



# Cyclone Series Device Thermal Resistance

May 2008, version 3.0

Data Sheet

## Revision History

The following table shows the revision history for this data sheet.

| Date       | Document Version | Changes Made                                                                   |
|------------|------------------|--------------------------------------------------------------------------------|
| May 2008   | 3.0              | Updated <a href="#">Tables 2, 4, and 5</a> .                                   |
| July 2007  | 2.2              | Updated values for EP3C25 (E144) device in Table 2.                            |
| May 2007   | 2.1              | Updated values for EP3C10 (E144) device in Table 2 and added Revision History. |
| March 2007 | 2.0              | Added Cyclone III information.                                                 |
| April 2006 | 1.0              | Initial release.                                                               |

[Tables 1](#) through [6](#) in this data sheet provide  $\theta_{JA}$  (junction-to-ambient thermal resistance) and  $\theta_{JC}$  (junction-to-case thermal resistance) values for Altera® Cyclone® series devices available in Ball-Grid Array (BGA), FineLine® BGA (FBGA), Micro FineLine BGA® (MBGA), Ultra FineLine BGA (UBGA), Pin-Grid Array (PGA), Plastic J-Lead Chip Carrier (PLCC), Plastic Enhanced Quad Flat Pack (EQFP), Thin Quad Flat Pack (TQFP), Plastic Quad Flat Pack (PQFP), and Power Quad Flat Pack (RQFP).



For additional packaging information, refer to the [Altera Device Packaging Data Sheet](#).

## Cyclone III Devices

Thermal resistance values for Cyclone III devices are provided for a board meeting JEDEC specifications and for a typical board. The JEDEC board specifications require two signals and two power/ground planes and are available at [www.jedec.org](http://www.jedec.org). The values are described in [Tables 1 through 4](#).

**Table 1. Thermal Resistance Values for Cyclone III Devices**

| Value                              | Description                                                                                                  |
|------------------------------------|--------------------------------------------------------------------------------------------------------------|
| $\theta_{JA}$ (C/W) Still Air      | Junction-to-ambient thermal resistance ( $\theta_{JA}$ ) with no airflow when a heat sink is not being used. |
| $\theta_{JA}$ (C/W) 100 ft./minute | Junction-to-ambient thermal resistance with 100 ft./minute airflow when a heat sink is not being used.       |
| $\theta_{JA}$ (C/W) 200 ft./minute | Junction-to-ambient thermal resistance with 200 ft./minute airflow when a heat sink is not being used.       |
| $\theta_{JA}$ (C/W) 400 ft./minute | Junction-to-ambient thermal resistance with 400 ft./minute airflow when a heat sink is not being used.       |
| $\theta_{JC}$ (C/W)                | Junction-to-case thermal resistance ( $\theta_{JC}$ ) for device.                                            |
| $\theta_{JB}$ (C/W)                | Junction-to-board thermal resistance ( $\theta_{JB}$ ) for specific board being used.                        |

[Table 2](#) provides  $\theta_{JA}$  (junction-to-ambient thermal resistance) values and  $\theta_{JC}$  (junction-to-case thermal resistance) values for Cyclone III devices on a board meeting JEDEC specifications for thermal resistance calculation.

**Table 2. Thermal Resistance of Cyclone III Devices for Board Meeting JEDEC Specifications (Part 1 of 2)**

| Device | Package | $\theta_{JA}$ (°C/W)<br>Still Air | $\theta_{JA}$ (°C/W)<br>100 ft./min. | $\theta_{JA}$ (°C/W)<br>200 ft./min. | $\theta_{JA}$ (°C/W)<br>400 ft./min. | $\theta_{JC}$ (°C/W) |
|--------|---------|-----------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|----------------------|
| EP3C5  | E144    | 20                                | 17.5                                 | 15.4                                 | 14                                   | 8.4                  |
|        | F256    | 32.4                              | 28.9                                 | 27                                   | 25.5                                 | 11.7                 |
|        | U256    | 32.5                              | 29.1                                 | 27.2                                 | 25.6                                 | 12.2                 |
|        | M164    | 38.2                              | 31.5                                 | 29.6                                 | 27.9                                 | 11.6                 |
| EP3C10 | E144    | 20                                | 17.5                                 | 15.4                                 | 14                                   | 8.4                  |
|        | F256    | 32.4                              | 28.9                                 | 27                                   | 25.5                                 | 11.7                 |
|        | U256    | 32.5                              | 29.1                                 | 27.2                                 | 25.6                                 | 12.2                 |
|        | M164    | 38.2                              | 31.5                                 | 29.6                                 | 27.9                                 | 11.6                 |

**Table 2. Thermal Resistance of Cyclone III Devices for Board Meeting JEDEC Specifications (Part 2 of 2)**

| Device  | Package | $\theta_{JA}$ (°C/W)<br>Still Air | $\theta_{JA}$ (°C/W)<br>100 ft./min. | $\theta_{JA}$ (°C/W)<br>200 ft./min. | $\theta_{JA}$ (°C/W)<br>400 ft./min. | $\theta_{JC}$ (°C/W) |
|---------|---------|-----------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|----------------------|
| EP3C16  | E144    | 20                                | 17.5                                 | 15.4                                 | 14                                   | 8                    |
|         | Q240    | 27.2                              | 24.7                                 | 22.1                                 | 17.8                                 | 4.3                  |
|         | F256    | 28.5                              | 25.1                                 | 23.2                                 | 21.7                                 | 9.1                  |
|         | U256    | 28.8                              | 25.4                                 | 23.5                                 | 22                                   | 9.7                  |
|         | U484    | 26.9                              | 23.5                                 | 21.6                                 | 20.1                                 | 8.5                  |
|         | F484    | 22.9                              | 19.4                                 | 17.7                                 | 16.2                                 | 6.9                  |
|         | M164    | 34.7                              | 28                                   | 26.1                                 | 24.4                                 | 9.2                  |
| EP3C25  | E144    | 20                                | 17.5                                 | 15.4                                 | 14                                   | 7.8                  |
|         | Q240    | 27                                | 24.5                                 | 21.8                                 | 17.6                                 | 4.2                  |
|         | F256    | 27.5                              | 24.1                                 | 22.2                                 | 20.7                                 | 8.5                  |
|         | U256    | 27.9                              | 24.5                                 | 22.6                                 | 21.1                                 | 9.1                  |
|         | F324    | 26.6                              | 23.1                                 | 21.3                                 | 19.8                                 | 8                    |
| EP3C40  | Q240    | 25.8                              | 23.2                                 | 20.6                                 | 17                                   | 4                    |
|         | F324    | 23.2                              | 19.7                                 | 18                                   | 16.5                                 | 5.9                  |
|         | U484    | 22.8                              | 19.3                                 | 17.6                                 | 16.1                                 | 5.9                  |
|         | F484    | 19.8                              | 16.3                                 | 14.6                                 | 13.2                                 | 4.8                  |
|         | F780    | 18.7                              | 15.2                                 | 13.5                                 | 12.2                                 | 4.5                  |
| EP3C55  | F484    | 21.6                              | 18.2                                 | 16.4                                 | 15                                   | 5.1                  |
|         | U484    | 18.9                              | 15.4                                 | 13.8                                 | 12.2                                 | 4.2                  |
|         | F780    | 17.8                              | 14.4                                 | 12.7                                 | 11.4                                 | 3.9                  |
| EP3C80  | U484    | 20.4                              | 16.9                                 | 15.2                                 | 13.8                                 | 4.4                  |
|         | F484    | 18                                | 14.5                                 | 12.9                                 | 11.5                                 | 3.6                  |
|         | F780    | 16.9                              | 13.5                                 | 11.8                                 | 10.5                                 | 3.3                  |
| EP3C120 | F484    | 17.1                              | 13.7                                 | 12                                   | 10.7                                 | 3.1                  |
|         | F780    | 16                                | 12.6                                 | 11                                   | 9.7                                  | 2.8                  |

Table 3 provides board dimension information for each package.

**Table 3. PCB Dimensions Notes (1), (2) (Part 1 of 2)**

| 2.5 mm Thick | Signal Layers | Power/Ground Layers | Package Dimensions (mm) | Board Dimensions (mm) |
|--------------|---------------|---------------------|-------------------------|-----------------------|
| F780         | 9             | 9                   | 29                      | 89                    |
| F484         | 7             | 7                   | 23                      | 83                    |

| <b>Table 3. PCB Dimensions</b> <i>Notes (1), (2)</i> <b>(Part 2 of 2)</b> |                      |                            |                                |                              |
|---------------------------------------------------------------------------|----------------------|----------------------------|--------------------------------|------------------------------|
| <b>2.5 mm Thick</b>                                                       | <b>Signal Layers</b> | <b>Power/Ground Layers</b> | <b>Package Dimensions (mm)</b> | <b>Board Dimensions (mm)</b> |
| U484                                                                      | 7                    | 7                          | 19                             | 79                           |
| F324                                                                      | 6                    | 6                          | 19                             | 79                           |
| F256                                                                      | 6                    | 6                          | 17                             | 77                           |
| U256                                                                      | 6                    | 6                          | 14                             | 74                           |

*Notes to Table 3:*

- (1) Power layer Cu thickness 35  $\mu\text{m}$ , Cu 90%
- (2) Signal layer Cu thickness 17  $\mu\text{m}$ , Cu 15%

Table 4 provides  $\theta_{JA}$  values and  $\theta_{JB}$  (junction-to-board thermal resistance) values for Cyclone III devices on a typical board.

| <b>Table 4. Thermal Resistance of Cyclone III Devices for Typical Board (Part 1 of 2)</b> |                |                                                                                 |                                                                                    |                                                                                    |                                                                                    |                                                                   |
|-------------------------------------------------------------------------------------------|----------------|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| <b>Device</b>                                                                             | <b>Package</b> | <b><math>\theta_{JA}</math> (<math>^{\circ}\text{C/W}</math>)<br/>Still Air</b> | <b><math>\theta_{JA}</math> (<math>^{\circ}\text{C/W}</math>)<br/>100 ft./min.</b> | <b><math>\theta_{JA}</math> (<math>^{\circ}\text{C/W}</math>)<br/>200 ft./min.</b> | <b><math>\theta_{JA}</math> (<math>^{\circ}\text{C/W}</math>)<br/>400 ft./min.</b> | <b><math>\theta_{JB}</math> (<math>^{\circ}\text{C/W}</math>)</b> |
| EP3C5                                                                                     | F256           | 32.2                                                                            | 27.9                                                                               | 25.5                                                                               | 23.6                                                                               | 17.3                                                              |
|                                                                                           | U256           | 32.7                                                                            | 28.2                                                                               | 25.7                                                                               | 23.7                                                                               | 16.3                                                              |
| EP3C10                                                                                    | F256           | 32.2                                                                            | 27.9                                                                               | 25.5                                                                               | 23.6                                                                               | 17.3                                                              |
|                                                                                           | U256           | 32.7                                                                            | 28.2                                                                               | 25.7                                                                               | 23.7                                                                               | 16.3                                                              |
| EP3C16                                                                                    | F256           | 28.4                                                                            | 24.2                                                                               | 21.8                                                                               | 20                                                                                 | 13.5                                                              |
|                                                                                           | U256           | 29                                                                              | 24.6                                                                               | 22.2                                                                               | 20.2                                                                               | 12.7                                                              |
|                                                                                           | U484           | 26.3                                                                            | 22.1                                                                               | 19.9                                                                               | 18.1                                                                               | 12.4                                                              |
|                                                                                           | F484           | 22.5                                                                            | 18.5                                                                               | 16.4                                                                               | 14.8                                                                               | 9.8                                                               |
| EP3C25                                                                                    | F256           | 27.5                                                                            | 23.2                                                                               | 20.9                                                                               | 19.1                                                                               | 12.6                                                              |
|                                                                                           | U256           | 28.1                                                                            | 23.7                                                                               | 21.3                                                                               | 19.4                                                                               | 11.8                                                              |
|                                                                                           | F324           | 26.4                                                                            | 22.3                                                                               | 20.1                                                                               | 18.3                                                                               | 12.4                                                              |
| EP3C40                                                                                    | F324           | 23.1                                                                            | 19                                                                                 | 16.9                                                                               | 15.1                                                                               | 9.2                                                               |
|                                                                                           | F484           | 22.3                                                                            | 18.2                                                                               | 16                                                                                 | 14.3                                                                               | 8.5                                                               |
|                                                                                           | U484           | 19.4                                                                            | 15.4                                                                               | 13.5                                                                               | 11.9                                                                               | 6.8                                                               |
|                                                                                           | F780           | 17.6                                                                            | 13.9                                                                               | 12.1                                                                               | 10.7                                                                               | 6.7                                                               |
| EP3C55                                                                                    | U484           | 21.2                                                                            | 17.1                                                                               | 15                                                                                 | 13.3                                                                               | 7.5                                                               |
|                                                                                           | F484           | 18.6                                                                            | 14.6                                                                               | 12.6                                                                               | 11.1                                                                               | 6                                                                 |
|                                                                                           | F780           | 16.8                                                                            | 13.1                                                                               | 11.3                                                                               | 9.9                                                                                | 5.9                                                               |

**Table 4. Thermal Resistance of Cyclone III Devices for Typical Board (Part 2 of 2)**

| Device  | Package | $\theta_{JA}$ (°C/W)<br>Still Air | $\theta_{JA}$ (°C/W)<br>100 ft./min. | $\theta_{JA}$ (°C/W)<br>200 ft./min. | $\theta_{JA}$ (°C/W)<br>400 ft./min. | $\theta_{JB}$ (°C/W) |
|---------|---------|-----------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|----------------------|
| EP3C80  | U484    | 20                                | 15.9                                 | 13.8                                 | 12.1                                 | 6.3                  |
|         | F484    | 17.7                              | 13.7                                 | 11.8                                 | 10.3                                 | 5.2                  |
|         | F780    | 15.9                              | 12.2                                 | 10.5                                 | 9.1                                  | 5.1                  |
| EP3C120 | F484    | 16.8                              | 12.9                                 | 11                                   | 9.4                                  | 4.4                  |
|         | F780    | 15.1                              | 11.4                                 | 9.6                                  | 8.3                                  | 4.2                  |

## Cyclone II Devices

Table 5 provides  $\theta_{JA}$  (junction-to-ambient thermal resistance) and  $\theta_{JC}$  (junction-to-case thermal resistance) values for Cyclone II devices.

**Table 5. Thermal Resistance of Cyclone II Devices**

| Device | Package | $\theta_{JA}$ (°C/W)<br>0 ft./min. | $\theta_{JA}$ (°C/W)<br>100 ft./min. | $\theta_{JA}$ (°C/W)<br>200 ft./min. | $\theta_{JA}$ (°C/W)<br>400 ft./min. | $\theta_{JC}$ (°C/W) |
|--------|---------|------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|----------------------|
| EP2C5  | F256    | 30.2                               | 26.1                                 | 23.6                                 | 21.7                                 | 8.7                  |
|        | T144    | 31                                 | 29.3                                 | 27.9                                 | 25.5                                 | 10                   |
|        | Q208    | 30.4                               | 29.2                                 | 27.3                                 | 22.3                                 | 5.5                  |
| EP2C8  | F256    | 27.0                               | 23.0                                 | 20.5                                 | 18.5                                 | 7.1                  |
|        | T144    | 29.8                               | 28.3                                 | 26.9                                 | 24.9                                 | 9.9                  |
|        | Q208    | 30.2                               | 28.2                                 | 26.9                                 | 21.7                                 | 5.4                  |
| EP2C20 | Q240    | 26.6                               | 24.0                                 | 21.4                                 | 17.4                                 | 4.2                  |
|        | F256    | 24.2                               | 20.0                                 | 17.8                                 | 16.0                                 | 5.5                  |
|        | F484    | 21.0                               | 17.0                                 | 14.8                                 | 13.1                                 | 4.2                  |
|        | T144    | 27.6                               | 26.4                                 | 25.4                                 | 23.8                                 | 9.6                  |
| EP2C35 | F484    | 19.4                               | 15.4                                 | 13.3                                 | 11.7                                 | 3.3                  |
|        | U484    | 20.6                               | 16.6                                 | 14.5                                 | 12.8                                 | 5.0                  |
|        | F672    | 18.6                               | 14.6                                 | 12.6                                 | 11.1                                 | 3.1                  |
| EP2C50 | F484    | 18.4                               | 14.4                                 | 12.4                                 | 10.9                                 | 2.8                  |
|        | U484    | 19.6                               | 15.6                                 | 13.6                                 | 11.9                                 | 4.4                  |
|        | F672    | 17.7                               | 13.7                                 | 11.8                                 | 10.2                                 | 2.6                  |
| EP2C70 | F672    | 16.9                               | 13.0                                 | 11.1                                 | 9.7                                  | 2.2                  |
|        | F896    | 16.3                               | 11.9                                 | 10.5                                 | 9.1                                  | 2.1                  |

Table 6 provides  $\theta_{JA}$  and  $\theta_{JB}$  (junction-to-board thermal resistance) values for Cyclone II devices on a typical board.

| <b>Table 6. Thermal Resistance of Cyclone II Devices</b> |         |                                   |                                      |                                      |                                      |                      |
|----------------------------------------------------------|---------|-----------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|----------------------|
| Device                                                   | Package | $\theta_{JA}$ (°C/W)<br>Still Air | $\theta_{JA}$ (°C/W)<br>100 ft./min. | $\theta_{JA}$ (°C/W)<br>200 ft./min. | $\theta_{JA}$ (°C/W)<br>400 ft./min. | $\theta_{JB}$ (°C/W) |
| EP2C5                                                    | F256    | 30.2                              | 25.8                                 | 22.9                                 | 20.6                                 | 14.8                 |
| EP2C8                                                    | F256    | 27.9                              | 23.2                                 | 20.5                                 | 18.4                                 | 12.3                 |
| EP2C20                                                   | F256    | 24.7                              | 20.1                                 | 17.5                                 | 15.3                                 | 9.1                  |
|                                                          | F484    | 20.5                              | 16.2                                 | 13.9                                 | 12.2                                 | 7.2                  |
| EP2C35                                                   | F484    | 18.8                              | 14.5                                 | 12.3                                 | 10.6                                 | 5.7                  |
|                                                          | U484    | 20.0                              | 15.5                                 | 13.2                                 | 11.3                                 | 5.3                  |
| EP2C50                                                   | F484    | 17.7                              | 13.5                                 | 11.4                                 | 9.8                                  | 4.5                  |
|                                                          | U484    | 19.0                              | 14.6                                 | 12.3                                 | 10.6                                 | 4.4                  |
| EP2C35                                                   | F672    | 17.4                              | 13.3                                 | 11.3                                 | 9.8                                  | 5.5                  |
| EP2C50                                                   | F672    | 16.5                              | 12.4                                 | 10.5                                 | 9.0                                  | 4.6                  |
|                                                          | F672    | 15.7                              | 11.7                                 | 9.8                                  | 8.3                                  | 3.8                  |
| EP2C70                                                   | F896    | 14.6                              | 10.7                                 | 8.9                                  | 7.6                                  | 3.7                  |

## Cyclone Devices

Table 7 provides  $\theta_{JA}$  (junction-to-ambient thermal resistance) and  $\theta_{JC}$  (junction-to-case thermal resistance) values for Cyclone devices.

| <b>Table 7. Thermal Resistance of Cyclone Devices (Part 1 of 2)</b> |           |         |                      |                                   |                                      |                                      |                                      |
|---------------------------------------------------------------------|-----------|---------|----------------------|-----------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|
| Device                                                              | Pin Count | Package | $\theta_{JC}$ (°C/W) | $\theta_{JA}$ (°C/W)<br>Still Air | $\theta_{JA}$ (°C/W)<br>100 ft./min. | $\theta_{JA}$ (°C/W)<br>200 ft./min. | $\theta_{JA}$ (°C/W)<br>400 ft./min. |
| EP1C3                                                               | 100       | TQFP    | 11.0                 | 37.5                              | 35.4                                 | 33.4                                 | 29.8                                 |
|                                                                     | 144       | TQFP    | 10.0                 | 31.1                              | 29.4                                 | 27.9                                 | 25.5                                 |
| EP1C6                                                               | 144       | TQFP    | 9.8                  | 29.4                              | 28.0                                 | 26.7                                 | 24.7                                 |
|                                                                     | 240       | PQFP    | 4.3                  | 27.2                              | 24.7                                 | 22.1                                 | 17.8                                 |
|                                                                     | 256       | FBGA    | 8.8                  | 28.7                              | 24.5                                 | 22.3                                 | 20.5                                 |
| EP1C12                                                              | 240       | PQFP    | 4.0                  | 26.0                              | 23.4                                 | 20.8                                 | 17.1                                 |
|                                                                     | 256       | FBGA    | 6.6                  | 24.3                              | 20.2                                 | 18.1                                 | 16.4                                 |
|                                                                     | 324       | FBGA    | 6.1                  | 23.0                              | 19.8                                 | 17.7                                 | 16.1                                 |

**Table 7. Thermal Resistance of Cyclone Devices (Part 2 of 2)**

| Device | Pin Count | Package | $\theta_{JC}$ (°C/W) | $\theta_{JA}$ (°C/W)<br>Still Air | $\theta_{JA}$ (°C/W)<br>100 ft./min. | $\theta_{JA}$ (°C/W)<br>200 ft./min. | $\theta_{JA}$ (°C/W)<br>400 ft./min. |
|--------|-----------|---------|----------------------|-----------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|
| EP1C20 | 324       | FBGA    | 5.0                  | 21.0                              | 17.7                                 | 15.6                                 | 14.1                                 |
|        | 400       | FBGA    | 4.7                  | 20.7                              | 17.5                                 | 15.5                                 | 13.9                                 |



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