TEXAS INSTRUMENTS

AFE4420

SBAS910A – JUNE 2018 – REVISED JULY 2019

AFE4420 Ultra-Small, Integrated AFE With FIFO for Multi-sensor Wearable, Optical Heart-rate Monitoring and Bio-sensing

1 Features

- Supports signal acquisition of up to 16 phases
- Flexible allocation of LEDs and PDs in each phase
- Accurate, continuous heart-rate monitoring:
  - Up to 100-dB dynamic range
  - Low current for continuous operation on a wearable device with a typical value
    - 15 µA for an LED, 20 µA for the receiver
- Transmitter:
  - Supports common anode LED configuration
  - 8-Bit programmable LED current with range adjustable from 50 mA to 200 mA
  - Mode to fire two LEDs in parallel
  - Programmable LED on-time
  - Simultaneous support of 4 LEDs for optimized SpO2, HRM, or multi-wavelength HRM
  - Programmable control signals to extend operation to 8 LEDs using external SPDT switches
- Receiver:
  - Supports 4 time-multiplexed photodiode inputs
  - Individual DC offset subtraction DAC at TIA input for each LED, ambient with 7-bit control and range up to ±254 µA
  - Transimpedance gain: 10 kΩ to 2 MΩ
  - Digital ambient subtraction at ADC output to suppress ambient tones
  - Noise filtering with programmable bandwidth
- Supports external clock and internal oscillator modes
- Automatic ambient cancellation mode (AACM) to increase receiver dynamic range
- Two programmable GPIO pins with flexible interrupt generation
- FIFO with 128-sample depth
- I^{2}C, SPI interfaces: selectable by pin
- Operating temperature range: –40°C to +85°C
- 2.6-mm × 2.1-mm DSBGA, 0.4-mm pitch

- Supplies:
  - Rx:
    - 1.7 V to 1.9 V (LDO bypass)
    - 1.9 V to 3.6 V (LDO enabled)
  - Tx: 3 V to 5.5 V
  - IO: 1.7 V to RX_SUP

2 Applications

- Optical heart-rate monitoring (HRM) for wearables, hearables
- Heart-rate variability (HRV)
- Pulse oximetry (SpO$_2$) measurements
- Maximum oxygen consumption (VO$_2$ Max)
- Calorie expenditure

3 Description

The AFE4420 is an analog front-end for optical bio-sensing applications, such as heart-rate monitoring (HRM) and saturation of peripheral capillary oxygen (SpO2). The device supports up to four switching light-emitting diodes (LEDs) and up to four photodiodes. Up to 16 signal phases can be defined and the signal can be acquired from each phase in a synchronized manner and stored in a 128-sample First in, First out (FIFO) block. The FIFO can be read out using either an I2C or a SPI interface. The AFE also has a fully integrated LED driver with an 8-bit current control. The device has a high dynamic range transmit-and-receive circuitry that helps with the sensing of very small signal levels.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
AFE4420	DSBGA (30)	2.60 mm × 2.10 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.
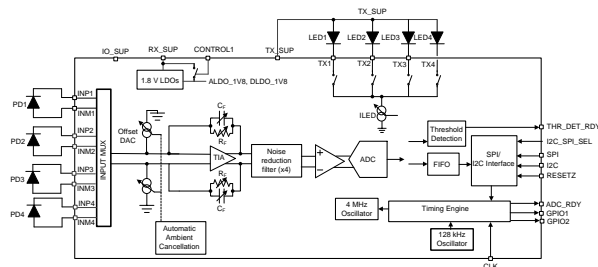
Simplified Schematic

Table of Contents

4 Revision History

Changes from Original (June 2018) to Revision A   **Page**

- Changed the *Mechanical Packaging* images 4

Product Folder Links: *AFE4420*

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.
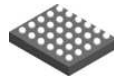
5.5 Glossary

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.
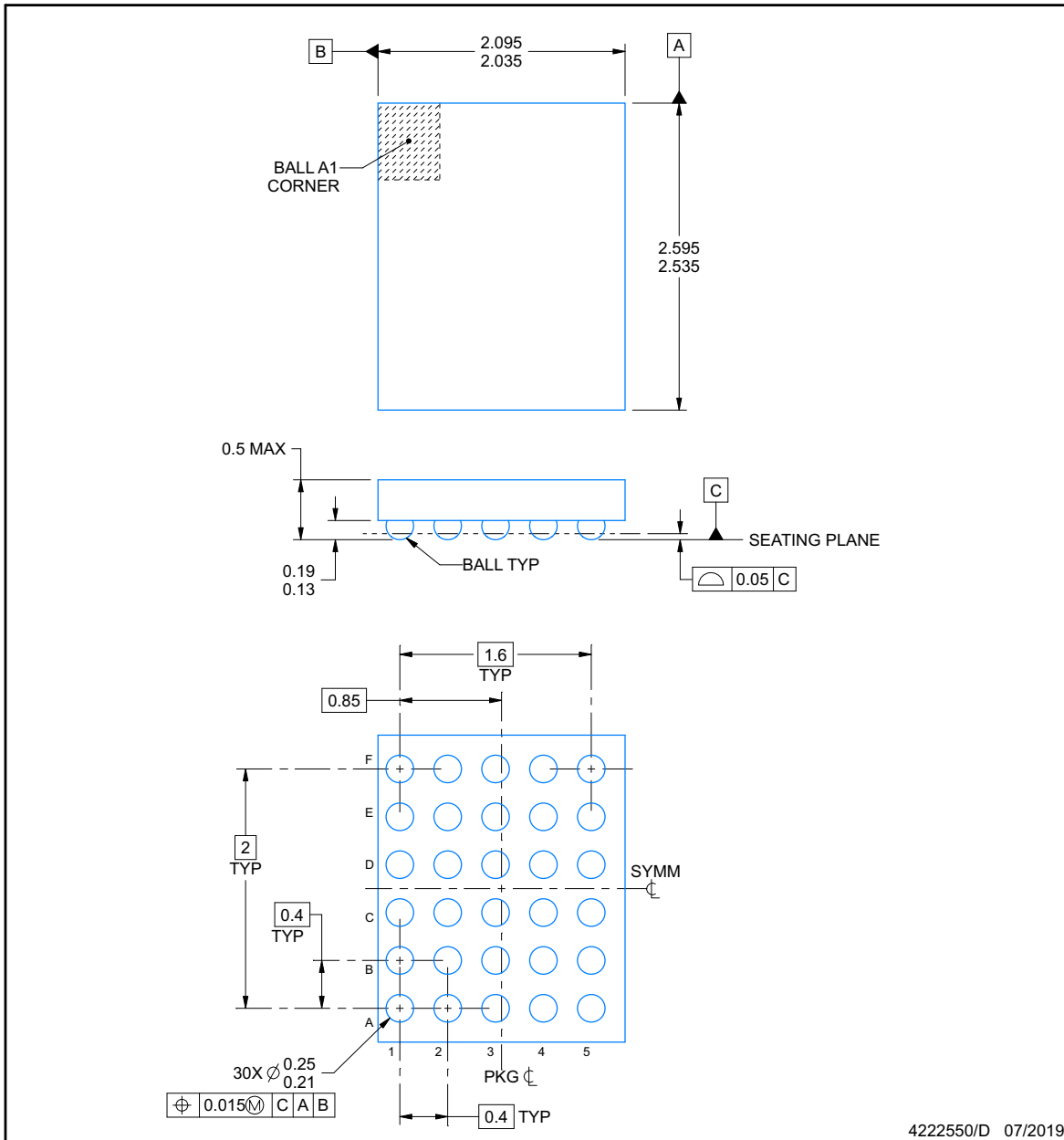
PACKAGE OUTLINE

YZ0030-C01

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY

2.095
2.035

BALL A1
CORNER

2.595
2.535

0.5 MAX

SEATING PLANE

BALL TYP

0.19
0.13

0.05 C

1.6
TYP

0.85

SYMM

2
TYP

0.4
TYP

0.4 TYP

30X ∅ 0.25
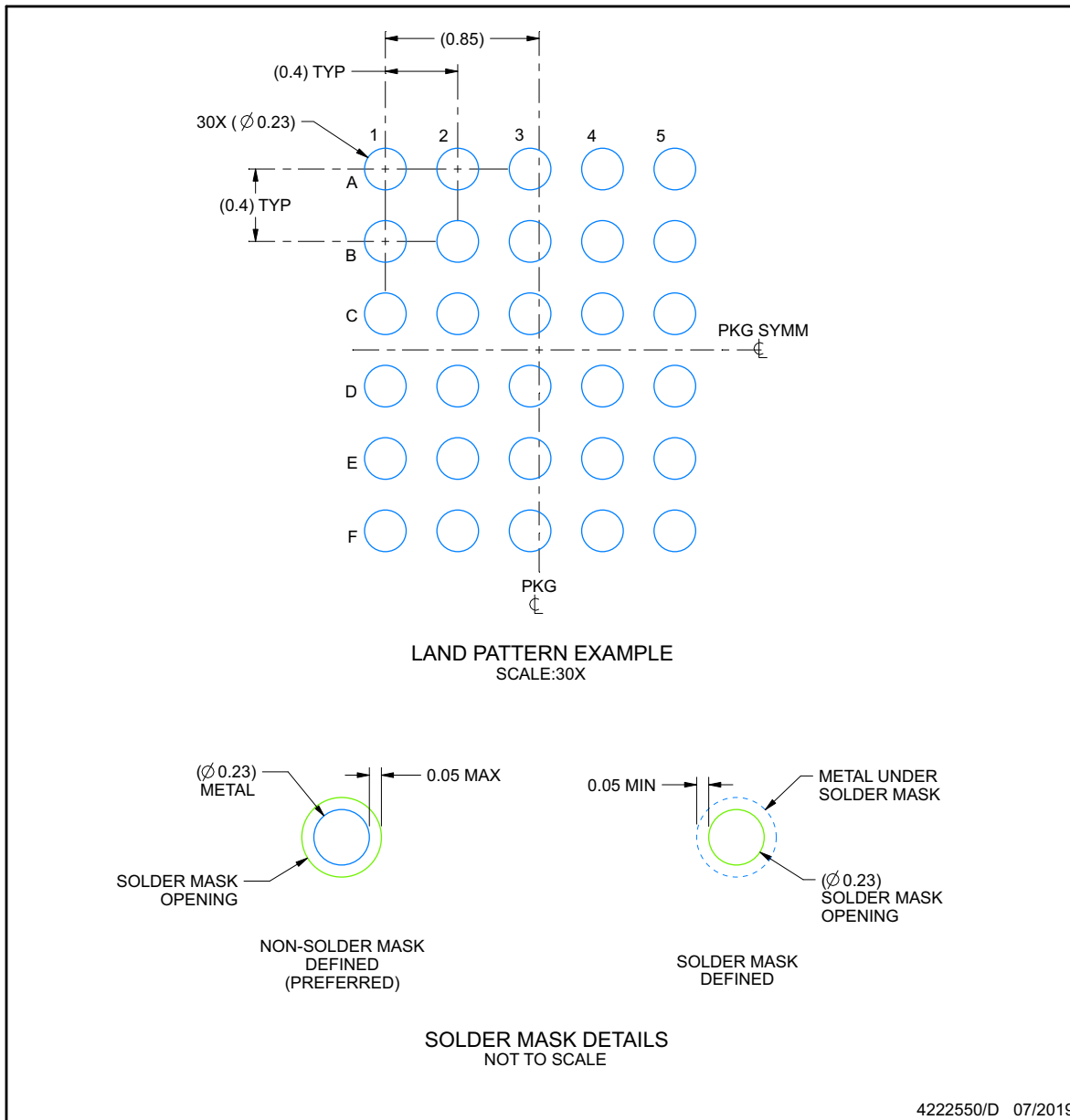0.21

PKG ⊄

0.015 Ⓜ C A B

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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.

Product Folder Links: *AFE4420*

EXAMPLE BOARD LAYOUT

YZ0030-C01

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY

LAND PATTERN EXAMPLE
SCALE:30X

SOLDER MASK DETAILS
NOT TO SCALE

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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).

www.ti.com

Product Folder Links: *AFE4420*

EXAMPLE STENCIL DESIGN

YZ0030-C01

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY

SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE:35X

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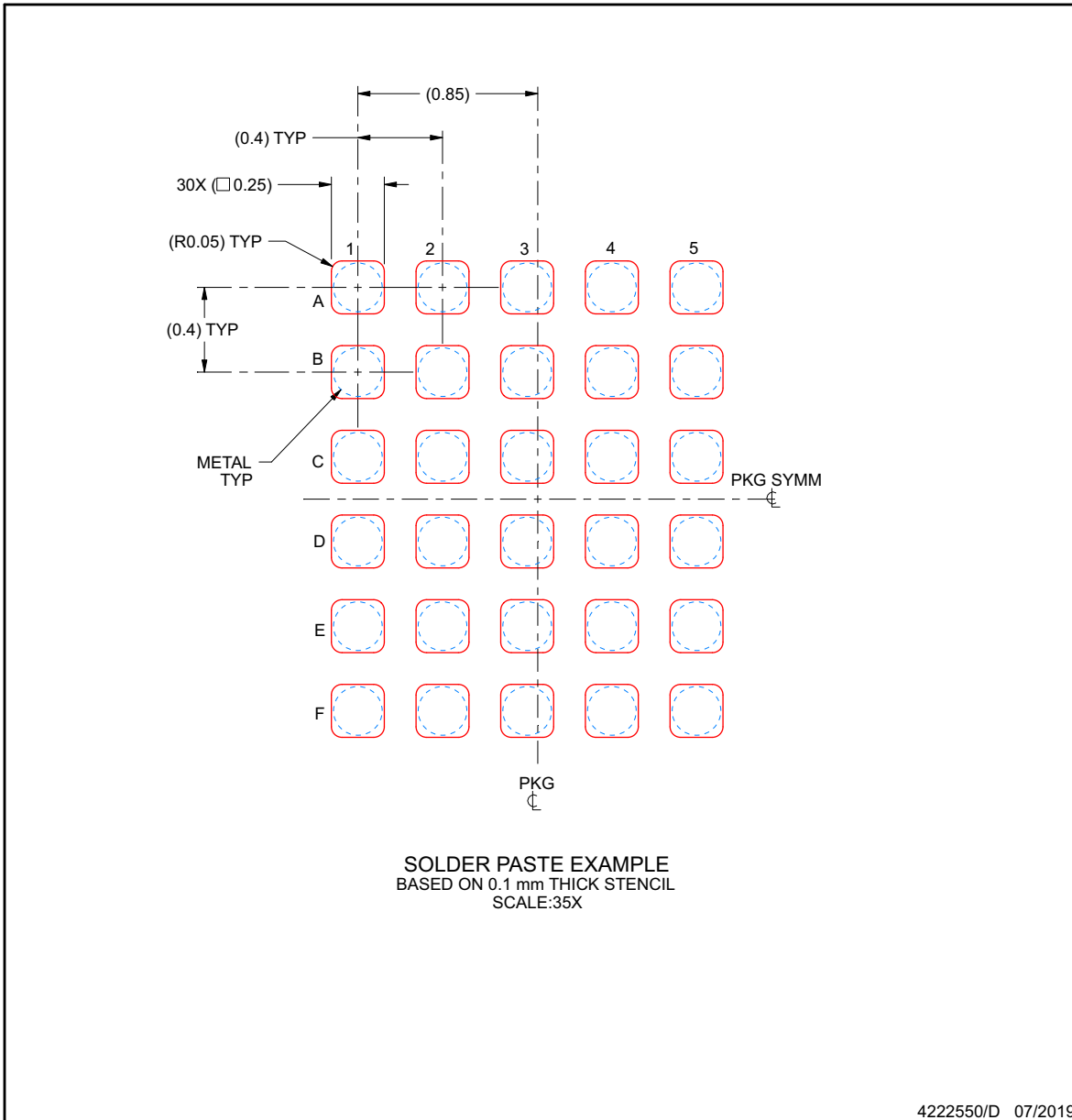
NOTES: (continued)

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

Product Folder Links: *AFE4420*

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
AFE4420YZR	ACTIVE	DSBGA	YZ	30	3000	RoHS & Green	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4420	Samples
AFE4420YZT	ACTIVE	DSBGA	YZ	30	250	RoHS & Green	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4420	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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