Low Power, Precision, Auto-Zero Op Amps

GENERAL DESCRIPTION

The AD8538/AD8539 are very high precision amplifiers featuring extremely low offset voltage, low input bias current, and low power consumption. The supply current is less than 215 µA maximum per amplifier at 5.0 V. Operation is fully specified from 2.7 V to 5.0 V single supply (±1.35 V to ±2.5 V dual supply).

The AD8538/AD8539 operate at very low power making these amplifiers ideal for battery-powered devices and portable equipment.

The AD8538/AD8539 are specified over the extended industrial temperature range (−40°C to +125°C).

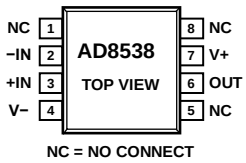
APPLICATIONS

- Mobile communications
- Portable instrumentation
- Battery-powered devices
- Sensor interfaces
- Temperature measurement
- Electronic scales

FEATURES

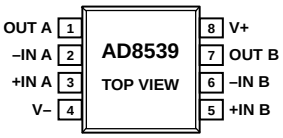
- Low offset voltage: 13 µV maximum
- Input offset drift: 0.03 µV/°C
- Single-supply operation: 2.7 V to 5.5 V
- High gain, CMRR, and PSRR
- Low input bias current: 25 pA
- Low supply current: 180 µA

PIN CONFIGURATIONS



NC = NO CONNECT

SOP-8



SOP-8

SPECIFICATIONS

AD8538 ELECTRICAL SPECIFICATIONS

@ V_S = 5.0 V, V_{CM} = 2.5 V, V_O = 2.5 V, T_A = 25°C, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Offset Voltage	V_{OS}			5	13	µV
		−40°C ≤ T_A ≤ +125°C			30	µV
Input Bias Current	I_B			15	25	pA
		−40°C ≤ T_A ≤ +85°C		35	100	pA
		−40°C ≤ T_A ≤ +125°C		0.7	1.0	nA
Input Offset Current	I_{OS}			20	50	pA
		−40°C ≤ T_A ≤ +125°C			150	pA
Input Voltage Range			0		5	V
Common -Mode Rejection Ratio	CMRR	V_{CM} = 0 V to 5 V	115	150		dB
		−40°C ≤ T_A ≤ +125°C, V_{CM} = 0.2 V to 4.8 V	100	135		dB
Large Signal Voltage Gain	A_{VO}	R_L = 10 kΩ, V_O = 0.1 V to 4.9 V	115	141		dB
		−40°C ≤ T_A ≤ +125°C	110	135		dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	−40°C ≤ T_A ≤ +125°C		0.03	0.1	µV/°C
Output Voltage High	V_{OH}	R_L = 100 kΩ to ground	4.99	4.998		V
		−40°C ≤ T_A ≤ +125°C, R_L= 100 kΩ to ground	4.98			V
		R_L = 10 kΩ to ground	4.95	4.970		V
		−40°C ≤ T_A ≤ +125°C, R_L = 10 kΩ to ground	4.94			V
Output Voltage Low	V_{OL}	R_L = 100 kΩ to V+		1.9	5	mV
		−40°C ≤ T_A ≤ +125°C, R_L= 100 kΩ to V+		2.8	7	mV
		R_L = 10 kΩ to V+		17	20	mV
		−40°C ≤ T_A ≤ +125°C, R_L= 10 kΩ to V+		20	30	mV
Short -Circuit Limit	I_{SC}			±25		mA
Power Supply Rejection Ratio	PSRR	V_S = 2.7 V to 5.0 V	105	125		dB
		−40°C ≤ T_A ≤ +125°C	100	125		dB
Supply Current/Amplifier	I_{SY}	I_O = 0		150	180	µA
		−40°C ≤ T_A ≤ +125°C		190	215	µA
Slew Rate	SR	R_L =10 kΩ		0.4		V/µs
Settling Time 0.01%	t_S	G = ±1, 2 V step, C_L= 20 pF, R_L= 1 kΩ		10		µs
Overload Recovery Time				0.05		ms
Gain Bandwidth Product	GBP			430		kHz
Phase Margin	$Ø_M$	R_L = 10 kΩ, R_L = 100 kΩ, C_L = 20 pF		65		Degrees
Voltage Noise	e_{np-p}	f = 0.1 Hz to 10 Hz		2.0		µV p-p
Voltage Noi se Density	e_n	f = 1 kHz		50		nV/√Hz

SPECIFICATIONS

AD8538 ELECTRICAL SPECIFICATIONS

@ V_S = 2.7 V, V_{CM} = 1.35 V, V_O = 1.35 V, T_A = 25°C, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Offset Voltage	V_{OS}			5	13	µV
		−40°C ≤ T_A ≤ +125°C			30	µV
Input Bias Current	I_B			15	25	pA
		−40°C ≤ T_A ≤ +85°C		35	100	pA
		−40°C ≤ T_A ≤ +125°C		0.7	1.0	nA
Input Offset Current	I_{OS}			20	50	pA
		−40°C ≤ T_A ≤ +125°C			150	pA
Input Voltage Range			0		2.7	V
Common -Mode Rejection Ratio	CMRR	V_{CM} = 0 V to 2.5 V	110	140		dB
		−40°C ≤ T_A ≤ +125°C	100	135		dB
Large Signal Voltage Gain	A_{VO}	R_L = 10 kΩ, V_O = 0.1 V to 1.7 V	110	140		dB
		−40°C ≤ T_A ≤ +125°C	105	135		dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	−40°C ≤ T_A ≤ +125°C		0.03	0.1	µV/°C
Output Voltage High	V_{OH}	R_L = 100 kΩ to ground	2.68	2.698		V
		−40°C ≤ T_A ≤ +125°C, R_L = 100 kΩ to ground	2.68			V
		R_L = 10 kΩ to ground	2.67	2.68		V
		−40°C ≤ T_A ≤ +125°C, R_L = 10 kΩ to ground	2.66			V
Output Voltage Low	V_{OL}	R_L = 100 kΩ to V+		1.7	5	mV
		−40°C ≤ T_A ≤ +125°C, R_L = 100 kΩ to V+		2.4	5	mV
		R_L = 10 kΩ to V+		14	20	mV
		−40°C ≤ T_A ≤ +125°C, R_L = 10 kΩ to V+		20	25	mV
Short-Circuit Limit	I_{SC}			±8		mA
Power Supply Rejection Ratio	PSRR	V_S = 2.7 V to 5.5 V	105	125		dB
		−40°C ≤ T_A ≤ +125°C	100	125		dB
Supply Current/Amplifier	I_{SY}	I_O = 0		150	180	µA
		−40°C ≤ T_A ≤ +125°C		190	215	µA
Slew Rate	SR	R_L = 10 kΩ		0.35		V/µs
Settling Time 0.01%	t_S	G = ±1, 1 V step, C_L = 20 pF, R_L = 1 kΩ		5		µs
Overload Recovery Time				0.05		ms
Gain Bandwidth Product	GBP			430		kHz
Phase Margin	$Ø_M$	R_L = 10 kΩ, R_L = 100 kΩ, C_L = 20 pF		65		Degrees
Voltage Noise	$e_{n\,p-p}$	f = 0.1 Hz to 10 Hz		2.0		µV p-p
Voltage Noise Density	e_n	f = 1 kHz		50		nV/√Hz

AD8539 **ELECTRICAL SPECIFICATIONS**

@ V_S = 5.0 V, V_{CM} = 2.5 V, V_O = 2.5 V, T_A = 25°C, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Offset Voltage	V_{OS}			5	15	µV
		−40°C ≤ T_A ≤ +125°C			30	µV
Input Bias Current	I_B			15	60	pA
		−40°C ≤ T_A ≤ +85°C		35	125	pA
		−40°C ≤ T_A ≤ +125°C		0.7	1.0	nA
Input Offset Current	I_{OS}			20	70	pA
		−40°C ≤ T_A ≤ +125°C			400	pA
Input Voltage Range			0		5	V
		−40°C ≤ T_A ≤ +125°C	0.2		4.8	V
Common -Mode Rejection Ratio	CMRR	V_{CM} = 0 V to 5 V	115	135		dB
		−40°C ≤ T_A ≤ +125°C, V_{CM} = 0.2 V to 4.8 V	100	130		dB
Large Signal Voltage Gain	A_{VO}	R_L = 10 kΩ, V_O = 0.1 V to 4.9 V	110	130		dB
		−40°C ≤ T_A ≤ +125°C	110	125		dB
Offset Voltage Dri ft	$\Delta V_{OS}/\Delta T$	−40°C ≤ T_A ≤ +125°C		0.03	0.1	µV/°C
Output Voltage High	V_{OH}	R_L = 100 kΩ to ground	4.99	4.994		V
		−40°C ≤ T_A ≤ +125°C, R_L = 100 kΩ to ground	4.98			V
		R_L = 10 kΩ to ground	4.95	4.97		V
		−40°C ≤ T_A ≤ +125°C, R_L = 10 kΩ to ground	4.94			V
Output Voltage Low	V_{OL}	R_L = 100 kΩ to V+		5	7	mV
		−40°C ≤ T_A ≤ +125°C, R_L = 100 kΩ to V+		6	8	mV
		R_L = 10 kΩ to V+		20	25	mV
		−40°C ≤ T_A ≤ +125°C, R_L = 10 kΩ to V+		24	30	mV
Short -Circuit Limit	I_{SC}			±25		mA
Power Supply Rejection Ratio	PSRR	V_S = 2.7 V to 5.0 V	105	125		dB
		−40°C ≤ T_A ≤ +125°C	100	125		dB
Supply Current/Amplifier	I_{SY}	I_O = 0		170	210	µA
		−40°C ≤ T_A ≤ +125°C			225	µA
Slew Rate	SR	R_L=10 kΩ		0.4		V/µs
Settling Time 0.01%	t_S	G = ±1, 2 V step, C_L= 20 pF, R_L= 1 kΩ		10		µs
Overload Recovery Time				0.05		ms
Gain Bandwidth Product	GBP			430		kHz
Phase Margin	$Ø_M$	R_L = 10 kΩ, R_L = 100 kΩ, C_L = 20 pF		65		Degrees
Voltage Noise	$e_{n\,p-p}$	f = 0.1 Hz to 10 Hz		1.2		µV p-p
Voltage Noise Density	e_n	f = 1 kHz		52		nV/√Hz

AD8539 **ELECTRICAL SPECIFICATIONS**

@ V_S = 2.7 V, V_{CM} = 1.35 V, V_O = 1.35 V, T_A = 25°C, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Offset Voltage	V_{OS}			5	16	µV
		−40°C ≤ T_A ≤ +125°C			30	µV
Input Bias Current	I_B			15	25	pA
		−40°C ≤ T_A ≤ +85°C		35	125	pA
		−40°C ≤ T_A ≤ +125°C		0.7	1.0	nA
Input Offset Current	I_{OS}			20	50	pA
		−40°C ≤ T_A ≤ +125°C			300	pA
Input Voltage Range			0		2.7	V
		−40°C ≤ T_A ≤ +125°C	0.2		2.5	
Common -Mode Rejection Ratio	CMRR	V_{CM} = 0 V to 2.7 V	110	130		dB
		−40°C ≤ T_A ≤ +125°C , V_{CM} = 0.2 V to 2.5 V	100	125		dB
Large Signal Voltage Gain	A_{VO}	R_L = 10 kΩ, V_O = 0.1 V to 2.6 V	110	130		dB
		−40°C ≤ T_A ≤ +125°C	105	125		dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	−40°C ≤ T_A ≤ +125°C		0.03	0.1	µV/°C
Output Voltage High	V_{OH}	R_L = 100 kΩ to ground	2.68	2.693		V
		−40°C ≤ T_A ≤ +125°C, R_L = 100 kΩ to ground	2.68			V
		R_L = 10 kΩ to ground	2.67	2.68		V
		−40°C ≤ T_A ≤ +125°C, R_L = 10 kΩ to ground	2.66			V
Output Voltage Low	V_{OL}	R_L = 100 kΩ to V+		5	7	mV
		−40°C ≤ T_A ≤ +125°C, R_L = 100 kΩ to V+		6	8	mV
		R_L = 10 kΩ to V+		14	20	mV
		−40°C ≤ T_A ≤ +125°C, R_L = 10 kΩ to V+		20	25	mV
Short-Circuit Limit	I_{SC}			±8		mA
Power Supply Rejection Ratio	PSRR	V_S = 2.7 V to 5.5 V	105	125		dB
		−40°C ≤ T_A ≤ +125°C	100	125		dB
Supply Current/Amplifier	I_{SY}	I_O = 0			210	µA
		−40°C ≤ T_A ≤ +125°C			225	µA
Slew Rate	SR	R_L = 10 kΩ		0.35		V/µs
Settling Time 0.01%	t_S	G = ±1, 1 V step, C_L = 20 pF, R_L = ∞		8		µs
Overload Recovery Time				0.05		ms
Gain Bandwidth Product	GBP			430		kHz
Phase Margin	$Ø_M$	R_L = 10 kΩ, R_L = 100 kΩ, C_L = 20 pF		65		Degrees
Voltage Noise	$e_{n\,p-p}$	f = 0.1 Hz to 10 Hz		2.0		µV p-p
Voltage Noise Density	e_n	f = 1 kHz		55		nV/√Hz

ABSOLUTE MAXIMUM RATINGS

T_A = 25°C, unless otherwise noted.

Parameter	Rating
Supply Voltage	+6V
Input Voltage	Vss-0.3Vto Voo+0.3V
Differential Input Voltage	±6V
Output Short-Circuit Duration to GND	Observe derating curve
Storage Temperature Range	-65℃ to +150℃
Lead Temperature (Soldering,60 sec)	300℃
Operating Temperature Range	-40℃ to +125℃
Junction Temperature Range	-65℃ to+150℃

Thermal Characteristics

θJA is specified for the worst-case conditions, that is, a device soldered in a circuit board for surface-mount packages.

Package Type	θJA	θJC	Unit
SOP-8	125	43	°C/W

TYPICAL PERFORMANCE CHARACTERISTICS

V_{SY} = 5 V or ±2.5 V, unless otherwise noted.

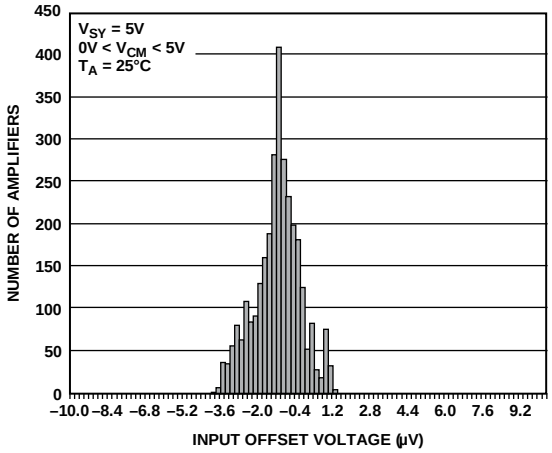


Figure 5. AD8538 Input Offset Voltage Distribution

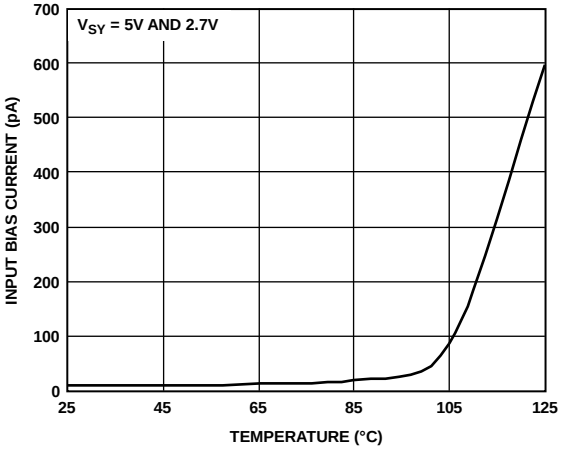


Figure 8. AD8538 Input Bias Current vs. Temperature

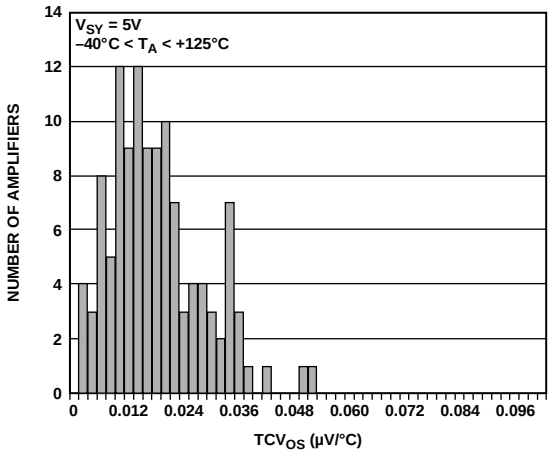


Figure 6. AD8538 Input Offset Voltage Drift Distribution

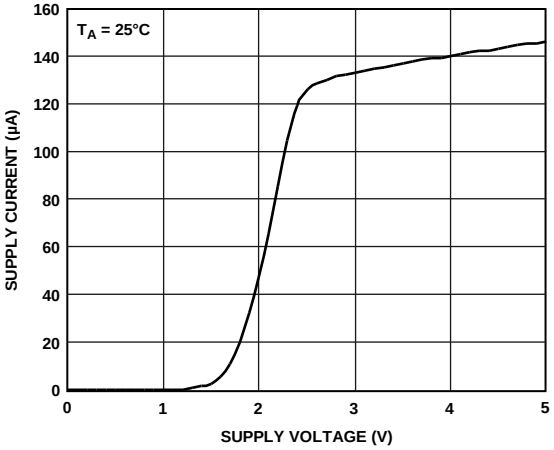


Figure 9. AD8538 Supply Current vs. Supply Voltage

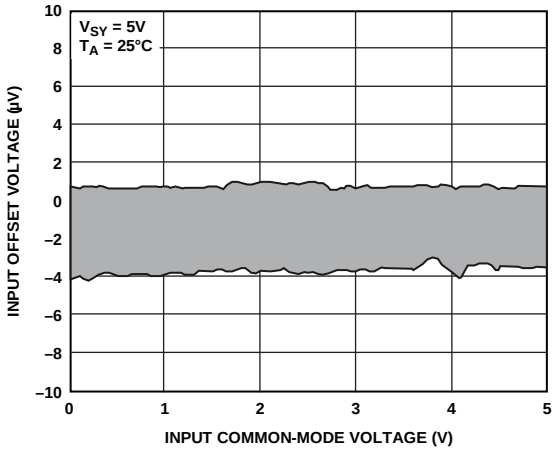


Figure 7. AD8538 Input Offset Voltage vs. Input Common -Mode Voltage

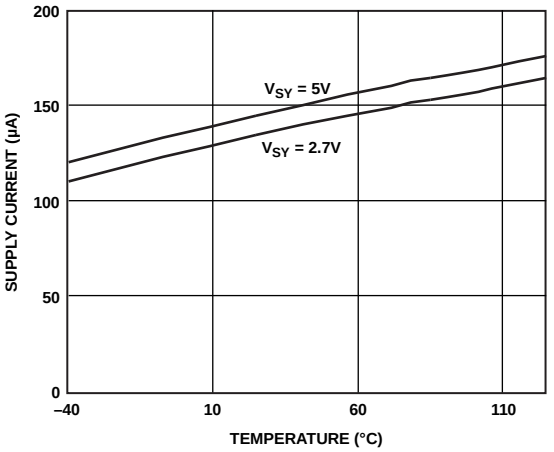


Figure 10. AD8538 Supply Current vs. Temperature

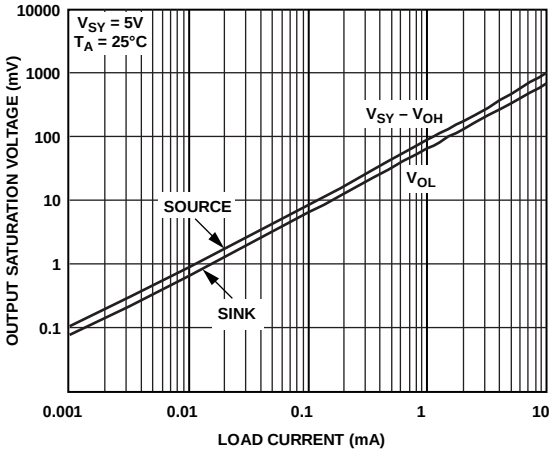


Figure 11. AD8538 Output Saturation Voltage vs. Load Current

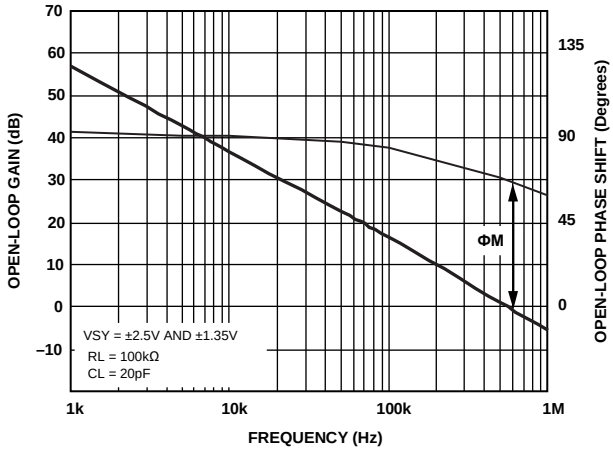


Figure 14. AD8538 Open-Loop Gain and Phase vs. Frequency

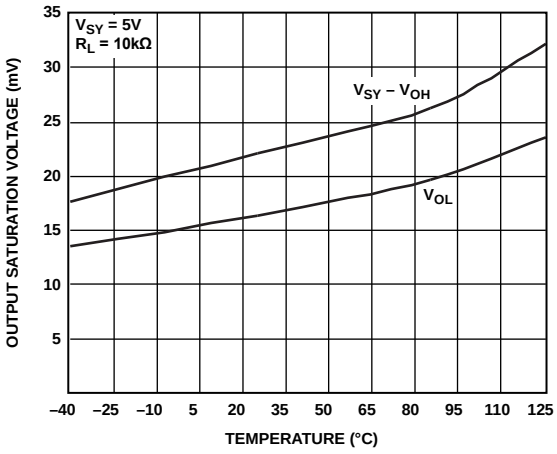


Figure 12. AD8538 Output Saturation Voltage vs. Temperature

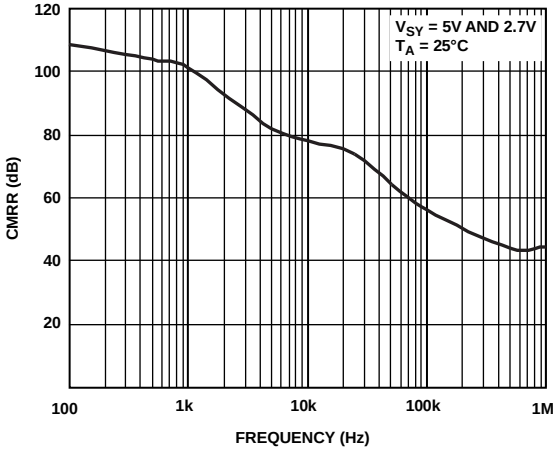


Figure 15. AD8538 CMRR vs. Frequency

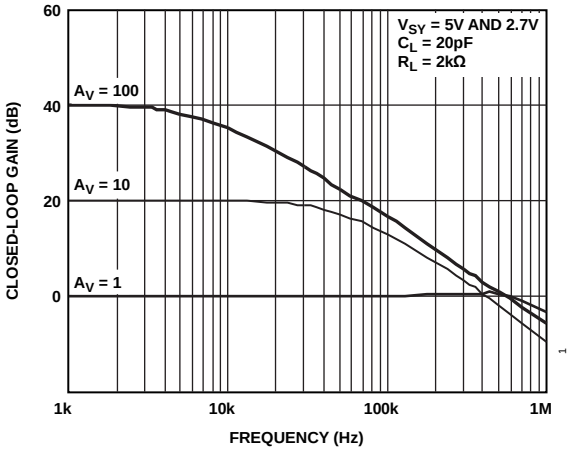


Figure 13. AD8538 Closed-Loop Gain vs. Frequency

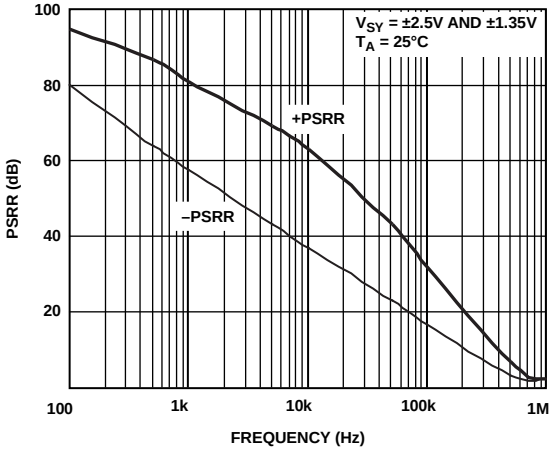


Figure 16. AD8538 PSRR vs. Frequency

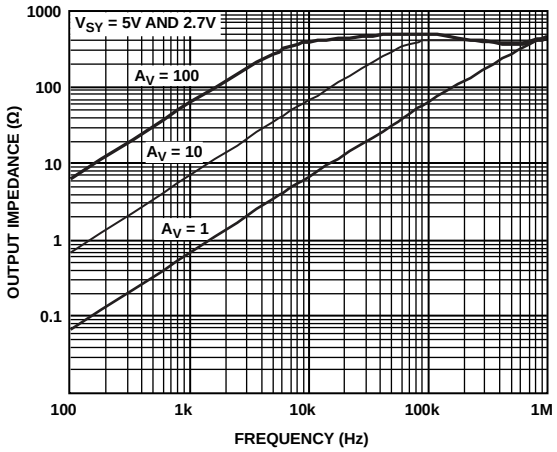


Figure 17. AD8538 Closed-Loop Output Impedance vs. Frequency

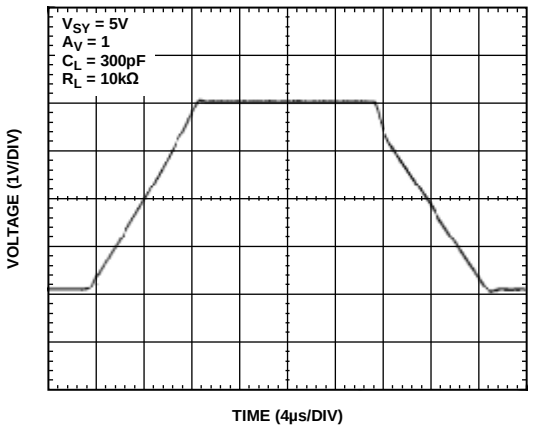


Figure 20. AD8538 Large Signal Transient Response

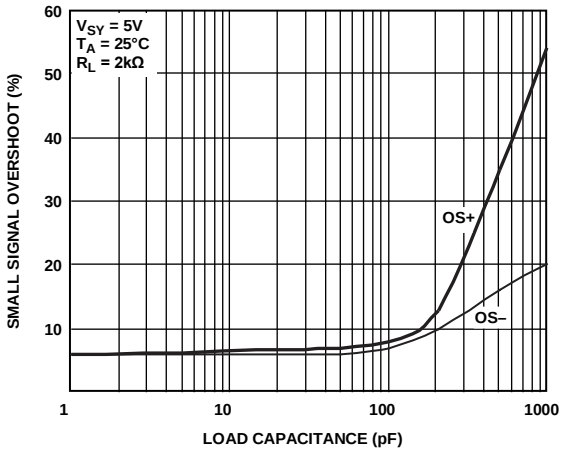


Figure 18. AD8538 Small Signal Overshoot vs. Load Capacitance

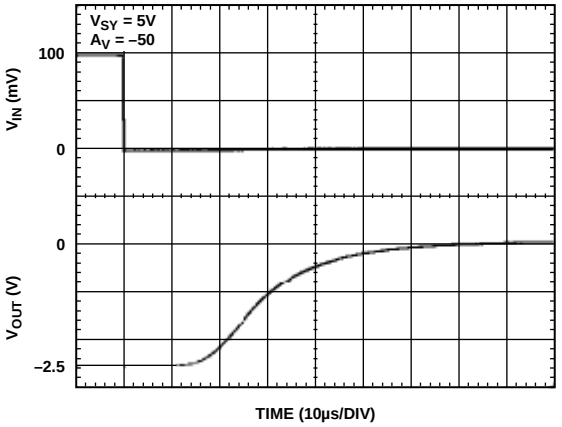


Figure 21. AD8538 Positive Overload Recovery

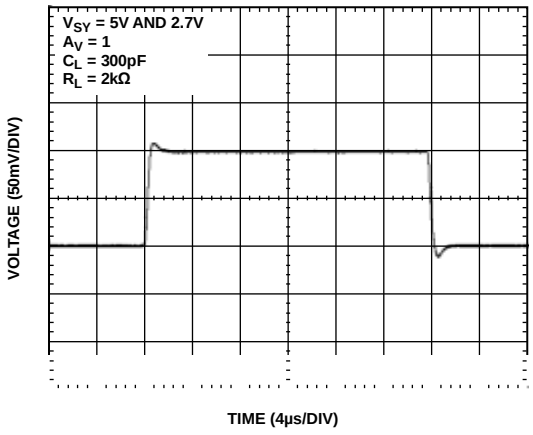


Figure 19. AD8538 Small Signal Transient Response

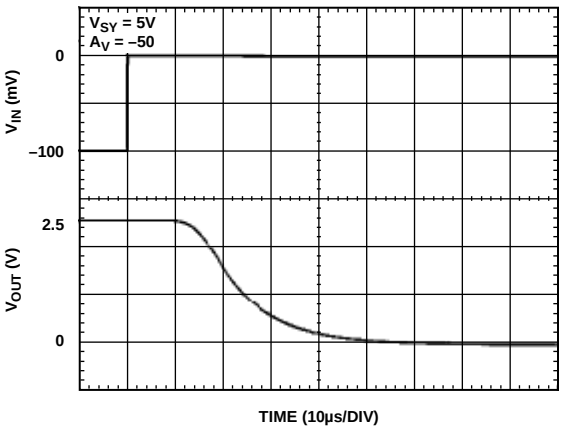


Figure 22. AD8538 Negative Overload Recovery

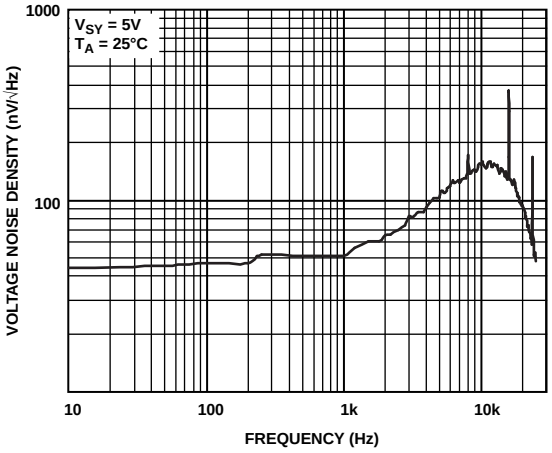


Figure 23. AD8538 Voltage Noise Density

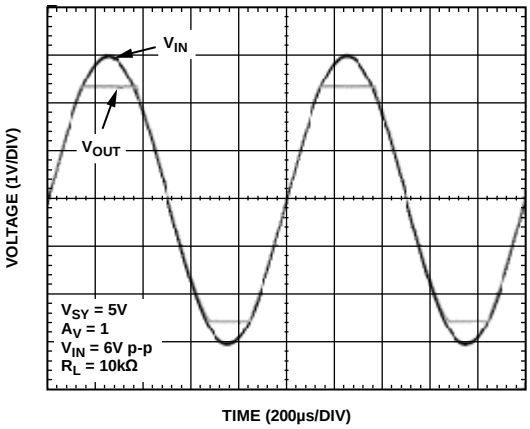


Figure 25. AD8538 No Phase Reversal

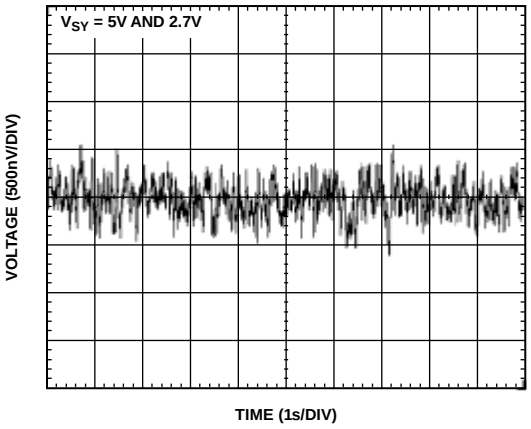


Figure 24. AD8538 0.1 Hz to 10 Hz Input Voltage Noise

V_{SY} = 2.7 V or ±1.35 V, AD8538 only, unless otherwise noted.

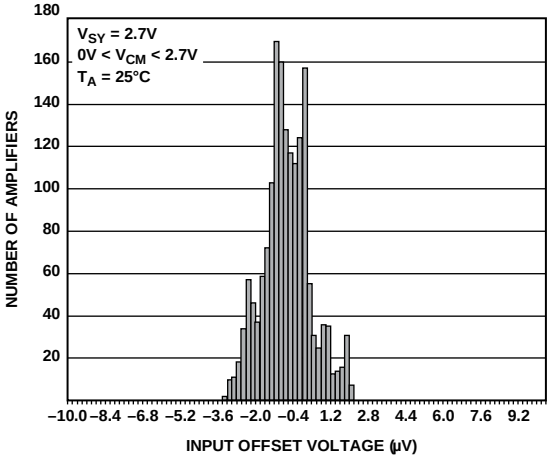


Figure 26. AD8538 Input Offset Voltage Distribution

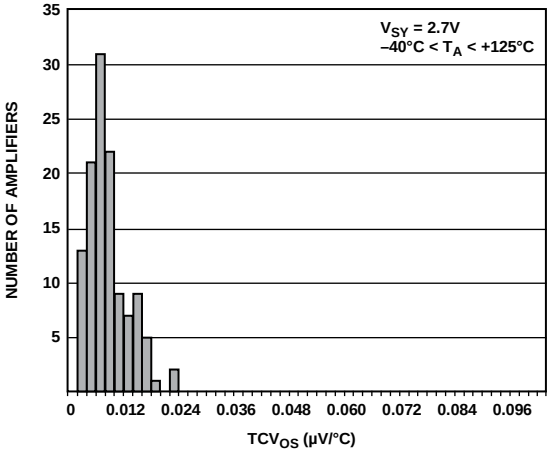


Figure 27. AD8538 Input Offset Voltage Drift Distribution

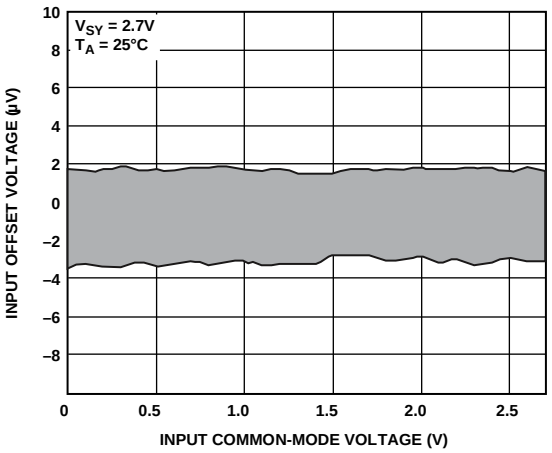


Figure 28. AD8538 Input Offset Voltage vs. Input Common -Mode Voltage

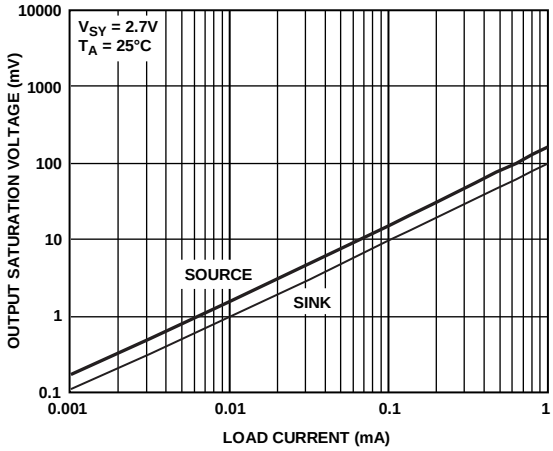


Figure 29. AD8538 Output Saturation Voltage vs. Load Current

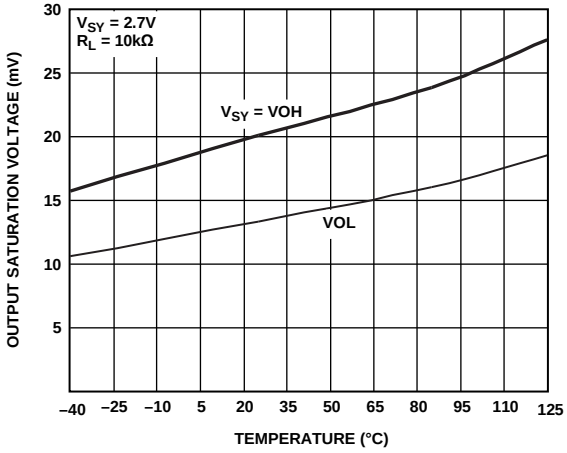


Figure 30. AD8538 Output Saturation Voltage vs. Temperature

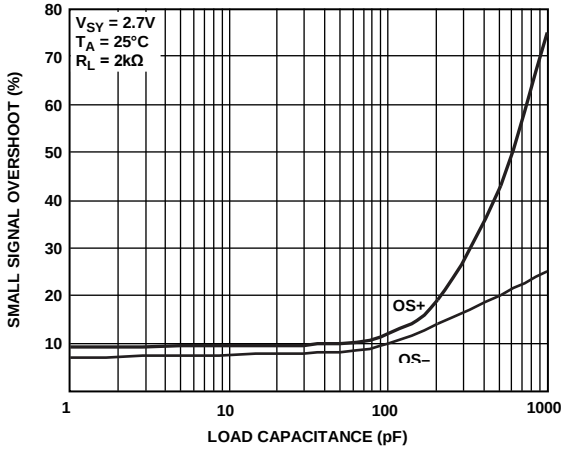


Figure 31. AD8538 Small Signal Overshoot vs. Load Capacitance

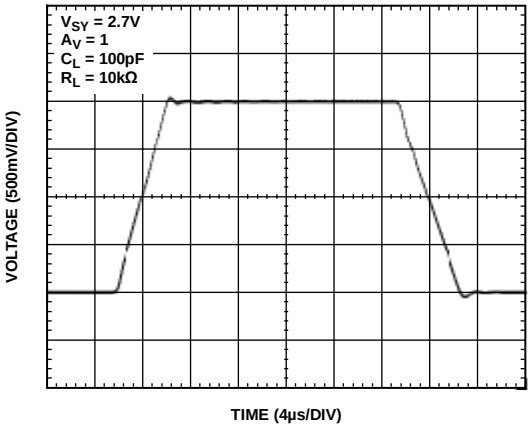


Figure 32. AD8538 Large Signal Transient Response

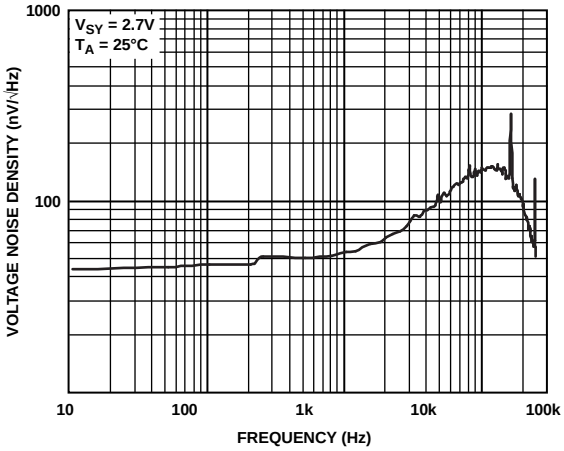


Figure 33. AD8538 Voltage Noise Density

AD8539 CHARACTERISTICS

AD8539 only, V_S = 5 V or ±2.5 V, unless otherwise noted.

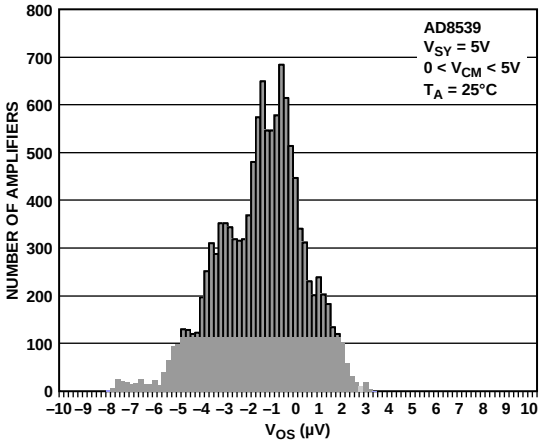


Figure 34. AD8539 Input Offset Voltage Distribution

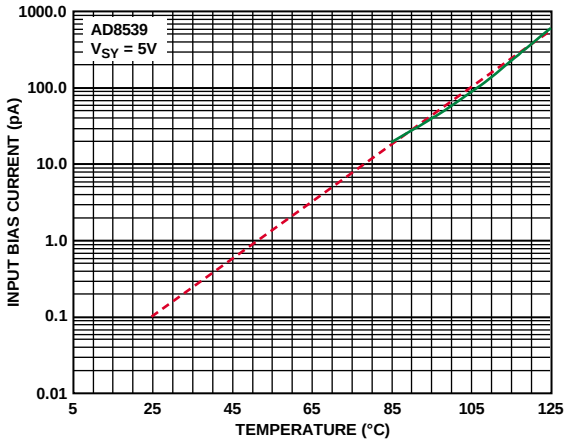


Figure 37. AD8539 Input Bias Current vs. Temperature

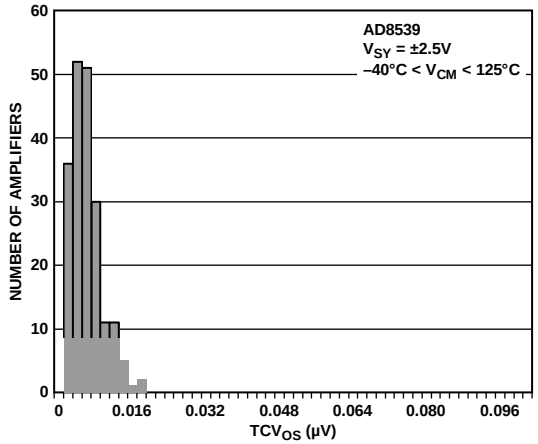


Figure 35. AD8539 Input Offset Voltage Drift Distribution

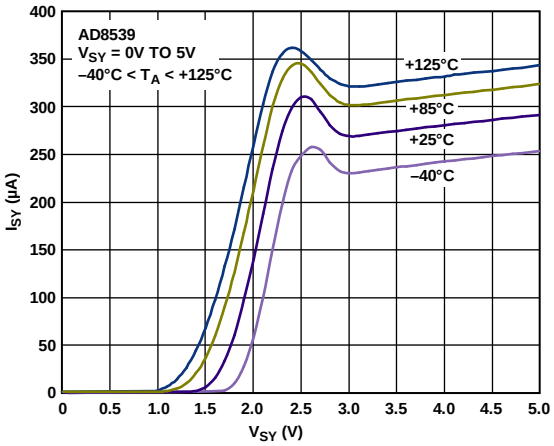


Figure 38. AD8539 SupplyCurrent vs. Supply Voltage

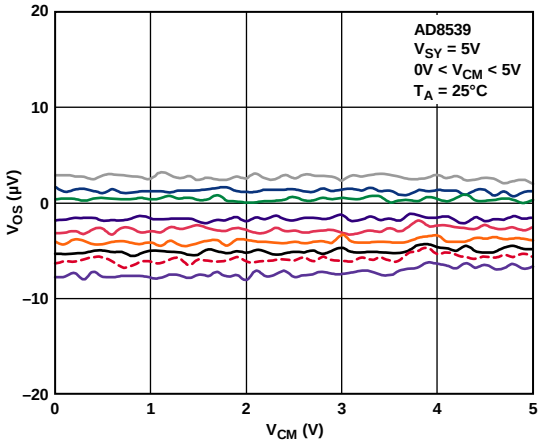


Figure 36. AD8539 Input Offset Voltage vs. Input Common-Mode Voltage

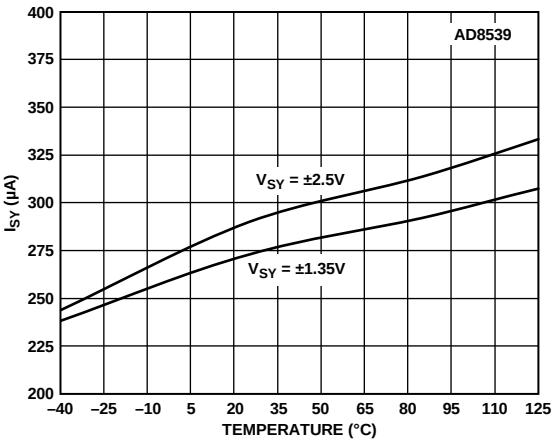


Figure 39. AD8539 Supply Current vs. Temperature

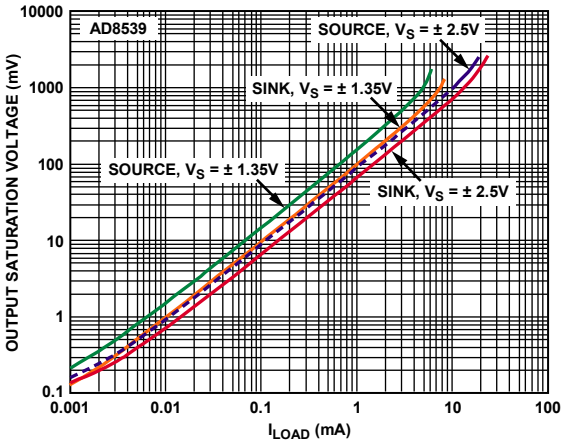


Figure 40. AD8539 Output Saturation Voltage vs. Load Current

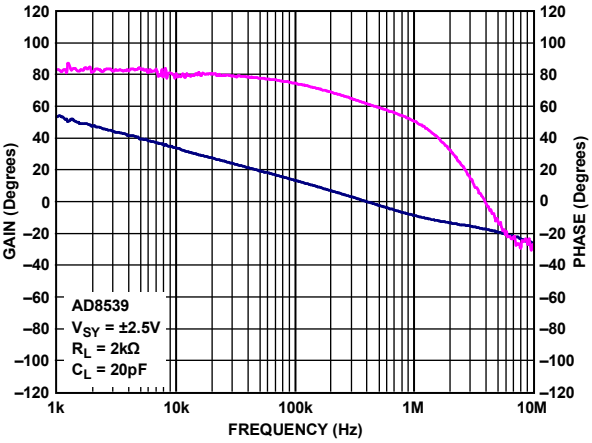


Figure 43. AD8539 Open-Loop Gain and Phase vs. Frequency

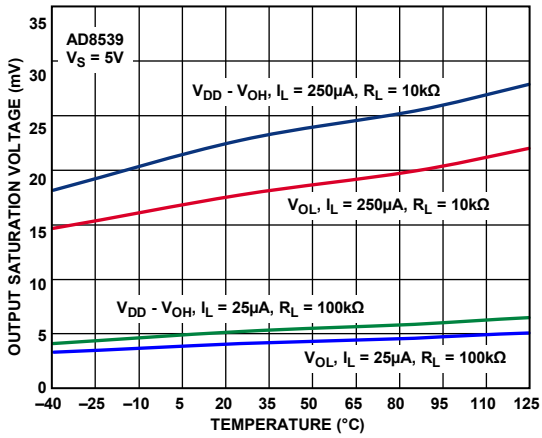


Figure 41. AD8539 Output Saturation Voltage vs. Temperature

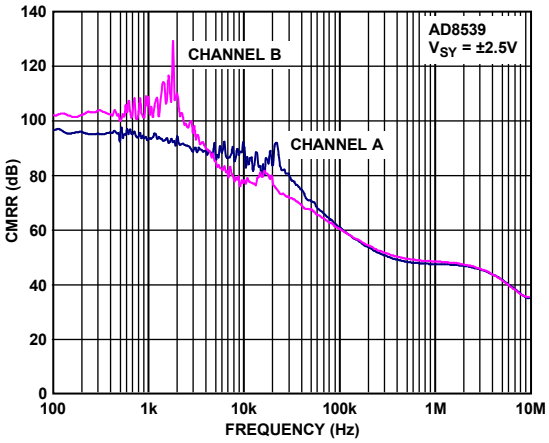


Figure 44. AD8539 CMRR vs. Frequency

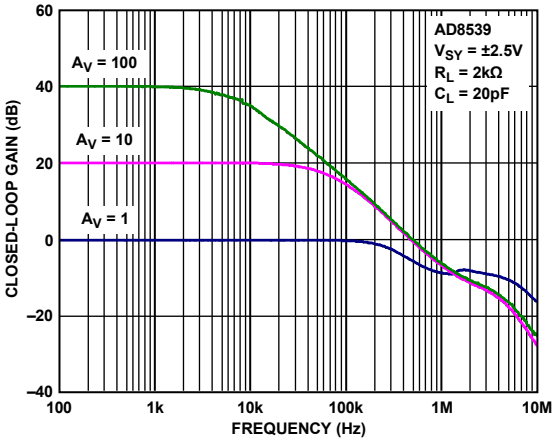


Figure 42. AD8539 Closed-Loop Gain vs. Frequency

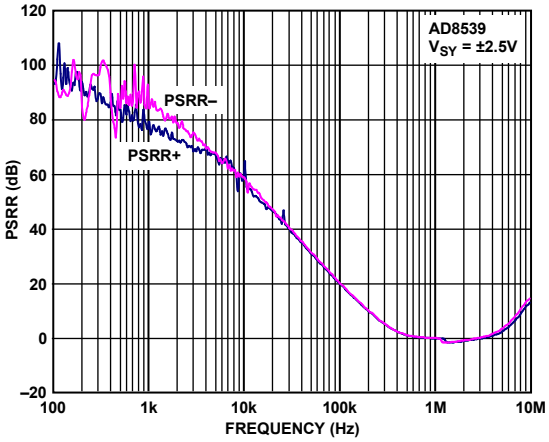


Figure 45. AD8539 PSRR vs. Frequency

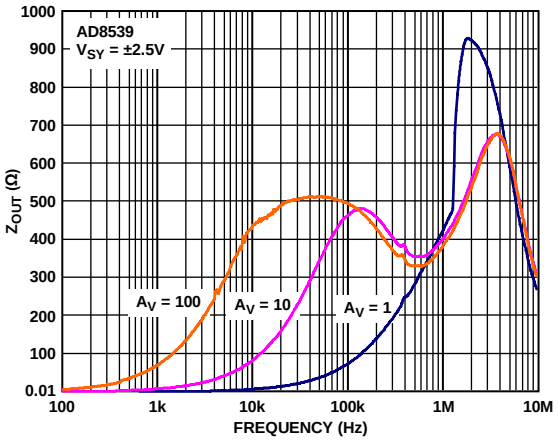


Figure 46. AD8539 Closed-Loop Output Impedance vs. Frequency

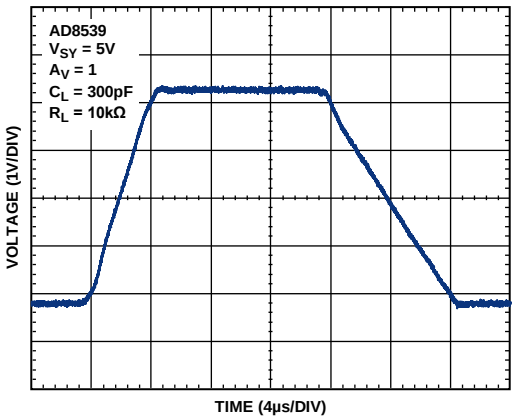


Figure 49. AD8539 Large Signal Transient Response

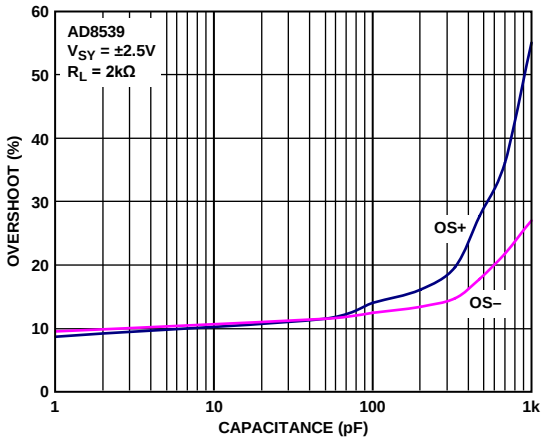


Figure 47. AD8539 Small Signal Overshoot vs. Load Capacitance

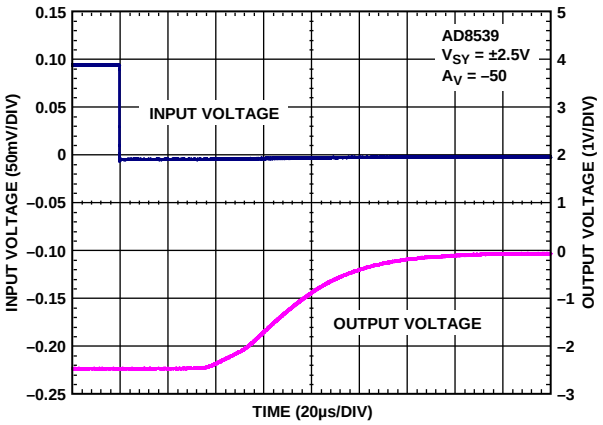


Figure 50. AD8539 Positive Overload Recovery

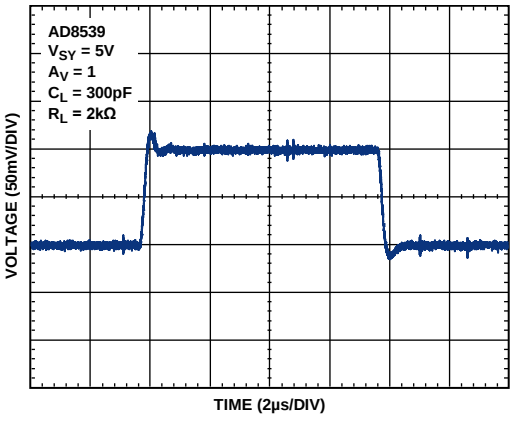


Figure 48. AD8539 Small Signal Transient Response

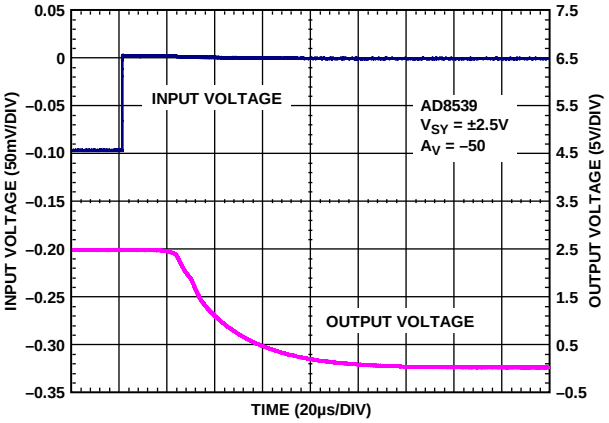


Figure 51. AD8539 Negative Overload Recovery

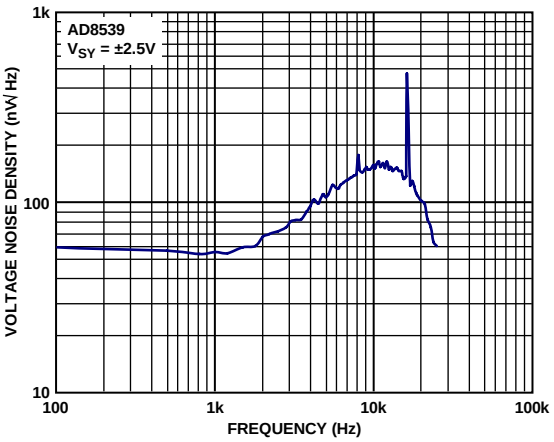


Figure 52. AD8539 Voltage Noise Density

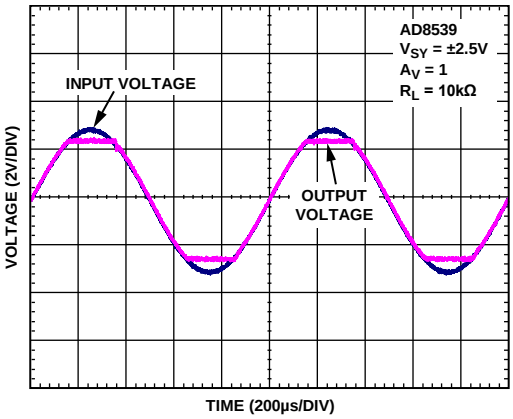


Figure 54. AD8539 No Phase Reversal

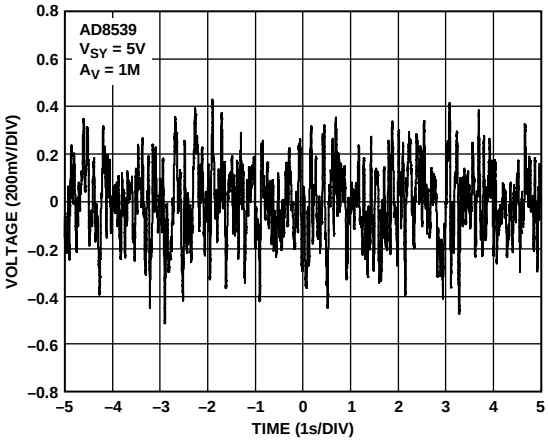


Figure 53. AD8539 0.1 Hz to 10 Hz Input Voltage Noise

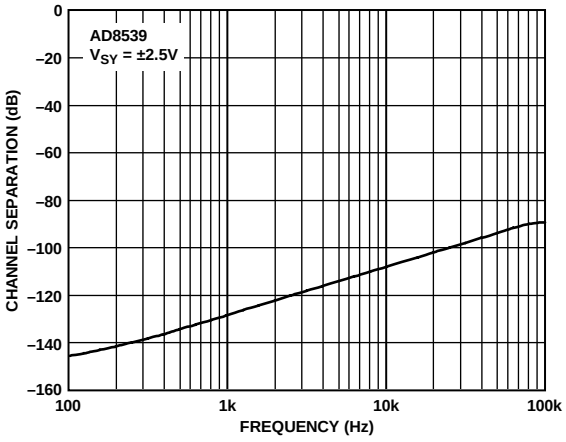


Figure 55. AD8539 Channel Separation vs. Frequency

V_S = 2.7 V or ±1.35 V, T_A = 25°C, AD8539 only, unless otherwise noted.

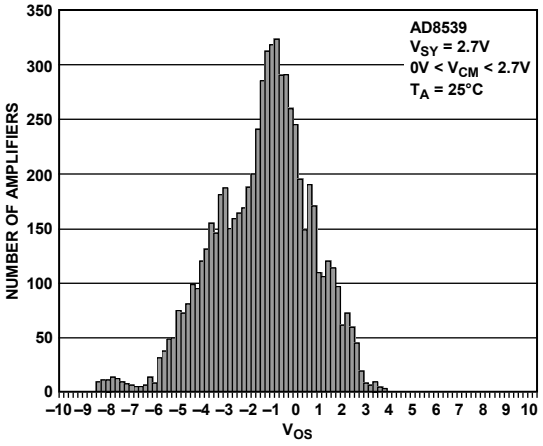


Figure 56. AD8539 Input Offset Voltage Distribution

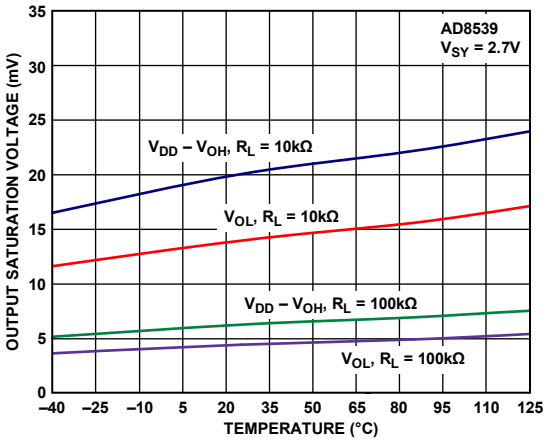


Figure 59. AD8539 Output Saturation Voltage vs. Temperature

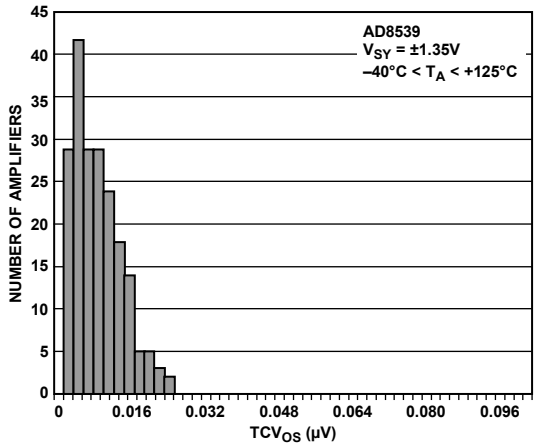


Figure 57. AD8539 Input Offset Voltage Drift Distribution

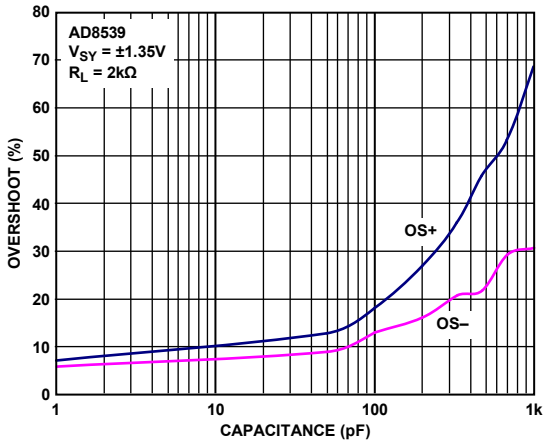


Figure 60. AD8539 Small Signal Overshoot vs. Load Capacitance

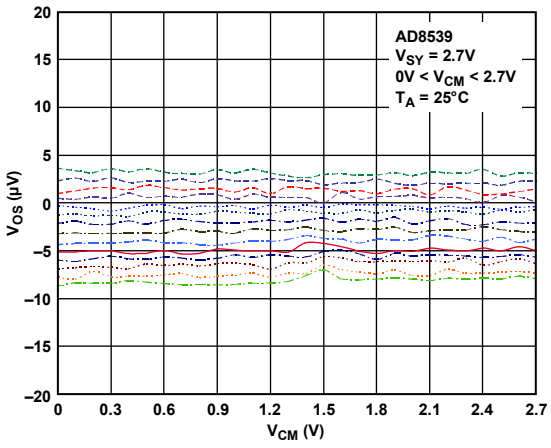


Figure 58. AD8539 Input Offset Voltage vs. Input Common-Mode Voltage

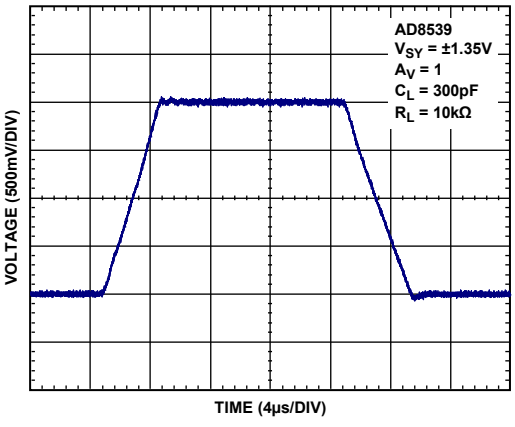


Figure 61. AD8539 Large Signal Transient Response

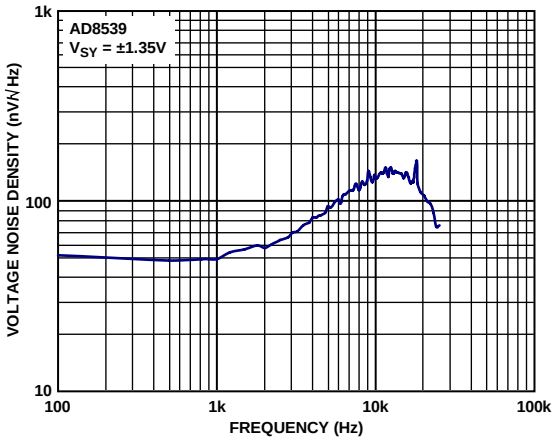


Figure 62. AD8539 Voltage Noise Density

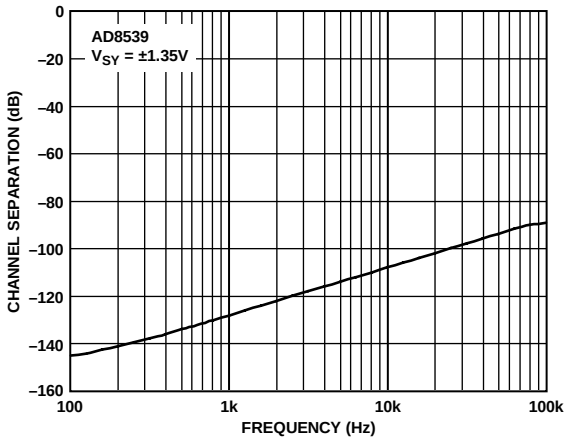
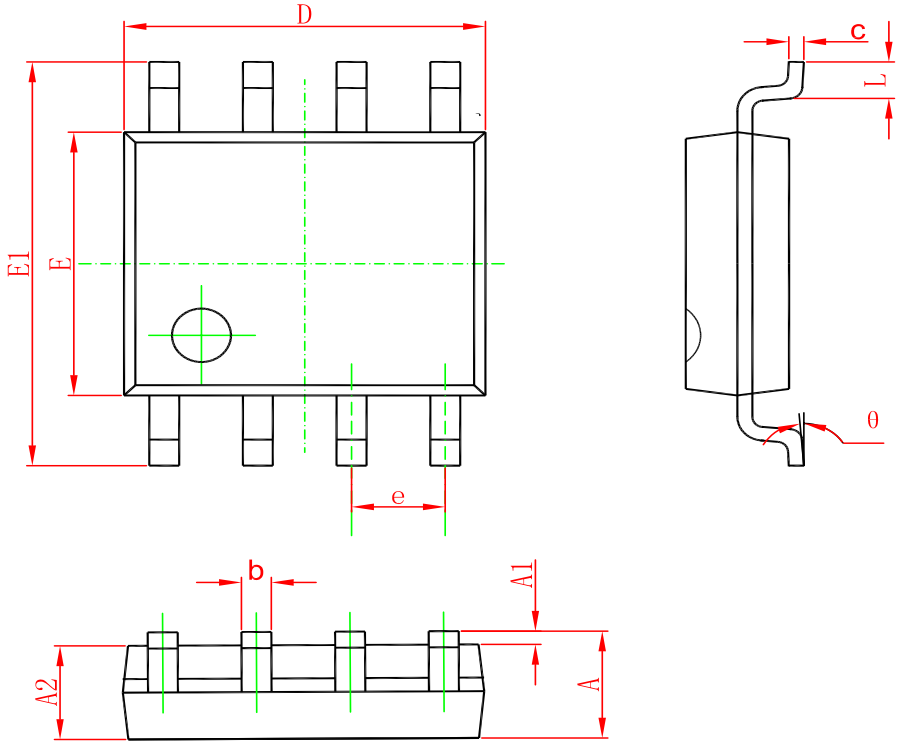


Figure 63. AD8539 Channel Separation vs. Frequency

Package Dimension

SOP-8



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	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Ordering information

Order code	Package	Baseqty	Deliverymode	Marking
UMW AD8539ARZ	SOP-8	2500	Tape and reel	AD8539
UMW AD8538ARZ	SOP-8	2500	Tape and reel	AD8538