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Design an Intelligent System for Measurement and Monitoring Using Wireless Sensor Network

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Abstract

In this paper, a Building Management System (BMS) is designed using NI-WSN to reduce the energy consumption using graphical software named LabVIEW. This system provides a low cost, in addition to a great flexibility of monitor and control for the buildings. The system is designed a real time for monitoring and controlling using NI-3202 nodes and the NI-9791 gateway to measure and control on temperature, gas flow, motion and light, in addition to the camera, then using the mobile device to show these data in the dangerous state.

Keywords*: Building Management System, Monitoring, Controlling, WSN*

1. Introduction

Wireless network refers to the type of network that is not connected with any kind of cables. This kind of contact, avoid the cost of connection cables into a building. Wireless communications networks are implemented and managed using a transmission system named radio waves [10]. A Radio Frequency network, which consists of device transceivers, sensors, microcontrollers and interfacing the devices is named Wireless Sensor Network (WSN). WSN consists of two nodes at least to communicate with each other. However, the numbers of nodes can be more than two nodes, which are based strategies of measurement [12].

A wireless sensor network (WSN) architecture made up of distributed freelance sensor nodes to monitor environmental or physical conditions, such as pressure, temperature, vibration, sound, motion and pass their data during the network to a central location (gateway). The modern networks are bi-directional and having the ability to control of sensor activity. At present as networks are utilized in several consumer and industrial applications, for example, industrial process for controlling and monitoring, machine health monitoring, and so on [3&6].

A WSN usually consists of many of the sensor nodes. These sensor nodes often deploy in the area of sensors and have the ability to collect signal and route signal back to the base station (BS). The architecture of the node focuses to increase flexibility, provide fault tolerance, reduce cost, conserve energy and improve the development process. A sensor node consists of four basic parts: a sensing unit includes sensors and analog to digital, the processing unit includes a processor and capacity, the communication unit is called transceiver, and the power unit [1, 7].

Due to technological innovations in the area of wireless communications, digital electronics, and personal micro-electromechanical systems, a revolution is occurring in the area of measurement with remote wireless sensors [5].

The sensing unit consists of two parts, sensors and analog to digital converter. It composes of a combination of various types of the sensor that is needed to measure a different phenomenon from the physical environment. The sensors are selected on the basis of their application. It contains different types of sensors as magnetic sensors, thermal sensors, vibration sensors, biosensors, light sensors, and chemical sensors. It

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measured parameters from the surround environment by sensor then fed into the processing unit. If signal measured analog signal is transformed to digital by using analog to digital converter (ADC) them sent to processing [1, 11], while the processing unit is the important unit of the sensor node. It includes processor and capacity in addition to the timer. The responsibility of it comprises collecting the data from different sources, and then processes then store. The timer used to make a sequential process. Processing unit executes different functions and controls the working of other components. The utilization rate of energy in the processor varies depended on the operation of the nodes. MSP 430, ATMEGA 16, ATMEGA 128L controllers supported to the processors. The calculation is executed in the processing unit and the result is sent to the base station over the communication unit [7]. The communication unit is a common transceiver communication unit and it is mainly using for transmitter and receiver an information wireless between the base station and nodes and vice versa. This is done through communication channels using the network protocols [11], and A power unit often made up a battery with a limited energy. Commonly the sensor node adds the abilities to sense, calculation and communication [4].

ZigBee (Wireless Sensor Network) is designed by the ZigBee Alliance and has a safe, low power, cost effective, wirelessly monitor and control product features networks. These features make it the most suitable for WSN. ZigBee includes IEEE 802.15.4 for the Physical (PHY) is one of the desirable aspects of wireless sensor nodes is their ability to communicate over a wireless link and Medium Access Control (MAC) layers. In addition to the suite ZigBee protocol has a Network (NWK) and Application (APL) layers [8, 2, 9].

This paper introduces the Building Management System (BMS) using NI-WSN to reduce the energy consumption.

2. The Proposed Building Management System

The proposed system is based the particular design of a 9600 b/s asynchronous wireless communication. The WSN is followed on the standard IEEE 802.15.4 and applied a routing protocol based on the ZigBee. The design is based on a wireless sensor network system of National Instruments. The programming is using LabVIEW. For the sensing part, LM35 temperature sensor, PIR sensor, LDR sensor, and gas sensor are used. In this work we present the design and implementation of a smart building based on LabVIEW using wireless sensor network system. The system can monitor the temperature, light, gas level, motion, and fire and burglar alarm of the building. By using wireless technology, one can easily control building's mechanical systems and appliances. As the GSM technology provides ubiquitous access to the system to monitor by using SMS application to monitor the building condition when the manager is away.

In this work focuses on the development of a new management system is a Building Management System (BMS), which provides a full real-time monitor of devices and building environmental parameters. Building Management System consists of the ZigBee network with five NI node types, the name and position of each node is taken according to its function in the proposed system: Sensing Node (SN), Hybrid Sensing/Control Node (SCN) and Gate Way Node (GWN). In addition, four USB cams have been implemented as a monitoring system.

2.1. Design Main Program

In the proposed system, each NI-3202 sensor node has the ability to collect the distributed data, sends this data to NI-9791 gateway node wirelessly. The NI-9791 gateway node function is to connect the ZigBee network to the computer via LAN port to process data and display the data obtained from the network. LabVIEW program was created as high level user interface application. In general, the design implements

ZigBee star topology in which Sensing node, Sensing/Control node set as ZigBee end device while gateway node represents ZigBee coordinator. The star topology is selected because it is easy to synchronize, very low delay, and low power. The star topology can perform the real time operation because there is a direct connection between the gateway and the other nodes without using router nodes. Figure 1 shows the main program of the system.

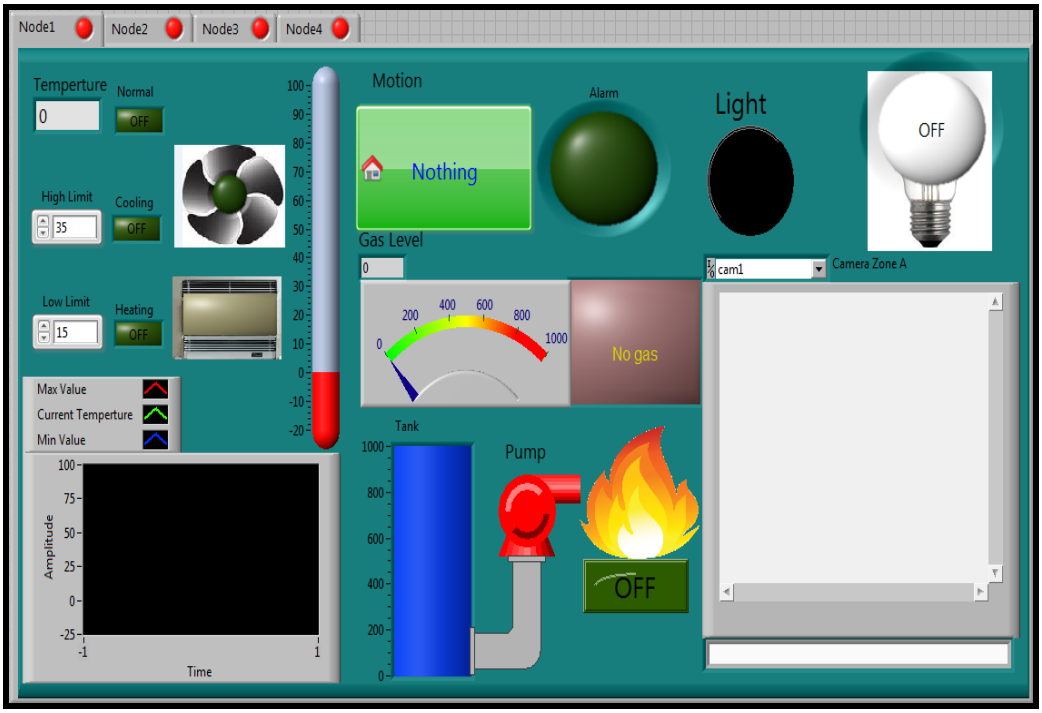

Figure 1. The Main Program

2.2. Voltage and Link Quality of System

It shows the number of nodes, battery voltage and link quality of them during connection with the network in real time as shown in Figure 2.

2.3. GSM Subsystem

It consists of three components, which are GSM shield, SIM Card, and At mega 2560 connected to the base station via USB port. GSM Shield used to send SMS message to the building manager if case it receives an SMS from Building manager contains special code. GSM compares if SMS which sent to it equal to code limited in GSM and it will return send SMS to sender number. Controlling on GSM subsystem via this block the GSM program allows the user to select the port of control of GSM subsystem. Figure 3 shows a program of GSM.

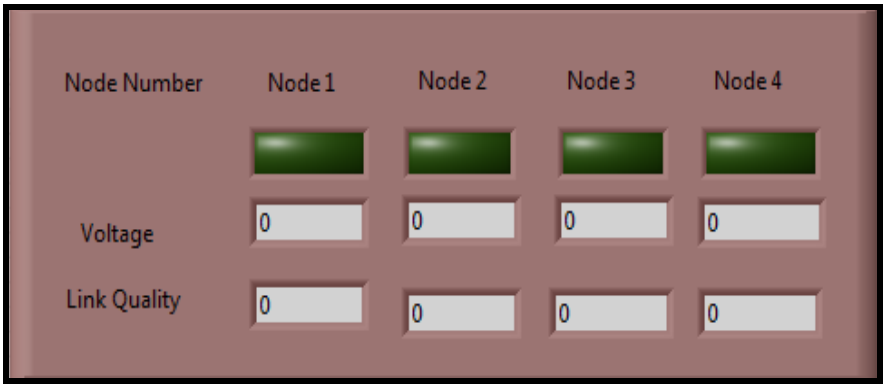

Figure 2. Voltage and Link Quality of System

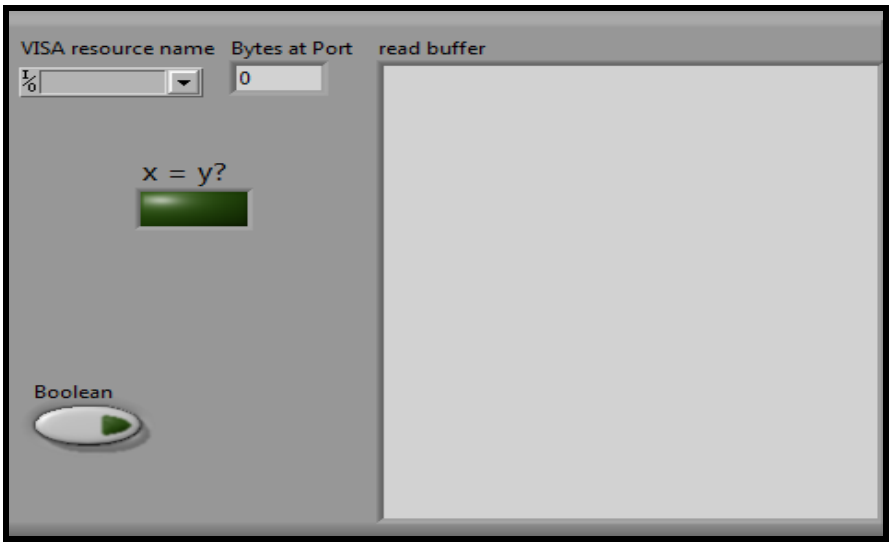

Figure 3. The GSM Program

3. Results and Discussion

The results of the proposed system displayed by using GUI program which is designed by LabVIEW to give sixteen measured values from the building related to four nodes, each node have a temperature sensor, light level sensor, GAS sensor, PIR motion as shown in Figure 4. In this figure, the node 1 is in normal state and the system doesn't take any decision.

If the read temperature sensor exceeded the high limit, it will indicate to the cooling is ON and the main program of LabVIEW sends a decision to run fans until the temperature back to normal the result shown in Figure 5 show that the temperature degree becomes is over high limit 33C^{o} and runs the fans.

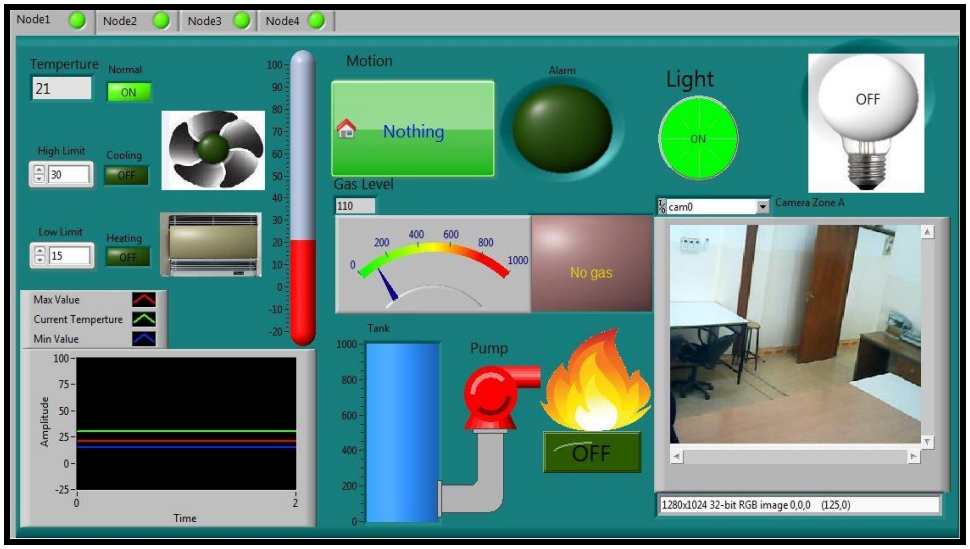

Figure 4. The Normal State of Node 1

Figure 5. Temperature over High Limit

This case the main program of LabVIEW sends a decision to the gateway, to give an order to operate the designated fan in this case. Here, the order is applied by the first node as shown in Figure 6, where node1 makes the test blue LED ON as an improve for working the system correctly. When the operation is done, the gateway sends an order to all nodes again to resend the new readings of all sensors, then making a new decision and so on.

If the read temperature sensor exceeded the lower limit it will indicate to the heat is ON and the main program of LabVIEW sends a decision to run heaters until the temperature back to normal. The result shown in Figure 7 show that the temperature degree becomes under low limits 13Co and runs the heaters. This case the main program of LabVIEW sends a decision to the gateway, to give an order to operate the designated heater in this case. Here, the order is applied by the first node as shown in Figure 8 where node1 makes the test red LED ON as an improve for working the system correctly. When the operation is done, the gateway sends an order to all nodes again to resend the new readings of all sensors, then making a new decision and so on.

Figure 6. Indication LED to Operate Fan

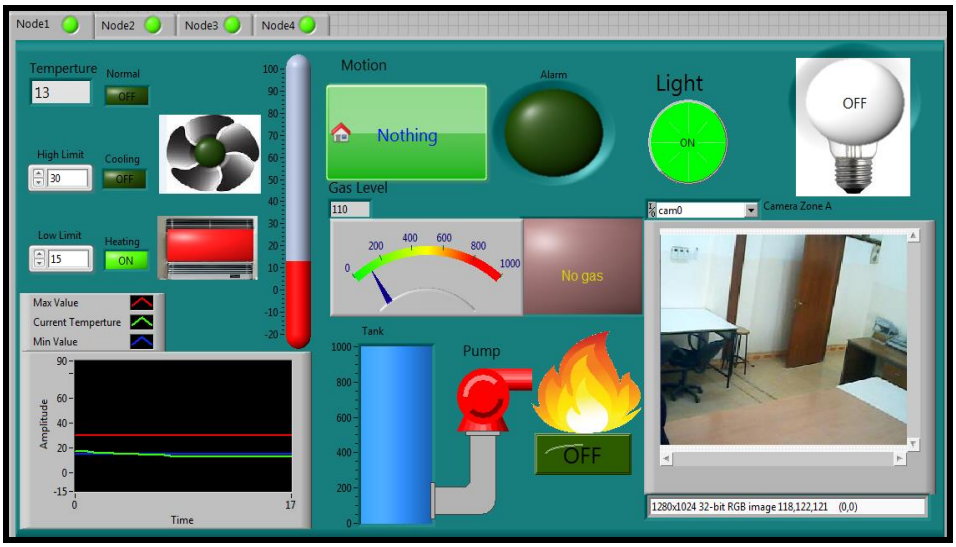

Figure 7. Temperature is Under Low Limit

The proposed system is being designed to maintain the light level inside the building. This system automatically turns on or off the lights depending upon the light, if the light sensor reading there indicated light is not enough due to the sunset or there is no outer light refer to black LED is OFF so the main program of LabVIEW sends a decision to run lamps. The result shown in Figure 9, that the light not enough and runs the lamps. Also, this case the main program of LabVIEW sends a decision to the gateway to give an order to operate the concerned light source in this case.

Figure 8. Indication LED to Operate Heater

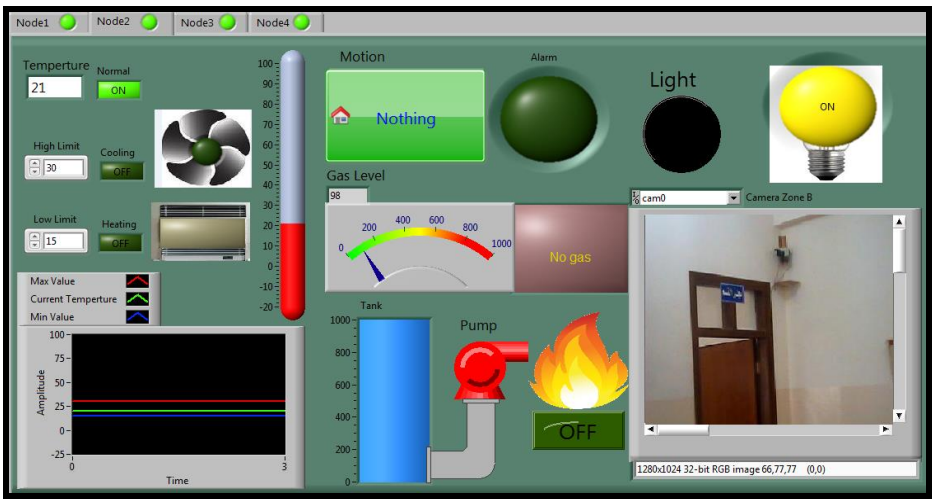

Figure 9. Light Not Enough and Lamp ON

Here the order is applied by the second node as shown in Figure 10, where node2 makes the test, yellow LED ON as an improve for working the system correctly.

When the operation is done, the gateway returns to send an order to all nodes to receive the reading of the sensors, and then send the reading to the central computer to give a suitable decision for the new case.

Figure 10. Indication LED to Operate Lump

The proposed system is designed to maintain the building secure, so when the manager is outside the building and the occurrence of the case of theft is happening, an alarm system is operated. This system contains four nodes, each node has PIR sensor. In case of movement detection through PIR sensors in any zone, the result depends on the places of movement detection. The results can be shown in Figure 11, that the system gives a red indication write someone when there is a movement and give the alarm, so that when there is any movement in zone 2, the rectangle of PIR 2 turn on with red color also writes someone and so on for the other Nodes.

Figure 11. Movement Case

Also, this case the main program of LabVIEW sends the decision to the gateway to operate an alarm device and sends a dangerous message to the building manager, if there is a message received.

The node2 applies the order as shown in Figure 12, where it makes the test LED ON as an improvement for working the system correctly, then instead of the LED, a buzzer alarm system can be added.

When the operation is done, the coordinator returns to send an order to all nodes to receive the reading of the sensors, then send this reading to the central computer to give a suitable decision for the new case.

Figure 12. Indication LED to Operate Buzzer

The proposed system is designed to maintain the building secure, so that when the manager is outside the building and the occurrence of the case of fire is happening, an indicator of fire is ON with red color and write FIRE alarm system is operated, with turn off the fans or heaters if they work. This system contains four Zones. This system contains four zones. In case of fire detection through GAS sensors in any zone, the result depends on the places of fire detection. The results can be shown in Figure 13.

The main program of LabVIEW sends the decision to operate a fire fighting pump and turn off the fans or heaters if they work in zone2 and sends a dangerous message to the building manager, if there is a message received. The applies the order as shown in Figure 14, where it makes the test LED ON as an improvement for working the system correctly.

In the propose system GSM Shield used to send SMS message to the building manager if case it receives an SMS from Building manager contains special code (100 used). GSM compares if SMS that's sent to it equal to code limited in GSM and it will indicate to equal with green LED of comparative and return send SMS to sender number as shown in Figure 15. And if the SMS is not equal to limited code it does not return sends SMS to sender number. Controlling on GSM subsystem via this block the GSM program allows the user to select the port of control of GSM subsystem.

Figure 13. Fire Case

Figure 14. Indication LED to Operate Firefighting Pump

In real time of the network when the system is operational the voltage and link quality of each node is good during connection with the network will indicate the green LED is ON as shown in Figure 16.

If the voltage is low will indicate the green LED is OFF the Figure 17 shows node1 not work so the voltage and link quality of it is zero in voltage and link quality panel.

Figure 15.The GSM Program Operation

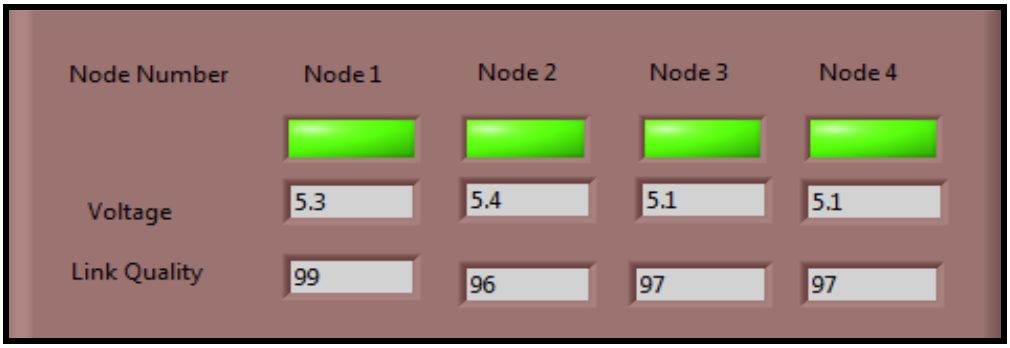

Figure 16.Voltage and Link Quality in Normal Case

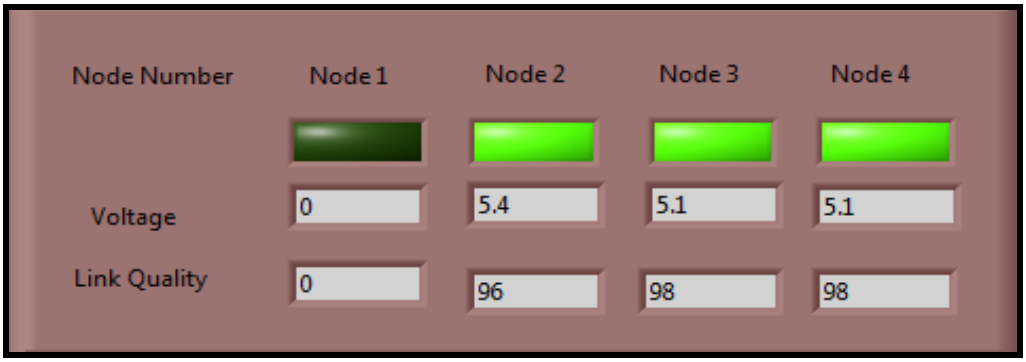

Figure 17. Voltage and Link Quality in Case Node1 Off

It can be seen from Figure 18, that the system gives an indication the LED of power is off when there is a node 1 is no work.

Figure 18. Indication LED for Power of Node1

As compared to J. Bangali and A. Shaligram (2013) [10], the important aim of their project can control and monitor the light, temperature, fire. Smart home system made up of many subsystems that can be decided by software (LabVIEW) with the assist of wireless sensor networks. While the proposed system control of the light, temperature, fire and detect the any movement, in addition to use USB camera. Also uses GSM if its danger the proposed system sends an alarm message to the manger.

Also Basil Hamed (2012) [7], illustrate the join software and hardware technologies. The main objective of this work is to design and implement a control and monitor for smart house by LabVIEW. While the proposed system uses the NI software and hardware to control the heating, lighting, and furthermore detecting the fire and any dangers movement, it can increase productivity and reduce development time for monitoring and control, in addition the radio transmits of it an outdoor distance up to 300 m, and up to 100 m indoors.

4. Conclusion

This work includes the design of Building Management System. The results of this system conclusion are using NI devices for easy using them with Graphical User Interface (GUI) in LabVIEW program that make connection between the nodes and gateways is flexible to build the control room far from the nodes about 100 meters, in addition to use the GSM is the best system to monitor the vital signs of sensors remotely. In this work, we are designed building management system based on the WSN. The system is able to monitoring and controlling the needful environmental conditions such as (temperature, light level, PIR and gas level) to obtain better control of the building. Also WSN technology has prefect features such as low power consumption, small size devices, low cost, and scalability. WSN is a better way to monitor, collect, controls, and process as well the system has flexible for any new requirements such as adding new nodes, changing the network topology. The results show the system can be described that the use of a central computer as a control unit is the best idea; also the use of LabVIEW has been a very good choice for its accurate and easy for programming. The system is depended on the short time response and high accuracy for collecting environmental data to provide lifetime of the design system.as well the system is designed to support the GSM and alarm device for sending alarm message to the building manager in danger case. The designed system supports multi-sensing nodes, we implemented this option in order to

increase reliability of the system; the building manager can modify or set the total number of sensing nodes by GUI program. The propose system used the LabVIEW program for easy using Graphical User Interface that offer to make the parameters of the front panel as friendly as possible. Additionally the Graphical User Interface of LabVIEW program awards a good window to the system to indicate any changes that happen to the system parameters.

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