

Remote Position Control System of Stepper Motor Using DTMF Technology

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Abstract

Stepper motor is found in a lot of applications such as computer peripherals, business machines, process control, machine tools and robotics. Especially in different areas of robotics, process control like silicon processing, I.C. Bonding and Laser trimming applications, it is necessary to control the stepper motor from remote places. The present paper describes a remote angular position control system of stepper motor using DTMF (Dual-Tone Multi-Frequency) Technology as an alternative means of communication using Radio Frequency (RF) with advantages of simplicity and audibility. DTMF Technology has been used here to implement acoustic communication for controlling the angular position of the stepper motor remotely anywhere in the world through mobile phone network. The desired value of angular position signals, in terms of DTMF tones have been generated by using a mobile phone. The microcontroller has been used to implement the control algorithm after receiving the DTMF tone. Since no extra transmitting and receiving device is needed except mobile phone, the system is very much simple, rugged, and cost effective. The experimental results indicate that the system has high resolution, repeatability and error is also within tolerable limit.

Keywords: DTMF Technology, Position Control, Stepper Motor, Acoustic Communication, Remote Control, Mobile Phone.

1. Introduction

Stepper motor, due to their positional accuracies and fast response, is now finding applications in computer peripherals [5], process control [1], machine tools, robotics [6], [7] and various surveillance systems [2], [8]. Especially in robotics and process control like silicon processing, I.C. Bonding and laser trimming applications, it is necessary to control the stepper motor from remote place. Moutinho et.al. [2] described RF communication for controlling stepper motor through PIC 16f877 microcontroller. For remote communication DTMF (Dual-Tone Multi frequency) signal can replace RF signal for the advantage of simplicity and audibility. Yun Chan Cho and Jae wook Jeon [9] used DTMF of mobile phone for controlling Robot remotely. D. Manojkumar et.al. [3] controlled a robot by a mobile phone that makes call to the other mobile phone attached to the robot which has a RF camera that transmits an actual video at the operation monitor. Based on the received video, the corresponding commands can be passed from the mobile phone which is connected with the transmitter side. Tulijappa M. Ladwa et.al. [10] used DTMF signal for controlling remotely located domestic system. Mobile devices, like cell phone or smart phone are being used to

monitor and control remote devices like mobile robot which is fitted with camera [11]. Human-Robot interaction mechanisms that allow a human commander to control a mobile robot via cellular phone have been developed and successfully tested by Ali Sekmen et.al. [4] and T. Kubik et.al. [12].

In the present project the angular position of a stepper motor has been controlled remotely using DTMF signal through microcontroller. Wireless position control can also be achieved through RF transmitter and receiver but in case of RF communication, devices using similar frequencies such as wireless phones, scanners, wrist radios, personal locators etc. can interfere with transmission. In the present scheme DTMF Technology has been used to implement acoustic communication for controlling the angular position of the stepper motor remotely anywhere in the world through mobile phone network. DTMF decoder has been used to decode the DTMF signal. The decoded signal has been read by the microcontroller through its I/O port and generates the control signal to position the stepper motor at the desired angle. Experimental results show that the system has good linearity and repeatability. The error in measurement of angular position is within $\pm 2.7\%$.

2. Block Diagram and Methodology

Overall block diagram of the present project is shown in Fig.1. From the block diagram it is clear that two mobile phones have been used, one is with the user or operator side and the other is in the system or experimental setup side which may be located at any distance from the user and connected through mobile network. When the user makes a call to the mobile phone of the system, it receives the call as it is always in auto receiving mode. Thus the user and the system are connected via mobile network. Now if user presses any key on the key pad, DTMF tone is generated which corresponds the desired angular position of the stepper motor. This DTMF signal is received by the system mobile phone located at the receiving side. There it is decoded by the DTMF decoder. The hex inverter has been used to maintain the voltage level properly.

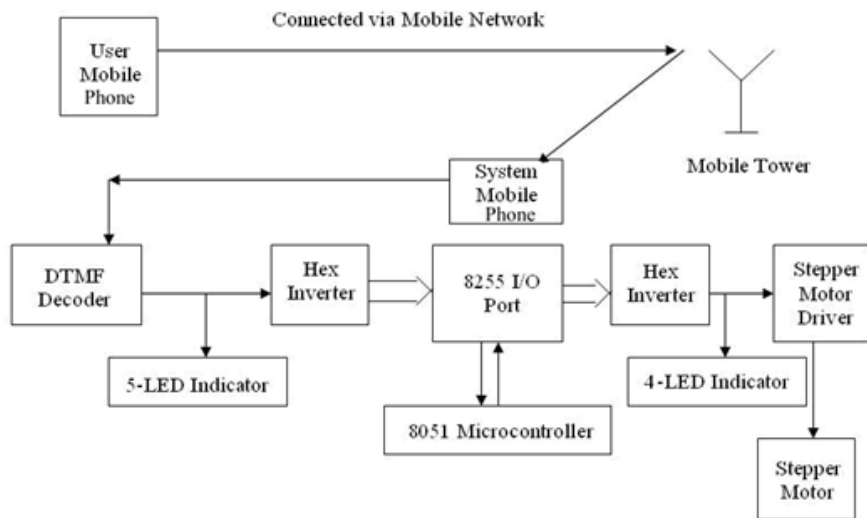


Figure.1 Block Diagram for Remote Angular Position Control of Stepper Motor

8051 Microcontroller receives the decoded data through the input port of 8255 and process the data according to the control software to generate the control signal for the stepper motor to rotate at the desired angular position. The control signal goes to the stepper

motor driver ULN 2003 to drive the stepper motor. Microcontroller generates the digital bit pattern of A, 6, 5, 9 for forward motion and 9, 5, 6, A for reverse motion repetitively. 5-LED indicators are attached with DTMF decoder output to show the decoded digital bit. Out of five, one bit shows the presence or absence of valid DTMF tone and other four LEDs indicate the decoded signal corresponding to the key pressed in the user mobile phone. Another 4-LED indicators have been used to understand the generated bit pattern of microcontroller which will drive the stepper motor at the desired angular position.

3. Sequence of Operation for Remote Angular Position Control

In the present project, following sequence of operations have been followed for remote position control of stepper motor.

- Step 1: The user makes a call to the system mobile phone. The system mobile phone is set in auto-receiving mode. Thus two mobile phones are connected via mobile network and the system mobile phone is now ready to receive the tone from the user mobile phone.
- Step 2: The specified key (1 or 2) of the user mobile phone is pressed for selecting the mode of the rotation of stepper motor (i.e. forward or reverse). The keypad tone (DTMF signal) generated due to pressing of keys of the user mobile phone is received by the system mobile phone.
- Step 3: The received tone for selection of direction of motion is decoded by the developed DTMF decoder circuit.
- Step 4: Microcontroller reads the decoded signal through the 8255 I/O port and store the data in its register which in turn decides the digital bit pattern of A, 6, 5, 9 for forward motion and 9, 5, 6, A for reverse motion of the stepper motor.
- Step 5: Now any key on the user mobile is pressed for desired angular position and the corresponding DTMF signal is decoded and then received by the Microcontroller which executes the software program and generates the control signal for motor rotation.
- Step 6: Control signal generated by the microcontroller is fed to the 8255 I/O port and then to the stepper motor driver for driving the stepper motor at desired angular position.

4. Detail Circuit Diagram and Explanation

The detail circuit for DTMF decoder and its interfacing with microcontroller, stepper motor and its driver circuit is shown in Fig. 2. In the present project CM8870 IC is used as DTMF decoder. A crystal or ceramic resonator having a resonant frequency of 3.579545 MHZ has been connected to complete the internal clock circuit. The circuit is powered by 5 volt supply.

The DTMF signal from the user mobile phone is picked up by the system mobile phone. The tip and ring of the microphone is connected to the specified pin of CM8870 as shown in the Fig. 2. C1, R1 and R2 has been adjusted for gain control of the input signal. Resistance R3 and capacitor C2 has been used to set the 'guard time' which is a time duration through which a valid DTMF tone must be present for its recognition. The 'Q-test' signal (pin 15) indicates that the valid DTMF tone has been detected.

The output of decoder (Q0, Q1, Q2, Q3) is sent to the microcontroller through 8255 input port. The microcontroller executes the developed control software and generates the sequence

of bit pattern which goes to the stepper motor driver IC ULN2003A through the output port of 8255. The driver in turn drives the stepper motor for rotation.

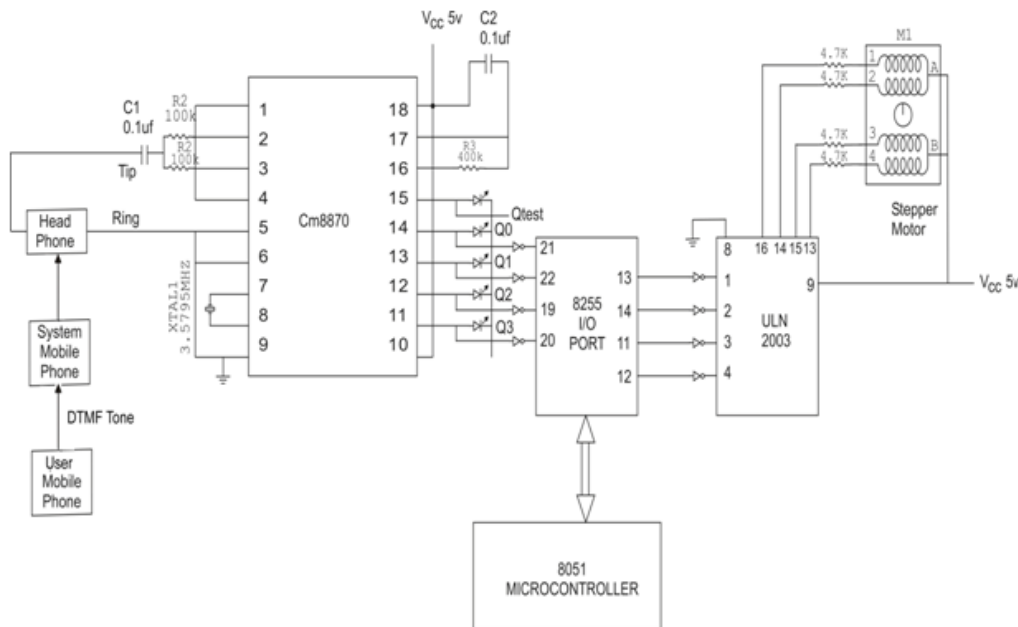


Figure.2 Detail Circuit Diagram for Remote Angular Position Control of Stepper Motor

5. Experimental Result

In the proposed work DTMF signal has been generated by pressing the keys on the user mobile phone key pad and the decoded output corresponding to the key pressed is shown in the “Table 1”. DTMF signals from 12 different keys on the user mobile key pad have been used here to generate the desired angular position signal for the stepper motor.

Transition from 1 to 0 of Q-test bit signifies that the system mobile phone is receiving the valid DTMF signal or the key pad tone from the user mobile phone. The decoded output bits are Q0, Q1, Q2 and Q3 respectively which after inversion have been fed to the microcontroller to store as desired angular position signal. The microcontroller then executes the software for generating the required bit pattern for the stepper motor and sends the same to the driver circuit so that the stepper motor rotates at the desired angular position as set by the user. Experimentation has been performed to record the key position pressed on the user mobile phone and the actual angular position achieved by the stepper motor and is shown in “Table 1”.

Table1. Experimental Data for Remote Positioning of Stepper Motor with Step Angle of 1.8°

Sl. No.	Key position pressed on the user mobile phone	Decoded output bits				Decoded output bits (after inversion) (D)	Equiv. decimal value of D(m)	No. of steps to be rotated by stepper motor n=(m-1)	Angular position achieved by the stepper motor corresponding to key position pressed in degree	
		Q3	Q2	Q1	Q0				Calculated ($\theta_c=n*1.8^\circ$)	Measured θ_m°
		1	1	0	0					
2	2	0	0	1	0	1101	13	12	21.6	22
3	3	0	0	1	1	1100	12	11	19.8	19.5
4	4	0	1	0	0	1011	11	10	18.8	18.5
5	5	0	1	0	1	1010	10	9	16.2	16
6	6	0	1	1	0	1001	9	8	14.4	14
7	7	0	1	1	1	1000	8	7	12.6	12.5
8	8	1	0	0	0	0111	7	6	10.8	11
9	9	1	0	0	1	0110	6	5	9	9
10	0	1	0	1	0	0101	5	4	7.2	7
11	*	1	0	1	1	0100	4	3	5.4	5.5
12	#	1	1	0	0	0011	3	2	3.6	3.5

Equivalent decimal value (m) of the decoded output of the corresponding key pressed on user mobile phone has been plotted against the measured angular position (θ_m) in Fig.3. The curve shows a linear relationship. Calculated angular position (θ_c) and the measured angular position (θ_m) in degree, corresponding to the key pressed on the user mobile phone has been plotted in Fig.4. This is also a linear curve. The percentage error in measuring the angular position has been shown in Fig.5 which indicates that the error lies within $\pm 2.77\%$.

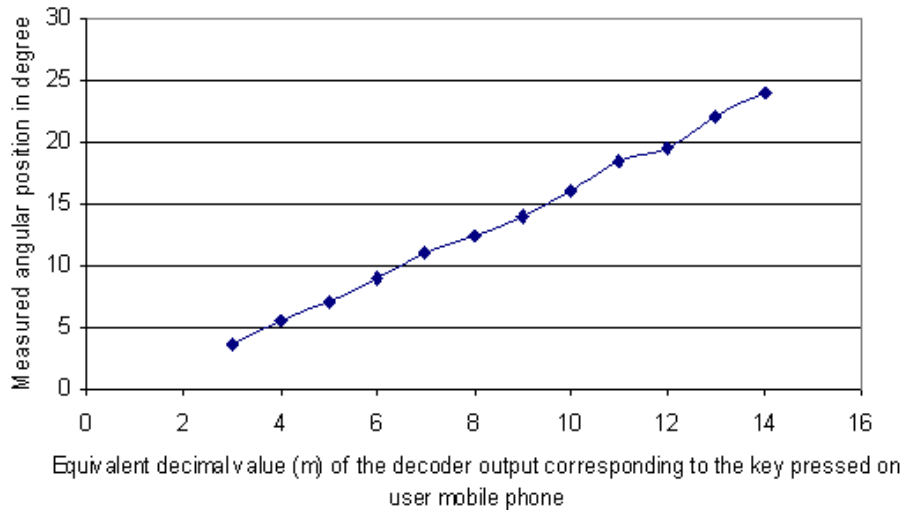


Figure 3 Equivalent Decimal Value (m) from the Decoder vs. Measured Angular Position (θ_c)

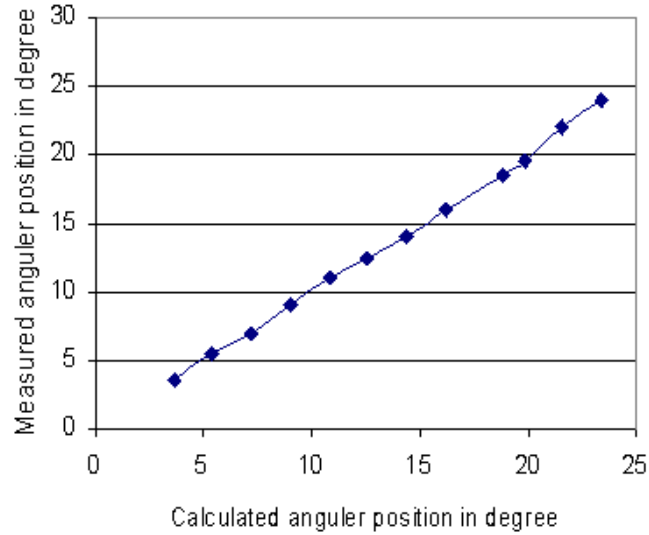


Figure 4 Calculated Angular Position (θ_c) vs. Measured Angular Position (θ_m)

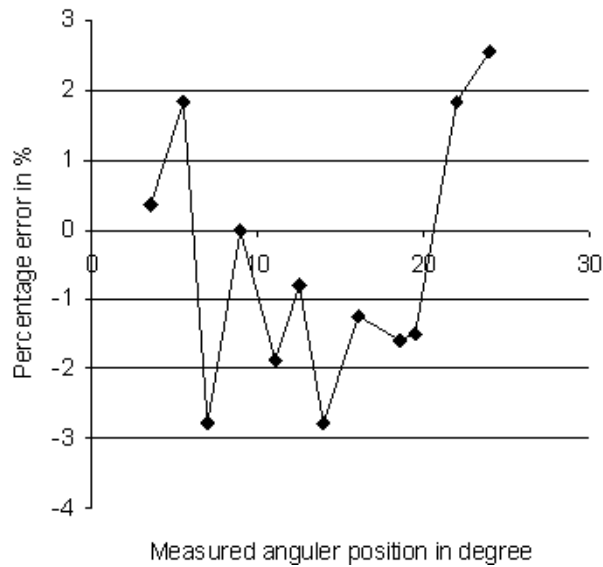


Figure 5 Percentage Error Curve

From “Table 1”, it is obtained that for serial no. 1-12 of the observation, the range of angular position achieved is 3.5° to 24° with a resolution of 1 step angle (1.8°). If the desired angular position is beyond 24° , a combination of two or more keys decided by “Table 1” may be pressed to achieve that particular angular position. As example, to achieve the angular position of 57° , where $57^\circ = 24^\circ + 24^\circ + 9^\circ$, a combination of key positions to be pressed may be 1, 1, 9. Thus any angular position in between 0 to 360° with a resolution of one step angle (1.8°) may be achieved with different combination of keys pressed following the “Table 1”. Also the mode of rotation i.e. forward or reverse can be selected by pressing the appropriate keys on the user mobile phone. The experimental results indicate that the system has good linearity and repeatability.

6. Conclusions

In the present project DTMF technology has been used to position the shaft of the stepper motor at a desired angle which in turn may be used in deferent application areas. As conventional RF wireless system has distance limitation, DTMF technology has been used here. The system developed in this project is very much simple, rugged, and cost effective. The experimental result shows that one step angle resolution has been achieved in the range between 3.5° and 24° . Also other angular positions beyond 24° can be achieved by pressing a combination of two or more keys on the key pad of the user mobile phone. The error in the measurement is within $\pm 2.77\%$ which is tolerable. Any angular position between 0° and 360° can be obtained from this system and the achieved angular position can be varied only in integral multiple of one step angle (1.8°). Application of such control system of stepper motor in remote surveillance system is the future scope of this work.

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