ZigBee Based Intelligent Wireless Overhead Tank Monitoring and Controlling System

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Abstract : The paper presents work on the design and development of overhead water tank monitoring and controlling system using IEEE 802.15.4 based wireless technology which provides a reliable and smart solution to overcome the problem of water wastage and damage of equipments. Energy efficiency, compactness, cost effectivness are the novelties of the proposed system. Different intelligent protocols like flexible operating modes, dynamic power management system, energy efficient routing protocols, two way communicationsare implemented in this system. Three sensor nodes are developed using Atmega328 based centralized embedded system platform. The wireless network offers multihop communication between node to base station. Data exchanged between nodes and base stations contain real time information which can be recorded for different statistical analysis.

Index Terms: Energy Efficiency, Cost Effective, Intelligent Protocol, Dynamic Power Management System, Atmega328, Multihop Communication.

I. INTRODUCTION

Water shortage is one of the significant issues confronting numerous urban areas of the world and wastage because of overflow and improper switching of pumpsets brings about enormous money related misfortunes. This is one of the real inspirations of this work. If the water tanks are deployed in a large area, observing and controlling of pump's singular tanks turn into a tedious job. As everyone knows water is most significant asset and utilized for some reasons. So to know the water depth in the tank, to fill the tank when the water level goes low and switch off the pump water level goes overflow, here is a system which consequently controls the pump to fill water.

Wireless sensor network (WSN) technology has been has been generally conveyed on the planet. Wireless sensor network is a champion among the most well known and dynamic research territories in networking and communication field lately. The wireless sensor network comprises of several sensor nodes [1]. A WSN is a self-arranging system of having little sensor hubs that are conveying, among themselves utilizing some radio flags and sent in quality to detect, monitor and comprehend the physical world. WSN is an exceptional type of ad-hoc network system made out of countless cost reduced scale sensor nodes conveyed in an observing zone and a multi-bounce self-dealing with the system by means of remote correspondence. WSN performs discernment, obtaining and preparing data of the articles in the coverage territory and conveys the information to the host computer of the observing system. Popular wireless communication technologies are radio frequency (RF), Wi-Fi, Bluetooth, and ZigBee. ZigBee technology is distinguishing highlights, for example, short proximity, low multifaceted nature, self-organization, low power, low rate and minimal effort. The best preferred viewpoint of wireless sensor gadgets is that they make establishments conceivable where cabling is unrealistic, for example, in vast solid structures and cargoes.

Various research works have been distributed over the latest coupleof years in the utilization ofwireless sensor networks like [2] exhibit survey of ZigBee advances. Features of ZigBee, introduction to ZigBee Alliance, distinctive topologies and protocols are depicted. [3] Presented investigation of the characteristics of ZigBee innovation and examination of wireless sensor networks which is modest, adaptable and dependable. [4] Describes ZigBee innovation in light of CC2530 system-on-chip of Texas Instruments. Temperature securing is actualized for confirmation of the framework. [5] Presents the wireless correspondence innovations in the information procurement, controlling and observing frameworks. Fundamentals of the standard are portrayed too. [6] Describes wireless sensor network systems extend applications with many testing issues like power utilization, routing protocol to make the framework reasonable, compelling and proficient for WSNs. But sensor hubs are essentially battery fueled gadgets so diminished vitality utilization and battery lifetime is one of the real issues. [7] Presents wireless sensor network routing protocols. The routing protocol chooses the way to transmit the information and keep up the routes in the system. Many routing systems in WSNs have been proposed yet not actualized on the grounds that a safe correspondence between hubs is an essential undertaking. [8] Discusses the outline and usage of a water level control system utilizing wireless communication which influences the system automatically, financially savvy and dependable but not power optimized. [9] Presents a water quality checking system utilizing WSN technology and fueled by solar

pane to display water quality in various field locales and in real time a system architecture constituted by a few appropriated sensor hubs and a base station is proposed. [10] Presents a water quality observing system utilizing wireless sensor network technology and controlled by solar plate. pH, turbidity, oxygen, and so on sensors are utilized for outlining the system.

This paper presents ZigBee Based Intelligent Wireless Overhead Water Tank Monitoring and Controlling System. In Section 2 we introduce point by point talk to various design challenges of sensor node for water tank observing regarding equipment. Section 3 describes definite parts of system architecture. In Section 4 we have demonstrated the development details of the node. Section 5 describes the detailsof the system functionality. Section 6 discusses the hardware validation of the overall system. In Section 7 we conclude the paper.

II. DESIGN CHALLENGES AND PROPOSED SOLUTION

There are several challenges in designing the system.Hardware selection plays a dynamic role indesigning a sensor node,the hardware components should be chosen carefully to gain high efficiency with low cost and compact size.

Sensor selection is the major challenges because in the market variety of sensors are available like ultrasonic level sensor, conductivity or resistance level sensor, magnetic sensor, capacitance level sensor, etc. ultrasonic level sensor has some drawback as low accuracy, slower speed. Out of all the water level detection sensors magnetic float sensor is more suitable because it gives high accuracy, low cost.

Power improvement is the other design challenge because all the senor nodes are battery powered. For charging battery normally solar power is used, but utilizing solar energy battery may get a discharge unexpectedly.

Compactness and robust, long term reliability are the challengesin designing the system.

III. SYSTEM ARCHITECTURE

Wireless sensor network comprises of several sensor nodes, which can send data from source to destination. Fig. 1. Shows the typical wireless sensor based water level detection controlling and monitoring system. Data are sent through the sink hub to the base station. The coordinator is configured at the base station which controls the overall system.

In this work five sensor nodes are utilized to communicate data. Fig. 2. shows the structure of Sikkim Manipal Institute of Technology academic building. From node 1 to node 5 information is sent wirelessly using ZigBee protocols. Node 4 and 5 are one hop communication with the base station so node 5 plays a significant role to send other node information. In case of node 5 failure, node 4 will take the control of the entire data packet for sending information to the base station.

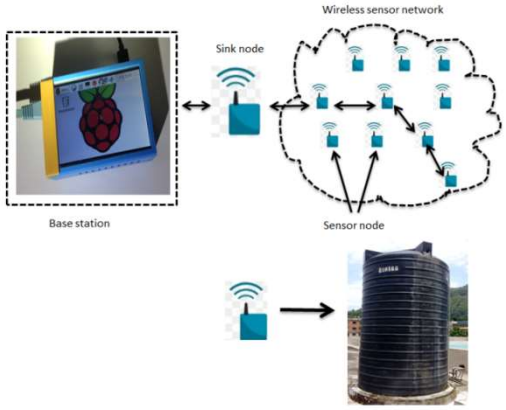

Fig.1. Typical wireless sensor network based water level monitoring and controlling system.

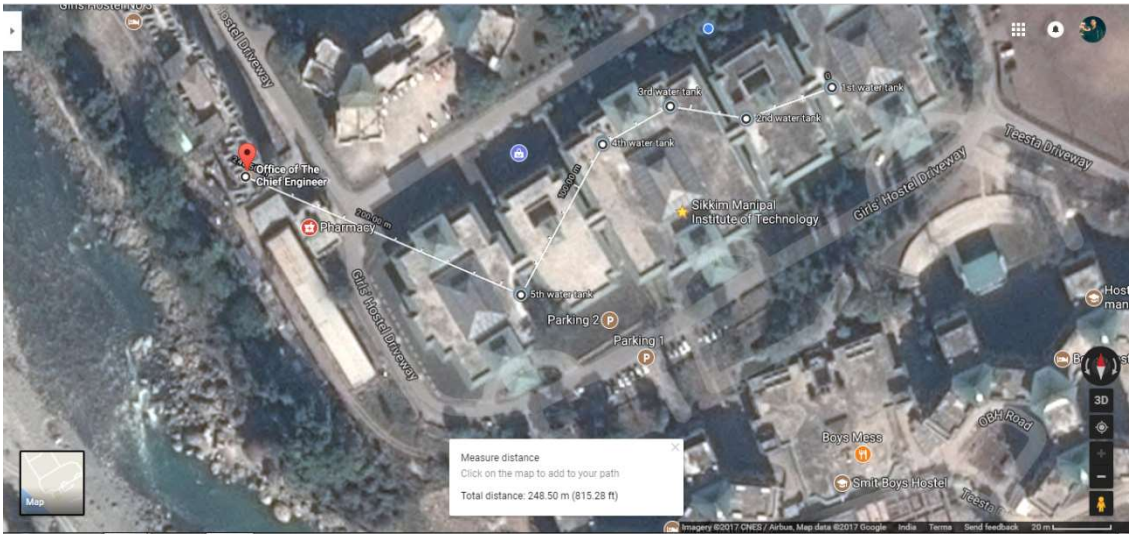

Fig. 2. Structure of Sikkim Manipal Institute of technology academic building

IV. DEVELOPMENT

The whole development work is two folded. First part is the wireless sensor node development and second is the base station development.

Fig.3. shows the block diagram of sensor node development.

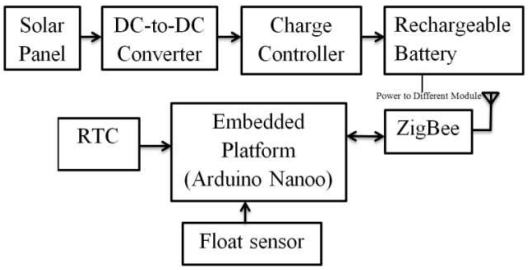

Fig. 3. Block diagram of sensor nodes

The details internal components of sensor nodes are shown in Fig.4.

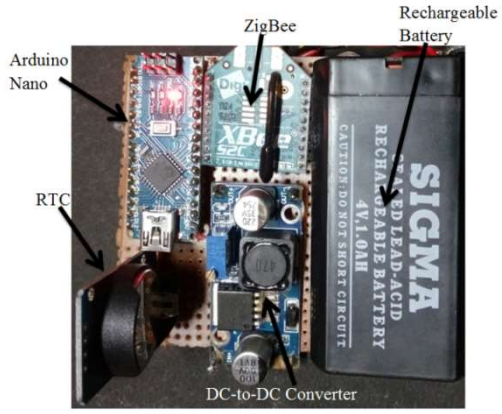

Fig.4. Internalcomponent details of sensor node

The overall wireless sensor node development of this work is shown in Fig.5.

Fig. 5. Wireless sensor node

A. ZigBee

ZigBee is aprogrammable wireless device based on IEEE 802.15.4 standard protocol. ZigBee is simpler, requires low power (45mA for boost mode and 33mA for normal mode for transmitting and 31mA for boost mode and 28mA for normal mode for receiving), compact and robust, low data rate (250 Kbps) and cost effective. ZigBee supports peer-to-peer, point-to-multipoint and a reliable mesh topology.

The Zigbee network involves three diverse types of Zigbee devices as Coordinator, Router and End device. Zigbee available in both Series 1 and series 2 named as XBee. Zigbee S2C is used in this work.

ZigBee operates the ISM 2.4 GHz frequency band and 16 channels spectrum. Zigbee uses CSMA-CA for collision avoidance and DSSS (Direct Sequence Spread Spectrum) for security and 65000 unique network addresses available for each channel. The indoor range of the Zigbee S2C is up to 60m while outdoor range is up to 1200m.Zigbee S2C transmits power 6.3mW for boost mode and 3.1mW for normal mode.

B. DC-to-DC Converter

DC-to-DC converter used to achieve maximum conversion efficiency. A DC-to-DC converter is an electromechanical device which gets voltage from a DC source and converts to the other DC voltage source. DC-to-DC converter has low noise, low cost and used to increase or decrease the voltage level.

In this work LM2596 DC-to-DC buck converterstep-down module is used. LM2596 provides input voltage is 4.5-40V and output Voltage is 1.5-35V and output current is 2A. The Conversion efficiency of LM2596 module is near about 92%. Potentiometer alteration bearingboth Clockwise (increase) and Anti-clockwise (decrease) and switching frequency is about 150 KHz.

C. RTC

DS3231 is a low-priced and highly accurate I2C Real Time Clock. RTC integrates a battery input and conserves accurate timekeeping when the device gets interrupted. The DS3231 module offered in a 16 pin, 300-mil SO package.

The RTC memory module can maintain hours, minutes and seconds, day, month and year information.The address and information of RTC are sent serially over an I2C bidirectional bus.Operating voltage of RTC module is on either 3.3 or 5 V and clock accuracy is 2ppm from 0 – 40 centigrade range.

D. Float sensor

There are different type of sensors can be used to identify liquid, water level like conductivity or resistance level sensor, float sensor, capacitance level sensor, ultrasonic level sensor, magnetic sensor, etc. These sensors have advantages and limitations but float sensor is highly reliable over the other counterparts.

The Magnetic float sensor is an electromagnetic ON/ OFFswitching device for detecting the level of water inside a tank shown in Fig. 6. In this paper two types of float sensor is used one is normally closed and other is normally open. The Float sensor gets triggered when it is being lifted by water. Floatsensor is the simple, highly

reliable and cheapest technology for water level measurement applications.

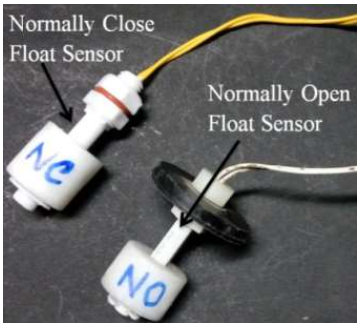

Fig.6. Magnetic float sensor

E. Embedded platform

Atmega328 based embedded platform used in this work. The Arduino Nano is a compact and a breadboard friendly type board based on Atmega328 processor. The Arduino Nano has 14 digital I/O pins of which 6 PWM outputs, 8 analog input pins, 16 MHz clock speed and 32kB of flash memory. There is no any need of external programmers to download the program into the Arduino Nano. It comes with Pre-loaded Bootloader to easily communicate with the Arduino IDE. Operating voltage of Atmega328 is 5V and DC Current is 40 mA per I/O pins.

F. Solar panel and battery charging system

The Solar panel is a device which absorbs the sunlight and generates electricity. The Solar panel is light weighted and very strong device which requires small space for installation. The solar panel is a very useful device which can be used in car, mining, camping, etc. portable solar panel is used in this work which have 5.5V output current and 250mA operating current.

Sealed lead acid rechargeable battery is maintenance free economic battery which gives maximum service life. SIGMA sealed lead acid rechargeable battery 4V, 1000mAh is used in this work.

The block diagram of a base station is shown in Fig.7. Atmega328 microcontroller based embedded platform is used for developing the base station. For display purpose LCD module is used.

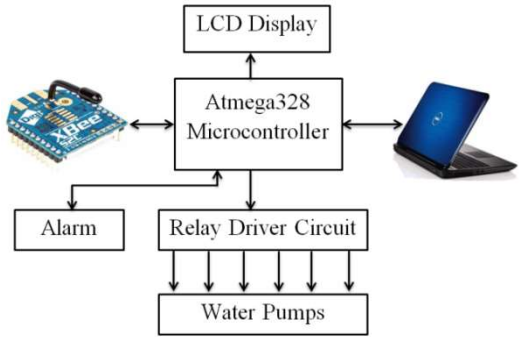

Fig. 7. Base station

V. SYSTEM FUNCTIONALITY

Fig. 8. shows the functional flow diagram of wireless sensor node which is used to monitor the water level of the tank. On power up, only a part of the node is activated and plays out the fundamental subroutines. The whole node can be activated from the base station so that power utilization of the node can be reduced by switching of the node when it is not required. On successful completion of basic subroutine, node updates its own health status like power supply voltage, sensors errors if any etc. In case any error,a local alarm is generated and also sent to the base station for further action and if health status is ok, node is configured to query mode, continuous mode or event mode depending upon the input from the base station. The next taskis to leave the level sensor data and forward the water level information to the base station. Shortest path routing algorithm has been used to send the information to the base station and this task schedules continuously as per the basic scheduling instruction.

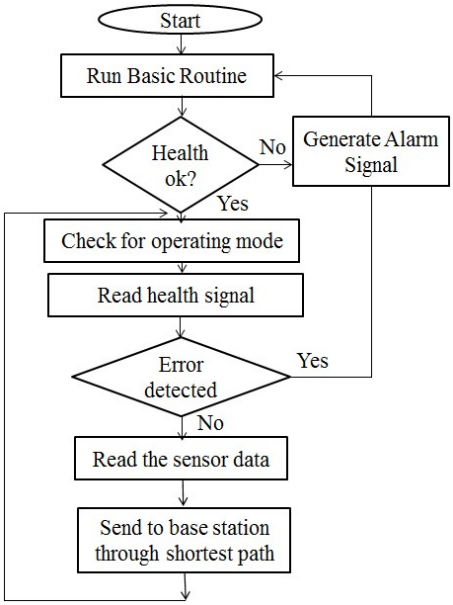

Fig. 8. Functionality of sensor node

All the data received at the base station using the ZigBee wireless device. A Dout pin of ZigBee is fed to the Rx pin of the microcontroller Atmega328. Microcontroller reads incoming data after appropriate conversion and display to the LCD. Generally the pumps are high power devices therefore, for electrical isolation purpose Relay driver circuit has been used. Depending upon the sensor data received at the base station, base stations actuate particular relay circuit to ON or OFF therequired water pump. Thebase station also consists of an alarm unit which blows whenever some ambiguity occurs in the system. Specials care has been taken in the relay driver circuit to protect the circuit from the back emf created by the water pump. To get high energy conversion efficiency DC-to-DC converter has been utilized which provides 90% conversion efficiency. To protect from over current flow, which may harm the battery a charge

control circuit is used. A real time clock circuit which is the common units of the basestation is in charge of time synchronization of the task, it also holds the time information of the sense data whichmight be utilized for further statistical analysis and intelligent decision making purposes.

VI. HARDWARE VALIDATION

The developed system is deployed and tested the operability for over one month on the campus of SMIT.

Fig. 9. shows the time frame activity of the system for 24 hrs. has been plotted in the graphical manner where x-axis shows time in minutes and y-axis shows system activity. This data taken from the base station for indicating the water level full and empty. To check the reliability of the system, two types of error are created one is system error and other is battery error. Both the errors are successfully detected and displayed on the monitor of the base station.

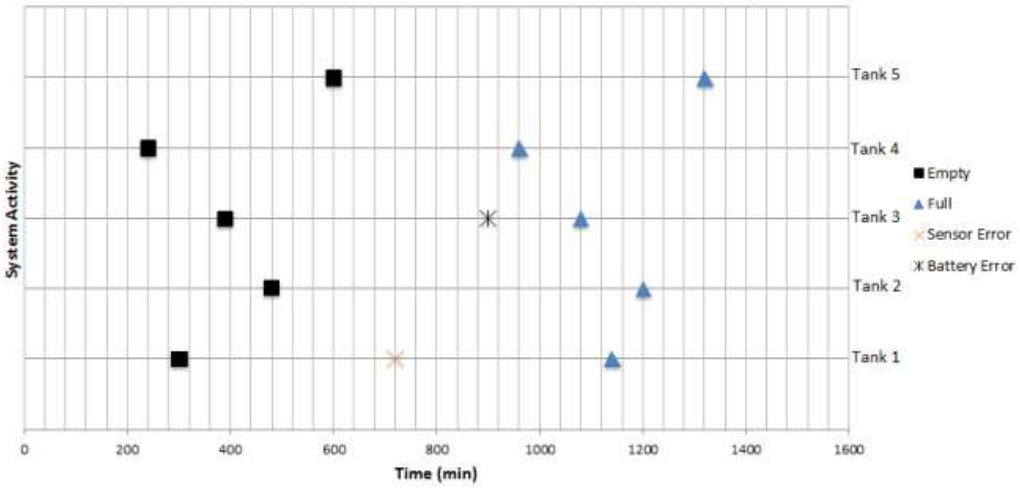

Fig. 9. Time frame activity of the system.

Wireless range of Zigbee modules does not perform as in the datasheet. The internal rechargeable batteries can provide 24 hrs. uninterrupted supply with the help of intelligent power management protocols. The level sensors worked 100% accurately withoutany fault. The total power consumption, including four wireless sensor nodes and base station the average power utilizationobtained is 70mA.

VII. CONCLUSION

The system has been developed and validated successfully at the hardware level. Four wireless sensor nodesare developed and deployed as per the proposed plan using the ZigBee wireless network.Multihoping of wireless data communications has been achieved. An intelligent power management protocol saves the power and makes the system operablefor 24x7. Overall provide wireless and wireless monitoring and controlling of water pump in a very cost effective and reliable way.

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