SGM8541/SGM8542/SGM8544
1.1MHz, 46μA, Rail-to-Rail I/O, CMOS Operational Amplifiers

GENERAL DESCRIPTION

The SGM8541 (single), SGM8542 (dual) and SGM8544 (quad) are low cost, rail-to-rail input and output voltage feedback amplifiers. They have a wide input common mode voltage range and output voltage swing, and take the minimum operating supply voltage down to 2.1V. The maximum recommended supply voltage is 5.5V.

The SGM8541/2/4 provide 1.1MHz bandwidth at a low current consumption of 46μA per amplifier. Very low input bias currents of 0.5pA enable SGM8541/2/4 to be used for integrators, photodiode amplifiers and piezoelectric sensors. Rail-to-rail input and output are useful to designers for buffering ASIC in single-supply systems.

Applications for these amplifiers include safety monitoring, portable equipment, battery and power supply control, and signal conditioning and interfacing for transducers in very low power systems.

The single SGM8541 is available in Green SOT-23-5, SC70-5 and SOIC-8 packages. The dual SGM8542 is available in Green SOIC-8, MSOP-8 and TSSOP-8 packages. The quad SGM8544 is available in Green TSSOP-14 and SOIC-14 packages. They are specified over the extended industrial temperature range (-40℃ to +125℃).

FEATURES

- **Low Cost**
- **Rail-to-Rail Input and Output**
- **Input Offset Voltage: 3.5mV (MAX)**
- **Unity Gain Stable**
- **Gain-Bandwidth Product: 1.1MHz**
- **Very Low Input Bias Current: 0.5pA**
- **Supply Voltage Range: 2.1V to 5.5V**
- **Input Voltage Range:**
  -0.1V to 5.6V with V_S = 5.5V
- **Low Supply Current: 46μA/Amplifier**
- **Small Packaging:**
  SGM8541 Available in Green SOIC-8, SC70-5 and SOT-23-5 Packages
  SGM8542 Available in Green SOIC-8, MSOP-8 and TSSOP-8 Packages
  SGM8544 Available in Green SOIC-14 and TSSOP-14 Packages

APPLICATIONS

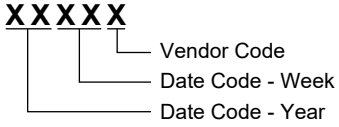
ASIC Input or Output Amplifiers
Sensor Interfaces
Piezoelectric Transducer Amplifiers
Medical Instrumentation
Mobile Communications
Audio Outputs
Portable Systems
Smoke Detectors
Mobile Telephones
Notebook PCs
PCMCIA Cards
Battery-Powered Equipment

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8541	SC70-5	-40℃ to +125℃	SGM8541XC5/TR	8541	Tape and Reel, 3000
	SOT-23-5	-40℃ to +125℃	SGM8541XN5/TR	8541	Tape and Reel, 3000
	SOIC-8	-40℃ to +125℃	SGM8541XS/TR	SGM8541XS XXXXX	Tape and Reel, 2500
SGM8542	SOIC-8	-40℃ to +125℃	SGM8542XS/TR	SGM8542XS XXXXX	Tape and Reel, 4000
	MSOP-8	-40℃ to +125℃	SGM8542XMS/TR	SGM8542 XMS XXXXX	Tape and Reel, 3000
	TSSOP-8	-40℃ to +125℃	SGM8542XTS8G/TR	SGM8542 XTS8 XXXXX	Tape and Reel, 4000
SGM8544	SOIC-14	-40℃ to +125℃	SGM8544XS14/TR	SGM8544XS14 XXXXX	Tape and Reel, 2500
	TSSOP-14	-40℃ to +125℃	SGM8544XTS14/TR	SGM8544 XTS14 XXXXX	Tape and Reel, 4000

MARKING INFORMATION

NOTE: XXXXX = Date Code and Vendor 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
Package Thermal Resistance @ T_A = +25℃
SC70-5, θ_{JA} ..... 333℃/W
SOT-23-5, θ_{JA} ..... 190℃/W
SOIC-8, θ_{JA} ..... 125℃/W
MSOP-8, θ_{JA} ..... 216℃/W
TSSOP-8, θ_{JA} ..... 175℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 4000V
MM 400V

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

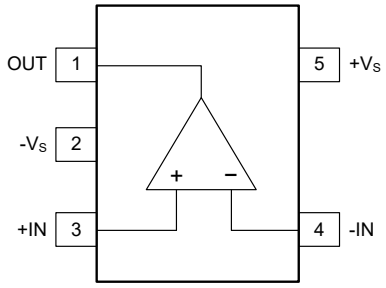
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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.

DISCLAIMER

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

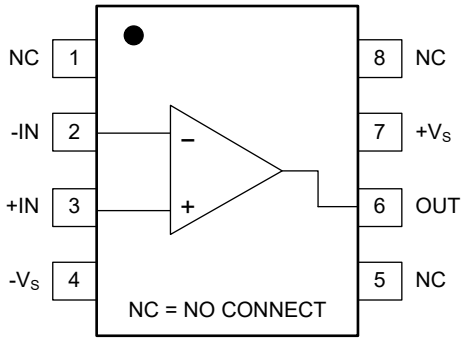
PIN CONFIGURATIONS

SGM8541 (TOP VIEW)



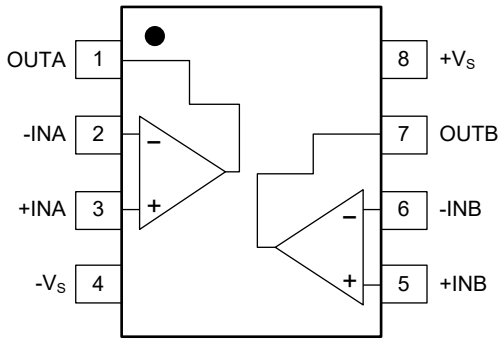
SC70-5/SOT-23-5

SGM8541 (TOP VIEW)



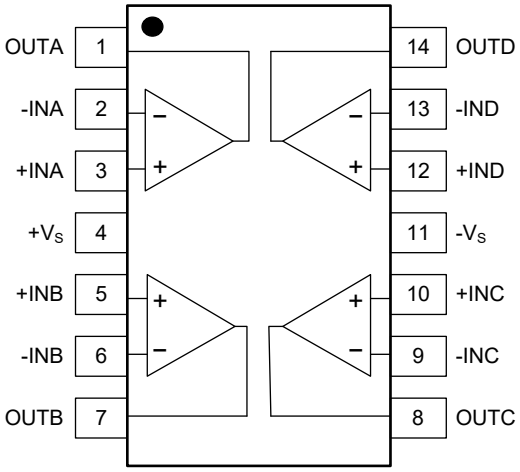
SOIC-8

SGM8542 (TOP VIEW)



SOIC-8/MSOP-8/TSSOP-8

SGM8544 (TOP VIEW)



SOIC-14/TSSOP-14

ELECTRICAL CHARACTERISTICS

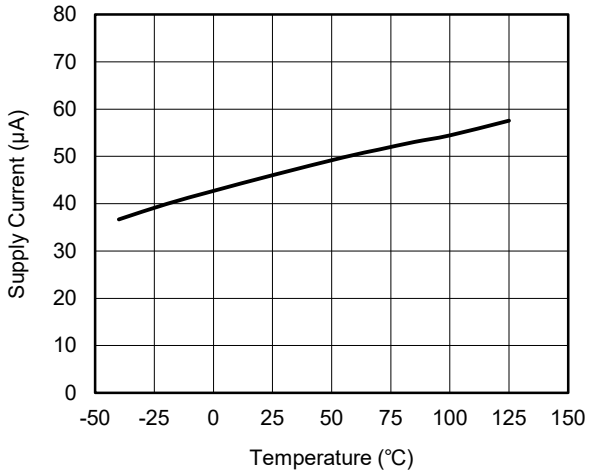
(At V_S = 5V, R_L = 100kΩ connected to V_S/2 and V_{OUT} = V_S/2, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	SGM8541/2/4				
			TYP	MIN/MAX OVER TEMPERATURE			
			+25℃	+25℃	-40℃ to +125℃	UNITS	MIN/MAX
INPUT CHARACTERISTICS							
Input Offset Voltage	V_{OS}	V_{CM} = V_S/2	0.8	3.5		mV	MAX
Input Bias Current	I_B		0.5			pA	TYP
Input Offset Current	I_{OS}		0.5			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	87	71	69	dB	MIN
		V_S = 5.5V, V_{CM} = -0.1V to 5.6V	80	60	56		
Open-Loop Voltage Gain	A_{OL}	R_L = 5kΩ, V_{OUT} = 0.1V to 4.9V	98	80	73	dB	MIN
		R_L = 100kΩ, V_{OUT} = 0.035V to 4.965V	105	85	74		
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		2.7			μV/℃	TYP
OUTPUT CHARACTERISTICS							
Output Voltage Swing from Rail	V_{OH}	R_L = 100kΩ	4.997	4.980	4.970	V	MIN
	V_{OL}	R_L = 100kΩ	5	20	30	mV	MAX
	V_{OH}	R_L = 10kΩ	4.992	4.970	4.960	V	MIN
	V_{OL}	R_L = 10kΩ	8	30	40	mV	MAX
Output Current	I_{SOURCE}	R_L = 10Ω to V_S/2	85	60	45	mA	MIN
	I_{SINK}		75	60	45		
POWER SUPPLY							
Operating Voltage Range				2.1	2.5	V	MIN
				5.5	5.5	V	MAX
Power Supply Rejection Ratio	PSRR	V_S = 2.5V to 5.5V, V_{CM} = 0.5V	87	70	64	dB	MIN
Quiescent Current/Amplifier	I_Q		46	69	89	μA	MAX
DYNAMIC PERFORMANCE (C_L = 100pF)							
Gain-Bandwidth Product	GBP		1.1			MHz	TYP
Slew Rate	SR	G = +1, 2V Output Step	0.52			V/μs	TYP
Settling Time to 0.1%	t_S	G = +1, 2V Output Step	5.3			μs	TYP
Overload Recovery Time		V_{IN} ·G = V_S	2.6			μs	TYP
NOISE PERFORMANCE							
Input Voltage Noise Density	e_n	f = 1kHz	27			nV/$\sqrt{Hz}$	TYP
		f = 10kHz	20			nV/$\sqrt{Hz}$	TYP

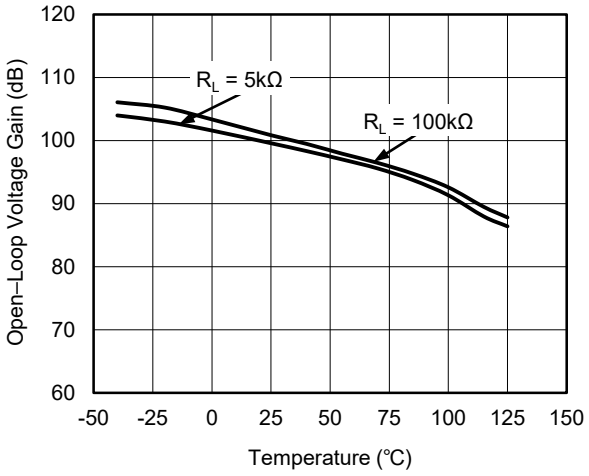
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_S = 5V, and R_L = 100kΩ connected to V_S/2, unless otherwise noted.

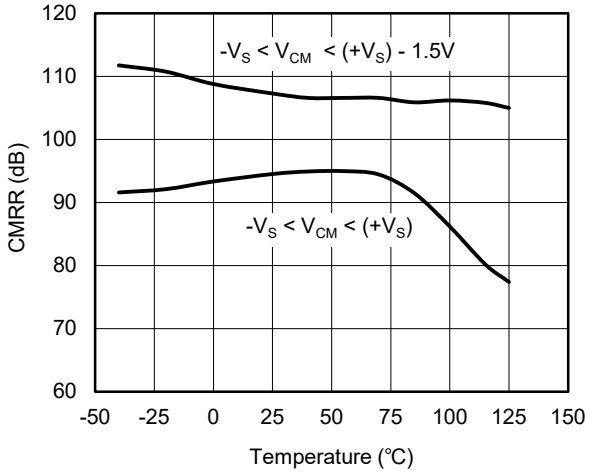
Supply Current vs. Temperature



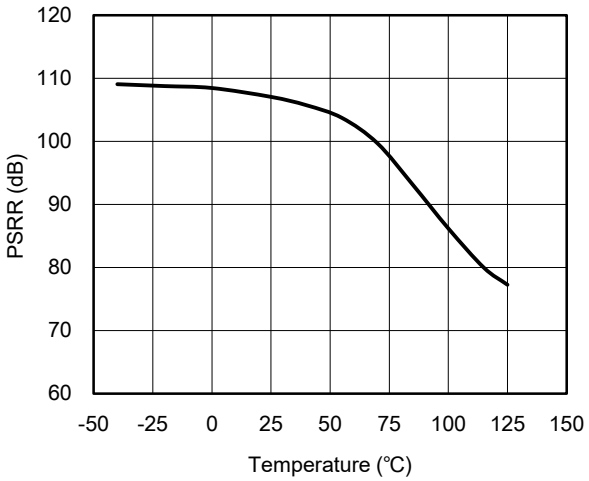
Open-Loop Voltage Gain vs. Temperature



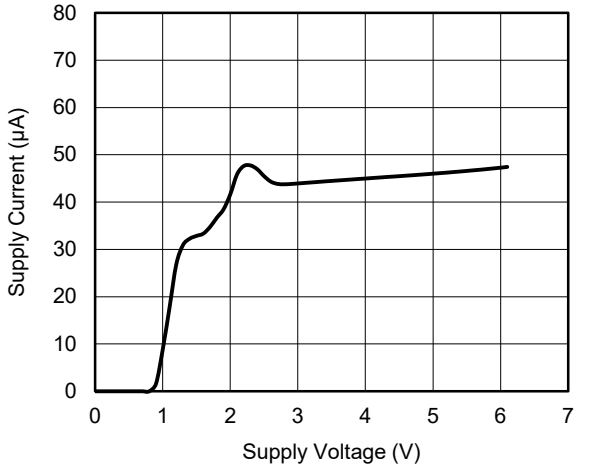
Common Mode Rejection Ratio vs. Temperature



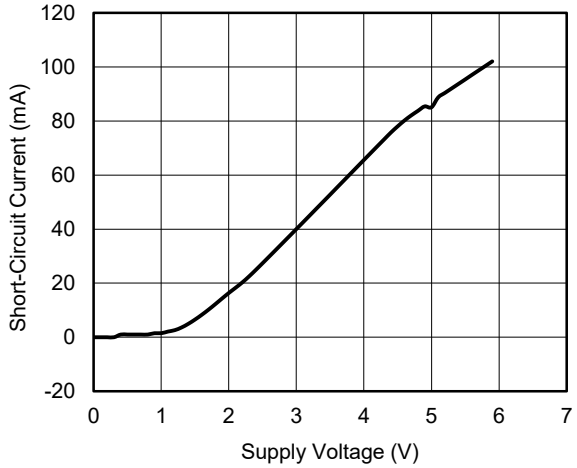
Power Supply Rejection Ratio vs. Temperature



Supply Current vs. Supply Voltage



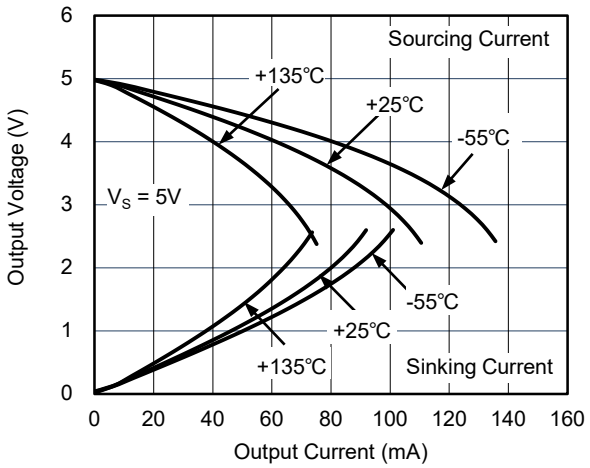
Short-Circuit Current vs. Supply Voltage



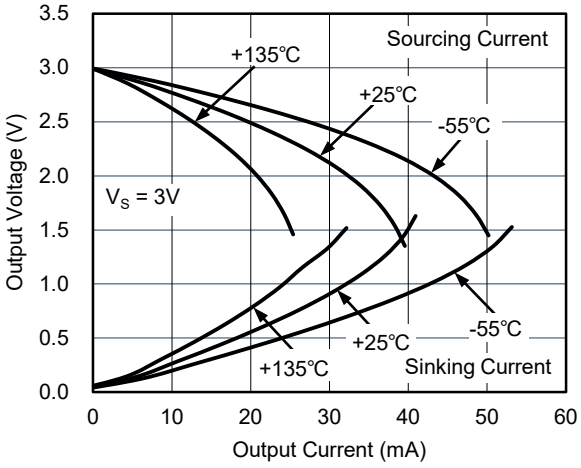
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 5V, and R_L = 100kΩ connected to V_S/2, unless otherwise noted.

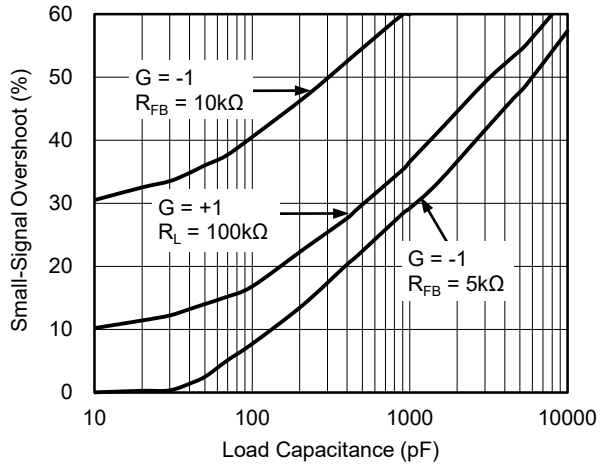
Output Voltage Swing vs. Output Current



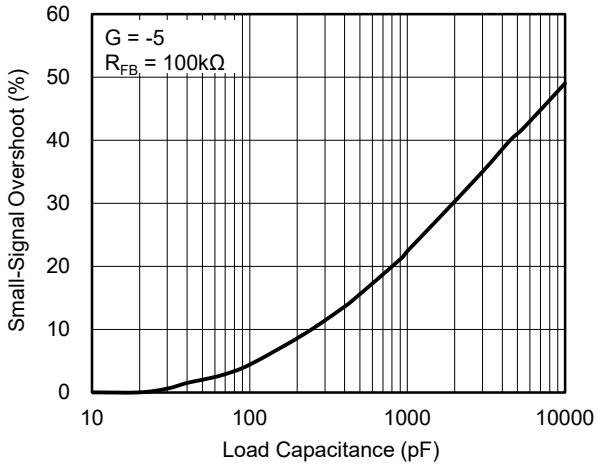
Output Voltage Swing vs. Output Current



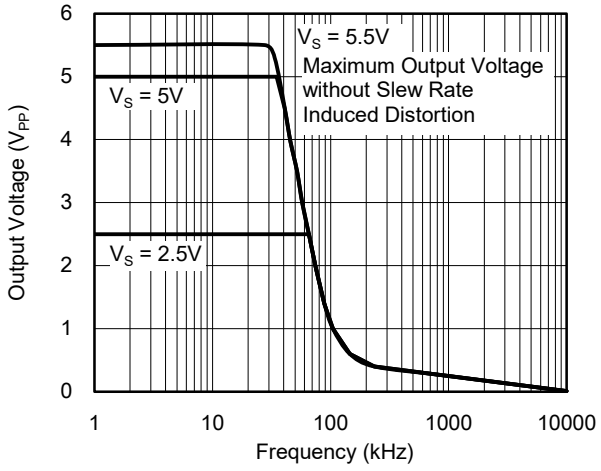
Small-Signal Overshoot vs. Load Capacitance



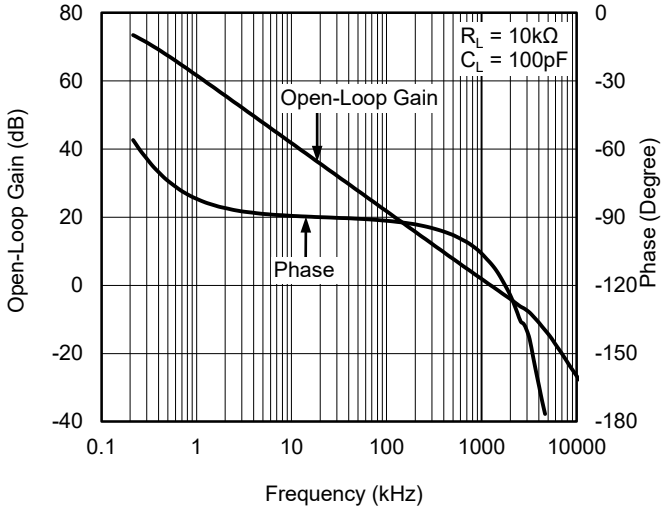
Small-Signal Overshoot vs. Load Capacitance



Maximum Output Voltage vs. Frequency



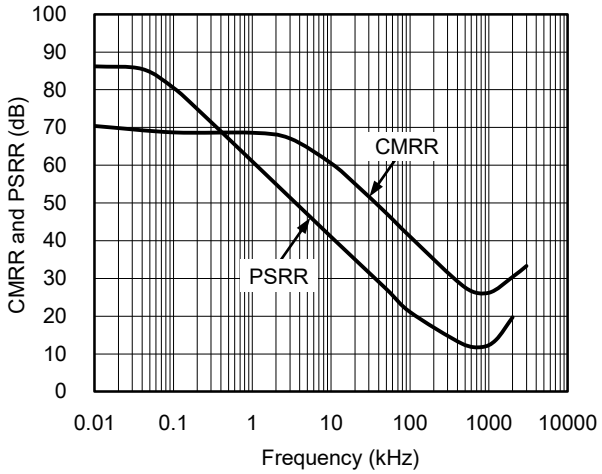
Open-Loop Gain and Phase vs. Frequency



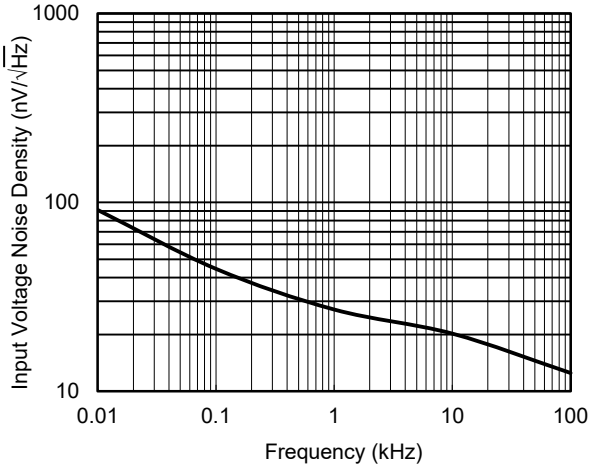
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 5V, and R_L = 100kΩ connected to V_S/2, unless otherwise noted.

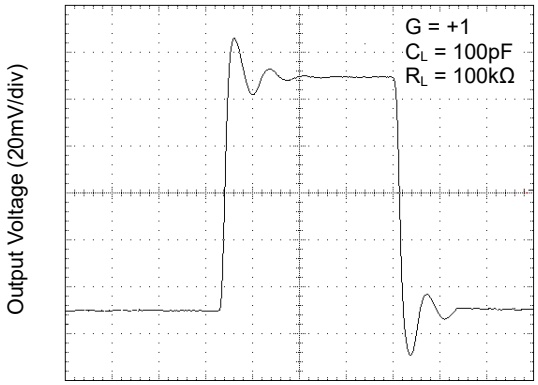
CMRR and PSRR vs. Frequency



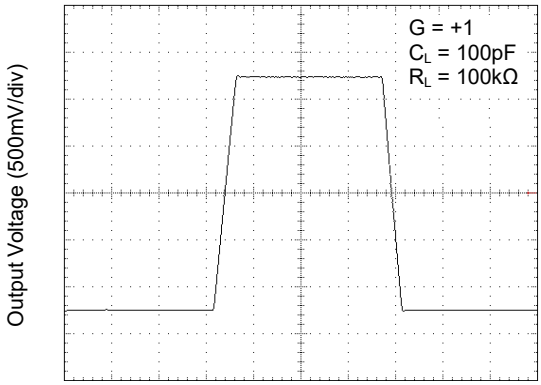
Input Voltage Noise Density vs. Frequency



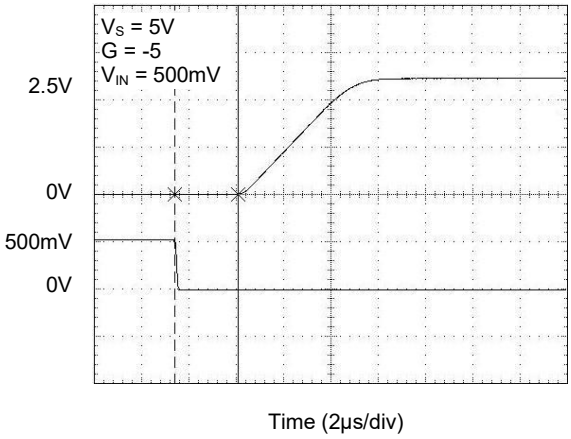
Small-Signal Step Response



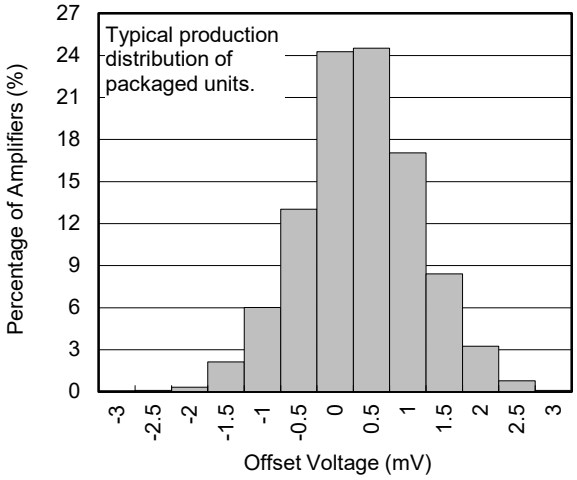
Large-Signal Step Response



Overload Recovery Time



Offset Voltage Production Distribution



APPLICATION NOTES

Driving Capacitive Loads

The SGM8541/2/4 can directly drive 250pF 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}.

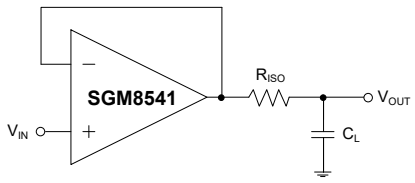


Figure 1. Indirectly Driving Heavy Capacitive Load

An improved circuit is shown in Figure 2. It provides DC accuracy as well as AC stability. RF 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.

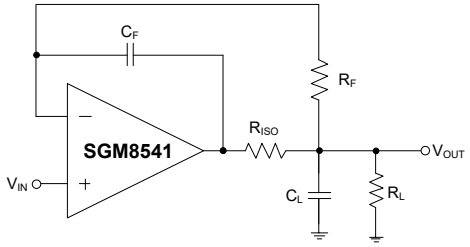


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

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 SGM8541/2/4 family 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.

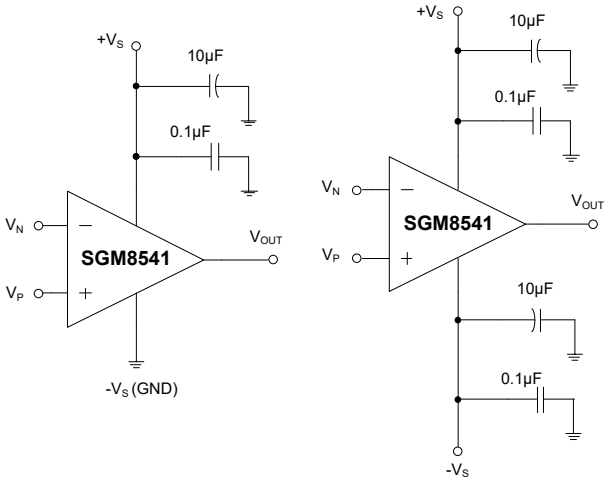


Figure 3. Amplifier with Bypass Capacitors

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

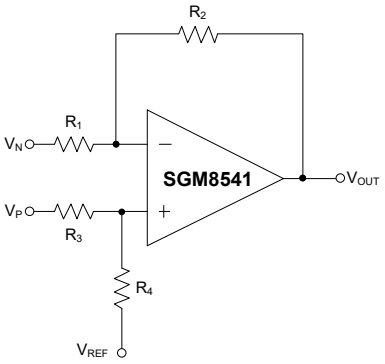


Figure 4. Differential Amplifier

Instrumentation Amplifier

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

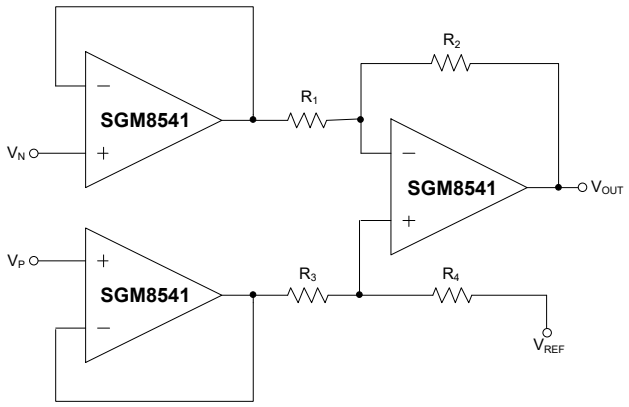


Figure 5. Instrumentation Amplifier

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.

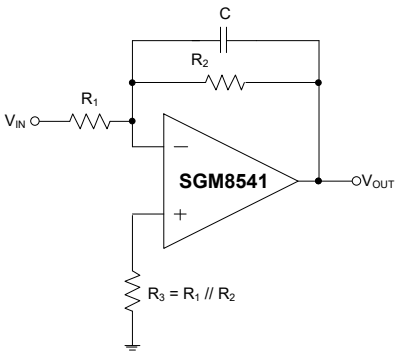


Figure 6. Active Low-Pass Filter

REVISION HISTORY

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

NOVEMBER 2018 – REV.C.3 to REV.C.4

Added Open-Loop Gain and Phase vs. Frequency 6

JANUARY 2018 – REV.C.2 to REV.C.3

Changed Packing Option 2

JULY 2014 – REV.C.1 to REV.C.2

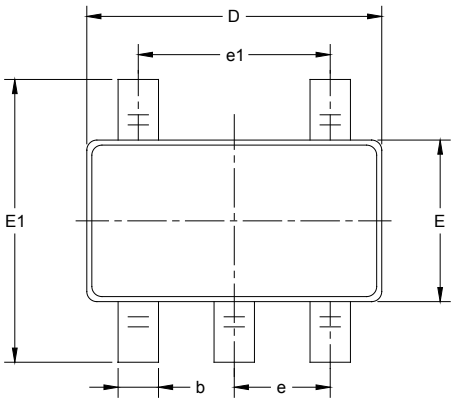
Added TSSOP-8 package for SGM8542 ..... 1, 2, 13, 16

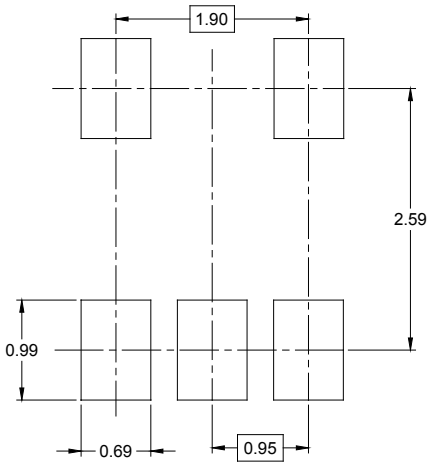
JANUARY 2013 – REV.C to REV.C.1

Added Tape and Reel Information 15, 16

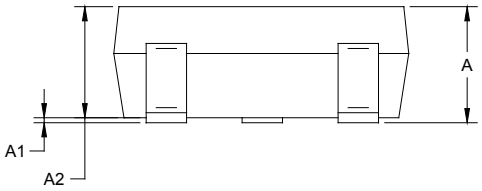
PACKAGE OUTLINE DIMENSIONS

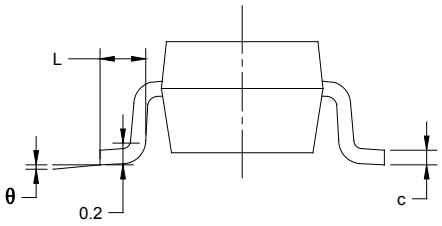
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)

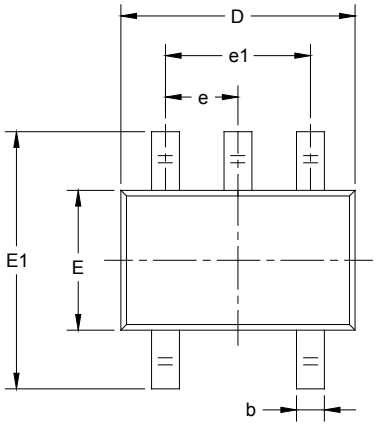


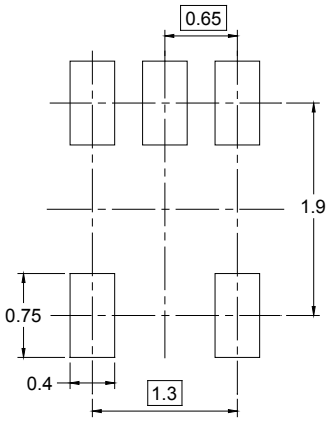


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

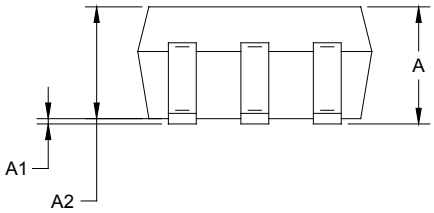
PACKAGE OUTLINE DIMENSIONS

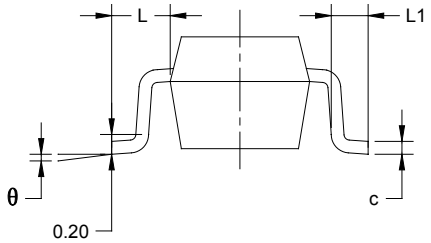
SC70-5





RECOMMENDED LAND PATTERN (Unit: mm)

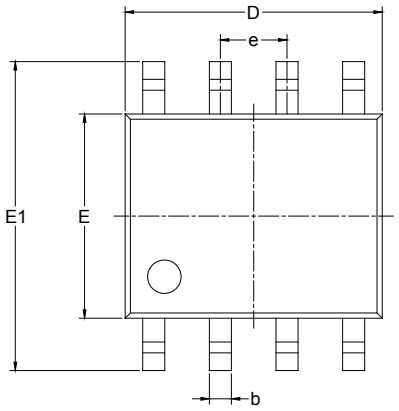


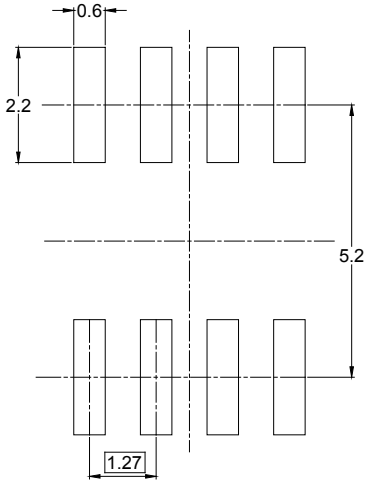


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026 TYP	
e1	1.300 BSC		0.051 BSC	
L	0.525 REF		0.021 REF	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°

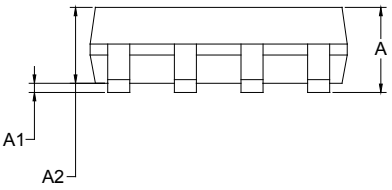
PACKAGE OUTLINE DIMENSIONS

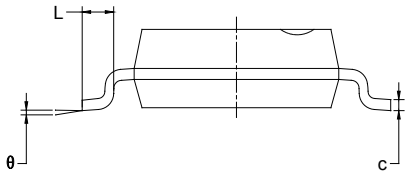
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)

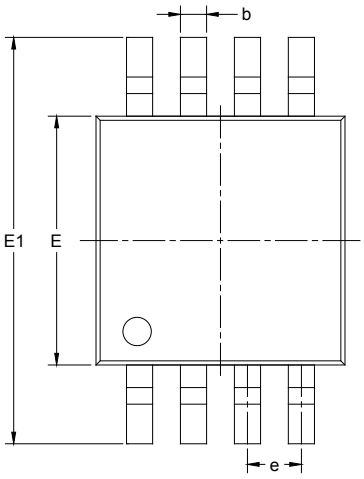


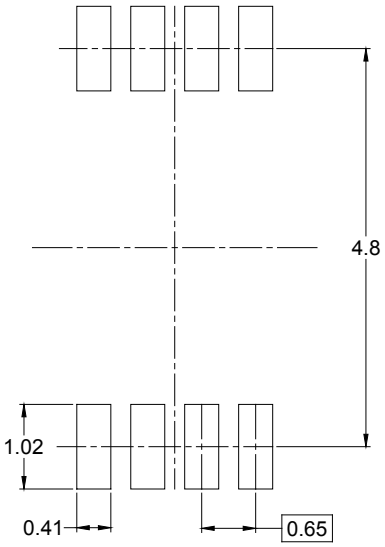


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

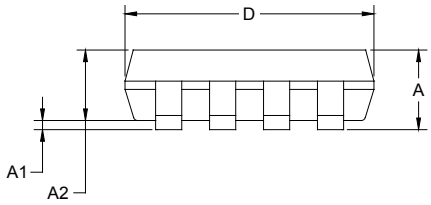
PACKAGE OUTLINE DIMENSIONS

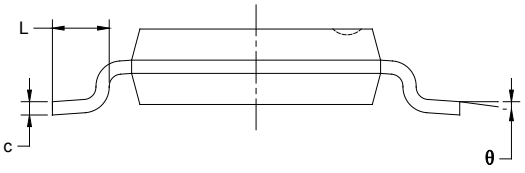
MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)

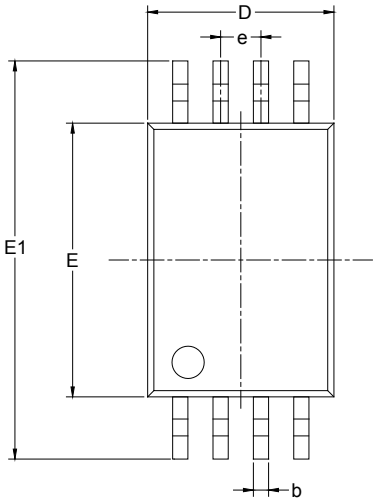


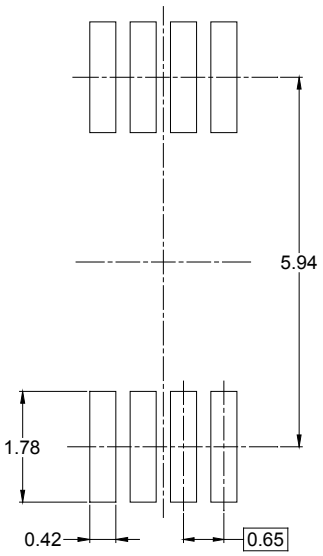


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

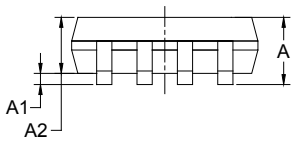
PACKAGE OUTLINE DIMENSIONS

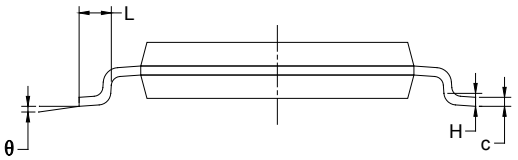
TSSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)

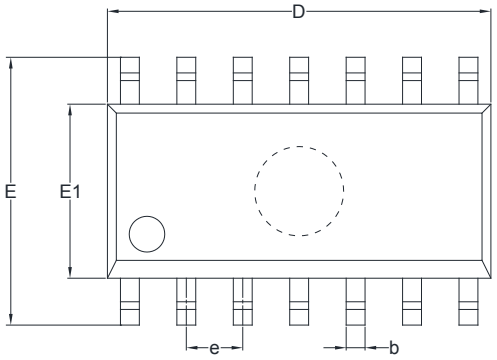


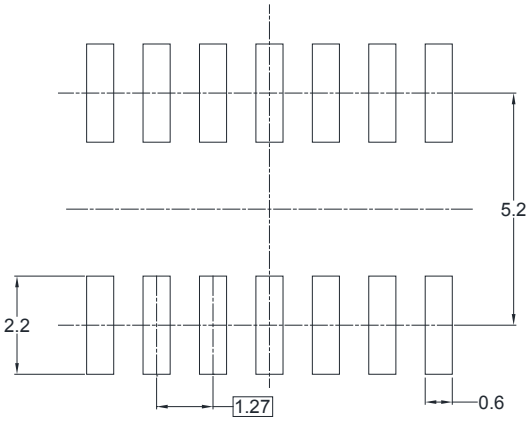


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.100		0.043
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.02	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

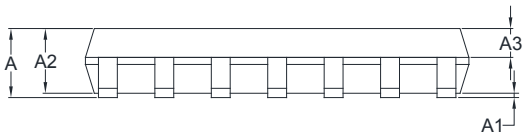
PACKAGE OUTLINE DIMENSIONS

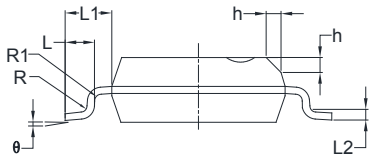
SOIC-14





RECOMMENDED LAND PATTERN (Unit: mm)

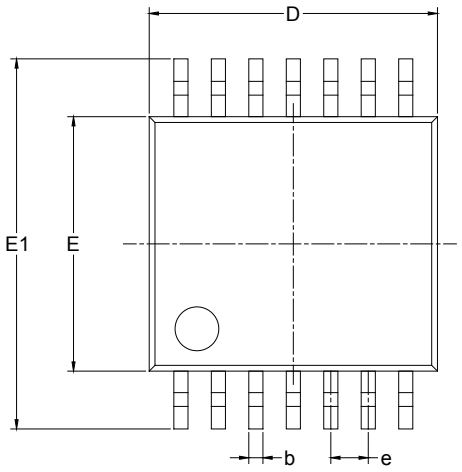


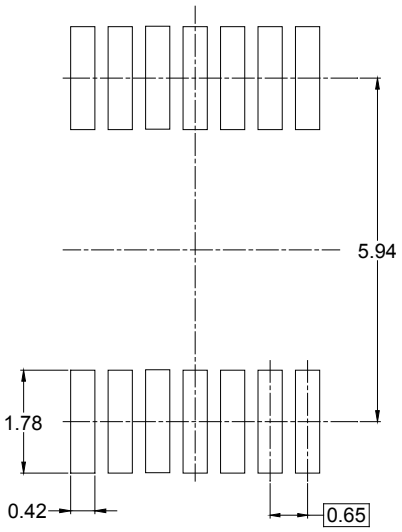


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80	0.018	0.032
L1	1.04 REF		0.040 REF	
L2	0.25 BSC		0.01 BSC	
R	0.07		0.003	
R1	0.07		0.003	
h	0.30	0.50	0.012	0.020
θ	0°	8°	0°	8°

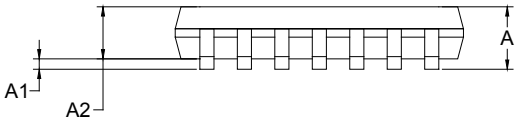
PACKAGE OUTLINE DIMENSIONS

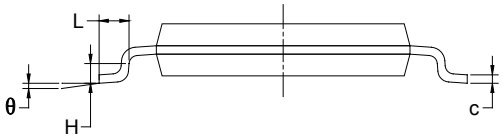
TSSOP-14





RECOMMENDED LAND PATTERN (Unit: mm)

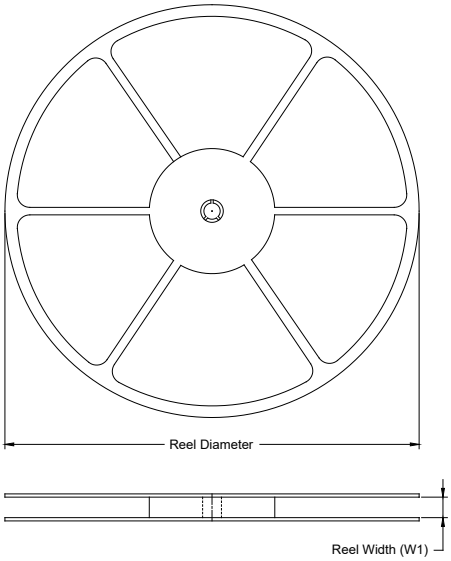




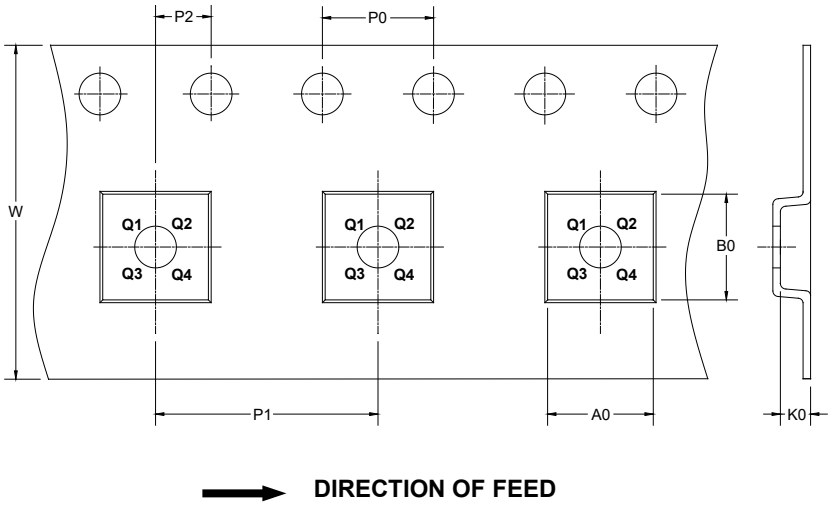
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.02	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



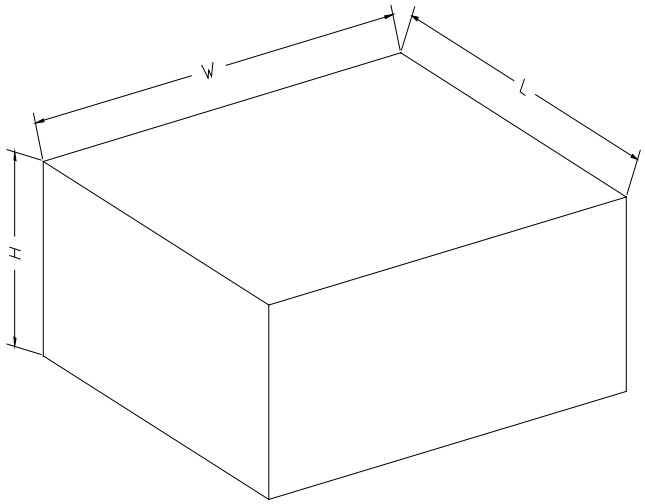
NOTE: The picture is only for reference. Please make the object as the standard.

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-23-5	7″	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
SC70-5	7″	9.5	2.25	2.55	1.20	4.0	4.0	2.0	8.0	Q3
SOIC-8	13″	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1
MSOP-8	13″	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1
TSSOP-8	13″	12.4	6.76	3.30	1.80	4.0	8.0	2.0	12.0	Q1
SOIC-14	13″	16.4	6.60	9.30	2.10	4.0	8.0	2.0	16.0	Q1
TSSOP-14	13″	12.4	6.95	5.60	1.20	4.0	8.0	2.0	12.0	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
13″	386	280	370	5

DD0002