The AIF Format

Die and Package Database Format

What's in an AIF File?

This format is intended to describe the bond shell area of BGA, Flex, uBGA and other types of integrated circuit packages. It is also used by chip designers to define the pad locations, nets and size of their die. As a simple ASCII format it should be readable and writable by a variety of software. It enables companies to use in house programmers to generate custom manufacturing software.

AIF uses syntax similar to Microsoft Windows' INI files since reading and writing such files is something most programmers know how to do well.

A properly written parser will skip over any section that it does not recognize. This enables companies to extend the AIF format for their own use and not break properly designed AIF readers.

AIF Main Sections

The AIF file format is broken into multiple sections:

[DATABASE] - Identifies the file format,version and database units enabling programs that read AIF to be sure that they are loading an AIF file and that the version they are reading is compatible. REQUIRED

[DIE] - Describes the die outline size, and die name. The actual die pad information is located in the NETLIST section. REQUIRED

[PADS] - This section defines as many pad types as needed: pads for die openings, bond fingers and ball pads. Think of these as padstack definitions you would encounter in a EDA database except that there is no vertical layer information. REQUIRED

[NETLIST] - This section is the actual netlist. Each net is listed along with the associated die pads, fingers, balls and coordinates. REQUIRED.

[RINGS] - This section lists ring names and associates each ring name with a net. These are actually polygon definitions that support both dark and clear polygons. OPTIONAL

[BONDABLE_RING_AREA] - A specialized section that results from taking the intersection of the rings, fingers and alignment marks on the top metal layer with the solder mask. It is meant to better represent the areas that can be bonded as they are "exposed by the solder mask. OPTIONAL

[BGA] - describes the extents of the package, and it's name or reference designator. OPTIONAL

[WIRE] - this section defines the wire diameter. OPTIONAL

[FIDUCIALS] - This section describes the location of the fiducials and defines their shape and location. OPTIONAL

[DIE_LOGO] Used to place a die logo or id on the die. It is a polygon or series of polygons that can be used to form text, or other shapes used to identify the die. OPTIONAL

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[DATABASE]

This section is REQUIRED and must be the first section to appear in the AIF file. It is used to identify the file as AIF and to identify the version of the file. This section also contains the units of all geometric data that follows.

```
[DATBASE]
TYPE=AIF
VERSION=2.0
UNITS=UM
```

This section identifies the file as an AIF file so that a parser can quickly know the file type and version. The units are specified here - um | mm | cm | inch | mil All coordinates and geometry that follows are in these units.

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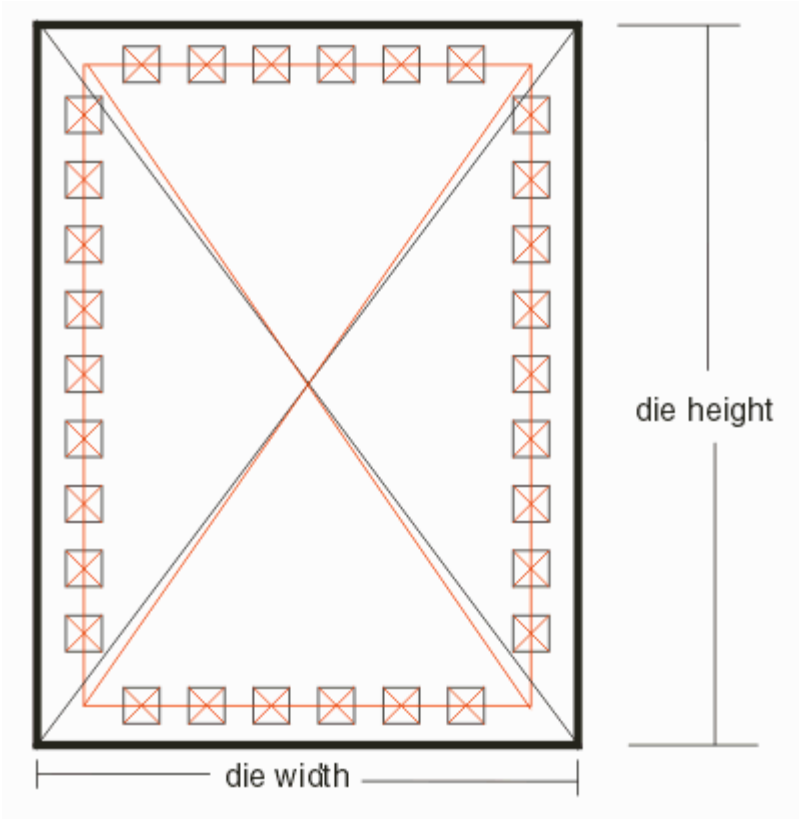
[DIE]

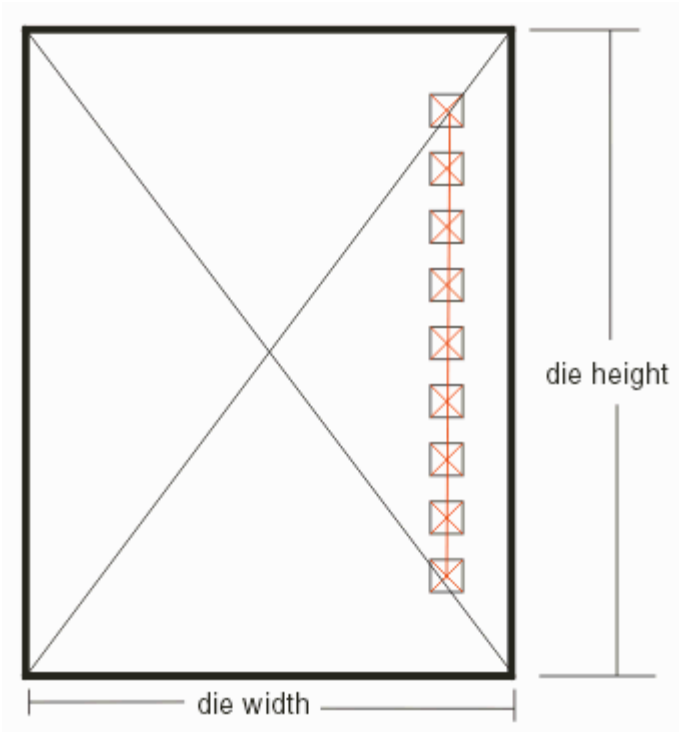
The die section is used to describe the "name" of the die along with the height, width and center location of the die outline. The acutal die pad openings and coordinates are described in the netlist section.

```
[DIE]
WIDTH=9220.20
HEIGHT=11226.8
NAME=DIE1G
CENTER=0 0
```

The CENTER keyword and values are optional. If CENTER is not used, the AIF reader will calculate the center by calculating the extents of the die pad centers and using the center of the die pad extents. This approach works well for digital die where the pads are symmetric around the center but it fails for certain types of pad arrangements -- hence the ability to specify the center if needed.

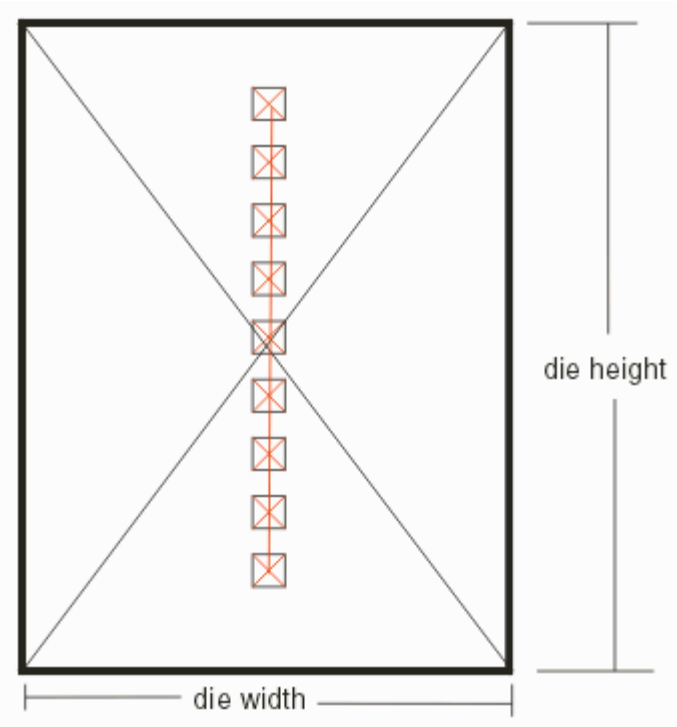
For a die with symmetrically arranged pads no CENTER is needed as the calculated center and the desired center are the same.





Consider this memory chip die with only one row of pads on the right side of the die. If the CENTER parameter for the outline is not specified then you won't get this relationship between the outline and the die pads. Instead you will get something in the illustration below.

Here is what you will see if the CENTER parameter is not provided. The program



will line up the center of the outline with the center of the die pad extents.

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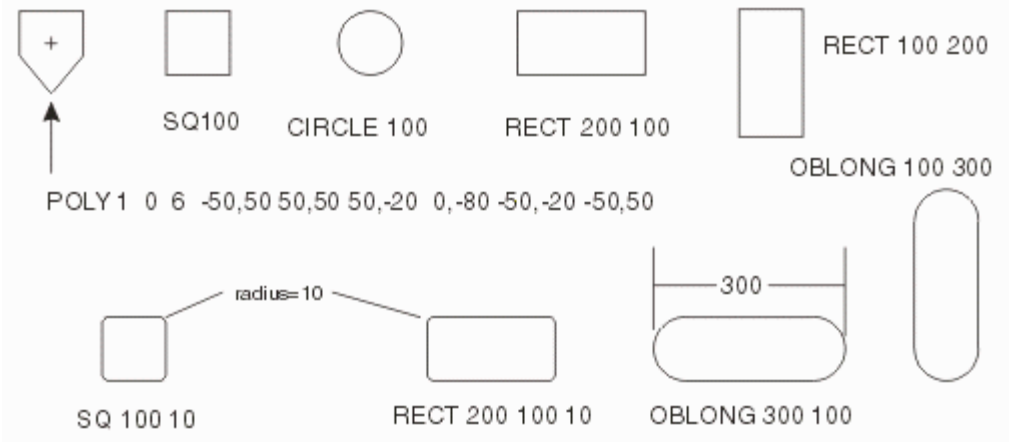
[PADS]

The PADS section defines pads needed for the die pads and package fingers and balls. Pads can have any of the following shape types:

- Square [fillet]
- Rectangular [fillet]
- Oblong
- Circular
- Polygon



The pad insertion point is always defined as the center of the pad. In the case of the polygon, all polygon coordinates are relative to the center at 0,0.

Pad Name Syntax

Pad names should start with a character. No spaces are allowed and avoid special characters except for:

_ - ( ) .

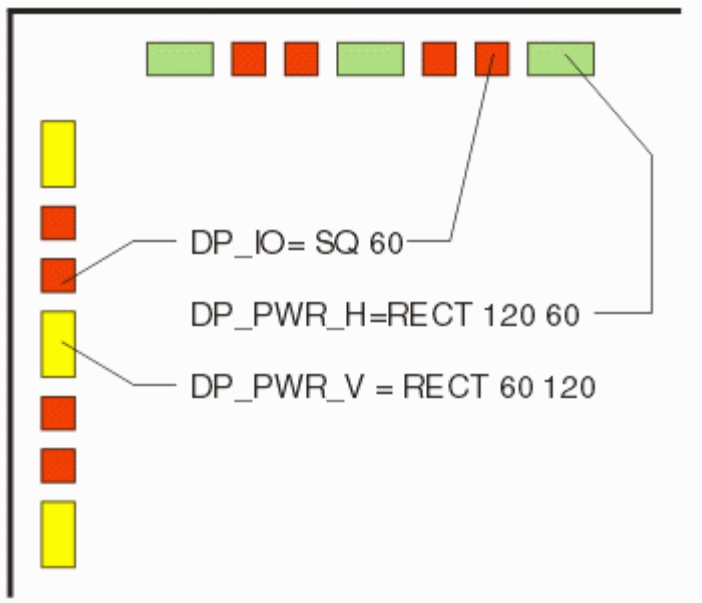
We recommend that the pad names be representative of the type of pad; for example die pads might be named dp_io, dp_vcc (if the vcc pad were say wider) and bond fingers might be named bf500x110. Pads representing the lands could be prefixed with land or ball. Sometimes the size is included in the name such as: dp_sq80um.

```
BALL=CIRCLE 770          or   BALL=ROUND 770
BF=OBLONG 100 300        or   BF=OBROUND 100 300
BF2=RECTANGLE 350 120 10 or   BF2=RECT 350 120 10
DP100 =SQUARE 100        or   DP100=SQ 100

DPOCT=POLY -38.27,92.39     38.27,92.39     (line breaks for clarity)
            92.39,38.27     92.39,-38.27
            38.27,-92.39   -38.27,-92.39
           -92.39, -38.27  -92.39,38.27
           -38.27,92.39
```

Die Pad Rotation

If you examine the netlist section, you will see that only bond fingers can be placed with rotation; die pads do not rotate. Hence, if your die pads are not symmetric you may need to define two separate pad stacks as shown in the illustration at right.



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[NETLIST]

The NETLIST section is the "heart" of the AIF file and defines each circuit net and associated pad, finger and ball. The netlist can be very simple or complex depending on whether you are describing only a die or a complete package shell. The coordinate data enables an AIF II reader to actually draw the package layout. It is also useful when developing test and manufacturing tools - for example the coordinates of the finger centers and ball centers directly supports probe station programming.

Placeholder - If a particular column item is not present or not known the dash (-) should be used as a place holder since the parser counts the number of entities per line to determine the context of the data.

Delimiter - Data items can be delimited by one or more spaces or a tab. Do not use commas or colons.

Comments - The semicolon (;) indicates a comment. Anything after a semicolon is ignored. Good practice demands that at the top of the netlist a commented line indicates the heading of each column.

Example - Simple Die Pad

```
;NETNAME    PAD#     TYPE     PAD_X      PAD_Y
   net23     23       DP60    -4493.5    -3325
```

This is the simplest case where a die designer may not even know the netname. Use an arbitrary netname such as net23. Each die pad should have a number, a padstack reference and x,y center coordinates. It is preferable if the true signal name is known -- the package designer will be able to automatically derive a netlist if this is done.

Example 2 Die with Ball Assignment

Very often a device designer will know which die pad (i.e. which signal) must go to which ball pad based on system design and requirements. This information is required

by the package designer. In such a case one can specify in column 6 the ball assignment. If no assignment put a dash as a place holder.

```
;NETNAME    PAD#     TYPE     PAD_X      PAD_Y    Ball
   net23     23       DP60    -4493.5    -3325     A6
   vss       24       DP60    -4593.5    -3325     -
   .
   .
   .
   vss        -        -        -          -       A1
   vss        -        -        -          -       A15
```

Example 3 Die Pad attached to a Ring

In thisexample die pad 166 is a ground net (VSS) located at -4493.5,-3325 is connected to ring2 at coordinates -5276.97 ,-3736.26. Note that no ball information is included for a net such as VSS because there would be a list of 15 to 20 balls all attached to ground. Instead the balls belonging to VSS should be listed further down in the netlist section. Note: some design tools use a "dummy" via to attach the wire to the ring.

```
;NETNAME    PAD#     TYPE     PAD_X     PAD_Y     BALL#     TYPE
BALL_X     BALL_Y
   VSS      166      DP60    -4493.5    -3325      -          -
-          -

 FIN#     FIN/RING        X             Y          ANGLE
   -         R2       -5276.97       -3736.26        -
```

Balls Attached to Power and Ground Nets or NoConnect

The VSS,VCC and NC nets normally attach to many balls; listing each one for each die pad would be very inefficient. Instead, balls attached to power and ground nets should be segregated at the end of the netlist section for readablity (although the parser doesn't care where they occur in the netlist.)

```
VSS      -      -      -      -      AF3     BP750    -13335     -
```

```
15875
VSS     -     -     -     -     AD1    BP750   -15875    -
13335
VSS     -     -     -     -     AC3    BP750   -13335    -
12065
VSS     -     -     -     -     AA2    BP750   -14605    -
9525
VTERM   -     -     -     -     AD4    BP750   -12065    -
13335
VTERM   -     -     -     -     AA4    BP750   -12065    -
9525
VDD     -     -     -     -      H6    BP750   -9525
6985
VDD     -     -     -     -      J6    BP750   -9525
5715
```

Your netlist should include all balls - even if they are no connect. Our AIF reader uses the range of balls to determine package size, population, depopulation and repopulation. For tools such as AIF translators you must list all balls or the symbols/library element for the BGA will be incomplete.

Ball coordinates need not be specified. It is possible to use the [BGA] section to define the package outline, ball diameter and pitch - the AIF reader can then use that information to place the ball correctly.

Common Netlist Errors

Netnames - may not have any spaces and should not use special characters other than "_" underscore, "-" dash, and "/" slash. Some target systems may have stricter rules than the AIF parser.

Missing Padstack Definitions

Any padstack referenced in the netlist must have a definition in the PADS section.

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[RINGS]

The RINGS section is used to describe metal on the bonding layer. We call it RINGS but in fact it can be used to define any metal on the bonding layer and even non-metal geometries. Generally, the RINGS section is not "hand" created from a spreadsheet but generated by a CAD translation or extraction program.

Basic Syntax

```
[RINGS]
NAME NET_NAME NUMBER_OF_POLYGONS WIDTH NUM_OF_VERTICES
X,Y
X,Y
X,Y
NUM_OF_VERTICES
X,Y
X,Y
X,Y
```

NAME - each ring entity must be assigned a name. No special use is made of names by the AIF parser but a user could make special use of the name.

NET_NAME - assuming the ring is a conductor, it should have a valid net name. If a ring is "not" a conductor, then some sort of placeholder name should be used i.e. DUMMY.

NUMBER_OF_POLYGONS - If this piece of the ring is a simple closed region it will consist of one polygon. However if it contains "cutouts" then there might be more than one polygon.

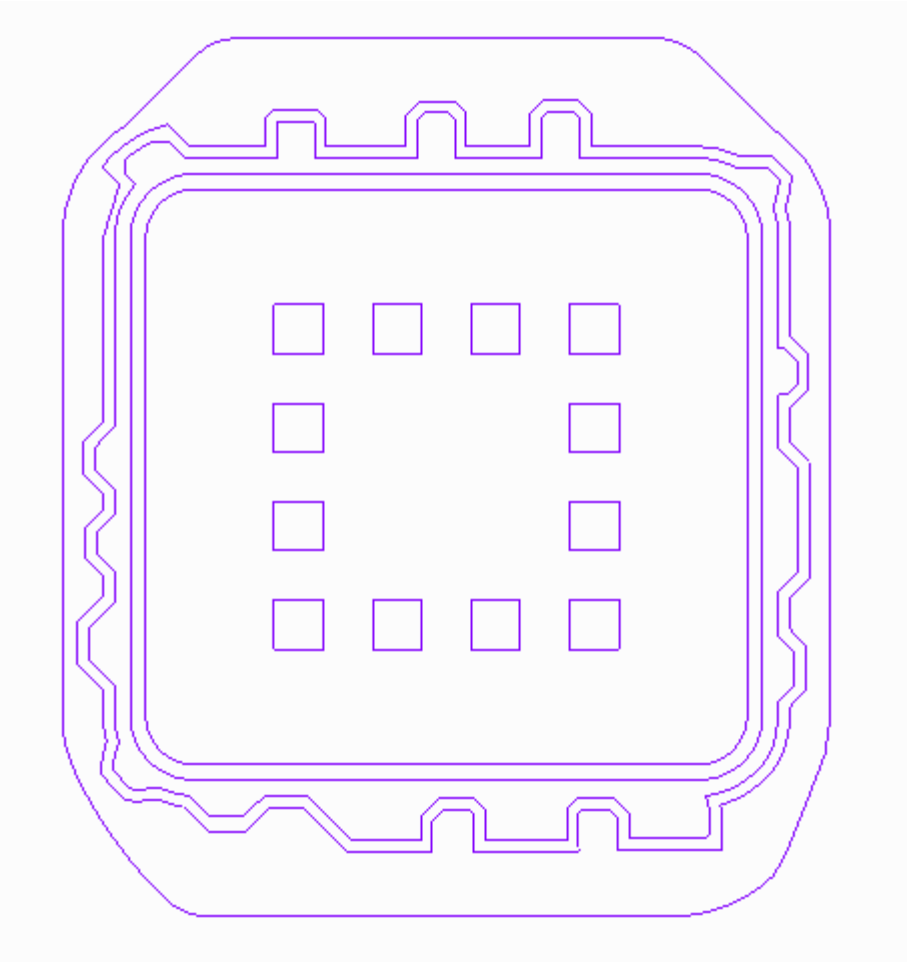
WIDTH - for a region the width = 0. However one could represent a trace using a finite width.

NUM_OF_VERTICES - the number of vertices (for this polygon) to follow. This makes life simpler for a parser. Note: if the number of vertices is expressed as a negative number, i.e. -25, this tells the parser that this is a cutout polygon and should be treated appropriately.

X,Y - coordinates of a vertex. There are no arcs in the RING definition. It is not necessary to limit a

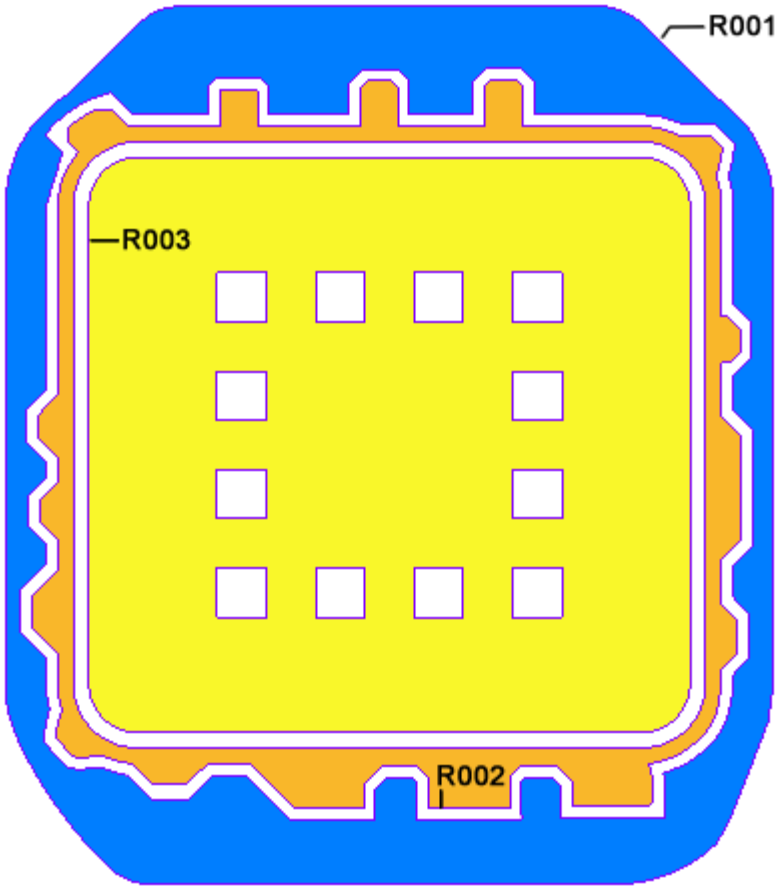
single pair of vertices per line but it makes the file more readable to do so.

Multiple Rings with Cutouts



This example shows a fairly complicated ring design for a large BGA. There are three rings - the outer VSS2, the middle VDD and the inner VSS1 ring. The outer ring is built from two polygons - the parent and a single cutout as is the middle ring. The inner ring is built from 13 polys - one outer and 12 cutouts. This is easier to see when the rings are colored below:

Notice that ring R003 has multiple square cutouts.



Here are some fragments of the RING definition that generates these figures:

```
[RINGS]
R001 VSS2 2 0 77            <-- ring R001; net VSS2 with 2 polygons
4830.460000, -3717.840000   <-- vertices for outer ring
4463.680000, -4654.470000
4389.530511, -4826.829327

4830.460000, -3717.840000
-228                         <-- 228 vertices in cutout polygon
-3726.610000, -4162.070000
-4011.950000, -4193.390000

-3716.880000, -4166.280000
-3726.610000, -4162.070000  <-- last vertex in cutout end of R001
R002 VDD 2 0 203            <-- ring R002; net VDD 2 polygons
3417.410000, -4105.660000   <-- vertices for outer part
3344.260000, -4126.180000
```

```
3417.410000, -4105.640000
3417.410000, -4105.660000
-49                          <-- cutout has 49 vertices
3247.840000, -3913.500000
-3247.840000, -3913.500000
R003 VSS1 13 0 41           <-- ring R003; net VSS1 13 polygons
-3247.840000, -3713.400000
-3357.238352, -3703.828884

-5                           <-- note square has 5 vertices
-2222.500000, 1587.500000
-1587.500000, 1587.500000
-1587.500000, 2222.500000
-2222.500000, 2222.500000
-2222.500000, 1587.500000   <-- last & first vertex are same
```

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[BONDABLE_RING_AREA]

The BONDABLE_RING_AREA section is used to describe metal on the top layer that is exposed by the solder mask. The UPD software (Sigrity) generates this data.

Basic Syntax

```
[BONDABLE_RING_AREA]
LAYER_NAME NET_NAME NUMBER_OF_POLYS WIDTH_OF_EDGE NUM_OF_VERTICES
X,Y
X,Y
X,Y
NUM_OF_VERTICES
X,Y
X,Y
X,Y
```

LAYER_NAME - each ring entity must be assigned to a layer name. The Bondgen parser will use this name to generate a layer name in AutoCAD for this polygon.

NET_NAME - assuming the ring is a conductor, it should have a valid net name. If a ring is "not" a conductor, then some sort of placeholder name should be used i.e. DUMMY.

NUMBER_OF_POLYGONS - If this piece of the ring is a simple closed region it will consist of one polygon. However if it contains "cutouts" then there might be more than one polygon.

WIDTH - for a region the width = 0. However one could represent a trace using a finite width.

NUM_OF_VERTICES - the number of vertices (for this polygon) to follow. This makes life simpler for a parser. Note: if the number of vertices is expressed as a negative number, i.e. -25, this tells the parser that this is a cutout polygon and should be treated appropriately.

X,Y - coordinates of a vertex. There are no arcs in the RING definition. It is not necessary to limit a single pair of vertices per line but it makes the file more readable to do so.

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[BGA]

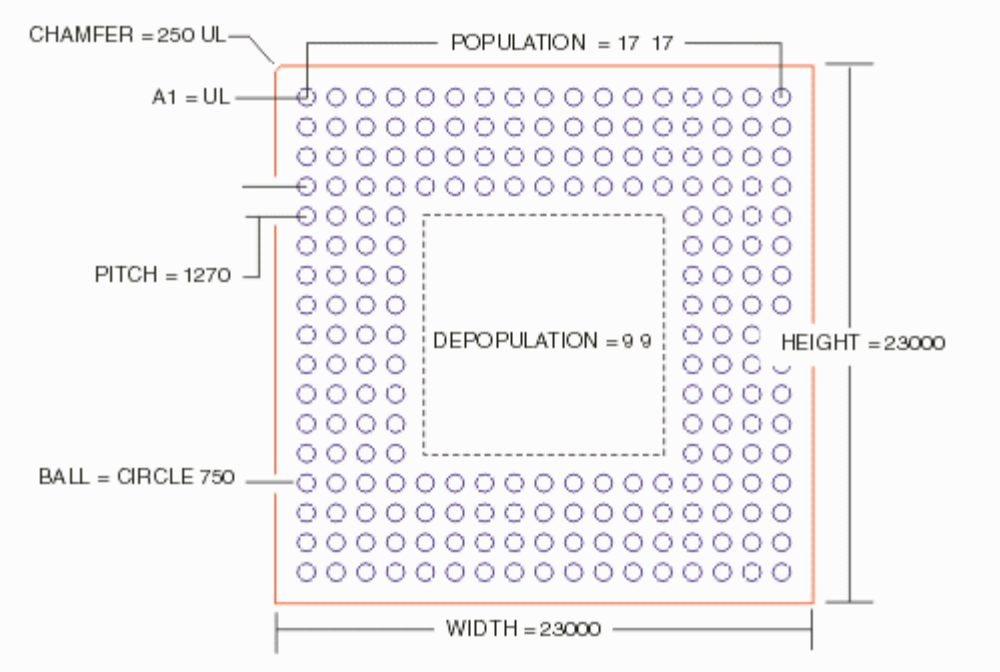
This section allows the user to define parameters of the BGA package; the AIF reader will be able to draw the ball pads and package outline.

Many times a die designer will know the signal name and even the ball assignment for his die pads but does not have the "coordinates" of the ball pads. However often he needs to explore different package options - package size, pitch, ball diameter ...

the [BGA] section in the AIF file allows him to quickly define a package from well known parameters; AIFVU will then draw the package footprint along with the die. This allows the die designer both to see the die together with the package and also to see a ratsnest from die pad to ball pad (assuming nets have been defined.)

Syntax

```
[BGA]
NAME=BGA                    name (ref designator)
WIDTH=23000                 package outline width in same units
as  AIF file
HEIGHT=23000                package outline height (y)
PITCH=1270                  center-center spacing between ball
pads
CHAMFER=UR 250              chamfer on the outline. You can
specify all 4 corners
POPULATION= 17 17           number of balls along x and y
DEPOPULATION= 9 9           remove this many balls in the
interior
REPOPULATION= 0 0           add back in this many balls
(typically ground)
BALL=CIRCLE 750             ball pad shape and size
A1=UL                        location of A1 (looking from above
the package)
```



Notes:

If population is even; depopulation and repopulation should be even. If population is odd, depopulation and repopulation should be odd.

rectangular packages are supported - but pitch must be equal in both directions.

the package outline can have up to four chamfers - UR 1000 LL 500 UL 250 LR 600

New BGA Polygonal Outline

[added 04/26/04]

In order to support more complicated packages (in this case a module containing two chips with an irregular outline) we have added a new parameter to the BGA section called:

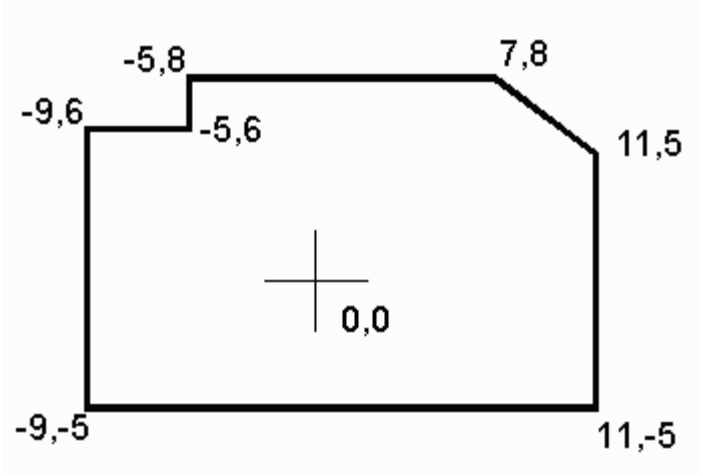
OUTLINE=POLYGON

with the following syntax:

```
OUTLINE=POLYGON <num_pgons> <width> <num_pts> x0 y0 x1 y1 ...
```

xn yn

Example




```
[BGA]
OUTLINE=POLYGON  1  0.1  7   -9 -5  11 -5  11 5  7 8  -5 8  -
5 6  -9 6
```

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[WIRE]

The WIRE section is used to define the diameter of the wires. Note that wires are automatically generated anytime in the netlist that there is a die and either a bond finger or ring attach defined.

Basic Syntax

```
[WIRE]
DIAMETER=20
```

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[FIDUCIALS]

The FIDUCIALS section is intended to allow a user to define geometries for aligning the package with equipment that processes it -- these alignment targets are known as fiducials.

Basic Syntax

```
[FIDUCIAL]
NAME=X,Y  SQUARE  DIMENSION
NAME=X,Y  POLYGON NUM_OF_POLYS WIDTH NUM_OF_VERTICES X,Y X,Y ...
```

NAME - A user defined name for the fiducial. No spaces or special characters.

X,Y - The center coordinates or reference point (if a polygon this point acts as the reference for the vertices that follow.)

SQUARE - If the fiducial is a simple square shape use the keyword square.

DIMENSION - for a square fiducial, this is the length of an edge.

POLYGON - more complex fiducials can be described using the polygon format.

NUM_OF_POLYGONS - the number of polygons that comprise this fiducial. Generally if more than one, the additional polygons are cutouts.

WIDTH - for a polygon, the width of the edge. Normally = 0.

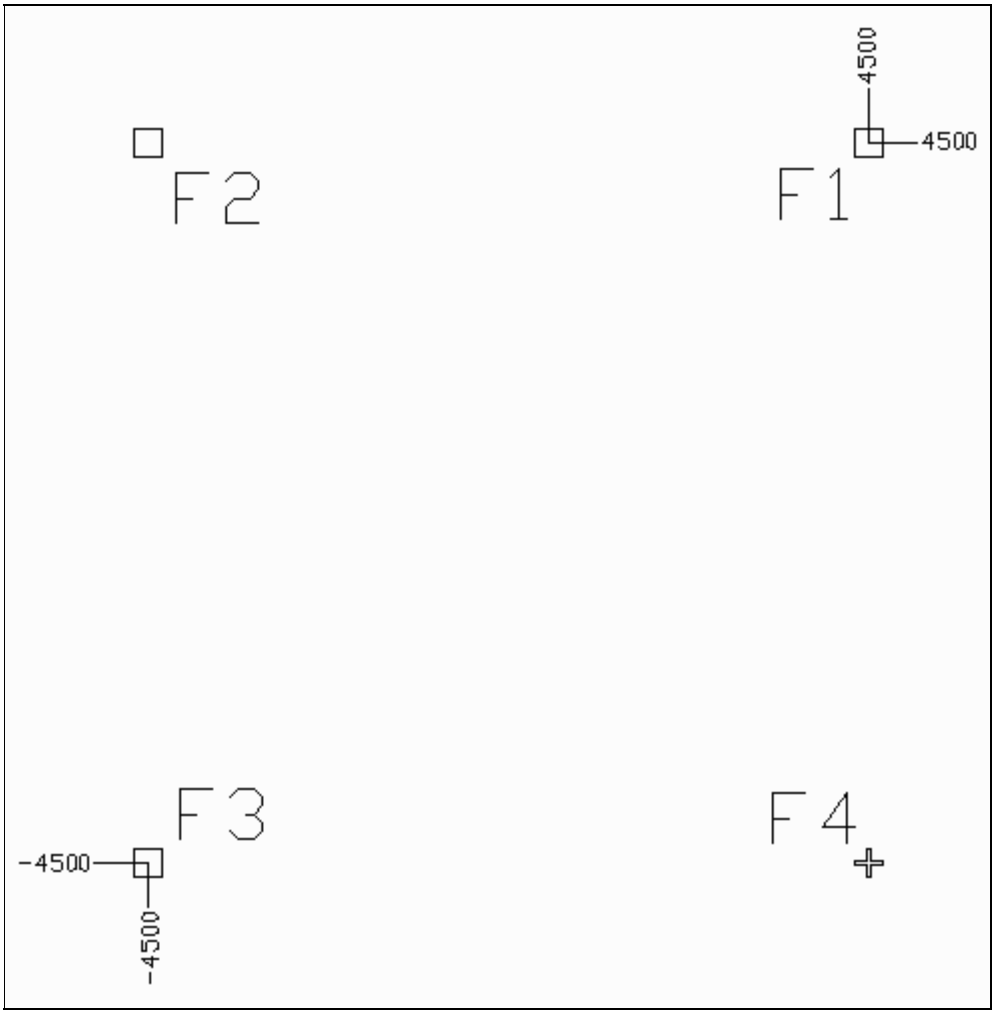
NUM_OF_VERTICES - the number of vertices to follow. (Note, first and last vertex must be explicitly stated so a "square" has 5 vertices.) If this number is negative, it indicates that the polygon is a "cutout."

X,Y - for a polygon the vertex coordinates are with respect to the reference coordinate - they are not absolute. Also the first vertex must be the same as the last to close the polygon.

Examples

The following fiducial data produces the image shown below:

```
F1=4500,4500 SQUARE 350
F2=-4500,4500 SQUARE 350
F3=-4500,-4500 SQUARE 350
F4=4500,-4500 POLYGON 1 0 13
25,25 175,25 175,-25
25,-25 25,-175 -25,-175
-25,-25 -175,-25 -175,25
-25,25 -25,175 25,175
25,25
```



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[DIE_LOGO]

The DIE_LOGO section is intended to allow designers to place within the die region small geometries that represent logos or alignment marks.

Logo Using Polygons as Text

```
[DIE_LOGO]
POLY NUM_OF_POLYS WIDTH NUM_OF_VERTICES X,Y X,Y ...
```

POLY - polygon used to define the die logo geometry.

NUM_OF_POLYGONS - the number of polygons that comprise this logo. Generally if more than one, the additional polygons are cutouts.

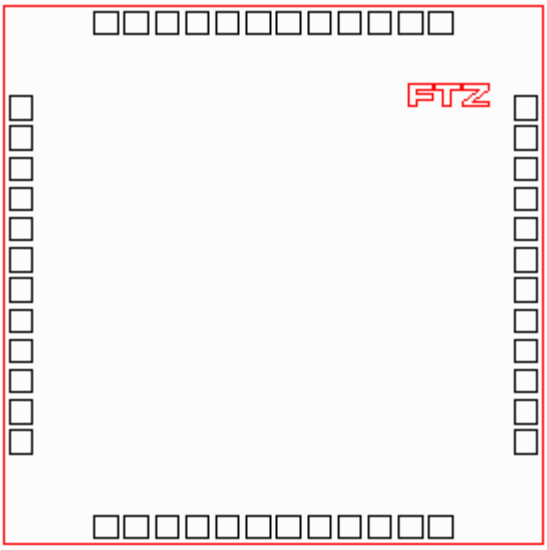
WIDTH - for a polygon, the width of the edge. Normally = 0.

NUM_OF_VERTICES - the number of vertices to follow. (Note, first and last vertex must be explicitly stated so a "square" has 5 vertices.) If this number is negative, it indicates that the polygon is a "cutout."

X,Y - for a polygon the vertex coordinates are with respect to the reference coordinate - they are not absolute. Also the first vertex must be the same as the last to close the polygon.

Example - Die Logo

Here is an example of a die logo.




```
[DIE_LOGO]
POLY 1 0.0000 12
623.1729,620.8145 623.1729,608.7412 674.2950,608.8473
622.1165,570.0706
622.1165,553.5322 711.2072,553.5322 711.2072,571.1263
656.6259,571.1263
710.1508,608.7764 710.1508,625.6891 623.1729,625.6849
623.1729,620.8145
POLY 1 0.0000 10
528.7961,625.6678 528.7961,608.7146 559.4320,608.7681
559.4320,553.8841
582.6731,553.8841 582.6731,608.7669 614.7176,608.7412
614.6827,625.6800
529.5004,625.6679 528.7961,625.6678
POLY 1 0.0000 12
446.4937,553.8841 446.4937,625.6678 520.7947,625.6678
520.7947,608.7775
469.0305,608.7775 469.0305,594.3504 520.4426,594.3504
520.4426,578.5158
469.0305,578.5158 469.0305,553.5322 446.4937,553.5322
446.4937,553.8841
```

Logo Using a Text String

It is also possible to use a string of text to stand in for the die logo. The syntax is shown below:

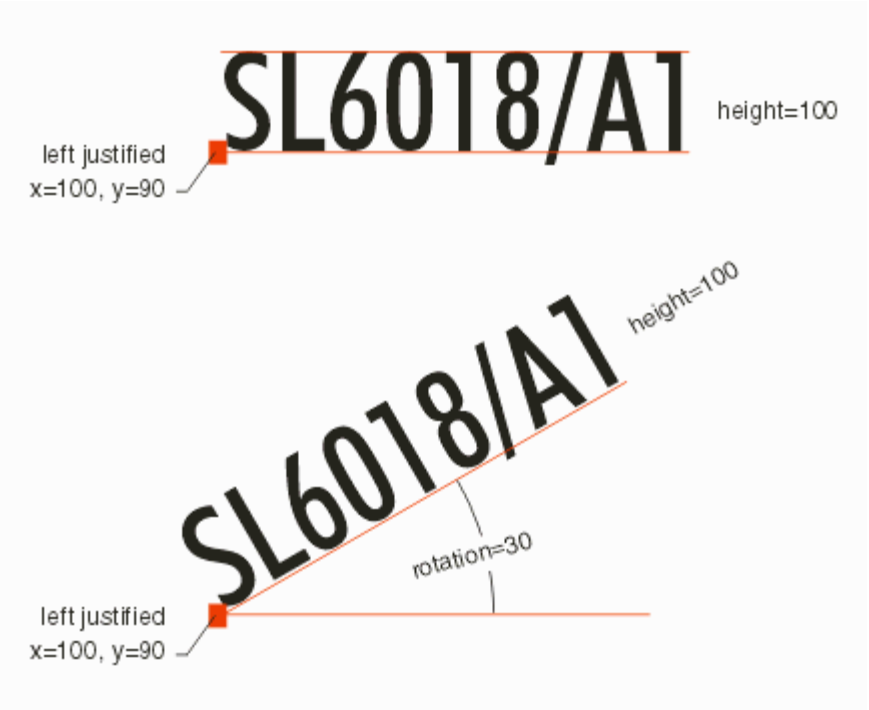
```
[DIE_LOGO]
TEXT x,y height rotation justification string
```

x,y - text insertion coordinates

height - height of the text.

rotation - Rotation of the text (CCW from horizontal)

justification - L|C|R - Justification of



the text (Left, Right, Center).

text_string - The string of text.

Example

```
[DIE_LOGO]
TEXT 100,90 100 0 L SL6018/A1
```

In this example, the string of text is "SL6018/A1", and it is inserted at 100,90 with a height of 100, 0 rotation and Left justified. The actual font will depend on the system that is reading the string of text.

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