AFE5812 Fully Integrated, 8-Channel Ultrasound Analog Front End with Passive CW Mixer, and Digital I/Q Demodulator, 0.75nV/$\sqrt{Hz}$, 14/12-Bit, 65 MSPS, 180mW/CH

1 Features

- 8-Channel Complete Analog Front-End
  - LNA, VCAT, PGA, LPF, ADC, and CW Mixer
- Programmable Gain Low-Noise Amplifier (LNA)
  - 24, 18, 15 dB Gain
  - 0.25, 0.5, 0.7 V_{PP} Linear Input Range
  - 0.63, 0.7, 0.9 nV/rtHz Input Referred Noise
  - Programmable Active Termination
- 40 dB Low Noise Voltage Controlled Attenuator (VCAT)
- 24/30 dB Programmable Gain Amplifier (PGA)
- 3rd Order Linear Phase Low-Pass Filter (LPF)
  - 10, 15, 20, 30, 35, 50 MHz
- 14-bit Analog to Digital Converter w/ LVDS output
  - 77 dBFS SNR at 65 MSPS
- Noise/Power Optimizations (Without Digital Demodulator)
  - 180 mW/CH at 0.75 nV/rtHz, 65 MSPS
  - 109 mW/CH at 1.1 nV/rtHz, 40 MSPS
  - 107 mW/CH at CW Mode
- Excellent Device-to-Device Gain Matching
  - ±0.5 dB(typical) and ±1.1 dB(max)
- Programmable Digital I/Q Demodulator after ADC
  - Wide Range Demodulation Frequency
  - <1KHz Frequency Resolution
  - Decimation Filter Factor M = 1 to 32
  - 16xM tap FIR Decimation Filter
  - LVDS Rate Reduction after Demodulation
  - On-chip RAM with 32 preset Profiles
- Low Harmonic Distortion
- Low Frequency Sonar Signal Processing
- Fast and Consistent Overload Recovery
- Passive Mixer for Continuous Wave Doppler(CWD)
  - Low Close-in Phase Noise –156 dBc/Hz at 1 KHz off 2.5 MHz Carrier
  - Phase Resolution of 1/16λ
  - Support 16X, 8X, 4X and 1X CW Clocks
  - 12dB Suppression on 3rd and 5th Harmonics
- Small Package: 15 mm x 9 mm, 135-BGA
- Operation Temperature: -40°C to 85°C

2 Applications

- Medical Ultrasound Imaging
- Nondestructive Evaluation Equipments
- Sonar applications
- Multichannel, High-Speed Data Acquisition

3 Description

The AFE5812 is a highly-integrated analog front-end (AFE) solution specifically designed for ultrasound systems in which high performance and small size are required. The AFE5812 integrates a complete time-gain-control (TGC) imaging path and a CWD path. It also enables users to select one of various power/noise combinations to optimize system performance. Therefore, the AFE5812 is a suitable ultrasound AFE solution not only for high-end systems, but also for portable ones.

The AFE5812 contains eight channels of voltage controlled amplifier (VCA), 14-bit and 12-bit ADC, and CW mixer. The VCA includes LNA, VCAT, PGA, and LPF. The LNA gain is programmable to support 250 mV_{PP} to 0.75 V_{PP} input signals. Programmable active termination is also supported by the LNA. The ultra-low noise VCAT provides an attenuation control range of 40 dB and improves overall low-gain SNR, which benefits harmonic imaging and near-field imaging. The PGA provides gain options of 24 and 30 dB. Before the ADC, a LPF can be configured as 10, 15, 20, 30, 35 or 50 MHz to support ultrasound applications with different frequencies. In addition, the signal chain of the AFE5812 can handle signal frequency lower than 100 kHz, which enables the AFE5812 to be used in both sonar and medical applications. The high-performance 14-bit/65-MSPS ADC in the AFE5812 achieves 77 dBFS SNR. It ensures excellent SNR at low chain gain. The ADC's LVDS outputs enable flexible system integration desired for miniaturized systems.

The AFE5812 integrates a low-power passive mixer and a low-noise summing amplifier to accomplish on-chip CWD beamformer. 16 selectable phase-delays can be applied to each analog input signal. Meanwhile, a unique third- and fifth-order harmonic suppression filter is implemented to enhance CW sensitivity.

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

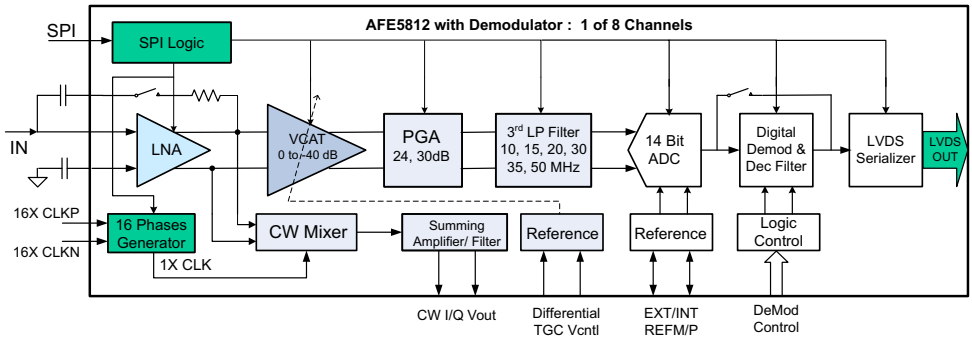
The AFE5812 also includes a digital in-phase and quadrature (I/Q) demodulator and a low-pass decimation filter. The main purpose of the demodulation block is to reduce the LVDS data rate and improve overall system power efficiency. The I/Q demodulator can accept ADC output with up to 65 MSPS sampling rate and 14-bit resolution. For example, after digital demodulation and 4× decimation filtering, the data rate for either in-phase or quadrature output is reduced to 16.25 MSPS and the data resolution is improved to 16 bits, consequently. Hence, the overall LVDS trace reduction can be a factor of 2. This demodulator can be bypassed and powered down completely if it is not needed.

The AFE5812 is available in a 15mm × 9mm, 135-pin BGA package, and it is specified for operation from –40°C to 85°C.

Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
AFE5812	ZCF (NFBGA, 135)	9mm × 15mm

(1) For all available packages, see Section 7.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Simplified Diagram

Copyright © 2024 Texas Instruments Incorporated

Table of Contents

1 Features....1
2 Applications....1
3 Description....1
4 Device Comparison....3
5 Device and Documentation Support....4
5.1 Receiving Notification of Documentation Updates....4
5.2 Support Resources....4
5.3 Trademarks....4
5.4 Electrostatic Discharge Caution....4
5.5 Glossary....4
6 Revision History....4
7 Mechanical, Packaging, and Orderable Information....4

4 Device Comparison

Table 4-1. Device Comparison

DEVICE	DESCRIPTION	PACKAGE	BODY SIZE (NOM)
AFE5818	16-Channel, Ultrasound, Analog Front-End (AFE) with 124-mW/Channel, 0.75nV/√Hz Noise, 14-Bit, 65-MSPS or 12-Bit, 80-MSPS ADC and Passive CW Mixer	NFBGA (289)	15mm × 15mm
AFE5812	Fully Integrated, 8-channel Ultrasound AFE with Passive CW Mixer, and Digital I/Q Demodulator, 0.75nV/√Hz, 14 and 12 Bits, 65 MSPS, 180mW/ch	NFBGA (135)	15mm × 9mm
AFE5809	8-Channel Ultrasound AFE with Passive CW Mixer, and Digital I/Q Demodulator, 0.75nV/√Hz, 14 and 12 Bits, 65 MSPS, 158mW/ch	NFBGA (135)	15mm × 9mm
AFE5808A	8-Channel Ultrasound AFE with Passive CW Mixer, 0.75nV/√Hz, 14 and 12 Bits, 65 MSPS, 158mW/ch	NFBGA (135)	15mm × 9mm
AFE5807	8-Channel Ultrasound AFE with Passive CW Mixer, 1.05nV/√Hz, 12 Bits, 80 MSPS, 117mW/ch	NFBGA (135)	15mm × 9mm
AFE5803	8-Channel Ultrasound AFE, 0.75nV/√Hz, 14 and 12 Bits, 65 MSPS, 158mW/ch	NFBGA (135)	15mm × 9mm
AFE5805	8-Channel Ultrasound AFE, 0.85nV/√Hz, 12 Bits, 50 MSPS, 122mW/ch	NFBGA (135)	15mm × 9mm
AFE5804	8-Channel Ultrasound AFE, 1.23nV/√Hz, 12 Bits, 50 MSPS, 101mW/ch	NFBGA (135)	15mm × 9mm
AFE5801	8-Channel Variable-Gain Amplifier (VGA) with Octal High-Speed ADC, 5.5nV/√Hz, 12 Bits, 65 MSPS, 65mW/ch	VQFN (64)	9mm × 9mm
AFE5851	16-Channel VGA with High-Speed ADC, 5.5nV/√Hz, 12 Bits, 32.5 MSPS, 39mW/ch	VQFN (64)	9mm × 9mm
VCA5807	8-Channel Voltage-Controlled Amplifier for Ultrasound with Passive CW Mixer, 0.75nV/√Hz, 99mW/ch	HTQFP (80)	14mm × 14mm
VCA8500	8-Channel, Ultra-Low-Power VGA with Low-Noise Pre-Amp, 0.8nV/√Hz, 65mW/ch	VQFN (64)	9mm × 9mm
ADS5294	Octal-Channel, 14-Bit, 80-MSPS ADC, 75dBFS SNR, 77mW/ch	HTQFP (80)	14mm × 14mm
ADS5292	Octal-Channel, 12-Bit, 80-MSPS ADC, 70dBFS SNR, 66mW/ch	HTQFP (80)	14mm × 14mm
ADS5295	Octal-Channel, 12-Bit, 100-MSPS ADC, 70.6dBFS SNR, 80mW/ch	HTQFP (80)	14mm × 14mm
ADS5296A	10-Bit, 200-MSPS, 4-Channel, 61dBFS SNR, 150mW/ch and 12-bBit, 80-MSPS, 8-Channel, 70dBFS SNR, 65mW/ch ADC	VQFN (64)	9mm × 9mm

Copyright © 2024 Texas Instruments Incorporated

5 Device and Documentation Support

5.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

5.2 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

5.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

5.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

5.5 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

6 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
March 2024	*	Initial Release

7 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

Copyright © 2024 Texas Instruments Incorporated

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
AFE5812ZCF	Active	Production	NFBGA (ZCF) | 135	160 | JEDEC TRAY (5+1)	Yes	SNAGCU	Level-3-260C-168 HR	-40 to 85	AFE5812
AFE5812ZCF.A	Active	Production	NFBGA (ZCF) | 135	160 | JEDEC TRAY (5+1)	Yes	SNAGCU	Level-3-260C-168 HR	-40 to 85	AFE5812

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale, TI’s General Quality Guidelines, or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025