AFE58JD48 16-Channel Ultrasound AFE with 140-mW/Channel Power, 0.8-nV/$\sqrt{Hz}$ Noise, 16-Bit, 125-MSPS ADC with JESD or LVDS Interface, Digital Demodulator, and Passive CW Mixer

1 Features

- 16-Channel AFE for ultrasound applications:
  - Four programmable TGC setting profiles
- Low-noise amplifier (LNA) With Active Termination:
  - Programmable gain: 21 dB, 18 dB, and 15 dB
  - Linear input amplitude: 0.37/0.5/0.71 V_{PP}
  - Maximum input amplitude: 1 Vpp
- Voltage-controlled attenuator (VCAT):
  - Attenuation range: 0 dB–36 dB
- Programmable gain amplifier (PGA):
  - 18 dB–27 dB in Steps of 3 dB
- 3rd-Order, 10 ~ 60 MHz Low-pass filter (LPF)
- ADC Idle-Channel SNR:
  - 16-Bit, 125-MSPS Mode: 80-dBFS
  - 14-Bit, 80-MSPS Mode: 79-dBFS
- Excellent near field SNR: 74-dBFS
- TGC Mode JESD204B output
  - 140 mW/Ch, 0.8 nV/$\sqrt{Hz}$, 125 MSPS, 16 bit
  - 120 mW/Ch, 0.8 nV/$\sqrt{Hz}$, 80 MSPS, 16 bit
  - 115 mW/Ch, 0.8 nV/$\sqrt{Hz}$, 65 MSPS, 16 bit
  - 105 mW/Ch, 0.8 nV/$\sqrt{Hz}$, 40 MSPS, 16 bit
- TGC Mode LVDS output
  - 120 mW/Ch, 0.8 nV/$\sqrt{Hz}$, 80 MSPS, 16 bit
  - 115 mW/Ch, 0.8 nV/$\sqrt{Hz}$, 65 MSPS, 16 bit
  - 150 mW/Ch, 0.8 nV/$\sqrt{Hz}$, 125 MSPS, 16 bit, Decimation by 2, LVDS 0.5x mode
- CW Mode: 63 mW/Ch, 1.15 nV/$\sqrt{Hz}$
- ±0.4 dB (typical) Device-to-device gain matching
- Fast and consistent overload recovery
- Continuous wave (CW) path with:
  - –159 dBc/Hz Phase noise at 1-kHz off carrier
  - λ / 16 Phase resolution
  - Supports 16x and 8x CW clocks
  - 12-dB Suppression of 3rd and 5th harmonics
- Digital I/Q demodulator w/ data reduction
  - Fractional decimation filter M = 1 to 63 with increments of 0.25
  - On-chip RAM with 32 preset profiles
- LVDS Interface with a speed Up to 1.28 Gbps
- 10-Gbps JESD204B Subclass 0, 1, and 2
  - Up to 12.8-Gbps with 10-cm PCB traces
  - 2, 4, or 8 Channels per JESD lane

2 Applications

- Medical ultrasound imaging
- High frequency ultrasound imaging
- Non-destructive testing (NDT)
- Sonar, radar, LiDAR imaging equipment
- Multi-channel data acquistion

3 Description

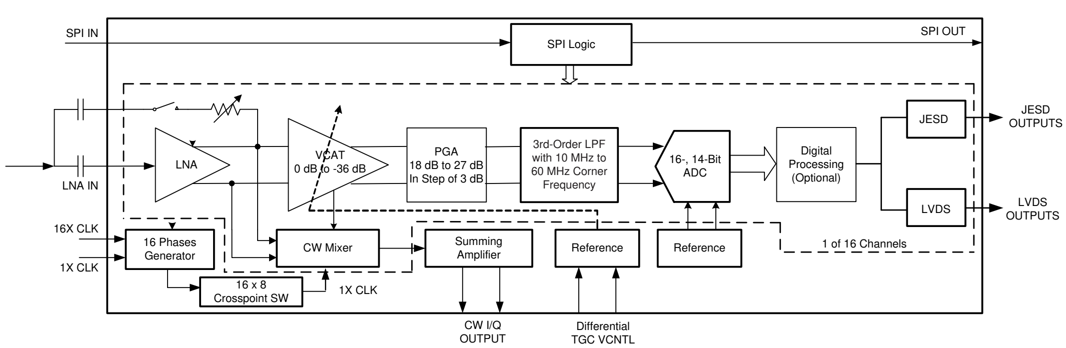
The AFE58JD48 device is a highly-integrated, analog front-end (AFE) solutions specifically designed for premium ultrasound systems.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
AFE58JD48	NFBGA (289)	15.00 mm × 15.00 mm

(1) For all available packages, see the package option addendum at the end of the datasheet.

Simplified Block Diagram



4 Revision History

Changes from Original (October 2019) to Revision A	Page
• Changed the device from *Advanced Information* to *Production* data	1

5 Description (continued)

The AFE58JD48 is an integrated AFE optimized for premium medical ultrasound application. The device is realized through a multichip module (MCM) with three dies: one 16-CH voltage-controlled amplifier (VCA) die and two 8-CH analog-to-digital converter (ADC) dies.

Each channel in the VCA die can be configured in one of two modes: time gain compensation (TGC) mode or continuous wave (CW) mode. In TGC mode, each channel includes a low-noise amplifier (LNA), a voltage-controlled attenuator (VCAT), a programmable gain amplifier (PGA), and a third-order, low-pass filter (LPF). The LNA is programmable in gains of 21 dB, 18 dB, or 15 dB. The LNA also supports active termination. The VCAT supports an attenuation range of 0 dB to 36 dB, with analog voltage control for the attenuation. The PGA provides gain options from 18 dB to 27 dB in steps of 3 dB. The LPF cutoff frequency can be set between 10 MHz and 60 MHz to support ultrasound applications with different frequencies, especially the emerging high frequency ultrasound imaging applications. In CW mode, the output of the LNA goes to a low-power passive mixer with 16 selectable phase delays followed by a summing amplifier with a band-pass filter. 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.

The ADC die can be configured to operate with a resolution of 16 bits or 14 bits. The ADC primarily supports a JESD204B interface that runs up to 12.8 Gbps and reduces the circuit-board routing challenges in high-channel count systems. The output interface of the ADC can also be set as a low-voltage differential signaling (LVDS) that can easily interface with low-cost field-programmable gate arrays (FPGAs). The ADC can operate at maximum speeds of 125 MSPS 16-bit and send out the digitized data with JESD204B interface. When the LVDS interface is used, the ADCs sampling rate and resolution are limited by the LVDS output rate of 1.28 Gbps, or 80 MSPS at 16-bit resolution. The ADC in 14-bit resolution can be configured in this scenario to sample at a higher speed but still maintain the same output data rate. The ADC is designed to scale its power with sampling rate.

The AFE58JD48 additionally includes a digital demodulator block. The digital in-phase and quadrature (I/Q) demodulator with programmable decimation filters accelerates computationally-intensive algorithms at low power.

The device also allows various power and noise combinations to be selected for optimizing system performance. Therefore, the device is a suitable ultrasound AFE solution for premium systems powered either by wall outlet or by batteries.

The device is available in a 15-mm × 15-mm NFBGA-289 package and is almost pin-compatible with the AFE58JD28 and AFE58JD18 devices.

6 Device and Documentation Support

6.1 Documentation Support

6.1.1 Related Documentation

For related documentation see the following:

- *AFE5828 16-Channel, Ultrasound, Analog Front-End with 102-mW/Channel Power, 0.8-nV/√Hz Noise, 14-Bit, 65-MSPS or 12-Bit, 80-MSPS ADC, and Passive CW Mixer*
- *AFE58JD28 16-Channel, Ultrasound, Analog Front-End with 102-mW/Channel Power, 0.8-nV/√Hz Noise, 14-Bit, 65-MSPS or 12-Bit, 80-MSPS ADC, and Passive CW Mixer*
- *AFE5818 16-Channel, Ultrasound, Analog Front-End with 140-mW/Channel Power, 0.75-nV/√Hz Noise, 14-Bit, 65-MSPS or 12-Bit, 80-MSPS ADC, and Passive CW Mixer*
- *AFE5816 16-Channel Ultrasound AFE with 90-mW/Channel Power, 1-nV/√Hz Noise, 14-Bit, 65-MSPS or 12-Bit, 80-MSPS ADC and Passive CW Mixer*
- *AFE58JD18 16-Channel, Ultrasound AFE with 14-Bit, 65-MSPS or 12-Bit, 80-MSPS ADC, Passive CW Mixer, I/Q Demodulator, and LVDS, JESD204B Outputs*
- *TLV5626 2.7-V to 5.5-V Low-Power Dual 8-Bit Digital-to-Analog Converter With Internal Reference and Power Down*
- *DAC7821 12-Bit, Parallel Input, Multiplying Digital-to-Analog Converter*
- *THS413x High-Speed, Low-Noise, Fully-Differential I/O Amplifiers*
- *OPA1632 High-Performance, Fully-Differential Audio Operational Amplifier*
- *Wideband Differential Transimpedance DAC Output*
- *LMK0482x Ultra Low-Noise JESD204B Compliant Clock Jitter Cleaner with Dual Loop PLLs*
- *CDCM7005 3.3-V High Performance Clock Synchronizer and Jitter Cleaner*
- *CDCE72010 Ten Output High Performance Clock Synchronizer, Jitter Cleaner, and Clock Distributor*
- *OPA2x11 1.1-nv/√Hz Noise, Low Power, Precision Operational Amplifier*
- *ADS8413 16-Bit, 2-MSPS, LVDS Serial Interface, SAR Analog-to-Digital Converter*
- *ADS8472 16-Bit, 1-MSPS, Pseudo-Bipolar, Fully Differential Input, Micropower Sampling Analog-to-Digital Converter With Parallel Interface, Reference*
- *Clocking High-Speed Data Converters* Technical Brief
- *ISO724x High-Speed, Quad-Channel Digital Isolators*
- *SN74AUP1T04 Low Power, 1.8/2.5/3.3-V Input, 3.3-V CMOS Output, Single Inverter Gate*
- *MicroStar BGA Packaging Reference Guide*

6.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* 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.

6.3 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.

6.4 Trademarks

E2E is a trademark of Texas Instruments.
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6.5 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

6.6 Glossary

SLYZ022 — *TI Glossary*.

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

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
AFE58JD48ZAV	ACTIVE	NFBGA	ZAV	289	126	RoHS & Green	SNAGCU	Level-3-260C-168 HR	0 to 85	AFE58JD48	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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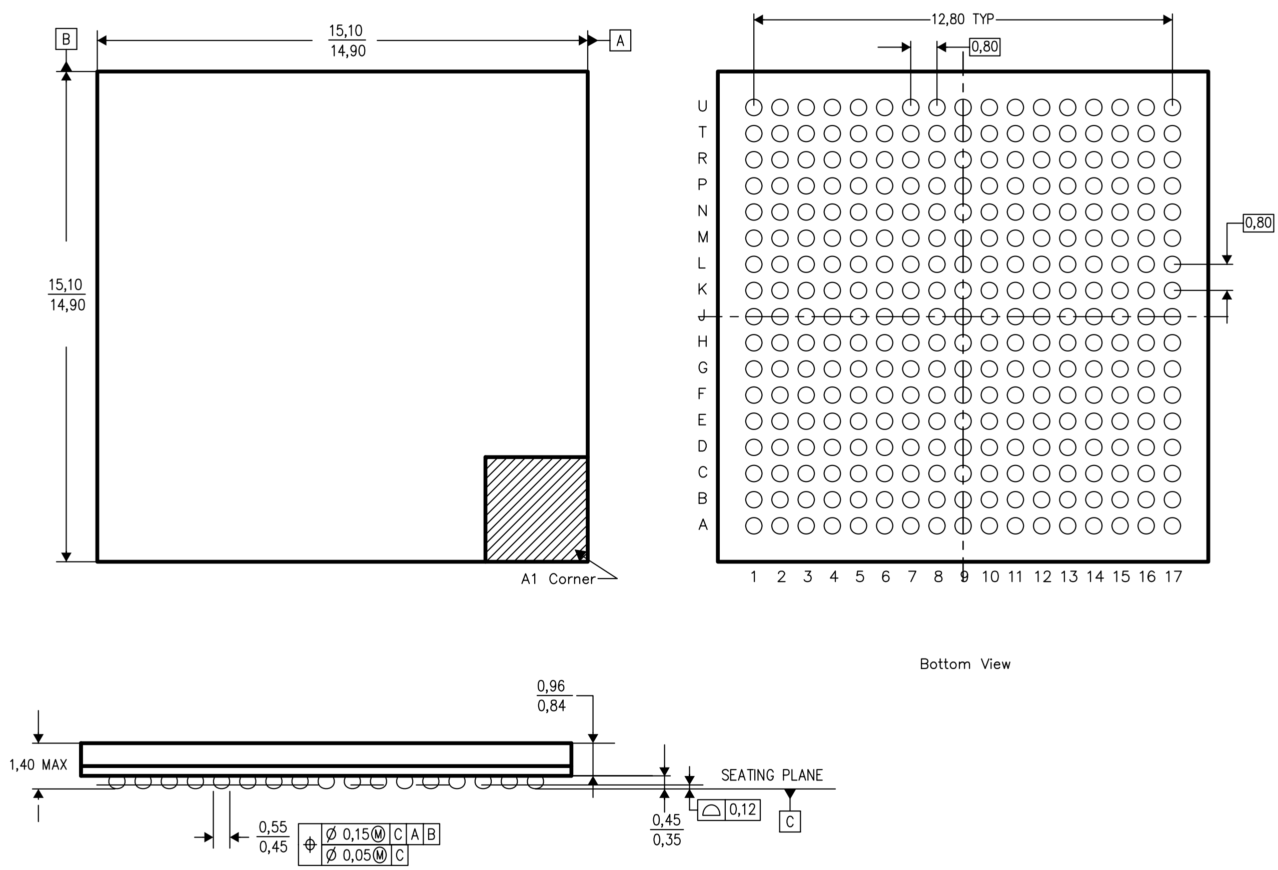
ZAV (S–PBGA–N289) PLASTIC BALL GRID ARRAY



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NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. This is a lead–free solder ball design.