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^2C, 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

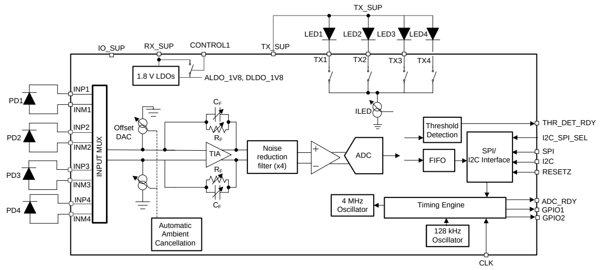
The AFE4420 is an analog front-end for optical bio-sensing applications, such as heart-rate monitoring (HRM) and saturation of peripheral capillary oxygen (SpO2). The device supports up to four switching light-emitting diodes (LEDs) and up to four photodiodes. Up to 16 signal phases can be defined and 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



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4 Revision History

Changes from Original (June 2018) to Revision A	Page
• Changed the *Mechanical Packaging* images	4

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

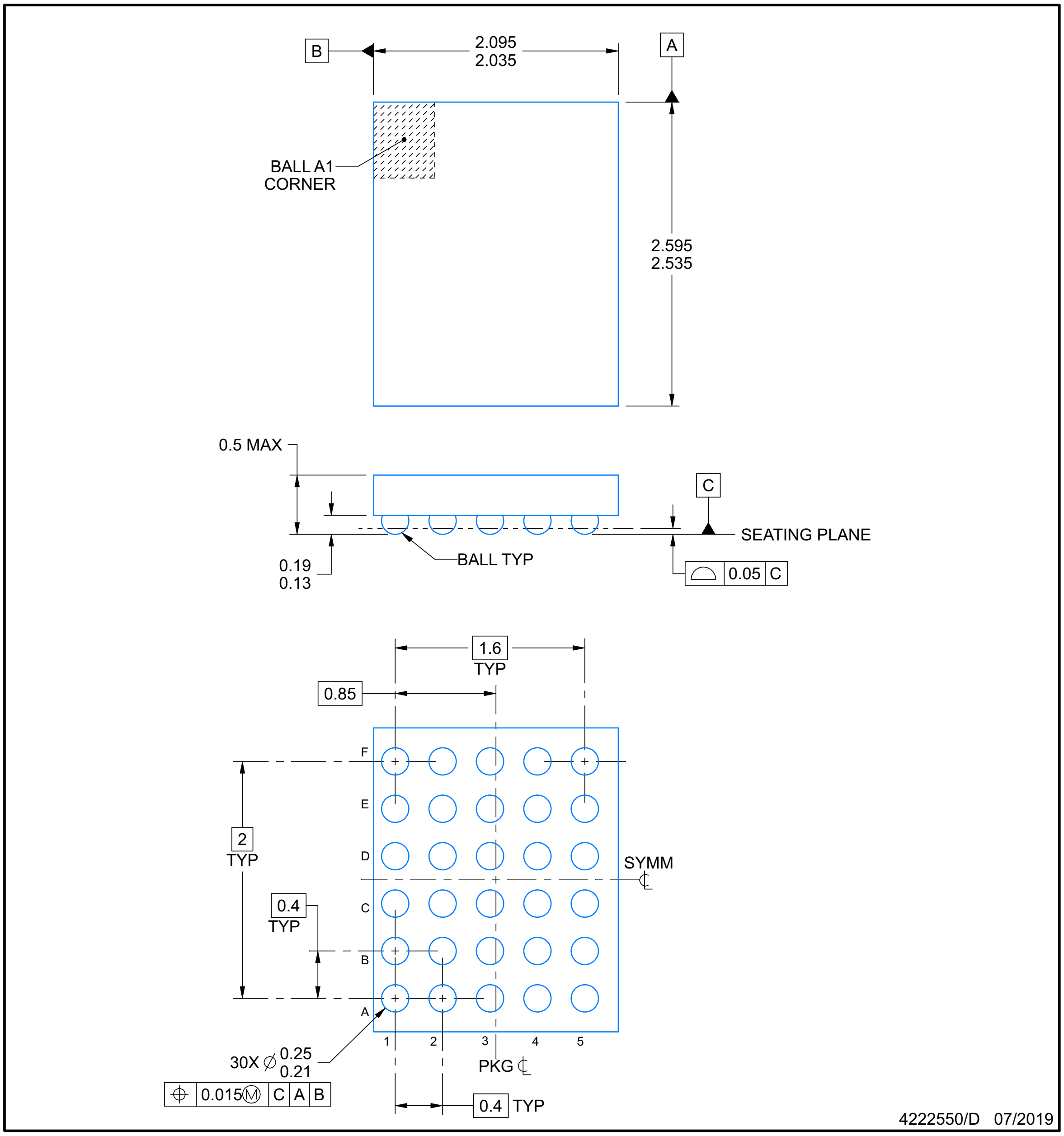
The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand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

PACKAGE OUTLINE

YZ0030-C01

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



NOTES:

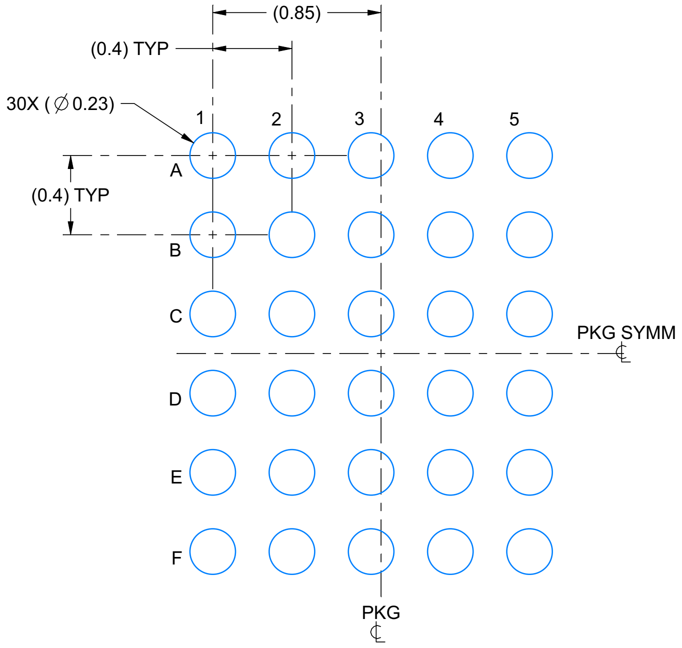
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

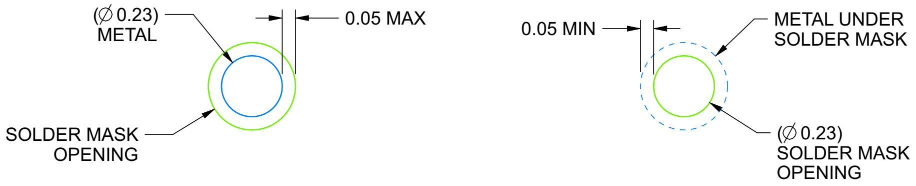
YZ0030-C01

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE
SCALE:30X



NON-SOLDER MASK
DEFINED
(PREFERRED)

SOLDER MASK
DEFINED

SOLDER MASK DETAILS
NOT TO SCALE

4222550/D 07/2019

NOTES: (continued)

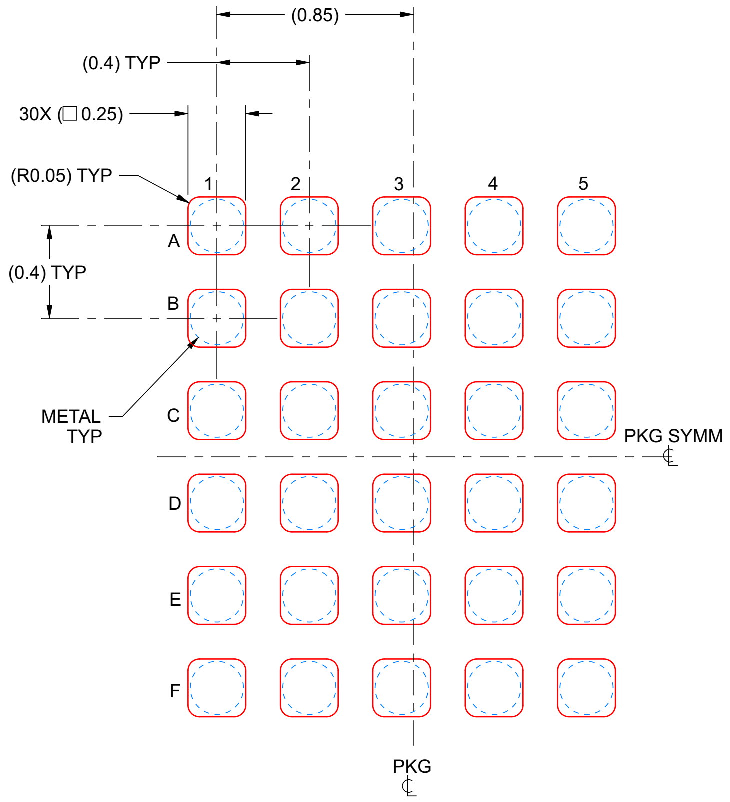
3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).

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.

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)
AFE4420YZR	Active	Production	DSBGA (YZ) | 30	3000 | LARGE T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4420
AFE4420YZR.A	Active	Production	DSBGA (YZ) | 30	3000 | LARGE T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4420
AFE4420YZT	Active	Production	DSBGA (YZ) | 30	250 | SMALL T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4420
AFE4420YZT.A	Active	Production	DSBGA (YZ) | 30	250 | SMALL T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4420

(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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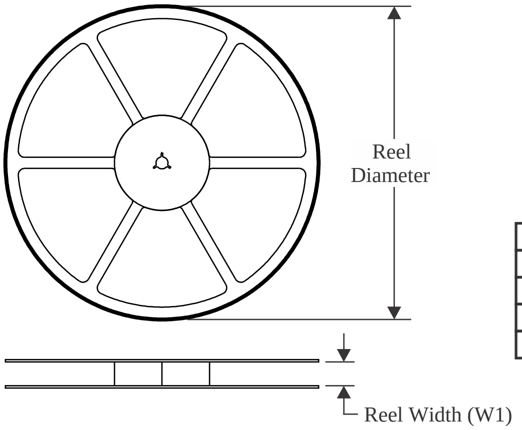
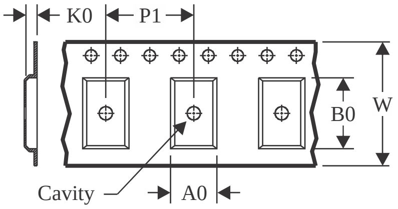
TAPE AND REEL INFORMATION

REEL DIMENSIONS

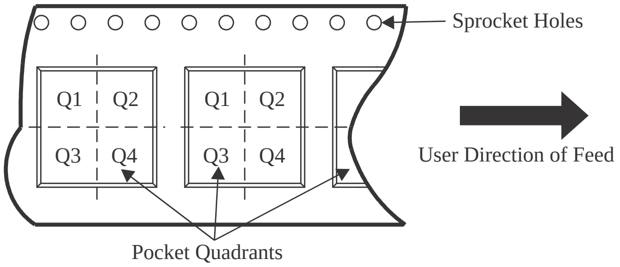


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

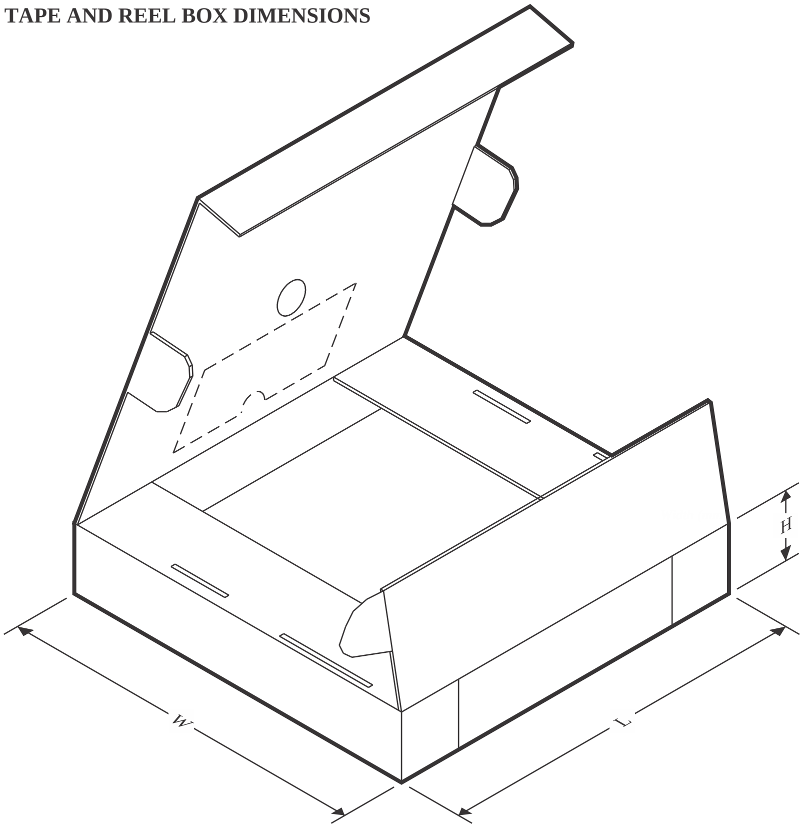
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
AFE4420YZR	DSBGA	YZ	30	3000	180.0	8.4	2.26	2.74	0.81	4.0	8.0	Q1
AFE4420YZT	DSBGA	YZ	30	250	180.0	8.4	2.26	2.74	0.81	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)
AFE4420YZR	DSBGA	YZ	30	3000	210.0	185.0	35.0
AFE4420YZT	DSBGA	YZ	30	250	210.0	185.0	35.0

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