Voice-Based Control of a DC Servo Motor

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Abstract: Problem statement: Motors play a very important role in our life and among which is the DC servo motors. The techniques of controlling these DC motors are plenty, among which is sound. In this study, a voce-based technique was implemented to control the speed and the direction of rotation for a DC motor. **Approach:** A Microcontroller-based electronic control circuit was designed and implemented to achieve this goal. **Results:** The speed of the motor was controlled, in both directions, using pulse width modulation and a microcontroller was used to generate the right signal to be applied to the motor. **Conclusion:** The loudness of human voice was successfully divided into different levels where each level drives the motor at different speed.

Key words: Width modulation, phonetic parameters, Pulse Width Modulation (PWM)

INTRODUCTION

DC servo motors plays an important role in many engineering applications. Engineers always search for an efficient and easy way to control these motors. This is normally carried out by varying the amount as well as the polarity of the applied voltage (Silva, 2005). Pulse width modulation is often used to control DC motors (Bishop, 2002). Another interesting alternative to control motor is through voice. Voice-operated control have been applied to different applications from medical field like surgical devices (Reichenspurner et al., 1999) to pc functions such as cursor movement (Harada et al., 2008), keyboard (Manaris et al., 2001) and in home applications through sound activated switches and painting (Harada et al., 2007). Some attempts was made to tackle issues related use of voice-control such as; continuous control (Igarashi and Hughes, 2001) traing efforts for voice recognition (Smith et al., 2010), noisy environment (Wijekoon et al., 2004). Acoustic phonetic parameters like pitch, loudness (House et al., 2009), vowel quality can be used to control the motion (Bilmes et al., 2005). Igarashi and Hughes (2001) used the presence of voice to switch on the electronic circuit. (Olwal and Feiner, 2005) considered the speed with which the sentence was spoken. In this study, authors attemps to use voice loudness' parameter to control both the speed as well as the direction of a DC servo motor.

MATERIALS AND METHODS

As illustrated in Fig. 1, the hardware design is classified into six main stages. Firstly, sound signal is to be changed to an electrical signal. SM58 SHURE dynamic microphone is used here to produce an electrical signal from the sound signal vibration. The electrical output signal from this microphone is to be amplified using a sound amplifier with a high slew rate. LM386 (Low Voltage Audio Power Amplifier) was used here to give the required amplification. The amplification circuit is shown in Fig. 2. The input was applied to the LM386 through 10KΩ variable resistor so as to meet the operating point of the internal transistors. Pin.1 was connected to pin.8 through 10μF capacitor to increase the gain to the maximum .pin.7 was connected to the ground through 220 μF as a bypass capacitor to bypass unwanted signals to the ground. After amplification the signal was converted to DC using four diodes as a full wave rectifier as shown in Fig. 3. In order to overcome the problem of rippling, a parallel combination of a capacitor and a resistor was used. The microcontroller (ATMEGA16) has three functions as shown in Fig. 4. The Pulse Width Modulation (PWM) that controls the rotational speed of the motor will be generated from the microcontroller.

The motor driving circuit consists of two parts; the ULN 2003 to protect the microcontroller from high voltage and current and the H-bridge (with 4 MOSFETs and pull up resistors) to control the direction of motor rotation. The complete circuit layout of all the previously mentioned stages is presented in Fig. 5.

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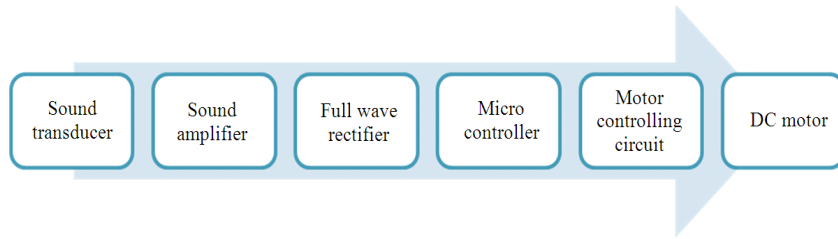
Fig. 1: The main stages of the control system
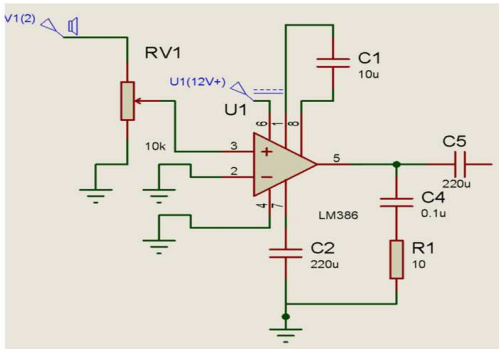

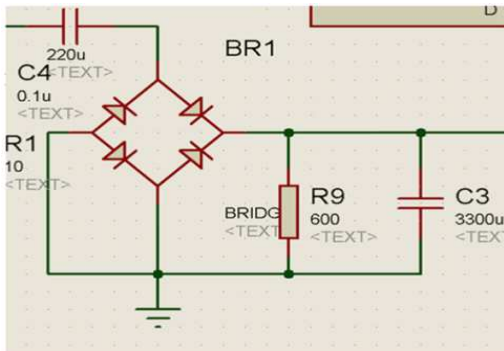Fig. 2: sound amplifier circuit
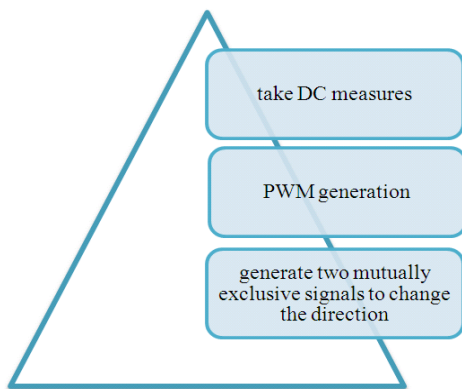

Fig. 3: Full wave rectifier circuit
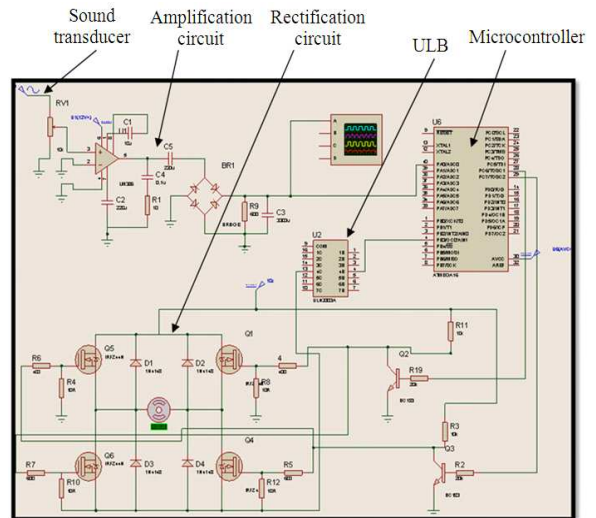

Fig. 4: Microcontroller functions

Fig. 5: layout of the control circuit

The final stage of the design was to program the microcontroller to control the speed of the motor. This was achieved by assigning four different speeds (different PWM signals) to four different levels of sound signal. The direction of rotation was set to change when the input voltage, or the sound level, is high (greater than 3.5 volts).

RESULTS

Prior to the hardware implementation, the speed controlling circuit was simulated in the Proteus simulator and the motor speed was displayed on a screen in the simulation. The level of motor speed was found to vary with the sound level.

As mentioned earlier, the loudness of the sound and its corresponding voltage was divided into four levels as shown in Table 1. Depending on the four levels of sound, the designed circuit should provide different PWM ratios. A comparison between the expected duty cycles and the measured ones is plotted in Fig. 6 while Fig. 7 shows the actual measured cycle as seen on the oscilloscope as compared to expected duty cycle.
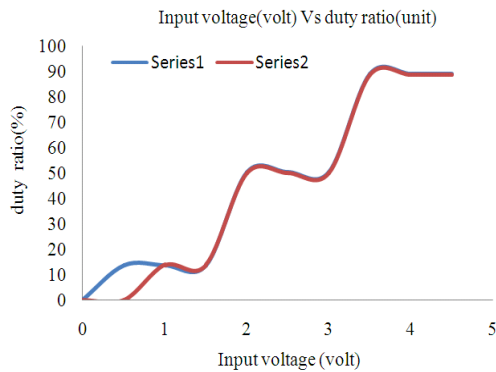
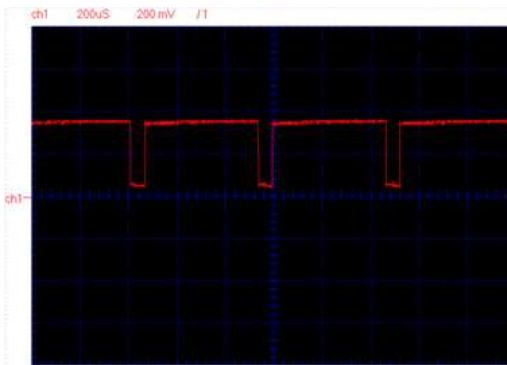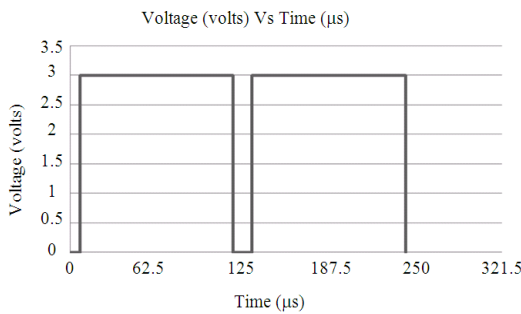Fig. 6: Generated Vs expected duty cycles at different input voltages

Fig. 7: Expected PWM (left) and generated PWM (right) at high sound level (V = 3.8 volts)

Table 1: Comparison between measures and expected duty cycles

Sound level	Input (volts)	Expected duty cycle (%)	Measures duty cycle (%)
Very low	0.0	0.0	0.0
Low	0.5	13.7	0.0
	1.0	13.7	13.8
	1.5	13.7	13.8
Medium	2.0	50.2	50.0
	2.5	50.2	50.0
	3.0	50.2	5.0
High	3.5	89.0	88.5
	4.0	89.0	88.5
	4.5	89.0	88.5

DISCUSSION

A good agreement was found between the expected and measured results as can be seen from Table 1 and Fig. 6. The only error appeared in the results is when the input was 0.5 volt. In this case, the expected duty ratio is 13.7% but no PWM was detected. This is due to the fact that supplied voltage is slightly less than 0.5 volts and the microcontroller were programmed to consider any value less than 0.5 as nil. It was also observed that the DC motor changes direction of rotation when the amplitude of sound reaches a value between (3.5- 4 volt).

CONCLUSION

Human voice was used successfully to control the speed, as well as the direction of rotation, of a DC motor. This was accomplished by designing and implanting a microcontroller-based electronic control circuit. Initially, the sound signal was converted to an electrical signal, amplified, rectified and finally applied to a DC motor via a microcontroller. The loudness of the sound was divided into four levels (very low, low, medium and high) and the motor was driven, in both directions, at three different speeds (low, medium and high) using PWM.

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