Simulation of Dynamic Voltage and Frequency Scaling using OpenRISC 1200 CPU Simulation

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Motivation
Today’s processors in the computing data, usually at the highest voltage and frequency operation. However, data follow changes over time, so the fixed voltage and frequency can sometimes result in unnecessary power consumption, which not only increases the product’s power consumption, but also shortens its standby time.

Main Contribution
Propose and investigate Dynamic Voltage and Frequency Scaling (DVFS) method, then redesign a Library based on TSMC 0.18 μm Library by Encounter Library Characterizer to make a power-level table, and then, become a standard of the power saving.

System Model

![Diagram of OpenRISC 1200 System Model](image)

(a) The architecture of OpenRISC 1200

(b) The advanced detail of CPU/DSP part

Dynamic Voltage and Frequency Scaling (DVFS)
From reference information, we know that there are three main sources of power consumption, as follows:

\[ P_{\text{total}} = P_{\text{Dynamic}} + P_{\text{Shortcircuit}} + P_{\text{leakage}} \]

- \( P_{\text{Dynamic}} \) is the dynamic-power, usually comes from the charge and recharge of capacitor, the frequently charge will cause considerable power consumption;
- \( P_{\text{Shortcircuit}} \) is the short-circuit-power, when switch transforms, there will a current generated in a flash, and flows from Vdd to Gnd to make additional power consumption;
- \( P_{\text{leakage}} \) is the power generated by leakage current inside the transistors.

The main reasons for behind both are element characterizations and circuit architecture, the effect of adjustment on them is limited, so DVFS is mainly focus on the adjustment of dynamic-power.

Background Knowledge
As above, DVFS is mainly focus on the adjustment of dynamic-power, and from the formulas of it, we can know:

\[ P_{\text{dynamic}} \propto C_L \times V^2 \times f \]

Energy = Power * Power

Assume the value of capacitor doesn’t change, then the dynamic power is proportional to the frequency and the square of voltage. Obviously, modifying the voltage is a more efficient way to reduce the dynamic power, but this also affects the working efficiency, so DVFS has to modify the voltage in the priority of acceptable working efficiency range.

Simulation

(c) The power consumption of OR1200 under the TestBench to calculate an infinite loop of +1

(d) The power consumption of OR1200 under the TestBench

Observation
When OR1200 processes more complicated operation, it will consume more energy.

Conclusion
By applying the DVFS on OR1200, we can change the voltage level to save some power consumption when data flow volume is not so high.

Reference
[1] OpenRISC 1200 IP Core Specification, Rev. 0.9
September, 2010
[2] http://opencores.org/project.or1k