SGM8602
2.2mA, 12MHz, Low Noise, Rail-to-Rail I/O Tiny Package, CMOS Operational Amplifier

GENERAL DESCRIPTION

The SGM8602 is a dual, low noise, low voltage and low power operational amplifier that can be designed into a wide range of applications. The SGM8602 has a high gain-bandwidth product of 12MHz, a slew rate of 9V/μs and a quiescent current of 2.2mA at 5V.

The SGM8602 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. The operating supply range is from 2.1V to 5.5V.

The dual SGM8602 is available in Green SOT-23-8 and TDFN-2×3-8L packages. It is specified over the extended -40℃ to +125℃ industrial temperature range.

APPLICATIONS

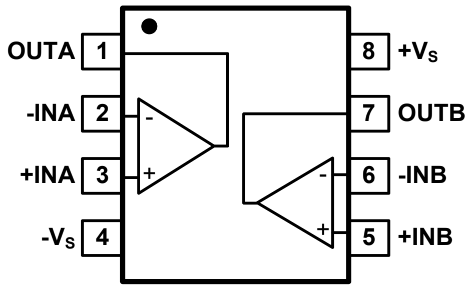
Sensors
Audio
Active Filters
A/D Converters
Communications
Test Equipment
Cellular and Cordless Phones
Laptops and PDAs
Photodiode Amplification
Battery-Powered Instrumentation

FEATURES

- **Rail-to-Rail Input and Output**
- **5.1mV Maximum Input Offset Voltage**
- **High Gain-Bandwidth Product: 12MHz**
- **High Slew Rate: 9V/μs**
- **Settling Time to 0.1% with 2V Step: 0.2μs**
- **Overload Recovery Time: 0.4μs**
- **Low Noise: $9nV/\sqrt{Hz}$ at 10kHz**
- **Supply Voltage Range: 2.1V to 5.5V**
- **Input Voltage Range: -0.1V to +5.6V with V_S = 5.5V**
- **Low Power: 2.2mA (TYP) Supply Current**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in Green SOT-23-8 and TDFN-2×3-8L Packages**

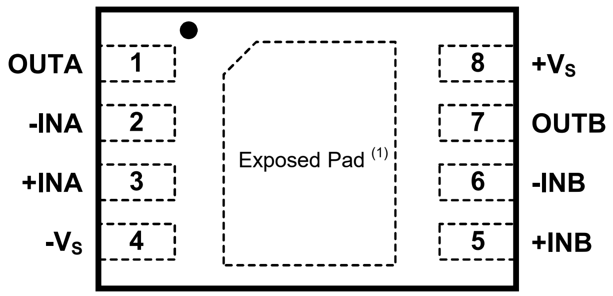
PIN CONFIGURATIONS

(TOP VIEW)



SOT-23-8

(TOP VIEW)



TDFN-2×3-8L

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

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8602	SOT-23-8	-40℃ to +125℃	SGM8602XN8G/TR	SUDXX	Tape and Reel, 3000
	TDFN-2×3-8L	-40℃ to +125℃	SGM8602XTDC8G/TR	8602 XXXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XX = Date Code. XXXX = Date Code.

SOT-23-8

YYY X X

X: Date Code - Month
X: Date Code - Year
YYY: Serial Number

TDFN-2×3-8L

XXXX

XX (last two): Date Code - Week
XX (first two): 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

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.

ELECTRICAL CHARACTERISTICS

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

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics					
Input Offset Voltage (V_{OS})			1.2	5.1	mV
	T_A = -40℃ to +125℃			5.5	
Input Bias Current (I_B)			1		pA
Input Offset Current (I_{OS})			1		pA
Input Common Mode Voltage Range (V_{CM})	V_S = 5.5V	-0.1		5.6	V
Common Mode Rejection Ratio (CMRR)	V_S = 5.5V, V_{CM} = - 0.1V to 4V	67	84		dB
	T_A = -40℃ to +125℃	66			
	V_S = 5.5V, V_{CM} = - 0.1V to 5.6V	60	75		dB
	T_A = -40℃ to +125℃	59			
Open-Loop Voltage Gain (A_{OL})	R_L = 10kΩ , V_{OUT} = 0.05V to 4.95V	97	104		dB
	T_A = -40℃ to +125℃	72			
	R_L = 600Ω , V_{OUT} = 0.15V to 4.85V	84	92		dB
	T_A = -40℃ to +125℃	64			
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta T$)			4.7		μV/℃
Output Characteristics					
Output Voltage Swing from Rail (V_{OL})	R_L = 10kΩ		6	12	mV
	T_A = -40℃ to +125℃			17	
	R_L = 600Ω		75	100	mV
	T_A = -40℃ to +125℃			144	
Output Current (I_{OUT})		52	65		mA
	T_A = -40℃ to +125℃	36			
Power Supply					
Operating Voltage Range		2.1		5.5	V
Power Supply Rejection Ratio (PSRR)	V_S = +2.1V to +5.5V, V_{CM} = ($-V_S$) + 0.5V	68	82		dB
	T_A = -40℃ to +125℃	63			
Quiescent Current (I_Q)	I_{OUT} = 0		2.2	2.8	mA
	T_A = -40℃ to +125℃			3.6	
Dynamic Performance					
Gain-Bandwidth Product (GBP)	R_L = 600Ω		12		MHz
Slew Rate (SR)	G = 1, 2V output step		9.0		V/μs
Settling Time to 0.1% (t_S)	G = 1, 2V output step		0.2		μs
Overload Recovery Time	V_{IN} × Gain = V_S		0.4		μs
Phase Margin (φ_O)	R_L = 600Ω		65		°
Noise Performance					
Input Voltage Noise Density (e_n)	f = 1kHz		13		$nV/\sqrt{Hz}$
	f = 10kHz		9		

ELECTRICAL CHARACTERISTICS (continued)

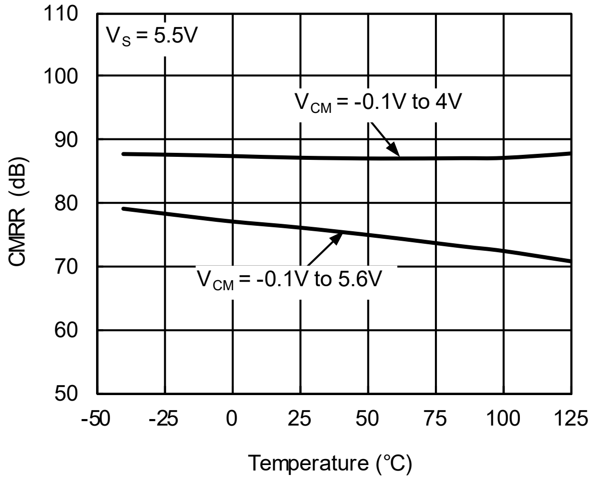
(At T_A = +25℃, V_S = 2.1V, V_{CM} = V_S/2, R_L = 600Ω, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics					
Input Offset Voltage (V_{OS})			1.2	5.5	mV
	T_A = -40℃ to +125℃			5.9	
Input Bias Current (I_B)			1		pA
Input Offset Current (I_{OS})			1		pA
Input Common Mode Voltage Range (V_{CM})	V_S = 2.1V	-0.1		2.2	V
Common Mode Rejection Ratio (CMRR)	V_S = 2.1V, V_{CM} = - 0.1V to 0.6V	60	77		dB
	T_A = -40℃ to +125℃	51			
	V_S = 2.1V, V_{CM} = - 0.1V to 2.2V	53	68		dB
	T_A = -40℃ to +125℃	46			
Open-Loop Voltage Gain (A_{OL})	R_L = 10kΩ , V_{OUT} = 0.05V to 2.05V	90	100		dB
	T_A = -40℃ to +125℃	68			
	R_L = 600Ω , V_{OUT} = 0.15V to 1.95V	75	88		dB
	T_A = -40℃ to +125℃	63			
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta T$)			4.5		μV/℃
Output Characteristics					
Output Voltage Swing from Rail (V_{OL})	R_L = 10kΩ		4	10	mV
	T_A = -40℃ to +125℃			12	
	R_L = 600Ω		36	51	mV
	T_A = -40℃ to +125℃			67	
Output Current (I_{OUT})		15	30		mA
	T_A = -40℃ to +125℃	7			
Power Supply					
Quiescent Current (I_Q)	I_{OUT} = 0		2.2	2.8	mA
	T_A = -40℃ to +125℃			3.6	
Dynamic Performance					
Gain-Bandwidth Product (GBP)	R_L = 600Ω		11.5		MHz
Slew Rate (SR)	G = 1, 2V output step		8.6		V/μs
Settling Time to 0.1% (t_S)	G = 1, 2V output step		0.2		μs
Overload Recovery Time	V_{IN} × Gain = V_S		0.7		μs
Phase Margin (φ_O)	R_L = 600Ω		65		°
Noise Performance					
Input Voltage Noise Density (e_n)	f = 1kHz		15		nV/$\sqrt{Hz}$
	f = 10kHz		9		

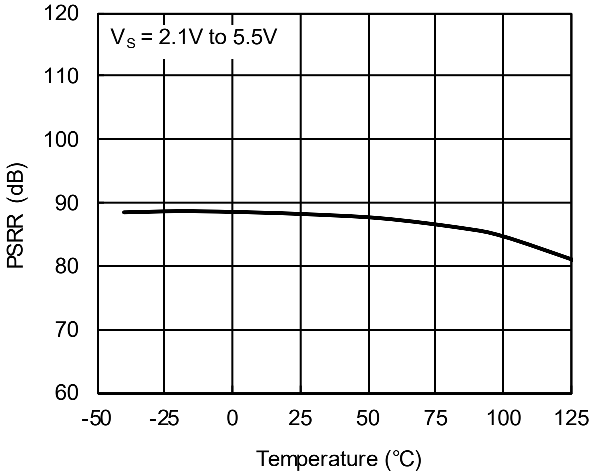
TYPICAL PERFORMANCE CHARACTERISTICS

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

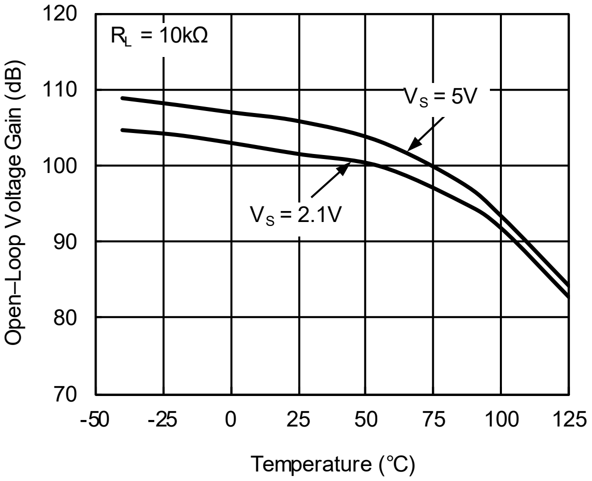
CMRR vs. Temperature



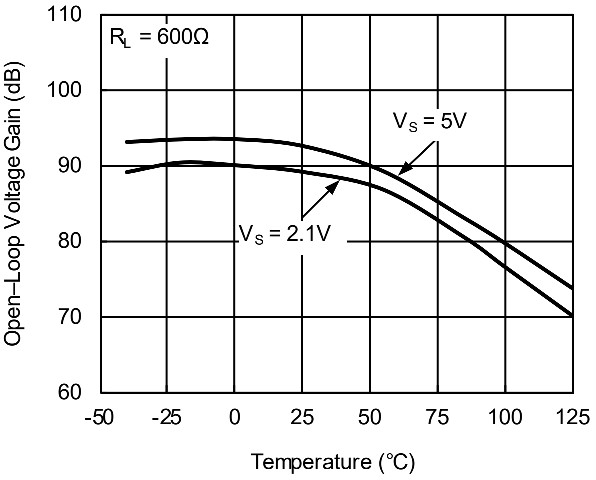
PSRR vs. Temperature



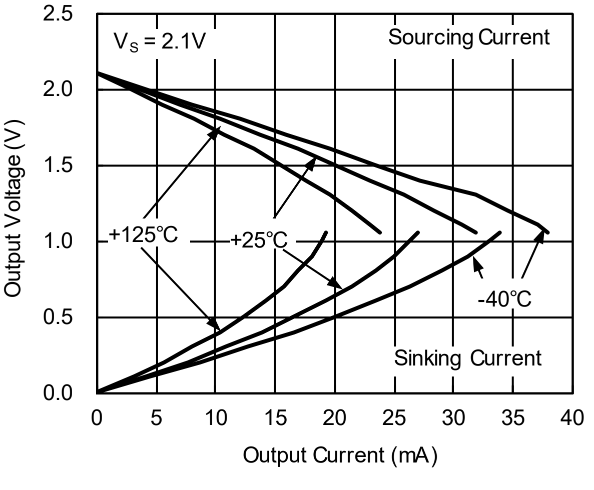
Open-Loop Voltage Gain vs. Temperature



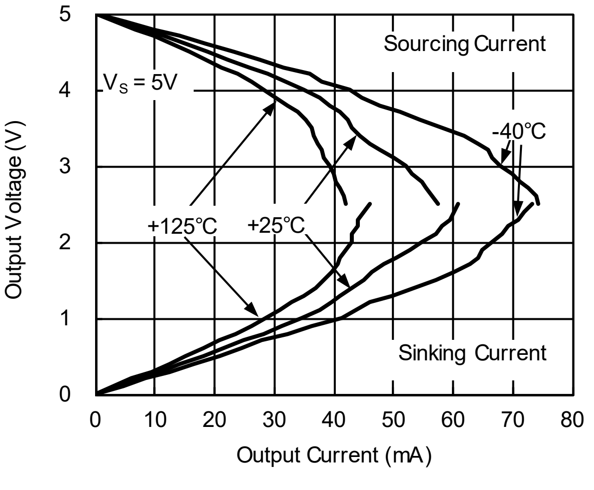
Open-Loop Voltage Gain vs. Temperature



Output Voltage Swing vs. Output Current



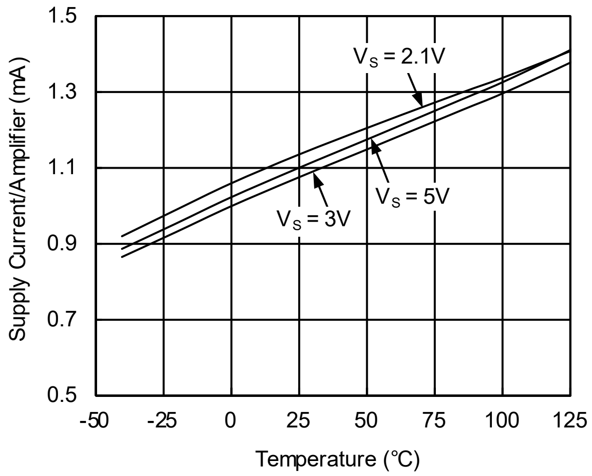
Output Voltage Swing vs. Output Current



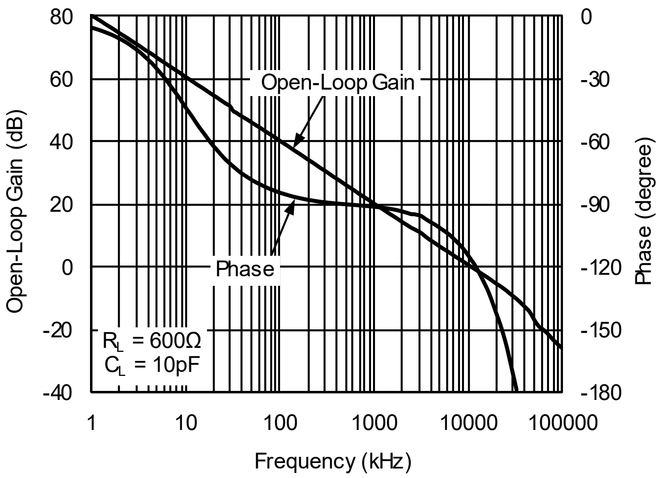
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

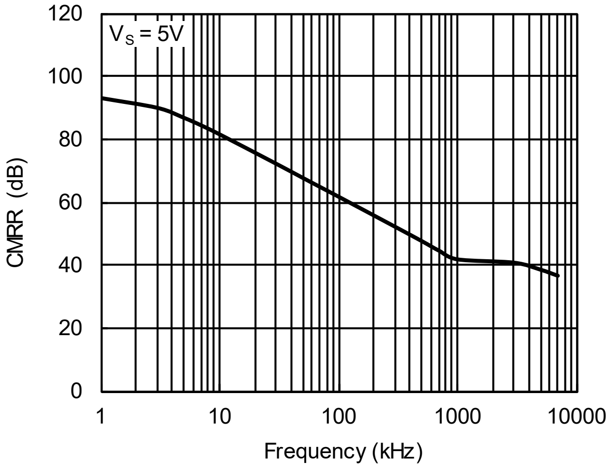
Supply Current vs. Temperature



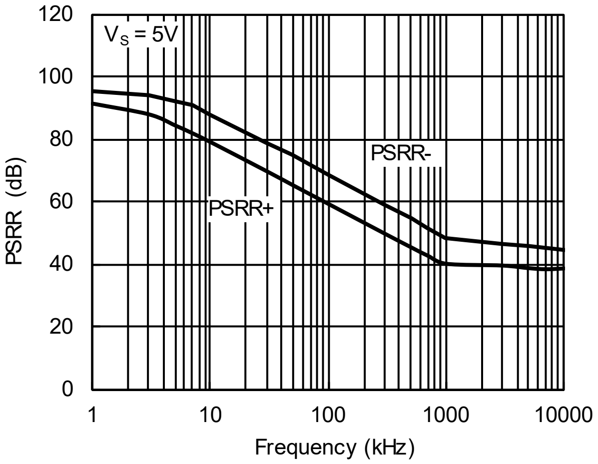
Open-Loop Gain and Phase vs. Frequency



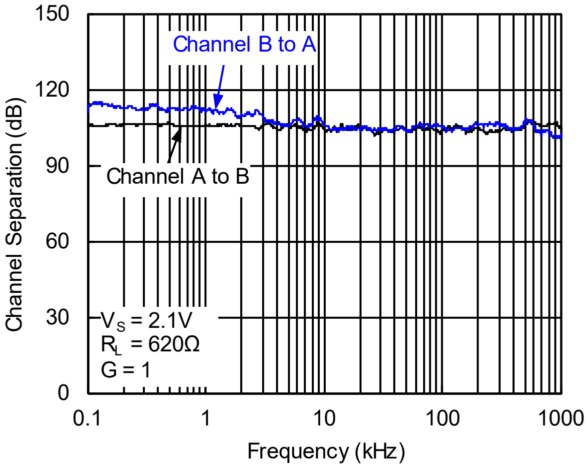
CMRR vs. Frequency



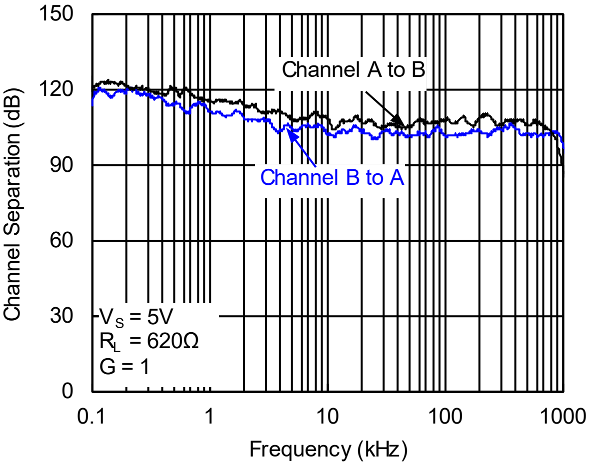
PSRR vs. Frequency



Channel Separation vs. Frequency

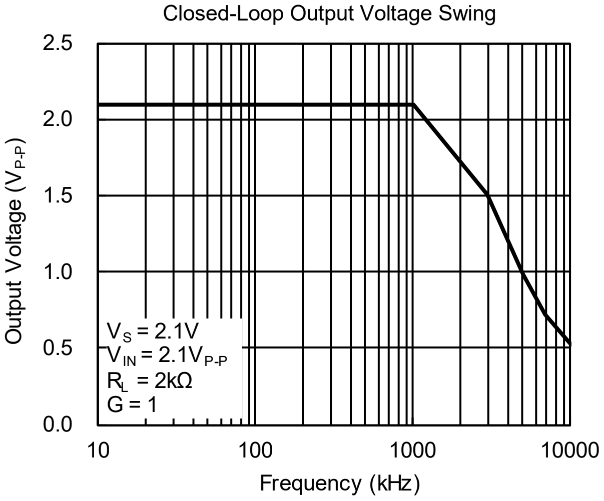


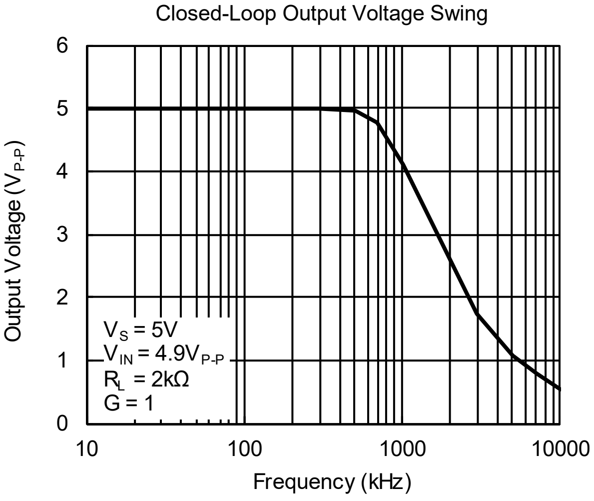
Channel Separation vs. Frequency

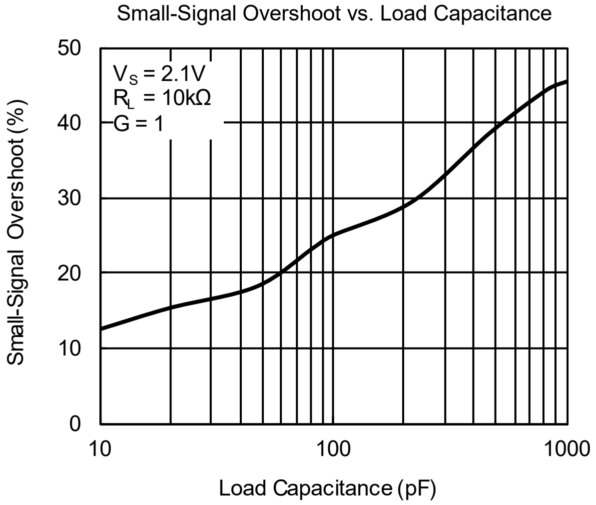


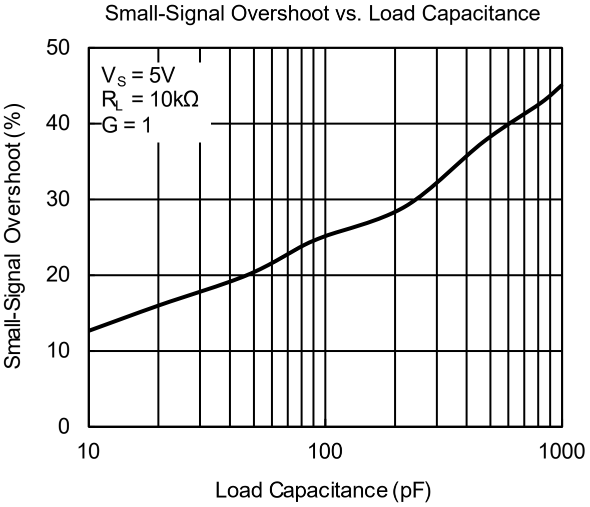
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

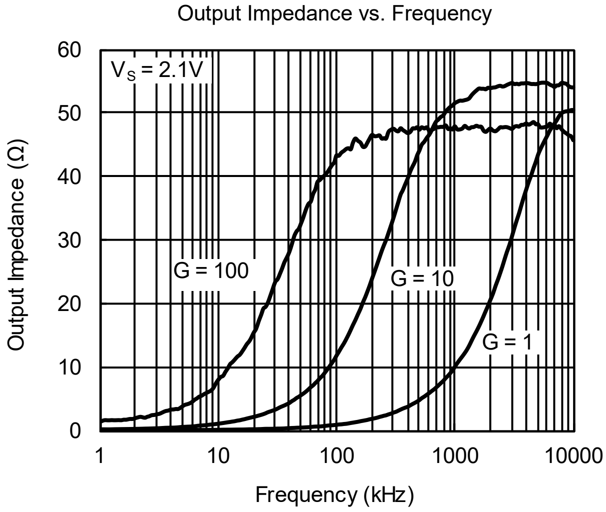
At T_A = +25℃, V_{CM} = V_S/2, R_L = 600Ω, unless otherwise noted.

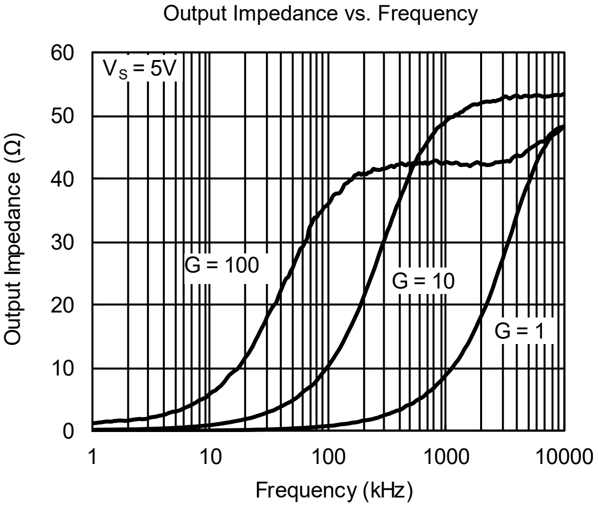








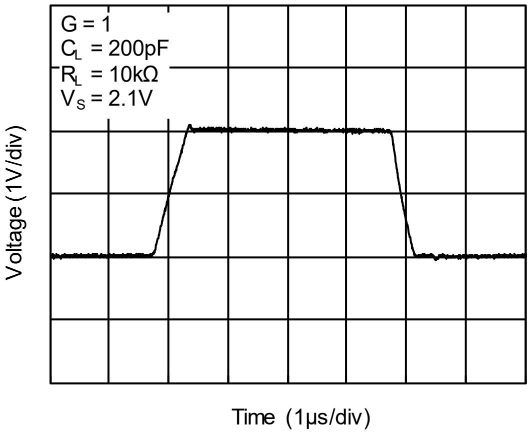




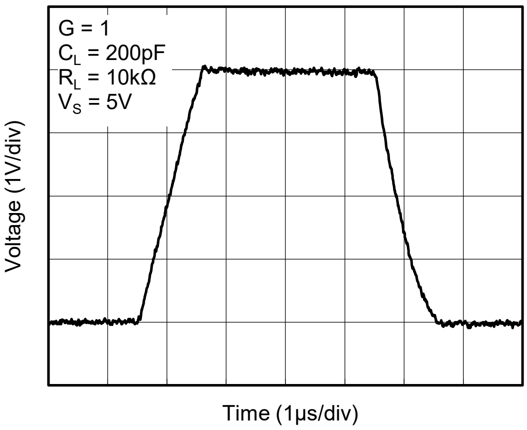
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

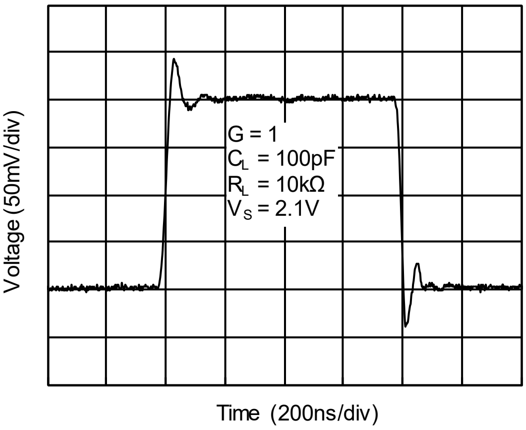
Large-Signal Step Response



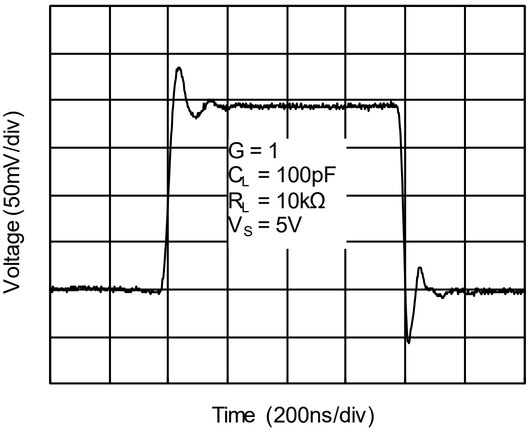
Large-Signal Step Response



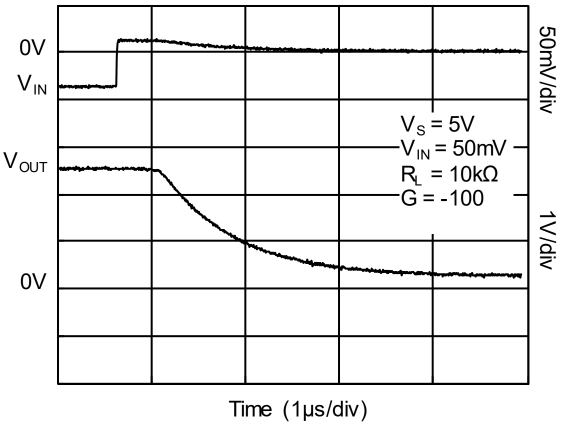
Small-Signal Step Response



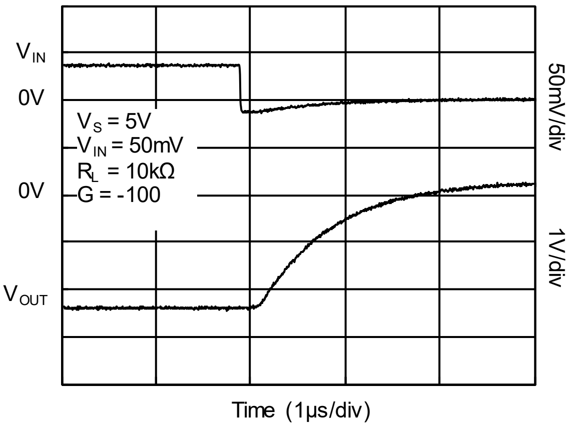
Small-Signal Step Response



Positive Overload Recovery

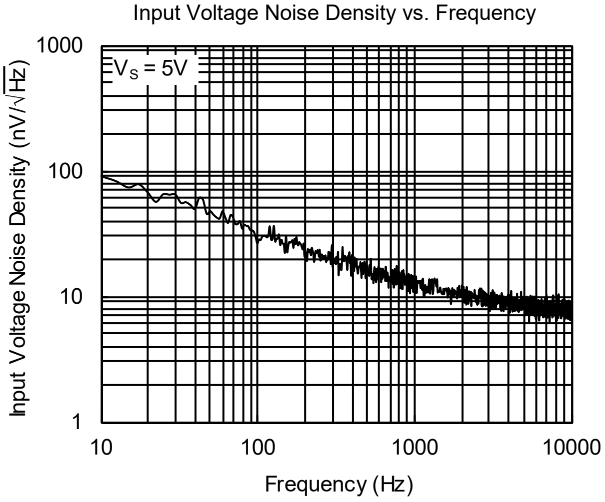


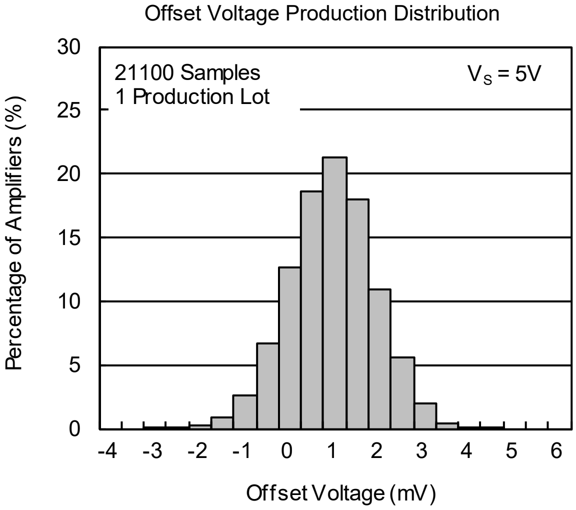
Negative Overload Recovery



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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





APPLICATION NOTES

Driving Capacitive Loads

The SGM8602 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}.

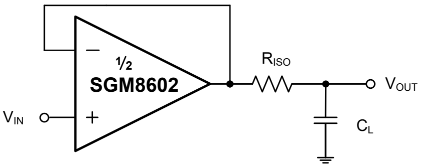


Figure 1. Indirectly Driving Heavy Capacitive Load

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.

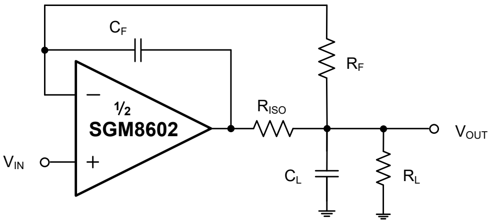


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

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 SGM8602 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).

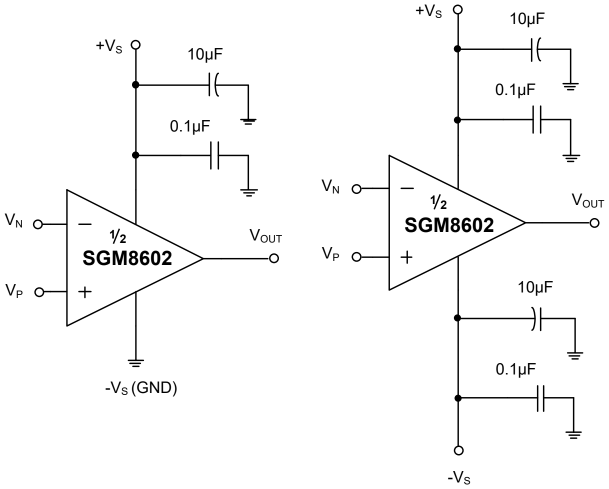


Figure 3. Amplifier with Bypass Capacitors

Grounding

A ground plane layer is important for SGM8602 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 $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$.

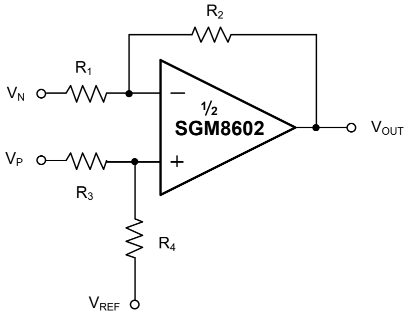


Figure 4. Differential Amplifier

Instrumentation Amplifier

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

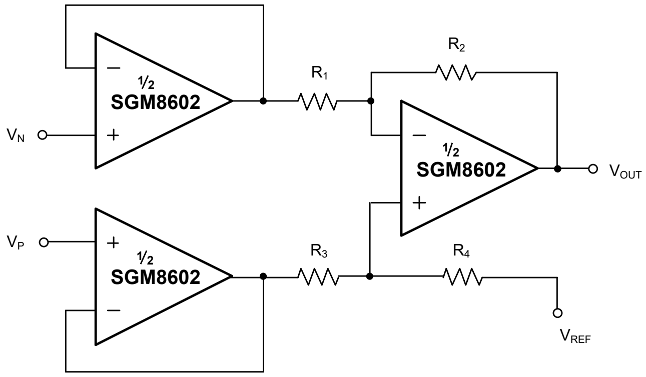


Figure 5. Instrumentation Amplifier

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.

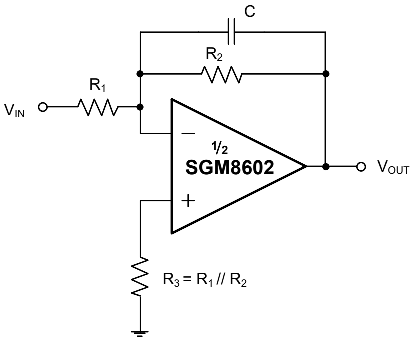


Figure 6. Active Low-Pass Filter

REVISION HISTORY

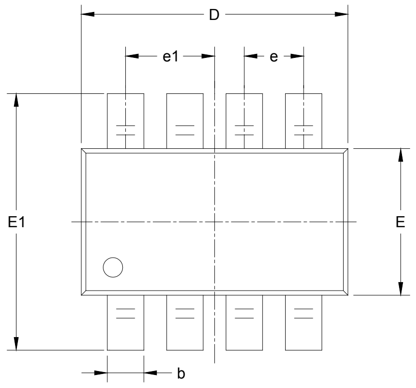
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

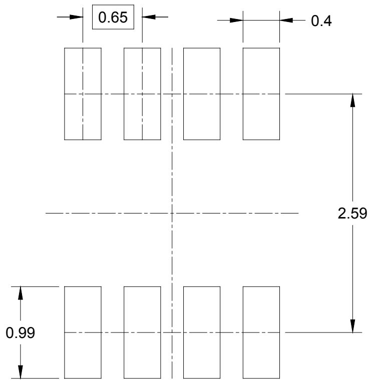
JANUARY 2018 – REV.A to REV.A.1	Page
Added Open-Loop Gain and Phase vs. Frequency	6

Changes from Original (AUGUST 2015) to REV.A	Page
Changed from product preview to production data	All

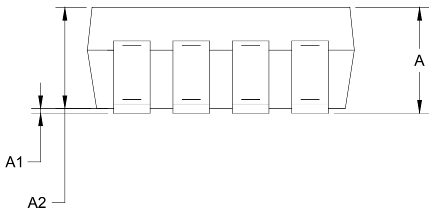
PACKAGE OUTLINE DIMENSIONS

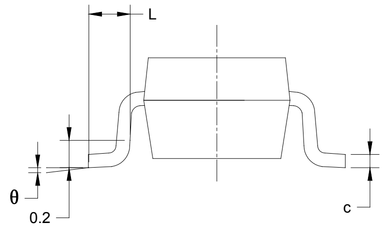
SOT-23-8





RECOMMENDED LAND PATTERN (Unit: mm)

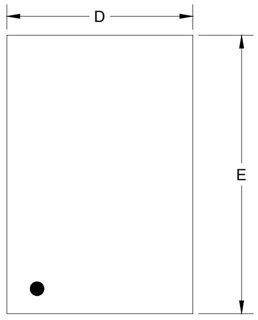




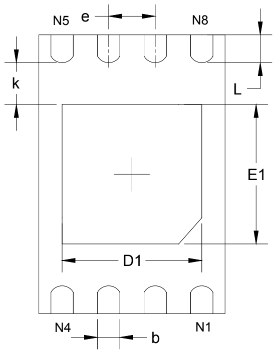
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.650 BSC		0.026 BSC	
e1	0.975 BSC		0.038 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

PACKAGE OUTLINE DIMENSIONS

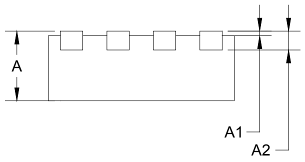
TDFN-2×3-8L



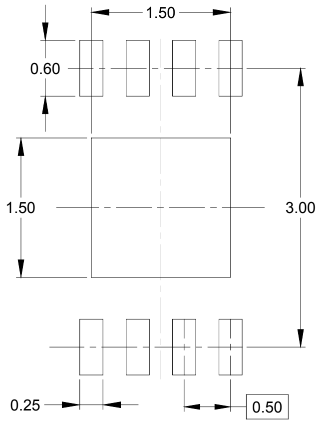
TOP VIEW



BOTTOM VIEW



SIDE VIEW

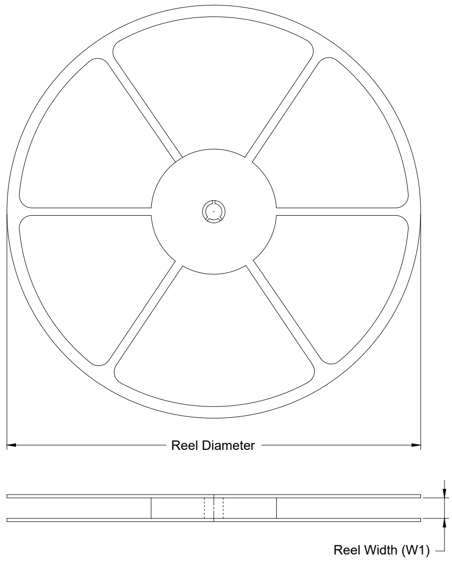


RECOMMENDED LAND PATTERN (Unit: mm)

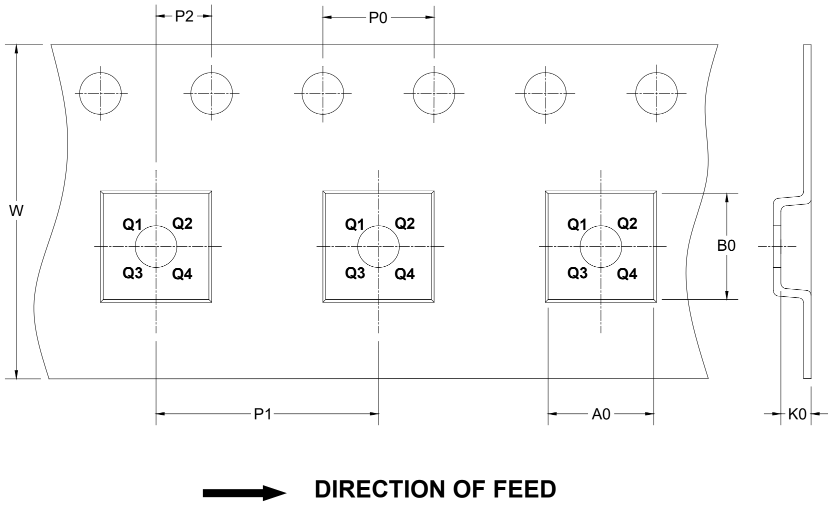
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.924	2.076	0.076	0.082
D1	1.400	1.600	0.055	0.063
E	2.924	3.076	0.115	0.121
E1	1.400	1.600	0.055	0.063
k	0.200 MIN		0.008 MIN	
b	0.200	0.300	0.008	0.012
e	0.500 TYP		0.020 TYP	
L	0.224	0.376	0.009	0.015

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



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

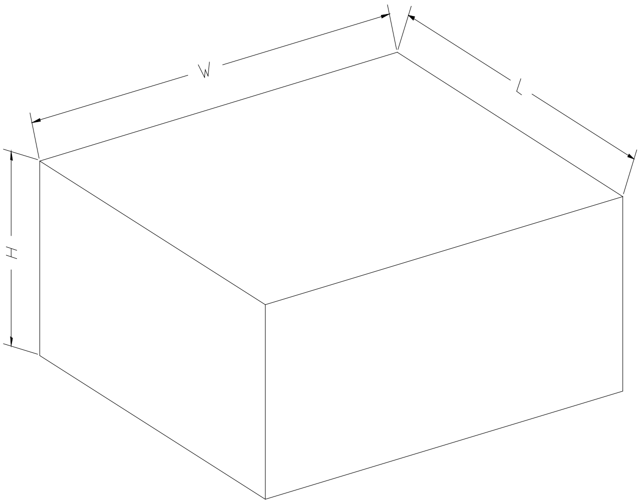
KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT-23-8	7″	9.5	3.17	3.23	1.37	4.0	4.0	2.0	8.0	Q3
TDFN-2×3-8L	7″	9.5	2.30	3.30	1.10	4.0	4.0	2.0	8.0	Q2

DD0001

PACKAGE INFORMATION

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