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Synced Speed Regulation of Several Motors for Industrial Uses

Synchronization Speed Control of Multiple Motors for Industrial Applications

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Abstract: The synchronization of motors with speed is critical in various industries. In the textile industry, differential speed errors can lead to high power consumption. This project aims to synchronize multiple motors using wireless technology. In a textile mill, where multiple motors run concurrently on a conveyor belt to draw clothing, all motors must run at the same speed to achieve balanced tension and prevent clothing damage. To reduce differential speed errors among multiple motors, wireless synchronization of the motors is used in this project. All motors act as receivers, with one serving as a transmitter. Brushless Direct Current Motors (BLDC) operate based on Pulse Width Modulation (PWM) control. The microcontroller's pulse width output is automatically adjusted to maintain the motor receiving DC power and ensure that the speed percentage entered corresponds to the rotation per minute of operation. "To drive the BLDC motor that is properly interfaced from the microcontroller, the above operation is performed using an electronic speed controller. "To drive the BLDC motor that is properly interfaced from the microcontroller, the above operation is performed using an electronic speed controller."

***IndexTerms* - BLDC motor, electronic speed control, microcontroller, speed synchronization.**

I. Introduction

Different types of motors are used in projects, mills for preparation, and other applications. The main challenge is maintaining the differentiating speed (RPM) of each motor, or speed control for each motor. We created a single controller that can change the speed of multiple motors simultaneously from one location to solve the issue of controlling the speed of various motors. It reduced the need for multiple controllers to regulate the speed of various motors. The motor's speed (RPM) in this project is controlled by a variable power source. The goal is to maintain a steady water flow at the motor's output side regardless of changes in the water flow at the input. Using a motor speed controller, the pumping action of the motor is adjusted in response to variations in flow, which alter the motor's speed. To prevent burning or damage, there is a relay facility that is used to turn off the motor when the water flow drops below a certain level. The effects of a DC motor's non-linearity are what cause problems when using a standard control system in a speed controller. The non-direct characteristics of a DC motor, such as submersion in erosion, may make the operation of a conventional controller look foolish. In the textile industry, clothing movement should be coordinated with the weaving axle's speed to prevent damage. In DC machines, significant load variations result in chasing or oscillatory behavior. Recent years have made it possible to use state-of-the-art control innovation to ensure the reliable and efficient operation of many different applications, including paper mills, transportation, electric cars, material factories, flour mills, and mechanical technology. Due to the vast majority of these operations involving electric motors, effective control strategies that incorporate advanced motor control are necessary. Conventionally, a mechanical transmission system consisting of pullers and a line shaft gear is used to synchronize motors. Therefore, speed control is essential for variable load conditions to achieve a robust framework. This project illustrates the concept and application of motor speed control using microcontrollers. Recent advancements in technology have made it feasible to employ contemporary control technology to manage the dependable and efficient operation of numerous applications, including paper mills, cruise ships, electric cars, textile and flour mills, and robotics. Electric motors are used in many of these operations, so practical and efficient control strategies with digital motor control are required. The closed-loop PWM technique is the most effective and widely used method for controlling motor speed. Using this technique, the motor's voltage, which is controlled by the PWM duty cycle, is changed to regulate the motor's speed. Using a microcontroller timer, the Pulse Width Modulation (PWM) duty cycle is produced by varying the input voltage pulses for both on and off durations, resulting in highly accurate PWM voltage control. To have a high dynamic response, it is crucial to develop a high motor drive.

II. BACKGROUND

In various industries, motor speed synchronization plays a crucial role. Specifically, in textile industries, differential speed errors can lead to excessive power consumption. The primary objective of this project is to synchronize multiple motors wirelessly. In textile mills, where several motors operate simultaneously on a conveyor belt to handle fabrics, maintaining uniform speed is essential to achieve balanced tension and prevent damage to the clothes. To address this, we propose a wireless synchronization system. One motor acts as the transmitter, while the remaining motors serve as receivers. We focus on Brushless Direct Current Motors (BLDC) controlled via Pulse Width Modulation (PWM). The microcontroller adjusts the pulse width to maintain DC power, ensuring that the entered speed percentage matches the actual Rotation Per Minute (RPM). An electronic speed controller interfaces with the BLDC motor to achieve precise speed control.

2.1 Discussion

The term "speed synchronization of multiple motors in industries" refers to the process of ensuring that every motor in a large factory or other industrial setting runs at the same speed. Consider a system of interconnected machines, such as large fans or conveyor belts. It could be problematic if they all operate at various speeds.
Thus, variable frequency drives (VFDs) are used to solve this. These resemble motor remote controls. They assist us in varying the amount of electricity each motor receives in order to modify its speed. We can synchronize the speeds of the motors by ensuring that they receive identical adjustments.

What makes us want to take action this, now? There are a few good reasons, though:
• Efficiency: When every motor operates at the same speed, energy is used more effectively, saving money and benefiting the environment.
• Smooth Operations: Everything functions better when machines are in harmony with one another. It's akin to a skillfully performed dance, with each person knowing exactly what to do.

However, it's not always simple to ensure that every motor remains in sync:
• Complex Controls: To ensure that all of the motors operate in unison, intelligent control systems are required, and these systems can be fairly complex.
• Variations Between Motors: Two motors may operate somewhat differently even if they have the exact same appearance. To ensure that they match, we must carefully adjust them.
• Variations in Conditions: Occasionally, factors like shifts in the factory's temperature or workload can have an impact on how quickly the motors should run. We have to monitor them and make necessary adjustments.
• Cost: Installing the necessary systems to synchronize motors can be costly. Although it's an investment, savings over time may make it worthwhile.
• Less Wear and Tear: Motors operating at varying speeds can overwork themselves and wear down more quickly. We can extend their lifespan and lower maintenance costs by coordinating them.

2.2 Problem Statement

When different motors in a factory or industrial setup run at different speeds, it can cause issues like inefficiency, wear and tear on machines, and disruptions in production. We need to find a way to make sure all the motors run at the same speed so that everything works smoothly and efficiently.

III. Component Requirements

- Microcontroller Atmega328
- Resistors 220E, 10K, 1K
- Voltage Regulator 7805
- LCD (16×2)
- BLDC Motor
- Electronic Speed Controller
- SMPS 12V/ 2Amp.
- Mains Cord
- Potentiometer 10K
- RF433 MHz Tx/Rx Module
- Transformer 12V/750mAmp
- Capacitors 25V/1000uF, 22pF
- Diodes
- Zero PCB
- LED
- Preset 10 k
- Crystal 16Mhz
- Micro Push Button

IV. BLOCK DIAGRAM

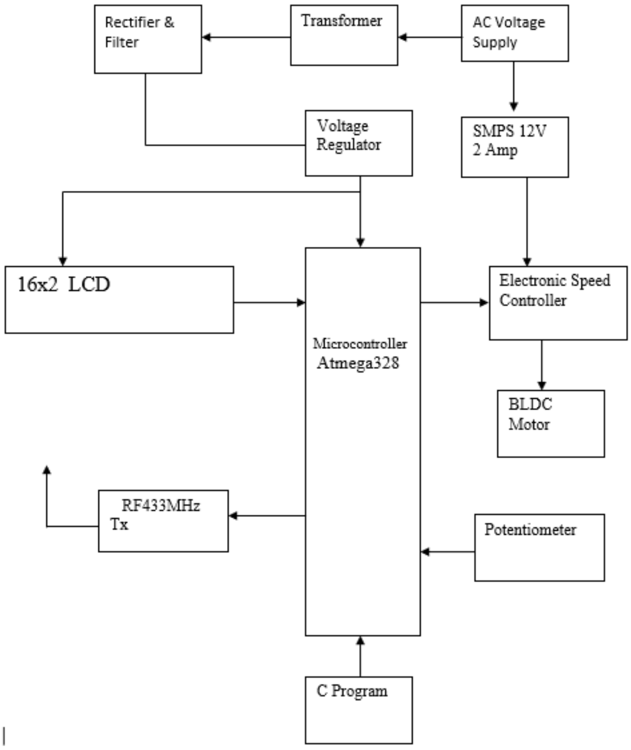


FIG NO . 4.1 TRANSMITTER

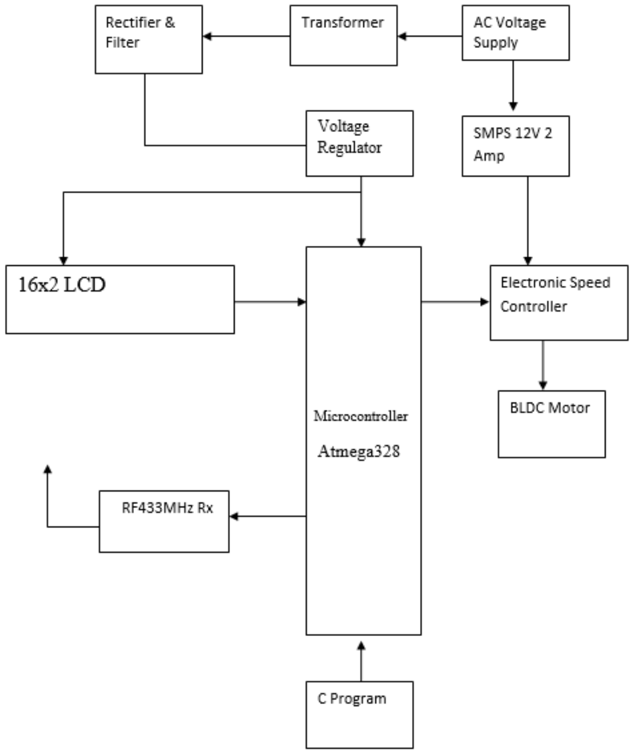


FIG NO . 4.2 RECEIVER

V. COMPONENTS DESCRIPTION

- Transformer: A device that transfers electric power from one circuit to another at the same frequency. It can adjust voltage levels while inversely affecting current. This is achieved through mutual induction between two separate circuits linked by a common magnetic flux. The primary winding receives alternating voltage, inducing a flux in the core, which in turn induces voltage in the secondary winding, transferring energy magnetically.

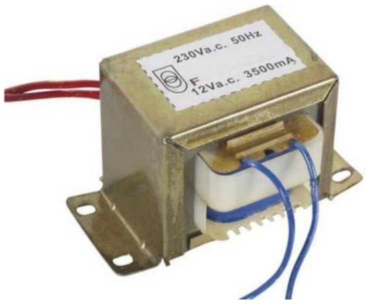


Fig no : 5.1 Transformer

- Voltage Regulators (7805): A type of voltage regulator integrated circuit (IC) belonging to the 78xx series. Specifically, the 7805 IC provides a fixed output voltage of +5V DC. It ensures a steady output despite fluctuations in the input voltage, up to 35V. Additionally, it includes provisions for heat dissipation and can handle various input voltages within its threshold.

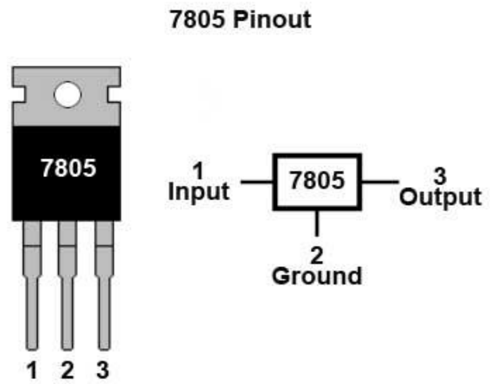


Fig no :5.2 Voltage Regulators (7805)

- 16x2 LCD: A common type of liquid crystal display (LCD) module featuring a 16-character-per-line, 2-line display capability. It's widely used due to its economic viability, programmability, and flexibility in displaying characters, custom symbols, and animations. The display operates with two registers: the command register for controlling LCD functions and the data register for storing characters to be displayed.

Fig no :5.3 16x2 LCD

- Zero PCB: A general-purpose printed circuit board (PCB) coated with copper, allowing for soldering without short circuits. It's commonly used for embedding circuits randomly to support hardware operations.

Fig no :5.4 Zero PCB

- Capacitors: Passive electrical components used to temporarily store electrical energy in an electric field.

Fig no :5.5 Capacitors

- Resistors: Passive electrical components used to implement resistance in a circuit. They regulate current flow, adjust signal levels, divide voltages, bias active elements, and terminate transmission lines.

Fig no :5.6 Resistors

- Crystal Oscillator: An electronic oscillator circuit utilizing the mechanical resonance of a vibrating crystal to generate an electrical signal with precise frequency. Commonly used for timekeeping, clock signal generation in digital circuits, and frequency stabilization in radio equipment.

Fig no :5.7 Crystal Oscillator

- BLDC Motor: Brushless direct current electric motors that feature high efficiency and reliability. They utilize control circuitry instead of brushes and commutators for operation, making them suitable for various applications including drones, quadcopters, and RC airplanes.

Fig no :5.8 BLDC Motor

- Electronics Signal Controller (ESC): An electronic speed controller responsible for controlling the movement or speed of brushless motors by activating appropriate MOSFETs. It determines rotor position using methods like Hall-effect sensors or back electromotive force to ensure efficient motor operation.

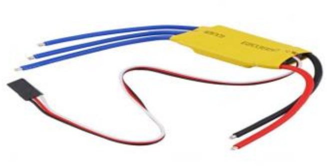
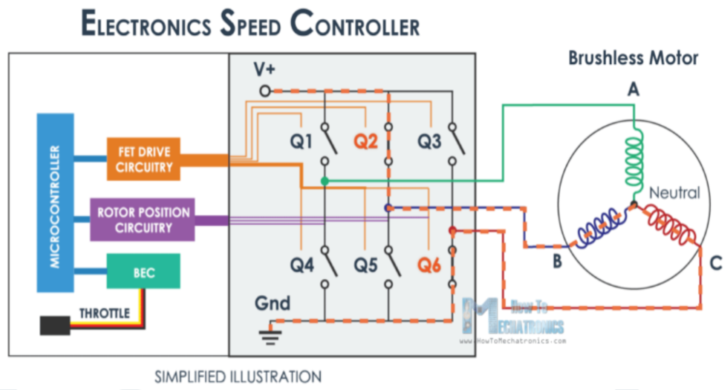


Fig no :5.9 Electronics Signal Controller



- SMPS 12V/2 Amp: A switched-mode power supply module that converts AC power to 12V DC with a 2A output. It includes built-in protection features against over-voltage, over-current, and short circuits.

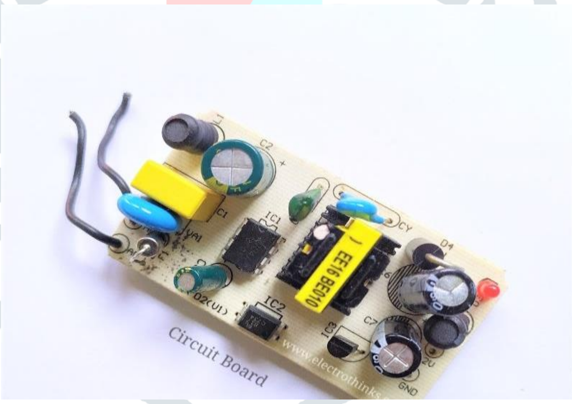


Fig no :5.10 SMPS 12V/2 Amp

- 433MHz RF Module: A radio frequency communication module comprising both transmitter and receiver components. It operates by generating electromagnetic waves at a source and detecting them at a destination. The transmitter and receiver communicate wirelessly, with the transmitter sending data and the receiver receiving it within a certain range.

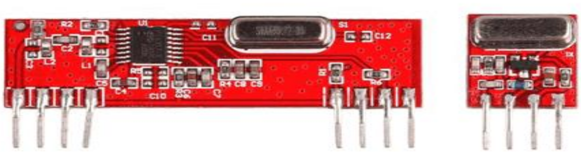


Fig no :5.11 433MHz RF Module

- Microcontroller (ATmega328): A high-performance 8-bit AVR RISC-based microcontroller featuring flash memory, EEPROM, SRAM, general-purpose I/O lines, timers/counters, UART, SPI, ADC, and other peripherals. It operates at voltages between 1.8V to 5.5V and offers efficient processing speed with low power consumption.

Fig no :5.12 Microcontroller (ATmega328)

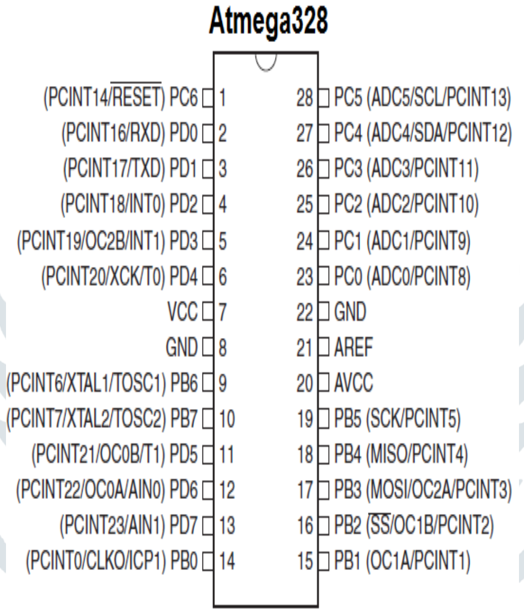


Fig No: 5.13 Pin of Diagram (ATmega328):

VI. WORKING METHODOLOGY

There are a plethora of alternative methods available to address this issue. However, they are not very trustworthy. Microcontrollers can be used to control, operate, and synchronize this task while reducing the need for human intervention and saving labor costs and time. In contrast to the conveyor belt method, this approach is compatible because it uses both hardware and software in this module. In order to complete our task, the microcontroller can be configured to regulate its speed and to set the necessary speed using a potentiometer. Here, synchronization has been achieved through wireless technology. Here, wireless communication has been facilitated by RF communication technology. The master-slave method is used to synchronize motors. The motor speed is received at the receiver side via PWM technique after being transmitted by the transmitter using an RF module. As a result, the motors operate at a synchronized speed. The circuit diagram for the transmitter is depicted in figure 4.1 above. It includes a potentiometer that serves as the input device, providing the transmitter motor with the speed input. The speed signal is sent to the radio frequency receiver module via the radio frequency (433 MHz) transmitter. The analog input provided by the potentiometer is converted into a digital signal and sent to the electronic speed controller via the analog to digital converter. By altering the pulse width of the signal sent to the BLDC motor, the electronic speed controller sets the speed. The receiver system's circuit diagram is displayed in figure 4.2. The Radio Frequency receiver module, which is used to obtain the signal transmitted in the RF transmitter from the transmitter motor, makes up the receiver system. The microcontroller has been given the received signal as an input. The electronic speed controller receives the generated pulse signal. The RF receiver module's received signal determines how wide the pulse signal should be. Consequently, the electronic speed controller has provided the receiver motors with a pulse signal in accordance with that.

VII. RESULT AND DISCUSSION

Table 1Speed of motor in Transmitter and Receiver

Attempts	TRANSMITTER MOTOR SPEED (RPM)	RECEIVER MOTOR 1 SPEED (RPM)
1	2500	2470
2	3300	3100
3	3800	3710
4	4500	4410
5	6000	5890

The speed that was entered into the transmitter and the speed that was received by the receiver are shown in Table 1. This suggested method uses a radio frequency module to transmit the speed. The primary goal of the project, which was to reduce motor power dissipation and get the motors roughly in sync with the transmitting speed, has been met by the proposed system.

VIII. SOFTWARE USED :ARDUINO IDEPROGRAMMING

Transmitter Code:

```
# // include the library code:
#include <LiquidCrystal.h>
#include <Servo.h>
#include <RH_ASK.h>
// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(7, 6, 5, 4, 3, 2);

Servo ESC;
const int potPin = A5;
int potValue;
int speed1;
int pwm;
void setup()
{
lcd.begin(16, 2);

  ESC.attach(9, 1000, 2000);
  pinMode(potPin, INPUT);
}

uint8_t data = 0;
void loop()
{
 lcd.print("  BLDC Motor 1  ");
  lcd.setCursor(0,1);
  lcd.print("  Speed : ");

  potValue = analogRead(A5);   // reads the value of the potentiometer (value between 0 and 1023)
  pwm = map(potValue, 0, 1023, 0, 180);   // scale it to use it with the servo library (value between 0 and 180)
  speed1 = map(pwm, 0, 180, 0, 100);
  lcd.setCursor(10,1);
  lcd.print(speed1);
  lcd.print("%");
  ESC.write(pwm);    // Send the signal to the ESC
```

```
  data = (uint8_t) (pwm);
  //data = (uint8_t) (analogRead(A5) / 4); //Map from max of 1023 to 255
  driver.send(&data, 1);
  driver.waitPacketSent();
  delay(1000);

  lcd.clear();
}
```

Receiver code:

```
#include <LiquidCrystal.h>
#include <RH_ASK.h>
#include <Servo.h>

// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(7, 6, 5, 4, 3, 2);



Servo ESC;

RH_ASK driver;
int potValue;
int pwm;
int speed2;

void setup()
{

lcd.begin(16, 2);
  ESC.attach(9, 1000, 2000); // (pin, min pulse width, max pulse width in microseconds)

void loop()
{

  lcd.setCursor(0, 0);
  lcd.print("  BLDC Motor 2  ");
  lcd.setCursor(0, 1);
  lcd.print("  Speed : ");
  uint8_t buflen = 1;
  uint8_t buf[buflen];
  if (driver.recv(buf, &buflen)) // Non-blocking
  {
    int i;
  }

  pwm = map(*buf, 0, 180, 0, 180);
  speed2 = map(pwm, 0, 180, 0, 100);
  lcd.setCursor(10, 1);
  lcd.print(speed2);
  lcd.print("%");

  ESC.write(pwm);
 delay(500);

  lcd.clear();

}
```

IX. CONCLUSIONS

The inability of the current system to synchronize speed at a specific range is a major flaw. Numerous research articles have suggested synchronizing the motors at specific speeds, but this always results in a failure scenario. The wired method of speed synchronization had some overrun and produced results of speed variation up to 600 RPM to 900 RPM, while the old method, which uses a conveyer belt, had a speed variation of over 1000 RPM. The speed of the motor can be synchronized at the maximum set point provided on the transmitter side thanks to the above suggested speed synchronization system, which has overcome all of its shortcomings. The variance has now been decreased by 100 to 150 RPM.

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