

AFE5816 16-Channel Ultrasound AFE With 90mW/Channel Power, 1nV/ $\sqrt{\text{Hz}}$ Noise, 14-Bit, 65-MSPS or 12-Bit, 80 MSPS ADC and Passive CW Mixer

1 Features

- 16-channel, AFE for ultrasound applications:
 - Input attenuator, LNA, LPF, ADC, and CW mixer
 - Optimized signal chains for TGC and CW modes
 - Digital time gain compensation (DTGC)
 - Total gain range: 6dB to 45dB
 - Linear input range: 1V_{PP}
- Input attenuator with DTGC:
 - 8dB to 0dB attenuation with 0.125dB step
 - Supports matched impedance for:
 - 50Ω to 800Ω source impedance
- Low-noise amplifier (LNA) with DTGC:
 - 14dB to 45dB gain with 0.125dB step
 - Low input current noise: 1.2pA/ $\sqrt{\text{Hz}}$
- 3rd-order, linear-phase, low-pass filter (LPF):
 - 10MHz, 15MHz, 20MHz, and 25MHz
- Analog-to-digital converter (ADC) with programmable resolution:
 - 14-bit ADC: 75dBFS idle channel SNR at 65 MSPS
 - 12-bit ADC: 72dBFS idle channel SNR at 80 MSPS
- LVDS interface with a maximum speed up to 1GBPS
- Optimized for noise and power:
 - 90mW/Ch at 1nV/ $\sqrt{\text{Hz}}$, 65 MSPS, TGC mode
 - 55mW/Ch at 1.45nV/ $\sqrt{\text{Hz}}$, 40 MSPS, TGC mode

- 59mW/Ch, CW mode
- Excellent device-to-device gain matching:
 - $\pm 0.5\text{dB}$ (typical)
- Low harmonic distortion: -60dBc level
- Fast and consistent overload recovery
- Continuous wave (CW) path with:
 - Passive mixer
 - Low close-in phase noise of -148dBc/Hz at 1kHz frequency
 - Phase resolution: $\lambda / 16$
 - Supports 16X, 8X, 4X, and 1X CW clocks
 - 12dB suppression of 3rd and 5th harmonics
- Small package: 15mm × 15mm NFBGA-289

2 Applications

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

3 Description

The AFE5816 is a highly-integrated, analog front-end (AFE) solution specifically designed for ultrasound systems where high performance, low power, and small size are required.

Package Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾
AFE5816	ZAV (NFBGA, 289)	15mm × 15mm

(1) For all available packages, see [Section 6](#).

(2) The package size (length × width) is a nominal value and includes pins, where applicable.

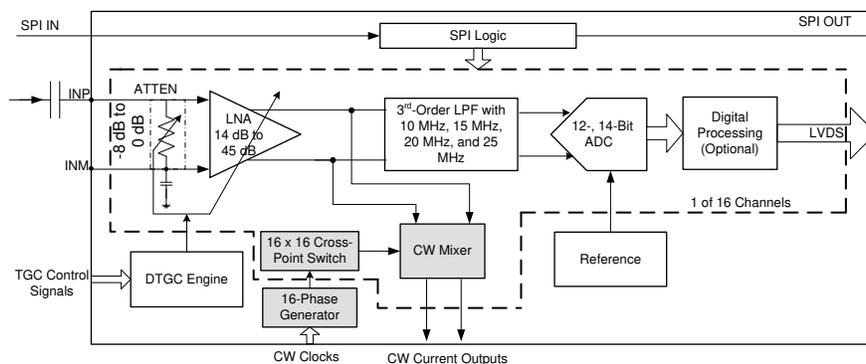


The AFE5816 is an integrated analog front-end (AFE) optimized for medical ultrasound application. The AFE5816 is a multichip module (MCM) device with two dies: VCA and ADC_CONV. Each die has total of 16 channels.

Each channel in the VCA die can be configured in two modes: time gain compensation (TGC) mode and continuous wave (CW) mode. In TGC mode, each channel includes an input attenuator (ATTEN), a low-noise amplifier (LNA) with variable-gain, and a third-order, low-pass filter (LPF). The attenuator supports an attenuation range of 8dB to 0dB, and the LNA supports gain ranges from 14dB to 45dB. The LPF cutoff frequency can be configured at 10MHz, 15MHz, 20MHz, or 25MHz to support ultrasound applications with different frequencies. In CW mode, each channel includes an LNA with a fixed gain of 18dB, and a low-power passive mixer with 16 selectable phase delays. Different phase delays can be applied to each analog input signal to perform an on-chip beamforming operation. A harmonic filter in the CW mixer suppresses the third and fifth harmonic to enhance the sensitivity of the CW Doppler measurement. CW mode supports three clock modes: 16X, 8X, and 4X.

Each channel of the ADC_CONV die has a high-performance analog-to-digital converter (ADC) with a programmable resolution of 14 bits or 12 bits. The ADC achieves 75dBFS signal-to-noise ratio (SNR) in 14-bit mode, and 72dBFS SNR in 12-bit mode. This ADC provides excellent SNR at low-channel gain. The devices operate at maximum speeds of 65 MSPS and 80 MSPS, providing 14-bit and 12-bit output, respectively. The ADC is designed to scale power with sampling rate. The output interface of the ADC is a low-voltage differential signaling (LVDS) interface that can easily interface with low-cost field-programmable gate arrays (FPGAs).

The AFE5816 also allows various power and noise combinations to be selected for optimizing system performance. Therefore, these devices are suitable ultrasound AFE solutions for systems with strict battery-life requirements. The AFE5816 is available in a 15mm × 15mm NFBGA-289 package (ZAV package, S-PBGA-N289) and is specified for operation from -40°C to $+85^{\circ}\text{C}$. The device is also pin-to-pin compatible with the [AFE5818](#) family.



Simplified Block Diagram

Table of Contents

1 Features	1	4.3 Community Resources.....	4
2 Applications	1	4.4 Trademarks.....	4
3 Description	1	4.5 Electrostatic Discharge Caution.....	4
4 Device and Documentation Support	4	4.6 Glossary.....	4
4.1 Receiving Notification of Documentation Updates.....	4	5 Revision History	4
4.2 Support Resources.....	4	6 Mechanical, Packaging, and Orderable Information	4

Device Family Comparison

Table 4-1. Device Family Comparison

DEVICE	DESCRIPTION	PACKAGE	BODY SIZE (NOM)
AFE5818	16-Channel, Ultrasound, Analog Front-End (AFE) with 124-mW/Channel, 0.75nV/ $\sqrt{\text{Hz}}$ 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/ $\sqrt{\text{Hz}}$, 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/ $\sqrt{\text{Hz}}$, 14 and 12 Bits, 65 MSPS, 158mW/ch	NFBGA (135)	15mm × 9mm
AFE5808A	8-Channel Ultrasound AFE with Passive CW Mixer, 0.75nV/ $\sqrt{\text{Hz}}$, 14 and 12 Bits, 65 MSPS, 158mW/ch	NFBGA (135)	15mm × 9mm
AFE5807	8-Channel Ultrasound AFE with Passive CW Mixer, 1.05nV/ $\sqrt{\text{Hz}}$, 12 Bits, 80 MSPS, 117mW/ch	NFBGA (135)	15mm × 9mm
AFE5803	8-Channel Ultrasound AFE, 0.75nV/ $\sqrt{\text{Hz}}$, 14 and 12 Bits, 65 MSPS, 158mW/ch	NFBGA (135)	15mm × 9mm
AFE5805	8-Channel Ultrasound AFE, 0.85nV/ $\sqrt{\text{Hz}}$, 12 Bits, 50 MSPS, 122mW/ch	NFBGA (135)	15mm × 9mm
AFE5804	8-Channel Ultrasound AFE, 1.23nV/ $\sqrt{\text{Hz}}$, 12 Bits, 50 MSPS, 101mW/ch	NFBGA (135)	15mm × 9mm
AFE5801	8-Channel Variable-Gain Amplifier (VGA) with Octal High-Speed ADC, 5.5nV/ $\sqrt{\text{Hz}}$, 12 Bits, 65 MSPS, 65mW/ch	VQFN (64)	9mm × 9mm
AFE5851	16-Channel VGA with High-Speed ADC, 5.5nV/ $\sqrt{\text{Hz}}$, 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/ $\sqrt{\text{Hz}}$, 99mW/ch	HTQFP (80)	14mm × 14mm
VCA8500	8-Channel, Ultra-Low-Power VGA with Low-Noise Pre-Amp, 0.8nV/ $\sqrt{\text{Hz}}$, 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-bit, 80-MSPS, 8-Channel, 70dBFS SNR, 65mW/ch ADC	VQFN (64)	9mm × 9mm

4 Device and Documentation Support

4.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.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.

4.2 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](#).

4.3 Community Resources

4.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

4.5 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.

4.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

5 Revision History

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

DATE	REVISION	NOTES
March 2024	*	Initial Release

6 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
AFE5816ZAV	ACTIVE	NFBGA	ZAV	289	126	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	AFE5816	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.

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 DATA SHEETS), 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 will 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](#) or other applicable terms available either on [ti.com](https://www.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.

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

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2024, Texas Instruments Incorporated