NEW HORIZON
COLLEGE OF ENGINEERING
New Horizon Knowledge Park, Ring Road, Marathalli
Autonomous College Permanently Affiliated to VTU, Approved by AICTE & UGC
Accredited by NAAC with 'A' Grade, Accredited by NBA

Outer Ring Road, Bellandur, Bengaluru – 560103

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

20EEE84A Project - Phase II

Report on

SOLAR POWERED INDUCTION MOTOR SPEED CONTROL USING IOT FOR AGRICULTURE

Submitted in the partial fulfilment of the Final Year Project - Phase I

Submitted by

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2023-24

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CERTIFICATE

Certified that the Project work entitled **"SOLAR POWERED INDUCTION MOTOR SPEED CONTROL USING IOT FOR AGRICULTURE"** carried out by **Kamalesh Badola (1NH20EE048), Kushal Naik K (1NH20EE056), Lava Kumar M N (1NH20EE057), Mohammed Aman (1NH21EE407),** Bonafide Student(s) of New Horizon College of Engineering submitted the report in the partial fulfilment for the award of Bachelor of Engineering in **Department of Electrical and Electronics Engineering, New Horizon College of Engineering** of Visvesvaraya Technological University, Belgaum during the Year 2023-24.

It is certified that all the corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the department library. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for said Degree.

Name & Signature of the Project Guide	**Name & Signature of Head of the Department**
Dr. Vinoth Kumar K	Dr. Sakthivel A

SEMESTER END EXAMINATION

Internal Examiner **External Examiner**

ACKNOWLEDGEMENT

I take this opportunity to convey my gratitude to all those who have been kind enough to offer their advice and provide assistance when needed which has led to the successful completion of the project.

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I would like to thank my parents for supporting and helping in the completion of the project.

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DECLARATION

We, **Kamalesh Badola (1NH20EE048), Kushal Naik K (1NH20EE056), Lava Kumar M N (1NH20EE057), Mohammed Aman (1NH21EE407),** students at New Horizon College of Engineering here by declare that this project work entitled **" SOLAR POWERED INDUCTION MOTOR SPEED CONTROL USING IOT FOR AGRICULTURE "** is an original and bonafide work carried out by me at New Horizon College of Engineering in partial fulfillment of Bachelor of Engineering in Electrical and Electronics Engineering Visvesvaraya Technological University, Belgaum.

We also declare that, to the best of our knowledge and belief, the work reported herein does not form part of any other thesis or dissertation based on which a degree or award was conferred on an earlier occasion by any student.

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CERTIFICATE

Certified that the Mini Project work entitled **"SOLAR POWERED INDUCTION MOTOR SPEED CONTROL USING IOT FOR AGRICULTURE"** carried out by **Kamalesh Badola (1NH20EE048), Kushal Naik K (1NH20EE056), Lava Kumar M N (1NH20EE057), Mohammed Aman (1NH21EE407)** a bonafide student of New Horizon College of Engineering in partial fulfilment for the award of **Bachelor of Engineering** in Electrical and Electronics Engineering of the Visvesvaraya Technological University, Belgaum during the year 2023-2024.It is certified that he/she has completed the project satisfactorily.

Name & Signature of the Project Guide	**Name & Signature of Head of the Department**
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We have verified the contents as summarized above and certified that the statement made above are true to the best of our knowledge and belief.

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Plagiarism - Coordinator

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ABSTRACT

In contemporary agriculture, the use of renewable energy sources, particularly solar power, combined with sophisticated control systems like the Internet of Things (IoT), has become increasingly prominent. This study proposes a novel approach for enhancing agricultural efficiency by employing a solar-powered induction motor with precise speed control. Leveraging IoT technology, real-time monitoring and control of the motor's speed are achieved, optimizing energy consumption and crop irrigation processes. The utilization of frequency control techniques further enhances the motor's operational efficiency, ensuring optimal performance under varying environmental conditions. Through extensive experimentation and analysis, the effectiveness of the proposed system in enhancing agricultural productivity while minimizing resource utilization is demonstrated. The integration of renewable energy, advanced control strategies, and IoT connectivity presents a sustainable solution for modern agriculture, addressing the challenges of energy scarcity and environmental conservation. This research contributes to the advancement of smart agriculture practices, fostering sustainable development in the agricultural sector. The findings underscore the potential of integrating renewable energy sources and IoT-based control systems for optimizing agricultural operations, paving the way for future innovations in precision farming.

Keywords: Induction motor, IoT, Speed Control.

CHAPTER 1
INTRODUCTION

In contemporary times, the induction motor reigns supreme, widely chosen across diverse fields. Its preeminence stems from various indispensable features like straightforward operation, commendable power factor, and minimal maintenance. With high efficiency and reliability, it surpasses alternative motor types in cost-effectiveness. The induction motor's versatility extends to exceptional speed regulation, sustainable overload capacity, and formidable starting torque, making it vital in industrial motors, electric vehicles, and agricultural machinery. However, the rising demand for induction motors across tasks with varying speed requirements necessitates speed control. Thus, the present project aims to regulate motor speed and harness power through solar panels. This innovative approach not only meets the need for precise speed control but also aligns with global sustainability goals. The intersection of speed control and solar power generation embodies efficiency, adaptability, and environmental consciousness. It strikes a balance between controlled motor speed and sustainable energy practices, driving forward-looking initiatives.

Motors are used in most industrial processes due to their reliability, rugged nature, low maintenance and reduced cost. However, induction motors are nonlinear and complex systems owing to their characteristics which require complex control, circuitry and inverter oversizing. Motion is required in any industrial application be it domestic or industrial. Induction motor use is in many industrial applications requiring variable speed due to high costs incurred in methods of speed control and inefficiency of the methods used. An induction motor's speed can be adjusted using a system known as a variable frequency drive, sometimes called a variable speed drive. Electric drives get their name from the fact that a variable frequency uses an electrical motor. This allows electrical motors to quickly and easily alter their speed. It does this by translating the frequency of the power supply to an adjustable value on the machine side. These use a variety of sensors and controls to regulate speed utilizing appropriate speed control meethods and, in this instance, employing a pulse width modulation inverter to change the frequency. We generate our own input power from solar and mains supplies, which we then store in a battery bank. So, our project can run on low voltage as well as high voltage also.

Variable frequency drives are used in many applications ranging from smallest to largest of industrial appliances. These include mining industries, compressors, and ventilation systems for large buildings, fans, pumps, conveyors and machine tools Providing power conversion from a certain frequency to another and enabling control over the output frequency are the two main purposes of the variable frequency.

Applications for variable frequency drives range widely, from small industrial equipment to big ones. These include the mining sector, machine tools, fans, pumps, conveyors, and ventilating systems for huge building

CHAPTER 2

LITERATURE REVIEW

Bhim Singh, Shailendra Kumar et al., in their paper "Solar PV array fed direct torque-controlled induction motor drive for water pumping" presented at the 2015 Annual IEEE India Conference (INDICON), investigate the use of a solar photovoltaic (PV) array to power a direct torque controlled (DTC) induction motor drive tailored for water pumping. The study highlights the efficiency gains and improved performance of integrating solar power with DTC technology, showcasing it as a sustainable and economical solution for agricultural water pumping needs.

Saurabh Shukla and Bhim Singh's paper, "Reduced-Sensor-Based PV Array-Fed Direct Torque Control Induction Motor Drive for Water Pumping," published in IEEE Transactions on Power Electronics in June 2019, introduces an induction motor drive powered by a PV array that uses fewer sensors for direct torque control (DTC). This approach aims to lower costs and increase system reliability while maintaining high efficiency and effective motor performance, making it an attractive option for water pumping applications in agriculture. In "Induction motor drive for PV water pumping with reduced sensors," published in IET Power Electronics in October 2018, Bhim Singh and Saurabh Shukla further explore the concept of a PV-powered induction motor drive with a reduced number of sensors. The paper discusses the cost benefits and enhanced robustness of the system, providing experimental evidence of its efficacy in water pumping tasks, thus promoting it as a viable and efficient solution for agricultural use.

Lastly, S. Parvathy and A. Vivek, in their paper "A photovoltaic water pumping system with high efficiency and high lifetime," presented at the International Conference on Advanced Power and Energy in June 2015, detail a photovoltaic water pumping system designed for high efficiency and long operational life. The study outlines various design and control strategies that improve system performance and durability, highlighting its suitability for prolonged agricultural applications and promoting it as a sustainable and reliable water pumping solution.

CHAPTER 3

SCOPE OF THE PROJECT

In response to the growing demand for sustainable farming practices, this project focuses on integrating renewable energy sources and IoT technology to enhance agricultural operations. By leveraging solar power and IoT, the aim is to design a system capable of controlling the speed of induction motors used in various agricultural processes. This initiative aligns with the global trend towards precision agriculture, where efficient resource utilization and automation play pivotal roles in optimizing yields while minimizing environmental impact.

The primary objective of this project is to develop a solar-powered system that can remotely control the speed of induction motors utilized in agricultural machinery. By incorporating IoT capabilities, farmers will have the flexibility to monitor and adjust motor speeds from anywhere using a smartphone or web interface. This level of control enables them to adapt to changing environmental conditions, optimize energy usage, and enhance overall operational efficiency. Additionally, the system aims to reduce dependency on conventional energy sources, thus lowering operating costs and promoting sustainability. The proposed system comprises three main components: a solar panel array, an IoT-enabled control unit, and induction motors used in agricultural equipment. The solar panels harness sunlight and convert it into electrical energy, which is stored in batteries for continuous power supply. The IoT control unit interfaces with the induction motors, allowing users to remotely adjust motor speeds based on real-time data and predefined parameters. Sensors integrated into the system provide crucial environmental and operational metrics, such as soil moisture levels and motor performance, facilitating informed decision-making.

The project focuses on addressing specific agricultural needs, such as irrigation, crop cultivation, or livestock management, where induction motors are commonly

employed. The system's adaptability to different farming contexts and scalability to varying operational scales (e.g., smallholder farms vs. large agricultural estates) is considered during design and implementation. Feedback from agricultural stakeholders, including farmers and agronomists, informs the customization of the system to suit specific crops, climates, and farming practices. Furthermore, the project explores the potential for integrating additional functionalities, such as data logging, predictive analytics, or automated decision-making algorithms, to further enhance agricultural productivity and sustainability.

Beyond the technical aspects, the project aims to disseminate knowledge and raise awareness about the benefits of solar-powered IoT solutions in agriculture. This involves engaging with local farming communities through workshops, demonstrations, and knowledge-sharing sessions. Educational materials, including manuals, guides, and online resources, are developed to support users in understanding, implementing, and maintaining the system. Collaboration with agricultural extension services, research institutions, and industry partners facilitates broader adoption and integration of similar technologies into agricultural practices regionally and globally. Additionally, documentation of the project's findings, challenges, and best practices contributes to the body of knowledge in the field of sustainable agriculture and renewable energy integration.

CHAPTER 4

METHODOLOGY

The project entails creating a solar-powered induction motor system for agricultural applications, integrating components such as an induction motor, MOSFET for motor control, Arduino Uno for data processing, ESP8266 Wi-Fi module for IoT connectivity, solar panel, battery bank, and Blynk IoT application for remote monitoring and control. The system's architecture is designed to optimize energy efficiency and ensure reliable operation in varying environmental conditions. After defining requirements and selecting appropriate components, the hardware setup involves connecting and configuring the components according to the system design. Arduino programming is then employed to control the induction motor's speed and direction using PWM signals, with logic to adjust operating parameters based on sensor data or user inputs from the Blynk application. Integration with the ESP8266 module enables IoT connectivity, allowing users to remotely monitor and control the system's performance and status via the Blynk platform. The solar panel and battery bank are sized to meet the system's power requirements, ensuring uninterrupted operation even during periods of low sunlight.

4.1 Block Diagram

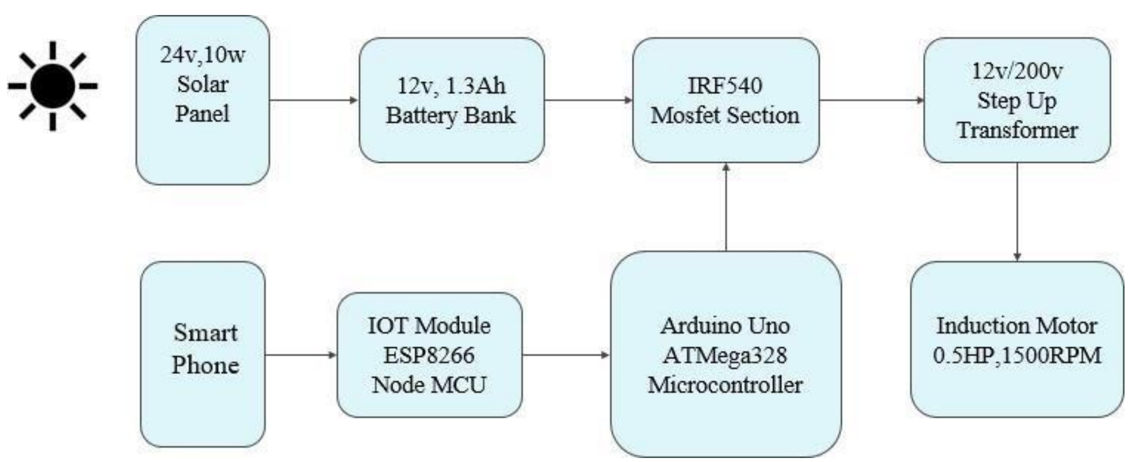


Figure. 1. Block Diagram

The above Figure 1 represents the block diagram in which the proposed system utilizes a 12V solar panel to generate electricity, which is then stored in a 1.3Ah battery bank for later use. The IRF540 MOSFET section serves as a controller, regulating the flow of power to a 12V/200V step-up transformer. This transformer increases the voltage to match the requirements of the induction motor, enabling its operation. Concurrently, a smartphone communicates with an IoT module (ESP8266 NodeMCU) and an Arduino Uno, establishing a network for remote monitoring and control. Acting as the central processor, the Arduino Uno receives commands from the smartphone and orchestrates the functioning of the MOSFET section. This setup empowers users to remotely manage the induction motor's operation, allowing for adjustments to settings and real-time performance monitoring. Ultimately, the system optimally harnesses solar energy to power the induction motor while offering remote control and monitoring capabilities through IoT integration.

4.2 Hardware Details

MOSFET Section

IRF540 is an N-Channel-powered MOSFET used for fast switching operations and amplification processes. It operates in enhancement mode. Its input impedance is quite high as compared to the general transistor so, it’s a lot sensitive in comparison

to them. It has a lot of applications in daily life, for example, switching regulators, relay drivers, switching converters, motor drivers, high speed power switching drivers etc. You should also have a look at other MOSFETs and can compare their values with IRF540.

- IRF 540 has three pins in total named as:

1. Drain
2. Gate
3. Source

- So, when we apply signal at the Gate of IRF540, then its Drain and Source got connected.
- All the IRF540 pins, their names and symbol are given in the table 1.

IRF540 Pinout				
Pin#	Name	Symbol	Type	Function
1	Gate	G	P-Type	Controls the current between Drain & Source
2	Drain	D	N-Type	Electrons Emitter
3	Source	S	N-Type	Electrons Collector

Table 1: IRF540 Pinout

- A properly labeled diagram helps in better standing of the user.
- So, I have provided the completely labeled diagram of IRF540 pins configuration.
- The diagram of this MOSFET is shown in the figure 2.

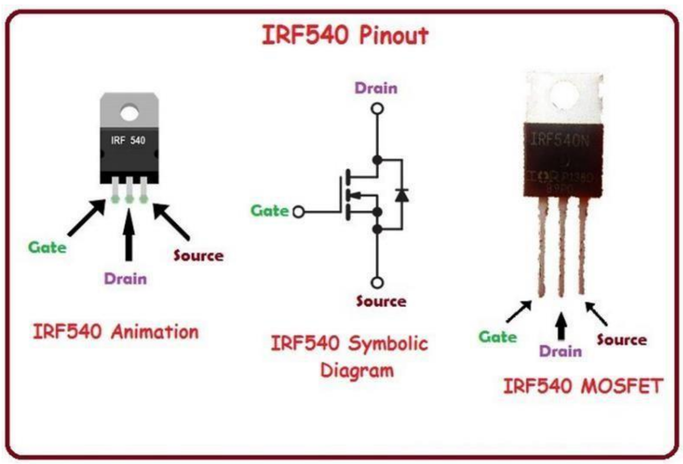


Figure 2: IRF540 MOSFET

The IRF540 module's three dimensions, such as its length, width, and height, are listed in Table 2 along with their corresponding units.

Dimensions of IRF540		
Parameters	**Dimensions**	**Units**
Height	9.01	mm
Length	10.51	mm
Width	4.7	mm
Lead shape	Through hole	--

Table 2: IRF540 MOSFET dimensions

Table 2 will go into further detail on the fundamental idea behind how IRF540 functions. IRF540 operates on a straightforward idea. There are three different types of terminals: drain, gate, and source. The gate and drain of the device shorten when a pulse is applied to the gate terminal, creating a single connection between them. We won't be able to receive the intended effects unless the Gate and the Drain are short; else, we'll get undesirable or unneeded consequences.

Listed below are the applications related to IRF540.

- It has switching converter applications.
- It is applicable as a relay driver.
- It is also applicable as a high-speed driver for switching.
- It may be applied to motor vehicles.

1.2. Arduino UNO

Figure 3: Arduino UNO

Figure 3 illustrates the Arduino Uno SMD microcontroller board, which is built around the ATmega328 microcontroller. This board includes 20 digital input/output pins, a 16 MHz resonator, a USB port, a power connector, an in- circuit system programming (ICSP) header, and a reset button. Out of these pins, 6 can function as PWM outputs and another 6 as analog inputs. It has all the components necessary to support the microcontroller; you simply need to power it with a battery, an AC-to-DC adapter, or connect it to a computer via a USB cable to start using it. Unlike earlier boards, the Uno does not use the FTDI USB-to- serial driver chip but instead utilizes the Atmega8U2 configured as a serial-to- USB converter.

Microcontroller: ATmega328 SMD

- Operating voltage: 5 V
- Voltage required for operation: 5 V;
- Recommended input voltage: 7–12 V;
- Number of digital I/O pins: 20 (of which 6 offer PWM output)
- Analog input pins: 6*
- DC current for each 3.3V pin: 50 mA;
- DC current per I/O pin: 40 mA
- SRAM: 2 KB (ATmega328);
- EEPROM: 1 KB (ATmega328); • Flash memory: 32 KB (ATmega328), of which
  0.5 KB is used by the bootloader.
- The Arduino Uno provides a total of 20 I/O lines, all of which can function as digital I/O lines, with six of them also usable as analog inputs. The Uno operates at a clock speed of 16 MHz.

Choosing the Right Controller

The table on the right contrasts the Arduino Uno with Orangutan robot controllers. Both are based on the AVR architecture, but the Orangutan controllers include integrated motor drivers and extra hardware tailored for robotics applications. We also offer the Basic Stamp, which offers a lot of support and educational materials for beginners, and the much higher performance embedded development board, which is based on a 96 MHz 32-bit ARM Cortex M3. See their product pages for further more information.

Schematic & Reference Design

- EAGLE files: Arduino Uno reference design (207k zip)
- Schematic: Arduino Uno schematic

Power

The Arduino Uno can be powered through a USB connection or an external power source. External (non-USB) power can come from an AC-to-DC adapter (wall wart) or a battery. The adapter connects by plugging a 2.1mm (approximately 0.08 inches) center-positive plug into the board's power jack. Battery leads can be inserted into the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply ranging from 6 to 20 volts. However, if the supply is less than 7 volts, the 5V pin may provide less than five volts, causing instability. If the supply exceeds 12 volts, the voltage regulator could overheat and damage the board. The recommended voltage range is 7 to 12 volts.

- VIN - When the Arduino board is powered by an external source instead of the 5 volts from the USB connection or another regulated power supply, you can supply voltage through this pin. Alternatively, if you're providing voltage via the power jack, you can access it through this pin.
- 5V The5V: This regulated power supply is utilized to power the microcontroller and other components present on the board. It can be sourced from VIN through an on-board regulator or from USB or another regulated 5V supply.
- 3V3: This is a 3.3-volt supply generated by the on-board regulator. The maximum current draw is 50 mA.
- GND: Ground pins.

Memory

Additionally, it includes 1 KB of EEPROM and 2 KB of SRAM, which can both be read from and written to using the EEPROM library.

Input and Output

Using the pinMode(), digitalWrite(), and digitalRead() methods, each of the twenty digital pins on the Arduino Uno can be configured as either an input or an output. These pins operate at five volts. Each pin has an internal pull-up resistor ranging from 20 to 50 kΩ, which is not connected by default. They can source or sink a maximum of 40 mA of current. Additionally, some pins have specific functions assigned to them.

- Serial communication is facilitated through RX (receive) and TX (transmit) pins labeled as 0 and 1. These pins are used for TTL serial data transmission (TX) and reception (RX) and are connected to corresponding pins on the ATmega8U2 USB-to-TTL Serial chip.

- Pins 2 and 3 on the Arduino Uno can be configured as external interrupts. These pins can be set up to trigger an interrupt on a low value, rising edge, falling edge, or state change. For more details, refer to the attachInterrupt() method.

- PWM: 11, 10, 11, 5, 6, 9, and 10. With the help of the analogWrite() method, provide 8-bit PWM output.
- SPI: SS (10), MOSI (11), MISO (12), and SCK (13). With the help of the SPI library, these pins enable SPI communication.

- LED: 13. Digital pin 13 is linked to an integrated LED. The LED is on when the pin has a HIGH value and off when it has a LOW valueThe six analog inputs on the Uno are designated A0 through A5, and each one offers 10 bits of resolution, or 1024 distinct values.

- They measure from ground to five volts by default, but the AREF pin and the analog Reference() function allow you to adjust the upper end of their range. Furthermore, several pins have specific functions:

- I2C: 4 (SDA) and 5 (SCL). Support I2C (TWI) communication using the Wire library.
  There are a couple of other pins on the board:

- ARF.The voltage reference for the analog inputs.when used with analogReference().

Restart. To reset the microcontroller, pull this wire down to zero. usually used to add a button for reset to shields that prevent the board's reset button from working.

Communication

The Arduino Uno can communicate with other microcontrollers, computers, or other Arduinos. Digital pins 0 (RX) and 1 (TX) on the ATmega328 facilitate UART TTL (5V) serial connection. The board's ATmega8U2 converts this serial connection to USB, presenting itself to PC applications as a virtual serial port. The ATmega8U2 firmware uses standard USB COM drivers; no additional driver is needed, except for a .inf file on Windows. The Arduino software includes a serial monitor for transferring simple textual data to and from the Arduino board. When data is sent to the computer via the USB-to-serial chip and USB connection, the board's RX and TX LEDs will light up (but not for serial communications on pins 0 and 1).

Any digital pin on the Arduino Uno can be utilized for serial communication using the Software Serial library. Moreover, the ATmega328 supports SPI and I2C (TWI) connections. The Arduino software includes a Wire library to simplify using the I2C bus. For more details, refer to the documentation. To enable SPI communication, utilize the SPI library.

Programming

The Arduino software is used to program the Arduino Uno. Select "Arduino Uno" from the Tools > Board menu based on your board's microcontroller. Refer to tutorials and the reference for more details. The ATmega328 microcontroller on the Arduino Uno comes with a pre-installed bootloader that allows you to upload new code without needing an additional hardware programmer. It communicates using the original STK500 protocol.

For more information, follow these instructions. Alternatively, you can program the microcontroller using the ICSP (In-Circuit Serial Programming) header and bypass the bootloader.

The source code for the ATmega8U2 firmware is available. The ATmega8U2 is equipped with a DFU bootloader pre-installed, which can be activated by resetting the 8U2 and bridging the solder jumper located next to the map of Italy on the board's rear. Afterward, you can load new firmware using the DFU programmer (Mac OS X and Linux) or Atmel's FLIP software (Windows). Alternatively, you can use an external programmer to overwrite the DFU bootloader via the ISP header.

Automatic (Software) Reset

The Arduino Uno is designed so that software running on a connected computer can reset it, eliminating the need to manually press the reset button before uploading code. A 100 nanofarad capacitor connects the DTR (hardware flow control) line of the ATmega8U2 to the reset line of the ATmega328. When the

DTR line is asserted low, the reset line briefly drops, resetting the chip. This feature allows users to upload code by simply clicking the upload button in the Arduino environment. Consequently, the bootloader can have a shorter timeout, ensuring that uploads begin promptly when the DTR signal drops.

This setup has other implications: the Uno resets itself whenever a software connection is established via USB, particularly on Mac OS X or Linux computers. During this time, the bootloader runs for about thirty seconds. The Uno is designed to reject incorrect data, so it will ignore anything other than fresh code being uploaded, although it will capture the initial bytes of data sent during connection establishment. It's important that any software communicating with a sketch running on the board waits for a second after establishing the connection before sending any one-time configuration or other data to the sketch at startup.

To disable the auto-reset feature, you can cut the trace labeled "RESET-EN" on the Uno. To re-enable it, you can solder the pads on either side of the trace back together. Alternatively, connecting a 110Ω resistor from 5V to the reset line can also disable the auto-reset.

USB Overcurrent Protection

The Arduino Uno includes a resettable polyfuse to protect the USB ports on your computer from short circuits and overcurrent. This fuse provides an extra layer of safety, although most computers already have built-in protection. If more than 500mA is drawn from the USB port, the fuse will trip and immediately disconnect the connection until the short circuit or overload is resolved.

IOT Module NODEMCU

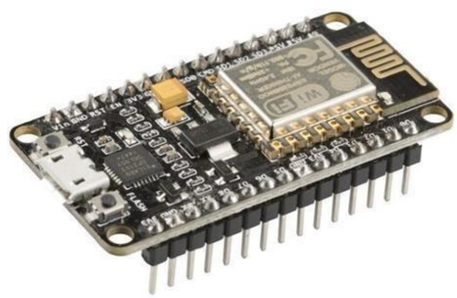


Figure 4: IOT ESP8266 NODEMCU

Figure.4 shows the Node MCU is excellent hardware, which provides enough versatility for us to do most of our developments. It is Arduino compatible, has Wi- Fi on board and has enough kick to power our IOT devices. Whether connecting to gateway or connecting to our cloud solutions. **Node MCU** is an open source IOT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Express if Systems, and hardware which is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language.

Pin Layout

Please find below an overview of the pin layout for this board.

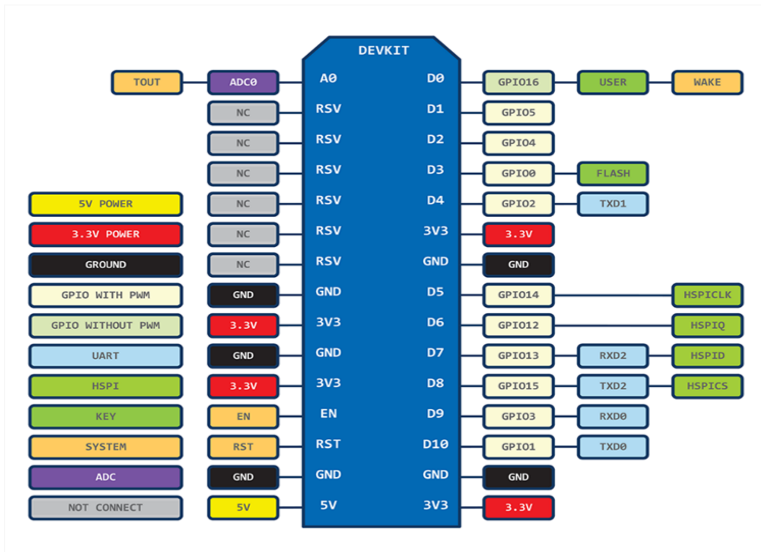


Figure 5: Pin Layout of NODEMCU

Please note that this causes quite some confusion. The numbers on the pins DO NOT map to the numbers of pins of the ESP8266. For example - pin D1 of the board does not map to GPIO1 as you would expect, but to GPIO5 instead! The above layout indicates how to interpret the mapping. For clarity, you can also see the mapping list between Node MCU pins and GPIO below:

- D0 = GPIO16
- D1 = GPIO5
- D2 = GPIO4
- D3 = GPIO0
- D4 = GPIO2
- D5 = GPIO14

- D6 = GPIO12
- D7 = GPIO13
- D8 = GPIO15
- D9 = GPIO3
- D10 = GPIO1

LED_BUILTIN = GPIO16 (auxiliary constant for the board LED, not a board pin)

Also note that many libraries include the mapping already, so you don't have to worry about the translation. If you write to D1 for instance, you will get this interpreted correctly as GPIO5 (PIN5). Check the docs.

Setting up in Arduino IDE

Here is a simple walk-through for setting up the device in your Arduino IDE. Basically, you need to add the board to the list of available boards and choose it (together with the appropriate port and speed setup) for Node MCU development. Using this approach, it is important to note the Lua firmware is overwritten. You can get it back if needed, so no issues.

We assume you have the Arduino IDE installed. If not, head to Arduino Home,

navigate to the 'Software' section, download and install the latest version. You can also install the portable version and can use the setup in another IDE of choice (such Visual Studio Code), but we will not focus on this here

Open 'Arduino IDE' and click **File – Preferences**

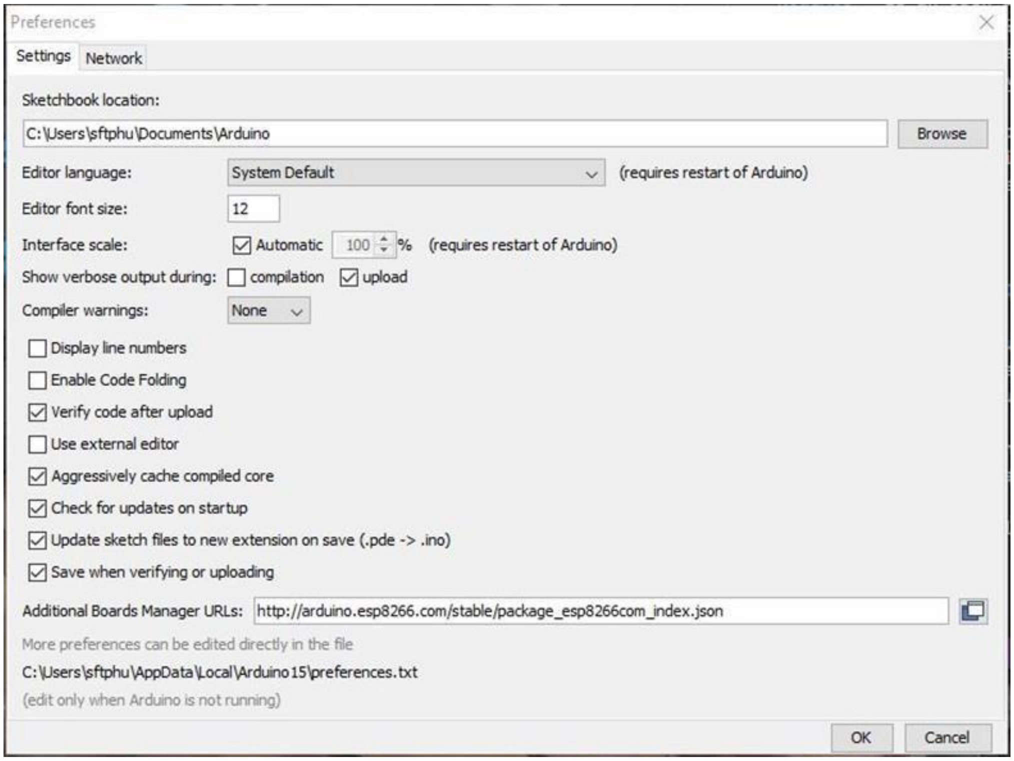


Figure 6: IOT Board Manager

Copy the URL below into the section **Additional boards Manager** and click OK to close the Preferences tab

http://arduino.esp8266.com/stable/package_esp8266com_index.json

Go to **Tools - Board ... - Board Manager**

Locate the **esp8266-by-esp8266 community** entry and install the software for Arduino (notice the Node MCU entry in this board list)

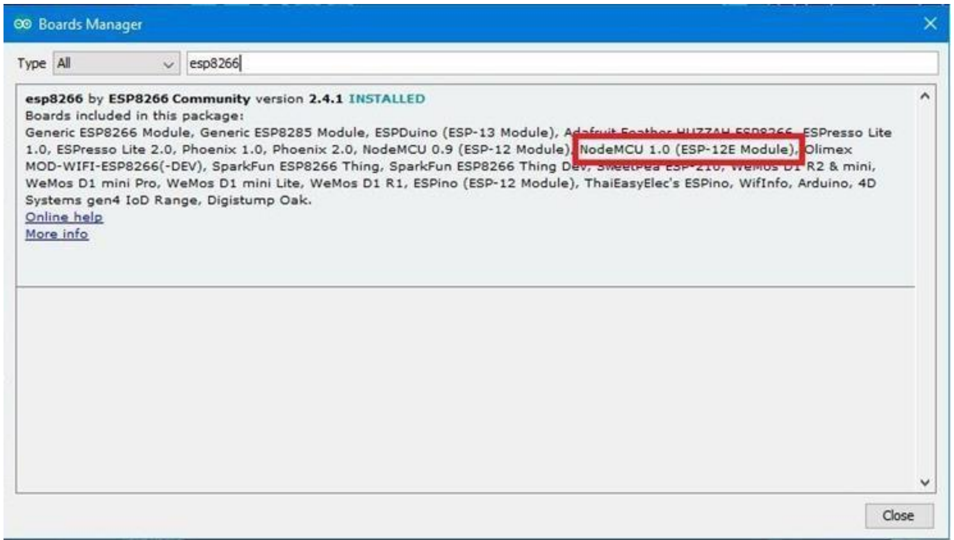


Figure 7: Install NODEMCU Manager

You can now select the Node MCU in the Boards menu.

Different kind of ESP8266 can be found on the market so your ESP8266 board may differ slightly from the one shown below:

Figure 8: NODEMCU

On the picture above, the ESP8266-12 block is where the processor, memory and WIFI unit are located. The rest ensures communication with external sensors, USB port, voltage regulator, etc. For those interested in computer architecture, have a look at the functional diagram of an ESP8266-12:

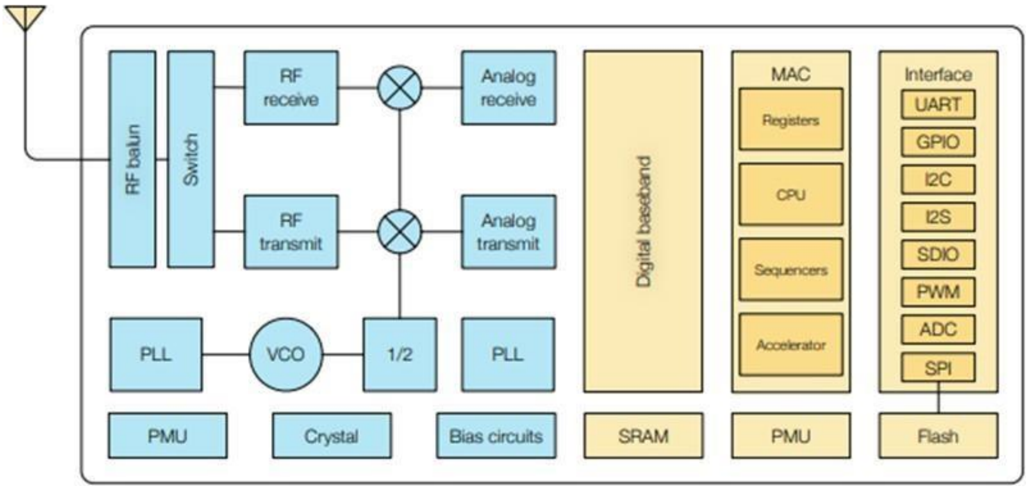


Figure 9: NODEMCU Architecture

Become familiar with the ESP8266-12 architecture On the picture above, can you identify:

- the CPU (Central Processing Unit)
- the memory SRAM (Static Random Access Memory)

The ESP8266 uses a 32-bit processor with 16-bit instructions. Harvard architecture mostly means instruction memory and data memory are separate.

The ESP8266 has one die program Read-Only Memory (ROM) which includes some library code and a first stage boot loader. The remaining code must be kept on external Serial flash memory, which only offers serial access to the data and lets users read or write big, consecutive groups of bytes in the address space rather than addressing individual bytes. The quantity of flash memory that is accessible will vary depending on your ESP8266. Like any other microcontroller, ESP8266 has a set of GPIO pins (General Purpose Input (Output pins) that we can use to “control” external sensors.

Our ESP8266 has 17 GPIO pins but only 11 can be used (among 17 pins, 6 are used for communication with the on-board flash memory chip). It also has an analog input (to convert a voltage level into a digital value that can be stored and processed in the ESP8266).

It also has a WIFI communication to connect your ESP8266 to your WIFI network, connect to the internet, host a web server, let your smartphone connect to it, etc. Another advantage of an ESP8266 is that it can be programmed like any other microcontroller and especially any Arduino.

Battery Bank

Figure 10: Battery Bank

Specification:

Manufacturer	Amptex
Voltage	12V
Battery capacity	1.3 Ah

A rechargeable battery with a 12V nominal voltage is a flexible power solution extensively employed in various applications, including automotive vehicles, marine devices, solar energy systems, and unattemptable power supplies. Lead-acid batteries, encompassing types like flooded, gel, and AGM, are commonly found in automotive applications, whereas lithium-ion batteries are gaining popularity due to their heightened energy density. These batteries differ in terms of capacity, maintenance requirements, and discharge rates. It is crucial to meticulously follow charging protocols to ensure optimal performance and prolonged lifespan. Users are advised to adhere to the manufacturer's guidelines and specifications for safe and effective utilization, recognizing distinctions between lead-acid and lithium-ion technologies.

Solar Panel

Figure 11: Solar Panel

Descriptions

Output Power	10 Watts
Operating Voltage	12 Volt
Panel Technology	Poly Crystalline
Manufacturer warranty	5 years on Manufacturing defects
Performance Warranty	25 Years
Wattage (Wp)	10
output Voltage rating	12

Current at Max Power, Imp (A)	0.59
Open Circuit Voltage, Voc (V)	20.9
number of cells	36

Solar panels, also referred to as photovoltaic (PV) panels, are devices crafted to transform sunlight into electrical energy. Constructed with interconnected solar

cells typically composed of silicon, these panels produce direct current (DC) electricity upon exposure to sunlight. The semiconductor properties of the materials within the cells enable the absorption of photons from sunlight, releasing electrons and generating an electric current. Solar panels hold a crucial role in renewable energy systems, providing a sustainable and ecologically sound means of power generation. They find widespread applications in residential, commercial, and industrial settings, capturing solar energy to produce electricity and contributing significantly to reducing reliance on non-renewable fossil fuels, thereby mitigating greenhouse gas emissions. Continuous technological advancements, including innovations such as thin-film solar panels and enhanced efficiency, continually enhance the effectiveness and affordability of solar energy systems, playing a vital role in the global shift toward cleaner and more sustainable energy sources.

Jumper Wires

Figure 12: Jumper Wires

Jumper wires are flexible and insulated wires with connectors at each end, used for making temporary connections within electronic circuits. They are essential for linking components on a breadboard, Arduino board, or other prototyping platforms. With their versatility and ease of use, jumper wires facilitate quick adjustments, prototyping, and experimentation in circuit design.

Induction Motor

Figure 13: Induction Motor

Figure.13 shows the single-phase induction motor is an electric motor specifically designed to function on a single-phase alternating current (AC) power supply. Its use is prevalent in residential and small commercial contexts owing to the widespread availability of single-phase power in household settings. These motors operate based on the principle of electromagnetic induction, featuring a stator equipped with a single-phase winding
rotor, which can be of the squirrel-cage or wound variety. Given the absence of a rotating magnetic field during startup, these motors often require additional starting mechanisms, such as capacitor-start, capacitor-run, split-phase, or shaded-pole designs. Commonly found in household appliances like fans, air conditioners, refrigerators, and small tools, these motors are chosen for their suitability in applications with lower power demands and simpler operational requirements.

Step Up Transformer

Figure 14: Step up Transformer

A step-up transformer plays a vital role in electrical systems by elevating the voltage of an alternating current (AC) power supply. This transformer variant comprises primary and secondary coils, with the primary coil having fewer windings compared to the secondary coil. The core, typically constructed from laminated iron or other magnetic materials, facilitates the transfer of energy between these coils. In operation, the application of AC voltage to the primary coil induces a magnetic field in the core, resulting in the generation of a higher voltage in the secondary coil. Widely employed in power transmission and distribution, step-up transformers are instrumental in increasing voltage levels for efficient long-distance energy transport, thereby minimizing energy losses associated with high current flows.

CHAPTER 5

HARDWARE IMPLEMENTATION

5.1 Introduction

Figure 15: MATLAB SIMULINK

MATLAB and Simulink work together seamlessly to provide a model-based design and simulation platform for dynamic and embedded systems. Created by MathWorks, this tool functions as a graphical programming language for the study, simulation, and modeling of dynamic systems in a variety of fields. In essence, Simulink is a graphical block diagramming tool that can be customized and comes with a variety of block libraries. This makes it easier for users to create and analyze complex models.

5.2 ARDUINO IDE

- The Arduino IDE is an official Arduino software that is primarily used for creating and compiling code into Arduino modules.
- It is open-source and makes code compilation so simple that even a layperson with no prior technical experience may begin learning the basics of programming.
- It runs on the Java Platform and includes built-in functions and commands crucial for debugging, editing, and compiling code within the environment. It is compatible with operating systems such as macOS, Windows, and Linux.
- The Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro, and many more are among the Arduino modules that are available.

- On the board of each of them is a microcontroller that has been designed to take data in the form of code.
- The core code, also referred to as a sketch, written on the IDE platform will eventually produce a Hex File, which is uploaded and sent to the board's controller.
- The two primary components of the IDE environment are the Editor and the Compiler, the former of which is used to write the necessary code and the latter of which is used to compile and upload the code into the designated Arduino Module.
- The C and C++ languages are supported in this environment.
- The IDE environment is mainly distributed into three sections

1. **Menu Bar**
2. **Text Editor**
3. **Output Pane**

When the IDE program downloads and launches, it will look like the picture below.

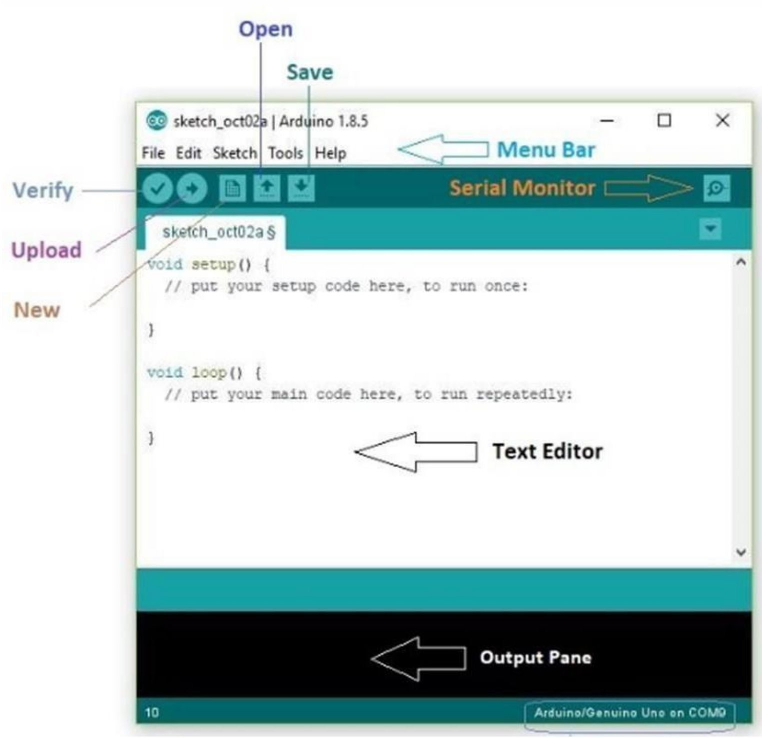


Figure 16: Arduino IDE menu

The Menu Bar is the bar that appears at the top and has the following five selections.

• File: You can open an existing window or create a new one to write the code in. The number of additional subdivisions into which the file choice is divided is displayed in the following table.

.

File	
New	This is used to open new text editor window to write your code
Open	Used for opening the existing written code
Open Recent	The option reserved for opening recently closed program
Sketchbook	It stores the list of codes you have written for your project
Examples	Default examples already stored in the IDE software
Close	Used for closing the main screen window of recent tab. If two tabs are open, it will ask you again as you aim to close the second tab
Save	It is used for saving the recent program
Save as	It will allow you to save the recent program in your desired folder
Page setup	Page setup is used for modifying the page with portrait and landscape options. Some default page options are already given from which you can select the page you intend to work on
Print	It is used for printing purpose and will send the command to the printer
Preferences	It is page with number of preferences you aim to setup for your text editor page
Quit	It will quit the whole software all at once

Figure 17: Opening a file

The code compilation will be displayed in the Output Pane when you click the upload button after going to the preferences section and checking the compilation section.

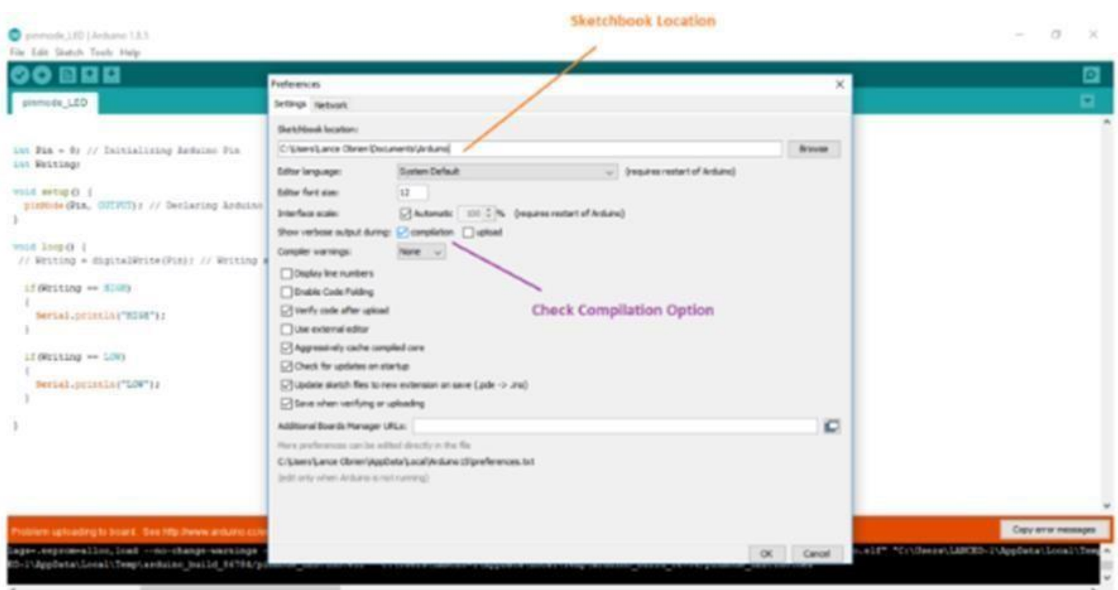


Figure 18: Sketch Location

When the compilation is complete, it will display the hex file it created for the most current sketch that will be transmitted to the Arduino Board in order to do the particular job you are trying to complete.

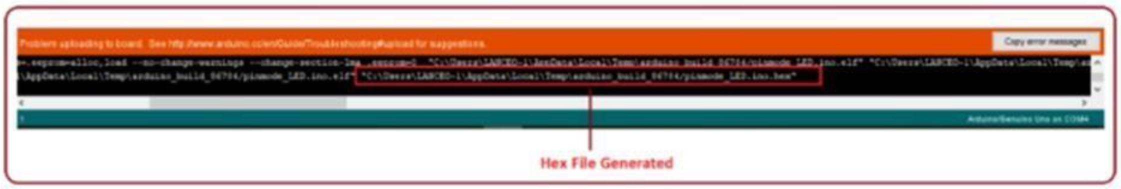


Figure 19: Error Tab

- Edit: This tool is used to copy and paste code while making additional font modifications.
- Sketch: Used for programming and compilation
- Tools: Mostly utilized in testing initiatives. This panel's Programmer area is where a bootloader is burned onto the new microcontroller.
- Assistance - Should you be feeling uneasy regarding software, comprehensive assistance is offered, ranging from first setup to troubleshooting.

The six buttons that show up under the Menu tab have the following relationships with the active program.

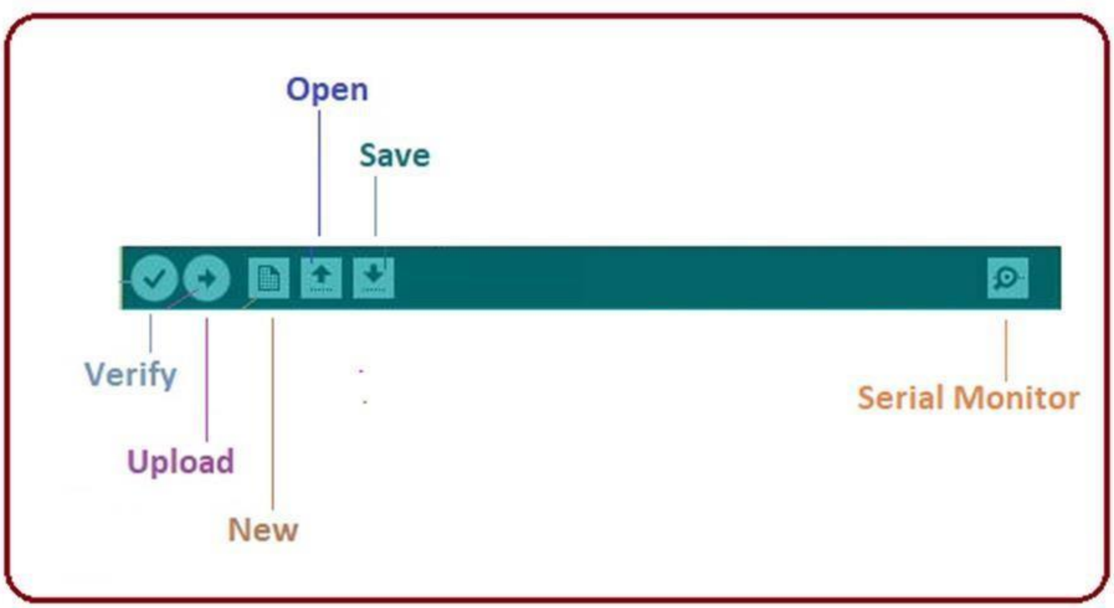


Figure 20: Menu Tab

Click this once you have written your code.

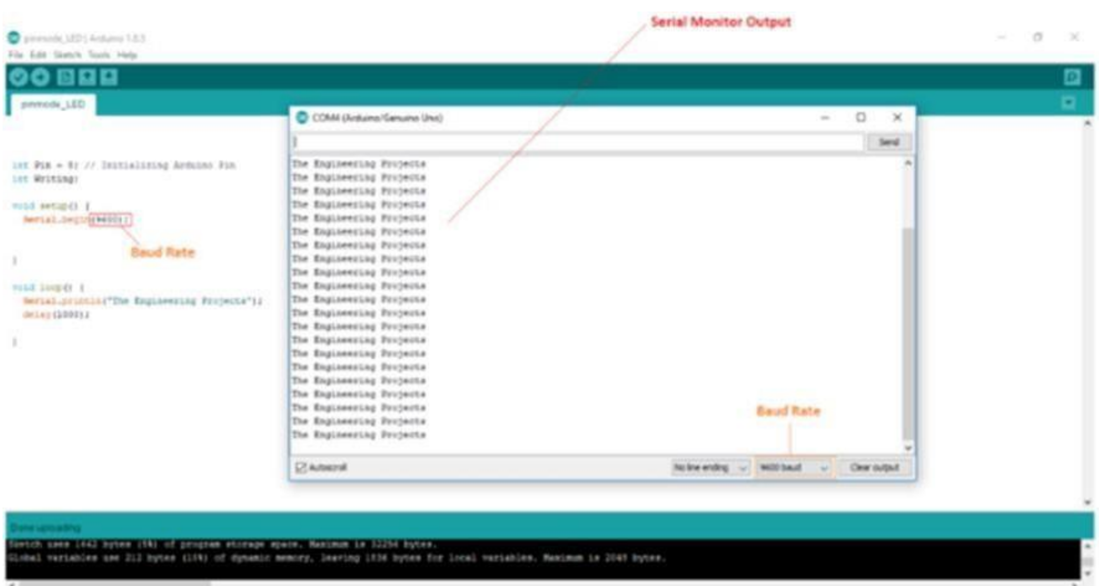
- The necessary code will be uploaded and sent to the Arduino board using the arrow key.
- To create a new file, use the dotted paper.
- To open an existing Arduino project, use the upward arrow.
- To save the running code, use the downward arrow.
- The icon located in the top right corner is for the Serial Monitor. This popup window acts as an independent terminal and is essential for sending and receiving serial data. Alternatively, you can launch the Serial Monitor by pressing Ctrl+Shift+M simultaneously, or you can access it from the Tools menu. The Serial Monitor is used for debugging sketches and monitoring program execution. To use the Serial Monitor, connect your Arduino module to your computer via a USB connection.
- You need to select the baud rate of the Arduino board you are currently using. When you add the following code and open the Serial Monitor, the output will appear similar to the image below. The baud rate for my Arduino Uno is set to 9600.
- 

Figure 21: Serial Monitoring

The main screen below the Menu bard is known as a simple text editor used for writing the required code.

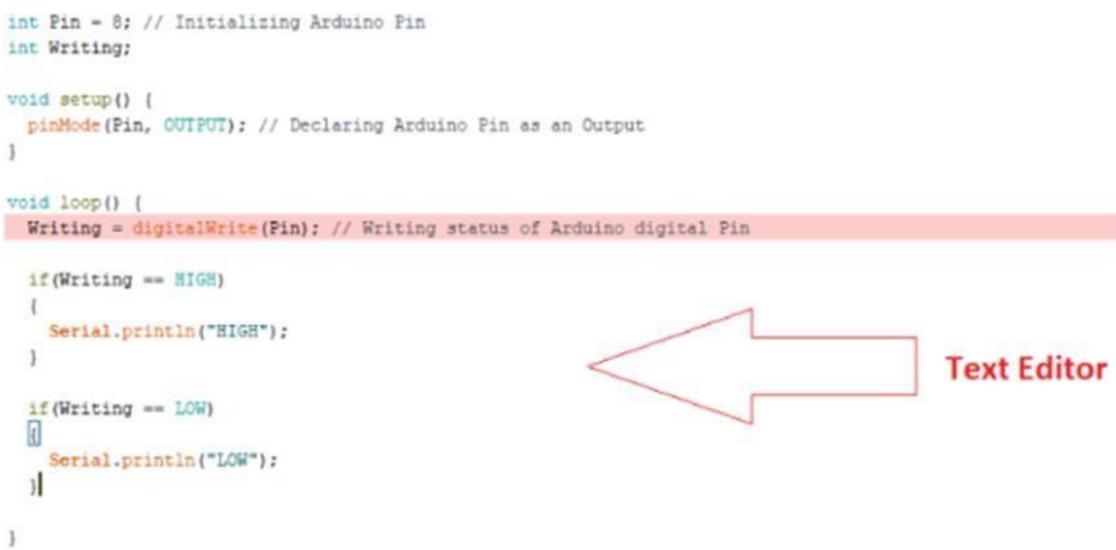


Figure 22: Error detection

The main screen's bottom is referred to as the "Output Pane," and it mostly shows the compilation status of the code that is now running, as well as the memory that the code is using and any program problems. Before uploading the hex file to your Arduino module, you must correct those problems.

Figure 23: Output Window

The Arduino C programming language acts similarly to standard C programming for any embedded system microcontroller; however, certain unique functions on the board may only be called and executed using specific libraries.

5.3 Arduino code

```
#define BLYNK_PRINT Serial #include <ESP8266WiFi.h> #include
<BlynkSimpleEsp8266.h>
#define BLYNK_TEMPLATE_ID "TMPL3kMKTbj4d" #define
BLYNK_TEMPLATE_NAME "IOT"
#define BLYNK_AUTH_TOKEN "QXg9MForjqbhSpuxhdF9UhZ5wpOn3WvP"
char auth[] = BLYNK_AUTH_TOKEN; char ssid[] = "IOTproject";
char pass[] = "87654321";

int state = HIGH;     // the current state of the output pin int per = 100;
float Freq = 50; int b1 = 0;
int b2 = 0; int b3 = 0; void setup()
{
pinMode(D0,OUTPUT); pinMode(D1,OUTPUT); pinMode(D2,OUTPUT);

pinMode(D5,INPUT); pinMode(D6,INPUT);
Blynk.begin(auth, ssid, pass, "blynk.cloud", 80); Serial.begin(115200);
Serial.println("Hello");

Serial.println("H");

}
BLYNK_WRITE(V0)

{

if (param.asInt())

{

b1 = 1;

}
```

```
else
{
b1 = 1;
}
}
BLYNK_WRITE(V1)
{
if (param.asInt())
{
b2 = 1;
}
else
{
b2 = 0;
}
}
BLYNK_WRITE(V2)
{
if (param.asInt())
{
b3 = 1;
}
else
{
```

```
b3 = 0;

}

}

void loop()

{

Blynk.run();
if ( (b1 == HIGH) )

{

b1 = 0;

if (state == HIGH){ state = LOW;
digitalWrite(D2, LOW);
}

else{

state = HIGH; digitalWrite(D2, HIGH)
delay(1000);

}
}
Blynk.virtualWrite(V6, per);
if ((b2 == HIGH) || (digitalRead(D5) == HIGH) ){

if(per > 10) per = per - 10;
if(Freq > 25) Freq = Freq - 2.5;
delay(1000); digitalWrite(D0,HIGH); delay(100); digitalWrite(D0,LOW);
}


if ( (b3 == HIGH) || (digitalRead(D6) == HIGH) ){ if(per < 100)
per = per + 10;
if(Freq < 50)
```

```
Freq = Freq + 2.5;
delay(1000); digitalWrite(D1,HIGH); delay(100); digitalWrite(D1,LOW);
}
delay(200);
}
```

5.5 Simulation

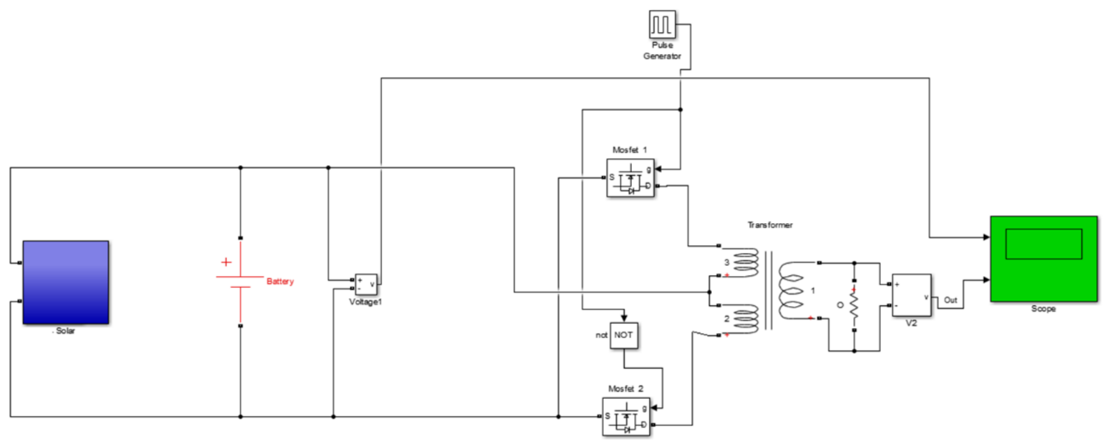


Figure 24: Simulation Circuit

Calculations

Frequency: 50Hz

Time taken for one cycle:

t=1/25

t=0.04s

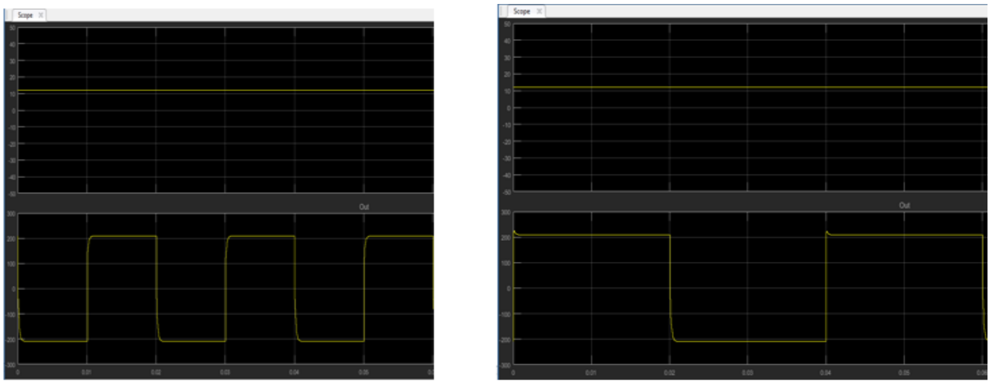
t=0.02s

Frequency: 25Hz

Time taken for one cycle:

t=1/f

t=1/50



50 Hz 25 Hz

Figure 25: Observed output

5.6 Hardware setup

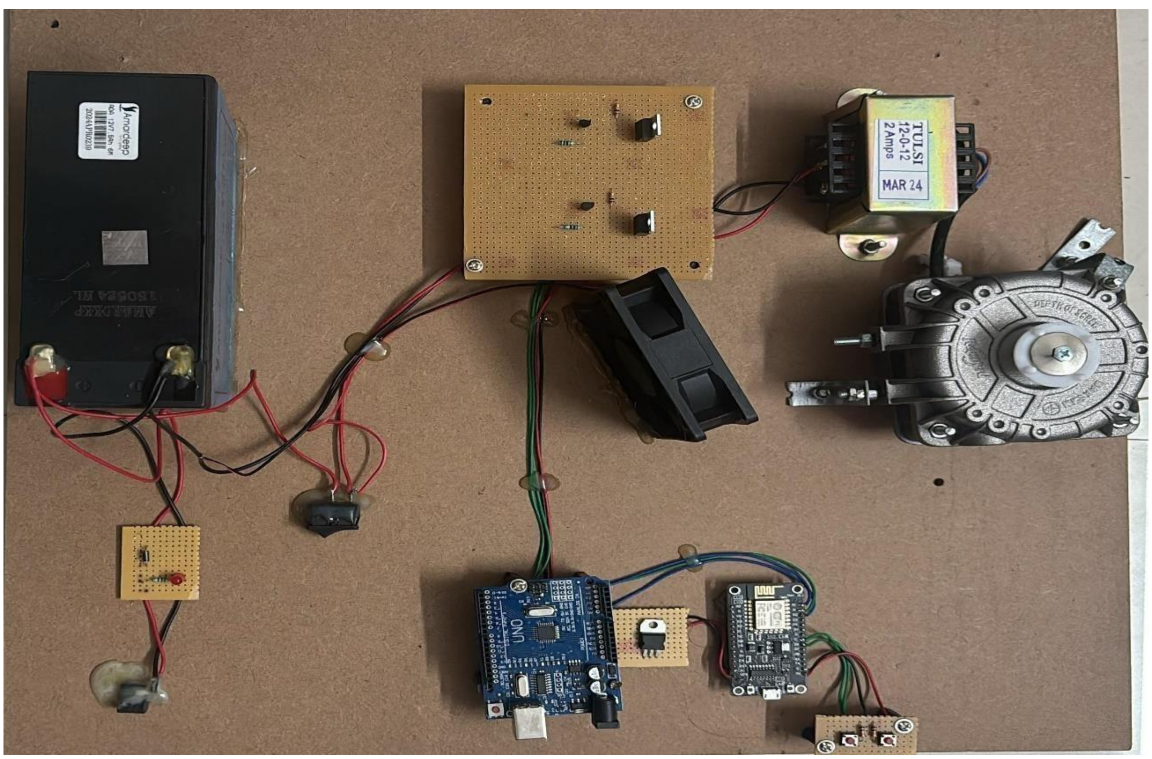


Figure 26: Hardware setup

5.7 Working

The system designed for agricultural purposes, which involves solar-powered control of induction motor speed, incorporates a diverse array of components including solar panels, a battery, IoT module NODEMCU, Arduino Uno (ATmega328), MOSFET, jumper wires, an induction motor, and a step-up transformer is shown in figure. 26. Solar panels convert sunlight into electricity, with surplus power stored in a battery for continuous energy supply during periods of limited sunlight. The NODEMCU facilitates internet connectivity for remote monitoring and control, while the Arduino Uno manages the induction motor's operation and speed through a MOSFET switch. This dynamic control mechanism allows for personalized adjustments in motor speed to meet specific agricultural needs. Optional sensor integration for data collection and the potential use of a step-up transformer for voltage regulation enhance the system's versatility.

Implementing solar-powered induction motor speed control using IoT for agriculture offers numerous advantages. Primarily, it enhances energy efficiency and sustainability by utilizing renewable solar power, significantly reducing reliance on fossil fuels and lowering greenhouse gas emissions. This not only contributes to environmental conservation but also results in substantial cost savings over time, as solar energy is a free resource once the initial setup costs are covered. Operational efficiency is markedly improved through precise control capabilities provided by IoT, allowing for real-time adjustments to motor speed, optimizing performance in critical agricultural processes like irrigation and climate control within greenhouses. This precision reduces wear and tear on machinery, thereby extending its lifespan and lowering maintenance expenses. Additionally, IoT integration enables remote monitoring and control, providing farmers with the convenience of managing their equipment from anywhere using smartphones or computers. This remote access facilitates timely interventions and adjustments, enhancing overall farm management and productivity. The continuous data collection from IoT sensors offers valuable insights into equipment performance and environmental conditions, supporting data-driven decision-making and

further optimizing operations to increase yields. Automation of various tasks such as irrigation and feeding through IoT reduces the need for manual labor, making farming operations more efficient and scalable without significant additional resource investments. Furthermore, solar-powered systems enhance reliability and resilience in agricultural operations. They provide energy independence, mitigating the impact of power outages and ensuring uninterrupted operation of essential processes. IoT systems can adapt motor operations based on real-time weather data, helping to manage environmental risks effectively. This adaptability ensures that agricultural practices can be adjusted to changing weather conditions, promoting consistent productivity. The integration of precision irrigation systems via IoT also conserves water by delivering precise amounts necessary for crops, thus promoting sustainable water management practices. Overall, the adoption of these technologies not only drives economic growth by improving efficiency and profitability for farmers but also fosters a more sustainable and resilient agricultural sector.

CHAPTER 6
APPLICATIONS

Irrigation Systems:

- **Precision Irrigation**: By integrating solar-powered induction motors with IoT, farmers can manage irrigation systems more efficiently. Real- time data from soil moisture sensors and weather forecasts can be used to adjust water delivery precisely, ensuring crops receive optimal hydration and reducing water waste.
- **Remote Monitoring and Control**: Farmers can use IoT applications to monitor and control irrigation pumps remotely. This capability allows for timely responses to changing conditions, reducing the need for physical presence in the fields and improving water use efficiency.

Grain Drying and Storage:

- **Environmental Control**: Solar-powered induction motors can be employed in grain drying and storage facilities to control airflow and temperature. IoT sensors can continuously monitor conditions and adjust motor speeds to maintain optimal drying rates and prevent spoilage.
- **Energy Efficiency**: Utilizing solar power for these operations reduces reliance on traditional energy sources, lowering operational costs and enhancing sustainability.

Greenhouse Climate Management:

- **Ventilation Systems**: Induction motors driven by solar power can control ventilation systems within greenhouses. IoT technology can monitor internal climate conditions such as temperature, humidity, and CO_2 levels, adjusting motor speeds to maintain ideal growing environments.

- **Automated Climate Control**: The integration of IoT allows for the automation of climate control systems, ensuring consistent and optimal conditions for plant growth while minimizing energy consumption.

Livestock Management:

- **Feeding and Milking Systems**: Solar-powered induction motors can automate feeding and milking processes. IoT integration enables precise control over these systems, ensuring animals are fed and milked at optimal times, improving productivity and animal welfare.
- **Environmental Monitoring**: In livestock barns, IoT sensors can monitor temperature, humidity, and air quality, adjusting ventilation systems powered by induction motors to maintain healthy conditions for animals.

Agricultural Machinery:

- **Variable Speed Drives**: Agricultural machinery such as conveyors, threshers, and harvesters can benefit from solar-powered induction motors with variable speed control. IoT technology allows for real-time adjustments based on operational needs, enhancing efficiency and reducing wear and tear.
- **Predictive Maintenance**: IoT sensors can monitor the condition of induction motors and predict maintenance needs before breakdowns occur. This proactive approach minimizes downtime and extends the life of machinery.

CHAPTER 7

FUTURE SCOPE AND TRENDS

Artificial intelligence (AI) and advanced data analytics combined can greatly improve the performance of Internet of Things (IoT)-enabled solar-powered induction motor systems. Based on past data and current inputs, predictive analytics may estimate equipment maintenance requirements, improve irrigation schedules, and anticipate crop yields.

Motor control systems may be made to operate more effectively and efficiently over time by utilizing machine learning techniques. These algorithms are able to improve motor speed settings, energy consumption, and operating efficiency by learning from the massive volumes of data supplied by IoT sensors.

The responsiveness and dependability of IoT systems in agriculture may be significantly increased by implementing edge computing and 5G technologies. Precision farming techniques will be improved by real-time control and automation of agricultural equipment made possible by faster data transmission speeds and localized data processing.

Future developments could see the integration of autonomous tractors, harvesters, and other machinery with solar-powered induction motors and IoT systems. These autonomous systems can perform complex tasks with minimal human intervention, increasing productivity and reducing labor costs.

Developing modular IoT-enabled motor control systems will allow for easy scaling and customization according to the specific needs of different agricultural operations. Farmers can add or remove modules based on their requirements, ensuring flexibility and cost-effectiveness.

Ensuring interoperability between different IoT devices and platforms will be crucial for the widespread adoption of these technologies. Standardization efforts can help create a more cohesive ecosystem where various sensors, controllers, and software applications work seamlessly together.

Sustainability and Energy Efficiency:

- **Hybrid Power Systems**: Integrating solar power with additional renewable energy sources like wind or bioenergy can enhance the resilience and reliability of power systems used in agricultural settings. Hybrid systems can maintain continuous operation, ensuring reliability even in periods when solar energy is unavailable.
- **Energy Storage Innovations**: Advances in energy storage technologies, such as more efficient batteries and supercapacitors, can enhance the reliability and efficiency of solar-powered motor systems. Improved storage solutions will enable better energy management and longer operation times during periods of low sunlight.

The trend towards precision agriculture will continue to drive the adoption of smart irrigation systems. These systems use real-time data from soil moisture sensors and weather forecasts to optimize water usage, improving crop yields and conserving water resources.

Increased use of drones and satellite imagery for monitoring crop health and soil conditions will complement IoT-enabled motor control systems, providing comprehensive data for informed decision-making.

Sustainable Farming Practices:

- **Renewable Energy Integration**: The integration of renewable energy sources in farming operations will become more prevalent. Solar- powered systems will play a significant role in reducing the carbon footprint of agricultural activities and promoting sustainability.
- **Eco-Friendly Technologies**: There will be a growing focus on developing and adopting technologies that minimize environmental

  impact, such as low-energy-consumption motors and biodegradable materials for equipment.

Digital Transformation in Agriculture:

- **IoT Expansion**: The expansion of IoT in agriculture will continue, with more devices and systems being connected to create a fully integrated digital farming ecosystem. This will enable better resource management, improved crop monitoring, and more efficient farming practices.
- **Blockchain for Agriculture**: Blockchain technology may be used to enhance the transparency and traceability of agricultural products. Combining IoT with blockchain can ensure secure and verifiable records of farming practices, from planting to harvesting and distribution.

Regulatory and Policy Support:

- **Government Initiatives**: Increased support from governments and international organizations for sustainable and smart farming practices will drive the adoption of solar-powered IoT systems. Subsidies, grants, and favorable policies can accelerate the deployment of these technologies.
- **Standards and Certifications**: The development of industry standards and certifications for IoT devices and solar-powered systems will ensure quality, reliability, and interoperability, fostering greater trust and adoption among farmers.

By embracing these future directions and trends, the agricultural sector can enhance productivity, sustainability, and resilience, paving the way for a more efficient and environmentally friendly future.

CHAPTER 8

CONCLUSION

The integration of solar power and IoT for induction motor speed control in agriculture presents a transformative approach to modern farming. This combination harnesses renewable energy and advanced technology to create efficient, sustainable, and intelligent agricultural practices. Solar-powered systems reduce dependency on conventional energy sources, lowering operational costs and minimizing environmental impact. The use of IoT enhances precision in motor control, enabling real-time monitoring and automated adjustments that optimize performance and resource utilization.

By implementing these technologies, farmers can achieve significant improvements in various agricultural operations, from irrigation and climate control in greenhouses to automated feeding and milking systems for livestock. The ability to remotely monitor and control equipment not only increases convenience but also ensures timely interventions, reducing waste and enhancing productivity.

Looking forward, the continuous advancement in IoT, AI, and renewable energy technologies will further enhance the capabilities and adoption of these systems. The development of more robust and scalable solutions, coupled with regulatory support and standardization, will drive widespread implementation, leading to more resilient and sustainable agricultural practices.

In conclusion, the synergy between solar power and IoT for induction motor speed control represents a vital step towards achieving smarter and more sustainable agriculture. This innovative approach not only addresses current challenges but also paves the way for future advancements that will continue to revolutionize the agricultural sector.

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