DYNAMIC VOLTAGE AND FREQUENCY SCHEDULING FOR MOBILE DEVICES

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Abstract-**An adaptive method to perform dynamic voltage and frequency scheduling (DVFS) for minimizing the energy consumption of microcontroller. Instead of using fixed update interval, the proposed DVFS system makes use of adaptive update intervals for optimal frequency and voltage scheduling. The system is interconnected with battery, the battery is connected to the ADC and it converts analytical electrical power to digital frequency. Then the microcontroller is internally connected to the oscillator and the oscillator maintains the operating frequency level in that controller. Thus the converted digital frequency is send to the microcontroller, the controller detects the battery power level. If the battery power value is low, the operating frequency level in the microcontroller can be reduced by an oscillator. The optimization enables the system to rapidly track the workload changes so as to meet soft real-time deadlines. The technique, which can be realized with very simple hardware, is completely transparent to the application.**

I. INTRODUCTION

In recent years, researchers have proposed several static and dynamic techniques to scale the operating frequency and voltage of embedded processors. These techniques address power and performance tradeoffs at either hardware [1] or software levels [2]. Software-based scheduling techniques rely on pre collected offline statistical information of different applications and adjust the voltage and frequency accordingly. In [5], static voltage-scheduling techniques for intra-task voltage-scheduling in hard real-time tasks based on the execution profile of the tasks are presented. The optimal intra-task voltage/frequency scheduling for single task real-time systems is found in [6]. The technique used statistical workload information. Both of these works use static voltage scaling approaches. A quasi-static voltage scaling proposed in [7] considers worst-case execution times (WCET) to guarantee the fulfillment of deadline constraints. In reality, the actual execution times of the tasks, for most of the cases, are shorter than their WCETs and may vary by up to 87% relative to the measured WCET execution times in the cases of real-world embedded tasks. In order to track the dynamic changes of the workload and reduce the power consumption accordingly, it is essential to dynamically adjust the voltage during the application run-time. The researchers in [9] and [10] have proposed power management approaches which track the critical path changes and consider the impact of process variations. There are also feedback-based online dynamic voltage and frequency scheduling (DVFS) solutions that dynamically control the clock frequency and supply voltage considering the real operating conditions of the underlying processing hardware [12]. Traditional feedback-based hardware modules for online voltage scaling such as [9] and [10] are computationally expensive, and can hamper the possible energy savings. In this paper we propose an adaptive DVFS method with low area and power overhead to overcome the hardware complexity of online methods. The proposed DVFS not only scale the frequency and voltage to a nearly optimum value, but also reduce the frequency and voltage update rates considering both power consumption and system responsiveness.

II. RELATED WORKS

In this section, we briefly review some of the hardware-based DVFS systems which are most relevant to our proposed scheme. A DVFS method that dynamically controls the clock frequency and supply voltage with a fixed update interval is proposed in [12]. Fixed interval dynamic voltage scheduling (DVS) scheme for multiple clock domain processors has also been presented in [11].

The online DVS method proposed in [9], exploits a scheduling algorithm based on fixed update intervals. The Razor DVS technique [2] uses a delay-error tolerant flip-flop for scaling the supply voltage to minimum allowed value for a given frequency. This method also works based on fixed update intervals. An online hardware-based DVFS scheme for dynamically selecting operating frequencies and voltages in multiprocessor globally asynchronous locally synchronous (GALS) systems is proposed in [5]. This DVFS approach monitors the application workload at predefined times called T sample and scales frequency and voltage values accordingly. The frequency prediction algorithm of this method exploits multipliers and dividers which complicate the hardware realization of this DVFS.

All of these work use fixed update intervals for scheduling voltage and frequency. The optimum value of the fixed update interval strictly depends on the application and patterns of the workloads. Therefore, the value of fixed interval should be carefully tuned for different applications. Fixed update interval DVFS methods can be used when the behavior of the application is predictable for various applications and input conditions and the worst-case behavior is not very different from the average-case behavior. In this system adaptive update intervals are used to predict the frequency and voltage.

III.FREQUENCY SCHEDULING METHODS

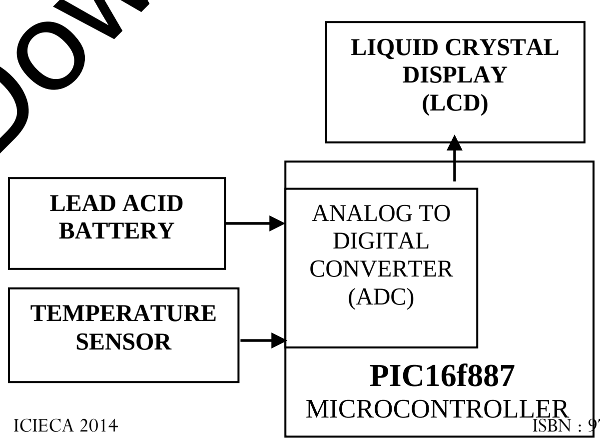
In DVFS algorithms, the supply voltage is adaptively adjusted based on the predicted frequency. Therefore, one of the major challenges of DVFS systems is how to determine the optimal working frequency without violating the deadlines. This can be assured by following a simple conservative rule, which states that the processing of the current workload must be finished prior to the arrival of the next workload. In this way, we may consider the arrival time of the next workload as an effective deadline for the current workload in soft real time applications. Knowing the effective deadline for each workload, the frequency maybe adjusted to the lowest required value. The importance of the effective deadline in the frequency adjustment is shown in [21] by considering greedy and deadline-aware frequency scheduling policies. The frequency scheduling circuitry presented in [12] exploits an activity monitor and counts the number of idle cycles of the processor in fixed update intervals. When the number of idle cycles in an interval exceeds a threshold value, the frequency is lowered otherwise, the frequency is increased or held steady. The frequency update rate in [12] directly depends on the value of the fixed interval, i.e., larger values for the interval lead to lower rates of the frequency changes, and hence, a weaker workload tracking ability. On the other hand, choosing small values for the fixed interval leads to unnecessary frequency and voltage updates.

3.1 Proposed Frequency Scheduling Method

An adaptive method to perform dynamic voltage and frequency scheduling (DVFS) for minimizing the energy consumption of microcontroller is presented.

Instead of using fixed update interval, the proposed DVFS system makes use of adaptive update intervals for optimal frequency and voltage scheduling. The system is interconnected with lead acid battery, the battery is connected to the Analog to Digital Converter (ADC) and it converts analytical electrical power to digital frequency.

Fig.1. Block Diagram of the System



Then the microcontroller is internally connected to the oscillator and the oscillator maintains the operating frequency level in that controller. Thus the converted digital frequency is send to the microcontroller, the controller detects the battery power level. If the battery power value is low, the operating frequency level in the microcontroller can be reduced by an oscillator .Then the frequency variation across the voltage is shown using LCD display. The optimization enables the system to rapidly track the workload changes so as to meet soft real-time deadlines.

IV. SIMULATION AND ITS RESULT

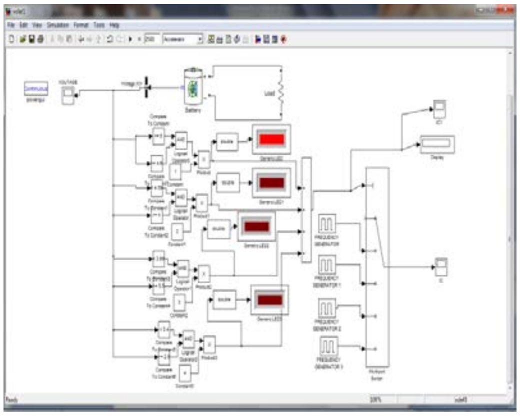


Fig.2. DVFS Simulation

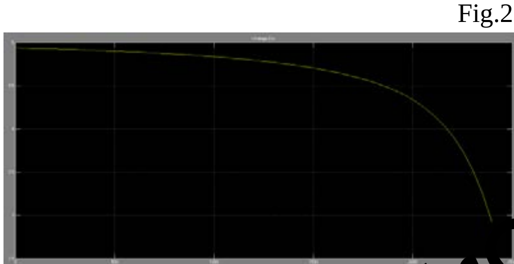


Figure.3. Input voltage waveform

Figure.4. Output waveform

Simulation is done in MATLAB-Simulink. Based on the particular voltage range the corresponding frequency is selected using switch. Particular task will be run based on the selected frequency is shown via graph.

CONCLUSION

In this work, an efficient and adaptive update interval method for dynamic voltage and frequency management was proposed. Thus system with adaptive update intervals has advantages such as highly reliable system, reduction in heat dissipation, high energy efficiency and increase in the access time of the device. The results showed that the proposed adaptive interval DVFS technique could save power more with fewer frequency updates as compared to the fixed interval DVFS systems.

REFERENCES

[1] B. C. Mochocki, X. S. Hu, and G. Quan, “A unified approach tovariable voltage scheduling for nonideal DVS processors,” IEEE Trans. Comput.-Aided Des. Integr. Circuits Syst., vol. 23, no. 9, pp.
1370–1377, Sep. 2004.

[2] T. Burd, T. Pering, T. Stratakos, and R. W. Brodersen, “A dynamic voltage scaled microprocessor system,” IEEE J. Solid-State Circuits, vol. 35, no. 2, pp. 294–295, Feb. 2000.

[3] J. R. Lorch and A. J. Smith, “PACE: A new approach to dynamic voltage scaling,” IEEE Trans. Comput., vol. 53, no. 7, pp. 856–869,Jul. 2004.

[4] S. Liu, Q. Qiu, and Q. Wu, “Energy aware dynamic voltage and frequency selection for real-time systems with energy harvesting,” in Proc. Des., Autom. Test Euro., 2008, pp. 236–241.

[5] J. Seo, T. Kim, and J. Lee, “Optimal intratask dynamic Voltage-Scaling technique and its practical extensions,” IEEE Trans. Comput.-Aided Des. Integr. Circuits Syst., vol. 25, no. 1, pp. 47–57, Jan. 2006.

[6] Z. Lu, Y. Zhang, M. Stan, J. Lach, and K. Skadron, “Procrastinating voltage scheduling with discrete frequency sets,” in Proc. Des., Autom. Test Euro., 2006, pp. 456–461.

[7] A. Andrei, M. Schmitz, P. Eles, Z. Peng, and B. M. Al-Hashimi, “Quasistatic voltage scaling for energy minimization with time constraints,”
in Proc. Des. Autom. Test Euro., 2005, pp. 514–519.

[8] M. Najibi, M. E. Salehi, A. Afzali Kusha, M. Pedram, S. M. Fakhraie, and H. Pedram, “Dynamic voltage and frequency management based on variable update intervals for frequency setting,” in Proc. IEEE/ACM Int. Conf. Comput.-Aided Des., Nov. 2006, pp. 775–780.

[9] Q. Wu, P. Juang, M. Martonosi, and D. W. Clark, “Formal online methods for voltage/frequency control in multiple clock domain microprocessors,” in Proc. ASPLOS-XI, Oct. 2004, pp. 248–259.

[10]P. Choudhary and D. Marculescu, “Power management of voltage/frequency Island-based systems using hardware-based methods,” IEEE
Trans. Very Large Scale Integr. (VLSI) Syst., vol. 17, no. 3, pp. 427–438, Mar. 2009.

[11] S. Herbert and D. Marculescu, “Analysis of dynamic voltage/frequency scaling in chip-multiprocessors,” in Proc. Low Power Electron. Des.,
Aug. 2007, pp. 38–43.

[12] M. Nakai, S. Akui, K. Seno, T. Meguro, T. Seki, T. Kondo, A. Hashiguchi, H. Kawahara and M. Shimura, “Dynamic voltage and frequency management for embedded processor,” IEEE, vol. 40, no. 1, pp. 28–35,Jan. 2005.

[13] S. Das, D. Roberts, S. Lee, S. Pant, D. Blaauw, T. Austin, K. Flautner, and T. Mudge, “A self-tuning DVS processor using delay-error detection and correction,” IEEE J. Solid-State Circuits, vol. 41, no. 4, pp. 792–804, Apr. 2006.

[14] K. J. Nowka, G. D. Carpenter, E. W. MacDonald, H. C. Ngo, B. C. Brock, K. I. Ishii, T. Y. Nguyen, and J. L. Burns, “A 32-bit PowerPC system-on-a-chip with support for dynamic voltage scaling and dynamic frequency scaling,” IEEE J. Solid-State Circuits, vol. 37, no. 11, pp. 1441–1447, Nov. 2002.