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A Prototype of a Wirelessly Controlled Nuclear Centrifuge

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Abstract: ***Centrifuge is a device used to separate materials from each other based on certain percentages. A nuclear centrifuge is a device that performs isotope separation of gases. It is used to separate uranium-235 from uranium-238. To perform the separation process, uranium hexafluoride gas is placed in a hollow cylinder and rotated at a high speed. This rotation creates a strong centrifugal force so that the heavier gas, U-238 is thrown towards the edge. The lighter U-235 moves up where it is collected. In this paper a prototype that simulates a nuclear centrifuge was designed using DC motors that operate at different speeds to perform the separation process. The centrifuge was wirelessly controlled allowing people working in that area to control it from a distance without being exposed to radiation and toxic chemicals.***

Keywords: Centrifuge, Microcontroller, Wireless Technology, DC Motors**.**

1. Introduction

The centrifuge is considered an important device in modern life, as it is used widely in various aspect of life such as in the medical and industrial field. The main idea of the device is based on the separation of materials from each other based on certain percentages. In the medical field it is used to separate blood samples. In factories it is used to separate materials so as to produce new ones; also it is used in filtering processes [1].

A centrifuge is a piece of equipment, generally driven by an electric motor; that puts an object in rotation around a fixed axis, applying a force perpendicular to the axis. The main idea of the device is based on the separation of materials from each other based on certain percentages.

The centrifuge works by using the sedimentation principle, where the centripetal acceleration causes more dense substances to separate out along the radial direction (the bottom of the tube). By the same token, lighter objects will tend to move to the top of the tube, the rotating unit, called the rotor,

The centrifuges used in nuclear reactors (nuclear power and nuclear weapon programs) are used to separate the isotopes of uranium. It is used to separate uranium-235 from uranium-238[2]. The separation process is performed by placing uranium hexafluoride in a hollow cylinder and rotating it at a very high speed. This rotation creates a strong centrifugal force resulting in the separation of isotopes where the heavier gas U-238 is thrown towards the edge and the lighter gas U-235 moves up where it is collected[1][2]. People working in this area are exposed to radiation and toxic chemicals which affect their health in the long run. In this paper, a prototype that simulates a nuclear centrifuge was designed using DC motors that operate at different speeds to perform the separation process. The centrifuge was wirelessly controlled where it operates remotely to prevent people from direct exposure to radiation and toxic chemicals.

2. Model Design and Operation

2.1 Model Design of the Centrifuge

The centrifuge prototype consists of a transmitter unit and a receiver unit as shown in Figure 1. At the transmitter unit; the Keypad is used for controlling the speed and revolution needed to rotate the motor, to perform the isolation process. The Liquid crystal display (LCD) is used to reveal the information before being transmitted. This allows the user to update, replace and cancel any information entered through the keypad. The microcontroller is used to translate the data from the keypad and generate the Pulse Width Modulation (PWM) that controls the rotational speed of the motor generated from the microcontroller. The encoder HT12E is used to encode the information. The Transmitter modulates and transmits the

encoded information using Amplitude Shift Keying (ASK) that operates at a frequency of 434 MHz[3][4].

The receiver is used to receive signal from free space through the antenna. At the receiver unit; the receiver demodulates the received signal, to obtain the original one. Similar to the transmitter, the receiver is an ASK-RX operating at a frequency of 433.92 MHz. The decoder HT12D is used to decode the information. The decoder receives the data which represented both the speed and revolution and send it to the microcontroller. The microcontroller will separate the data received into; the speed and revolution needed to rotate the motor**.** The L293D`motor driver is used to drive the DC motor [3].

Figure 2 and Figure 3 show the transmitter and receiver unit respectively on the circuit board

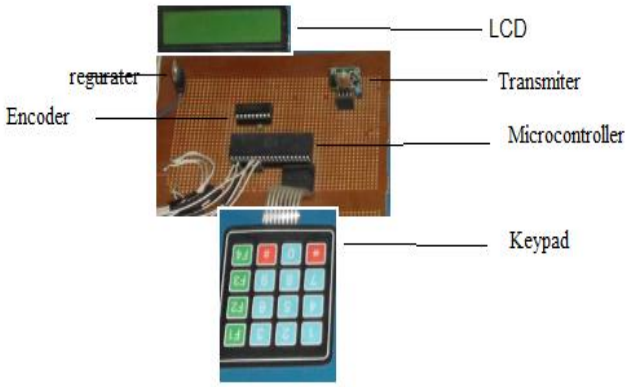
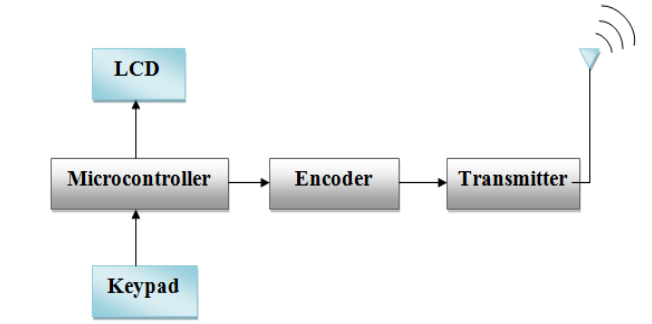


Figure 2: Transmitter Unit on the Circuit Board



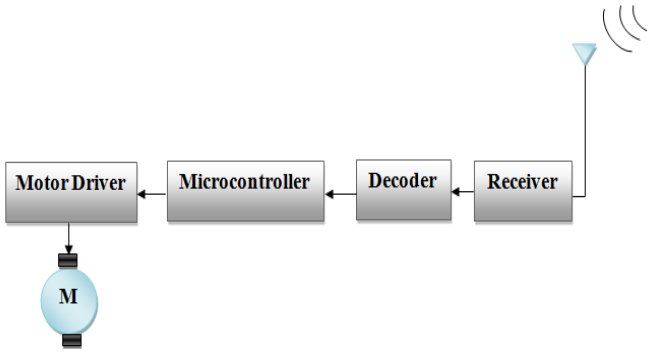


Figure 1: Model Design of the Centrifuge

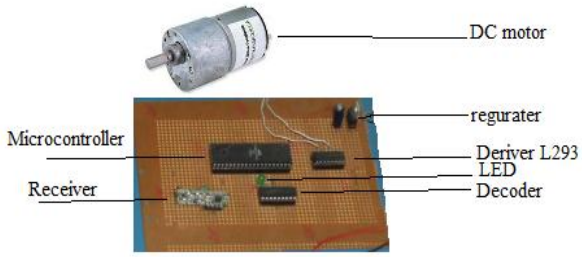


Figure 3: Receiver Unit on the Circuit Board

2.2 Operation of the Centrifuge

The operation procedure of the centrifuge is as follow:

At the transmitter unit shown in Figure 2;

- The operator inserts the speed and revolutions using the keypad. F1and F2, represent the different speeds of the centrifuge, and key1and key2 represent the number of revolutions.
- The microcontroller receives the data in port D from the keypad and processes it.
- The output can be observed on the LCD which is connected to port B of the microcontroller.
- The encoder is connected to port A of the microcontroller; it converts the parallel inputs (from the microcontroller) into serial set of signals.
- These signals are serially transferred through RF to the reception point.

At the receiver unit shown in Figure 3;

- The receiver, upon receiving these signals, sends them to the decoder IC.
- The decoder is used after the RF receiver to decode the serial format and convert the serial input to parallel signal; it is connected to port D of the microcontroller. The output of microcontroller from port B is connected to the motor driver which is connected to motor.
- The motor movement depends on the data transmitted

3. Results and Discussion

The common keypad is 4 *4 (matrix keypad) that consists of 4 rows and 4 columns as shown in Fig. 2. It consists of 16 keys, certain keys were used for inserting the speed and others for inserting the revolution. In a nuclear centrifuge normally a speed of 340m/s and revolution of 90,000 R.P.M is used to isolate uranium 235 and a speed of 540m/s, with revolution 150,000 R.P.M is used to isolate uranium 234 as shown in Table 1

Table 1: Speed and Revolution Used in Uranium

Speed	*Revolution*	*Application*
340	90,000	Gives Uranium 235
540	150,000	Gives Uranium 234

Since both these speeds and revolution are very high and a motor to perform these rotations is not available, a small model of the centrifuge was designed with different speed and revolution as shown in Table 2

Table 2: Speed and Revolution Used in Model

Speed	*Revolution*
20	50
50	250

The keypad was used to insert both speed and revolution needed. Table 3 shows the key operations used in the model.

Table 3: Keys Operation Used in the Model

Operation1		Operation2	
Keypad no.	*Speeds*	*Keypad no.*	*Revolutions*
F1	20	1	50
F2	50	2	250

The ATmega32L Microcontroller acts as the brain of the centrifuge. It generates desired outputs for corresponding inputs. Table 4 shows the microcontroller representation of speed and revolution entered by the keypad [4].

Table 4: Speed and Revolution Representation by Microcontroller

Speed	*Code*	*Revolution*	*Code*
Key F1	1010	Key 1	0001
Key F2	1011	Key 2	0010

If key F1 is pressed, the microcontroller sends the speed as (1010) to the encoder as shown in Figure 4. Then when key 1 is pressed, the microcontroller sends the revolution as (0001) to the encoder as shown in Figure 5 [4]. The parallel inputs (speed and revolution) will be sent from the encoder to the transmitter as a serial set of data. In an ASK transmitter, the transmission of a binary 1 is represented by the presence of a carrier for a specific time interval, whereas the transmission of a binary 0 is represented by a carrier absence for the same interval. The first set of data –the speed- received by the ASK-TX is modulated as shown in Figure 6 [5]. While, the second set of data-the revolution- is modulated as shown in Figure 7

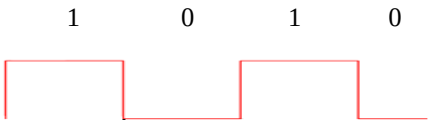


Figure 4: Speed Representation by the Microcontroller

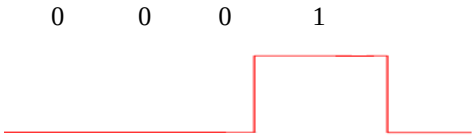


Figure 5: Revolution Representation by the Microcontroller

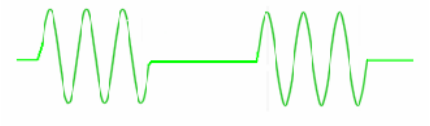


Figure 6: Speed Modulated Signal

Figure 7: Revolution Modulated Signal

The ASK-RX receives the speed modulated signal first, followed by the revolution modulated signal. The receiver demodulates both signals to regain the original data to be sent in sequence to the decoder. The decoder receives the data which represents both the speed and revolution and send it to the microcontroller. The microcontroller separates the data

received into the speed and revolution and sends a signal to the motor to rotate.

4. Conclusion

Centrifuges are used in many applications such as in the medical, commercial and nuclear field for separating particles from a solution according to their size, shape, density and viscosity of the medium and rotor speed.
Nuclear reactors centrifuge is used to separate the isotopes of Uranium In this paper, a prototype that simulates a nuclear centrifuge was implemented. It operates at different speed to perform the separation process. The centrifuge was wirelessly controlled to prevent people working in that area from direct exposure to radiation and poison's chemicals.

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