



SGM8956XTDE8G

High Precision, Low Power, Rail-to-Rail I/O, CMOS Operational Amplifier

GENERAL DESCRIPTION

The SGM8956XTDE8G is a dual, low power and high precision CMOS operational amplifier, which can operate from 1.8V to 5.5V single supply or from $\pm 0.9V$ to $\pm 2.75V$ dual power supplies, while consuming only 20 μA quiescent current per amplifier. The device supports rail-to-rail input and output operation. The input common mode voltage range is from $(-V_S) - 0.1V$ to $(+V_S) + 0.1V$, and the output range is from $(-V_S) + 0.014V$ to $(+V_S) - 0.014V$.

The SGM8956XTDE8G is designed to provide optimal performance in low voltage and low power systems. It has high impedance inputs and zero-drift 50 μV (MAX) offset voltage. These specifications make the device appropriate for a wide range of applications requiring high precision, such as high linearity driver of high precision ADC.

The SGM8956XTDE8G is available in a Green TDFN-2 \times 2-8L package. It operates over an ambient temperature range of $-40^{\circ}C$ to $+125^{\circ}C$.

FEATURES

- **Low Input Offset Voltage: 50 μV (MAX)**
- **Low Noise: 2 μV_{P-P} at 0.1Hz to 10Hz**
- **Integrated RFI Filter**
- **Rail-to-Rail Input and Output**
- **Support Single or Dual Power Supplies:
1.8V to 5.5V or $\pm 0.9V$ to $\pm 2.75V$**
- **Quiescent Current: 20 μA /Amplifier (TYP)**
- **$-40^{\circ}C$ to $+125^{\circ}C$ Operating Temperature Range**
- **Available in a Green TDFN-2 \times 2-8L Package**

APPLICATIONS

Industrial Equipment
Battery-Powered Equipment
Sensor Signal Conditioning

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8956XTDE8G	TDFN-2×2-8L	-40°C to +125°C	SGM8956XTDE8G/TR	8956 XXXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XXXX = Date Code.

XXXX



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.....	6V
Input Common Mode Voltage Range (-V _S) - 0.3V to (+V _S) + 0.3V	
Package Thermal Resistance TDFN-2×2-8L, θ _{JA}	83.2°C/W
Junction Temperature	+150°C
Storage Temperature Range.....	-65°C to +150°C
Lead Temperature (Soldering, 10s)	+260°C
ESD Susceptibility	
HBM.....	4000V
MM.....	400V
CDM	1000V

RECOMMENDED OPERATING CONDITIONS

Specified Voltage Range	1.8V to 5.5V
Operating Temperature Range	-40°C to +125°C

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.

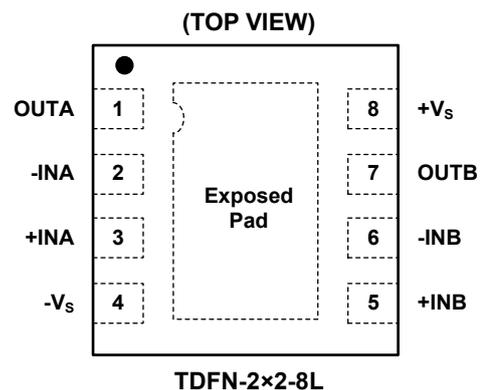
ESD SENSITIVITY CAUTION

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



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

ELECTRICAL CHARACTERISTICS

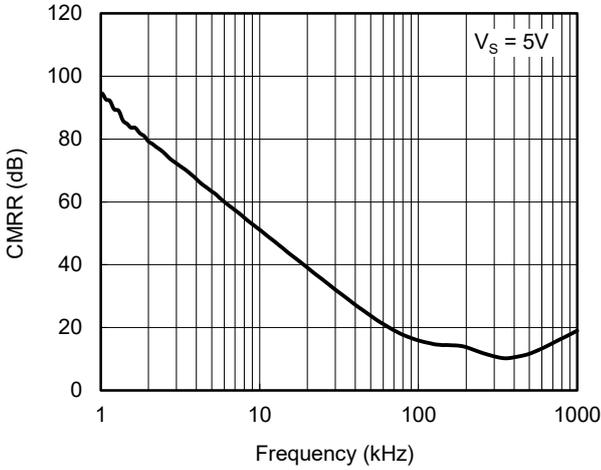
($V_S = 1.8V$ to $5.5V$, $V_{CM} = +V_S/2$, $V_{OUT} = +V_S/2$ and $R_L = 10k\Omega$ to $+V_S/2$, Full = $-40^\circ C$ to $+125^\circ C$, typical values are at $T_A = +25^\circ C$, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Characteristics							
Input Offset Voltage	V_{OS}	$V_S = 5V$	+25°C		22	50	μV
			Full			83	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		Full		0.08		$\mu V/^\circ C$
Input Bias Current	I_B		+25°C		130		pA
Input Common Mode Voltage Range	V_{CM}		+25°C	$(-V_S) - 0.1$		$(+V_S) + 0.1$	V
Common Mode Rejection Ratio	CMRR	$(-V_S) - 0.1V < V_{CM} < (+V_S) + 0.1V$	+25°C	89	100		dB
			Full	85			
Open-Loop Voltage Gain	A_{OL}	$(-V_S) + 0.1V < V_{OUT} < (+V_S) - 0.1V$, $R_L = 10k\Omega$	+25°C	95	121		dB
			Full	94			
Input Impedance							
Differential			+25°C		10^9		Ω
Common Mode			+25°C		10^9		Ω
Output Characteristics							
Output Voltage Swing from Rail		$R_L = 10k\Omega$	+25°C		14	25	mV
			Full			27	
Output Short-Circuit Current	I_{SC}	$V_S = 1.8V$	+25°C		6		mA
		$V_S = 5V$	+25°C		60		
Open-Loop Output Impedance		$f = 350kHz$, $I_{OUT} = 0A$	+25°C		1		k Ω
Power Supply							
Specified Voltage Range	V_S		Full	1.8		5.5	V
Power Supply Rejection Ratio	PSRR	$V_S = 1.8V$ to $5.5V$	+25°C		4	20	$\mu V/V$
			Full			25	
Quiescent Current/Amplifier	I_Q	$I_{OUT} = 0A$	+25°C		20	37	μA
			Full			48	
Turn-On Time		$V_S = 5V$	+25°C		220		μs
Dynamic Performance							
Gain-Bandwidth Product	GBP	$C_L = 100pF$	+25°C		350		kHz
Slew Rate	SR	$G = +1$	+25°C		0.18		V/ μs
Noise							
Input Voltage Noise		$f = 0.1Hz$ to $10Hz$	+25°C		2		μV_{P-P}

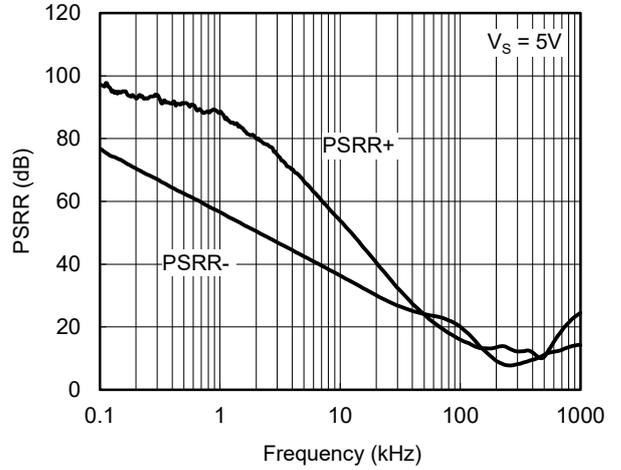
TYPICAL PERFORMANCE CHARACTERISTICS

At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$ and $C_L = 0\text{pF}$, unless otherwise noted.

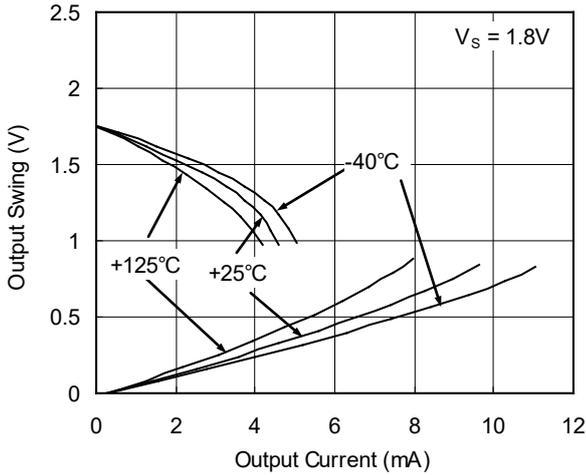
Common Mode Rejection Ratio vs. Frequency



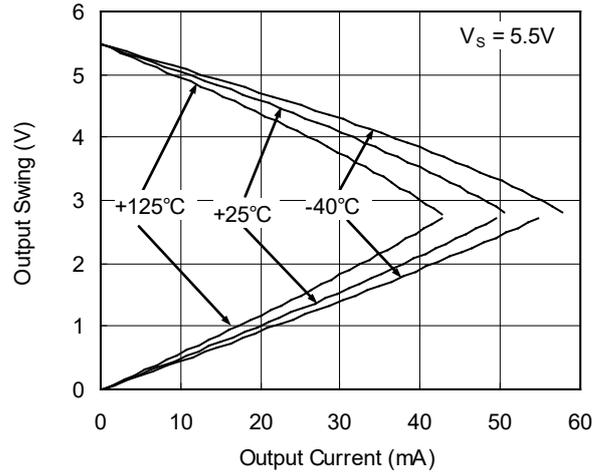
Power Supply Rejection Ratio vs. Frequency



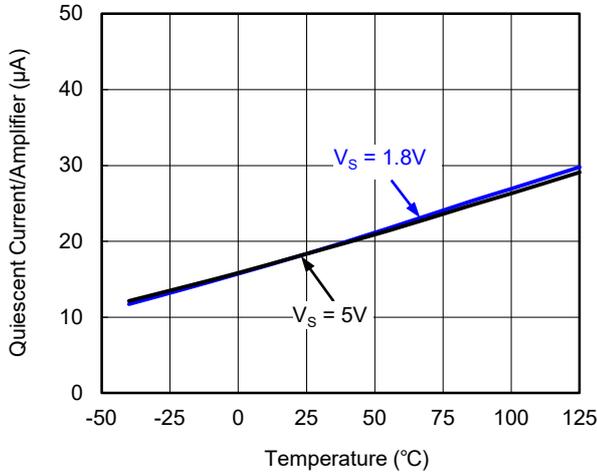
Output Voltage Swing vs. Output Current



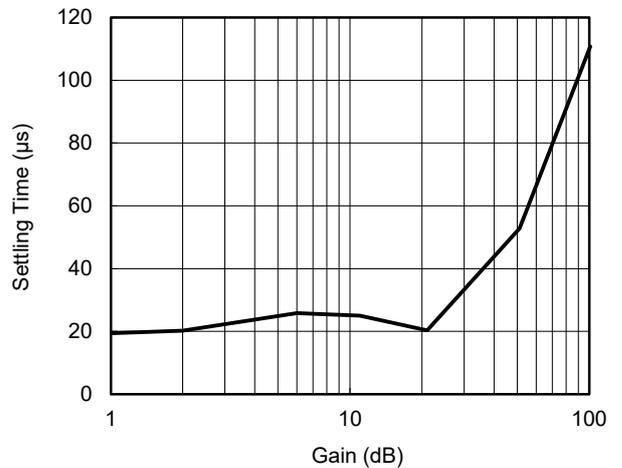
Output Voltage Swing vs. Output Current



Quiescent Current vs. Temperature



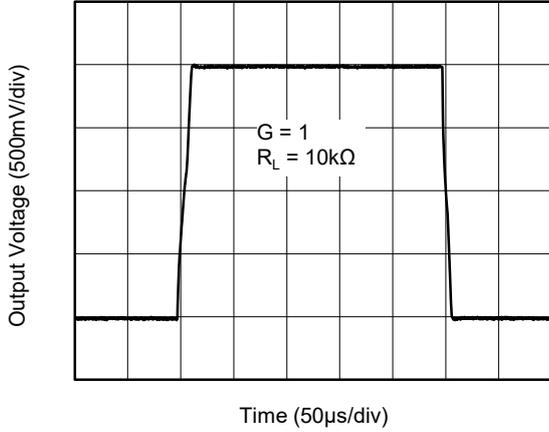
Settling Time vs. Closed-Loop Gain



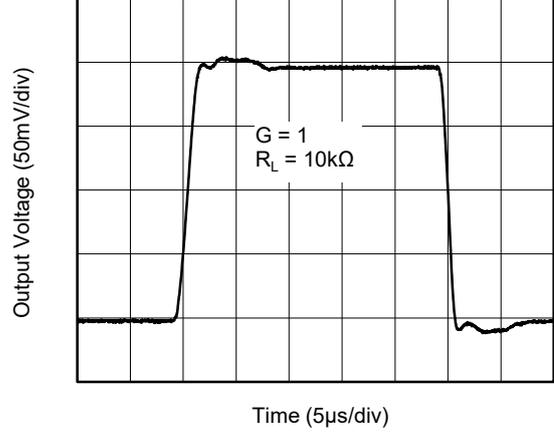
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$ and $C_L = 0\text{pF}$, unless otherwise noted.

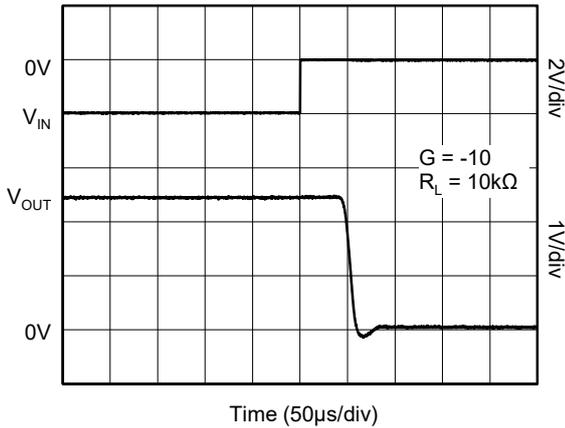
Large-Signal Step Response



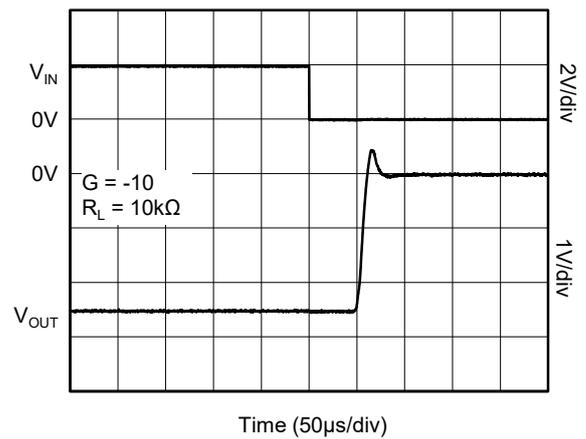
Small-Signal Step Response



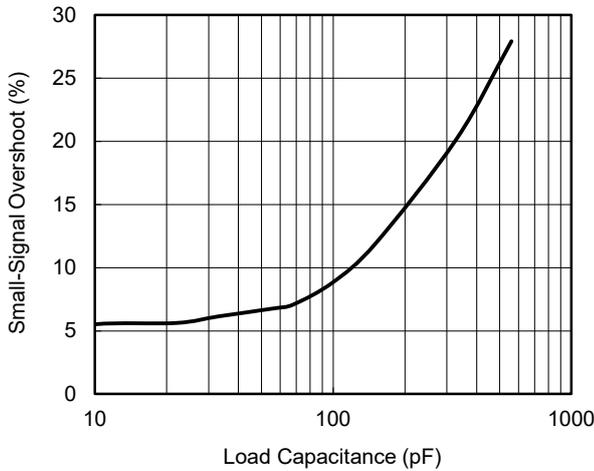
Positive Over-Voltage Recovery



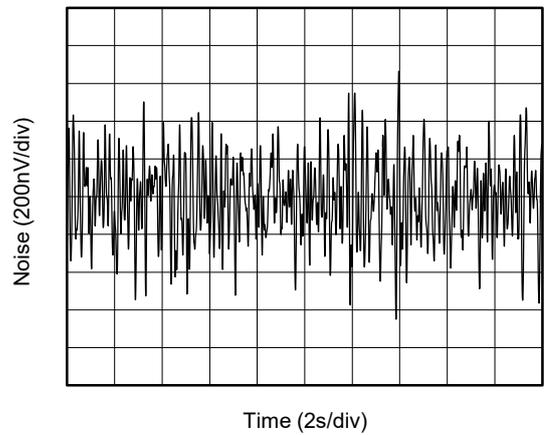
Negative Over-Voltage Recovery



Small-Signal Overshoot vs. Load Capacitance

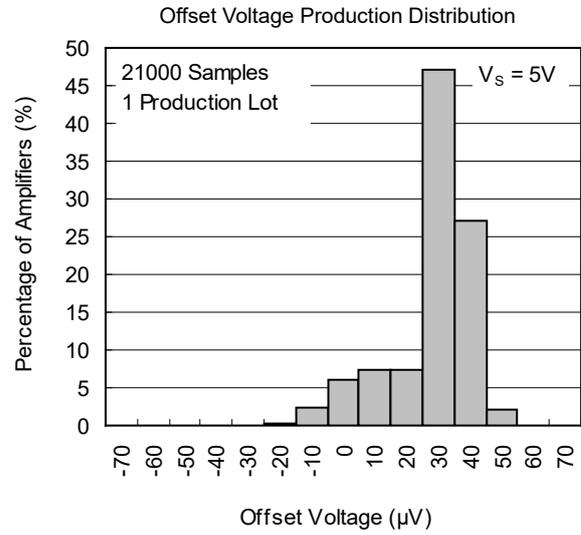
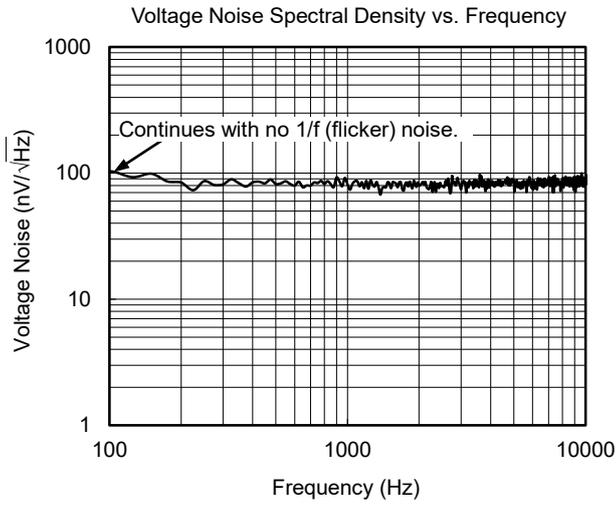


0.1Hz to 10Hz Noise



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$ and $C_L = 0\text{pF}$, unless otherwise noted.



APPLICATION INFORMATION

Rail-to-Rail Input

When SGM8956XTDE8G works at the power supply between 1.8V 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.

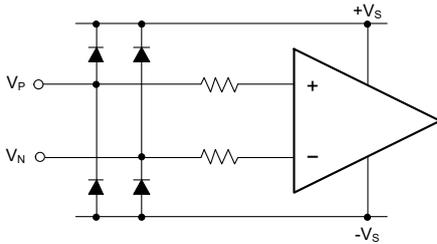


Figure 1. Input Equivalent Circuit

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.

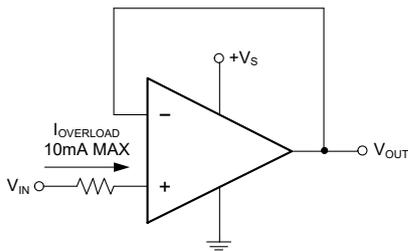


Figure 2. Input Current-Limit Protection

Rail-to-Rail Output

The SGM8956XTDE8G supports rail-to-rail output operation. In single power supply application, for example, when $+V_S = 5.5V$, $-V_S = GND$, 10kΩ load resistor is tied from OUT pin to $+V_S/2$, the typical output swing range is from 0.014V to 5.486V.

Driving Capacitive Loads

The SGM8956XTDE8G is unity-gain stable with heavy capacitive load. 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.

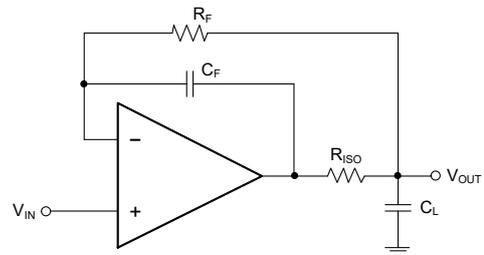


Figure 3. Circuit to Drive Heavy Capacitive Load

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.

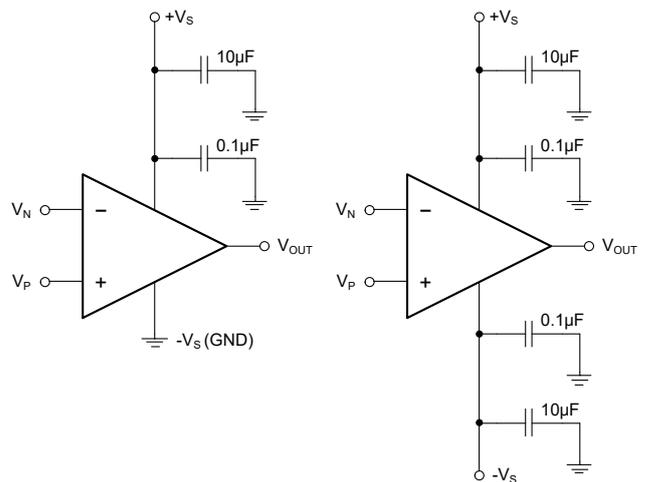


Figure 4. Amplifier Power Supply Bypassing

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

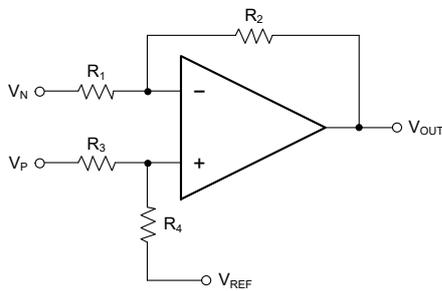


Figure 5. Difference Amplifier

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.

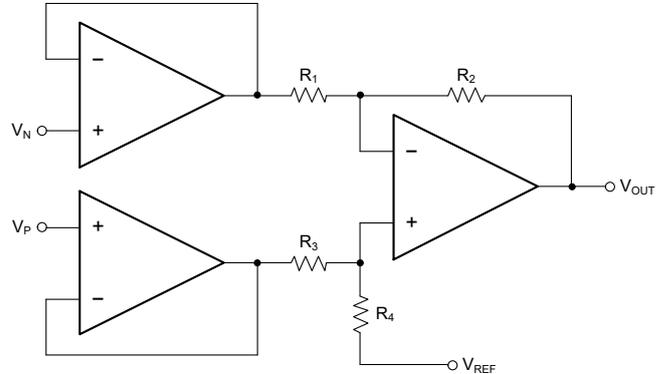


Figure 6. High Input Impedance Difference Amplifier

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 $1/(2\pi R_2 C)$. 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.

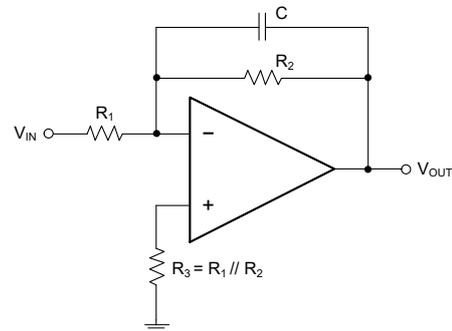


Figure 7. Active Low-Pass Filter

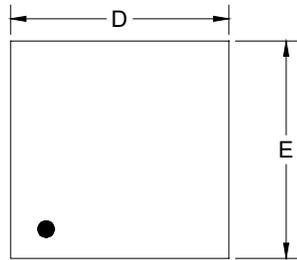
REVISION HISTORY

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

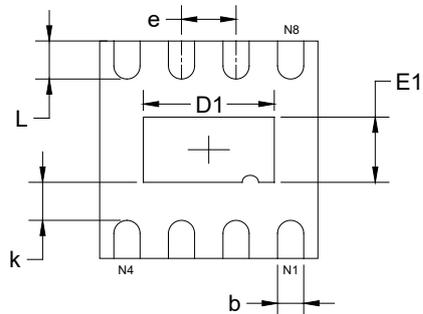
FEBRUARY 2025 – REV.A.1 to REV.A.2	Page
Updated Absolute Maximum Ratings section.....	2
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OCTOBER 2020 – REV.A to REV.A.1	Page
Updated Typical Performance Characteristics section.....	5
<hr/>	
Changes from Original (MARCH 2018) to REV.A	Page
Changed from product preview to production data.....	All

PACKAGE OUTLINE DIMENSIONS

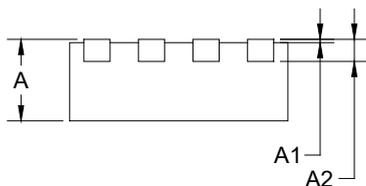
TDFN-2x2-8L



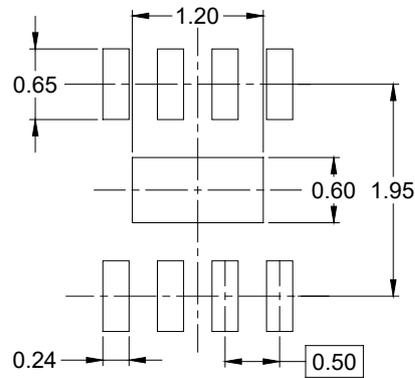
TOP VIEW



BOTTOM VIEW



SIDE VIEW



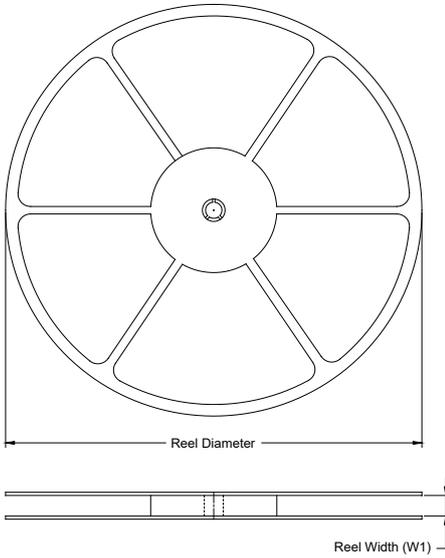
RECOMMENDED LAND PATTERN (Unit: mm)

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	1.900	2.100	0.075	0.083
D1	1.100	1.300	0.043	0.051
E	1.900	2.100	0.075	0.083
E1	0.500	0.700	0.020	0.028
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.250	0.450	0.010	0.018

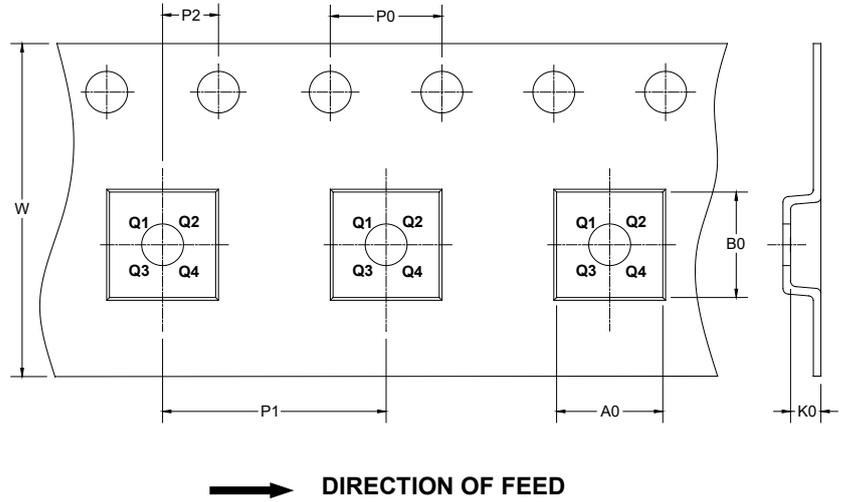
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



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

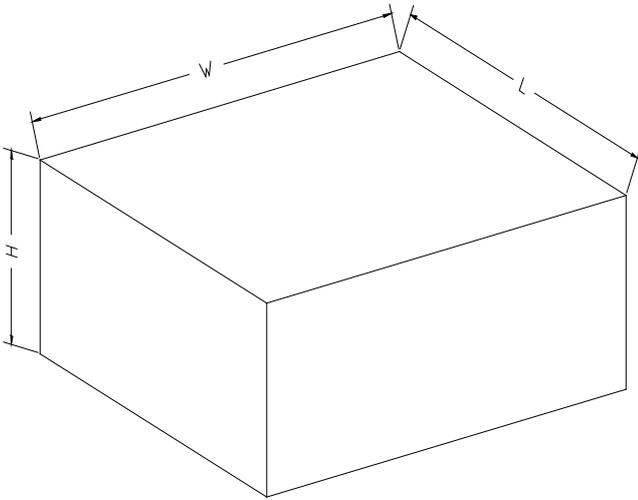
KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
TDFN-2×2-8L	7"	9.5	2.30	2.30	1.10	4.0	4.0	2.0	8.0	Q1

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

D00002