A HYBRID WIRELESS NETWORKING INFRASTRUCTURE FOR GREENHOUSE MANAGEMENT USING ARM

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ABSTRACT ---The technological development in Wireless Sensor Networks made it possible to use in monitoring and control of greenhouse parameter in precision agriculture. Due to uneven natural distribution of rain water it is very crucial for farmers to monitor and control the equal distribution of water to all crops in the whole farm or as per the requirement of the crop. All the parameters of greenhouse require a detailed analysis in order to choose the correct method. With the evolution in wireless sensor technologies and miniaturized sensor devices, it is possible to use them for automatic environment monitoring and controlling the parameters of greenhouse, for Precision Agriculture (PA) application. In the Field bus concept, the data transfer is mainly controlled by a suitable wired communication system, now can be replaced with the hybrid system(wired and wireless) to extract the benefits of both and to automate the system performance and throughput. ZigBee protocols based on IEEE 802.15.4 – 2003 for wireless system are used. The atmospheric conditions are monitored and controlled online by using Ethernet IEEE 802.3. Partial Root Zone Drying Process can be implemented to save water at the maximum extent. Online interaction can be made with the farmers by the consultant to give them the knowledge about this technique and implement it effectively in their farms to extract more yield with advanced technology.

Index Terms—Controller Area Network (CAN), greenhouse monitoring, hybrid network, wireless sensor networks (WSNs), ZigBee, Partial Root zone Technique.

I.INTRODUCTION

In the Green House farms, data transfer is very important factor. The process of using either fully wired or wireless systems may create some problems. This can be overcome by using hybrid system of using both wired and wireless systems. Thus power consumed will be reduced as low as possible and data transfer will be efficient with automation to get better yield. The entire farm can be controlled by LAN Network. The network topology that has to be implemented depends on the requirement of the farm application. Various network topologies can be implemented. Each node will be connected with the sensors, solenoid valves, ARM Microcontroller. They are connected with each other by wireless systems. The implementation of a wireless backbone, which contain several nodes should be high enough in number to provide a certain level of redundancy for both fault tolerance and performances, to allow multiple paths, and to avoid bottlenecks. An integrated wired/wireless solution allows one to exploit the positive aspects of both technologies by improving performances and productivity. While moving on to the wired section a Controller Area Network (CAN) type network has been chosen because of its simplicity, Robustness, flexibility, cheapness, and good performances. For the wireless section, a ZigBee type network has been chosen because it resembles the modern art of wireless sensor network. ZigBee protocols based on IEEE 802.15.4 –

2003 is used for the internodal communication. All the nodes will communicate with the master node by which they are controlled. Ethernet whose standard is IEEE 802.3 in 1985.is used for connecting the system to internet so that the whole system can be controlled online. All these nodes can be connected to the control unit through wired system using CAN. The sensors are designed for collecting information about the Climatic condition of the green house like Temp, Light, Humidity. All these parameters give the outside world information about the climate. With the help of this system will decide the action about the controls like, screen control (protect the direct sunlight and sun heat) and sprinkler.

Modern agriculture offers a range of benefits, including greater production and higher incomes for farmers including small producers in both developed and developing countries. Technical advances also have sharply reduced environmental impacts, enabling reduced pesticide, herbicide and fertilizer use, less tillage, and less land and water use per unit of output all decreasing pressure on fragile global ecosystems. It is clear that we have a productivity gap going forward, a gap that we must begin now to close. If we are to double agricultural output by 2050 and do so with basically the same amount of land and water as we have today while also reducing the environmental footprint then clearly we must become more productive than we have been in the past. That is the productivity gap, which is our challenge. Recently, potentiometric sensors have

appeared that take profit of the electric field generated by the membrane potential caused by presence of specific ions; the electric field modulates current in a field effect transistor, in this way these sensors are known as Ion Selective Field Effect Transistors (ISFETs). ISFET sensors have a great future in continuous monitoring, given that they are able to determine ions at very low concentrations and they can be massively produced using VLSI technology. In agricultural farms where operation and environmental conditions are quite aggressive the robust and cheap ionic sensors that provide exact information of the ionic composition of the nutrient solution are very useful, although accuracy is not excessively high. The technique is also suitable for expensive crops like strawberry and mushrooms in closed soilless systems. The closed soilless systems is a techniques implemented in modern horticulture in order to improve the efficiency in the use of water and fertilizers and to preserve the environment. In few words, in this technique, plants grow on artificial substrates which substitute natural soil. A fertilizer supply unit provides nutrients and the solution not used by the plants is collected and regenerated to be reused several cycles. The addition of new fertilizer ions (ammonium, potassium, nitrate, phosphate) and tap water is controlled by the value of electrical conductivity (EC) and pH signals. However, this protocol can only give a qualitative control over these species given ions uptake by the plants may vary. In the closed soilless systems non-essential ions such as sodium and chloride accumulate in nutrient solution causing an increase in the overall EC and consequently a decrease of the concentration of the nutrient ions if the conductivity is maintained at a fixed value. Therefore, the measurement of the concentration of each individual ion in the nutrient solution in continuous mode, and in real-time can be a clear improvement to normal use in this area, and can lead to fine control of fertilizer dosage adapted to each plant stage. This is my simple concept and approach, to bring our agricultural system into the world class recognition.

II. SYSTEM ARCHITECTURE

Earlier GMH was designed in either fully wired or wireless systems. As the wireless systems are battery operated, they should be checked periodically for battery life to avoid the failure of the system. Also these wireless components will cover a minimum area or distance due to limited bandwidth range of communication. By the time, if fully wired system is considered, the installation and the maintenance cost will be more compared to the other. Also wiring is not possible in all the area like plants growing in fully wet area. There should be a person always to monitor the farm from the control room. The Real- Time Automation and Monitoring System consist of Sensors for measuring different parameters, number of nodes, ARM Controller,

Communication mediums like CAN bus for wired system, Zigbee for wireless system, Ethernet for controlling and monitoring the parameters online and solenoid valves to control the water flow for the plants.
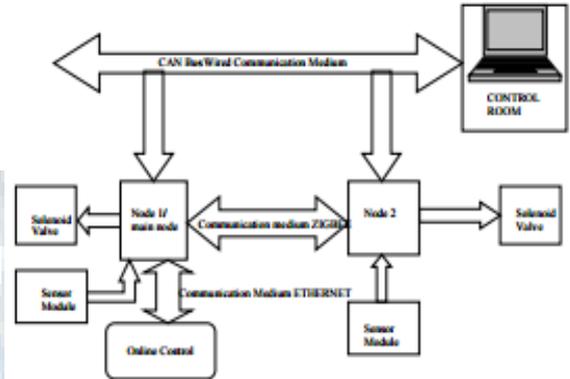

Figure 1: Greenhouse Controlling and Monitoring System

III. NODAL NETWORK

In the Greenhouse Management, the network is defined as a collection of nodes and other hardware interconnected by communication channels that allow the sharing of resources and information, where at least one process in one device is able to send/receive data to/from at least one process residing in a remote device. Node is a point in which the set of components like sensors, ARM microcontroller are all connected along with the bus. Each node is placed at different locations in the greenhouse farm so that all the parameters can be measured in that particular place which also covers certain space around it. Thus the number of nodes used depends upon the area of the farm. Functions of Node: The Sensors which are present on each node measures the parameters. They are then converted to digital form by the analog to digital converter which are present within the ARM microcontroller. A real time clock is set within the node. MAX232 which are present in each node is used for communicating with the serial port to the main control room. All nodes can be communicated with each other by Zigbee. Finally in the output of each node, solenoid valves are connected. Thus according to the parameters and the requirement of water by the plants by analyzing the data, the water will be controlled and supplied to the farms through the valve. Master Node: The components present in the main node and their functions will be the same as that of the other nodes. But an additional feature of Ethernet is present within this node. Thus all the parameters from all other nodes which are fetched by the main node can be monitored online through Ethernet. Each nodes are connected to the main control room through CAN bus.

IV. HARDWARE COMPONENTS DESCRIPTION

A. Sensors

Many types of sensors are used to measure various parameters like temperature, humidity, light which are to be controlled for effective growth of greenhouse plants.

B. ARM Controller

The ARM Microcontroller used here is LPC2138 based on Cortex M3.The ARM Cortex-M3 CPU incorporates a 3-stage pipeline and uses a Harvard architecture with separate local instruction and data buses as well as a third bus for peripherals. The ARM Cortex-M3 CPU also includes an internal prefetch unit that supports speculative branching. The peripheral complement of the LPC1768 includes up to 512 kB of flash memory, up to 64 kB of data memory, Ethernet MAC, USB Device/Host/OTG interface, 8-channel general purpose DMA controller, 4 UARTs, 2 CAN channels, 2 SSP controllers, SPI interface, 2C-bus 3winterfaces, 2-input plus 2-output ,2S-bus interface, 8-channel 12-bit ADC, 10-bit DAC, motor control PWM, Quadrature Encoder interface, four general purpose timers, 6-output general purpose PWM, ultra-low power Real-Time clock (RTC) with separate battery supply, and up to 70 general purpose I/O pins. Here the ARM Controller performs the entire controlling function. There are 8 Analog to Digital converters which are inbuilt within the ARM controller. Thus the analog signals from the sensor are converted to digital form for further process. The communication medium like CAN and Ethernet are connected to the ARM Controller which controls the data flow. Also the relay connected to the ARM Controller will be controlled for the flow of water through the Solenoid valves according to the data give to the Controller.

C. Relay Driver

Relays are simple switches which are operated both electrically and mechanically. Relays consist of an electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. The main operation of a relay comes in places where only a low-power signal can be used to control a circuit. It is also used in places where only one signal can be used to control a lot of circuits. Here Relays are used for controlling the Solenoid Valves.

D. Solenoid Valve

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid. A solenoid valve has two main parts: the solenoid and the valve. The solenoid converts electrical energy into mechanical energy which, in turn, opens or closes the valve mechanically. A direct acting valve has only a small flow circuit. A diaphragm piloted valve multiplies this small pilot flow, by using it to control the flow through a much larger orifice. Solenoid valves may use metal seals or rubber seals, and may also have electrical interfaces to allow for easy control. A spring may be used to hold the valve opened (normally open) or closed (normally closed) while the valve is not activated. Here it is used for controlling the flow of water to the plants in the greenhouse farm.

E. Analog to Digital Converter

The Successive Approximation (SAR) architecture is very suitable for data acquisition; it has resolutions ranging from 8bits to 18 bits and sampling rates ranging from 50 KHz to 50 MHz. The most effective way to create a Giga rate application with 8 to 16 bit resolution is the pipeline ADC architecture.
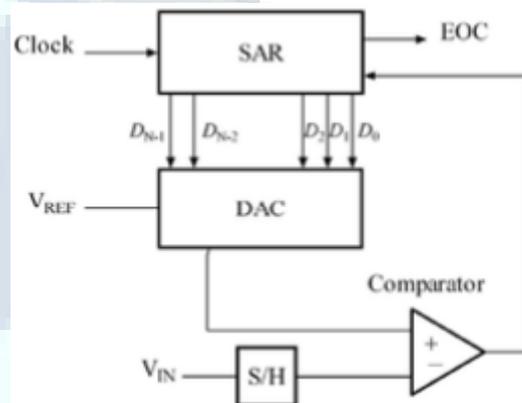

Figure 2: Successive Approximation ADC Block Diagram

Algorithm The successive approximation Analog to digital converter circuit typically consists of four chief sub circuits:

- A sample and hold circuit to acquire the input voltage (Vin).
- An analog voltage comparator that compares Vin to the output of the internal DAC and outputs the result of the comparison to the successive approximation register (SAR).
- A successive approximation register sub circuit designed to supply an approximate digital code of Vin to the internal DAC.
- An internal reference DAC that supplies the comparator with an analog voltage equivalent of the digital code output of the SAR for comparison with VIN.

The successive approximation register is initialized so that the most significant bit (MSB) is equal to a digital 1. This code is fed into the DAC, which then supplies the analog equivalent of this digital code (Vref/2) into the comparator circuit for comparison with the sampled input voltage. If this analog voltage exceeds Vin the comparator causes the SAR to reset this bit; otherwise, the bit is left a 1. Then the next

bit is set to 1 and the same test is done, continuing this binary search until every bit in the SAR has been tested. The resulting code is the digital approximation of the sampled input voltage and is finally output by the DAC at the end of the conversion (EOC). Mathematically, let Vin = xVref, so x in [-1, 1] is the normalized input voltage. The objective is to approximately digitize x to an accuracy of 1/2n. The algorithm proceeds as follows:

1. Initial approximation $x_0 = 0$.

2. i th approximation $x_i = x_{i-1} - s(x_{i-1} - x)/2^i$. where, s(x) is the signum-function(sgn(x)) (+1 for x ≥ 0, -1 for x < 0). It follows using mathematical induction that $|x_n - x| \leq 1/2^n$.

As per the algorithm, a SAR ADC requires:

I. An input voltage source Vin.

II. A reference voltage source Vref to normalize the input.

III. A DAC to convert the ith approximation xi to a voltage. 4. Comparator to perform the function s(xi - x) by comparing the DAC's voltage with the input voltage.

IV. A Register to store the output of the comparator and apply $x_{i-1} - s(x_{i-1} - x)/2^i$.

V. OTHER FEATURES

Partial Root Zone Drying:

The technique of using limited quantity of water for the purpose of agriculture has become an important feature all over the world. The Partial Root Zone Drying approach is used to irrigate alternatively wet and dry prescribed parts of the plant root system, to maintain the plant water status control vegetative growth for prescribed parts of the seasonal cycle of plant development. This Technique can be implemented by using solenoid valves through which the direction of the flow of water can be changed for any periodic time interval.

V.IMPLEMENTATION

The system was designed in Embedded C and implemented in Proteus with JAVA background.
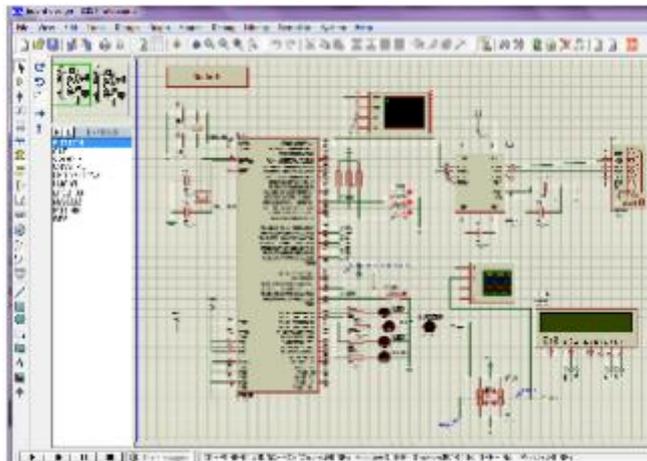

Figure 3: Design of single node in Proteus

Software used:

The following are the software used for designing the system to monitor and control the greenhouse farm.

A. KEIL µVision IDE:

The µVision IDE from Keil combines project management, make facilities, source code editing, program debugging, and complete simulation in one powerful environment. The µVision development platform is easy-to-use and helping you quickly create embedded programs that work. The µVision editor and debugger are integrated in a single application that provides a seamless embedded project development environment.

B. Flash Magic:

Flash Magic is a PC tool for programming flash based microcontrollers from NXP using a serial or Ethernet protocol while in the target hardware. It is used to load the ARM Controller with Necessary Embedded C Programming, by which the Controller performs its function.

Languages used:

A. Embedded-C:

The functions of analog to Digital Conversion are implemented in Embedded C Language.

VII. RESULTS

A. Simulation Result for Analog to Digital Conversion

The following is the design of Analog to Digital Converter Implemented using PROTEUS software. As the Switch is turned on the LED glows and it starts its function.
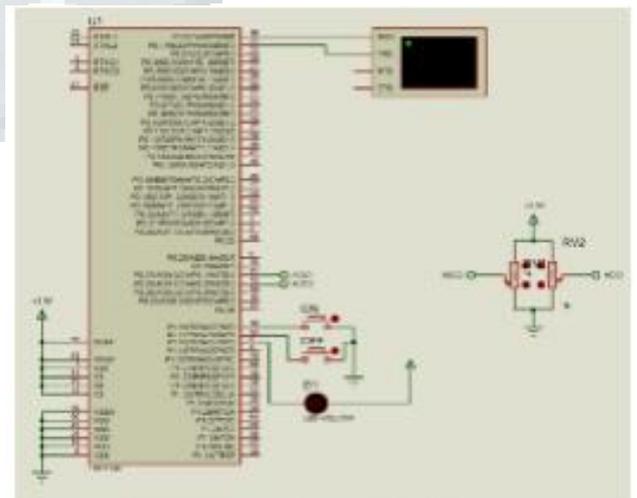

Figure 4: Design of ADC in Proteus

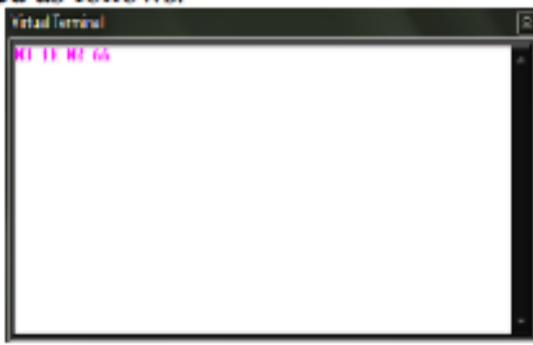The output of the A/D converter will be generated as follows

Figure 5: Simulation of ADC in Proteus

VIII. CONCLUSION

In future this project can be extended by using Optical communication System with wavelength routing networks. This can be implemented using advanced ARM Controllers and core processors. Also long term deployment and implementation in many rooms to improve the monitoring condition can be deployed including the challenges mentioned above. Also future research can be focused on the energy saving, data fusion and other directions.

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