JEITA

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JEITA EDR-7315B

Design guide for semiconductor packages Ball Grid Array (BGA)

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Introduction

Over the last few years, increasing requirements for higher functionality and better performances in electronics have driven the surface mount devices toward higher pin count. This design guide intends to standardize the outline dimensions and tolerances of BGA packages, which are widely adopted as higher pin-count surface mount devices, and indicates the recommended package variations to enhance the compatibility of packages among suppliers.

This document is also intended for better design guide to the standard package outline, providing the nominal values for all dimensions wherever possible.

1. Scope

This Design guide for semiconductor packages defines the general outline drawings, dimensions and tolerances for square-body packages of Plastic Ball Grid Array (P-BGA), Tape Ball Grid Array (T-BGA) and Ceramic Ball Grid Array (C-BGA), which are categorized as Form-D in the Recommended Practice on Standard for the Preparation of Outline Drawings of Semiconductor Packages, **JEITA ED-7300**, with a terminal pitch of 1.0 mm and higher.

2. Normative references

- Recommended Practice on Standard for the Preparation of Outline Drawings of Semiconductor Packages, **JEITA ED-7300**
- Manual for Integrated Circuits Package Design Guideline, **JEITA ED-7302**
- Name and code for integrated package, **JEITA ED-7303**

3. Terminology

General terminology complies with **JEITA ED-7300** and specific terminology is defined in the text.

4. Definition of BGA

A Ball Grid Array package is defined as a package whose package substrate contains an array pattern of metallic balls or bumps that provide the mechanical and electrical connection from the package body to the printed circuit board. A P-BGA features the package substrate made of organic printed circuit board, a T-BGA made of polyimide tape, and a C-BGA made of ceramic circuit board.

5. Terminal position numbering

When a package is viewed from the terminal side with the index corner in the bottom left corner position, terminal rows are lettered from bottom to top starting with A, then B, C..., AA, AB, etc., while terminal columns are numbered from left to right starting with 1. Terminal positions are designated by a row-column grid system and shown as alphanumeric identification, e.g., A1, B1, or AC34. The letters I, O, Q, S, X and Z are not used for naming the terminal rows.

6. Nominal package dimension

A nominal package dimension is defined as “the package width (E) × length (D)”, which is expressed in the tenths place in millimeter.

7. Symbols and drawings

7.1 BGA outline

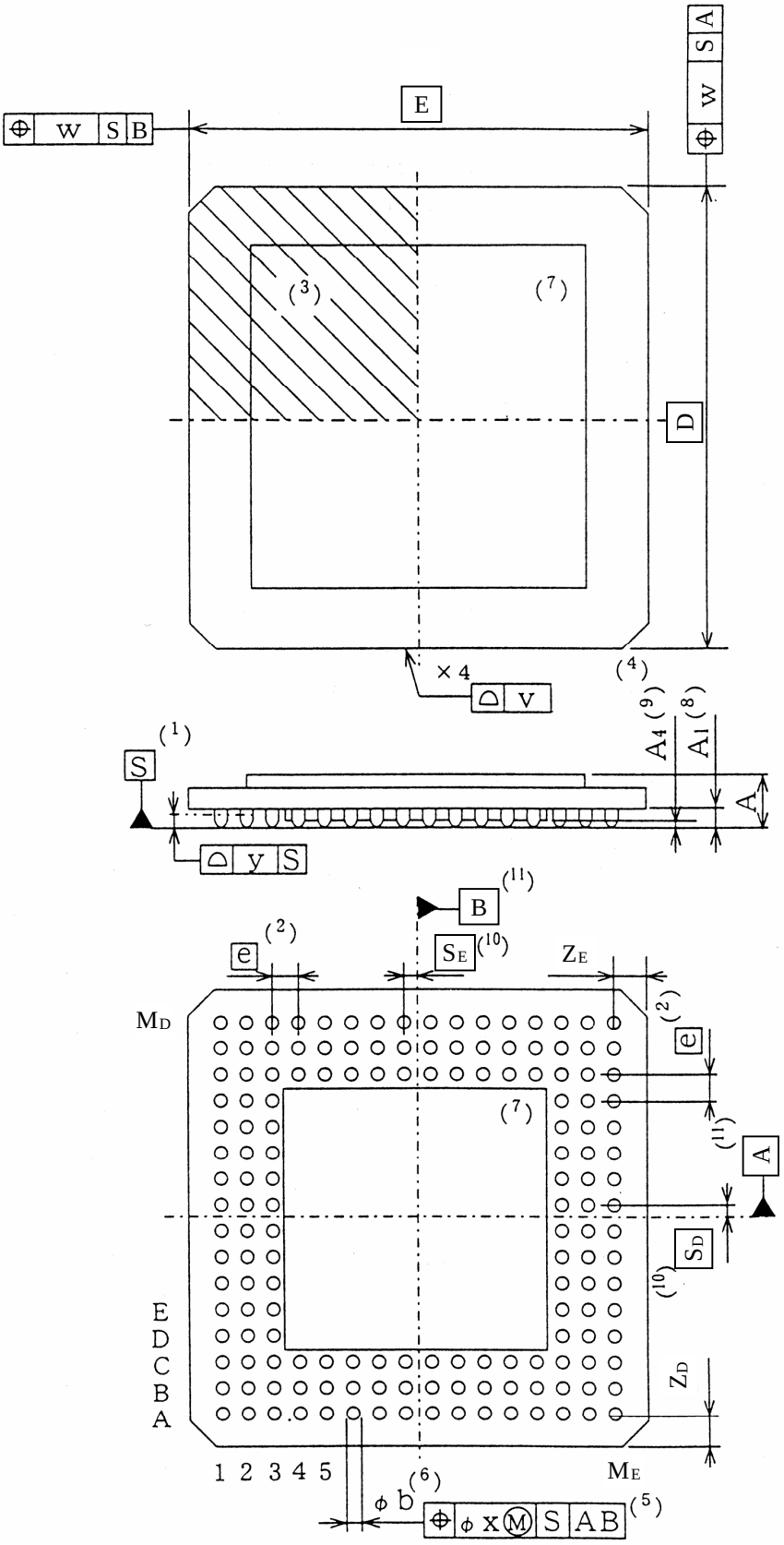


Figure 1 Cavity down type

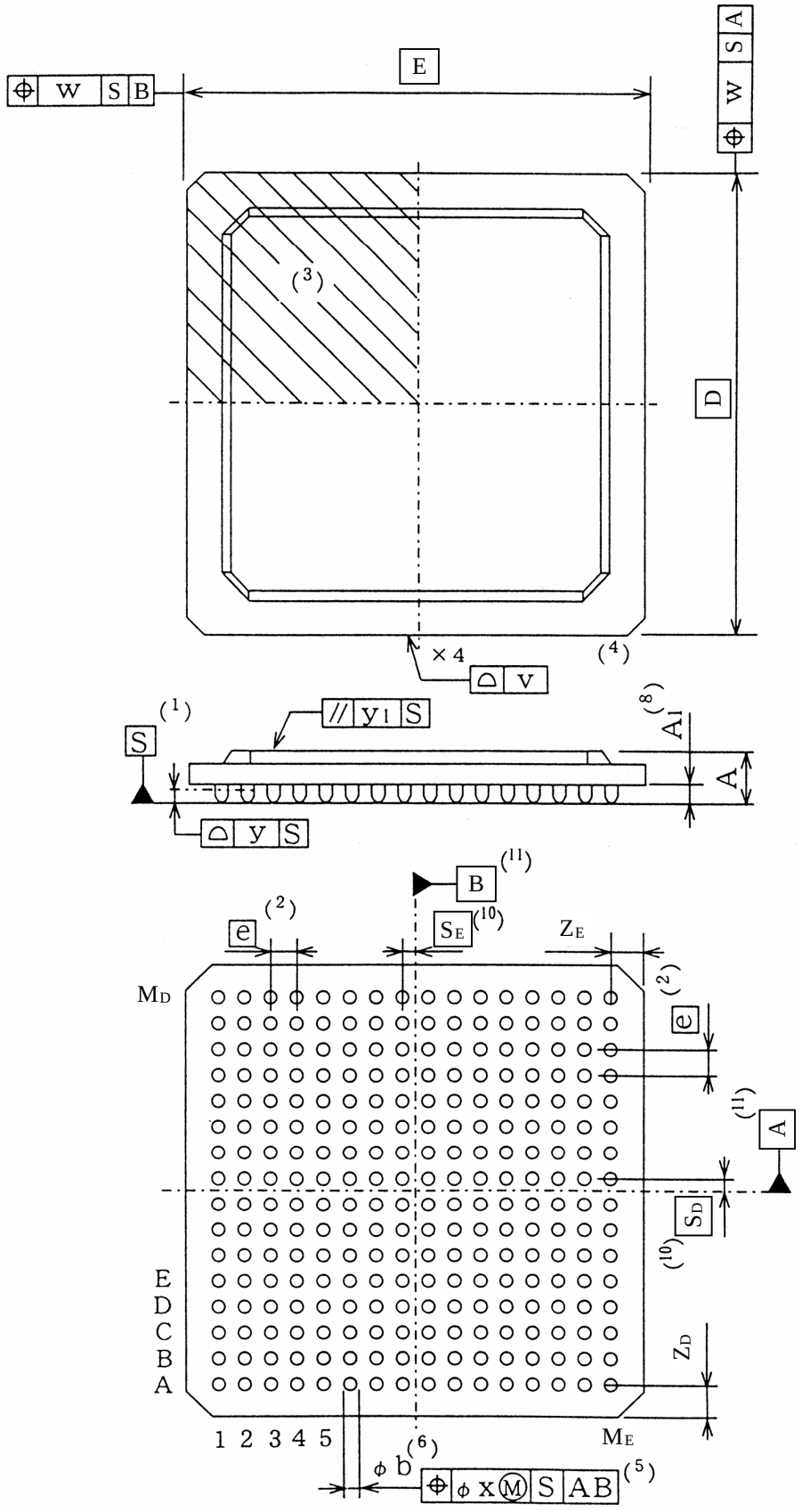


Figure 2 Cavity up type

Note ([1]): Datum [S] is defined as the seating plane on which a package free stands by contact of the balls.

([2]) : The distance between the centerlines of any two adjacent rows or columns of balls.

([3]): The hatched zone indicates the index-marking area where whole index mark will be contained.

([4]): The profile tolerance that controls of package size and orientation is applied to all four sides of the package outline.

([5]): The tolerance of position that controls the relationship of the balls applies to all balls.

([6]): The terminal diameter “b” is the maximum diameter of individual balls as measured in the plane parallel to the seating plane.

([7]): It shows the lid made of mold compound, glob top resin, metal cap, ceramics, etc. It may be flat, convex, or concave shape.

([8]): The primary stand-off height is defined by the height from seating plane to the package substrate.

([9]): The secondary stand-off height is defined by the height from the seating plane to the lid thet is the lowest surface on the cavity-down configuration.

([10]): [S_D] and [S_E] are the dimensions that define the positions of balls next to the datum [A] and [B].

([11]): Datum [A] and [B] are defined by the calculation from all terminal centers by using the least mean square method

Remarks: An array pattern of permissible terminal-existing zones including true position tolerance is shown in **Figure 3**.

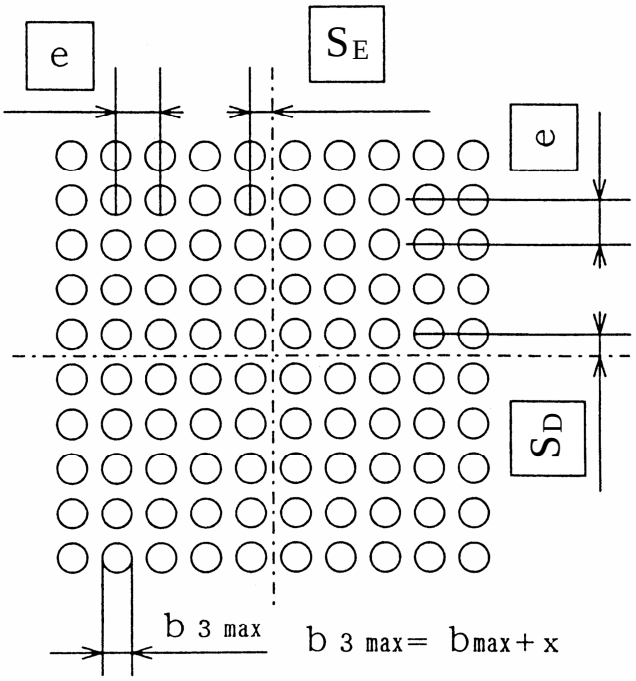


Figure 3

8. Dimensions

8.1 Group Ⅰ

Table 1

Unit: mm

Term	Symbol	Specification	Recommended value	Notes
Nominal package dimension	E × D	(1) A nominal package dimension is defined as "the package width (E) × length (D)", which is expressed in the tenths place in millimeter. (2) Variations on nominal package dimensions are: 7.0 × 7.0 — 25.0 × 25.0 8.0 × 8.0 — 27.0 × 27.0 9.0 × 9.0 — 29.0 × 29.0 10.0 × 10.0 — 31.0 × 31.0 11.0 × 11.0 — 33.0 × 33.0 12.0 × 12.0 — 35.0 × 35.0 13.0 × 13.0 — 37.5 × 37.5 14.0 × 14.0 — 40.0 × 40.0 15.0 × 15.0 — 42.5 × 42.5 16.0 × 16.0 — 45.0 × 45.0 17.0 × 17.0 — 47.5 × 47.5 18.0 × 18.0 — 50.0 × 50.0 19.0 × 19.0 — 52.5 × 52.5 20.0 × 20.0 — 55.0 × 55.0 21.0 × 21.0 — 57.5 × 57.5 23.0 × 23.0 — 60.0 × 60.0	Refer to **Table 5** through **10**.	
Package length	D	(1) Package length D 7.0 — 25.0 8.0 — 27.0 9.0 — 29.0 10.0 — 31.0 11.0 — 33.0 12.0 — 35.0 13.0 — 37.5 14.0 — 40.0 15.0 — 42.5 16.0 — 45.0 17.0 — 47.5 18.0 — 50.0 19.0 — 52.5 20.0 — 55.0 21.0 — 57.5 23.0 — 60.0	Refer to **Table 5** through **10**.	

Table 1 (continued)

Unit: mm

<table>
<tr><th>Term</th><th>Symbol</th><th>Specification</th><th>Recommended value</th><th>Notes</th></tr>
<tr><td>Package width</td><td>E</td><td>(1) Package width E
7.0 25.0
8.0 27.0
9.0 29.0
10.0 31.0
11.0 33.0
12.0 35.0
13.0 37.5
14.0 40.0
15.0 42.5
16.0 45.0
17.0 47.5
18.0 50.0
19.0 52.5
20.0 55.0
21.0 57.5
23.0 60.0</td><td>Refer to Table 5 through 10.</td><td></td></tr>
<tr><td>Profile tolerance of package body</td><td>v</td><td>v = 0.20</td><td>-</td><td>Profile tolerance includes body-edge burr.</td></tr>
<tr><td>Off-center tolerance</td><td>w</td><td><table><tr><th>e</th><th>w</th></tr><tr><td>1.27</td><td>0.30</td></tr><tr><td>1.00</td><td>0.30</td></tr></table></td><td>-</td><td></td></tr>
<tr><td>Profile height</td><td>A</td><td><table><tr><th>A max</th></tr><tr><td>1.20</td></tr><tr><td>1.70</td></tr><tr><td>6.00</td></tr></table></td><td>-</td><td>“A” includes;
(1) Heat slug thickness.
(2) Package warpage and tilt errors.
“A” does not include the height of external heat sink or chip capacitors.</td></tr>
<tr><td>The primary Stand-off height</td><td>A_1</td><td><table><tr><th>e</th><th>$A_{1\ min}$</th><th>$A_{1\ nom}$</th><th>$A_{1\ max}$</th></tr><tr><td>1.27</td><td>0.5</td><td>0.6</td><td>0.7</td></tr><tr><td>1.00</td><td>0.4</td><td>0.5</td><td>0.6</td></tr></table></td><td>-</td><td></td></tr>
</table>

Table 1 (continued)

Unit mm

<table>
<tr><th>Term</th><th>Symbol</th><th>Specification</th><th>Recommended value</th><th>Notes</th></tr>
<tr><td>The secondary Stand-off height</td><td>A_4</td><td>$A_{4\ min}$ = 0.25</td><td>-</td><td></td></tr>
<tr><td>Terminal grid pitch</td><td>e</td><td>1.27
1.00</td><td>-</td><td></td></tr>
<tr><td>Terminal diameter</td><td>b</td><td><table><tr><th>e</th><th>b_{min}</th><th>b_{nom}</th><th>b_{max}</th></tr><tr><td>1.27
1.00</td><td>0.60
0.50</td><td>0.75
0.60</td><td>0.90
0.70</td></tr></table></td><td>-</td><td></td></tr>
<tr><td>True position tolerance</td><td>x</td><td><table><tr><th>e</th><th>x</th></tr><tr><td>1.27
1.00</td><td>0.15
0.10</td></tr></table></td><td>-</td><td></td></tr>
<tr><td>Coplanarity</td><td>y</td><td><table><tr><th>e</th><th>y</th></tr><tr><td>1.27
1.00</td><td>0.20
0.20</td></tr></table></td><td>-</td><td></td></tr>
<tr><td>Parallelism tolerance of the top surface</td><td>y_1</td><td>y_1 = 0.35</td><td>-</td><td></td></tr>
<tr><td>Center terminal(s) position in length</td><td>S_D</td><td>When M_D is an odd number, S_D = 0
When M_D is an even number, S_D = e / 2</td><td>-</td><td></td></tr>
<tr><td>Center terminal(s) position in width</td><td>S_E</td><td>When M_E is an odd number, S_E = 0
When M_E is an even number, S_E = e / 2</td><td>-</td><td></td></tr>
<tr><td>Terminal matrix</td><td></td><td>Terminal balls will be placed on the matrix determined by terminal pitch e, matrix size M_D and M_E, and center ball position S_D and S_E. Any terminal balls may be omitted from the terminal matrix.</td><td>-</td><td></td></tr>
</table>

Table 1 (continued)

Unit mm

Term	Symbol	Specification	Recommended value	Notes
Number of terminals	n	Refer to **Table 3**.	Refer to **Table 5** through **10**.	
Maximum matrix size in length	M_D			
Maximum matrix size in width	M_E			

8.2 Group II

Table 2

Unit: mm

Term	Symbol	Specification	Recommended value	Notes
Overhang dimension in length	Z_D	$Z_D = \{\boxed{D} - (M_D - 1) \times \boxed{e}\} / 2$	-	
Overhang dimension in width	Z_E	$Z_E = \{\boxed{E} - (M_E - 1) \times \boxed{e}\} / 2$	-	

Table 3 Combination of [D], [E], [e], M_D, M_E and n

[D] and [E]	[e] = 1.27				[e] = 1.00			
	$M_{D\ max}$ $M_{E\ max}$	n_{max}	$M_{D\ max-1}$ $M_{E\ max-1}$	n_{max}	$M_{D\ max}$ $M_{E\ max}$	n_{max}	$M_{D\ max-1}$ $M_{E\ max-1}$	n_{max}
7.0	5	25	4	16	6	36	5	25
8.0	6	36	5	25	7	49	6	36
9.0	6	36	5	25	8	64	7	49
10.0	7	49	6	36	9	81	8	64
11.0	8	64	7	49	10	100	9	81
12.0	9	81	8	64	11	121	10	100
13.0	10	100	9	81	12	144	11	121
14.0	10	100	9	81	13	169	12	144
15.0	11	121	10	100	14	196	13	169
16.0	12	144	11	121	15	225	14	196
17.0	13	169	12	144	16	256	15	225
18.0	13	169	12	144	17	289	16	256
19.0	14	196	13	169	18	324	17	289
20.0	15	225	14	196	19	361	18	324
21.0	16	256	15	225	20	400	19	361
23.0	18	324	17	289	22	484	21	441
25.0	19	361	18	324	24	576	23	529
27.0	21	441	20	400	26	676	25	625
29.0	22	484	21	441	28	784	27	729
31.0	24	576	23	529	30	900	29	841
33.0	25	625	24	576	32	1024	31	961
35.0	27	729	26	676	34	1156	33	1089
37.5	29	841	28	784	37	1369	36	1296
40.0	31	961	30	900	39	1521	38	1444
42.5	33	1089	32	1024	42	1764	41	1681
45.0	35	1225	34	1156	44	1936	43	1849
47.5	37	1369	36	1296	47	2209	46	2116
50.0	39	1521	38	1444	49	2401	48	2304
52.5	41	1681	40	1600	52	2704	51	2601
55.0	43	1849	42	1764	54	2916	53	2809
57.5	45	2025	44	1936	57	3249	56	3136
60.0	47	2209	46	2116	59	3481	58	3364

Note: "n_{max}" indicates the maximum number of terminals that will fit on a package. Actual number of the terminal may be less than n_{max} by depopulating terminals from the matrix.

9. Registration procedure of standard outline drawings

The committee member who wishes to propose a new outline standard will fill in the **Appendix Form 5** in the Administrative Rules of the TSC on Semiconductor Device Packages, and proceed to the registration procedure of the standard, following the Manual for the Standard of Integrated Circuit Packages.

Symbol "*" in **Table 4** indicates the cells which will be filled with dimensions or descriptions.

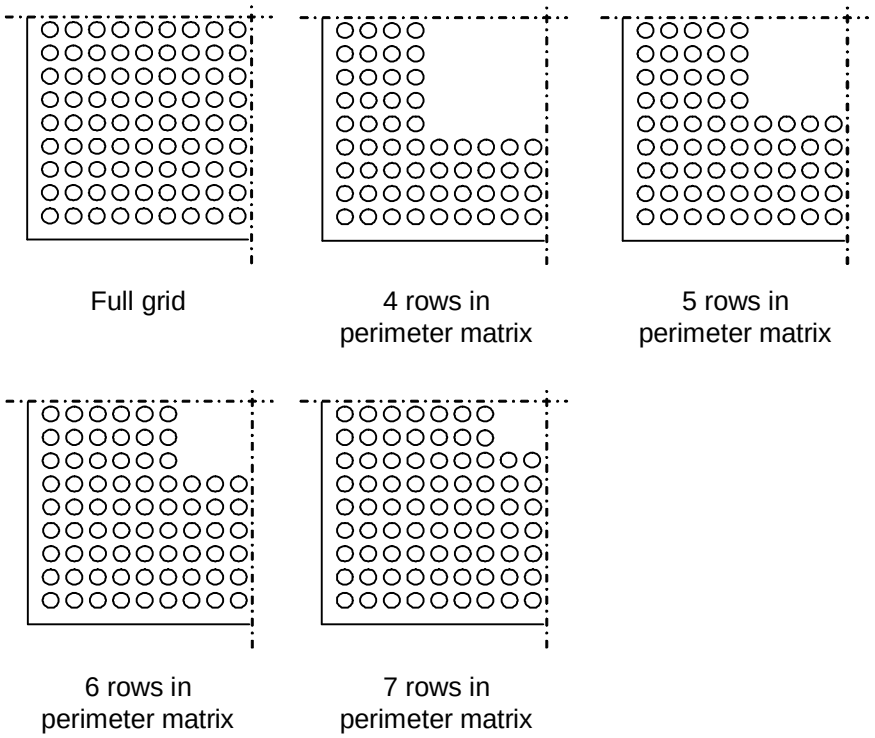
Table 4

Reference Number				
Package codes		#-#BGA####-##.####-#.##		
Symbols		MIN	NOM	MAX
Group I	D		*	
	E		*	
	V			*
	W			*
	A	*	*	*
	A_1	*	*	*
	A_4	*		
	e		*	
	b	*	*	*
	x			*
	y			*
	y_1			*
	S_D		*	
	S_E		*	
	n		*	
	M_D		*	
	M_E		*	
	Terminal depopulation	* (**Note**)		
Group II	Z_D		*	
	Z_E		*	

Note: This cell will be filled in either "Full matrix", "Staggered matrix" or "Perimeter matrix with x rows" here, where "x" is natural number. Any other unique patterns would be defined or illustrated in each standard of individual package outline.

Example of the terminal depopulations

Index marking is in the left bottom corner.



10. Recommended BGA variations

Table 5 P-BGA (Cavity up) 1.27mm pitch

D and E	M	e	Number of rows in perimeter matrix	Number of rows in center matrix	Number of terminals
27	20	1.27	4	0	256
27	20	1.27	4	4	272
27	20	1.27	5	0	300
27	20	1.27	5	4	316
27	20	1.27	6	0	336
27	20	1.27	6	4	352
31	23	1.27	4	0	304
31	23	1.27	4	5	329
31	23	1.27	5	0	360
31	23	1.27	5	5	385
31	23	1.27	6	0	408
31	23	1.27	6	5	433
35	26	1.27	4	0	352
35	26	1.27	4	6	388
35	26	1.27	5	0	420
35	26	1.27	5	6	456
35	26	1.27	6	0	480
35	26	1.27	6	6	516
40	30	1.27	6	0	576
40	30	1.27	6	8	640
40	30	1.27	7	0	644
40	30	1.27	7	8	708

Table 6 P-BGA (Cavity up) 1.0 mm pitch

D and E	M	e	Number of rows in perimeter matrix	Number of rows in center matrix	Number of terminals
13	12	1.00	Full	Full	144
14	13	1.00	Full	Full	169
15	14	1.00	Full	Full	196
16	15	1.00	Full	Full	225
17	16	1.00	Full	Full	256
18	17	1.00	Full	Full	289
19	18	1.00	Full	Full	324
20	19	1.00	Full	Full	361
21	20	1.00	4	0	256
21	20	1.00	4	6	292
21	20	1.00	Full	Full	400
23	22	1.00	4	0	288
23	22	1.00	4	6	324
23	22	1.00	5	0	340
23	22	1.00	5	6	376
23	22	1.00	6	0	384
23	22	1.00	6	6	420
23	22	1.00	Full	Full	484
27	26	1.00	4	0	352
27	26	1.00	4	6	388
27	26	1.00	5	0	420
27	26	1.00	5	6	456
27	26	1.00	6	0	480
27	26	1.00	6	6	516
27	26	1.00	Full	Full	676
31	30	1.00	4	0	416
31	30	1.00	4	6	452
31	30	1.00	5	0	500
31	30	1.00	5	6	536
31	30	1.00	6	0	576
31	30	1.00	6	6	612
31	30	1.00	Full	Full	900
35	33	1.00	4	0	464
35	33	1.00	4	9	545
35	33	1.00	5	0	560
35	33	1.00	5	9	641
35	33	1.00	6	0	648
35	33	1.00	6	9	729
35	33	1.00	7	0	728
35	33	1.00	7	9	809
35	33	1.00	Full	Full	1089
37.5	36	1.00	4	0	512
37.5	36	1.00	4	10	612
37.5	36	1.00	5	0	620
37.5	36	1.00	5	10	720
37.5	36	1.00	6	0	812
37.5	36	1.00	6	10	912
37.5	36	1.00	7	0	896
37.5	36	1.00	7	10	996
37.5	36	1.00	Full	Full	1296
40	38	1.00	6	0	768
40	38	1.00	6	10	868
40	38	1.00	7	0	868
40	38	1.00	7	10	968
40	38	1.00	Full	Full	1444

Table 7 P-BGA (Cavity down)

D and E	M	e	Number of rows in perimeter matrix	Number of terminals
27	20	1.27	4	256
31	23	1.27	4	304
35	26	1.27	4	352
35	26	1.27	5	420
40	30	1.27	4	416
40	30	1.27	5	500
40	30	1.27	6	576
42.5	32	1.27	5	540
45	34	1.27	4	480
45	34	1.27	5	580
45	34	1.27	6	672
45	34	1.27	7	756

Table 8 T-BGA 1.27 mm pitch

D and E	M	e	Number of rows in perimeter matrix	Number of terminals
27	20	1.27	4	256
31	23	1.27	4	304
35	26	1.27	4	352
35	26	1.27	5	420
35	26	1.27	6	480
40	30	1.27	5	500
40	30	1.27	6	576
40	30	1.27	7	644

Table 9 T-BGA 1.0 mm pitch

D and E	M	e	Number of rows in perimeter matrix	Number of terminals
27	25	1.0	4	336
31	29	1.0	4	400
31	29	1.0	5	480
31	29	1.0	6	552
35	33	1.0	4	464
35	33	1.0	5	560
35	33	1.0	6	648
40	38	1.0	5	660
40	38	1.0	6	768
40	38	1.0	7	868

Table 10 P-BGA/C-BGA (Flip-chip interconnection)

D and E	M	e	Number of rows in perimeter matrix	Number of terminals
23	22	1.0	Full	484
27	26	1.0	Full	676
31	30	1.0	Full	900
35	34	1.0	Full	1156
37.5	36	1.0	Full	1296
40	39	1.0	Full	1521
42.5	41	1.0	Full	1681
45	44	1.0	Full	1936
47.5	46	1.0	Full	2116
50	49	1.0	Full	2401
52.5	51	1.0	Full	2601
55	53	1.0	Full	2809

EXPLANATION

1. Purpose of this design guide

The purpose of this design guide is to establish the design requirements that shall be followed for designing future package standard outlines or related parts.

2. History of deliberations

The U.S. standardization committee of semiconductor package, **JEDEC JC-11**, had first deliberated the standardization of BGA, and published **MO-151** on Nov. 1993 and **MO-149** on Dec. 1993. Following the standardization activity in **JEDEC**, the BGA Package Work Group was formed on Apr. 1994 as the subordinate of the Special Committee on Semiconductor Device Packages for the purpose of concentrated discussion about standardization of BGA in Japan. The working group finished the tasks on Mar. 1995 by completing the final draft of the General rules for Package Outline.

The Technical Standardization Committee on Semiconductor Device Packages was constituted on Apr. 1995 and succeeded the Special Committee. It reviewed the specification system of standard and the registration procedure to realize an agile efficient system to establish the standards of the semiconductor package that could be adopted in the global society. The General Rules for Package Outline in the previous system was reformed and split into three specifications; entry table, design guide and individual specification.

The Plastic Package Subcommittee, a subordinate of the Technical Standardization Committee on Semiconductor Device Packages, reviewed the final draft of the General Rules of BGA Outlines made by the former BGA Package Working Group to meet the new requirements including three premises:

(1) The committee determined that the recommended package variations listed in the final draft would be removed and transferred to the Individual Specifications.

(2) Ceramic Package Subcommittee had deliberated the standardization of C-BGA made of the ceramic substrate and found that major portion of the standard was similar to other type of BGA. Therefore, it was agreed that single design guide applies to all BGA packages regardless of materials.

(3) Geometrical datum was adopted to accurately determine the terminal position which is most important for the surface mount assembly.

The plastic Package Subcommittee completed the deliberation in detail on Jul. 1996. The final draft of the design guide was approved by the Committee and published as **EIAJ EDR-7315**.

The year 2003 saw the growing number of the variations that had slightly different ball numbers and ball depopulations in the same body size, even after BGA had reached the matured phase. Unlimited proliferation was questioned by suppliers, manufacturers who assemble the devices on the printed circuit board, and IPC organization. Although it was the results of the moderate control of the proliferation of BGA design guide, unlimited proliferation is not the intention of the Committee. BGA Design Guide Task Force was formed on Dec. 2003 to establish the recommended BGA variations, which were expected to prevent further proliferation.

From the view point of the specification system in **JEITA**, even though the Individual Standard had once been considered specifying recommended variations, the Committee changed its perception and redefined the Individual Standard as the standards of the individual package outlines and design guide as the one including recommended package variations.

Changes in this amendment were:

(1) Recommended BGA variations were established.

(2) Variations of body size, 52.5, 55, 57.5, 60 mm were added to meet the demand of higher pin count.

(3) Variations of body size, 16, 18, 20 mm were added to harmonize with the FBGA design guide.

(4) Expressions of overhang dimension, $\boxed{Z_D}$ and $\boxed{Z_E}$, were corrected to Z_D and Z_E.

(5) Length D was exchanged with width E to be consistent with the design guide for FBGA.

The task force completed the draft amendment of the **EIAJ EDR-7315A** and finished its task on Apr. 15 2005.

3. Main dimensions reviewed

(1) Datum ($\boxed{A}$, $\boxed{B}$)

The committee adopted the ball-based datums to accurately determine the ball position.

(2) Code of package nominal dimension (E × D)

A code of package nominal dimension is defined as the combination of the package width and length which are expressed in the tenths place in millimeter.

(3) Maximum matrix size (M_D, M_E)

$M_{D\ max}$ and $M_{E\ max}$ represent the maximum matrix sizes in length and width, respectively. The maximum matrix size is calculated by the following algorithms and truncated into integer.

$$M_{D\ max} \leq (\boxed{D} - b_{max} - v - w - x) / \boxed{e} + 1$$

$$M_{E\ max} \leq (\boxed{E} - b_{max} - v - w - x) / \boxed{e} + 1$$

$\boxed{D}$, $\boxed{E}$: Package length and width

b_{max} : Maximum ball diameter

v : Profile tolerance of the package body

w : The tolerance of the body position with respect to the datum $\boxed{A}$ and $\boxed{B}$

x : Terminal true position tolerance

$\boxed{e}$: Terminal pitch

(4) Profile height (A)

Additional categories of 1.2 mm and 1.7 mm were specified as A_{max} in addition to 6.0 mm, in compliance to **JEITA ED-7303B**.

(5) Overhang dimension (Z_D, Z_E)

The package overhang dimensions, Z_D and Z_E, which used to be basic dimensions expressed by $\boxed{Z_D}$ and $\boxed{Z_E}$, were redefined as the reference values, since overhang dimension could be derived from the ball pitch and package size that are basic dimensions.

(6) The primary and secondary stand-off height (A_1, A_4)

The primary stand-off height is defined by the height from seating plane to the package substrate, while the secondary stand-height is defined by the height from the seating plane to the lid that is the lowest surface of the cavity-down configuration.

4. Off-center tolerance (w)

The off-center tolerance “w” is defined as the tolerance of the body center position with regard to the datum $\boxed{A}$ and $\boxed{B}$, and was 0.15 mm in the first issue. But after reviewing the actual measurement and process capability of the commercially available BGA, the Area Array Subcommittee relaxed the tolerance to 0.3 mm on Sep. 1998.

5. Members of deliberative bodies

This amendment of the design guide was deliberated in the Subcommittee on Integrated Circuit Packages. Details of technical issues were discussed in the task force, which had been formed by experts from the member companies of the Subcommittee on Integrated Circuit Packages specifically for this task.

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Special members	Shin-Etsu Polymer Co., Ltd.	Ken Tamura
	Toyojushi Co., Ltd.	Hitoshi Kazama

<BGA design guide Task Force>

Leader	NEC Electronics Corp.	Hirofumi Nakajima
Members	Toshiba Corp.	Yuji Fukuzawa
	Renesas Technology Corp.	Yoshinori Miyaki
	Kyocera Corp.	Akihiko Funahashi
	Yamaichi Electric Co., Ltd.	Yoshiaki Nishiyama

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Published by Technical Standardization Center of Japan Electronics & Information Technology Industries Association

11, Kanda-Surugadai 3-chome, Chiyoda-ku, Tokyo 101-0062, Japan

TEL +81-3-3518-6434 FAX +81-3-3295-8727