Technical Brief

# Extended Temperature Support for MAX 7000AE, Cyclone, Stratix, and ACEX 1K Devices

## Introduction

The Altera® MAX® 7000AE, Cyclone®, Stratix®, and ACEX® 1K device families support an extended range of temperatures (see Table 1) to meet the production needs of automotive, communications, military, and industrial applications. Extended temperature support allows design engineers who are working on systems with stringent temperature requirements to benefit from the cost and flexibility advantages of programmable logic devices (PLDs).

## Military Temperature Support

As part of Altera's initiative to provide enhanced commercial off-the-shelf (COTS) devices for military applications, the temperature range for the Stratix device family has been extended to enable operation across the military temperature range (-55°C to 125°C). This allows military programs to benefit from new technology and economies of scale by using commercially available Stratix FPGAs.

## Temperature Grades

MAX 7000AE, Cyclone, Stratix, and ACEX 1K devices are available in three different temperature grades, each verified to work within specifications at the specified temperature range, as shown in Table 1.

*Table 1. Device Junction Temperature Ranges*

| Family | Commercial | Industrial | Extended |
|---|---|---|---|
| MAX 7000AE | 0°C to 90°C | -40°C to 105°C | -40°C to 130°C |
| Cyclone | 0°C to 85°C | -40°C to 100°C | -40°C to 125°C |
| Stratix *(1)* | 0°C to 85°C | -40°C to 100°C | -55°C to 125°C |
| ACEX 1K | 0°C to 85°C | -40°C to 100°C | -40°C to 125°C |

***Note to Table 1:***

(1) In addition to meeting the extended temperature range, the Stratix device family also meets the requirements for military temperature range applications.

## Extended Temperature Support

Extended temperature operation requires additional timing margin over industrial temperature operation to compensate for the potential increased variation of $f_{MAX}$. With Altera devices, increased timing margin is achieved by compiling the design to a slower speed-grade in the Quartus® II software. The support method, called derating, specifies that a device with a particular speed grade and temperature range has been verified to operate at the extended temperature range but with a slower performance (i.e., slower speed grade). For example, one can increase timing margin for a -6 device by utilizing a -7 device setting in the Quartus II software. This technique can be utilized to increase the timing margin of an industrial device to meet the constraints of extended temperature range operation.

## Device Support

The device and package combinations shown in Table 2 support the extended temperature range.

*Table 2. Extended Temperature Range Device Support*

| Family | Device | Package |
|---|---|---|
| MAX 7000AE | EPM7032AE | 44-pin thin quad flat pack (TQFP) |
| | EPM7064AE | 44-pin TQFP<br>100-pin TQFP |
| | EPM7128AE | 100-pin TQFP<br>144-pin TQFP |
| | EPM7256AE | 144-pin TQFP<br>256-pin FineLine BGA (FBGA) |
| Cyclone *(1), (2)* | EP1C3 | 144-pin TQFP |
| | EP1C4 | 324-pin FBGA |
| | EP1C6 | 144-pin TQFP<br>256-pin FBGA |
| | EP1C12 | 256-pin FBGA<br>324-pin FBGA |
| | EP1C20 | 400-pin FBGA |
| Stratix *(3)* | EP1S30 | 780-pin FBGA |
| | EP1S40 | 780-pin FBGA |
| | EP1S60 | 1020-pin FBGA |
| ACEX 1K *(1)* | EP1K10 | 100-pin TQFP |
| | EP1K30 | 144-pin TQFP |
| | EP1K50 | 208-pin quad flat pack (QFP)<br>256-pin FBGA |
| | EP1K100 | 208-pin QFP<br>256-pin FBGA |

***Notes to Table 2:***

(1) The EPC1LI20 and EPC2LI20 configuration devices support configuration within the extended temperature range for ACEX 1K and Cyclone devices. These configuration devices do not require derating.

(2) The EPCS1SI8 and EPCS4SI8 serial configuration devices support configuration within the extended temperature range for Cyclone devices. These configuration devices do not require derating.

(3) The EP16UC88 configuration devices manufactured starting the second quarter of 2006 support configuration within the extended/military temperature range for Stratix devices. These configuration devices do not require derating.

For MAX 7000AE devices, the extended temperature range devices are supported for -10 speed grade performance. The -10 speed grade extended temperature range performance is achieved through derating of -7 speed grade industrial devices (-I7).

For Cyclone devices, the extended temperature range devices are supported for -8 speed grade performance. The -8 speed grade extended temperature range performance is achieved through derating of -7 speed grade industrial devices (-I7).

For Stratix devices, the extended/military temperature range devices are supported for -7 speed grade performance. The -7 speed grade extended/military temperature range performance is achieved through derating of -6 speed grade industrial devices (-I6).

For ACEX 1K devices, the extended temperature range devices are supported for -3 speed grade performance. The -3 speed grade extended temperature range performance is achieved through derating of -2 speed grade industrial devices (-I2).

## Software Support

When using extended temperature range devices, you must assign the slower commercial speed grade device in the Quartus II software. The compilation result for these device and speed grades will show the worst-case timing for your extended temperature range device. The software will generate the necessary programming file (e.g., Programmer Object File (**.pof**) or SRAM Object File (**.sof**)). To support this performance at the higher operating temperature, the device ordered and shipped will be a - I7 (MAX 7000AE), - I7 (Cyclone), -I6 (Stratix), or - I2 (ACEX 1K). The slower speed grade commercial POF or SOF is compatible with their respective faster industrial speed grade devices. See Table 3 for derating information.

*Table 3. Derating for Extended Temperature Families*

| Family | Speed Grade of Device to Order | Speed Grade of Device to Select in the Quartus II Software |
|---|---|---|
| MAX 7000AE | -I7 | -C10 |
| Cyclone | -I7 | -C8 |
| Stratix | -I6 | -C7 |
| ACEX 1K | -I2 | -C3 |

Table 4 shows the Quartus II software target device along with the corresponding faster industrial device ordered.

*Table 4. Extended Temperature Range Device Software Selection*

| Family | Industrial Device Ordered & Shipped | Device Selected in Software |
|---|---|---|
| MAX 7000AE | EPM7032AETI44-7 | EPM7032AETC44-10 |
| | EPM7064AETI44-7 | EPM7064AETC44-10 |
| | EPM7064AETI100-7 | EPM7064AETC100-10 |
| | EPM7128AETI100-7 | EPM7128AETC100-10 |
| | EPM7128AETI144-7 | EPM7128AETC144-10 |
| | EPM7256AETI144-7 | EPM7256AETC144-10 |
| | EPM7256AEFI256-7 | EPM7256AEFC256-10 |
| Cyclone | EP1C3T144I7 | EP1C3T144C8 |
| | EP1C4F324I7 | EP1C4F324C8 |
| | EP1C6T144I7 | EP1C6T144C8 |
| | EP1C6F256I7 | EP1C6F256C8 |
| | EP1C12F256I7 | EP1C12F256C8 |
| | EP1C12F324I7 | EP1C12F324C8 |
| | EP1C20F400I7 | EP1C20F400C8 |
| Stratix | EP1S30F780I6 | EP1S30F780C7 |
| | EP1S40F780I6 | EP1S40F780C7 |
| | EP1S60F1020I6 | EP1S60F1020C7 |
| ACEX 1K | EP1K10TI100-2 | EP1K10TC100-3 |
| | EP1K30TI144-2 | EP1K30TC144-3 |
| | EP1K50QI208-2 | EP1K50QC208-3 |
| | EP1K50FI256-2 | EP1K50FC256-3 |
| | EP1K100QI208-2 | EP1K100QC208-3 |
| | EP1K100FI256-2 | EP1K100FC256-3 |

## Testing

Semiconductor devices undergo at least two types of testing: device characterization and production testing. Device characterization is used to verify the performance of a semiconductor design and its physical implementation. Production testing is used to find manufacturing defects that randomly occur during the manufacture of all

semiconductor devices. This section of the white paper describes these testing methods and the roles they play in supporting extended temperature MAX 7000AE, Cyclone, Stratix, and ACEX 1K devices.

Device characterization is performed on a small sample of devices to characterize performance and performance variations across process, voltage, and temperature changes. Once device characterization has been performed, the operation of the device is well understood across a variety of operating conditions including commercial, industrial, and extended temperatures. Device characterization allows Altera to determine if a product can be utilized in commercial, industrial, and extended temperature conditions.

Production testing is used to identify manufacturing defects in devices prior to shipment to customers. There are two key stages for production testing: wafer sort and post device assembly (packaging). Wafer sort identifies good dies, which continue in the manufacturing process to device assembly. After assembly, additional testing is performed to verify device functionality and determine performance binning (speed and temperature grades).

Altera has characterized these devices across the commercial, industrial, and extended temperature ranges, and verified that they perform within our stringent specifications. However, note that while commercial-grade devices have been production tested and screened at commercial temperatures, and industrial-grade devices have been production tested and screened at the industrial high-end temperatures, Altera does not perform production screening for extended temperature operation.

## Conclusion

Altera supports extended temperature range MAX 7000AE, Cyclone, Stratix, and ACEX 1K devices in the Quartus II software through a derating strategy enabling customers to target their designs for automotive, communications, military, and industrial applications.

101 Innovation Drive
San Jose, CA 95134
(408) 544-7000
http://www.altera.com