# Thermal Data

## Thermal Considerations

Due to the variety of applications in which Virtex-II FPGA devices are likely to be used, it is traditionally a challenge to predict the power requirements, and thus the thermal management needs, of a particular application. Virtex-II devices in general are characterized by high I/O counts and very high user gate counts. The attributes that make the devices popular with users also give the devices the potential of being clocked fast, which results in high power consumption. Because of this high heat-generating potential, the Virtex-II package offering (see Table 4-3) includes medium and high power capable packaging options.

Table 4-3 shows thermal resistance parameters for Virtex-II packages. These include: Junction-to-ambient, Junction-to-case and Junction-to-board. Estimated power consumption capability is given, as well. These values were derived with some typical thermal management assumptions, stated in the table.

*Table 4-3:* **Thermal Data for Virtex-II Packages**

| Package | Lead Pitch (mm) | Junction to Ambient Theta-$J_A$ Range °C/Watt in Air | Junction to Case Theta-$J_C$ Typical °C/Watt | Junction to Board Psi-$J_B$ ("Theta-$J_B$") Typical °C/Watt | Max Power Bare Pkg (Watts) $T_A$ = 50 °C $T_{JMAX}$ = 100 °C | Power With Heatsink (Watts) Theta-SA = 1.5 °C/Watt Theta-cs = 0.1 °C/Watt $T_A$ = 50° C $T_J$ = 100° C |
|---|---|---|---|---|---|---|
| CS144 Flex Based 12x12 | 0.8 | 32 - 36 | 1 | 20 | 1.5 | |
| FG256 2- 4L PCB 17x17 | 1.0 | 30 -35 | 3.5 | 19 | 1.5 | |
| FG456 4L PCB 23x23 | 1.0 | 15 - 28 | 2.0 | 11 | 2.4 | |
| FG676 4L PCB 27x27 | 1.0 | 14 -22 | 1.8 | 9 | 2.8 | 15 |
| BG575 4L PCB 31x31 | 1.27 | 13 - 20 | 1.6 | 7 | 3.1 | 16 |
| BG728 4L PCB 35x35 | 1.27 | 12 -20 | 1.5 | 6 | 3.3 | 16 |
| BF957 40x40 Flip-Chip | 1.27 | 8 - 13 | 0.7 | 3 | 5.0 | 22 |
| FF896 31x31 Flip-Chip | 1.0 | 9 - 14 | 0.8 | 4 | 4.5 | 21 |
| FF1152 35x35 Flip-Chip | 1.0 | 8 - 13 | 0.8 | 4 | 4.5 | 21 |
| FF1517 40x40 Flip-Chip | 1.0 | 8 - 12 | 0.7 | 3 | 5.0 | 22 |

Virtex-II packages can be grouped into three broad performance categories: low, medium, and high, based on their power handling capabilities. All of the packages can use external thermal enhancements, which can range from simple airflow to schemes that can include passive as well as active heatsinks. This is particularly true for high-performance flip-chip packages where system designers have the option to further enhance the packages to handle in excess of 25 watts, with arrangements that take system physical constraints into consideration. Table 4-4 shows simple but incremental power management schemes that can be brought to bear on flip-chip packages.

*Table 4-4:* **Virtex-II Flip-Chip Thermal Management**

| Power | Technique | Description |
|---|---|---|
| Low End (1 - 6 watts) | Bare package with moderate air 8 - 12 **°C/Watt** | Bare package. Package can be used with moderate airflow within a system. |
| Mid Range (4 - 10 watts) | Passive heatsink with air 5 - 10 **°C/Watt** | Package is used with various forms of passive heatsinks and heat spreader techniques. |
| High End (8 - 25 watts) | Active heatsink 2 - 3 **°C/Watt or better** | Package is used with active heatsinks, TEC, and board-level heat spreader techniques |

## Thermal Management Options

The following are thermal management options to consider:

- For moderate power dissipation (2 to 6 watts), the use of passive heatsinks and heatspreaders attached with thermally conductive double-sided tapes or retainers can offer quick thermal solutions.
- The use of lightweight finned external passive heatsinks can be effective for dissipating up to 10 watts. If implemented with forced air as well, the benefit can be a 40% to 50% increase in heat handling efficiency over bare packages. The more efficient external heatsinks tend to be tall and heavy. To help protect component joints from bulky heatsink induced stresses, the use of spring loaded pins or clips that transfer the mounting stress to a circuit board is advisable. The diagonals of some of these heatsinks can be designed with extensions to allow direct connections to the board.
- Flip-chip packages: All flip-chip packages are thermally enhanced BGAs with die facing down. They are offered with exposed metal heatsink at the top. These high-end thermal packages lend themselves to the application of external heatsinks (passive or active) for further heat removal efficiency. Again, precaution should be taken to prevent component damage when a bulky heatsink is attached.
- Active heatsinks can include a simple heatsink incorporating a mini fan or even a Peltier Thermoelectric Cooler (TECs) with a fan to blow away any heat generated. Any considerations to apply TEC in heat management should require consultation with experts in using the device, since these devices can be reversed and cause damage to the components. Also, condensation can be an issue.
- Molded packages (FG456, FG676, BG575, BG728, and so forth) with or without exposed metal at the top can also use heatsinks at the top for further heat removal. These BGA packages are similar in construction to those used in Graphics cards in PC applications, and heatsinks used for those applications can easily be used for these packages, as well. In this case, the Junction-to-Case resistance is the limiting consideration.
- Outside the package itself, the board on which the package sits can have a significant impact on thermal performance. Board designs can be implemented to take advantage of a board's ability to spread heat. The effect of the board is dependent on its size and how it conducts heat. Board size, the level of copper traces on it, and the number of buried copper planes all lower the junction-to-ambient thermal resistance for packages mounted on the board.

  The junction-to-board thermal resistance for Virtex-II packages are given in Table 4-3. A standard JEDEC type board was used for obtaining the data. Users need to be aware that a direct heat path to the board from a component also exposes the component to the effect of other heat sources - particularly if the board is not cooled effectively. An otherwise cooler component might be heated by other heat contributing components on the board.