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Research paper

High accuracy system for the measurement of a directional antenna using an Arduino microcontroller

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Abstract

Telecommunication system based on sensors became part of our daily life. The development of two simple methods for high accuracy of antenna direction techniques is presented. Incremental encoder and endless potentiometer are sensing devices that convert the motion to electrical signal which can be read by some types of microcontroller devices. In our research article, two methods of transducers are suggested and implemented to provide feedback from the physical world. Electrical signals are generated by coupling the sensing device to the mechanical motor shaft. The accuracy of the first proposed setup depends on the number of pulses per revolution which is 0.351 degree per pulse. The accuracy of the second setup depends on range of input voltage reading by the microcontroller per revolution which is 0.072 degree per mv. According to our readings the second method has better accuracy than the first method. Highlights of these methods are the easy to installation, portability, cost effectiveness and better accuracy.

Keywords: *Accuracy; Antenna; Microcontroller; Encoder.*

1. Introduction

An antenna is a major component in wireless communication. One important factor that limits the life of many industrial applications is the accuracy. A technique of data acquisition, signal processing and data display was proposed and implemented to operate interface to microcontroller [1].The design of control system based on GPS receiver, microcontroller and personal computer is implemented to select the geosynchronous satellite antenna positioning [2].Review in the wireless micro systems for biomedical applications[3]. The adjustments of elevation and azimuth angles of base station antenna are analyzed [4]. Investigation of a dish control automatically was represented [5]. PIC microcontroller was used to design and develop a satellite parabola positioning system which canbe worked using a Bluetooth technique [6].The development of a system by controlling the movement of the parabola antenna in all directions using android applications [7]. Development of a geostationary satellite parabola reflector positioning system was represented which can be worked using a remote control [8]. Demonstration of real-time localization based on steerable antennas where the antennas are implemented digitally by Electrically-Steerable Parasitic Array Radiator (ESPAR) from a microcontroller [9], [10]. IR T-V remote control was combined with microcontroller chip to control the position of satellite reflector antenna [11]. A method to overcome the problem of adjusting manually was proposed todevelop control method of smart antenna in all directions [12]. Smart antenna system of adaptive and a Switched Beamwas designed for Wireless Communications [13].The incremental optical encoder has proved its potential for measuring the position and angle. [14].

In this research article, two types of position to angle transducers are proposed, designed and implemented for applications in some antennas such as parabola reflector and horn antenna. First transducer based on incremental encoder, electronic circuits to increase the number of pulses per revolution, up/down counter, microcontroller and liquid crystal display. Alternative transducer consists of endless sensor, electronic circuit which is interfaced to microcontroller. Signal will be processed in the microcontroller and displayed at liquid crystal display. Comparison is done between the two setups to select the suitable model.

2. Experimental works details

The first setup has involved antenna in coupling with the following components as shown in Fig.1

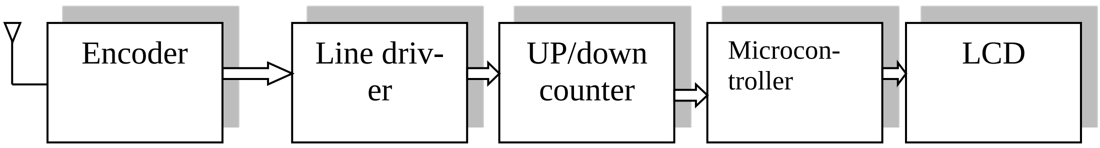

Fig. 1: Block Diagram of Incremental Shaft Encoder Setup.

1.1. Incremental optical shaft encoder

The encoder can be defined as transducer of position which converts the angular linear motion of a shaft into a series of electrical digital pulses. Rotary incremental encoders are specified for form factor, level of ruggedness, and resolution.Reference was made to a coded disc pattern to reset the up/down counter.

For incremental encoders, resolution is defined as counts per revolution. Incremental encoder is different from absolute encoder which has single-turn, specified as a multi-bit word. Measurements are specified in positions per input shaft turn. Incremental optical encoders, the most widespread encoder In industrial application has involved an LED light source, light detector, code disc, and signal processor. The disc has opaque and transparent segments and passes between the LED and detector to intermittently interrupt a light beam. The detector tracks the series of light exposures it receives and sends that information to the processor that extracts motion information.Encoder is consists of three discs. Generally,the incremental encoder generates two kinds of squared pulses, out-of-phase shift of 90° degrees, which are usually called channel A and B. Channel A provides data about the rotation speed (number of pulses per revolution). Channel B gives data about the direction of rotation, according to the sequence producedby the two signals. The resolution may be determined by multiplying two or four readingnon only rising edges but also falling edges of A and B signals. According to this method, an encoder with physically 1000 pulses perrevolutions can supplied 2*1000 or 4*1000 pulses per revolution as shown in Fig.2. The last signal, named Zero provides zero position of the encoder shaft and can be adjusted as areference point. Three coded discshave the output signals A, B and C respectively as shown in Fig.3

The accuracy of shaft encoder is calculated as number of pulses/ one revolution, so if the counter counts up to 1024 that mean each 1 degree is equal to (360/1024) for each step.

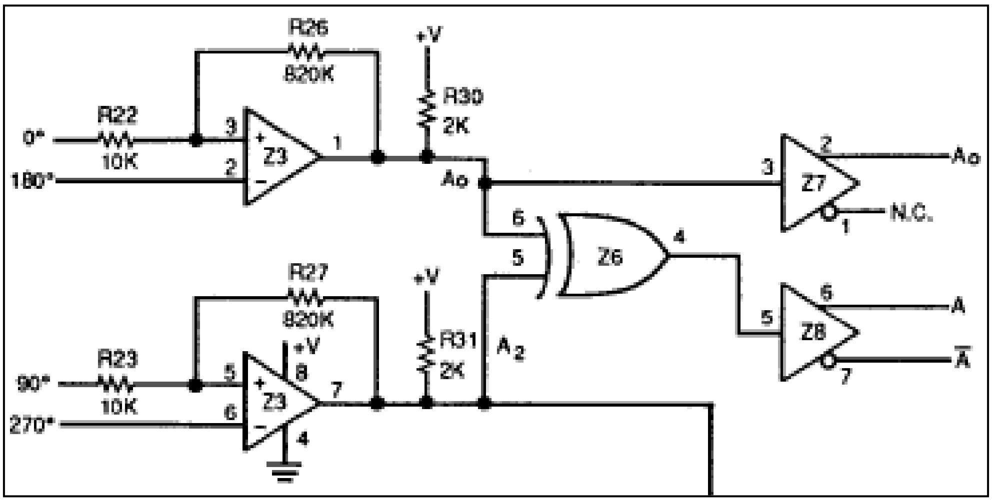

Fig. 2: Two Times Resolution of Incremental Encoder.

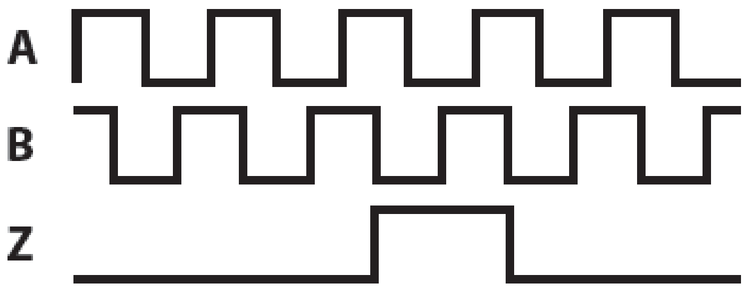

Fig. 3: Timing Diagram with Z Pulses per Revolution.

1.2. Microcontroller

Arduino microcontroller shown in Fig.4 has digital and analog inputs / outputs ports that can be interfaced to many external boards.There are many types of Arduino microcontrollers. The type used for this research is Uno board type. It is supplied with fourteen digital inputs/ outputs, six analog inputs and five analog outputs pins. The Arduino microcontroller is programmed with Arduino IDE (Integrated Development Environment) using USB cable.The digital inputs/outputs may be (LOW ,or, HIGH) level ,while the analog inputs/outputs may be with the range of (0-5) volts DC .

Fig. 4: Arduino Microcontroller.

1.3. Up/down counter

The synchronous chip 1024 up/down binary counter is manufactured with MOS P−channel and N−channel enhancement mode devices in a monolithic structure. The state of the counter changes on the positive transition of the clock input. Cascading can be accomplished by connecting the Carry Out to the Carry In of the next stage while clocking each counter in parallel. The outputs (Q0, Q1, Q2, Q3) can be reset to a low state by applying a high to the reset (R) pin.

1.4. I2C 1602 serial LCD module

The front and the back views of this LCD is shown in Fig. 5.
The LCD is a 2 lines by 16 characters display ,where it requires 2 data connections ,+5VDC and GND for the operation .For this paper it is used for the measurements of the antenna direction angle.The second setup consists of the end-less resistance instead of incremental encoder. The block diagram of the angle measurement is shown in Fig.6 and the circuit of it is shown in Fig.7. Photograph for it is shown in Fig. 8.
Fig. 7 shows the circuit diagram of the angle measurement.

Fig. 5: The Front & Back Views of the Liquid Crystal Display (L.C.D).

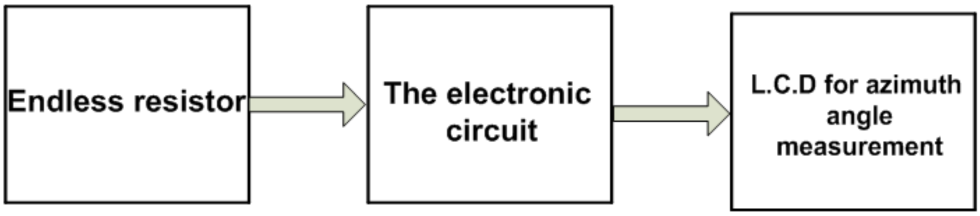

Fig. 6: Angle Measurement Block Diagram.

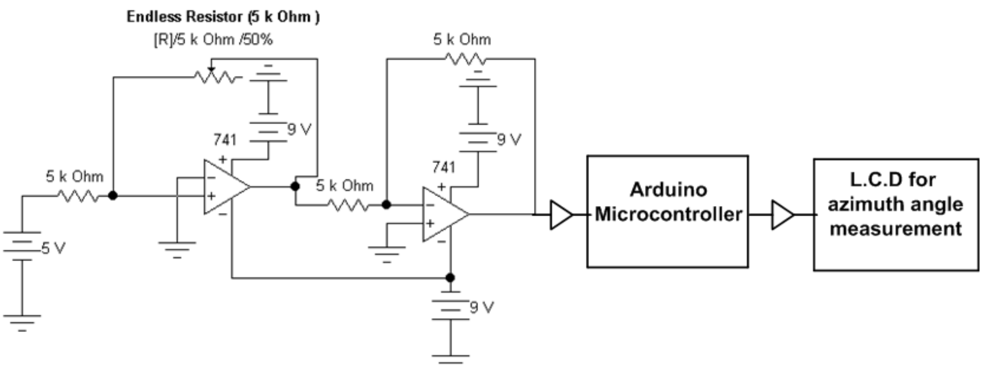

Fig. 7: Angle Measurement Circuit Diagram.

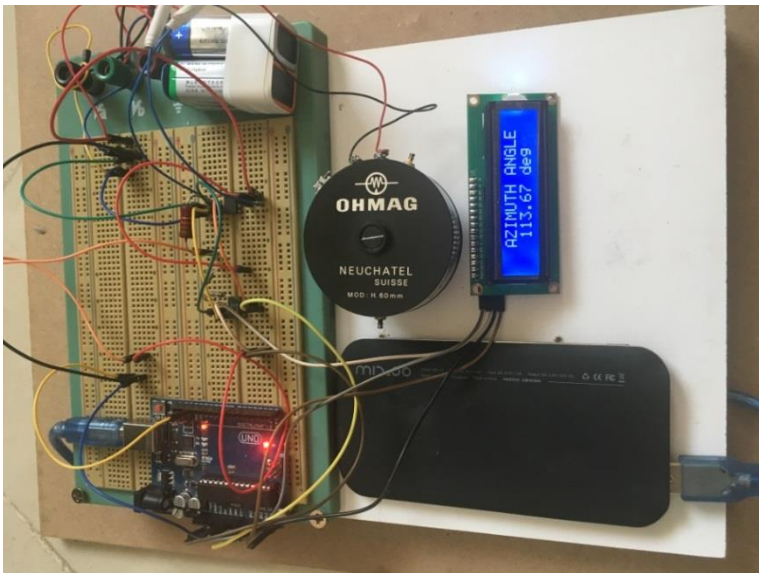

Fig. 8: Photograph of the Electronic Circuit for Angle Measurement.

1.5. End-less resistance

Fig.9 shows us a sample of an endless resistor .The endless resistor is a variable resistor used to indicate the rotational angle for any rotational part of any control system .The endless resistor used by this paper has a value of (5 kΩ) that represents a rotational angle of (360 degree) ,for example (2.5 kΩ) represents of (180 degree).

Fig. 9: The Endless Resistor.

1.6. Operating soft ware

To indicate the azimuth angle on the LCD there must be have a code. For this purpose, the code is written by arduino C language . This code is listed below.

```
#include <Wire.h>

#include <LCD.h>

#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,2,1,0,4,5,6,7);

void setup(){

Serial.begin(9600);

lcd.begin (16,2);

lcd.setBacklightPin(3,POSITIVE);

lcd.setBacklight(HIGH);

lcd.home ();

 A:float ANGLE= analogRead(A0);

lcd.setCursor(2,0);

lcd.print("AZIMUTH ANGLE");

lcd.setCursor(3,1);

lcd.print(ANGLE*360/1023);

lcd.print(" deg");

delay(1000);

goto A;

}

void loop(){}
```

3. Results and discussion

Table .1 shows how the angle of antenna is related to the change of the BCD counter output when the reading of the counter is changed from 0 to 1024 in Binary Code Decimal. It is clear that the angle of the antenna will be changed up or down according to direction of movement step of 0.351 degree for each step of increasing or decreasing in counter value. The measurements shown in table 2 are the results that obtained by connecting the endless resistor with the electronic circuit shown in Figure 7 ,where the endless resistor is a variable resistor its value depends upon the rotational angle of it. It has minimum value when the rotational angle approaches zero degree value, and has a maximum value when the rotational angle approaches 360 degree.

We can say that if the endless resistor with the range (5 k Ohm $\geq$ endless resistor $\geq$ 0 Ohm) the rotational angle will be in the range of (360 Degree $\geq \phi \geq$ 0 Degree) , where(ϕ) is the rotational angle of the designed system .The voltage across the endless resistor has been read and sent to the arduino microcontroller then to the LCD indicator,where this voltage is converted to the rotational angle according to its value.As well as for the indication of the rotational angle a special code has been designed using C language which is listed in operating software section. Thirty-six measurements taken between the voltage across the endless resistor and the rotational angle of the moving part of the system that shown in table 2.

4. Conclusions and future work

High accuracy system for the measurement of a directional antenna using an arduino micro controller was proposed, designed and implemented. The system is efficient, reliable, easy to install, low cost components, small size and portable. The accuracy of the two setups is acceptable for the applications of antenna positioning. The results are accurate and tested by revolving the endless resistor more than one revolution while all the measurements did not change at all,this is a guide that states our design is accurate .The performance of the practical system can be improved using new models of microcontroller.

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