AFE4432 Ultra-Small, Integrated AFE for Optical Bio-Sensing

1 Features

- Supports signal acquisition of up to 12 phase sets
- Supports up to 4 LEDs, 3 PDs
- Flexible allocation of LEDs, PDs in each phase
- Simultaneous signal acquisition from different sensors at different data rates
- Accurate, continuous PPG monitoring:
  - Low current for continuous heart-rate monitoring on a wearable device with a typical value: 12 µA for the receiver
  - Peak system SNR of 115 dB in 0.5-10 Hz band enables high-accuracy SpO2 measurement
- Transmitter:
  - 8-Bit Programmable LED current with range adjustable from 25 mA to 250 mA
  - Mode to fire two LEDs in parallel with independent per-phase current control
  - Programmable LED on-time per-phase
  - Simultaneous support of 4 LEDs for SpO2, Multi-Wavelength HRM
- Receiver:
  - Supports 3 Time-Multiplexed PD Inputs
  - 2 parallel receivers (2 sets of TIA/filter)
  - Individual ambient offset subtraction DAC at each TIA Input with 8-bit per-phase control and range adjustable up to 255-µA
  - Individual LED offset subtraction DAC at each TIA input with 9-bit per-phase control and 64-µA range
  - Digital ambient subtraction at ADC output
  - Noise filtering with programmable bandwidth
  - Transimpedance gain: 3.7 kΩ to 1 MΩ
- Supports external clock or internal oscillator
- Option to acquire data synchronized with a system clock
- Automatic cancellation of DC from Ambient, LED
- FIFO with 160-sample depth
- SPI™ interface/ I2C interface
- 1.9-mm × 1.8-mm DSBGA, 0.35-mm Pitch
- Supplies: Rx:1.7 - 1.9 V, Tx: 3-5.5 V

2 Applications

- Optical Heart-Rate Monitoring (HRM) for wearables, hearables
- Heart-Rate Variability (HRV)
- Pulse Oximetry (SpO2) measurements

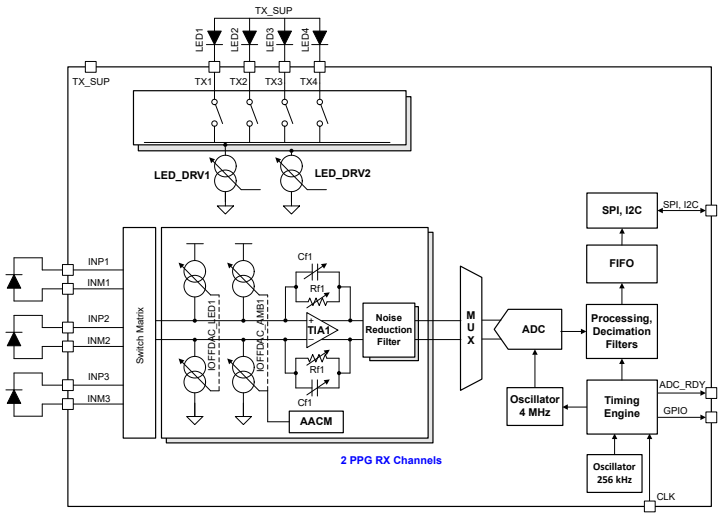
3 Description

The AFE4432 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 4 switching light-emitting diodes (LEDs) and up to three photodiodes (PDs). The AFE has two LED drivers each with 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. Up to 12 signal phase sets can be defined, each phase set comprising a combination of LED and Ambient phases. Low noise offset DACs at the receiver inputs can be automatically controlled to cancel DC from Ambient and LED light. The current from the PDs in each phase is converted into voltage by TIAs, filtered, and then digitized using a common ADC. The ADC code can be stored in a 160-sample FIFO block. The FIFO can be read out using a SPI or I^2C interface.

Device Information

PART NUMBER	PACKAGE(1)	BODY SIZE (NOM)
AFE4432	DSBGA (25)	1.80 mm x 1.92 mm

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



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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4 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

4.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* 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.

4.2 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.

4.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.
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4.4 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.

4.5 Glossary

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

5 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.

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5.1 Package Option Addendum

Packaging Information

Orderable Device	Status(1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan(2)	Lead/Ball Finish(6)	MSL Peak Temp(3)	Op Temp (°C)	Device Marking(4) (5)
AFE4432YCHR	ACTIVE	DSBGA	YCH	25	3000	Green (RoHS & no Sn/Br)	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE4432
AFE4432YCHT	ACTIVE	DSBGA	YCH	25	250	Green (RoHS & no Sn/Br)	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE4432

(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.
PRE_PROD Unannounced device, not in production, not available for mass market, nor on the web, samples not available.
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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material).

(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.

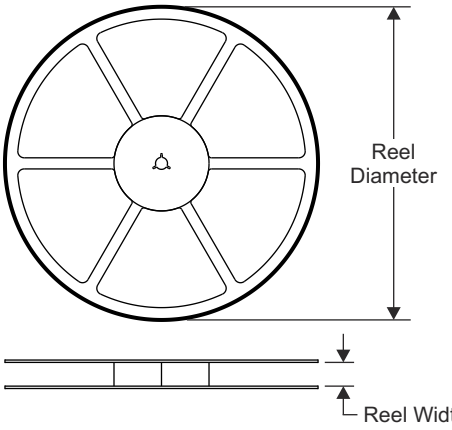
(5) Multiple Device markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

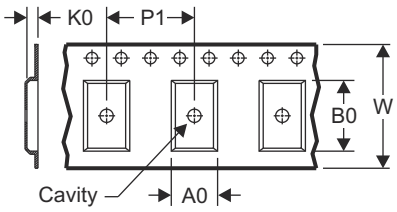
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5.2 Tape and Reel Information

REEL DIMENSIONS

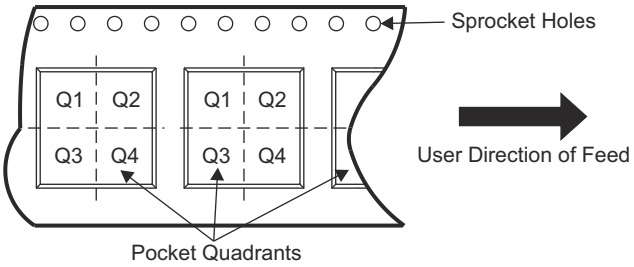


TAPE DIMENSIONS



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

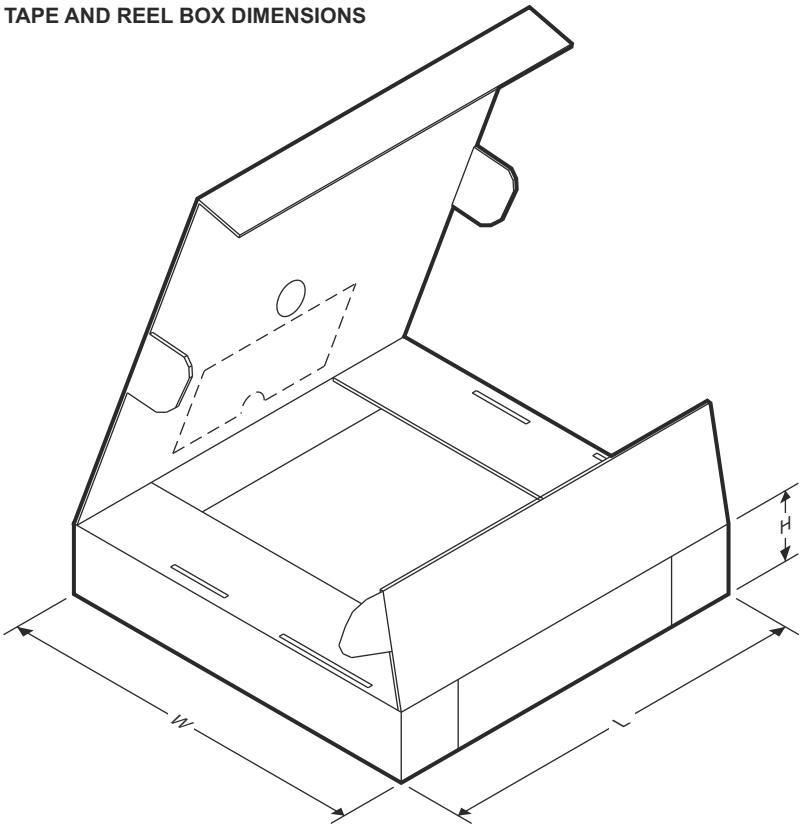
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



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
AFE4432YCHR	DSBGA	YCH	25	3000	128.0	9.2	1.92	2.02	0.48	4.0	12.0	Q1
AFE4432YCHT	DSBGA	YCH	25	250	128.0	9.2	1.92	2.02	0.48	4.0	12.0	Q1

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TAPE AND REEL BOX DIMENSIONS



Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
AFE4432YCHR	DSBGA	YCH	25	3000	345.0	365.0	55.0
AFE4432YCHT	DSBGA	YCH	25	250	345.0	365.0	55.0

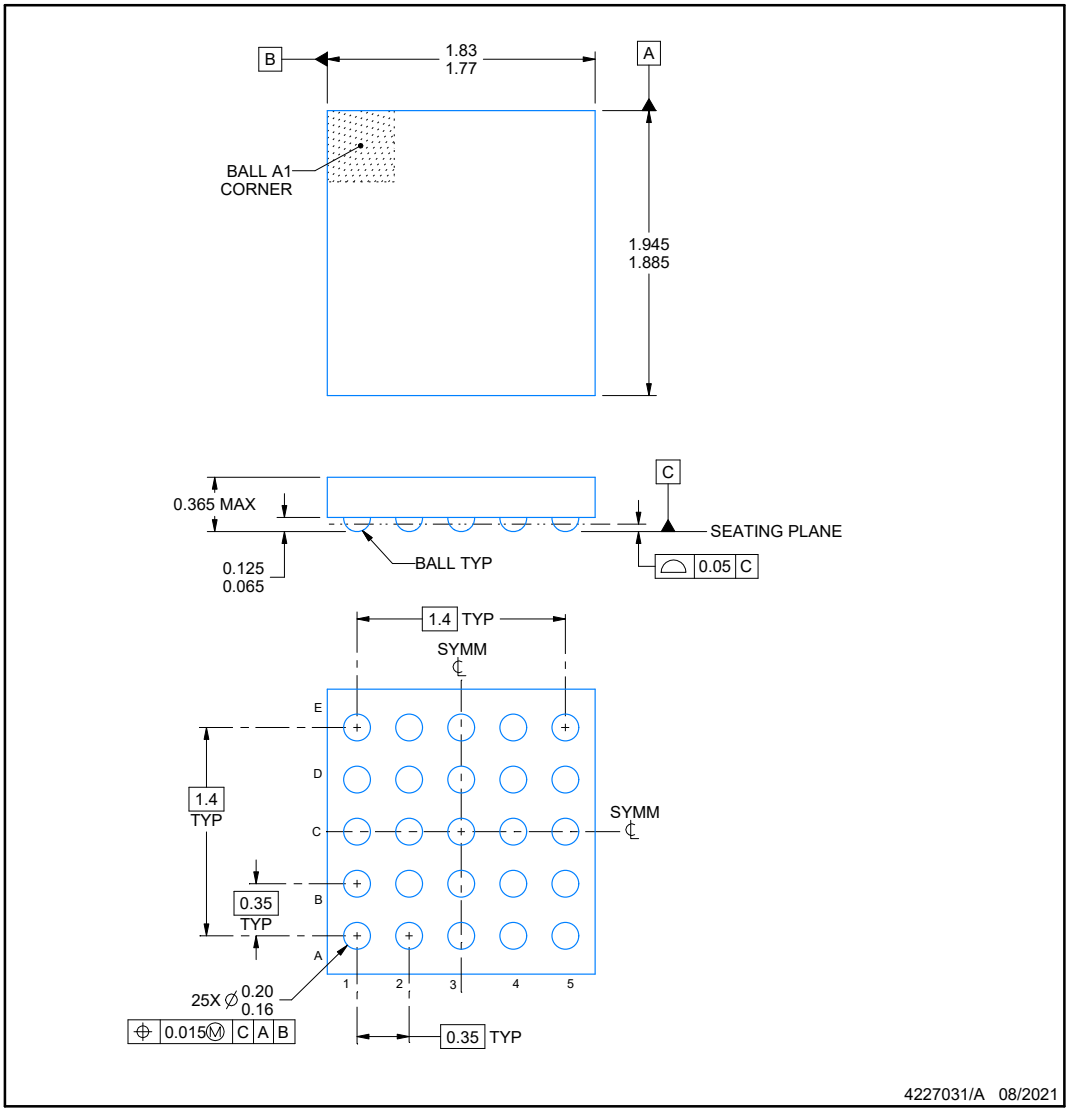
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5.3 Mechanical Data

PACKAGE OUTLINE

YCH0025-C01 — **DSBGA - 0.365 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.

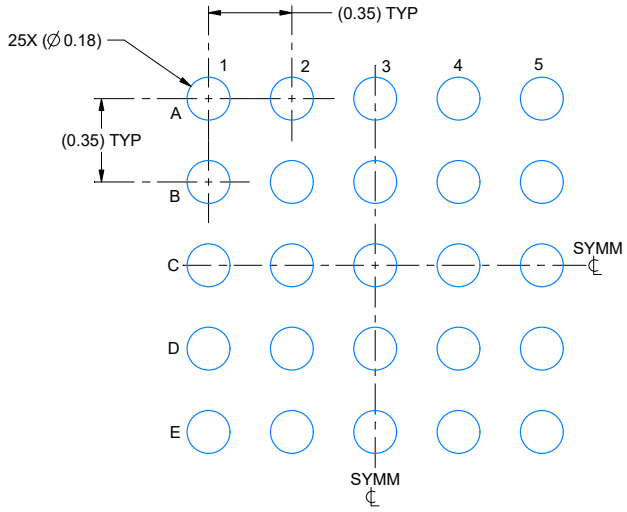
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EXAMPLE BOARD LAYOUT

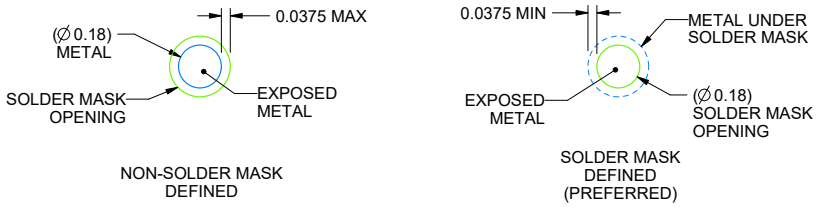
YCH0025-C01

DSBGA - 0.365 mm max height

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 40X



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).

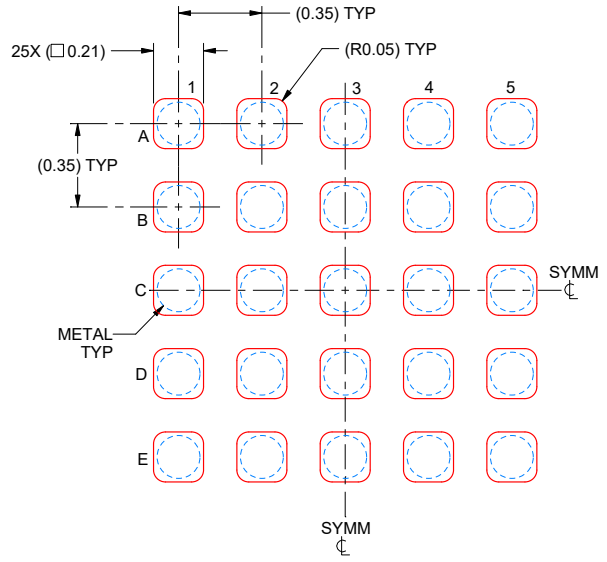
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EXAMPLE STENCIL DESIGN

YCH0025-C01

DSBGA - 0.365 mm max height

DIE SIZE BALL GRID ARRAY



SOLDER PASTE EXAMPLE
BASED ON 0.075 mm THICK STENCIL
SCALE: 40X

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NOTES: (continued)

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

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