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"Microcontroller Based Automated Multi-BLDC Motor Synchronization and Monitoring System"

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Abstract

The project titled "Speed Synchronization of Multiple DC Motors in Textile and Paper Mills Using Microcontroller" aims to develop an efficient and reliable system for maintaining uniform speed among multiple DC motors used in industrial applications. In textile and paper mills, synchronized motor operation is crucial to ensure smooth material handling, constant tension control, and consistent product quality. Any variation in motor speed can lead to material damage, uneven thickness, and production loss.

The proposed system uses an ATmega328 microcontroller to implement a closed-loop control mechanism. Speed sensors provide real-time feedback, and a PID control algorithm along with PWM technique is used to minimize speed error and maintain synchronization between master and slave motors. The system improves productivity, reduces material wastage, enhances stability, and supports industrial automation.

CHAPTER NO.1

INTRODUCTION

DC motors have been commonly used in many industrial applications such as the

steel rolling mills, electric cranes, electric vehicles and robotic manipulator due to wide, precise, simple and continuous control characteristics. Generally, a higher for mince motor drive system should have load regulating response and good dynamic speed. DC drives, because of their ease of applications, reliability, simplicity and favorable cost have been a backbone of industrial applications. In many applications motors should be precisely synchronized to give the desired performance. Motor control constraints: Unpredictable and variable inputs, Unknown parameters, non-linearity in dc motors, Propagation of noise, Load dynamic changes. Need of speed synchronization**:** The non-linearity in a DC motor is the major problem in applying a conventional control algorithm. Mainly, saturation and friction are the nonlinear characteristics of DC motor which degrade the performance of conventional controllers.

To reduce these effects many advanced model-based control methods such as model reference adoptive control and variable structure have been developed. In textile mills where all the motors run at same speed to draw the clothes, so that balanced tension can be achieved to avoid the damage of cloths. Thus, if a particular speed is set in the transmitter, then all the other motor speed would me matched to the same speed of the main motor. However, it has controllable, highly efficient, cheap and higher current carrying capability of static power converters has brought major change in the performance of electrical drives.

Motors have been widely used in industrial variable speed applications owing to their fascinating speed torque characteristic and ease of control. A motor's basic purpose is to drive any load. Motors are extensively used in factories, traction systems, etc. where variable speed is needed according to the requirement. For instance, in saw mills, high speed motors are required to cut down small and heavy logs or in some cases like the paper mills, we need low speeds. DC motors have the simplest speed control methods

The Microcontroller-Based Automated Multi-BLDC Motor Synchronization and Monitoring System is an innovative approach to efficiently control and supervise multiple Brushless DC (BLDC) motors in a coordinated manner. BLDC motors are widely used in modern applications due to their high efficiency, reliability, low maintenance, and superior speed control compared to traditional motors. However, when multiple motors are required to operate together, maintaining proper.

CHAPTER NO.2

LITERATURE SURVEY

Speed synchronization of multiple DC motors plays a crucial role in industrial applications such as textile and paper mills, where continuous material processing and uniform tension control are required. In these industries, multiple motors are used to drive rollers, conveyors, spinning units, and winding mechanisms. Any variation in motor speed may result in material breakage, uneven thickness, production loss, and mechanical stress. Therefore, accurate and reliable speed synchronization techniques have been widely studied by researchers. Initially, DC motor speed control was achieved using conventional analog methods such as rheostatic control and thyristor- based DC drives. Although these methods provided basic speed variation, they lacked precision and were difficult to maintain. Analog controllers were sensitive to noise and component aging, which reduced system reliability in industrial environments. With the advancement of control systems, closed-loop speed control techniques were introduced. In closed-loop systems, speed feedback is obtained using tachogenerators or optical encoders. The actual speed is continuously compared with the reference speed, and the error signal is processed through controllers such as Proportional–Integral–Derivative (PID) controllers. This method significantly improved speed regulation and reduced steady-state error

Further developments in embedded systems led to the implementation of microcontroller-based speed control systems. Microcontrollers such as 8051, PIC, AVR, and ARM are widely used for generating Pulse Width Modulation (PWM) signals to control motor voltage and speed efficiently. Digital PID algorithms implemented through microcontrollers provide better accuracy, flexibility, and ease of tuning compared to analog controllers. These systems also reduce hardware complexity and improve system reliability.

CHAPTER NO.3

SCOPE OF THE PROJECT

The scope of the project "Speed Synchronization of Multiple DC Motors in Textile and Paper Mills Using Microcontroller" focuses on designing and implementing a reliable system to maintain uniform speed among multiple DC motors in industrial applications. This project aims to develop a microcontroller-based closed-loop control system that ensures accurate synchronization of motors using feedback mechanisms. The system will monitor the speed of each motor through sensors such as encoders and adjust the motor speed using PWM (Pulse Width Modulation) techniques. A digital PID control algorithm will be implemented to minimize speed variation and maintain synchronization under varying load conditions.

3.1 Importance of Project:

Speed synchronization of multiple DC motors is very important in textile and paper mills where continuous and uniform production is required. Even small speed variations between motors can cause material breakage, uneven thickness, and production loss. By using a microcontroller-based control system, accurate and reliable speed synchronization can be achieved. It improves product quality, reduces material wastage, increases efficiency, and supports industrial automation. Thus, this project is important for ensuring smooth operation, better performance, and higher productivity in industrial applications.

3.1 Problem Statement:

In modern textile and paper mills, multiple DC motors are widely used to drive rollers, conveyors, feeders, spinning units, and winding mechanisms. These motors must operate in perfect coordination to ensure continuous production and consistent product quality. In such industries, maintaining uniform speed among all motors is highly critical because even a slight variation in speed can disturb the entire production process. In textile mills, improper synchronization between feeder and take-up motors can lead to uneven yarn tension, thread breakage, fabric defects, and material wastage. Similarly, in paper mills, rollers driven by multiple motors must rotate at the same speed to maintain uniform paper thickness and smooth sheet movement. If synchronization is not maintained, problems such as wrinkling, stretching, tearing, and misalignment of paper sheets may occur. These issues directly affect product quality and increase operational costs.

To overcome these challenges, a microcontroller-based closed-loop speed synchronization system is required. Such a system can monitor real-time speed using sensors, compare it with a reference speed, and automatically adjust motor speed using PWM techniques and digital control algorithms. This approach ensures minimal speed error, better system stability, reduced material wastage, and improved overall industrial performance. Hence, the problem addressed in this project is to design and implement an efficient microcontroller-based system that ensures precise speed synchronization of multiple DC motors in textile and paper mill applications.

3.2 Objective of the Project.

The main objective of the project “Speed Synchronization of Multiple DC Motors in Textile and Paper Mills Using Microcontroller” is to design and develop a reliable system that ensures accurate speed synchronization among multiple DC motors used in industrial applications. Proper synchronization is essential to maintain smooth operation, uniform tension control, and consistent product quality in textile and paper mills. The project also aims to create a system that is cost-effective, easy to maintain, and scalable for larger industrial setups. By achieving these objectives, the proposed system will enhance production quality and support modern industrial automation practices.

CHAPTER NO.4

METHODOLOGY

4.1 Block Diagram:

The block diagram of the proposed system “Speed Synchronization of Multiple DC Motors in Textile and Paper Mills Using Microcontroller” represents the functional components involved in achieving motor speed synchronization.

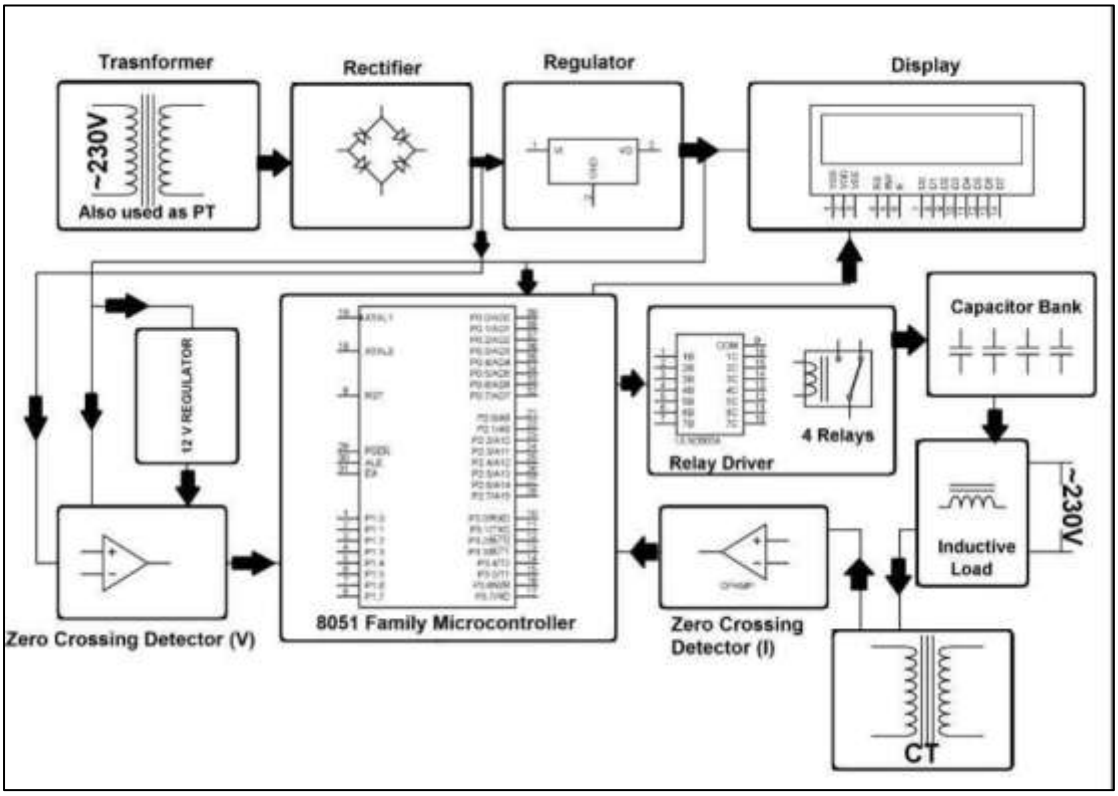

Fig 4.1 Block Diagram.

4.1.1. Requirement Analysis.

The project aims to synchronize multiple DC motors in textile and paper mills using a microcontroller.

4.1.2 Functional Requirements:

Monitor motor speeds using sensors. Compare speeds and adjust automatically to maintain synchronization. Use PWM and microcontroller for speed control.

4.1.3 Non-Functional Requirements:

Fast, accurate, and stable operation. Reliable and cost-effective for industrial use.

4.1.4 Hardware:

Microcontroller, DC motors, motor drivers, speed sensors, power supply, LCD

4.1.5 Software:

Embedded C / Arduino IDE, PID control algorithm.

4.1.6 Industrial Needs:

Uniform material movement, prevention of tearing, reduced production losses.

4.1.7 Design and Planning:

The design and planning phase focus on how the system will achieve speed synchronization of multiple DC motors efficiently.

4.1.8 System Design:

Microcontroller-Based Control: A microcontroller reads speed sensor data from each motor. Feedback Mechanism: Sensors provide real-time speed feedback. Control Algorithm: PID control is implemented to minimize speed differences. Motor Drive: PWM signals from the microcontroller control motor drivers to adjust motor speed.

4.1.9 Planning:

Identify number of motors and sensors needed. Design motor driver circuits for safe operation. Program microcontroller with PID algorithm.

4.1.10 Procurement of Materials and Components:

Microcontroller: Adriano/AT mega DC Motors: Multiple motors for simulation Motor Drivers: L293D / L298N / MOSFETs Speed Sensors: Encoders, IR, or Hall sensors Power Supply: Regulated DC supply Display (Optional): LCD for monito ring

4.1.11 Fabrication and Installation:

Motors mounted and aligned; driver circuits and sensors assembled. Microcontroller, drivers, and power supply connected safely. Testing points added, and initial dry runs conducted. Ensures a safe and reliable setup for accurate speed synchronization.

4.1.12 Electrical and Control Integration:

Microcontroller, motor drivers, and sensors interconnected. PWM signals from the controller regulate motor speed. Feedback from sensors used for real-time speed correction.
Ensures coordinated control and precise synchronization of all motors.

4.1.13 Testing and Commissioning:

System tested and adjusted; synchronization verified for reliable operation.

4.1.14 Maintenance Planning:

Regular inspection of motors, sensors, and drivers.

CHAPTER NO.5

DESING, WORKING AND PROCESSES

5.1 Circuit Diagram:

The microcontroller receives speed feedback from sensors and compares it with the reference speed. It generates PWM signals based on the error. The motor driver controls the DC motors accordingly. Thus, speed synchronization is maintained.

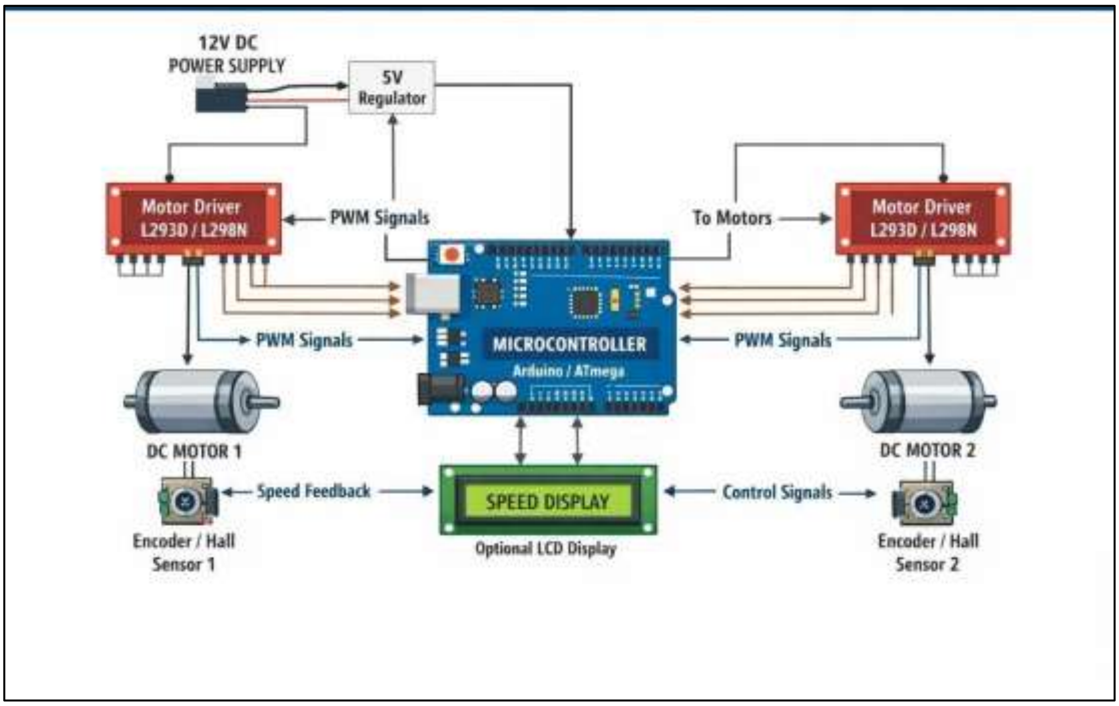

Fig.5.1. Circuit Diagram.

5.2 Explanation of Circuit Diagram:

The circuit uses a microcontroller (Adriano/AT mega) as the central controller. Speed sensors (encoders or Hall sensors) on each DC motor provide real-time feedback to the microcontroller. Based on this feedback, the microcontroller uses PWM signals to control motor drivers (L293D/L298N), adjusting motor speeds to maintain synchronization. A regulated power supply powers the motors and controller, while an optional LCD displays motor speeds for monitoring. This setup ensures precise and

5.1 Component Used:

Table 5.2 Component list

Sr. No.	Component / Material	Purpose / Use
1	At 328	ATmega328 microcontroller is used to control and synchronize multiple DC motor speeds by processing feedback signals and generating PWM outputs.
2	Supply Adapter	The supply adapter provides the required DC power to the microcontroller and motor driver circuit for proper system operation.
3	Motor driver	The motor driver amplifies the PWM signals from the microcontroller to drive and control the DC motors.

4	DC gear motor	The DC gear motor converts electrical energy into controlled mechanical rotation with high torque and low speed for synchronized operation.
5	connecting cables	Connecting cables are used to establish electrical connections between the components for proper signal and power transmission.
6	Lcd Display	The LCD display is used to show motor speed and system status for real-time monitoring.
7	I2C model	The I2C module is used to enable communication between the microcontroller and LCD using only two wires (SDA and SCL).
8	Zero pcb	General purpose PCB used for circuit assembly.
9	L clamp	Mounting support.

Explanation of Circuit Diagram:

5.1.1 Speed Sensor Module:

Reason: Your project depends on measuring the speed of each DC motor for synchronization. Sensors like encoders or Hall-effect sensors provide real-time feedback to the microcontroller. This is the correct and relevant module for your system. Optional alternatives (less ideal):

Motor Driver Module (L293D / L298N) – if you want to describe the driver separately. Microcontroller Module (Adriano / AT mega) – if you want to describe the control

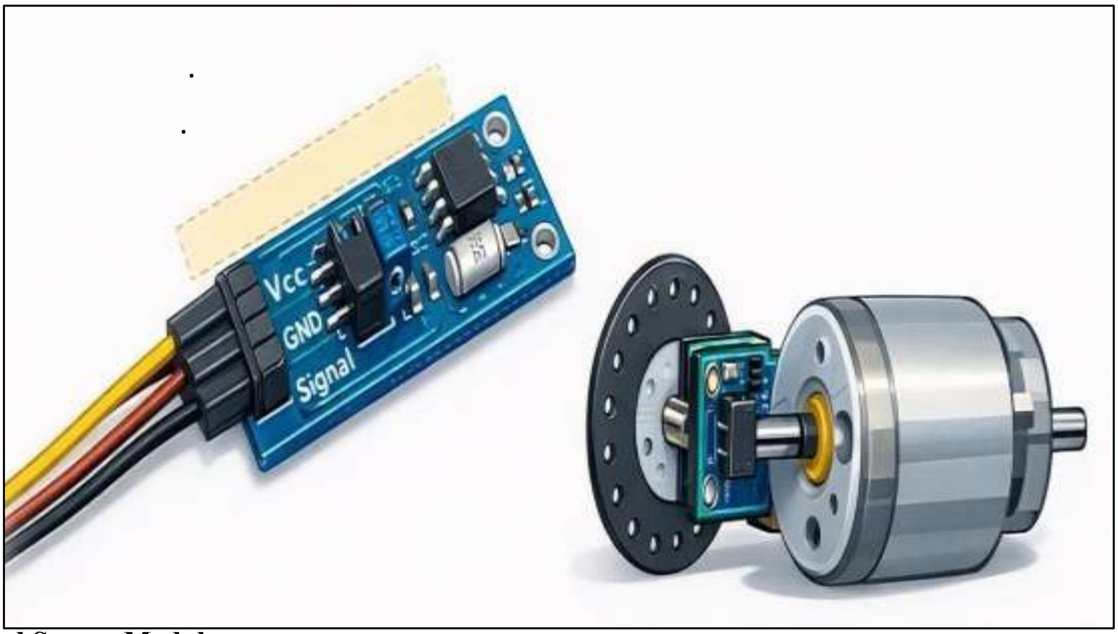

Fig.5.2.1. Speed Sensor Module.

5.1.2 Microcontroller (Arduino UNO / Nano).

The microcontroller acts as the central control unit of the system. It receives speed feedback from sensors, processes the data using a control algorithm (e.g., PID), and sends PWM signals to motor drivers to synchronize the speeds of multiple DC motors. Arduino UNO or Nano can be used depending on availability.

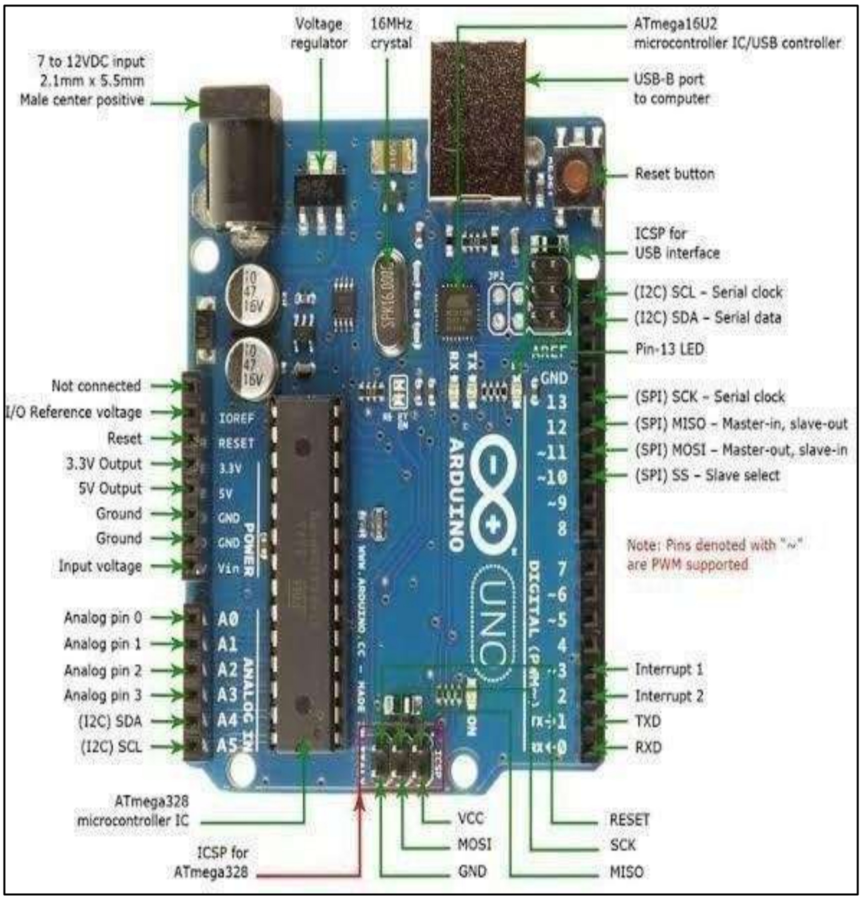

Fig.5.2.2. Microcontroller (Adriano Uno / Nano).

5.1.3 Printed Circuit Board (PCB).

A Printed Circuit Board (PCB) is an essential component in electronic systems, providing both mechanical support and electrical connectivity for various components. It consists of a flat, insulating base, typically made of fiberglass or epoxy, with thin layers of copper etched to form conductive pathways called traces. These traces replace traditional wiring, making the circuit compact, organized, and reliable. In the project "Speed Synchronization of Multiple DC Motors in Textile and Paper Mills", the PCB serves as the backbone for connecting the microcontroller, motor drivers, speed sensors, and optional display. It ensures proper signal flow between sensors and the controller, allowing accurate monitoring and adjustment of motor speeds. By reducing wiring complexity and minimizing electrical noise, the PCB contributes to smooth and synchronized operation of multiple DC motors. Its use also enhances durability, stability, and ease of maintenance, making the overall system more efficient and professional for industrial applications.

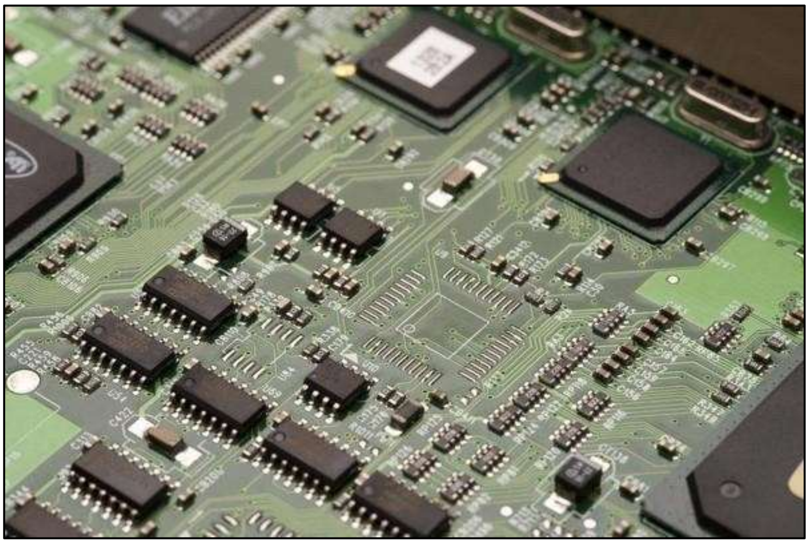

Fig.5.2.3 Printed Circuit Board (PCB)

5.1.4 Motor Driver Module (L298N).

In an solar powered smart rain proof roof system, the motor driver module L298N plays a crucial role in controlling the movement of the roof motor. Since the Arduino cannot supply the high current required to drive a DC motor directly, the L298N acts as an interface between the microcontroller and the motor. It allows the Arduino to control the direction and speed of the motor safely using low-current digital signals. The L298N has dual H-bridge circuits, which enable forward and reverse rotation of the motor, making it ideal for opening and closing the roof automatically. In operation, when the rain sensor detects rainfall, the Arduino sends a signal to the L298N, which then powers the motor to move the roof to the closed position. When the rain stops, the Arduino reverses the motor through the L298N to reopen the roof. The module also often provides a 5V output to power the Arduino, and it can be used with additional features like PWM control to adjust motor speed, ensuring smooth and reliable operation of the automatic roof mechanism.

Fig. 5.2.4. Motor Driver Module (L298N).

5.2.5. Infrared (IR) sensor.

It is used to sense certain characteristics of its surroundings by either emitting detecting infrared radiation. These sensors function by using a certain light sensor to detect a light wavelength in the IR spectrum. By the use of an LED, which produces light at the same wavelength as the sensor detects, we can study the intensity of the received light. At the time when the object is near the sensor, the light from the LED bounces off the object and into the light sensor. This results in increment in energy on a large-scale intensity, which we can detect using a threshold. Infrared sensors are also capable of measuring the heat being emitted by an object and detecting motion. IR transceiver is used here for determining the number of rotations of the motor shaft per second. This is done by counting the number of times the slot comes in line of sight with the transmitter receiver pair.

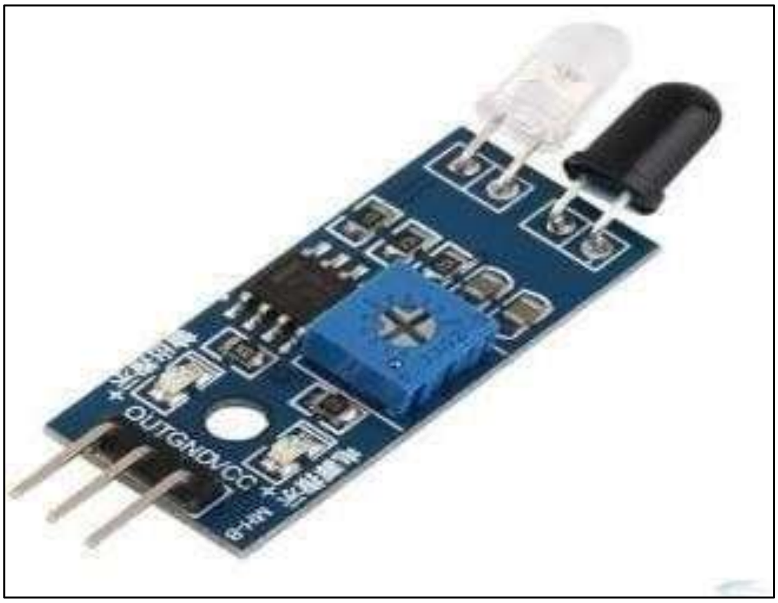

Fig. 5.2.5. Infrared (Ir) Sensor.

5.2.6. LCD PIN:

An LCD (Liquid Crystal Display) is commonly used in embedded projects to display data such as motor speed, system status, or sensor readings. A standard 16x2 LCD (16 characters per line, 2 lines) typically has 16 pins, which are used for power, control, and data signals. Pin Explanation:

1. VSS (Pin 1): Ground (0V).
2. VDD / VCC (Pin 2): +5V power supply.
3. V0 (Pin 3): Contrast adjustment (connected to a potentiometer).
4. RS (Pin 4): Register Select; selects command or data register.
5. RW (Pin 5): Read/Write; usually set to 0 (write mode).
6. E (Pin 6): Enable pin; triggers the LCD to read data.

7–14. D0–D7 (Pins 7–14): Data pins; used to send 8-bit data/commands. In 4-bit mode, only D4–D7 are used.

7. A (Pin 15): LED + (backlight positive).
8. K (Pin 16): LED − (backlight negative).

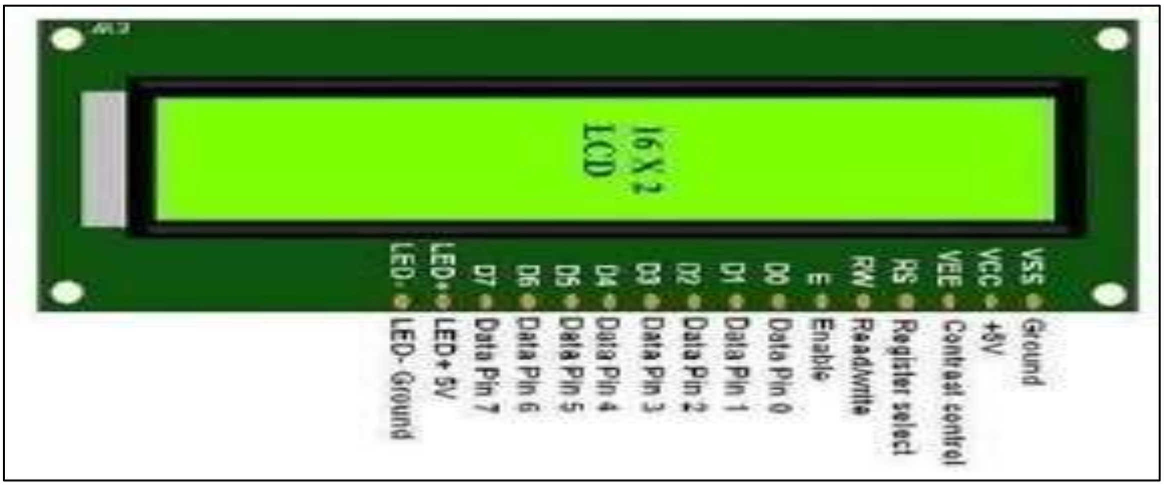

Fig. 5.2.6. LCD PIN.

5.2.7 Power Supply (Battery / Adapter).

An solar powered smart rain proof roof system can be powered either by a battery, an AC adapter, or a combination of both, depending on usage and reliability needs. A battery-powered system typically uses a 12V or 24V DC rechargeable battery to operate the motor, rain sensor, and control unit. This option is useful in areas with frequent power cuts or where wiring is difficult, as it allows the roof to close automatically even when mains power is unavailable. However, batteries require periodic charging or replacement and are better suited for light to medium roof loads with limited daily operation.

An adapter-based power supply uses standard AC mains power (110V or 220–240V) and converts it to low-voltage DC for safe operation of the roof motor and control system. This setup supports continuous operation and higher motor loads, making it ideal for larger or commercial automatic roofs. The main limitation is that it depends on electricity availability unless a backup system is added. For best performance and safety, many modern systems use a hybrid power supply, where the adapter serves as the primary power source and a battery act as backup, ensuring the rain-proof roof functions reliably even during power failure.

Fig. 5.2.7. Power Supply (Battery / Adapter).

5.2.8 Wires & Connectors.

In an solar powered smart rain proof roof system, wires and connectors play a critical role in ensuring reliable power transmission and control signal flow between the power supply, controller, relay module, sensors, and motor. High-quality copper wires with proper insulation are used to handle the required current for the motor, typically thicker gauge wires for power lines and thinner wires for sensor and control signals. All wiring should be routed neatly and protected using conduits or cable sleeves to prevent damage from moisture, heat, or mechanical stress. The connectors used in the system must be weather-resistant and securely locked to avoid loose connections caused by vibration or movement of the roof. Waterproof connectors, terminal blocks, and cable glands with appropriate IP ratings (IP65 or higher) are recommended for outdoor installation. Proper labelling, strain relief, and secure grounding further enhance safety and simplify maintenance, ensuring the automatic rain-proof roof operates smoothly and reliably in all weather conditions.

Fig. 5.3.8. Wires & Connectors.

CHAPTER NO.6

RESULTS AND APPLICATION

6.1. Result.

The proposed system for "Speed Synchronization of Multiple DC Motors Using Microcontroller" was successfully designed and implemented. The system was able to maintain synchronized speed between the master and slave DC motors under different operating conditions. The ATmega328 microcontroller effectively processed the feedback signals from the IR sensors and generated appropriate PWM signals to control the motor driver. The speed difference between motors was minimized using the PID based control method. The LCD display showed real-time motor speed and system status.

The experimental results demonstrate that the system provides stable operation, reduced speed variation, improved synchronization accuracy, and reliable performance. Hence, the developed system is suitable for textile and paper mill applications where precise motor speed synchronization is required.

6.2. Advantages.

1. Provides accurate speed synchronization of multiple DC motors.
2. Reduces material wastage in textile and paper mills.
3. Improves product quality and production efficiency.
4. Minimizes speed error using closed-loop control.
5. Easy to implement using microcontroller and PWM technique.
6. Low cost and less maintenance compared to conventional systems.
7. Supports automation and modern industrial applications.

6.3. Disadvantages.

1. The system becomes more complex as the number of motors increases.
2. Proper tuning of PID parameters is required for accurate synchronization.

6.4. Applications.

1. Textile industries for spinning, weaving, and winding machines.
2. Paper mills for synchronized roller and sheet processing systems.
3. Conveyor belt systems in manufacturing industries.
4. Printing and packaging industries requiring uniform material movement.
5. Rolling mills and material handling systems.
6. Industrial automation systems involving multiple motor drives.

CHAPTER NO. 7

CONCLUSION AND FUTURE SCOPE

1.1. Conclusion.

The project "Speed Synchronization of Multiple DC Motors in Textile and Paper Mills Using Microcontroller" has been successfully designed and implemented. The system effectively maintains synchronized speed between multiple DC motors using a microcontroller-based closed-loop control mechanism. By utilizing speed sensors, PWM technique, and PID control, the system minimizes speed variations and ensures smooth and stable operation. The developed model improves production efficiency, reduces material wastage, and enhances product quality in textile and paper mill applications. Overall, the proposed system is cost-effective, reliable, and suitable for industrial automation where accurate motor speed synchronization is required.

7.2. FUTURE SCOPE.

The proposed system for speed synchronization of multiple DC motors can be further enhanced with advanced technologies to improve performance and industrial applicability. In the future, the system can be expanded to control a larger number of motors in large-scale industrial setups. Advanced control techniques such as Fuzzy Logic Control or Adaptive Control can be implemented to improve system response under sudden load variations. The system can also be integrated with IoT technology for remote monitoring, data logging, and real-time performance analysis. Additional features such as over-speed protection, overload protection, and automatic fault detection can be added to increase safety and reliability. A graphical user interface (GUI) or mobile-based monitoring system can also be developed for easier operation and control.

COST ESTIMATION AND HARDWARE

5.2 Cost Estimation:

Table of Cost Estimation.

Sr. no.	**Name**	**Quantity**	**Cost (Rs)**
1	Arduino UNO	2	900
2	Speed sensor	2	500
3	Connecting Wire	10	120
4	BLDC Motor	3	900
5	Microcontroller	1	500
6	LCD Display	2	450
7	Plywood	1	350

8	Receiver	1	700
9	PVC Site	-	1100
10	Motor Control unit	2	800
11	Keypad	1	250
12	Transmitter	1	600
13	Missenses item	-	4000
	Total		**Rs. 11,870**

Hardware Design:

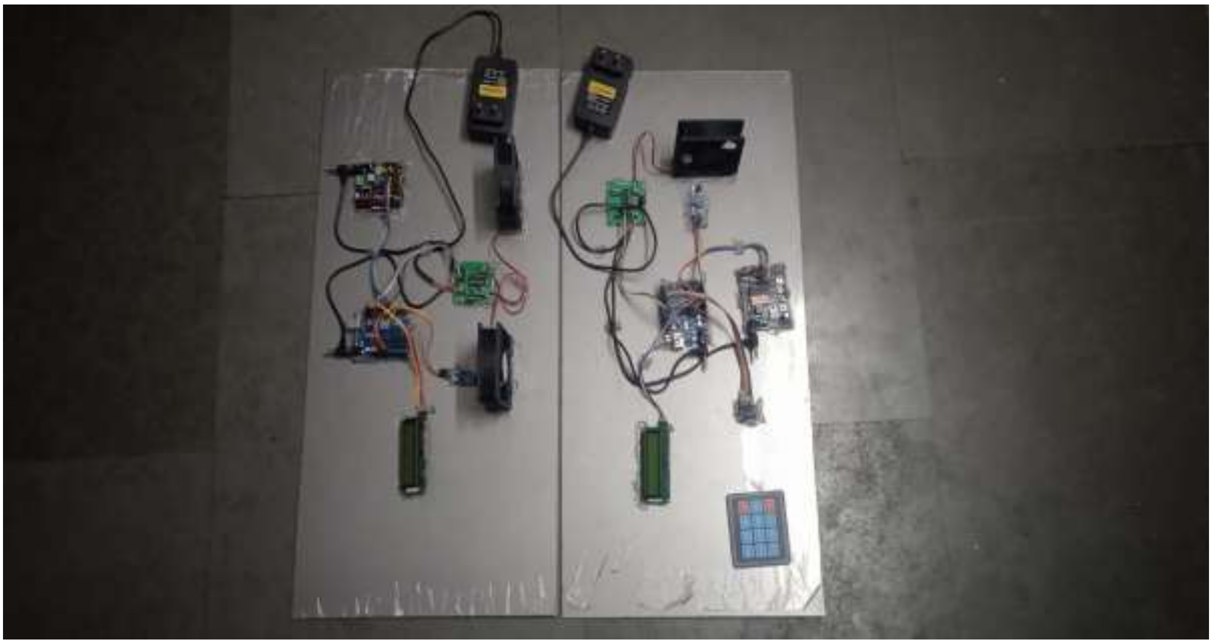

Fig. Hardware Design.

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APPENDIX