SameFrame Pin-Out Design for FineLine BGA Packages

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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® APEX™, 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™ 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 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 APEX, 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.

Table 1. Vertical Migration *Note (1)*

MAX 7000A 100-Pin TQFP	FLEX 6000 144-Pin TQFP	FLEX 10KE 356-Pin BGA
EPM7064AE EPM7128AE EPM7256AE	EPF6010A EPF6016 EPF6016A EPF6024A	EPF10K50E EPF10K50S EPF10K100E EPF10K130E EPF10K200S

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.

SameFrame Benefits

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, which uses APEX 20K ESBs to store internal signals. 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 ESBs, allowing you to monitor more internal signals.

SameFrame Flexibility

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

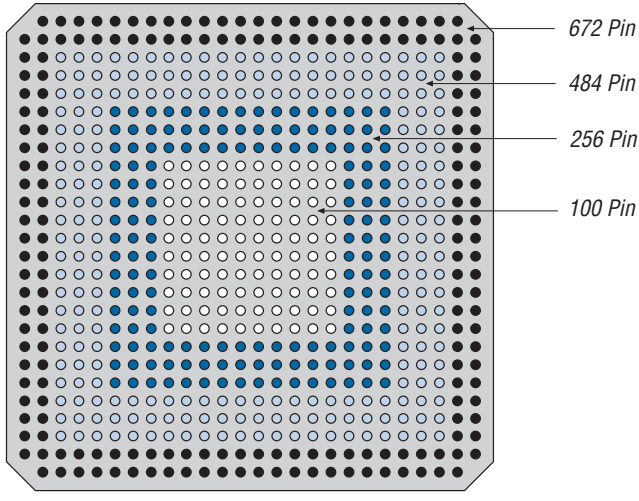
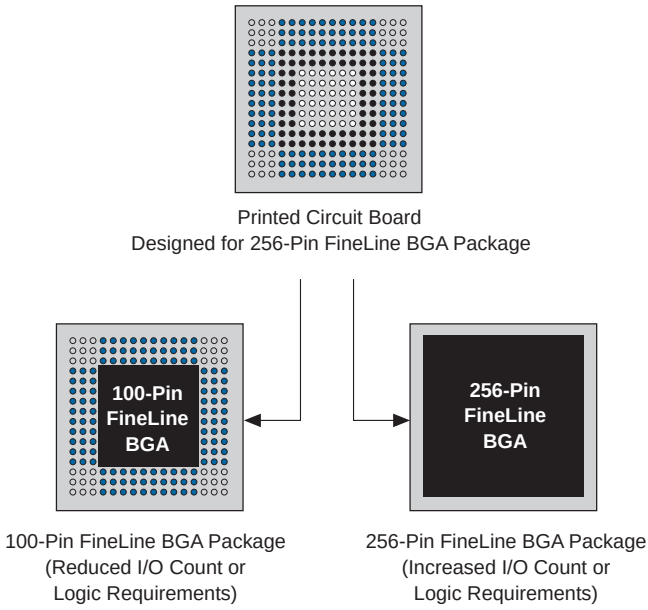


Figure 2 illustrates cross-package migration using 100-pin and 256-pin FineLine BGA packages.

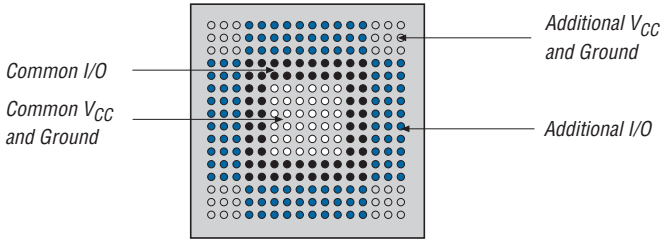
Figure 2. Migration Using FineLine BGA Packages



SameFrame Pin-Out

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 (white) are common to all FineLine BGA packages. I/O and configuration pins (black) 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 not all placed together and 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 APEX 20K device family. For example, if you design a PCB for APEX 20K devices, you could easily retarget your design from the 672-pin EP20K400 device to the 324-pin EP20K100 device or vice versa.

Table 2. Migration Options for APEX 20K Device Family *Notes (1), (2)*

Device	324-Pin FineLine BGA	400-Pin FineLine BGA	484-Pin FineLine BGA	672-Pin FineLine BGA	784-Pin FineLine BGA
EP20K100	✓	✓ (1)	✓ (1)	✓ (1)	✓ (1)
EP20K100E	✓	✓ (1)	✓ (1)	✓ (1)	✓ (1)
EP20K160E		✓	✓ (1)	✓ (1)	✓ (1)
EP20K200			✓	✓ (1)	✓ (1)
EP20K200E			✓	✓	✓ (1)
EP20K300E				✓	✓ (1)
EP20K400				✓	✓ (1)
EP20K400E				✓	✓ (1)
EP20K600E				✓	✓
EP20K1000E					✓

Notes:
(1) All FineLine BGA packages shown are compatible via the SameFrame feature.
(2) APEX 20K and APEX 20KE devices operate at different voltage levels. PCB design may vary to accommodate the voltage difference.

Due to the smaller die size made possible by advanced processes, some APEX 20KE devices have fewer I/O pins than the equivalent APEX 20K devices. Therefore, you should avoid using these pins if you expect to migrate your design to APEX 20KE devices in the future. Altera design software can help you automatically avoid these pins when compiling a design. Consult the APEX 20KE data sheet for details on I/O pin counts.

Table 3 shows the migration options for the FLEX 10K device family.

Table 3. Migration Options for FLEX 10K Device Family (Part 1 of 2) *Notes (1), (2)*

Devices	256-Pin FineLine BGA	484-Pin FineLine BGA	672-Pin FineLine BGA
EPF10K10A	✓		
EPF10K30A	✓	✓	
EPF10K50A		✓	
EPF10K100A		✓ (2)	
EPF10K30E	✓	✓	
EPF10K50E	✓	✓	
EPF10K50S	✓	✓	
EPF10K100E	✓ (2)	✓ (2)	
EPF10K100B	✓ (2)		

Table 3. Migration Options for FLEX 10K Device Family (Part 2 of 2) *Notes (1), (2)*

Devices	256-Pin FineLine BGA	484-Pin FineLine BGA	672-Pin FineLine BGA
EPF10K130E		✓	✓
EPF10K200E			✓
EPF10K200S		✓	✓

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 4). Altera design software can help you automatically avoid these pins when compiling a design.

Table 4. Devices with Fewer I/O Pins

FLEX 10KE Devices	Fewer I/O Pins	FLEX 10KA Devices
EPF10K30EF256	15	EPF10K30AF256
EPF10K30EF484	26	EPF10K30AF484
EPF10K100EF484	31	EPF10K100AF484
EPF10K50EF484	37	EPF10K50VF484

Table 5 shows the migration options for the FLEX 6000 device family.

Table 5. Migration Options for FLEX 6000 Device Family

Devices	100-pin FineLine BGA	256-pin FineLine BGA
EPF6010A	✓	✓
EPF6016A	✓	✓
EPF6024A		✓

Table 6 shows the migration options for the MAX 7000A device family.

Table 6. Migration Options for MAX 7000A Device Family

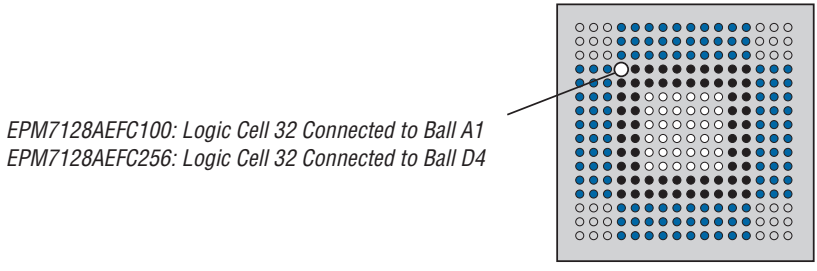
Devices	100-pin FineLine BGA	256-pin FineLine BGA
EPM7064AE	✓	
EMP7128B	✓	✓
EPM7128AE	✓	✓
EPM7256B		✓
EPM7256AE	✓	✓
EPM7512B		✓
EPM7512AE		✓

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.

Figure 4. Compatibility within a Device Family



Software Support

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.**

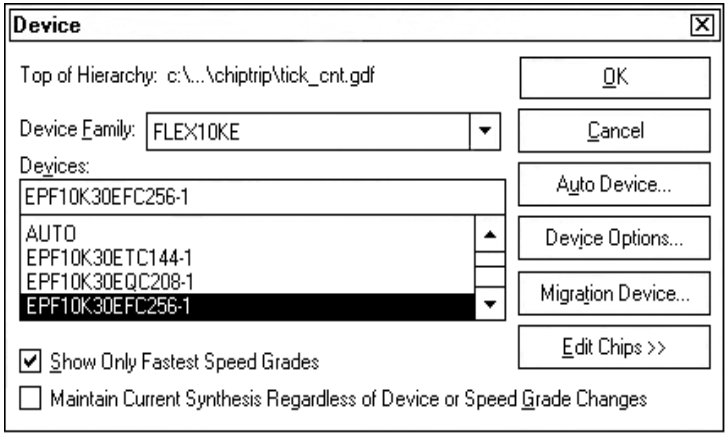
Device Migration Using the MAX+PLUS II Software

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.

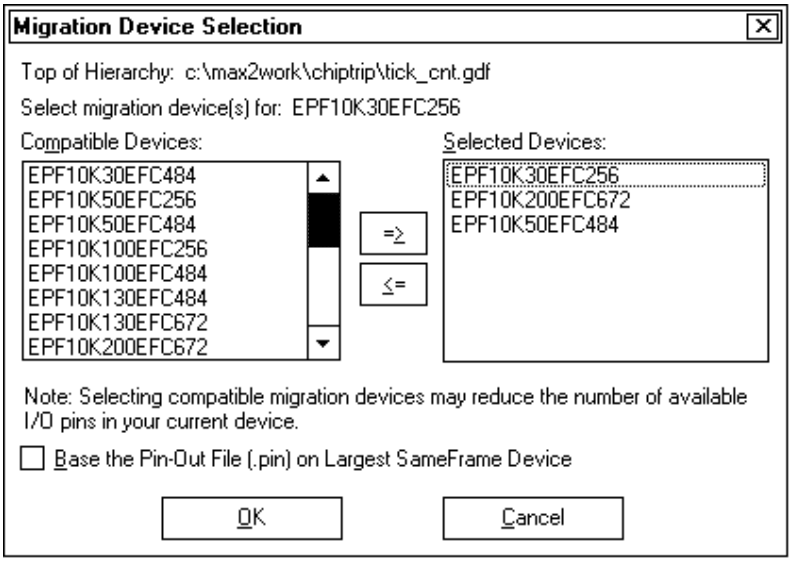
You cannot select a migration device if *Auto* is chosen in the *Devices* drop-down list box.

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 the 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

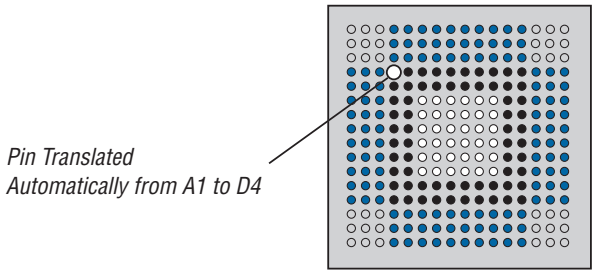
Pin assignments must be translated when changing packages or density. If a new device has a different BGA grid size than a previous device, the MAX+PLUS II software translates the pins and converts the pin assignments from the old device to match the new device. If a corresponding pin is illegal (e.g., 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-Out File

A Pin-Out File (.**pin**) 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.

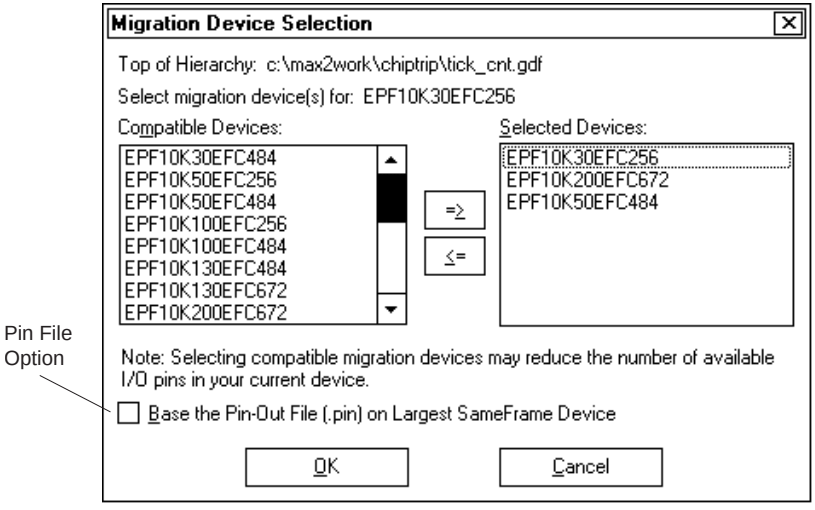
Figure 8 shows a sample Pin-Out File.

Figure 8. Sample Pin-Out 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.
-----------------------------------------------------

CHIP interface Assigned to an EPM7128AEF100-5

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

This option allows you to choose which device the files are based on. Checking this box 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 this option is unchecked, then the software will generate a file based on the device you are currently using. The Pin-Out 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 on Largest SameFrame Device option. See Figure 9.

Figure 9. 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-out File (.**pin**) according to the selected device or the largest device targeted for migration.

101 Innovation Drive
San Jose, CA 95134
(408) 544-7000
http://www.altera.com
Applications Hotline:
(800) 800-EPLD
Customer Marketing:
(408) 544-7104
Literature Services:
(888) 3-ALTERA
lit_req@altera.com