10 μA, Rail-to-Rail I/O, Zero Input Crossover Distortion Amplifiers

GENERAL DESCRIPTION

The ADA4505-1/ADA4505-4 are singleand quad micropower amplifiers featuring rail-to-rail input and output swings while operating from a single 1.8 V to 5 V power supply or from dual ±0.9 V to ±2.5 V power supplies.

Employing a new circuit technology, these low cost amplifiers offer zero input crossover distortion (excellent PSRR and CMRR performance) and very low bias current, while operating with a supply current of less than 10 μA per amplifier.

This combination of features makes the ADA4505-x amplifiers ideal choices for battery-powered applications because they minimize errors due to power supply voltage variations over the lifetime of the battery and maintain high CMRR even for a rail-to-rail op amp.

Remote battery-powered sensors, handheld instrumentation and consumer equipment, hazard detectors (for example, smoke, fire, and gas), and patient monitors can benefit from the features of the ADA4505-x amplifiers.

The ADA4505-x family is specified for both the industrial temperature range (−40°C to +85°C) and the extended industrial temperature range (−40°C to +125°C).

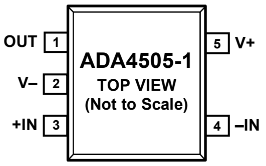
FEATURES

- PSRR: 100 dB minimum
- CMRR: 105 dB typical
- Very low supply current: 10 μA per amplifier maximum
  1.8 V to 5 V single-supply or ±0.9 V to ±2.5 V dual-supply
- operation Rail-to-rail input and output
  3 mV offset voltage maximum
- Very low input bias current: 0.5 pA typical

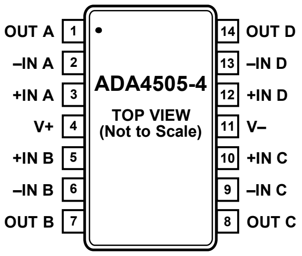
APPLICATIONS

- Pressure and position sensors
- Remote security
- Medical monitors
- Battery-powered consumer equipment
- Hazard detectors

PIN CONFIGURATIONS



SOT23-5



TSSOP-14

SPECIFICATIONS

ELECTRICAL CHARACTERISTICS—1.8 V OPERATION

V_{SY} = 1.8 V, V_{CM} = V_{SY}/2, T_A = 25°C, R_L = 100 kΩ to GND, unless otherwise specified.

Parameter	Symbol	Test Conditions/Comments	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage	V_{OS}	0 V ≤ V_{CM} ≤ 1.8 V		0.5	3	mV
		−40°C ≤ T_A ≤ +125°C			4	mV
Input Bias Current	I_B			0.5	2	pA
		−40°C ≤ T_A ≤ +85°C			50	pA
		−40°C ≤ T_A ≤ +125°C			375	pA
Input Offset Current	I_{OS}			0.05	1	pA
		−40°C ≤ T_A ≤ +85°C			25	pA
		−40°C ≤ T_A ≤ +125°C			130	pA
Input Voltage Range		−40°C ≤ T_A ≤ +125°C	0		1.8	V
Common-Mode Rejection Ratio	CMRR	0 V ≤ V_{CM} ≤ 1.8 V	85	100		dB
		−40°C ≤ T_A ≤ +85°C	85			dB
		−40°C ≤ T_A ≤ +125°C	80			dB
Large Signal Voltage Gain	A_{VO}	0.05 V ≤ V_{OUT} ≤ 1.75 V,	95	115		dB
		R_L = 100 kΩ to V_{CM}				
		−40°C ≤ T_A ≤ +125°C	95			dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	−40°C ≤ T_A ≤ +125°C		2.5		μV/°C
Input Resistance	R_{IN}			220		GΩ
Input Capacitance Differential Mode	C_{INDM}			2.5		pF
Input Capacitance Common Mode	C_{INCM}			4.7		pF
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	R_L = 100 kΩ to GND	1.78	1.79		V
		−40°C ≤ T_A ≤ +125°C	1.78			V
		R_L = 10 kΩ to GND	1.65	1.75		V
		−40°C ≤ T_A ≤ +125°C	1.65			V
Output Voltage Low	V_{OL}	R_L = 100 kΩ to V_{SY}		2	5	mV
		−40°C ≤ T_A ≤ +125°C			5	mV
		R_L = 10 kΩ to V_{SY}		12	25	mV
		−40°C ≤ T_A ≤ +125°C			25	mV
Short-Circuit Limit	I_{SC}	V_{OUT} = V_{SY} or GND		±3.8		mA
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V_{SY} = 1.8 V to 5 V	100	110		dB
		−40°C ≤ T_A ≤ +85°C	100			dB
		−40°C ≤ T_A ≤ +125°C	95			dB
Supply Current per Amplifier	I_{SY}	V_{OUT} = V_{SY}/2				
ADA4505-1				10	11.5	μA
		−40°C ≤ T_A ≤ +125°C			15	μA
ADA4505-4				7	10	μA
		−40°C ≤ T_A ≤ +125°C			15	μA
DYNAMIC PERFORMANCE						
Slew Rate	SR	R_L = 100 kΩ, C_L = 20 pF, G = 1		6.5		mV/μs
Gain Bandwidth Product	GBP	R_L = 1 MΩ, C_L = 20 pF, G = 1		50		kHz
Phase Margin	Φ_M	R_L = 1 MΩ, C_L = 20 pF, G = 1		52		Degrees
NOISE PERFORMANCE						
Voltage Noise	e_n p-p	f = 0.1 Hz to 10 Hz		2.95		μV p-p
Voltage Noise Density	e_n	f = 1 kHz		65		nV/√Hz
Current Noise Density	i_n	f = 1 kHz		20		fA/√Hz

ELECTRICAL CHARACTERISTICS—5 V OPERATION

V_{SY} = 5 V, V_{CM} = $V_{SY}/2$, T_A = 25°C, R_L = 100 kΩ to GND, unless otherwise specified.

Table2.

Parameter	Symbol	TestConditions /Comments	Min	Typ	Max	Unit
Offset Voltage	V_{OS}	0 V ≤ V_{CM} ≤ 5 V		0.5	3	mV
		−40°C ≤ T_A ≤ +125°C			4	mV
Input Bias Current	I_B			0.5	2	pA
		−40°C ≤ T_A ≤ +85°C			50	pA
		−40°C ≤ T_A ≤ +125°C			375	pA
Input Offset Current	I_{OS}			0.05	1	pA
		−40°C ≤ T_A ≤ +85°C			25	pA
		−40°C ≤ T_A ≤ +125°C			130	pA
Input Voltage Range		−40°C ≤ T_A ≤ +125°C	0		5	V
Common -Mode Rejection Ratio	CMRR	0 V ≤ V_{CM} ≤ 5 V	90	105		dB
		−40°C ≤ T_A ≤ +85°C	90			dB
		−40°C ≤ T_A ≤ +125°C	85			dB
Large Signal Voltage Gain	A_{VO}	0.05 V ≤ V_{OUT} ≤ 4.95 V,	105	120		dB
		R_L = 100 kΩ to V_{CM}				
		−40°C ≤ T_A ≤ +125°C	100			dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	−40°C ≤ T_A ≤ +125°C		2		µV/°C
Input Resistance	R_{IN}			220		GΩ
Input Capacitance Differential Mode	C_{INDM}			2.5		pF
Input Capacitance Common Mode	C_{INCM}			4.7		pF
Output Voltage High	V_{OH}	R_L = 100 kΩ to GND	4.98	4.99		V
		−40°C ≤ T_A ≤ +125°C	4.98			V
		R_L = 10 kΩ to GND	4.9	4.95		V
		−40°C ≤ T_A ≤ +125°C	4.9			V
Output Voltage Low	V_{OL}	R_L = 100 kΩ to V_{SY}		2	5	mV
		−40°C ≤ T_A ≤ +125°C			5	mV
		R_L = 10 kΩ to V_{SY}		10	25	mV
		−40°C ≤ T_A ≤ +125°C			25	mV
Short-Circuit Limit	I_{SC}	V_{OUT} = V_{SY} or GND		±40		mA
Power Supply Rejection Ratio	PSRR	V_{SY} = 1.8 V to 5 V	100	110		dB
		−40°C ≤ T_A ≤ +85°C	100			dB
		−40°C ≤ T_A ≤ +125°C	95			dB
Supply Current per Amplifier	I_{SY}	V_{OUT} = $V_{SY}/2$				
ADA4505-1				9	10.5	µA
		–40°C ≤ T_A ≤ +125°C			15	µA
ADA4505 4				7	10	µA
		-40°C ≤ T_A ≤ +125°C			15	µA
Slew Rate	SR	R_L = 100 kΩ, C_L = 20 pF, G = 1		6		mV/µs
Gain Bandwidth Product	GBP	R_L = 1 MΩ, C_L = 20 pF, G = 1		50		kHz
Phase Margin	Φ_M	R_L = 1 MΩ, C_L = 20 pF, G = 1		52		Degrees
Voltage Noise	e_n p-p	f = 0.1 Hz to 10 Hz		2.95		µV p-p
Voltage Noise Density	e_n	f = 1 kHz		65		nV/√Hz
Current Noise Density	i_n	f = 1 kHz		20		fA/√Hz

ABSOLUTE MAXIMUM RATINGS

[1] Input pins have clamp diodes to the supply pins. Limit input current to 10 mA or less whenever the input signal exceeds the power supply rail by 0.1 V.
[2] Differential input voltage is limited to 5 V or the supply voltage, whichever is less.

TYPICAL PERFORMANCE CHARACTERISTICS

T_A = 25°C, unless otherwise noted.

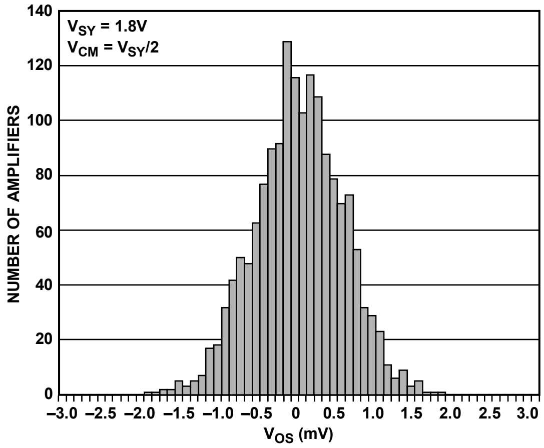


Figure 7. Input Offset Voltage Distribution

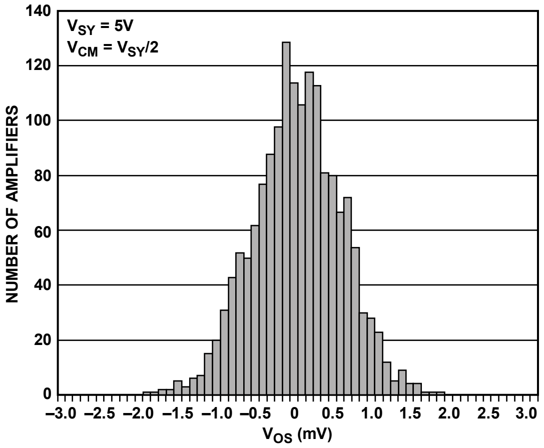


Figure 10. Input Offset Voltage Distribution

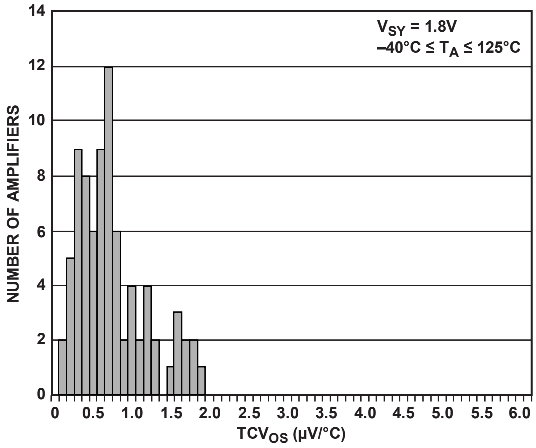


Figure 8. Input Offset Voltage Drift Distribution

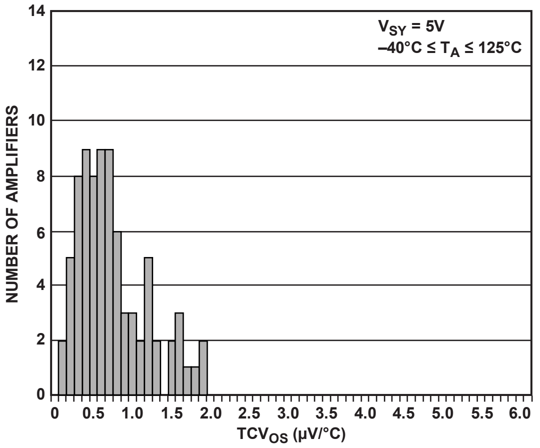


Figure 11. Input Offset Voltage Drift Distribution

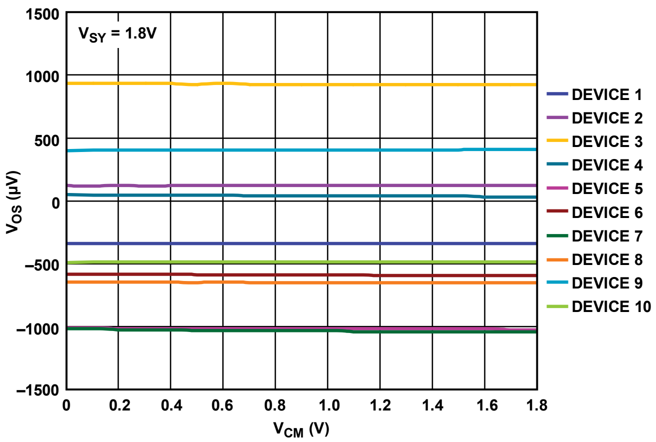


Figure 9. Input Offset Voltage vs. Common-Mode Voltage

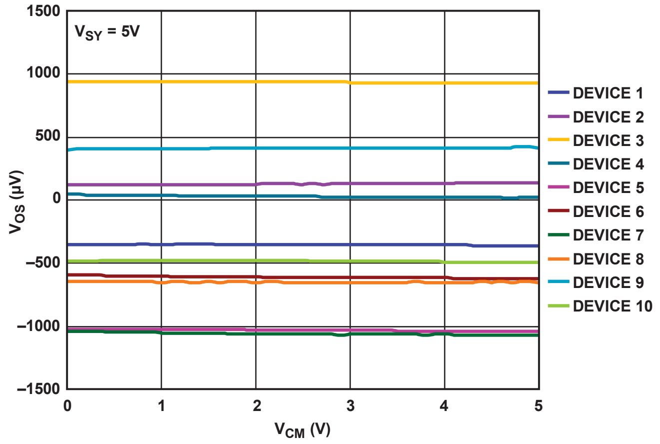


Figure 12. Input Offset Voltage vs. Common-Mode Voltage

T_A = 25°C, unless otherwise noted.

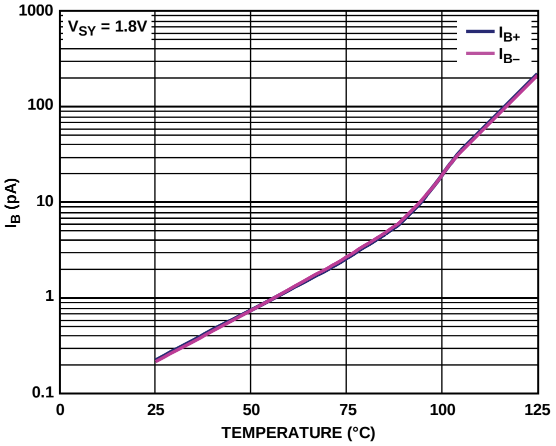


Figure 13. Input Bias Current vs. Temperature

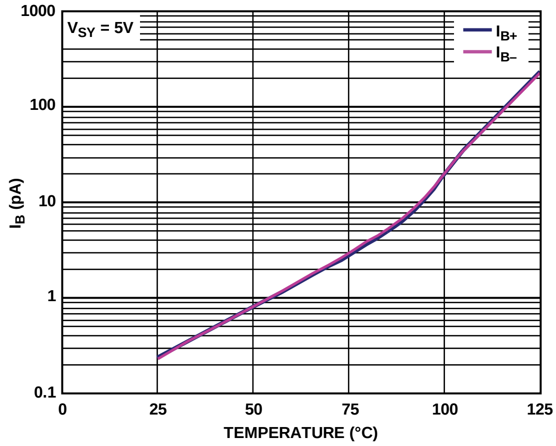


Figure 16. Input Bias Current vs. Temperature

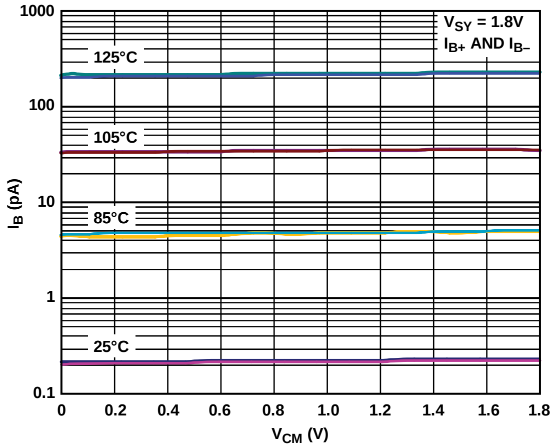


Figure 14. Input Bias Current vs. Common-Mode Voltage and Temperature

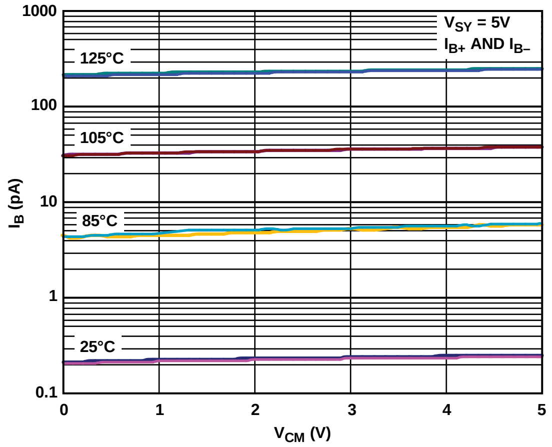


Figure 17. Input Bias Current vs. Common-Mode Voltage and Temperature

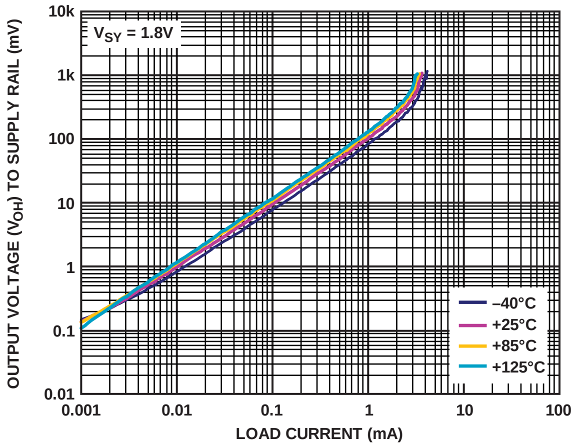


Figure 15. Output Voltage (V_{OH}) to Supply Rail vs. Load Current and Temperature

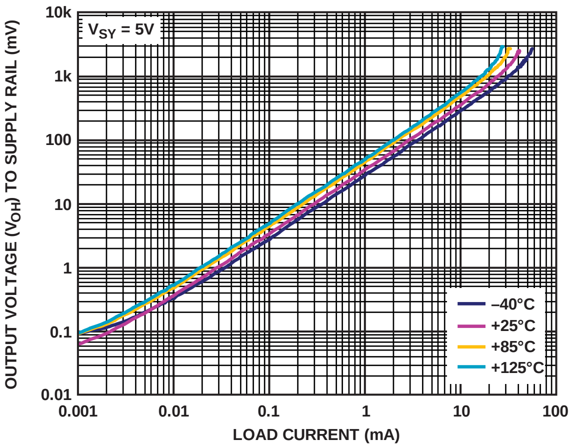


Figure 18. Output Voltage (V_{OH}) to Supply Rail vs. Load Current and Temperature

T_A = 25°C, unless otherwise noted.

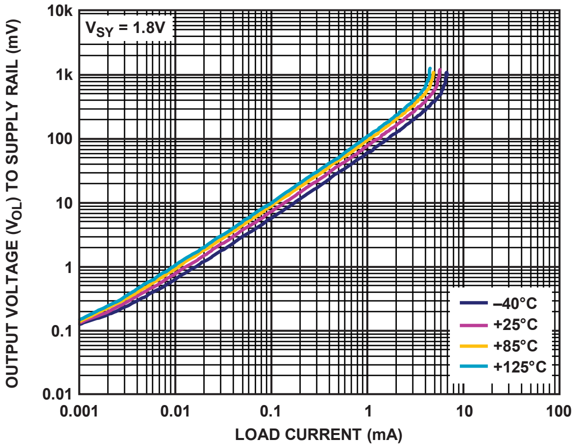


Figure 19. Output Voltage (V_{OL}) to Supply Rail vs. Load Current and Temperature

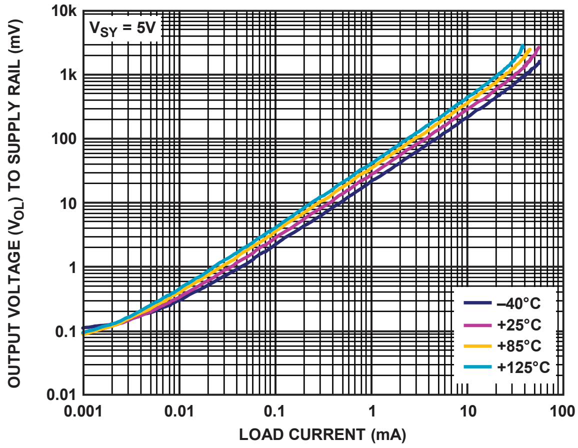


Figure 22. Output Voltage (V_{OL}) to Supply Rail vs. Load Current and Temperature

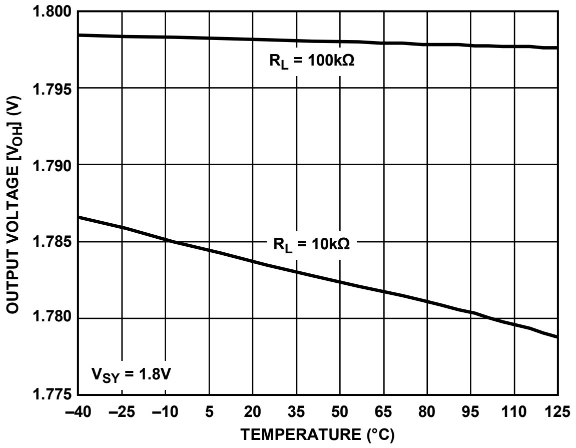


Figure 20. Output Voltage (V_{OH}) vs. Temperature

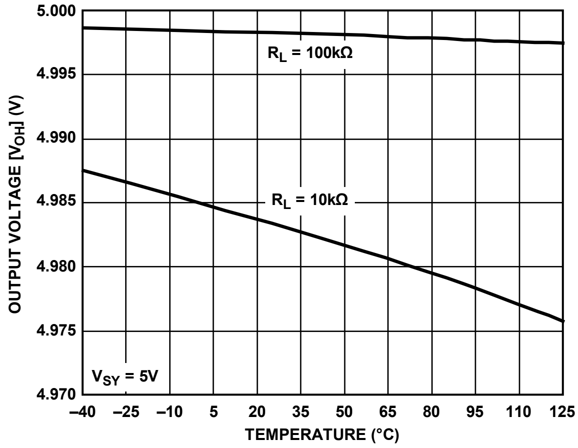


Figure 23. Output Voltage (V_{OH}) vs. Temperature

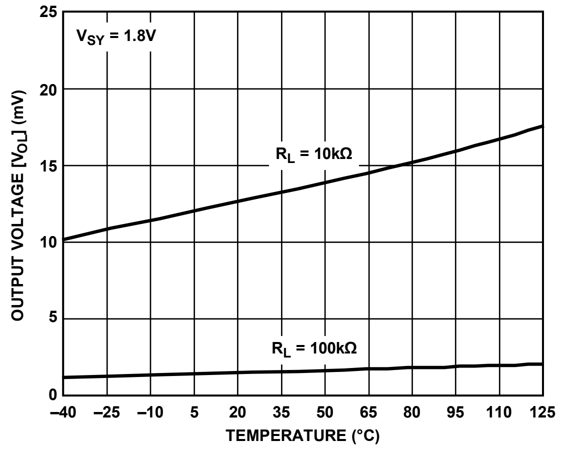


Figure 21. Output Voltage (V_{OL}) vs. Temperature

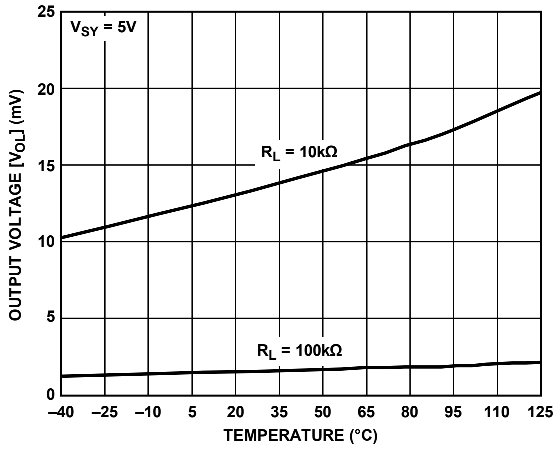


Figure 24. Output Voltage (V_{OL}) vs. Temperature

T_A = 25°C, unless otherwise noted.

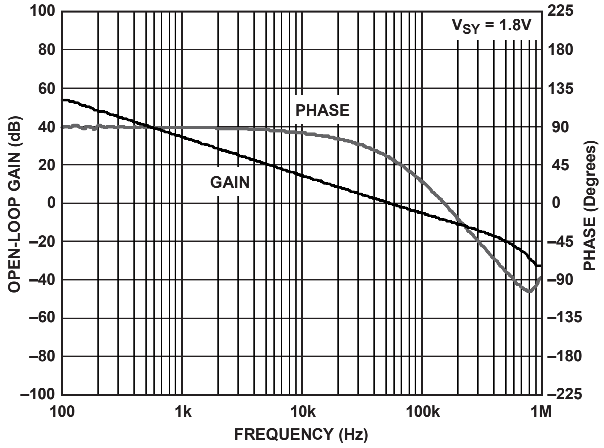


Figure 25. Open-Loop Gain and Phase vs. Frequency

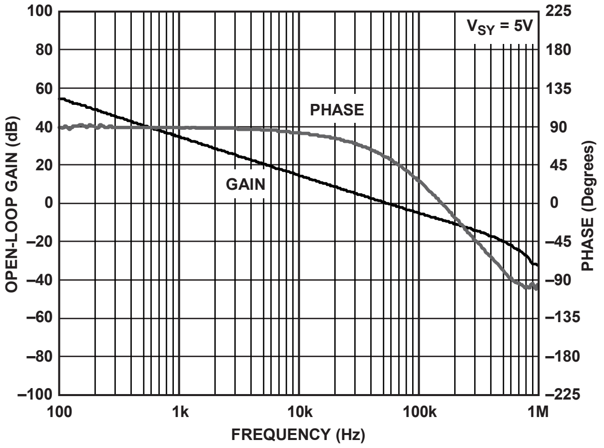


Figure 28. Open-Loop Gain and Phase vs. Frequency

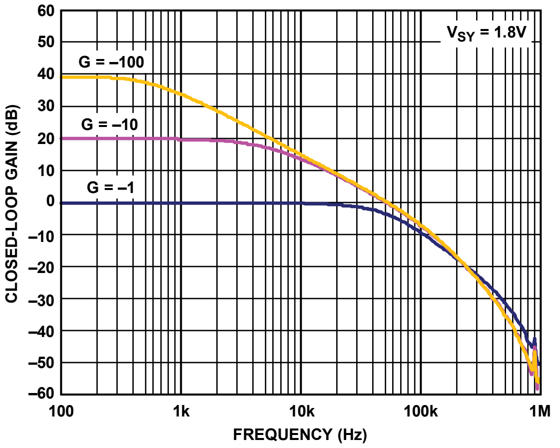


Figure 26. Closed-Loop Gain vs. Frequency

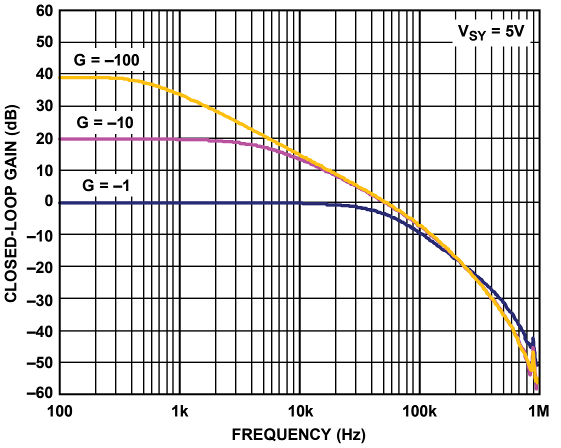


Figure 29. Closed-Loop Gain vs. Frequency

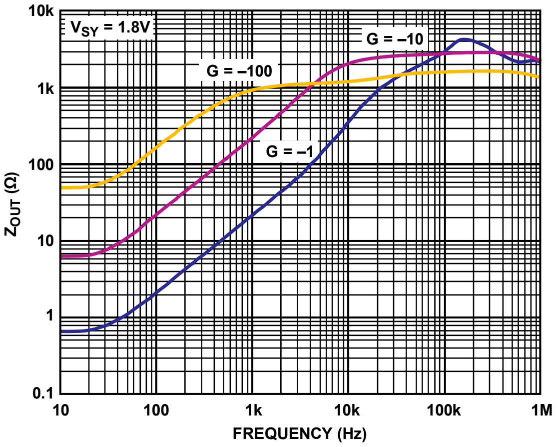


Figure 27. Output Im pedance vs. Frequency

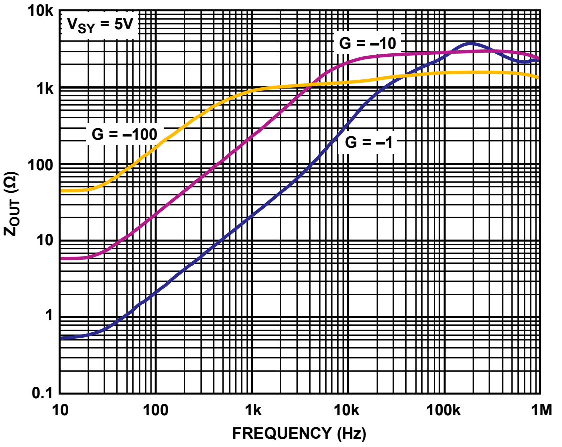


Figure 30. Output Im pedance vs. Frequency

T_A = 25°C, unless otherwise noted.

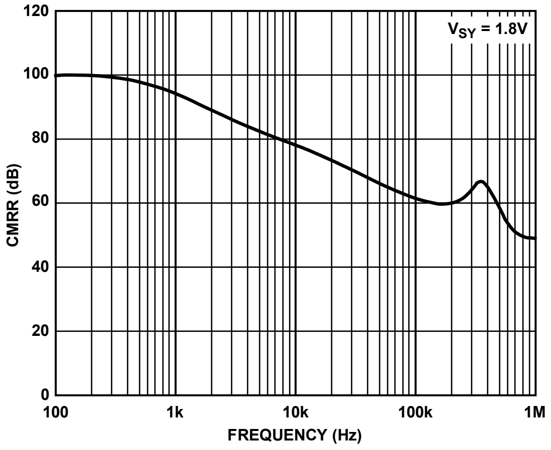


Figure 31. CMRR vs. Frequency

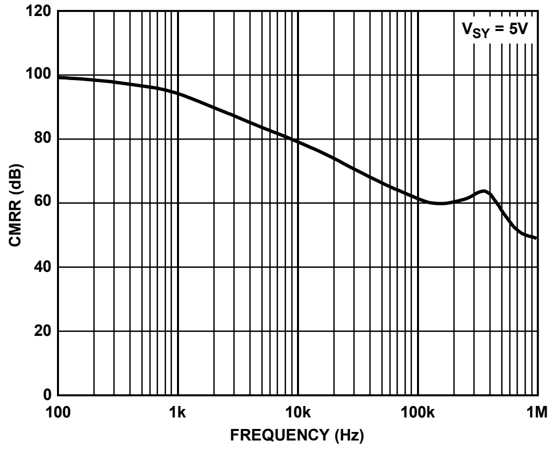


Figure 34. CMRR vs. Frequency

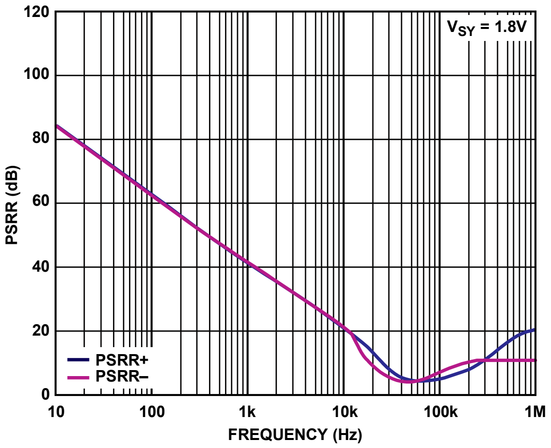


Figure 32. PSRR vs. Frequency

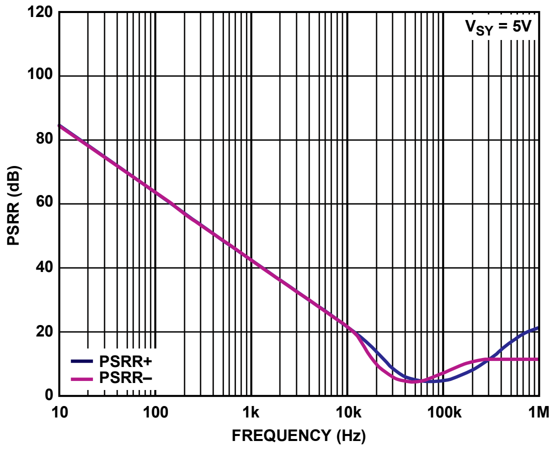


Figure 35. PSRR vs. Frequency

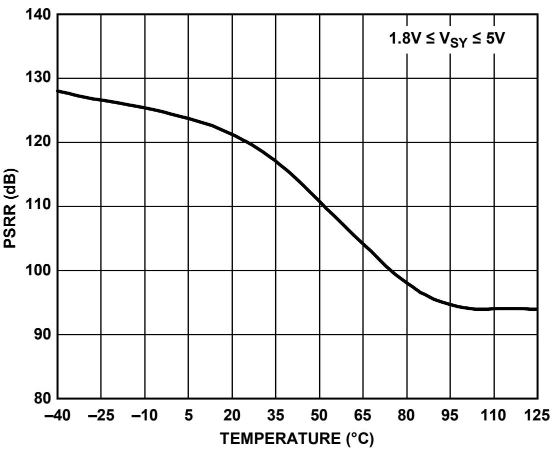


Figure 33. PSRR vs. Temperature

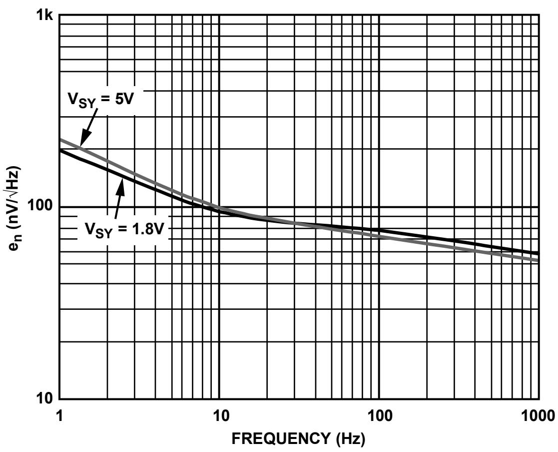


Figure 36. Voltage Noise Density vs. Frequency

T_A = 25°C, unless otherwise noted.

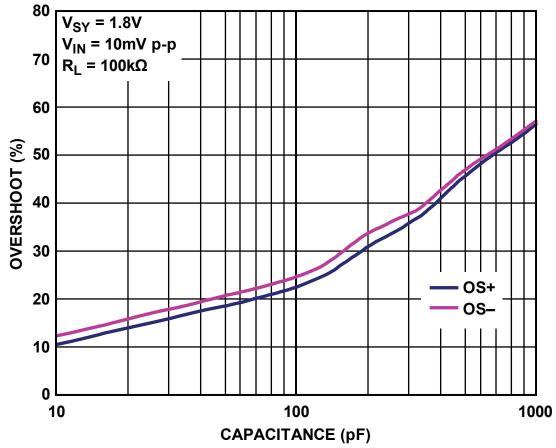


Figure 37. Small Signal Overshoot vs. Load Capacitance

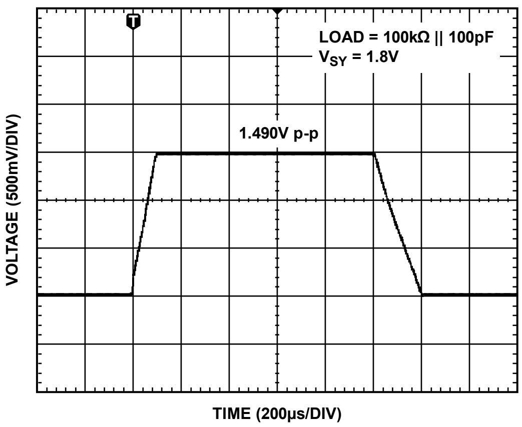


Figure 38. Large Signal Transient Response

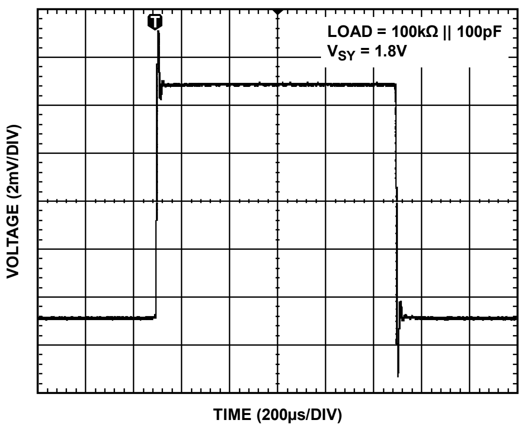


Figure 39. Small Signal Transient Response

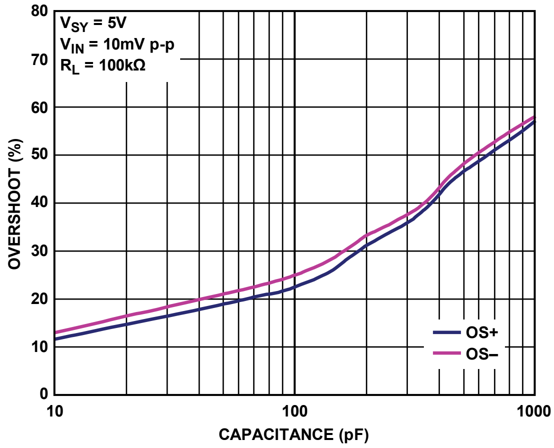


Figure 40. Small Signal Overshoot vs. Load Capacitance

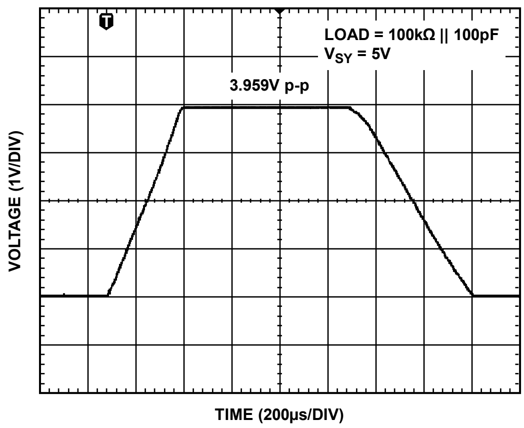


Figure 41. Large Signal Transient Response

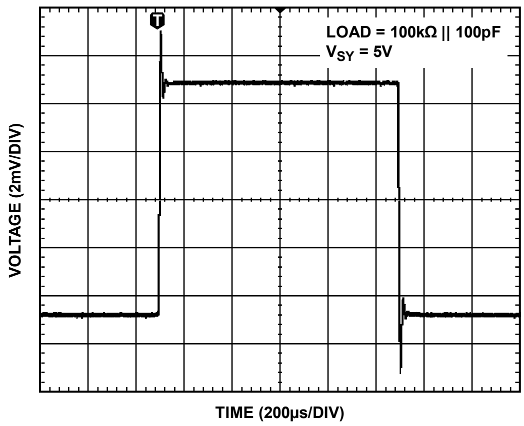


Figure 42. Small Signal Transient Response

T_A = 25°C, unless otherwise noted.

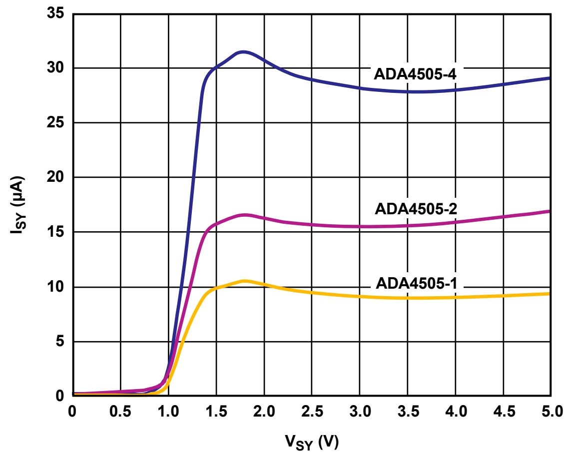


Figure 43. Supply Current vs. Supply Voltage

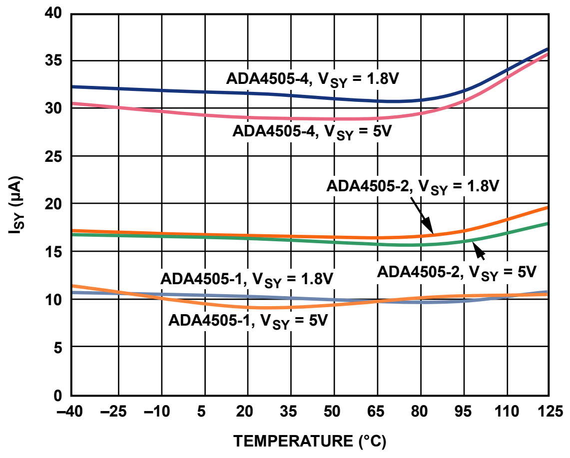


Figure 46. Total Supply Current vs. Temperature

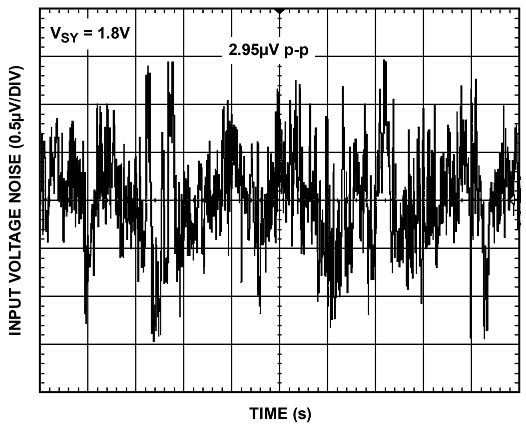


Figure 44. Input Voltage Noise, 0.1 Hz to 10 Hz Noise

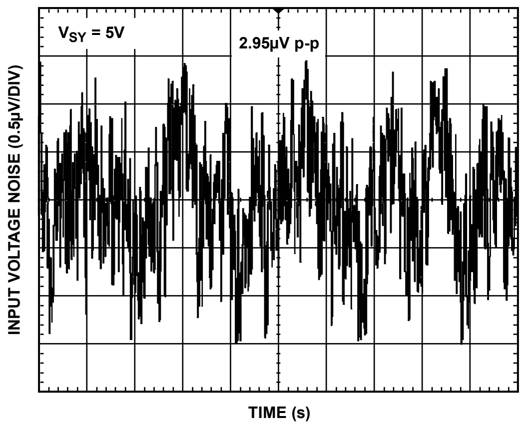


Figure 47. Input Voltage Noise, 0.1 Hz to 10 Hz Noise

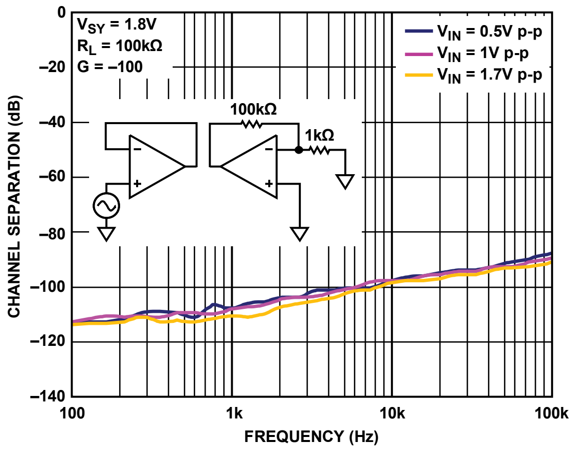


Figure 45. Channel Separation vs. Frequency

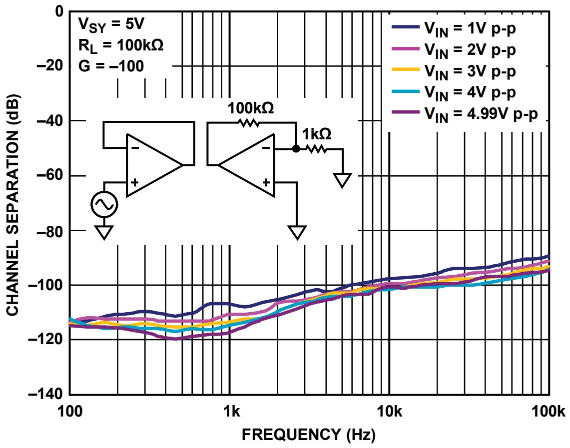


Figure 48. Channel Separation vs. Frequency

T_A = 25°C, unless otherwise noted.

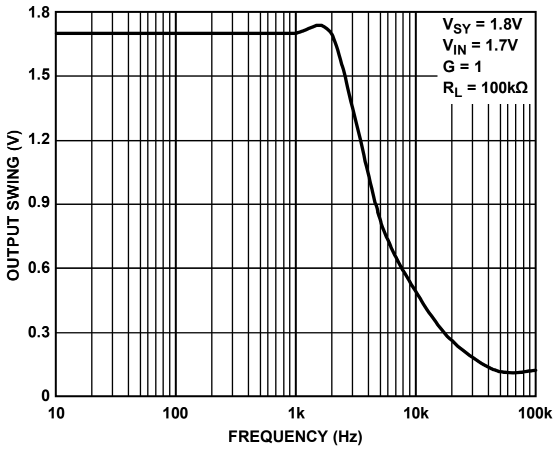


Figure 49. Output Swing vs. Frequency

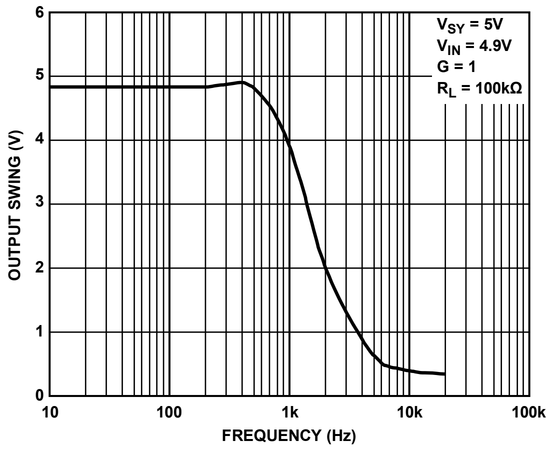


Figure 51. Output Swing vs. Frequency

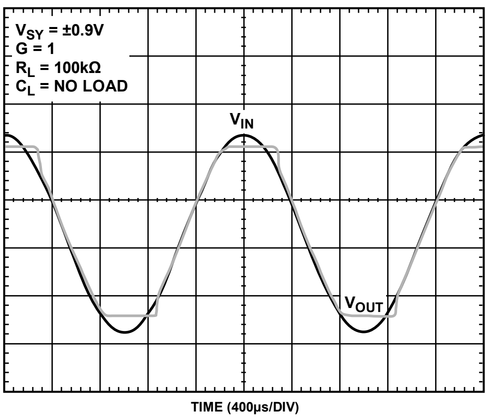


Figure 50. No Phase Reversal

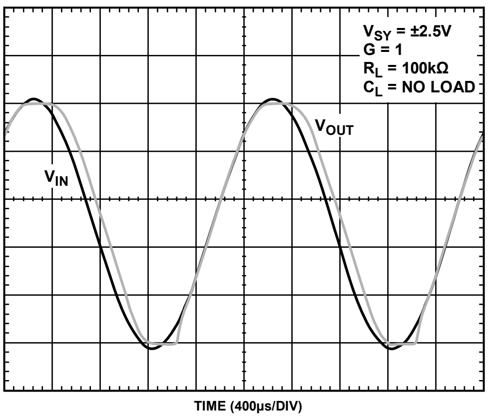
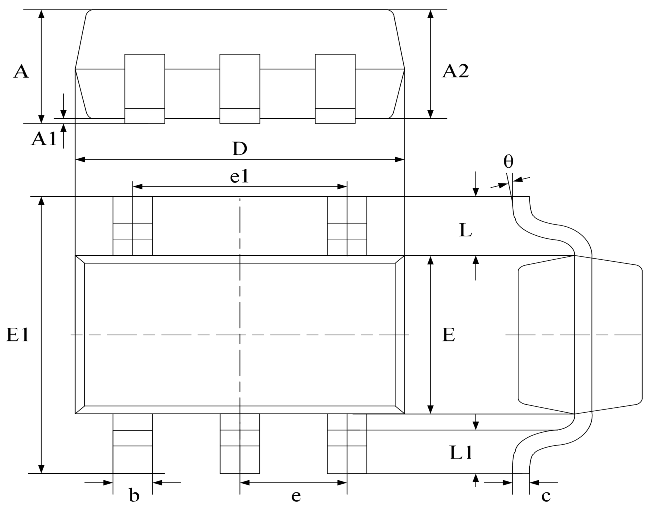


Figure 52. No Phase Reversal

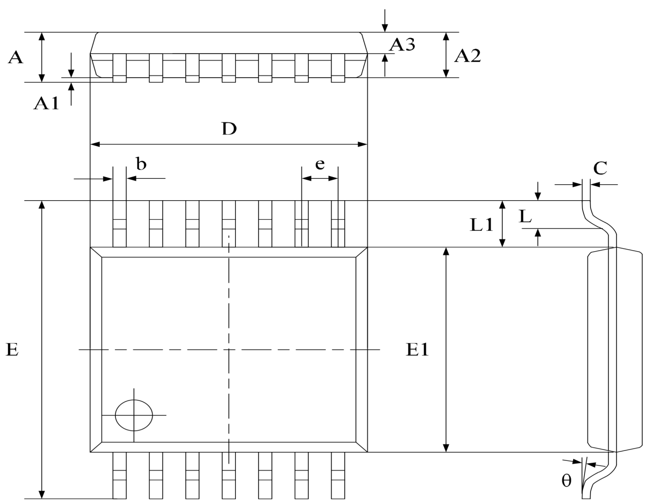
Package Dimension

SOT23-5



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.040	1.350	0.042	0.055
A1	0.040	0.150	0.002	0.006
A2	1.000	1.200	0.041	0.049
b	0.380	0.480	0.015	0.020
c	0.110	0.210	0.004	0.009
D	2.720	3.120	0.111	0.127
E	1.400	1.800	0.057	0.073
E1	2.600	3.000	0.106	0.122
e	0.950 typ.		0.037 typ.	
e1	1.900 typ.		0.078 typ.	
L	0.700 ref.		0.028 ref.	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

TSSOP-14



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	-	1.200	-	0.0472
A1	0.050	0.150	0.002	0.006
A2	0.900	1.050	0.037	0.043
A3	0.390	0.490	0.016	0.020
b	0.200	0.290	0.008	0.012
C	0.130	0.180	0.005	0.007
D	4.860	5.060	0.198	0.207
E	6.200	6.600	0.253	0.269
E1	4.300	4.500	0.176	0.184
e	0.650 typ.		0.0256 typ.	
L1	1.000 ref.		0.0393 ref.	
L	0.450	0.750	0.018	0.031
θ	0°	8°	0°	8°

Ordering information

Order code	Package	Baseqty	Deliverymode	Marking
UMW ADA4505-1ARJZ	SOT23-5	3000	Tape and reel	A2D U
UMW ADA4505-4ARUZ	TSSOP-14	4000	Tape and reel	ADA4505

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