

适用于可穿戴设备、连续光学心率监测和生物传感且具有 FIFO 功能的 AFE4410 超小型集成式 AFE

1 特性

- 精确、连续的心率监测：
 - 高达 100dB 的动态范围可实现精确心率监测
 - 用于在可穿戴设备上持续运行的低电流，其典型值为：
 - 对于 LED 为 30 μ A，对于接收器为 25 μ A
- 发送器：
 - 4 个采用共阳极配置的 LED
 - 高达 200mA 的 8 位可编程 LED 电流
 - 支持同时点亮两个 LED 的模式
 - 可编程 LED 导通时间
 - 同时支持 3 个 LED，适用于优化型 SpO₂ 测量、HRM 或多波长 HRM
 - 平均电流为 30 μ A，可满足典型的心率监测情形：
 - 20mA 设置、60 μ s 脉冲持续时间、25Hz 采样率
- 接收器：
 - 支持 3 路时分多路复用 PD 输入
 - 以 24 位二进制补码格式表示 PD 的电流输入
 - TIA 输入端的独立直流失调消减 DAC（范围高达 $\pm 127\mu$ A），用于每个 LED 和环境光相位
 - ADC 输出端的数字环境减法
 - 跨阻增益：10k Ω 至 2M Ω
 - 具有带宽可配的噪声滤波器
 - 接收器在约 1 μ A/Hz 的采样率（例如 25 μ A/25Hz）下运行
 - 硬件断电模式：约 0 μ A 电流
- 灵活的脉冲排序和时序控制
- 通过外部时钟或者内部振荡器作为参考时钟
- 采样深度为 128 的 FIFO：
 - 可针对各阶段编程设定分区
- 可通过引脚来选择 I²C、SPI 接口
- 工作温度范围：-20°C 至 +70°C
- 2.6mm × 2.1mm、0.4mm 间距 DSBGA 封装
- 电源：
 - Tx: 3V 至 5.25V
 - Rx: 1.8V 至 1.9V（LDO 旁路），2.0V 至 3.6V（LDO 使能）
 - IO: 1.7V 至 Rx_SUP

2 应用

- 光学心率监测 (HRM)（可穿戴设备和可听设备）
- 心率变异分析 (HRV)
- 血氧饱和度 (SpO₂) 测量
- 最大耗氧量 (VO₂ Max)

3 说明

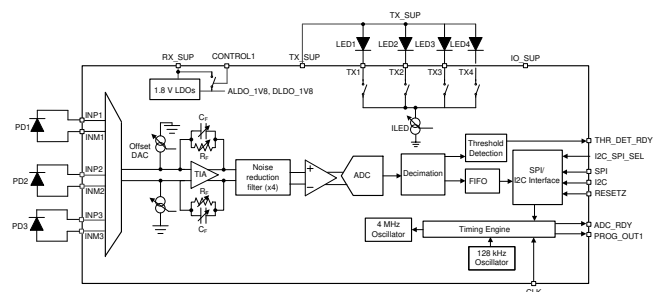
AFE4410 是一款模拟前端，适用于光学生物传感应用，比如心率监测 (HRM)。该器件最多支持四个可切换发光二极管 (LED) 和三个光电二极管 (PD)。光电二极管的电流通过跨阻放大器 (TIA) 转换为电压，并由模数转换器 (ADC) 进行数字化处理。ADC 编码可存储到深度可编程的 128 采样先入先出块 (FIFO) 中。您可以使用 I²C 接口或串行外设接口 (SPI) 读取 FIFO。该 AFE 还带有 8 位电流控制的完全集成式 LED 驱动器。该器件具有高动态范围的收发电路，可提供高达 100dB 的动态范围，从而精确地感应心率。该 AFE 通过以超低功耗 (ULP) 模式（通过使用 ENABLE_ULP 寄存器位进行设置）运行来实现极低的电流电平。

器件信息⁽¹⁾

器件型号	封装	封装尺寸（标称值）
AFE4410	DSBGA (30)	2.6mm × 2.1mm

(1) 如需了解所有可用封装，请参阅数据表末尾的封装选项附录。

简化方框图



4 修订历史记录

Changes from Revision A (May 2017) to Revision B	Page
• 更改了机械封装 图像	5
Changes from Original (May 2017) to Revision A	Page
• 已更改 将范围从 $\pm 126\mu\text{A}$ 更改为 $\pm 127\mu\text{A}$	1

5 器件和文档支持

5.1 接收文档更新通知

要接收文档更新通知，请导航至 ti.com.cn 上的器件产品文件夹。单击右上角的通知我进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

5.2 社区资源

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 商标

E2E is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

5.4 静电放电警告



ESD 可能会损坏该集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理措施和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

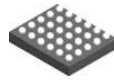
5.5 Glossary

[SLYZ022](#) — *TI Glossary*.

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

6 机械、封装和可订购信息

以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。数据如有变更，恕不另行通知，且不会对此文档进行修订。如需获取此数据表的浏览器版本，请查阅左侧的导航栏。

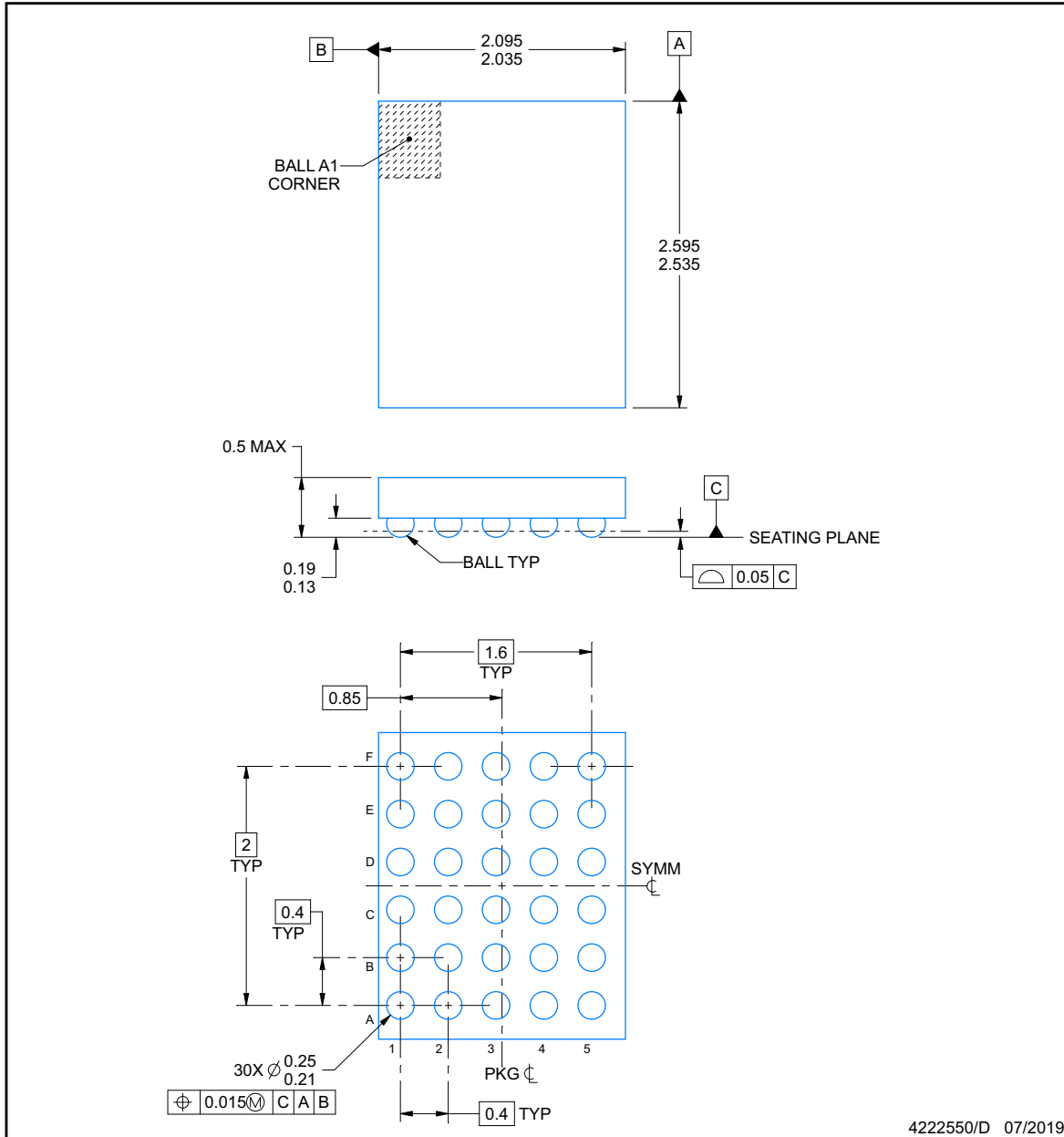


YZ0030-C01

PACKAGE OUTLINE

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



NOTES:

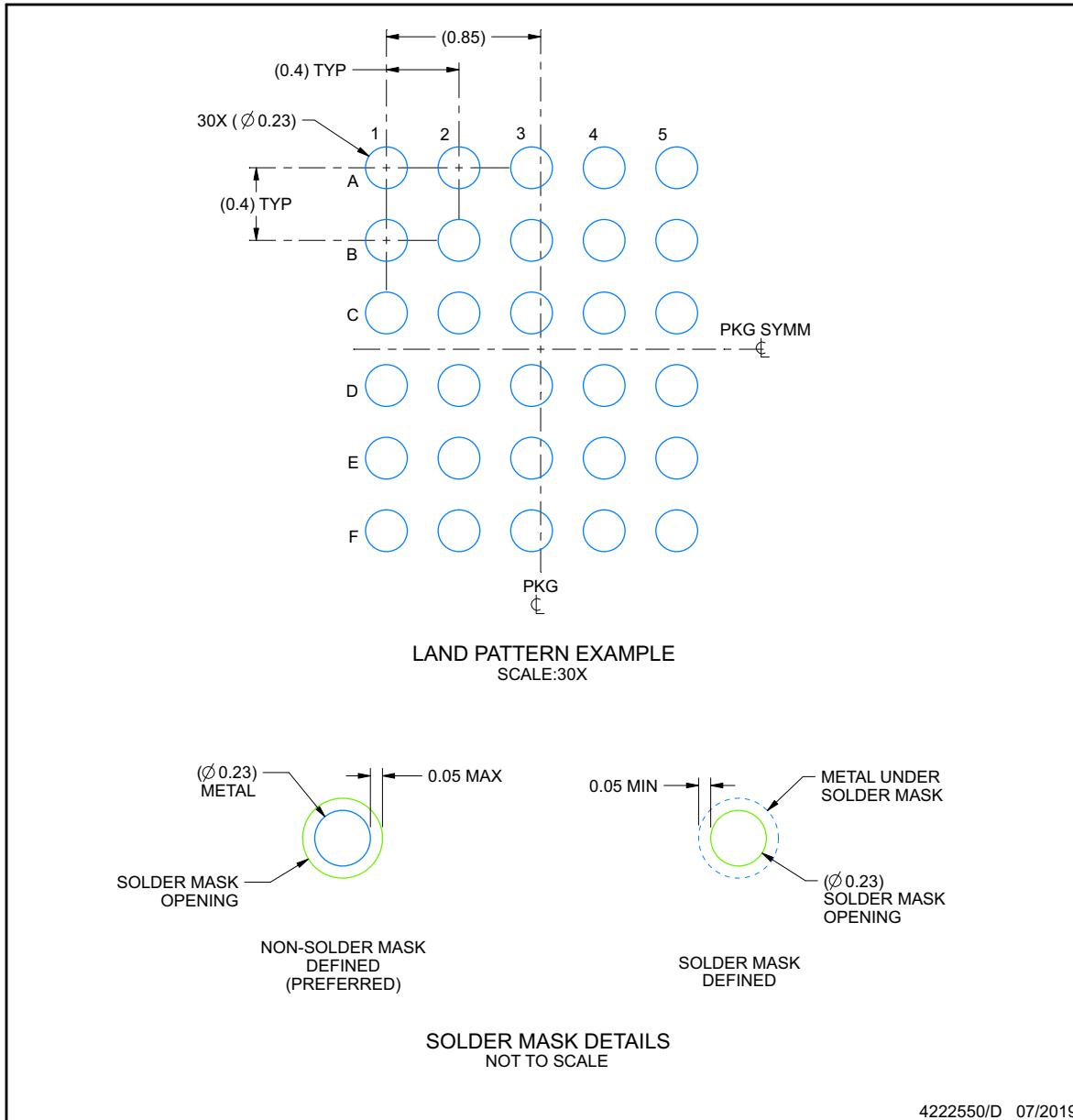
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

YZ0030-C01

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



NOTES: (continued)

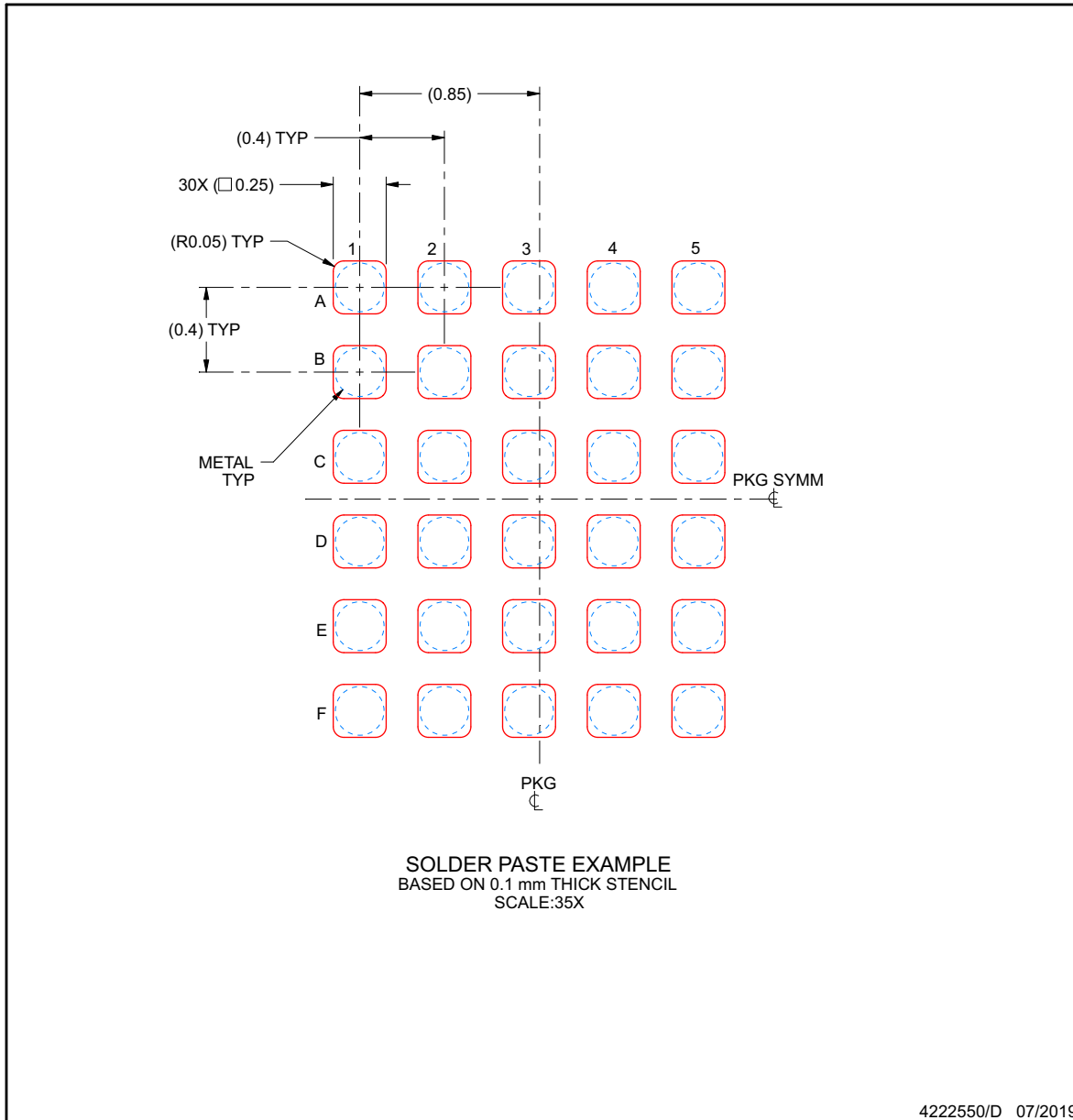
- Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints.
See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).

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 (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)
AFE4410YZR	Active	Production	DSBGA (YZ) 30	3000 LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	0 to 0	AFE4410
AFE4410YZR.A	Active	Production	DSBGA (YZ) 30	3000 LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	0 to 0	AFE4410
AFE4410YZT	Active	Production	DSBGA (YZ) 30	250 SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 70	AFE4410
AFE4410YZT.A	Active	Production	DSBGA (YZ) 30	250 SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 70	AFE4410

⁽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.

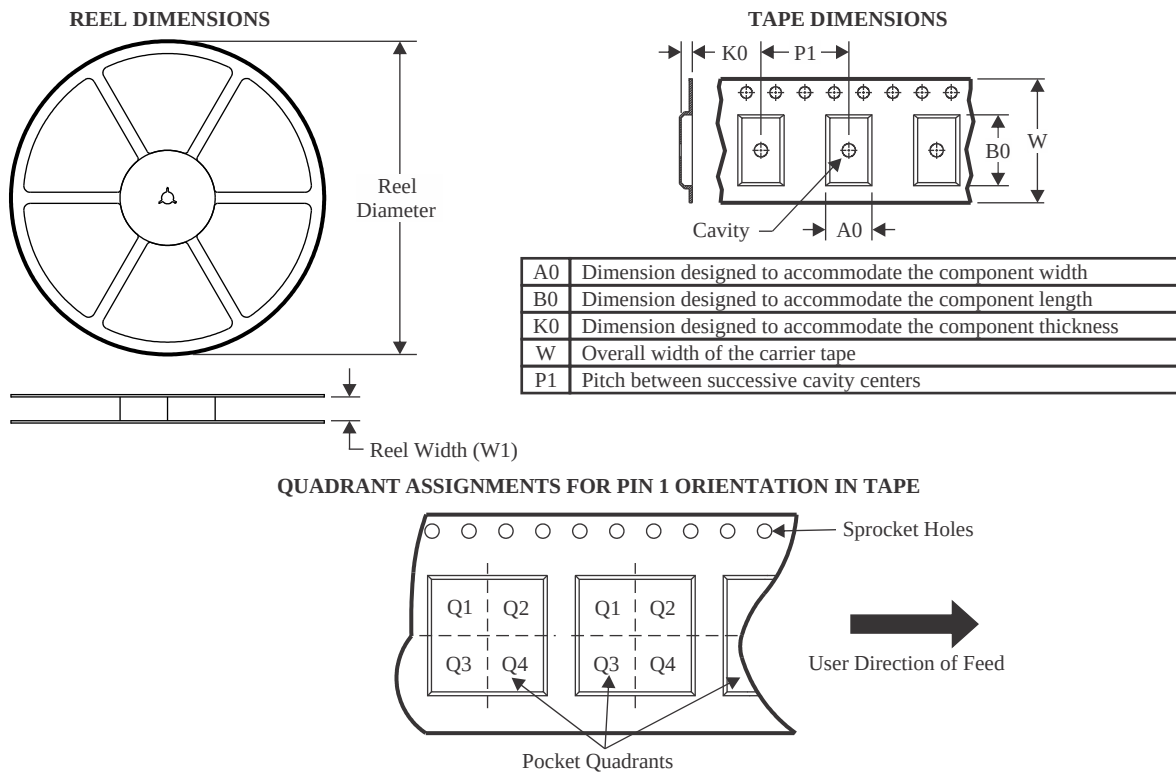
⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

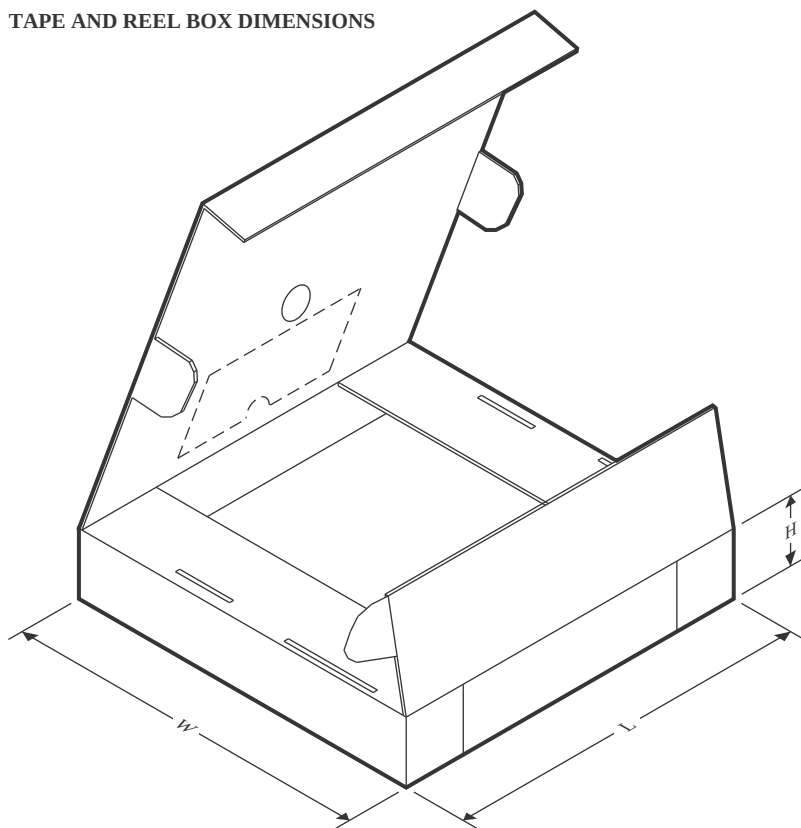
TAPE AND REEL INFORMATION



*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
AFE4410YZR	DSBGA	YZ	30	3000	180.0	8.4	2.16	2.66	0.6	4.0	8.0	Q1
AFE4410YZT	DSBGA	YZ	30	250	180.0	8.4	2.16	2.66	0.6	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)
AFE4410YZR	DSBGA	YZ	30	3000	182.0	182.0	20.0
AFE4410YZT	DSBGA	YZ	30	250	182.0	182.0	20.0

重要通知和免责声明

TI“按原样”提供技术和可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证没有瑕疵且不做任何明示或暗示的担保，包括但不限于对适销性、与某特定用途的适用性或不侵犯任何第三方知识产权的暗示担保。

这些资源可供使用 TI 产品进行设计的熟练开发人员使用。您将自行承担以下全部责任：(1) 针对您的应用选择合适的 TI 产品，(2) 设计、验证并测试您的应用，(3) 确保您的应用满足相应标准以及任何其他安全、安保法规或其他要求。

这些资源如有变更，恕不另行通知。TI 授权您仅可将这些资源用于研发本资源所述的 TI 产品的相关应用。严禁以其他方式对这些资源进行复制或展示。您无权使用任何其他 TI 知识产权或任何第三方知识产权。对于因您对这些资源的使用而对 TI 及其代表造成的任何索赔、损害、成本、损失和债务，您将全额赔偿，TI 对此概不负责。

TI 提供的产品受 [TI 销售条款](#)、[TI 通用质量指南](#) 或 [ti.com](#) 上其他适用条款或 TI 产品随附的其他适用条款的约束。TI 提供这些资源并不会扩展或以其他方式更改 TI 针对 TI 产品发布的适用的担保或担保免责声明。除非德州仪器 (TI) 明确将某产品指定为定制产品或客户特定产品，否则其产品均为按确定价格收入目录的标准通用器件。

TI 反对并拒绝您可能提出的任何其他或不同的条款。

版权所有 © 2025，德州仪器 (TI) 公司

最后更新日期：2025 年 10 月