

Review Research on Home Automation based on Different Wireless Sensor Network Techniques

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Abstract- These days, the utilization of building and home systems with automation way is more commonly things. So that, the homes will be more comfortable than the ordinary one. Therefore, making the automatic systems in any buildings will also add another benefit like controlling the temperature, making a ventilation, with the air condition and suitable lights. At this context, the system will reduce the total cost and save the energy. Now days, the reduction of power consider the major aims in smart home design. Home with smart system is mainly depends on sensor devices. Meanwhile, some disadvantages can depicted by utilizing smart systems like the disability of power wastage control since the unknowingness of the pattern behavior for each user.

Wireless techniques seen to be evolution very rapidly in recent years, also the advantages of the transmission wirelessly reduced the wiring and harness in addition to the system simplification. Small devices and cheap one named "Sensor Nodes" is used in this design which supplied to computing modules, sensing system, power, with short-range communication device to monitor a phenomenon like object tracking or sometimes environmental data. Wireless Sensor Network (WSN) can use Arduino, Raspberry PI, or Panda 10 microcontroller to make the control and take the suitable decision. In addition, it utilize many technologies of communication such as WiMAX, ZigBee, Global System for Mobile communication (GSM), Bluetooth, and Wireless LAN (Wi-Fi). Here a review on wireless sensor network is depicted with different wireless techniques and then they used in home automation as a modern application.

Key words: Home automation, Wireless sensor, Wireless sensor network, Sensor node, WIFI, ZigBee, Arduino.

I. Brief Introduction

Everyone who wants to build a home has a good idea of the types of amenities that the building should has, and these favorite needs reflect the tastes of the homeowner. One of these preferences is the home automation or automated home. Some homeowners think that it means time clock controls a lamp and others think that it presents a managed service like a "big brother" may do different things and make adjustments if necessary. While others think, it is a high-end system, which handles all the chores. All of these are true with saving the effort and energy [1, 2]. Home Automation System (HAS) interweave by itself in the daily life, since it works behind scenes for making the routine of us in our day simpler. This work like ensuring the doors are locked at sleep time or when outing from home also ON-OFF the light of home or the work building finally giving a comfortable weather by controlling the temperature [3].

First home computer experimented in the 1966, while automated house project was experimented in the early of 1980's as a project (work or research) of the National Research Center (NRC). When rising the number of controllable appliances in the building, the ability for interconnections and communications of these devices within each other becomes very useful and suitable features. AHS can be provided a remote interface to home appliances or the automation system itself [4].

I. Potamitis, et al in (2003) [5] give in their research a suggestion of utilizing a speech that remotely interact with the appliances of home to produce an action on the user. At that time this paper gives the people the disability to produce an operation of the real-life at home by pointing different appliances via different speech words, while B. Ciubotaru et al in (2006) [6] stated in their research the design with the implementation of monitoring the home devices by using a way depend on SMS. they do that by three methods: sensing unit to monitor different applications, processing unit (microcontroller) to take the decision and a communication one to connect between them, which is here used the cell phone or GPRS modem.

K. Gill, et al. in (2009) [7] suggested a low-cost ZigBee in the automation of home system. Here the system gives the ability to the owner to control or just monitor the appliances at home by connecting them to ZigBee network which in turn allow the system to ON or OFF the devices by two control ways. In 2012, A. ElShafee et al. [8] stated in their work the home automation design and implementation system by utilizing the Wi-Fi technology. The system composed of a server, which is here a traditional PC (offcourse with Wi-Fi card) in addition to various hardware, which composed of different actuators and sensors for managing the power with security.

S. Thomas et al in (2015) [9] explained the ability of predicting and recognizing activities that done by user daily in Internet of Things (IoT), depending on smart environment. The recognition of the certain activity is done usually via activity pattern splitting then decision. Z. A. Jabbar et al. in (2016) [10] make a design then Implement a system of smart home depends on Smart Phone (Android). the system composed of: wireless network uses ZigBee with intelligent gateway and outer network.

G. Pau, and V. Mario Salerno in (2019) [11] proposed a fuzzy algorithm that controlling the throughput ratio for the Workload and battery life and selecting the WSNs sleeping time for the certain smart home. The work aims to execute self ON-OFF system for the hardware and gives better performance for other approaches.

This paper aims to give a brief review on automatic home automation systems with their applications, types and equipment, also the techniques that can be used in it. For general the layers that the home-automated system composed from may depict in figure (1) [12].

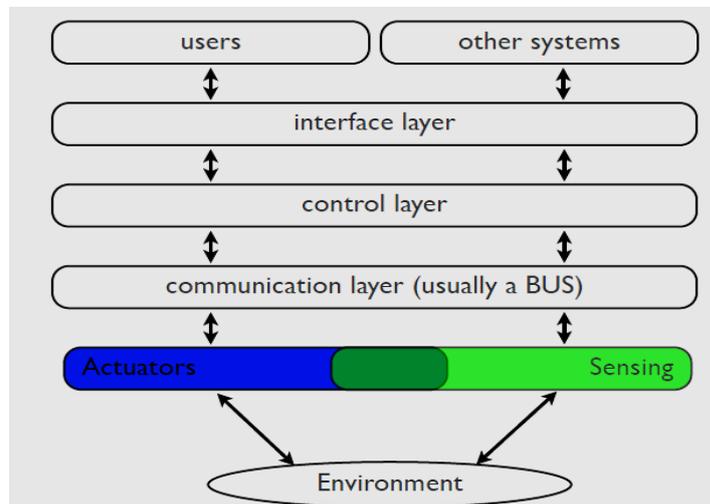


Figure (1) The Layers of Home Automated technique

II. System for Smart Home [13]

Smart Home as a term is used usually to illustrate a residence, which provide a Home Controller to collect various Automation for Home appliances. The Controller can consider as Intelligent may also name as Home Controller is simply composed from the software with all the devices that may utilize a controlling appliances smartly. The HAS combination may divided to many types:

1. Devices to be controlled.
2. Sense devices.
3. Interface devices (I/O).
4. Controller devices.
5. Interfaces with home users.
6. Wired or wireless System Network.
7. Controlling or Programming unit.

III. Categories of Home Automation System

Many various kinds of the systems for home automation are available, and these systems are design and implement generally for various purposes. These kinds can be summarize as follows [14]:

1. The energy management.
2. The control units.
3. The access control and security systems.
4. The window control and Lighting systems.
5. The appliances inside the home.
6. The entertainment and Audio-visual systems.
7. The assisted living and healthcare units.

IV. Overall System Design

Figure (2) states the blocks of all the subsystems of Home automation with their components. In addition, in this context, the system composed mainly of the following [15]:

1. The Sensing subsystem.
2. The Base station.
3. The Communication subsystem (wired, wireless or GSM).

Here the base station can be a computer, Smart Phone, Microcontroller, Microprocessor or Microcomputer, and the connections either wire or wireless. In addition, the actuators may be a Heater, Fan, light lumps, Air conditioner, water motor, and alarm system or any home appliances.

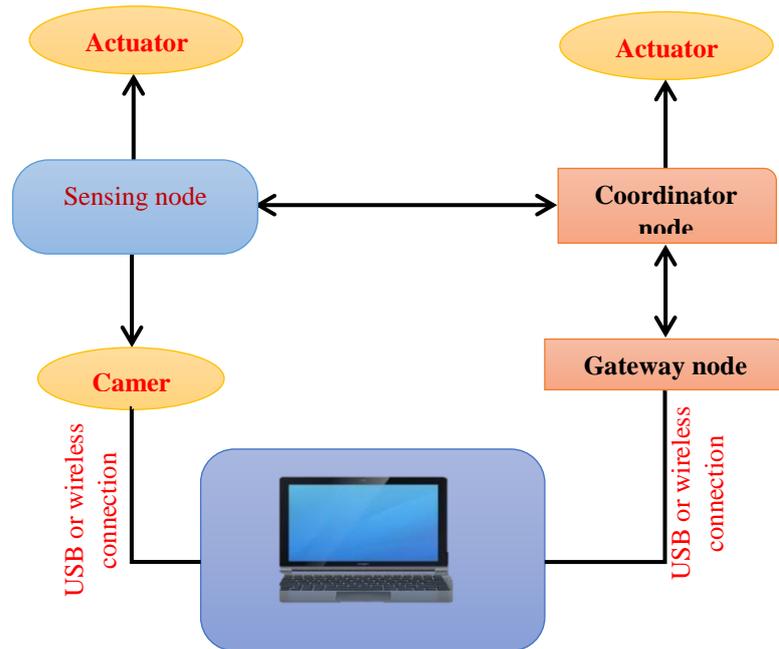


Figure (2) General System for Home Automation.

V. The Comprehensible of Wireless Sensor Network (WSN)

WSN composed of many embedded devices and equipment that wirelessly distributed and employing various electronic sensors. In WSN, there are nodes in wireless network, and equipped with wireless transceiver, sensors, microcontroller or microprocessor and source energy. These components (transceiver, microcontroller with electronic sensors) are implemented in WSN to perform the required system functions [16].

WSN consists of various distributed sensors that may responsible of specific area covering so that measuring the corresponding data in that area. The nodes that contain sensor have the ability communicate wirelessly also there are a somehow logics required for signal processing in addition to topology management and transmission handling. The components (units) of the hardware for wireless nodes are: sensing with actuating unit, processing unit, power unit and communicating unit in addition to other application-dependent units. Figure (3) states the hardware components (units) of a basic sensing node [17].

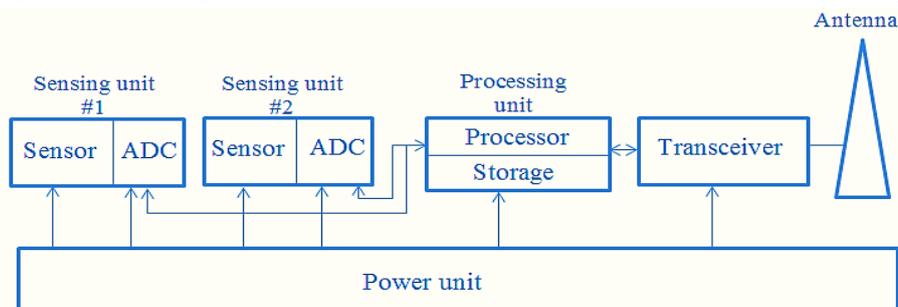


Figure (3) Typical Sensing Node.

The subsystem of sensing node can be described as follows [15]:

A. Sensing Subsystem

This is a group of various sensors used in the network to implement a particular purpose, there are two kinds of typical sensors may use in the subsystem: analog and digital sensors. Generally, the analog sensor needs a conversion of the output signal to digital one by using a circuit of Analog to Digital Converter (ADC) then provided the converted signal to the processing system.

B. Processor Subsystem

The processor unit that perform the processor subsystem may consider a central component of the node. The subsystem processor brings together all the other subsystems. The main purpose is to execute instructions related to sensing, communication, and self-organization. The tradeoff between efficiency and flexibility of both performance and energy depends on processor choice. The processor can be a Microcontrollers (MCU), Digital Signal processing (DSP), or Field Programmable Gate Arrays (FPGA).

C. Communication Subsystem

The subsystem here is relating generally to standard protocols, which may depending on applications that use a certain operating frequency and standards that may use like ZigBee, UWB, and Bluetooth or others. It composed of short-range radio signals that utilized to communicate with each neighboring nodes with the outside one. RF transceiver may work transmitter module and receiver with standby and sleep mode of operation.

D. The Subsystem of Power Supply

The energy efficiency is the important feature in a WSN that is considered as a key metric in many researches, where the WSN hardware developers provide many techniques to reduce power consumption. Usually, the main power source to the WSN nodes is the battery that may be supported by solar cells, DC-DC converter, and energy saving.

Various standards of communication units will give a short-range network which may use a WSN like IEEE 802.11 Wireless Local Area Network (WLAN) or Bluetooth or sometimes Wireless Personal Area Network (WPAN) IEEE 802.15.4. A suitable comparison among the technologies stated earlier can show the disadvantages and advantages of each standard unit and you can see them in Table (1) [18].

Table (1) General wireless LAN specification as compared to ZigBee and Bluetooth.

Features	Wi-Fi (IEEE 802.11 b)	Bluetooth (IEEE 802.15.1)	ZigBee (IEEE 802.15.4)
Radio	DSSS	FHSS	DSSS
Data rate	11 Mbps	1Mbps	250 kbps
Slave enumeration latency	32	7	64,000
Node per master	Up to 3 s	Up to 10 s	30 ms
Data type	Video, audio, graphics, pictures, files	Audio, graphics, pictures, files	Small data packet
Range (m)	100	10	70
Extend ability	Roaming possible	No	Yes
Battery life	Hours	1 week	>1 year
Bill of material	9	6	3
Complexity	complex	Very complex	simple

The wonderful advantages of ZigBee (low power consumed also cost and data rate) that noticed from the comparison stated in Table (1), the ZigBee may consider a better subsystem to be utilized in WSN applications over other applications.

VI. ZigBee as WSN Subsystem

ZigBee device has a reliable specification like effective cost and low power in addition to networked them wirelessly and monitoring with controlling the connected devices within it. The features stated may give the great importance for WSN. IEEE 802.15.4 standard is included in ZigBee device for physical and Medium Access Control layers. Also the protocol of it has layers of network and application. It becomes a global sensor / control network via the features summarized as follows [19].

1. Low capacity with Low-cost.
2. The consumption of power is low.
3. The protocol is efficient and simple.
4. High-density scalability deployment.
5. The short-range data transfer is reliable.

The network layer of ZigBee is responsible of giving functionality that required for the correct operation to the IEEE 802.15.4 (MAC sub-layer). In addition to provide the application layer with suitable service interface. The topologies of ZigBee network that are supported by network layer are: mesh, tree, and star as seen in Figure (4) [20].

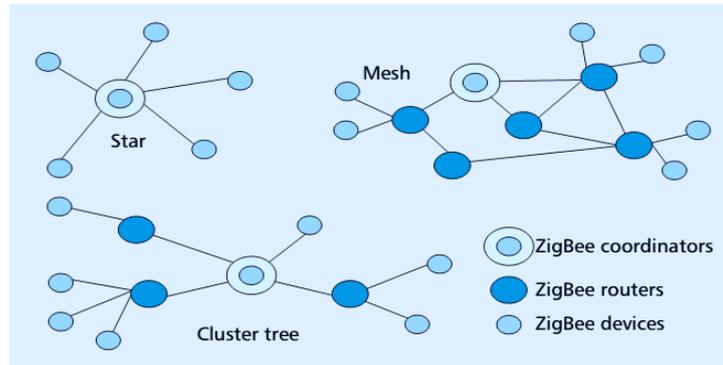


Figure (4) The Networks of ZigBee technology.

VII. The Technology of Wi-Fi [13]

The Institute of Electrical and Electronics Engineers standard (IEEE) standard 802.11 or known commonly as Wi-Fi is a protocol of wireless network which utilized widely for short range in networking to give a high speed to communicate the devices within hundred meters. The power consumption of Wi-Fi is somehow high with respect to the high speed. At These days, the modules of Wi-Fi that consume low power are available widely in many devices, which make them used in a wide range of appliances.

Therefore, the electronic devices may connect throw Wi-Fi technology within each other and perform the exchanging of data through wirelessly by microwaves with bands of 2.4 GHz and 5 GHz. In addition, the technology of Wi-Fi may utilize as a considerable choice in sensitive applications. Wi-Fi also supports protocols for multiple network in addition to the transparent transmission and generally gives a long battery life since it a saving mechanism for power. TCP/IP protocol consider the standard of Wi-Fi technology with the stack of universal serial interface network. TCP/IP protocol enables conversions interface i.e. serial port, Ethernet then wireless network.

VIII. Sensors for Automated Home System

Sensors may use in home automation system contain the following equipment: the Light Dependent Resistor (LDR) for light which reads the values of the intensity of the light threw all of the day time to make the automatic control of ON or OFF is possible, sensor of temperature & humidity. In addition to gas sensor, that detects the cooking gas and the smoke to avoid the fire possibility, Ultrasonic Sensors or Passive Infrared Sensor (PIR) for movement detecting in building or home especially when there is a security system.

A. The Sensor of Light Dependent Resistor (LDR) [21]

LDR is an equipment sense the light by having a variable resistance varied its value whit respect to light intensity. LDR details as shown in Figure (5) and you can see that it is clearly a resistor with a value altered with respect to the falling light on the surface of it, in addition, the resistance of LDR decreases as the light fallen increases and vice versa.

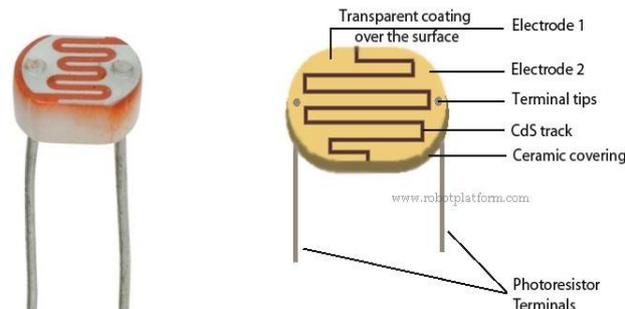


Figure (5) The Sensor of LDR

The relation between the resistance RL in the LDR device and the intensity of light Lux is depicted from eq. 1 to 3.

$$RL = \frac{500}{Lux} K\Omega \quad \dots 1$$

Now, as a connection of LDR to a source of 5V via R₁, then the output of LDR voltage is seen in eq. (2)

$$V_o = \frac{5 \cdot RL}{R_1 + RL} \quad \dots 2$$

$$Lux = \frac{2500 \cdot R_1}{V_o - 500} \quad \dots 3$$

Lux: Light intensity.

V_o: LDR output voltage.

R₁: LDR series connected resistance.

B. Temperature and Humidity Sensor (DHT11) [22]

The features of Temperature and Humidity Sensor are complex with a calibrated digital signal output. By using the temperature and humidity sensing technology and exclusive digital-signal-acquisition technique, it ensures excellent long-term stability and high reliability. This sensor connects to a high-performance 8-bit microcontroller, offering fast response, excellent quality, cost-effectiveness and anti-interference ability. The accuracy rate is 5% for humidity and ±2° Celsius for temperature. The Temperature and Humidity sensor can be shown in Figure(6).

The DHT11 sensor is using in the work of digital I/O of Arduino mega. The values through the single line digitally anwith the connected VCC and GND beside the power supply of 3-5.5V DC are all seen in Figure (7).

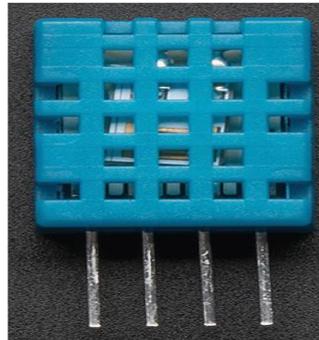


Figure (6) Temperature and Humidity Sensor DHT11

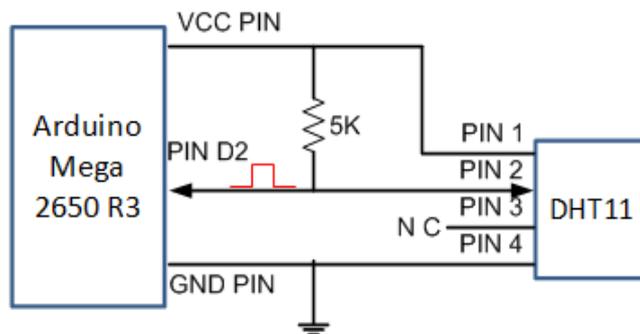


Fig. (7) DHT11 Sensor Circuit

C. Gas Sensor [15]

It is an equipment that detect many different gases in a close area. The utilization of it occurs mostly in security systems via detecting various types of gases like liquid petroleum gas (LPG), hydrogen, methane, smoke, and so on. The gas sensor basically composed of the following: ionized material and steel exoskeleton from gases. As sensor exposed to a certain gas, ionized material will heated and moved to sensing element, which change the resistance of sensing element and in turn vary the current exiting the sensor.

Various types are available of gas sensor in the world market like: MQ306, MQ2, MQ137 and MQ135 such that each of them work with specific gas type. MQ2 sensor is the most general one and it utilizes for combustible gas by detecting combustible gas and smoke within a concentrations between 300 and 10,000 ppm. Figure (8) depicts the sensor gas (MQ2), its structure beside its configuration.

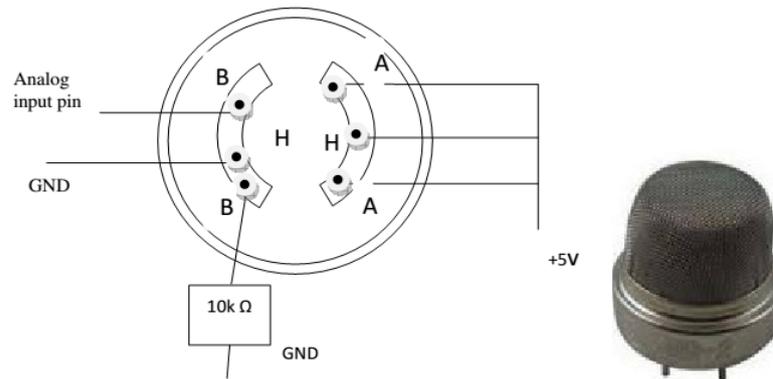


Figure (8): The Sensor named MQ2 with its structure beside its configuration

D. The Sensor of Passive Infrared Sensors (PIR) Structure and Configuration [23]

PIR sensor has the ability of sense the motion in addition to detecting the movement of human that lies in range of it. This equipment detects the surrounding object movement via calculating the variation of the values of infrared that emitted. PIR sensor (Module) available in the market as a completely detecting circuit contain the PIR sensor. The operation of the sensor is a simple and its output is just ON-OFF, so that, if there is a motion, then a logic (high signal) is send to the output pin and so on. Figure (9) states the PIR sensor with its traditional circuit model.

Any objects (Devices) has a temperature greater than absolute zero will emit heat in a radiation shape, and generally, that radiation cannot seen by the eye of human since it radiated via infrared wavelengths. This radiation can detected by electronic devices. Detection in PIR sensor may seen obviously in Figure (10).

Here the range (in feet) of PIR Sensor is approximately around 20. PIR Sensor is designed mainly for indoor use. It responds by making its output when unexpected changes occur, such as when there is motion.

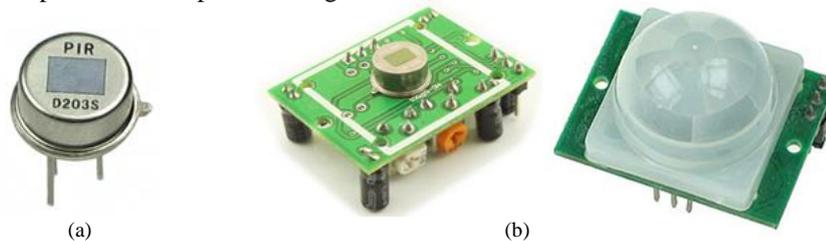


Figure (9) PIR configuration (a) Sensor (b) Model of PIR

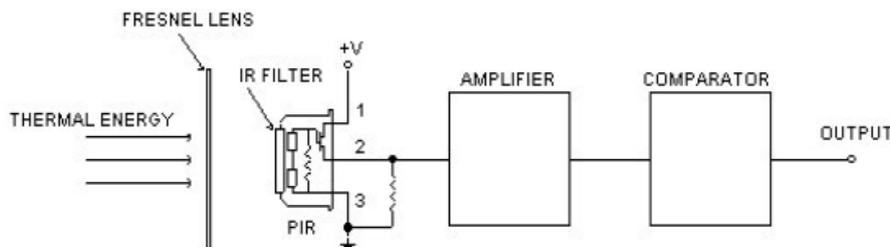


Figure (10) Internal Structure of PIR

E. The Configuration of the Ultrasonic Sensor (HC - SR04)

The Ultrasonic sensor, which may know sometimes as transceivers or transducers, is work generally similar to the radar or sonar. The technology of it and the technology of the radar and sonar measure the position of the certain object via calculating the echoes from radio waves or sound, for this reason the sensor is very suitable for applications that lies indoor or outdoor. The configuration of it may seen in figure (11).



Figure (11) Module configuration of ultrasonic sensor (HC-SR04)

The module range is from 2-400 cm and the resolution of it is 0.3cm. It takes a voltage 5V and consume a 2mA (less than this value) standby current. Ultrasonic module compose of ultrasonic transmitters, ultrasonic receiver and a circuit for controlling the sensing value. The distance here may calculated by transmitting an ultrasonic signal, then calculating the duration time when receiving echo from the transmitted signal. The time between the two events will generate a signal with a time peak proportional to the measured distance [13].

When the echo stop, the timing of ultrasonic receiver stops too. By taking the ultrasonic velocity for spreading in the air is 340m/s, then depending on t (record time), the distance (s) between obstacle and transmitter can be founded as you can see in eq. (4) [24].

$$s=340 * \frac{t}{2} \quad \dots 4$$

IX. Gateway Node (GWN)

The GW is a wireless node in the WSN, it is used for passing the data between coordinator node and PC using the serial connection. It composed of two components: XBee implemented circuit and the USB explorer as you can see in Figure (12). USB explorer gives a supply (voltage) with the serial connection to XBee module, while, the router is used in the automation system to make the wireless control capable in sensing subsystem.



Fig. (12) Gateway Node

X. Conclusions

This research examine the methods and kinds of Automated home system with different topologies: wired and wireless ways. Both of them used Wireless sensor network to connect between them, then send the readings of sensors to the base station to take the disicion of what to do. The temperature of home, the level of light, with gas density via home in addition to the detection of movement give a suiatable live conditions for the residence of home, so by utilizing sensor that measuring them, an Automated home system can work perectly to introduce a confort life for us.

The protocol of wireless technology that utilize ZigBee equipment in WSN may consider the best choice in AHS. This is due to the features of ZigBee technology such as: the data rate is low, the cost and power consumption is low too. In addition to the range of communication is up to 40 m and finally it provides self-organization. Meanwhile the use of WSN technology may gives a well features like: low power consumption with small size, and low cost. WSN is allso the better way to process, monitor, collect, and control different information wirelessly.

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