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Microcontroller Based Industrial Switchgear Protection System

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ABSTRACT: The main intention of this paper is to design Arduino based system that can be used in power protection the system checks the operating parameters of the System i.e. current and reports the quantity that is flowing through the system. The system is designed such that it is able to detect currents above the normal acceptable level and isolate the system power from the distribution line. This isolation process is to ensure that the system is safe from any excess current levels that can make it to overheat thus get damaged. It gives a solution to the need to reduce cost of maintenance and ensure that system is protected and interrupted for long periods.

KEYWORDS: Transformer protection, Arduino, Current Sensor, SMPS

I. INTRODUCTION

In the design of electrical power transmission and distribution system, there are various factors that need to be considered in the quest to satisfy the needs of electricity consumers. Electrical power systems experience faults at various times due to various reasons. These faults must be foreseen and safety precautions applied to the power system. Power system protection is very essential and necessary for a dependable electrical power supply. It ensures that the system is protected from itself and that the consumer is also safe as he benefits from the electrical power supply. An electrical power system consists of various components such as generators, switches, transmission cables, transformers, capacitor banks among other components. It cannot therefore operate without an effective protective device to keep these components safe and the system stable. Faults in a power system refer to the undesired conditions that occur in the electrical power system. These conditions may include short circuit, over current, overvoltage, high temperatures among others. An increase in load leads to a lot of current drawn from the power line. Every transformer is designed to comfortably supply a given load. Cases of overload or short circuits can lead to transformer being damaged. To combat such occurrence, an elaborate system that monitors these excesses in supply parameters needs to be built. Such a device controls the flow of electrical power to the load so that the transformer is not overworked. Over current relays and overvoltage relays have been used for a long period of time and have been electromechanically controlled. In this system, a microcontroller is used to monitor cases of electrical faults and communicate to a switch to isolate the transformer from the system.

Sridevi P., et al. [1] measured power and energy of electrical systems with Arduino. They utilized offset current and voltage conditioning cards to feed output values from current and potential transformers and the conditioned output values were fed to an Arduino which in turn measured power using sketches when interfaced with a personal computer. The tests were done on resistive, inductive, capacitive loads and also on lamp loads of 200 W rating. Naseem, Adil, and Naveed Alam [2] implemented a protection scheme of distribution transformers to offer protection from malfunctions arising out due to overloading currents, high voltage spikes and over- heating of transformer oil. They utilized Arduino Uno as the preferred microcontroller and it yielded favourable results with elevated sensitivity and accuracy. Bhat, Aakanksha, et al. [3] proposed an integrated architecture to offer automation in measurement of power using Arduino Uno and Raspberry Pi. The proposed system could detect abnormal power usage, analyze power consumption and monitor load and health of electrical appliances. Titu Bhowmick, Dharmasa, [4] proposed an electrical protection scheme for a solar power system using Arduino. The proposed setup used a 115V/15V transformer; a 50 W variable rheostat; an electro-mechanical relay and low burden electronic current sensors (ACS712). The author validated the proposed prototype model by creating a fault using the variable rheostat as load and investigated the efficiency to

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obtain accurate results on both internal and external faults. It was further concluded that the scheme was energy efficient. Thus, Arduino Uno microcontroller has been preferred for this proposed protection scheme [5-7].

II. OBJECTIVE

Power system protection is a very important consideration in the design of an electrical power system. There is need to protect electrical power components from dangerous faults. This is warranted by the need to increase the life of the components, avoid unnecessary expenditure in frequent replacement of obsolete components and to ensure that there is a continuous supply of power to serve the needs of the ever growing economy. This project therefore seeks to design a microcontroller based system that will intelligently monitor faults and prompt a safety measure to protect the power transformer in case of power overload. The extent of the work is to build a device that detects current spikes/overload in the primary and secondary sides of a single phase transformer and isolate it from the power system.

III. PROPOSED SYSTEM

PROPOSED SYSTEM

In proposed system Arduino based system will intelligently monitor faults and prompt a safety measure to protect the system case of power overload. A device must be designed to cut off consumption if the system oversteps its ability thus being dangerous to users and the components. In this paper, we look at the protection of system from various faults that may occur and may be destructive to the component if left undetected.

Basic block diagram of whole model as shown in figure 1. The functions of each block or device which are used in this methodology for the protection purposed are explained below.

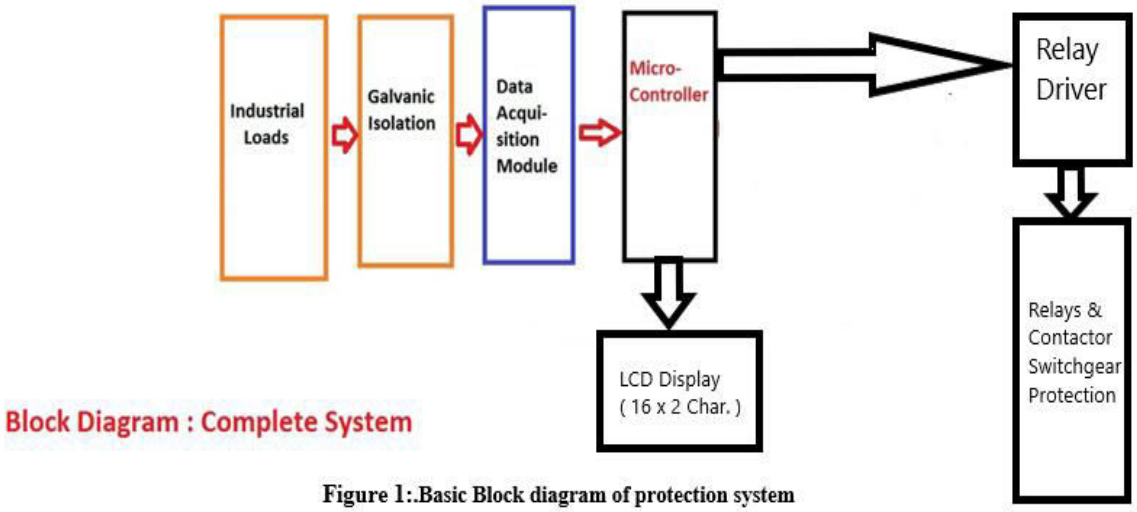

Figure 1:.Basic Block diagram of protection system

MAIN COMPONENTS OF PROTECTION SYSTEM:

1.RELAY: The function of relay is to disconnect the supply when the faulty condition is happened. The relay circuit is connected to Arduino Board with using of opto-coupler (pc817). Opto-coupler is used for protects the microcontroller from high voltage spikes and the isolation purpose. The transistor is used in relay circuit to operate the relay. The output of Arduino become high, the relay circuit will operate and trips the load. In this project 16Amp PLA MPR2C 24 relay is used.

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Figure 2: Relay

Relay Specifications:

Table 1

Sr.No.	Particulars	Specifications
1	Contact rating	16 Amps Resistive At 24 VDC/250VAC
2	Typical Life Expectancy	10^5 operations
3	Contact material	Silver alloy
4	Initial Contact Resistance	0.050 ohms (max)
5	Ambient Temperature	-40^0 C to $+70^0$ C
6	Di-electric Strength	2 KV between contacts or coil to ground
7	Insulation resistance	100 Meg. Ohms min at 500 V DC at 27^0C &65% RH
8	Operate time	0.025sec. at nominal voltage
9	Release time	0.015sec. at nominal voltage
10	Max. Weight	80 gms

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2. **CONTACTOR:**When a relay is used to switch a large amount of electrical power through its contacts, it is referred to as a contactor.Contactorsbasicallyhaveseveralcontacts,andwhichareusually (but not always) normally-open, so that power to theload isshutoffwhenthecoilisde-energized.3TF power contactors are suitable for switching and controlling squirrel cage and slip-ring motors as well as other AC loads, such as solenoids, capacitors, lighting loads, heating loads and transformer loads.

Figure 3: Power contactor

Power Contractor Specifications:

Table 2

Sr.No.	Particulars	Specifications
1	Standards	IS/IEC 60947-5-1
2	Rated Operational Voltage	690V
3	Rated Impulsive withstand voltage	8kv
4	Permissible ambient temp.	-50 to +80^{0}c -25 to +55^{0}c
5	Mechanical endurance cycles	30mill
6	Rated operating current le/AC 12	16A
7	Coil Voltage tolerance	0.8 to 1.1
8	Frequency of operation at AC15/DC13duty	3600
9	Rated operating current le/AC15/AC14 at operating voltage 230 V 415V 690V	 10A 4A 2A
10	Short circuit protection HRC fuse links Miniature circuit breaker	 16A 16A
11	Degree of protection	IP 20

5)LCD:LCD is used to show all result on screen. Most common LCDs connected to the microcontrollers are 16x2 and 20x2 displays. In research 16pin (LMB162AFC) LCD is used to display the parameters of transformer such as voltage, current and temperature. Arduino Platform communicates with the LCD using serial communication protocol.

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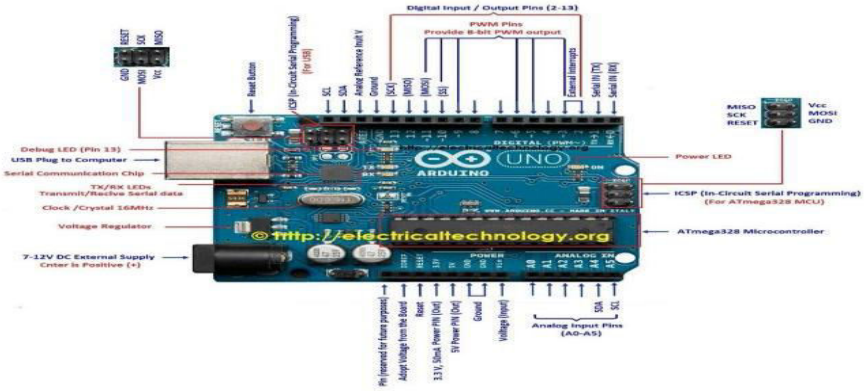
3. ARDUINO KIT: Arduino Uno is used for implementing the digital controller. Arduino Uno is an AVR based upon microcontroller board. It has ATmega328 microcontroller and other on board peripherals including 16 MHz crystal. Programming is done in C language. Detailed Arduino board diagram is shown in figure 4.



Figure

Microcontroller ATmega328: Specifications
Table 3

Sr.No.	Particulars	specification
1	Operating voltage	5V
2	Input voltage	7V-12V
3	Input voltage limit	6V-20V
4	Digital I/O pins	14 (6- PWM output)
5	Analog input pins	6
6	DC current I/O pins	40mA
7	DC current 3.3vpin	50mA
8	Flash memory	32kb
9	SRAM	2kb
10	EPROM	1kb

4. SMPS SPECIFICATIONS:

Table 4

eSr. No.	Particulars	Specifications
1	Input Voltage Range AC	160-290V AC
2	Input Voltage Range DC	20-425V DC
3	Input Frequency	40-60 Hz
4	Output voltage adjustment	+- 10%
5	Inrush current	30Amps
6	Efficiency @full load & 230 V AC Input	>85%
7	Hold-up time	20msec
8	Operating Temperature	0 TO 50^0c
9	Leakage current	<2A at 230 vac
10	Line Regulation	<1%
11	Load regulation	<1%
12	Ripple and noise	150mv p-p
13	Isolation between: Input & Output Input & Earth Output &Earth	 3000V AC 3000V AC 1500V AC

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IV. RESULTS

Experiments were conducted on a resistive element and a lamp load. A photograph ofthecircuit beforetheconnection oftheloads is shown herein:

In this, we have used wood board to mount the whole circuitry and devices like, Arduino kit, current sensor, voltage sensor, LCD. Also, used one extension board to give the supply easily.

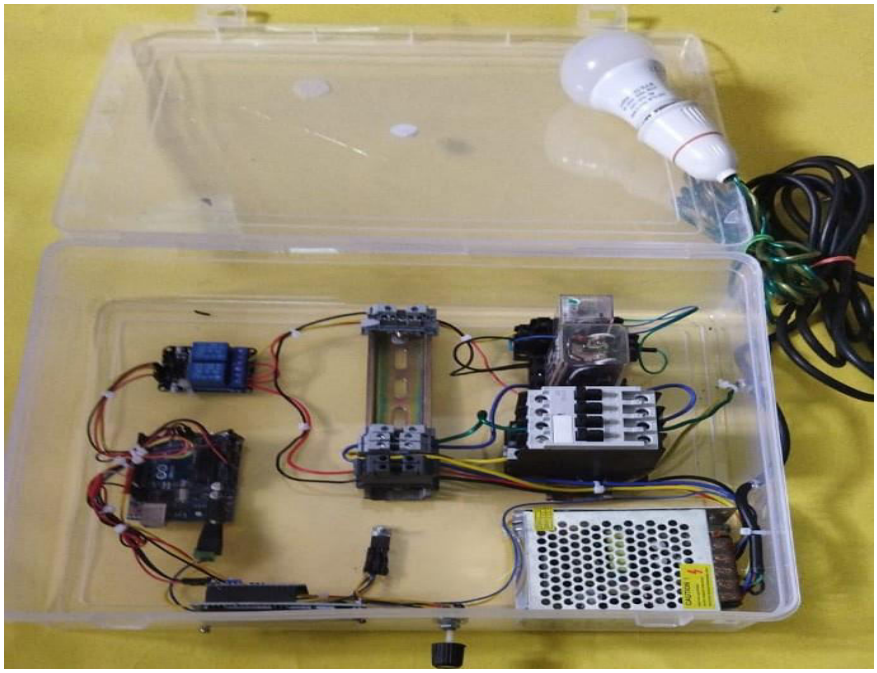

Figure.5 Experimental Setup

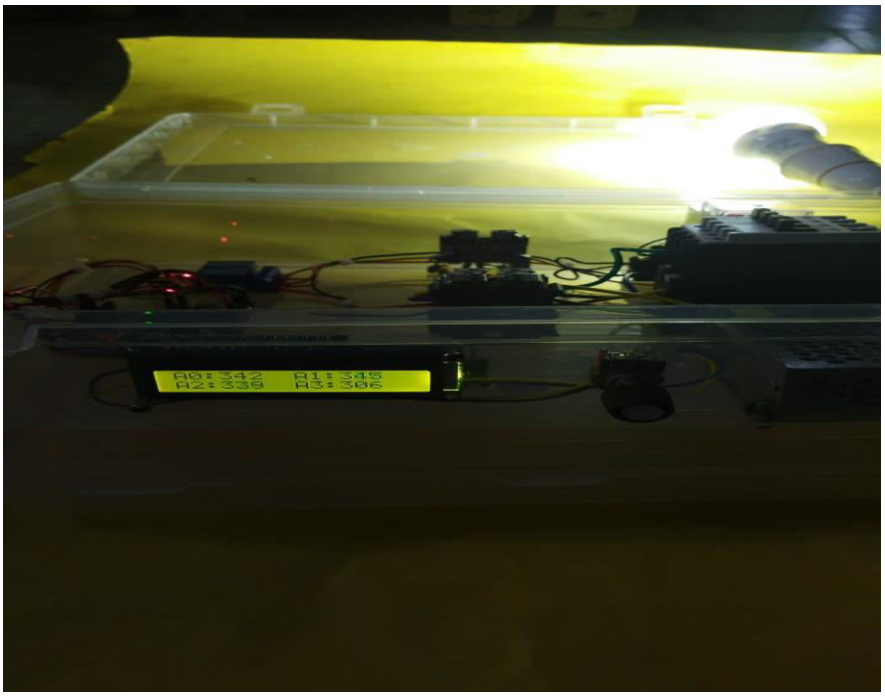

Figure.6 Experimental Setup (when Load is below the Threshold Level: Set Value on)

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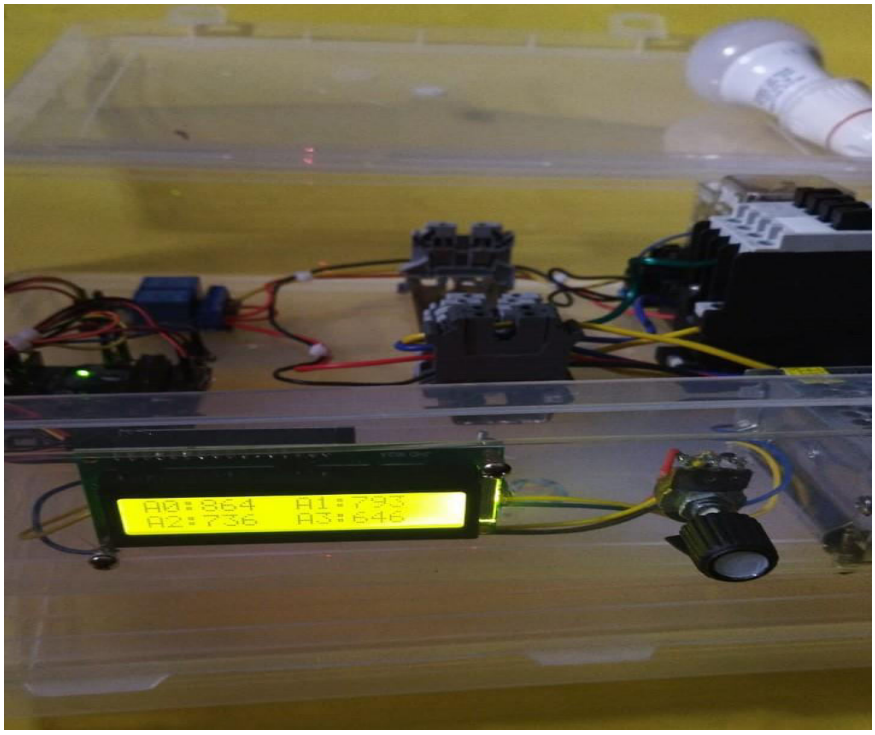

Figure.7 Experimental Setup (when Load is more than the Threshold Level: Set Value Off)

V. OBSERVATIONS

When the rating of current and voltage reaches its defined threshold value, then the load is cut-off. If current or voltage exceeds its defined limits then load would be cut-off and bulb would be turn OFF. Testing results are as given below.

Table 5 : Effect of Load Variation

Sr.No.	Current	Load
1	$> 793\ A$	OFF
2	$<343A$	ON

VI. CONCLUSION

In this paper we can, calculate the current flowing through the circuit and analysed it. To measure the exact current but it is not used in the experimental setup. But its simulated value with DC Voltage Stimulus, proportional to the Load Current is displayed on the LCD display. In the Experimental Setup, the Load Current is simulated by incorporating stimulus using Potentiometer, which delivers Variable DC Voltage, which is a Function of Load Current, and is given to read the same Load current Function through Analog Input Channel of Arduino Board. The relay is used for tripping operation. When the fault occurs due to overloading or over voltages then microcontroller will energies the relay coil to trip the circuit thus protects the transformer and Electrical Circuitry in the Industrial Environment.

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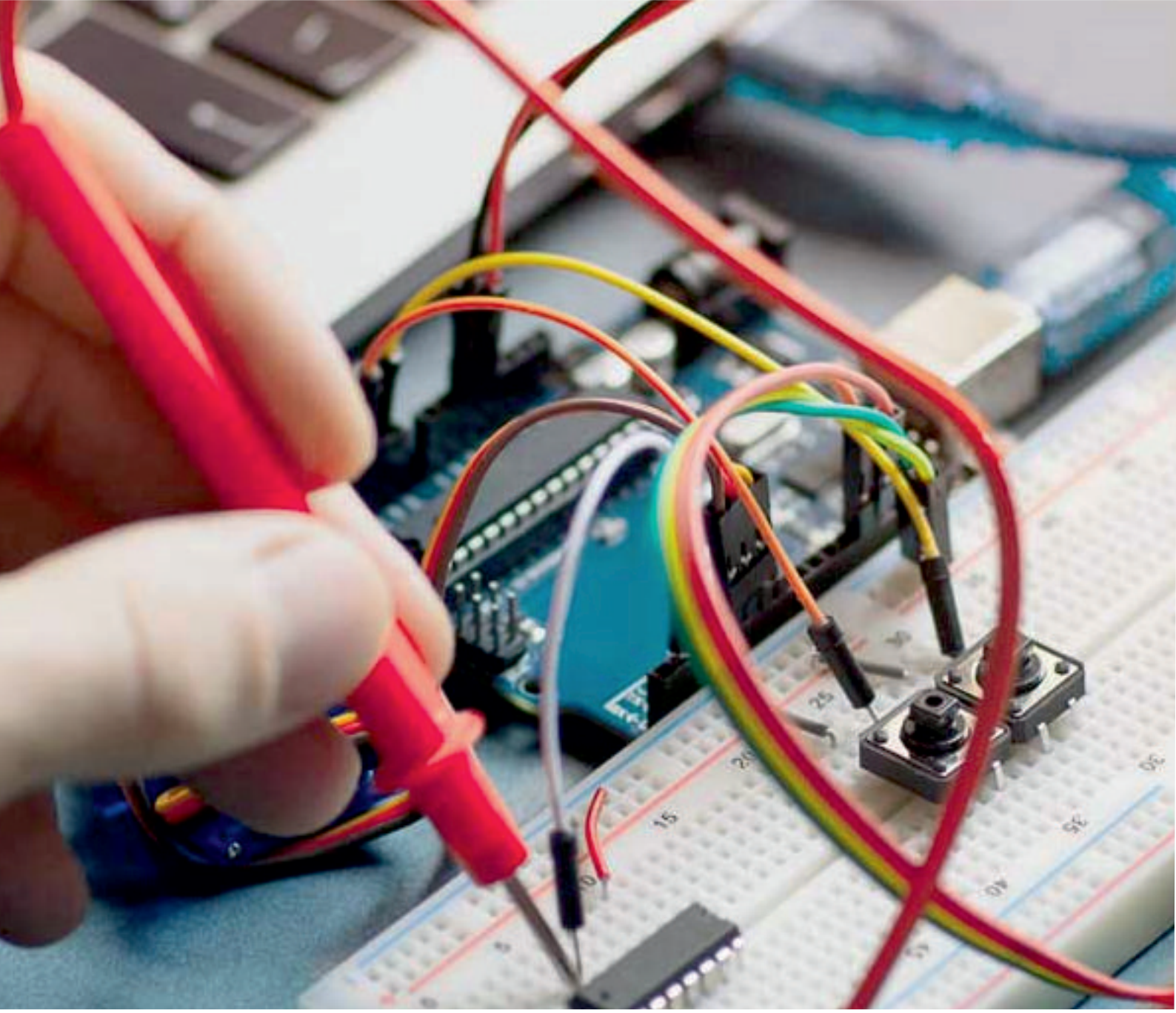

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