

# AFE4410 Ultra-Small, Integrated AFE With FIFO for Wearable, Continuous Optical Heart-Rate Monitoring and Biosensing

## 1 Features

- Accurate, Continuous Heart-Rate Monitoring:
  - Up to 100-dB Dynamic Range for Accurate Heart-Rate Detection
  - Low Current for Continuous Operation on a Wearable Device With a Typical Value:
    - 30  $\mu$ A for an LED, 25  $\mu$ A for the Receiver
- Transmitter:
  - 4 LEDs in Common Anode Configurations
  - 8-Bit Programmable LED Current to 200 mA
  - Mode to Fire Two LEDs in Parallel
  - Programmable LED On-Time
  - Simultaneous Support of 3 LEDs for Optimized SpO<sub>2</sub>, HRM, or Multiwavelength HRM
  - Average Current of 30  $\mu$ A Adequate for a Typical Heart-Rate Monitoring Scenario:
    - 20-mA Setting, 60- $\mu$ s Pulse Duration, 25-Hz Sampling Rate
- Receiver:
  - Supports 3 Time-Multiplexed PD Inputs
  - 24-Bit Representation of Current Input From PD in Two's-Complement Format
  - Individual DC Offset Subtraction DAC (Up to  $\pm 127$ - $\mu$ A Range) at TIA Input for Each LED, Ambient
  - Digital Ambient Subtraction at ADC Output
  - Transimpedance Gain: 10 k $\Omega$  to 2 M $\Omega$
  - Noise Filtering With Programmable Bandwidth
  - Receiver Operates at Approximately 1- $\mu$ A/Hz Sampling Rate (Example, 25  $\mu$ A at 25 Hz)
  - Hardware Power-Down Mode: Approximately 0- $\mu$ A Current
- Flexible Pulse Sequencing and Timing Control
- Clocking Via External Clock or Internal Oscillator
- FIFO With 128-Sample Depth:
  - Programmable Partitioning Across Phases
- Pin-Selectable I<sup>2</sup>C, SPI Interface
- Operating Temperature Range: –20°C to +70°C
- 2.6-mm x 2.1-mm, 0.4-mm Pitch DSBGA Package
- Supplies:
  - Tx: 3 V to 5.25 V
  - Rx: 1.8 V to 1.9 V (LDO Bypass), 2.0 V to 3.6 V (LDO Enabled)
  - IO: 1.7 V to Rx\_SUP

## 2 Applications

- Optical Heart-Rate Monitoring (HRM) for Wearables, Hearables
- Heart-Rate Variability (HRV)
- Pulse Oximetry (SpO<sub>2</sub>) Measurements
- Maximum Oxygen Consumption (VO<sub>2</sub> Max)

## 3 Description

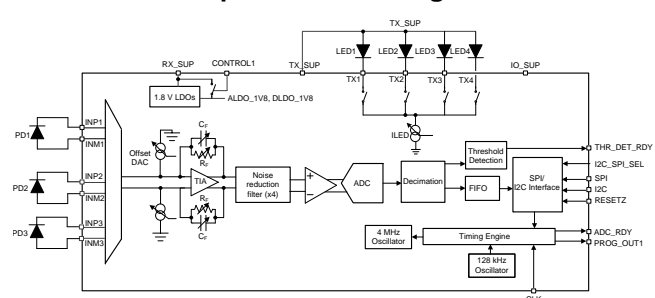
The AFE4410 is an analog front-end for optical biosensing applications, such as heart rate monitoring (HRM). The device supports a maximum of four switching light-emitting diodes (LEDs) and a maximum of three photodiodes (PDs). The electrical current from the photodiode is converted into voltage by the transimpedance amplifier (TIA) and digitized using an analog-to-digital converter (ADC). The ADC code is stored in a 128-sample first-in, first-out block (FIFO) with programmable depth. The FIFO can be read out using either an I<sup>2</sup>C interface or a serial peripheral interface (SPI). The AFE also has a fully integrated LED driver with 8-bit current control. The device has high dynamic range transmit-and-receive circuitry offering a dynamic range of up to 100 dB that enables accurate heart rate sensing. The AFE achieves extremely low current levels by operating an ultralow power (ULP) mode set by using the ENABLE\_ULP register bit.

### Device Information<sup>(1)</sup>

PART NUMBER	PACKAGE	BODY SIZE (NOM)
AFE4410	DSBGA (30)	2.60 mm x 2.10 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 Revision A (May 2017) to Revision B	Page
--	------

---

- Changed the *Mechanical Packaging* images ..... 4
- 

Changes from Original (May 2017) to Revision A	Page
--	------

---

- Changed  $\pm 126\text{-}\mu\text{A}$  Range to  $\pm 127\text{-}\mu\text{A}$  Range ..... 1
-

## 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. 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.

### 5.2 Community Resources

The following links connect to TI community resources. Linked contents are 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](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 5.3 Trademarks

E2E is a trademark of Texas Instruments.  
All other 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.

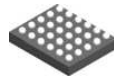
### 5.5 Glossary

[SLYZ022](#) — *TI Glossary*.

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

## 6 Mechanical, Packaging, and Orderable Information

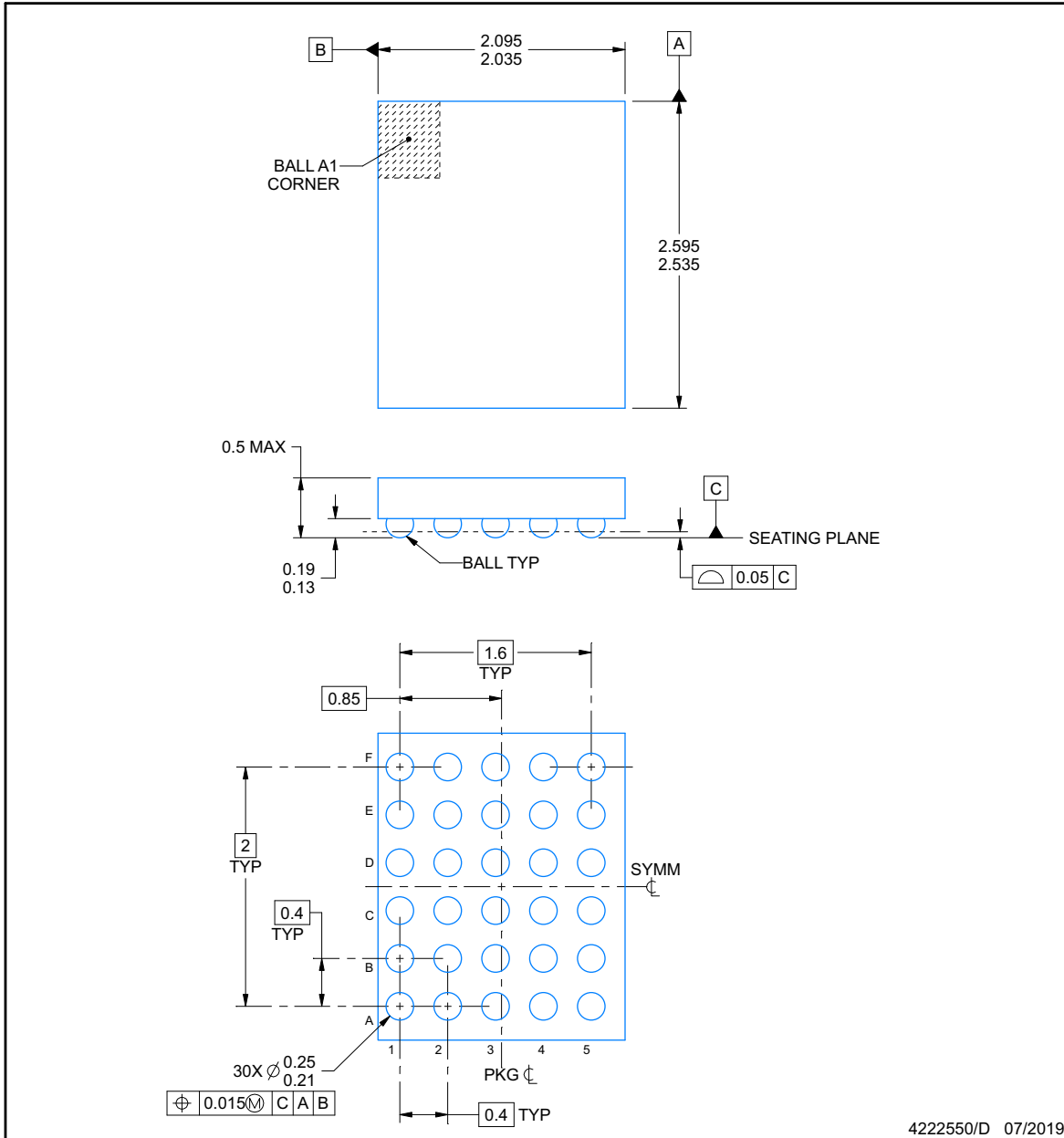
The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand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



YZ0030-C01

PACKAGE OUTLINE  
DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



NOTES:

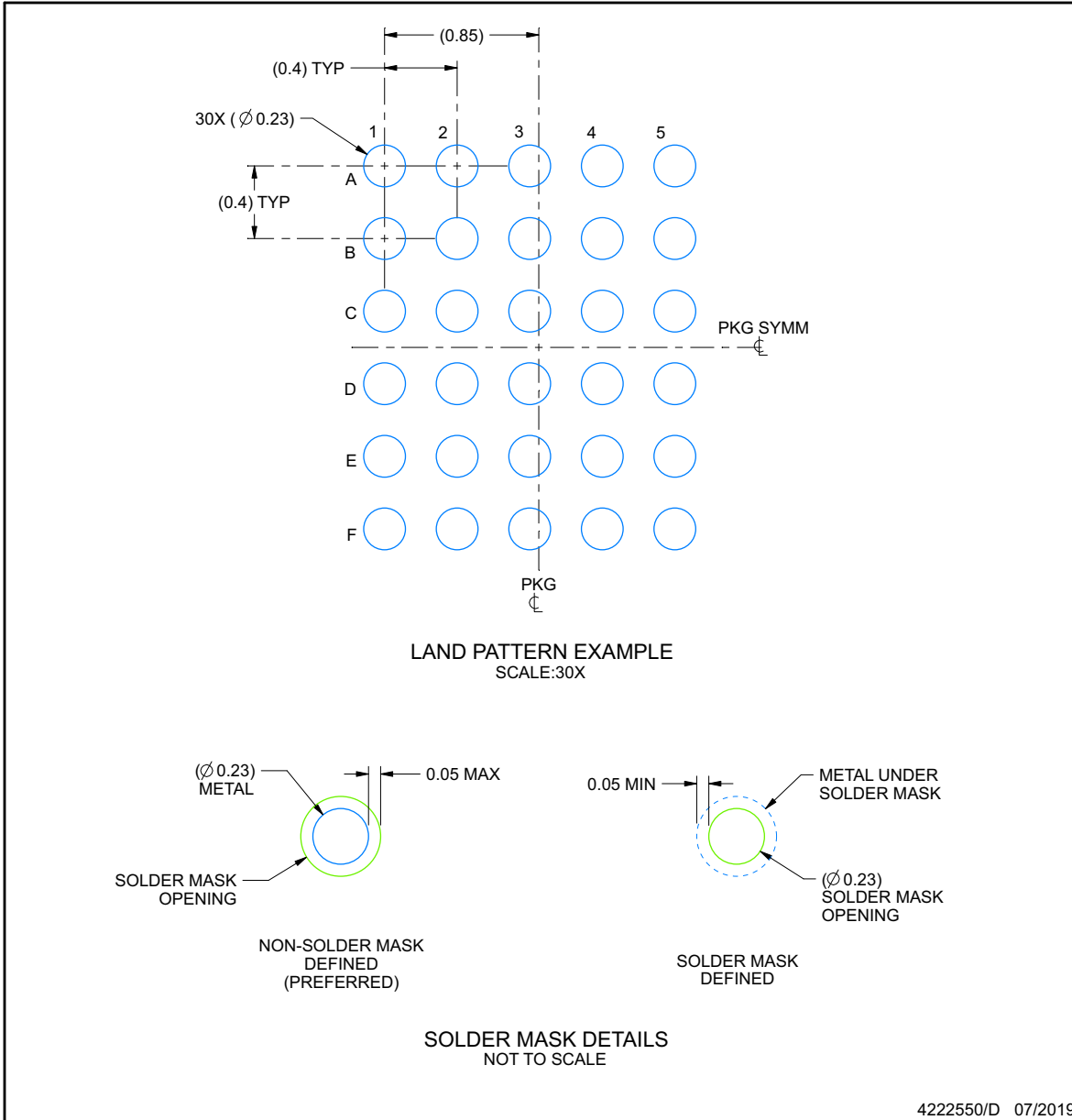
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

**EXAMPLE BOARD LAYOUT**

**YZ0030-C01**

**DSBGA - 0.5 mm max height**

DIE SIZE BALL GRID ARRAY



4222550/D 07/2019

NOTES: (continued)

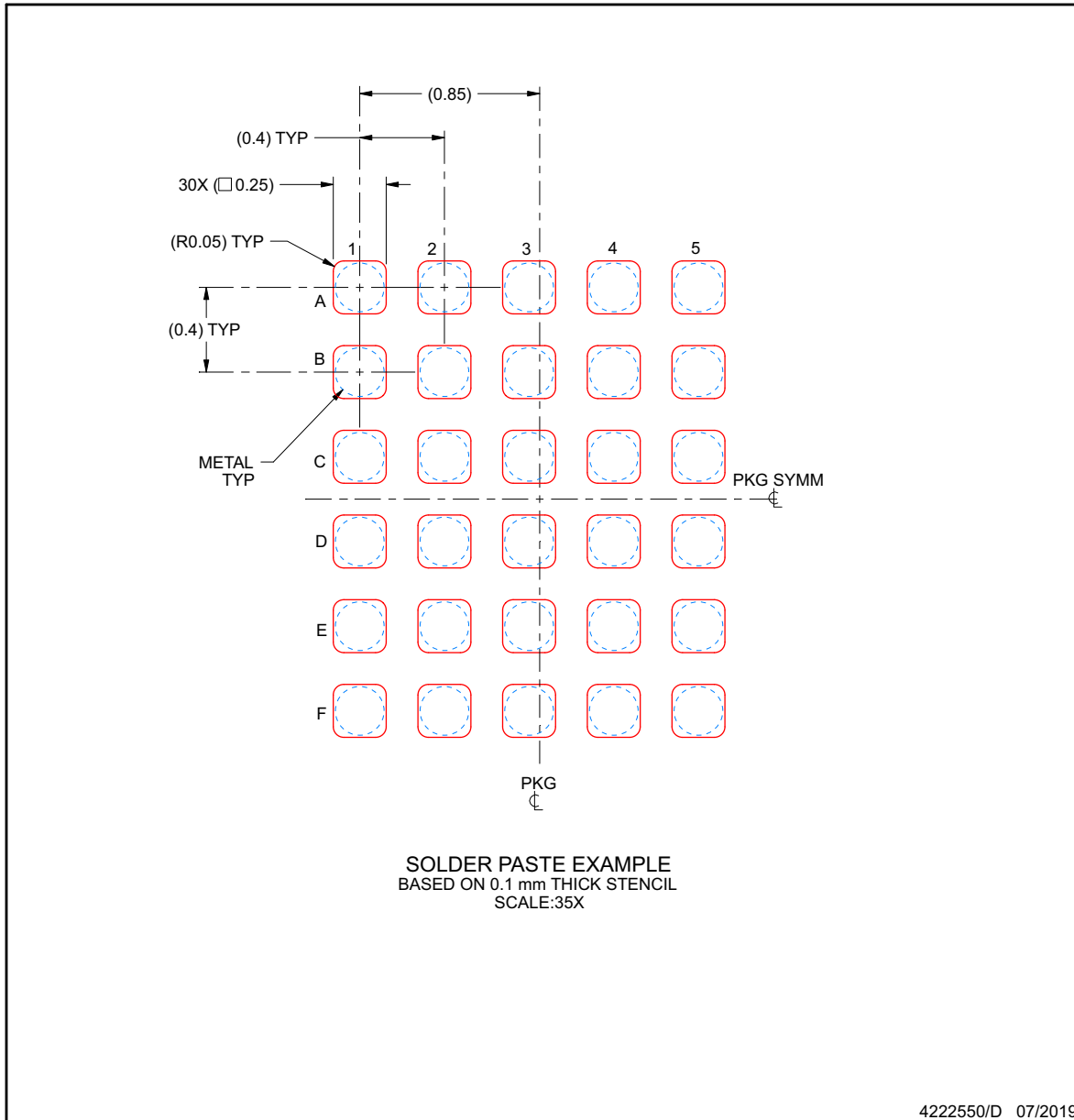
- 3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. See Texas Instruments Literature No. SNVA009 ([www.ti.com/lit/snva009](http://www.ti.com/lit/snva009)).

**EXAMPLE STENCIL DESIGN**

**YZ0030-C01**

**DSBGA - 0.5 mm max height**

DIE SIZE BALL GRID ARRAY



NOTES: (continued)

- 4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

**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)
<a href="#">AFE4410YZR</a>	Active	Production	DSBGA (YZ)   30	3000   LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	0 to 0	AFE4410
AFE4410YZR.A	Active	Production	DSBGA (YZ)   30	3000   LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	0 to 0	AFE4410
<a href="#">AFE4410YZT</a>	Active	Production	DSBGA (YZ)   30	250   SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 70	AFE4410
AFE4410YZT.A	Active	Production	DSBGA (YZ)   30	250   SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 70	AFE4410

(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.

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
AFE4410YZR	DSBGA	YZ	30	3000	180.0	8.4	2.16	2.66	0.6	4.0	8.0	Q1
AFE4410YZT	DSBGA	YZ	30	250	180.0	8.4	2.16	2.66	0.6	4.0	8.0	Q1



**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
AFE4410YZR	DSBGA	YZ	30	3000	182.0	182.0	20.0
AFE4410YZT	DSBGA	YZ	30	250	182.0	182.0	20.0

## 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 © 2025, Texas Instruments Incorporated

Last updated 10/2025