LM2904Q
Automotive, Rail-to-Rail Output, Dual Operational Amplifier

GENERAL DESCRIPTION

The LM2904Q is a dual operational amplifier with internal frequency compensation. It is optimized for high voltage operation from 3V to 32V single supply or ±1.5V to ±16V dual supplies, and consumes only 440μA quiescent current.

The LM2904Q features low power, low offset voltage and low bias current. The device can offer high open-loop voltage gain. It is well suited for various applications.

The device is AEC-Q100 qualified (Automotive Electronics Council (AEC) standard Q100 Grade 1) and it is suitable for automotive applications.

The LM2904Q is available in Green SOIC-8 and MSOP-8 packages. It is specified over the -40℃ to +125℃ temperature range.

FEATURES

- **AEC-Q100 Qualified for Automotive Applications**
  Device Temperature Grade 1
  T_A = -40℃ to +125℃
- **Support Single or Dual Power Supplies:**
  3V to 32V or ±1.5V to ±16V
- **Low Quiescent Current: 440μA (TYP)**
- **Low Input Offset Voltage: ±5.8mV (MAX)**
- **Low Input Offset Current: ±10pA (TYP)**
- **Low Input Bias Current: ±10pA (TYP)**
- **Minimum Input Common Mode Voltage: ($-V_S$) - 0.1V**
- **Open-Loop Differential Voltage Gain: 108dB (TYP)**
- **Gain-Bandwidth Product: 1.1MHz**
- **Unity-Gain Stable**
- **Available in Green SOIC-8 and MSOP-8 Packages**

APPLICATIONS

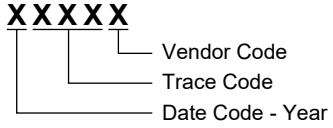
Automotive Applications
Wearable Products
Temperature Measurements
Battery-Powered Systems
Sensors
Audio
Active Filters
Communications
Test Equipment

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE TOP MARKING	PACKING OPTION
LM2904Q	SOIC-8	-40℃ to +125℃	LM2904QS8G/TR	1IWS8 XXXXX	Tape and Reel, 4000
	MSOP-8	-40℃ to +125℃	LM2904QMS8G/TR	1IXMS8 XXXXX	Tape and Reel, 4000

MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace 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 Range, V_S (1) ..... -0.3V to 34V
Differential Input Voltage Range, $IV_{ID}I$ (2) ..... $(+V_S)$ - $(-V_S)$
Input Voltage Range (Either Input)
..... $(-V_S)$ - 0.3V to $(+V_S)$ + 0.3V
Package Thermal Resistance
SOIC-8, θ_{JA} ..... 122.5℃/W
SOIC-8, θ_{JB} ..... 69.2℃/W
MSOP-8, θ_{JA} ..... 142.1℃/W
MSOP-8, θ_{JB} ..... 85.8℃/W
Junction Temperature.....+150℃
Storage Temperature Range.....-65℃ to +150℃
Lead Temperature (Soldering, 10s).....+260℃
ESD Susceptibility (3) (4)
HBM.....±6000V
CDM .....±1000V

NOTES:

1. The network GND is the reference point for all voltage values, except for differential voltages and V_S when measuring I_{SC}.
2. Differential voltage is between +IN and -IN.
3. For human body model (HBM), all pins comply with AEC-Q100-002 specification.
4. For charged device model (CDM), all pins comply with AEC-Q100-011 specification.

RECOMMENDED OPERATING CONDITIONS

Input Common Mode Voltage Range
..... $(-V_S)$ - 0.1V to $(+V_S)$ - 1.5V
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

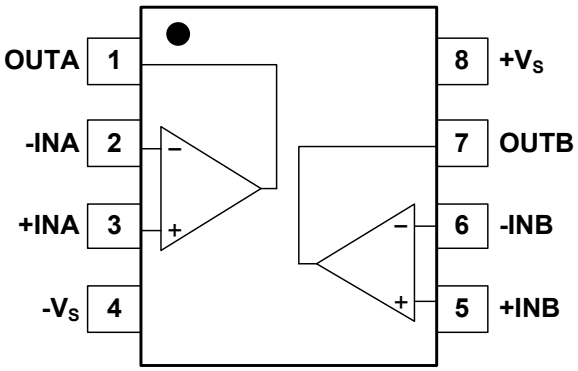
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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.

PIN CONFIGURATIONS

(TOP VIEW)



SOIC-8/MSOP-8

ELECTRICAL CHARACTERISTICS

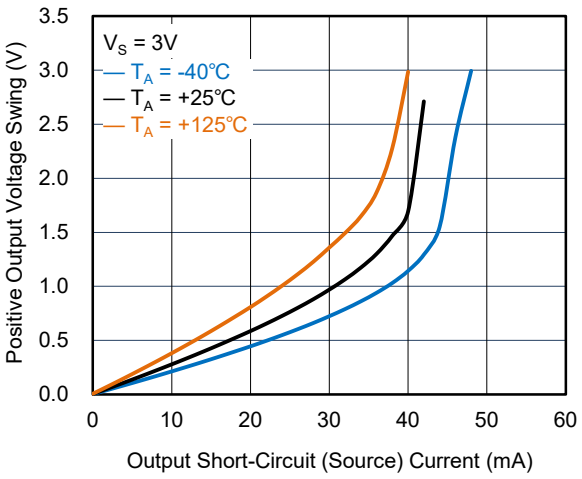
(V_S = 3V to 32V, -0.1V < V_{CM} < (+V_S) - 1.5V, R_L = 10kΩ connected to V_S/2, Full = -40℃ to +125℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Characteristics							
Input Offset Voltage	V_{OS}		+25℃		±1.2	±5.8	mV
			Full			±6	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		Full		3.5		μV/℃
Input Bias Current	I_B	V_{CM} = V_S/2	+25℃		±10	±160	pA
Input Offset Current	I_{OS}	V_{CM} = V_S/2	+25℃		±10	±160	pA
Input Common Mode Voltage Range	V_{CM}		Full	-0.1		(+V_S) - 1.5	V
Common Mode Rejection Ratio	CMRR	-0.1V < V_{CM} < (+V_S) - 1.5V	+25℃	82	120		dB
			Full	79			
Open-Loop Voltage Gain	A_{OL}	R_L = 10kΩ to V_S/2	+25℃	88	108		dB
			Full	83			
Output Characteristics							
Output Voltage Swing from Rail	V_{OH}	R_L = 10kΩ	+25℃		42	60	mV
			Full			80	
	V_{OL}	R_L = 10kΩ	+25℃		110	190	
			Full			240	
Output Short-Circuit Current	I_{SC}		+25℃	±12	±18		mA
Power Supply							
Operating Voltage Range	V_S		Full	3		32	V
Quiescent Current	I_Q	I_{OUT} = 0mA	+25℃		440	680	μA
			Full			950	
Power Supply Rejection Ratio	PSRR		+25℃	102	120		dB
			Full	98			
Turn-On Time		G = +1	+25℃		42		μs
Dynamic Performance (C_L = 100pF)							
Gain-Bandwidth Product	GBP		+25℃		1.1		MHz
Phase Margin	φ_O	G = +1	+25℃		60		°
Slew Rate	SR	G = +1	+25℃		0.35		V/μs
Overload Recovery Time	ORT	V_{IN} × G > V_S	+25℃		5		μs
Noise							
Input Voltage Noise		f = 0.1Hz to 10Hz	+25℃		9		μV_{P-P}
Input Voltage Noise Density	e_n	f = 1kHz	+25℃		36		$nV/\sqrt{Hz}$

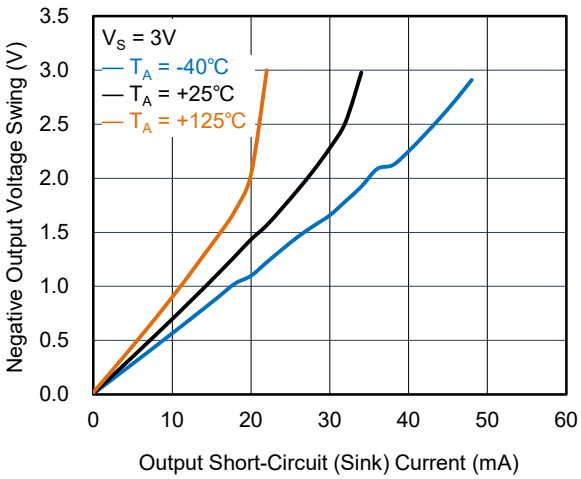
TYPICAL PERFORMANCE CHARACTERISTICS

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

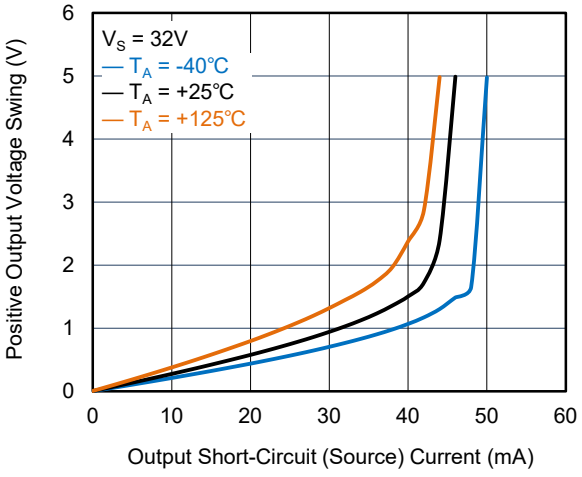
Positive Output Voltage Swing vs. Load Current



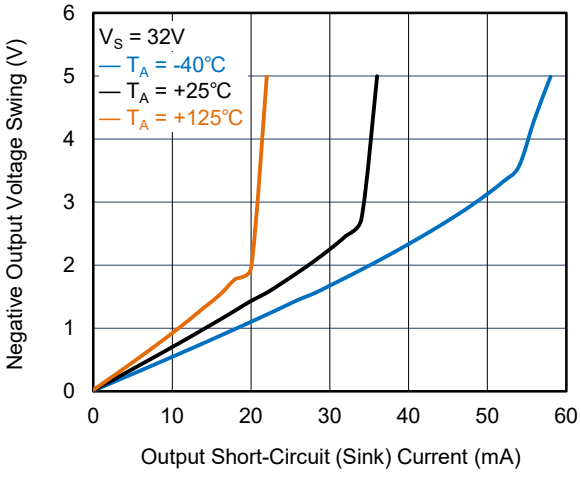
Negative Output Voltage Swing vs. Load Current



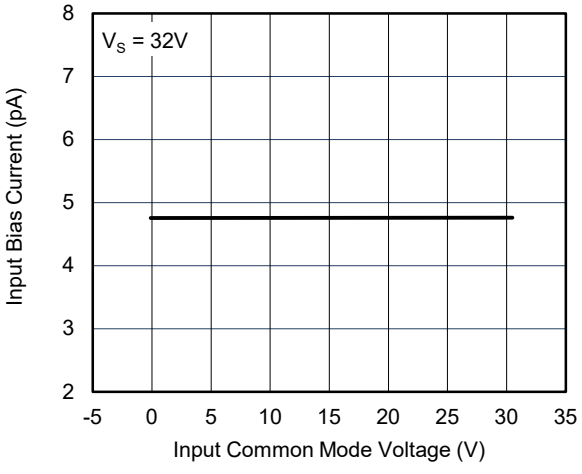
Positive Output Voltage Swing vs. Load Current



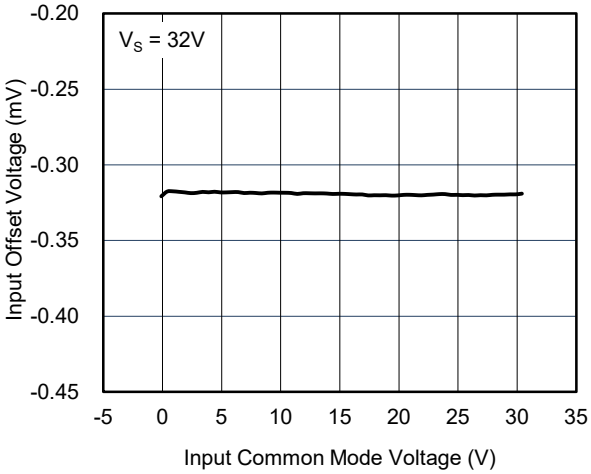
Negative Output Voltage Swing vs. Load Current



Input Bias Current vs. Input Common Mode Voltage



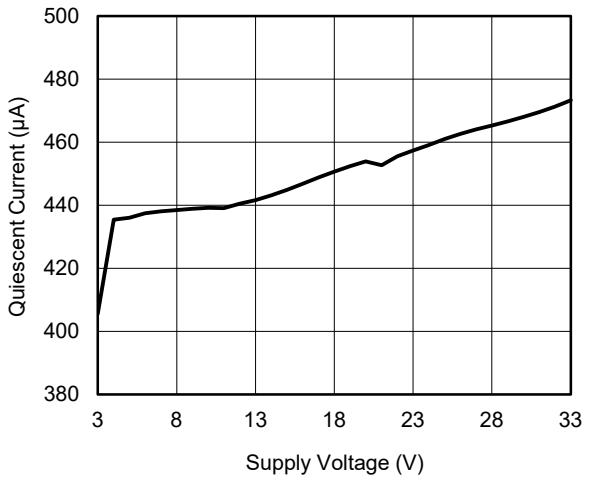
Input Offset Voltage vs. Input Common Mode Voltage



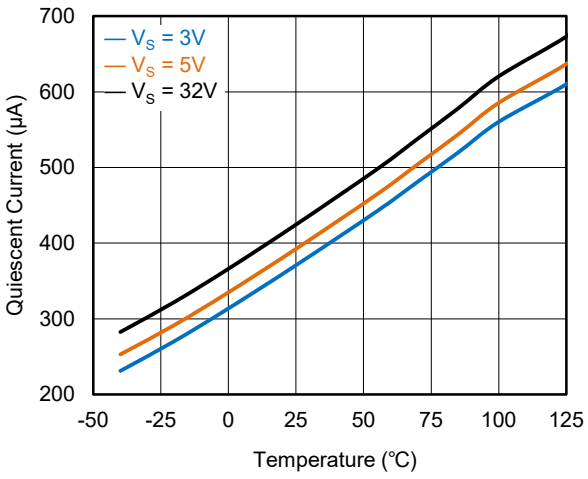
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

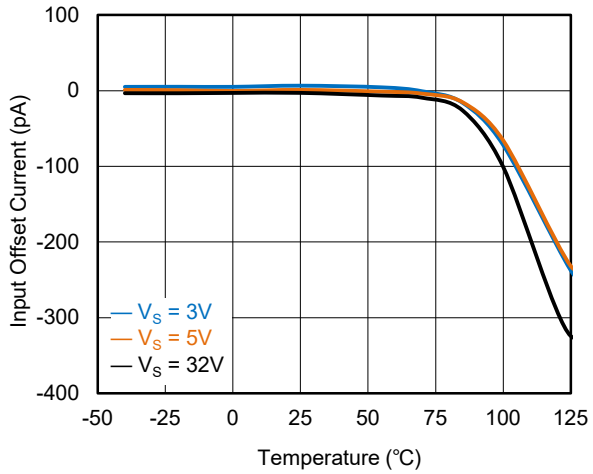
Quiescent Current vs. Supply Voltage



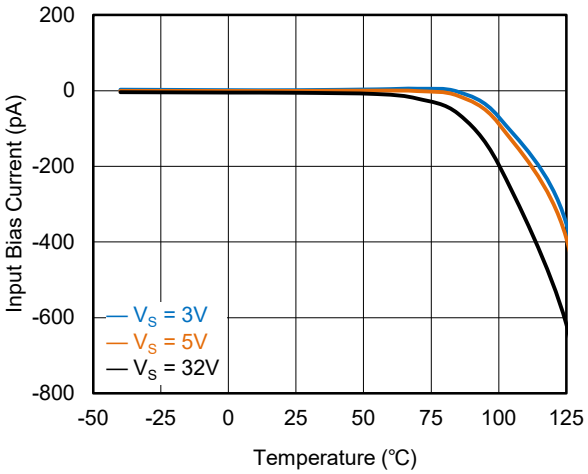
Quiescent Current vs. Temperature



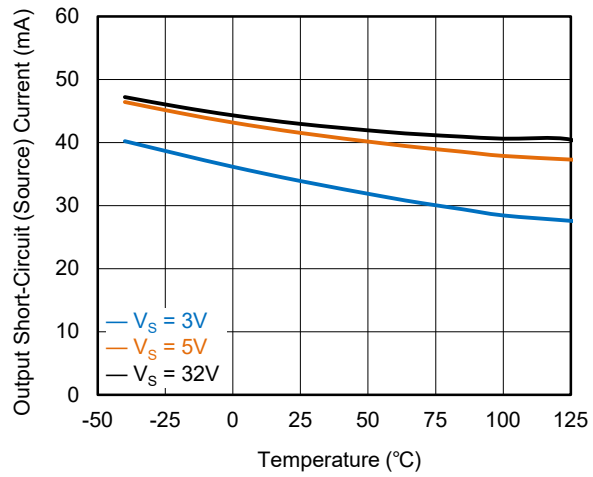
Input Offset Current vs. Temperature



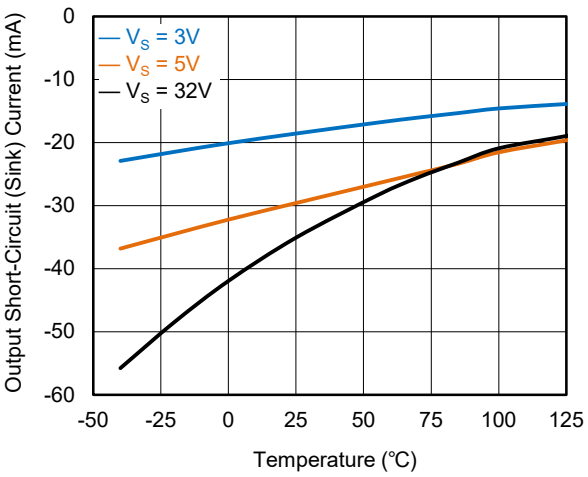
Input Bias Current vs. Temperature



Output Short-Circuit Current (I_{SOURCE}) vs. Temperature



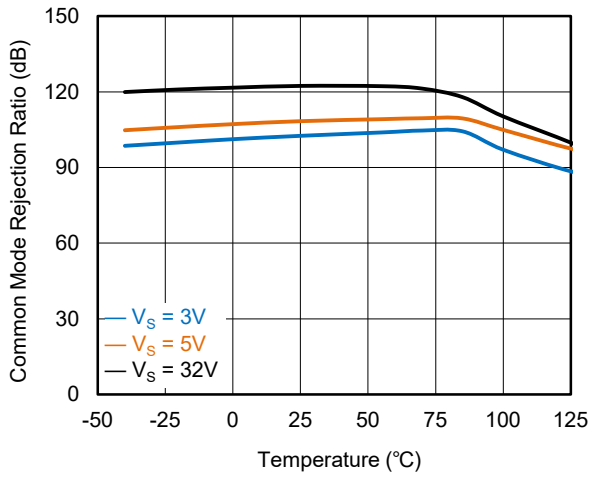
Output Short-Circuit Current (I_{SINK}) vs. Temperature



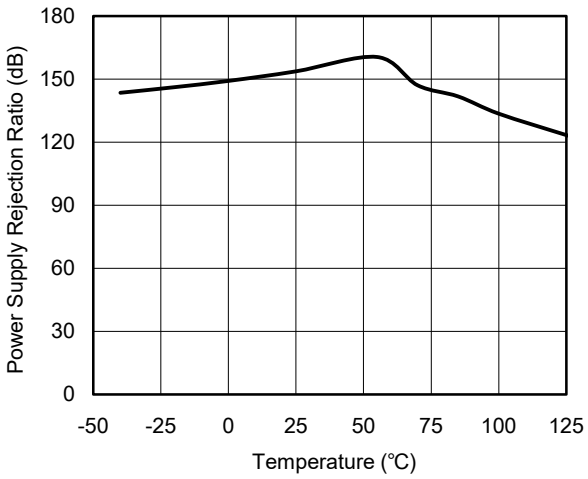
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

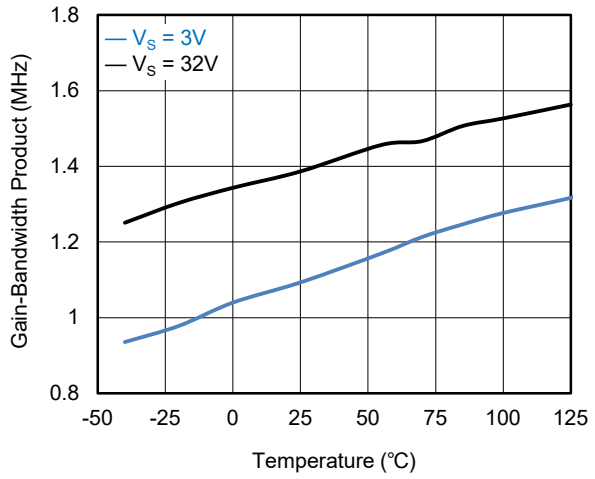
CMRR vs. Temperature



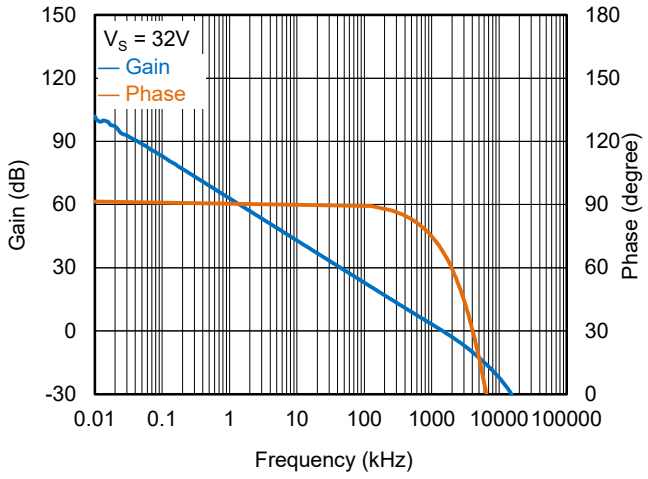
PSRR vs. Temperature



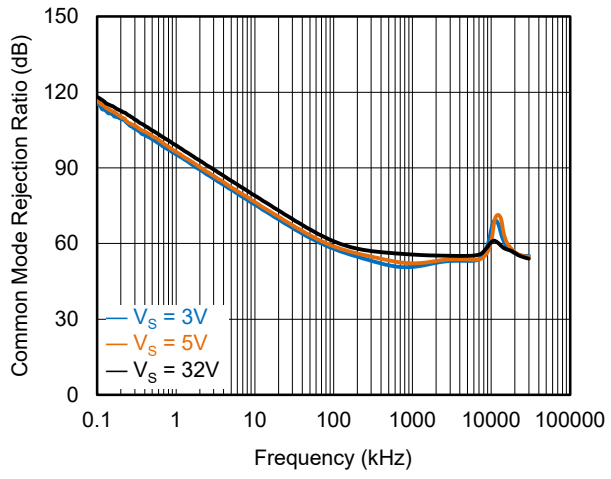
Gain-Bandwidth Product vs. Temperature



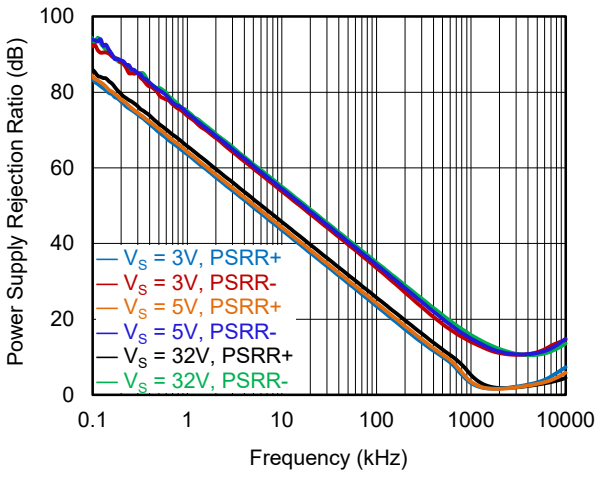
Open-Loop Gain and Phase vs. Frequency



CMRR vs. Frequency



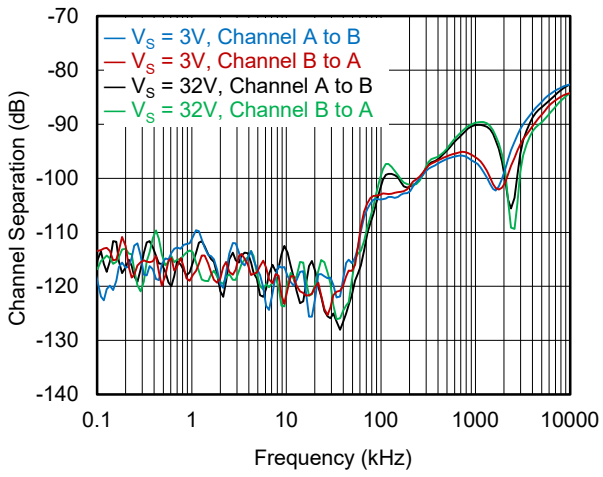
PSRR vs. Frequency



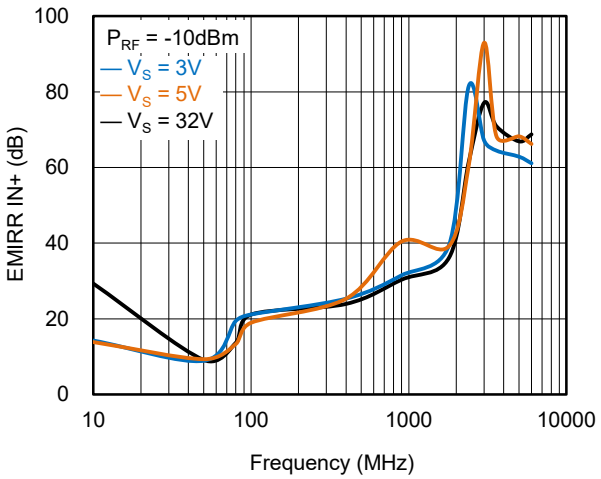
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

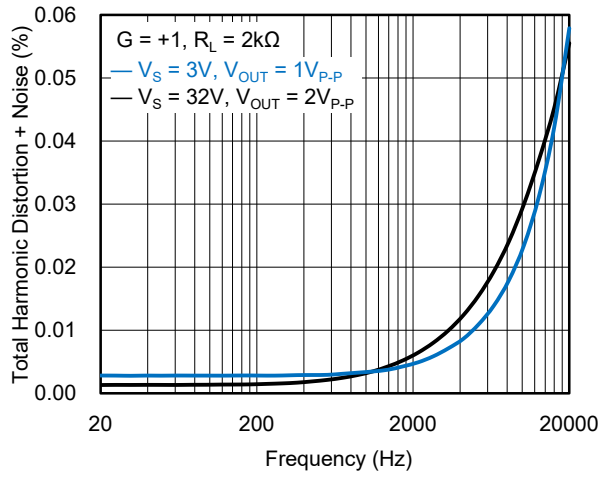
Channel Separation vs. Frequency



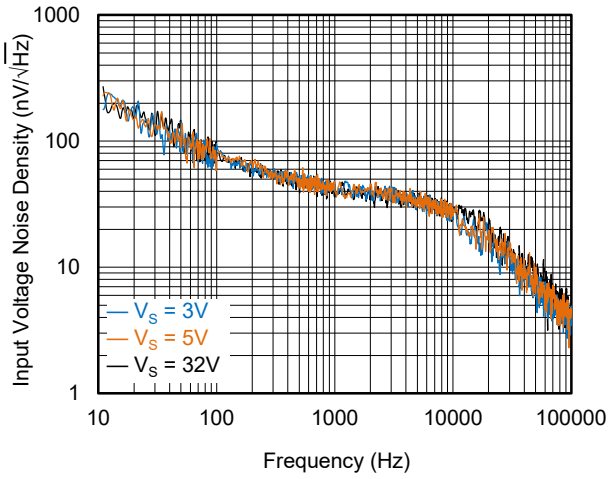
EMIRR IN+ vs. Frequency



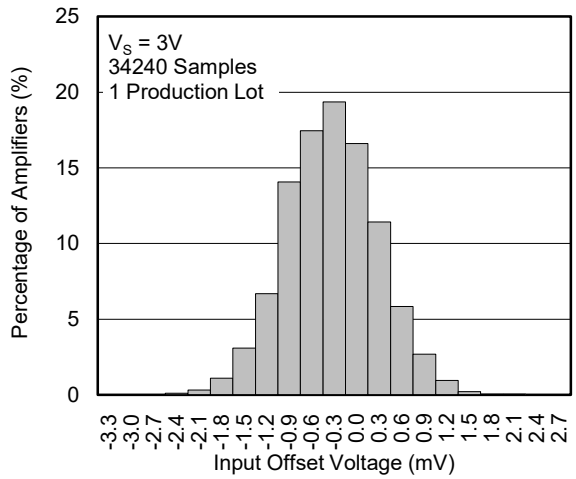
THD+N vs. Frequency



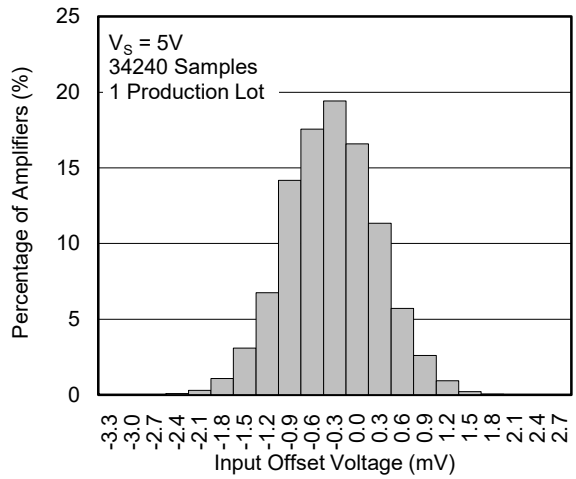
Input Voltage Noise Density vs. Frequency



Input Offset Voltage Production Distribution



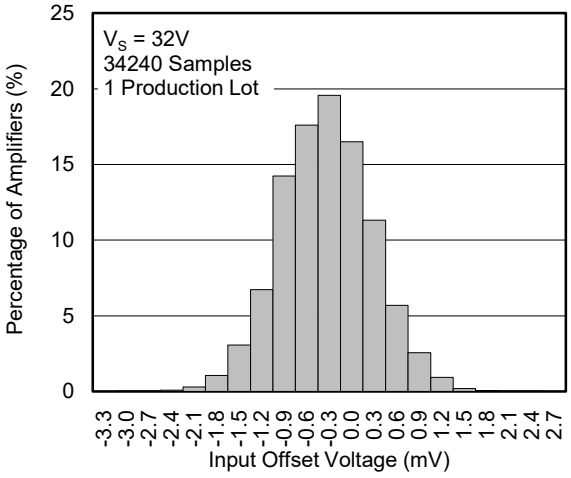
Input Offset Voltage Production Distribution



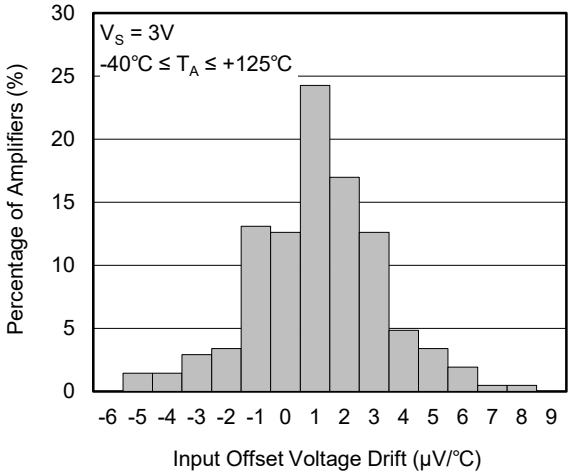
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

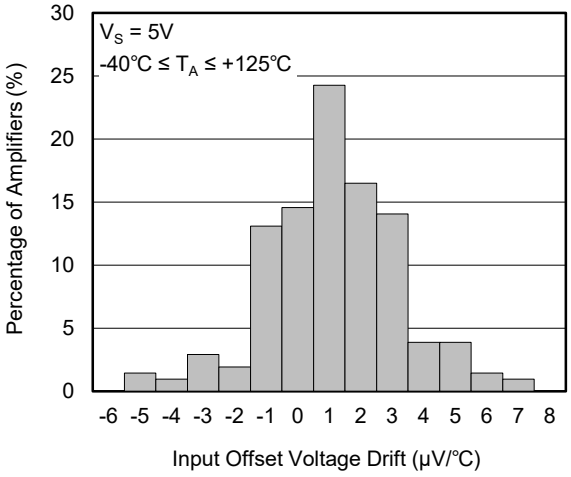
Input Offset Voltage Production Distribution



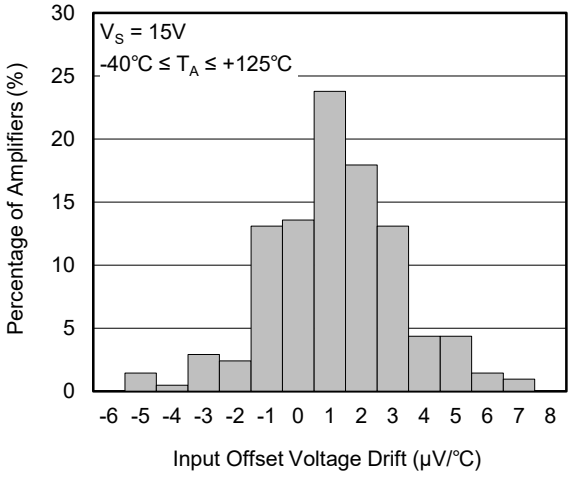
Input Offset Voltage Drift Distribution



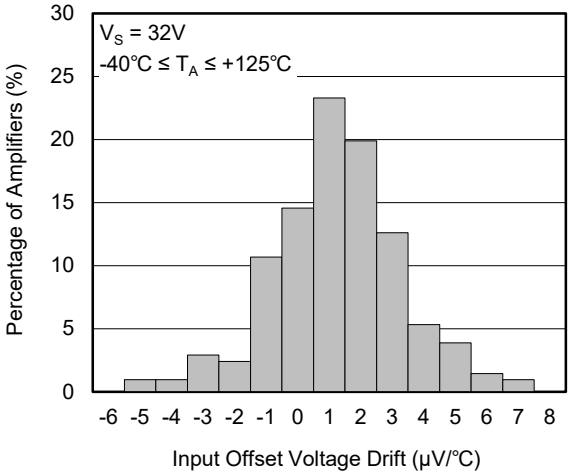
Input Offset Voltage Drift Distribution



Input Offset Voltage Drift Distribution



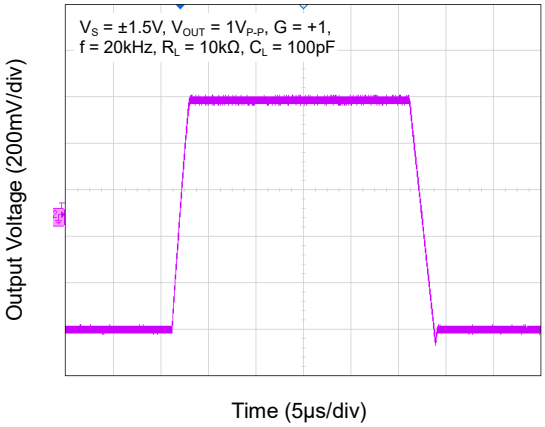
Input Offset Voltage Drift Distribution



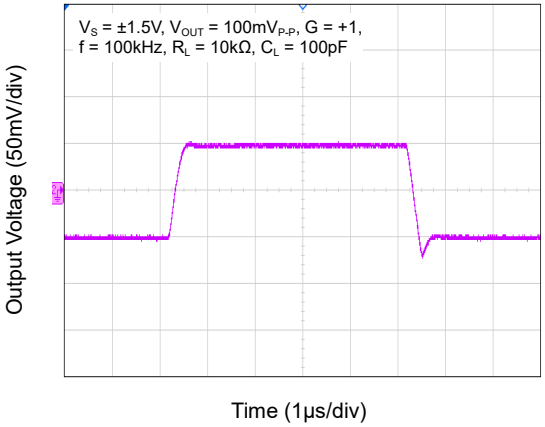
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

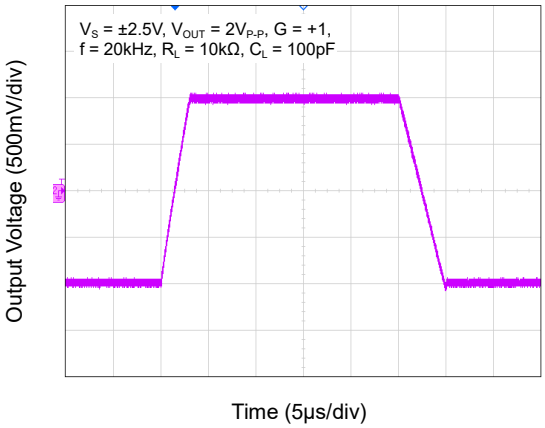
Large-Signal Step Response



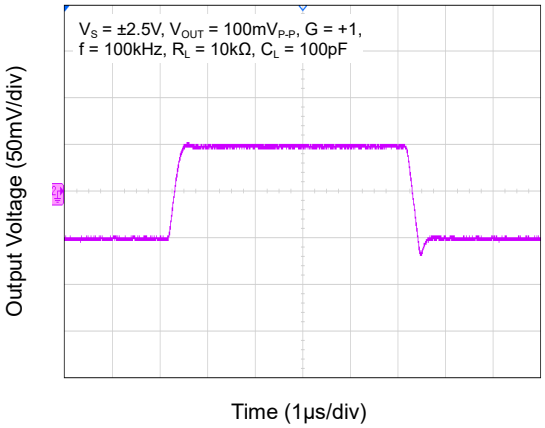
Small-Signal Step Response



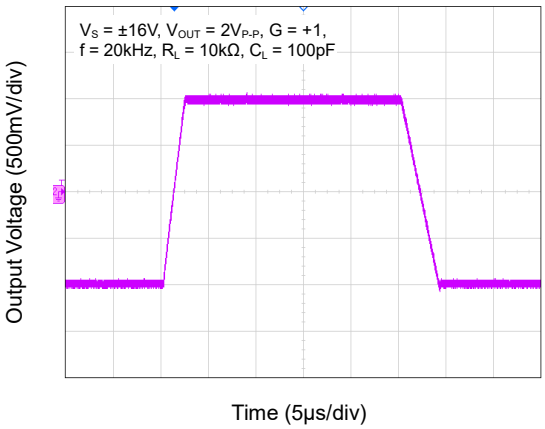
Large-Signal Step Response



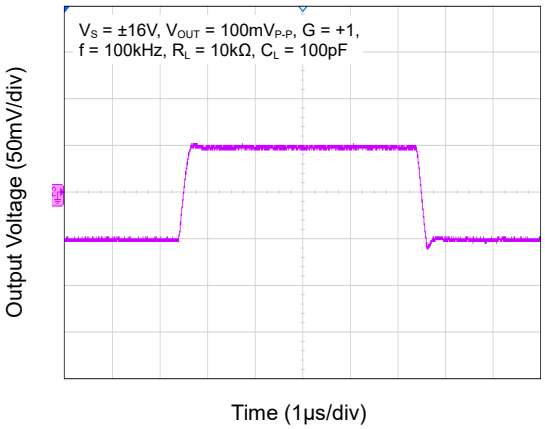
Small-Signal Step Response



Large-Signal Step Response



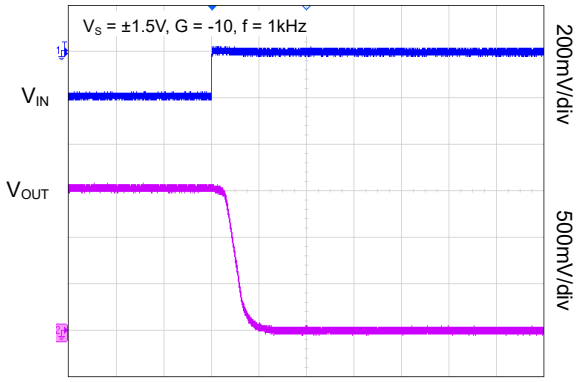
Small-Signal Step Response



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

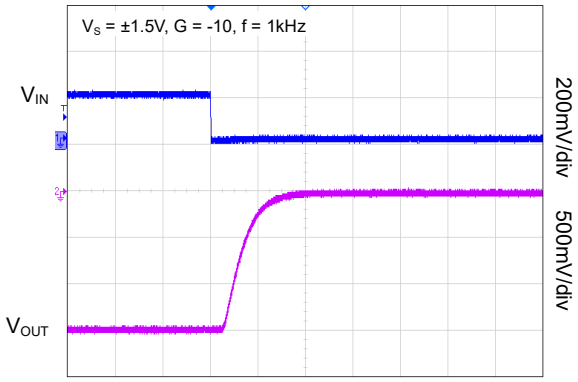
At T_A = +25℃, V_{CM} = V_S/2, unless otherwise noted.

Positive Overload Recovery Time



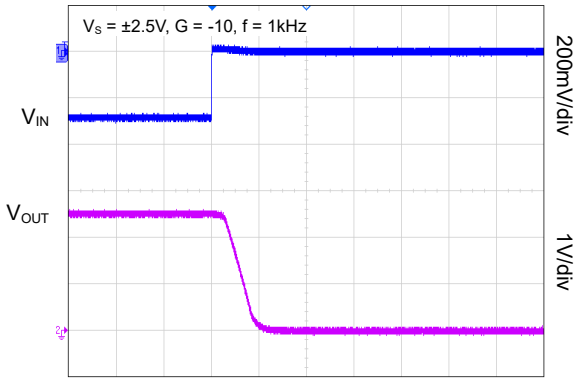
Time (10μs/div)

Negative Overload Recovery Time



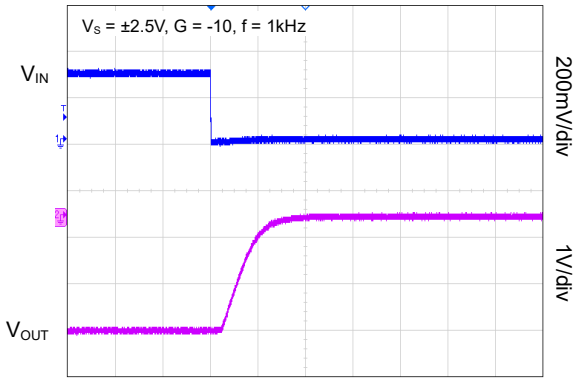
Time (5μs/div)

Positive Overload Recovery Time



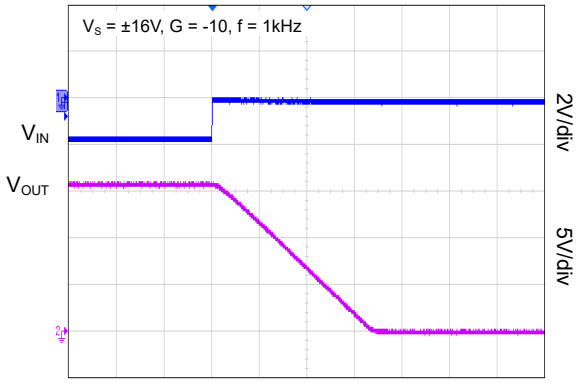
Time (10μs/div)

Negative Overload Recovery Time



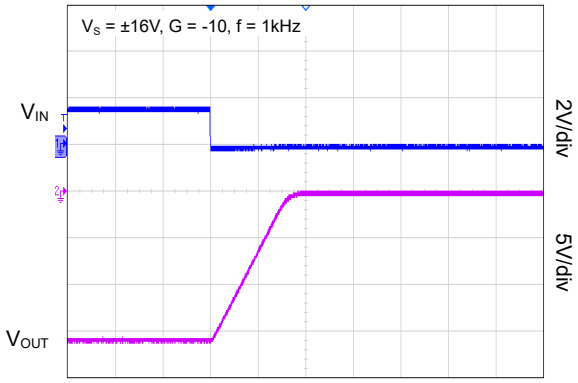
Time (5μs/div)

Positive Overload Recovery Time



Time (10μs/div)

Negative Overload Recovery Time

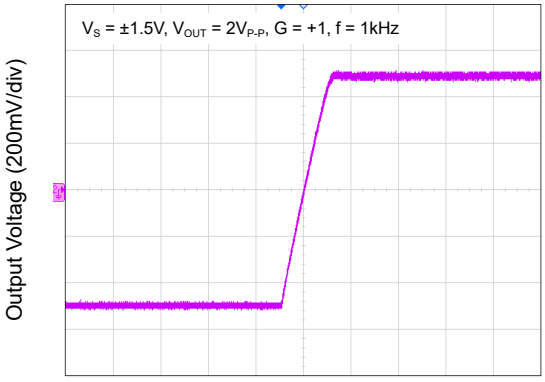


Time (10μs/div)

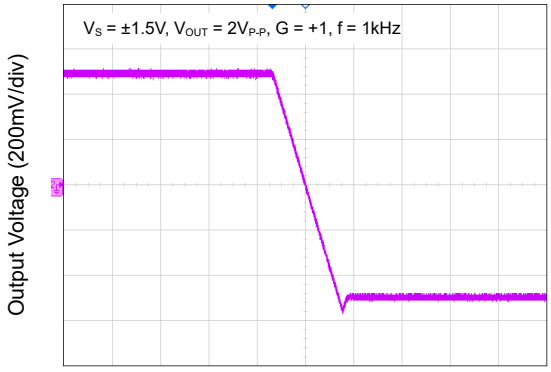
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

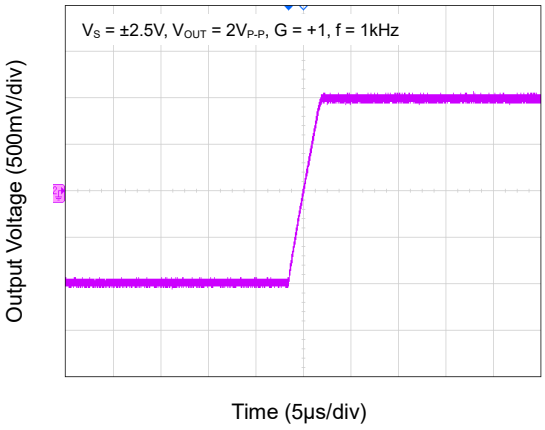
Slew Rate (up)



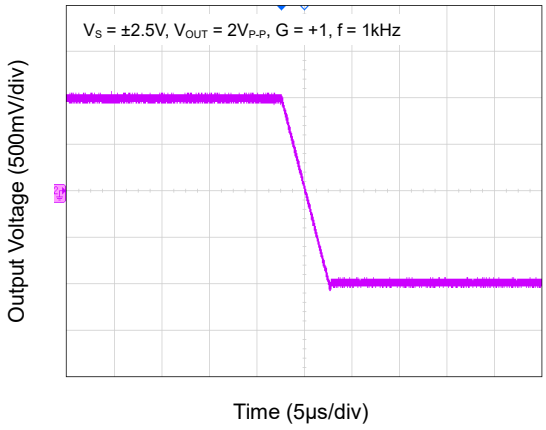
Slew Rate (down)



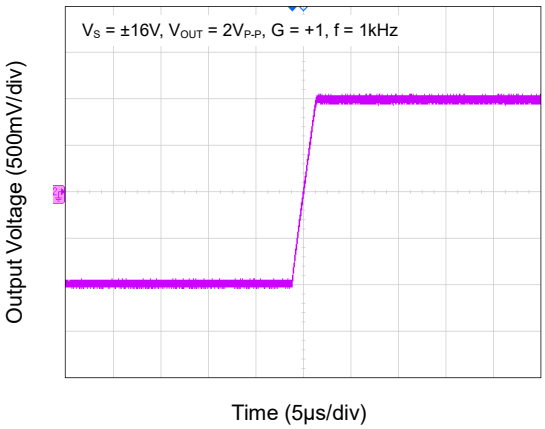
Slew Rate (up)



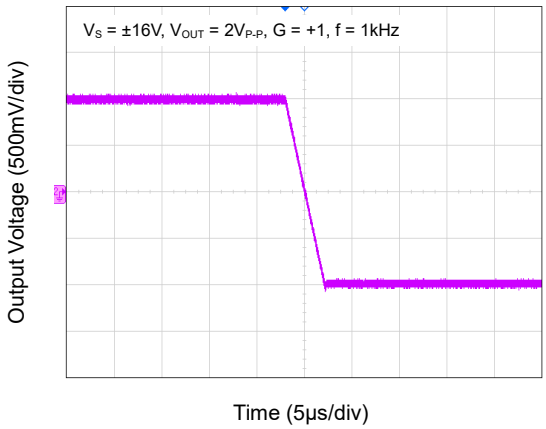
Slew Rate (down)



Slew Rate (up)



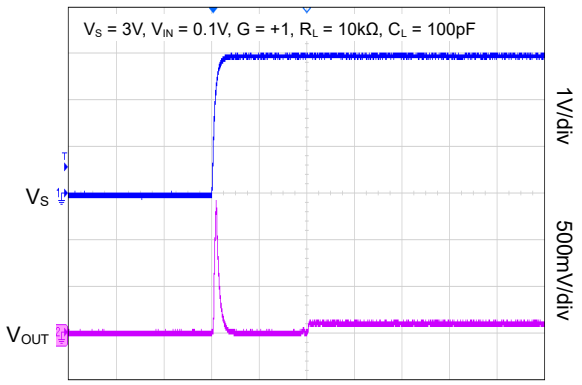
Slew Rate (down)



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

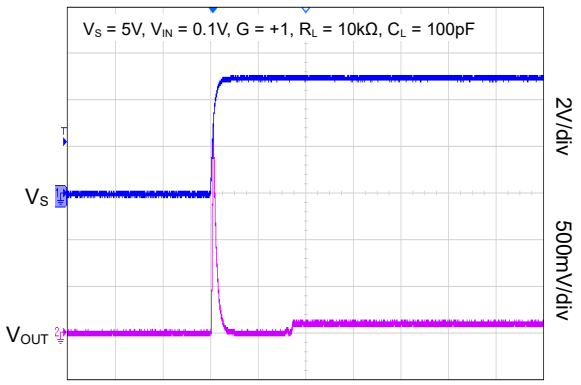
At T_A = +25℃, V_{CM} = V_S/2, unless otherwise noted.

Turn-On Time



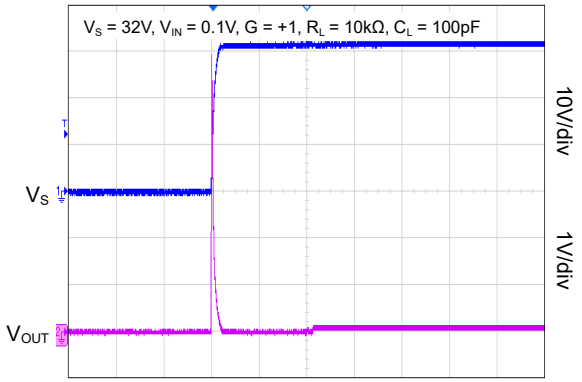
Time (20μs/div)

Turn-On Time



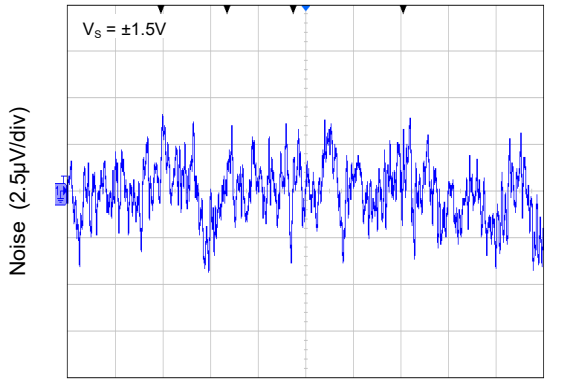
Time (20μs/div)

Turn-On Time



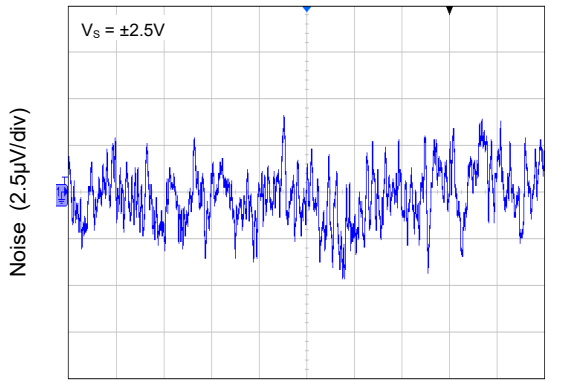
Time (20μs/div)

0.1Hz to 10Hz Input Voltage Noise



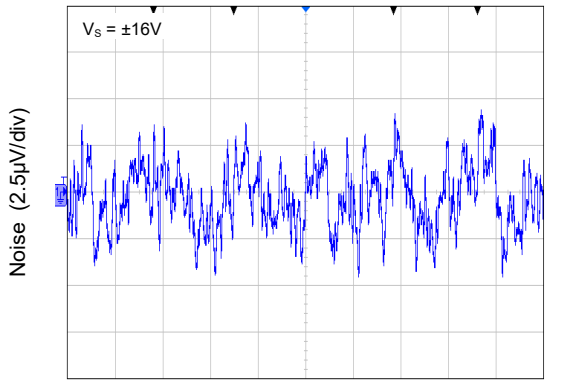
Time (2s/div)

0.1Hz to 10Hz Input Voltage Noise



Time (2s/div)

0.1Hz to 10Hz Input Voltage Noise



Time (2s/div)

DETAILED DESCRIPTION

The LM2904Q is a dual, high open-loop gain operational amplifier with internal frequency compensation. It is optimized for high voltage operation from 3V to 32V single supply or ±1.5V to ±16V dual supplies. The input common mode voltage range is from ($-V_S$) - 0.1V to ($+V_S$) - 1.5V.

This LM2904Q makes it easier to implement all conventional operational amplifier circuits in a single-supply system, such as DC amplifier modules and transducer amplifiers. For instance, the device does not need extra ±5V supplies to work with the interface electronics, as it can be easily operated on the 5V source that is common for digital systems.

Input Common Mode Voltage Range

The input common mode voltage range is from ($-V_S$) - 0.1V to ($+V_S$) - 1.5V. Also, the voltage level at the inputs can reach V_S without damaging the device. If the users desire the correct phase at the output of the operational amplifier, they need to make sure that at least one of the inputs is within the input common mode voltage range. If both of them are outside the input common mode voltage range, the state of the output will be undefined. However, if either input is below -0.3V, the input current should be limited and the output state will also be undefined.

Unity-Gain Bandwidth

The unity-gain bandwidth is the maximum supported frequency which can be amplified by an amplifier without distortion. The unity-gain bandwidth of LM2904Q is 1.1MHz.

Slew Rate

The slew rate is the time period for the output change when input signal is changed. The slew rate of LM2904Q is 0.35V/μs.

APPLICATION INFORMATION

The LM2904Q can be widely used for various signal processing purposes.

Typical Application

The following circuit is an application of an inverting amplifier. To explain, the input is positive while the output is negative. However, if the input signal is negative, the output will be positive as well.

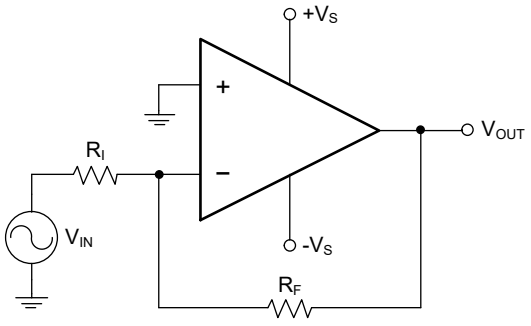


Figure 1. Application Schematic

The supply voltage range should always be larger than the input and the output range. The following example scales a signal with ±0.5V to ±1.8V, which means that the ±12V of the supply voltage is sufficient.

The following equations determine the voltage gain of the inverting amplifier circuit.

$$G = \frac{V_{OUT}}{V_{IN}} \quad (1)$$

$$G = \frac{1.8}{-0.5} = -3.6 \quad (2)$$

After setting the voltage gain, the value of the gain and feedback resistors should be determined as well. Since the operating current inside the circuit is in the mA range, the R_I and R_F should be at the level of kΩ. In this example, the R_I is 10kΩ and the R_F is 36kΩ.

$$G = -\frac{R_F}{R_I} \quad (3)$$

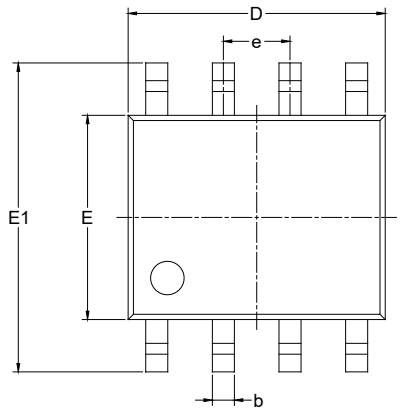
REVISION HISTORY

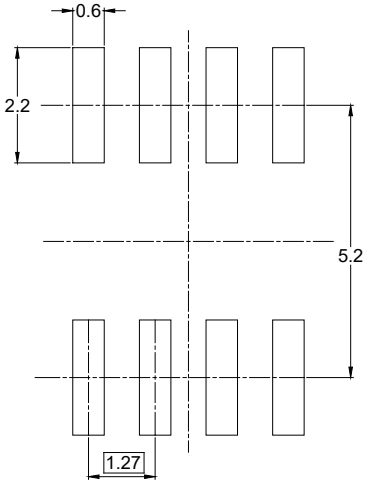
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (MAY 2025) to REV.A	Page
Changed from product preview to production data	All

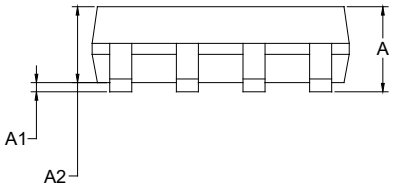
PACKAGE OUTLINE DIMENSIONS

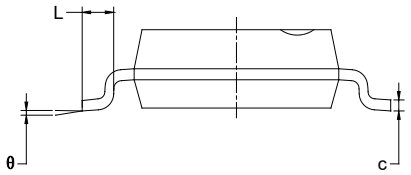
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)



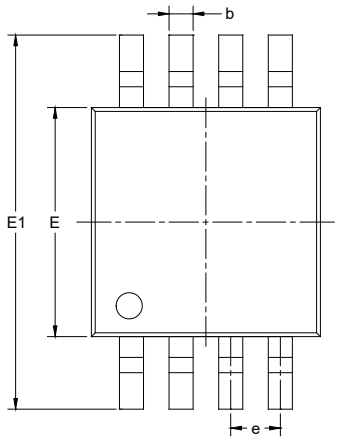


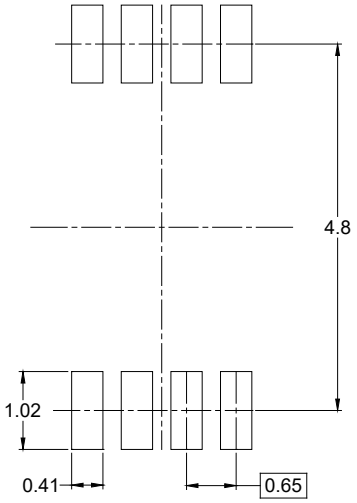
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

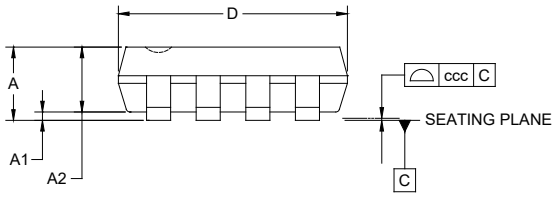
PACKAGE OUTLINE DIMENSIONS

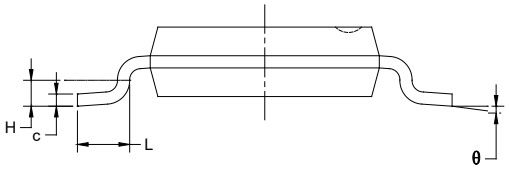
MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)



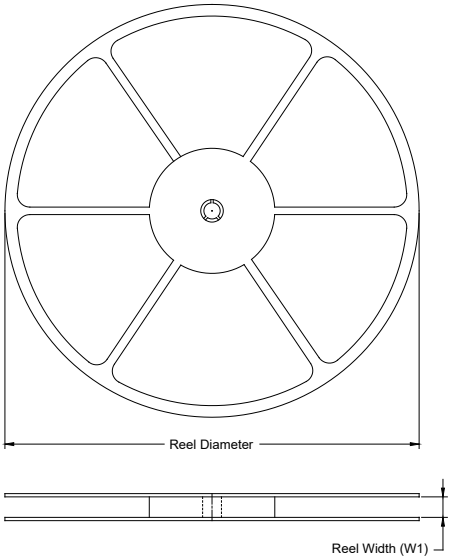


Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	-	-	1.100
A1	0.000	-	0.150
A2	0.750	-	0.950
b	0.220	-	0.380
c	0.080	-	0.230
D	2.800	-	3.200
E	2.800	-	3.200
E1	4.650	-	5.150
e	0.650 BSC		
L	0.400	-	0.800
H	0.250 TYP		
θ	0°	-	8°
ccc	0.100		

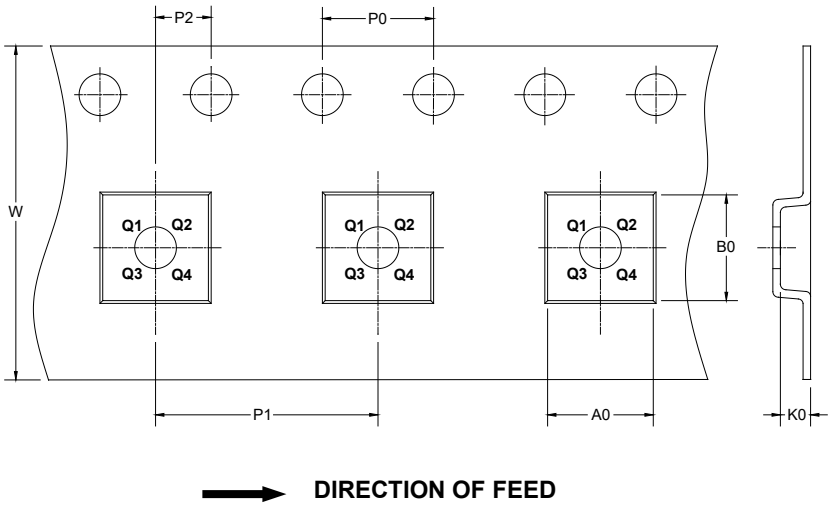
NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MO-187.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



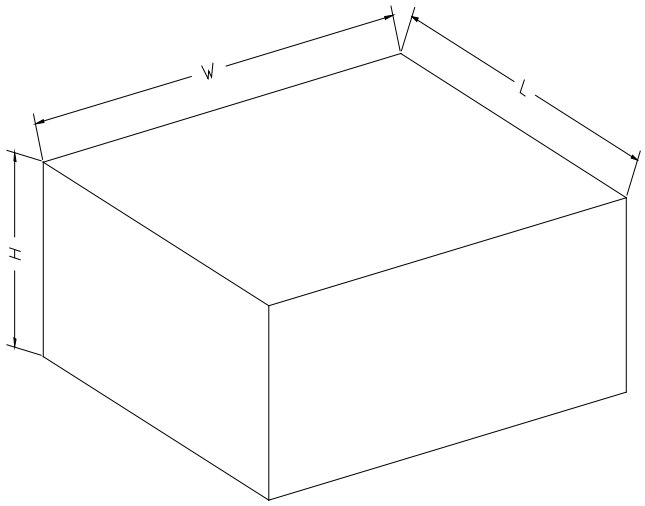
NOTE: The picture is only for reference. Please make the object as the standard.

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
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

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
13″	386	280	370	5

DD0002