AFE5816 16-Channel Ultrasound AFE With 90mW/Channel Power, 1nV/√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/√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/√Hz, 65 MSPS, TGC mode
  - 55mW/Ch at 1.45nV/√Hz, 40 MSPS, TGC mode
  - 59mW/Ch, CW mode
- Excellent device-to-device gain matching:
  - ±0.5dB (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: λ / 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

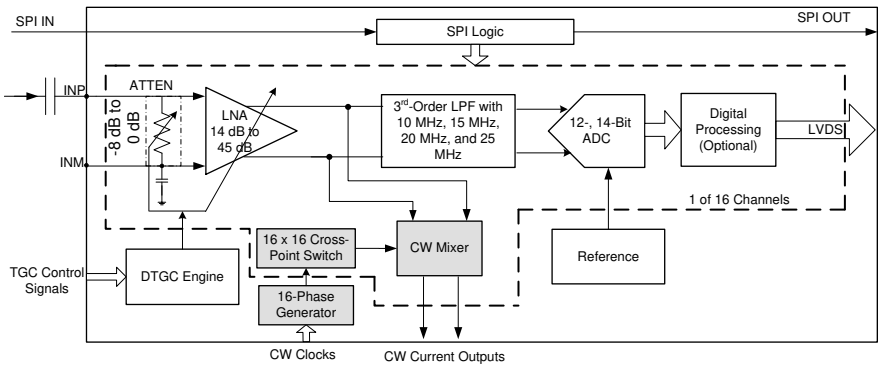
(1) For all available packages, see Section 6.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.

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°C. The device is also pin-to-pin compatible with the AFE5818 family.



Simplified Block Diagram

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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/√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

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. 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.

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4.3 Community Resources

4.4 Trademarks

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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 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)
AFE5816ZAV	Active	Production	NFBGA (ZAV) | 289	126 | JEDEC TRAY (5+1)	Yes	SNAGCU	Level-3-260C-168 HR	-40 to 85	AFE5816
AFE5816ZAV.A	Active	Production	NFBGA (ZAV) | 289	126 | JEDEC TRAY (5+1)	Yes	SNAGCU	Level-3-260C-168 HR	-40 to 85	AFE5816

(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.

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Last updated 10/2025