

# 具有 14 位 9GSPS DAC 和 14 位 3GSPS ADC 的 AFE76xx 四通道/双通道、射频采样模拟前端

## 1 器件概述

### 1.1 特性

- 14 位分辨率
- 采样率：
  - DAC: 9GSPS
  - ADC: 3GSPS
- 射频频率范围：高达 5.2GHz
- 最大射频信号带宽
  - 四通道模式 (4T4R)：800MHz (单频带)；300MHz (双频带)
  - 双通道模式 (2T2R)：1200MHz (TX)/1000MHz (RX) (单频带)；800MHz (双频带)
- 每 RX 通道配备片上双频可选择 DSA
- 集成型 TX DSA 功能
- 数字：
  - 双频带数字上变频器 (DUC)
  - 双频带数字下变频器 (DDC)
- 用于 DUC/DDC 的 32 位 NCO
- 插值率：6 倍、8 倍、9 倍、12 倍、16 倍、18 倍、24 倍、36 倍
- 抽取率：/2、/3、/4、/6、/8、/9、/12、/16、/18、/24、/32
- 适用于 TDD 的 RX/FB 动态转换
- 接口：
  - 8 个高达 15Gbps 的 SerDes 收发器
  - 采用 8b/10b 编码的 16 位和 12 位 JESD204B 传输层格式
  - 子类 1 多器件同步
- 时钟：
  - 用于生成 DAC 和 ADC 时钟的内部 PLL/VCO
- 封装：17mm x 17mm FC BGA，间距为 0.8mm
- 电源：1.85V、1.15V、1.0V、-1.8V

### 1.2 应用

- 蜂窝基站
- 宽带通信
- 微波回程连线
- 分布式天线系统 (DAS)

### 1.3 说明

AFE76xx 是一系列高性能四通道/双通道 14 位集成式射频采样模拟前端 (AFE)，配备 9 个 GSPS DAC 和 3 个 GSPS ADC，支持合成和数字化宽带信号。高动态范围使得 AFE76xx 能够为无线基站生成和数字化 3G/4G 信号。在 TDD 模式下，接收器通道经过配置可在流量接收器 (TDD RX) 状态和宽带反馈接收器 (TDD FB) 状态间动态切换以辅助发送器路径上功率放大器 (PA) 的 DPD (数字预失真)。

AFE76xx 系列在接收器通道上具有集成式 DSA，同时支持发送器通道上等同于 DSA 的功能。每个接收器通道都有一个模拟射频峰值功耗检测器和多个数字功耗检测器，可在接收器通道上辅助进行自动增益控制 (AGC)，另有两个射频过载检测器可实现器件可靠性保护。AFE76xx 系列拥有 8 个兼容 JESD204B 的 SerDes 收发器，运行速率高达 15Gbps。这些器件每 TX 通道拥有多达 2 个 DUC，每 RX 通道拥有 2 个 DDC，采用多种插值/抽取率以及具有频率灵活的独立 NCO 的数字正交调制器/解调器。这些器件在单频带模式下支持超过 1000MHz (4T4R 下为 800MHz) 射频信号带宽，在双频带模式下支持每频带高达 800MHz (4T4R 下为 300MHz) 射频信号带宽。低抖动 PLL/VCO 通过允许使用频率较低的参考时钟来简化采样时钟的生成。

器件信息<sup>(1)</sup>

| 器件型号    | 封装     | 封装尺寸              |
|---------|--------|-------------------|
| AFE7685 | FC-BGA | 17.00mm x 17.00mm |
| AFE7686 | FC-BGA | 17.00mm x 17.00mm |
| AFE7684 | FC-BGA | 17.00mm x 17.00mm |
| AFE7683 | FC-BGA | 17.00mm x 17.00mm |
| AFE7681 | FC-BGA | 17.00mm x 17.00mm |

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。



1.4 功能方框图

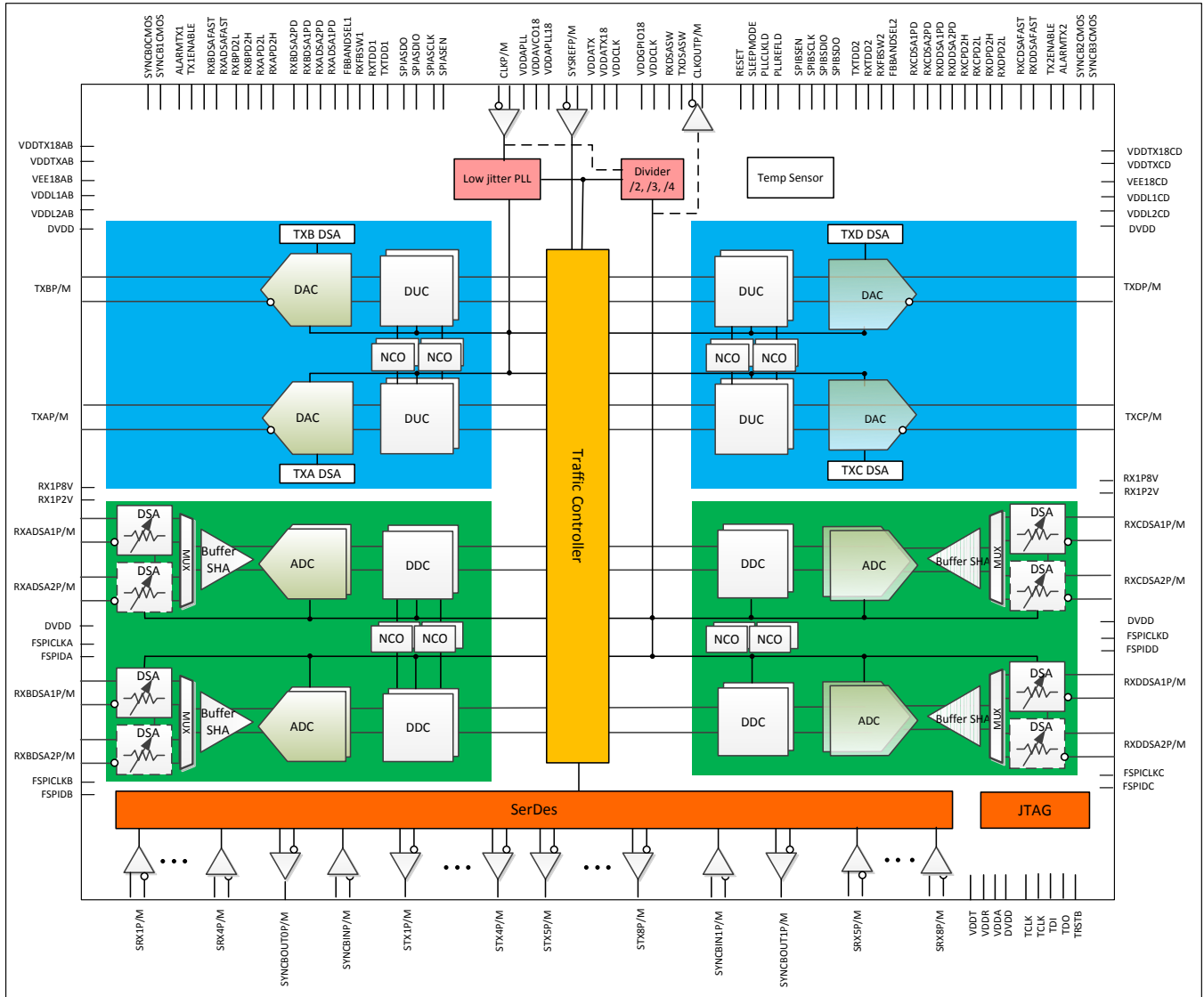


图 1-1. AFE7685/AFE7686 功能方框图

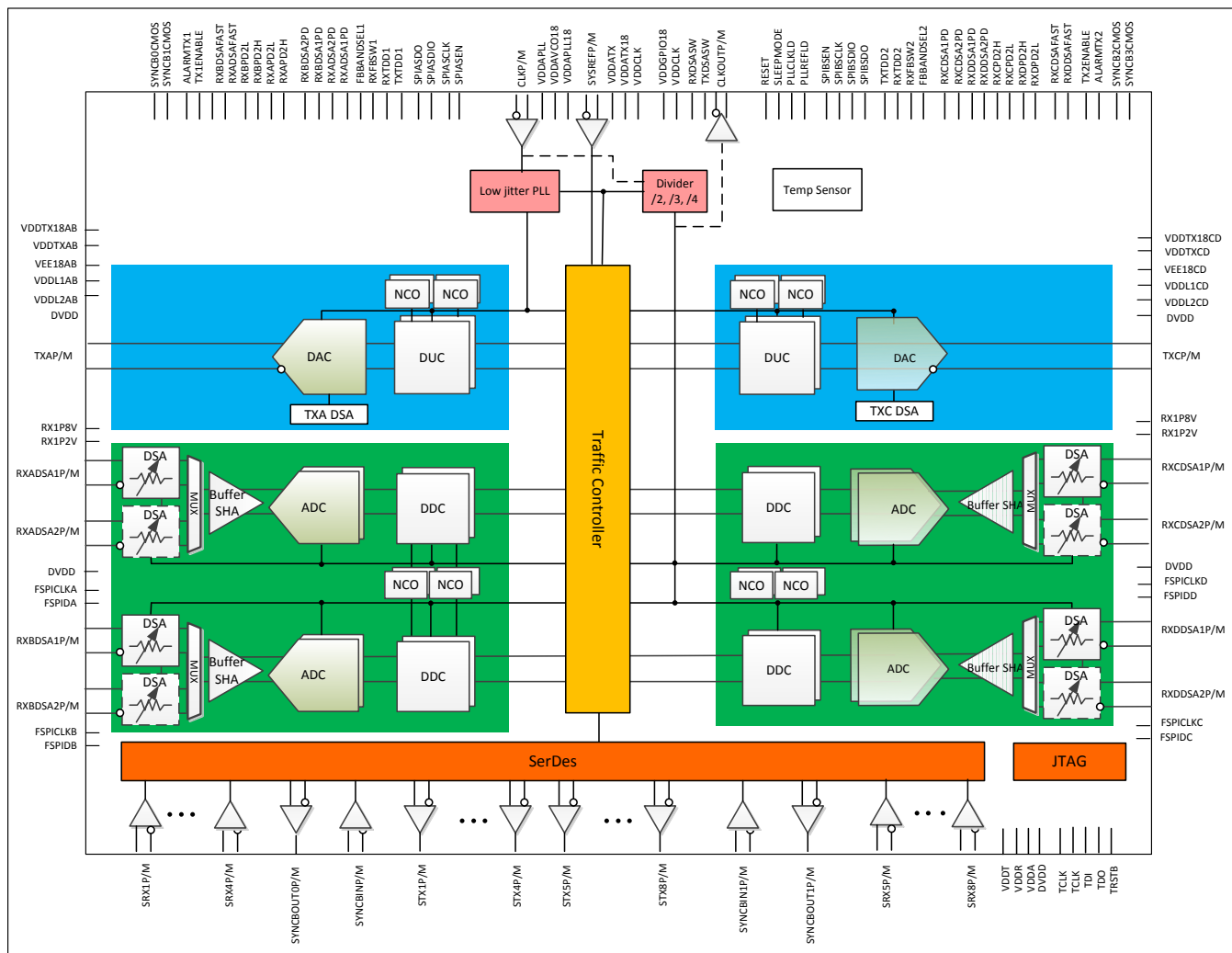


图 1-2. AFE7684 功能方框图

## 2 修订历史记录

| Changes from Revision D (December 2018) to Revision E  | Page              |
|--|-------------------|
| <ul style="list-style-type: none"> <li>已更改 将 AFE7681 从“预告信息”更改为“生产数据”.....</li> </ul>        | <a href="#">1</a> |
| Changes from Revision C (October 2018) to Revision D   | Page              |
| <ul style="list-style-type: none"> <li>已添加 AFE7681 作为“预告信息”，AFE7683 作为“生产数据”.....</li> </ul> | <a href="#">1</a> |
| Changes from Revision B (September 2018) to Revision C                                       | Page              |
| <ul style="list-style-type: none"> <li>已更改 将 AFE7684 从“预告信息”更改为“生产数据”.....</li> </ul>        | <a href="#">1</a> |
| Changes from Revision A (July 2018) to Revision B  | Page              |
| <ul style="list-style-type: none"> <li>已更改 将 AFE7686 从“预告信息”更改为“生产数据”.....</li> </ul>        | <a href="#">1</a> |

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| Changes from Original (May 2018) to Revision A                   | Page              |
|--|-------------------|
| • 已更改 将 AFE7684 从“产品预览”更改为“预告信息”，将 AFE7685 从“产品预览”更改为“生产数据”..... | <a href="#">1</a> |
| • 已删除 从数据手册中删除了 AFE7683 .....                                    | <a href="#">1</a> |

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### 3 Device Comparison

**Table 3-1. Device Features Comparison**

| DEVICE  | # of TXs/RXs | # of DUCs/TX | # of DDCs/RX | MAX INPUT/OUTPUT DATA RATE (MSPS) |
|---------|--------------|--------------|--------------|-----------------------------------|
| AFE7685 | 4T4R         | 1            | 1            | 750                               |
| AFE7686 | 4T4R         | 2            | 2            | 1500                              |
| AFE7684 | 2T4R         | 2            | 2            | 1500                              |
| AFE7683 | 2T4R         | 1            | 1            | 750                               |
| AFE7681 | 4T2R         | 1            | 1            | 750                               |

## 4 器件和文档支持

### 4.1 器件支持

#### 4.1.1 第三方产品免责声明

TI 发布的与第三方产品或服务有关的信息，不能构成与此类产品或服务或保修的适用性有关的认可，不能构成此类产品或服务单独或与任何 TI 产品或服务一起的表示或认可。

### 4.2 文档支持

如需接收文档更新通知，请访问 [ti.com.cn](http://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，请查阅已修订文档中包含的修订历史记录。

下面列出了介绍 DSP、相关外设以及其他配套技术资料的最新文档。

#### 4.2.1 相关文档

《AFE76xx EVM 设计文档用户指南》(SLAU761)

《AFE76xx 技术参考手册》(SLAU744)

《AFE76xx 编程人员用户指南》(SLAU767)

### 4.3 相关链接

下表列出了快速访问链接。类别包括技术文档、支持与社区资源、工具和软件，以及申请样片或购买产品的快速链接。

表 4-1. 相关链接

| 器件      | 产品文件夹                 | 样片与购买                 | 技术文档                  | 工具与软件                 | 支持和社区                 |
|---------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| AFE7681 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| AFE7683 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| AFE7684 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| AFE7685 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| AFE7686 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |

### 4.4 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** The TI engineer-to-engineer (E2E) community was created to foster collaboration among engineers. At [e2e.ti.com](http://e2e.ti.com), you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**TI Embedded Processors Wiki** Established to help developers get started with Embedded Processors from Texas Instruments and to foster innovation and growth of general knowledge about the hardware and software surrounding these devices.

### 4.5 商标

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### 4.6 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。

## 4.7 Export Control Notice

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## 4.8 Glossary

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

## 5 机械、封装和可订购信息

### 5.1 封装信息

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。



**PACKAGING INFORMATION**

| Orderable part number       | Status<br>(1) | Material type<br>(2) | Package   Pins    | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|-----------------------------|---------------|----------------------|-------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">AFE7681IABJ</a> | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | Yes         | SNAGCU                               | Level-3-260C-168 HR               | -40 to 85    | AFE7681I            |
| AFE7681IABJ.Z               | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | Yes         | SNAGCU                               | Level-3-260C-168 HR               | -40 to 85    | AFE7681I            |
| <a href="#">AFE7683IABJ</a> | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | Yes         | SNAGCU                               | Level-3-260C-168 HR               | -40 to 85    | AFE7683I            |
| AFE7683IABJ.Z               | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | Yes         | SNAGCU                               | Level-3-260C-168 HR               | -40 to 85    | AFE7683I            |
| <a href="#">AFE7684IABJ</a> | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | Yes         | SNAGCU                               | Level-3-260C-168 HR               | -40 to 85    | AFE7684I            |
| AFE7684IABJ.Z               | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | Yes         | SNAGCU                               | Level-3-260C-168 HR               | -40 to 85    | AFE7684I            |
| <a href="#">AFE7685IABJ</a> | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | Yes         | SNAGCU                               | Level-3-260C-168 HR               | -40 to 85    | AFE7685I            |
| AFE7685IABJ.Z               | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | Yes         | SNAGCU                               | Level-3-260C-168 HR               | -40 to 85    | AFE7685I            |
| <a href="#">AFE7686IABJ</a> | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | Yes         | SNAGCU                               | Level-3-260C-168 HR               | -40 to 85    | AFE7686I            |
| AFE7686IABJ.Z               | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | Yes         | SNAGCU                               | Level-3-260C-168 HR               | -40 to 85    | AFE7686I            |

(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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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.

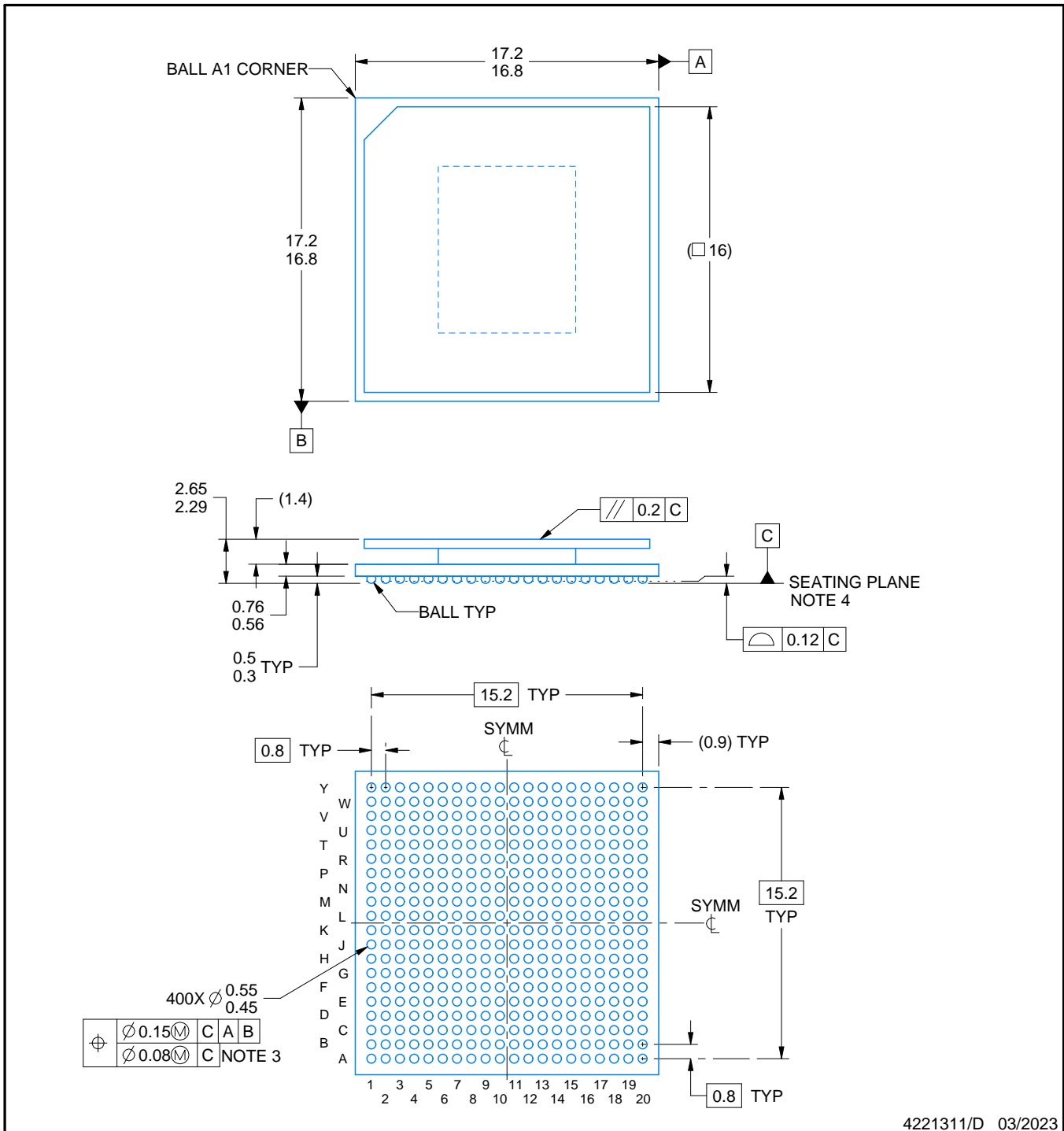
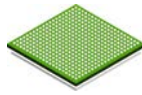
**TRAY**


Chamfer on Tray corner indicates Pin 1 orientation of packed units.

\*All dimensions are nominal

| Device        | Package Name | Package Type | Pins | SPQ | Unit array matrix | Max temperature (°C) | L (mm) | W (mm) | K0 (µm) | P1 (mm) | CL (mm) | CW (mm) |
|---------------|--------------|--------------|------|-----|-------------------|----------------------|--------|--------|---------|---------|---------|---------|
| AFE7681IABJ   | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7681IABJ   | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7681IABJ.Z | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7681IABJ.Z | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7683IABJ   | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7683IABJ   | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7683IABJ.Z | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7683IABJ.Z | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7684IABJ   | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7684IABJ   | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7684IABJ.Z | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7684IABJ.Z | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7685IABJ   | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7685IABJ   | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7685IABJ.Z | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7685IABJ.Z | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7686IABJ   | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |

| Device        | Package Name | Package Type | Pins | SPQ | Unit array matrix | Max temperature (°C) | L (mm) | W (mm) | K0 (µm) | P1 (mm) | CL (mm) | CW (mm) |
|---------------|--------------|--------------|------|-----|-------------------|----------------------|--------|--------|---------|---------|---------|---------|
| AFE7686IABJ   | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7686IABJ.Z | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7686IABJ.Z | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |



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NOTES:

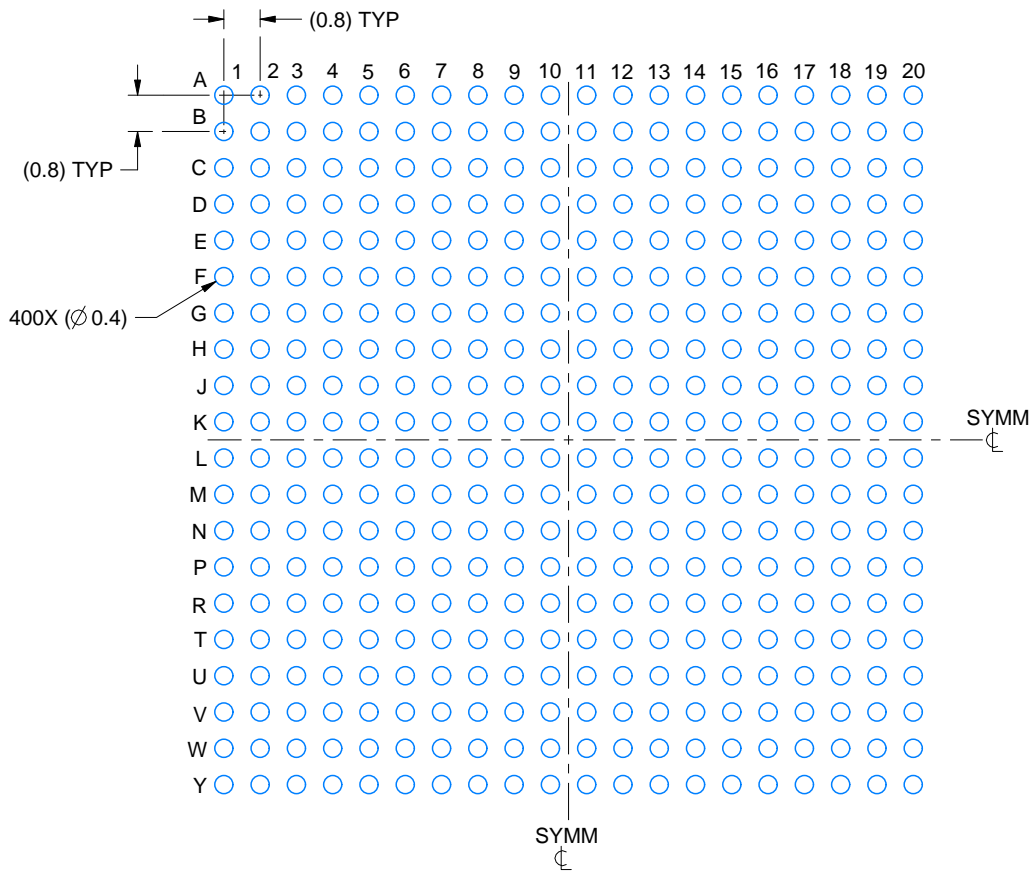
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Dimension is measured at the maximum solder ball diameter, parallel to primary datum C.
4. Primary datum C and seating plane are defined by the spherical crowns of the solder balls.
5. The lids are electrically floating (e.g. not tied to GND).

# EXAMPLE BOARD LAYOUT

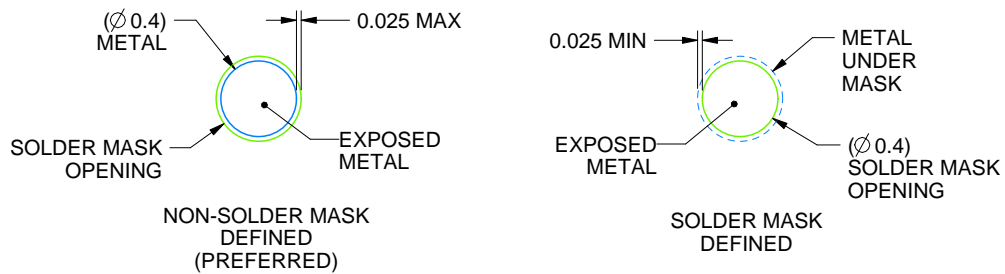
ABJ0400A

FCBGA - 2.65 mm max height

BALL GRID ARRAY



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:6X



SOLDER MASK DETAILS  
NOT TO SCALE

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NOTES: (continued)

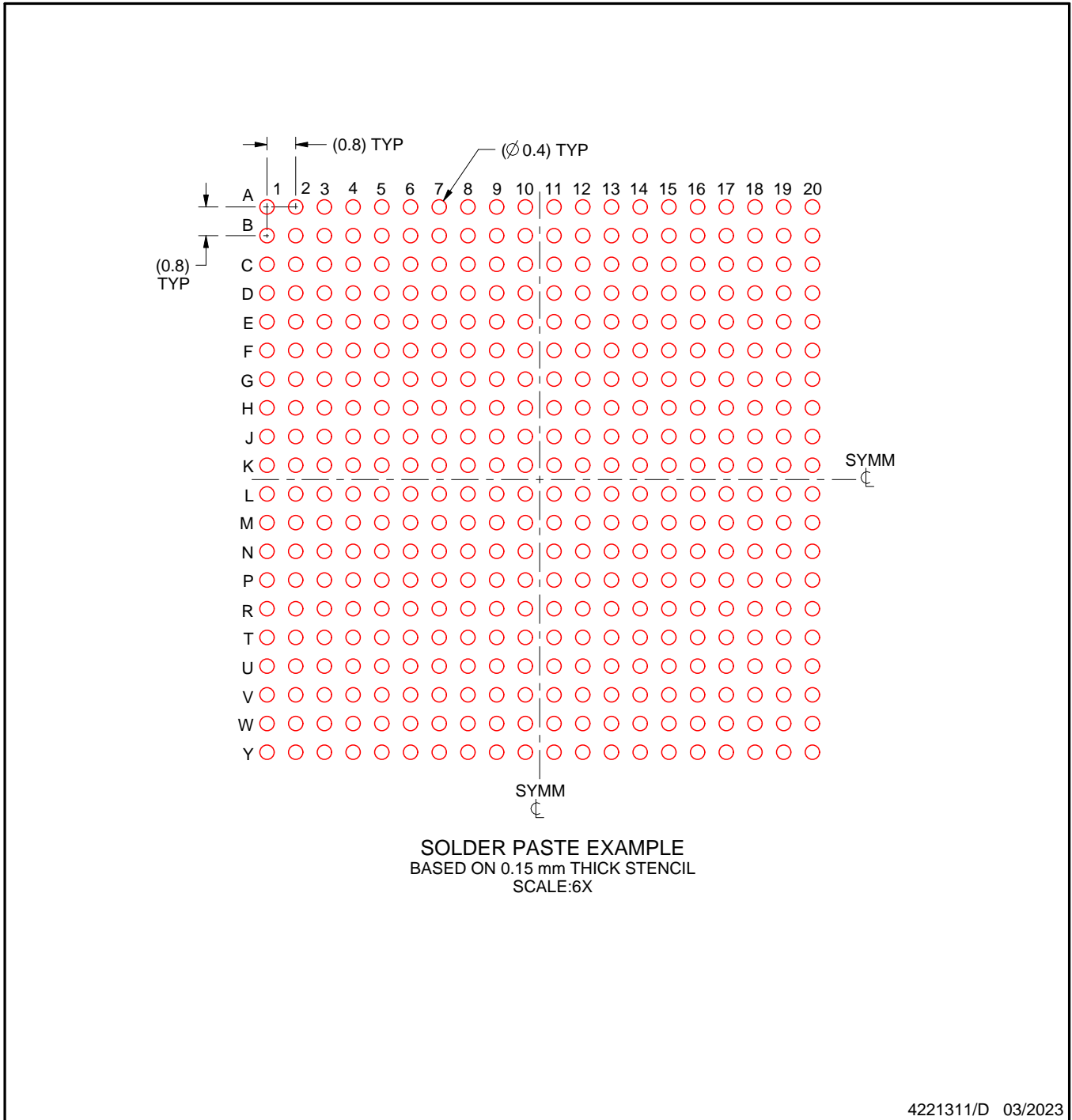
- Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. For more information, see Texas Instruments literature number SPRU811 ([www.ti.com/lit/spru811](http://www.ti.com/lit/spru811)).

# EXAMPLE STENCIL DESIGN

## ABJ0400A

### FCBGA - 2.65 mm max height

BALL GRID ARRAY



NOTES: (continued)

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

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