UMW AD8538/AD8539

Low Power, Precision, Auto-Zero Op Amps

1.Description

The UMW 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 5.0V. Operation is fully specified from 2.7V to 5.0V 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 UMW AD8538/AD8539 are specified over the extended industrial temperature range (-40°C to +125°C).

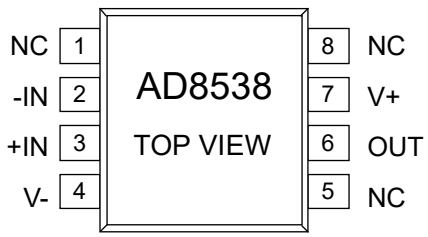
2.Features

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

3.Applications

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

4.Pinning Information



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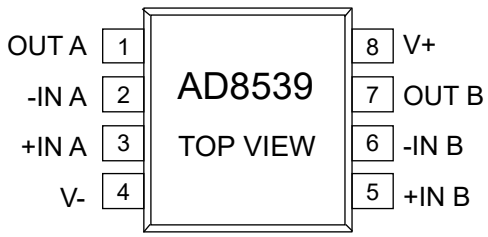

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5.Absolute Maximum Ratings (T_A=25°C, unless otherwise noted)

Parameter	Ratings
Supply Voltage	+6V
Input Voltage	V_{SS}-0.3 to V_{OO}+0.3V
Differential input Voltage	±6V
Output Short-Circuit Duration to GND	Observe derating curve
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering,60 sec)	300°C
Operating Temperature Range	-40°C to 125°C
Junction Temperature Range	-65°C to 150°C

6.1 Electrical characteristics (AD8538)

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

Parameter	Symbol	Conditions	Min	Typ	Max	Units
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	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}=0V to 5V	115	150		dB
		−40°C≤T_A≤+125°C, V_{CM}=0.2V to 4.8V	100	135		dB
Large Signal Voltage Gain	A_{VO}	R_L=10kΩ, V_O=0.1V to 4.9V	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=100kΩ to ground	4.99	4.998		V
		−40°C≤T_A≤+125°C, R_L=100kΩ to ground	4.98			V
		R_L=10kΩ to ground	4.95	4.970		V
		−40°C≤T_A≤+125°C, R_L=10kΩ to ground	4.94			V
Output Voltage Low	V_{OL}	R_L=100kΩ to V+		1.9	5	mV
		−40°C≤T_A≤+125°C, R_L=100kΩ to V+		2.8	7	mV
		R_L=10kΩ to V+		17	20	mV
		−40°C≤T_A≤+125°C, R_L=10kΩ to V+		20	30	mV
Short-Circuit Limit	I_{SC}			±25		mA
Power Supply Rejection Ratio	PSRR	V_S=2.7V to 5.0V	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

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Slew Rate	SR	R_L=10kΩ		0.4		V/μs
Settling Time 0.01%	t_s	G=±1, 2V step, C_L=20pF, R_L=1kΩ		10		μs
Overload Recovery Time				0.05		ms
Gain Bandwidth Product	GBP			430		kHz
Phase Margin	$Ø_M$	R_L=10kΩ, R_L=100kΩ, C_L=20pF		65		Degrees
Voltage Noise	$e_{n\ p-p}$	f=0.1Hz to 10Hz		2		$μV_{p-p}$
Voltage Noise Density	e_n	f=1kHz		50		nV/√Hz

6.2 Electrical characteristics (AD8538)

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

Parameter	Symbol	Conditions	Min	Typ	Max	Units
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	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}=0V to 2.5V	110	140		dB
		−40°C≤T_A≤+125°C	100	135		dB
Large Signal Voltage Gain	A_{VO}	R_L=10kΩ, V_O=0.1V to 1.7V	105	140		dB
		−40°C≤T_A≤+125°C		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=100kΩ to ground	2.68	2.698		V
		−40°C≤T_A≤+125°C, R_L=100kΩ to ground	2.68			V
		R_L=10kΩ to ground	2.67	2.68		V
		−40°C≤T_A≤+125°C, R_L=10kΩ to ground	2.66			V
Output Voltage Low	V_{OL}	R_L=100kΩ to V+		1.7	5	mV
		−40°C≤T_A≤+125°C, R_L=100kΩ to V+		2.4	5	mV
		R_L=10kΩ to V+		14	20	mV
		−40°C≤T_A≤+125°C, R_L=10kΩ to V+		20	25	mV
Short-Circuit Limit	I_{SC}			±8		mA
Power Supply Rejection Ratio	PSRR	V_S=2.7V to 5.5V	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

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Slew Rate	SR	R_L=10kΩ		0.35		V/μs
Settling Time 0.01%	t_s	G=±1, 1V step, C_L=20pF, R_L=1kΩ		5		μs
Overload Recovery Time				0.05		ms
Gain Bandwidth Product	GBP			430		kHz
Phase Margin	$Ø_M$	R_L=10kΩ, R_L=100kΩ, C_L=20pF		65		Degrees
Voltage Noise	$e_{n\ p-p}$	f=0.1Hz to 10Hz		2		$μV_{p-p}$
Voltage Noise Density	e_n	f=1kHz		50		nV/√Hz

6.3 Electrical characteristics (AD8539)

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

Parameter	Symbol	Conditions	Min	Typ	Max	Units
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	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}=0V to 5V	115	135		dB
		−40°C≤T_A≤+125°C, V_{CM}=0.2V to 4.8V	100	130		dB
Large Signal Voltage Gain	A_{VO}	R_L=10kΩ, V_O=0.1V to 4.9V	110	130		dB
		−40°C≤T_A≤+125°C	110	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=100kΩ to ground	4.99	4.994		V
		−40°C≤T_A≤+125°C, R_L=100kΩ to ground	4.98			V
		R_L=10kΩ to ground	4.95	4.97		V
		−40°C≤T_A≤+125°C, R_L=10kΩ to ground	4.94			V
Output Voltage Low	V_{OL}	R_L=100kΩ to V+		5	7	mV
		−40°C≤T_A≤+125°C, R_L=100kΩ to V+		6	8	mV
		R_L=10kΩ to V+		20	25	mV
		−40°C≤T_A≤+125°C, R_L=10kΩ to V+		24	30	mV
Short-Circuit Limit	I_{SC}			±25		mA
Power Supply Rejection Ratio	PSRR	V_S=2.7V to 5.0V	105	125		dB
		−40°C≤T_A≤+125°C	100	125		dB

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Current/Amplifier	I_{SY}	I_O=0		170	210	μA
		−40°C≤T_A≤+125°C			225	μA
Slew Rate	SR	R_L=10kΩ		0.4		V/μs
Settling Time 0.01%	t_s	G=±1, 2V step, C_L=20pF, R_L=1kΩ		10		μs
Overload Recovery Time				0.05		ms
Gain Bandwidth Product	GBP			430		kHz
Phase Margin	$Ø_M$	R_L=10kΩ, R_L=100kΩ, C_L=20pF		65		Degrees
Voltage Noise	$e_{n\ p-p}$	f=0.1Hz to 10Hz		1.2		$μV_{p-p}$
Voltage Noise Density	e_n	f=1kHz		52		nV/√Hz

6.4 Electrical characteristics (AD8539)

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

Parameter	Symbol	Conditions	Min	Typ	Max	Units
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	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	V
Common-Mode Rejection Ratio	CMRR	V_{CM}=0V to 2.7V	110	130		dB
		−40°C≤T_A≤+125°C, V_{CM}=0.2V to 2.5V	100	125		dB
Large Signal Voltage Gain	A_{VO}	R_L=10kΩ, V_O=0.1V to 2.6V	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=100kΩ to ground	2.68	2.693		V
		−40°C≤T_A≤+125°C, R_L=100kΩ to ground	2.68			V
		R_L=10kΩ to ground	2.67	2.68		V
		−40°C≤T_A≤+125°C, R_L=10kΩ to ground	2.66			V
Output Voltage Low	V_{OL}	R_L=100kΩ to V+		5	7	mV
		−40°C≤T_A≤+125°C, R_L=100kΩ to V+		6	8	mV
		R_L=10kΩ to V+		14	20	mV
		−40°C≤T_A≤+125°C, R_L=10kΩ to V+		20	25	mV
Short-Circuit Limit	I_{SC}			±8		mA
Power Supply Rejection Ratio	PSRR	V_S=2.7V to 5.5V	105	125		dB
		−40°C≤T_A≤+125°C	100	125		dB

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Current/Amplifier	I_{SY}	I_O=0			210	μA
		−40°C≤T_A≤+125°C			225	μA
Slew Rate	SR	R_L=10kΩ		0.35		V/μs
Settling Time 0.01%	t_s	G=±1, 1V step, C_L=20pF, R_L=∞		8		μs
Overload Recovery Time				0.05		ms
Gain Bandwidth Product	GBP			430		kHz
Phase Margin	$Ø_M$	R_L=10kΩ, R_L=100kΩ, C_L=20pF		65		Degrees
Voltage Noise	$e_{n\ p-p}$	f=0.1Hz to 10Hz		2		$μV_{p-p}$
Voltage Noise Density	e_n	f=1kHz		55		nV/√Hz

7.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	θJA	θJA
SOP-8	125	43	°C/W

8.1 Typical Characteristic

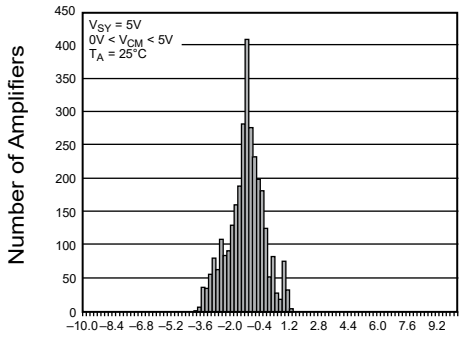


Figure 1: AD8538 Input Offset Voltage Distribution

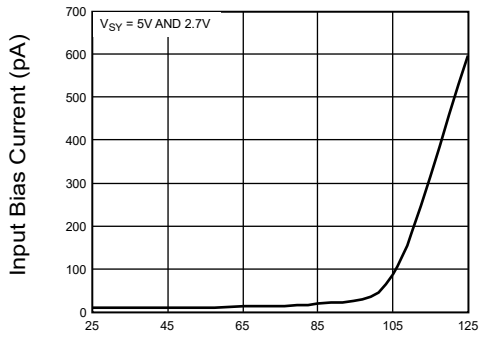


Figure 2: AD8538 Input Bias Current vs. Temperature

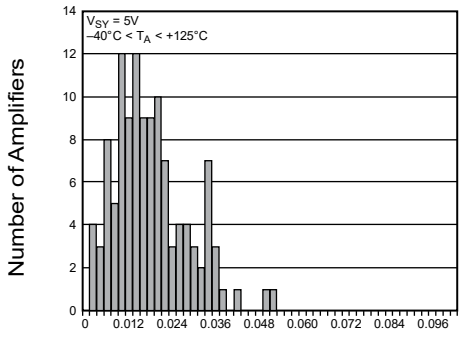


Figure 3: AD8538 Input Offset Voltage Drift Distribution

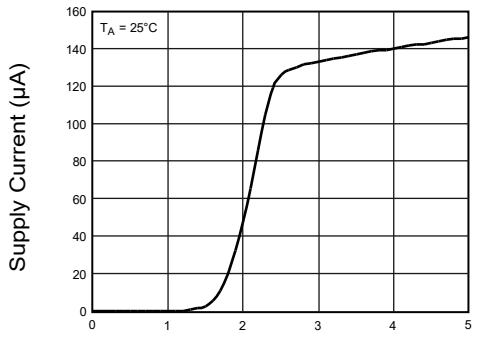


Figure 4: AD8538 Supply Current vs. Supply Voltage

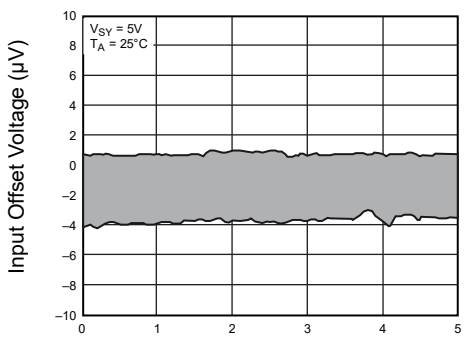


Figure 5: AD8538 Input Offset Voltage vs. Input Common -Mode Voltage

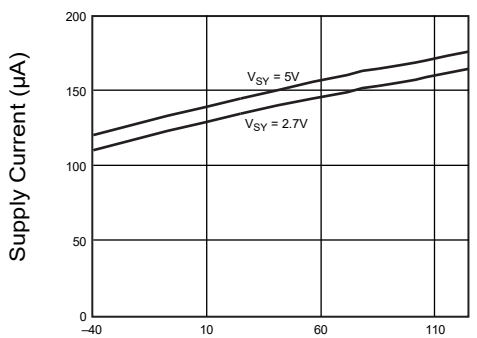


Figure 6: AD8538 Supply Current vs. Temperature

8.2 Typical Characteristic

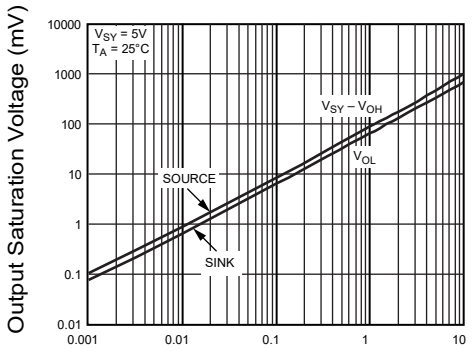


Figure 7: AD8538 Output Saturation Voltage vs. Load Current

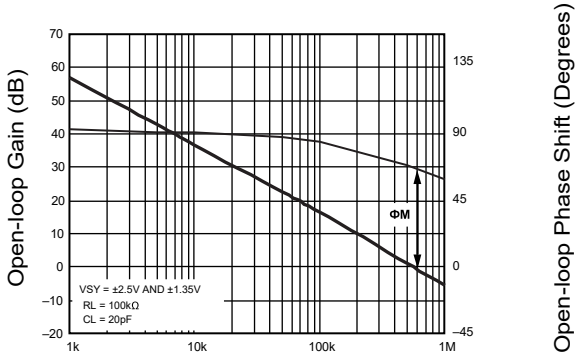


Figure 8: AD8538 Open-Loop Gain and Phase vs. Frequency

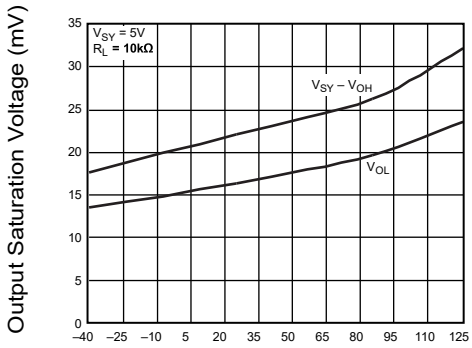


Figure 9: AD8538 Output Saturation Voltage vs. Temperature

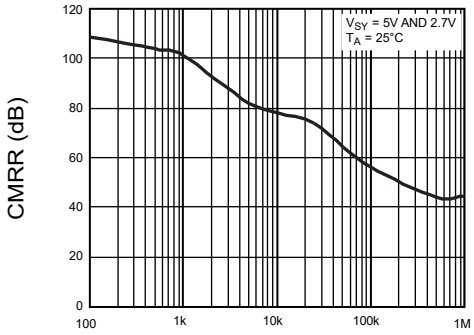


Figure 10: AD8538 CMRR vs. Frequency

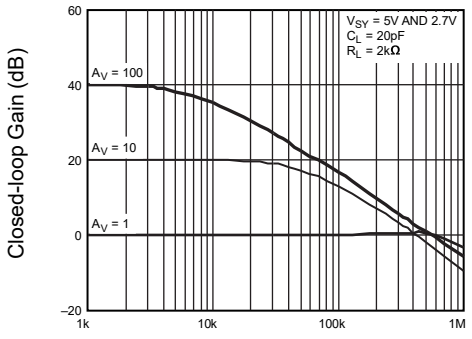


Figure 11: AD8538 Closed-Loop Gain vs. Frequency

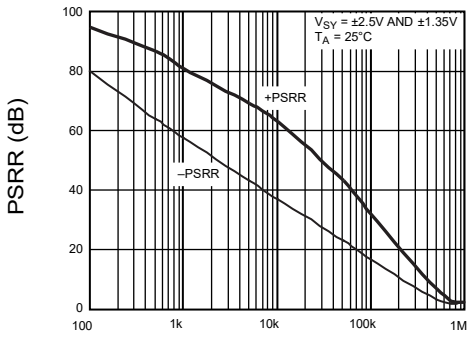


Figure 12: AD8538 PSRR vs. Frequency

8.3 Typical Characteristic

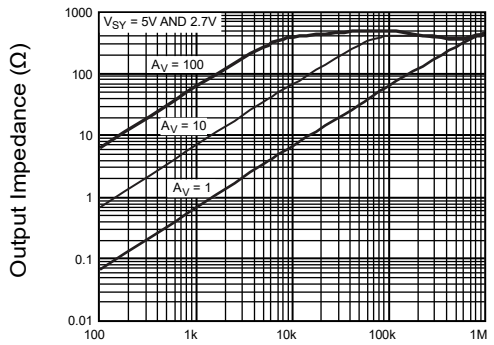


Figure 13: AD8538 Closed-Loop Output Impedance vs. Frequency

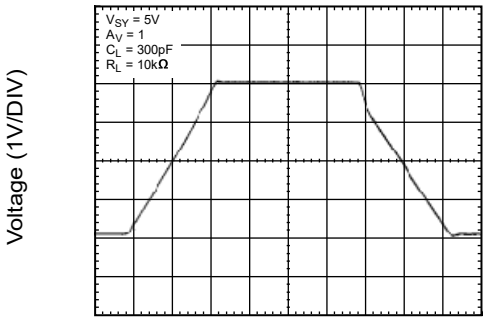


Figure 14: AD8538 Large Signal Transient Response

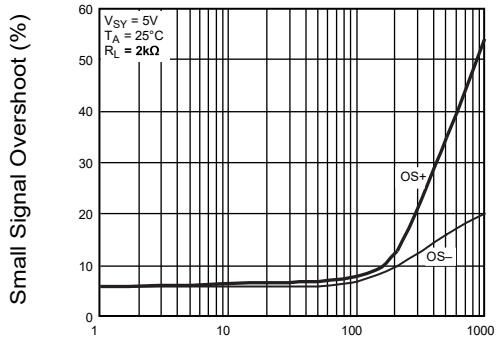


Figure 15: AD8538 Small Signal Overshoot vs. Load Capacitance

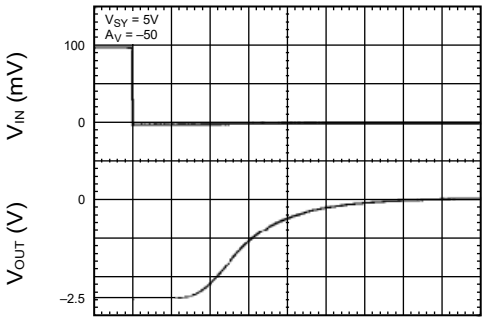


Figure 16: AD8538 Positive Overload Recovery

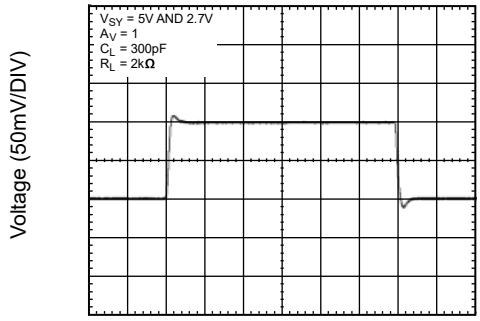


Figure 17: AD8538 Small Signal Transient Response

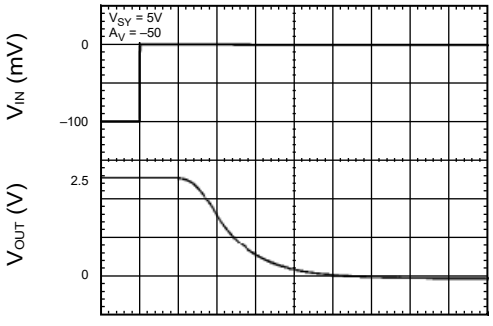


Figure 18: AD8538 Negative Overload Recovery

8.4 Typical Characteristic

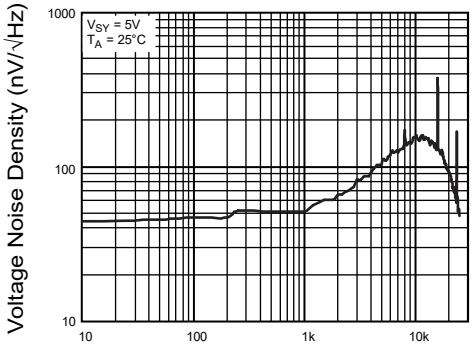


Figure 19: AD8538 Voltage Noise Density

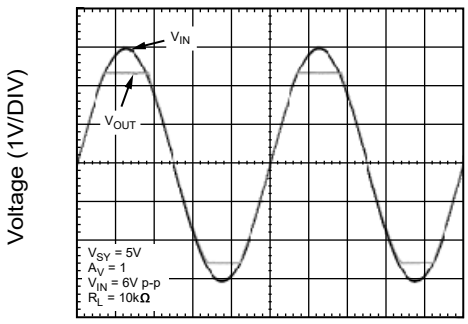


Figure 20: AD8538 No Phase Reversal

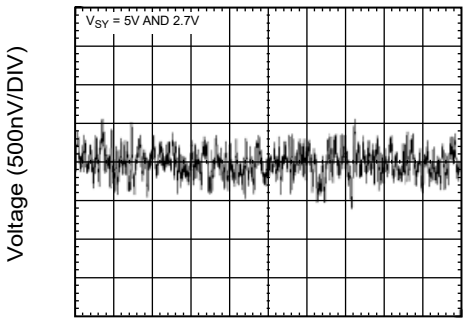


Figure 21: AD8538 0.1Hz to 10Hz Input Voltage Noise

8.5 Typical Characteristic

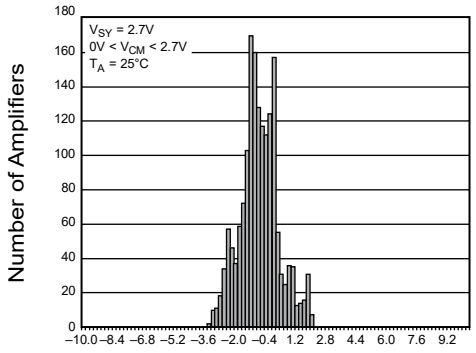


Figure 22: AD8538 Input Offset Voltage Distribution

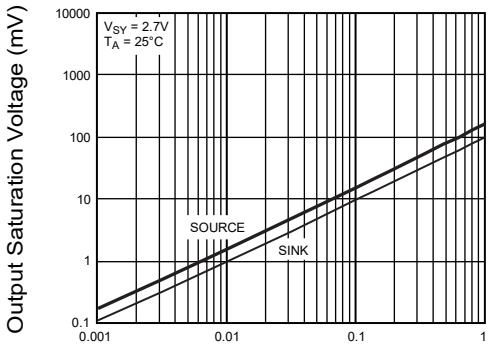


Figure 23: AD8538 Output Saturation Voltage vs. Load Current

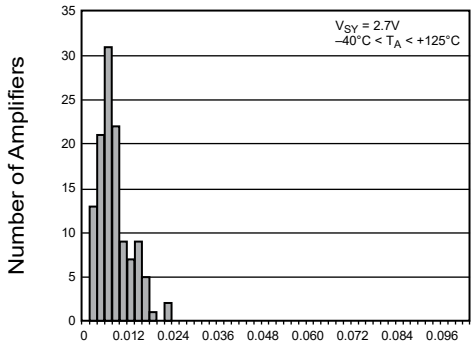


Figure 24: AD8538 Input Offset Voltage Drift Distribution

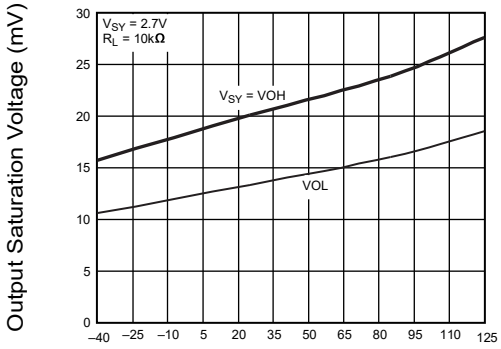


Figure 25: AD8538 Output Saturation Voltage vs. Temperature

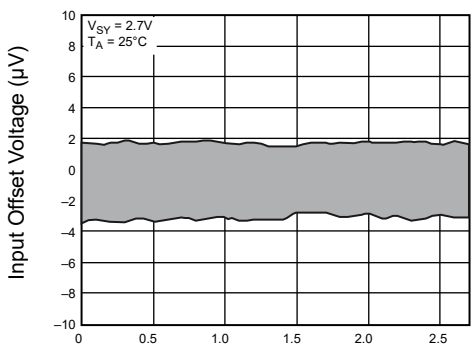


Figure 26: AD8538 Input Offset Voltage vs. Input Common -Mode Voltage

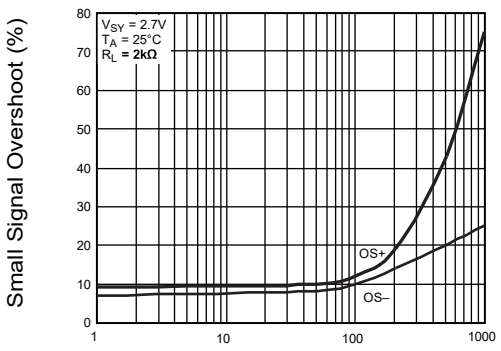


Figure 27: AD8538 Small Signal Overshoot vs. Load Capacitance

8.6 Typical Characteristic

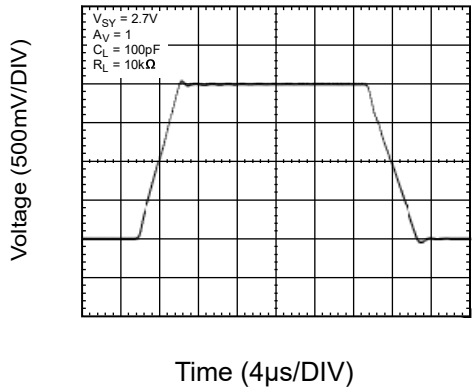


Figure 28: AD8538 Large Signal Transient Response

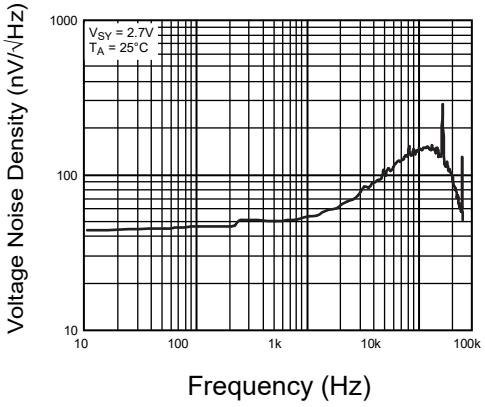


Figure 29: AD8538 Voltage Noise Density

8.7 Typical Characteristic

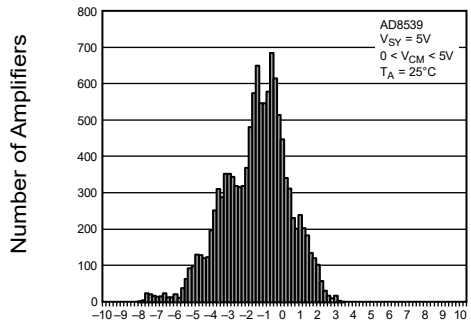


Figure 30: AD8539 Input Offset Voltage Distribution

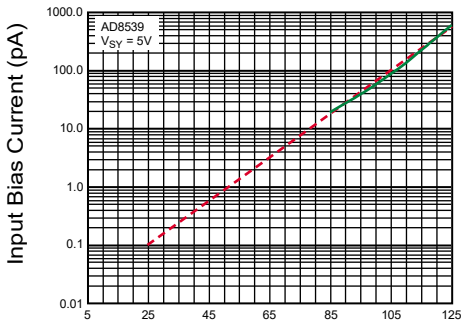


Figure 31: AD8539 Input Bias Current vs. Temperature

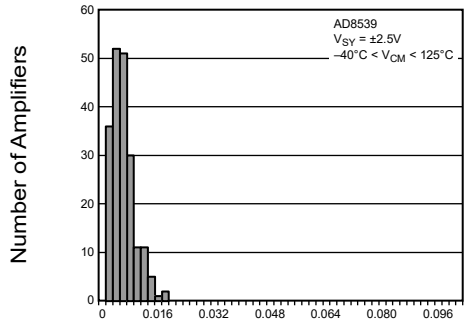


Figure 32: AD8539 Input Offset Voltage Drift Distribution

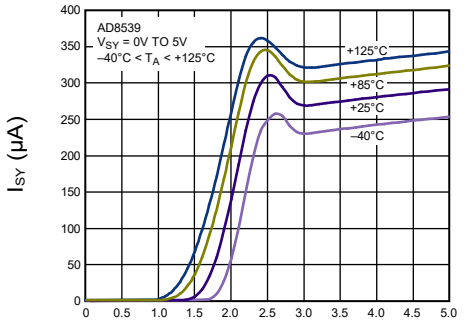


Figure 33: AD8539 Supply Current vs. Supply Voltage

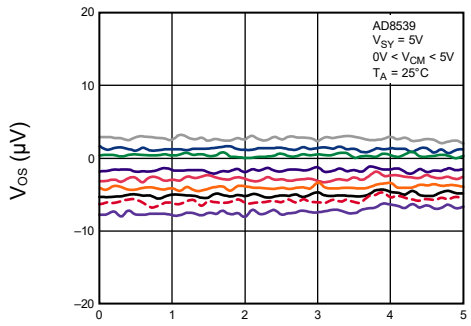


Figure 34: AD8539 Input Offset Voltage vs. Input Common-Mode Voltage

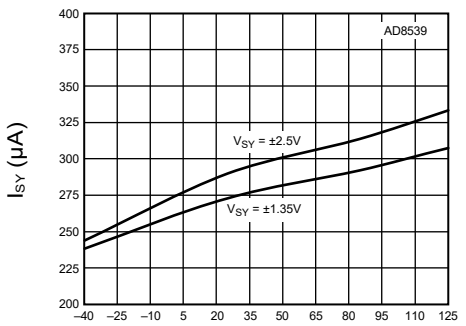


Figure 35: AD8539 Supply Current vs. Temperature

8.8 Typical Characteristic

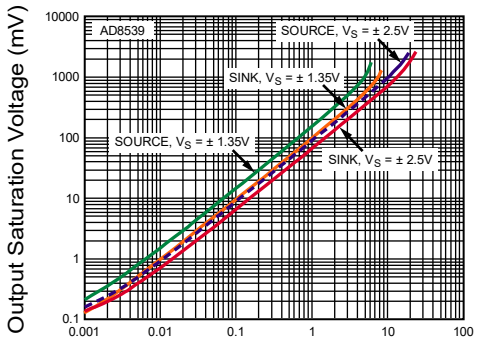


Figure 36: AD8539 Output Saturation Voltage vs. Load Current

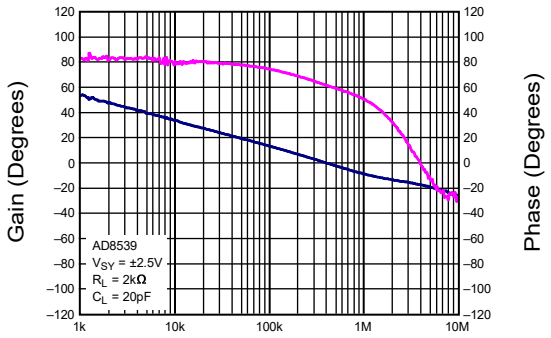


Figure 37: AD8539 Open-Loop Gain and Phase vs. Frequency

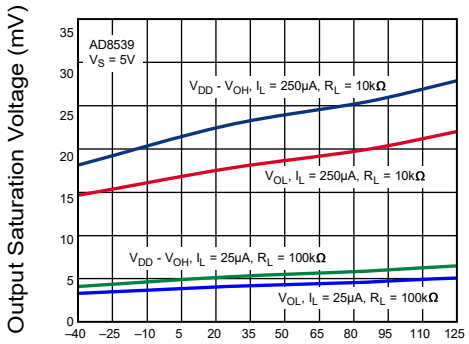


Figure 38: AD8539 Output Saturation Voltage vs. Temperature

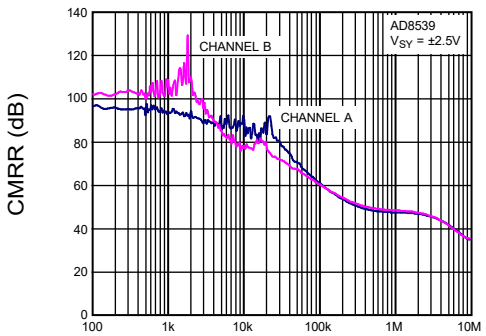


Figure 39: AD8539 CMRR vs. Frequency

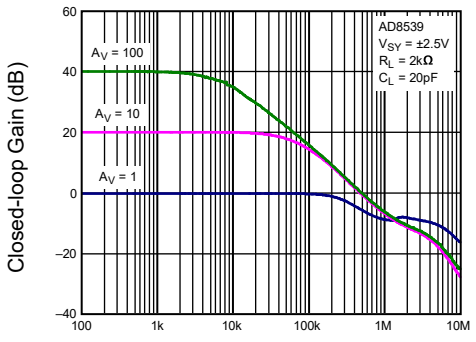


Figure 40: AD8539 Closed-Loop Gain vs. Frequency

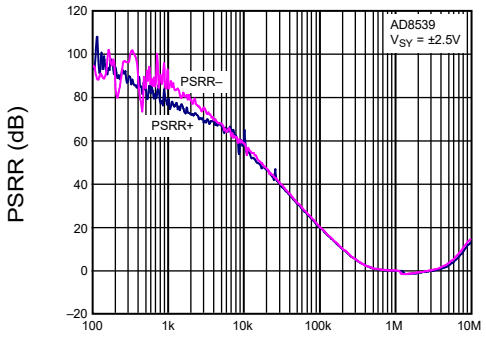


Figure 41: AD8539 PSRR vs. Frequency

8.9 Typical Characteristic

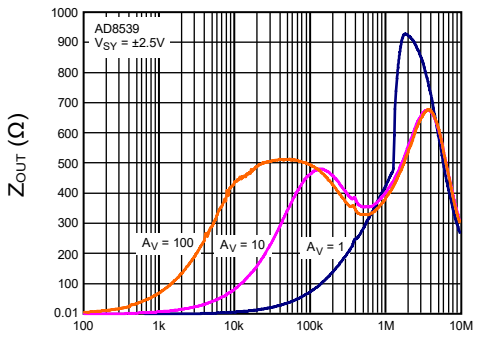


Figure 42: AD8539 Closed-Loop Output Impedance vs. Frequency

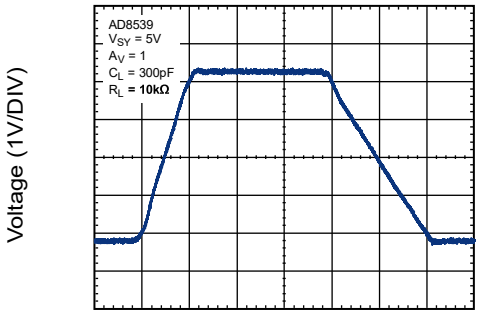


Figure 43: AD8539 Large Signal Transient Response

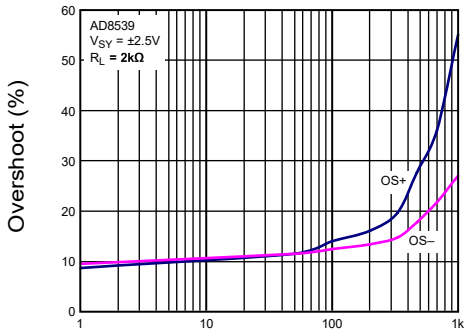


Figure 44: AD8539 Small Signal Overshoot vs. Load Capacitance

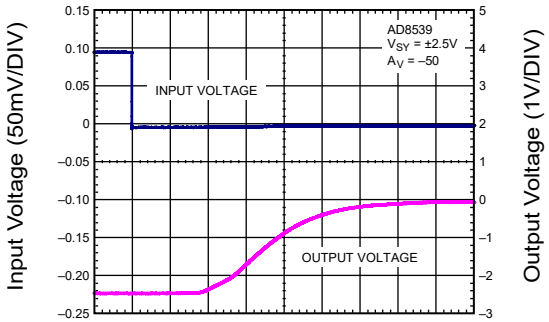


Figure 45: AD8539 Positive Overload Recovery

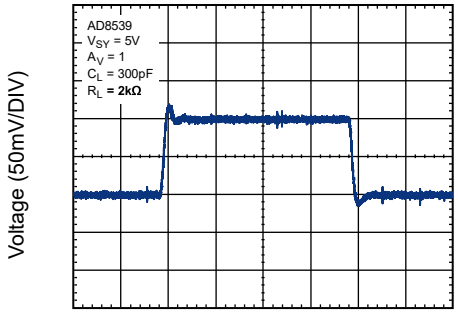


Figure 46: AD8539 Small Signal Transient Response

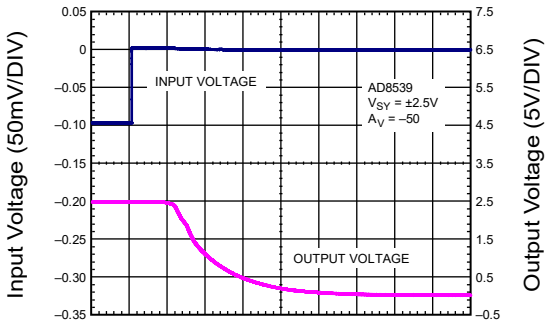


Figure 47: AD8539 Negative Overload Recovery

8.10 Typical Characteristic

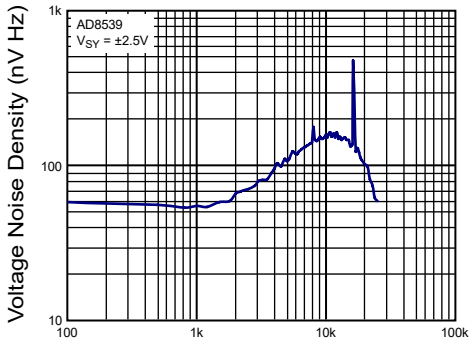


Figure 48: AD8539 Voltage Noise Density

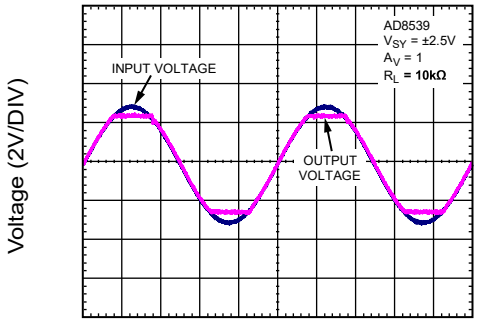


Figure 49: AD8539 Large Signal Transient Response

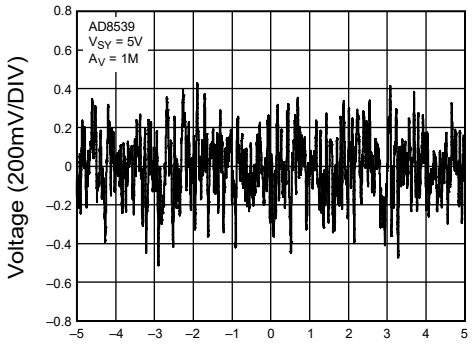


Figure 50: AD8539 0.1 Hz to 10 Hz Input Voltage Noise

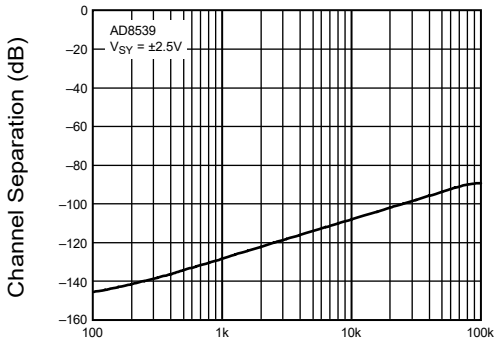


Figure 51: AD8539 Channel Separation vs. Frequency

8.11 Typical Characteristic

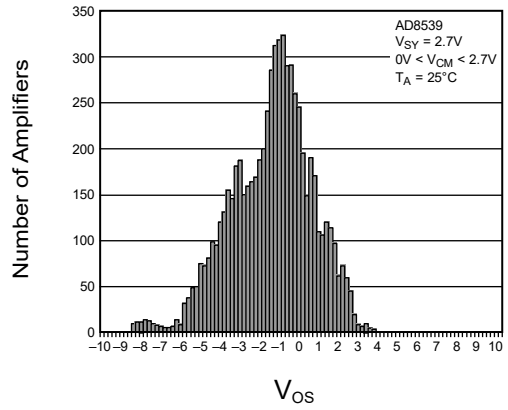


Figure 52: AD8539 Input Offset Voltage Distribution

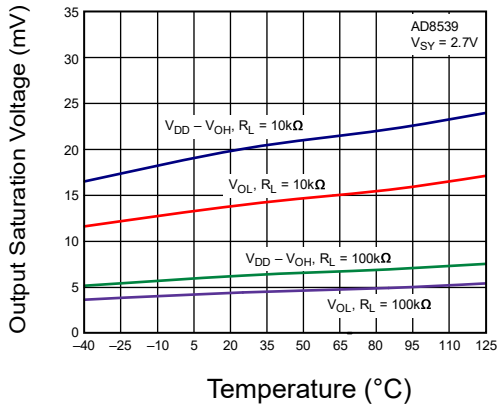


Figure 53: AD8539 Output Saturation Voltage vs. Temperature

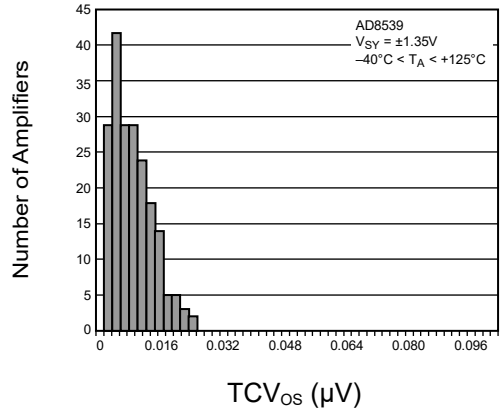


Figure 54: AD8539 Input Offset Voltage Drift Distribution

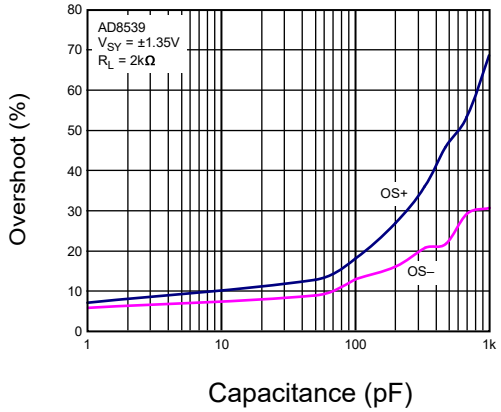


Figure 55: AD8539 Small Signal Overshoot vs. Load Capacitance

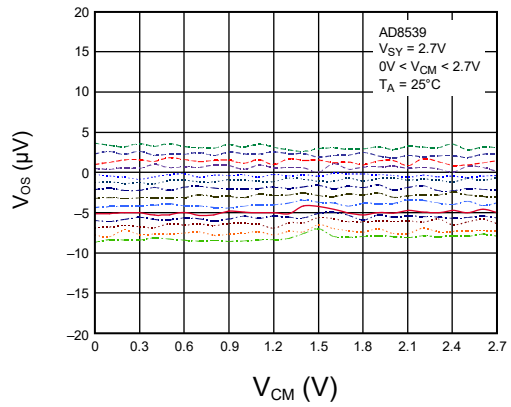


Figure 56: AD8539 Input Offset Voltage vs. Input Common-Mode Voltage

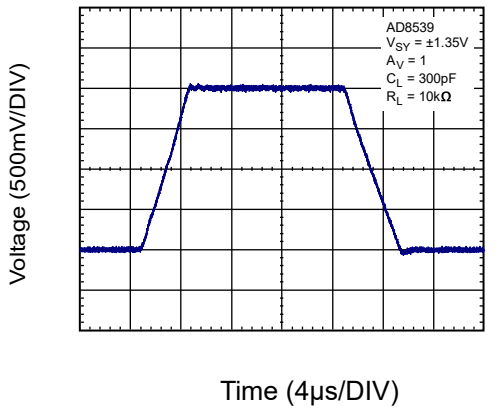


Figure 57: AD8539 Large Signal Transient Response

8.12 Typical Characteristic

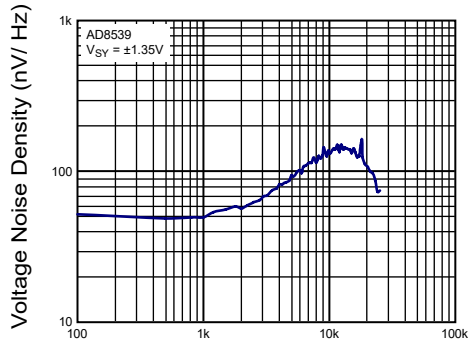


Figure 58: AD8539 Voltage Noise Density

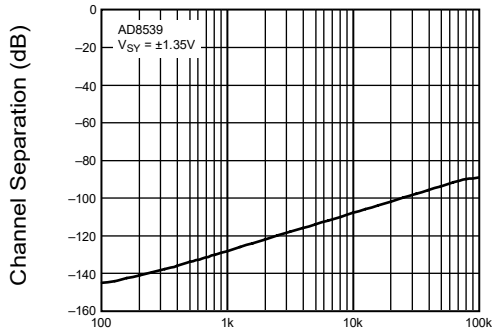
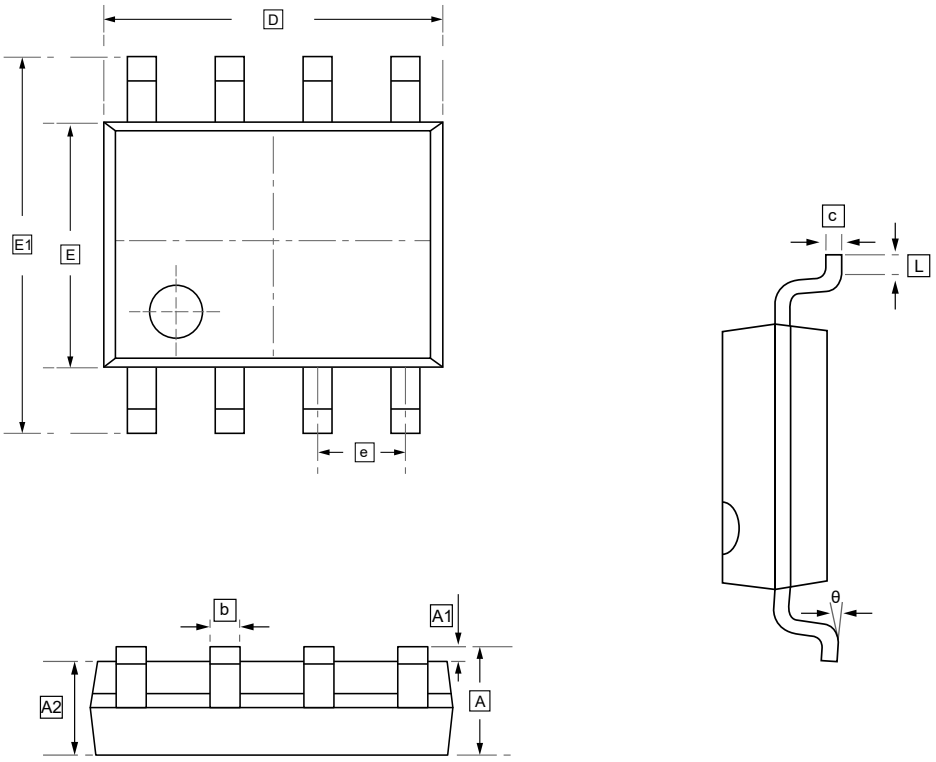


Figure 59: AD8539 Channel Separation vs. Frequency

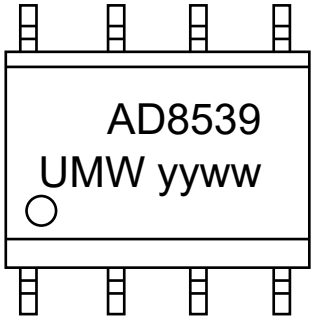
9.SOP-8 Package Outline Dimensions



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°

9.Ordering information



yy: Year Code
ww: Week Code

Order Code	Marking	Package	Base QTY	Delivery Mode
UMW AD8538ARZ	AD8538	SOP-8	2500	Tape and reel
UMW AD8539ARZ	AD8539	SOP-8	2500	Tape and reel

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