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Printed board and printed board assemblies – Design and use –
Part 5-8: Attachment (land/joint) considerations – Area array components (BGA, FBGA, CGA, LGA)

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Cartes imprimées et cartes imprimées équipées – Conception et utilisation –
Partie 5-8: Considérations sur les liaisons pastilles/joints – Composants matriciels (BGA, FBGA, CGA, LGA)

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Part 5-8: Attachment (land/joint) considerations – Area array components (BGA, FBGA, CGA, LGA)

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This bilingual version, published in 2010-01, corresponds to the English version.

The text of this standard is based on the following documents:

FDIS	Report on voting
91/705/FDIS	91/737/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IEC 61188-5-8 is to be read in conjunction with IEC 61188-5-1.

A list of all parts of the IEC 61188 series, under the general title *Printed boards and printed board assemblies – Design and use*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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INTRODUCTION

This part of IEC 61188 covers land patterns for area array components which include ball grid array (BGA) parts (rigid, flexible or ceramic substrate); fine pitch ball grid array (FBGA) parts (rigid or flexible substrate); column grid array (CGA) parts (ceramic substrates) and land grid array (LGA) parts (ceramic substrates). Each clause contains information in accordance with the area array family of components and their requirements for appropriate land patterns.

The proposed land pattern dimensions in this standard are based upon the fundamental tolerance calculation combined with the given land geometries and courtyard excesses (see IEC 61188-5-1, Generic requirements). The courtyard includes all issues of the normal manufacturing necessities.

The unaltered land pattern dimensions of this part are generally applicable for the solder paste application plus the reflow soldering process.

Although other standards in the IEC 61188-5 series define three levels of land pattern dimensioning, this standard will only define two levels. One level (level 2) is for non collapsing BGA balls; the other level (level 3) is for those BGA components where the ball does collapse around the land. All land descriptions are non-solder mask defined. Each land pattern has been assigned an identification number to indicate the characteristics of the specific robustness of the land patterns. Users also have the opportunity to organize the information so that it is most useful for their particular design.

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If a user has good reason to use a concept different from that of IEC 61188-5-1, or if the user prefers unusual land geometries, this standard should be used for checking the resulting ball to land relationship.

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It is the responsibility of the user to verify the SMD land patterns used for achieving an undisturbed mounting process including testing and an ensured reliability for the product stress conditions in use. In addition, the size and shape of the proposed land pattern may vary according to the solder resist aperture, the size of the land pattern extension (dog bone), the via within the extension, or if the via is in the land pattern itself.

Dimensions of the components listed in this standard are of those available in the market, and regarded as reference only.

PRINTED BOARD AND PRINTED BOARD ASSEMBLIES – DESIGN AND USE –

Part 5-8: Attachment (land/joint) considerations – Area array components (BGA, FBGA, CGA, LGA)

1 Scope

This part of IEC 61188 provides information on land pattern geometries used for the surface attachment of electronic components with area array terminations in the form of solder balls, solder columns or protective coated lands. The intent of the information presented herein is to provide the appropriate size, shape and tolerances of surface mount land patterns to ensure sufficient area for the appropriate solder joint, and also allow for inspection, testing and reworking of those solder joints.

Each clause contains a specific set of criteria such that the information presented is consistent, providing information on the component, the component dimensions, the solder joint design and the land pattern dimensions.

The land pattern dimensions are based on a mathematical model that establishes a platform for a solder joint attachment to the printed board. The existing models create a platform that is capable of establishing a reliable solder joint no matter which solder alloy is used to make that joint (lead-free, tin lead, etc.).

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Process requirements for solder reflow are different depending on the solder alloy and should be analyzed so that the process is taking place above the liquidus temperature of the alloy, and remains above that temperature a sufficient time to form a reliable metallurgical bond.

Area array land patterns do not use "land protrusion" concepts and attempt to match the characteristics of the physical and dimensional termination properties. There are several configurations available, as shown in Figure 1. However, the tables provided show only the optimum dimension across the outer construction of the land.

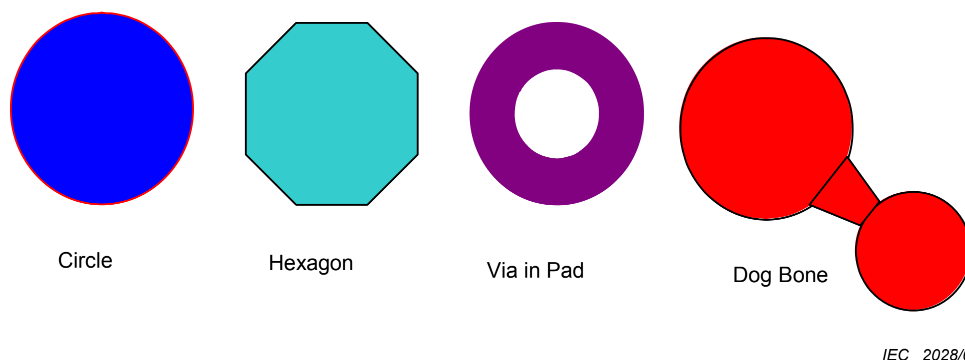

Figure 1 – Area array land pattern configuration

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-58, *Environmental testing – Part 2-58: Tests: Test Td – Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60191-2 (all parts), *Mechanical standardization of semiconductor devices – Part 2: Dimensions*

IEC 61188-5-1, *Printed boards and printed board assemblies – Design and use – Part 5-1: Attachment (land/joint) considerations – Generic requirements*

IEC 62090, *Product package labels for electronic components using bar code and two-dimensional symbologies*

3 General information

3.1 General component description

The area array family is characterized by terminations that are on a particular pitch and contain a number of rows and columns for the total IO termination pin count. The BGA family uses a solder ball as a termination and may have a square or rectangular package configuration. The family includes both moulded plastic and ceramic case styles. The acronyms PBGA (plastic ball grid array), CBGA (ceramic ball grid array), FBGA (fine pitch ball grid array), and TBGA (tape ball grid array) are also used to describe the family since they all use a ball termination in an array format. Other enhancements such as the addition of thermal heat distributors may be included in any of the package types described.

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There are several ball pitch variations within the family; these range from 1,50 mm to 0,25 mm as shown in Table 1. The lower pitch items (below 0,40 mm) are predicted for future component configurations.

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Table 1 – Ball diameter sizes

Pitch mm	Solder bump nominal diameter mm	Solder bump diameter variation mm
1,50; 1,27	0,75	0,90 – 0,65
1,00	0,60	0,70 – 0,50
1,00; 0,80	0,50	0,55 – 0,45
1,00; 0,80; 0,75	0,45	0,50 – 0,40
0,80; 0,75; 0,65	0,40	0,45 – 0,35
0,80; 0,75; 0,65; 0,50	0,30	0,35 – 0,25
0,40	0,25	0,28 – 0,22
0,30	0,20	0,22 – 0,18
0,25	0,15	0,17 – 0,13

3.2 Marking

The area array family of parts are generally marked with the manufacturer’s part numbers, manufacturer’s name or symbol and a pin 1 indicator. Some parts may have a pin 1 feature in the case shape instead of a pin 1 marking. Additional markings may include date-code manufacturing lot and/or manufacturing location. Bar code marking should be in accordance with IEC 62090.

3.3 Carrier packaging format

Carrier tray packaging format or tape and reel may be provided. Either format is acceptable and is usually specified by the component manufacturer or the assembler. Choice of format is usually dependent on size of component and volume to be assembled. Bulk packaging is not acceptable because of termination coplanarity issues and the requirements for placement and soldering.

3.4 Process considerations

Area array packages are normally processed by reflow solder operations. There is also a process difference between the solder application for those terminations that collapse slightly during soldering as defined in level 3 of this standard, and those terminations that do not collapse (level 2) where a significant amount of additional solder paste is required.

In conjunction with the right land size, the volume of the solder paste application is a fundamental parameter to keep under control in order to have a good reflow quality yield and reliable solder joint. Paste volume deposition may be a matter of SPC adoption at the print process step.

Fine pitch ball parts may require special processing outside the normal pick/place and reflow manufacturing operations. This requirement relates to the amount of solder paste, the precision of the placement machine and the soldering process profile, in order to permit all parts to become attached at the same time that the FBGA is reflowed.

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4 BGA (square)

4.1 Field of application

This clause provides the component and land pattern dimensions for square type BGA (ball grid array) components. The basic construction of the BGA device is also covered. At the end of this clause is a listing of the tolerances and target solder joint dimensions used to arrive at the land pattern dimensions.

4.2 Component descriptions

BGAs are widely used in a variety of applications for commercial, industrial or military electronics.

4.2.1 Basic construction

The ball grid array has been developed for applications requiring low height and high density. The BGA components may take many forms, as illustrated in Figure 2. Variations include the method of die attach (wire bonding, flip chip, etc.), the substrate material (organic rigid or flexible material, ceramic, etc.) and the method of protecting the device from the environment (plastic encapsulation, hermetic sealing etc.). All variations can use the same land patterns defined in this clause, as all types may be used in many printed circuit board assemblies for device applications.

Plastic BGA with wire bond chip attach	Au bond wires IC die Epoxy overmold BT/glass PCB AG filled die attach Solder balls (62/36/2 Sn/Pb/Ag) IEC 2029/07
Ceramic BGA, hermetically sealed, with flip chip die attach	Underfill Thermal grease Silicon die Solder balls (97PB/3Sn) Sealing adhesive Multiplayer alumina substrate Solder (37PB/63Sn) Solder balls (90PB/10Sn) IEC 2030/07
Tape bonded grid array, with flip chip die attach and enhanced thermal heat spreader	Thermal grease Silicon die Underfill Heat spreader Adhesive Copper ring Copper ring Flex circuit Solder balls (95Pb/5Sn) Solder balls (90Pb/10Sn) IEC 2031/07

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Figure 2 – BGA physical configuration examples

4.2.2 Termination materials

The BGA ball termination may consist of a variety of metal alloys. Some of these include balls with some lead content such as 37Pb63Sn, 90Pb10Sn, 95Pb5Sn, while others do not contain lead such as Sn96,5Ag3,0Cu0,5, Sn96,5Ag3,5, Sn-9Zn-0,003Al. It is a good recommendation to use the same alloy, in a paste form, to attach the BGA balls to the mounting substrate, however, some of the balls that do not collapse, as shown in Figure 3, require a paste that is more conducive to reflow temperatures.

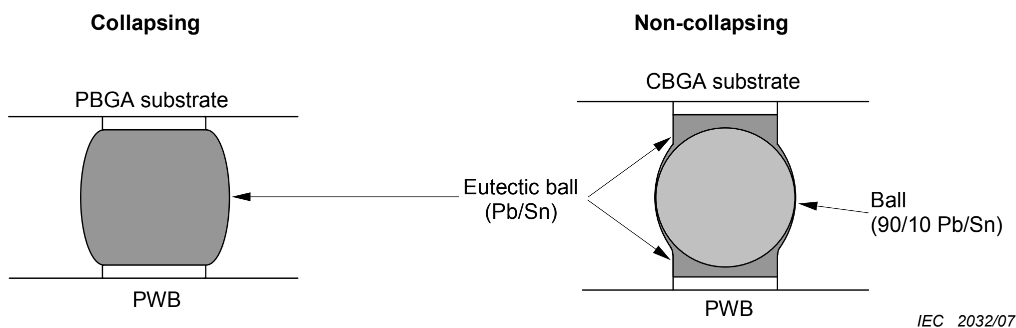

Figure 3 – High land and eutectic solder ball and joint comparison

4.2.3 Marking

All parts shall be marked with a part number and an index area. The index area shall identify the location of pin 1.

4.2.4 Carrier package format

The carrier package format for BGAs may be tray or tape and reel format. In most instances, BGAs are delivered in a carrier tray.

4.2.5 Process considerations

BGAs are usually processed using standard reflow solder processes. Parts should be capable of withstanding three cycles through a standard reflow system operating within a range of 235 °C to 260 °C depending on the attachment alloy being used. Each cycle shall consist of a 60 s to 90 s exposure at the particular temperature selected. The construction of the BGA resin system used for encapsulation, as shown in Figure 4, shall be capable of withstanding the process temperature exposure. This capability may be verified through test methods indicated in IEC 60068-2-58, Method 2, for three cycles with an appropriate dwell time to allow the specimens to cool.

It is important to consider that plastic BGAs are moisture sensitive device/components. Precaution shall be taken during the printed board assembly process in order to avoid MSD damages (delamination, cracks, etc). Traceability for baking PBGA, might be required mainly when attached in a double sided/reflow printed board assembly.

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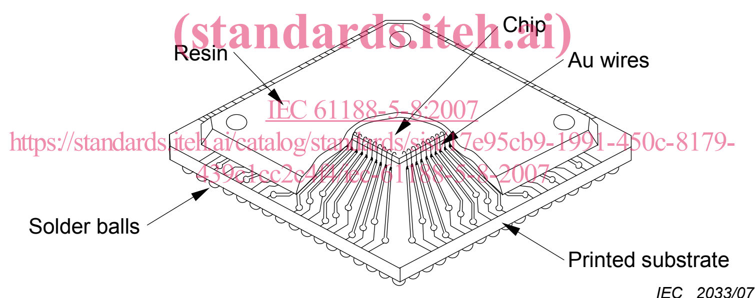

Figure 4 – BGA (square)

4.3 Component dimensions (square)

This subclause contains the physical dimensions of various PBGAs that have been standardized so that land pattern analysis can be performed. Figure 5 provides the general characteristic of the component and shows a depopulated version of the BGA device. Each manufacturer of a semiconductor may take the fully populated version and remove those terminations (balls), as appropriate, to establish the final configuration of the part.

Land pattern dimensional data may need to be adjusted if the component dimensional data does not match JEDEC and/or JEITA sheets.

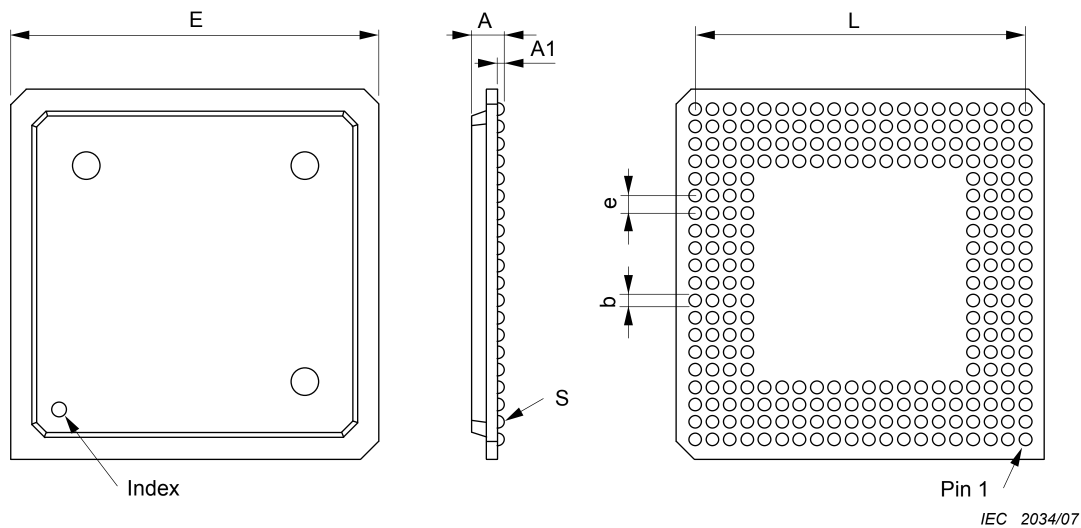

Figure 5 – General BGA dimensional characteristics

The following tables have been segmented according to the know pitch of those devices presently in use. The requirements are fully documented in IEC 60191-2. The information is provided for fully populated parts only, so that all the corresponding land patterns can be derived. Users of the information are cautioned to be sure that their land pattern version is identical to the part that they have purchased from the component supplier. It should also be known that not every supplier follows the same removal of termination pattern for a similar product. Thus, when looking for multiple sources, the user shall establish complete compliance with the design image in the computer library before making the commitment that the end use patterns may be used to mount different BGA component supplier parts.

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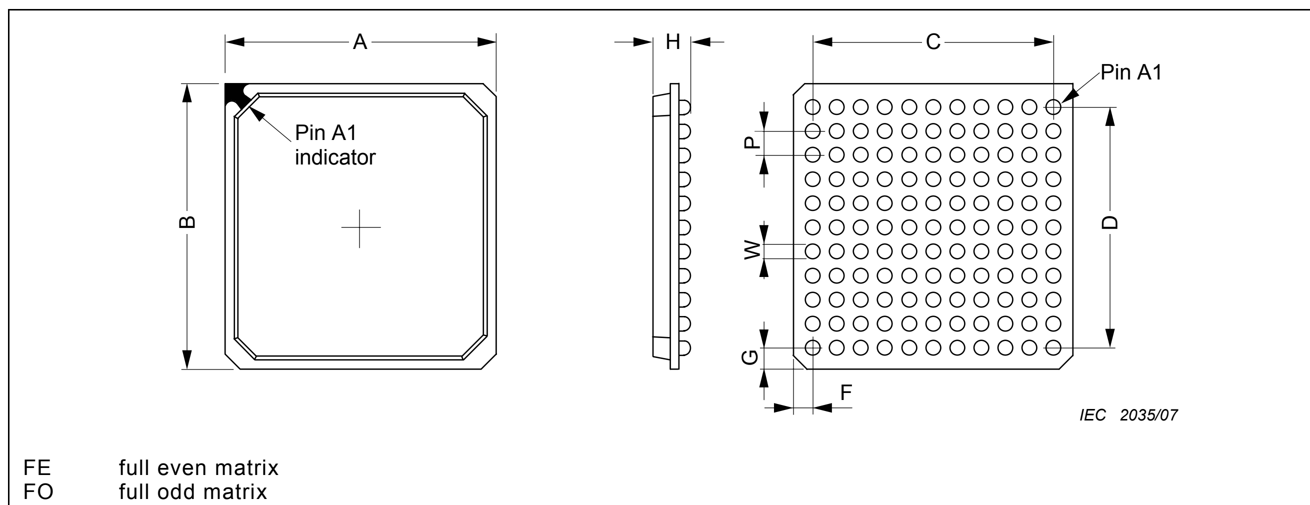
4.3.1 PBGA 1,5 mm pitch component dimensions (square)

Table 2 defines the requirements for BGA components with a pitch of 1,5 mm.

Table 2 – BGA products with pitch of 1,5 mm



FE full even matrix
FO full odd matrix

Component identifier	Contact array rows x columns	A	B	C	D	W	P	H	F or G
		Max.	Max.	Max.	Max.	Nom.	Basic	Max.	Nom.
PBGA 7x7 FE16	4x4	7,00	7,00	4,50	4,50	0,75	1,50	3,50	1,25
PBGA 7x7 FO9	3x3	7,00	7,00	3,00	3,00	0,75	1,50	3,50	2,00
PBGA 8x8 FO25	5x5	8,00	8,00	6,00	6,00	0,75	1,50	3,50	1,00
PBGA 8x8 FE16	4x4	8,00	8,00	4,50	4,50	0,75	1,50	3,50	1,75
PBGA 9x9 FE36	6x6	9,00	9,00	7,50	7,50	0,75	1,50	3,50	0,75
PBGA 9x9 FO25	5x5	9,00	9,00	6,00	6,00	0,75	1,50	3,50	1,50
PBGA 10x10 FE36	6x6	10,00	10,00	7,50	7,50	0,75	1,50	3,50	1,25
PBGA 10x10 FO25	5x5	10,00	10,00	6,00	6,00	0,75	1,50	3,50	2,00
PBGA 11x11 FO49	7x7	11,00	11,00	9,00	9,00	0,75	1,50	3,50	1,00
PBGA 11x11 FE36	6x6	11,00	11,00	7,50	7,50	0,75	1,50	3,50	1,75
PBGA 12x12 FE64	8x8	12,00	12,00	10,50	10,50	0,75	1,50	3,50	0,75
PBGA 12x12 FO49	7x7	12,00	12,00	9,00	9,00	0,75	1,50	3,50	1,50
PBGA 13x13 FE64	8x8	13,00	13,00	10,50	10,50	0,75	1,50	3,50	1,25
PBGA 13x13 FO49	7x7	13,00	13,00	9,00	9,00	0,75	1,50	3,50	2,00
PBGA 14x14 FO81	9x9	14,00	14,00	12,00	12,00	0,75	1,50	3,50	1,00
PBGA 14x14 FE64	8x8	14,00	14,00	10,50	10,50	0,75	1,50	3,50	1,75
PBGA 15x15 FE100	10x10	15,00	15,00	13,50	13,50	0,75	1,50	3,50	0,75
PBGA 15x15 FO81	9x9	15,00	15,00	12,00	12,00	0,75	1,50	3,50	1,50
PBGA 17x17 FO121	11x11	17,00	17,00	15,00	15,00	0,75	1,50	3,50	1,00
PBGA 17x17 FE100	10x10	17,00	17,00	13,50	13,50	0,75	1,50	3,50	1,75
PBGA 19X19 FE144	12x12	19,00	19,00	16,50	16,50	0,75	1,50	3,50	1,25
PBGA 19X19 FO121	11x11	19,00	19,00	15,00	15,00	0,75	1,50	3,50	2,00
PBGA 21X21 FE196	14x14	21,00	21,00	19,50	19,50	0,75	1,50	3,50	0,75
PBGA 21X21 FO169	13x13	21,00	21,00	18,00	18,00	0,75	1,50	3,50	1,5
PBGA 23X23 FO225	15x15	23,00	23,00	21,00	21,00	0,75	1,50	3,50	1,00
PBGA 23X23 FE196	14x14	23,00	23,00	19,50	19,50	0,75	1,50	3,50	1,75
PBGA 25X25 FE256	16x16	25,00	25,00	22,50	22,50	0,75	1,50	3,50	1,25
PBGA 25X25 FO225	15x15	25,00	25,00	21,00	21,00	0,75	1,50	3,50	2,00
PBGA 27X27 FE324	18x18	27,00	27,00	25,50	25,50	0,75	1,50	3,50	0,75
PBGA 27X27 FO289	17x17	27,00	27,00	24,00	24,00	0,75	1,50	3,50	1,50
PBGA 29X29 FO361	19x19	29,00	29,00	27,00	27,00	0,75	1,50	3,50	1,00
PBGA 29X29 FE324	18x18	29,00	29,00	25,50	25,50	0,75	1,50	3,50	1,75
PBGA 31X31 FE400	20x20	31,00	31,00	28,50	28,50	0,75	1,50	3,50	1,25
PBGA 31X31 FO361	19x19	31,00	31,00	27,00	27,00	0,75	1,50	3,50	2,00
PBGA 33X33 FE484	22x22	33,00	33,00	31,50	31,50	0,75	1,50	3,50	0,75
PBGA 33X33 FO441	21x21	33,00	33,00	30,00	30,00	0,75	1,50	3,50	1,50
PBGA 35X35 FO529	23x23	35,00	35,00	33,00	33,00	0,75	1,50	3,50	1,00
PBGA 35X35 FE484	22x22	35,00	35,00	31,50	31,50	0,75	1,50	3,50	1,75

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