SGM721Q Automotive, 11MHz, Rail-to-Rail I/O CMOS Operational Amplifier

GENERAL DESCRIPTION

The SGM721Q is a single, low voltage, low noise and low power operational amplifier for automotive applications. This device can operate from 2.1V to 5.5V single supply, and consumes low quiescent current.

The SGM721Q features a ±6.5mV maximum input offset voltage. The minimum input common mode voltage is within 0.1V below the negative rail, and the output swing is rail-to-rail with heavy loads. It exhibits a high gain-bandwidth product of 11MHz and a slew rate of 6V/μs. These specifications make the operational amplifier appropriate for various applications.

The device is AEC-Q100 qualified (Automotive Electronics Council (AEC) standard Q100 Grade 1) and it is suitable for automotive applications.

The SGM721Q is available in a Green SOT-23-5 package. It operates over an ambient temperature range of -40℃ to +125℃.

FEATURES

- **AEC-Q100 Qualified for Automotive Applications**
  Device Temperature Grade 1
  T_A = -40℃ to +125℃
- **Input Offset Voltage: ±6.5mV (MAX)**
- **High Gain-Bandwidth Product: 11MHz**
- **High Slew Rate: 6V/μs**
- **Settling Time to 0.1%: 0.4μs**
- **Overload Recovery Time: 0.8μs**
- **Low Noise: 8.5nV/$\sqrt{Hz}$ at 10kHz**
- **Rail-to-Rail Input and Output**
- **Supply Voltage Range: 2.1V to 5.5V**
- **Input Voltage Range: -0.1V to 5.6V with V_S = 5.5V**
- **Low Quiescent Current: 1.2mA (TYP)**
- **Available in a Green SOT-23-5 Package**

APPLICATIONS

Automotive Application
Sensor
Automotive Inverter
Automotive Audio
Active Filter
Driver of A/D Converter
Photodiode Amplification

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM721Q	SOT-23-5	-40℃ to +125℃	SGM721QN5G/TR	0GQXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XX = Date Code.

YYY X X
- X — Date Code - Week
- X — Date Code - Year
- YYY — 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
Package Thermal Resistance
SOT-23-5, θ_{JA} .... 163.5℃/W
Junction Temperature...+150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s)............................+260℃
ESD Susceptibility
HBM...8000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

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

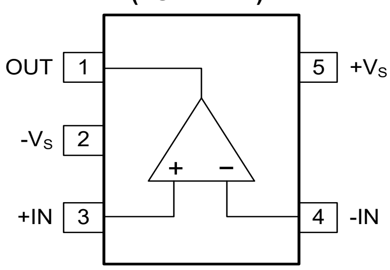
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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



SOT-23-5

ELECTRICAL CHARACTERISTICS

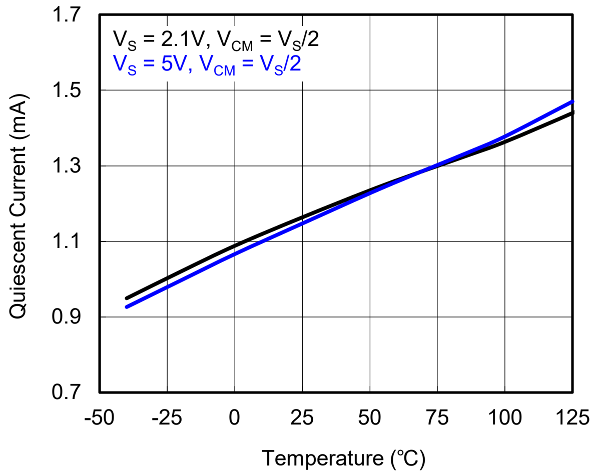
(At T_A = +25℃, V_S = 2.1V to 5V, V_{CM} = V_S/2 and R_L = 600Ω, unless otherwise noted.)

PARAMETER	CONDITIONS	TYP	MIN/MAX OVER TEMPERATURE				
		+25℃	+25℃	-40℃ to +85℃	-40℃ to +125℃	UNITS	MIN/ MAX
Input Characteristics							
Input Offset Voltage (V_{OS})		±2	±5.5	±6	±6.5	mV	MAX
Input Bias Current (I_B)		0.01		1	6	nA	MAX
Input Offset Current (I_{OS})		0.01		1	3	nA	MAX
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 = 2.1V, V_{CM} = -0.1V to 2.2V	67	53	50	46	dB	MIN
	V_S = 5.5V, V_{CM} = -0.1V to 4V	81	66	63	61	dB	MIN
	V_S = 5.5V, V_{CM} = -0.1V to 5.6V	75	60	57	55	dB	MIN
Open-Loop Voltage Gain (A_{OL})	R_L = 600Ω, V_{OUT} = 0.15V to (+V_S) - 0.15V	86	80	72	62	dB	MIN
	R_L = 10kΩ, V_{OUT} = 0.05V to (+V_S) - 0.15V	98	91	80	68	dB	MIN
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta T$)		5.5				μV/℃	TYP
Output Characteristics							
Output Voltage Swing from Rail	R_L = 600Ω	76	100	110	120	mV	MAX
	R_L = 10kΩ	6	20	30	40	mV	MAX
Output Current (I_{OUT})	V_S = 2.1V	±25	±19	±15	±13	mA	MIN
	V_S = 5V	±58	±48	±38	±34	mA	MIN
Closed-Loop Output Impedance	f = 1MHz, G = +1	9.5				Ω	TYP
Power Supply							
Operating Voltage Range					2.1	V	MIN
					5.5	V	MAX
Power Supply Rejection Ratio (PSRR)	V_S = 2.1V to 5.5V, V_{CM} = (-V_S) + 0.5V	79	67	64	62	dB	MIN
Quiescent Current (I_Q)	I_{OUT} = 0A	1.2	1.5	1.7	1.85	mA	MAX
Dynamic Performance							
Gain-Bandwidth Product (GBP)	C_L = 50pF	11				MHz	TYP
Phase Margin (φ_O)	C_L = 50pF	60				°	TYP
Full-Power Bandwidth (BW_P)	< 1% distortion, V_{OUT} = 1V_{P-P}	200				kHz	TYP
Slew Rate (SR)	G = +1	6				V/μs	TYP
Settling Time to 0.1% (t_S)	G = +1	0.4				μs	TYP
Overload Recovery Time	V_{IN} × G = V_S	0.8				μs	TYP
Noise Performance							
Input Voltage Noise Density (e_n)	f = 1kHz	12.5				nV/$\sqrt{Hz}$	TYP
	f = 10kHz	8.5				nV/$\sqrt{Hz}$	TYP

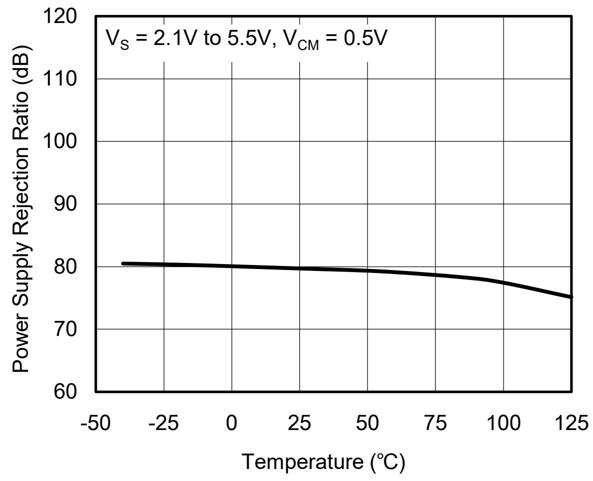
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_S = 5V, unless otherwise noted.

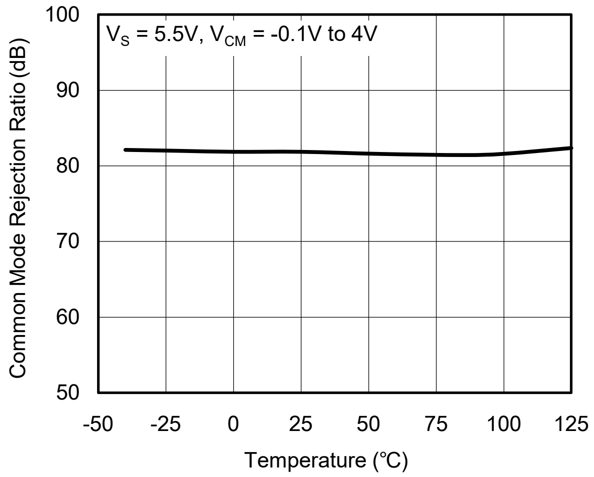
Quiescent Current vs. Temperature



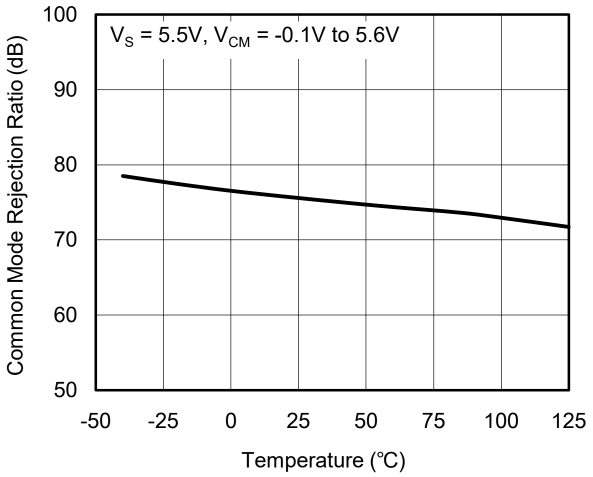
PSRR vs. Temperature



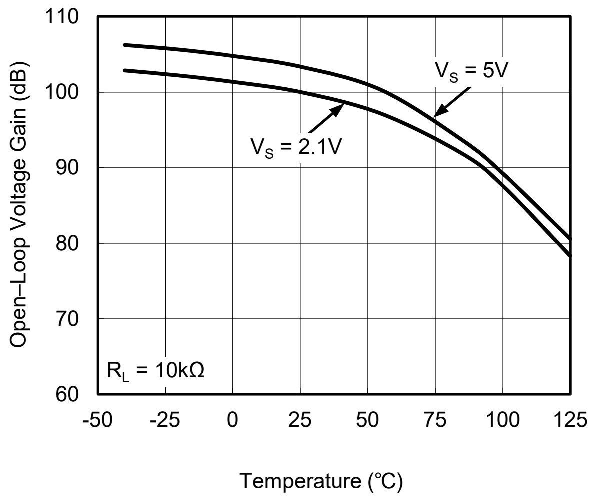
CMRR vs. Temperature



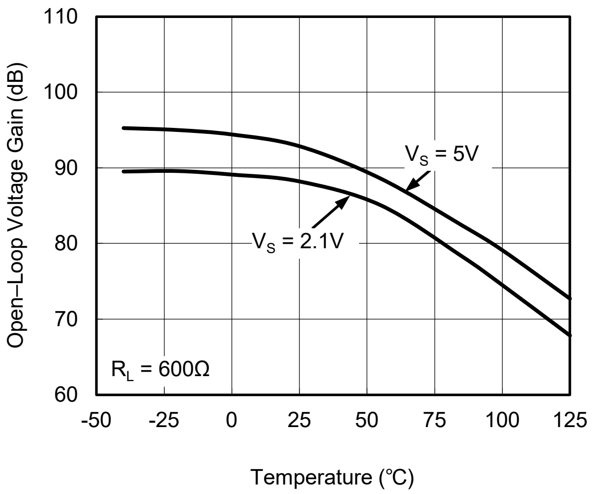
CMRR vs. Temperature



Open-Loop Voltage Gain vs. Temperature



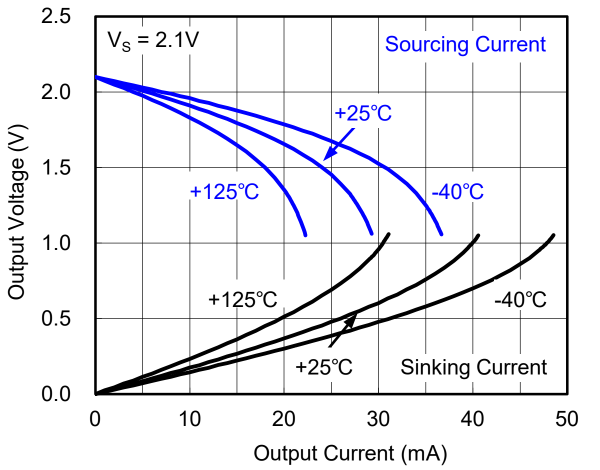
Open-Loop Voltage Gain vs. Temperature



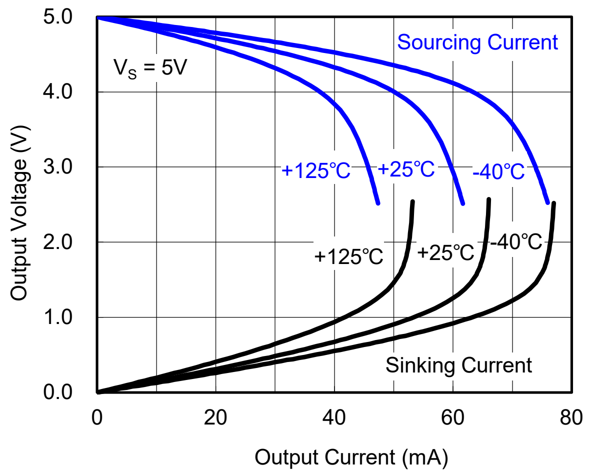
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 5V, unless otherwise noted.

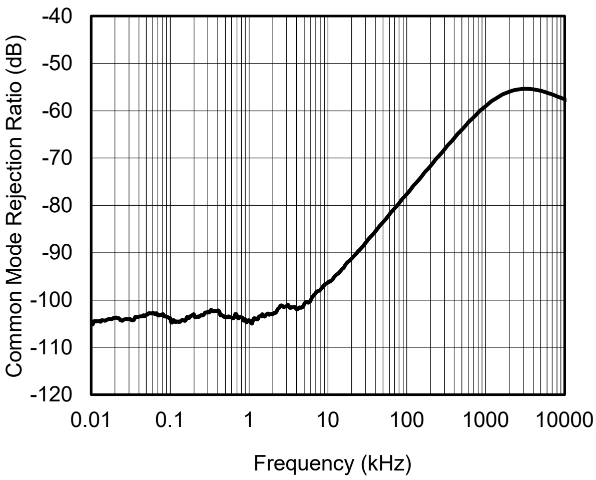
Output Voltage Swing vs. Output Current



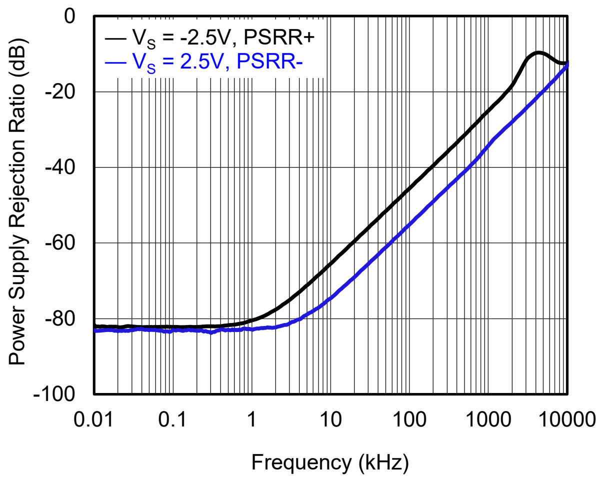
Output Voltage Swing vs. Output Current



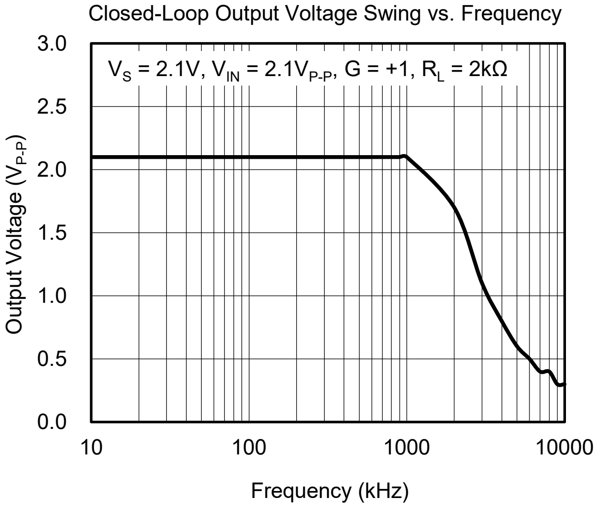
CMRR vs. Frequency



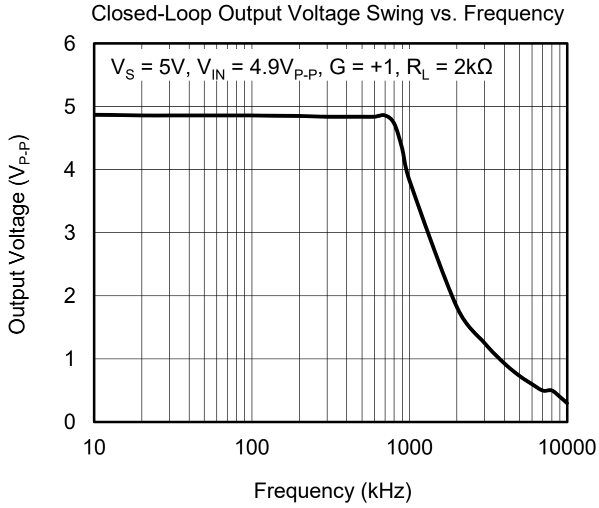
PSRR vs. Frequency



Closed-Loop Output Voltage Swing vs. Frequency

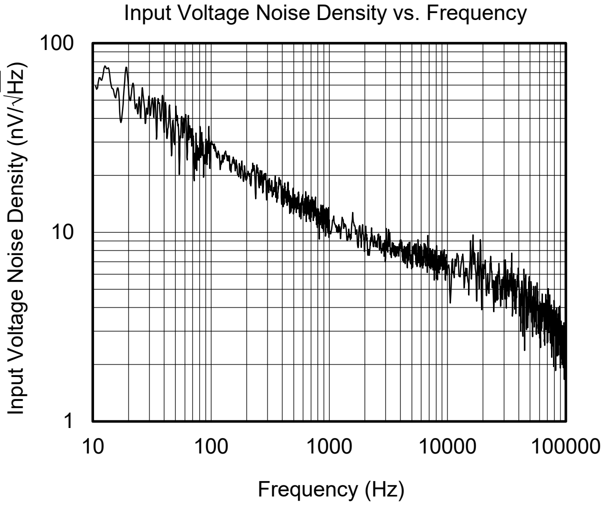


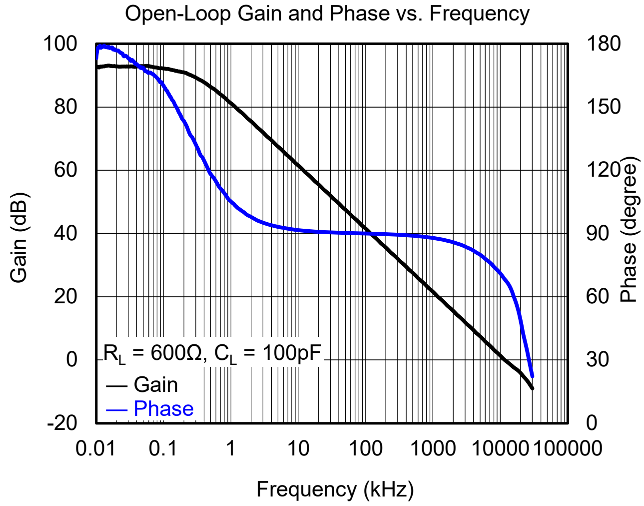
Closed-Loop Output Voltage Swing vs. Frequency

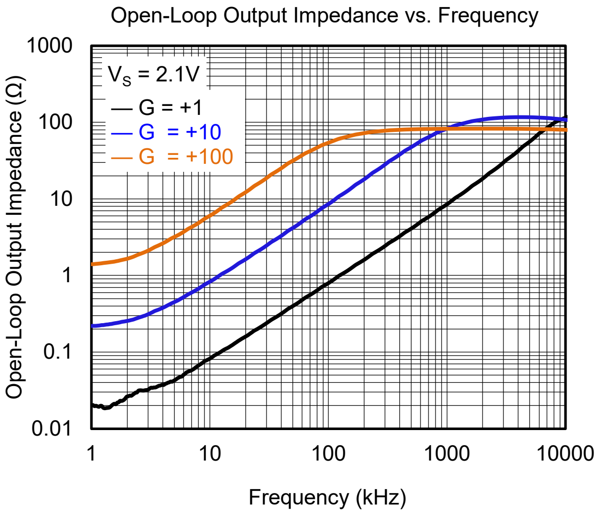


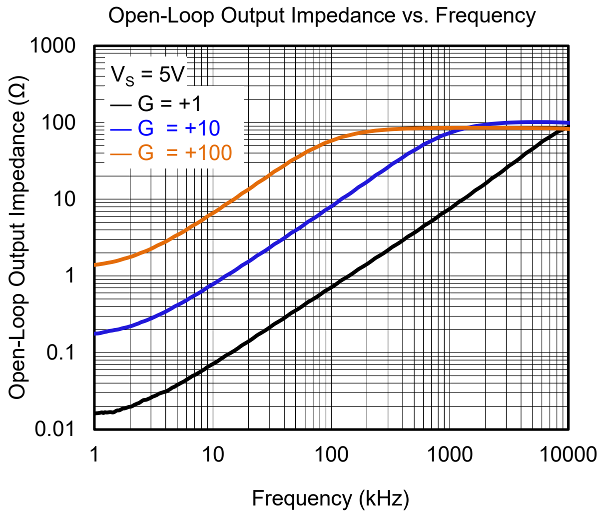
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 5V, unless otherwise noted.





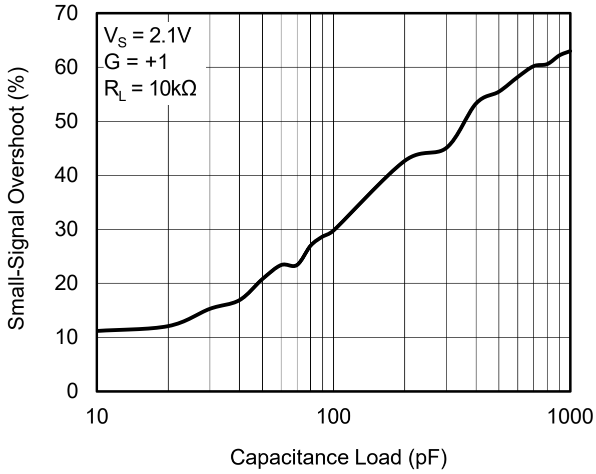




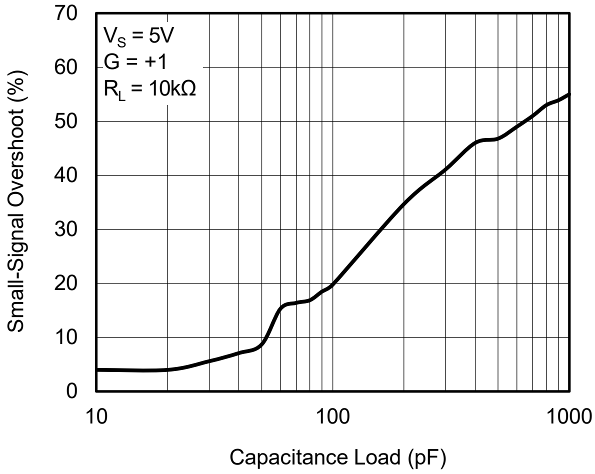
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 5V, unless otherwise noted.

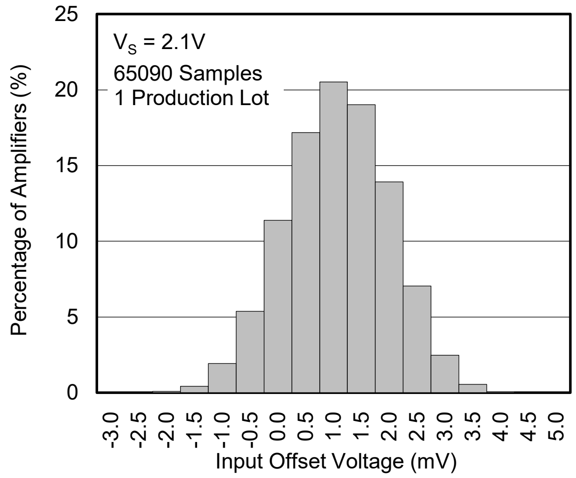
Small-Signal Overshoot vs. Load Capacitance



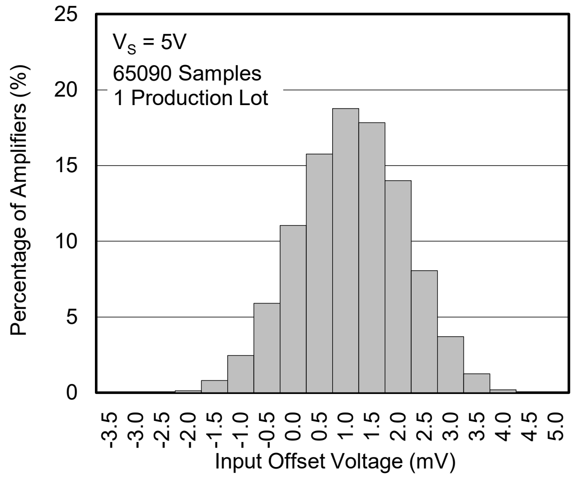
Small-Signal Overshoot vs. Load Capacitance



Input Offset Voltage Production Distribution



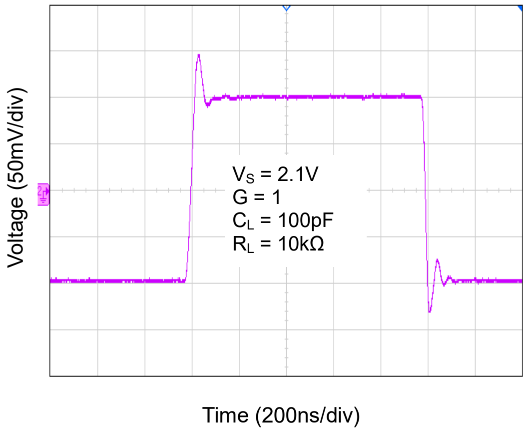
Input Offset Voltage Production Distribution



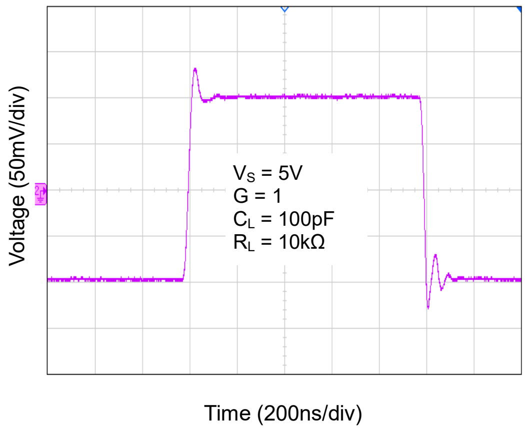
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 5V, unless otherwise noted.

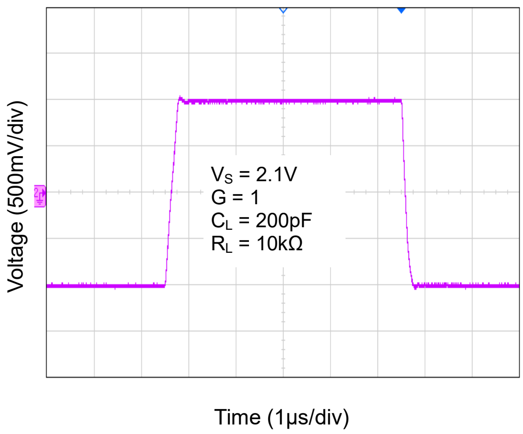
Small-Signal Step Response



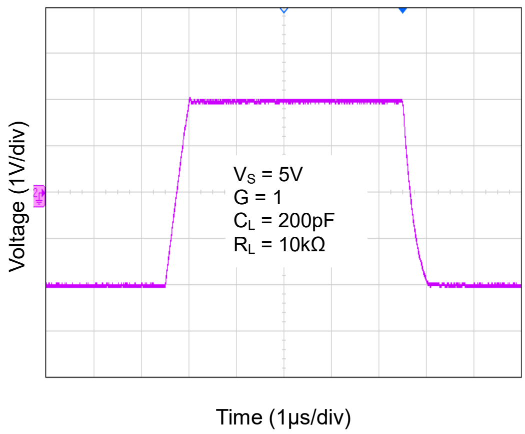
Small-Signal Step Response



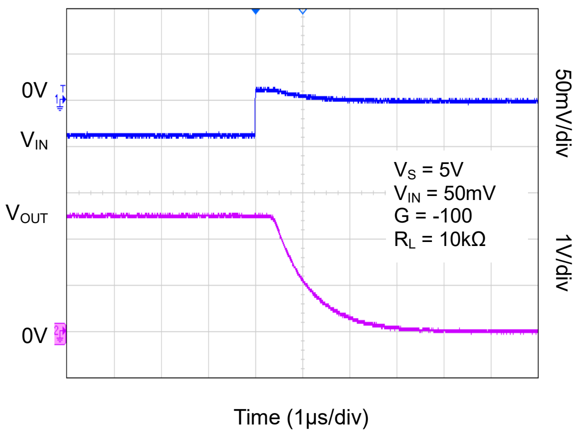
Large-Signal Step Response



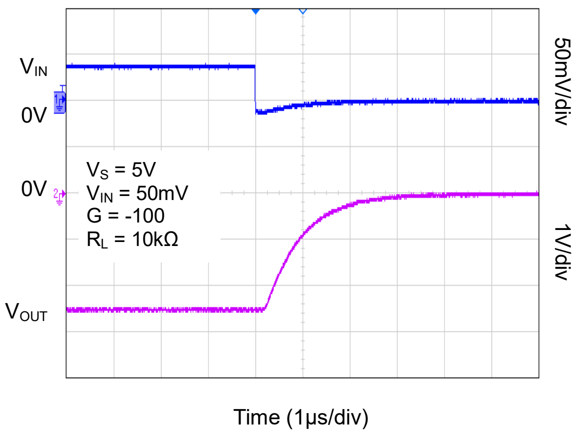
Large-Signal Step Response



Positive Overload Recovery



Negative Overload Recovery



APPLICATION INFORMATION

Rail-to-Rail Input

When SGM721Q works at the power supply between 2.1V and 5.5V, the input common mode voltage range is from ($-V_S$) - 0.1V to ($+V_S$) + 0.1V. In Figure 1, the ESD diodes between the inputs and the power supply rails will clamp the input voltage so that it does not exceed the rails.

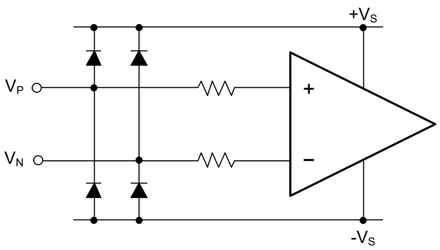


Figure 1. Input Equivalent Circuit

Input Current-Limit Protection

For ESD diode clamping protection, when the current flowing through ESD diode exceeds the maximum rating value, the ESD diode and amplifier will be damaged, so current-limit protection will be added in some applications. One resistor is selected to limit the current not to exceed the maximum rating value. In Figure 2, a series input resistor is used to limit the input current to less than 10mA, but the drawback of this current-limit resistor is that it contributes thermal noise at the amplifier input. If this resistor must be added, its value must be selected as small as possible.

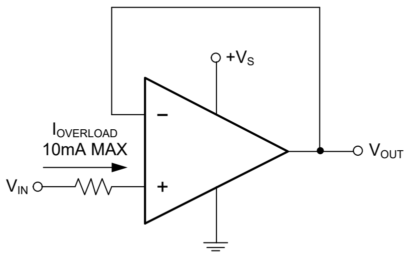


Figure 2. Input Current-Limit Protection

Rail-to-Rail Output

The SGM721Q supports rail-to-rail output operation. In single power supply application, for example, when $+V_S$ = 5V, $-V_S$ = GND, 10kΩ load resistor is tied from OUT pin to ground, the typical output swing range is from 0.006V to 4.994V.

Driving Capacitive Loads

The SGM721Q is designed for driving the 4700pF capacitive load with unity-gain stable. If greater capacitive load must be driven in application, the circuit in Figure 3 can be used. In this circuit, the IR drop voltage generated by R_{ISO} is compensated by feedback loop.

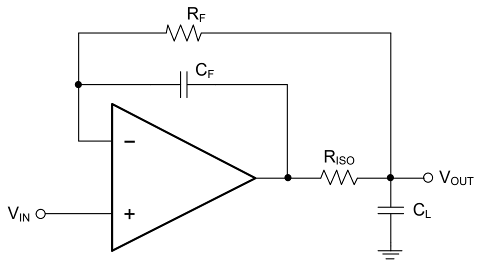


Figure 3. Circuit to Drive Heavy Capacitive Load

Power Supply Decoupling and Layout

A clean and low noise power supply is very important in amplifier circuit design. Besides of input signal noise, the power supply is one of important source of noise to the amplifier through $+V_S$ and $-V_S$ pins. Power supply bypassing is an effective method to clear up the noise at power supply, and the low impedance path to ground of decoupling capacitor will bypass the noise to GND. In application, 10μF ceramic capacitor paralleled with 0.1μF or 0.01μF ceramic capacitor is used in Figure 4. The ceramic capacitors should be placed as close as possible to $+V_S$ and $-V_S$ power supply pins.

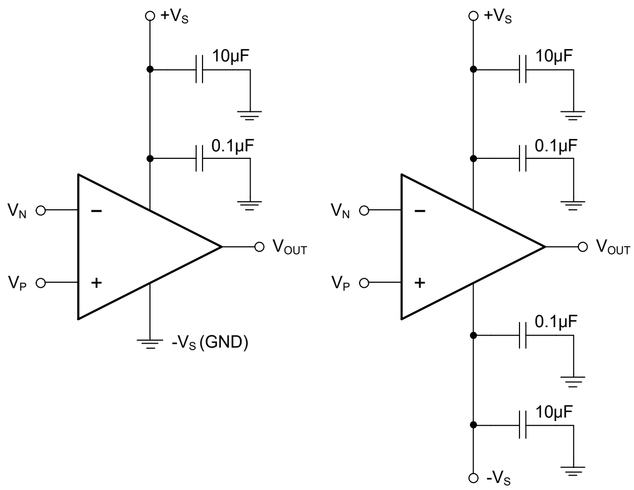


Figure 4. Amplifier Power Supply Bypassing

APPLICATION INFORMATION (continued)

Grounding

In low speed application, one node grounding technique is the simplest and most effective method to eliminate the noise generated by grounding. In high speed application, the general method to eliminate noise is to use a complete ground plane technique, and the whole ground plane will help distribute heat and reduce EMI noise pickup.

Reduce Input-to-Output Coupling

To reduce the input-to-output coupling, the input traces must be placed as far away from the power supply or output traces as possible. The sensitive trace must not be placed in parallel with the noisy trace in the same layer. They must be placed perpendicularly in different layers to reduce the crosstalk. These PCB layout techniques will help to reduce unwanted positive feedback and noise.

Typical Application Circuits

Difference Amplifier

The circuit in Figure 5 is a design example of classical difference amplifier. If $R_4/R_3 = R_2/R_1$, then $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$.

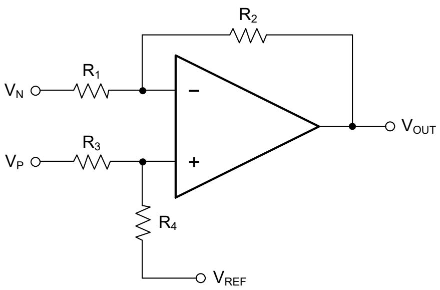


Figure 5. Difference Amplifier

High Input Impedance Difference Amplifier

The circuit in Figure 6 is a design example of high input impedance difference amplifier. The added amplifiers at the input are used to increase the input impedance and eliminate drawback of low input impedance in Figure 5.

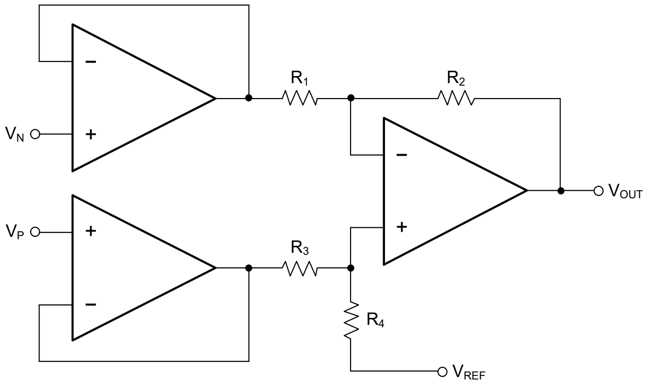


Figure 6. High Input Impedance Difference Amplifier

Active Low-Pass Filter

The circuit in Figure 7 is a design example of active low-pass filter, the DC gain is equal to $-R_2/R_1$ and the -3dB corner frequency is equal to $1/(2\pi R_2C)$. In this design, the filter bandwidth must be less than the bandwidth of the amplifier, and the resistor values must be selected as low as possible to reduce ringing or oscillation generated by the parasitic parameters in PCB layout.

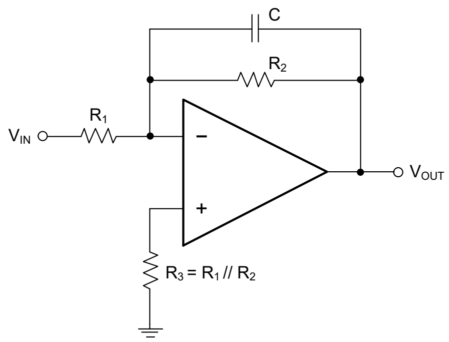


Figure 7. Active Low-Pass Filter

REVISION HISTORY

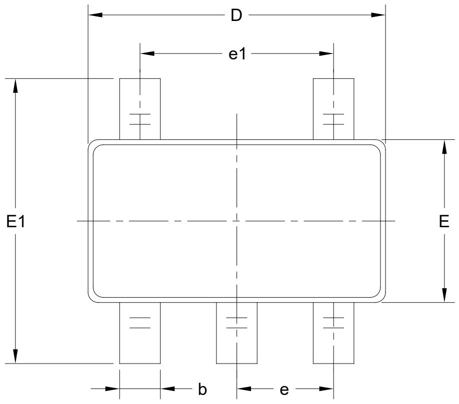
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

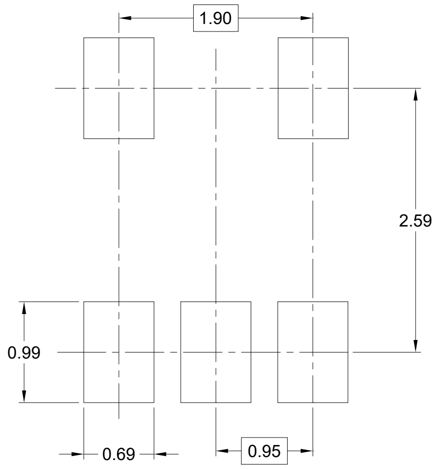
JANUARY 2025 – REV.A to REV.A.1	Page
Updated General Description section	1
Updated Features section	1

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

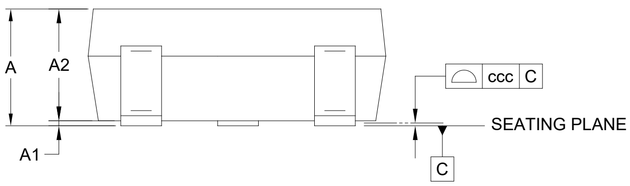
PACKAGE OUTLINE DIMENSIONS

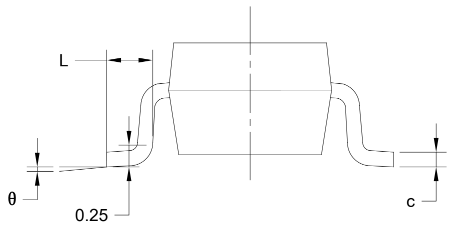
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)



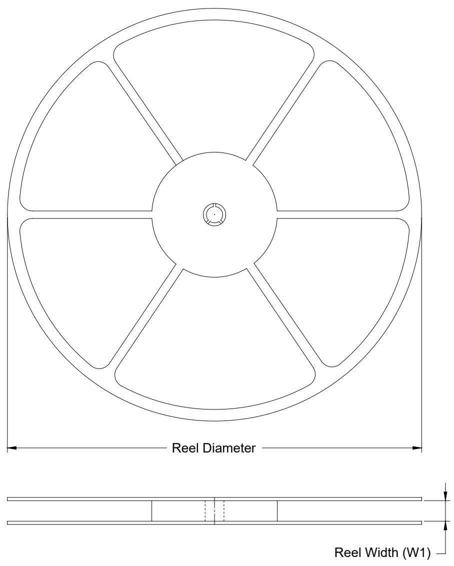


Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	-	-	1.450
A1	0.000	-	0.150
A2	0.900	-	1.300
b	0.300	-	0.500
c	0.080	-	0.220
D	2.750	-	3.050
E	1.450	-	1.750
E1	2.600	-	3.000
e	0.950 BSC		
e1	1.900 BSC		
L	0.300	-	0.600
θ	0°	-	8°
ccc	0.100		

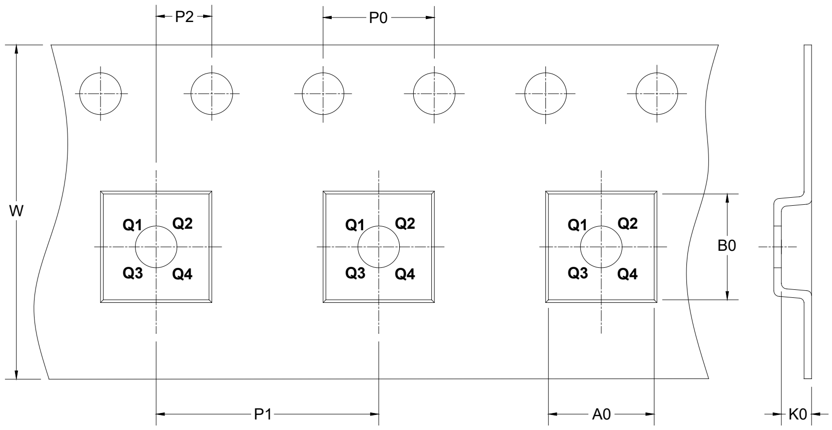
NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MO-178.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

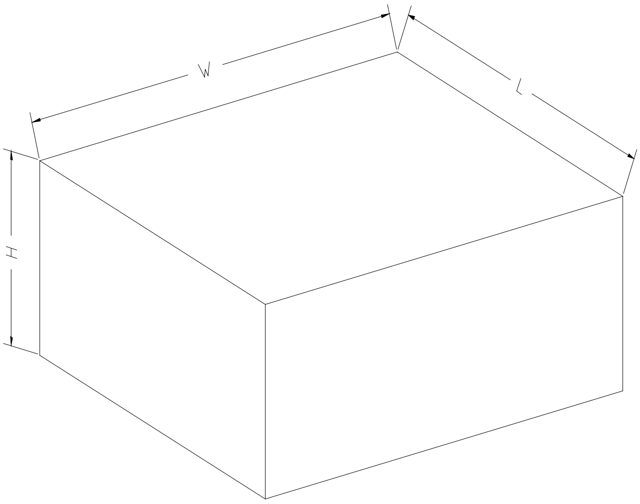
NOTE: The picture is only for reference. Please make the object as the standard.

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
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

DD0002