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Building A Computerized System For The Position Control Of A Dc Motor

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ABSTRACT: In this research a computerized position control system for a Direct Current (DC) motor was built and tested for accuracy and repeatability. The angular position of the shaft of a DC motor was monitored and controlled using an optical encoder and a computer program written in turbo C. In the experimental setup the motor shaft was deliberately seized for a while, the program produced a message that the motor was not moving, when the motor shaft was released the program drives the motor to its target position. The research idea may be applied to stepper motors used in Computer Numerical Controlled machines and robots, to monitor and control their response to programmed commands, when not used within their specified range of load and speed, as well as many applications such as dc motor driven computerized wire winding machines, and electric passenger's lifts.

Keywords: Position control system, Direct Current motor ,Accuracy, Repeatability, turbo C, optical encoder.

1 INTRODUCTION

Computerized control systems lie at the foundation of almost every manufacturing industry. Through amazingly complex structures of electronic and mechanical hardware, computer software, engineering controls, and instrumentation technicians can monitor, adjust and regulate virtually every industrial process. Martindale, Shawnee, KS (2005) [1], in his work titled "Controlling Antennas Powered by AC or Large DC motors with the RC1500 or RC2000 antenna controllers", applied a technique to use the antenna controller's +/- 36 volt output voltage to activate AC and higher voltage DC motors . In this research a computerized position monitoring system applied to a DC motor in order to drive it to the required correct position. In case of erroneous causalities, a monitoring system via an optical encoder and a computer program corrects the lagging position of the motor. An experimental model was built and tested for accuracy and repeatability.

2 MATERIALS AND METHODS:-

The system will be explained, regarding components, functions, and programming. This system includes both hardware and software.

2.1 Materials:

The hardware was composed of a DC motor, a 25 pin Parallel Port, a Current amplifying chip (UN2003A), Relays, a J-K flip-flop, a Slotted Opto-Switch, and a rotary incremental optical encoder disk(a used CD-ROM disk with an equally spaced slots machined on its perimeter).

2.2 Methods:

The slotted opto-switch is placed at the perimeter of the optical encoder disk. The shaft of encoder disk is driven by the shaft of the motor of concern via a gearbox that increases the speed of the motor in the ratio of 1:18. (18 turns of the encoder shaft to one turn of the motor shaft). The purpose of the gearbox is to increase the resolution of the encoder. The opto-switch develops a half sine wave in response to the rotation of encoder disk. The signal generated is noted to be very weak (when detected by an oscilloscope) and thus, need to be amplified using the current amplifying chip (ULN2003A). This amplified signal is used as a clock on the JK flip flop, the shape of signal produced is a square wave of an amplitude of +4v.

The square signal is sent to the parallel port of a desktop computer. A program written in Turbo-C was develop to obtain the sum of theses pulses in order to compute the angular position of the encoder disk connected to the shaft of the DC motor through the gearbox. The circuit diagram for the experimental setup is shown in figure 1.

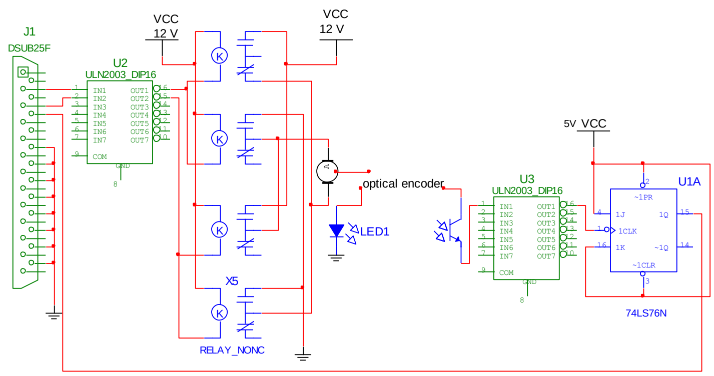

Fig1: *The circuit diagram for the experimental setup*

In this study two modules of the control programs were developed. The first one when the DC motor was commanded to achieve a target angular position. The purpose of this module is to test the control system for accuracy and repeatability, the second when the DC motor was hindered midway for some time, then released. The purpose of the control program is to detect that the motor was stopped and to display a message (the motor is not working), then drives the motor to the target position when the motor is released.

3 Results & Discussions:-

a) The motor commanded to reach a target position:

When The DC Motor was allowed to move under control up to the target position, the accuracy was measured and shown i figure 2. The effect of repeating the same command on realizing the desired angular position of 36^0, 120^0, 180^0,and 288^0 is shown in figure 3.

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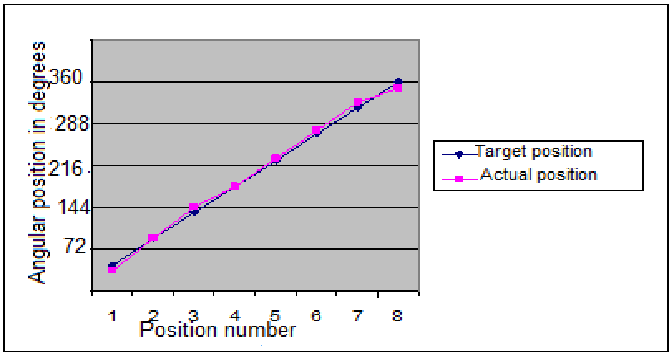

Fig2: *The accuracy through the first 360^0*

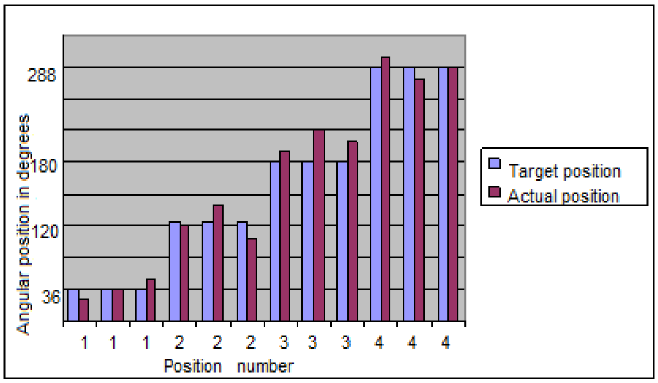

Fig3: *The repeatability for 36^0, 120^0, 180^0,and 288^0 targeted angular position.*

b) The motor commanded to reach a target position, but hindered midway for a while:

When the DC Motor was hindered midway for a while, then left to resume its course to a target position, the accuracy is measured and is shown in figures 4. The effect of repeating the same command on realizing the desired angular position 120^0 is shown in figure 5.

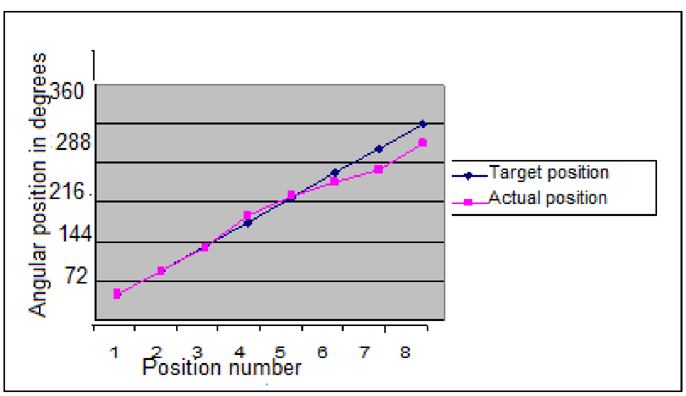

Fig4: *The accuracy through the first 360^0 with the motor hindered midway for a while*

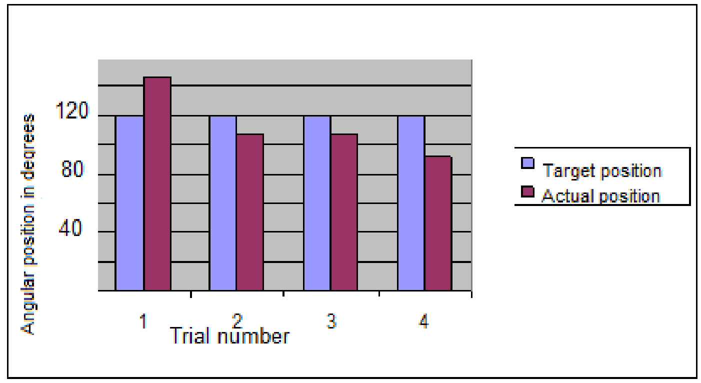

Fig5: *The repeatability for a 120^0 targeted angular position, with the motor hindered midway for a while*

It could be noted from figure 2 that the accuracy of positioning of the encoder is high (as high as 0.973% of the value of the desired angular position, (as calculated from the table of readings of which figure 2 is obtained). It worth mentioning that this accuracy is correct only for points within the resolution of the 30 slots encoder which, theoretically speaking, is 12^0. The gearbox increases this resolution eighteen times, which becomes 0.667^0. Thus, the experimental resolution is $0.667/0.973=0.686^0$. When hindered at mid position and then released, the accuracy is a little bit affected, and was found to become in the order of 0.944% of the value of the desired angular position. The experimental resolution becomes 0.707^0. It could be noted from figure 3 that the repeatability of the encoder system (as calculated from the table of readings of which figure 3 is obtained) is ±3.95% of the value of the desired angular position. When hindered, the repeatability drops to ±23% of the value of the desired angular position.

4 CONCLUSIONS AND RECOMMENDATIONS:

In this research a positioning control system for a DC motor was designed, built, and tested. The motor control circuit is connected to an IBM PC parallel port, via an ULN2003A 7-bit Buffer. The first two data lines are used to control four relays, which are used to switching the motor. The motor driver circuit comprises a buffer chip and the four relays.The shaft encoders attached is a plastic disc with 30 equally spaced holes drilled on its perimeter, a reflective opto-switch was used, with an infrared beam detected by its phototransistor. The current amplifying chip was used as an amplifier to increase the produced signal's current, which is fed to the JK Flip Flop, The pulses by the Flip Flop indicates the position of the motor. These pulses are send to the computer through the parallel port, counted by software program and compared with number of pulses that was set previously in the program. The accuracy and the repeatability of the system are practically reasonable. To use this position control system for robots and CNC machines, an absolute optical encoder, is recommended to be used in place of the incremental optical encoder used in this research. It is also recommended to research the possibility of applying the research idea to built a feed back position control for stepper motors in place of the reference pulse system [2], now in use.

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