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A Novel Approach FPGA Based High Performance Wireless Embedded System

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Abstract:

Traditional wired system has limited performance and complex system with low sample rate for multiple applications. For particular application it needs to design particular hardware and software. With wireless system low-power modules that offer limited computational performance and communication bandwidth. In this paper, a hardware platform which combines microcontroller and FPGA is presented. This hardware platform is application independent. This platform has features that allow easy reuse of the hardware in several applications avoiding redesigning the system. The flexibility provided through dynamically configurable interfaces and power management, helps optimizing performance and power consumption for different applications.

Keywords: FPGA, Microcontroller, Wireless system, low power consumption, Sensors, LCD, Android application

1. Introduction

The limited bandwidth and high-power consumption of radio transceivers that are typically used, the major challenge lies in transmitting a large amount of data generated by high-sample rate applications. In order to overcome this challenge, researchers have proposed in-sensor processing in which, raw data is processed locally in a sensor node, and only results are transmitted wirelessly. Therefore, it reduces communication activity and the associated power consumption. However, it is observed that typical low-power micro-controllers integrated in sensor nodes, often lack high-throughput performance when complex mathematical and signal processing algorithms are involved. Therefore, to meet the demands of high computational performance, the prototype design reported in employs a high throughput micro-controller for in-sensor data processing, in addition to a low-power 8-bit micro-controller. FPGA-based commercial evaluation kits and micro-controller based wireless nodes were used to investigate their performance and energy consumption for high-sample rate applications. Based on the presented results in these articles, it can be concluded that high-throughput processing requirements can only be fulfilled through an FPGA, however, by accurately distributing the processing, communication and control specific tasks on a micro-controller and an FPGA, it is possible to optimize both the performance and power consumption for an application. Apart from that, inter module communication interfaces such as between FPGA and micro-controller, and between wireless transceiver and micro-controller are fixed in these nodes and therefore, cannot be re-Configured for different applications without modifying the hardware design. Additionally, the compactness of these nodes is compromised because of the extra height, resulting from the interface connectors on both sides of a layer and also stacking of four layers on top of each other to form a complete working node

2. Method

2.1. Hardware

A simplified design of platform, representing all major components and their interconnections is shown in Figure 1. With the exception of power source, all other components are integrated in platform.

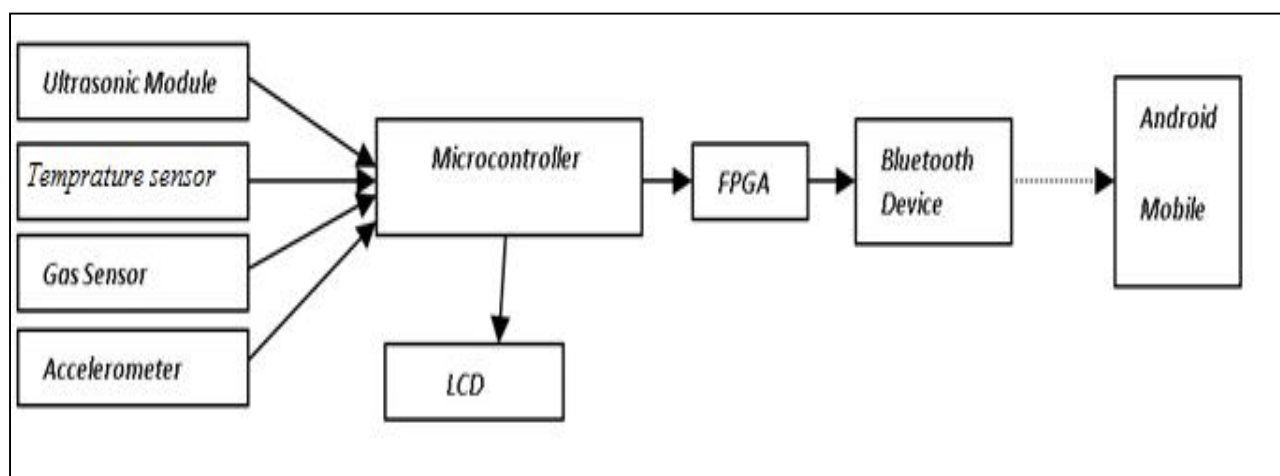


Figure 1: Block diagram

In order to achieve a high-computational performance, two processing resources, a PIC microcontroller PIC16f877A and a Spartan-6 FPGA XC35250 are integrated together. The micro-controller can be used to process the application data, read the sensor's data, and/or communicate with the radio transceiver in order to transmit or receive data/results. In addition to its application dependent data processing, the micro-controller performs all the control specific operations such as power and FPGA configuration management and therefore, acts as a central control unit in the platform. The micro-controller can be used as the main processing unit for a wide variety of monitoring applications. In order to achieve a high-throughput computational performance as required in many high-sample rate applications, the FPGA is integrated into the platform. Due to hardware parallelism, it is possible for multiple independent tasks to be realized using dedicated hardware logic in the FPGA, which thus be performed simultaneously at high speed. In addition, the re-configurability of the FPGA allows synthesizing different algorithms with optimized control and data paths, without modifying any real hardware. In order to enable wireless communication in the platform, an IEEE 802.15.4 compliant low-power radio transceiver, HC05(CC2540) is integrated in the design. The transceiver operates at the 2.4 GHz license free band and provides a maximum throughput of 250 kbpS. So here microcontroller reading sensors output and processing data in microcontroller and in FPGA output is displayed through radio transceiver on android mobile with use of self developed android application.

2.2. Software

In order to use this platform for an application, supporting software must be developed for both the micro-controller and the FPGA. Currently, this is achieved using two different software development environments. The programming is done in c code so its user friendly. For both PIC and FPGA different software is used to burn code and to write code. Arduino is used to write and burn the code in FPGA and PICKIT is used to burn the code in PIC. And mikro c used to write code for PIC. Diptrace is used for pcb designing.

3. Results and Discussion

Following tables describes the sensors output collected on android application and both tables explains how power consumption is lowered by switching off the components when there is no use of them.

Total power with gas sensor:-

Sensor No.	Type of sensor	Reading	Units
1.	Accelorameter	10	cm
2.	Ultrasonic module	X data =1372, Y data= 1640	mm
3.	Gas leakage sensor	98	%
4.	Temperature sensor	34	Degree Celsius

Table 1: Total power without gas sensor

Sensor No.	Type of sensor	Reading	Units
1.	Accelerometer	10	cm
2.	Ultrasonic module	X data =1372, Y data= 1640	mm
3.	Gas leakage sensor	00	%
4.	Temperature sensor	34	Degree Celsius

Table 2

4. Conclusion

I presented a high-performance and low-power wireless hardware platform, that is capable of performing high-throughput in-sensor processing, as typically required for high-sample rate monitoring applications. The platform integrates a micro-controller, an FPGA and a radio transceiver in order to realize a high-performance compact wireless platform. This application independent platform allows for the integration of any kind of sensors through an application specific and customized sensor layer.

5. References

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