Precision CMOS Single-Supply Rail-to-Rail Input/Output Wideband Operational Amplifiers

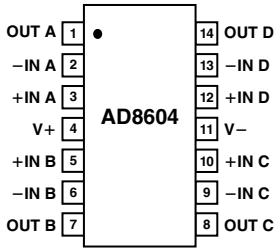
AD8601/AD8602/AD8604

FEATURES
Low Offset Voltage: 500 μV Max
Single-Supply Operation: 2.7 V to 5.5 V
Low Supply Current: 750 μA/Amplifier
Wide Bandwidth: 8 MHz
Slew Rate: 5 V/μs
Low Distortion
No Phase Reversal
Low Input Currents
Unity Gain Stable

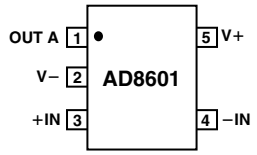
APPLICATIONS
Current Sensing
Barcode Scanners
PA Controls
Battery-Powered Instrumentation
Multipole Filters
Sensors
ASIC Input or Output Amplifiers
Audio

FUNCTIONAL BLOCK DIAGRAM

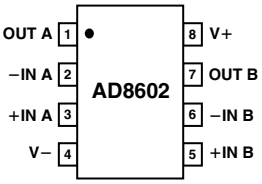
14-Lead TSSOP (RU Suffix)



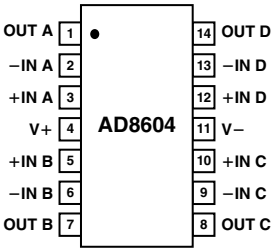
5-Lead SOT-23 (RT Suffix)



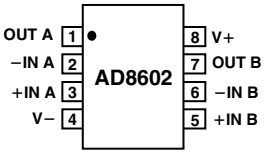
8-Lead MSOP (RM Suffix)



14-Lead SOIC (R Suffix)



8-Lead SOIC (R Suffix)



GENERAL DESCRIPTION

The AD8601, AD8602, and AD8604 are single, dual, and quad rail-to-rail input and output single-supply amplifiers featuring very low offset voltage and wide signal bandwidth. These amplifiers use a new, patented trimming technique that achieves superior performance without laser trimming. All are fully specified to operate on a 3 V to 5 V single supply.

The combination of low offsets, very low input bias currents, and high speed make these amplifiers useful in a wide variety of applications. Filters, integrators, diode amplifiers, shunt current sensors, and high impedance sensors all benefit from the combination of performance features. Audio and other ac applications benefit from the wide bandwidth and low distortion. For the most cost-sensitive applications, the D grades offer this ac performance with lower dc precision at a lower price point.

Applications for these amplifiers include audio amplification for portable devices, portable phone headsets, bar code scanners, portable instruments, cellular PA controls, and multipole filters.

The ability to swing rail-to-rail at both the input and output enables designers to buffer CMOS ADCs, DACs, ASICs, and other wide output swing devices in single-supply systems.

The AD8601, AD8602, and AD8604 are specified over the extended industrial (–40°C to +125°C) temperature range. The AD8601, single, is available in the tiny 5-lead SOT-23 package. The AD8602, dual, is available in 8-lead MSOP and narrow SOIC surface-mount packages. The AD8604, quad, is available in 14-lead TSSOP and narrow SOIC packages.

SOT, MSOP, and TSSOP versions are available in tape and reel only.

AD8601/AD8602/AD8604–SPECIFICATIONS

ELECTRICAL CHARACTERISTICS (V_S = 3 V, V_{CM} = V_S/2, T_A = 25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	A Grade Min	A Grade Typ	A Grade Max	D Grade Min	D Grade Typ	D Grade Max	Unit
INPUT CHARACTERISTICS									
Offset Voltage (AD8601/AD8602)	V_{OS}	0 V ≤ V_{CM} ≤ 1.3 V		80	500		1,100	6,000	µV
		–40°C ≤ T_A ≤ +85°C			700			7,000	µV
		–40°C ≤ T_A ≤ +125°C			1,100			7,000	µV
		0 V ≤ V_{CM} ≤ 3 V*		350	750		1,300	6,000	µV
		–40°C ≤ T_A ≤ +85°C			1,800			7,000	µV
		–40°C ≤ T_A ≤ +125°C			2,100			7,000	µV
Offset Voltage (AD8604)	V_{OS}	V_{CM} = 0 V to 1.3 V		80	600		1,100	6,000	µV
		–40°C ≤ T_A ≤ +85°C			800			7,000	µV
		–40°C ≤ T_A ≤ +125°C			1,600			7,000	µV
		V_{CM} = 0 V to 3.0 V*		350	800		1,300	6,000	µV
		–40°C ≤ T_A ≤ +85°C			2,200			7,000	µV
		–40°C ≤ T_A ≤ +125°C			2,400			7,000	µV
Input Bias Current	I_B			0.2	60		0.2	200	pA
		–40°C ≤ T_A ≤ +85°C		25	100		25	200	pA
		–40°C ≤ T_A ≤ +125°C		150	1,000		150	1,000	pA
Input Offset Current	I_{OS}			0.1	30		0.1	100	pA
		–40°C ≤ T_A ≤ +85°C			50			100	pA
		–40°C ≤ T_A ≤ +125°C			500			500	pA
Input Voltage Range			0		3	0		3	V
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0 V to 3 V	68	83		52	65		dB
Large Signal Voltage Gain	A_{VO}	V_O = 0.5 V to 2.5 V,							
		R_L = 2 kΩ , V_{CM} = 0 V	30	100		20	60		V/mV
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$			2			2		µV/°C
OUTPUT CHARACTERISTICS									
Output Voltage High	V_{OH}	I_L = 1.0 mA	2.92	2.95		2.92	2.95		V
		–40°C ≤ T_A ≤ +125°C	2.88			2.88			V
Output Voltage Low	V_{OL}	I_L = 1.0 mA		20	35		20	35	mV
		–40°C ≤ T_A ≤ +125°C			50			50	mV
Output Current	I_{OUT}			±30			±30		mA
Closed-Loop Output Impedance	Z_{OUT}	f = 1 MHz, A_V = 1		12			12		Ω
POWER SUPPLY									
Power Supply Rejection Ratio	PSRR	V_S = 2.7 V to 5.5 V	67	80		56	72		dB
Supply Current/Amplifier	I_{SY}	V_O = 0 V		680	1,000		680	1,000	µA
		–40°C ≤ T_A ≤ +125°C			1,300			1,300	µA
DYNAMIC PERFORMANCE									
Slew Rate	SR	R_L = 2 kΩ		5.2			5.2		V/µs
Settling Time	t_S	To 0.01%		<0.5			<0.5		µs
Gain Bandwidth Product	GBP			8.2			8.2		MHz
Phase Margin	Φo			50			50		Degrees
NOISE PERFORMANCE									
Voltage Noise Density	e_n	f = 1 kHz		33			33		nV/√Hz
	e_n	f = 10 kHz		18			18		nV/√Hz
Current Noise Density	i_n			0.05			0.05		pA/√Hz

*For V_{CM} between 1.3 V and 1.8 V, V_{OS} may exceed specified value.

Specifications subject to change without notice.

ELECTRICAL CHARACTERISTICS (V_S = 5.0 V, V_{CM} = V_S/2, T_A = 25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	A Grade Min	A Grade Typ	A Grade Max	D Grade Min	D Grade Typ	D Grade Max	Unit
INPUT CHARACTERISTICS									
Offset Voltage (AD8601/AD8602)	V_{OS}	0 V ≤ V_{CM} ≤ 5 V		80	500		1,300	6,000	µV
		–40°C ≤ T_A ≤ +125°C			1,300			7,000	µV
Offset Voltage (AD8604)	V_{OS}	V_{CM} = 0 V to 5 V		80	600		1,300	6,000	µV
		–40°C ≤ T_A ≤ +125°C			1,700			7,000	µV
Input Bias Current	I_B			0.2	60		0.2	200	pA
		–40°C ≤ T_A ≤ +85°C			100			200	pA
		–40°C ≤ T_A ≤ +125°C			1,000			1,000	pA
Input Offset Current	I_{OS}			0.1	30		0.1	100	pA
		–40°C ≤ T_A ≤ +85°C		6	50		6	100	pA
		–40°C ≤ T_A ≤ +125°C		25	500		25	500	pA
Input Voltage Range			0		5	0		5	V
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0 V to 5 V	74	89		56	67		dB
Large Signal Voltage Gain	A_{VO}	V_O = 0.5 V to 4.5 V, R_L = 2 kΩ, V_{CM} = 0 V	30	80		20	60		V/mV
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$			2			2		µV/°C
OUTPUT CHARACTERISTICS									
Output Voltage High	V_{OH}	I_L = 1.0 mA	4.925	4.975		4.925	4.975		V
		I_L = 10 mA	4.7	4.77		4.7	4.77		V
		–40°C ≤ T_A ≤ +125°C	4.6			4.6			V
Output Voltage Low	V_{OL}	I_L = 1.0 mA		15	30		15	30	mV
		I_L = 10 mA		125	175		125	175	mV
		–40°C ≤ T_A ≤ +125°C			250			250	mV
Output Current	I_{OUT}			±50			±50		mA
Closed-Loop Output Impedance	Z_{OUT}	f = 1 MHz, A_V = 1		10			10		Ω
POWER SUPPLY									
Power Supply Rejection Ratio	PSRR	V_S = 2.7 V to 5.5 V	67	80		56	72		dB
Supply Current/Amplifier	I_{SY}	V_O = 0 V		750	1,200		750	1,200	µA
		–40°C ≤ T_A ≤ +125°C			1,500			1,500	µA
DYNAMIC PERFORMANCE									
Slew Rate	SR	R_L = 2 kΩ		6			6		V/µs
Settling Time	t_S	To 0.01%		<1.0			<1.0		µs
Full Power Bandwidth	BWp	< 1% Distortion		360			360		kHz
Gain Bandwidth Product	GBP			8.4			8.4		MHz
Phase Margin	Φo			55			55		Degrees
NOISE PERFORMANCE									
Voltage Noise Density	e_n	f = 1 kHz		33			33		nV/√Hz
	e_n	f = 10 kHz		18			18		nV/√Hz
Current Noise Density	i_n	f = 1 kHz		0.05			0.05		pA/√Hz

Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS*

Supply Voltage . . . . . 6 V
Input Voltage . . . . . GND to V_S
Differential Input Voltage . . . . . ±6 V
Storage Temperature Range
R, RM, RT, RU Packages . . . . . –65°C to +150°C
Operating Temperature Range
AD8601/AD8602/AD8604 . . . . . –40°C to +125°C
Junction Temperature Range
R, RM, RT, RU Packages . . . . . –65°C to +150°C
Lead Temperature Range (Soldering, 60 sec) . . . . . 300°C
ESD . . . . . 2 kV HBM

*Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Package Type	θ_{JA}*	θ_{JC}	Unit
5-Lead SOT-23 (RT)	230	92	°C/W
8-Lead SOIC (R)	158	43	°C/W
8-Lead MSOP (RM)	210	45	°C/W
14-Lead SOIC (R)	120	36	°C/W
14-Lead TSSOP (RU)	180	35	°C/W

*θ_{JA} is specified for worst-case conditions, i.e., θ_{JA} is specified for device in socket for PDIP packages; θ_{JA} is specified for device soldered onto a circuit board for surface-mount packages.

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option	Branding
AD8601ART-R2	–40°C to +125°C	5-Lead SOT-23	RT-5	AAA
AD8601ART-REEL	–40°C to +125°C	5-Lead SOT-23	RT-5	AAA
AD8601ART-REEL7	–40°C to +125°C	5-Lead SOT-23	RT-5	AAA
AD8601DRT-R2	–40°C to +125°C	5-Lead SOT-23	RT-5	AAD
AD8601DRT-REEL	–40°C to +125°C	5-Lead SOT-23	RT-5	AAD
AD8601DRT-REEL7	–40°C to +125°C	5-Lead SOT-23	RT-5	AAD
AD8602AR	–40°C to +125°C	8-Lead SOIC	R-8	
AD8602AR-REEL7	–40°C to +125°C	8-Lead SOIC	R-8	
AD8602AR-R2	–40°C to +125°C	8-Lead SOIC	R-8	
AD8602DR	–40°C to +125°C	8-Lead SOIC	R-8	
AD8602DR-REEL	–40°C to +125°C	8-Lead SOIC	R-8	
AD8602DR-REEL7	–40°C to +125°C	8-Lead SOIC	R-8	
AD8602ARM-R2	–40°C to +125°C	8-Lead MSOP	RM-8	ABA
AD8602ARM-REEL	–40°C to +125°C	8-Lead MSOP	RM-8	ABA
AD8602DRM-REEL	–40°C to +125°C	8-Lead MSOP	RM-8	ABD
AD8604AR	–40°C to +125°C	14-Lead SOIC	R-14	
AD8604AR-REEL	–40°C to +125°C	14-Lead SOIC	R-14	
AD8604AR-REEL7	–40°C to +125°C	14-Lead SOIC	R-14	
AD8604DR	–40°C to +125°C	14-Lead SOIC	R-14	
AD8604DR-REEL	–40°C to +125°C	14-Lead SOIC	R-14	
AD8604ARU	–40°C to +125°C	14-Lead TSSOP	RU-14	
AD8604ARU-REEL	–40°C to +125°C	14-Lead TSSOP	RU-14	
AD8604DRU	–40°C to +125°C	14-Lead TSSOP	RU-14	
AD8604DRU-REEL	–40°C to +125°C	14-Lead TSSOP	RU-14	

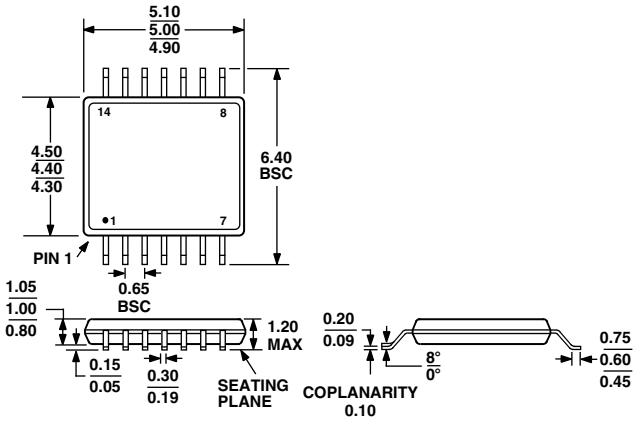
CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the AD8601/AD8602/AD8604 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

OUTLINE DIMENSIONS

14-Lead Thin Shrink Small Outline Package [TSSOP] (RU-14)

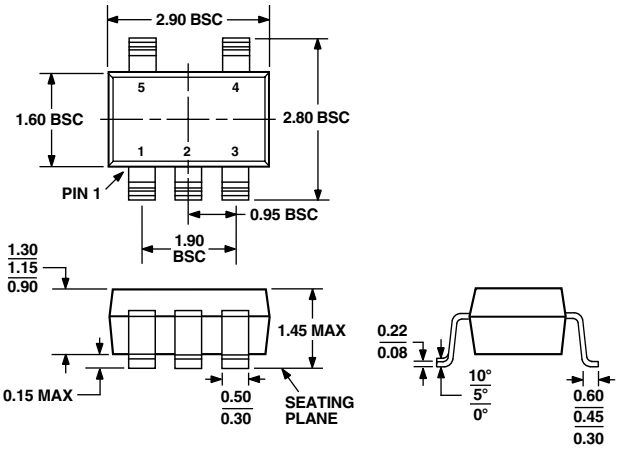
Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-153AB-1

5-Lead Small Outline Transistor Package [SOT-23] (RT-5)

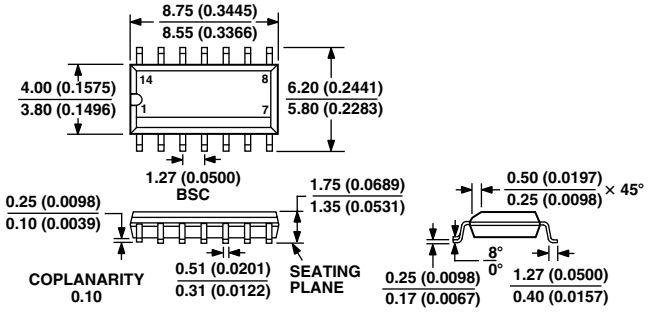
Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-178AA

14-Lead Standard Small Outline Package [SOIC] (R-14)

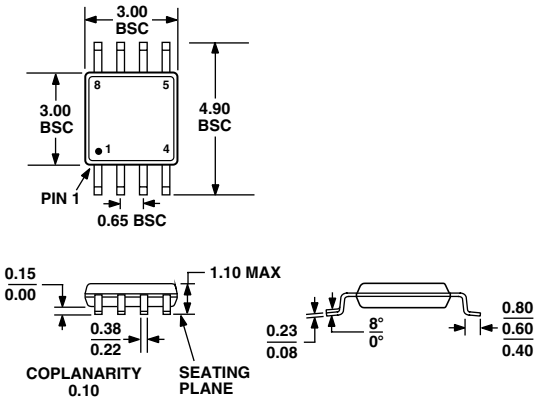
Dimensions shown in millimeters and (inches)



COMPLIANT TO JEDEC STANDARDS MS-012AB
CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS
(IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR
REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN

8-Lead Mini Small Outline Package [MSOP] (RM-8)

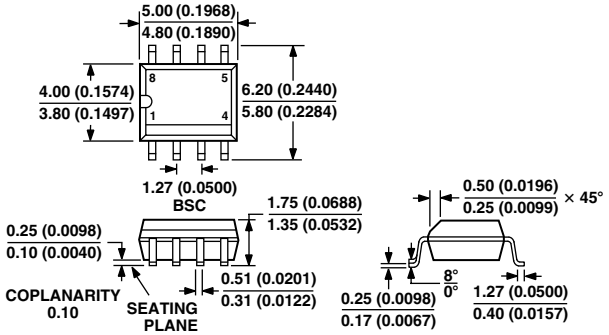
Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-187AA

8-Lead Standard Small Outline Package [SOIC] (R-8)

Dimensions shown in millimeters and (inches)



COMPLIANT TO JEDEC STANDARDS MS-012AA
CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS
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