Low Noise, High Speed Amplifier for 16-Bit Systems

AD8021

FEATURES

- **Low noise**
  - **2.1 nV/√Hz input voltage noise**
  - **2.1 pA/√Hz input current noise**
- **Custom compensation**
  - **Constant bandwidth from G = −1 to G = −10**
- **High speed**
  - **200 MHz (G = −1)**
  - **190 MHz (G = −10)**
- **Low power**
  - **34 mW or 6.7 mA typical for 5 V supply**
- **Output disable feature, 1.3 mA**
- **Low distortion**
  - **−93 dBc second harmonic, f_C = 1 MHz**
  - **−108 dBc third harmonic, f_C = 1 MHz**
- **DC precision**
  - **1 mV maximum input offset voltage**
  - **0.5 µV/°C input offset voltage drift**
- **Wide supply range, 5 V to 24 V**
- **Low price**
- **Small packaging**
  - **Available in SOIC-8 and MSOP-8**

APPLICATIONS

- **ADC preamps and drivers**
- **Instrumentation preamps**
  - **Active filters**
- **Portable instrumentation**
- **Line receivers**
- **Precision instruments**
  - **Ultrasound signal processing**
  - **High gain circuits**

GENERAL DESCRIPTION

The AD8021 is an exceptionally high performance, high speed voltage feedback amplifier that can be used in 16-bit resolution systems. It is designed to have both low voltage and low current noise (2.1 nV/√Hz typical and 2.1 pA/√Hz typical) while operating at the lowest quiescent supply current (7 mA @ ±5 V) among today's high speed, low noise op amps. The AD8021 operates over a wide range of supply voltages from ±2.25 V to ±12 V, as well as from single 5 V supplies, making it ideal for high speed, low power instruments. An output disable pin allows further reduction of the quiescent supply current to 1.3 mA.

CONNECTION DIAGRAM

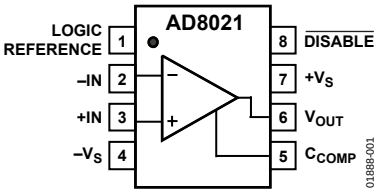


Figure 1. SOIC-8 (R-8) and MSOP-8 (RM-8)

The AD8021 allows the user to choose the gain bandwidth product that best suits the application. With a single capacitor, the user can compensate the AD8021 for the desired gain with little trade-off in bandwidth. The AD8021 is a well-behaved amplifier that settles to 0.01% in 23 ns for a 1 V step. It has a fast overload recovery of 50 ns.

The AD8021 is stable over temperature with low input offset voltage drift and input bias current drift, 0.5 µV/°C and 10 nA/°C, respectively. The AD8021 is also capable of driving a 75 Ω line with ±3 V video signals.

The AD8021 is both technically superior and priced considerably less than comparable amps drawing much higher quiescent current. The AD8021 is a high speed, general-purpose amplifier, ideal for a wide variety of gain configurations and can be used throughout a signal processing chain and in control loops. The AD8021 is available in both standard 8-lead SOIC and MSOP packages in the industrial temperature range of −40°C to +85°C.

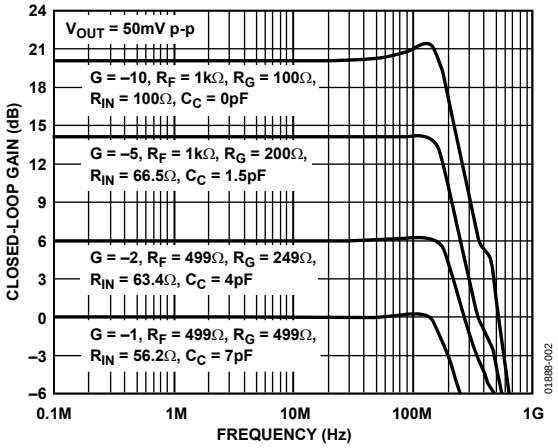


Figure 2. Small Signal Frequency Response

SPECIFICATIONS

V_S = ±5 V, @ T_A = 25°C, R_L = 1 kΩ, gain = +2, unless otherwise noted.

Table 1.

Parameter	Conditions	AD8021AR/AD8021ARM Min	Typ	Max	Unit
DYNAMIC PERFORMANCE					
−3 dB Small Signal Bandwidth	G = +1, C_C = 10 pF, V_O = 0.05 V p-p	355	490		MHz
	G = +2, C_C = 7 pF, V_O = 0.05 V p-p	160	205		MHz
	G = +5, C_C = 2 pF, V_O = 0.05 V p-p	150	185		MHz
	G = +10, C_C = 0 pF, V_O = 0.05 V p-p	110	150		MHz
Slew Rate, 1 V Step	G = +1, C_C = 10 pF	95	120		V/µs
	G = +2, C_C = 7 pF	120	150		V/µs
	G = +5, C_C = 2 pF	250	300		V/µs
	G = +10, C_C = 0 pF	380	420		V/µs
Settling Time to 0.01%	V_O = 1 V step, R_L = 500 Ω		23		ns
Overload Recovery (50%)	±2.5 V input step, G = +2		50		ns
DISTORTION/NOISE PERFORMANCE					
f = 1 MHz					
HD2	V_O = 2 V p-p		−93		dBc
HD3	V_O = 2 V p-p		−108		dBc
f = 5 MHz					
HD2	V_O = 2 V p-p		−70		dBc
HD3	V_O = 2 V p-p		−80		dBc
Input Voltage Noise	f = 50 kHz		2.1	2.6	nV/√Hz
Input Current Noise	f = 50 kHz		2.1		pA/√Hz
Differential Gain Error	NTSC, R_L = 150 Ω		0.03		%
Differential Phase Error	NTSC, R_L = 150 Ω		0.04		Degrees
DC PERFORMANCE					
Input Offset Voltage			0.4	1.0	mV
Input Offset Voltage Drift	T_{MIN} to T_{MAX}		0.5		µV/°C
Input Bias Current	+Input or −input		7.5	10.5	µA
Input Bias Current Drift			10		nA/°C
Input Offset Current			0.1	0.5	±µA
Open-Loop Gain		82	86		dB
INPUT CHARACTERISTICS					
Input Resistance			10		MΩ
Common-Mode Input Capacitance			1		pF
Input Common-Mode Voltage Range			−4.1 to +4.6		V
Common-Mode Rejection Ratio	V_{CM} = ±4 V	−86	−98		dB
OUTPUT CHARACTERISTICS					
Output Voltage Swing		−3.5 to +3.2	−3.8 to +3.4		V
Linear Output Current			60		mA
Short-Circuit Current			75		mA
Capacitive Load Drive for 30% Overshoot	V_O = 50 mV p-p/1 V p-p		15/120		pF
DISABLE CHARACTERISTICS					
Off Isolation	f = 10 MHz		−40		dB
Turn-On Time	V_O = 0 V to 2 V, 50% logic to 50% output		45		ns
Turn-Off Time	V_O = 0 V to 2 V, 50% logic to 50% output		50		ns
$\overline{\text{DISABLE}}$ Voltage—Off/On	$V_{\overline{\text{DISABLE}}}$ − $V_{\text{LOGIC REFERENCE}}$		1.75/1.90		V
Enabled Leakage Current	LOGIC REFERENCE = 0.4 V		70		µA
	$\overline{\text{DISABLE}}$ = 4.0 V		2		µA

Parameter	Conditions	AD8021AR/AD8021ARM Min	Typ	Max	Unit
Disabled Leakage Current	LOGIC REFERENCE = 0.4 V		30		µA
	$\overline{\text{DISABLE}}$ = 0.4 V		33		µA
POWER SUPPLY					
Operating Range		±2.25	±5	±12.0	V
Quiescent Current	Output enabled		7.0	7.7	mA
	Output disabled		1.3	1.6	mA
+Power Supply Rejection Ratio	V_{CC} = 4 V to 6 V, V_{EE} = −5 V	−86	−95		dB
−Power Supply Rejection Ratio	V_{CC} = 5 V, V_{EE} = −6 V to −4 V	−86	−95		dB

V_S = ±12 V, @ T_A = 25°C, R_L = 1 kΩ, gain = +2, unless otherwise noted.

Table 2.

Parameter	Conditions	AD8021AR/AD8021ARM Min	Typ	Max	Unit
DYNAMIC PERFORMANCE					
−3 dB Small Signal Bandwidth	G = +1, C_C = 10 pF, V_O = 0.05 V p-p	520	560		MHz
	G = +2, C_C = 7 pF, V_O = 0.05 V p-p	175	220		MHz
	G = +5, C_C = 2 pF, V_O = 0.05 V p-p	170	200		MHz
	G = +10, C_C = 0 pF, V_O = 0.05 V p-p	125	165		MHz
Slew Rate, 1 V Step	G = +1, C_C = 10 pF	105	130		V/µs
	G = +2, C_C = 7 pF	140	170		V/µs
	G = +5, C_C = 2 pF	265	340		V/µs
	G = +10, C_C = 0 pF	400	460		V/µs
Settling Time to 0.01%	V_O = 1 V step, R_L = 500 Ω		21		ns
Overload Recovery (50%)	±6 V input step, G = +2		90		ns
DISTORTION/NOISE PERFORMANCE					
f = 1 MHz					
HD2	V_O = 2 V p-p		−95		dBc
HD3	V_O = 2 V p-p		−116		dBc
f = 5 MHz					
HD2	V_O = 2 V p-p		−71		dBc
HD3	V_O = 2 V p-p		−83		dBc
Input Voltage Noise	f = 50 kHz		2.1	2.6	nV/√Hz
Input Current Noise	f = 50 kHz		2.1		pA/√Hz
Differential Gain Error	NTSC, R_L = 150 Ω		0.03		%
Differential Phase Error	NTSC, R_L = 150 Ω		0.04		Degrees
DC PERFORMANCE					
Input Offset Voltage			0.4	1.0	mV
Input Offset Voltage Drift	T_{MIN} to T_{MAX}		0.2		µV/°C
Input Bias Current	+Input or −input		8	11.3	µA
Input Bias Current Drift			10		nA/°C
Input Offset Current			0.1	0.5	±µA
Open-Loop Gain		84	88		dB
INPUT CHARACTERISTICS					
Input Resistance			10		MΩ
Common-Mode Input Capacitance			1		pF
Input Common-Mode Voltage Range			−11.1 to +11.6		V
Common-Mode Rejection Ratio	V_{CM} = ±10 V	−86	−96		dB

Parameter	Conditions	AD8021AR/AD8021ARM Min	Typ	Max	Unit
OUTPUT CHARACTERISTICS					
Output Voltage Swing		−10.2 to +9.8	−10.6 to +10.2		V
Linear Output Current			70		mA
Short-Circuit Current			115		mA
Capacitive Load Drive for 30% Overshoot	V_O = 50 mV p-p/1 V p-p		15/120		pF
DISABLE CHARACTERISTICS					
Off Isolation	f = 10 MHz		−40		dB
Turn-On Time	V_O = 0 V to 2 V, 50% logic to 50% output		45		ns
Turn-Off Time	V_O = 0 V to 2 V, 50% logic to 50% output		50		ns
$\overline{\text{DISABLE}}$ Voltage—Off/On	$V_{\overline{\text{DISABLE}}} - V_{\text{LOGIC REFERENCE}}$		1.80/1.95		V
Enabled Leakage Current	LOGIC REFERENCE = 0.4 V		70		µA
	$\overline{\text{DISABLE}}$ = 4.0 V		2		µA
Disabled Leakage Current	LOGIC REFERENCE = 0.4 V		30		µA
	$\overline{\text{DISABLE}}$ = 0.4 V		33		µA
POWER SUPPLY					
Operating Range		±2.25	±5	±12.0	V
Quiescent Current	Output enabled		7.8	8.6	mA
	Output disabled		1.7	2.0	mA
+Power Supply Rejection Ratio	V_{CC} = 11 V to 13 V, V_{EE} = −12 V	−86	−96		dB
−Power Supply Rejection Ratio	V_{CC} = 12 V, V_{EE} = −13 V to −11 V	−86	−100		dB

V_S = 5 V, @ T_A = 25°C, R_L = 1 kΩ, gain = +2, unless otherwise noted.

Table 3.

Parameter	Conditions	AD8021AR/AD8021ARM Min	Typ	Max	Unit
DYNAMIC PERFORMANCE					
−3 dB Small Signal Bandwidth	G = +1, C_C = 10 pF, V_O = 0.05 V p-p	270	305		MHz
	G = +2, C_C = 7 pF, V_O = 0.05 V p-p	155	190		MHz
	G = +5, C_C = 2 pF, V_O = 0.05 V p-p	135	165		MHz
	G = +10, C_C = 0 pF, V_O = 0.05 V p-p	95	130		MHz
Slew Rate, 1 V Step	G = +1, C_C = 10 pF	80	110		V/µs
	G = +2, C_C = 7 pF	110	140		V/µs
	G = +5, C_C = 2 pF	210	280		V/µs
	G = +10, C_C = 0 pF	290	390		V/µs
Settling Time to 0.01%	V_O = 1 V step, R_L = 500 Ω		28		ns
Overload Recovery (50%)	0 V to 2.5 V input step, G = +2		40		ns
DISTORTION/NOISE PERFORMANCE					
f = 1 MHz					
HD2	V_O = 2 V p-p		−84		dBc
HD3	V_O = 2 V p-p		−91		dBc
f = 5 MHz					
HD2	V_O = 2 V p-p		−68		dBc
HD3	V_O = 2 V p-p		−81		dBc
Input Voltage Noise	f = 50 kHz		2.1	2.6	nV/√Hz
Input Current Noise	f = 50 kHz		2.1		pA/√Hz

Parameter	Conditions	AD8021AR/AD8021ARM Min	Typ	Max	Unit
DC PERFORMANCE					
Input Offset Voltage			0.4	1.0	mV
Input Offset Voltage Drift	T_{MIN} to T_{MAX}		0.8		µV/°C
Input Bias Current	+Input or −input		7.5	10.3	µA
Input Bias Current Drift			10		nA/°C
Input Offset Current			0.1	0.5	±µA
Open-Loop Gain		72	76		dB
INPUT CHARACTERISTICS					
Input Resistance			10		MΩ
Common-Mode Input Capacitance			1		pF
Input Common-Mode Voltage Range			0.9 to 4.6		V
Common-Mode Rejection Ratio	1.5 V to 3.5 V	−84	−98		dB
OUTPUT CHARACTERISTICS					
Output Voltage Swing		1.25 to 3.38	1.10 to 3.60		V
Linear Output Current			30		mA
Short-Circuit Current			50		mA
Capacitive Load Drive for 30% Overshoot	V_O = 50 mV p-p/1 V p-p		10/120		pF
DISABLE CHARACTERISTICS					
Off Isolation	f = 10 MHz		−40		dB
Turn-On Time	V_O = 0 V to 1 V, 50% logic to 50% output		45		ns
Turn-Off Time	V_O = 0 V to 1 V, 50% logic to 50% output		50		ns
$\overline{\text{DISABLE}}$ Voltage—Off/On	$V_{DISABLE} - V_{LOGIC\ REFERENCE}$		1.55/1.70		V
Enabled Leakage Current	LOGIC REFERENCE = 0.4 V		70		µA
	$\overline{\text{DISABLE}}$ = 4.0 V		2		µA
Disabled Leakage Current	LOGIC REFERENCE = 0.4 V		30		µA
	$\overline{\text{DISABLE}}$ = 0.4 V		33		µA
POWER SUPPLY					
Operating Range		±2.25	±5	±12.0	V
Quiescent Current	Output enabled		6.7	7.5	mA
	Output disabled		1.2	1.5	mA
+Power Supply Rejection Ratio	V_{CC} = 4.5 V to 5.5 V, V_{EE} = 0 V	−74	−82		dB
−Power Supply Rejection Ratio	V_{CC} = 5 V, V_{EE} = −0.5 V to +0.5 V	−76	−84		dB

ABSOLUTE MAXIMUM RATINGS

Table 4.

Parameter	Rating
Supply Voltage	26.4 V
Power Dissipation	Observed power derating curves
Input Voltage (Common Mode)	$\pm V_S \pm 1$ V
Differential Input Voltage[1]	±0.8 V
Differential Input Current	±10 mA
Output Short-Circuit Duration	Observed power derating curves
Storage Temperature Range	−65°C to +125°C
Operating Temperature Range	−40°C to +85°C
Lead Temperature (Soldering, 10 sec)	300°C

[1] The AD8021 inputs are protected by diodes. Current-limiting resistors are not used to preserve the low noise. If a differential input exceeds ±0.8 V, the input current should be limited to ±10 mA.

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 indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

MAXIMUM POWER DISSIPATION

The maximum power that can be safely dissipated by the AD8021 is limited by the associated rise in junction temperature. The maximum safe junction temperature for plastic encapsulated devices is determined by the glass transition temperature of the plastic, approximately 150°C. Temporarily exceeding this limit can cause a shift in parametric performance due to a change in the stresses exerted on the die by the package. Exceeding a junction temperature of 175°C for an extended period can result in device failure.

While the AD8021 is internally short-circuit protected, this can not be sufficient to guarantee that the maximum junction temperature (150°C) is not exceeded under all conditions. To ensure proper operation, it is necessary to observe the maximum power derating curves.

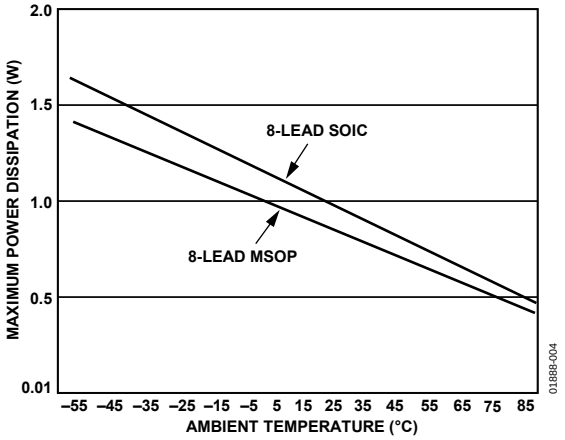


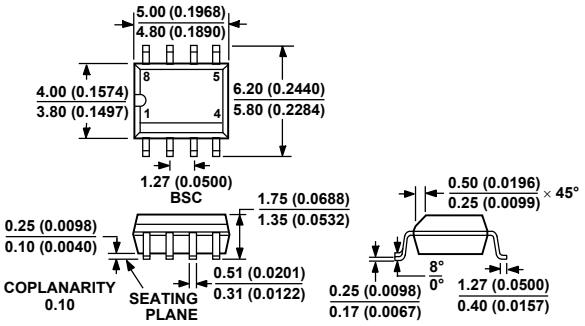
Figure 3. Maximum Power Dissipation vs. Temperature[1]

[1] Specification is for device in free air: 8-lead SOIC: θ_{JA} = 125°C/W; 8-lead MSOP: θ_{JA} = 145°C/W.

ESD CAUTION

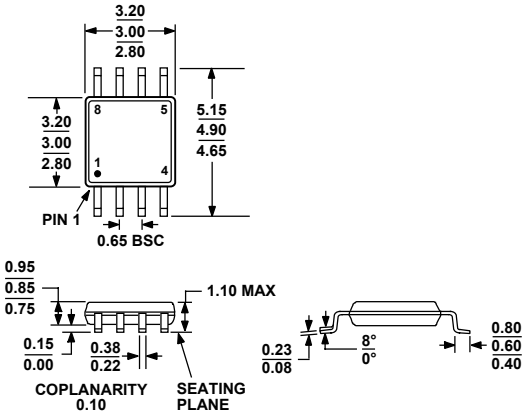
ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to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

OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MS-012-AA
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.

Figure 72. 8-Lead Standard Small Outline Package [SOIC]
Narrow Body (R-8)
Dimensions shown in millimeters and (inches)



COMPLIANT TO JEDEC STANDARDS MO-187-AA

Figure 73. 8-Lead Mini Small Outline Package [MSOP]
(RM-8)
Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option	Branding
AD8021AR	−40°C to +85°C	8-Lead SOIC	R-8	
AD8021AR-REEL	−40°C to +85°C	8-Lead SOIC	R-8	
AD8021AR-REEL7	−40°C to +85°C	8-Lead SOIC	R-8	
AD8021ARZ[1]	−40°C to +85°C	8-Lead SOIC	R-8	
AD8021ARZ-REEL[1]	−40°C to +85°C	8-Lead SOIC	R-8	
AD8021ARZ-REEL7[1]	−40°C to +85°C	8-Lead SOIC	R-8	
AD8021ARM	−40°C to +85°C	8-Lead MSOP	RM-8	HNA
AD8021ARM-REEL	−40°C to +85°C	8-Lead MSOP	RM-8	HNA
AD8021ARM-REEL7	−40°C to +85°C	8-Lead MSOP	RM-8	HNA
AD8021ARMZ[1]	−40°C to +85°C	8-Lead MSOP	RM-8	HNA#
AD8021ARMZ-REEL[1]	−40°C to +85°C	8-Lead MSOP	RM-8	HNA#
AD8021ARMZ-REEL7[1]	−40°C to +85°C	8-Lead MSOP	RM-8	HNA#

[1]Z = Pb-free part, # denotes lead-free product may be top or bottom marked.