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IoT based Frequency and PF Measurement System

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ABSTRACT: This paper presents the IoT based frequency and power factor measurement system for vfd controlled induction motor. It is a continuous monitoring device which is very essential in today's drastically developing era of energy consumption with vastly varying load systems. Whatever is the type of load or nature of supply, the power factor and frequency must be in desirable limit for smooth operation of equipment and also for its longer life. This device continuously monitors the frequency of supply whether it is lying in acceptable limit and also keep an eye on the system power factor. This is very essential that it allow the user to turn on safety devices in case of any abnormality in supply avoiding the possible hazards to the equipment.

KEYWORDS: Frequency Monitoring, Power Factor Monitoring, Safety Of Equipment, vfd control

I. INTRODUCTION

This is the modification of the complex and cumbersome power system monitoring equipment that are available in market right now. The major simplification here that can be seen is it employs Arduino Atmega328 than other complex controllers. Anyone who is not familiar with Arduino programming, can be able to handle the device in short period of time. Arduino is much simpler to program. It is more forgiving, as well, to problems and mistakes in the wiring. It's more robust, so it's easier to set up. Here the device is intended to monitor two major parameters of vfd controlled three phase induction motor that are very essential when it comes to the quality of power supply. Those are power factor and frequency of the supply. Generally, it is assumed that grid voltage and frequency are independent of each other. But in fact, any kind of fault in power system can affect the supply voltage and frequency. This device alerts to the operator in case of any changes in the frequency beyond permissible value so that safety devices can be turned on. Another thing this system keeps an eye upon is the power factor of the system. It continuously provides the value of the power factor so that the best quality of supply is assured. For measurement of frequency, zero crossing method is employed. It is the simplest method to calculate frequency of any quantity as it measures the time period of the quantity as it passes through the zero. Then this measured quantity is reversed using Arduino because frequency is reciprocal of time. For measurement of power factor, again the measurement of time is essential. Here the time difference between the current wave and voltage wave is measured. This is nothing but the phase difference between two waves. The cosine of this quantity is taken using Arduino to calculate final power factor. All this data can be transferred, stored and used from anywhere using IoT. It allows the system to be operated remotely and it will maintain convenience eliminating confusion between different operators of the device. The overall system layout is shown in following figure.

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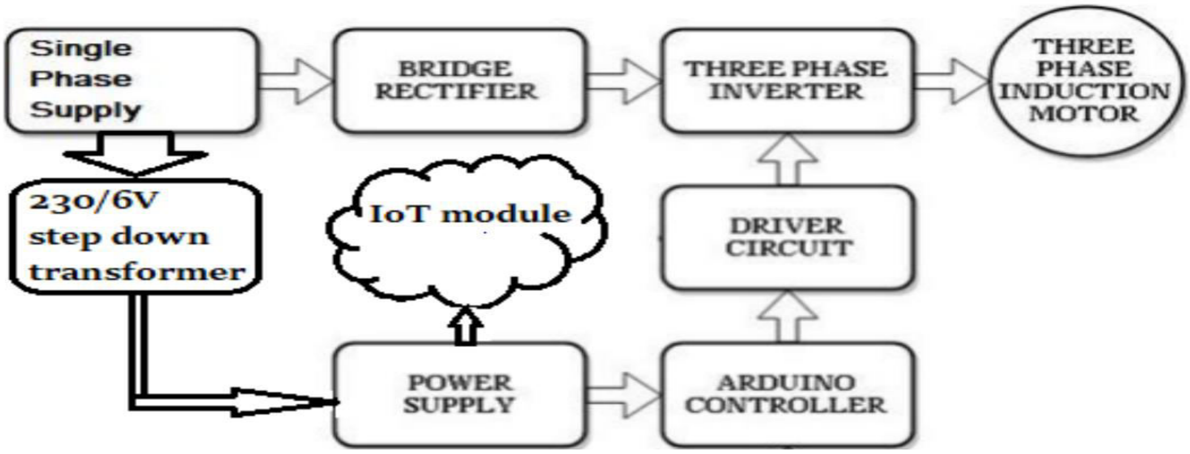

Fig 1: Block diagram for frequency and PF measurement

II. LITERATURE SURVEY

1) In paper "Measurement of low frequency signal of power grid using Arduino" Written by Mohd Firdaus bin Mohd Ab Halim, Mohamad Haniff Harun, Khalil Azha Mohd Annuar, Suziana Ahmad and Mohd Hanif Bin Che Hasan, the author explains how grid frequency monitoring is essential to the energy provider and its relevant stakeholder. Nowadays PMU provides the means to perform the grid frequency monitoring task. Monitoring the quality and reliability of the grid is also important to the consumer especially to the heavy industrial player because it uses large portion of the electricity for its activity. The data from the monitoring activity also helps liven research activities in energy transmission area. PMU user does not share the data publicly due to business reason. In Europe for instance, the energy is traded in daily basis. By having the data of demand and supply, it gives an upper hand to these traders usually TSO's company and energy provider over its competitor. In Malaysia the energy is not traded and supply - demand balancing is managed solely by Tenaga Nasional.
2) Development of Power Factor Meter using Arduino First Teddy Surya Gunawan, Muhamad Hadzir Anuar, Mira Kartiwi, Zuriati Janin. This paper has presented the development of power factor meter using Arduino. To measure the current, a non-invasive current sensor was used for ease of installation. The accuracy of the selected sensor was calibrated using the manual ammeter, in which the difference is around ±1.79%. Further research includes experiments on various electrical appliances, data logging, and automatic power factor improvement using selected switch on parallel connected capacitor bank.
3) Shodhganga.com From this research website I learned about the basic frequency measurement method i.e. zero crossing method. Then I implemented it into my project.
4) Comparative analysis between ACS800 VFD and conventional DTC using different speed estimation methods to control, by Anas Wael Nassar Direct torque control is one of the methods that has been introduced in research in mid-eighties and implemented in early nineties. Among several developed methods, DTC is very simple to implement and it has a very fast transient response and an accurate steady state performance. ABB has developed several drives which integrate the DTC with adaptive state estimation and parameter identification techniques. ACS800 is one of the most developed and widely used sensor less drives based on DTC and over the years it has proven robust and accurate performance. In this research work, the simulation of IM controlled through a sensor less DTC has been carried out for different loading conditions and using three different adaptive estimation techniques. The same IM has been connected to ACS800 and the performance of ACS800 has been monitored and analysed. The performance of both, the simulation and the ACS800 drive have been compared and evaluated. The effect of each estimation method on DTC performance has been determined and the choice is made on which method the most is recommended to be adopted in commercial drive.
5) "THREE PHASE INDUCTION MOTOR CONTROL BY VFD" By Ms. Puja Vilas Patil and Dr. S. A. NAVEED In this paper the author has presented a simple method of controlling the speed of three phase induction motor using VFD. Here the speed control is mainly emphasised. No monitoring is provided.

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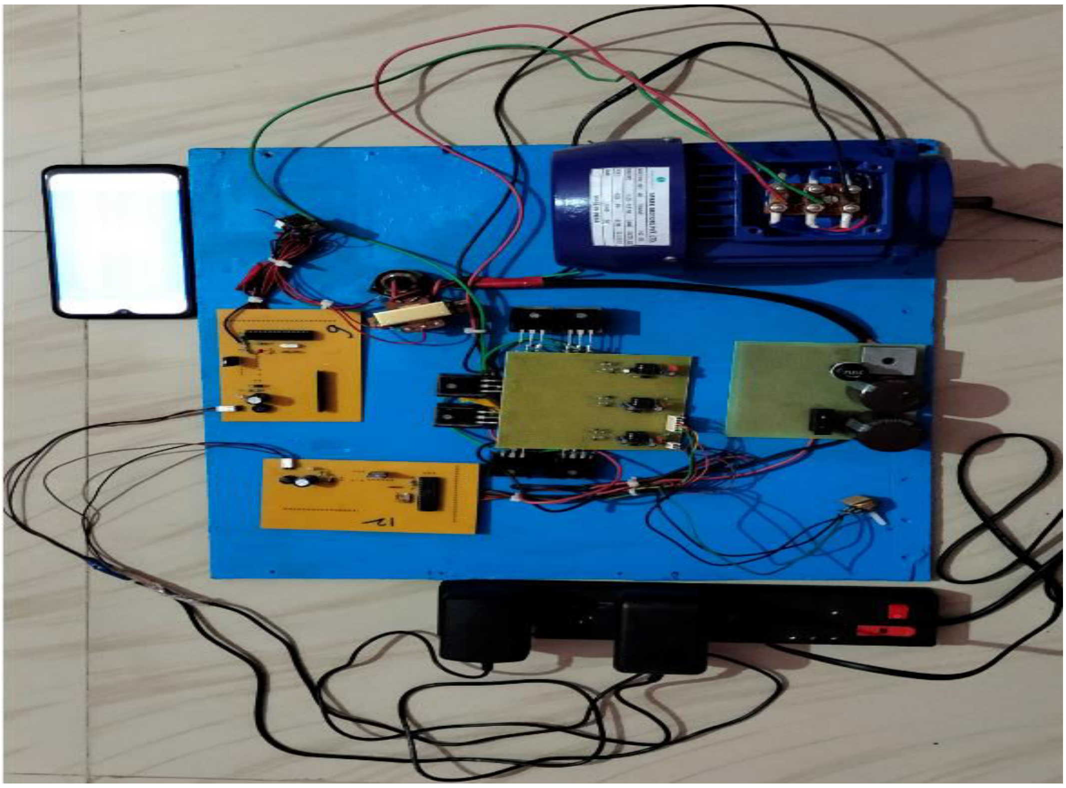

Fig. 2: Hardware Implementation For Corresponding System

1. Frequency Measurement: Frequency is measured at input of VFD on 12V board. Pass one of the input signal out of three phases through a low pass filter such that all the higher order harmonics present in the input signal are eliminated. The voltage is already brought down to 6V. This signal is now fed to the inverting pin of a 741 Op-Amp (operational amplifier). To the non-inverting pin of the 741 Op-amp, give a DC signal of magnitude less than 5V. Adjust the output by feeding the AC and the DC signals individually so that the net signal obtained at the output terminal of the 741 op-amp is: $V_o = 2.5 + 2.5\sin(\omega t)$. The voltage thus varies sinusoidal between 0 to 5V and can be safely given to the analog pin of the micro-controller.
2. Power factor: Power factor is measured on the 9V board. First of all, with the use of current transformer and potential transformer, the incoming current and voltage are stepped down suitable for electronic components which is our ATmega 328 controller. Arduino measures the time difference between current waveform and voltage waveform. The time difference between current wave form and voltage wave form is basically, a phase difference between two waves. This phase difference is used to calculate power factor with the help cos function that is cos (phase difference). 5V supply is taken from step down transformer and ACS 712 is used for current sensing.
3. VFD controller: The converter converts three-phase AC supply into DC hence the DC supply after a filter is connected to the inverter where the frequency of the output is controlled. This controlled supply is connected to the motor for controlling. The feedback is given from inverter to converter to control the output of inverter with desire change in the frequency of output supply. The system is controller driven and Arduino is used for developing the system control effectively.

III. RESULT

As we turn the knob of potentiometer, motor speed varies. Generally motor is started on the full rated frequency i.e. 50Hz. At this rated frequency, the full voltage of 230V is applied to the stator of motor. As we begin to vary the frequency the voltage varies proportionally as shown in the graph below.

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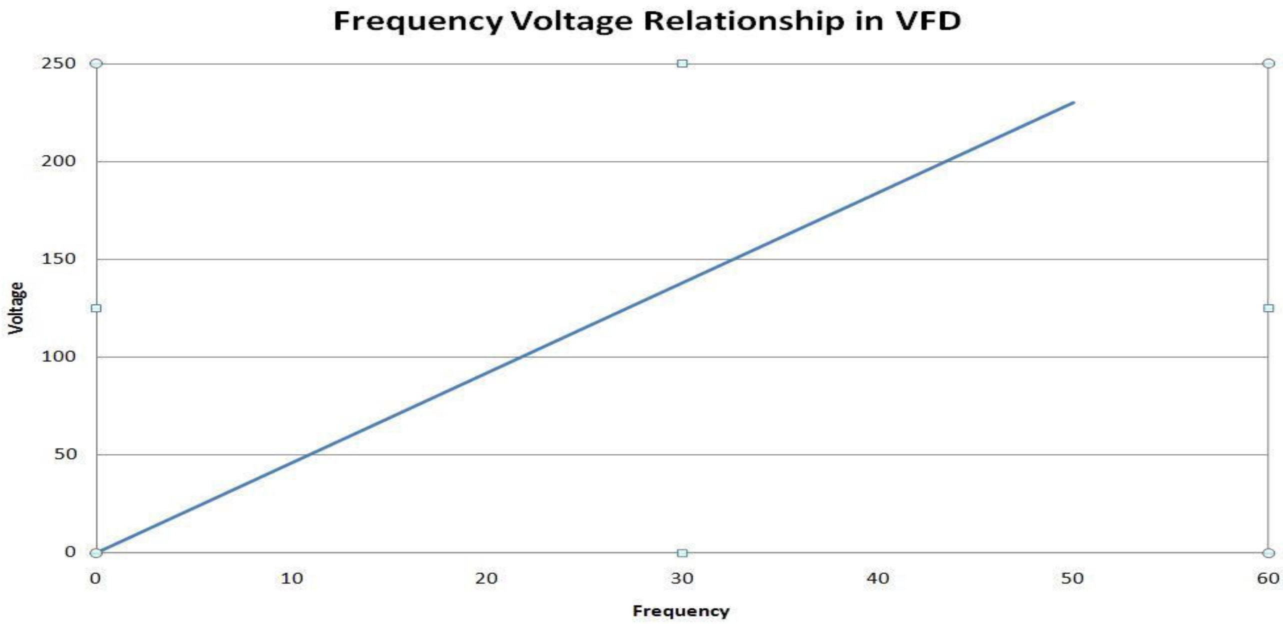
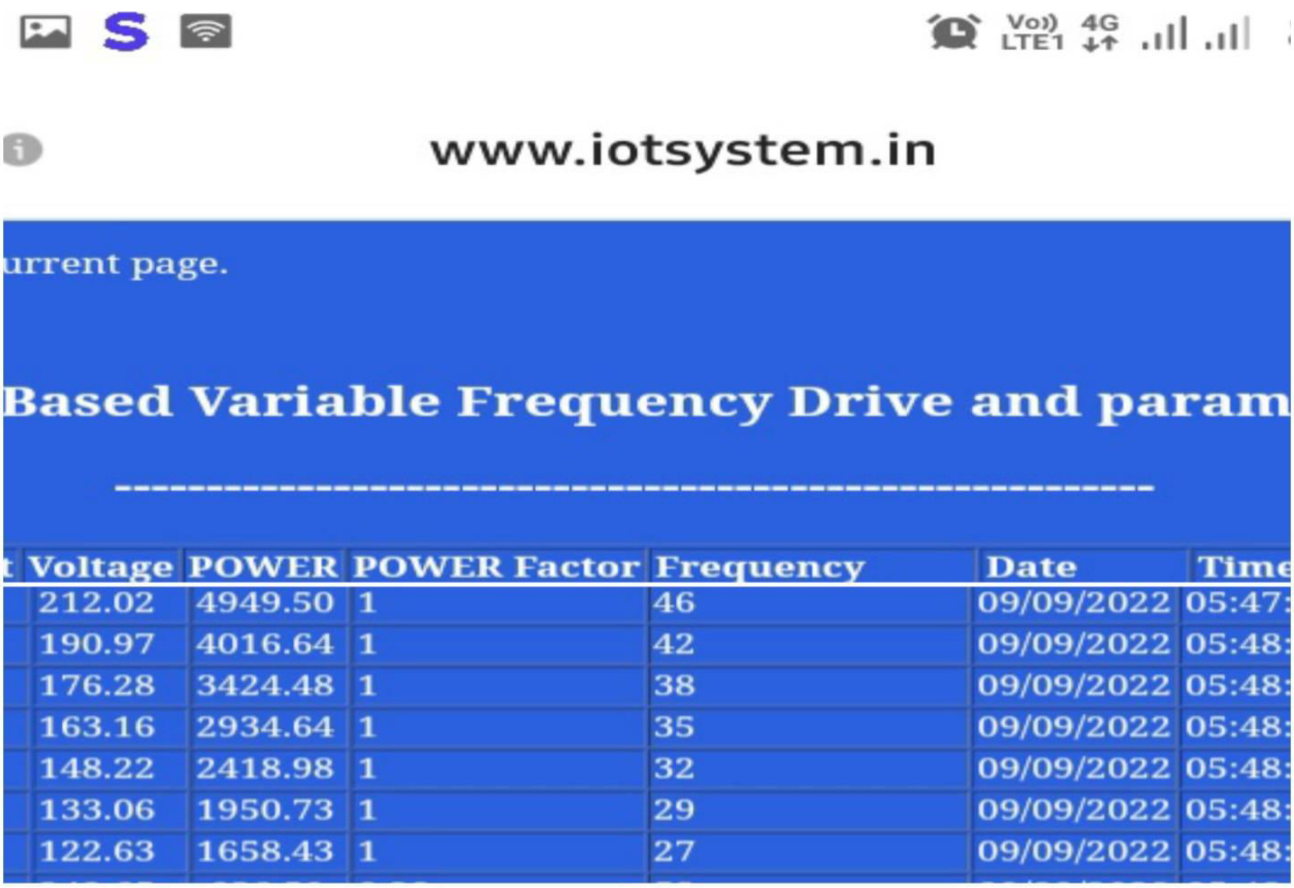


Fig 3: Frequency Voltage Relationship in VFD

As we know, DC link used in hardware aids in improvement of power factor. So power factor is always healthy nearly 1. The continuously measured frequency and PF is updated on the portal in a form of chart as shown below.



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Based Variable Frequency Drive and param

Voltage	POWER	POWER Factor	Frequency	Date	Time
212.02	4949.50	1	46	09/09/2022	05:47:
190.97	4016.64	1	42	09/09/2022	05:48:
176.28	3424.48	1	38	09/09/2022	05:48:
163.16	2934.64	1	35	09/09/2022	05:48:
148.22	2418.98	1	32	09/09/2022	05:48:
133.06	1950.73	1	29	09/09/2022	05:48:
122.63	1658.43	1	27	09/09/2022	05:48:

Fig 4: Real time values of continuously measured PF and Frequency

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IV. CONCLUSION

Induction motors are used in about 80% of industrial applications. The characteristics of these motors make them useful for various applications. The variation of torque to control the speed was implemented by many researchers. Another approach to keep the torque constant and control the speed of the motor is possible with the help of variation in the frequency of supply achieved with a variable frequency drive. The model consists of the converters which convert the supply from AC to DC and vice versa. Also, when supply itself is being modified it becomes very necessary to continuously monitor the supply frequency and load power factor. Zero crossing method is simpler to implement and can be implemented where only measurement is required and not for protection system. IOT based frequency and PF measurement system is highly accurate system. This continuously monitors the power quality through frequency and PF measurement and stores the data at easily accessible universal portal. The loads under observation can be easily changed making this device perfect for experimental purposes. This system is accurate than conventional frequency meters. Unlike analogue and digital frequency meters its readings are not affected by warming of instrument. This is very easy to install and use. High voltage is stepped down using transformer also the harmonics are eliminated hence no external means for conditioning power supply are needed. Frequency measurement using zero crossing conditions works effective during sinusoidal conditions and is prone to error under multiple zero crossings, harmonics and sub-harmonic conditions. The time required to compute the frequency is more than one cycle.

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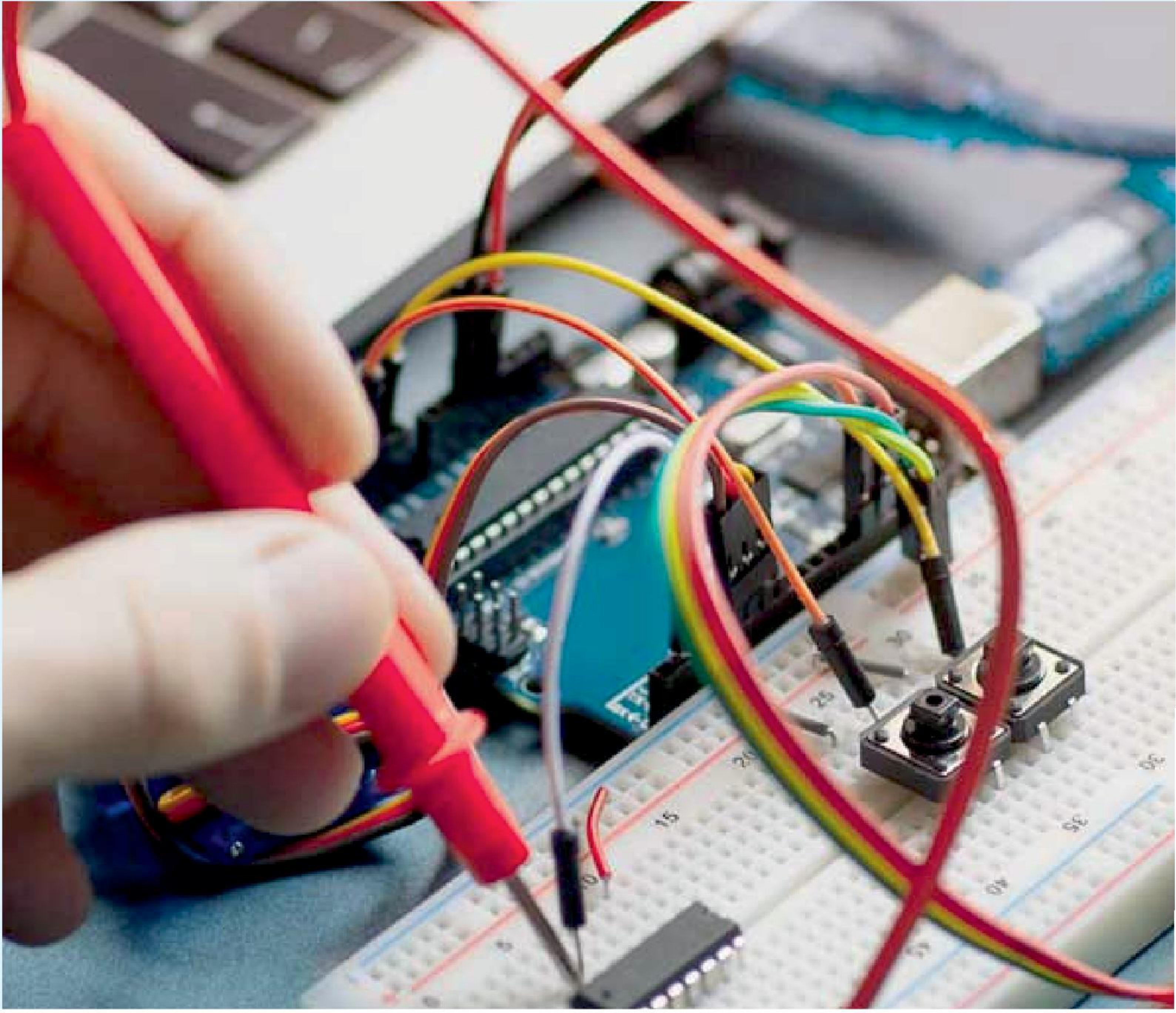

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