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Monitoring the Environmental Parameters of Ring Conner Unit of Cotton Industry Using Wireless Sensor Network (WSN)

S. V. Chavan[1], B. P. Ladgaonkar[2], S. K. Tilekar[2]
[1]MIT Arts, Commerce and Science College Alandi, Pune, India
[2]VLSI Design and Research Centre, Department of Electronics, Shankarrao Mohite Mahavidyalaya, Akluj, India
sachin3885@gmail.com

Abstract: ***The industrial sector is demanding sophisticated electronics system, wherein the industrial parameters should be centrally monitored. In cotton yarn manufacturing industry, monitoring of the environmental parameters such as environmental temperature and relative humidity is essential to maintain the quality of the cotton yarn. The environmental temperature and relative humidity is maintained at the précised level in cotton industry. In fact, these parameters depict site specific variability (SSV). For monitoring the indoor environmental parameters of ring conner unit of textile industry, deployment of the Wireless Sensor Network is most suitable solution. To monitor such parameters the wireless sensor network is implemented. With the greater reliability and flexibility the wireless sensors nodes are designed, wherein ARM 32-microcontroller, ARM LM4F120H5QR, is used as a core for computational task and RF transceiver module Xbee chip, from DIGI International Inc, is used for Wireless communication. Deploying embedded technology the sensor nodes have been designed for monitoring of the two parameters such as, environmental temperature (^{0}C) and relative humidity in ring conner unit of the textile industry. The sensors, SY-HS-220 for humidity measurement and LM-35 for temperature measurement are deployed. Deploying such sensor nodes and the coordinator node along with the base station(BS), the wireless sensor network is established by employing Zigbee technology and implemented for monitoring of the devoted parameters of the textiles industry. The results of implementation of WSN for monitoring of environmental parameters of ring conner unit of textile industry are interpreted in present paper.***

Keywords: wireless Sensor Node, Wireless Sensor Networks, RF Module, ARM microcontroller.

I. INTRODUCTION

The industrial parameters such as environmental humidity, temperature, leakages of hazardous gasses from process plants etc are widely distributed and depict spatio-temporal variations. The industrial environmental pollution monitoring has global significance. Therefore, emphasizing present needs of the industries, it is proposed to develop the Wireless Sensor Network (WSN), wherein typical industrial parameters are precisely monitored at base station. In fact, the WSN consists of autonomous sensor nodes, battery powered, connected to the base station using wireless networking topology[1-3]. Deploying a ubiquitous embedded technology the sensor nodes of required features can be designed. Recently, ARM technology is resulting into the microcontrollers of promising features, deploying which the wireless sensor node can be designed. The Zigbee technology is pervasively advancing. Therefore, to overcome present day problem of industrial sector and to ensure wireless data transfer with high accuracy and reliability, it is proposed to design Wireless Sensor Network and implement the same for industrial applications. The WSN is developed to monitor typical parameters of the devoted industries and design issues are presented in this paper. Present paper encompasses the field such as WSN, Zigbee, IEEE 802.15.4, embedded design etc. Therefore, it becomes possible to design the intelligent, autonomous and energy efficient wireless sensor nodes to facilitate the desired WSN. Emphasizing an implementation at textile industry, the WSN is designed and results of investigation are presented in this paper. The paper is organized such that, Section 1 is of introduction. Section 2 is devoted for design and establishment of the WSN. Results of on-site implementation are interpreted in section 3 and 4 and conclusion is given in section 5.

II. WIRELESS SENSOR NETWORK (WSN)

Wireless sensor network (WSN) is the distributed network of large number of wirelessly connected autonomous devices, called Wireless Sensor Nodes, which collaboratively collects the information about physical world and disseminates the same towards the monitoring stations called Base Station (BS) for the deterministic analysis and presentation [4-6]. The WSN is an infrastructure comprised of sensing, computing and communication elements, which provides the information about area and process of interest to the administrator, to ensure the sustainable management [7]. The WSN comprises an assembly of distributed Sensor Nodes, an interconnecting wireless network in suitable protocol, smart base station etc.

2.1 Development of Wireless Sensor Network for Industrial Applications:

The processes of the textile industries were studied and it is observed that, to maintain the quality of the cotton yarn, the parameter such as environmental temperature and relative humidity etc should be precisely controlled. To optimize the quality of the cotton yarn, essentially, the temperature is maintained precisely at 32^{0}C [8-9]. The relative humidity of an environment should be controlled at 55%RH [10-11]. At present, for monitoring of temperature and humidity, electronic and monitoring units, are installed, wherein usually only local values of these parameters are displayed. This unit

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of textile industry is spread over wide area and the said parameters are depicting Site Specific Variability.

Fig. 1. The Photograph of Wireless Sensor Node

To monitor the parameter values very few numbers of such devices have been deployed. Therefore, these rarely spaced monitoring units could not cover the area of textile industry. Moreover, normally these monitoring units are not networked. Therefore, it is essential to collect the data manually. This hardly provides the data in real time. Therefore, precision controlling of the temperature as well as relative humidity of the environment is not ensured. This may adversely affect the quality of the cotton yarn. Therefore, textile industry is demanding an electronic system to cater this need.

For establishment of the WSN to collect the site specific data, the five sensor nodes of promising capabilities have been successfully designed. In addition to this, to facilitate the Base Station, the inherent part of the WSN, a coordinator is also deployed. The Senor Nodes are identified with the name as Node1, Node2, Node3, Node4 and Node5. The photograph of the Sensor Node is shown in the figure 1. On scrutiny of figures 1, it is found the sensor nodes are associated with the transducer interface modules, which comprises of an array of the sensors. To ensure autonomous operation, the nodes are facilitated with the chargeable battery. The Zigbee device is interfaced to the serial port of the microcontroller. The sensor nodes are encapsulated in box.

The Node ID and Parameter ID are allocated to each of the nodes and process of assembling and disassembling of the packets is carried out. Thus, the WSN of five sensor nodes and the Base Station is developed and deployed for monitoring of the environmental parameters at the site of manufacturing of cotton yarn in the textile industry [12].

III. Onsite Implementation of Wireless Sensor Network

The major objective of the present research work is to design and deployment of the Wireless Sensor Network (WSN) for monitoring of indoor industrial environment. It is found that, in many industries monitoring and controlling of indoor environment is vital job. The quality as well as quantity of the products depends upon the environmental conditions. Unfavorable environment adversely affect on the Quality of Product. Therefore, indoor environment of the industry must be precisely monitored and controlled as well. As discussed earlier, the WSN is dedicatedly developed for monitoring of industrial environment and it is made ready for deployment. To ensure on site deployment various industries have been studied. The Fabtech Group of Industries is performing pioneering job in establishment of renowned industries such as textile industries. This group of Engineers has established the textile industry at Ekatpaure near Sangola with title as "Fabtech Projects and Engineers Ltd (Textile Division), Ekhatpur, Tal Sangola Dist-Solapur". The indoor area of the Phase –I is 250m x 40 m (=10,000 sq.m.) wide. Therefore, monitoring the parameters of the indoor environment is very tedious task. Due to this wide area, it is found that, the environmental parameters are depicting Site Specific Variability (SSV). It is found that, the environmental parameters such as temperature and relative humidity are playing significant role on the process of manufacturing of the yarn. Therefore, it is attempted to monitor these two parameters by using WSN under investigation.

The WSN under investigation is arranged in such a way that, it will cover entire area of the phase-I. According to the architecture of WSN, to realize the site specific variability, an area under consideration should be divided into the cells of typical area. It is supposed that, a Sensor Node is collecting the information of the respective cell. In fact, the phase-I is fragmented into four sections such as blower section, prefatory section, spinning section and ring conner section etc. While deploying the WSN into phase-I, the ring conner section is separately considered. The WSN is established and the parameters such as temperature and relative humidity are monitored in real time. Thus Wireless Sensor Network under investigation is implemented in Fabtech (Textile division) Sangola and results of investigation are interpreted.

IV. Implementation of Wireless Sensor Network at Ring Conner Section of Fabtech (Textile Division) Industries Sangola

The wireless sensor network (WSN) under investigation is established in the Ring Conner Section of the Fabtech industry (Textile Division). This section realizes the conning process on the yarn. The environmental parameter of this section is also equally important. Both relative humidity and temperature of the environment is monitored by the WSN and results of the implementation are interpreted in this section. The photograph of the Ring Conner section is depicted in figure 2.

i). Experimental Set-up:

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Fig. 2. Photograph of Ring Conner Section of the Fabtech Industry (Textile Division)

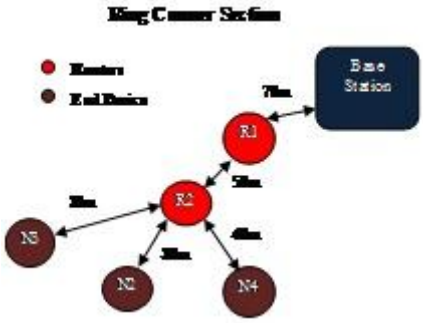

Figure 3 The Schematic of the Deployment of the Sensor Nodes in Ring Conner Section

To realize the collection of widely distributed environmental parameters, the WSN, comprising five sensor nodes, has been established in the Ring Conner section of the said industry. The WSN is implemented for monitoring of relative humidity and temperature of the environment. In present deployment the the WSN has been configured in multiple-hopping protocol. Instead of configuration of all Nodes in Broadcast mode, the three nodes have been configured as End devices, whereas remaining two nodes have been configured as Routers. Therefore, present WSN consists of three End Devices and two Routers. In fact, the Ring Conner section is far away from the Base Station which is located at Blower section of the textile industry. Therefore, three nodes are playing the job of sensing an nodes (ED) and two nodes carrying out the task of opping the data packets towards the Base Station. As shown in figure 3, the first Router node is about 70m away from the Base station and second Router Node is about 120m away from the Base Station. The distance of the nodes from the base station is tabulated and presented in table 1.

Table I. Distance of Nodes Placed in the Ring Conner Section from Base Station

S. No.	Sensor Node	Distance from Base Station (m)
1	Router1	70
2	Router2	35
3	Node 3	140
4	Node 4	120
5	Node 5	135

Actually, at the Ring Conner section, heavy machinery are providing obstacle to the wireless communication. Therefore, to establish the wireless sensor network at the Ring Conner section, the multiple hopping principles is emphasized. Actual placement of the Sensor Nodes in Ring Conner section is given in figure 4 (a-c). Moreover, the placement of the Routers are depicted in figure 5(a & b) Present WSN is established to monitor the environmental parameters of the Ring Conner section. The data is recorded at the Base Station and presented in real time. The experiment is carried for different days. However, results of typical period of implementation are used for presentation.

(a). Sensor Node-1

(b). Sensor Node-2

(c). Node-3 Placement

Fig. 4. Experimental Arrangement of the Sensor Node 1 - 3 within Ring Conner Section of the Fabtech Industry (Textile Division)

Router Node - 1

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Router Node - 2

Fig. 5. Experimental Arrangement of the Router Node 1 & 2

V. RESULTS AND DISCUSSION

The WSN is established in Ring Conner section of the textile division of Fabtech industries in multi hopping modes and instantaneous values of the parameters are demonstrated on the GUI and logged as well.

a). Monitoring of Relative Humidity (%RH) in the Ring Conner Section:

The instantaneous values of relative humidity in %RH are recorded with real time. The graph of relative humidity shown by the sensor nodes, plotted against the time in Minute, is presented in 6. On the inspection from figure 6 it is observed that, the sensor node-2 shows the humidity in the range of 63%RH to 69%RH. However, the sensor node-2 shows the humidity in the range of 69%RH to 71%RH, while the sensor node-3 depicts the humidity in the range of 72%RH to 73%RH. From these it can be commented that, indoor environmental parameters show Site Specific Variability.

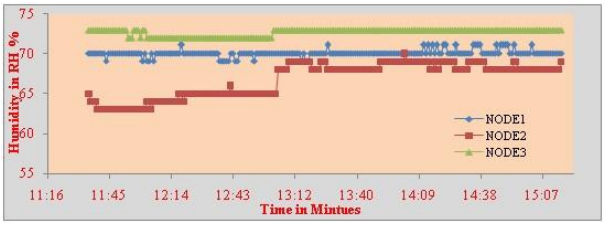

Fig. 6. Instantaneous Values of Relative Humidity in (RH%) Measured in an Environment of the Ring Conner Section of the Textile Division of the Fabtech Industry

b). Monitoring of Environmental Temperature (^{0}C) in the Ring Conner Section:

The instantaneous values of temperature (^{0}C) are recorded in the real time. The graph of temperature shown by the sensor nodes, plotted against the time in Minute, is presented in 7. The figure 7 depicts the graph of measured temperature values against the time in minutes. On the inspection results, it is observed that, the temperature of the region where sensor node 3 is installed is almost constant at about 34 ^{0}C. Moreover, temperature of the region of node 2 was initially 32^{0}C. Later on it increases to 33 and then found almost constant. The temperature of the region, where node 1 is established varies 31 ^{0}C to 34 ^{0}C. With the help of multi-hopping technique, the wireless sensor network disseminates the data of temperature and humidity towards the base station (BS). From the graph shown in the 7, it is found the WSN under investigation can collect the data from long distance only.

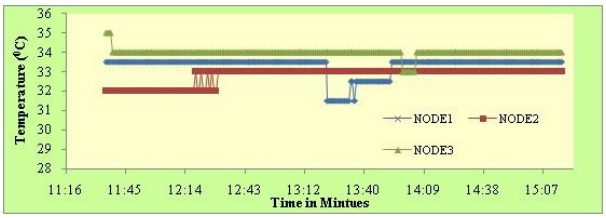

Fig. 7. Instantaneous Values of Temperature in (^{0}C) Measured in an Environment of Ring Conner Section of the Textile Division of the Fabtech Industry

VI. CONCLUSION

The wireless sensor network of five sensor nodes and the coordinator node along with base station is successfully established and deployed for monitoring of industrial environmental parameters such as indoor relative humidity, indoor environmental temperature in the ring conner section of textile industry. For realization of on-site implementation, the industries such as fabtech industry (Textile Division), milk processing industry and alcohol manufacturing plant of sugar industry are selected. The WSN under investigation is deployed for monitoring of above parameters. Under the frame of IEEE 802.15.4, the WSN is successfully implemented in multiple hopping topologies. On investigation of instantaneous values of various parameters, it can be concluded that the environmental parameters depict site specific variability with spatio-temporal variations. On investigation of the results of on-site deployment of WSN under investigation, it can be concluded that, the WSN under investigation is operating with great reliability and preciseness.

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