



# **DESIGN REQUIREMENTS FOR OUTLINES OF SOLID STATE AND RELATED PRODUCTS**

## **JEDEC PUBLICATION 95 (JEP95) DESIGN REGISTRATION 4.5**

**Ball Grid Array Package  
Ball Pitch  $\leq 0.80$  mm  
Body sizes  $\leq 21$  mm**

**(For body sizes  $> 21$  mm see Design Registration 4.27)**

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**JEDEC SOLID STATE TECHNOLOGY ASSOCIATION**

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## BALL GRID ARRAY PACKAGE

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#### 4.5 BALL GRID ARRAY (BGA) PACKAGE

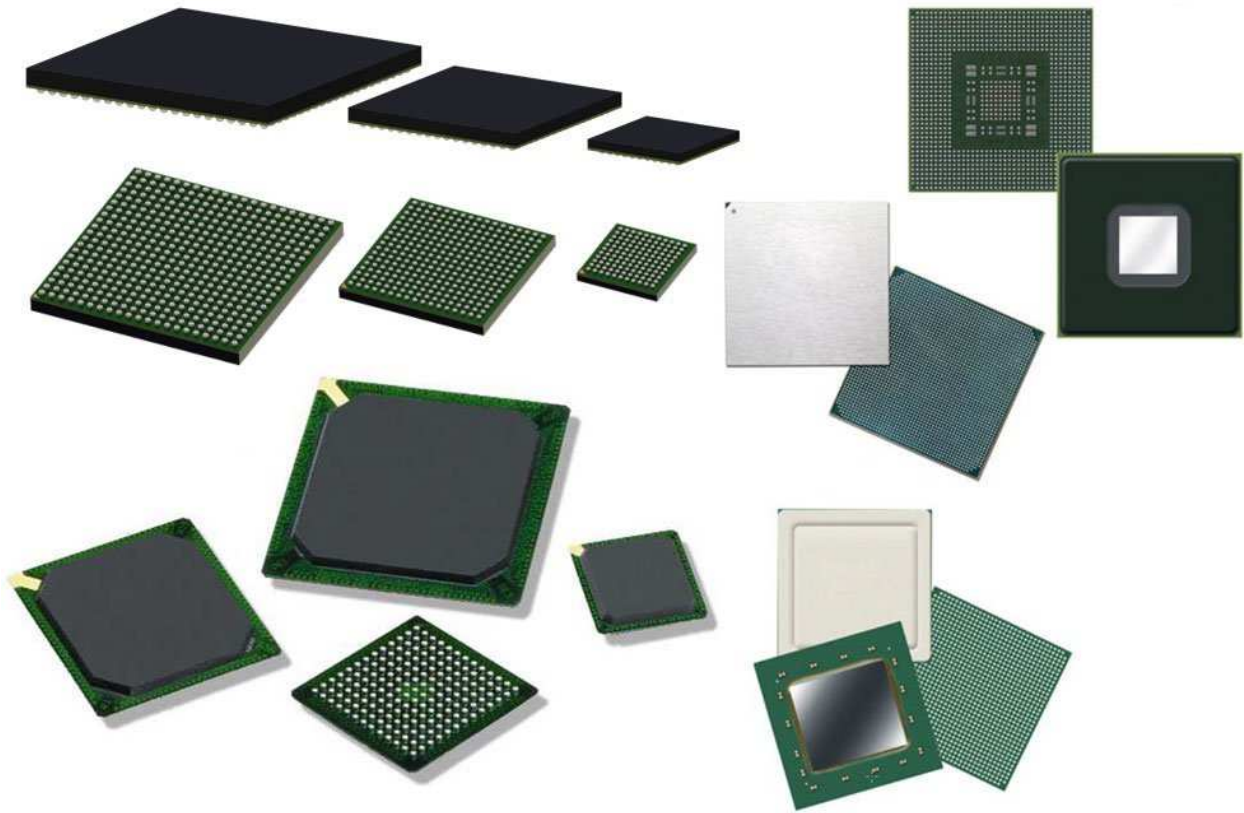


FIGURE 4.5-1 — Ball Grid Array (BGA) Packages

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## 4.5 BALL GRID ARRY PACKAGE (BGA/IBGA)

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### 4.5.1 Introduction

A Ball Grid Array (BGA) is a package with an array of metallic balls at a pitch of 0.40, 0.50, 0.65 mm, 0.75 mm, or 0.80 mm on the underside of the package. The (IBGA) is the above (BGA) package with a staggered array of metallic balls. The main body of the package has a metalized circuit pattern applied to a dielectric structure. To this package body, the semiconductor die(s) is attached to either the top or bottom surface; e.g., Flip chip. On the underside of the dielectric carrier is an array pattern of metalized balls, that form the mechanical and electrical connection from the package body to a mating feature such as a printed circuit board. The surface that contains the die may be encapsulated by various techniques to protect the semiconductor.

### 4.5.2 Scope

This Design Registration defines the symbols, definitions, algorithms, and recommended dimensions and tolerances for various BGA/IBGA packages. This standard uses metric dimensioning per JEP95, Section 3, SPP-003, and adheres to the geometric dimensioning and tolerancing methods defined in ASME Y14.5-2009.

This standard does not attempt to document all BGA/IBGA designs being produced. It establishes the design practices that shall be followed for future BGA/IBGA standard outlines included in JEDEC Publication 95 (JEP95).

### 4.5.3 Terms and Definitions

#### 4.5.3.1 Flange-Type Ball Grid Array Package

A ball grid array package whose body size (length D and width E) is defined without regard to a specific die size. The body dimensions are intended to accommodate assembly of die with various sizes, and usually will not change as a result of future die shrinks for a specific device function. The package is called a “flange-type” because the substrate or carrier of the package typically extends outward beyond the perimeter of the die forming a flange with respect to the die. Some type of encapsulant or lid usually covers the extended portion of the substrate.

#### 4.5.3.2 Ball Grid Array Package

A ball grid array package with a metallic ball grid pitch of 0.40 mm, 0.50 mm, 0.65 mm, 0.75 mm, or 0.80 mm and a body size  $\leq 21$  mm.

#### 4.5.3.3 Common Designator

A common designator is a shorthand means for referring to the packages defined in this document. The common designator for BGA packages takes the form <profile><aspect><pitch>BGA. In this section of JEP95 <profile> and <pitch> take values as specified in SPP-025.

For Descriptive Designations refer to JEDEC Standard No. 30 (JESD30).

#### 4.5.3.4 Ball Contact

A ball contact is the terminal for electrical contact on an BGA/IBGA package. The ball contacts on the BGA/IBGA are balls, bumps or other protruding terminals (excluding pins) constructed from a variety of alloy and/or polymer materials. When balls are present, they typically consist of lead free eutectic tin/silver based or eutectic tin/lead solder. For purposes of this document, contacts of whatever form will be referenced generically as “balls”.

#### 4.5.3.5 Low-melt solder ball

Low-Melt Solder ball: A solder ball whose metallurgical composition allows it to go into the liquidus state when subjected to the applicable standard industry surface mount reflow profile as defined in IPC/JEDEC Joint Standard, J-STD-020.

#### 4.5.3.6 High-melt solder ball

High-Melt Solder ball: A solder ball whose metallurgical composition allows it to remain in a solid state when subjected to the applicable standard industry surface mount reflow profile as defined in IPC/JEDEC Joint Standard, J-STD-020.

#### 4.5.3.7 Lowest Ball Reference (LBR) Plane

The lowest ball reference plane is an alternative method for defining the seating plane and Datum C. (See 4.5.3.6 and 4.5.4.6)

#### 4.5.3.8 Seating Plane

The seating plane is a plane simulated by contact of the crowns of three non-collinear balls that support the free-standing package when it is placed on a reference surface. More than 3 balls may contact this reference surface, but only 3 such balls are required to define the seating plane. The seating plane becomes the basis for measurements with respect to Datum C. The triangle formed by the three balls constituting the seating plane shall include the center of gravity of the package.

An alternative method for measurements with respect to Datum C uses the lowest ball reference (LBR) plane. The LBR plane is established by first determining the least mean square (LMS) plane derived by standard methods from measurement of the locations of the crowns of all the solder balls on the package. The LBR plane is a plane parallel to the LMS plane that contacts the solder ball crown with the greatest distance below the LMS plane (away from the package body). See Figure 4.5-5 for illustration.

Use of the seating plane reference has precedence over the LBR method in any dispute over measurements with respect to Datum C.

#### 4.5.3.9 Profile Height

The profile height, A, of an BGA/IBGA is the distance from the seating plane to the highest point on the package body. This distance is measured perpendicular to the seating plane.

#### 4.5.4 Design Requirements

##### 4.5.4.1 Body Size

The D and E dimensions define the body size for an BGA/IBGA. Dimensions D and E are BASIC dimensions with values defined on 0.01 mm increments. Variations in size and orientation are controlled by profile tolerance aaa (see Table 4.5-1).

##### 4.5.4.2 Matrix Size

Matrix size is defined by MD and ME or MDS and MES which represent the maximum matrix size corresponding to body dimensions D and E or MDS and MES respectively as determined in 4.5.4.3. An allowed standard option reduces the MD x ME or MDS x MES array size by 1 row and 1 column. This option is identified in the appropriate tables of this standard by use of the MD-1 x ME-1 and MDS-1 x MES-1 designation. Each of the two array patterns must be symmetrically located on the package body (see 4.5.4.5) and they form incompatible footprints.

NOTE MDS and MES equal the total numbers of adjacent balls in a single staggered row or staggered column.

The allowed values for MD, ME, MDS, MES, and MD-1, ME-1, MDS-1 and MES-1, are shown in Table 4.5-3.

When selecting the matrix size, the designer should consider issues relating to handling and shipping systems and to socketing. Use of the MD-1 x ME-1 or MDS-1 x MES-1 option provides a wider ball keep out zone for support in shipping and clearance in handling.

##### 4.5.4.3 Maximum Matrix Size

The maximum matrix size is defined by MD and ME and represents the maximum ball matrix size corresponding to body direction D and E, respectively. The maximum matrix size permissible is determined by the following algorithms:

$$\text{MD(max)} = \frac{[(D - \text{aaa}) - (\text{bmax} + \text{eee}) - (2 \times 0.13)]}{e} + 1 \quad \text{Truncated to an integer}$$

$$\text{ME(max)} = \frac{[(E - \text{aaa}) - (\text{bmax} + \text{eee}) - (2 \times 0.13)]}{e} + 1 \quad \text{Truncated to an integer}$$

The maximum matrix size is defined by MDS and MES and represents the maximum ball matrix size corresponding to body direction D and E, respectively. The maximum matrix size permissible is determined by the following algorithms:

$$\text{MDS(max)} = \frac{[(D - \text{aaa}) - (\text{bmax} + \text{eee}) - (2 \times 0.13)]}{e_{\text{DS}}/2} + 1 \quad \text{Truncated to an integer}$$

$$\text{MES(max)} = \frac{[(E - \text{aaa}) - (\text{bmax} + \text{eee}) - (2 \times 0.13)]}{e_{\text{DS}}/2} + 1 \quad \text{Truncated to an integer}$$

NOTE 1 The minimum clearance between the edge of the outermost row or column of balls and the edge of the body shall be 0.13 mm per side when D or E are at their minimum value and b is at its maximum value (as used in the above formulas).

NOTE 2 Odd or even matrices for a given body size are allowable by depopulation (4.5.4.2).

NOTE 3 The maximum permitted ball count (N) for BGA is determined by:  $N = MD \times ME$ .

NOTE 4 The maximum permitted ball count (N) for IBGA is determined by:  $N = MDS \times MES/2$  rounded up to the next whole number, i.e.,  $5 \times 5 = 25/2 = 12.5$ ,  $N=13$ .

#### 4.5.4.4 Depopulation

Depopulation is the omission of balls from a full matrix defined by MD ME MDS and MES (or MD-1 ME-1, MDS-1 and MES-1). Any depopulation pattern is allowed. Figure 4.5-2 illustrates examples of depopulated matrix patterns.

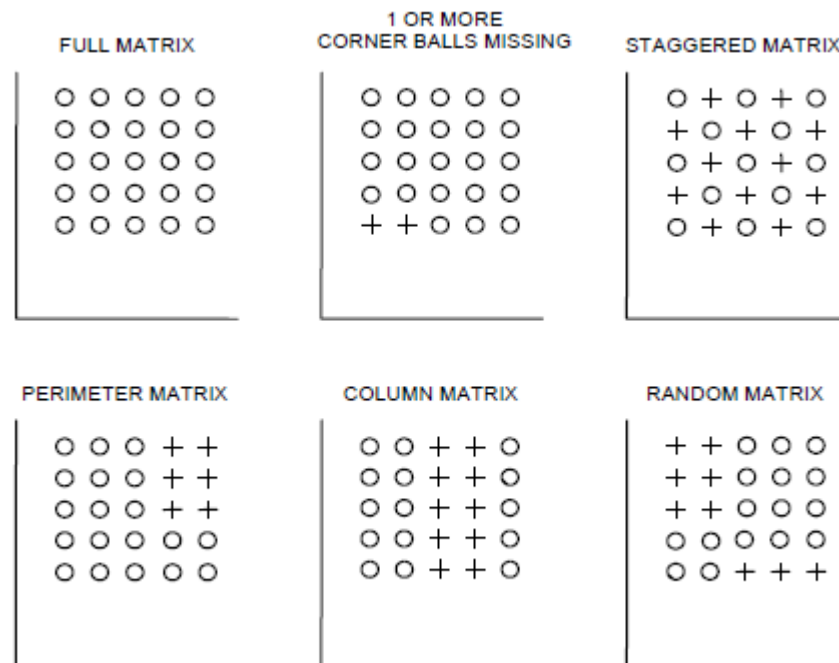


**FIGURE 4.5-2 — Examples of Depopulated Matrix Patterns**  
(+ = Depopulated Ball Locations)

#### 4.5.4.5 Depopulated Ball Patterns

BGA/IBGA packages may be defined with standardized depopulation patterns. In such cases, the depopulation pattern should be illustrated in the outline. See Figure 4.5-6 for examples.

#### 4.5.4.6 Datums

Datum A is the axis of the body feature that is defined by dimension D. Datum B is the axis of the body feature that is defined by dimension E. Datums A and B are used for defining the true position of the ball matrix. Datum C is the seating plane or LBR plane per Figure 4.5-5.

#### 4.5.4.7 Ball Location

The matrix pitch and the offset of the central row(s) or column(s) of balls from Datum A or B defines the ball location on an BGA/IBGA package. The ball offset is specified by dimension  $S_x$  that represents the distance from the respective datum to the centerline of the first row or column of balls in a fully populated matrix, MD x ME, MDS x MES (MD-1 x ME-1 or MDS-1 x MES-1).

If the value of MD, ME, MDS and MES (or MD-1, ME-1, MDS-1 and MES-1) is an odd number, then the center row or column of balls will lie on the respective datum. If the value of MD, ME, MDS and MES (or MD-1, ME-1, MDS-1 and MES-1) is an even number, then the central pair of rows or columns of balls will straddle the respective datum.

If the central rows or columns of the matrix are depopulated, then the offset from the appropriate datum to the first actual balls in the matrix may be specified as an aid to the user.

#### 4.5.5 Outline Format

Refer to Figure 4.5-3 through Figure 4.5-8 for the outline format for BGA packages.

#### 4.5.6 Dimensional Values and Tolerances

Table 4.5-1 and Table 4.5-2 define the symbols, algorithms, and specified dimensions and tolerances that shall be used when preparing BGA/IBGA outlines.

Refer to Table 4.5-1 (Symbols, Dimensions and Tolerances for BGA/IBGA Packages) for definitions of A, A2, A3, A5, A6, D, E, D1, E1, e, eS, eDS, eES, MD, MDS, ME, MES, N,  $S_x$ , aaa, bbb and ccc.

Refer to Table 4.5-2 (Symbols, Dimensions and Tolerances Related to Ball Diameters) for definitions of A1, b, b1, ddd, eee, and fff.

This design standard defines BGA (BGA/IBGA) outlines only.

**TABLE 4.5-1 — Symbols, Dimensions and Tolerances for BGA/IBGA Packages**

| Symbol | Definition                                                                                                                                                                                                                                                                                                                                                                             | Values                                        |                                                                          |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|--------------------------------------------------------------------------|
| A      | The distance from the seating plane to the highest point on the package. This dimension includes the standoff height (A1), package thickness (A2), and lid/encapsulation thickness, but does not include attached features such as external heat sinks or chip capacitors. An integral heat slug is not considered an attached feature.<br><br>Only a maximum value must be specified. | A = Design Specific                           |                                                                          |
| A2     | The thickness of the package body, including the lid or encapsulation height and exclusive of ball height.                                                                                                                                                                                                                                                                             | A2 = Design Specific                          |                                                                          |
| A3     | The distance from the top of the package body to the top of the lid or encapsulation. Mold cap thickness.                                                                                                                                                                                                                                                                              | Design specified for cavity up configurations |                                                                          |
| A5     | Substrate thickness                                                                                                                                                                                                                                                                                                                                                                    | Optional – design specific                    |                                                                          |
| A6     | Mold cap thickness                                                                                                                                                                                                                                                                                                                                                                     | Optional – design specific                    |                                                                          |
| D      | The distance between the package body edges measured parallel to the minor package body axis.<br><br>D is a BASIC dimension                                                                                                                                                                                                                                                            | $D \geq E$                                    |                                                                          |
|        |                                                                                                                                                                                                                                                                                                                                                                                        | $e$                                           | $D$ or $E$                                                               |
|        |                                                                                                                                                                                                                                                                                                                                                                                        | 0.80                                          | 2.00 – 21.00                                                             |
| E      | The distance between the package body edges measured parallel to the minor package body axis.<br><br>E is a BASIC dimension                                                                                                                                                                                                                                                            | 0.75                                          | 2.00 – 21.00                                                             |
|        |                                                                                                                                                                                                                                                                                                                                                                                        | 0.65                                          | 2.00 – 21.00                                                             |
|        |                                                                                                                                                                                                                                                                                                                                                                                        | 0.50                                          | 2.00 – 21.00                                                             |
|        |                                                                                                                                                                                                                                                                                                                                                                                        | 0.40                                          | 2.00 – 21.00                                                             |
| D1     | The distance between the centerlines of the two outermost rows of balls parallel to the D axis of the package.<br><br>D1 is a BASIC dimension                                                                                                                                                                                                                                          | FBGA                                          | $D1 = (MD-1) \times e$<br>or<br>$D1 = (MD-2) \times e$                   |
|        |                                                                                                                                                                                                                                                                                                                                                                                        | FIBGA                                         | $D1 = (MDS-1) \times (eDS / 2)$<br>or<br>$D1 = (MDS-2) \times (eDS / 2)$ |
| E1     | The distance between the centerlines of the two outermost rows of balls parallel to the E axis of the package.<br><br>E1 is a BASIC dimension                                                                                                                                                                                                                                          | FBGA                                          | $E1 = (ME-1) \times e$<br>or<br>$E1 = (ME-2) \times e$                   |
|        |                                                                                                                                                                                                                                                                                                                                                                                        | FIBGA                                         | $E1 = (MES-1) \times (eES / 2)$<br>or<br>$E1 = (MES-2) \times (eES / 2)$ |