Data Sheet

ADH8412S

Commercial Space Product

Low Noise Amplifier, 0.4 GHz to 11 GHz

FEATURES

- Low noise figure: 1.4 dB typical at 0.4 GHz to 3 GHz
- Single positive supply (self biased)
- High gain: ≤15.5 dB typical
- High OIP3: ≤33 dBm typical
- RoHS compliant, 2 mm × 2 mm, 6-lead LFCSP

COMMERCIAL SPACE FEATURES

- Supports aerospace applications
- Wafer diffusion lot traceability
- Radiation monitor
  - TID benchmark characterization
  - Radiation lot acceptance test (RLAT) for production TID assurance
  - Single event latch-up (SEL) benchmark characterization
- Outgassing characterization
- Commercial space high (CSH) features
  - Certificate of conformance
  - Qualification based on flows per NASA PEM-INST-001 and SAE AS6294
  - Burn-in, life test, and delta analysis

APPLICATIONS

- Aerospace
- Satellite missions across multiple orbits:
  - Commercial space low (CSL) product flow targeted at short mission-life low Earth orbit (LEO) missions
  - CSH product flow targeted at high-reliability, longer-life, or higher-orbit missions
- Military radar
- Satellite communications
- Avionics
- Electronic warfare

FUNCTIONAL BLOCK DIAGRAM

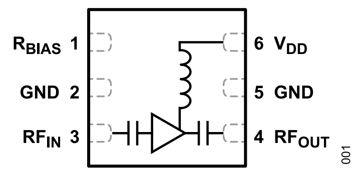

Figure 1. Functional Block Diagram

GENERAL DESCRIPTION

The ADH8412S is a gallium arsenide (GaAs), monolithic microwave IC (MMIC), pseudomorphic high electron mobility transistor (pHEMT), low noise wideband amplifier that operates from 0.4 GHz to 11 GHz.

The ADH8412S provides a typical gain of 15.5 dB, a 1.4 dB typical noise figure, and a typical output third-order intercept (OIP3) of ≤33 dBm, requiring only 60 mA from a 5 V drain supply voltage. The saturated output power (P_{SAT}) of ≤20.5 dBm typical enables the low noise amplifier (LNA) to function as a local oscillator (LO) driver for many Analog Devices, Inc., balanced, in-phase and quadrature (I/Q), or image rejection mixers.

The ADH8412S also features inputs and outputs that are internally matched to 50 Ω, making the device ideal for surface-mount technology (SMT)-based, space applications.

The ADH8412S is housed in a 2 mm × 2 mm, 6-lead lead frame chip scale package [LFCSP].

Additional application and technical information can be found in the Commercial Space Products Program brochure and HMC8412 data sheet.

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REVISION HISTORY

9/2025—Rev. 0 to Rev. A

Changed ADH8412S-CSL to ADH8412S (Throughout).. 1
Changes to Commercial Space Features Section, Applications Section, and Figure 1................................. 1
Changes to 0.4 GHz to 3 GHz Frequency Range Section and Table 1..3
Changes to 3 GHz to 9 GHz Frequency Range Section and Table 2..4
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Added Explanation of Test Levels section and Table 8...7
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2/2024—Revision 0: Initial Version

SPECIFICATIONS

0.4 GHz TO 3 GHz FREQUENCY RANGE

V_{DD} = 5V, supply current (I_{DQ}) = 60mA, and bias resistor (R_{BIAS}) = 1.47kΩ. Minimum and maximum specifications represent performance at −55°C ≤ T_A ≤ +125°C, unless otherwise noted. Typical specifications represent performance at T_A = 25°C.

Table 1. 0.4 GHz to 3 GHz Frequency Range

Parameter	Test Conditions/Comments	Test Level [1]	Temperature (T_A)[2]	Min	Typ	Max	Unit
FREQUENCY RANGE				0.4		3	GHz
GAIN		I	Full	13	15.5		dB
Gain Variation over Temperature		III	Full		0.010		dB/°C
NOISE FIGURE		III	Full		1.4		dB
RETURN LOSS		III	Full				
Input					14		dB
Output					13		dB
OUTPUT							
Power for 1 dB Compression (OP1dB)		I	Full	15	18		dBm
P_{SAT}		III	Full		20.5		dBm
OIP3	Measurement taken at output power (P_{OUT}) per tone = 0 dBm	I	Full		32		dBm
Second-Order Intercept (OIP2)	Measurement taken at P_{OUT} per tone = 0 dBm	III	Full		40		dBm
POWER ADDED EFFICIENCY (PAE)	Measured at P_{SAT}	III	Full		28		%
V_{DD}	Minimum and maximum limit specifications apply to the CSH models only			2	5	6	V
Supply Current							
I_{DQ}		I	Full	40	60	80	mA
Amplifier Current (I_{DQ_AMP})		II	25°C		58.04		mA
R_{BIAS} Current (I_{RBIAS})		II	25°C		1.96		mA

1 Refer to Explanation of Test Levels for an explanation of the test levels.

2 The CSH models are tested at minimum, room, and maximum temperatures, while the CSL models are tested only at ambient temperature.

SPECIFICATIONS

3 GHz TO 9 GHz FREQUENCY RANGE

V_{DD} = V, I_{DQ} = 60mA, and R_{BIAS} = 1.47kΩ. Minimum and maximum specifications represent performance at −55°C ≤ T_A ≤ +125°C, unless otherwise noted. Typical specifications represent performance at T_A = 25°C.

Table 2. 3 GHz to 9 GHz Frequency Range

Parameter	Test Conditions/Comments	Test Level[1]	Temperature (T_A)[2]	Min	Typ	Max	Unit
FREQUENCY RANGE				3		9	GHz
GAIN		I	Full	13	15		dB
Gain Variation over Temperature		III	Full		0.012		dB/°C
NOISE FIGURE		I	Full		1.5		dB
RETURN LOSS		III	Full				
Input					15		dB
Output					16		dB
OUTPUT							
OP1dB		I	Full	15.5	18		dBm
P_{SAT}		III	Full		20.5		dBm
OIP3	Measurement taken at P_{OUT} per tone = 0dBm	I	Full		33		dBm
OIP2	Measurement taken at P_{OUT} per tone = 0dBm	III	Full		41.5		dBm
PAE	Measured at P_{SAT}	III	Full		29		%
V_{DD}	Minimum and maximum limit specifications apply to the CSH models only			2	5	6	V
Supply Current							
I_{DQ}		I	Full	40	60	80	mA
Amplifier Current (I_{DQ_AMP})		II	25°C		58.04		mA
R_{BIAS} Current (I_{RBIAS})		II	25°C		1.96		mA

1 Refer to Explanation of Test Levels for an explanation of the test levels.

2 The CSH models are tested at minimum, room, and maximum temperatures, while the CSL models are tested only at ambient temperature.

SPECIFICATIONS

9 GHz TO 11 GHz FREQUENCY RANGE

V_{DD} = 5V, I_{DQ} = 60mA, and R_{BIAS} = 1.47kΩ. Minimum and maximum specifications represent performance at −55°C ≤ T_A ≤ +125°C, unless otherwise noted. Typical specifications represent performance at T_A = 25°C.

Table 3. 9 GHz to 11 GHz Frequency Range

Parameter	Test Conditions/Comments	Test Level[1]	Temperature (T_A)[2]	Min	Typ	Max	Unit
FREQUENCY RANGE				9		11	GHz
GAIN		I	Full	12	14		dB
Gain Variation over Temperature		III	Full		0.022		dB/°C
NOISE FIGURE		III	Full		1.8		dB
RETURN LOSS		III	Full				
Input					14		dB
Output					10		dB
OUTPUT							
OP1dB		I	Full	11	14		dBm
P_{SAT}		III	Full		18		dBm
OIP3	Measurement taken at P_{OUT} per tone = 0dBm	I	Full		31		dBm
OIP2	Measurement taken at P_{OUT} per tone = 0dBm	III	Full		49.5		dBm
PAE	Measured at P_{SAT}	III	Full		15.5		%
V_{DD}	Minimum and maximum limit specifications apply to the CSH models only			2	5	6	V
Supply Current							
I_{DQ}		I	Full	40	60	80	mA
Amplifier Current (I_{DQ_AMP})		II	25°C		58.04		mA
R_{BIAS} Current (I_{RBIAS})		II	25°C		1.96		mA

1 Refer to Explanation of Test Levels for an explanation of the test levels.

2 The CSH models are tested at minimum, room, and maximum temperatures, while the CSL models are tested only at ambient temperature.

SPECIFICATIONS

BURN-IN DELTA LIMIT SPECIFICATIONS

V_{DD} = 5V, I_{DQ} = 60mA, and R_{BIAS} = 1.47kΩ. Delta limits apply at room temperature (T_A = 25°C) for post 240 hour burn-in test. Delta calculation is based on absolute maximum changes.

The burn-in delta limit specifications only apply to the CSH models.

Table 4. Burn-In Delta Limit Specifications

Parameter[1, 2]	Delta	Unit
I_{DQ}	7.5	mA
GAIN		
1GHz	1.5	dB
3GHz	1.5	dB
6GHz	2	dB

1 Delta = Maximum (Absolute (Maximum Post 240 Hour Burn-In Data − Minimum Pre 240 Hour Burn-In Data), Absolute (Minimum Post 240 Hour Burn-In Data − Maximum Pre 240 Hour Burn-In Data))

2 Devices are not serialized during testing.

RADIATION TEST AND LIMIT SPECIFICATIONS

V_{DD} = 5 V, I_{DQ} = 60 mA, R_{BIAS} = 1.47 kΩ, and T_A = 25°C, unless otherwise noted. Total ionizing dose (TID) testing is characterized to 30 krads for the CSL models and 100 krads for the CSH models.

Table 5. Radiation Test and Limit Specifications

Parameter	Min	Typ	Max	Unit
GAIN				
Frequency (f) = 1 GHz to 3 GHz	13	15.5		dB
f = 6 GHz	13	15		dB
f = 10 GHz	12	14		dB
OUTPUT				
OP1dB				
f = 1 GHz to 3 GHz	15	18		dBm
f = 6 GHz	15.5	18		dBm
f = 10 GHz	11	14		dBm
SUPPLY				
I_{DQ}		60	80	mA

ABSOLUTE MAXIMUM RATINGS

Table 6. Absolute Maximum Ratings

Parameter	Rating
V_{DD}	7 V
RF Input Power	25 dBm
Continuous Power Dissipation (P_{DISS})	
T_{CASE} = 85°C	0.82 W
T_{CASE} = 125°C	0.46 W
Temperature	
Storage Range	−65°C to +150°C
Operating Range	−55°C to +125°C
Peak Reflow (Moisture Sensitivity Level 1 (MSL1))	260°C
T_J to Maintain 1,000,000 Hours Mean Time to Failure (MTTF)	175°C
Nominal Channel Temperature (T_A = 125°C, V_{DD} = 5 V, I_{DQ} = 60 mA)	157.8°C

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

THERMAL RESISTANCE

Thermal performance is directly linked to printed circuit board (PCB) design and operating environment. Close attention to PCB thermal design is required.

θ_{JC} is the junction to case thermal resistance.

Table 7. Thermal Resistance

Package Type	θ_{JC}	Unit
CP-6-12	109.3	°C/W

EXPLANATION OF TEST LEVELS

Table 8. Explanation of Test Levels

Test Level	Description
I	100% production tested at minimum, room, and maximum operating temperature.
II	Parameter is guaranteed by design and not production tested.
III	Parameter is guaranteed by bench characterization and not production tested.

POWER DERATING CURVES

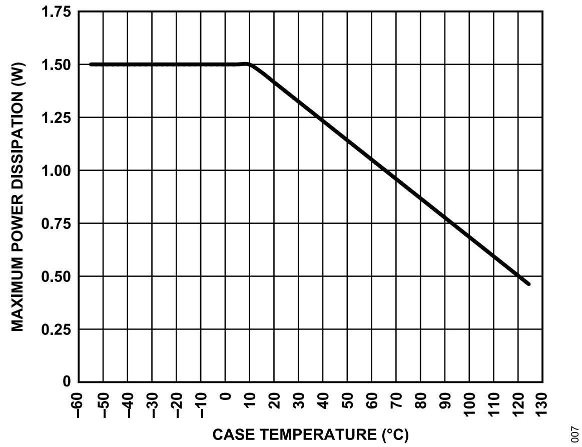

Figure 2. Maximum Power Dissipation vs. Case Temperature

OUTGAS TESTING

The criteria used for the acceptance and rejection of materials must be determined by the user and be based upon specific component and system requirements. Historically, a total mass loss (TML) of 1.00% and collected volatile condensable material (CVCM) of 0.10% have been used as screening levels for rejection of spacecraft materials.

Table 9. Outgas Testing

Specification (Tested per ASTM E595-15)	Value	Unit
Total Mass Loss	0.05	%
Collected Volatile Condensable Material	<0.01	%
Water Vapor Recovered	0.02	%

RADIATION FEATURES

Table 10. Radiation Features

Specification	Value	Unit
Maximum Total Dose Available (Dose Rate = 50 rad(Si)/s to 300 rad(Si)/s)[1]		
CSL Models	30	krad (Si)
CSH Models	100	krad (Si)

[1] Guaranteed by device and process characterization. Contact Analog Devices, Inc., Technical Support for data available from 30 krads to 100 krads.

ABSOLUTE MAXIMUM RATINGS

ELECTROSTATIC DISCHARGE (ESD) RATINGS

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

Human body model (HBM) per ANSI/ESDA/JEDEC JS-001.

Charged device model (CDM) per ANSI/ESDA/JEDEC JS-002.

ESD Ratings for ADH8412S

Table 11. ADH8412S, 6-Lead LFCSP

ESD Model	Withstand Threshold (V)	Class
HBM	±500	1B
CDM	±2000	C3

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

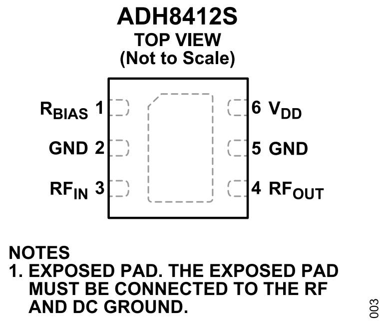

Figure 3. Pin Configuration

Table 12. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	R_{BIAS}	Current Mirror Bias Resistor. Use the R_{BIAS} pin to set the quiescent current by connecting the external bias resistor. Refer to the HMC8412 data sheet for the bias resistor connection and recommended bias resistor values. See Figure 4 for the interface schematic.
2, 5	GND	Ground. The GND pins must be connected to RF and DC ground. See Figure 7 for the interface schematic.
3	RF_{IN}	RF Input. The RF_{IN} pin is AC-coupled and matched to 50 Ω. See Figure 5 for the interface schematic.
4	RF_{OUT}	RF Output. The RF_{OUT} pin is AC-coupled and matched to 50 Ω. See Figure 6 for the interface schematic.
6	V_{DD}	Drain Supply Voltage for the Amplifier. See Figure 6 for the interface schematic.
	EPAD	Exposed Pad. The exposed pad must be connected to the RF and DC ground.

INTERFACE SCHEMATICS

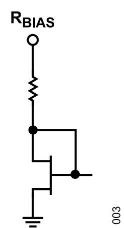

Figure 4. R_{BIAS} Interface Schematic

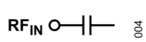

Figure 5. RF_{IN} Interface Schematic

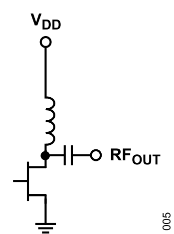

Figure 6. V_{DD} and RF_{OUT} Interface Schematic

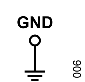

Figure 7. GND Interface Schematic

TYPICAL PERFORMANCE CHARACTERISTICS

See the HMC8412TCPZ-EP data sheet for a full set of Typical Performance Characteristics plots.

OUTLINE DIMENSIONS

Package Drawing Option	Package Type	Package Description
CP-6-12	LFCSP	6-Lead Lead Frame Chip Scale Package

For the latest package outline information and land patterns (footprints), go to Package Index.

ORDERING GUIDE

Model[1, 2]	Temperature Range	Package Description	Packing Quantity	Package Option
ADH8412TCPZ-R7-CSL	−55°C to 125°C	6-Lead Lead Frame Chip Scale Package [LFCSP]	Reel, 500	CP-6-12
ADH8412TCPZ-PT-CSL	−55°C to 125°C	6-Lead Lead Frame Chip Scale Package [LFCSP]	Cut Tape, 500	CP-6-12
ADH8412TCPZ-R7-CSH	−55°C to 125°C	6-Lead Lead Frame Chip Scale Package [LFCSP]	Reel, 500	CP-6-12
ADH8412TCPZ-PT-CSH	−55°C to 125°C	6-Lead Lead Frame Chip Scale Package [LFCSP]	Cut Tape, 500	CP-6-12

[1] Z = RoHS Compliant Part.

[2] The lead finish of all models is nickel palladium gold (NiPdAu).