AFE4460 Ultra-Small, Integrated AFE for Optical Bio-Sensing

1 Features

- Supports signal acquisition of up to 16 phase sets
- Supports up to 32 LEDs, 4 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: 15 µA for an LED, 15 µA for the receiver
  - Peak system SNR of 115 dB
- 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 32 LEDs for SpO2, Multi-Wavelength HRM, and Spectroscopy
- Receiver:
  - Supports 4 Time-Multiplexed PD Inputs
  - 4 parallel receivers (4 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 256-sample depth
- SPI™ interface/ I2C interface
- 2.6-mm × 2.6-mm DSBGA, 0.4-mm Pitch
- Supplies: Rx:1.7 - 1.9 V (LDO Bypass); 1.9 - 3.6 V (LDO Enabled), Tx: 3-5.5 V, IO: 1.7-RX_SUP

2 Applications

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

3 Description

The AFE4460 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 32 switching light-emitting diodes (LEDs) and up to four 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 16 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 each of the 4 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 256-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)
AFE4460	DSBGA (36)	2.60 mm × 2.60 mm

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

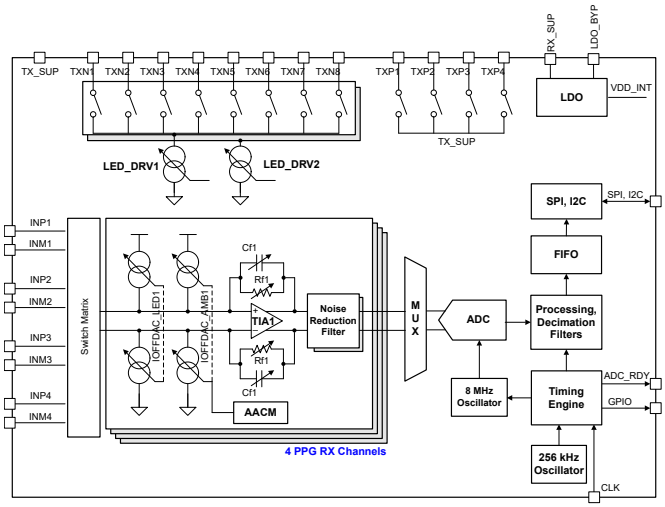

Table of Contents

4 Revision History

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

DATE	REVISION	NOTES
June 2022	*	Initial Release

5 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.

5.1 Documentation Support

5.1.1 Related Documentation

5.2 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.

5.3 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.

5.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.
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5.5 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.

5.6 Glossary

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.

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
AFE4460YBGR	ACTIVE	DSBGA	YBG	36	3000	RoHS & Green	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4460	Samples
AFE4460YBGT	ACTIVE	DSBGA	YBG	36	250	RoHS & Green	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4460	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.

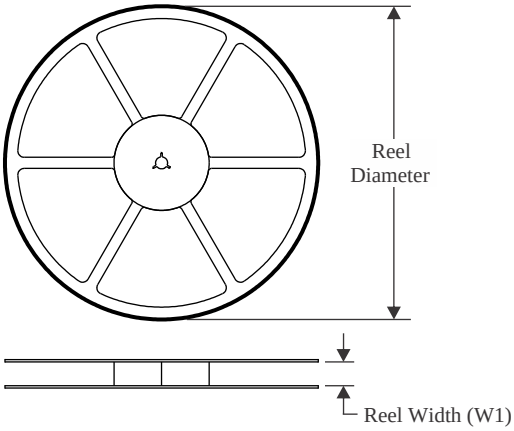
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

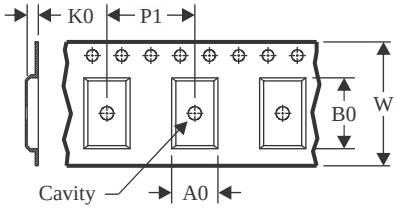
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

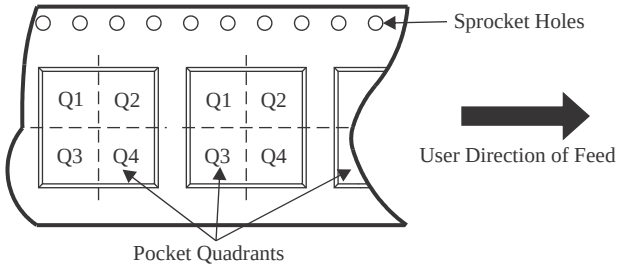


TAPE DIMENSIONS



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

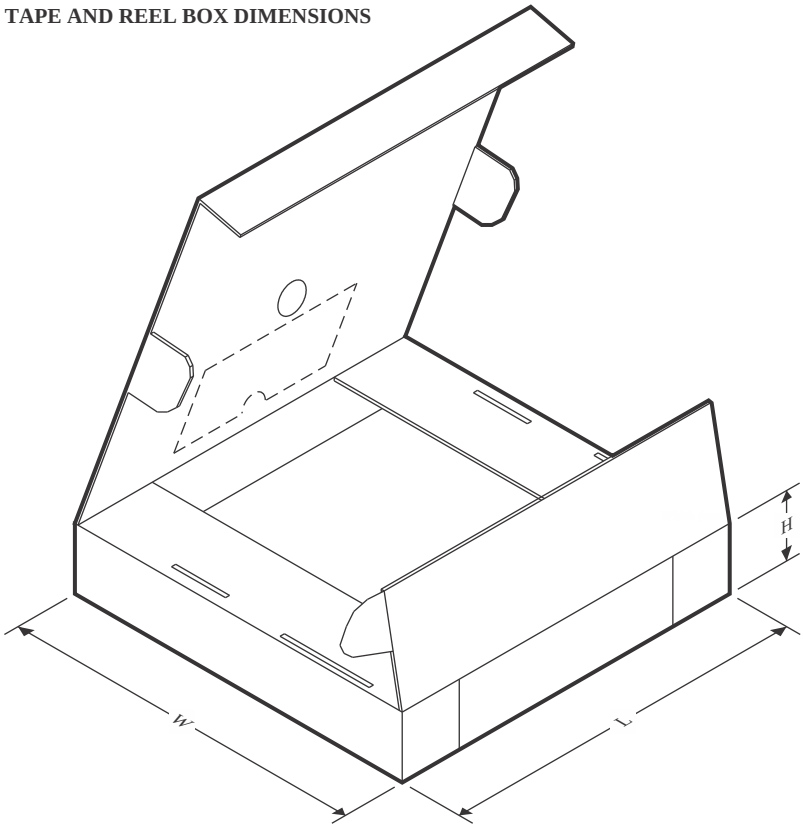
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
AFE4460YBGR	DSBGA	YBG	36	3000	330.0	12.4	2.73	2.73	0.67	8.0	12.0	Q1
AFE4460YBGT	DSBGA	YBG	36	250	330.0	12.4	2.73	2.73	0.67	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

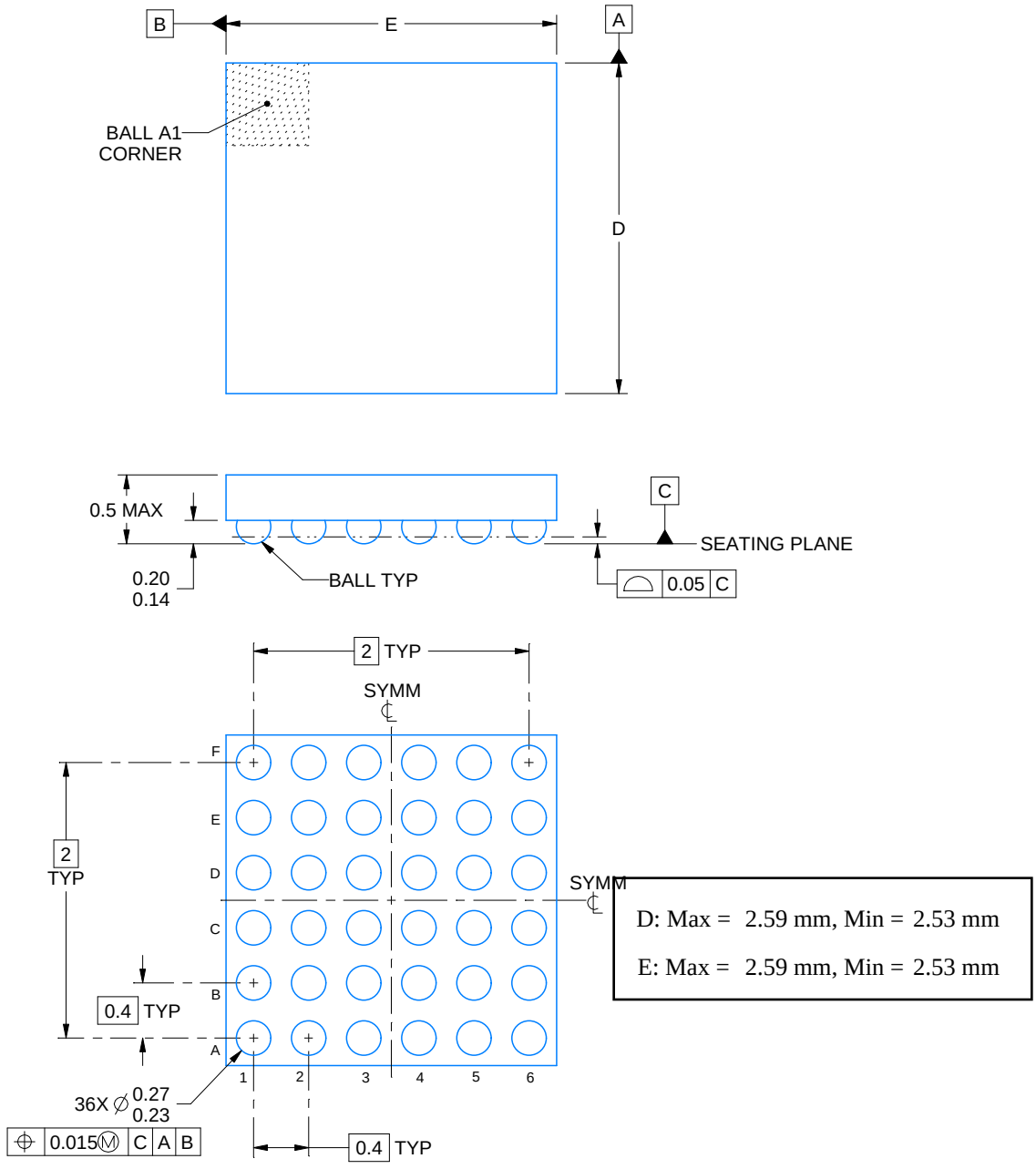
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
AFE4460YBGR	DSBGA	YBG	36	3000	345.0	365.0	55.0
AFE4460YBGT	DSBGA	YBG	36	250	345.0	365.0	55.0

PACKAGE OUTLINE

YBG0036

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



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NOTES:

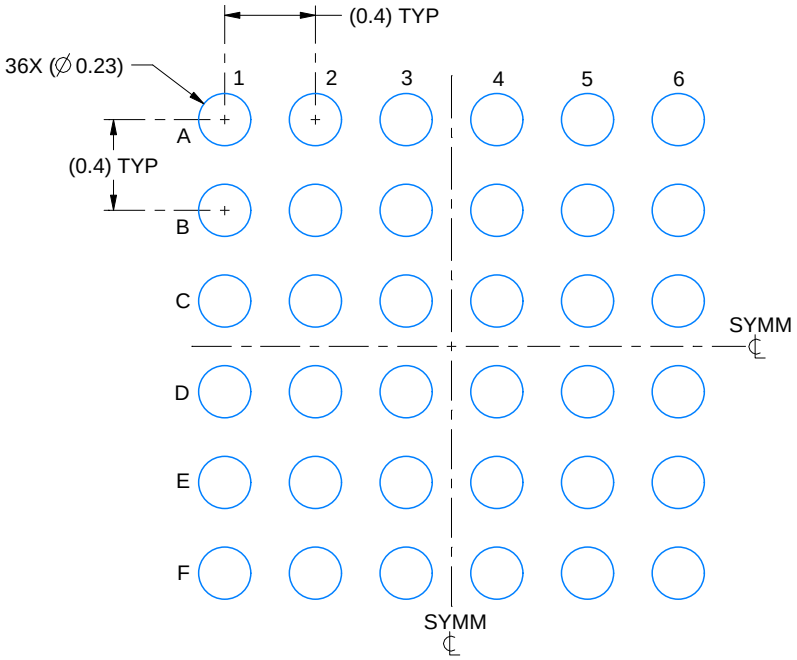
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

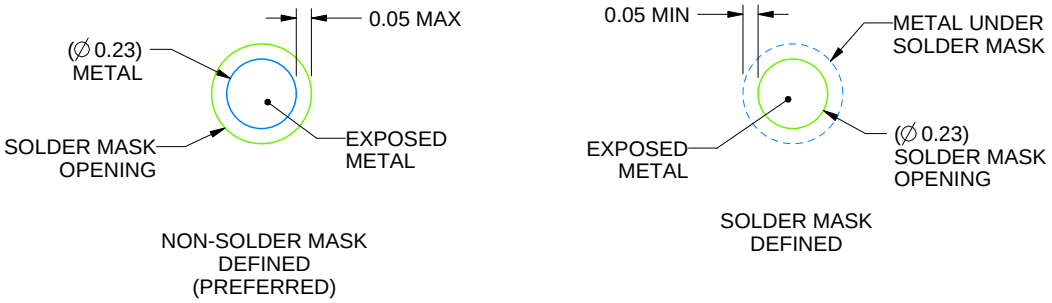
YBG0036

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 30X



SOLDER MASK DETAILS
NOT TO SCALE

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NOTES: (continued)

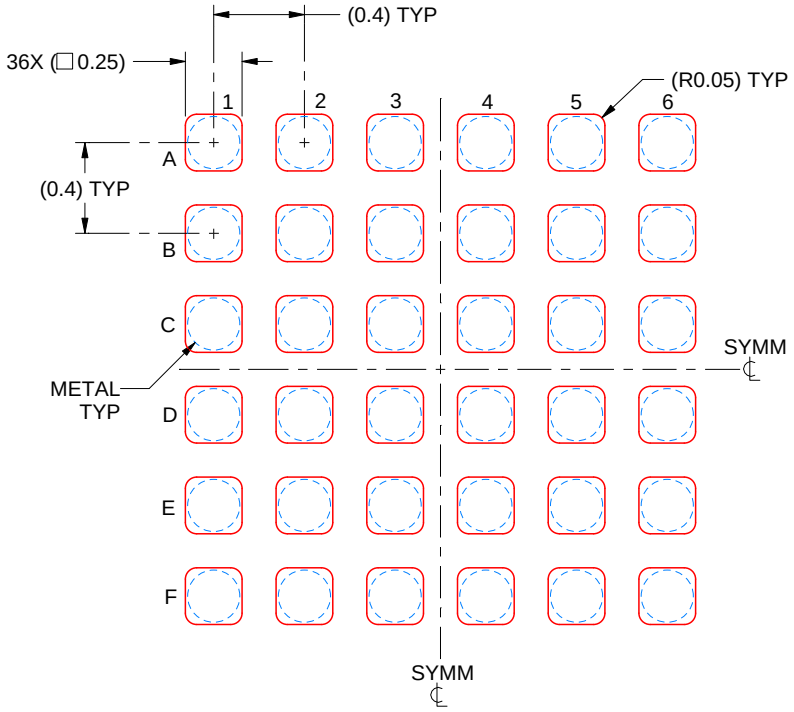
3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints.
   See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).

EXAMPLE STENCIL DESIGN

YBG0036

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 30X

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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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