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Wire Prepping Machine Design Report

1. Introduction

In this project, I designed a wire prepping machine for handling a 5.5mm diameter, 4-core wire. The machine will perform various operations, such as cutting of wire, removing the external sheathing, stripping the cores, and tinning the cores. The design will be controlled via a local web portal (i.e. we can use XYremote software) and will feature error-handling mechanisms displayed both on the machine and the web interface. The project focuses on control system design, automation, and integration of sensors and actuators, with the mechanical design being handled separately.

2. Objectives and Design Requirements

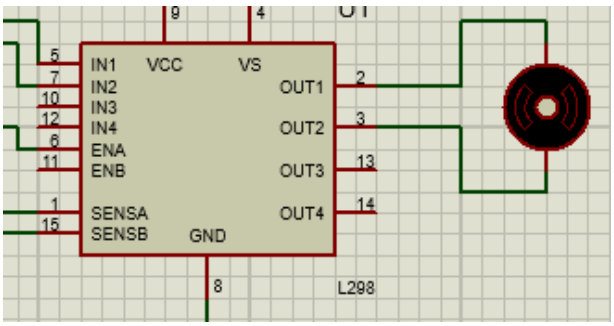
The wire-prepping machine design aims to achieve the following objectives:

1. *Wire Handling:* The machine will handle 5.5mm diameter, 4-core wire, which is continuously fed from an endless roll.
2. *Cutting the wire:* The machine will also be responsible for cutting the wire in a programmable fashion.
3. *Sheathing Removal:* The machine will remove the external sheathing on both ends of the wire, with programmable lengths for processing.
4. *Core Stripping and Tinning:* The machine will strip and tin the cores on both ends of the wire, also with programmable lengths.
5. *Machine Operation:* The machine can be operated via a local web portal to start and stop tasks.
6. *Error Reporting:* Errors in operation will be displayed both on the machine's screen (Oled or 7-segment display) and on the web portal. Additionally, dry contact points will indicate errors.
7. *Runout Sensor:* A sensor will detect the wire's runout to prevent malfunction (limit switch).

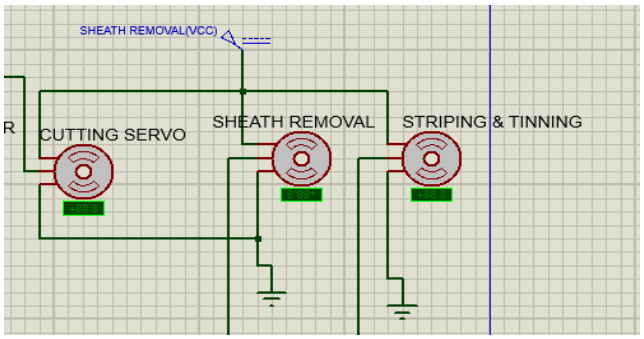
3. System Components and Architecture

3.1. Actuators and Sensors

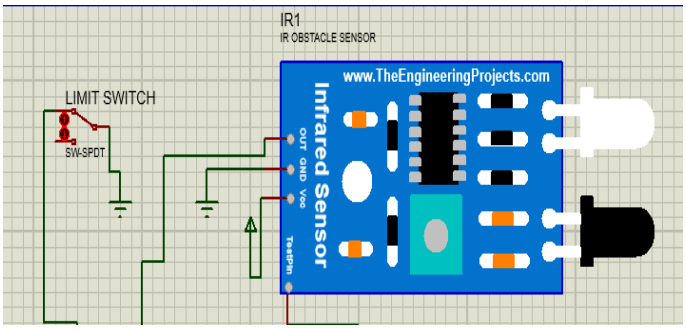
- **DC Motors**: Used for feeding the wire, moving it forward, and operating the motorized mechanisms for wire feeding.



- **Servo motors**: Controls the cutting of the wire, sheathing removal mechanism, and stripping/tinning of the cores.

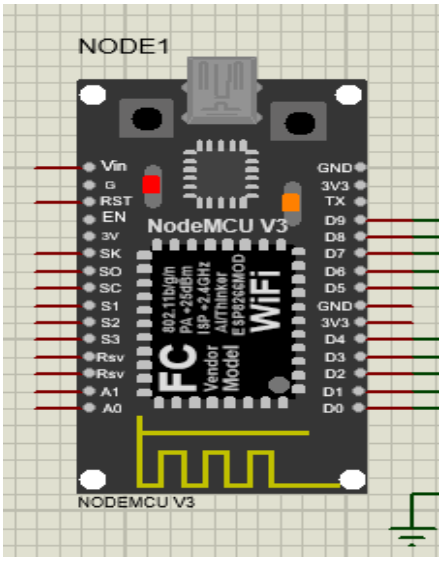


- **Sensors**:
  - **Runout Sensor**: a *limit switch* detects the end of the wire to halt operations.
  - **IR Sensor**: Detects the wire length as it moves through the DC motor.



3.2. Control Unit

- **NodeMCU V3 ESP8266**: Handles control of the motors, servos, sensors, and web portal interface. It will manage all operations.



4. Operational Flow and Task Execution

The wire-prepping machine will follow the following steps:

1. Wire Detection

Limit Switch Activation: The wire is continuously fed through the system from the roll. The **limit switch** will detect the initial position of the wire. Once the wire is in position, the system is ready to begin feeding.

2. Feeding the Wire

DC Motor Operation: The **DC motor** will draw the wire forward. The wire will move through the system, and the **IR sensor** will be used to measure the length of wire fed.

- **IR Sensor Role**: The **IR sensor** counts the rotations of the DC motor. For instance, one complete rotation of the motor corresponds to 5 cm of wire being fed forward.
- **Length Calculation**: When the DC motor completes two full rotations (i.e., 10 cm), the system recognizes that the correct length of wire has been fed.

3. Wire Cutting

Servo Motor for Cutting: Once 10 cm of wire has been fed, a **servo motor** attached to the cutting mechanism will activate. The servo will cut the wire into the required segment length.

4. Sheathing Removal

Servo Motor for Sheathing Removal: After cutting, the wire will be moved forward to a **servo motor** responsible for sheathing removal. This servo will strip the external sheathing of both ends of the wire. The length of the sheathing to be removed will be programmable, allowing for flexibility.

5. Core Stripping and Tinning

- **Motorized Core Stripping Mechanism**: The wire will then move to the next step, where another **motorized mechanism** grabs the cores inside the wire.
- **Servo Motor for Stripping**: The **servo motor** will strip the wire cores, preparing them for tinning.
- **Soldering**: A **soldering head** will be positioned over the wire cores to tin them with solder. The soldering head will be moved to each core as required.

6. Error Handling

If there are issues such as wire runout, or if a mechanism fails, the machine will display an error message on both the machine's screen and the local web portal. Additionally, LED will indicate the error externally.

➔ And the process will repeat again and again.

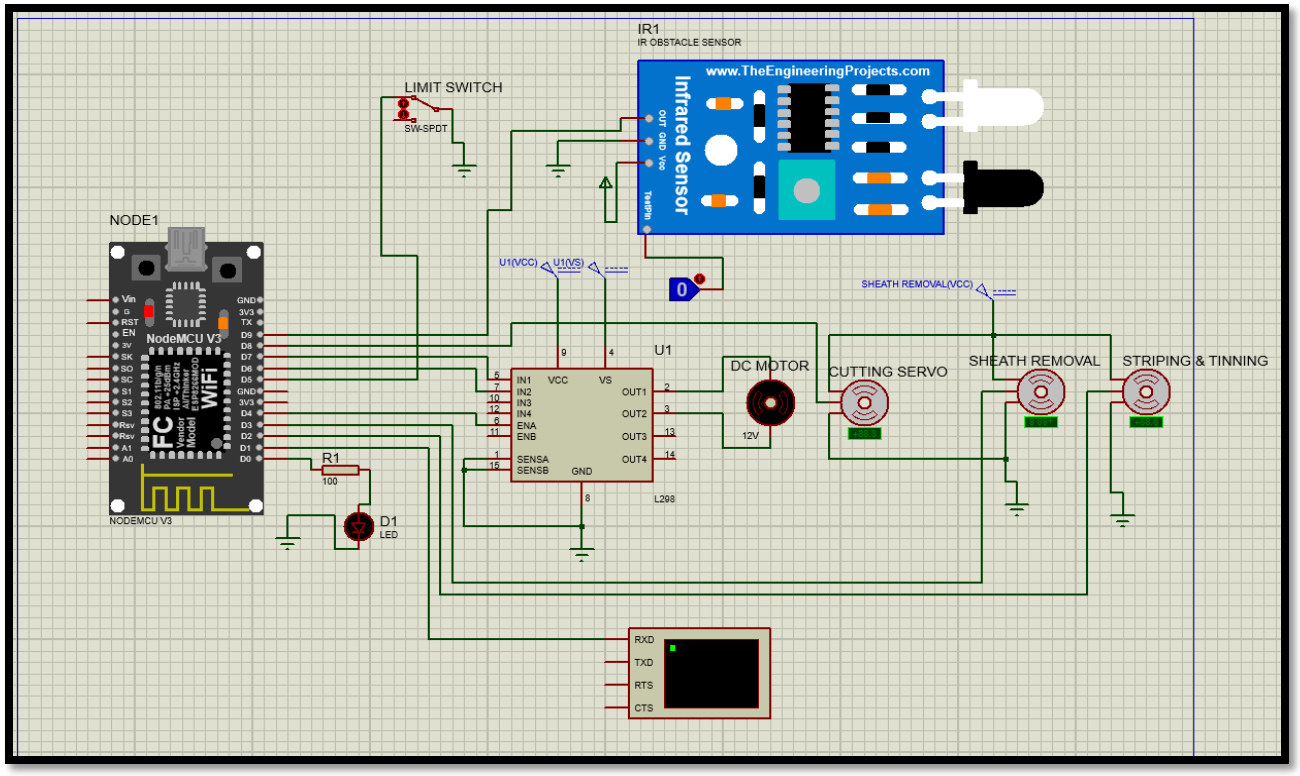


Figure 2: Wire Prepping Machine Design 1

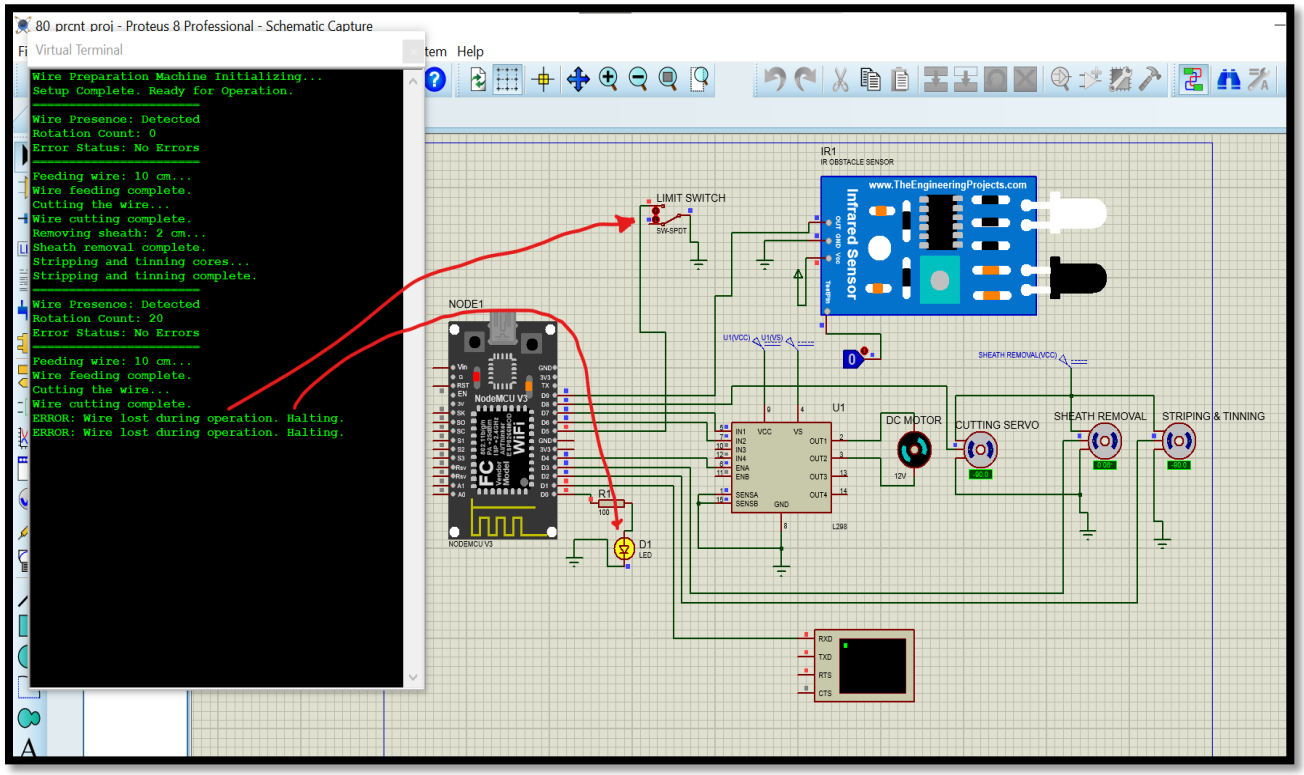


Figure 1: Result on virtual terminal

5. Design and Control System

The control system of the wire-prepping machine includes both the hardware (motors, servos, sensors, displays, LED's) and software (Arduino IDE).

5.1. Hardware Design

The following components are used:

- *DC Motors* for wire feeding.
- *Display(Oled or 7-segment)*
- *Servo motors* for cutting, sheathing removal, and stripping/tinning.
- *NodeMCU ESP8266* as the central controller.
- *LED's for error indications*
- *Sensors* (runout → limit switch, wire length sensor → IR sensor, and error sensors) for operation and error detection.

5.2. Software Design

The machine's software will be written using Arduino IDE, with the following functionalities:

- *Web Interface:* A local web portal will control the machine's actions, including starting/stopping tasks, setting wire lengths, and displaying the current machine status.
- *Motor and Servo Control:* The DC motors and servos will be controlled to perform wire feeding, cutting, sheathing removal, and core tinning in sequence.
- *Error Handling:* The system will continuously check for errors such as wire runout or malfunctioning mechanisms and report them to the web portal and machine display.

6. Assumptions and Limitations

6.1. Assumptions

- The wire is continuously fed from an endless roll, and no custom feeder system is required.
- The machine will handle only 5.5mm diameter, 4-core wires.
- External mechanical design for wire handling (cutting, stripping) will be handled by mechanical design team.
- The local web portal is only for local operation and monitoring & remote access are not included in this design.
- The Wifi portal will be set up properly as required in real-time.
- In real-time the display will be properly configured with esp8266.

6.2. Limitations

- In proteus simulation the wifi doesn't work as expected, that's why web portal or wifi capabilities in proteus were not set up properly.
- The proper display is not set up properly because of proteus limitations.
- Precision in wire length depends on motor rotation calibration.

7. Code Implementation

The following is the basic code implementation that will control the motors and servos, and handle web interface interactions:

```
#include <Servo.h>
#include <ezButton.h>
// #include <ESP8266WiFi.h>
// #include <ESP8266WebServer.h>

// Define pins for peripherals
#define LIMIT_SWITCH_PIN 5   // Limit switch to detect wire runout
#define IR_SENSOR_PIN 9      // IR sensor for rotation count
#define DC_MOTOR_IN1 7       // DC motor IN1
#define DC_MOTOR_IN2 6       // DC motor IN2
#define DC_MOTOR_ENA 4       // DC motor enable (PWM control)
#define SERVO_SHEATH 3       // Servo for sheathing removal
#define SERVO_SOLDER 2       // Servo for soldering
#define SERVO_CUTTER 8       // Servo for wire cutting
#define ERROR_LED 0          // LED for error indication
//#define ERROR_CONTACT_PIN 10 // Dry contact for external error reporting

// WiFi credentials
//const char* ssid = "Your_SSID";
//const char* password = "Your_PASSWORD";

// Servo objects
Servo servoSheath;
Servo servoSolder;
Servo servoCutter;

// Button object for the limit switch
ezButton limitSwitch(LIMIT_SWITCH_PIN);

// Variables for system state
volatile int rotationCount = 0;  // Count of rotations detected by the IR sensor
bool wirePresent = false;        // Wire presence status
bool errorFlag = false;          // System error state
bool taskRunning = false;        // Task in progress

// Configurable parameters
int wireLength = 10;         // Wire length in cm (can be adjusted via web input)
int sheathLength = 2;        // Sheathing removal length in cm
int rotationsPerCm = 2;      // IR sensor rotations per cm of wire
```

```
// ESP8266 Web Server
// ESP8266WebServer server(80);

void setup() {
  // Initialize Serial communication
  Serial.begin(9600);
  Serial.println("Wire Preparation Machine Initializing...");

  // Limit switch debounce setup
  limitSwitch.setDebounceTime(50);

  // Initialize IR sensor pin
  pinMode(IR_SENSOR_PIN, INPUT);

  // Initialize DC motor pins
  pinMode(DC_MOTOR_IN1, OUTPUT);
  pinMode(DC_MOTOR_IN2, OUTPUT);
  pinMode(DC_MOTOR_ENA, OUTPUT);

  // Initialize error LED
  pinMode(ERROR_LED, OUTPUT);
  //pinMode(ERROR_CONTACT_PIN, OUTPUT); // Optional dry contact for error

  // Attach servo motors
  servoSheath.attach(SERVO_SHEATH);
  servoSolder.attach(SERVO_SOLDER);
  servoCutter.attach(SERVO_CUTTER);

  // Reset components
  stopDCMotor();
  servoSheath.write(0);
  servoSolder.write(0);
  servoCutter.write(0);

  // Setup WiFi
  //WiFi.begin(ssid, password);
  //while (WiFi.status() != WL_CONNECTED) {
  //  delay(500);
  //  Serial.print(".");
  //}
  //Serial.println("\nWiFi connected");
  //Serial.print("IP Address: ");
  //Serial.println(WiFi.localIP());

  // // Configure Web Server routes
```

```
  // server.on("/", handleRoot);
  // server.on("/set", handleSetParameters);
  // server.begin();
  // Serial.println("Web server started.");

  Serial.println("Setup Complete. Ready for Operation.");
}

void loop() {
  // Update limit switch state
  limitSwitch.loop();

  // Check for wire presence
  wirePresent = limitSwitch.getState() == LOW;

  // Handle web server requests
  // server.handleClient();

  // Display status on Serial Monitor
  displayStatus();

  // Handle errors if wire is not detected
  if (!wirePresent) {
    handleError("Wire not detected. System halted.");
    return;
  } else {
    clearError();
  }

  // If no errors and not already running, start task
  if (!taskRunning) {
    taskRunning = true;

    // Execute the steps in sequence
    if (checkWirePresence()) feedWire(wireLength);
    if (checkWirePresence()) cutWire();
    if (checkWirePresence()) removeSheath(sheathLength);
    if (checkWirePresence()) stripAndTinCores();

    taskRunning = false; // Mark task complete
  }

  // Pause briefly before next iteration
  delay(1000);
}
```

```
// Check wire presence during operation
bool checkWirePresence() {
  limitSwitch.loop();
  wirePresent = limitSwitch.getState() == LOW;
  if (!wirePresent) {
    handleError("Wire lost during operation. Halting.");
    return false;
  }
  return true;
}

// Feed wire by rotating the motor
void feedWire(int length) {
  Serial.print("Feeding wire: ");
  Serial.print(length);
  Serial.println(" cm...");

  rotationCount = 0; // Reset rotation count
  analogWrite(DC_MOTOR_ENA, 200); // Set motor speed
  digitalWrite(DC_MOTOR_IN1, HIGH);
  digitalWrite(DC_MOTOR_IN2, LOW);

  while (rotationCount < length * rotationsPerCm) {
    if (digitalRead(IR_SENSOR_PIN) == HIGH) {
      rotationCount++;
      delay(50); // Debounce delay
    }
  }

  stopDCMotor();
  Serial.println("Wire feeding complete.");
}

// Cut wire using servo
void cutWire() {
  Serial.println("Cutting the wire...");
  servoCutter.write(90); // Move cutter servo to cutting position
  delay(1000);           // Simulate cutting time
  servoCutter.write(0);  // Return servo to initial position
  Serial.println("Wire cutting complete.");
}

// Remove sheath using servo
void removeSheath(int length) {
```

```
  Serial.print("Removing sheath: ");
  Serial.print(length);
  Serial.println(" cm...");
  servoSheath.write(90); // Move servo to sheathing removal position
  delay(length * 500);   // Simulate removal time
  servoSheath.write(0);  // Return to initial position
  Serial.println("Sheath removal complete.");
}

// Strip and tin cores using soldering servo
void stripAndTinCores() {
  Serial.println("Stripping and tinning cores...");
  servoSolder.write(90); // Move soldering servo to position
  delay(2000);           // Simulate tinning process
  servoSolder.write(0);  // Return to initial position
  Serial.println("Stripping and tinning complete.");
}

// Stop the DC motor
void stopDCMotor() {
  digitalWrite(DC_MOTOR_IN1, LOW);
  digitalWrite(DC_MOTOR_IN2, LOW);
  analogWrite(DC_MOTOR_ENA, 0);
}

// Display current status on Serial Monitor
void displayStatus() {
  Serial.println("========================");
  Serial.print("Wire Presence: ");
  Serial.println(wirePresent ? "Detected" : "Not Detected");
  Serial.print("Rotation Count: ");
  Serial.println(rotationCount);
  Serial.print("Error Status: ");
  Serial.println(errorFlag ? "ERROR" : "No Errors");
  Serial.println("========================");
}

// Handle errors and halt operation
void handleError(const char* errorMessage) {
  errorFlag = true;
  digitalWrite(ERROR_LED, HIGH);
  //digitalWrite(ERROR_CONTACT_PIN, HIGH); // Indicate error via dry contact

  stopDCMotor();
  Serial.print("ERROR: ");
```

```
  Serial.println(errorMessage);
  delay(1000); // Wait before retry
}

// Clear error state
void clearError() {
  errorFlag = false;
  digitalWrite(ERROR_LED, LOW);
  //digitalWrite(ERROR_CONTACT_PIN, LOW); // Reset dry contact
}

// // Web server root handler
// void handleRoot() {
//   server.send(200, "text/html", "<h1>Wire Preparation Machine</h1><p>Use
/set?length=VALUE&sheath=VALUE to set parameters.</p>");
// }

// Web server parameter handler
// void handleSetParameters() {
  // if (server.hasArg("length")) {
    // wireLength = server.arg("length").toInt();
  // }
  // if (server.hasArg("sheath")) {
    // sheathLength = server.arg("sheath").toInt();
  // }
//   String message = "<h1>Parameters Updated</h1><p>Wire Length: ";
//   message += wireLength;
//   message += " cm<br>Sheath Length: ";
//   message += sheathLength;
//   message += " cm</p>";
//   server.send(200, "text/html", message);
// }
```

The commented parts will be set up properly in real time so that it work properly as required.

9. Conclusion

The wire-prepping machine design meets all the defined objectives, including wire feeding, cutting, sheathing removal, core stripping, and tinning. The design is automated, and error-handling mechanisms are incorporated for reliable operation. The system will be controlled via a local web portal, making it easy to operate and monitor.

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Simulation link:
https://drive.google.com/file/d/1CkSaYsOIHAxI7CTLz5GeMTcRr7Sm1Ert/view?usp=sharing

Diagram of the design in proteus: