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Low-cost System for Transmitting and Receiving Data by 433MHz Wirelessly for Educational Purposes

Mahfoud Y. A. Abdulrazigh [a*], Salim Abdallah El Hussain [a] and Abdulhakim Ibrahim Fadlallah [a]

[a] College of Technical Sciences, Derna, Libya.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The concept of project-based learning is very popular among students as it allows them to solve problems and gain the necessary skills to design and implement wireless communication systems. However, it can be very challenging to implement and operate a system due to its high cost and closed architecture. This model uses project-based learning methodology to teach students how to design and construct wireless communication systems. It is a good study case for those pursuing their undergraduate degrees in electrical and electronic engineering. During the course, the students exhibited a lot of interest in the tool. This is due to the various theoretical and practical issues that are covered in the lectures. The project-based learning method is designed to prepare students for the job market by equipping them with the necessary skills and knowledge to make informed decisions. In this study, a simple wireless communication system is designed and implemented. That has ability to transmit and receive data in various ranges and environments to enhance the learning process of undergraduate students in the field of communication. Considering the length of the antenna and the environment (in/out door) the range of transmission and receiving data can be extended clearly in reality.

Keywords: Wireless communication system; DHT22; Arduino-UNO; RF module 433MHz; educational purposes.

**Corresponding author: Email: Mahfoud_DC@yahoo.com;*

1. NTRODUCTION

Radiofrequency technology has long been regarded as one of the most promising information technologies of this century. The technology uses radio frequency for non-contact two-way communication, and it can automatically identify the target item and capture important data. It has a number of benefits, including high accuracy, strong environmental adaptation, strong anti-interference ability, and quick operation. Wireless communication is the transmission of data over a long distance without the need of cables. The distance might be small (a few meters in the case of a television remote control) or large (thousands or millions of kilo meters in the case of radio communications) [1]. In wireless communication, several technologies are employed, the cheapest of which being GSM technology. A wireless weather monitoring system includes a few basic components, such as a microcontroller, a sensor, a display, an RF module, and a GSM module [2]. In a wide range of technical applications, microcontrollers are becoming increasingly significant [3]. In particular, the construction of wireless communications systems is heavily reliant on the usage of microcontrollers. ZigBee is a wireless communication system that is short-range and low-power. ZigBee is widely used in the field of automated control and remote control due to its low complexity, low consumption, and self-organization [4]. Rani and Kamalesh describe the design of a distributed control system of indoor wireless temperature and humidity to increase the system's overall effectiveness in detecting changes in temperature and humidity [5]. Wireless soil moisture sensor networks for irrigation scheduling were designed and developed by Hedley et al. [6]. A nutrient management system was also incorporated into the design system in order to optimize plant nutrition while minimizing negative environmental effects. Another study [7] focuses on the creation of a SCADA system for use in a flexible manufacturing cell for educational purposes in various fields of automation engineering (SCADA development, PLC programming and industrial communications). Make a concerted effort in research [8] to achieve the required knowledge/skill in academia and higher education to protect Industrial Control Systems, or ICS, from cyber-attacks.

The goal of this project is to create a low-cost wireless communications system that transmits and receives digital information utilizing the Arduino-UNO, a microcontroller-based board. The transmission part was built with a sensor, a transmitter, and an Arduino-UNO, while the reception section was built with a receiver, an Arduino-UNO, and a computer. The material provided in this article might be used as a reference guide for future research studies at various levels of schooling.

2. PROPOSED SYSTEM METHODOLOGY

In order to choose the most appropriate software and equipment for education, certain criteria must be defined.

(1). The availability of the free version for unlimited utilization. Clearly, this is an initial and foundational requirement. Moreover, it is obvious that there are no licensing problems during the installation and deployment of such software. Thus, it is able to provide courses at the lowest cost, which can also be considered an essential criterion;
(2). Availability of a variety of ready-made models with a variety of complexities.
(3). Interaction and the ability to modify certain initial parameters to figure out the system response.
(4). The resultant data, i.e. tables and other functional dependencies, which are presented, compared;
(5). Examine the theoretical knowledge in practice.

According to the benefits mentioned above, a simple and cheap wireless communication system was worked out. Based on RF Module (TX/RX), Microcontroller, and sensor.

The original purpose of designing a system is spread out into two main parts, the transmission section, and the receiving section. The transmission section is composed of an Arduino-UNO, a DHT22 humidity and temperature sensor, and 433MHz RF transmitter, while the receiving section consists of an Arduino-UNO, a 433MHz RF receiver, and computer to visualize the data.

2.1 Hardware Components

(1) In this research work, a DHT22 sensor has been used. It is a low-cost sensor able to measure the temperature and humidity surrounding every two sec. It can be measured at temperatures between -40 to 80°c while humidity is from 0 to 100%. It is easy to deal with for students. It also consists of a small integrated circuit

responsible for converting analog values into digital values. That makes it easier for us to read the digital output of any microcontroller. As shown in Fig. 1, it has three terminals- one is the measured signal (DATA) and the other are representing the source (VCC-GND) [9,10].

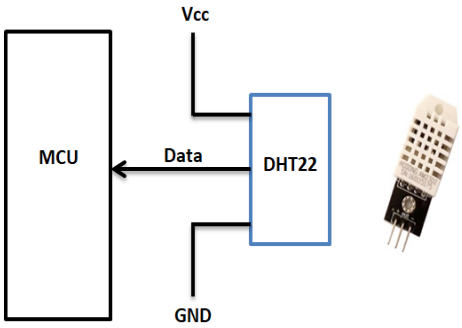

Fig. 1. DHT22 temperature and humidity sensor

(2) RF Module 433MHz (Transmitter) is a simple radio frequency transmitter. It is tuned to the SAW resonator in order to generate a 433MHz signal. A switching transistor exists with several passive components. When a HIGH logic is applied to the DATA input, the oscillation is executed, generating a constant 433 RF output carrier wave of xx MHz and when the DATA input is taken in logic LOW, the oscillator stops. This technique is called (ASK) Amplitude Shift Keying [11].

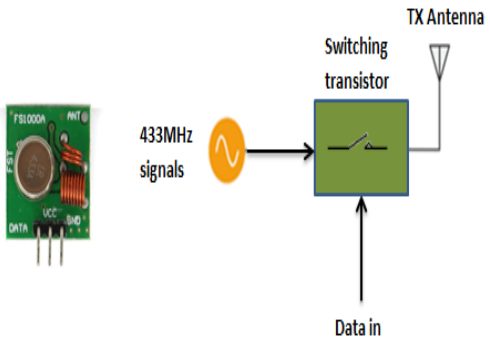

Fig. 2. RF Module 433MHz

(3) The RF Module 433MHz (Receiver) appears complex compared to the transmitter module. It consists of a tuned RF circuit and some Opamps to amplify the carrier wave received from the transmitter. The amplified signal is sent to a PLL (Phase Lock Loop) which enables the decoder to "lock" a digital bit stream that gives a better-decoded output and noise immunity [12].

In this study TX module (Model: XD-FST) is used, as well as (Model: XD-RF-5V) for Rx module. Specifications and characteristics of these modules can be found at [13].

2.2 Modular Wireless Commutation System

In this design of wireless communication system, data are temperature and humidity. Fig. 4 is shown, a system that measures temperature and humidity by a DHT22 sensor as digital information and sent it to the microcontroller. That information is coded and sent to the transmitter of the RF module. Then, the information signal is carried on the 433 MHz (modulated signal) by the ASK technique. That modulated signal can be radiated away in the space according to the power signal and the gain of the transmitting antenna. On the other side, receiver of the RF module collects the modulated signal which includes information. The receiver of the RF module is responsible to demodulate the signal and send it to the microcontroller. Then, decoding is applied to obtain the data and visualize it in the serial monitor on the computer.

2.3 Transmitter and Receiving Units

A transmitter and receiver module, called a radio frequency (RF) module, was used in the design of the system. The RF module is a small electronics unit capable of transmitting and receiving radio signals and mainly used in wireless projects. Several spectrums are used in the RF module, including 315MHz, 433.92MHz, 868MHz, 915MHz and 2400MHz. A 433MHz RF unit was used in our design objective.

2.3.1 Transmission unit

The DHT22 sensor is initially linked to the Arduino in the transmission part. The (+) pin of the DHT22 sensor is linked to the (+5V) pin of the Arduino, while the (-) pin is linked to the (GND) pin of the Arduino. In like manner, data pin of the DHT22 sensor is attached to Arduino pin4. The complete transmission module circuit connection is presented in Fig. 5.

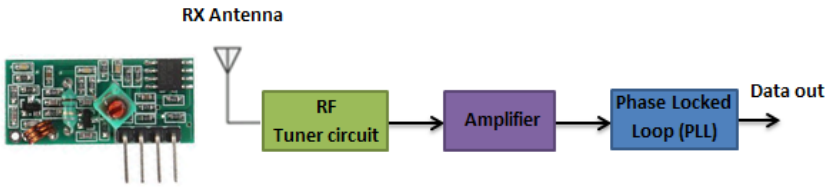

Fig 3. RF Module 433MHz

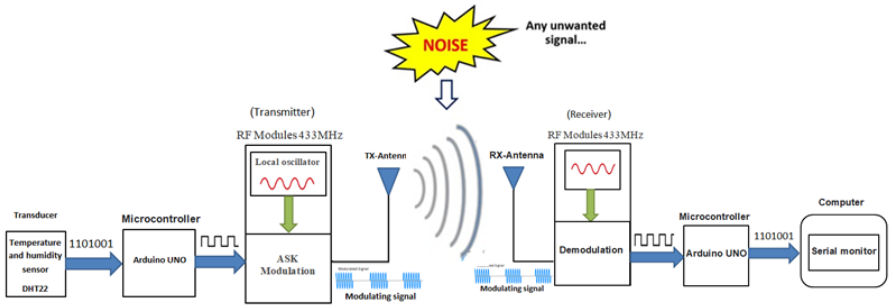

Fig. 4. Proposed system

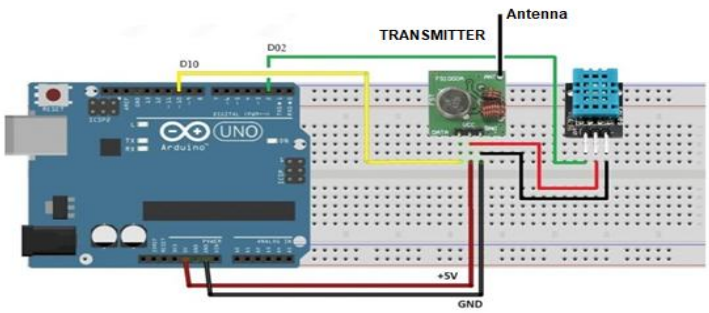

Fig. 5. Transmission unit

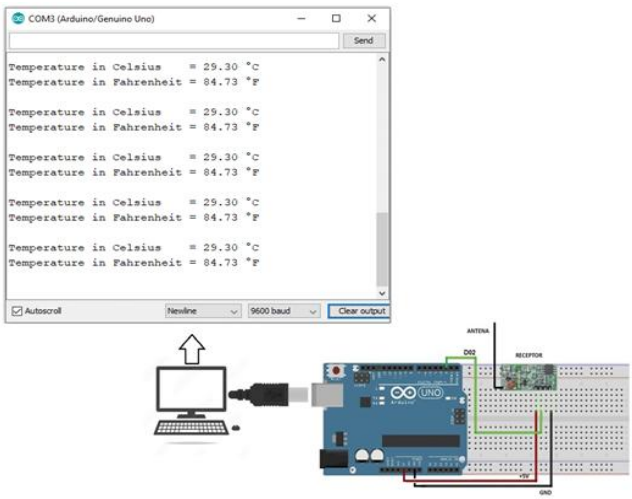

Fig. 6. Reception unit

2.3.2 Reception unit

The computer, An Arduino Uno, and RF 433MHz receiver are shown in Fig. 6 as receiving section circuit connections. The red lines indicate that they are linked to the (+5V) power supply pin, the black lines indicate that they are connected to the (GND) pin, and the green lines indicate that it is connected to the data pin, while the computer linked by USB to show the data on the serial monitor.

3. PROGRAMS AND FLOWCHARTS

A system design consists of two parts. This includes the transmission and receipt units, so there are two programs as well as two flowcharts in total, which have been created to make the system work properly. The program flowchart used in the transmission unit and the receiver unit is shown in Fig.7 and Fig. 8, respectively.

4. THE PROPOSED CIRCUIT'S DESIGN AND CONSTRUCTION

RF modules are used in a large number of consumer electronics products. It is also used in wireless data transmission and in remote control systems. These units are capable of transferring 4 bits of data at the same time and at a rate of 1Kbps.

The 433MHz RF Module uses the antenna to increase the transmission. Thus, the test process is divided into several stages. First of all, the range of the system without an antenna is tested inside the building (indoor). Then, the system is moved to an open position (outdoor) where the direct distance from the transmitter to the receiver can be measured. Data is sent every 5 seconds and the movement is done in the transmitting circuit away from the receiving circuit by a distance of 2m if the measurement is inside the building or 5m if it is outside the building every 10 seconds. The test stops when data is lost in the receiver circuit at a certain distance. The following Table 1 presents the test cases with and without antennas in and out of the building.

The design of this work has been planned incrementally and systemically. At first, the whole system was outlined in a block diagram as shown in Fig. 9 and then the different parts of the circuits of the block were designed and tested.

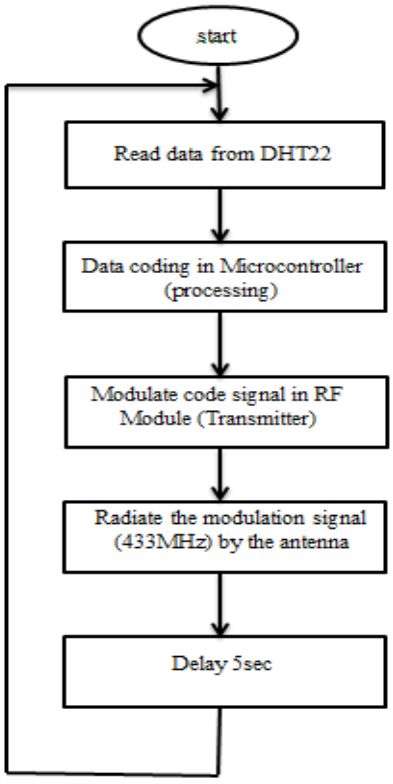

Fig. 7. Transmission flowchart

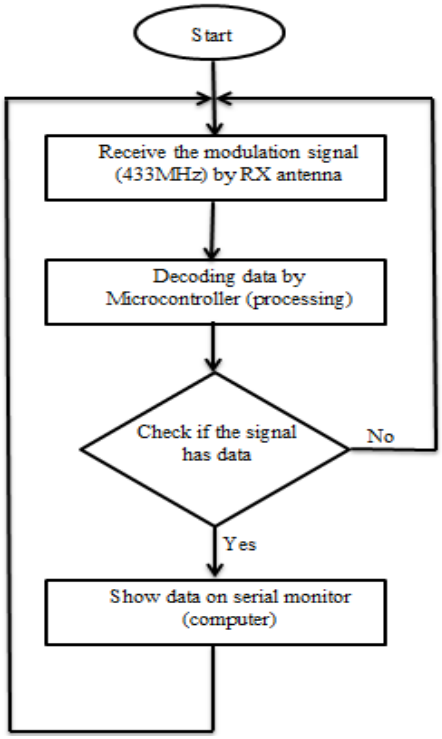

Fig. 8. Reception flowchart

Table 1. The maximum distance according to the length of antenna

The maximum distance according to the length of antenna		
Length of antenna	**maximum distance**	
	Indoor	**outdoor**
Without antenna	6m	10m
Less than 1/4 $\boldsymbol{Wavelength}(\boldsymbol{\lambda})$ (8cm)	13m	34m
1/4 $\boldsymbol{Wavelength}(\boldsymbol{\lambda})$ (17cm)	20m	52m
More than 1/4 $\boldsymbol{Wavelength}(\boldsymbol{\lambda})$ (30cm)	18m	43m

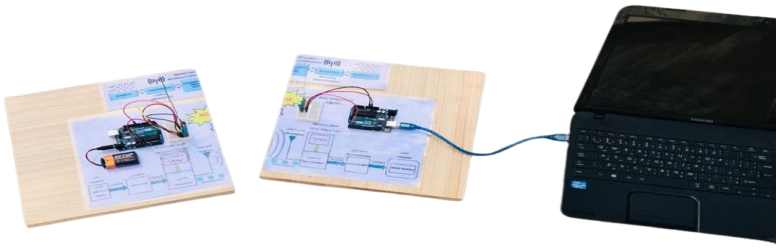

Fig. 9. The full system of transmitting and receiving digital information wirelessly at 433MHz

5. CONCLUSION

This study describes the design and implementation of a simple and inexpensive telecommunications system to enhance undergraduate students' learning in the field of telecommunications engineering. Due to their ease of use and consistent results, hardware tools such as Arduino microcontrollers, C programming and transducers have produced good results in building laboratory investigations. Important principles such as encoding/decoding method, modulation/extraction, antenna fitting, and programming are taught to students who build their own communication system with these tools. Students will have a better understanding of how data is sent and received. As a result of students' acceptance of this realistic implementation of the communication system, the goals were achieved.

In this paper, a low-cost system for transmitting and receiving data at 433MHz wirelessly has been presented. In addition, different cases of implementation have been discussed. By increasing the gain of the TX/RX signal by various lengths of antenna and environmental (in/out door). The performance of transceiver data is greatly improved. The ability to transmit and receive data increased from 6m indoor to 20m as well as outdoor to 52m instead of 10m apart sections.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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