ZIGBEE Operated FPGA Based Nodes in Wireless Industrial Automation Monitoring and Control

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***Abstract*: There has been a rapid growth in the extremes of Industrial Monitoring and Control, particularly in the domain of Automation processes. This is due to the extensive involvement of automation in every industry possible and the ease of maintenance is only multiplied by the advances of the automation technology. This needs an efficient way of monitoring and control of the industrial processes. More and more applications are wireless oriented these days. Hence this paper aims at bringing the flexibility of Field Programmable Gate Arrays with a layered architecture that facilitates the maintenance of the Operations in a efficient way and the ZigBee wireless technology together onto one integrated application. It is a prototype technology where a node is more flexible using FPGA and the data and control statements are communicated using ZigBee Standard protocols.**

Keywords: ZigBee, FPGA, Wireless Monitoring, Control techniques.

I.INTRODUCTION

The industry has developed in all aspects of control and monitoring. There have been developments on wired control and automation technologies. But a FPGA included with a Zigbee wireless Monitor and Control Authority is a welcomed innovation in the industries run by automation techniques like Textile, Automotive Manufacturing etc.

II.FOUR LAYER ARCHITECTURE

For a detailed approach, the operation of any system can be divided into 4 layers. This accounts for the famous 4 layered modular concept used in the industry. Many appliances are designed on the grounds of this approach.

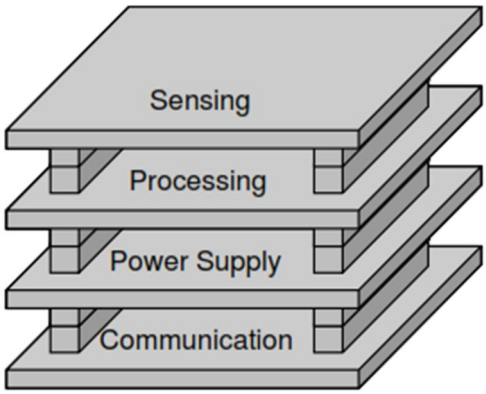


Fig 1 Modular Architecture (See Ref [1])

MODULARITY: Modularity is an important feature of the node. The purpose is to have a modular platform, flexible and adaptable to several applications and scenarios, and to be able to reuse and interchange between different layers when the application changes. Moreover, the architecture must satisfy several design requirements as it has been said before.

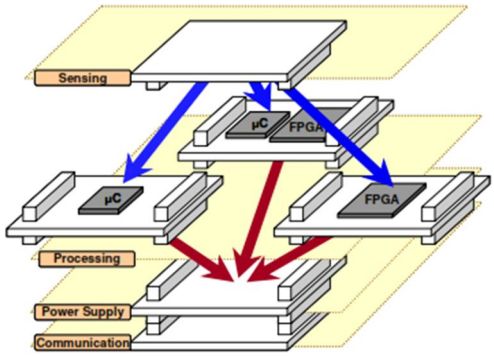


Fig 2 Modular Architecture explained (See Ref [1])

To achieve this goal, a four layers modular architecture is proposed.

With a modular platform new advantages arise, like easy redesigning or the possibility of reusing and interchanging layers,which reduces cost and time.

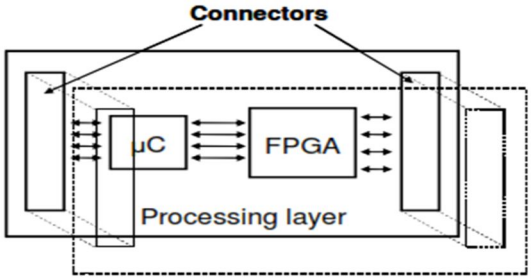


Fig 3 Processing Layer of Modular Architecture

PROCESSING LAYER: This module provides the smart sensor with intelligence. Here, the signals from the sensors are converted into appropriate digital and processed signals. Moreover, the control of the communications is carried out in this module. Searching of neighbor nodes, setting and breaking links, and management of all the tasks related with the network are controlled here by generating commands to the ZigBee module, and interpreting commands from the ZigBee module and other network nodes. Power saving modes are managed here too in order to extend the battery life. This is an important matter in wireless sensor networks because it is required that the network works autonomously for a long time without human intervention.

The FPGA: The FPGA is a Spartan III from Xilinx, This device gives the node a big freedom to adapt to new applications, and makes the system versatile in its processing capabilities.
The main feature of FPGAs is concurrency. This allows the processing layer to manage complex digital sensors in a fast way and the FPGA processes the most complex signals. The FPGA needs three different power voltages, specifically 3.3, 2.5 and 1.2 V. These voltages come from the power supply layer; this point will be commented later on.

SENSING LAYER:
This module includes sensors and/or actuators to interact with the environment. According to the use of the smart sensor network, multiple combinations are possible. Multiple kinds of sensors can be included in this level, and actuators may be incorporated as well in order to act according to parameters measured from the environment.

COMMUNICATION LAYER: In the communication layer a ZigBee module has been chosen for the first prototype. This election was done because ZigBee has low power consumption, enough data rate for the intended applications; it is a widely used technology and works in the 2.4 GHz ISM free license frequency band. This module acts as a serial cable replacement. The FPGA communicates with the ZigBee module through its UART port. Anyways, the FPGA can solve any problem related to interfacing with the communications layer because it is possible to virtually implement any circuit inside this device. Vertical connectors make this possible, because many signals pass through the communication layer to the processing layer. This point has been taken into account specially to ensure compatibility of the node with future versions of the different layers. Other technologies are being studied in order to adapt the module to other application scenarios and to reduce power consumption and network complexity, like Bluetooth or a proprietary protocol.

POWER SUPPLY LAYER: This layer generates all the voltages that are needed by the different devices of the node. In the first prototype, the layer takes 5V from an external power supply. With linear regulators the layer supplies 3.3, 2.5 and 1.2 V to the node.

III.APPLICATION

A. Wireless Control and Monitoring:

The processes in the industry are very well automated and developed in the recent years.

But the control and Monitoring of each machine is still manual. There is no single control for every device in the industry. This project aims at this very point of importance. The main modules used in the project are:

- Spartan III from Xilinx, specifically an XC3S200 (which integrates 200k logic gates). IR Based Counter
- On Site First Person Interface
- Prototype of Conveyer tracks used in the industry
- ZigBee Module
- PC Interface

The Project Idea:

There are 4 modules that can be controlled in the industry using this project. This can be extended to meet the required industry's demands by using FPGA in processing layer unlike a Microcontroller with limited processing and i/o capabilities.

1. Industrial Product Counter:

Fig 4 IR Transmitter and Receiver

In the industry, there are conveyer belts either to transport the products or to convey the raw materials depending on the industry. This is modeled by the Conveyer belt in the prototype. Whenever a person picks up an item from the belt and IR Sensor based counter at the end of the belt counts the item.

2. Fuel or Water Level Monitoring

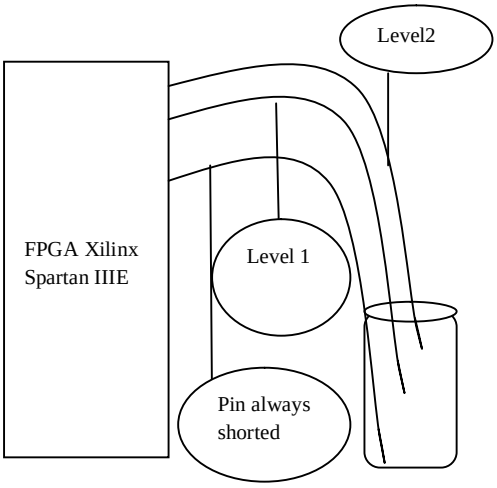


Fig 5 Water Level Indicator depiction

In the industry, the fuel and water levels are to be constantly monitored and accounted for. Hence a Water Level Indicator is used for this purpose.

3. Smoke Detector:

Fig 5 Smoke Sensor

In the industry, even a small fire can cause irrevocable damage. So a fire Detection mechanism based on Smoke Sensing is embedded in the prototype project to prevent the huge losses by pre detecting the fire. So MQ2 Smoke Sensor is used to detect the smoke. It is an optical based Smoke detection sensor.

4. First Person Monitoring Terminal :

Fig 6 2X16 LCD Module

A First Person monitor ensures there is an interface for the onsite personnel to have an idea of what is happening around them and a supervisor can monitor the status of the machinery.

5. Wireless Control of the Machinery:

Fig 6 ZigBee Transmitter

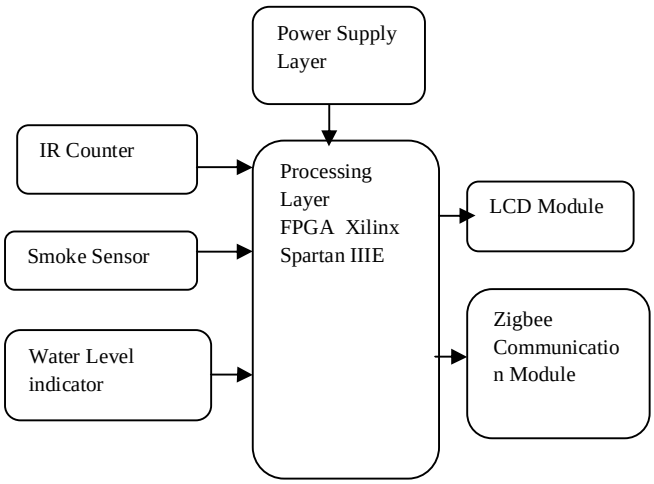
In the industry the control of machinery is the key to a profitable and optimum production. SO a Wireless Control using ZigBee ensures uninterrupted connectivity and Superior Control. The prime reason for using ZigBee is its low Cost and high efficiency.

The ZigBee communicates at 2.4Ghz Ism free license band. It can detect the surrounding nodes and send and receive date seamlessly. The aim of the project to control the machinery wirelessly can

be achieved using this ZigBee pair by NSK Electronics available in India.

Finally using this module we can monitor the inputs, outputs, machinery in the industry through one pc using a wireless communication. We can automate an industry to a maximum extent using this module.

6. Project Block Diagram:



IV.CONCLUSION

This Project idea when implemented commercially will result in efficient monitoring and control of industrial automation. Energy efficient routing in wireless sensor networks constitute a challenging research area. More energy saving methods are being developed so that the applications of wireless sensor networks can be further extended to many fields.

There will be immense control and monitoring capabilities once this product is launched in industries. In future, further development is envisaged that may lead to a commercially available product.

ACKNOWLEDGMENT

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