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AC Digital Smart Meter using Arduino and PZEM-004T

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ABSTRACT: Energy demand is increasing day-to-day according to the increase in population and industrial expansion. There exists a lack of technical knowledge in the case of monitoring and controlling energy consumptions. Conventional energy meters which we use to measure energy consumption in households are offline devices. Readings are taken manually from such devices. Smart energy meter can overcome such situations. The proposed system using PZEM-004T helps people to take the readings from anywhere in the world. Along with energy consumption it will also give status of parameters such as: voltage, current, power, power factor, energy and frequency. Every management system is trying to make an automatic, portable, accurate and reliable system for measurement. This work presents a novel smart meter for an automatic and superior metering and warning system. The integration of the Arduino and LCD provide the meter reading system with some pre-defined values. The proposed smart meter system can incorporate with an embedded microcontroller (Arduino) and PZEM-004T. AC digital multi function meter PZEM-004T having the ability to measure electrical parameters such as voltage, current, active power and energy, power factor and frequency. Measured parameters are directly transmitted with TTL serial interface with Arduino NANO board and displayed on 16*2 LED Display.

KEYWORDS: Digital Smart Meter, Electrical Parameters, Arduino, PZEM-004T, Embedded C.

I. INTRODUCTION

Electricity has become one of the basic requirements of humans. It is used in domestic, industrial, and agricultural purposes. Existing system is a time consuming system. smart energy meters can overcome the existing problems like reducing man power, energy monitoring, load management, power theft etc [1]. Smart meters are same as normal meters. It is an advanced technology for reading, billing, and controlling the energy consumption. Smart meters are referred as smart because it includes a two way communication system. It monitors the system very quickly and provides real time data to the user. They also collect power outages from loads and communicates this information to the user [2].

The main advantage of smart meter is that we don't require many components to take readings since smart meter sensor itself will give different parameter readings. Smart meter allow switching on/off loads remotely with the help of relay. In this work, user monitors the electrical energy and controls the loads in our home using relay, and pzem-004T sensor module [3]. The objective of this proposed system is to monitor the energy consumption and manage them accordingly so that the user can overcome high bill amount. PZEM-004T module can measure voltage, current, power, power factor, energy consumption and frequency.

1.1. Literature Review

A smart meter is an electronic device to measure and manage the power consumption. The proposed system [1] replaces regular electricity meter with hall sensor and ESP8266 interfaced with Arduino UNO to transmit data. Data collected from various households and send directly to Arduino UNO module. From Arduino UNO module, data transfer to Arduino YUN module through ESP 8266 Ethernet shield. From Arduino YUN module, data stored at temboo cloud. User can access the data from Temboo cloud. Therefore, server uses the details of user and can retrieve it using their Id. Regular updates from server is send to user through SMS or email. Electricity bill generated at every month and send to user. If the user doesn't pay the bill, electricity connection is automatically interrupted using relay switch. Here hall sensor sense amount of current is consumed using current sensing theory. The phase wire is passed through hole of hall sensor. When current passed through phase wire, it is measured from magnetic field generated. Therefore, potential differences referred to as a hall voltage. The advantage of hall sensor is measured the current without breaking the system. Per capita power

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consumption is rapidly increasing with increasing population. When user concerned about electricity bill and power consumption, there are high chance for reducing per capita power consumption. This system increases privacy and will reduce health hazards compared to previous systems. Hiremath et al. [2] presented IOT-based energy control and managing devices. They designed and implemented an energy meter which uses Arduino as its microcontroller. This system is used to measure the power consumed by electrical devices. Power consumption is monitored and is send to the server via Wi-Fi module. Web based application is used so that the user can monitor the consumption anywhere in the world. The researcher mainly focused only on the tools used in the experiment. Measurement data and their details are not discussed in it. In [3], Prasetyo et al. Researched smart Home for monitoring and control of electrical energy. The research was taken place in Indonesia. The research aims to conduct the effectiveness of electricity usage by monitoring and controlling power using cloud-based IOT. The smart home design was built using several devices such as an Arduino microcontroller, Internet module, AC Voltmeter, Relay, LDR Sensor, and PIR Motion Sensor. The output of the research is still in the form of design, not yet at the stage of developing and implementing the tool.

1.2 Objectives of the Proposed Work

The main objectives of this project are:

- To develop the energy measurement system, which is reliable, portable and accurate with low cost.
- To overcome power theft and have effective load management at feeders.

By knowing more about how much energy is in use and also the amount of energy consumer spent in a minute, it will help the consumer to choose the way to use energy and save it.

II. PROPOSED METHODOLOGY

Figure 1 shows the block diagram and figure 2 shows the corresponding circuit diagram of the proposed methodology.

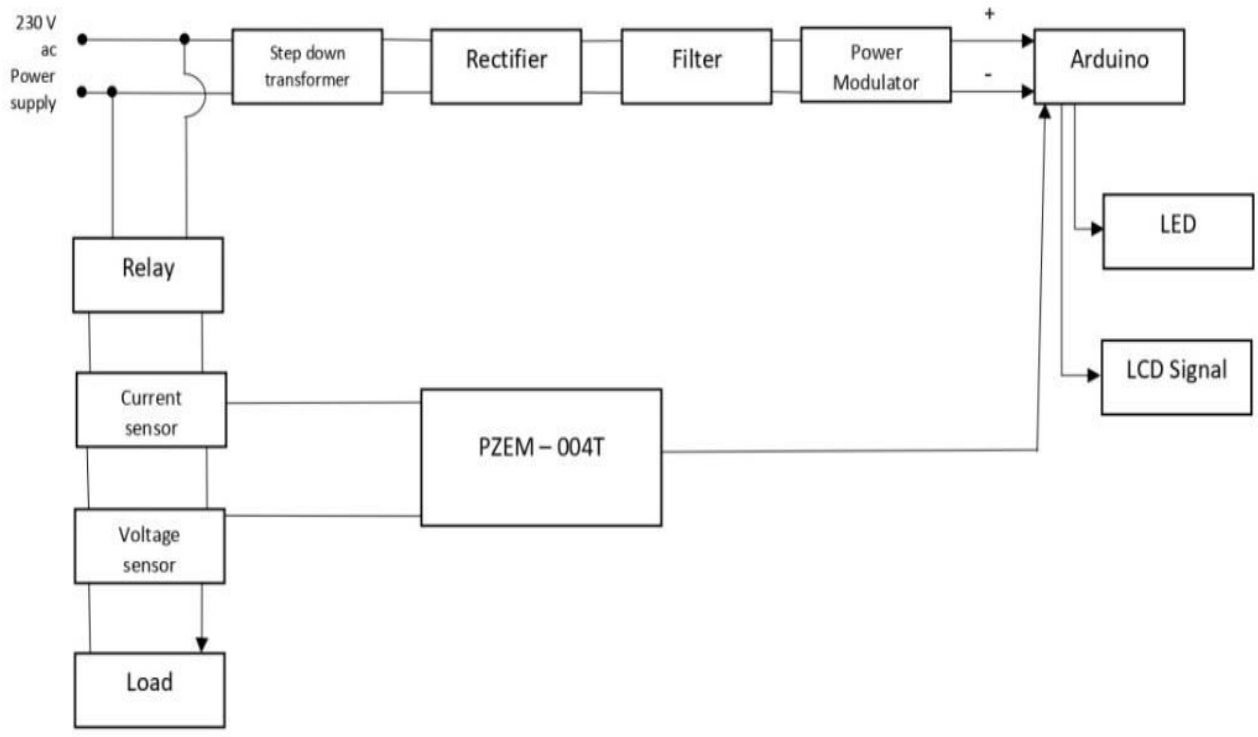

Fig. 1: Block diagram of the proposed methodology

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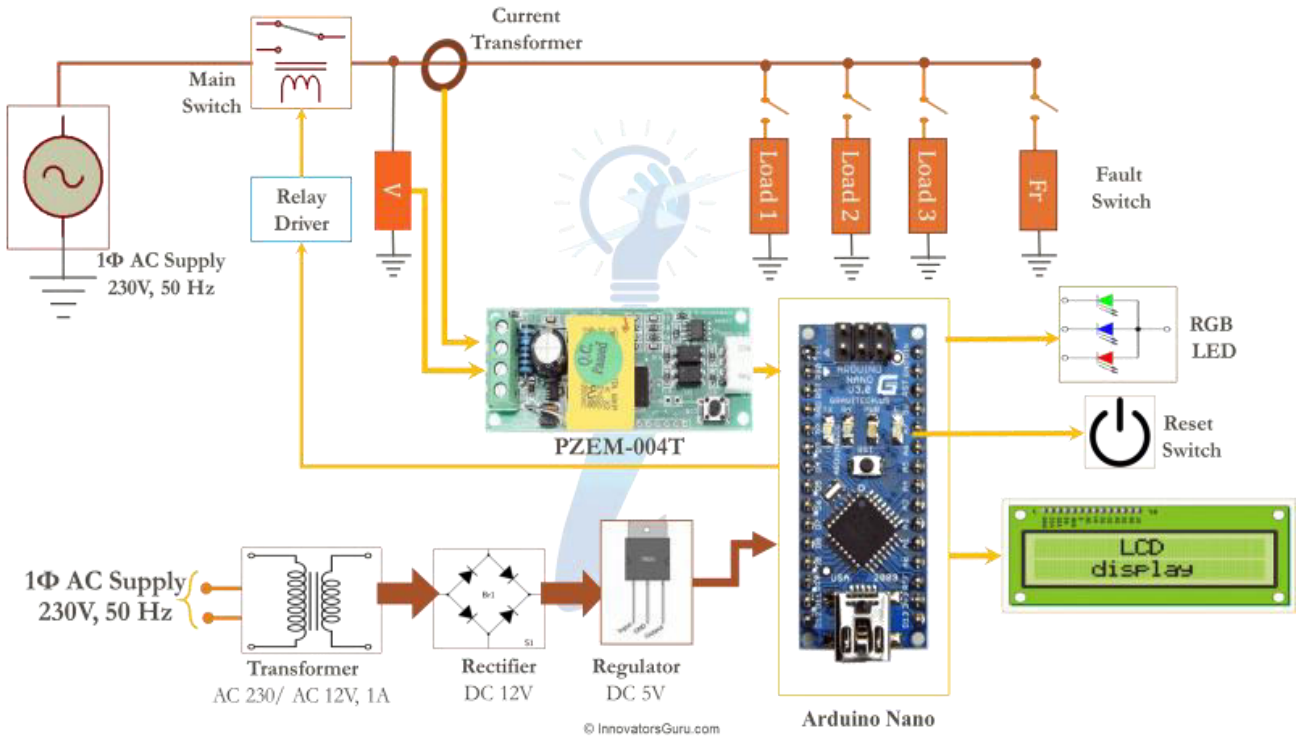

Fig. 2: Circuit diagram of the proposed methodology

2.1. Working Principle

AC Digital multifunction meter makes use of ARDUINO-NANO as microcontroller to read the input from an electronic module, PZEM-004T. The PZEM-004T works on 5V DC power supply. It is interfaced with Arduino Nano to read the parameters such as: voltage, current, power, power factor, energy and frequency and displays the same on16*2 LCD.
A single phase 230V AC supply is stepped down to 12V AC using transformer. The output voltage across the step down transformer is 12V AC, by tapping a 6V AC voltage is given as input to the bridge rectifier. The rectifier converts 6V AC to pulsating 6V DC supply. The filter capacitor is connected in parallel to the rectifier; it filters 6V DC ripple current in order to prevent noise and produces constant DC voltage. After receiving the input from the power modulator relay is used for high voltage or high current switching. The power modulator consists of regulator-7805, these regulator converts 6V DC to constant 5V DC. The function of power modulator is to divert the power from rectifier to the relay, microcontroller and LCD. Current sensor detects the electric current in the circuit and generates a signal proportional to the current. The PZEM -004T having the ability to measure electrical parameters such as voltage, current, power, energy, power factor and frequency, Measured parameters are directly transmitted with TTL serial interface with ARDUINO UNO board and displayed on 16*2 LCD. Arduino UNO is used to inter phase the hardware components with a Arduino IDE software. It reads the parameters from the PZEM-004T electronic module and passes to the LCD and serial monitor to display the result. This work is accomplished by loading embedded C-programming to Arduino software. The code is compiled for errors and then uploaded to the Arduino UNO board. Finally, the result is displayed on the serial monitor on the desktop. LED Indicate the working condition of the electric module and other components. After receiving the input from Arduino Uno, LCD displays the output. When the load is switched on, current starts flowing towards the load circuit. The current flowing in the load circuit is sensed by the current transformer and it is read by the PZEM-004T. The PZEM-004T in turn sends a command to Arduino in order to display the current flowing through the load circuit. Similarly, voltage is read by PZEM-004T and commands Arduino to display. Based on the current flowing and voltage across the load, the voltage, current, power, energy, frequency and power factor values are displayed.

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III. RESULTS AND DISCUSSION

Figure 4 shows the Practical Setup of the proposed work.

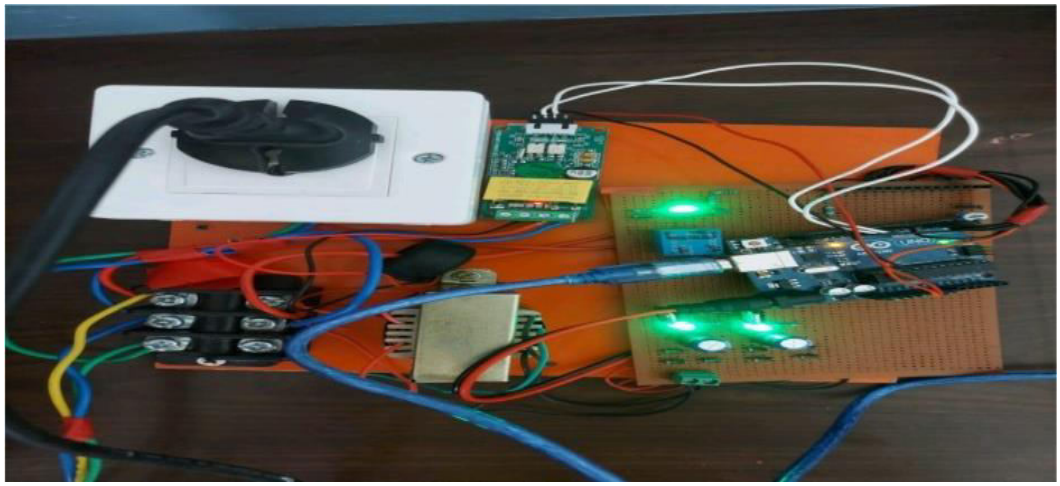

Fig. 4: Practical Setup of Proposed Work

3.1 Resistive load

Table 1, 2, 3, 4 and 5 gives the results of parameter values obtained for different considered resistive loading conditions, i.e. No load, 60W, 120W, 180W and 240W, respectively. It can be seen from tables that when the load is zero, the parameter values viz. the power and energy consumed by the load and load power factor value is displayed as zero whereas, when the load is varied in steps of 60W, the parameter values, viz. the power and energy consumed by the load also varies in a step manner as shown in the tables with unity load power factor, and the same is displayed on LCD.

Table 1: Without Load

Parameters	Output
Voltage	223.60V
Current	0.0A
Power	00.00W
Energy	0.00kWh
Frequency	50.0Hz
PF	0.00

Table 2: For 60W load

Parameters	Output
Voltage	223.60V
Current	0.27A
Power	63.80W
Energy	0.014kWh
Frequency	50.0Hz
PF	1.00

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Table 3: For 120W load

Parameters	Output
Voltage	223.60V
Current	0.54A
Power	127.70W
Energy	0.023kWh
Frequency	50.0Hz
PF	1.00

Table 4: For 180W load

Parameters	Output
Voltage	223.60V
Current	0.80A
Power	190.70W
Energy	0.045kWh
Frequency	50.0Hz
PF	1.00

Table 5: For 240W load

Parameters	Output
Voltage	223.40V
Current	1.07A
Power	254.30W
Energy	0.063kWh
Frequency	50.0Hz
PF	1.00

3.2 Inductive load

Also, table 6 and 7 gives the results of parameter values obtained for the without and with inductive loading conditions. It can be seen that under no load conditions (table 6) the power, energy consumed and power factor values of the load is zero, and that same is displayed as zero on LCD display. Whereas when the inductive load is applied the parameter values of power and energy consumed by the inductive load and corresponding power factor values are displayed on LCD as given in table 7.

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Table 6: Without load

Parameters	Output
Voltage	238.l0V
Current	0.0A
Power	0.00W
Energy	0.00kWh
Frequency	50.0Hz
PF	0.00

Table 7: With load

Parameters	Output
Voltage	233.10
Current	0.79
Power	121.90W
Energy	0.012kWh
Frequency	50.0Hz
PF	0.66

IV. CONCLUSION

The smart energy meter proposed reduces the human labor and also makes a more structural and organized method of electricity consumption and monitoring system. The over load and power theft detection also gives user security from unwanted treats. The daily limit gives the user more awareness about their energy consumption and helps them to reduce their overconsumption. Different meters are used for measuring different electrical parameters, but with the design of AC digital smart meter it helps to measure all the electrical parameters by using single unit. Thereby we can save the amount invested on different meters. Billing: The calculated data can be stored with the help of cloud storage and then can be analyzed and later on the consumers can be billed accordingly. As a scope for future work an android app can be created, which collects and stores the data through internet and hence, the user even being far can get the calculated parameter reading and also the status of load on his android mobile phone.

V. ACKNOWLEDGEMENT

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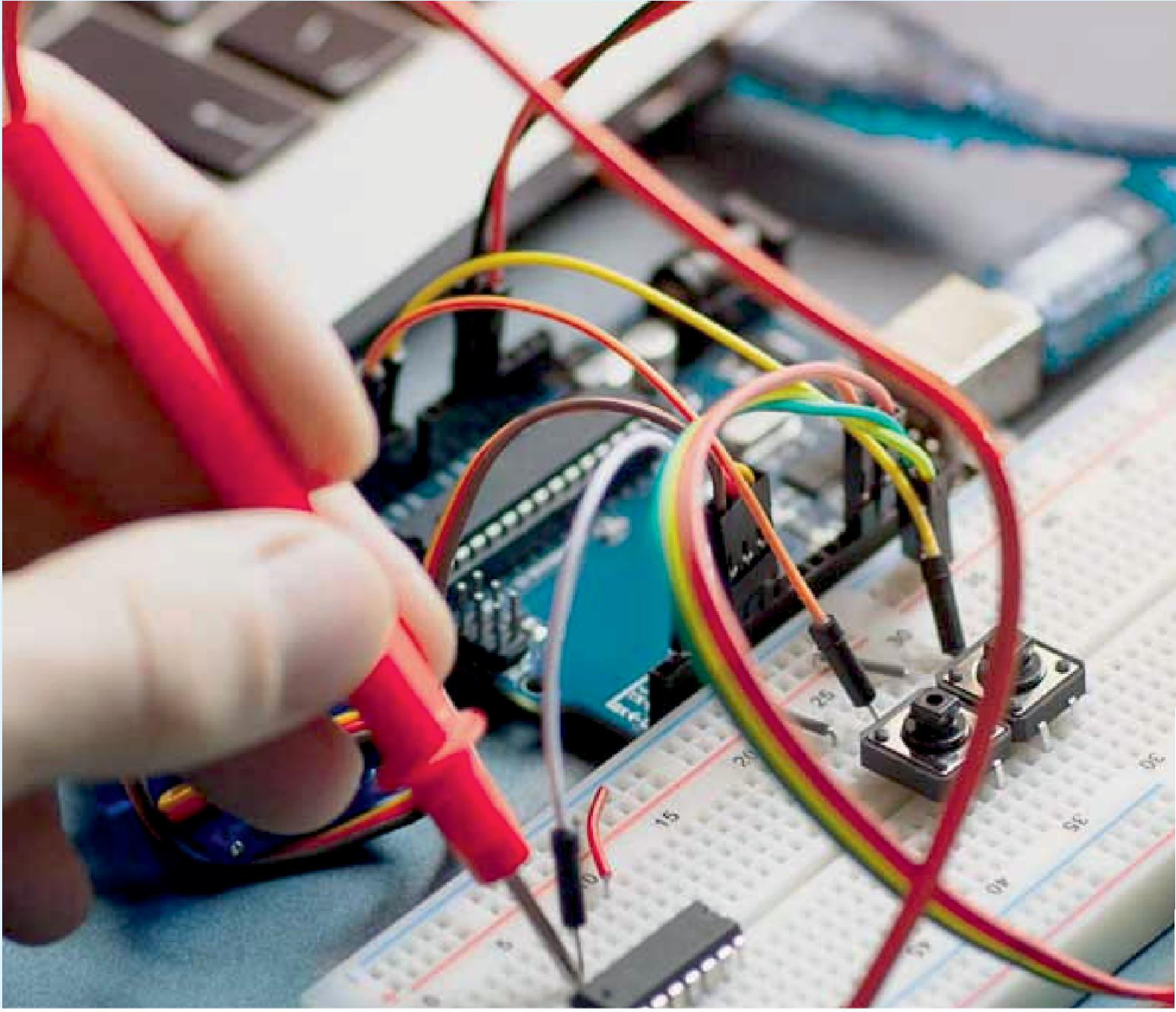

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