Power Measurements: FLEX 10KA vs. XC4000 Devices

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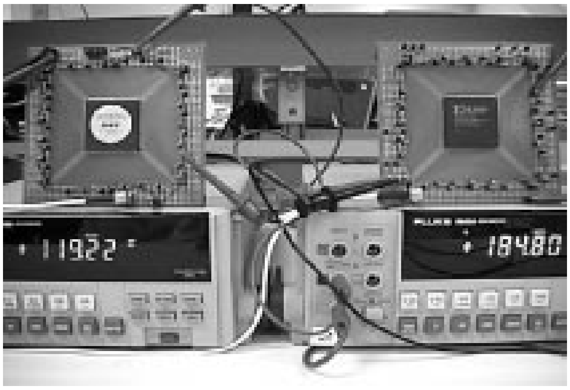
Many factors, such as supply voltage, current consumption, die size, and routing structure, affect semiconductor power consumption. For devices with the same supply voltages, the device current determines power consumption. Although modeling can be an effective tool for estimating the current consumption of a particular design, it is not appropriate for comparing the relative current consumption of the same design in different devices. In addition, modeling current consumption in complex programmable logic devices (CPLDs) is difficult because many factors need to be considered, including the percentage of signals switching, channel capacitance, die size, and device utilization.

In the Xilinx application brief *Low Power Benefits of XC4000E/X Overview* (XBRF 002, May 4, 1997), Xilinx used models to compare the power consumption of its XC4000, XC4000E, XC4000EX, and XC4000XL devices to the Altera® FLEX® 10K and FLEX 10KA devices. The models used a "K" factor, a device-specific scaling factor used to determine current consumption. However, the models did not provide an accurate comparison of device power consumption, because the devices were not evaluated under similar operating conditions. To achieve a fair power consumption comparison, Altera Applications recently performed lab experiments on Altera's EPF10K100A and Xilinx's XC4062XL devices using six typical designs.

Lab Setup

During the experiment, Altera Applications used a Hewlett-Packard 8110A 150-MHz pulse generator to generate the clock signals. Each device was mounted on an individual PC board, and the clock was routed to the device through a terminated connection. All designs had a clock input, one or two control inputs to set the mode of operation, and one output to verify circuit operation. Because the designs were self-exciting, the device required no other inputs. Figure 1 shows the lab setup used in the experiments.

Figure 1. Current Consumption Comparison Note (1)



Note:
(1) Current was measured with a Fluke 8840A volt-ohm meter.

Power Consumption Experiments

The Altera EPF10K100A and Xilinx XC4062XL devices were chosen because they have similar densities and functionality. Designs using RAM and ROM functions were implemented in the FLEX 10KA device's embedded array blocks (EABs) and in the XC4062XL device's configurable logic blocks (CLBs). Table 1 describes the devices used in the experiment.

Table 1. Devices Used in the Experiment

Feature	Altera	Xilinx
Device	EPF10K100ARC240-3	XC4062XLHQ240-3
Logic elements (LEs)	4,992	4,608
EABs	12	0

The first two experiments (i.e., the 14-tap FIR filter and 32 × 32-bit multiplier) represented typical designs and included both registered and logic functionality that used a high percentage of each device. The other experiments tested the current consumption of various RAM implementations as well as the global clock tree. Table 2 details the six designs used in the experiment.

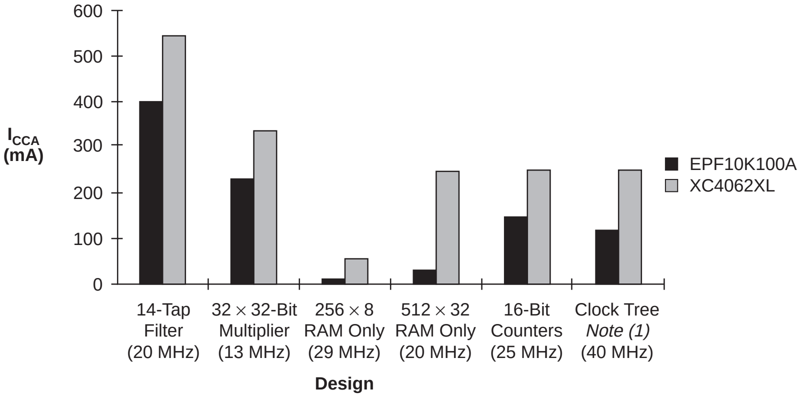
Table 2. Designs Used in the Experiment

Designs	EPF10K100A LEs	XC4062XL LEs, *Note (1)*
14-tap FIR filter (12-bit data)	3,135	3,322
32 × 32-bit multiplier (6-level pipeline)	2,155	2,402
256 × 8-bit synchronous RAM	59	234
512 × 32-bit synchronous RAM	84	1,476
Device half-full of 16-bit counters (144 counters)	2,449	2,452
Clock tree (loaded by 3,000 registers)	3,000	3,000

Note:
(1) One Xilinx CLB is equivalent to two Altera logic elements (LEs).

Figure 2 shows the results of the power consumption experiment.

Figure 2. Power Consumption



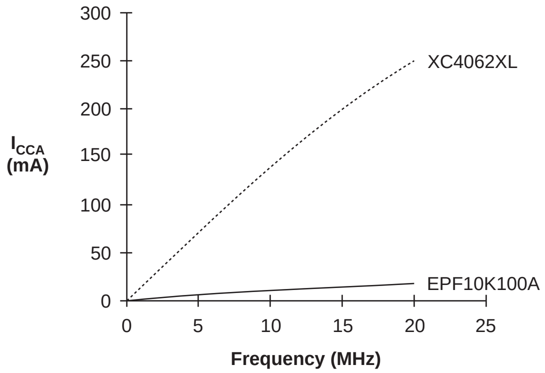
Note:
(1) The clock tree was loaded by 3,000 registers.

The experiment showed that the EPF10K100A device consumed considerably less power than the XC4062XL device. On average, the EPF10K100A device consumed 28% less current than the XC4062XL device for logic-only designs (i.e., designs that do not use EABs in FLEX 10KA devices or distributed RAM in XC4000XL devices).

RAM Power Consumption

In XC4062XL devices, each CLB can be used as a 32 × 1 RAM structure, and larger RAM blocks are built by combining multiple CLBs. In EPF10K100A devices, RAM is implemented in EABs, which contain 2,048 bits of RAM that can be configured in several configurations with widths up to 8 bits wide. On average, RAM implemented in FLEX 10KA EABs used 90% less current than RAM implemented in XC4000XL CLBs (see Figure 3).

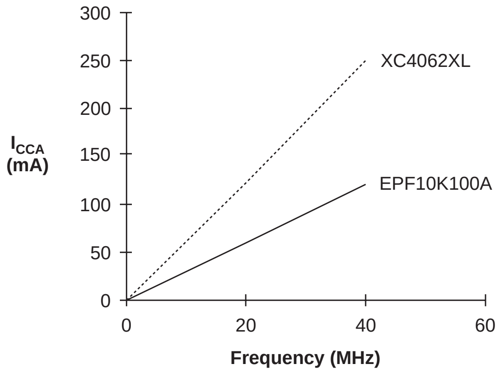
Figure 3. RAM Power Consumption



Clock Tree Power Consumption

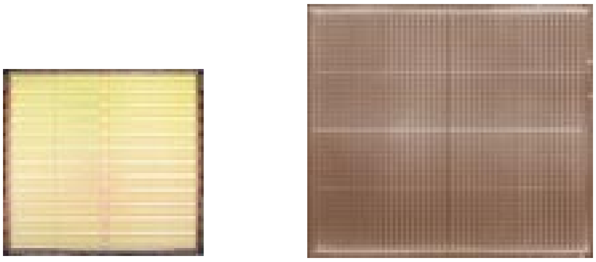
The EPF10K100A device consumed less power than the XC4062XL device for several reasons. For instance, the XC4062XL device had a large clock tree that consumed more power than the EPF10K100A clock tree (see Figure 4). A global clock tree is a network of buffers and signal lines that are connected to all of the registers in the device to ensure that all destinations receive signal transitions simultaneously. In the experiments, the EPF10K100A clock tree consumed 42% less power than the XC4062XL clock tree.

Figure 4. Clock Tree Power Consumption



The clock tree power consumption is directly affected by the size of a clock tree, which, in turn, is directly related to the device's die size. The die of the XC4062XL device is 1.9 times larger than that of the EPF10K100A device (see Figure 5). Therefore, the XC4062XL clock tree consumes more power than the EPF10K100A clock tree.

Figure 5. Die Size Comparison



Altera EPF10K100A
Relative Die Size = 1
0.35-μm Process
4,992 LEs, 12 EABs

Xilinx XC4062XL
Relative Die Size = 1.9
0.35-μm Process
4,608 LEs, 0 EABs

Continuous Routing & Segmented Routing

There are several possible reasons why Altera EPF10K100A devices consume less power than Xilinx XC4000XL devices. The most significant reason is the device interconnect structure. EPF10K100A devices use a continuous interconnect routing structure that is better suited for interconnect routing than the pass transistors used in XC4062XL devices. To demonstrate this difference, model the pass transistors and metal lines as parallel-plate capacitors. The following equation shows that power is linearly related to capacitance (C), voltage (V), and voltage switching.

$$P = Cv\frac{dv}{dt}$$

Because both devices have similar voltage switching characteristics and operate at a 3.3-V core voltage, the capacitance will be a major factor in determining which interconnect structure consumes more power.

$$C \sim \frac{A}{T}$$

The equation above shows that for equivalent unit areas (A = 1), the device with the thicker insulator (T) has less capacitance. The thickness of the XC4062XL pass-gate oxide is about 100 Å versus about 10,000 Å for the EPF10K100A metal line. Thus, EPF10K100A devices have less capacitance and consume less power.

Revision History

The information contained in *Technical Brief 41 (Power Measurements: FLEX 10KA vs. XC4000 Devices)* version 1.01 supersedes information published in *Technical Brief 41 (Power Measurements: FLEX 10KA vs. XC4000 Devices)* version 1.

Technical Brief 41 (Power Measurements: FLEX 10KA vs. XC4000 Devices) version 1.01 contains corrected information on the number of bits per EAB in "RAM Power Consumption" on page 3.

References

The following documents provide more detailed information. Part numbers are shown in parentheses.

- *FLEX 10K Embedded Programmable Logic Family Data Sheet*, available in the ***1998 Data Book*** (A-DB-0198-01)
- *AN 74: Evaluating Power in Altera Devices*, available in the ***1998 Data Book*** (A-DB-0198-01)
- *TB 23: FLEX 10K Power Consumption* (M-TB-023-02)

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