



## AFE4900 Ultra-low Power, Integrated AFE for Wearable Optical, Electrical Bio-sensing with FIFO

## 1 Features

- Synchronized PPG, ECG signal acquisition at data rates up to 1 kHz
- ECG signal chain:
  - Standalone ECG acquisition up to 4 kHz
  - Input bias: 1-lead ECG with RLD bias
  - Programmable INA gain: 2.15 to 12.92
  - Input noise (1 Hz to 150 Hz): 2.5  $\mu\text{Vrms}$  at 1 kHz, 1.25  $\mu\text{Vrms}$  at 4-kHz data rate
  - AC, DC lead-off detect: 12.5-nA to 100-nA
  - IEC 60601 Test report available on request
- PPG receiver:
  - Supports three time-multiplexed PD inputs
  - 24-Bit representation of current from PD
  - DC offset subtraction DAC (Up to  $\pm 126\text{-}\mu\text{A}$ ) at TIA input for each LED, ambient
  - Digital ambient subtraction at ADC output
  - Noise filtering with programmable bandwidth
  - Transimpedance gain: 10 k $\Omega$  to 2 M $\Omega$
  - Dynamic range up to 100 dB
  - Receiver operates in PPG-only mode at approximately 1- $\mu\text{A}/\text{Hz}$  sampling rate
  - Power-down mode: approximately 0  $\mu\text{A}$
- PPG transmitter:
  - Four LEDs in common anode configuration
  - 8-Bit LED current up to 200 mA
  - Mode to fire two LEDs in parallel
  - Programmable LED on-time
  - Simultaneous support of three LEDs for  $\text{SpO}_2$ , or multiwavelength HRM
  - Average current of 30  $\mu\text{A}$  adequate for a typical heart-rate monitoring scenario:
    - 20-mA Setting, 60- $\mu\text{s}$  pulse duration, 25-Hz sampling rate
- Clocking using an external or internal clock
- FIFO with 128-sample depth for ECG and PPG
- I<sup>2</sup>C, SPI interfaces: selectable by pin
- 2.6-mm  $\times$  2.1-mm, 0.4-mm Pitch DSBGA package
- Supplies:
  - Rx: 1.8 V to 1.9 V (LDO bypass), 2.0 V to 3.6 V (LDO enabled)
  - Tx: 3 V to 5.25 V
  - IO: 1.7 V to Rx SUP

## 2 Applications

- Synchronized PPG, ECG for blood pressure estimation
- HRM for wearables, hearables
- Heart-rate variability (HRV)
- Pulse oximetry (SpO<sub>2</sub>) measurements

### 3 Description

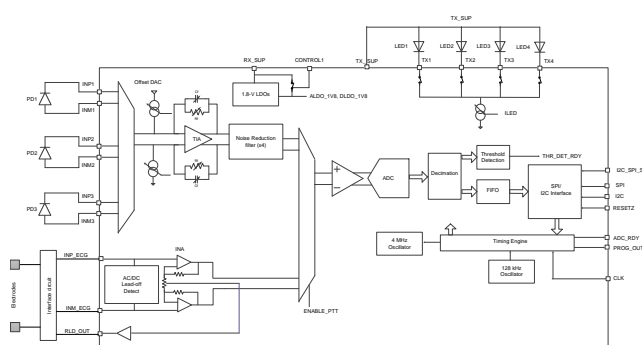
The AFE4900 device is an analog front-end (AFE) for synchronized electrocardiogram (ECG), photoplethysmogram (PPG) signal acquisition. The device can also be used for optical bio-sensing applications, such as heart-rate monitoring (HRM) and saturation of peripheral capillary oxygen (SpO<sub>2</sub>). The PPG signal chain supports up to four switching light-emitting diodes (LEDs) and up to three photodiodes (PDs). The LEDs can be switched on using a fully integrated LED driver. The current from the photodiode is converted into voltage by the transimpedance amplifier (TIA) and digitized using an analog-to-digital converter (ADC). The ECG signal chain has an instrumentation amplifier (INA) with a programmable gain that interfaces to the same ADC. A right-leg drive (RLD) amplifier set can be used to the bias for the ECG input pins. AC and dc lead-off detect schemes are supported. The ADC codes from the PPG and ECG phases can be stored in a 128-sample first in, first out (FIFO) block and read out using either an I<sup>2</sup>C or a serial programming interface (SPI) interface.

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

| PART NUMBER | PACKAGE    | BODY SIZE (NOM)   |
|-------------|------------|-------------------|
| AFE4900     | 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

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

| Changes from Revision A (February 2019) to Revision B                                | Page |
|--|------|
| • Changed the values of <i>Programmable INA Gain</i> in <i>Features</i> section..... | 1    |
| • Changed the <i>Mechanical Packaging</i> images .....                               | 4    |
| <hr/>  |      |
| Changes from Original (August 2017) to Revision A                                    | Page |
| • Changed the values of <i>Programmable INA Gain</i> in <i>Features</i> section..... | 1    |
| • Added "IEC 60601 Test Report Available on Request" in <i>Features</i> section..... | 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.  
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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.

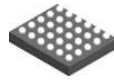
### 5.5 Glossary

[SLYZ022](#) — *TI Glossary*.

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

## 6 Mechanical, Packaging, and Orderable Information

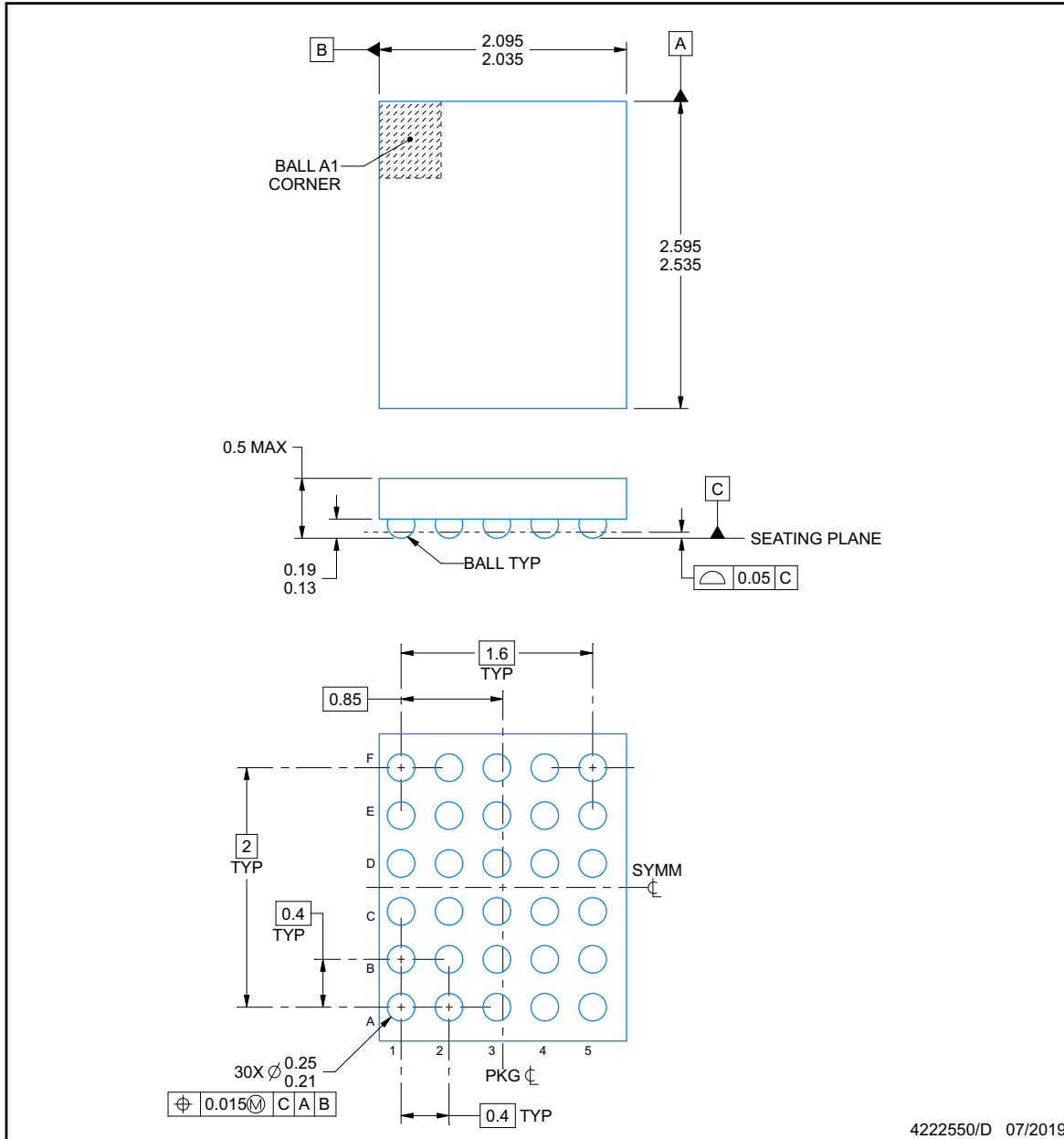
The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand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



# YZ0030-C01

## PACKAGE OUTLINE DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



### NOTES:

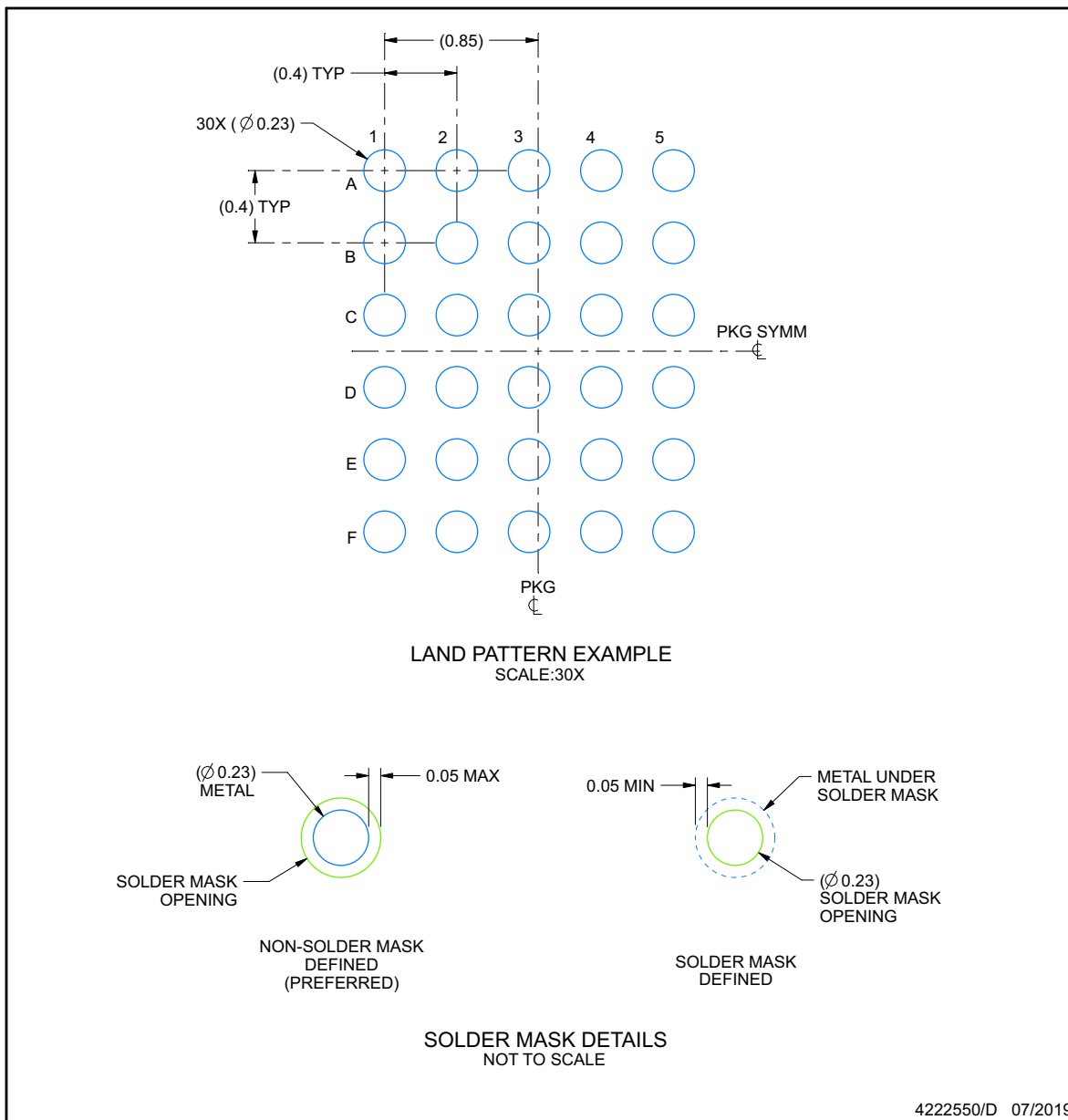
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

## EXAMPLE BOARD LAYOUT

**YZ0030-C01**

**DSBGA - 0.5 mm max height**

DIE SIZE BALL GRID ARRAY



NOTES: (continued)

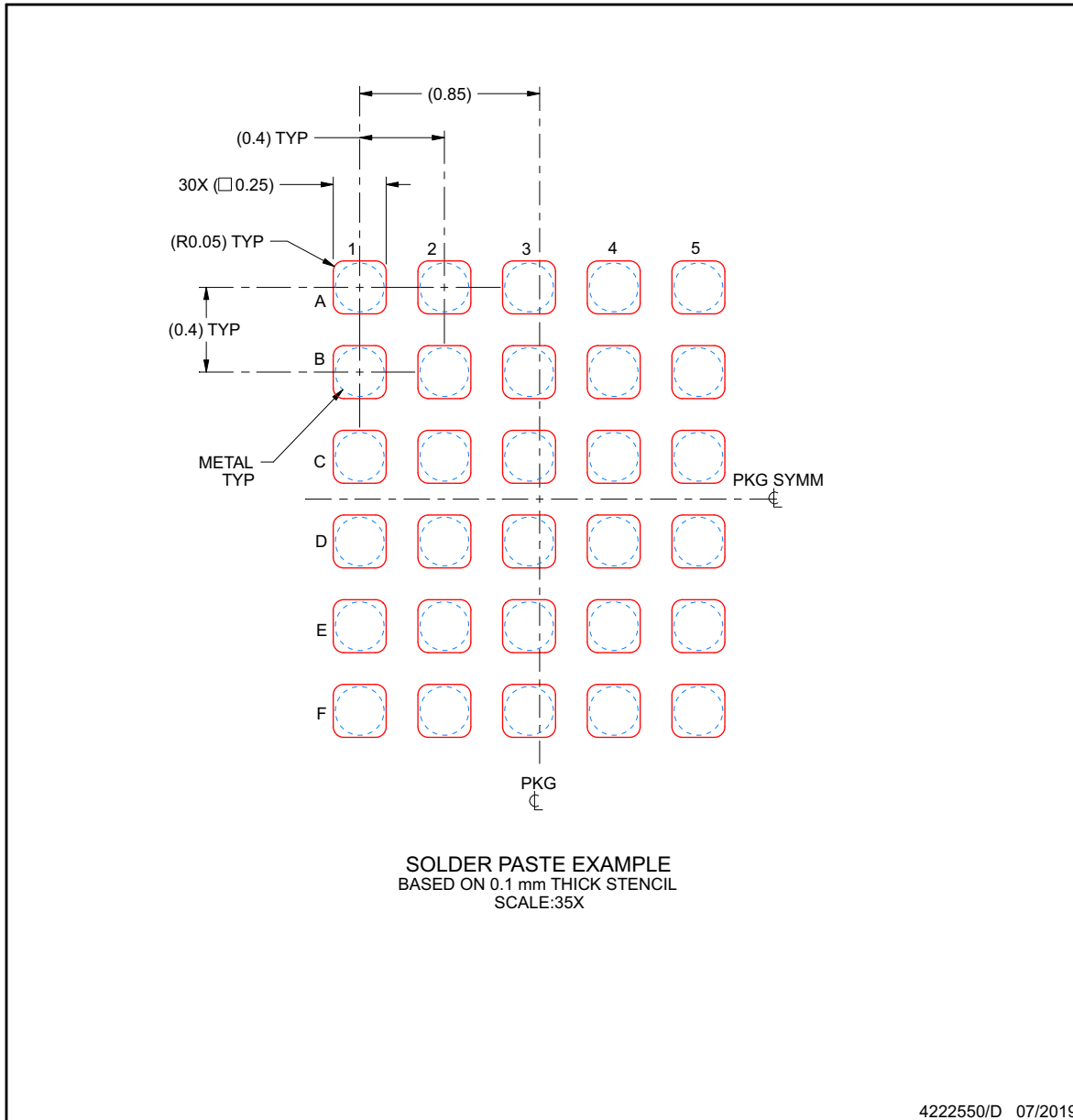
- Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints.  
See Texas Instruments Literature No. SNVA009 ([www.ti.com/lit/snva009](http://www.ti.com/lit/snva009)).

## 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<br>(1) | Material type<br>(2) | Package   Pins  | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|----------------------------|---------------|----------------------|-----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">AFE4900YZR</a> | Active        | Production           | DSBGA (YZ)   30 | 3000   LARGE T&R      | Yes         | SNAGCU                               | Level-1-260C-UNLIM                | -20 to 70    | AFE4900             |
| AFE4900YZR.A               | Active        | Production           | DSBGA (YZ)   30 | 3000   LARGE T&R      | Yes         | SNAGCU                               | Level-1-260C-UNLIM                | -20 to 70    | AFE4900             |
| <a href="#">AFE4900YZT</a> | Active        | Production           | DSBGA (YZ)   30 | 250   SMALL T&R       | Yes         | SNAGCU                               | Level-1-260C-UNLIM                | -20 to 70    | AFE4900             |
| AFE4900YZT.A               | Active        | Production           | DSBGA (YZ)   30 | 250   SMALL T&R       | Yes         | SNAGCU                               | Level-1-260C-UNLIM                | -20 to 70    | AFE4900             |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **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.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **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.

<sup>(5)</sup> **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.

<sup>(6)</sup> **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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