Introduction

A key advantage of designing with programmable logic is the flexibility which allows designers to quickly modify or add features to a design. When modifying a design, it is often necessary to move to a larger or smaller device. Altera® FLEX® and MAX® devices offer vertical migration, which allows designers to use different devices in the same packages. The Altera SameFrame™ pin-out feature with FineLine™ ball-grid array (BGA) extends the flexibility of vertical migration across different packages as well as different devices.

SameFrame pin-out refers to the arrangement of balls on FineLine BGA packages, which offers maximum design flexibility and ease of use by providing both vertical and cross-package migration on the same printed circuit board (PCB).

This application note covers the following topics:

- Pin-out migration
- SameFrame benefits
- SameFrame flexibility
- SameFrame pin-out
- Software support

Pin-Out Migration

Pin-out migration, available in Altera’s FLEX and MAX devices, allows you to move designs from one device to another without changing your PCB layout. This flexibility enhances both ease-of-use and time-to-market.

Vertical Migration

Vertical migration is the ability to move a design from one member of a device family to a different member of the same device family in the same package. Pin assignments remain the same even while adding or reducing the number of logic cells. This prototyping flexibility reduces PCB layout time and allows you to plan for future design requirements without re-engineering PCBs. Table 1 shows examples of vertical migration.
Note:
(1) Packages include plastic quad flat pack (PQFP), thin quad flat pack (TQFP), and ball-grid array (BGA).

For example, if a design uses an EPF10K50E device, you could increase the number of logic cells without changing the board design by using either an EPF10K100E or an EPF10K130E device.

Vertical migration is possible only for similar packages within each device family. If design requirements exceed the logic cell count available in a given device, or if the design requires more pins, the board must be redesigned for a different package and pin-out.

Cross-Package Migration with SameFrame Pin-Outs

Until now, vertical migration has been the only pin-out migration capability offered by PLD vendors. The SameFrame capability in Altera’s FineLine BGA packages gives you the ability to migrate between packages with different densities and ball counts. Rather than being restricted to vertical migration for a subset of devices, you can use the SameFrame pin-out feature to migrate across an entire family of devices. This flexibility provides you with many ways to reduce development time and costs.

Table 1. Vertical Migration

<table>
<thead>
<tr>
<th></th>
<th>FLEX 6000</th>
<th>FLEX 10KE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX 7000A</td>
<td>144-Pin TQFP</td>
<td>356-Pin BGA</td>
</tr>
<tr>
<td>100-Pin TQFP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPM7064AE</td>
<td>EPF6010A</td>
<td>EPF10K50E</td>
</tr>
<tr>
<td>EPM7128AE</td>
<td>EPF6016</td>
<td>EPF10K50S</td>
</tr>
<tr>
<td>EPM7256AE</td>
<td>EPF6016A</td>
<td>EPF10K100E</td>
</tr>
<tr>
<td></td>
<td>EPF6024A</td>
<td>EPF10K130E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EPF10K200S</td>
</tr>
</tbody>
</table>

Note:
(1) Packages include plastic quad flat pack (PQFP), thin quad flat pack (TQFP), and ball-grid array (BGA).

The SameFrame feature gives you more flexibility than vertical migration when designing PCBs. This feature lets you use more I/O pins, change device density, reduce design times, and cut costs.

Because the SameFrame feature allows a single PCB layout to support multiple device density/package combinations, the board layout can be designed prior to final device selection. This lets you focus on design functionality rather than on fitting a design in a particular device or package.

The SameFrame feature allows you to use a large device for prototyping and then migrate to a smaller, lower density, lower-cost device for volume production. You can start a design in a currently available device and migrate to smaller devices as they become available.
You can also use higher I/O ball-count packages to monitor test signals during prototyping, and then migrate to a smaller and less expensive package for production. Another technique for monitoring internal signals is the SignalTap™ embedded logic analyzer. These signals can be read out of the device and monitored with the Quartus™ software. You can use the SameFrame pin-out to temporarily test a design in a larger device with more embedded system blocks (ESBs), allowing you to monitor more internal signals.

For increased flexibility, you can design a PCB for a package that supports the maximum number of I/O pins that the design may need. With the flexibility to move up or down within this footprint, you can migrate from a smaller package to a larger package or vice-versa. Using SameFrame pin-out does not require more board space than vertical migration; to plan for vertical migration, you would have to lay out a board for a larger package to accommodate the larger device you may migrate to, even if the smaller starting device is available in a smaller package.

Figure 1 shows the layout for SameFrame device packages.

**Figure 1. SameFrame Layout**

Figure 2 illustrates cross-package migration using 100-pin and 256-pin FineLine BGA packages.
For packages that support SameFrame pin-out, the ball layout is such that the smaller ball-count packages form a footprint-compatible subset of the larger packages. By designing the board for the largest ball count, you maintain the flexibility to choose from any device density or FineLine BGA ball count before the design is finalized (see Figure 3).

**Figure 3. SameFrame Ball Layout**

Note:
(1) This figure is for reference only. Actual placement of I/O pins may vary.
In Figure 3, VCC and GND (black) are common to all FineLine BGA packages. I/O and configuration pins (white) are used for packages with 100 or more balls and are also common to all devices with the SameFrame feature. Additional VCC and GND (grey) and I/O pins (blue) are placed on the perimeter and are used in device packages with more than 100 pins.

With higher ball-count packages, more power and ground pins are present. The grey balls, shown in each corner of Figure 3, are extra power and ground balls associated with the 256-pin FineLine BGA feature. The extra power and ground balls are shown at the corners of Figure 3 for ease of representation; in an actual device, they are spread throughout the package. The blue balls are the additional I/O pins associated with the 256-pin FineLine BGA. The 100-pin FineLine BGA forms a subset of the 256-pin FineLine BGA. The 484-pin and 672-pin FineLine BGA packages are constructed similarly to allow lower pin-count packages to form subsets of larger pin count packages.

For example, a PCB designed for a 672-pin FineLine BGA package can accept either a 484-pin or 256-pin FineLine BGA package without requiring a board redesign. This flexibility is possible because the layout of the lower-ball count packages are included in the layout of the higher-ball count packages.

Table 2 shows the migration options for the FLEX device family. For example, if you design a PCB for FLEX 10KE devices, you could easily retarget your design from the 484-pin EPF10K50E device to the 256-pin EPF10K30A device or vice versa.
Table 2. Migration Options for FLEX 10K Device Family

<table>
<thead>
<tr>
<th>Devices</th>
<th>256-Pin FineLine BGA</th>
<th>484-Pin FineLine BGA</th>
<th>672-Pin FineLine BGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPF10K10A</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPF10K30A</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>EPF10K50A</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>EPF10K100A</td>
<td></td>
<td></td>
<td>✓ (2)</td>
</tr>
<tr>
<td>EPF10K30E</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>EPF10K50E</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>EPF10K50S</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPF10K100E</td>
<td>✓ (2)</td>
<td>✓ (2)</td>
<td></td>
</tr>
<tr>
<td>EPF10K100B</td>
<td>✓ (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPF10K130E</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>EPF10K200E</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>EPF10K200S</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

(1) FLEX 10KA and FLEX 10KE devices operate at different voltage levels. PCB design may vary to accommodate the voltage difference.

(2) For the EPF10K100A, EPF10K100B, and EPF10K100E devices in 256- and 484-pin packages, the I/O pins remain I/O pins with package migration but may route to different pads on the die. For example, row pins may become column pins. This routing change has little effect on fitting, but may cause timing differences from one package to another.

Due to the small die size made possible by advanced processes, some FLEX 10KE devices have fewer I/O pins than the equivalent FLEX 10KA devices. Therefore, you should avoid using these pins when designing for FLEX 10KA devices if you expect to migrate your design to FLEX 10KE devices in the future (see Table 3). Altera design software can help you automatically avoid these pins when compiling a design.

Table 3. Devices with Fewer I/O Pins

<table>
<thead>
<tr>
<th>FLEX 10KE Devices</th>
<th>Fewer I/O Pins</th>
<th>FLEX 10KA Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPF10K30EF256</td>
<td>15</td>
<td>EPF10K30AF256</td>
</tr>
<tr>
<td>EPF10K30EF484</td>
<td>26</td>
<td>EPF10K30AF484</td>
</tr>
<tr>
<td>EPF10K100EF484</td>
<td>31</td>
<td>EPF10K100AF484</td>
</tr>
<tr>
<td>EPF10K50EF484</td>
<td>37</td>
<td>EPF10K50VF484</td>
</tr>
</tbody>
</table>
Table 4 shows the migration options for the FLEX 6000 device family.

<table>
<thead>
<tr>
<th>Devices</th>
<th>100-pin FineLine BGA</th>
<th>256-pin FineLine BGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPF6010A</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EPF6016A</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EPF6024A</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 5 shows the migration options for the MAX 7000A device family.

<table>
<thead>
<tr>
<th>Devices</th>
<th>100-pin FineLine BGA</th>
<th>256-pin FineLine BGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPM7064AE</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EMP7128B</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EPM7128AE</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EPM7256B</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EPM7256AE</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EPM7512B</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EPM7512AE</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Compatibility within SameFrame Devices

An important feature of SameFrame pin-out is that pin mapping is consistent within the same family. Specifically, a given pin is corrected to the same routing channel or macrocell in different packages of the same device. Fitting and performance is not affected from one package to another.

Figure 4 shows an example of compatibility within the same device family using different packages. Common pins have the same routing path, although the pin number varies with different packages.
The Quartus and MAX+PLUS® II software support SameFrame pin-out designs and are identical in their functionality. The Quartus and MAX+PLUS II software allows designers to:

- Migrate from one device to another (pin reservations)
- Translate pins for SameFrame pin-out upon migration
- Generate a Pin-Out file (.pin) for migration

For more information on Quartus SameFrame support, contact Altera Applications at (800) 800-EPLD or visit the Altera web site at http://www.altera.com.

Device Migration Using the MAX+PLUS II Software

For vertical and cross-package migration, you can enter the future migration device or devices in the MAX+PLUS II software. To migrate from one device to another, perform the following steps:

1. Choose Device (Assign Menu). The Device dialog box appears (see Figure 5).

2. Select the appropriate device information in the Devices and Device family drop-down list box.

   You cannot select a migration device if Auto is chosen in the Devices drop-down list box.
Figure 5. Device Option Dialog Box

3. Click on Migration Device. The Migration Device Selection dialog box appears (see Figure 6).

Figure 6. Migration Device Selection Dialog Box

When the Migration Device Selection dialog box appears, the current device is always listed as a selected device and cannot be deleted.
The Migration Device Selection dialog box indicates the devices and packages that are compatible with the selected device. You can choose any device in the Compatible Devices list for migration and then add it to the Selected Devices list. Devices are compatible if they have the same ball spacing and are SameFrame compatible. The die must be from or compatible with the same device family.

4. Select the device(s) you wish to migrate to under the Compatible Devices list.

5. Click the Arrow button to move the highlighted device(s) to the Selected Devices list.

6. Click OK to save your changes.

If the device you are migrating to has changed, and it is in the same family as the old device, you have the option to keep the previous migration list. A box appears with the following options: Keep, Delete, or Cancel the device assignment.

The MAX+PLUS II Compiler sends error messages for conflicting or missing pin assignments. For example, if you migrate from an EPM7512AEQC208 device with 176 I/O pins to an EPM7256AEQC208 device with 164 I/O pins, the compiler will send an error message and designate the extra EPM7512AE I/O pins as no-connect pins.

Pin Translation

Pin assignments must be translated when changing packages or density. If a new device has a different BGA grid size than a previous device, the MAX+PLUS II software translates the pins and converts the pin assignments from the old device to match the new device. If a corresponding pin is illegal (e.g., pin A1 on the larger device does not exist on the smaller device), the MAX+PLUS II software gives an error message. The MAX+PLUS II software also checks for no-connect pins on the new device. If any pin assignments exist, an error message appears.

If the device is SameFrame compatible and has the same BGA grid size, the MAX+PLUS II software checks to see if the pin assignments are legal without performing pin translation.

When the MAX+PLUS II software performs a pin translation in a device in which the package and density are the same as the old device, the pad assignments remain constant, and the fitting and performance are not affected except in devices with fewer I/O pins and different voltages.
Figure 7 shows an example of pin translation from the EPM7128AEFC100 device to the EPM7256AEFC256 device.

**Figure 7. Pin Translation Example**

Pin Translated
Automatically from A1 to D4

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**Pin-Out File**

A Pin file is generated by the MAX+PLUS II software after successful compilation. This file contains all pin assignments. Third-party tools can use this file to automatically generate a symbol for the Altera device during PCB layout.

Figure 8 shows a sample PIN file.
Figure 8. Sample PIN File

N.C. = Not Connected
VCCINT = Dedicated power pin, which MUST be connected to VCC.
VCCIO = Dedicated power pin, which MUST be connected to VCC.
GND = Dedicated ground pin or unused dedicated input, which MUST be connected to GND.
RESERVED = Unused I/O pin, which MUST be left unconnected.
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CHIP interface Assigned to an EPM7128AEF100-5

TDI : A1
Data0 : A2
Data1 : A3
Data2 : A4
GND : A5
Clk : A6
...

Figure 9 shows the Migration Device Selection dialog box. The Base the Pin-Out File on Largest SameFrame Device option allows you to choose which device the files are based on. Checking this option in the Migration Device Selection dialog box generates the files for the largest compatible SameFrame device, even if the device you are using is smaller in density or ball count. If the Base the Pin-Out File on Largest SameFrame Device option is unchecked, then the software will generate a file based on the device you are currently using. The PIN file indicates to which device the pin-out refers to, and how to switch to the other base scheme. The Report and Fit files are not affected by the Base the Pin-Out File (.pin) on Largest SameFrame Device option.
Conclusion

Altera offers FineLine BGA packages with the SameFrame feature to provide migration capability between devices of different densities and ball counts. With SameFrame pin-outs, lower ball-count packages form a subset of higher ball-count packages. This layout gives you the ability to migrate from one FineLine BGA package to another without redesigning your PCB layout. By designing the PCB layout for the highest possible ball count, you maintain the flexibility to choose from any density or FineLine BGA ball count. This approach gives more flexibility than traditional vertical migration, as you can migrate to different densities across an entire device family.

The Quartus and MAX+PLUS II software are the ideal design tools for SameFrame pin-out. If any device for future migration has been selected, the software automatically reserves pins accordingly. Upon migration, pin assignments are translated and converted to the new device’s assignments. After successful compilation, the Quartus and MAX+PLUS II software generates the PIN file according to the selected device or the largest device targeted for migration.
The information contained in *Application Note 90 (SameFrame Pin-Out Design for FineLine BGA Packages)* version 1.01 supersedes information published in previous versions.

**Version 1.01 Changes**

*Application Note 90 (SameFrame Pin-Out Design for FineLine BGA Packages)* version 1.01 contains the following changes:

- Updated *Note (1)* and *Note (2)* in Table 2.
- Updated Figure 1, Figure 2, Figure 3, Figure 4, and Figure 7 for readability.
- Updated first paragraph on page 5 regarding Figure 3.
- Made minor style and textual changes.