Induction Motor Based Speed and Direction Controller

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***Abstract* — Induction motors are widely employed in a variety of sectors, from household gadgets to industrial machinery. This mandates the deployment of an effective and safe speed control device. Induction motors may also run in either direction, which is beneficial in a variety of applications. The Induction Motor Speed and Direction Controller Project are designed to regulate the induction motor's speed and direction. Induction motors run on straight AC lines, and the amount of power they receive determines how fast they revolve. Through AC driver circuitry, we may regulate the power of the AC line to change the speed of the induction motor. A microcontroller from the Atmega family is utilized to provide PWM power to an opto-coupler, which drives the TRIAC that supplies power to the induction motor. The microcontroller receives instructions via a mobile phone connection to the system. The mobile phone sends DTMF signals to the system, which the system recognizes and responds to appropriately. A button is used to raise the speed of the induction motor, a button to change direction, and a button to lower the speed of the induction motor, according to the video. On the LCD, the entire procedure may be observed in real time. In this way, this project demonstrates how to control the speed and direction of an induction motor.**

***Keywords* — Arduino Nano, Induction Moor, RPM Counter, Rotating Magnetic Field, Speed Controller.**

I. INTRODUCTION

Induction motors are widely employed in a variety of applications, including residential, industrial, commercial, and utility. Induction motors with a single phase are commonly utilized in household and industrial equipment. This project is meant to utilize a simple operational knob to regulate the speed of a single-phase induction motor, which is often used in home automation applications. The capacity to run on a single-phase power source is the fundamental benefit of these motors. Induction motors are becoming increasingly used in a variety of industries, including industrial and domestic applications. In recent years, the improvement of variable speed drive technology has been both commendable and astounding. Variable frequency drive (VFD) is a sort of speed converter. Variable frequency drives are also known as ac drives, variable speed drives, adjustable frequency drives, inverter drives, and so on. The speed of the motor is controlled to perform a variety of tasks and multispeed functions. Previously, the variable speed drive had several drawbacks, such as low efficiency, unstable speed control, and huge space requirements, but these issues have gradually been addressed thanks to the development of power electronics. The importance of induction motors in numerous sectors must first be appreciated. When compared to other types of electrical motors, induction motors provide significant benefits. The following are some of the benefits [1]. Thanh Nguyen's research goal was to develop a model that could anticipate the remaining usable life of an induction motor with little plant investment. His work contributes to expanding the horizons of electronics students in the realm of automation and machine learning. In the Fourth Industrial Revolution, it answers if Siemens Programmable Logical Controllers (PLCs) can cooperate with other Internet of Things (IoT) instruments [2]. To overcome the challenge, Seyedjalal Seyedshenava and Ali Ahmadpour used a robustness method. In his research, he uses the non–linear solver of the transient Finite Element Method to do a unique categorization of VS (FEM). To improve the precision of the results, the suggested technique uses the Jiles–Atherton (JA) vector hysteresis model to simulate the nonlinear behavior of the transformer's iron core. Different connections of transformer windings, as well as numerous sorts of short circuits, are analyzed to establish a thorough classification, and the impact of these classes on Induction Motor (IM) performance is presented [3]. Zuhair Shakor Mahmood and his colleagues created a computational speed controller approach that employs a neural network to forecast speed and then generates a reference voltage to update the armature terminal voltage. In his research, a three-layer neural network was used to execute motor speed control, and the model outperformed traditional controller models [4]. William Cai and his colleagues gave a presentation on recent research and technical advancements in electric motor systems and electric powertrains for new energy vehicles. The permanent magnet synchronous motor outperforms direct current, induction, and synchronous motors in terms of overall performance; in comparison to converters with Si-based IGBTs, converters with SiC MOSFETs outperform converters with Si-based IGBTs in terms of efficiency and driving mileage per charge [5].

In this work, the major goals of this project are to create a low-cost digital rpm meter, monitor motor speed, and regulate motor speed using Bluetooth technology on our mobile phone. This project's process includes gathering knowledge from books and the internet, as well as acquiring components from the local market.

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II. System Design and Development

The following components were used in this project: Arduino Nano, 12v relay, LCD display, IR Sensor Module, Capacitors, Some resistors, battery, Diode, Transformer, DIAC and TRIAC, and Voltage Regulator (7085). Because of its open-source hardware characteristic, an Arduino is a microcontroller-based kit that may be purchased directly from the manufacturer or built at home using the components. It is mostly utilized for communications as well as managing and running a variety of devices. Massimo Banzi and David Cuartielles started it in 2005.

The Contactless Digital Tachometer works on the basis of a simple embedded system comprising a sensor, controller, and actuator. The sensor is an infrared (IR) transmitter-receiver pair, the controller is a pic16f876 Microcontroller loaded with compiled code, and the actuator is a display device that displays the motor's speed.

By using the concept of light transmission and reflection, the sensor detects the motor's speed without actually coming into touch with it and provides a signal. This signal is translated to an electric signal and sent to the microcontroller, which is programmed to determine the speed of motor rotations per minute. On the LCD display, this speed is displayed.

Synchronous speed refers to the rotational speed of a revolving magnetic field. where ‘f’ is the supply frequency and ‘P’ is the number of poles.

$$N_s = 120 \times \frac{f}{P} \text{ (RPM)} \tag{1}$$

Rotor rotates as it strives to catch up to the synchronous speed of the stator field. Rotor, on the other hand, never manages to catch up in practice. There will be no relative speed between the stator flux and the rotor if the rotor catches up to the stator speed, hence there will be no induced rotor current and no torque production to keep the rotation going. However, the motor will not stop; the rotor will slow down owing to torque loss, and torque will be applied again due to relative speed. As a result, the rotor revolves at a lower speed than the synchronous speed.

Slip is the difference between the rotor's synchronous speed (Ns) and its actual speed (N).

$$\%\, Slip, S = \frac{N_s - N}{N_s} \times 100 \tag{2}$$

A crystal oscillator is an electrical oscillator circuit that is used to generate mechanical resonance in a piezoelectric crystal. It will generate a frequency-specific electrical pulse. This frequency is often used to maintain track of time, for example, in digital integrated circuits to give a reliable clock signal and in radio transmitters and receivers to stabilize frequencies. Radiofrequency (RF) oscillators primarily employ quartz crystal. Quartz crystals are the most prevalent sort of piezoelectric resonator, and we use them in oscillator circuits, thus they're called crystal oscillators. A load capacitance must be built into crystal oscillators.

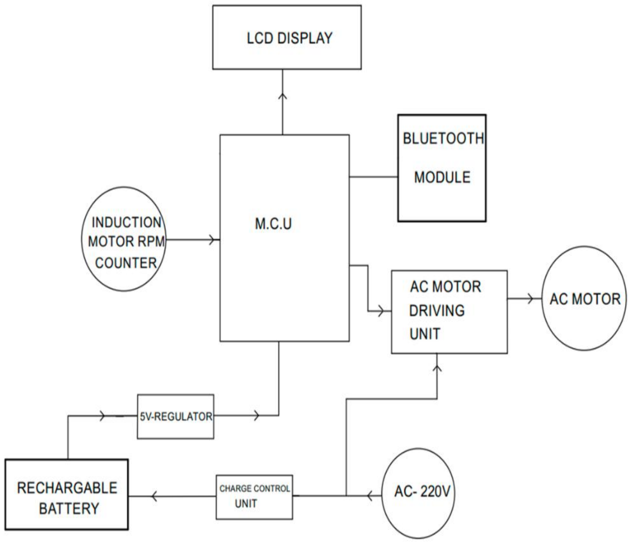
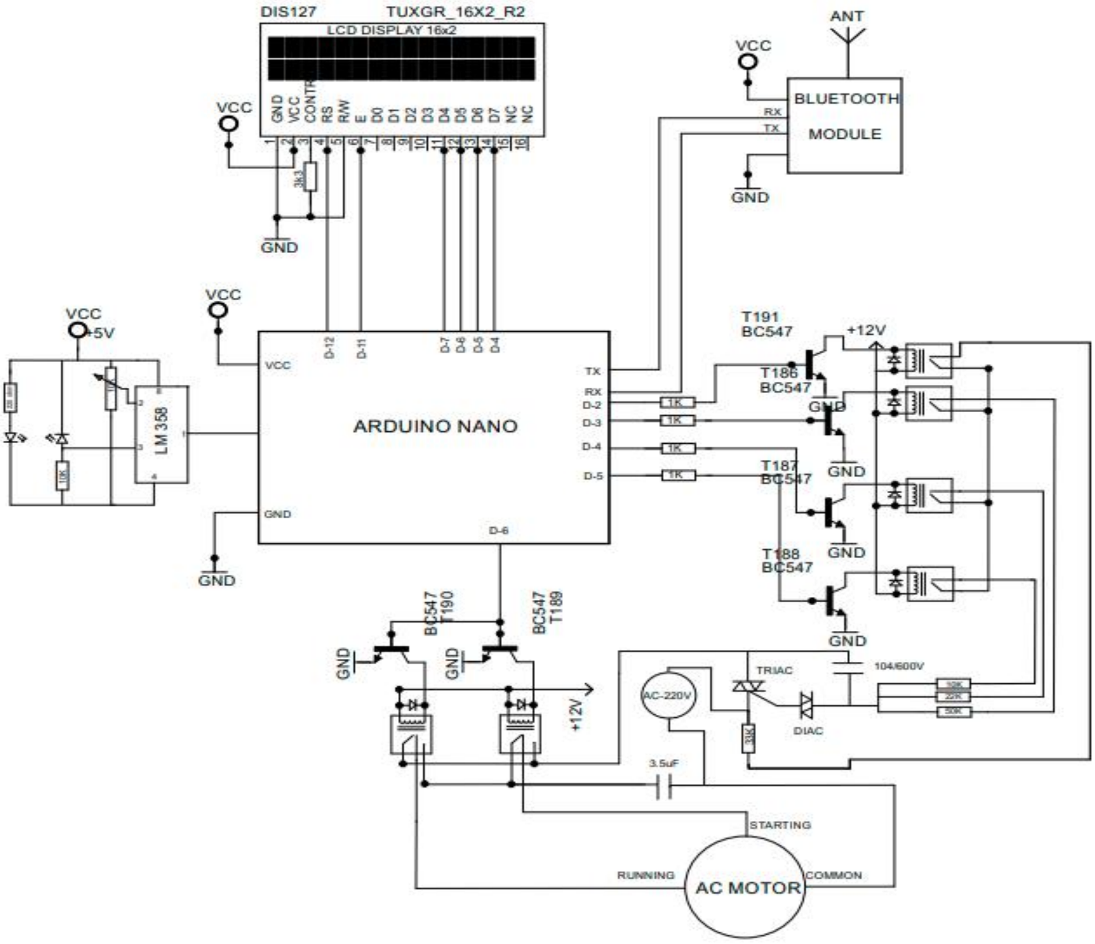


Fig. 1. Block diagram demonstrating the methods used.

Fig. 2. Crystal Oscillator.

Transformers are devices that vary (transform) the voltage of electricity delivered to match the demands of particular power users. The voltage (alternating difference) is changed from one value to another using the principle of electromagnetic induction. A transformer is constructed out of a soft iron coil with two more coils wrapped around it but not linked. The iron coils can be coiled on distinct limps of the iron core or stacked on top of each other. The primary winding or primary coil while is the coil to which the alternating voltage is provided. When an alternating potential is applied to the primary winding, the alternating current creates a fluctuating magnetic field surrounding it. The changing field in the secondary coil produces an alternating current, and the quantity of current generated is proportional to the number of windings in the secondary coil. Step down and step-up transformers are the two types of transformers. The amount of voltage produced, which varies based on the number of secondary coils, is the main difference between them. The secondary windings of a step-down transformer are less than the main windings. In other words, the secondary voltage of the transformer is lower than the main voltage. As a result, the transformer is designed to convert high-voltage, low-current electricity into low-voltage, high-current power for household use. This is simply a pic16f876 modification of the preceding digital tachometer. The output is shown on a 162 LCD module in this case. The output is expressed in revolutions per minute (rpm), with the number of digits increasing from three to five. This circuit can show up to 10200 revolutions per minute.



Because the rotor conductors are short-circuited, induced emf produces rotor current. Induction motors get their name from this fact. Supply must be provided for both the stator and rotor windings in a DC motor. In an induction motor, however, only the stator winding receives an AC supply. The AC supply produces alternating flux around the stator coil. This alternating flux rotates at the same time. "Rotating Magnetic Field" describes the revolving flux (RMF). According to Faraday's law of electromagnetic induction, the relative speed between the stator RMF and the rotor conductors creates an induced emf in the rotor conductors.

The voltage level is controlled by a voltage regulator. The voltage regulator is the preferred device when a constant, stable voltage is required. It produces a constant output voltage regardless of changes in the input voltage or load circumstances. It protects components from harm by acting as a buffer. A voltage regulator is a device that employs negative feedback control loops and has a basic feed-forward construction. Voltage regulators are divided into two types: linear voltage regulators and switching voltage regulators, which are employed in a variety of applications. The simplest sort of voltage regulator is the linear voltage regulator. The rotor will strive to catch up with the stator RMF since the relative velocity between the spinning stator flux and the rotor is of electromagnetic induction, the relative speed between the stator RMF and the rotor conductors creates an induced emf in the rotor conductors.

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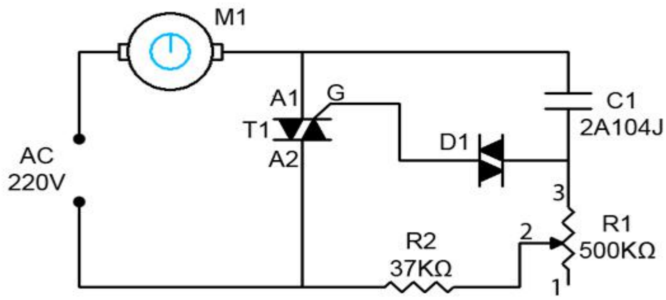

Fig. 4. Induction Motor Speed control circuit.

TABLE I: COST ANALYSIS OF THIS WORK

S.N.	Components Name	Quantity	Price in Taka
01	Arduino nano	1	500/=
02	HC-05 Bluetooth module	1	200/=
03	AC motor	1	500/=
04	Step-down transformer	1	200/=
05	LCD Display	1	200/=
06	IR module	1	100/=
07	12V relay	6	150/=
08	Rechargeable battery	3	200/=
09	3.5uF capacitor	1	50/=
10	7805 voltage regulator	1	20/=
11	TRIAC	1	50/=
12	DIAC	1	20/=
13	Capacitor- 1000uF,470uF	1	50/=
14	Power switch	1	20/=
15	PVC board	1	500/=
16	Connecting wire	some	100/=
	Total		2840/=

III. ANALYSIS OF RESULTS

The result is the output of any project. The result presents the success of a project. We find out the successful result of this project through different experiments. We can see, the system is off. Now we need to start the system.

In Fig. 5, we can see, the motor is rotating, and the motor speed controller circuit measure it and send it to the microcontroller and the microcontroller shows it on an LCD display. To design, Construct and design analysis of the circuit is the basic purpose of our project. Our project work is already completed. The constructed circuit is very nicely working. At first, we did a project, then we used this concept in this project by studying books, searching the internet, and discussing with my teacher. Finally, we overcome this problem and complete my project.

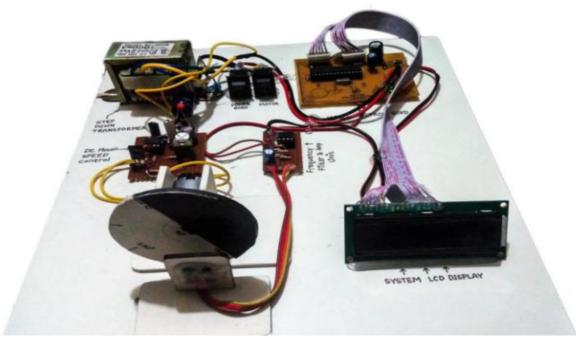

Fig. 4. Before starting the system.

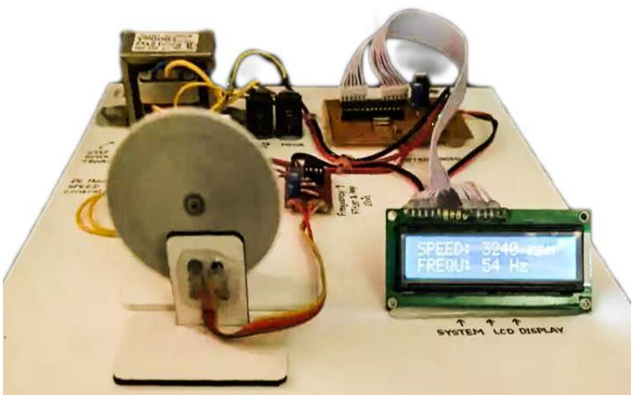

Fig. 5. After starting the system.

IV. CONCLUSION

This is a work in progress. This project demonstrates how a Digital Tachometer works. For monitoring motor speed, we utilize a Digital Tachometer system as a prototype. It also provides security and makes adjusting motor speed simple. This project is built on microcontroller platforms, both of which are open-source and free. As a result, the implementation rate is low and accessible to the average individual. The method for measuring motor speed has been successfully devised and prototyped. This project has a modest prototype, but it may be expanded to many additional places in the future. For a three-phase load, the project may be improved by utilizing six SCRs, two connected back-to-back for each phase, and the same project can also be improved to drive the motor in both directions. We utilize a microcontroller in our project since it is simple to calibrate. However, this controller has a limited number of output ports. We can add many more functions to any other board, such as Adriano Mega. There are several possibilities with this project, such as using a laser instead of a motor control circuit.

REFERENCES

[1] Mahfoud S, Derouich A, El Ouanjli N, El Mahfoud M, Taoussi M. A New Strategy-based PID controller optimized by genetic algorithm for DTC of the doubly fed induction motor. *Systems.* 2021 Jun; 9(2): 37.

[2] Seyedshenava S, Ahmadpour A. Finite element method for optimal transformer connection based on induction motor characteristics analysis. *Ain Shams Engineering Journal*, 2021; 12(2): 1943-57.

[3] Mahmood ZS, Nasret AN, Mahmood OT. Separately excited DC motor speed using ANN neural network. In *AIP Conference Proceedings,* 2021 Oct 11; 2404(1): 080012. AIP Publishing LLC.

[4] Cai W, Wu X, Zhou M, Liang Y, Wang Y. Review and development of electric motor systems and electric powertrains for new energy vehicles. *Automotive Innovation*. 2021; 4(1): 3-22.

[5] Vadi S, Bayindir R, Toplar Y, Colak I. Induction motor control system with a Programmable Logic Controller (PLC) and Profibus communication for industrial plants-An experimental setup. *ISA Transactions*, 2022 Mar 1; 122: 459-71.

[6] Aziz AG, Rez H, Diab AA. Robust Sensorless Model-Predictive Torque Flux Control for High-Performance Induction Motor Drives. *Mathematics,* 2021 Jan; 9(4): 403.

[7] Nayak MR. A photovoltaic based multilevel inverter fed induction motor drive. *Turkish Journal of Computer and Mathematics Education (TURCOMAT).* 2021; 12(10): 6196-212.

[8] Gudur BR, Poddar G, Muni BP. Parameter Estimation and Online Adaptation of Rotor Time Constant for Induction Motor Drive. *IEEE Transactions on Industry Applications*. 2022 Jan 10.

[9] Al Rakib MA, Rana MS, Rahman MM, Abbas FI. Dry and Wet Waste Segregation and Management System. *European Journal of Engineering and Technology Research*, 2021; 6(5): 129-133.

[10] Bhuiyan GM, Abbas FI. Local minimum in effective pairpotentials: Pseudopotential theory revisited. *Cornell University Library, arXiv preprint arXiv:1710.07931*, 2017.

[11] Islam MAM, Gosh RC, Abbas FI, Bhuiyan GM. Effects of interionic pair interactions on atomic transport properties of liquid Al*, Indian Journal of Physics*, pp. 1-10, Springer India, 2021.

[12] Abbas FI, Bhuiyan GM, Kasem R. Critical Properties of Segregation for Al1- xBix Liquid Binary Alloys. *Journal of the Physical Society of Japan*, 2020; 89(11): 114004.

[13] Dubinin N, Ryltsev R. Effective Pair Interactions and Structure in Liquid Noble Metals within Wills-Harrison and Bretonnet-Silbert Models. *Metals*, 2021; 11(7): 1115. https://doi.org/10.3390/met11071115.

[14] Bhuiyan GM, Abbas FI. Local minimum in pair potentials of polyvalent metals: A limitation of pseudopotential theory. *International Journal of Modern Physics B*, 2019; 33(7): 1950049.

[15] Kasem R, Abbas FI, Bhuiyan GM. A study of thermodynamics of mixing for Al1-xSnx liquid binary alloy, *Journal of non-crystalline solids,* 2018;481:391-396, Publisher North-Holland.

[16] Abbas FI, Bhuiyan GM, Ziauddin Ahmed AZ. Energy of mixing and entropy of mixing for CuxAl1-x liquid binary alloys, *arXiv preprint arXiv:1607.05827*, 2016.
[17] Al Rakib MA, Rahman MM, Rahman MA, Chakraborty S, Shawon MMAS, Abbas FI. IoT based Controlling of Power Grid. *European Journal of Engineering and Technology Research*, 2021; 6(6): 54-57.
[18] Al Rakib MA, Rahman MM, Rana MS, Islam MS, Abbas FI. GSM Based Home Safety and Security System. *European Journal of Engineering and Technology Research* 2021;6(6): 69-73.
[19] Ahmad S, Mehedee HM, Bin HMR, Hasan RR, Abbas FI, Imam MH. Design of a Compact Simple Structural Dual-band Patch Antenna for Wireless On-body Medical and Sports Devices, 2021 *2nd International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), IEEE,* pp. 577-581, 2021.
[20] Al Rakib MA, Mahamud MS, Zishan MSR, Abbas FI. An Arduino Based Smart Hand Gloves for Load Control and Physician Notification, *2021 International Conference on Automation, Control and Mechatronics for Industry 4.0 (ACMI), IEEE*, 2021: 1-5.
[21] Al Rakib MA, Rahman MM, Samad M, Islam S, Rahman MA, Abbas FI. Low-Cost Pulmonary Ventilator for Patient Monitoring Covid19 Disease. Submitted to *European Journal of Engineering and Technology Research*, 2021.
[22] Al Rakib MA, Uddin S, Rahman MM, Chakraborty S, Abbas FI. Smart Wheelchair with Voice Control for Physically Challenged People. *European Journal of Engineering and Technology Research,* 2021; 6(7): 97-102.
[23] Al Rakib MA, Rahman MM, Anik MS, Masud FA, Rahman MA, Islam S, Abbas FI. Arduino Uno Based Voice Conversion System for Dumb People. *European Journal of Engineering and Technology Research.* 2022 Apr 11;7(2):118-23.
[24] Al Rakib MA, Rahman MM, Uddin S, Anik MS, Talukder AH, Abbas FI. Fingerprint Based Smart Home Automation and Security System. *European Journal of Engineering and Technology Research*. 2022 Apr 18;7(2):140-5.
[25] Al Rakib MA, Rahman MM, Anik MS, Masud FA, Islam S, Rahman MA, Chakraborty S, Abbas FI. Arduino Based Efficient Energy Storage Systems Using Solar and Wind Power. *European Journal of Engineering and Technology Research*. 2022 Apr 15;7(2):134-9.
[26] Al Rakib MA, Rahman MM, Anik MS, Masud FA, Rahman MA, Hossain MS, Abbas FI. Fire Detection and Water Discharge Activity for Fire Fighting Robots using IoT. *European Journal of Engineering and Technology Research.* 2022 Apr 13;7(2):128-33.
[27] Al Rakib MA, Rahman MM, Anik MS, Masud FA, Rahman MA, Islam S, Abbas FI. Arduino Uno Based Voice Conversion System for Dumb People. *European Journal of Engineering and Technology Research*. 2022 Apr 11;7(2):118-23.

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