

1.Description

This amplifier has ultralow offset, drift, and bias current. The AD8628/AD8629/AD8630 are wide bandwidth auto-zero amplifiers featuring rail-to-rail input and output swing and low noise. Operation is fully specified from 2.7 V to 5 V single supply ($\pm 1.35\text{V}$ to $\pm 2.5\text{V}$ dual supply).

The AD8628/AD8629/AD8630 provide benefits previously found only in expensive auto-zeroing or chopper-stabilized amplifiers. With an offset voltage of only 1 μV , drift of less than 0.005 $\mu\text{V}/^\circ\text{C}$, and noise of only 0.5 μV p-p (0Hz to 10Hz), the AD8628/AD8629/AD8630 are suited for applications where error sources cannot be tolerated. Position and pressure sensors, medical equipment, and strain gage amplifiers benefit greatly from nearly zero drift over their operating temperature range. Many systems can take advantage of the rail-to-rail input and output swings provided by the AD8628/AD8629/AD8630 to reduce input biasing complexity and maximize SNR.

3.Applications

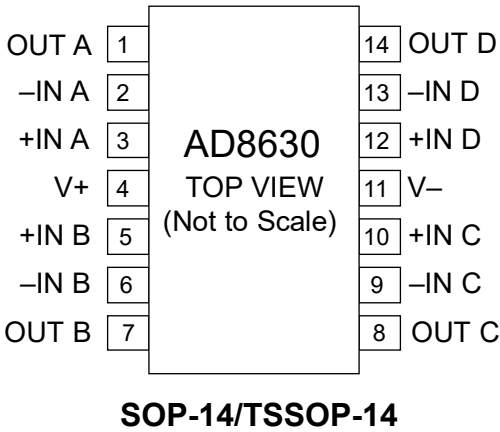
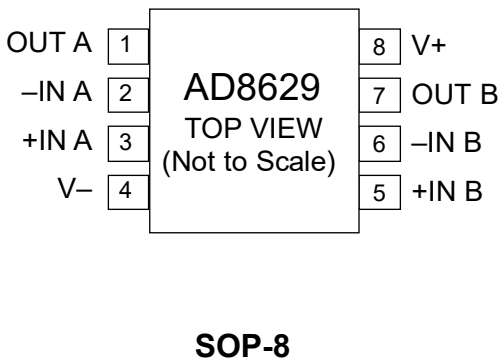
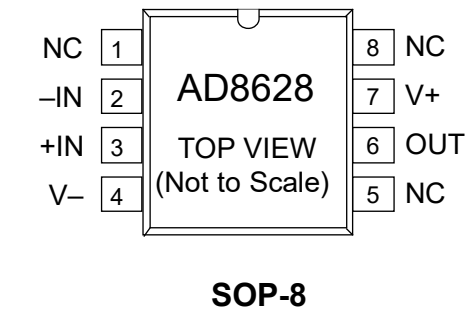
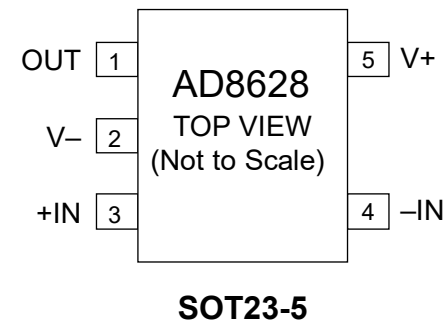
- Automotive sensors
- Pressure and position sensors
- Strain gage amplifiers
- Medical instrumentation

2.Features

- Lowest auto-zero amplifier noise
- Low offset voltage: 1 μV
- Input offset drift: 0.002 $\mu\text{V}/^\circ\text{C}$
- Rail-to-rail input and output swing
- 5 V single-supply operation
- High gain, CMRR, and PSRR: 130dB
- Very low input bias current: 100pA
- maximum Low supply current: 1.0mA
- Overload recovery time: 50 μs
- No external components required



4.Pinning information





5. Absolute Maximum Ratings

Description	Rating
Supply Voltage	6V
Input Voltage	GND – 0.3V to $V_{S-} + 0.3V$
Differential input Voltage ⁽¹⁾	±5.0V
Output Short-Circuit Duration to GND	Indefinite
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	-40°C to +125°C
Junction Temperature Range	-65°C to +150°C
Lead Temperature Range (Soldering, 60 sec)	300°C

(1) Differential input voltage is limited to ±5 V or the supply voltage, whichever is less.



6.1 Electrical characteristics

$V_S=5V$, $V_{CM}=2.5V$, $T_A=25^\circ C$, unless otherwise noted.

Parameter		Symbol	Conditions	Min	Typ	Max	Units
INPUT CHARACTERISTICS							
Offset Voltage		V_{OS}			1	5	μV
			$-40^\circ C \leq T_A \leq +125^\circ C$			10	μV
Input Bias Current	AD8628/AD8629	I_B			30	100	pA
	AD8630				100	300	pA
			$-40^\circ C \leq T_A \leq +125^\circ C$			1.5	nA
Input Offset Current		I_{OS}			50	200	pA
			$-40^\circ C \leq T_A \leq +125^\circ C$			250	pA
Input Voltage Range				0		5	V
Common-Mode Rejection Ratio		CMRR	$V_{CM}=0V$ to 5V	120	140		dB
			$-40^\circ C \leq T_A \leq +125^\circ C$	115	130		dB
Large Signal Voltage Gain		A_{VO}	$R_L=10k\Omega$, $V_O=0.3V$ to 4.7V	125	145		dB
			$-40^\circ C \leq T_A \leq +125^\circ C$	120	135		dB
Offset Voltage Drift		$\Delta V_{OS}/\Delta T$	$-40^\circ C \leq T_A \leq +125^\circ C$		0.002	0.02	$\mu V/^\circ C$
OUTPUT CHARACTERISTICS							
Output Voltage High		V_{OH}	$R_L=100k\Omega$ to ground	4.99	4.996		V
			$-40^\circ C \leq T_A \leq +125^\circ C$	4.99	4.995		V
			$R_L=10k\Omega$ to ground	4.95	4.98		V
			$-40^\circ C \leq T_A \leq +125^\circ C$	4.95	4.97		V
Output Voltage Low		V_{OL}	$R_L=100k\Omega$ to V_+		1	5	mV
			$-40^\circ C \leq T_A \leq +125^\circ C$		2	5	mV
			$R_L=10k\Omega$ to V_+		10	20	mV
			$-40^\circ C \leq T_A \leq +125^\circ C$		15	20	mV
Short-Circuit Limit		I_{SC}		± 25	± 50		mA
			$-40^\circ C \leq T_A \leq +125^\circ C$		± 40		mA
Output Current		I_O			± 30		mA
			$-40^\circ C \leq T_A \leq +125^\circ C$		± 15		mA



Parameter	Symbol	Conditions	Min	Typ	Max	Units
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	$V_S=2.7V$ to $5.5V$, $-40^{\circ}C \leq T_A \leq 125^{\circ}C$	115	130		dB
Supply Current per Amplifier	I_{SY}	$V_O=V_S/2$		0.85	1.1	mA
		$-40^{\circ}C \leq T_A \leq +125^{\circ}C$		1	1.2	mA
Input Capacitance	C_{IN}					
Differential				1.5		pF
Common Mode				8		pF
DYNAMIC PERFORMANCE						
Slew Rate	SR	$R_L=10k\Omega$		1		V/ μs
Overload Recovery Time				0.05		ms
Gain Bandwidth Product	GBP			2.5		MHz
NOISE PERFORMANCE						
Voltage Noise	$e_{n,p-p}$	0.1Hz to 10Hz		0.5		μV_{p-p}
		0.1Hz to 1Hz		0.16		μV_{p-p}
Voltage Noise Density	e_n	$f=1kHz$		22		nV/ $\sqrt{Hz}$
Current Noise Density	i_n	$f=10Hz$		5		fA/ $\sqrt{Hz}$



6.2 Electrical characteristics

$V_S=2.7V$, $V_{CM}=1.35V$, $V_O=1.4V$, $T_A=25^\circ C$, unless otherwise noted.

Parameter		Symbol	Conditions	Min	Typ	Max	Units
INPUT CHARACTERISTICS							
Offset Voltage		V_{OS}			1	5	μV
			$-40^\circ C \leq T_A \leq +125^\circ C$			10	μV
Input Bias Current	AD8628/AD8629	I_B			30	100	pA
	AD8630				100	300	pA
			$-40^\circ C \leq T_A \leq +125^\circ C$		1	1.5	nA
Input Offset Current		I_{OS}			50	200	pA
			$-40^\circ C \leq T_A \leq +125^\circ C$			250	pA
Input Voltage Range				0		2.7	V
Common-Mode Rejection Ratio		CMRR	$V_{CM}=0V$ to $2.7V$	115	130		dB
Large Signal Voltage Gain		A_{VO}	$-40^\circ C \leq T_A \leq +125^\circ C$	110	120		dB
			$R_L=10k\Omega$, $V_O=0.3V$ to $2.4V$	110	140		dB
			$-40^\circ C \leq T_A \leq +125^\circ C$	105	130		dB
Offset Voltage Drift		$\Delta V_{OS}/\Delta T$	$-40^\circ C \leq T_A \leq +125^\circ C$		0.002	0.02	$\mu V/^\circ C$
OUTPUT CHARACTERISTICS							
Output Voltage High		V_{OH}	$R_L=100k\Omega$ to ground	2.68	2.695		V
			$-40^\circ C \leq T_A \leq +125^\circ C$	2.68	2.695		V
			$R_L=10k\Omega$ to ground	2.67	2.68		V
			$-40^\circ C \leq T_A \leq +125^\circ C$	2.67	2.675		V
Output Voltage Low		V_{OL}	$R_L=100k\Omega$ to $V+$		1	5	mV
			$-40^\circ C \leq T_A \leq +125^\circ C$		2	5	mV
			$R_L=10k\Omega$ to $V+$		10	20	mV
			$-40^\circ C \leq T_A \leq +125^\circ C$		15	20	mV
Short-Circuit Limit		I_{SC}		± 10	± 15		mA
			$-40^\circ C \leq T_A \leq +125^\circ C$		± 10		mA
Output Current		I_O			± 10		mA
			$-40^\circ C \leq T_A \leq +125^\circ C$		± 5		mA



Parameter	Symbol	Conditions	Min	Typ	Max	Units
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	$V_S=2.7V$ to $5.5V$, $-40^{\circ}C \leq T_A \leq 125^{\circ}C$	115	130		dB
Supply Current per Amplifier	I_{SY}	$V_O=V_S/2$		0.75	1	mA
		$-40^{\circ}C \leq T_A \leq +125^{\circ}C$		0.9	1.2	mA
Input Capacitance	C_{IN}					
Differential				1.5		pF
Common Mode				8		pF
DYNAMIC PERFORMANCE						
Slew Rate	SR	$R_L=10k\Omega$		1		V/ μs
Overload Recovery Time				0.05		ms
Gain Bandwidth Product	GBP			2		MHz
NOISE PERFORMANCE						
Voltage Noise	$e_{n,p-p}$	0.1Hz to 10Hz		0.5		μV_{p-p}
Voltage Noise Density	e_n	$f=1kHz$		22		nV/ $\sqrt{Hz}$
Current Noise Density	i_n	$f=10Hz$		5		fA/ $\sqrt{Hz}$



7.1 Typical Characteristic

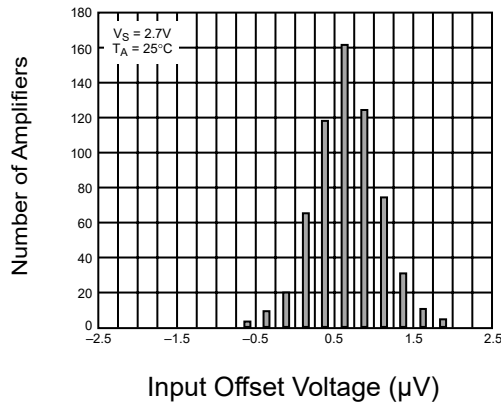


Figure 5: Input Offset Voltage Distribution at 2.7V

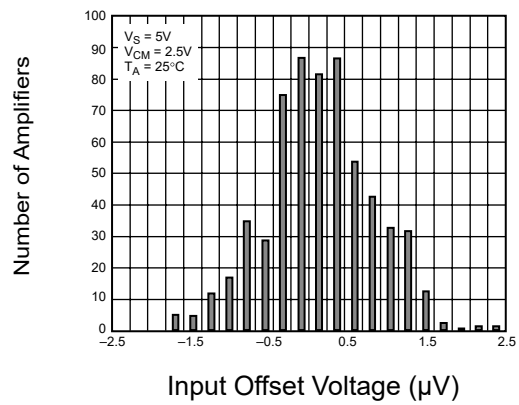


Figure 8: Input Offset Voltage Distribution at 5V

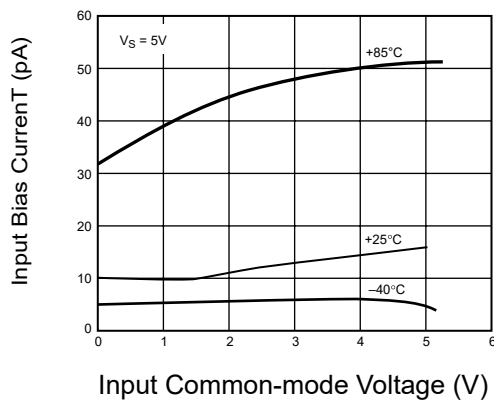


Figure 6: AD8628 Input Bias Current vs. Input Common-Mode Voltage at 5 V

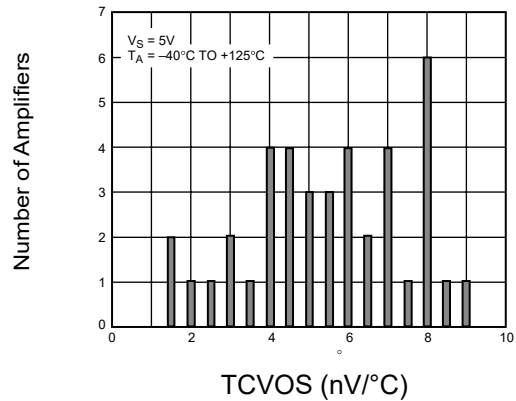


Figure 9: Input Bias Current vs. Common-Mode Voltage

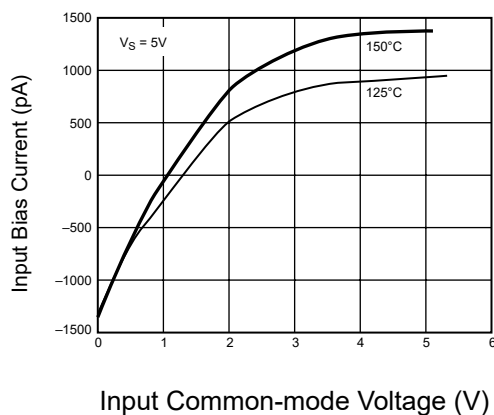


Figure 7: AD8628 Input Bias Current vs. Input Common-Mode Voltage at 5 V

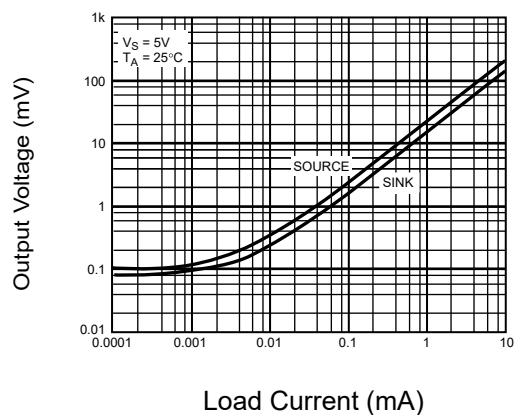


Figure 10: Output Voltage to Supply Rail vs. Load Current at 5 V



7.2 Typical Characteristic

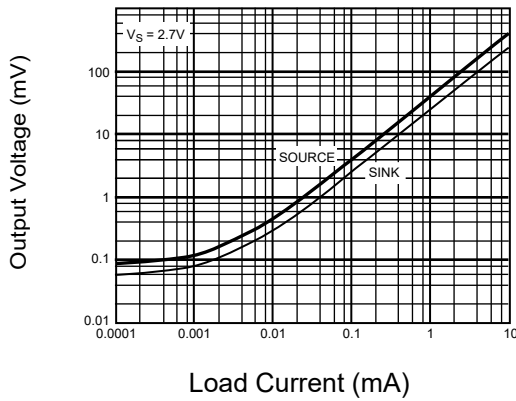


Figure 11: Output Voltage to Supply Rail vs. Load Current at 2.7 V

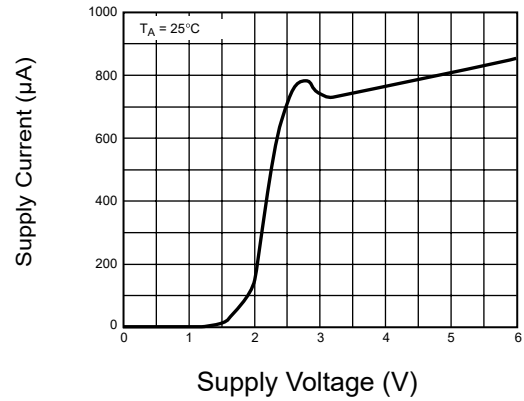


Figure 14: Supply Current vs. Supply Voltage

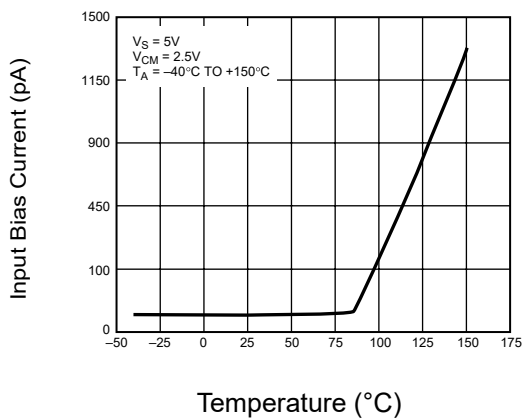


Figure 12: AD8628 Input Bias Current vs. Temperature

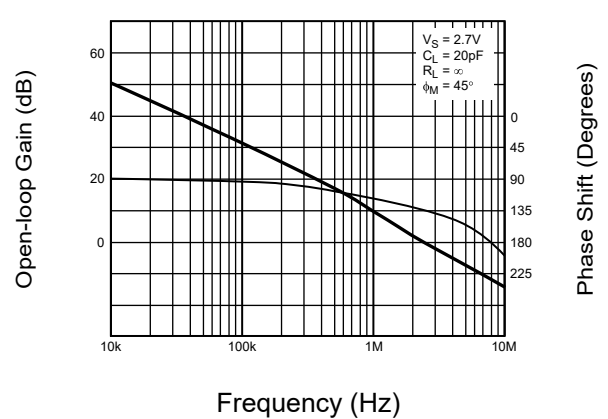


Figure 15: Open-Loop Gain and Phase vs. Frequency

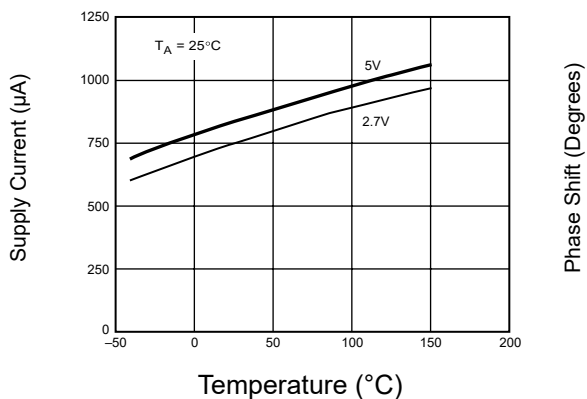


Figure 13: Supply Current vs. Temperature

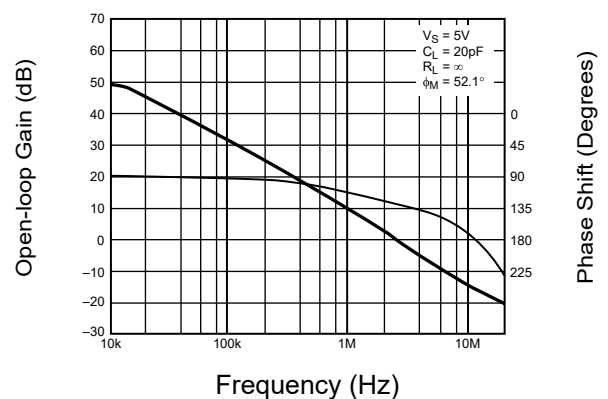


Figure 16: Open-Loop Gain and Phase vs. Frequency



7.3 Typical Characteristic

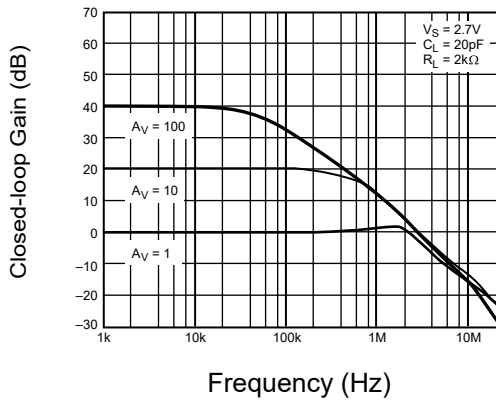


Figure 17: Closed-Loop Gain vs. Frequency at 2.7 V

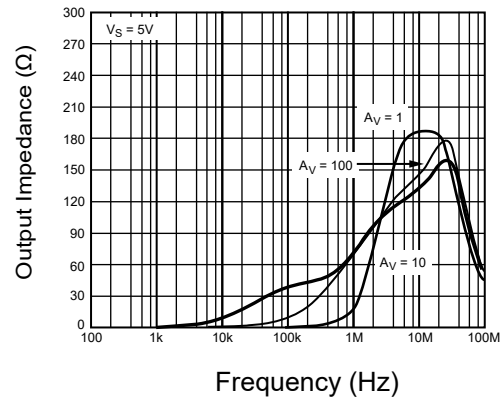


Figure 20: Output Impedance vs. Frequency at 5 V

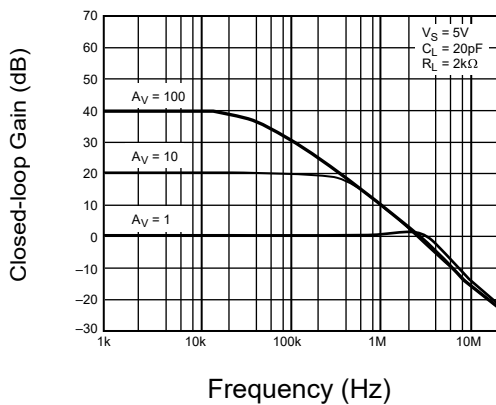


Figure 18: Closed-Loop Gain vs. Frequency at 5 V

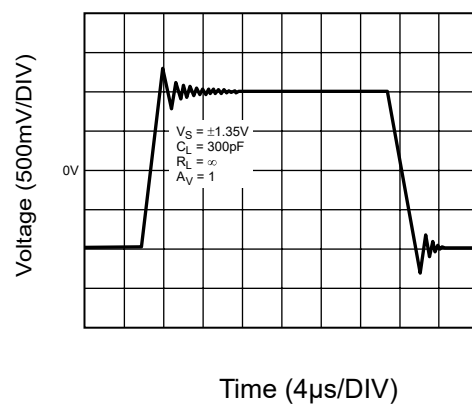


Figure 21: Large Signal Transient Response at 2.7 V

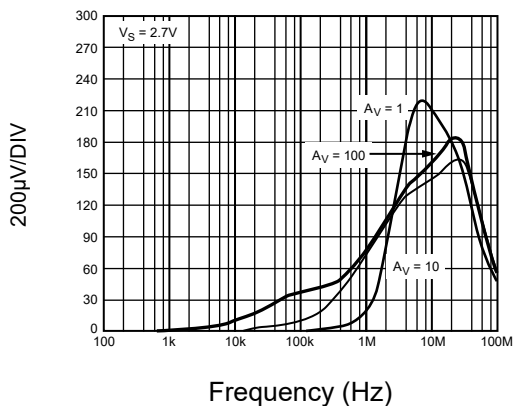


Figure 19: Output Impedance vs. Frequency at 2.7 V

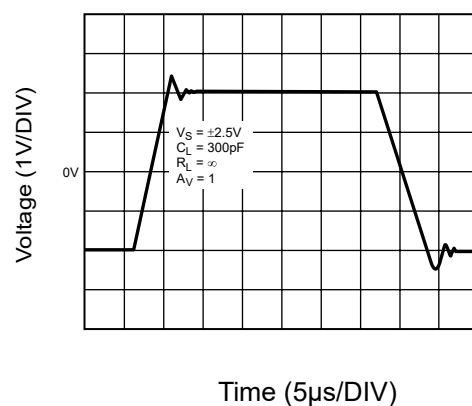
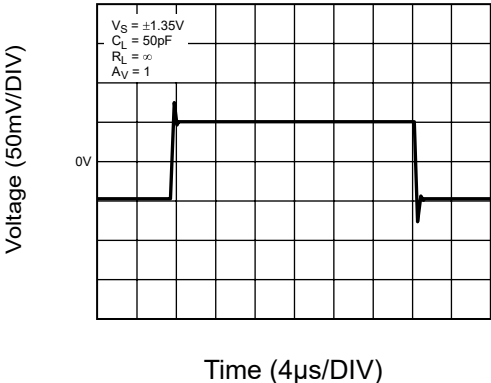
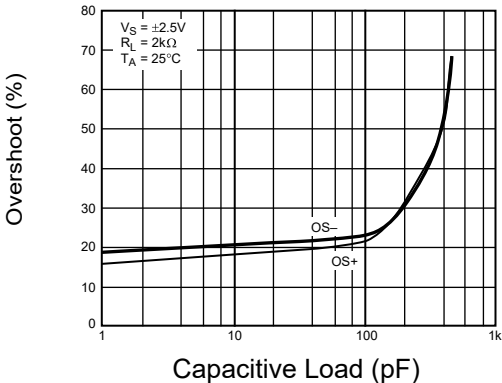
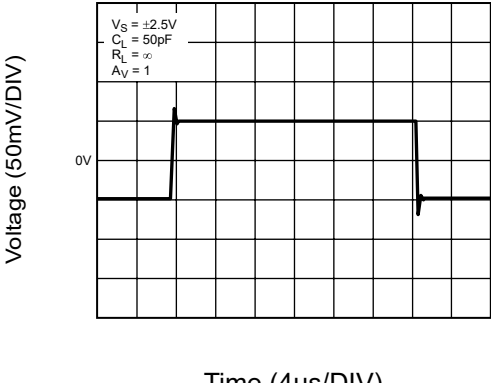
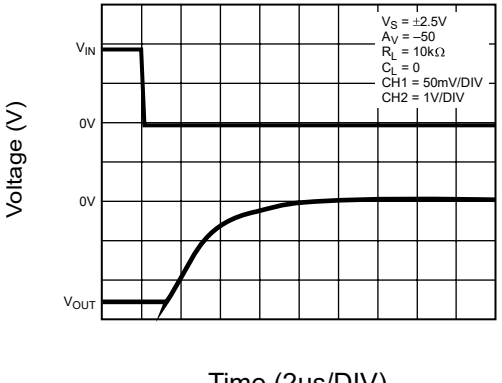
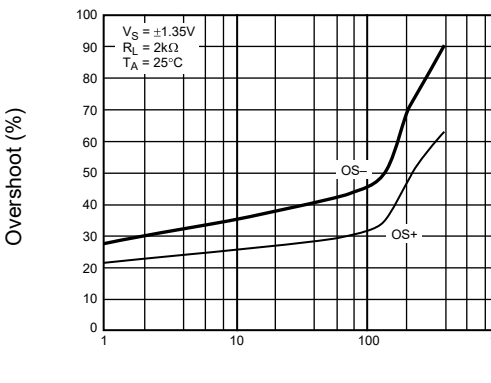
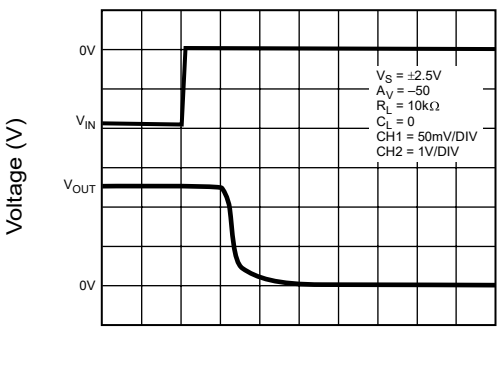


Figure 22: Large Signal Transient Response at 5 V

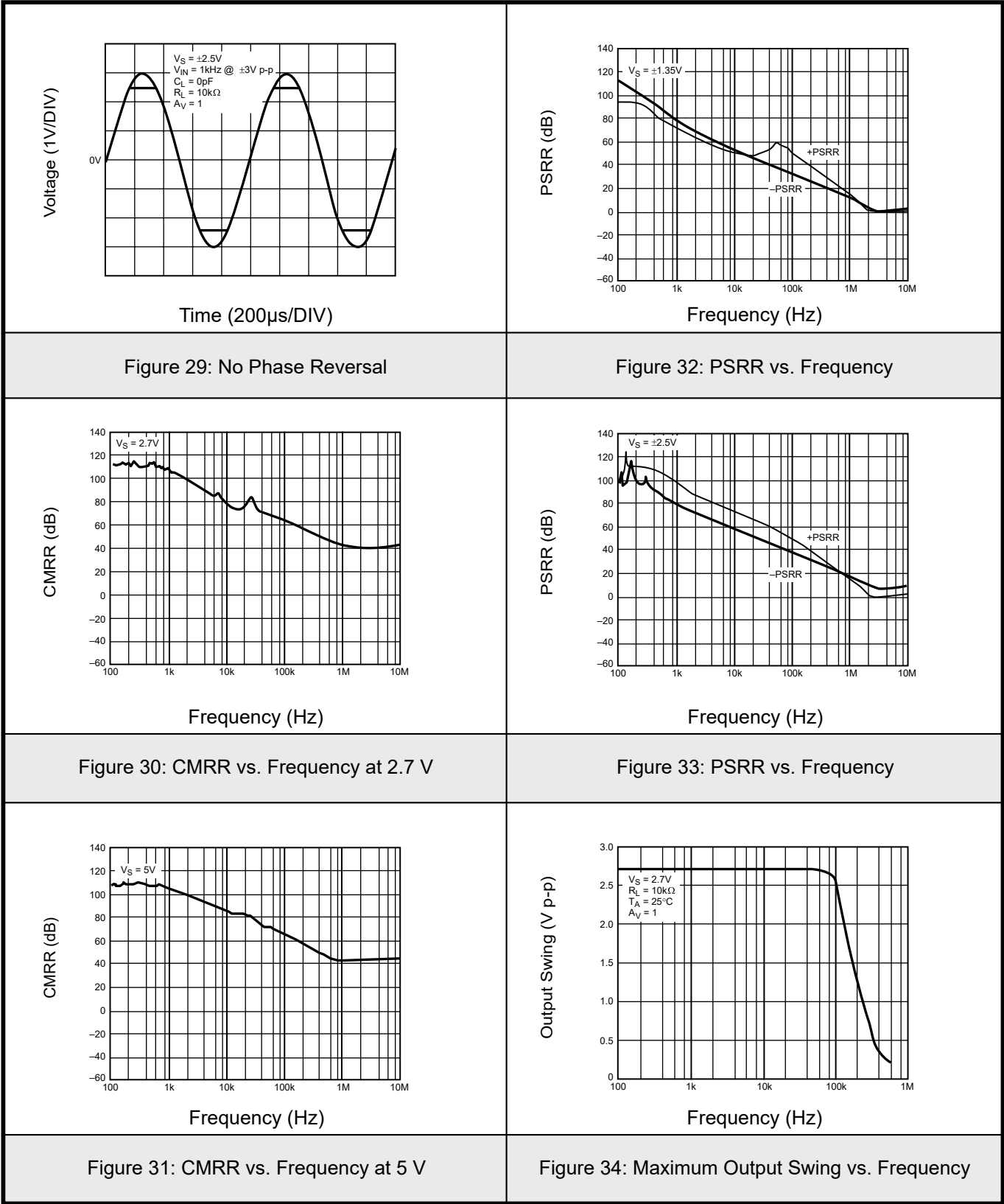


7.4 Typical Characteristic

 Figure 23: Small Signal Transient Response at 2.7 V	 Figure 26: Small Signal Overshoot vs. Load Capacitance at 5 V
 Figure 24: Small Signal Transient Response at 5 V	 Figure 27: Positive Overvoltage Recovery
 Figure 25: Small Signal Overshoot vs. Load Capacitance at 2.7 V	 Figure 28: Negative Overvoltage Recovery



7.5 Typical Characteristic





7.6 Typical Characteristic

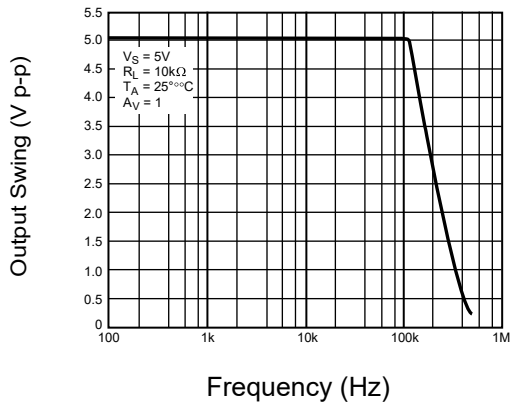


Figure 35: Maximum Output Swing vs. Frequency at 5V

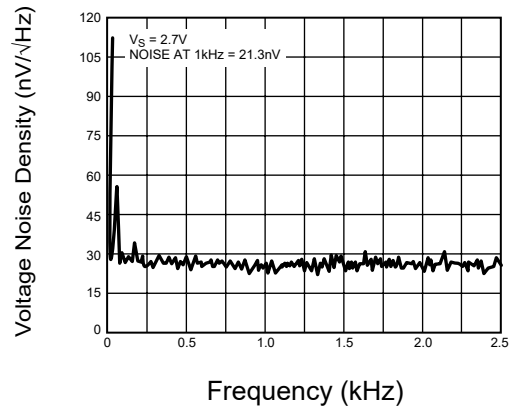


Figure 38: Voltage Noise Density at 2.7V from 0Hz to 2.5kHz

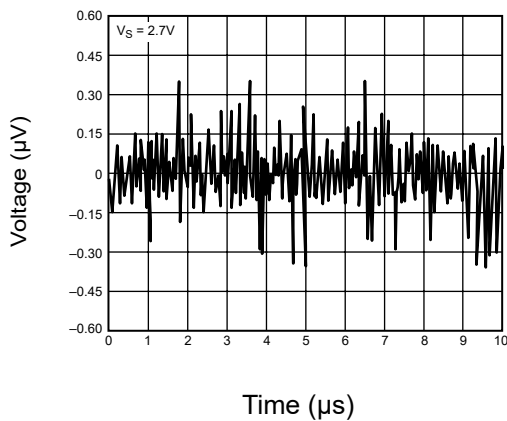


Figure 36: 0.1 Hz to 10 Hz Noise at 2.7V

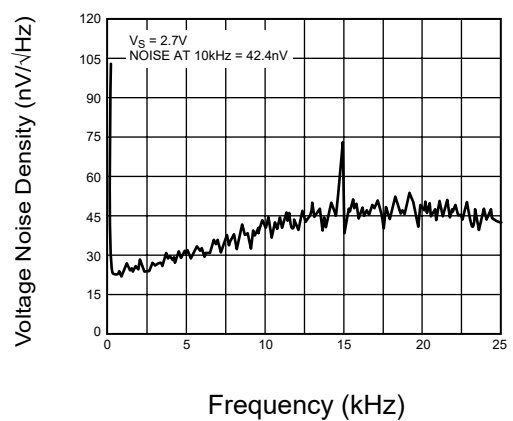


Figure 39: Voltage Noise Density at 2.7V from 0 Hz to 25 kHz

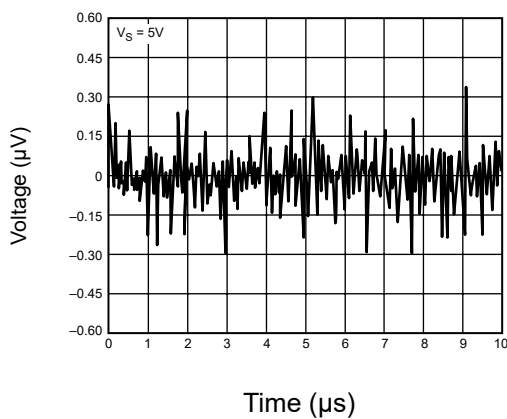


Figure 37: 0.1 Hz to 10 Hz Noise at 5 V

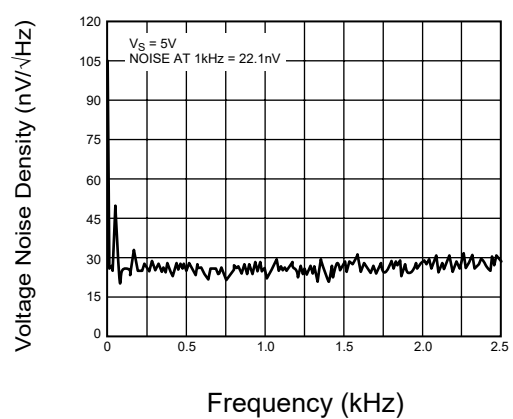


Figure 40: Voltage Noise Density at 5 V from 0 Hz to 2.5 kHz



7.7 Typical Characteristic

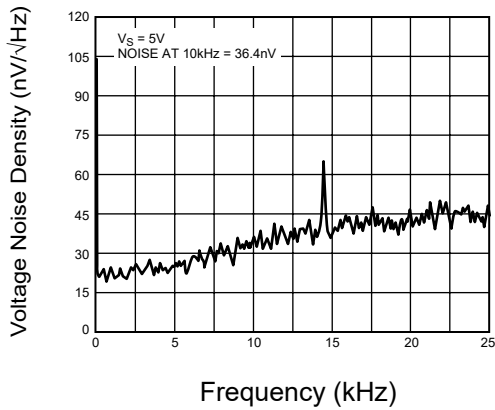


Figure 41: Voltage Noise Density at 5 V from 0 Hz to 25 kHz

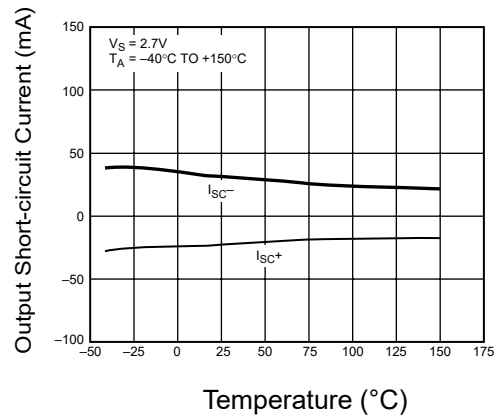


Figure 44: Output Short-Circuit Current vs. Temperature

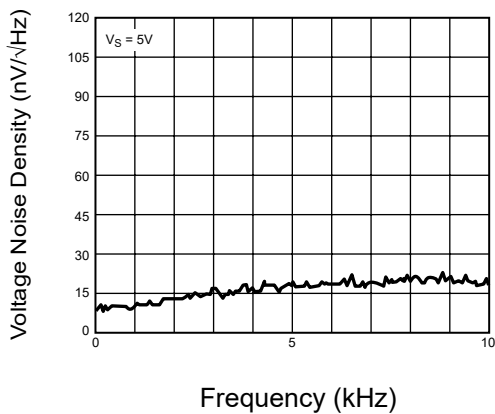


Figure 42: Voltage Noise

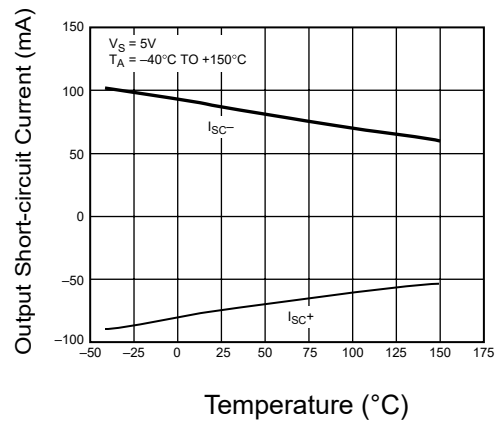


Figure 45: Output Short-Circuit Current vs. Temperature

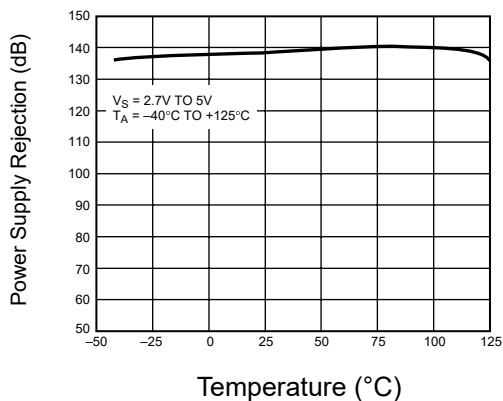


Figure 43: Power Supply Rejection vs. Temperature

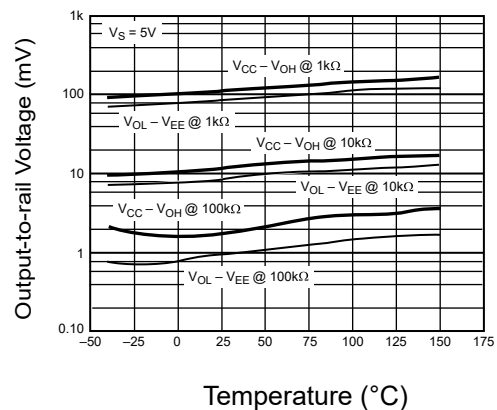
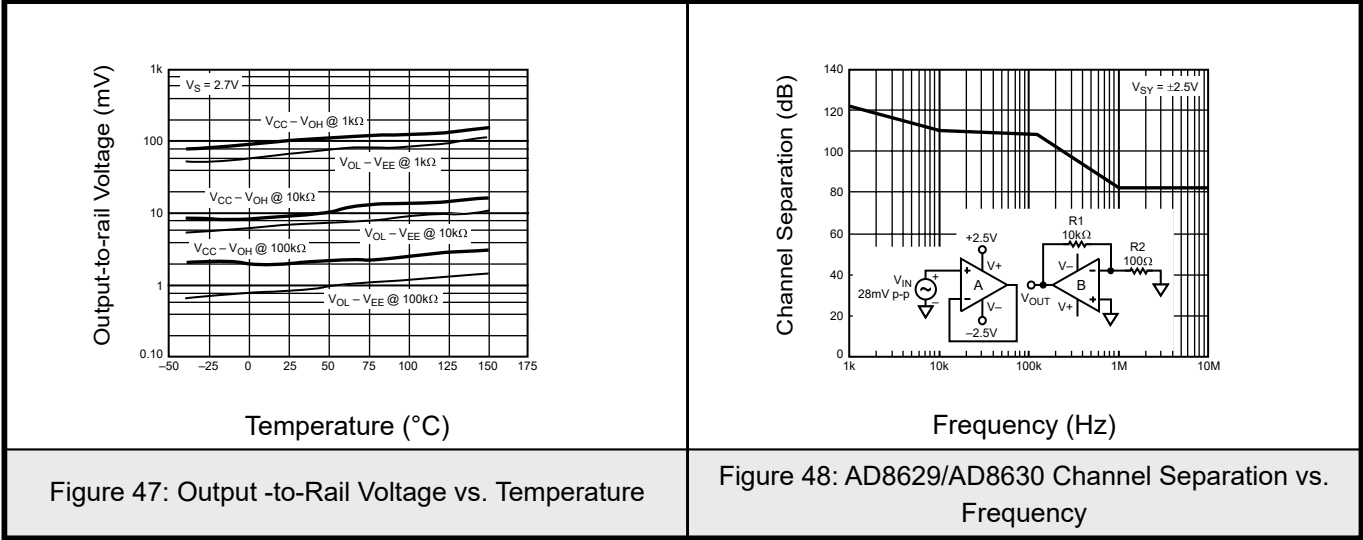


Figure 46: Output-to-Rail Voltage vs. Temperature

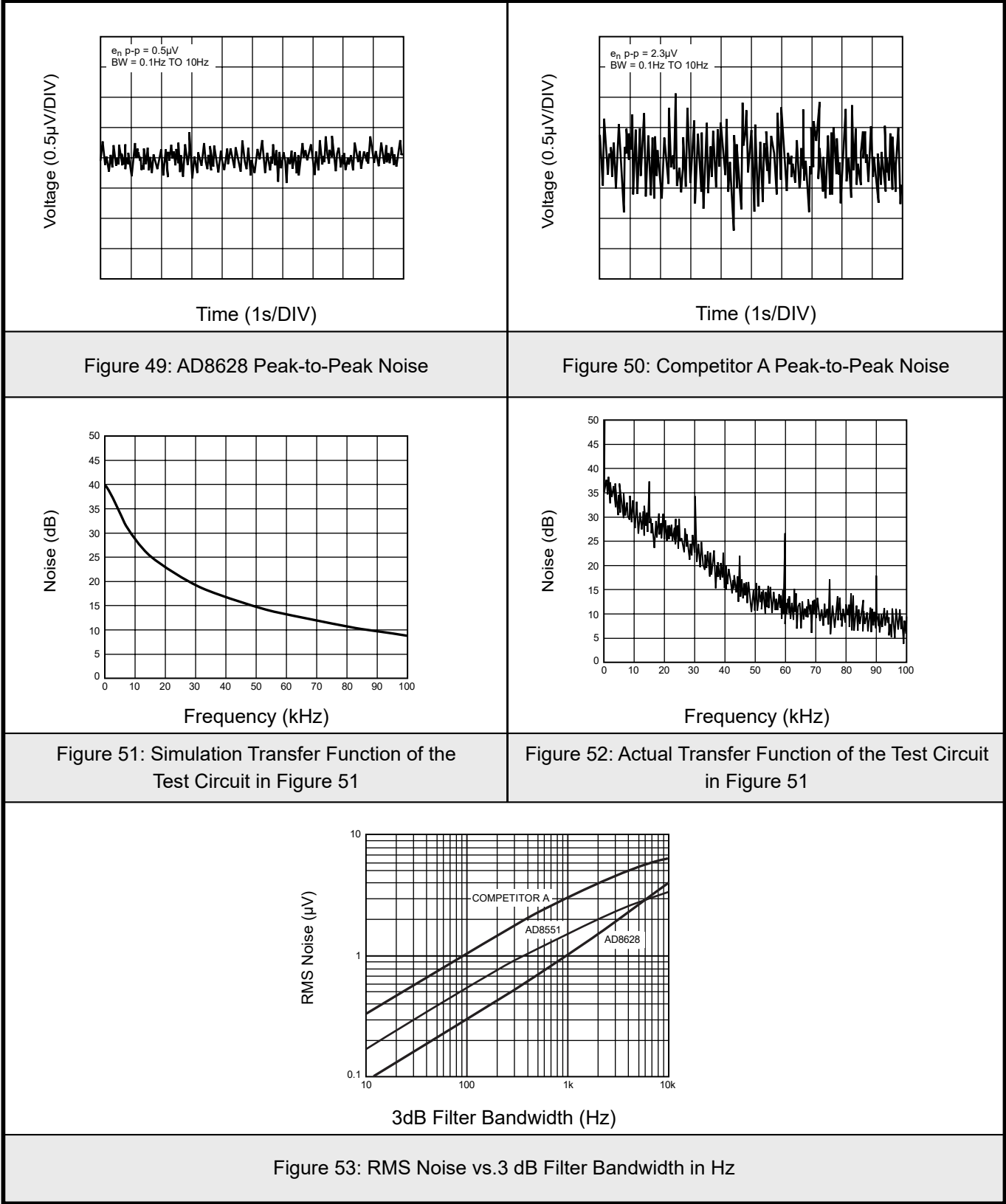


7.8 Typical Characteristic





7.9 Typical Characteristic



**PEAK-TO-PEAK NOISE**

Because of the ping-pong action between auto-zeroing and chopping, the peak-to-peak noise of the AD8628/AD8629/AD8630 is much lower than the competition. Figure 50 and Figure 54 show this comparison.

NOISE BEHAVIOR WITH FIRST-ORDER, LOW-PASS FILTER

The AD8628 was simulated as a low-pass filter (see Figure 52) and then configured as shown in Figure 51. The behavior of the AD8628 matches the simulated data. It was verified that noise is rolled off by first-order filtering. Figure 52 and Figure 53 show the difference between the simulated and actual transfer functions of the circuit shown in Figure 51. The measured noise spectrum of the test circuit charted in Figure 53 shows that noise between 5 kHz and 45 kHz is successfully rolled off by the first-order filter.

TOTAL INTEGRATED INPUT-REFERRED NOISE FOR FIRST-ORDER FILTER

For a first-order filter, the total integrated noise from the AD8628 is lower than the noise of Competitor A.

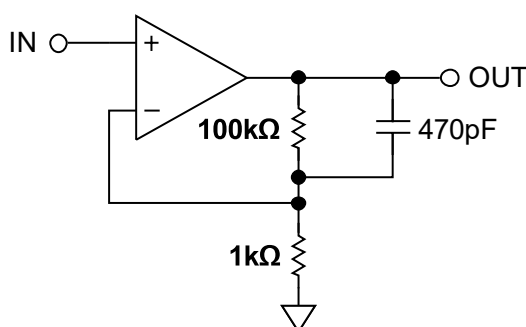
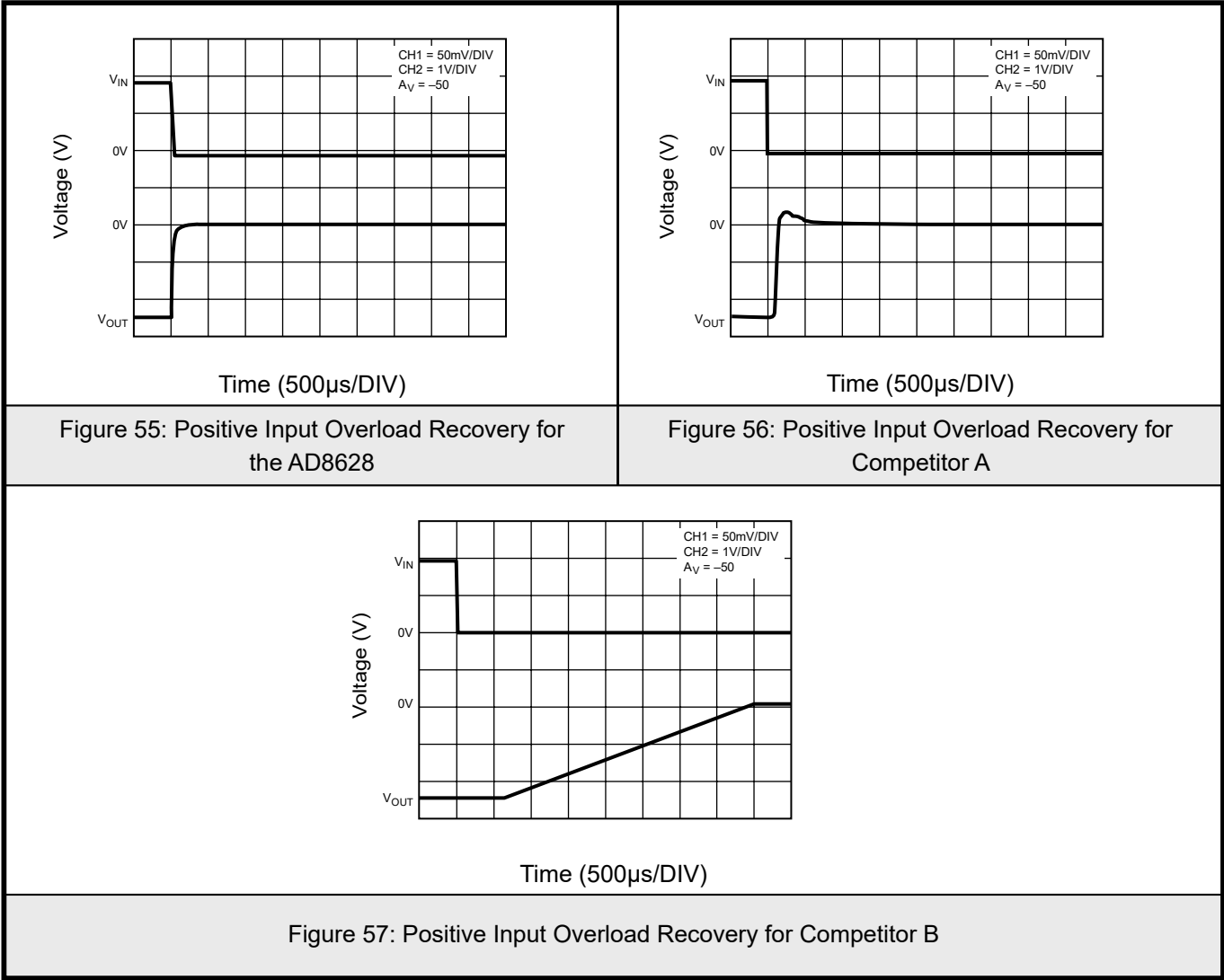


Figure 54: First-Order Low-Pass Filter Test Circuit,
×101 Gain and 3 kHz Corner Frequency



7.10 Typical Characteristic





INPUT OVERVOLTAGE PROTECTION

Although the AD8628/AD8629/AD8630 are rail-to-rail input amplifiers, care should be taken to ensure that the potential difference between the inputs does not exceed the supply voltage. Under normal negative feedback operating conditions, the amplifier corrects its output to ensure that the two inputs are at the same voltage. However, if either input exceeds either supply rail by more than 0.3 V, large currents begin to flow through the ESD protection diodes in the amplifier.

These diodes are connected between the inputs and each supply rail to protect the input transistors against an electrostatic discharge event, and they are normally reverse-biased. However, if the input voltage exceeds the supply voltage, these ESD diodes can become forward-biased. Without current limiting, excessive amounts of current could flow through these diodes, causing permanent damage to the device. If inputs are subject to overvoltage, appropriate series resistors should be inserted to limit the diode current to less than 5 mA maximum.

OUTPUT PHASE REVERSAL

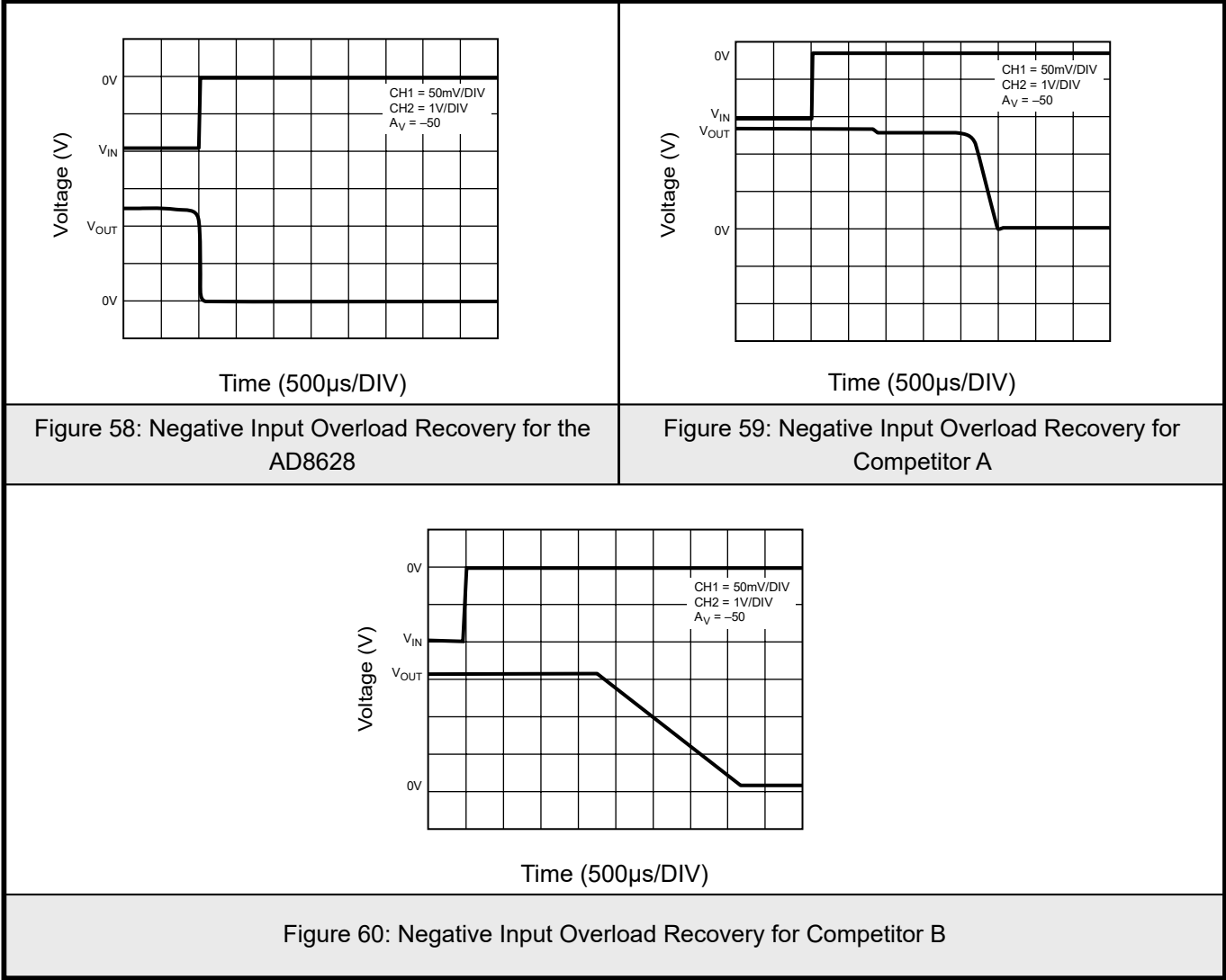
Output phase reversal occurs in some amplifiers when the input common-mode voltage range is exceeded. As common-mode voltage is moved outside the common-mode range, the outputs of these amplifiers can suddenly jump in the opposite direction to the supply rail. This is the result of the differential input pair shutting down, causing a radical shifting of internal voltages that results in the erratic output behavior. The AD8628/AD8629/AD8630 amplifiers have been carefully designed to prevent any output phase reversal, provided that both inputs are maintained within the supply voltages. If one or both inputs could exceed either supply voltage, a resistor should be placed in series with the input to limit the current to less than 5mA. This ensures that the output does not reverse its phase.

OVERLOAD RECOVERY TIME

Many auto-zero amplifiers are plagued by a long overload recovery time, often in ms, due to the complicated settling behavior of the internal nulling loops after saturation of the outputs. The AD8628/AD8629/AD8630 have been designed so that internal settling occurs within two clock cycles after output saturation occurs. This results in a much shorter recovery time, less than 10 μ s, when compared to other auto-zero amplifiers. The wide bandwidth of the AD8628/AD8629/AD8630 enhances performance when the parts are used to drive loads that inject transients into the outputs. This is a common situation when an amplifier is used to drive the input of switched capacitor ADCs.



7.11 Typical Characteristic



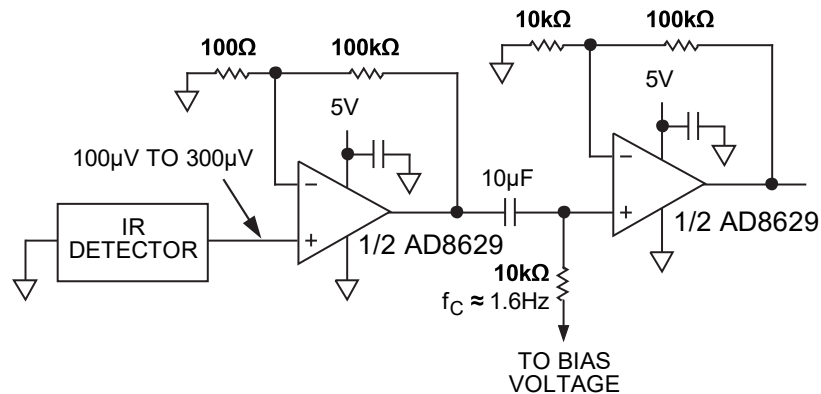


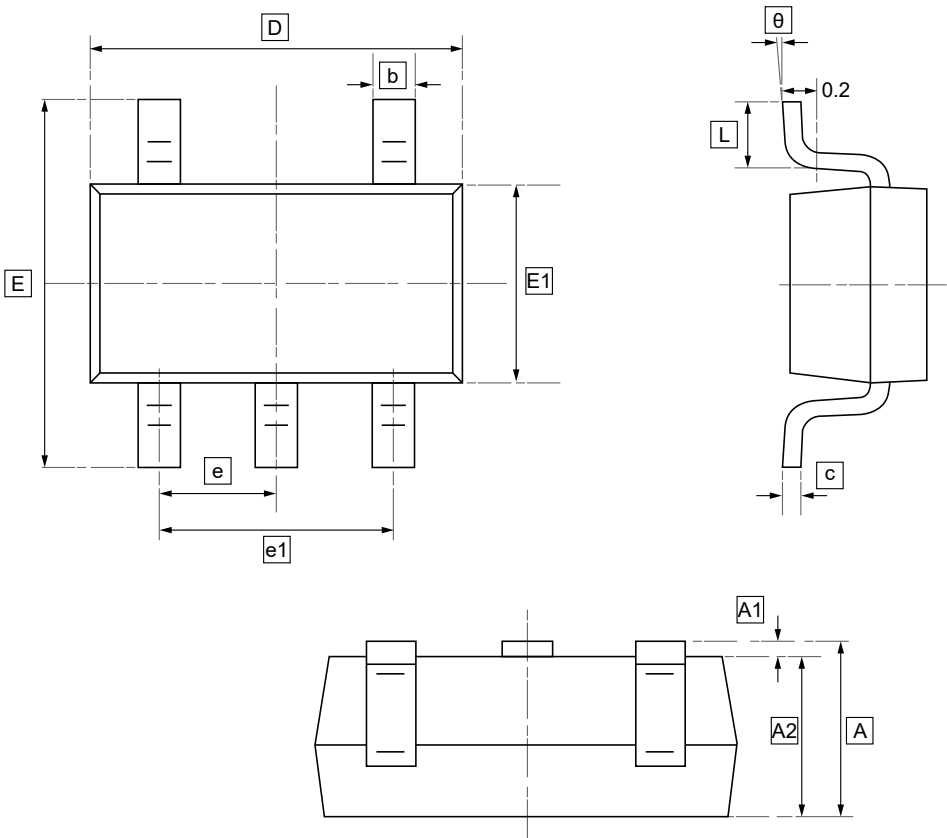
Figure 61. AD8629 Used as Preamplifier for Thermopile

SENSORS

Infrared (IR) sensors, particularly thermopiles, are increasingly being used in temperature measurement for applications as wide ranging as automotive climate control, human ear thermometers, home insulation analysis, and automotive repair diagnostics. The relatively small output signal of the sensor demands high gain with very low offset voltage and drift to avoid dc errors. If interstage ac coupling is used, as in Figure 61, low offset and drift prevent the output of the input amplifier from drifting close to saturation. The low input bias currents generate minimal errors from the output impedance of the sensor. As with pressure sensors, the very low amplifier drift with time and temperature eliminate additional errors once the temperature measurement is calibrated. The low $1/f$ noise improves SNR for dc measurements taken over periods often exceeding one-fifth of a second. Figure 61 shows a circuit that can amplify ac signals from 100 μV to 300 μV up to the 1 V to 3 V levels, with a gain of 10,000 for accurate analog-to-digital conversion.



8.1 SOT-23-5 Package Outline Dimensions

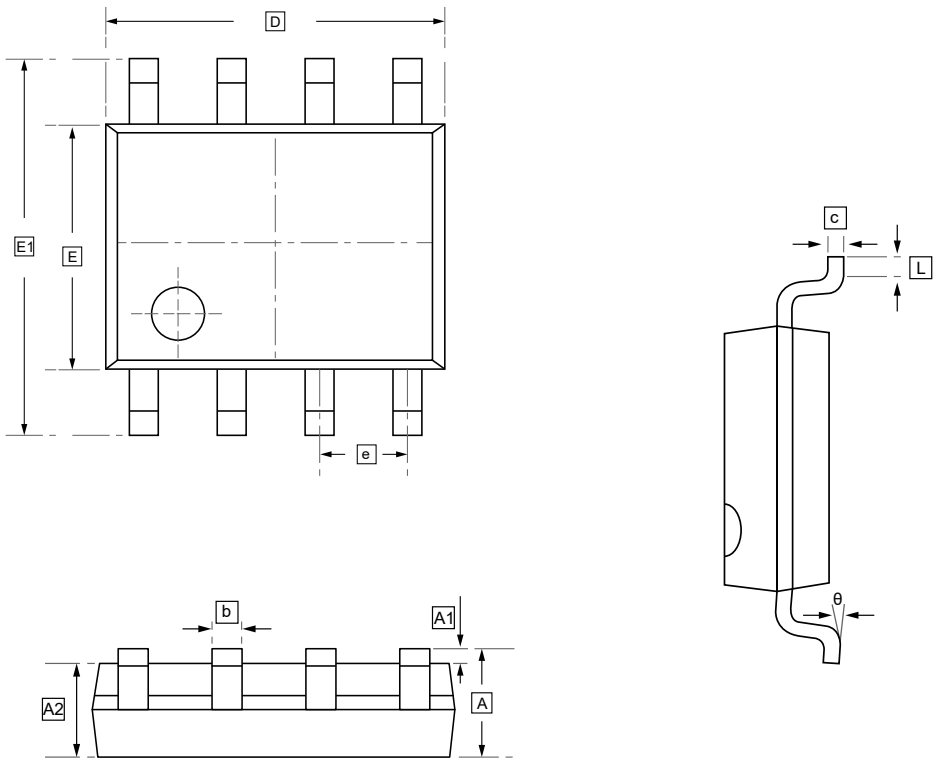


DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	b	c	D	E1	E	e	e1	L	θ
Min	1.050	0.000	1.050	0.300	0.100	2.820	1.500	2.650	0.950	1.800	0.300	0°
Max	1.250	0.100	1.150	0.500	0.200	3.020	1.700	2.950	BSC	2.000	0.600	8°



8.2 SOP-8 Package Outline Dimensions

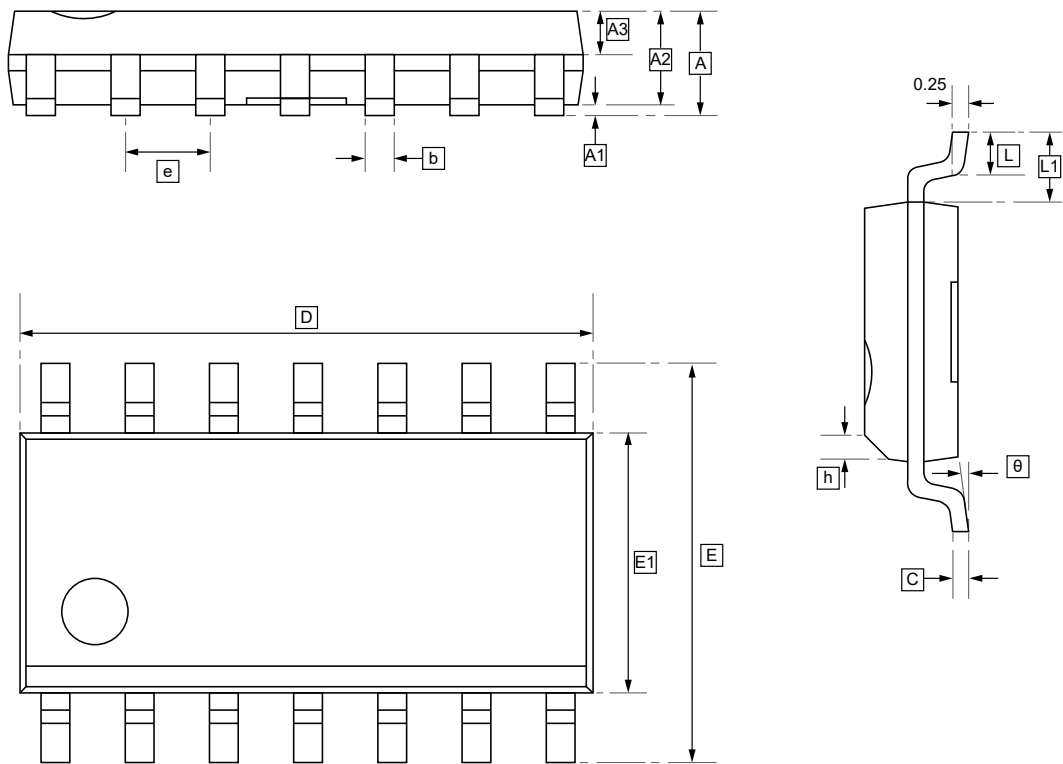


DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	b	c	D	E	E1	e	L	θ
Min	1.350	0.000	1.350	0.330	0.170	4.700	3.800	5.800	1.270	0.400	0°
Max	1.750	0.100	1.550	0.510	0.250	5.100	4.000	6.200	BSC	1.270	8°



8.3 SOP-14 Package Outline Dimensions



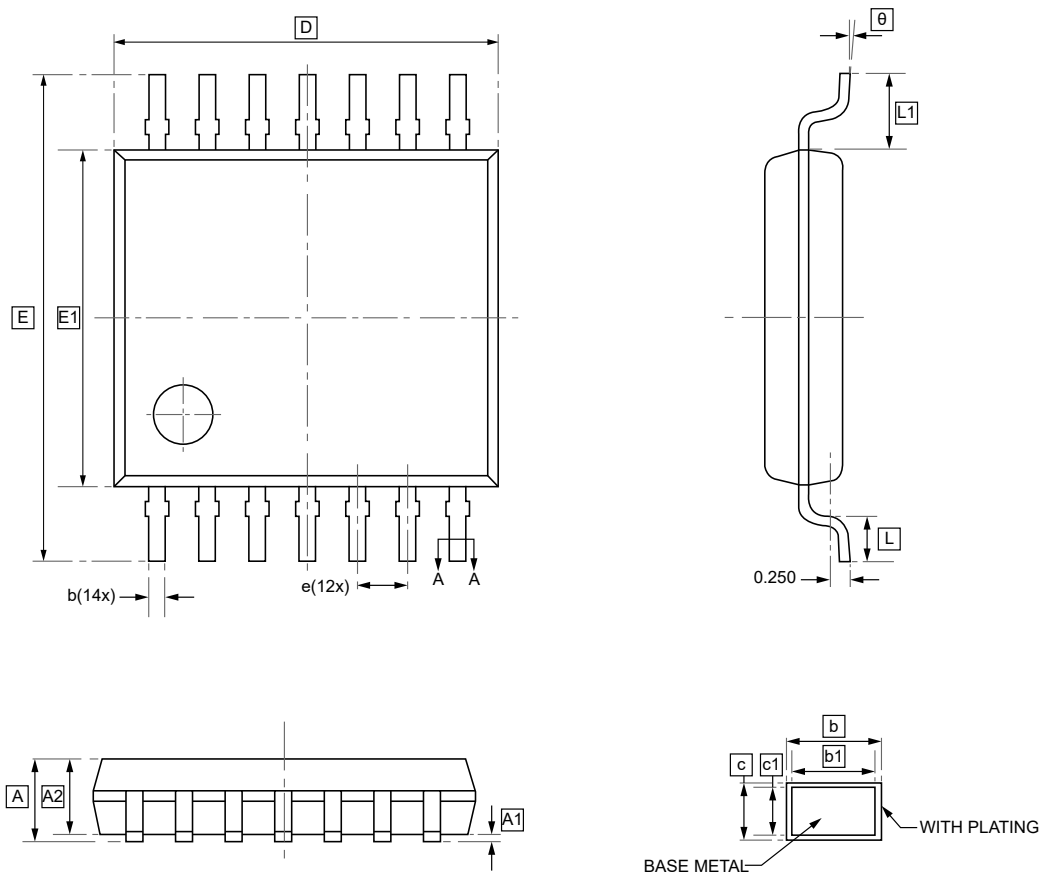
DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	A3	b	C	D	E	E1	e	h	L
Min	-	0.05	1.35	0.65	0.203	0.17	8.45	5.80	3.80	1.24	0.25	0.40
Max	1.75	0.25	1.55	0.75	0.305	0.25	8.85	6.20	4.00	1.30	0.50	0.80

Symbol	L1	θ
Min	1.00	0°
Max	1.10	8°



8.4 TSSOP-14 Package Outline Dimensions



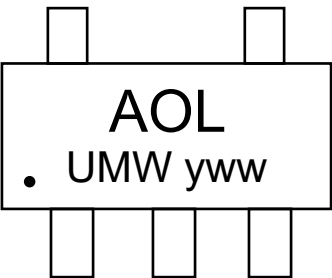
DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	b	b1	c	c1	D	E	E1	e	L1
Min	-	0.05	0.90	0.20	0.19	0.13	0.120	4.90	6.20	4.30	0.65	0.85
Max	1.20	0.15	1.05	0.28	0.25	0.17	0.14	5.10	6.60	4.50	BSC	1.15

Symbol	L	θ
Min	0.45	0°
Max	0.75	8°



9.Ordering Information



yww: Batch Code

Order Code	Marking	Package	Base QTY	Delivery Mode
UMW AD8628ARTZ	AOL	SOT-23-5	3000	Tape and reel
UMW AD8628ARZ	AD8628	SOP-8	2500	Tape and reel
UMW AD8629ARZ	AD8629	SOP-8	2500	Tape and reel
UMW AD8630ARUZ	AD8630	TSSOP-14	4000	Tape and reel
UMW AD8630ARZ	AD8630	SOP-14	2500	Tape and reel



10.Disclaimer

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