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.

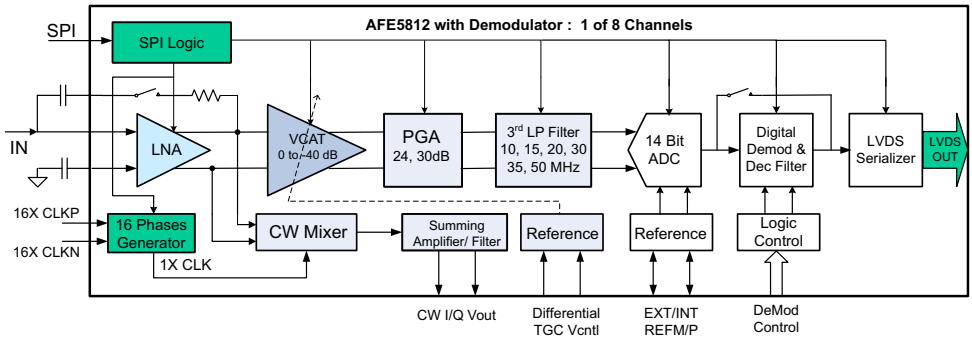
The AFE5812 also includes a digital in-phase and quadrature (I/Q) demodulator and a low-pass decimation filter. The main purpose of the demodulation block is to reduce the LVDS data rate and improve overall system power efficiency. The I/Q demodulator can accept ADC output with up to 65 MSPS sampling 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

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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

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.

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5.3 Trademarks

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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.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
AFE5812ZCF	ACTIVE	NFBGA	ZCF	135	160	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	AFE5812	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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