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Synchronisation of Two Wiper Motors using PIC Microcontroller

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ABSTRACT: Synchronisation of motors is an application, where two or more motors are used. Conventional Tandem motion in wiper system uses the high speed DC motor; where it is problematic to vary the speed of the wiper arms. Also there are weight and space constraints. Proposed system deals with synchronisation of a pair of windshield wipers, where each arm is driven by its own independent motor. Traditional rigid mechanical coupling driven by a single constant speed motor has been removed for the sake of weight and space. For synchronisation and collision avoidance a closed loop control system is used. By Synchronising Two DC Motors, which are controlled using PIC, problems regarding Weight and Space are solved. At present, synchronisation is achieved using DSP. As Cost of DSP is more, it is proposed to implement design using PIC. The results, which are obtained with PIC, are compared with the results that have obtained with existing method of Synchronisation by using DSP.

KEYWORDS: Synchronisation, Wiper Motors, Feedback using Position Sensors, ADC, PWM.

I. INTRODUCTION

Synchronisation of motors is required in applications, where two or more motors are used. In industries to achieve synchronisation, Digital Signal Processors (DSP)'s are used. However, its cost is high as compared to controllers. Synchronisation is normally used for drive mechanisms in industries like Belt drive, Chain drive, Electric Motor, Robotic applications, etc. [1] [6].

Windscreen Wiper is a device used to remove rain and debris from windshield. Almost all four wheel vehicles are equipped with such wipers. A wiper generally consists of an arm, pivoting at one end and a long rubber blade attached to the other. The blade is swung back and forth over the glass, pushing water from its surface. The speed is normally adjustable with several speed settings. Most automobiles use two synchronized radial type arms, while many commercial vehicles use one or more arms. Conventional tandem motion uses the high speed DC motor [1].

This is undesirable as it would require counter rotating force to stop and then reverse the wiper arm at the end of its sweep. Also a large current drive is required to produce the counter rotational force, which causes retentive surges in the supplied power. With a high speed DC motor, it is also problematic to vary the speed of the wiper motor arm as it sweeps across the windshield. There is also problem of the weight and space requirement of that wiper arms. Hence there is a need of superior DC motor control system that can be employed in vehicle having smaller windshield and under hood areas where space is limited [1].

By Synchronising two wiper arms using two separate DC Motors and controlling them electronically by Periferal Interface Controller (PIC), problems related Weight and Space are solved. Instead of using processors for such an application, system is implemented using PIC. Hence the processor resources will be secured from wastage. The results which are obtained using PIC are compared with existing methods of Synchronisation.

Optimisation of synchronisation through two wiper motor is major task to achieve. Proposed system is based on it. Synchronisation deals more strongly with proper movement of the wiper arms. Both the wiper arms should move with the same speed and accuracy. The Accuracy of system should get improved [1] [5] [6] [7].

Objectives of Proposed system are as follows-

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- ❖ To get positions of two motors in advanced.
- ❖ To achieve accuracy in the system.
- ❖ To control the speed of the motors.
- ❖ To control the starting positions of the motors.
- ❖ To reduce the bulkiness of the system.
- ❖ To reduce the power that will be consumed during reversing of the wiper arm.

The rest of the paper is organized as follows: In next Section II, different techniques used for DC Motor control are discussed; this section also contains different methods used for DC motor Synchronisation. Section III describes the Methodology used to achieve synchronisation. Section IV presents Results that are obtained using this methodology. Finally, Section V concludes the paper.

II.RELATED WORK

Lot of literature is reviewed related to DC motor control and synchronisation. Brief review is presented in this section.

Jean Levine *et al.* worked on Synchronisation of pair of independent windshield wipers and presented results using PID controller in [1]. Author proposed to remove a single almost constant speed motor from wiper system to reduce weight and space. They proposed use of synchronised pair of independent windshield wipers using PID controller. Therefore, collision avoidance and reference trajectory tracking is guaranteed by feedback and synchronisation. Collision free reference trajectories and a PID output feedback are designed using flatness and pole placement. Synchronization is obtained by clock control i.e. delaying the reference trajectory of the following wiper when the leader is behind its reference trajectory.

K. Boudjit *et al.* Worked and presented its results on Synchronisation of multiple motors using DSP processor for synchronisation in [5]. Author proposed use of DSP to achieve the co-ordination and synchronisation of multiple motors. A real time control approach is used to drive synchronisation of the multiple motors. A new Master-Slave configuration is developed. Imperfect synchronisation can be corrected using DSP.

K. Giridharan *et al.* worked on FPGA Based Digital Controllers for BLDC Motors and presented their results in [6]. According to the author, in brushless motor, the rotor incorporates the magnets and the stator contains the windings. Commutation is implemented electronically with a drive amplifier that uses semiconductor switches to change current in the windings based on rotor position feedback. Commutation is implemented on FPGA as it provides greater flexibility and higher resources for implementing control algorithms. Thereby authors deal with the development of a virtual BLDC motor controller in FPGA and model of the BLDC motor is simulated. Authors had implemented controller on a FPGA system.

Panduranga Talavaru *et al.* presented their work on Microcontroller Based Closed Loop Speed and Position Control of DC Motor in [7]. According to the author, Direct current (DC) motor has become an important drive configuration for many applications across a wide range of powers and speeds, due to its easy control and excellent performance. Authors mainly focused on design and implementation of bidirectional dc motor speed and position control system by using microcontroller ATMEGA 32 and Lab VIEW software. It is a closed loop real time control system, where optical encoder is coupled to the motor shaft to provide the feedback speed signal and angular position of shaft to the microcontroller. Authors used Pulse Width Modulation (PWM) technique, which is generated using microcontroller ATMEGA 32. The generated PWM signal is going to drive the motor driver circuit.

Nikola Milivojevic *et al.* worked on Stability Analysis of FPGA Based Control of Brushless DC Motors and Generators Using Digital PWM Technique and presented their results in [8]. According to the author, Digital Pulse Width Modulation control is used for BLDC drive in both motoring and generating modes of operation. This control strategy is simple, robust, requires no current sensors and is not computationally intensive. Owing to these attributes, the technique can be implemented on Field Programmable Gate Array. Author investigates an approximate discrete model. The stability of the system is analysed to ensure closed loop operation under various sets of loads, speeds, and input voltages. Also authors have presented Simulation and experimental results to verify the claims.

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Steve C. Hsiung *et al.* presented their work on The Use of PIC Microcontrollers in Multiple DC Motors Control Applications and presented results in [9]. According to the author, by expanding the role of existing small scale PIC microcontrollers into a multiple microcontrollers system, problems of limited resource issues in meeting complex project are resolved.

Shashank Pujari *et al.* presented their work on A Simple Closed Loop DC Motor Speed Control System on FPGA Platform for VHDL Beginner and presented their results in [11]. This paper Present VHDL language learning, with lab sessions based on a FPGA based simple DC motor control application.

Rajesh Singh *et al.* presented their work on Synchronisation, Speed and Direction Control of DC Motor and presented their results in [12]. According to the author, Industrial environment in day-to-day life demands for synchronisation between multiple devices present in the industry. So there should be a common synchronisation between all these motors. Among the available motors even for single motor, the loss may be more. So keeping all these factors into consideration, they have designed a system, which is capable of driving multiple DC motors with the same speed. This system finds very useful in paper mills, steel industries etc. Motion control plays a vital role in industrial atomization. Different types of motors AC, DC, SERVO or stepper are used depending upon the application and because of easier controlling.

III. DESIGN METHODOLOGY

In this section, design methodology is presented. System block diagram is shown in figure 1. Manual switch is used to switch on and off the system. Control unit consists of PIC18F4520 and Encoder circuitry, which is used to control speed and position of both motors. Battery Supply is used to provide power to the system.

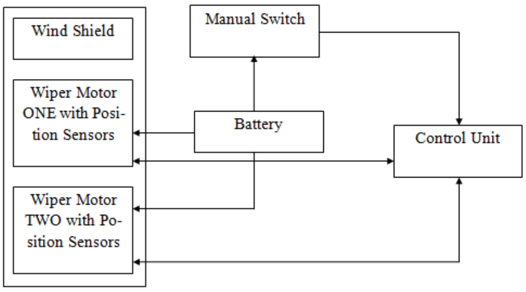

Fig.1: System Block diagram

System is designed in parts. Position and speed control of both DC motors is achieved in two parts as follows-

- Open loop synchronisation
- Close loop synchronisation

Open loop synchronisation is nothing but, to achieve synchronisation without any feedback i.e. in the absence of sensors network. Close loop synchronisation is nothing but, to achieve synchronisation in presence of feedback i.e. in the presence of sensors network.

A. Open Loop Synchronisation

As shown in figure 2, Open loop synchronisation is achieved by interfacing on chip ADC and PWM block to both DC motors with the help of 16x2 LCD and Motor Driver unit.

In open loop Synchronisation, Combination of ADC and PWM blocks are used. On chip ADC is used with On board Potentiometer, which is used to vary voltages for ADC; whereas PWM block is used to vary Duty Cycle for both motors to use different Speed options.

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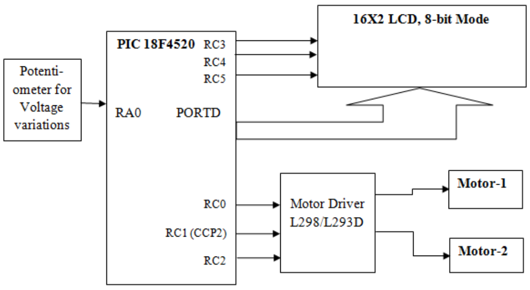

Fig.2 Open loop Synchronisation method

1) Design Challenges of Open Loop Synchronisation: Design challenges of Open loop synchronisation are as follows-

- To Interface Controller with the motor driver and to design motor driver connection circuitry.
- To vary Duty cycle using onboard switches.
- To interface in built ADC with controller.
- To save and move the Results that are obtained digitally from ADRESH and ADRESL registers.
- To display output of ADC and PWM block on the LCD at the same time.
- To combine both ADC interface and PWM variations.
- Duty cycle variations became a challenging task, because the values which were available to set the particular duty cycle were not matched.

B. Close Loop Synchronisation

As there are problems in open loop synchronisation with on chip ADC; Close loop synchronisation is done with the help of Encoders and newly designed patterned disc.

A simple disc is made, which is having binary patterns on to it from 000-111 at an angle of 45 degrees in circular manner. Logical zeros are marked with holes in the disc and logical ones are marked without holes. Figure 3 below shows the designed patterned Disc.

This patterned disc is then moved in between encoder circuitry. Encoders are able to get different readings in combinations from that designed disc. That readings are then applied to the microcontroller and based on that readings microcontroller decides the direction of movement of those motor shafts. This disc is attached to the one of the motor and that motor is moved in between the encoder blocks. Then the controlled input that is coming from the microcontroller block is given to both the motors.

The designed disc is attached to one of the motor shaft and both shafts are controlled with respect to positions of the first motor shaft. The controlled input is common, which is attached to both the motor is now able to control the position of both the motor at the same time. Speed control of both motors is achieved using PWM block; hence the synchronisation is achieved. Encoder circuitry consists of the encoders and decoders arranged as shown in figure 3. To the decoder block there is provision of attachment of Transistors. Those transistors are giving an output when the encoder’s lines of sights are getting disturbed due to the disc.

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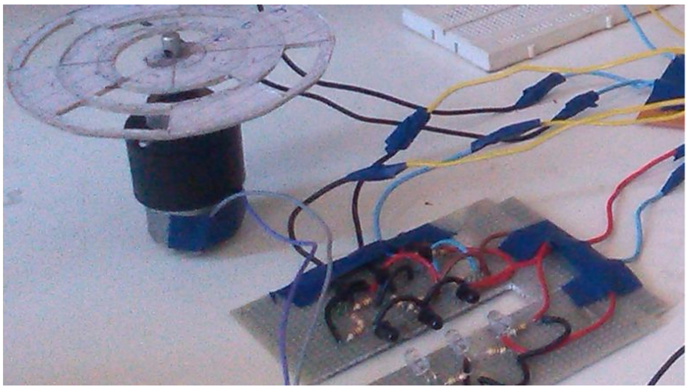


Fig.3: Encoder Circuitry

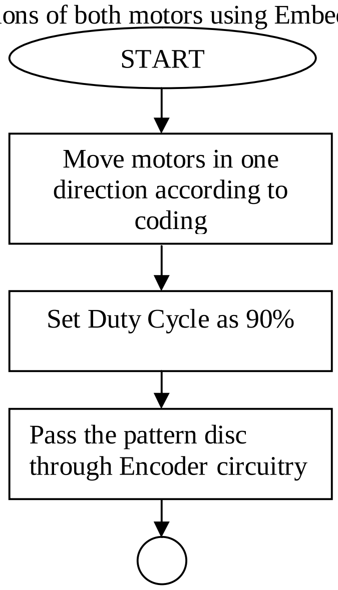
Transistorised circuitry along with the encoder and decoder block is helping to get the positions of the motor shafts. Using Embedded C coding, at every instant the position of the motor, which is attached to the patterned disc is getting checked. System is designed more accurately to control the positions of the other motors shaft likewise the first motors shaft, by designing another encoder and decoder circuitry for the other motors shaft.

Using Embedded C coding the position of the motor shaft is achieved using AND logic for three inputs, which are coming from the encoder circuitry towards the microcontroller block. In this manner the comparator is designed to get position of the motor shaft using Embedded C coding and Encoder block.

Below figure 4 shows the design flow for working conditions of Patterned disc and encoder circuitry.

1) Design Challenges of Close Loop Synchronisation: Design challenges of close loop synchronisation are as follows:

- To implement Encoder and Decoder logic using transistors.
- To place the encoders side by side according to movement of the motor shaft.
- To take feedback from the motor shaft and to move that information towards microcontroller for taking decisions about direction of motor shafts movement.
- During that feedback process to achieve speed control for both the motors.
- To design of the patterned disc for binary patterns from 000-111.
- To design of comparators using logical ANDing for each 45 degree intervals.
- Design starting and ending positions of both motors using Embedded C language coding.



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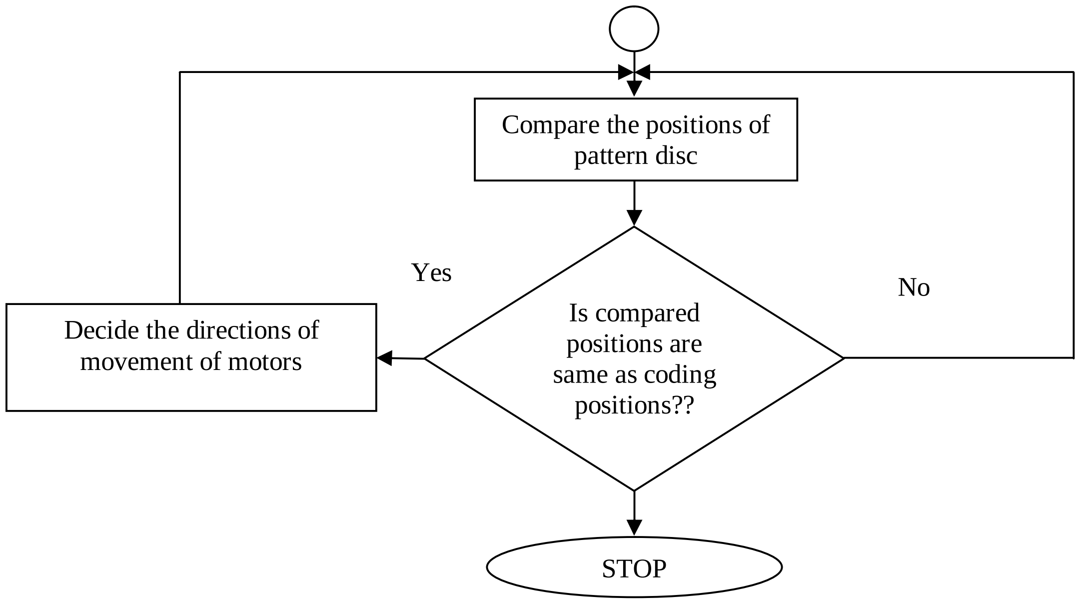

Fig.4: Working flow of Patterned Disc

IV. RESULT AND DISCUSSIONS

In this section, results which are obtained using software platforms are presented. Results are presented using Equal status approach.

System is designed using software platform like PROTEUS-7. As design is implemented by Open loop synchronisation and Close loop synchronisation methods, outputs which are obtained using these methods in software platforms are presented here. Below figure 5 and figure 6 shows snapshots of output windows that are obtained after simulating designs in PROTEUS-7.

A. Results using Open loop Synchronisation

In case of open loop synchronisation, system is implemented as shown in figure 5. For achieve synchronisation, Duty cycle of 99 % is used and input of 5V is applied at the input of channel RA0 i.e. AD0 channel. By changing the delay in between the motor supply directions i.e. changing the delay during reversing the polarities between supplies of the motor, angle of rotation for the motor shaft is controlled.

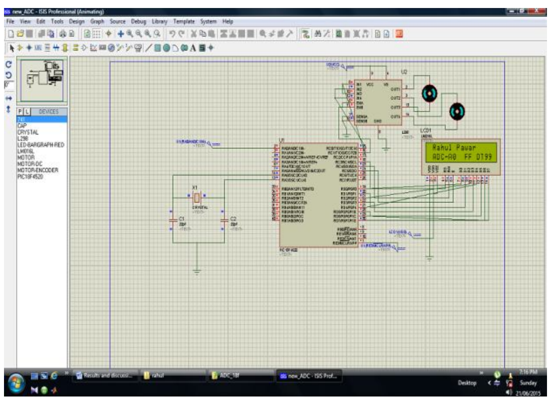

Fig.5: Outputs of Open Loop Synchronisations Using PROTUS-7

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B. Results using Close loop Synchronisation

Similarly Close loop synchronisation is done using PROTEUS-7 platform. Figure 6 shows snapshot of output for Close loop synchronisation. In the case of close loop synchronisation system is implemented as shown in figure 6. To achieve synchronisation, Duty cycle of 99% is used; the input other than 5V is applied at the input of channel RA0. By changing the delay in between the motor supply directions i.e. changing the delay during reversing the polarities between supplies of the motor, angle of rotation for the motor shaft is controlled.

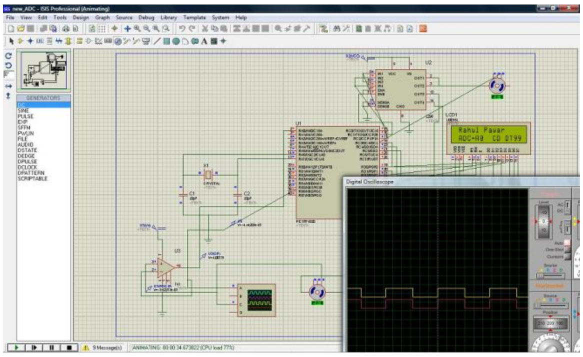

Fig.6: Outputs of Close Loop Synchronisations Using PROTUS-7

In this project Open loop synchronisation is used, which is nothing but output without feedback is obtained using PROTEUS-7. Also the open loop synchronisation is done on PIC Universal board. Below table number 1 shows software results of angle control using Open loop synchronisation method.

TABLE I: Observed Values of Delay in Units and Angle in Degrees

Value of Delay in Units	100	200	300
Value of Angle in Degrees	30	65	90

As shown in table number 2, In the case of close loop synchronisation, using Encoders as sensors, the position of both motor shafts is controlled using designed patterned disc, which shows patterned from 000-111 on a circle at an angle of 45 degrees each.

Microcontroller is able to control the position of motor shafts by changing coding conditions in the main program. Like, by moving the disc from 111-110 system controls an angle of 45 degrees for both the motors. Likewise from 111-101 and 111-100 system is controlled to move both motor shafts in 90 and 135 degrees respectively.

Table II: Observed Values of Encoders Positions and Angle in Degrees

Value of Encoders Positions	111-110	111-101	111-100
Value of Angle in Degrees	45	90	135

V. CONCLUSIONS

- Proposed system deals with synchronisation of DC motors using Periferal Interface Controller (PIC). Synchronisation, which is normally used in the high end vehicles, it is implemented to our low profile vehicles.
- Synchronisation is achieved by Open loop and Close Loop method. For collision avoidance a closed loop control system is used.
- System is designed using Patterned disc and Encoders. DC motor is controlled for 45, 90 and 135 degrees

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using encoder positions 111-110, 111-101, 111-100 respectively.

- ❖ Design using PIC is much simpler as compared to DSP with respect to design parameters like System Accuracy, Design Cost, Design Bulkiness, Ease of Coding and Logic implementation etc.

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BIOGRAPHY

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