

Design and Development of ARM based Embedded System for Remote Position control of Stepper Motor Using DTMF Technology

Dr.T. Narmada¹, Prof. K. Nagabhushan Raju², Dr. M. V. Lakshmaiah³ and Dr. C. Chandra Mouli⁴

¹Department of Electronics, Sri Krishnadevaraya University, Ananthapuramu, India;

²Department of Instrumentation, Sri Krishnadevaraya University, Ananthapuramu, India;

³Department of Physics and Electronics, Sri Krishnadevaraya University, Ananthapuramu, India;

⁴Department of Instrumentation, Sri Krishnadevaraya University, Ananthapuramu, India;

Abstract:

This work is mainly concerned on the Stepper motor direction and operating period control system using ARM7 micro controller. Stepper motor control has a number of applications like drives, dot matrix printer, machine tools, computer peripherals, business machines, process control and robotics. DTMF Technology is used in number of ways like digital answering machine, call forward back device called id terminal, call blocker, DTMF remote control recorder etc. This present work describes angular position control of stepper motor using DTMF decoder as an alternative means of communication using Radio Frequency with advantage of simplicity and audibility. The proposed system has two mobile phones, one is user mobile and other mobile is attached to the system. System mobile is connected to ARM7 through DTMF decoder and controller to stepper motor. If any key is pressed in user mobile the read that signal and sends to the ARM7 micro controller that sends angle to the stepper motor that rotate either clockwise or anticlockwise. The system is simple, low cost and it has a high resolution, repeatability and error is also

within tolerable limits. This work is also used to design a real time electronic control system that can be used to control the speed of stepper motor kept at remote locations using an embedded technology.

Keywords: DTMF 8870 Decoder, Stepper motor, Two Mobile phone, Acoustic communication, position control.

Introduction: The position controlling of the stepper motor using DTMF decoder with 8051 microcontroller as an alternative means of communication using Radio Frequency with advantages of simplicity and audibility. [1,6]. The car controlling using DTMF decoder with ATmega 16 microcontroller. This project user mobile call to system mobile through DTMF decoder to the microcontroller that relays the command of the car of the motor in forward, backward left and right direction [2]. To control the Robot car [3,10]. DC motor control using DTMF decoder using microcontroller [4]. A novel secure remote device access procedure and control system is presented in this paper [5]. DC motor and its domestic application in robot using mobile control [7]. Many remote home/office automation controller and alarm system [8,11]. Industrial automation in 3G using GSM

communication [9]. The remote control technologies have been used in the fields like factory automation, space exploration in places where human mind always needs information in interest to control systems of our choice in everywhere [12]. Voice controlling of the Robot using DTMF technology [13]. To control the call processing in Telephone exchange system of Microcontroller using DTMF [14].

Block Diagram

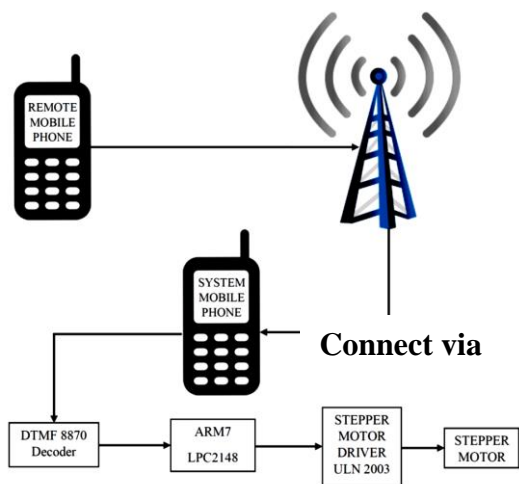


Figure 1: Block diagram of position controlling of stepper motor using ARM7 through DTMF decoder

ARM7 (LPC2148) Microcontroller:The ARM7 is a 32-bit microprocessor with very low power consumption. A three stage pipeline occupies a minimal silicon area yet allows division of the execution time of each instruction into three parts instruction fetch from memory, instruction decode, and instruction execution. The instruction execution stage is the most complex, register read, a shift applied to one operand, an ALU

operation, and finally a register write all executed in one clock cycle. This limits the processor’s maximum clock speed to around 80MHz on a 0.35 micro silicon process. However, that speed is more than enough for the cost sensitive applications using ARM7. ARM has a 32-bit data bus and a 32-bit address bus. The data types the processor supports are words, where words must be aligned to four byte boundaries. Instructions are exactly one word, and data operations are only performed on word quantities. Load and store operations can transfer words.

DTMF 8870 decoder:This circuit detects the dial tone from a telephone line and decodes the keypad pressed on the remote telephone. The dial tone we heard when we pick up the phone set is call Dual Tone Mult-Frequency. The name was given because the tone that we heard over the phone is actually make up of two distinct frequency tone, hence the name dual tone. The DTMF tone is a form of one way communication between the dialer and the telephone exchange.DTMF was developed at Bell Labs in order to allow dialing signals to dial long distance numbers. It made by California Micro Devices (CMD). Manufactured using CMOS process technology and low power consumption.

Decoder uses digital counting techniques to detect and decode all 16 DTMF tone pairs into a 4-bit code. Its clock frequency is 3.5795MHz. It requires a small external component count, more reliable, easier to use, implement and then software defined DTMF decoders. It’s very low cost.

Table 1: Keypad Dial Tone Frequency Table

Frequency	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C

941 Hz	*	0	#	D
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Stepper motor:A stepper motor is an mechanical device, which converts electrical pulses into mechanical movements. It has brought about one of the biggest advancements in the fields of engineering and technology ever since the invention of electricity. The electrical command pulses are applied to it in the proper sequence shafts of a motor rotates in discrete step increments. The related to the direction of motor shafts rotation is directional proportional to the sequence of the applied pulses. The speed of the motor shafts rotation is related to the frequency of the input pulses and the length of rotation of input pulses applied. These type of stepper motors are very popular in digital control circuits such as robotics because they are ideally suited for receiving digital pulses for step control. Each step causes the shaft to rotate a certain number of degrees.

OVERALL SYSTEM IMPLEMENTATION

The schematic diagram of an ARM based embedded system for remote position control of stepper motor using DTMF technology is described as shown in the Figure 2. The ARM7 controller has 64 I/O lines which are divided into two 32 – bit ports namely P0 and P1. The system mobile phone is connected to the DTMF decoder through 3.5mm jack and the output of the DTMF decoder Q1, Q2, Q3 and Q4 is passed to P0.4 through P0.8 of the LPC2148. P1 port pins P1.26 through P1.29 are connected to the stepper motor driver ULN2003 pins I1 through I6 and the output pins O1 through O4 and COM of ULN2003 is connected to stepper motor using a jumper. In this system design we use only 9 I/O lines of the controller to interface the stepper motor through ULN 2003 and the DTMF 8870 decoder to the micro controller. The remote mobile is called to the system mobile in wireless communication.

The system mobile is connected to the DTMF through pin 2 (IN-) and corresponding result (Q1-Q4) pass to the port of the ARM7 that relevant stepper motor controlling using driver from port of the ARM7 microcontroller. The different keys pressing on the remote mobile that relevant control of the stepper motor [1].

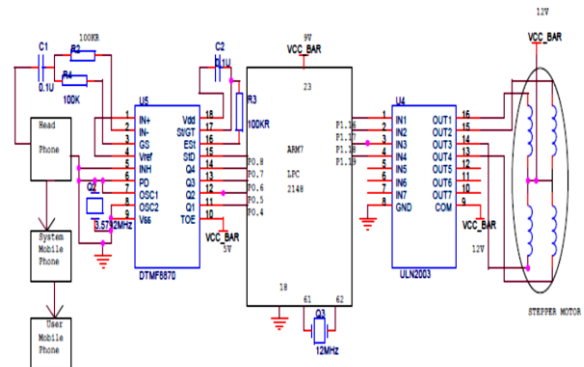


Figure 2: Schematic diagram of the present work

Experimental Result

Remote mobile call to the system mobile and system mobile receives the call. System mobile is always in auto receiving mode. The remote mobile presses any key to generate relevant DTMF tone which corresponds to the desired angular position of the stepper motor. The system mobile is connected to the LPC2148 microcontroller through DTMF decoder. If any key is pressed is sensed then the DTMF decoder generates corresponding hexadecimal number [2].

A Q-test conducted to verify, whether a valid DTMF signal is receiving or not. Transition from 1 to 0 of Q-test bit signifies that the system mobile phone is receiving the valid DTMF signal from the remote mobile phone. The decoded output bits are Q0, Q1, Q2 and Q3 respectively which after inversion have been fed to the LPC2148 to store desired angular position.

The LPC2148 then executes the command for generating the required bit pattern for the stepper motor, 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 2[1].

Table 2: Experimental Data for Stepper Motor control with a Step angle of 1.8°

S.No.	Key Position Pres within the user Mobilephone	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 ($\theta_c=n \times 1.8^{\circ}$)	Measured θ_m°
1	1	0	0	0	1	1110	14	13	23.4	23.9
2	2	0	0	1	0	1101	13	12	21.6	22.1
3	3	0	0	1	1	1100	12	11	19.8	19.9
4	4	0	1	0	0	1011	11	10	18.8	18.9
5	5	0	1	0	1	1010	10	9	16.2	15.9
6	6	0	1	1	0	1001	9	8	14.4	14.1
7	7	0	1	1	1	1000	8	7	12.6	12.3
8	8	1	0	0	0	0111	7	6	10.8	11.1
9	9	1	0	0	1	0110	6	5	9.0	9.1
10	0	1	0	1	0	0101	5	4	7.2	6.9
11	*	1	0	1	1	0100	4	3	5.4	5.6
12	#	1	1	0	0	0011	3	2	3.6	3.2

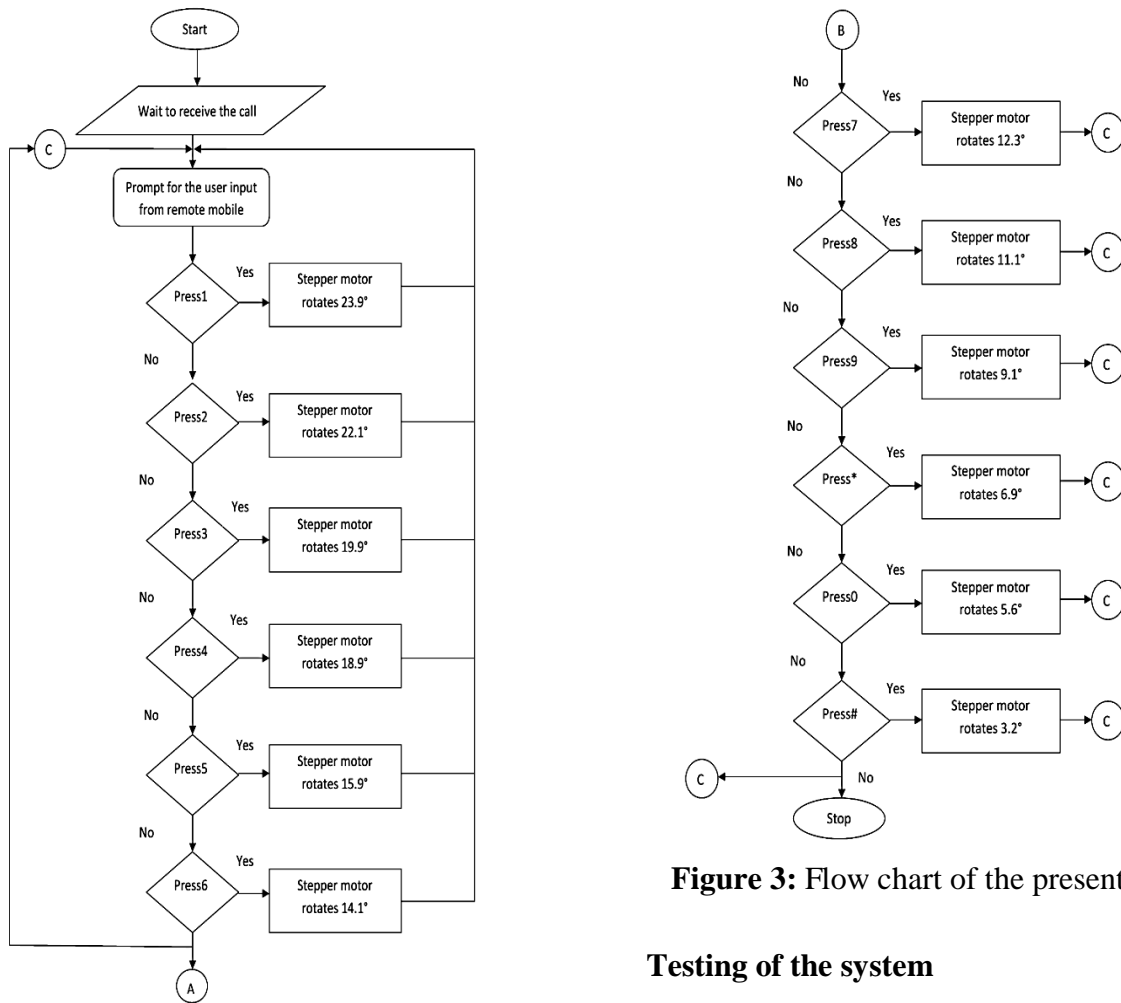


Figure 3: Flow chart of the present work

Testing of the system

In the present work the angular position of a stepper motor has been controlled remotely using DTMF signal through LPC2148. 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, personal locators can interface. 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 [1].

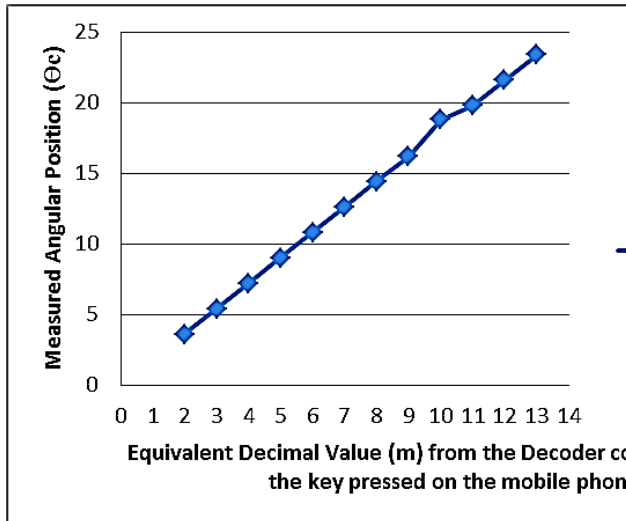


Figure 4 :Equivalent Decimal Value (m) from the Decoder vs. Measured Angular Position (θc)

The equivalent decimal value (m) of the decoded output of corresponding key pressed on the user mobile has been plotted against the measured angular position (θm) in Figure 4. This curve shows a linear relationship between m and θc.

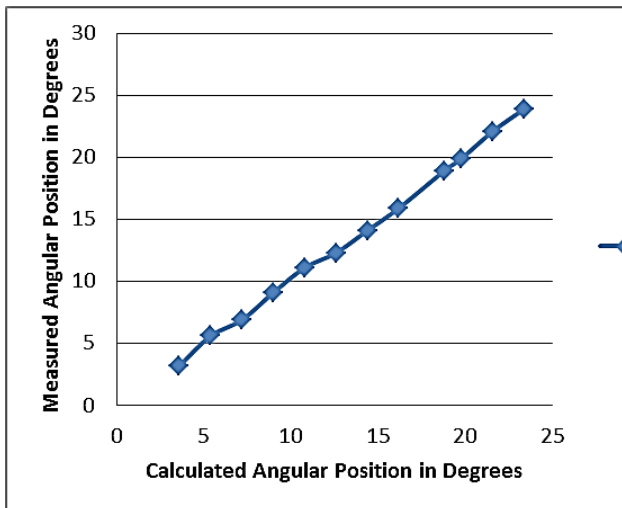


Figure 5 :Calculated Angular Position (θc) vs. Measured Angular Position (θm)

The calculated angular position (θc) and the measured angular position (θm) of

the stepper motor in degrees, corresponding to the key pressed on the user mobile phone has been plotted in Figure 5. This is also a linear curve as same as the Figure 4. The percentage error in measuring the angular position indicates that the error lies within $\pm 2.77\%$ [2, 4].



Figure 6: Photograph of the experimental setup

From Table 2, it is obtained that for serial no. 1-12, 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° , then it will be achieved by pressing a combination of two or more keys 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 2. Also on the user mobile phone, the experimental results indicate that the system has good linearity and repeatability [3, 4]. The overall experimental setup is shown in the Figure 5.3.

Conclusions

The position controlling of the stepper motor at a desired angle using DTMF 8870 technology has been done. The wireless radio frequency system has very short distance using the DTMF technology.

This is very simple, cost effective and strong. The angular position beyond 24° can be achieved by pressing either two or more keys on the remote mobile phone. The experimental result shows that one step angle resolution has been achieved in the range between 3.5° and 24° . The error in the measurement is within $\pm 2.77\%$ is tolerable. The stepper motor any angular position between 0° and 360° can be obtained from this system and angular position can be varied only in motor integral multiple of one step angle (1.8°) [1, 2, 3].

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