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Wireless EV Charging Station

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ABSTRACT: Wireless Electric Vehicle (EV) charging is an advanced technology that eliminates the need for conventional charging cables by transferring electrical energy through electromagnetic fields. The Wireless EV Charging Station project focuses on developing a wireless power transfer system capable of charging an EV battery safely and efficiently. The system operates on the principle of Inductive Coupling, where energy is transferred between a transmitting coil and a receiving coil without direct electrical contact. The transmitting coil generates a magnetic field that is captured by the receiving coil placed in the vehicle and converted into electrical energy to charge the battery.

A Microcontroller is used to control and monitor the charging process, detect the receiving coil, and display system status through LED indicators. The system also integrates Solar Energy to support sustainable power generation. Components such as the IC555 Timer, MOSFET switching circuits, and inductive coils enable efficient wireless power transmission while reducing Electromagnetic Interference.

KEYWORDS: Wireless Power Transfer, Electric Vehicle Charging, Inductive Coupling, Microcontroller, Solar Powered EV, Charging Efficiency, Smart Charging System.

I. INTRODUCTION

The rapid growth of electric vehicles (EVs) has created a strong demand for advanced and convenient charging technologies. Conventional plug-in charging systems require physical cables and connectors, which may lead to problems such as cable wear, safety risks, and inconvenience for users. To overcome these limitations, Wireless Electric Vehicle (EV) Charging Stations have emerged as a modern and efficient solution. This technology allows electric vehicles to be charged without any direct physical connection between the power source and the vehicle. Instead, electrical energy is transferred through electromagnetic fields using the principle of wireless power transfer. The concept significantly improves user convenience, safety, and automation in EV charging infrastructure. A wireless EV charging station mainly operates based on inductive power transfer (IPT) technology. In this system, electrical energy is transmitted from a transmitting coil installed in the charging station to a receiving coil mounted underneath the electric vehicle.

When alternating current flows through the transmitting coil, it generates a changing magnetic field. This magnetic field induces voltage in the receiving coil, which is then converted into electrical energy to charge the vehicle's battery. The efficiency of power transfer depends on factors such as coil alignment, distance between coils, operating frequency, and the design of the power electronics circuit. The wireless EV charging system typically consists of several key components including a power supply unit, inverter circuit, transmitting coil, receiving coil, rectifier circuit, voltage and current sensors, microcontroller unit (such as Arduino), and battery management system.

The power supply first converts the grid AC voltage into controlled high-frequency AC using an inverter. This high-frequency signal is applied to the transmitting coil, which generates the magnetic field necessary for wireless power transfer. The receiving coil captures this magnetic field and converts it back into electrical energy. The rectifier circuit then converts the received AC power into DC power suitable for charging the EV battery. Microcontrollers play an important role in monitoring and controlling the wireless charging process. Sensors such as voltage and current sensors continuously measure the charging parameters and send the data to the microcontroller. Based on this information, the system can regulate power flow, ensure safe operation, and improve charging efficiency. Additional protection features such as overvoltage protection, overcurrent protection, and temperature monitoring are also integrated into the system to enhance safety and reliability.

II. OBJECTIVE

- Develop a Wireless Power Transfer System
- To Improve User Convenience

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- To Enhance Safety in Charging Systems
- To Reduce Mechanical Wear and Maintenance
- To Improve Charging Efficiency

III. METHODOLOGY

The Wireless EV Charging Station works on the principle of electromagnetic induction, which enables electrical energy to be transferred from a power source to an electric vehicle battery without any direct electrical connection. The system mainly consists of several important modules such as a power supply unit, step-down converter, microcontroller, LCD display, voltage sensor, high-frequency inverter circuit, transmitting coil, receiving coil, battery charging circuit, and EV battery. Each component performs a specific function to ensure efficient and safe wireless charging of the electric vehicle.

The working process begins with the 230V AC power supply, which provides the main electrical energy for the system. Since electronic circuits and microcontrollers require low DC voltage, the high AC voltage is first passed through a step-down transformer and power converter module. This module converts the 230V AC supply into a lower DC voltage, typically 12V and then regulated to 5V using a voltage regulation circuit. This regulated voltage is used to power the microcontroller, sensors, LCD display, and other control circuits. The stable power supply ensures that the system operates reliably without fluctuations.

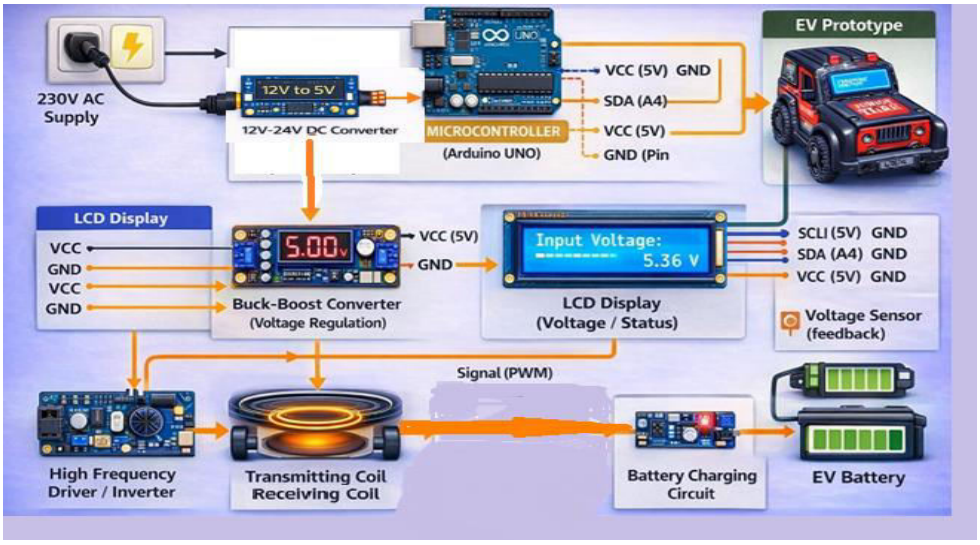

Fig.1.Proposed System of the Project

The microcontroller unit (Arduino UNO) acts as the central controller of the wireless charging system. It manages the operation of various components by processing input signals from sensors and controlling the output signals required for system operation. The microcontroller receives voltage data from the voltage sensor and processes this information to monitor the system's electrical parameters. Based on the programmed instructions, it controls the power flow and displays important information such as input voltage and system status on the LCD display.The LCD display module provides a user interface for monitoring the system. It displays real-time data such as input voltage, charging status, and system conditions. The LCD is connected to the microcontroller using communication lines such as SDA and SCL, which allow the microcontroller to send display data to the screen. This feature helps users easily monitor the operation of the wireless charging station and detect any abnormal conditions during the charging process.

After the control section is powered, the system activates the high-frequency driver or inverter circuit. The inverter circuit converts the low-voltage DC power into high-frequency alternating current (AC).High-frequency AC is necessary for efficient wireless power transfer because it produces a rapidly changing magnetic field in the transmitting coil. The inverter uses electronic switching devices such as MOSFETs or transistors to generate this high-frequency signal.

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The output from the inverter is supplied to the transmitting coil, which is located in the charging pad. When high-frequency AC current flows through the transmitting coil, it generates a strong alternating magnetic field around the coil. This magnetic field is the key element in wireless power transfer. When an electric vehicle equipped with a receiving coil is placed close to the transmitting coil, the magnetic field produced by the transmitting coil passes through the receiving coil.

According to Faraday's law of electromagnetic induction, the changing magnetic field induces voltage in the receiving coil. This process allows electrical energy to be transferred wirelessly from the transmitting coil to the receiving coil without the use of physical wires. The amount of induced voltage depends on factors such as coil alignment, distance between the coils, operating frequency, and coil design. The electrical energy received by the receiving coil is in the form of alternating current, which cannot be directly used to charge the EV battery. Therefore, the output of the receiving coil is connected to a battery charging circuit that includes a rectifier and voltage regulation components. The rectifier converts the induced AC voltage into DC voltage, and filtering circuits smooth the output to provide stable DC power suitable for battery charging. The voltage sensor continuously measures the voltage levels in the system and sends this information back to the microcontroller as feedback. This feedback mechanism allows the microcontroller to monitor the charging process and ensure that the system operates within safe voltage limits. If the voltage exceeds the safe range or any abnormal condition occurs, the microcontroller can adjust the system operation or display warning information on the LCD display.

IV. BLOCK DIAGRAM COMPONENT DESCRIPTION

1. Microcontroller

The microcontroller plays a crucial role in the operation and control of a wireless EV charging station. It acts as the central processing unit of the system and is responsible for monitoring, controlling, and coordinating various components involved in the wireless charging process. In most prototype projects, a microcontroller such as Arduino is used because of its simplicity, flexibility, and ability to interface with different sensors and electronic circuits. The microcontroller ensures that the wireless charging system operates efficiently, safely, and automatically. One of the primary functions of the microcontroller is system monitoring. It continuously collects data from sensors such as voltage sensors and current sensors placed in different parts of the charging circuit. These sensors measure important parameters including input voltage, output voltage, charging current, and power transfer conditions.

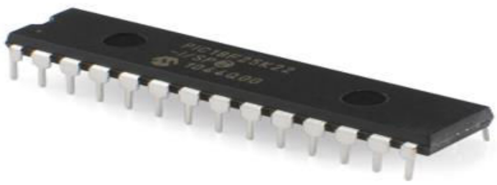

Fig 2. Microcontroller

2. Receiving Coil and Transmitting

The transmitting coil is one of the most important components in a wireless EV charging station because it is responsible for generating the magnetic field required for wireless power transfer. The transmitting coil is placed in the charging pad or charging station and acts as the primary side of the inductive power transfer system. Its main function is to convert electrical energy from the power supply and inverter circuit into a high-frequency alternating magnetic field that can transfer energy wirelessly to the receiving coil located in the electric vehicle. In the wireless charging system, the electrical energy first passes through a power supply unit where the AC input is converted into DC voltage.

The receiving coil is another essential component of a wireless EV charging station and functions as the secondary side of the wireless power transfer system. It is installed inside the electric vehicle, usually on the underside of the vehicle chassis, directly above the transmitting coil when the vehicle is parked over the charging pad. The electrical energy obtained from the receiving coil is in the form of alternating current, which is not suitable for directly charging the battery. Therefore, the output of the receiving coil is connected to a rectifier circuit that converts the AC voltage into DC voltage.

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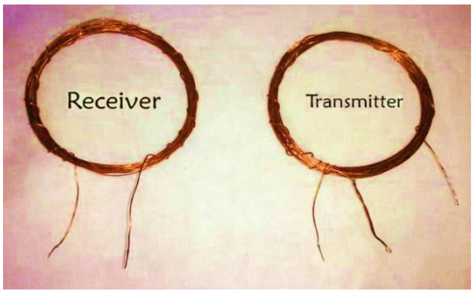

Fig.3 Receiving coil and Transmitting Coil

3. High Frequency Inverter

The High Frequency Inverter is a key component used in a Wireless EV Charging Station to convert DC power into high-frequency AC power required for wireless power transfer. In the charging system, the input power supply is first converted into DC using a rectifier and filtering circuit. This DC voltage is then supplied to the high frequency inverter. The inverter uses semiconductor switching devices such as MOSFETs or IGBTs that operate at high switching speeds.

These switches are controlled using Pulse Width Modulation (PWM) signals generated by a controller such as an Arduino or driver circuit. When the switches turn ON and OFF rapidly, the DC voltage is converted into a high-frequency alternating current. This high-frequency AC is supplied to the transmitting coil placed in the charging pad. The alternating current flowing through the transmitting coil produces a rapidly changing magnetic field. According to the principle of electromagnetic induction, this magnetic field induces an AC voltage in the receiving coil placed in the electric vehicle.

Fig.4 High Frequency Inverter

4. Battery Charging Circuit

The battery charging circuit plays an important role in a Wireless EV Charging Station because it regulates and supplies the correct voltage and current required to safely charge the electric vehicle battery. In a wireless charging system, electrical energy is transferred from the transmitting coil to the receiving coil through electromagnetic induction. The receiving coil generates alternating current (AC) due to the changing magnetic field produced by the transmitting coil. This AC power cannot be directly used to charge the battery, so it is first converted into direct current (DC) using a rectifier circuit.

The rectifier, usually made of diodes, converts the induced AC voltage into DC voltage. After rectification, a filter capacitor is used to smooth the DC output by reducing ripple. The filtered DC voltage is then passed through a DC-DC converter or voltage regulator, which maintains a constant voltage and current suitable for the EV battery.

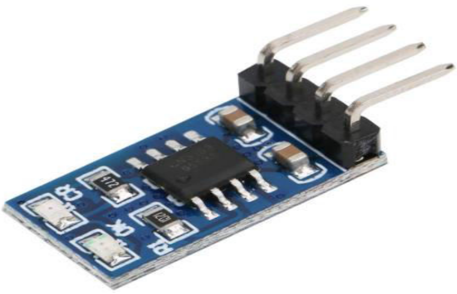

Fig.5 Battery Charging Circuit

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5. Buck Boost Converter

The Buck–Boost Converter is an important power electronic circuit used in a Wireless EV Charging Station to regulate and stabilize the DC voltage obtained from the wireless power transfer system. In wireless charging, electrical energy is transferred from the transmitting coil to the receiving coil through electromagnetic induction. The receiving coil generates AC power, which is converted into DC using a rectifier circuit. However, this DC voltage may vary due to factors such as coil alignment, distance between coils, and load conditions. The buck–boost converter is used to maintain a stable output voltage by either increasing (boost) or decreasing (buck) the input voltage according to the system requirement.

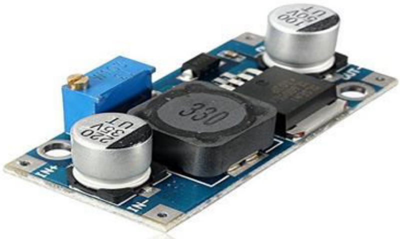

Fig.6 Buck Boost Converter

Flow Chart of the Proposed System

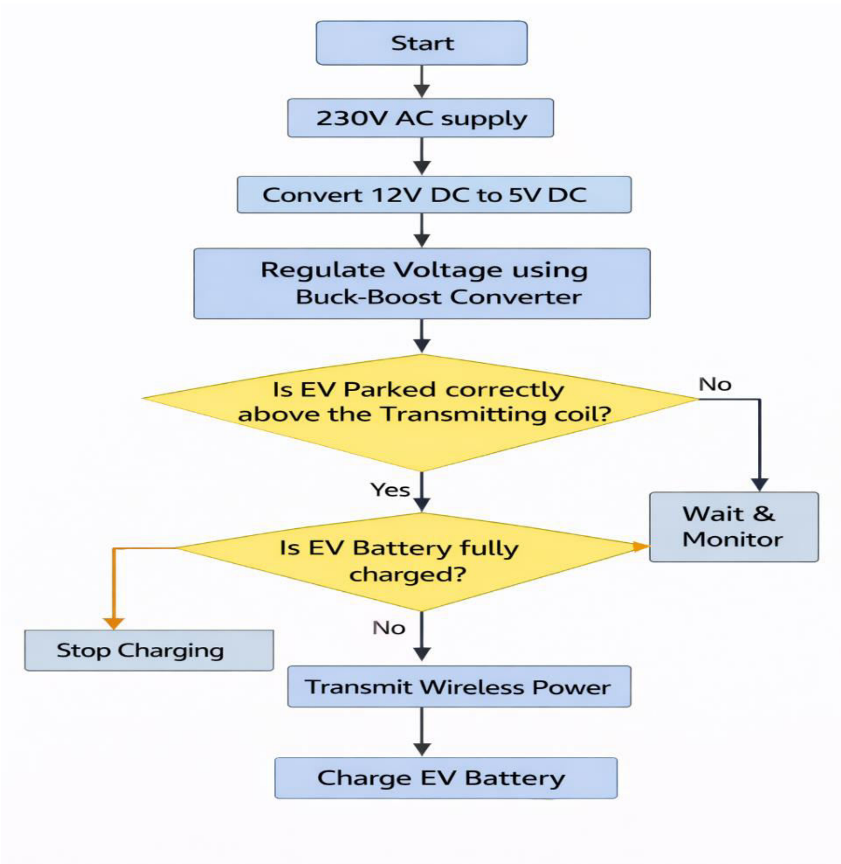

Fig. 7 Flow Chart of the System

The flowchart of the Wireless EV Charging Station explains the sequence of operations for transferring electrical energy wirelessly to an EV battery. The process starts when the system power is ON and checks the main power supply. If available, the microcontroller initializes components such as the inverter, transmitting coil, voltage sensor, display, and charging circuit. The system then verifies whether the vehicle is properly aligned with the charging pad. If aligned, the inverter generates high-frequency AC that creates a magnetic field in the transmitting coil. The receiving coil captures this energy through Electromagnetic Induction, converts it to DC using a rectifier, regulates voltage via a buck-boost converter, and charges the battery until full.

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IV. EXPRIMENTAL RESULT

The Wireless EV Charging Station using the microcontroller was successfully implemented using inductive wireless power transfer between a transmitting coil and a receiving coil, as shown in the previously developed system diagram. In this project, electrical energy is transferred wirelessly through electromagnetic induction. This signal energizes the primary (transmitting) coil, creating a magnetic field around the charging pad. When the electric vehicle is placed above the pad, the secondary (receiving) coil inside the vehicle captures this magnetic field and converts it into electrical energy. Experimental readings from the prototype system show that with an input voltage of approximately.

Sr.No.	Input Voltage	Input Current	Power
1	12 V	0.6	7.2
2	9 V	0.5	6.3

The received AC signal is then rectified and regulated using a rectifier circuit and DC-DC converter before charging the EV battery. The Microcontroller monitors system parameters such as voltage levels and charging status through a voltage sensor. The microcontroller also controls the operation of the system and provides visual indications through LED indicators. In the prototype system, a green LED on the transmitting side indicates that the transmitting coil is active and generating the magnetic field. On the receiving side, another LED turns ON when power is successfully received, confirming proper alignment between the transmitting and receiving coils. When the battery reaches its full charge level, a separate LED indicator glows to indicate “Battery Fully Charged.”

Experimental Set up

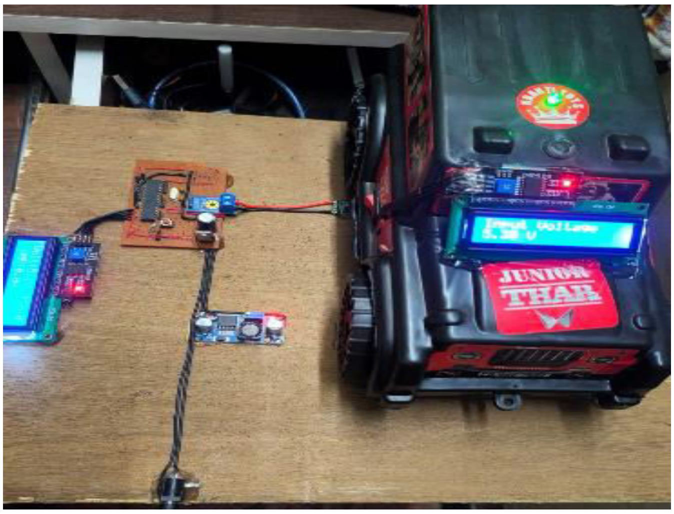

Fig.8 Experimental Set up

V. CONCLUSION

The Wireless EV Charging Station project demonstrates an innovative approach to charging electric vehicles using wireless power transfer technology. By utilizing inductive coupling with transmitting and receiving coils, power can be transferred efficiently without the need for physical cables. The system is controlled by Microcontroller, which manages the operation of the charging process, monitors battery conditions, and controls indicators such as LEDs to display the charging status of both transmitting and receiving coils.

This project also integrates renewable energy by incorporating solar power, allowing the electric vehicle battery to store energy from both wireless charging and solar sources. The results show that the system can successfully transfer energy across a short distance with reasonable efficiency while maintaining safety and reducing cable dependency.

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Important factors such as efficiency, range, electromagnetic interference (EMI), and system safety were considered during the design and implementation.

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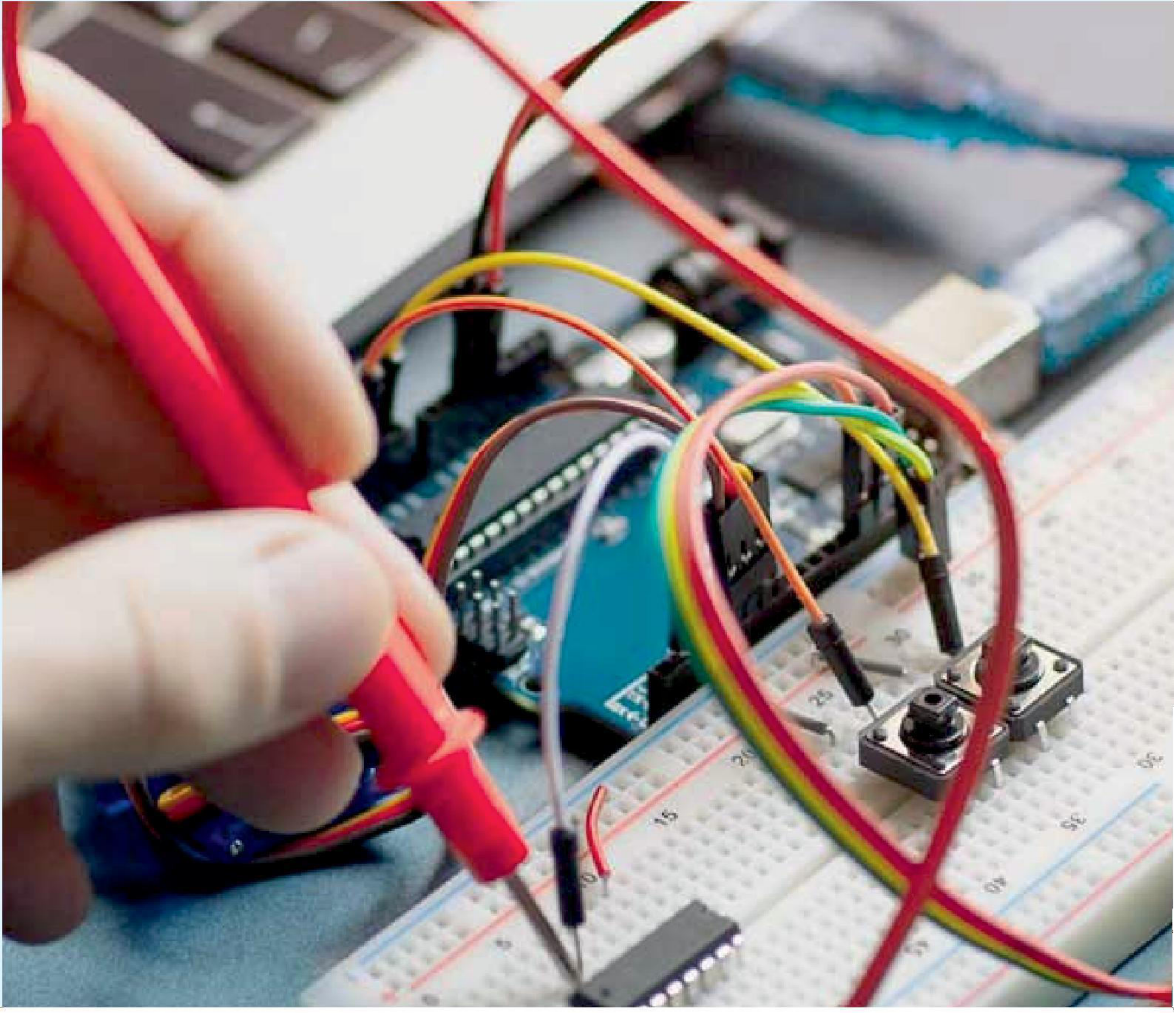

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