

JEDEC DESIGN REGISTRATION

DESIGN REQUIREMENTS FOR OUTLINES OF SOLID STATE AND RELATED PRODUCTS

JEDEC PUBLICATION 95 DESIGN REGISTRATION 4.22

Fine-pitch, Square Ball Grid Array Package (FBGA) Package-on-Package (PoP)

**JEDEC
SOLID STATE TECHNOLOGY ASSOCIATION**

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FINE-PITCH, SQUARE BALL GRID ARRAY PACKAGE PoP DESIGN REQUIREMENTS

Contents

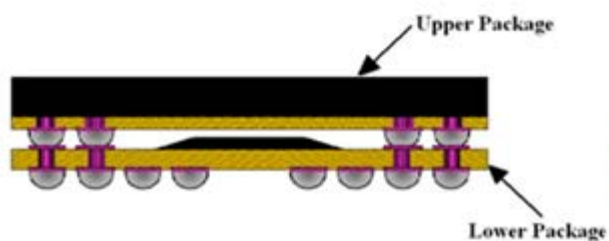
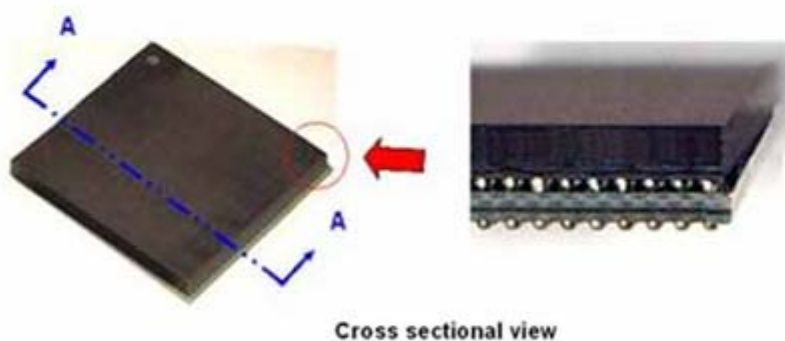
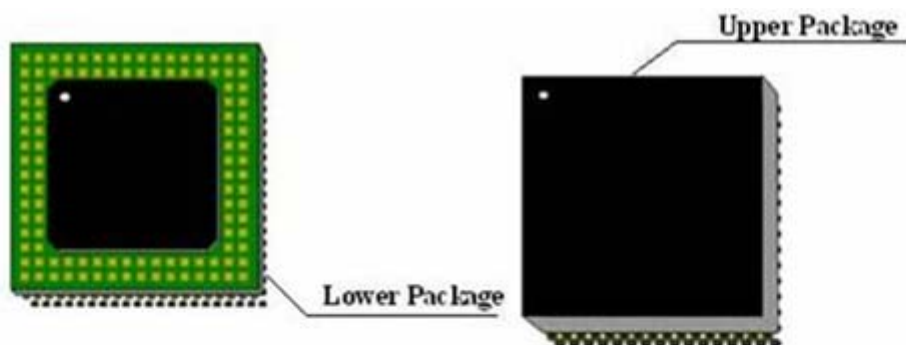
Sections	Page
4.22.1 Introduction	4.22-4
4.22.2 Scope	4.22-4
4.22.3 Terms and Definitions Common to Lower and Upper Packages	4.22-4
4.22.3.1 “flange-type” ball grid array package	4.22-4
4.22.3.2 “Through Mold Via” (TMV) PoP package	4.22-4
4.22.3.3 Fine-pitch ball grid array package	4.22-4
4.22.3.4 Descriptive designator	4.22-4
4.22.3.5 Ball contact	4.22-4
4.22.3.6 Lowest ball reference (LBR) plane	4.22-5
4.22.3.7 Seating plane	4.22-5
4.22.3.8 Profile height	4.22-5
4.22.3.9 Package on package (PoP)	4.22-5
4.22.4 Terms and Definitions Lower Package	4.22-5
4.22.4.1 Landing pads lower package	4.22-5
4.22.5 Terms and Definitions Upper Package	4.22-5
4.22.6 Design Requirements Common to Lower and Upper Packages	4.22-5
4.22.6.1 Body Size	4.22-5
4.22.6.2 Ball Matrix Size	4.22-6
4.22.6.3 Depopulated Ball Patterns	4.22-6
4.22.6.4 Datums	4.22-6
4.22.6.5 Ball Location	4.22-6
4.22.6.6 Upper and Lower Package Mating Requirements	4.22-6
4.22.7 Design Requirements Lower Package	4.22-6
4.22.7.1 Mold Cap Size Lower Package	4.22-6
4.22.7.2 Maximum Ball Matrix Size Lower Package	4.22-7
4.22.7.3 Depopulation Lower Package	4.22-7
4.22.7.4 Land Matrix Size Lower Package	4.22-7
4.22.7.5 Maximum Land Matrix Size Lower Package	4.22-8
4.22.7.6 Depopulated Land Patterns Lower Package	4.22-8
4.22.7.7 Land Location Lower Package	4.22-8
4.22.8 Design Requirements Upper Package	4.22-9
4.22.8.1 Maximum Ball Matrix Size Upper Package	4.22-9
4.22.8.2 Depopulation Upper Package	4.22-9
4.22.9 Outline Format	4.22-9
4.22.10 Dimensional Values and Tolerances	4.22-9

Tables

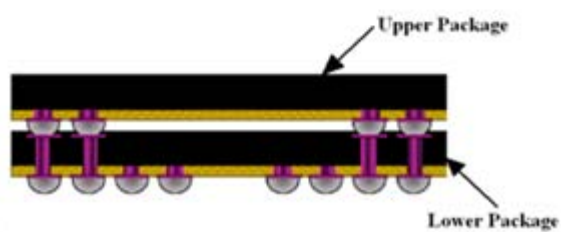
4.22-1	Symbols, Dimensions and Tolerances for PoP FBGA Packages Common to Lower and Upper Packages	4.22-10-11
4.22-2	Symbols, Dimensions and Tolerances for PoP FBGA Packages Lower Package Specific	4.22-11-13
4.22-3	Symbols, Dimensions and Tolerances for PoP FBGA Packages Upper Package Specific	4.22-14
4.22-4	Symbols, Dimensions and Tolerances Related to Ball and Land Diameters For PoP FBGA Packages Common to Lower and Upper Packages	4.22-15
4.22-5	Symbols, Dimensions and Tolerances Related to Ball and Land Diameters for PoP FBGA Packages Lower Package Specific	4.22-16-17
4.22-6	Symbols, Dimensions and Tolerances Related to Ball and Land Diameters for PoP FBGA Packages Upper Package Specific	4.22-18
4.22-7	Maximum Ball Matrix Sizes for PoP FBGA packages with 0.80 mm ball pitch Lower Package Specific	4.22-19
4.22-8	Maximum Ball Matrix Sizes for PoP FBGA packages with 0.65 mm ball pitch Lower Package Specific	4.22-20
4.22-9	Maximum Ball Matrix sizes for PoP FBGA packages with 0.50 mm ball pitch Lower Package Specific	4.22-21
4.22-10	Maximum Ball Matrix sizes for PoP FBGA packages with 0.40 mm ball pitch Lower Package Specific	4.22-22
4.22-11	Maximum Ball Matrix Sizes for POP FBGA Packages with 0.80 mm Ball Pitch Upper Package Specific and Maximum Land Matrix sizes for PoP FBGA packages with 0.80 mm land pitch Lower Package Specific	4.22-23
4.22-12	Maximum Ball Matrix Sizes for POP FBGA Packages with 0.65 mm Ball Pitch Upper Package Specific and Maximum Land Matrix sizes for PoP FBGA packages with 0.65 mm land pitch Lower Package Specific	4.22-24
4.22-13	Maximum Ball Matrix Sizes for POP FBGA Packages with 0.50 mm Ball Pitch Upper Package Specific and Maximum Land Matrix sizes for PoP FBGA packages with 0.65 mm land pitch Lower Package Specific	4.22-25
4.22-14	Maximum Ball Matrix Sizes for POP FBGA Packages with 0.40 mm Ball Pitch Upper Package Specific and Maximum Land Matrix sizes for PoP FBGA packages with 0.40 mm land pitch Lower Package Specific	4.22-26

Figures

4.22-1	Fine-pitch, Square Ball Grid Array FBGA POP Capable Packages	4.22-3
4.22-2	Examples of Depopulated Matrix Patterns Lower Package	4.22-7
4.22-3	Examples of Depopulated Matrix Patterns Upper Package	4.22-9
4.22-4	Upper Package FBGA POP Outline: Datums and Principal Dimensions	4.22-28
4.22-5	Lower Flange Type Package FBGA POP Outline: Datums and Principal Dimensions	4.22-29
4.22-6	Lower TMV Package FBGA PoP Outline: Datums and Principal Dimensions	4.22-30
4.22-7	Upper Package FBGA POP Outline: Detail Drawings	4.22-31
4.22-8	Lower Flange Type Package FBGA POP Outline: Detail Drawings	4.22-32
4.22-9	Lower Package TMV FBGA PoP Outline: Detail Drawings	4.22-33
4.22-10	FBGA POP Outline: Coplanarity Requirements	4.22-34
4.22-11	Upper Package FBGA POP Outline: Ball Patterns	4.22-35
4.22-12	Lower Flange Type Package FBGA POP Outline: Ball Patterns	4.22-36
4.22-13	FBGA POP Outline: Notes	4.22-37
4.22-14	FBGA POP Outline: Application Notes	4.22-38



Flange Type PoP Construction



Through Mold Via PoP Construction

4.22-1 — Fine-pitch, Square Ball Grid Array FBGA PoP Capable Packages

4.22 Fine-pitch, Square Ball Grid Array FBGA PoP Packages

4.22.1 Introduction

A Package-on-Package (PoP) solution consists of at least two Micro-electronic packages assembled in a vertical stack. Although package stacking can be done with a variety of package styles, this design guide will focus only on utilizing Fine-pitch Ball Grid Array (FBGA) packages to create the stack. The lower package of the stack includes a pattern of metallized lands on the top surface of the package through which mechanical and electrical attachment is made with the upper package. The ball pattern of the upper package is designed to facilitate the connection between the packages. This guide will focus on land and ball patterns needed to facilitate the stacking. Wherever possible, dimensions common to standard FBGA will be used and dimensions specific to package stacking will be identified.

4.22.2 Scope

This Design Requirement standard defines the symbols, definitions, algorithms, and specified dimensions and tolerances for molded FBGA packages with square bodies that are compatible for PoP. The specification uses metric dimensioning per JEDEC Publication 95 (JEP95), Section 3, SPP-003, and adheres to the geometric dimensioning and tolerancing methods defined in ASME Y14.5M-1994.

This section of JEP95 is a companion to Design Guide for Fine-pitch, Square Ball Grid Array FBGA Packages, JEP95, Section 4.5.

This standard does not attempt to document all PoP FBGA designs being produced. It establishes the design requirements that shall be followed for future PoP FBGA outlines included in JEP95.

4.22.3 Terms and Definitions Common to Lower and Upper Packages

4.22.3.1 “Flange-type” ball grid array package

A type of ball-grid-array (BGA) package whose substrate or carrier extends outward beyond the perimeter of the die forming a flange with respect to the die.

NOTE 1 Its 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 of various sizes, and usually will not change as a result of future die shrinks for a specific device function.

NOTE 2 Some type of encapsulant or lid usually covers the extended portion of the substrate.

4.22.3.2 “Through Mold Via” (TMV) PoP package

A fully overmolded ball-grid-array PoP package with through mold via technology

4.22.3.3 Fine-pitch ball grid array package

A ball-grid-array package with a grid pitch that is less than 1.00 mm

4.22.3.4 Descriptive designator

A code created in accordance with JESD30 for identifying the physical features of an electronic-device package.

NOTE: The descriptive designator for fine pitch ball-grid-array packages is FBGA.

4.22.3.5 Ball Contact

Any terminal on the bottom surface of an FBGA in the form of a ball, bump, or other protrusion (excluding a pin) constructed from a variety of alloy and/or polymer materials.

NOTE Balls typically consist of eutectic lead/tin solder or lead-free solder

4.22.3.6 Lowest ball reference (LBR) plane

The plane that includes the solder ball crown that is farthest from the LMS plane (away from the package body) and is parallel to the least mean square (LMS) plane.

NOTE 1 The LMS plane is derived by standard methods from measurement of the locations of the crowns of all the solder balls on the package.

NOTE 2 The LBR plane may be used as an alternative to the seating plane for Datum C (see 4.22.6.4); however, use of the seating plane reference has precedence over the LBR method in any dispute over measurements with respect to datum C.

4.22.3.7 Seating plane

The plane established by the contact points of three or more non-collinear terminals that support the freestanding package when it is placed on a planar surface.

NOTE 1 The seating plane is the primary basis for measurements with respect to Datum C (see 4.22.6.4).

NOTE 2 See figure 4.22-6 for illustration.

4.22.3.8 Profile height

The perpendicular distance from the seating plane to the highest point on the package body.
(See JESD 30)

NOTE 1 The profile height, A, represents the profile height of either individual (lower or upper) package. This design guide does not address the overall collapsed profile height of the combined packages. The overall un-collapsed profile height of the combined packages is dimension A of the upper package plus A4 of the lower for Flange Type packages and A minus c1 of the lower package for Through Mold Via packages.

4.22.3.9 Package-on-package (PoP)

An assembly of two packages in which the upper package's solder balls bond directly to lands on the top surface of the lower package.

4.22.4 Terms and definitions for the lower package

4.22.4.1 Landing pads

Any contact region on the top surface of the lower package constructed from a variety of alloy and/or polymer materials, typically consisting of copper, nickel, and/or gold.

4.22.5 Terms and definitions for the upper package

-----Additional Definitions TBD-----

4.22.6 Design Requirements Common to Lower and Upper Packages

4.22.6.1 Body size

The D and E dimensions define the body size for an FBGA. Dimensions D and E are BASIC dimensions with values defined on 1.0 mm increments. Variations in size and orientation are controlled by profile tolerance aaa (table 4.22-1).

4.22.6.2 Ball matrix size

MD and ME represent the maximum matrix size corresponding to body dimensions D and E respectively as determined in 4.22.7.2 and 4.22.8.1

The allowed values for MD and ME are shown in tables 7 through 11.

When selecting the matrix size, the designer should consider issues relating to handling and shipping systems and to socketing.

4.22.6.3 Depopulated ball patterns

FBGA packages may be defined with standardized depopulation patterns. In such cases, the depopulation pattern should be illustrated in the outline. See figure 4.22-10 for examples.

4.22.6.4 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

See figure 4.22-4 for drawing format.

4.22.6.5 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 FBGA package. The ball offset is specified by dimension S that represents the distance from the respective datum to the centerline of the first row or column of balls in a fully populated matrix, MDL x MEL or MDU x MEU.

If the value of MDL and MEL or MDU and MEU is an odd number, then the center row or column of balls will lie on the respective datum. If the value of MDL and MEL or MDU and MEU 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.

4.22.6.6 Upper and lower package mating requirements

In order for a successful mating of the upper and lower package the designer must carefully design the packages to align. The key parameters are: A1, e, N and n of the upper package and A5 (for Flange Type), f, P and p of the lower package. Reference 4.22.7 and 4.22.8, and tables 4.22.1 through 6.

4.22.7 Design Requirements Lower Package

4.22.7.1 Mold Cap Size Lower Package

The F and G dimensions define the mold cap size for the bottom PoP package. Variations in size and orientation are controlled by profile tolerance ggg (table 4.22-2) for Flange Type PoP packages. Dimensions F and G do not apply to Through Mold Via PoP packages.

4.22.7.2 Maximum Ball Matrix Size Lower Package

MDL and MEL represent the Maximum Ball Count in body direction D and E, respectively. The following algorithms determine the maximum permissible matrix size:

$$\begin{aligned} \text{MDL(max)} &= \frac{[(D - \text{aaa}) - (b_{\text{max}} + \text{eee}) - (2 \times 0.13)]}{e} + 1 && \text{Truncated to an integer} \\ \text{MEL(max)} &= \frac{[(E - \text{aaa}) - (b_{\text{max}} + \text{eee}) - (2 \times 0.13)]}{e} + 1 && \text{Truncated to an integer} \end{aligned}$$

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 (4.22.7.3)

NOTE 3 The maximum permitted ball count (N) is determined by: $N = \text{MDL} \times \text{MEL}$.

4.22.7.3 Depopulation Lower Package

Depopulation is the omission of balls or lands from a full matrix defined by MDL and MEL or MD2 and ME2 respectively. For the ball array, any depopulation pattern is allowed. For the land array, only perimeter matrix, and depopulated perimeter matrix type patterns are allowed. Figure 4.22-2 illustrates examples of depopulated matrix patterns.

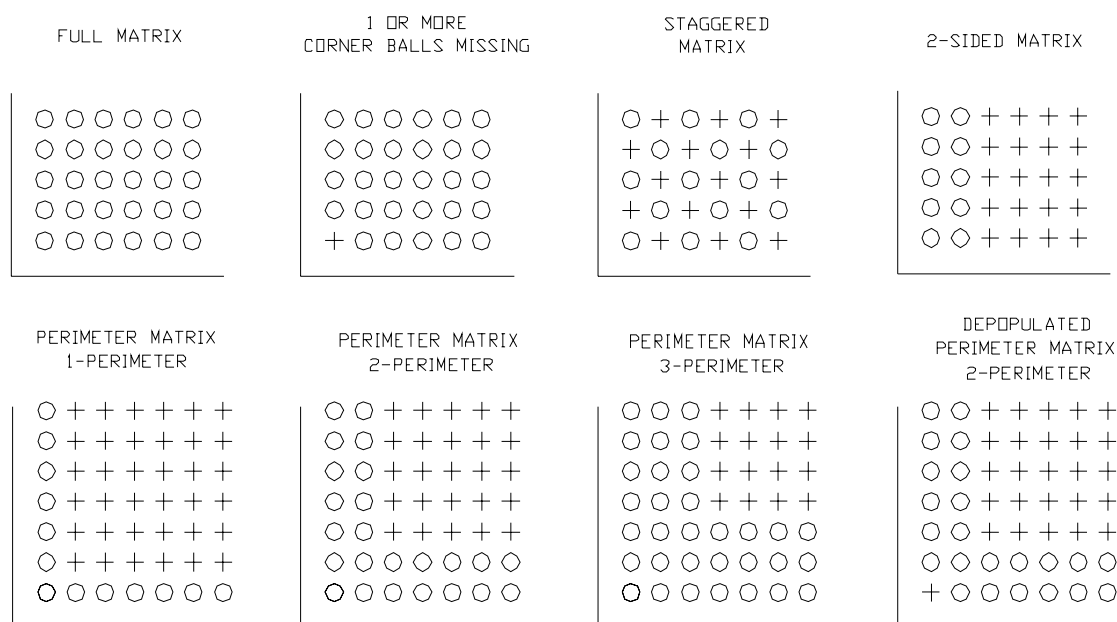


Figure 4.22-2 — Examples of Depopulated Matrix Patterns Lower Package
(+ = depopulated ball locations)

4.22.7.4 Land Matrix Size Lower Package

MD2 and ME2 represent the maximum matrix size corresponding to body dimensions D and E respectively as determined in 4.22.7.5.

The allowed values for MD2 and ME2 are shown in Tables 10 and 11.

4.22.7.5 Maximum Land Matrix Size Lower Package

MD2 and ME2 represent the Maximum Land Count in body direction D and E, respectively. The following algorithms determine the maximum permissible matrix size:

$$MD2(max) = \frac{[(D - aaa) - (cmax + kkk) - (2 \times 0.1)]}{f} + 1 \quad \text{Truncated to an integer}$$

$$ME2(max) = \frac{[(E - aaa) - (cmax + kkk) - (2 \times 0.1)]}{f} + 1 \quad \text{Truncated to an integer}$$

NOTE 1 The minimum clearance between the edge of the outermost row or column of lands and the edge of the body shall be 0.1 mm per side when D or E are at their minimum value and c 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 (4.22.7.3)

NOTE 3 For the lower package, the maximum permitted land count (P) is determined by: $P = (MD2 \times ME2) - \{[MD2 - (2 \times R)] \times [ME2 - (2 \times R)]\}$, where R is the number of perimeter rows of lands

NOTE 4 For the upper package, the maximum permitted ball count (N) cannot exceed the maximum permitted land count (P) of the intended lower package.

4.22.7.6 Depopulated Land Patterns Lower Package

PoP FBGA packages must be defined with perimeter depopulation patterns. The depopulation pattern should be illustrated in the outline. See Figure 4.22.10 for an example. The number of perimeter rows of lands is defined as the number R; permitted values are shown in table 2.

4.22.7.7 Land Location Lower Package

The matrix pitch and the offset of the central row(s) or column(s) of lands from datum A or B defines the land location on an FBGA package. The land offset is specified by dimension T that represents the distance from the respective datum to the centerline of the first row or column of lands in a fully populated matrix, MD2 x ME2.

If the value of MD2 and ME2 is an odd number, then the center row or column of lands will lie on the respective datum. If the value of MD2 and ME2 is an even number, then the central pair of rows or columns of lands 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 lands in the matrix may be specified as an aid to the user.

Since the lands will always be depopulated matrices the measurements should be made as if the array was a fully populated array for the purpose of determining the central row(s) or column(s) of lands.

4.22.8 Design Requirements Upper Package

4.22.8.1 Maximum Ball Matrix Size Upper Package

MDU and MEU represent the Maximum Ball Count in body direction D and E, respectively. The following algorithms determine the maximum permissible matrix size:

$$\begin{aligned} \text{MDU(max)} &= \frac{[(D - \text{aaa}) - (b_{\text{max}} + \text{eee}) - (2 \times 0.1)]}{e} + 1 && \text{Truncated to an integer} \\ \text{MEU(max)} &= \frac{[(E - \text{aaa}) - (b_{\text{max}} + \text{eee}) - (2 \times 0.1)]}{e} + 1 && \text{Truncated to an integer} \end{aligned}$$

NOTE 1 The minimum clearance between the edge of the outermost row or column of balls and the edge of the body shall be 0.1 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 (4.22.8.2)

NOTE 3 For the upper package, the maximum permitted ball count (N) is determined by: $N = (\text{MDU} \times \text{MEU}) - \{[\text{MDU} - (2 \times R)] \times [\text{MEU} - (2 \times R)]\}$, where R is the number of perimeter rows of balls

NOTE 4 For the upper package, the maximum permitted ball count (N) cannot exceed the maximum permitted land count (P) of the intended lower package.

4.22.8.2 Depopulation Upper Package

Depopulation is the omission of balls from a full matrix defined by MDU and MEU. Only perimeter matrix, and depopulated perimeter matrix type patterns are allowed. Figure 4.22-3 illustrates examples of depopulated matrix patterns

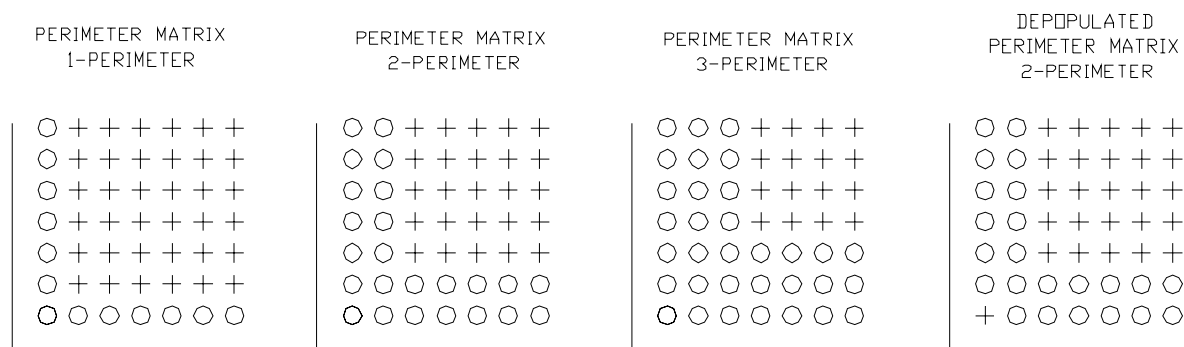


Figure 4.22-3 – Examples of Depopulated Matrix Patterns Upper Package
(+ = depopulated ball locations)

4.22.9 Outline Format

Refer to Figures 4.22-4 through 4.22-12 for the outline format for FBGA packages.

4.22.10 Dimensional Values and Tolerances

Tables 4.22-1, 4.22-2, 4.22-3, 4.22-4, 4.22-5 and 4.22-6 defines the symbols, algorithms, and specified dimensions and tolerances that shall be used when preparing FBGA outlines.

Refer to Table 1 (SYMBOLS, DIMENSIONS and TOLERANCES FOR PoP FBGA PACKAGES COMMON TO LOWER AND UPPER PACKAGES) for definitions of A, A2, D, E, D1, E1, S, aaa, bbb, and ccc.

Refer to Table 2 (SYMBOLS, DIMENSIONS and TOLERANCES FOR PoP FBGA PACKAGES LOWER PACKAGE SPECIFIC) for definitions of A4, A5, e, F, G, D2, E2, f, H, J, MDL, MEL, MD2, ME2, N, P, R, T, ggg, and Θ (Theta).

Refer to Table 3 (SYMBOLS, DIMENSIONS and TOLERANCES FOR PoP FBGA PACKAGES UPPER PACKAGE SPECIFIC) for definitions of e, MDU, MEU, N, and R.

Refer to Table 4 (SYMBOLS, DIMENSIONS and TOLERANCES RELATED TO BALL and LAND DIAMETERS for PoP FBGA PACKAGES COMMON TO LOWER AND UPPER PACKAGES) for definitions of ddd, eee, and fff.

Refer to Table 5 (SYMBOLS, DIMENSIONS and TOLERANCES RELATED TO BALL and LAND DIAMETERS for PoP FBGA PACKAGES LOWER PACKAGE SPECIFIC) for definitions of A1, b, b1, c, kkk, and mmm.

Refer to Table 6 (SYMBOLS, DIMENSIONS and TOLERANCES RELATED TO BALL and LAND DIAMETERS for PoP FBGA PACKAGES UPPER PACKAGE SPECIFIC) for definitions of A1, b, and b1.

This design standard defines fine-pitch, square PoP BGA (FBGA) outlines only.

Table 4.22-1 — Symbols, Dimensions and Tolerances for PoP FBGA Packages Common to Lower and Upper Packages

SYMBOL	DEFINITION	VALUES
A	The distance from the seating plane to the highest point on the package. A includes the standoff height, A1 (See Tables 5 and 6), package thickness, A2, and lid/encapsulation thickness. Only a maximum value must be specified	See JESD 30
A2	The thickness of the package body exclusive of ball height.	A2 = Design specific
D	The distance between the extreme body edges. D is a BASIC dimension	$\boxed{D} = \boxed{E}$ Range: 8.00 mm to 21.00 mm Increment: 1.0 mm (See tables 4.22-7, 8 and 9)
E	The distance between the extreme body edges in the direction perpendicular to D E is a BASIC dimension	
D1	The distance between the centerlines of the two outermost rows of balls parallel to the D axis of the package. D1 is a BASIC dimension	$\boxed{D1} = \boxed{E1} = (MD-1) \times \boxed{e}$ Or $\boxed{D1} = \boxed{E1} = (MD-2) \times \boxed{e}$
E1	The distance between the centerlines of the two outermost rows of balls parallel to the E axis of the package. E1 is a BASIC dimension	
S	The distance from the centermost ball in a row or column to datum A or B. S is a BASIC dimension	When MD and ME are odd: $\boxed{S} = 0.00$ When MD and ME are even: $\boxed{S} = e/2$
n	The actual number of balls present after depopulation on an FBGA PoP Package.	$n \leq N$
aaa	The profile tolerance controlling the location and orientation of the sides of the package. The spacing of the centerlines of the tolerance zones for opposite sides is established by basic dimensions D or E.	0.10 mm
bbb	The parallelism tolerance controlling the orientation of the top surface of the package carrier with respect to the seating plane, datum C.	0.10 mm
ccc	The parallelism tolerance controlling the orientation of the top surface of the package with respect to the seating plane, datum C. This specification will not apply to the fillet or sloped region of glob-top encapsulation.	0.20 mm

Table 4.22-1 — Symbols, Dimensions and Tolerances for PoP FBGA Packages Common to Lower and Upper Packages

SYMBOL	DEFINITION	VALUES
aaa	The profile tolerance controlling the location and orientation of the sides of the package. The spacing of the centerlines of the tolerance zones for opposite sides is established by basic dimensions D or E.	0.10 mm
bbb	The parallelism tolerance controlling the orientation of the top surface of the package carrier with respect to the seating plane, datum C.	0.10 mm
ccc	The parallelism tolerance controlling the orientation of the top surface of the package with respect to the seating plane, datum C. This specification will not apply to the fillet or sloped region of glob-top encapsulation.	0.20 mm

Table 4.22-2 — Symbols, Dimensions and Tolerances for PoP FBGA Packages Lower Package Specific

SYMBOL	DEFINITION	VALUES
A4	The thickness of the package's substrate and solder balls.	$A4 = A - A5$
A5	The thickness of the lid or encapsulation or mold cap. Note: There is a critical dependency between the maximum mold cap height of the Flange Type package and the ball diameter of the upper package. (See Application Note 18)	When $f = 0.80$ mm A5 (max, lower package) = 0.43 mm When $f = 0.65$ mm A5 (max, lower package) = 0.38 mm When $f = 0.50$ mm A5 (max, lower package) = 0.22 mm When $f = 0.40$ mm A5 (max, lower package) = 0.16 mm
e	The distance between the centerlines of any two adjacent rows or columns of balls. e is a BASIC dimension.	$e = 0.80$ mm $e = 0.65$ mm $e = 0.50$ mm $e = 0.40$ mm

Table 4.22-2 — Symbols, Dimensions and Tolerances for PoP FBGA Packages Lower Package Specific

SYMBOL	DEFINITION	VALUES
F	The distance between the extreme mold cap edges for the Flange Type lower package in the direction parallel to D. Note: F is a maximum value, and only maximum values must be specified	$F = G$ regardless of the value of f
G	The distance between the extreme mold cap edges in the direction perpendicular to F, and parallel to E (Applicable to Flange Type packages only). Note: G is a maximum value, and only maximum values must be specified	
D2	The distance between the centerlines of the two outermost rows of lands parallel to the D axis of the package. D2 is a BASIC dimension	$D2 = E2 = (MD2-1) \times f$
E2	The distance between the centerlines of the two outermost rows of lands parallel to the E axis of the package. E2 is a BASIC dimension	
f	The distance between the centerlines of any two adjacent rows or columns of lands. f is a BASIC dimension	$f = 0.80 \text{ mm}$ $f = 0.65 \text{ mm}$ $f = 0.50 \text{ mm}$ $f = 0.40 \text{ mm}$
H	The distance between the edge of the lid, encapsulation, or mold cap and the edge of the land in the direction parallel to the D axis of the Flange Type package.	When $f = 0.80 \text{ mm}$ $H(\text{min}) = J(\text{min}) = 0.10 \text{ mm}$ When $f = 0.65 \text{ mm}$ $H(\text{min}) = J(\text{min}) = 0.10 \text{ mm}$ When $f = 0.50 \text{ mm}$ $H(\text{min}) = J(\text{min}) = 0.10 \text{ mm}$ When $f = 0.40 \text{ mm}$ $H(\text{min}) = J(\text{min}) = 0.10 \text{ mm}$
J	The distance between the edge of the lid, encapsulation, or mold cap and the edge of the land in the direction parallel to E axis of the Flange Type package.	
MDL	The maximum number of balls in a fully populated row parallel to the D axis of the package. (4.22.6.2 & 4.22.7.2)	See tables 4.22-7, 8 and 9
MEL	The maximum number of balls in a fully populated row parallel to the E axis of the package. (4.22.6.2 & 4.22.7.2)	