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TPV358S8/M8

1MHz,Low Power,CMOS,EMI Hardened, Rail to Rail Dual Operational Amplifier

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General Description

The TPV358 is a single supply, low power CMOS dual operational amplifier; these amplifiers offer bandwidth of 1MHz, rail-to-rail inputs and outputs, and single-supply operation from 2.2V to 5.5V. The embedded anti-RF filter can significantly increase the RF immunity without extra components. Typical low quiescent supply current of 80μA in dual operational amplifiers within one chip and very low input bias current of 10pA make the devices an ideal choice for low offset, low power consumption and high impedance applications such as smoke detectors, photodiode amplifiers, and other sensors.

The TPV358 is available in SOP-8L and MSOP-8L packages. The extended temperature range of -40 ℃ to +125 ℃ over all supply voltages offers additional design flexibility.

Features

- Single-Supply Operation from +2.2V ~ +5.5V
- Rail-to-Rail Input / Output
- Gain-Bandwidth Product: 1MHz (Typ.)
- Low Input Bias Current: 10pA (Typ.)
- Low Offset Voltage: 5mV (Max.)
- Quiescent Current: 40μA per Amplifier (Typ.)
- Operating Temperature: -40°C ~ +125°C
- Available in SOP-8L and MSOP-8L Packages

Applications

- Portable Equipment
- Mobile Communications
- Smoke Detector
- Medical Instrumentation
- Battery-Powered Instruments
- Sensor Interface
- Handheld Test Equipment

Ordering Information

Part Number	Package	QTY Per Reel	Reel Size
TPV358S8	SOP-8L	4000	12″
TPV358M8	MSOP-8L	3000	12″

Pin Assignments

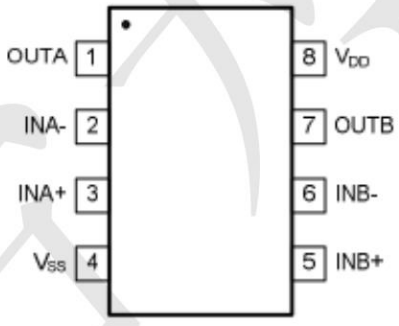
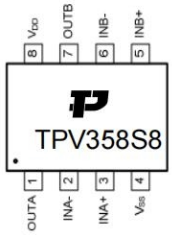


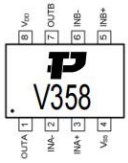
Figure 1. Pin Assignment Diagram (SOP-8L and MSOP-8L Package)

Marking:

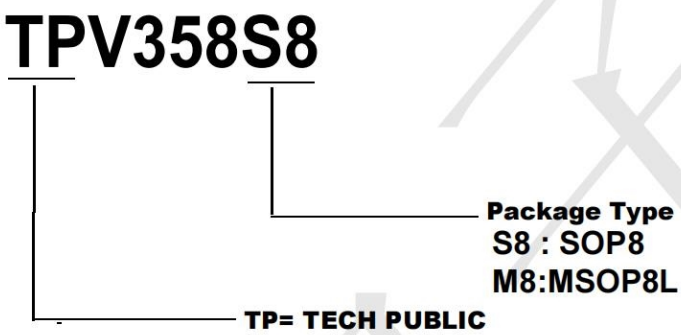
TPV358S8(SOP8)



TPV358M8(MSOP-8L)



Ordering Information



Electrical Characteristics

Absolute Maximum Ratings

Condition	Min	Max
Power Supply Voltage (V_{DD} to Vss)	-0.5V	+7V
Analog Input Voltage (IN+ or IN-)	Vss-0.5V	V_{DD}+0.5V
PDB Input Voltage	Vss-0.5V	+7V
Operating Temperature Range	-40°C	+125°C
Junction Temperature	+150°C	
Storage Temperature Range	-65°C	+150°C
Lead Temperature (soldering, 10sec)	+300°C	
Package Thermal Resistance (T_A=+25℃)		
SOP-8L, θ_{JA}	130°C	
MSOP-8L, θ_{JA}	210°C	

Note: Stress greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions outside those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Electrical Characteristics

(V_{DD} = +5V, Vss = 0V, V_{CM} = 0V, V_{OUT} = V_{DD}/2, R_L=100K tied to V_{DD}/2, SHDNB = V_{DD}, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at T_A =+25°C.) (Notes 1)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Supply-Voltage Range	V_{DD}	Guaranteed by the PSRR test	2.2	-	5.5	V
Quiescent Supply Current (per Amplifier)	I_Q	V_{DD} = 5V	30	40	60	μA
Input Offset Voltage	V_{OS}		-	0.5	±5	mV
Input Offset Voltage Tempco	$\Delta V_{OS}/\Delta T$		-	2	-	μV/°C
Input Bias Current	I_B	(Note 2)	-	10	-	pA
Input Offset Current	I_{OS}	(Note 2)	-	10	-	pA
Input Common-Mode Voltage Range	V_{CM}		-0.1	-	V_{DD}+0.1	V
Common-Mode Rejection Ratio	CMRR	V_{DD}=5.5 Vss-0.1V V_{CM} V_{DD}+0.1V	55	65	-	dB
		Vss≤V_{CM}≤5V	60	80	-	dB
Power-Supply Rejection Ratio	PSRR	V_{DD} = +2.5V to +5.5V	75	94	-	dB
Open-Loop Voltage Gain	A_V	V_{DD}=5V, R_L=100kΩ , 0.05V≤V_O≤4.95V	100	110	-	dB
		V_{DD}=5V, R_L=5kΩ , 0.05V≤V_O≤4.95V	70	80	-	dB
Output Voltage Swing	V_{OUT}	|V_{IN+}-V_{IN-}|γ10mV V_{DD}-V_{OH}	-	6	-	mV
		R_L = 100kΩ to V_{DD}/2 V_{OL}-V_{SS}	-	6	-	mV
		|V_{IN+}-V_{IN-}|γ10mV V_{DD}-V_{OH}	-	60	-	mV
		R_L = 5kΩ to V_{DD}/2 V_{OL}-V_{SS}	-	60	-	mV
Output Short-Circuit Current	I_{SC}	Sinking or Sourcing	-	±20	-	mA
Gain Bandwidth Product	GBW	A_V = +1V/V	-	1	-	MHz
Slew Rate	SR	A_V = +1V/V	-	0.6	-	V/μs
Settling Time	t_S	To 0.1%, V_{OUT} = 2V step A_V = +1V/V	-	5	-	μs
Over Load Recovery Time		V_{IN} X Gain=V_S	-	2	-	μs
Input Voltage Noise Density	e_n	f = 10kHz	-	20	-	nV/√Hz

Note 1: All devices are 100% production tested at T_A = +25°C; all specifications over the automotive temperature range is guaranteed by design, not production tested.

Note 2: Parameter is guaranteed by design.

Application Information

Size

TPV358 series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the TPV358 series packages save space on printed circuit boards and enable the design of smaller electronic products.

Power Supply Bypassing and Board Layout

TPV358 series operates from a single 2.2V to 5.5V supply or dual ±1.1V to ±2.75V supplies. For best performance, a 0.1μF ceramic capacitor should be placed close to the V_{DD} pin in single supply operation. For dual supply operation, both V_{DD} and V_{SS} supplies should be bypassed to ground with separate 0.1μFceramic capacitors.

Low Supply Current

The low supply current (typical 80μA) of TPV358 series will help to maximize battery life. They are ideal for battery powered Systems

Operating Voltage

TPV358 series operate under wide input supply voltage (2.2V to 5.5V). In addition, all temperature specifications apply from -40℃ to +125℃. Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime.

Rail-to-Rail Input

The input common-mode range of TPV358 series extends 100mV beyond the supply rails (V_{SS}-0.1V to V_{DD}+0.1V). This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

Rail-to-Rail Output

Rail-to-Rail output swing provides maximum possible dynamic range at the output. This is particularly important when operating in low supply voltages. The output voltage of TPV358 series can typically swing to less than 10mV from supply rail in light resistive loads (>100kΩ), and 60mV of supply rail in moderate resistive loads (10kΩ).

Capacitive Load Tolerance

The TPV358 series can directly drive 250pF capacitive load in unity-gain without oscillation. Increasing the gain enhances the amplifier's ability to drive greater capacitive loads. In unity-gain configurations, the capacitive load drive can be improved by inserting an isolation resistor R_{ISO} in series with the capacitive load, as shown in Figure 2.

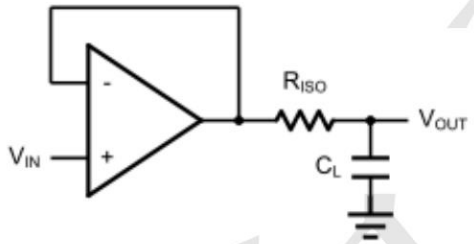


Figure 2. Indirectly Driving a Capacitive Load Using Isolation Resistor

The bigger the R_{ISO} resistor value, the more stable V_{OUT} will be. However, if there is a resistive load RL in parallel with the capacitive load, a voltage divider (proportional to R_{ISO}/R_L) is formed, this will result in a gain error.
The circuit in Figure 3 is an improvement to the one in Figure 2. R_F provides the DC accuracy by feed-forward the V_{IN} to R_L. 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 the phase margin in the overall feedback loop. Capacitive drive can be increased by increasing the value of C_F. This in turn will slow down the pulse response.

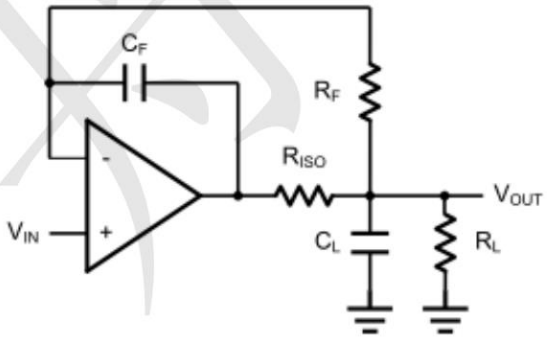


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common the two inputs. It is useful as a computational amplifier in making a differential to single-end conversion or in rejecting a common mode signal. Figure 4. shown the differential amplifier using

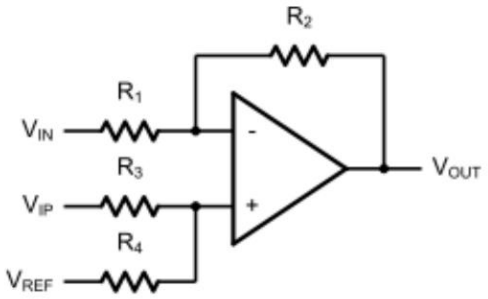


Figure 4. Differential Amplifier

$$V_{OUT} = \left(\frac{R1+R2}{R3+R4}\right)\frac{R4}{R1}V_{IN} - \frac{R2}{R1}V_{IP} + \left(\frac{R1+R2}{R3+R4}\right)\frac{R3}{R1}V_{REF}$$

If the resistor ratios are equal (i.e. R1=R3 and R2=R4), then

$$V_{OUT} = \frac{R2}{R1}(V_{IP} - V_{IN}) + V_{REF}$$

Instrumentation Amplifier

The input impedance of the previous differential amplifier is set by the resistors R1, R2, R3, and R4. To maintain the high input impedance, one can use a voltage follower in front of each input as shown in the following two instrumentation amplifiers.

Three-Op-Amp Instrumentation Amplifier

The dual TPV358 can be used to build a three-op-amp instrumentation amplifier as shown in Figure 5.

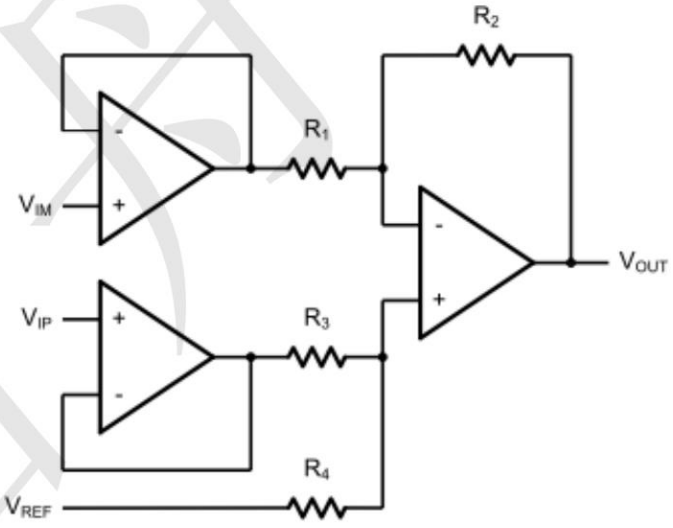


Figure 5. Three-Op-Amp Instrumentation Amplifier

The amplifier in Figure 5 is a high input impedance differential amplifier with gain of R2/R1. The two differential voltage followers assure the high input impedance of the amplifier.

$$Vo = (1 + \frac{R_4}{R_3})(V_{IP} - V_{IN})$$

Two-Op-Amp Instrumentation Amplifier

TPV358 can also be used to make a high input impedance two-op-amp instrumentation amplifier as shown in Figure 6.

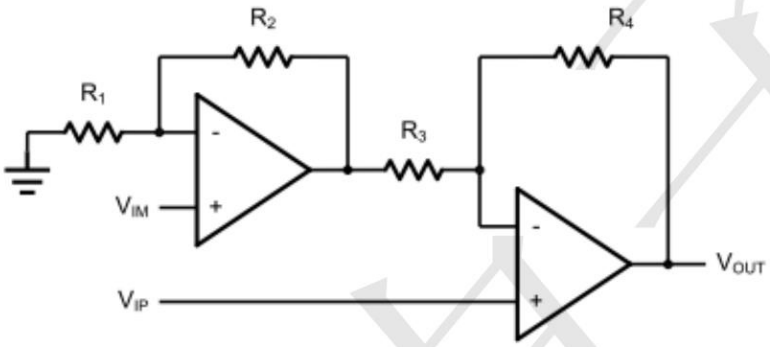


Figure 6. Two-Op-Amp Instrumentation Amplifier

Where R1=R3 and R2=R4. If all resistors are equal, then *Vo=2(VIP-VIN)*

Single-Supply Inverting Amplifier

The inverting amplifier is shown in Figure 6. The capacitor C1 is used to block the DC signal going into the AC signal source VIN. The value of R1 and C1 set the cut-off frequency to f_C=1/(2πR1C1). The DC gain is defined by VOUT=-(R2/R1)VIN

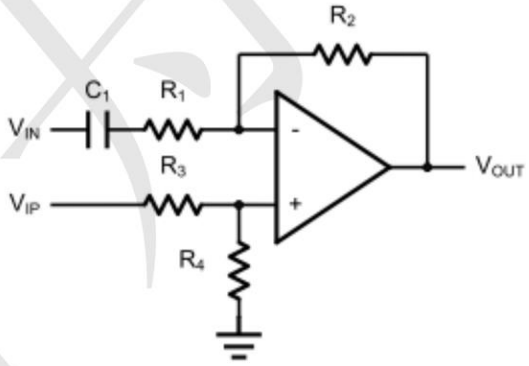


Figure 7. Single Supply Inverting Amplifier

Low Pass Active Filter

The low pass active filter is shown in Figure 8. The DC gain is defined by –R2/R1. The filter has a -20dB/decade roll-off after its corner frequency f_C=1/(2πR3C1).

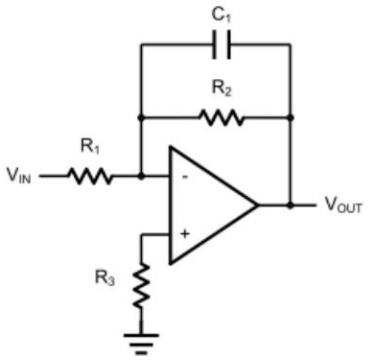


Figure 8. Low Pass Active Filter

Sallen-Key 2nd Order Active Low-Pass Filter

TPV358 can be used to form a 2nd order Sallen-Key active low-pass filter as shown in Figure 9. The transfer function from VIN to VOUT is given by

$$\frac{V_{OUT}}{V_{IN}}(S)=\frac{\frac{1}{C_1C_2R_1R_2}A_{LP}}{S^2+S(\frac{1}{C_1R_1}+\frac{1}{C_1R_2}+\frac{1}{C_2R_2}-\frac{A_{LP}}{C_2R_2})+\frac{1}{C_1C_2R_1R_2}}$$

Where the DC gain is defined by $A_{LP}=1+R_3/R_4$, and the corner frequency is given by

$$\omega C=\sqrt{\frac{1}{C_1C_2R_1R_2}}$$

The pole quality factor is given by

$$\frac{\omega C}{Q}=\frac{1}{C_1R_1}+\frac{1}{C_1R_2}+\frac{1}{C_2R_2}-\frac{A_{LP}}{C_2R_2}$$

Let $R_1=R_2=R$ and $C_1=C_2=C$, the corner frequency and the pole quality factor can be simplified as below

$$\omega_C=\frac{1}{CR}$$

And $Q=2-R_3/R_4$

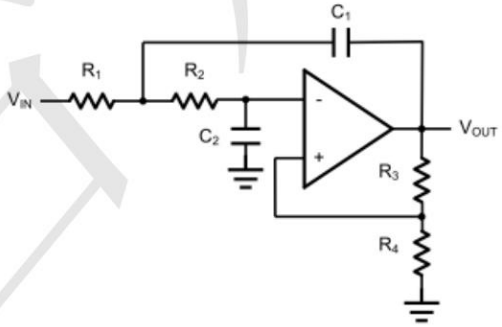


Figure 9. Sanllen-Key 2nd Order Active Low-Pass Filter

Sallen-Key 2nd Order high-Pass Active Filter

The 2nd order Sallen-key high-pass filter can be built by simply interchanging those frequency selective components R_1, R_2, C_1,and C_2 as shown in Figure 10.

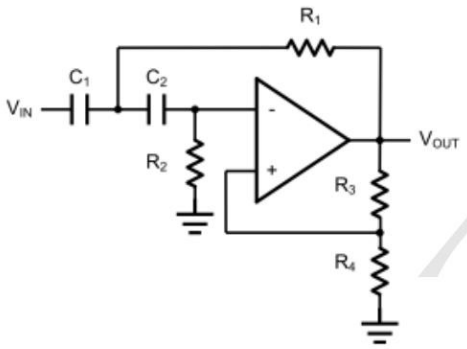


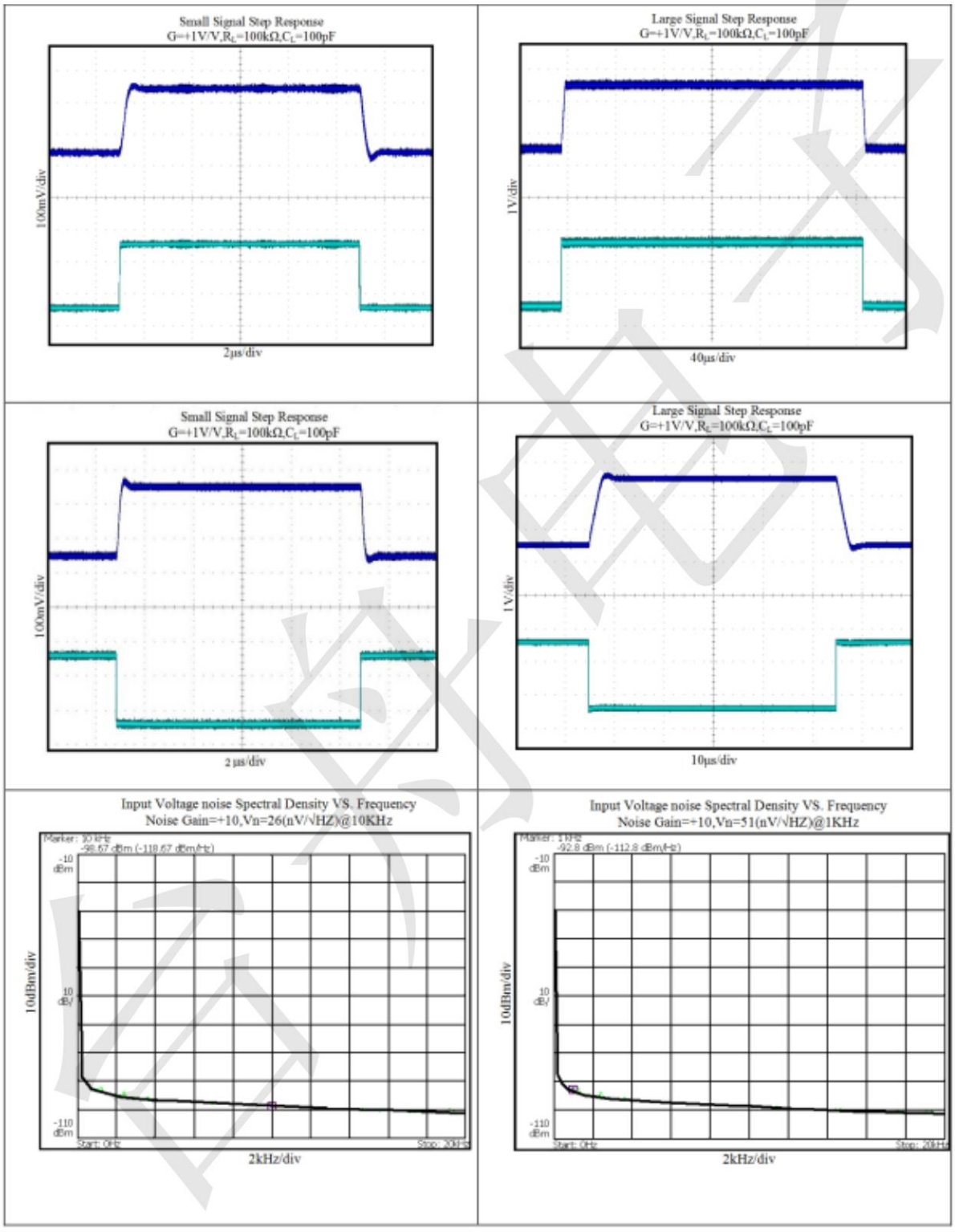
Figure 10. Sanllen-Key 2nd Order Active High-Pass Filter

$$\frac{V_{OUT}}{V_{IN}}(S)=\frac{S^2 A_{HP}}{S^2+S\left(\frac{1}{C_1R_1}+\frac{1}{C_2R_2}+\frac{1-A_{HP}}{C_1R_1}\right)+\frac{1}{C_1C_2R_1R_2}}$$

Where $A_{HP}=1+R_3/R_4$

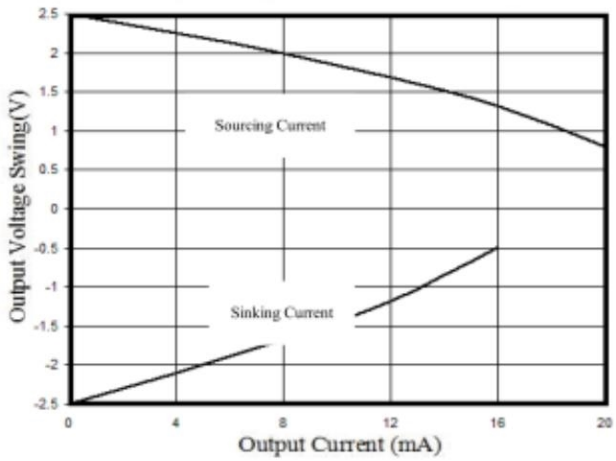
Typical characteristics

At T_A=+25°C, R_L=100 kΩ connected to V_S/2 and V_{OUT}= V_S/2, unless otherwise noted.

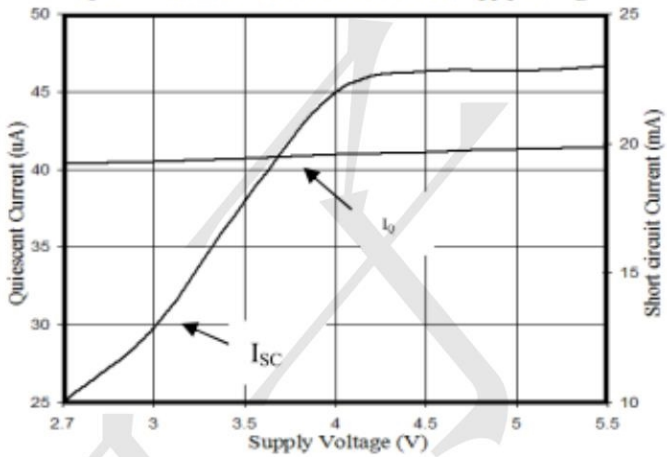


At T_A=+25°C, R_L=100 kΩ connected to V_S/2 and V_{OUT}= V_S/2, unless otherwise noted.

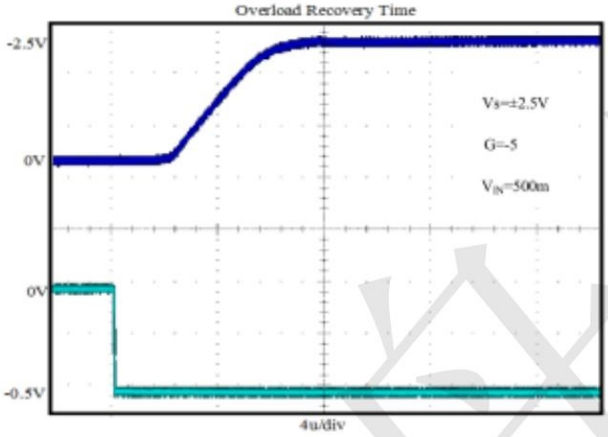
Output Voltage swing VS. Output Current



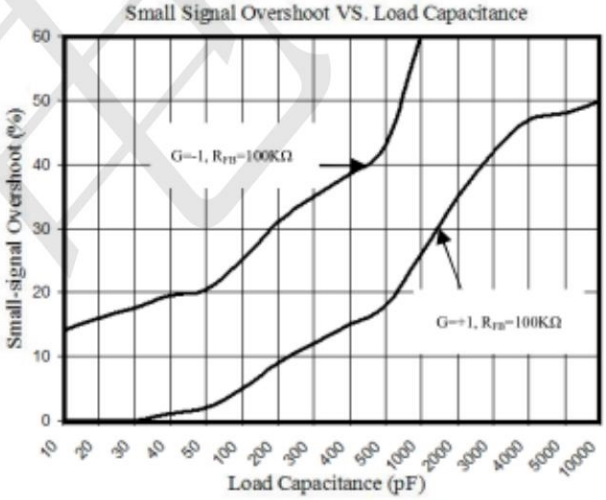
Quiescent and Short-Circuit Current VS. Supply Voltage



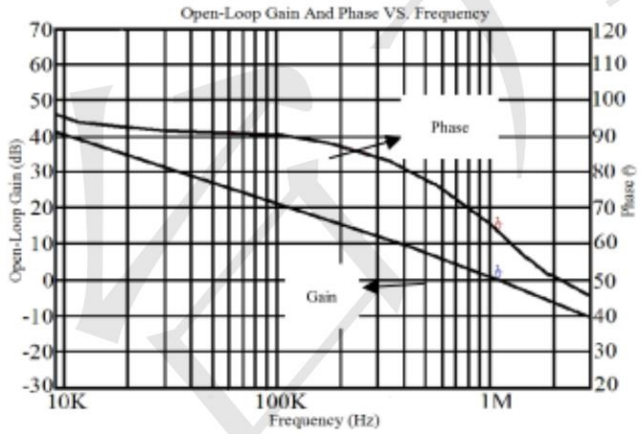
Overload Recovery Time



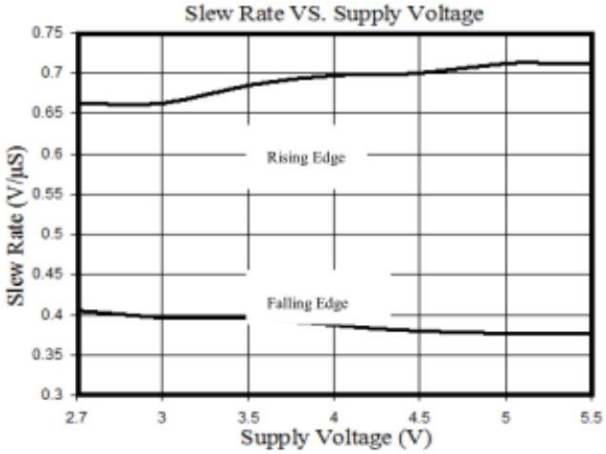
Small Signal Overshoot VS. Load Capacitance



Open-Loop Gain And Phase VS. Frequency



Slew Rate VS. Supply Voltage



Package Information

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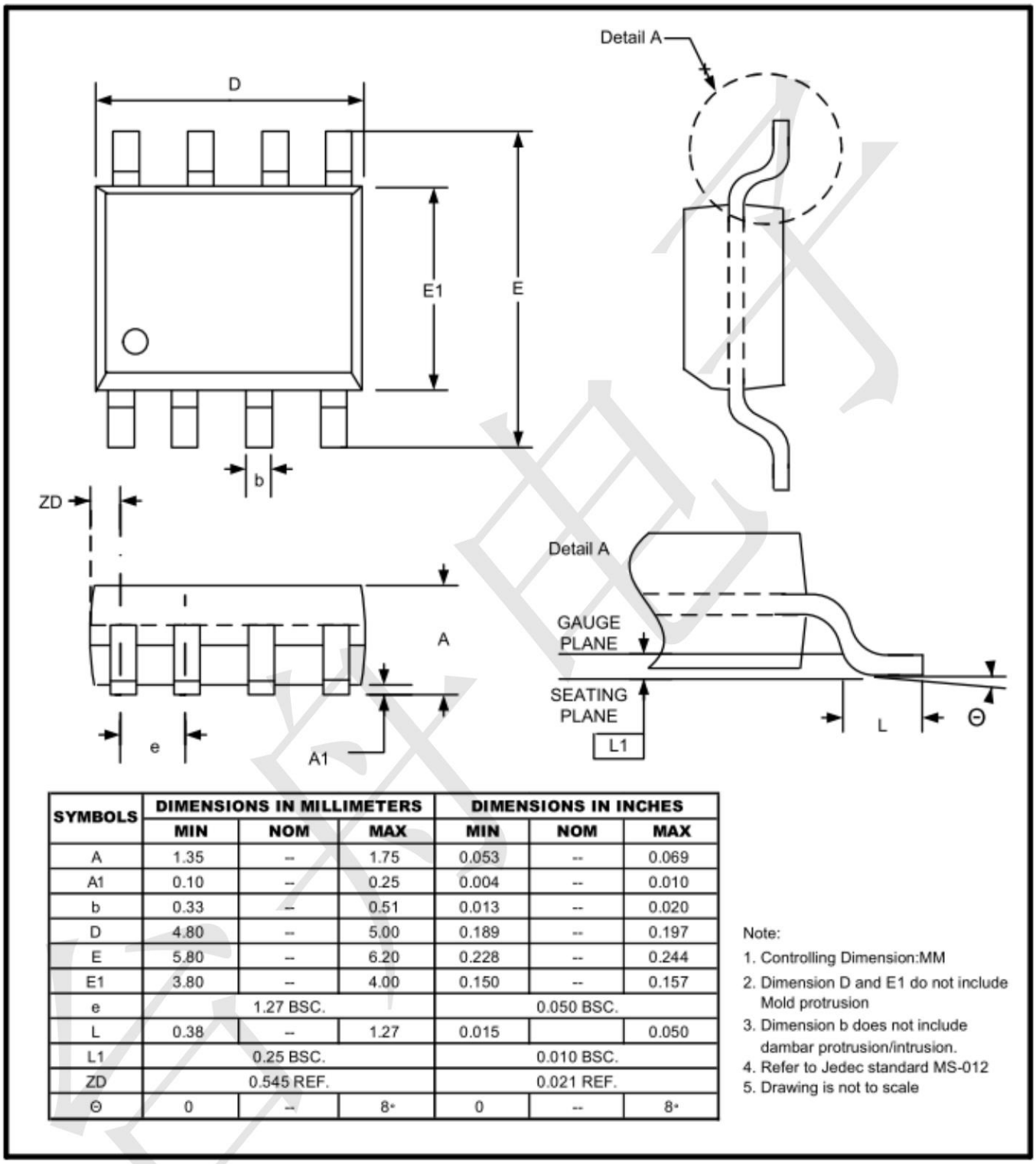
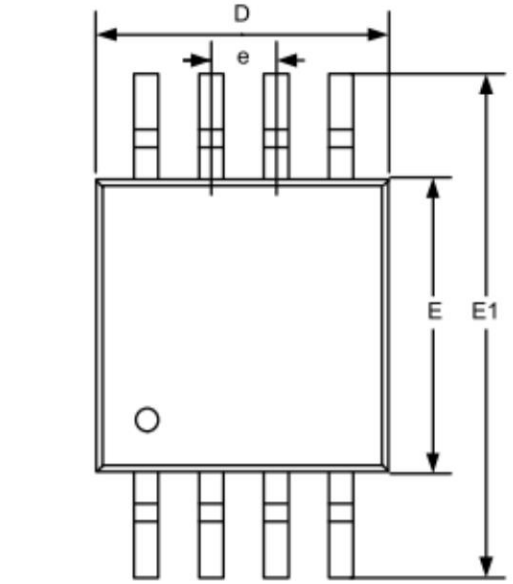
SOP-8L

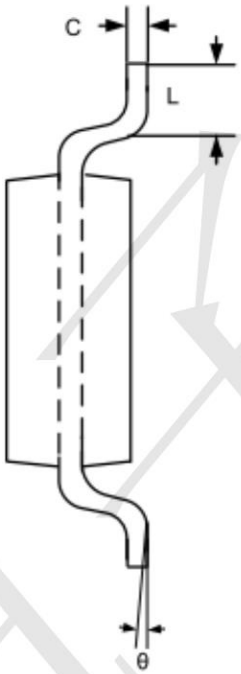


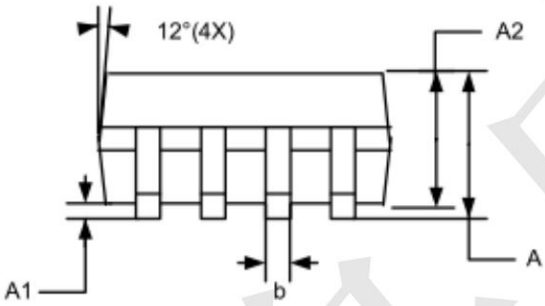
SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.35	--	1.75	0.053	--	0.069
A1	0.10	--	0.25	0.004	--	0.010
b	0.33	--	0.51	0.013	--	0.020
D	4.80	--	5.00	0.189	--	0.197
E	5.80	--	6.20	0.228	--	0.244
E1	3.80	--	4.00	0.150	--	0.157
e	1.27 BSC.			0.050 BSC.		
L	0.38	--	1.27	0.015		0.050
L1	0.25 BSC.			0.010 BSC.		
ZD	0.545 REF.			0.021 REF.		
Θ	0	--	8°	0	--	8°

Note:
1. Controlling Dimension:MM
2. Dimension D and E1 do not include Mold protrusion
3. Dimension b does not include dambar protrusion/intrusion.
4. Refer to Jedec standard MS-012
5. Drawing is not to scale

MSOP-8L







SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	--	--	1.10	--	--	0.043
A1	0.05	--	0.15	0.002	--	0.006
A2	0.75	0.85	0.95	0.030	0.033	0.037
b	0.25	--	0.40	0.010	--	0.016
C	0.13	--	0.23	0.005	--	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	2.90	3.00	3.10	0.114	0.118	0.122
E1	4.90 BSC			0.193 BSC		
e	0.65 BSC			0.026 BSC		
L	--	--	0.55	--	--	0.022
θ	0	--	7°	0	--	7°

Note:
1. Controlling Dimension:MM
2. Dimension D and E1 do not include Mold protrusion
3. Refer to Jedec standard MO187
4. Drawing is not to scale