6.5MHz, Rail-to-Rail I/O CMOS Operational Amplifier

FEATURES

- **AEC-Q100 qualified for automotive applications**
- **Low Offset Voltage: 3.5mV (MAX)**
- **High Gain: 105dB (TYP)**
- **High Gain Bandwidth Product: 6.5MHz**
- **Rail-to-Rail Input/Output**
- **Low I_B: 1pA (TYP)**
- **Low Supply Voltage: +2.5V to +5.5V**
- **Low Power Consumption: 580μA at 5V**
- **Extended Temperature: -40℃ to +125℃**

APPLICATIONS

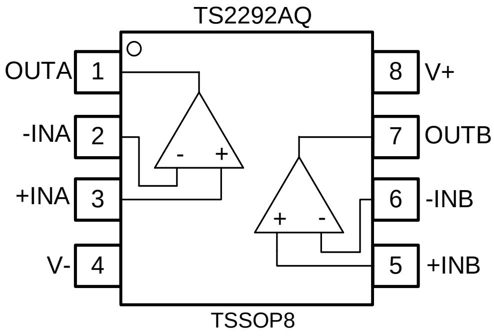
- **Signal Conditioning**
- **Current Sensor Amplifier**
- **Battery-Powered Applications**
- **Portable Devices**
- **Active Filtering**
- **Weight Scale Sensor**
- **Medical/Industrial Instrumentation**
- **Power Converter/Inverter**

PRODUCT DESCRIPTION

The TS2192AQ of product is low noise, low voltage and low power operational amplifiers with high gain-bandwidth product of 6.5MHz and slew rate of 5V/μs. The maximum input offset voltage is only 3.5mV and the input common mode range extends beyond the supply rails.

TS2292AQ of operational amplifiers are specified at the full temperature range of −40˚C to +125˚C under single or dual power supplies of 2.7V to 5.5V, however these products will operate under an extended supply range from 2.5V to 5.5V at a reduced temperatures range.

PIN ASSIGNMENTS



ORDERING INFORMATION

Model	Part Number	Eco Plan	Package	AMP	Container, Pack Qty
TS2292AQ	TS2292ATSSOP8R	RoHS	TSSOP8	2	Reel, 4000

ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature range (unless otherwise noted) (1)

Parameter	Min	Max	Unit
Supply Voltage		7	V
Signal Input Terminal Voltage	(V-) - 0.5	(V+) + 0.5	V
Operating Temperature	-50	150	°C
Junction Temperature		150	°C
Storage Temperature Range	-65	150	°C
Lead Temperature (Soldering, 10s)		260	°C
ESD HBM		±3000	V
ESD MM		±400	V
ESD CDM		±1000	V

(1) Stresses beyond 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 beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ESD CAUTION

ESD (electrostatic discharge) sensitive device

Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjects to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

ELECTRICAL CHARACTERISTICS: V_S = +2.7V to +5.5V

Boldface limits apply over the specified temperature range, **T_A = −40˚C to +125˚C.**

At T_A = +25˚C, R_L = 10kΩ connected to V_S / 2, and V_{OUT} = V_S / 2 (unless otherwise noted)

Parameter		Operating Conditions	Min	Typ	Max	Unit
V_S	Power Supply Voltage		2.7		5.5	V
$V_{IN +/-}$	Input Voltage Range		(V-) - 0.2		(V+) + 0.2	V
I_S	Supply Current (Per Amplifer)	I_O = 0		580	750	µA
PSRR	Power Supply Rejection Ratio	V_S = 2.7V to 5.5V, V_{CM} < (V+) - 2V		25	125	µV/V
		T_A = −40˚C to +125˚C			**150**	**µV/V**
Input Characteristics						
V_{OS}	Input Offset Voltage	V_S = 5.5V		1	3.5	mV
dV_{OS}/dT	**Average Drift**			**3**		**µV/˚C**
I_B	Input Bias Current			1		pA
I_{OS}	Input Offset Current			1		pA
CMRR	Common Mode Rejection Ratio	(V-) - 0.2V < V_{CM} < (V+) - 2V	76	88		dB
		T_A = −40˚C to +125˚C	**68**	**72**		**dB**
		V_S = 5.5V, (V−) − 0.2V < V_{CM} < (V+) + 0.2V	64			dB
		T_A = −40˚C to +125˚C	**58**			**dB**
AOL	Open-Loop Gain	Vs = 5V, R_L = 5KΩ (V-) + 0.125V < Vout < (V+) - 0.125V	95	104		dB
		T_A = −40˚C to +125˚C	**85**			**dB**
		Vs = 5V, R_L = 100kΩ (V-) + 25mV < Vout < (V+) - 25mV	96	105		dB
		T_A = −40˚C to +125˚C	**85**			**dB**
Output Characteristics						
V_{OUT}	Output Voltage Swing from Rail	R_L = 100KΩ		18	25	mV
		T_A = −40˚C to +125˚C			**25**	**mV**
		R_L = 5KΩ		100	125	mV
		T_A = −40˚C to +125˚C			**125**	**mV**
I_{OUT}	Output Current	See Typical Characteristics				
R_{OUT}	Open-Loop Output Impedance	f = 1MHz, I_O = 0mA		40		Ω
Dynamic Performance						
GBW	Gain Bandwidth Product			6.5		MHz
t_S	Settling Time to 0.1%	V_{OUT} = 2V step, G = +1		1		µs
	Settling Time to 0.01%	V_{OUT} = 2V step, G = +1		1.5		µs
	Overload Recovery Time	Vin * Gain > V_S		0.2		µs
SR	Slew Rate	G = +1		5		V/µs
THD+N	Total Harmonic Distortion+ Noise	V_S = 5V, Vo = 3Vpp, G = +1, f = 1kHz		0.001		%

ELECTRICAL CHARACTERISTICS: V_S = +2.7V to +5.5V

Boldface limits apply over the specified temperature range, **T_A = −40˚C to +125˚C.**

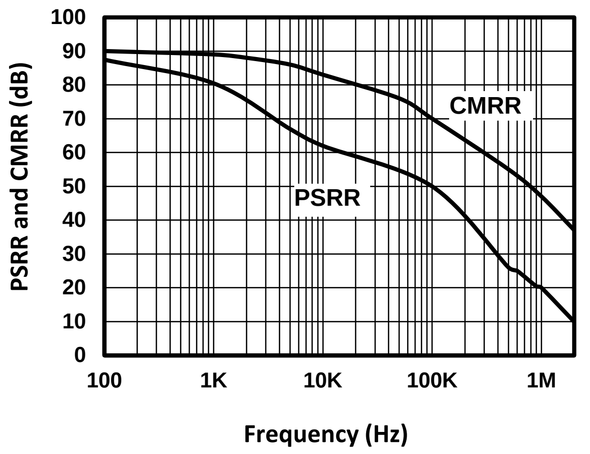
At T_A = +25˚C, R_L = 10kΩ connected to V_S / 2, and V_{OUT} = V_S / 2 (unless otherwise noted)

Parameter		Operating Conditions	Min	Type	Max	Unit
Noise Performance						
V_{noise}	Input Voltage Noise	f = 0.1Hz to 10Hz		5		μVpp
e_n	Input Voltage Noise Density	f = 10kHz		15		$nV/\sqrt{Hz}$
i_n	Input Current Noise Density	f = 10kHz		4		$fA/\sqrt{Hz}$
Temperature Range						
	Specified Range		−40		+125	˚C
	Operating Range		-55		+150	˚C
θ_{JA}	Storage Range		-65		+150	˚C
	Thermal Resistance					
	TSSOP8			100		˚C/W

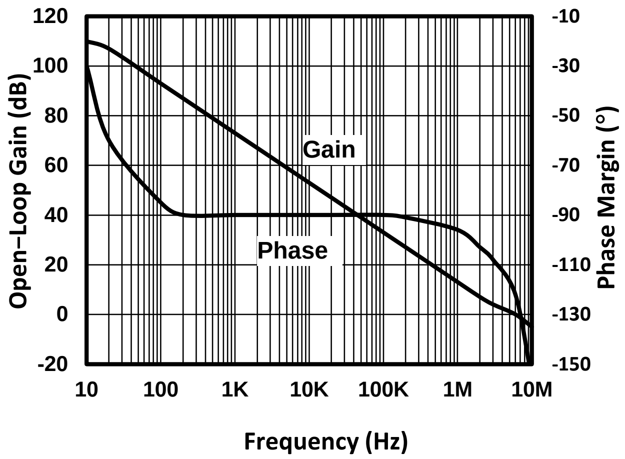
TYPICAL CHARACTERISTICS

At T_A = +25˚C, R_L = 10kΩ connected to V_S / 2, and V_{OUT} = V_S / 2 (unless otherwise noted)

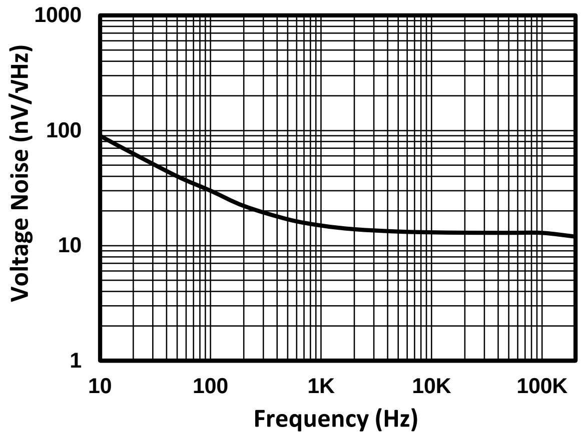
Power–Supply and Common–Mode Rejection Ratio vs Frequency



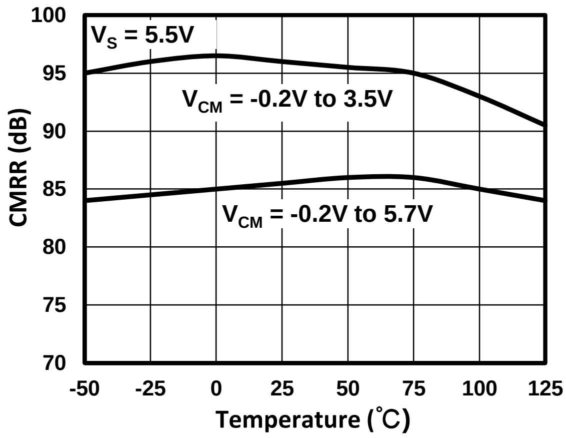
Open–Loop Gain and Phase vs Frequency



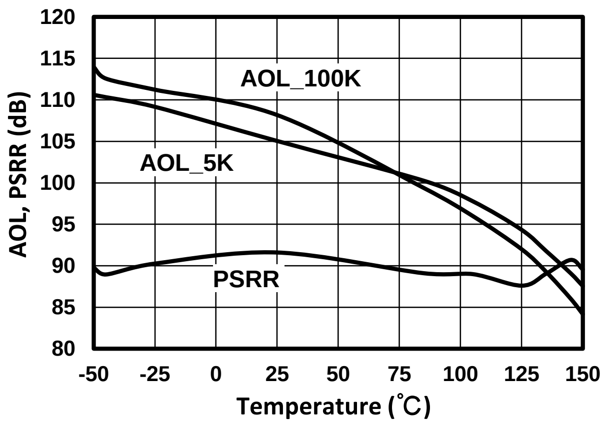
Input Voltage Noise Spectral Density vs Frequency



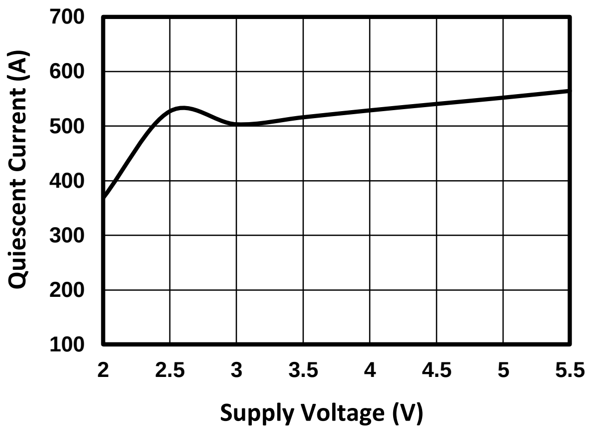
Common-Mode Rejection Ration vs Temperature



Open–Loop Gain and Power–Supply Rejection Ratio vs Temperature

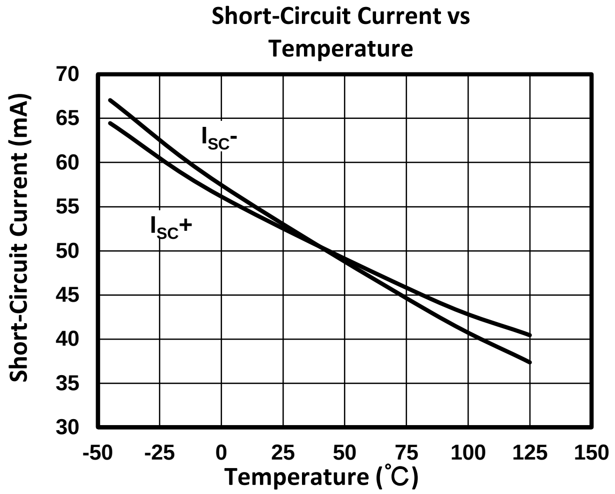


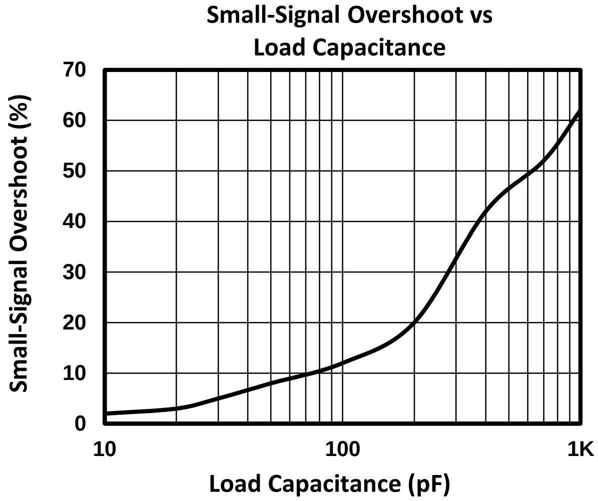
Quiescent Current vs Supply Voltage

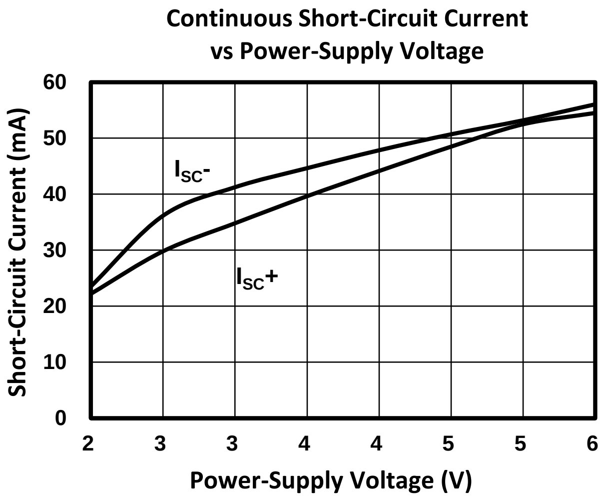


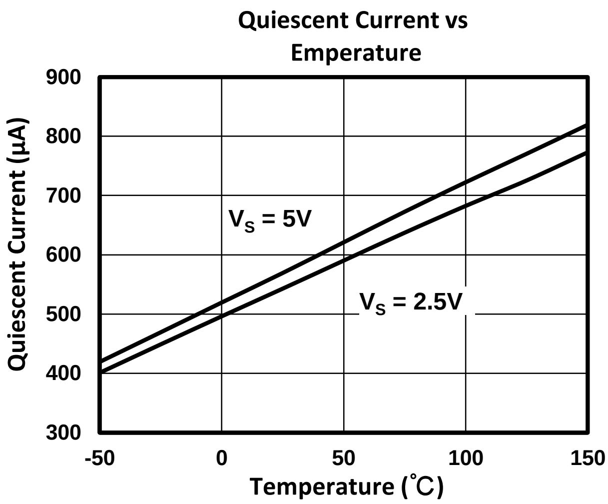
TYPICAL CHARACTERISTICS

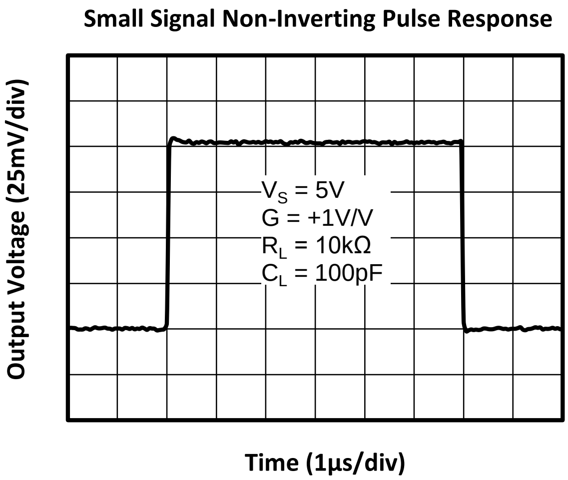
At T_A = +25˚C, R_L = 10kΩ connected to V_S / 2, and V_{OUT} = V_S / 2 (unless otherwise noted)

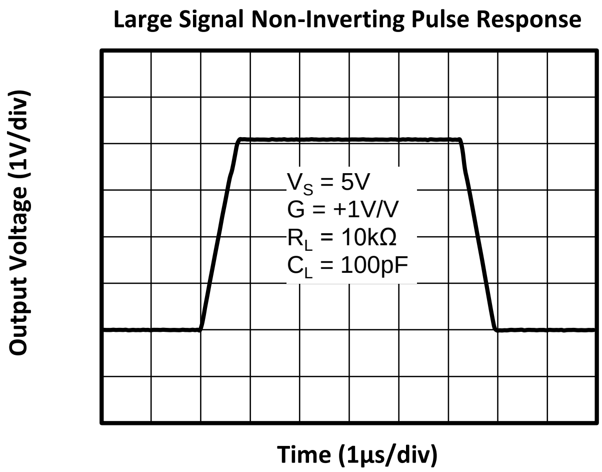








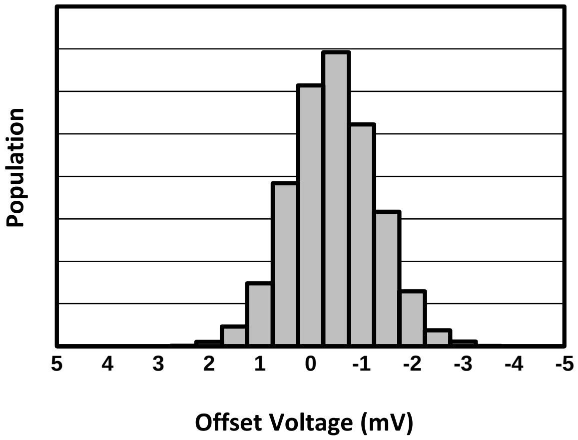




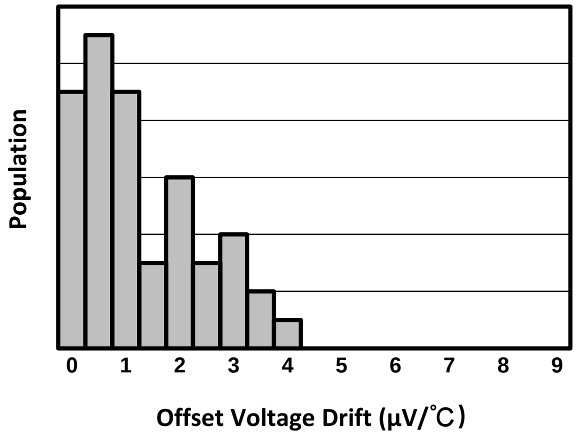
TYPICAL CHARACTERISTICS

At T_A = +25°C, R_L = 10kΩ connected to V_S / 2, and V_{OUT} = V_S / 2 (unless otherwise noted)

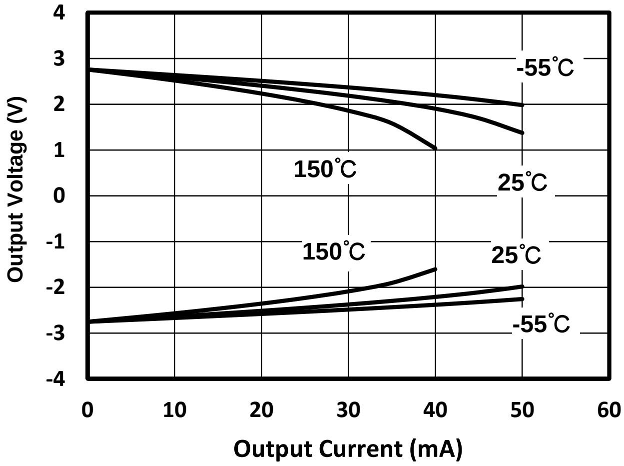
Offset Voltage Production Distribution



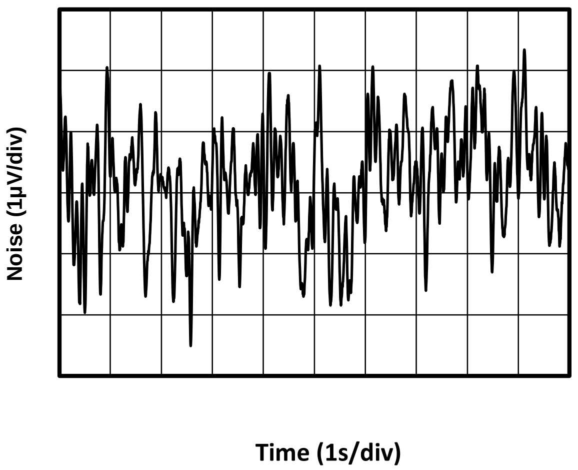
Offset Voltage Drift Magnitude Production Distribution



Output Voltage Swing vs Output Current



0.1Hz-10Hz Noise



APPLICATION NOTES

The TS2192EN and TS2192A families of op amps are suitable for a wide range of general-purpose applications. They provide Rail-to-rail input and output. Excellent ac performance makes them well-suited for audio and sensor applications. The input common-mode voltage range includes both rails, allowing the TS2192EN and TS2192A families op amps to be used in bipolar and unipolar application.

Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications.

Power-supply pins should be bypassed with 0.1μF ceramic capacitors.

POWER SUPPLY

The TS2192EN and TS2192A families operate from a single +2.5V to +5.5V supply or dual ±1.25V to ±2.75V supplies. For single supply operation, bypass the power supply +VS with a 0.1μF 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.

The TS2192EN and TS2192A families are ideal for battery-powered instrumentation and handheld devices because it can operate at the end of discharge voltage of most popular batteries.

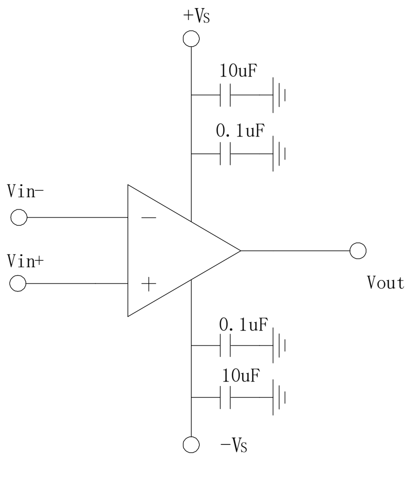


Figure1. Amplifier with Bypass Capacitors

DRIVING CAPACITIVE LOADS

The TS2192EN and TS2192A families can directly drive 1000pF 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 result 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 Figure2. The isolation resistor R_{ISO} and the load capacitor CL 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}.

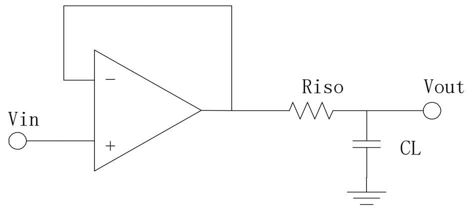


Figure 2. Indirectly Driving Heavy Capacitive Load

An improved circuit is shown in Figure 3. It provides DC accuracy as well as AC stability. Rf provides the DC accuracy by connecting the inverting signal with the output. Cf 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.

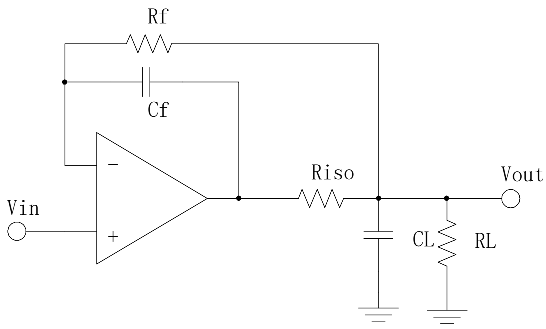


Figure 3. Indirectly Driving Heavy Capacitive Load with DC Accuracy

For non-buffer configuration, there are two other ways to increase the phase margin: (a) by increasing the amplifier's gain or (b) by placing a capacitor in parallel with the feedback resistor to counteract the parasitic capacitance associated with inverting node.

TYPICAL APPLICATION

Difference Amplifier

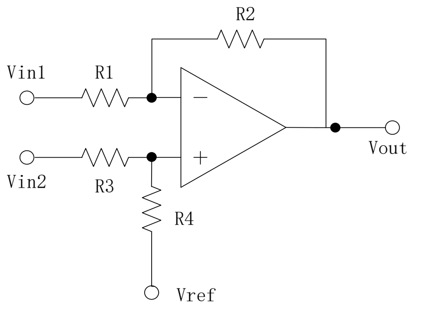


Figure 4. Differential Amplifier

The circuit shown in Figure 4 performs the difference function. If the resistor ratios are equal (R4 / R3 = R2 / R1) then Vout = (Vin2 – Vin1) × R2 / R1 + Vref.

Low Pass Active Filter

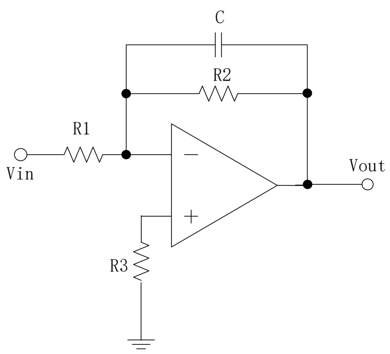


Figure 5. Low Pass Active Filter

The low pass filter shown in Figure 5 has a DC gain of (-R2 / R1) and the –3dB corner frequency is 1/2πR2C. Make sure the filter within the bandwidth of the amplifier. The Large values of feedback resistors can couple with parasitic capacitance and cause undesired effects such as ringing or oscillation in high-speed amplifiers. Keep resistors value as low as possible and consistent with output loading consideration.

Instrumentation Amplifier

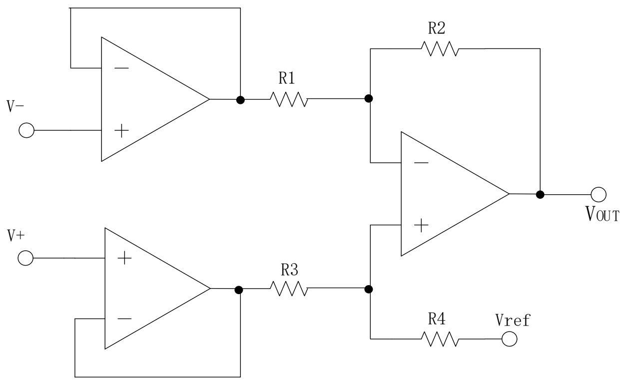
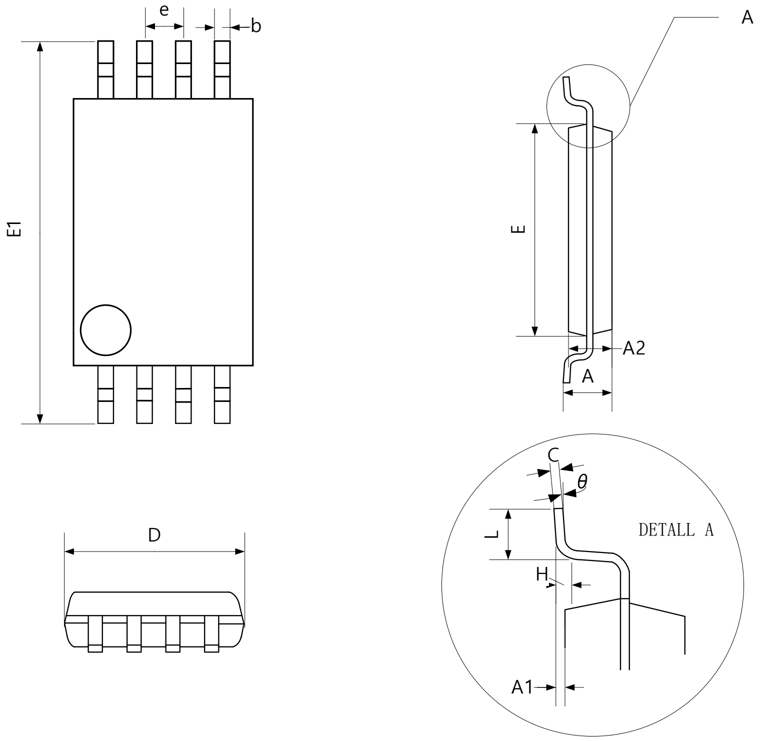


Figure 6. Instrumentation Amplifier

The circuit in Figure 6 performs the same function as that in Figure 4 but with the high input impedance.

MECHANICAL DIMENSIONS

TSSOP8 PACKAGE MECHANICAL DRAWING

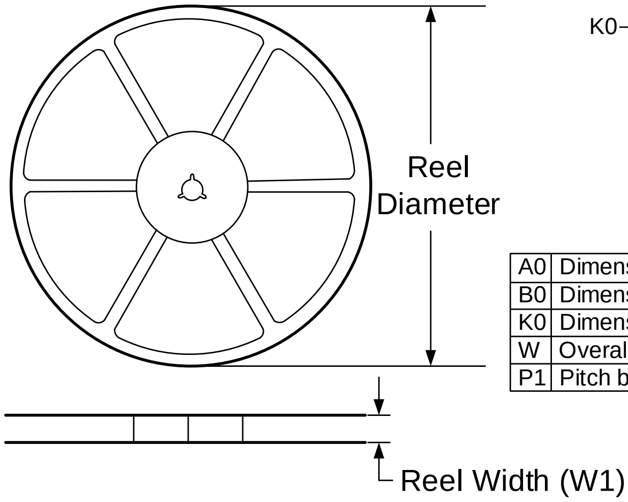


TSSOP8 PACKAGE MECHANICAL DATA

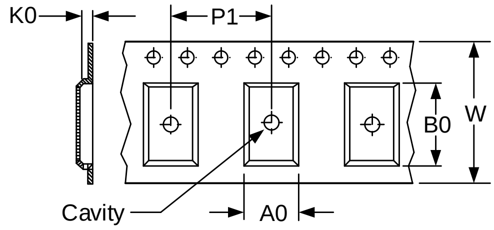
symbol	dimensions			
	millimeters		inches	
	min	max	min	max
D	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A		1.200		0.047
A2	0.800	1.000	0.031	0.039
A1	0.050	0.150	0.002	0.006
e	0.650		0.026	
L	0.500	0.700	0.020	0.028
H	0.250		0.010	
θ	1°	7°	1°	7°

TAPE AND REEL INFORMATION

REEL DIMENSIONS

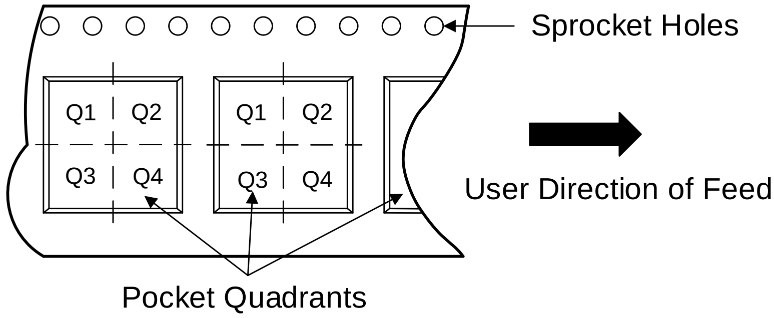


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component width thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Device	Package Type	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TS2292ATSSOP8R	TSSOP8	8	4000	330.0	12.4	6.4	5.4	2.1	8.0	12.0	Q1

REVISION HISTORY

NOTE: Page numbers for previous revisions may be different from that of the current version.

2022/10/24 — REV KY0.0.0A

This Version Is Informal…….………………………………………………………….………………….All Pages

2023/03/30 — REV KY0.0.0A to REV KY1.1.0A

Adjust Page Format……………………………………………………………..……………………………All pages
Add *AEC-Q100 qualified for automotive applications*……..………………. ………… ……… ………… ..………….1

CONTACT INFORMATION

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