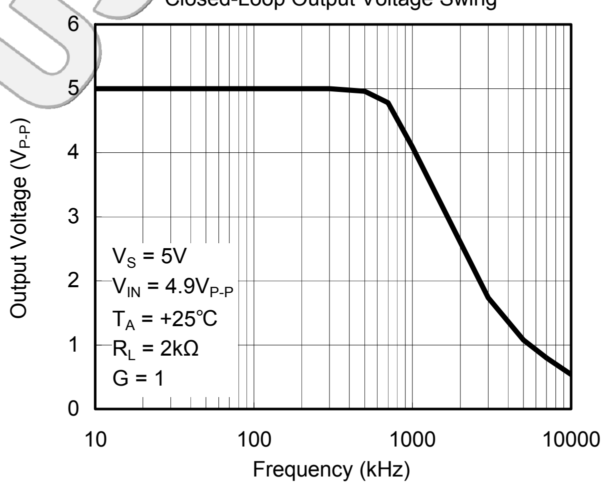
Output Voltage Swing vs. Output Current



Closed-Loop Output Voltage Swing



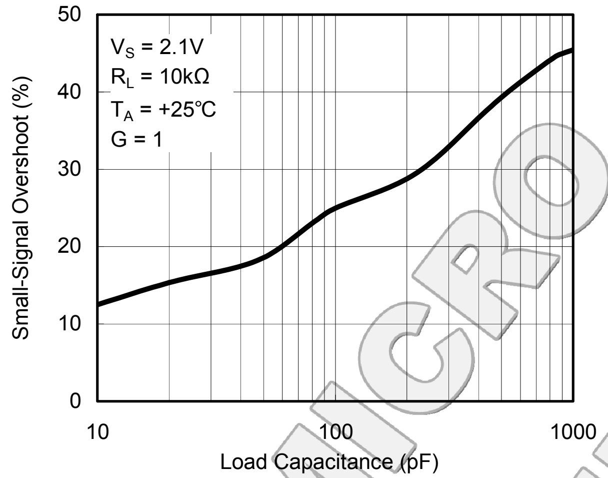
Closed-Loop Output Voltage Swing



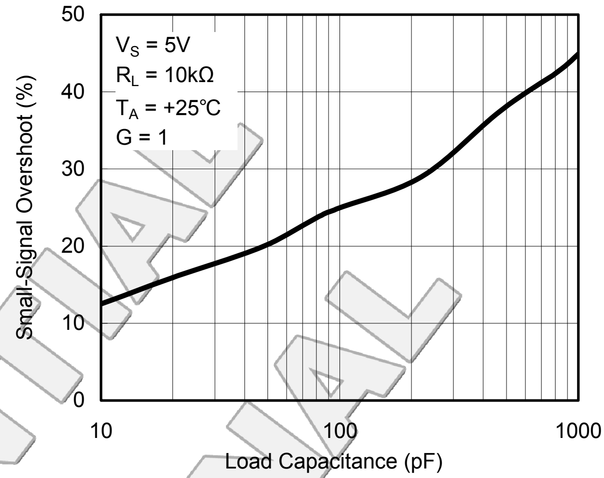
TYPICAL PERFORMANCE CHARACTERISTICS

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

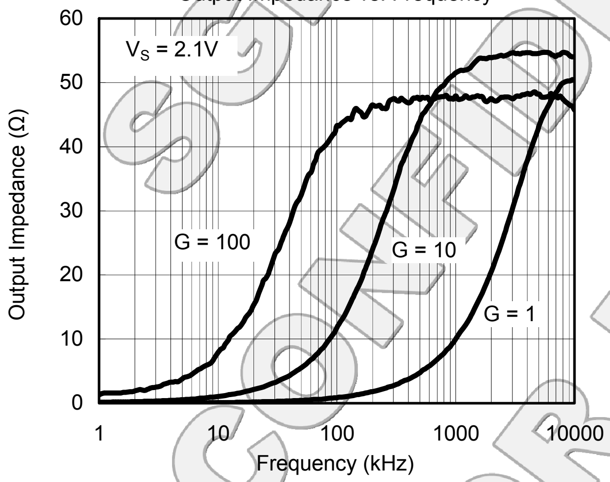
Small-Signal Overshoot vs. Load Capacitance



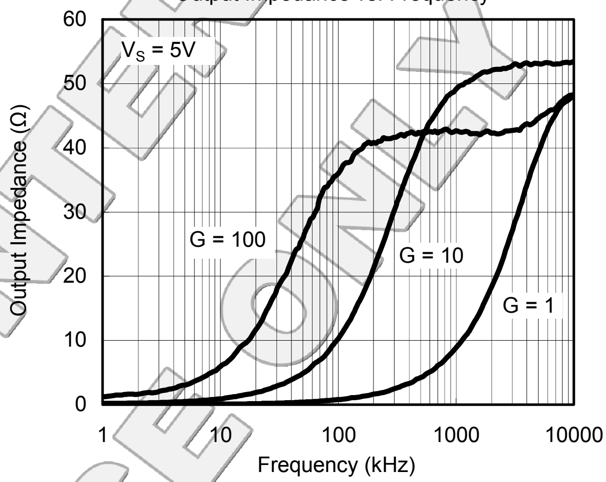
Small-Signal Overshoot vs. Load Capacitance



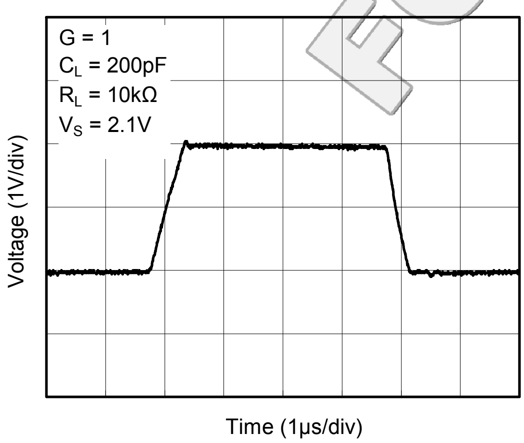
Output Impedance vs. Frequency



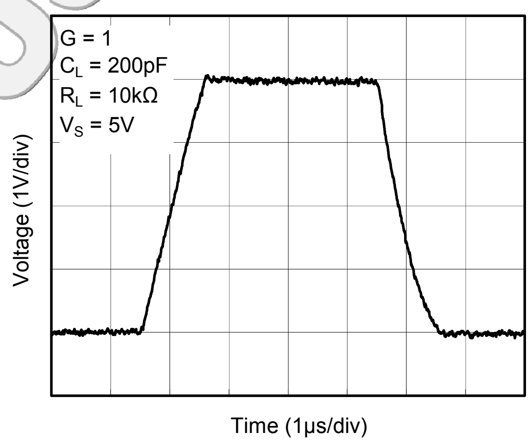
Output Impedance vs. Frequency



Large-Signal Step Response



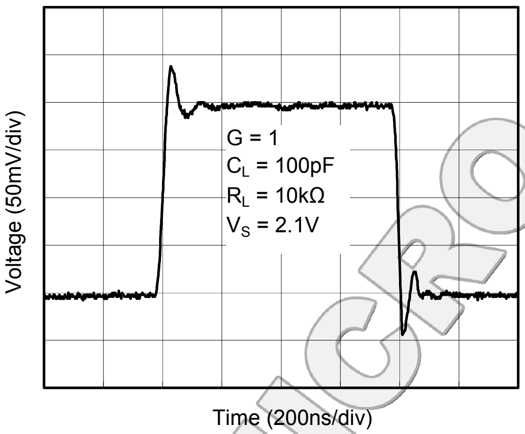
Large-Signal Step Response



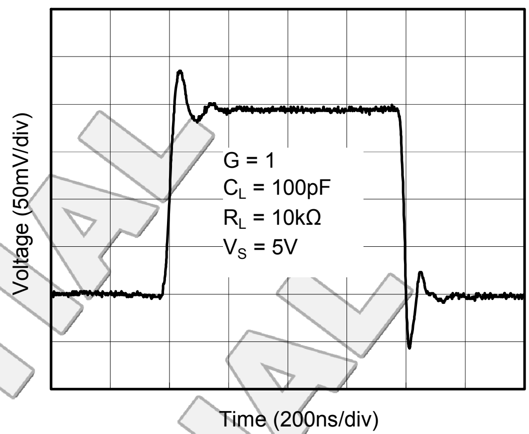
TYPICAL PERFORMANCE CHARACTERISTICS

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

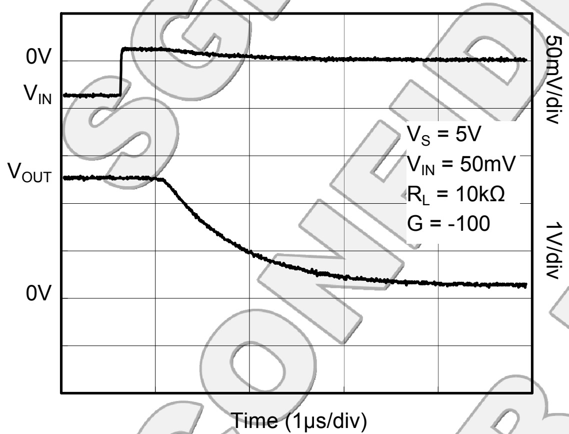
Small-Signal Step Response



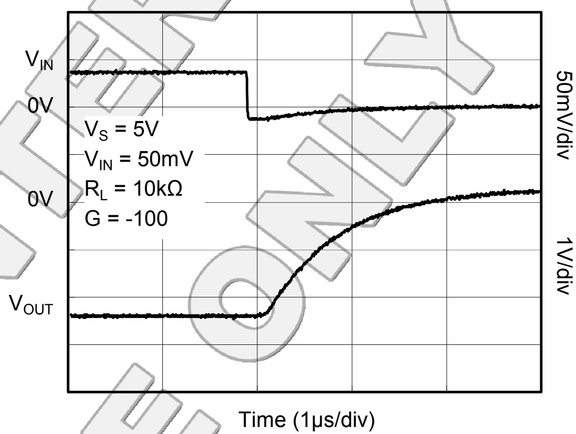
Small-Signal Step Response



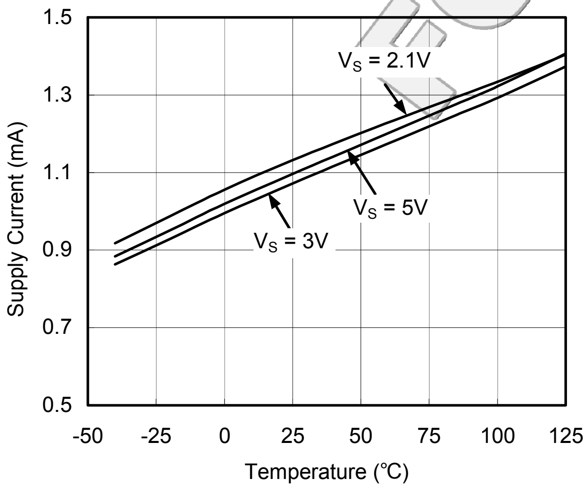
Positive Overload Recovery



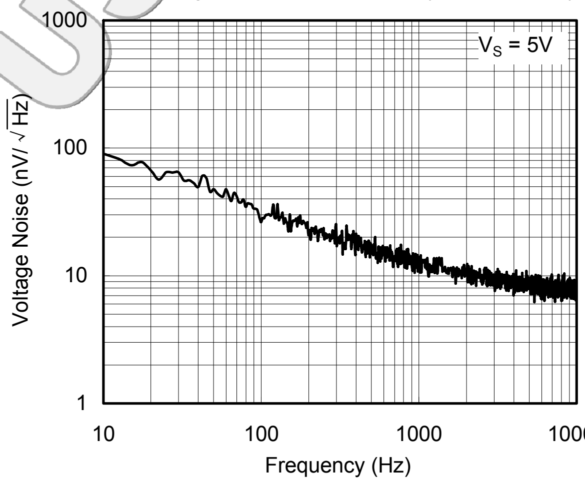
Negative Overload Recovery



Supply Current vs. Temperature



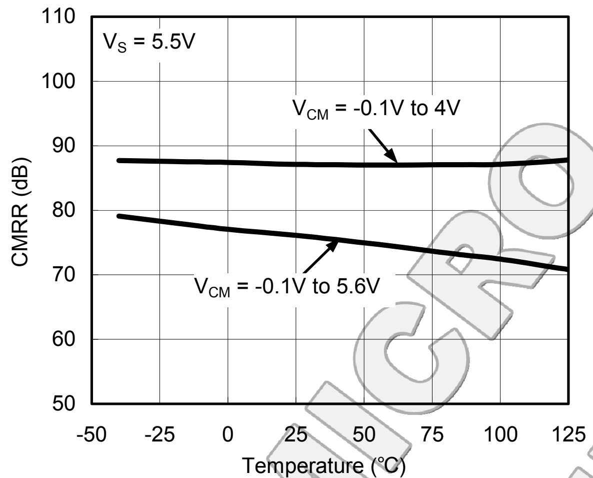
Input Voltage Noise Spectral Density vs. Frequency



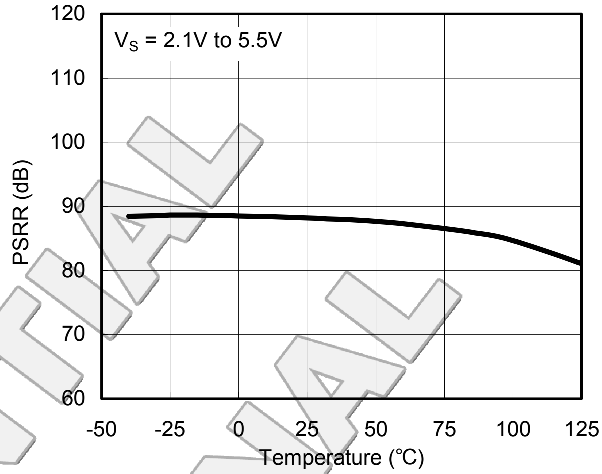
TYPICAL PERFORMANCE CHARACTERISTICS

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

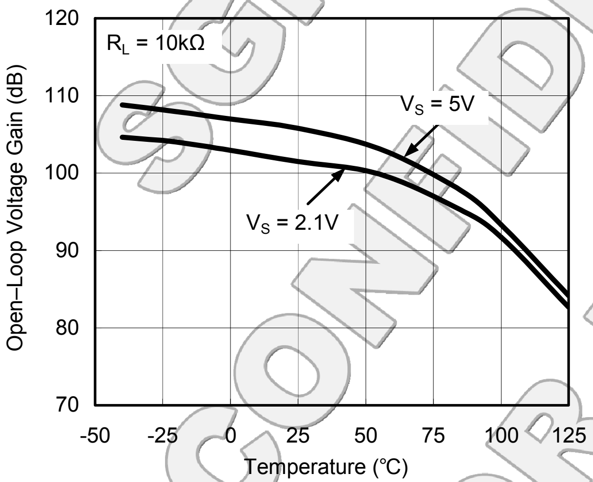
CMRR vs. Temperature



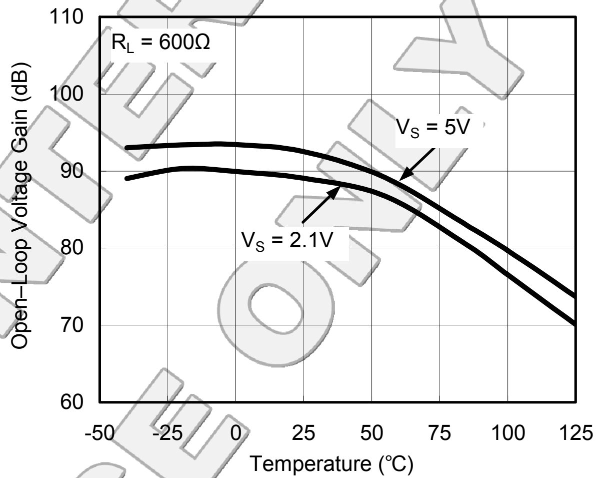
PSRR vs. Temperature



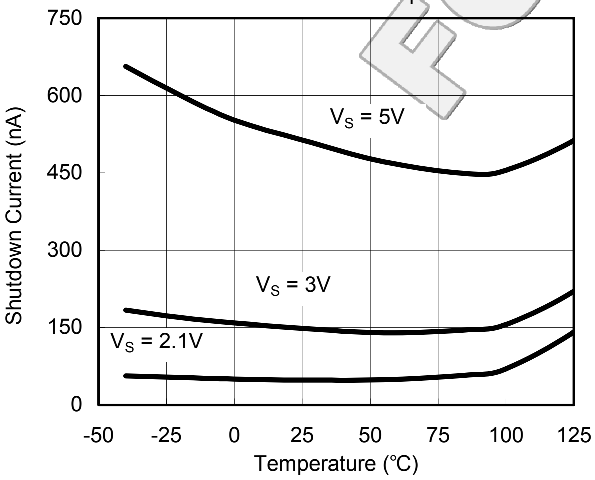
Open-Loop Voltage Gain vs. Temperature



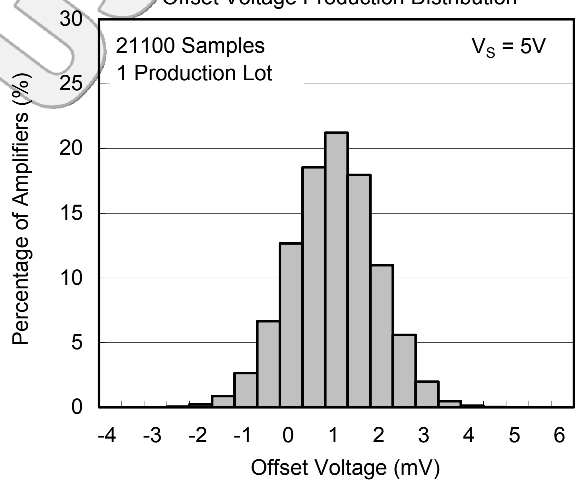
Open-Loop Voltage Gain vs. Temperature



Shutdown Current vs. Temperature



Offset Voltage Production Distribution



APPLICATION INFORMATION

Driving Capacitive Loads

The SGM8603 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}.

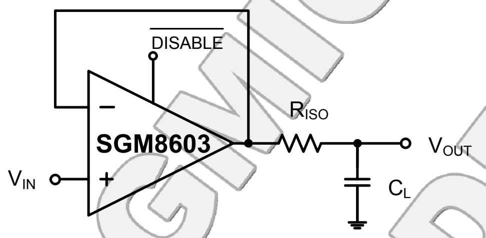


Figure 1. Indirectly Driving Heavy Capacitive Load

An improved circuit is shown 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.

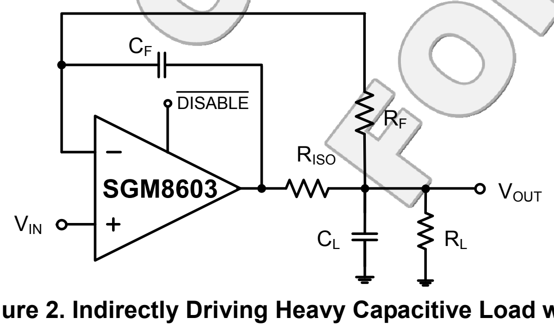


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

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 SGM8603 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 op amp'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 interfacing).

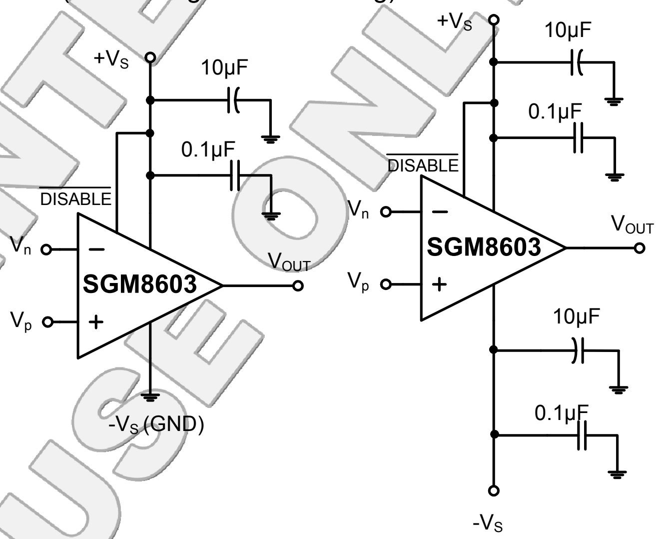


Figure 3. Amplifier with Bypass Capacitors

Grounding

A ground plane layer is important for SGM8603 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.

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.

TYPICAL APPLICATION CIRCUITS

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 $V_{OUT} = (V_p - V_n) \times R_2/R_1 + V_{REF}$.

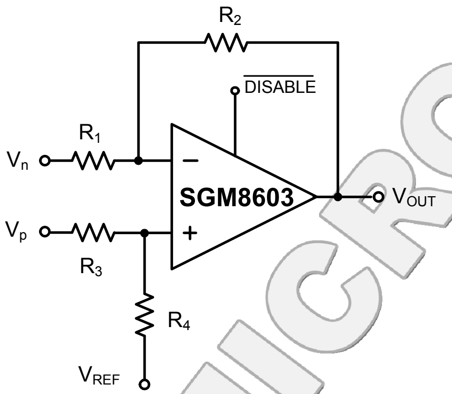


Figure 4. Differential Amplifier

Instrumentation Amplifier

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

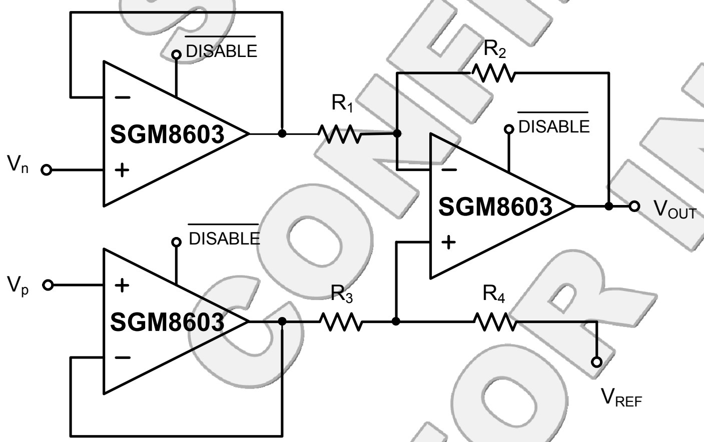


Figure 5. Instrumentation Amplifier

Low-Pass Active 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. The large values of feedback resistors 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.

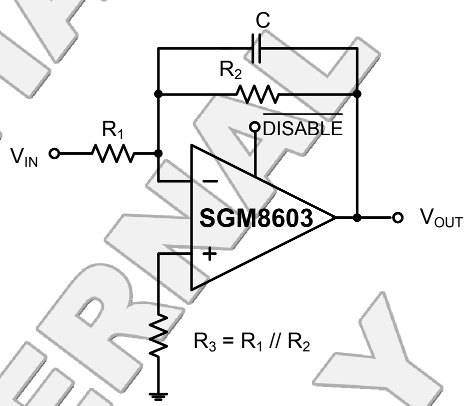
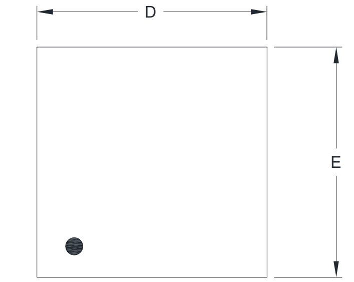


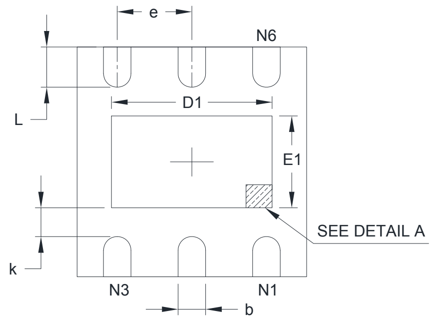
Figure 6. Low-Pass Active Filter

PACKAGE OUTLINE DIMENSIONS

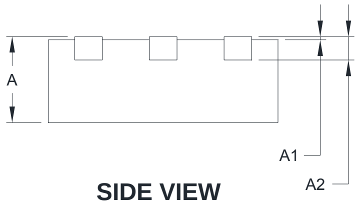
TDFN-2×2-6L



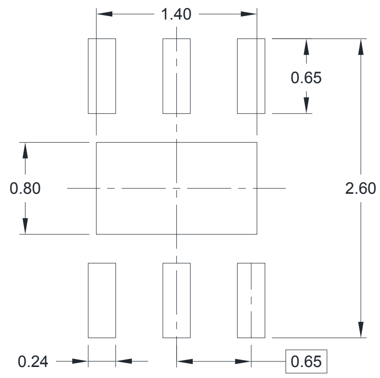
TOP VIEW



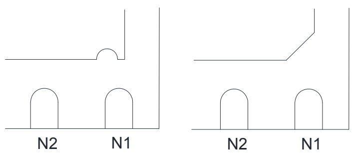
BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN (Unit: mm)



DETAIL A

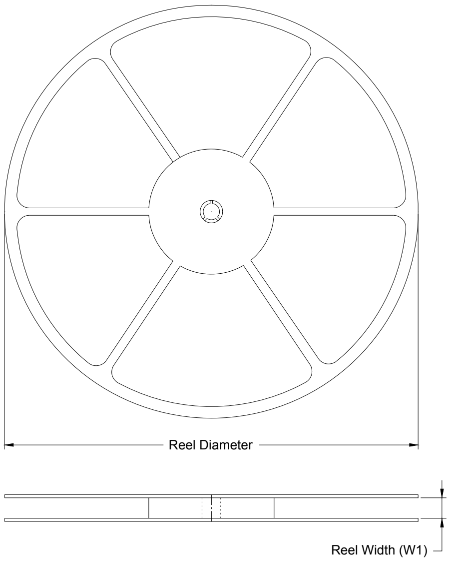
Pin #1 ID and Tie Bar Mark Options

NOTE: The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

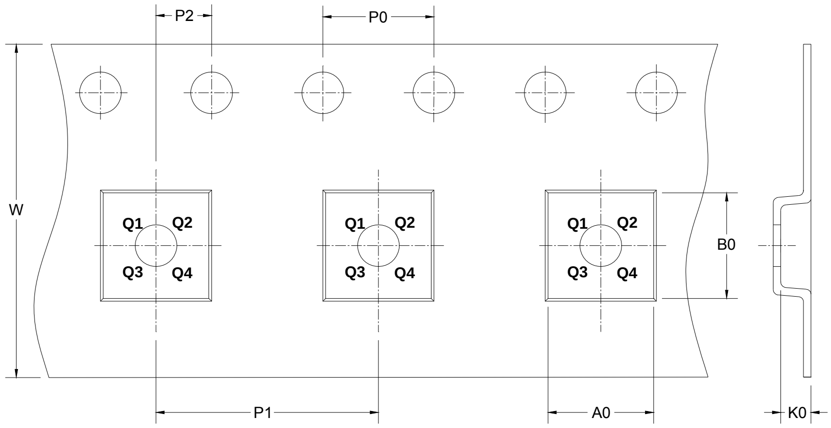
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.900	2.100	0.075	0.083
D1	1.100	1.450	0.043	0.057
E	1.900	2.100	0.075	0.083
E1	0.600	0.850	0.024	0.034
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.650 TYP		0.026 TYP	
L	0.250	0.450	0.010	0.018

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

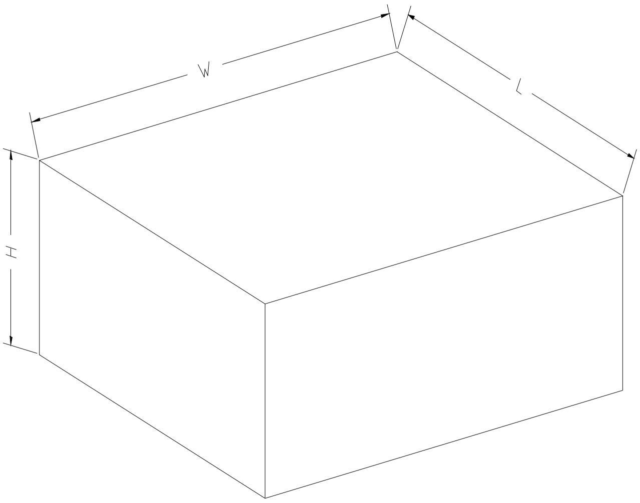
NOTE: The picture is only for reference. Please make the object as the standard.

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-2×2-6L	7″	9.5	2.30	2.30	1.10	4.00	4.00	2.00	8.00	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

REVISION HISTORY

VERSION	DATE	PAGE	LOCATION	REMARK