LM358
Dual Rail-to-Rail Output Operational Amplifier

GENERAL DESCRIPTION

The LM358 is a dual, high-gain frequency-compensated operational amplifier, which can operate from 3V to 32V single supply or from ±1.5V to ±16V dual supplies while consuming only 440μA quiescent current.

The LM358 features low power, low offset voltage and low bias current. It is well suited for a wide range of applications.

The LM358 is available in Green SOIC-8 and MSOP-8 packages. It is specified over the 0℃ to +70℃ temperature range.

APPLICATIONS

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

FEATURES

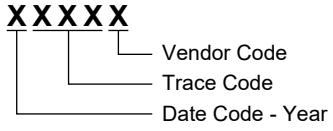
- **Wide Supply Ranges**
  Single Supply: 3V to 32V
  Dual Supplies: ±1.5V to ±16V
- **Low Quiescent Current: 440μA (TYP)**
- **Low Input Offset Voltage: 5.8mV (MAX)**
- **Low Input Offset Current: 20pA (TYP)**
- **Low Input Bias Current: 10pA (TYP)**
- **Minimum Input Common Mode Voltage: ($-V_S$) - 0.1V**
- **Maximum Differential Input Voltage: +32V/-32V**
- **Gain-Bandwidth Product: 1.1MHz**
- **Open-Loop Differential Voltage Gain: 111dB (TYP)**
- **Internal Frequency Compensation**
- **0℃ to +70℃ Operating Temperature Range**
- **Available in Green SOIC-8 and MSOP-8 Packages**

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
LM358	SOIC-8	0℃ to +70℃	LM358ZS8G/TR	LM 358ZS8 XXXXX	Tape and Reel, 4000
	MSOP-8	0℃ to +70℃	LM358ZMS8G/TR	LM358 ZMS8 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, V_S ..... -0.3V to 32V
Differential Input Voltage, V_{ID} (1) ..... -32V to 32V
Input Voltage (Either Input) ..... -0.3V to 32V
Junction Temperature.....+150℃
Storage Temperature Range.....-65℃ to +150℃
Lead Temperature (Soldering, 10s).....+260℃
ESD Susceptibility
HBM.....6000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Input Common Mode Voltage Range..... -0.1V to V_S - 1.5V
Operating Temperature Range..... 0℃ to +70℃

NOTE:
1. Differential voltage is between +IN and -IN.

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.

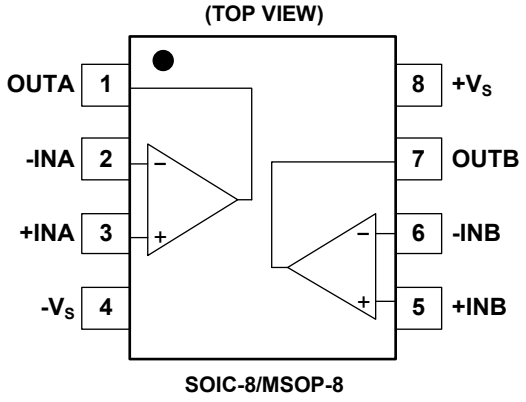
ESD SENSITIVITY CAUTION

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



ELECTRICAL CHARACTERISTICS

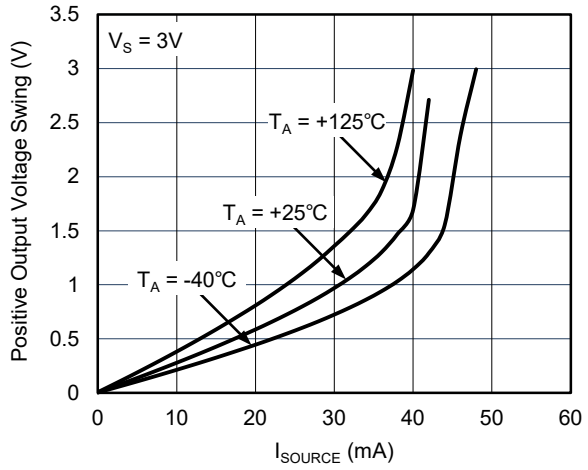
(At T_A = +25℃, V_S = 3V to 32V, R_L = 10kΩ connected to V_S/2, -0.1V < V_{CM} < V_S - 1.5V, Full = 0℃ to +70℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Characteristics							
Input Offset Voltage	V_{OS}		+25℃		1.2	5.8	mV
			Full			6.6	
Input Bias Current	I_B	V_{CM} = V_S/2	+25℃		10		pA
Input Offset Current	I_{OS}	V_{CM} = V_S/2	+25℃		20		pA
Maximum Differential Input Voltage	$\|V_{ID}\|$		Full			V_S	V
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	118		dB
			Full	80			
Open-Loop Voltage Gain	A_{OL}	R_L = 10kΩ to V_S/2	+25℃	92	111		dB
			Full	90			
Output Characteristics							
High-Level Output Voltage	V_{OH}	R_L = 10kΩ	+25℃		42	60	mV
			Full			70	
Low-Level Output Voltage	V_{OL}	R_L = 10kΩ	+25℃		110	190	mV
			Full			210	
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} = 0A	+25℃		440	680	μA
			Full			800	
Power Supply Rejection Ratio	PSRR		+25℃	102	122		dB
			Full	100			
Turn-On Time		G = +1	+25℃		42		μs
Dynamic Performance (C_L = 100pF)							
Gain-Bandwidth Product	GBP		+25℃		1.1		MHz
Slew Rate	SR	G = +1	+25℃		0.35		V/μs
Overload Recovery Time	ORT	V_{IN} × G > V_S	+25℃		2.3		μs
Phase Margin			+25℃		60		°
Noise							
Input Voltage Noise		f = 0.1Hz to 10Hz	+25℃		8.7		μV_{P-P}
Input Voltage Noise Density	e_n	f = 1kHz	+25℃		36		$nV/\sqrt{Hz}$

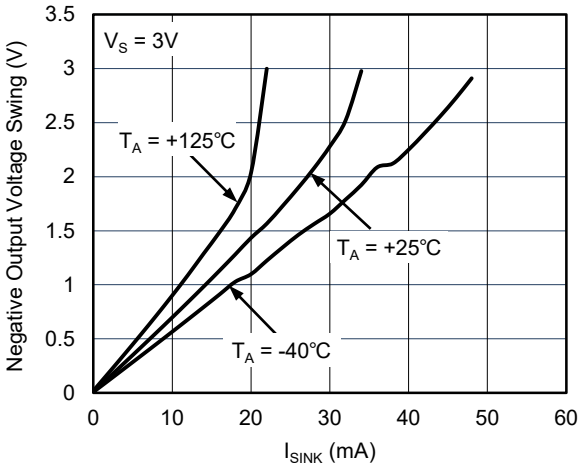
TYPICAL PERFORMANCE CHARACTERISTICS

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

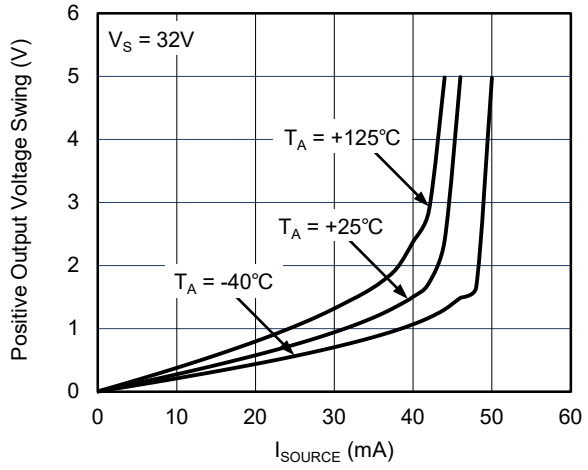
Positive Output Voltage Swing vs. Load Current



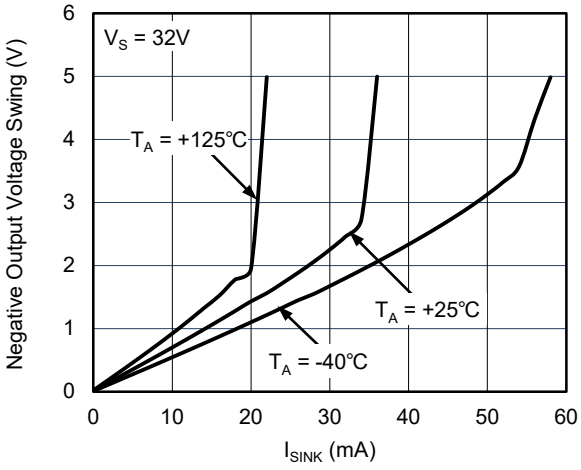
Negative Output Voltage Swing vs. Load Current



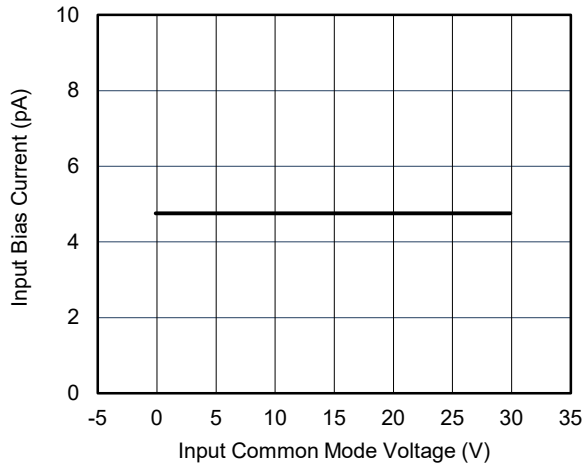
Positive Output Swing vs. Load Current



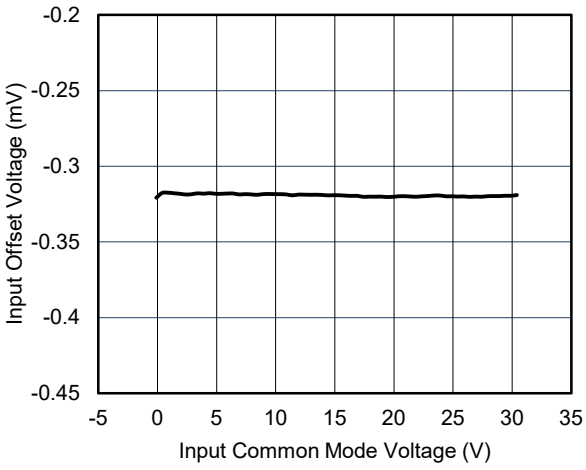
Negative Output Swing vs. Load Current



Input Bias Current vs. Input Common Mode Voltage



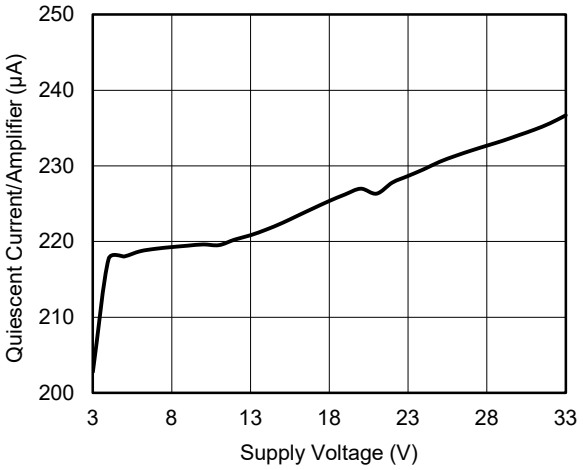
Input Offset Voltage vs. Input Common Mode Voltage



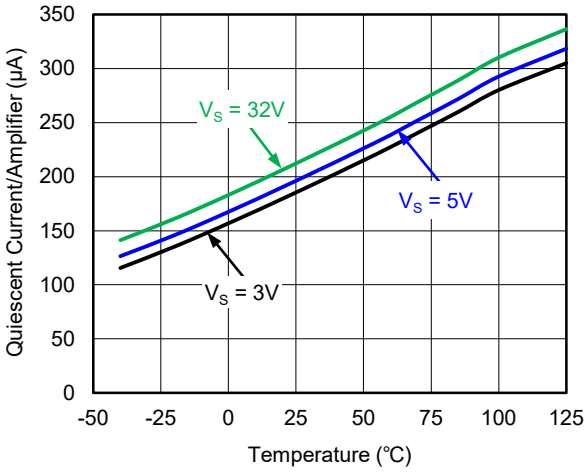
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

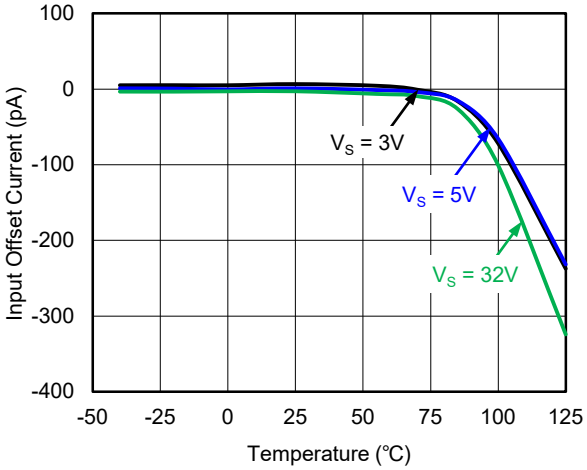
Quiescent Current vs. Supply Voltage



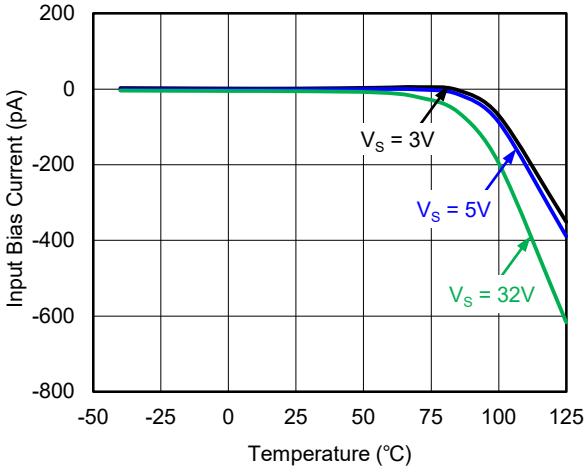
Quiescent Current vs. Temperature



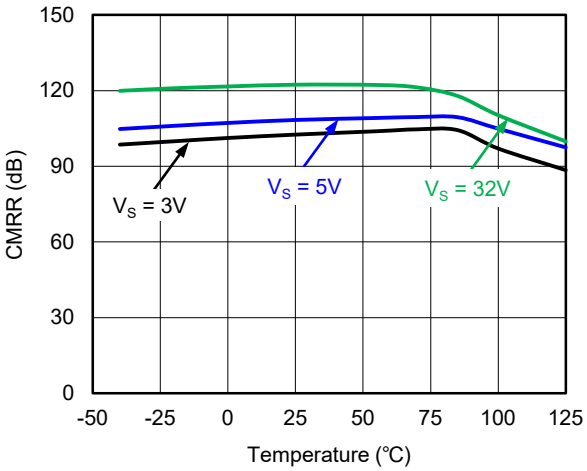
Input Offset Current vs. Temperature



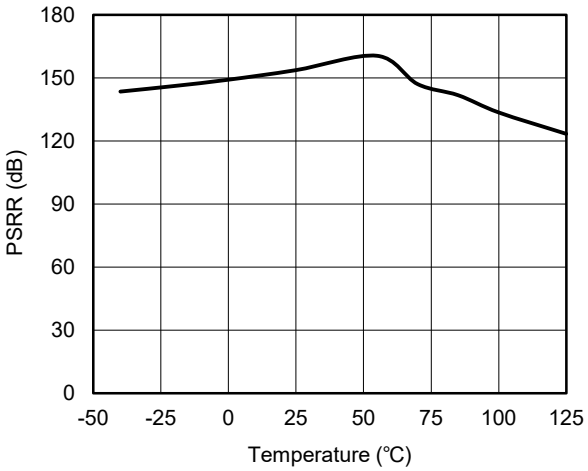
Input Bias Current vs. Temperature



CMRR vs. Temperature



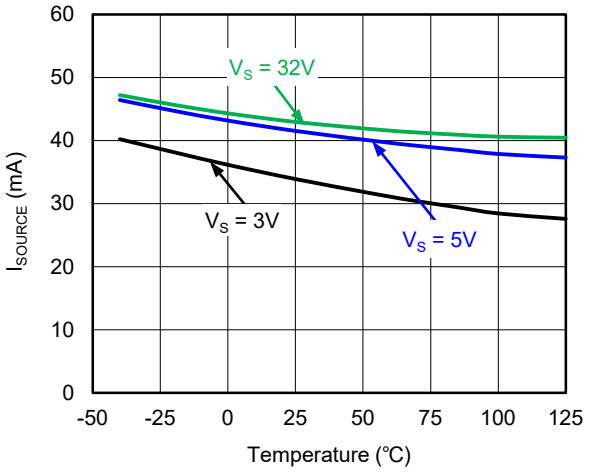
PSRR vs. Temperature



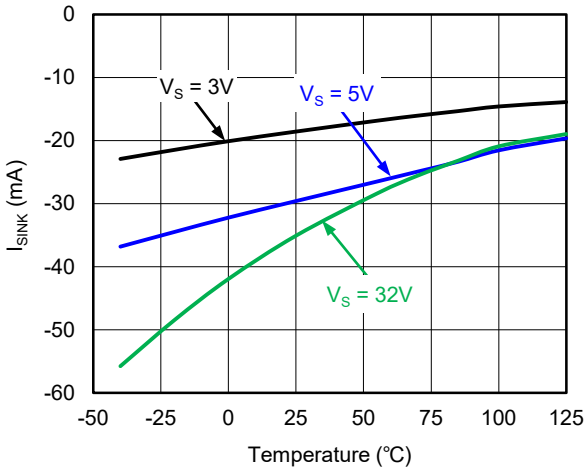
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

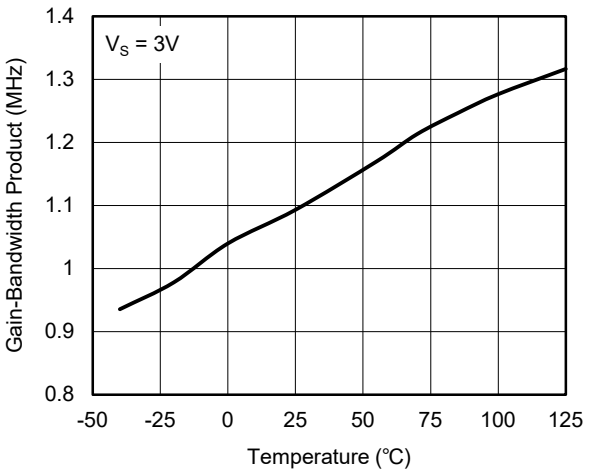
Output Short-Circuit Current (I_{SOURCE}) vs. Temperature



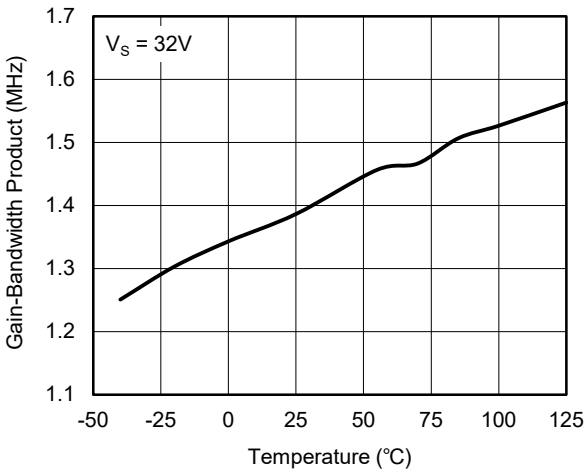
Output Short-Circuit Current (I_{SINK}) vs. Temperature



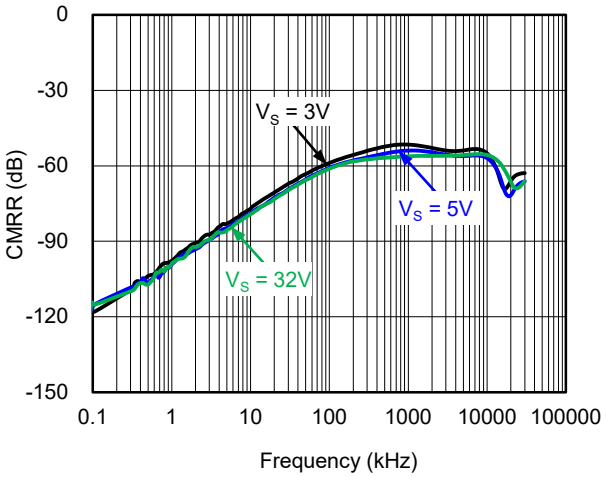
Gain-Bandwidth Product vs. Temperature



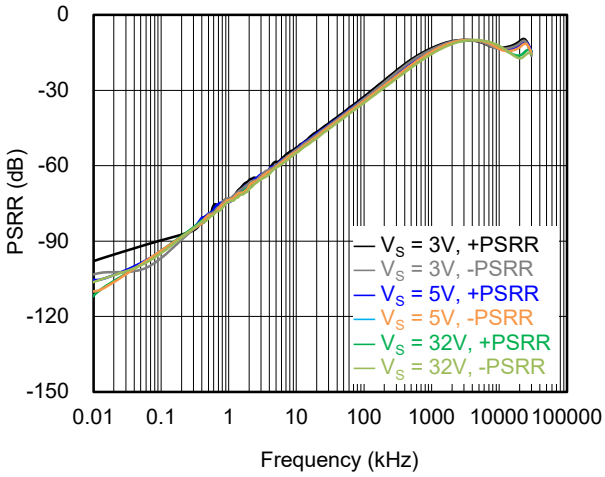
Gain-Bandwidth Product vs. Temperature



CMRR vs. Frequency



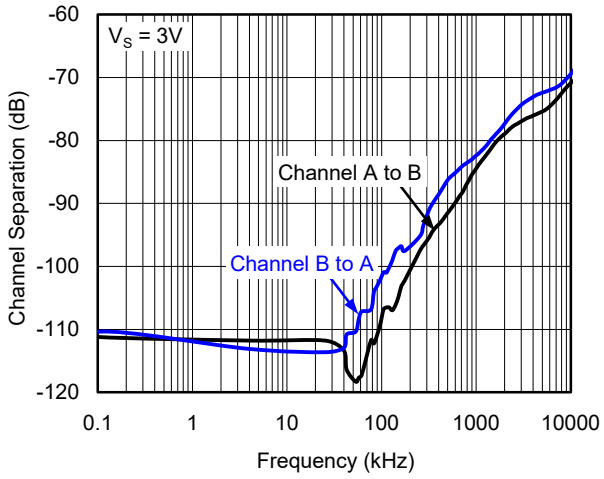
PSRR vs. Frequency



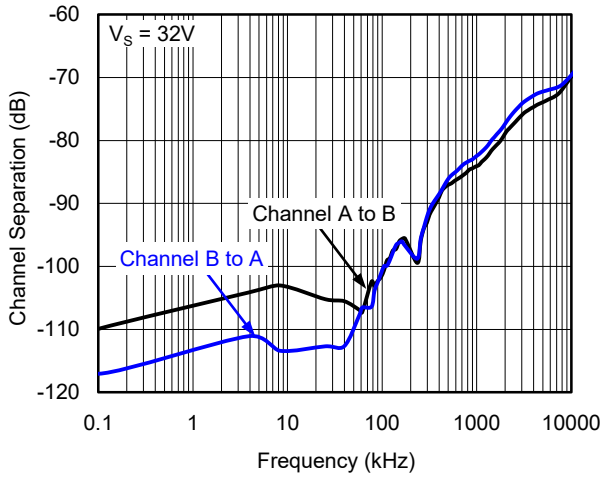
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

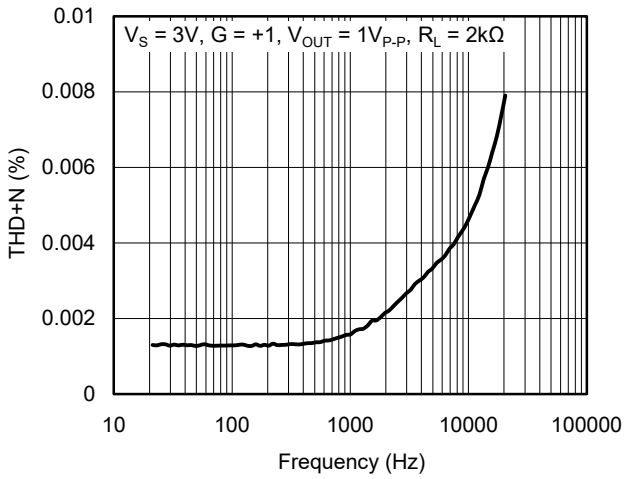
Channel Separation vs. Frequency



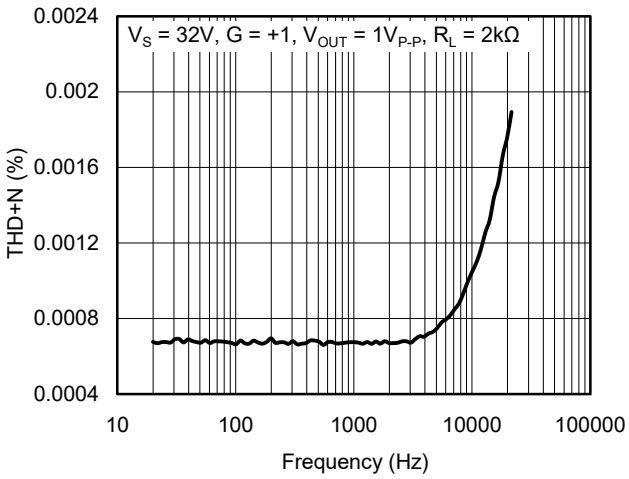
Channel Separation vs. Frequency



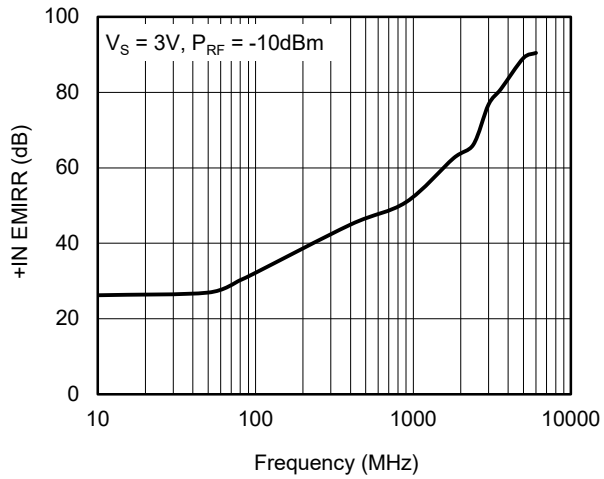
THD+N vs. Frequency



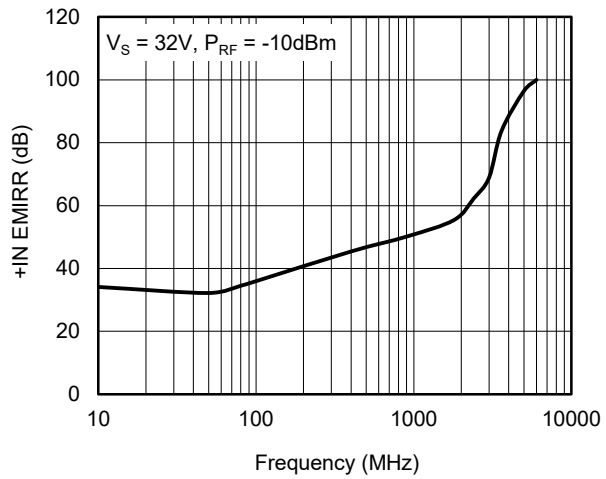
THD+N vs. Frequency



+IN EMIRR vs. Frequency



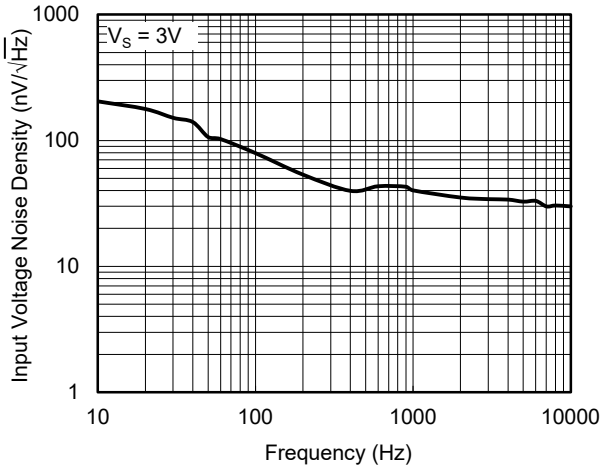
+IN EMIRR vs. Frequency



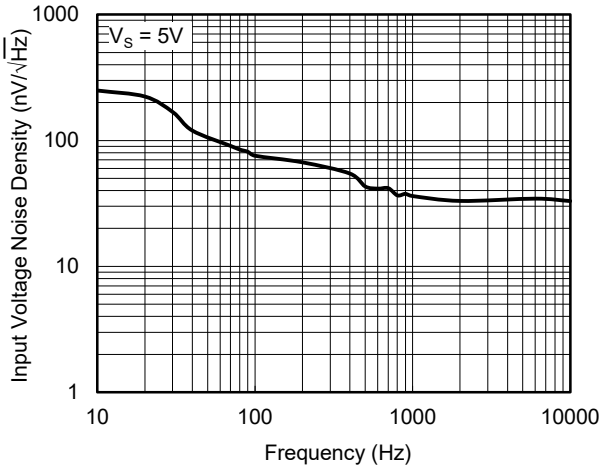
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

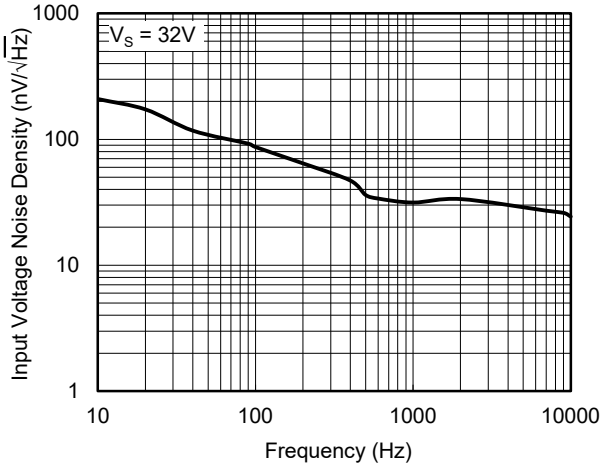
Input Voltage Noise Density vs. Frequency



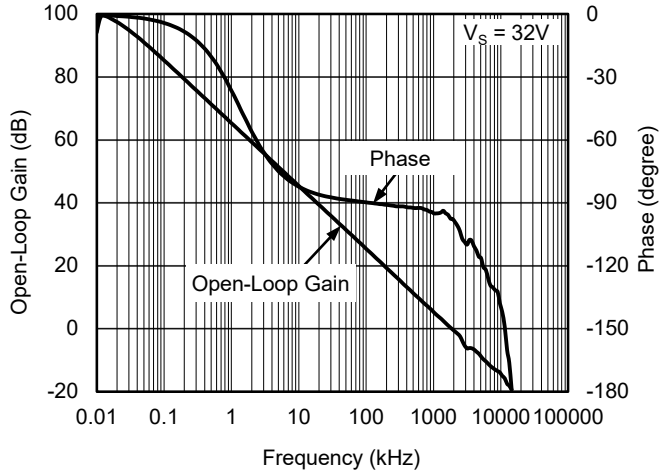
Input Voltage Noise Density vs. Frequency



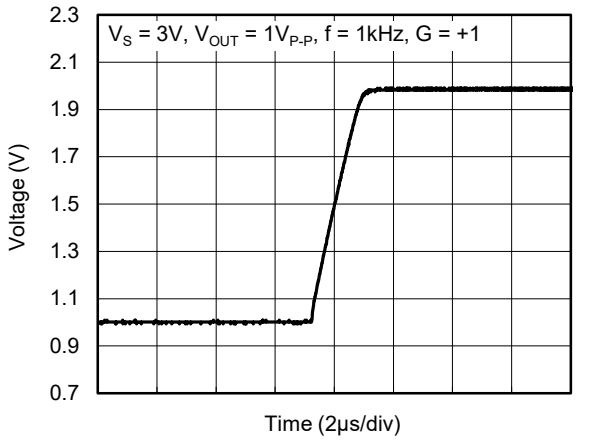
Input Voltage Noise Density vs. Frequency



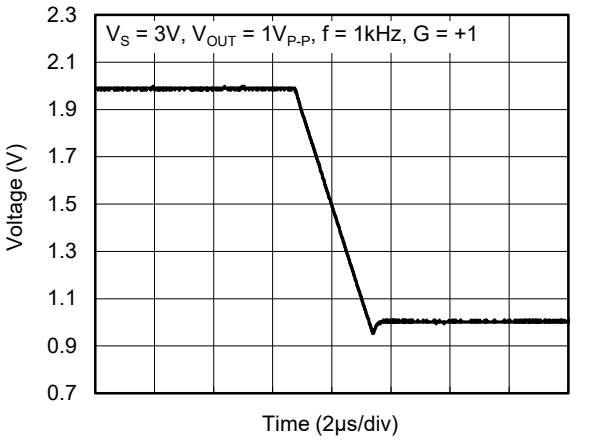
Open-Loop Gain and Phase vs. Frequency



Slew Rate (up)



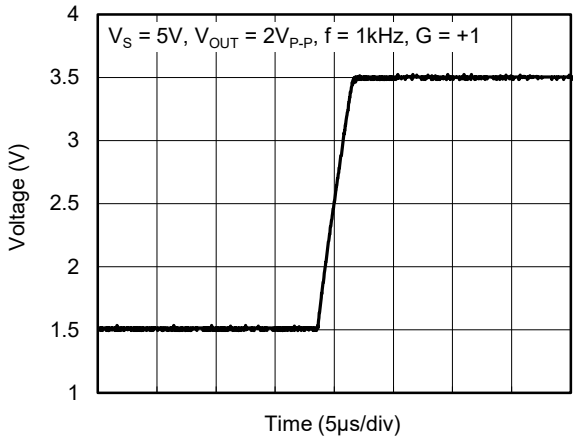
Slew Rate (down)



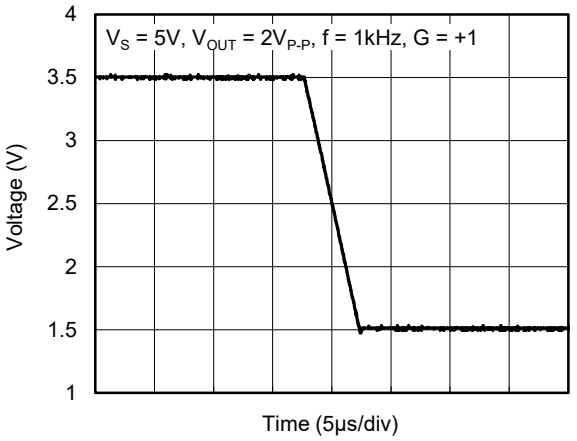
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

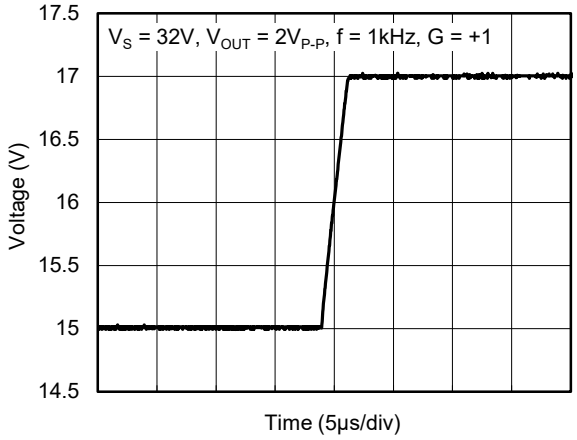
Slew Rate (up)



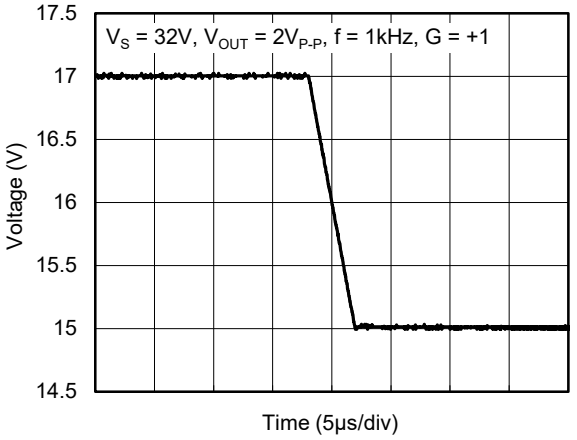
Slew Rate (down)



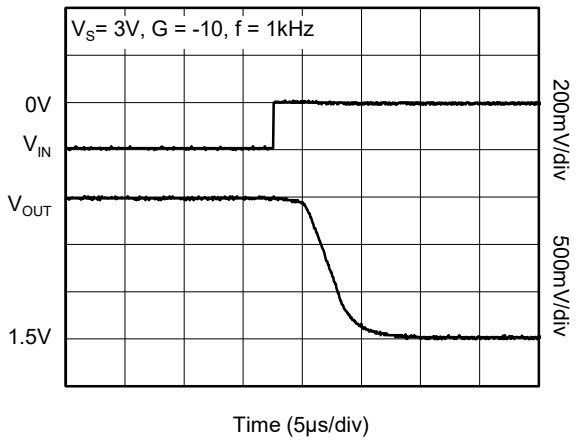
Slew Rate (up)



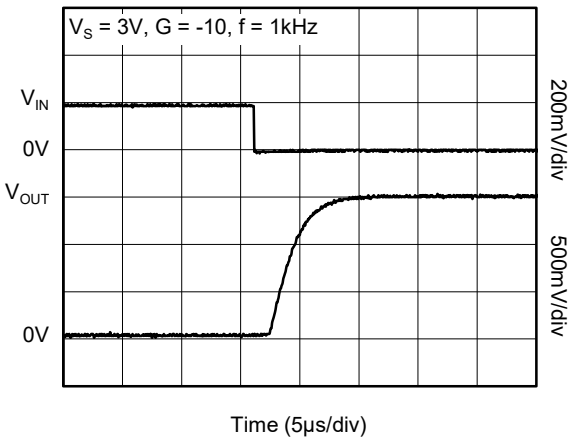
Slew Rate (down)



Positive Overload Recovery Time



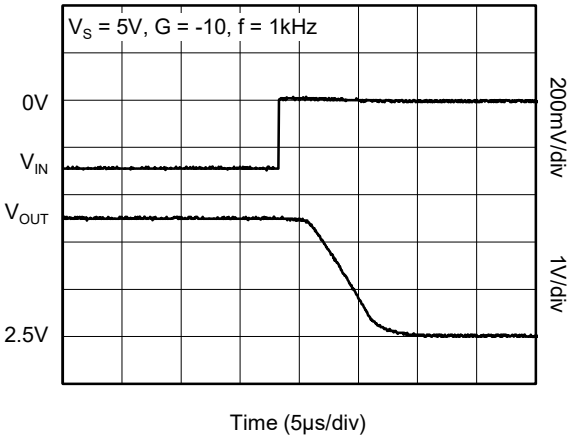
Negative Overload Recovery Time



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

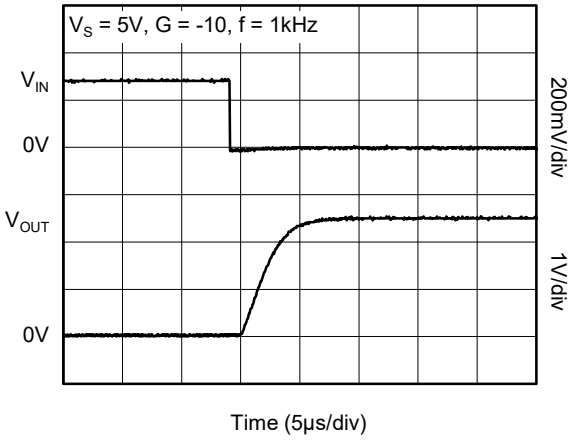
At T_A = +25℃, V_{CM} = V_S/2, unless otherwise noted.

Positive Overload Recovery Time



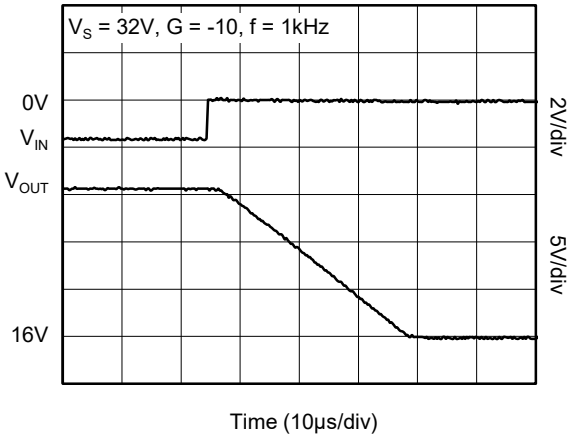
Time (5μs/div)

Negative Overload Recovery Time



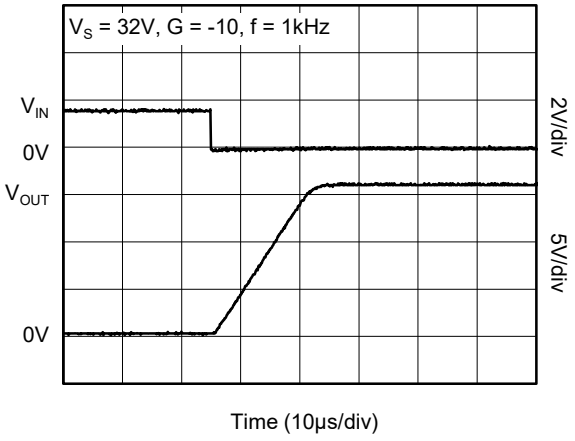
Time (5μs/div)

Positive Overload Recovery Time



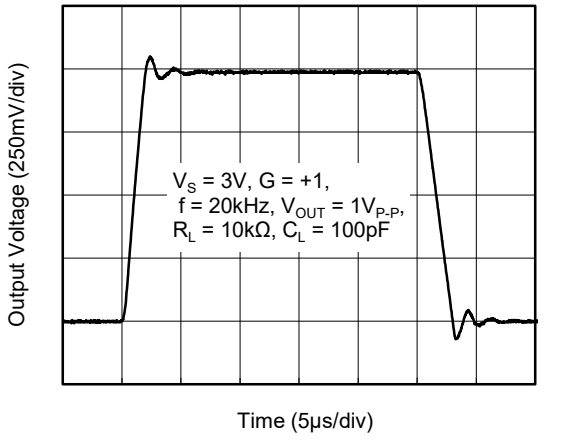
Time (10μs/div)

Negative Overload Recovery Time



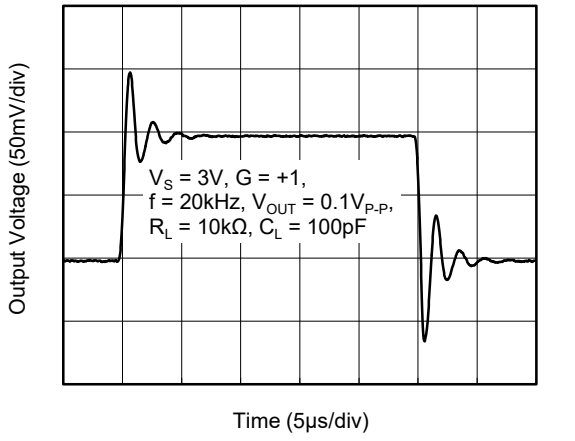
Time (10μs/div)

Large-Signal Step Response



Time (5μs/div)

Small-Signal Step Response

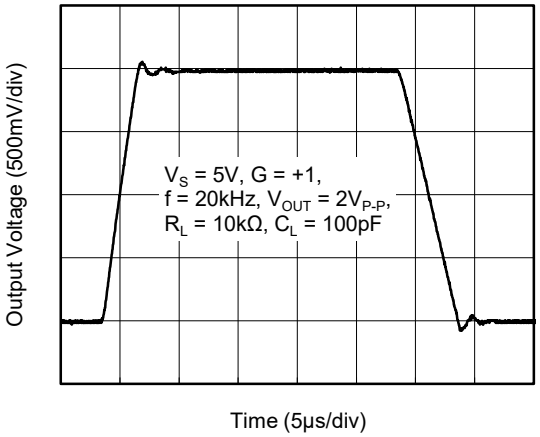


Time (5μs/div)

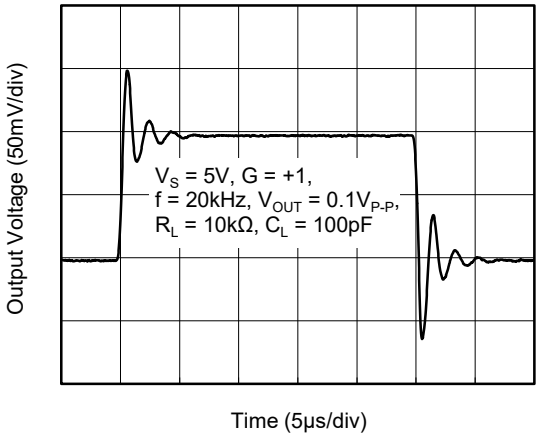
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

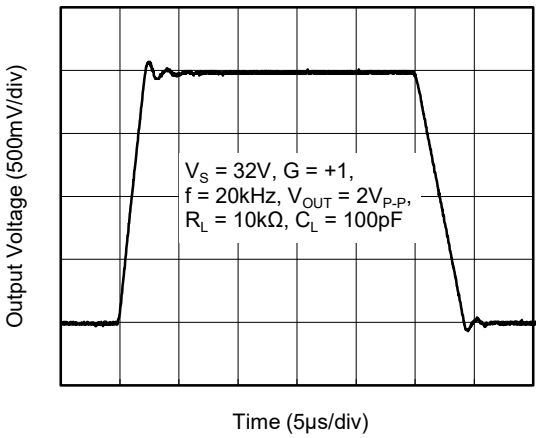
Large-Signal Step Response



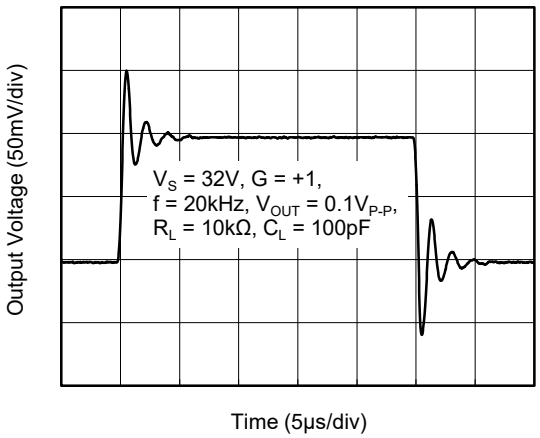
Small-Signal Step Response



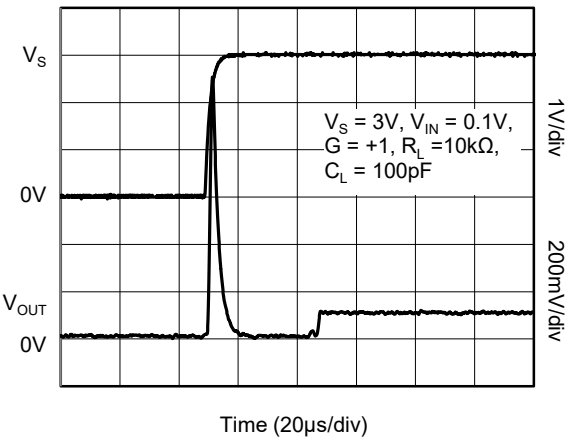
Large-Signal Step Response



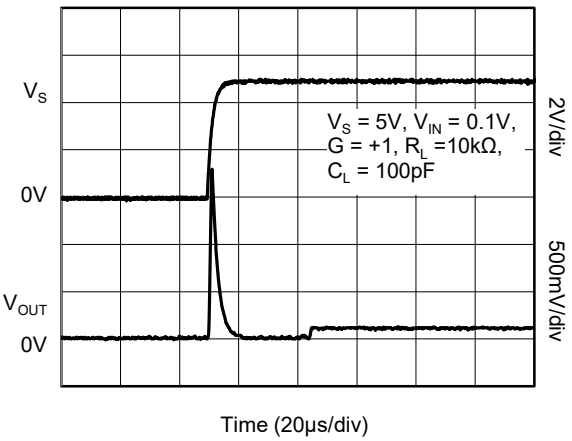
Small-Signal Step Response



Turn-On Time



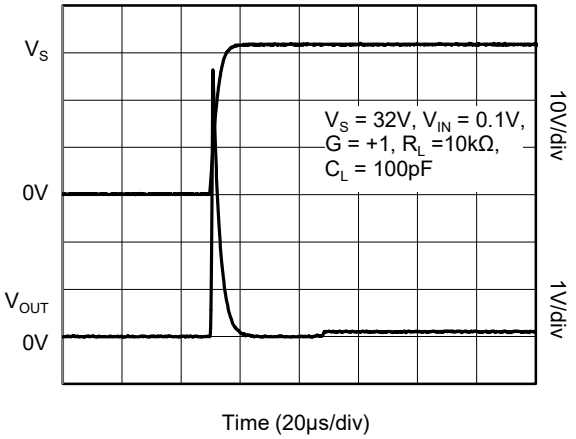
Turn-On Time



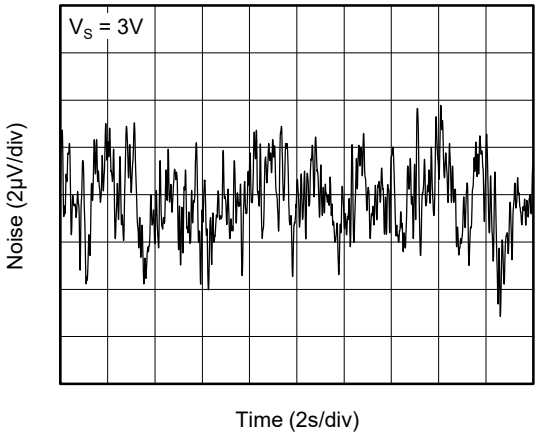
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

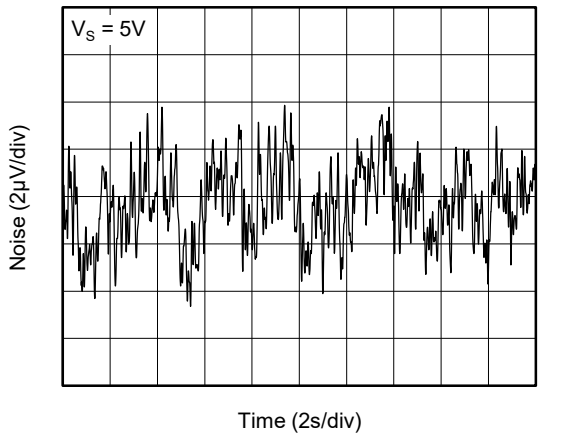
Turn-On Time



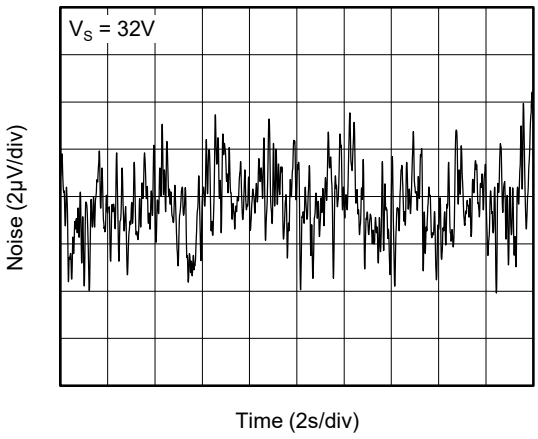
0.1Hz to 10Hz Input Voltage Noise



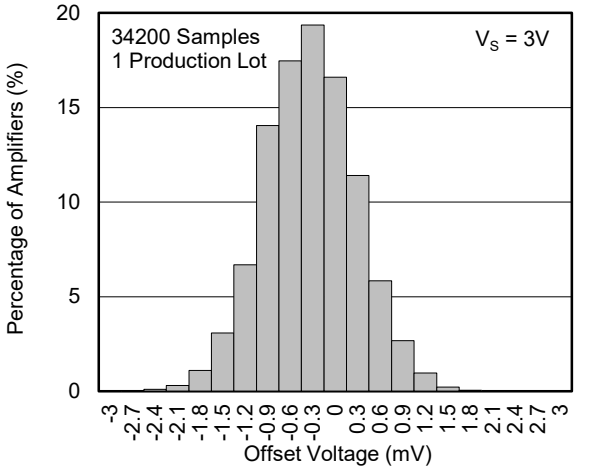
0.1Hz to 10Hz Input Voltage Noise



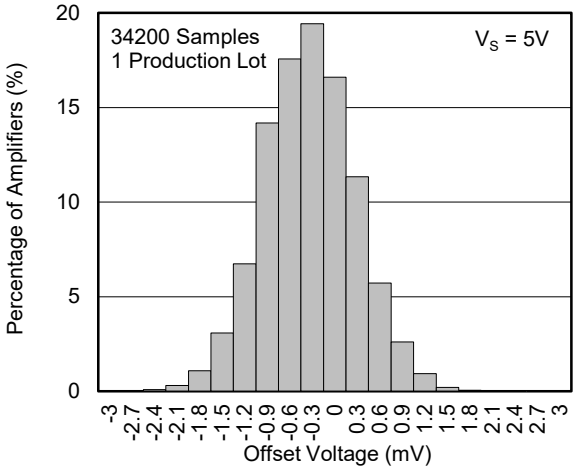
0.1Hz to 10Hz Input Voltage Noise



Offset Voltage Production Distribution



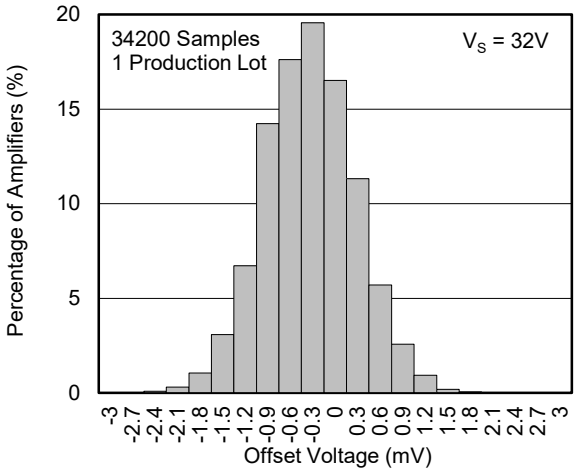
Offset Voltage Production Distribution



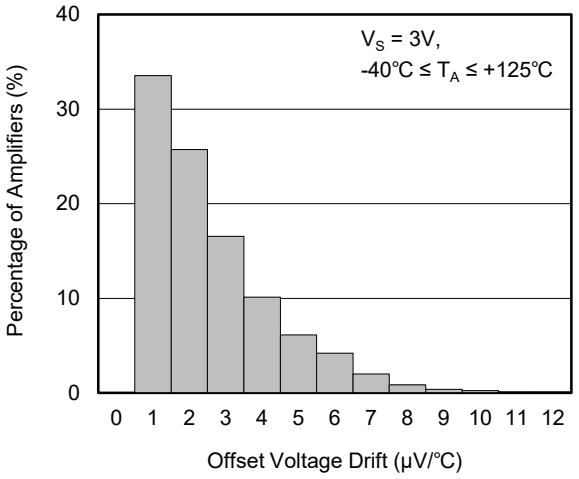
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

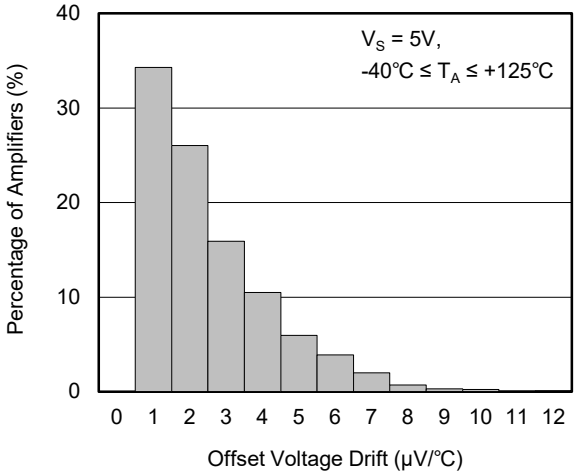
Offset Voltage Production Distribution



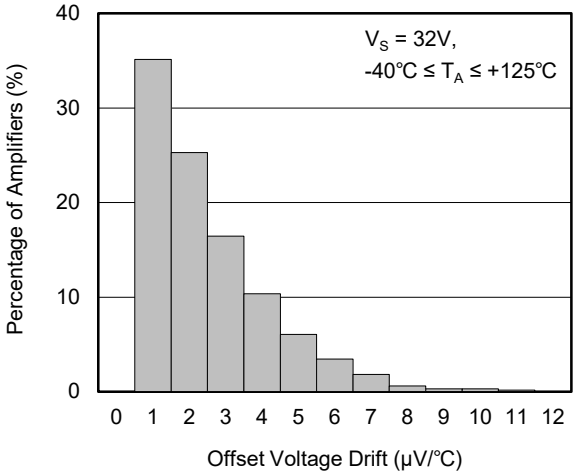
Offset Voltage Drift Distribution



Offset Voltage Drift Distribution



Offset Voltage Drift Distribution



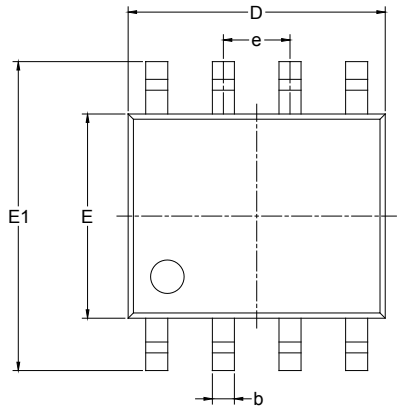
REVISION HISTORY

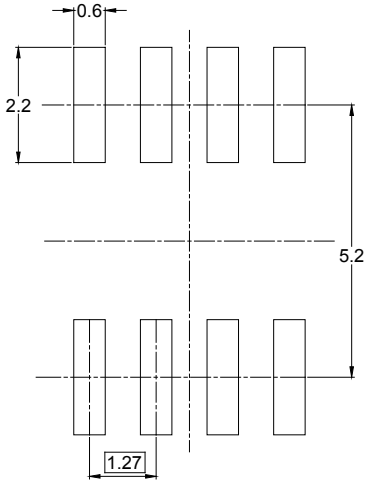
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (JUNE 2019) to REV.A	Page
Changed from product preview to production data	All

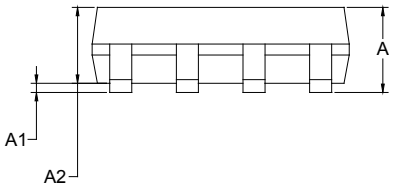
PACKAGE OUTLINE DIMENSIONS

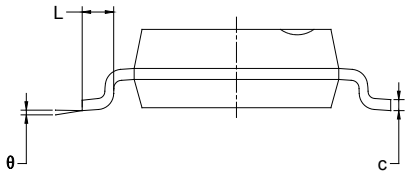
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)

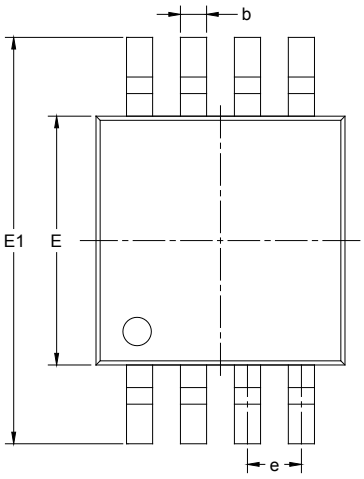


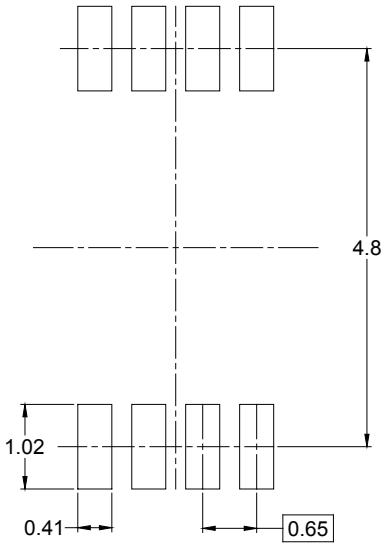


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

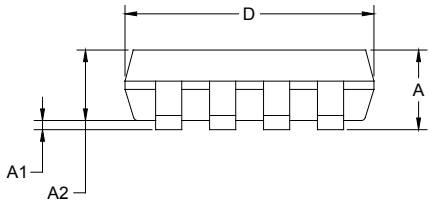
PACKAGE OUTLINE DIMENSIONS

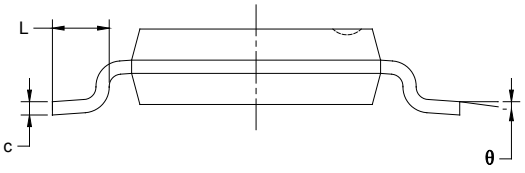
MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)

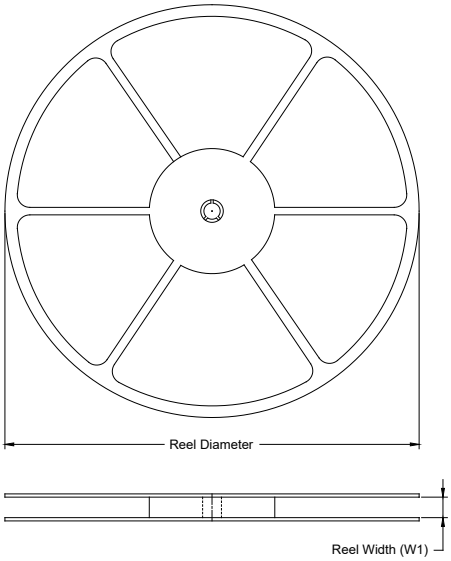




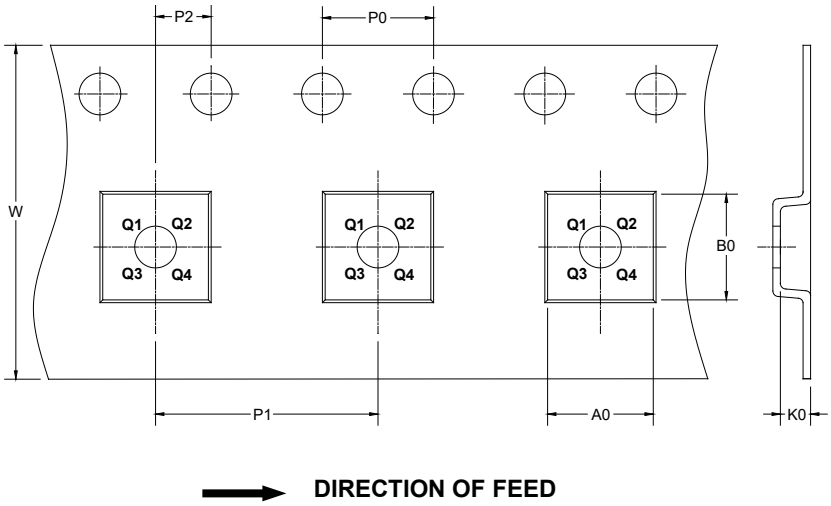
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



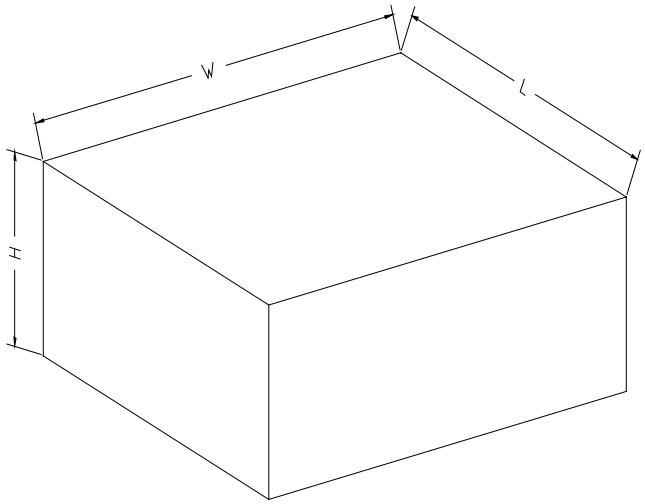
NOTE: The picture is only for reference. Please make the object as the standard.

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