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Analysis of Single Phase to Three Phase Converter for Small Capacity Three Phase Induction Motor Drives

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ABSTRACT: This paper addresses new single-phase starting techniques of a three phase induction motor. Three-phase induction motors operating with a single phase ac supply are not self starting of their own, hence an external device must be used to get them started. The former starting technique with capacitor is often used. So, this system proposed a simple and low cost single-phase to three-phase converter using SVPWM control in order to start up a three phase induction motor operating with a single-phase ac supply. PWM has been a very popular technique used in Ac motor control but it produces relatively high harmonic distortion in supply. Where Space vector Pulse width modulation (SVPWM) is more sophisticated technique for generating a fundamental sine wave that provides a higher voltage to motor along with sinusoidal PWM control technique. The effectiveness of the proposed starting method will be verified by experimental results. The goal of this system is to provide a complete range on the status of single phase to three phase power conversion technologies.

KEYWORDS: Converter, rectifier, inverter, IGBT, ph.(phase)

I.INTRODUCTION

3 phase power is often used form of electrical power supply for large electrical installations. a three phase power is usually installed in commercial & industrial buildings but does not installed in small and domestic buildings. A electrical equipment that consume larger amounts of current such as air conditioners, heaters, motors, pumps, farming equipment and heavy machinery require a three phase power supply. Nowadays, the industrial machine that operates in three phase power is often available on market at very attractive prices for small entrepreneurs. The greatest obstacle for these potential buyers to purchase the machines for their industrial used is the unavailability of a three phase power at their premises or workshops. Power consume at local place do not install three phase power because they must needs a higher cost than single phase installation. Power distributing authority will be charge higher fee for a three phase service because of extra equipment for transformer, metering & extra transmission wire. There is certain circumstance that due to location factors, the local power utilities will not entertain any suggestion for additional lines to their unserved location especially in rural areas.

In previously existing1 ph. to 3 ph. converter is blinded to use of capacitors & reactors along withautotransformer converters. this system having high cost & less efficient, so to avoid this power electronics components are used. For initial state of solid state power electronics devices, these were normally used as switches and were the major technology used for power processor. Apart from power switches different circuit terminology were invented with use of power electronics devices for example three-phase to three-phase, single phase to single phase & three-phase to single phase conversion systems. There are few rural areas in that single phase supply is only available, so therefore it is very tedious job to get a three phase supply for industrial purpose therefore it is better to convert single phase to three phase converter. This system state an alternative option for phase conversion with less cost, mediocre performance at start up& high steady-state performance at line frequency. Such system suitable for according to requirements in rural areas where only a single-phase supply is available.

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II SYSTEM DESIGN

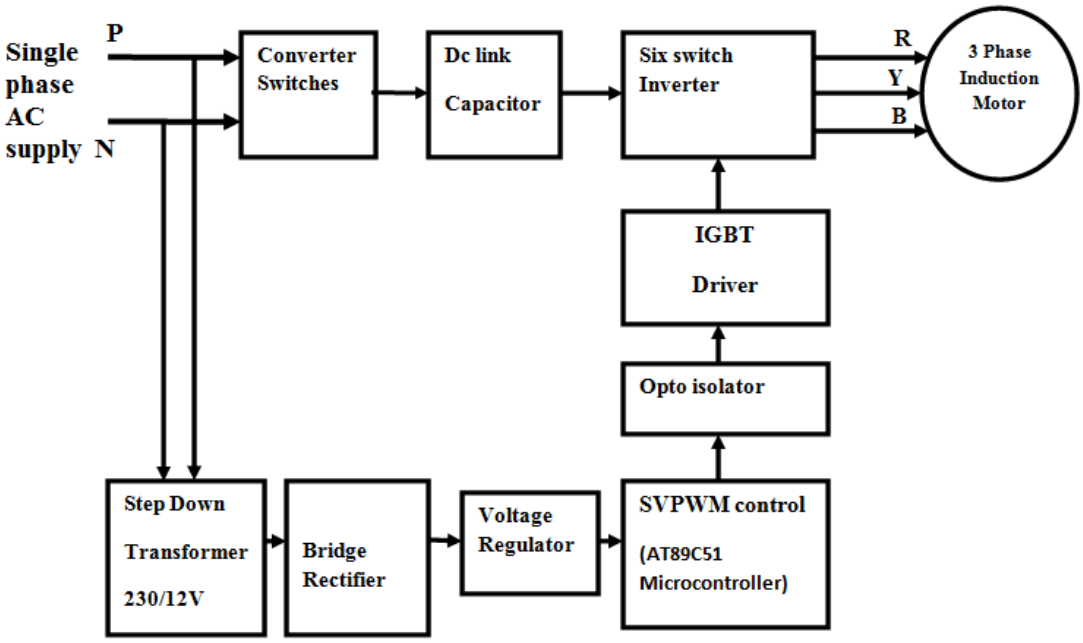

Fig.1. Block diagram of proposed system

Working of Hardware Development:

As shown in above fig 1.block diagram that the single phase 230V AC input voltage supply is given to the input of the rectifier the and the rectifier circuit will convert the single phase AC to DC. Such filter is attached to decrease harmonics present in AC and gives pure DC, fuse is connected to protect circuit &resistor is connected to limit current.

Each gate of IGBTs is connected to of microcontroller AT89C51. Three ph. inverter in which fundamental sine wave is analysed to develop pulse width modulated signals so generated due to execution of a program written in microcontroller. In microcontroller AT89C51 the embedded program of SVPWM is loaded and which drives the IGBTs . Given output is send to a set of six opto-isolators, U1 to U6 (MCT2E) from one of ports of the MC i.e., PORT-0 from pin no. 34 to 39. Objective of using opto-isolator is to achieve galvanic isolation between the low voltage control circuit to the high voltage power circuits comprising of six no's of power switches such as IGBT s Q1 to Q6 (IRF730), 3 for top bank & balance 3 for bottom bank. Snubber circuits comprising of resistors (R21-R26), diodes (D25-D30) & capacitors (C11-C16) are provided across drain, source of each of the IGBT to take care of inductive loads. At bottom bank source of IGBT has ground reference. Therefore driving them through control signal is easy. Driving top three it is tedious as it not having ground reference. In order to overcome such problem 3 no's of driver ICs U7, U8, U9 (IR2101) are used, for each driver handling a pair of power switches in complementary mode to make sure that both of the power switches do not conduct simultaneously (for e.g. Q1 and Q4) which would otherwise cause a short circuit of the DC power fed to the bank. Boot strap capacitors C5, C7 & C9 in combination with D1, D2 & D3 of the circuit, Space Vector pulse width modulation 2 of 3 take care of the control supply source of the 3 top power switches. It keep restrict space vectors to be applied according region where output voltage vector is located. A different approach towards PWM modulation is based onspace vector representation of voltage in the α,βplane. Componentsα,βarefound by transformations. Determination of switching instant may be achievedusing space vector modulation technique based on the representation of switching vectorsin α,β plane.

The control power requirement is achieved by small low power transformers, bridge rectifier and the filter capacitor in the level of 12V to 15V range. Microcontroller power requirement of 5V is derived from the 12V source and voltage regulator. Three phase output is taken from the junction points of top IGBT source and the bottom IGBT's Emitter.

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III. SPACE VECTOR MODULATION FOR THREE PHASE VOLTAGE SOURCE INVERTER

Topology of a 3-leg voltage source inverter is represent in Fig. 2.This is also known AS two-level voltage source inverterinverter is composed of six groups of active switches, *S*1 to S6. Depending on DC operating voltage of inverter, each switch is an IGBT switching device. This part emphasize on pulse width modulation (PWM) schemes for two-level inverter&analysison space vector modulation (SVM) algorithms.Space Vector modulation (SVM)technique was originally developed as a vector approach to pulse-width modulation (PWM) for three-phase inverters. It is a more sophisticated technique for generating a sine wave that provides a higher voltage to motor with lower total harmonic distortion.

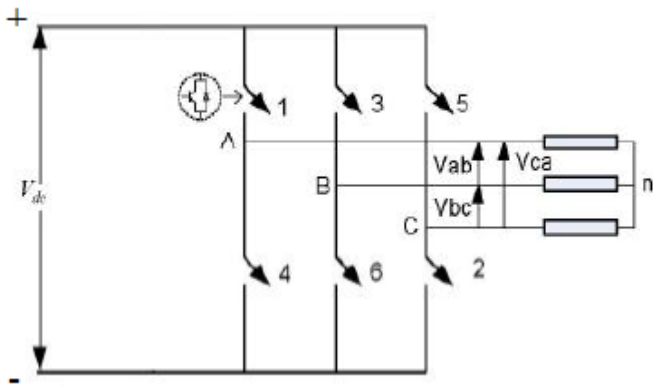

Figure 2.1 circuit diagram for two-level inverter

A. Space Vector Modulation

Space vector modulation (SVM) is most adoptedreal-time modulation techniques and is widely used for voltage source inverters.

B. Switching States

For switching purpose which having eight possible combinations of switching states in two-level inverter as mention in Table2.1 switching state [100], Where, corresponds to the conduction of *S*1, *S*6, and *S*2 in inverter legs *A*, *B*, and *C*, respectively. In eight switching states, [111] and [000] are zero states &others are active states.

Space Vector		Switching State (Three Phases)	On-State Switch
Zero Vector	V_0	[1 1 1]	S1, S3, S5
		[0 0 0]	S4, S6, S2
Active Vector	V_1	[1 0 0]	S1, S6, S2
	V_2	[1 1 0]	S1, S3, S2
	V_3	[0 1 0]	S4, S3, S2
	V_4	[0 1 1]	S4, S3 ,S5
	V_5	[0 0 1]	S4, S6, S5
	V_6	[1 0 1]	S1, S6, S5

Table 2.1, space vector switching states and on state switches

C. Space Vectors Concept

Concept of space vectors is based on from rotating field of AC machine which is used for modulating inverter output voltage. Modulation technique 3 ph parameter can be transformed to their equivalent 2-phase quantity in synchronously rotating frame or stationary frame. From this 2-phase component vector magnitude can be found and used for modulating inverter output.

A space vector diagram for two-level inverter is shown in Fig. 2.2, where six active vectors V1toV6 form a regular hexagon with six equal sectors (I to VI). The zero vector 0 V lies on the center of the hexagon. Where

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$$Vao + Vbo + Vco = 0 \quad (3.1)$$

Where Vao ,Vbo, and Vco are the instantaneous load phase voltages.

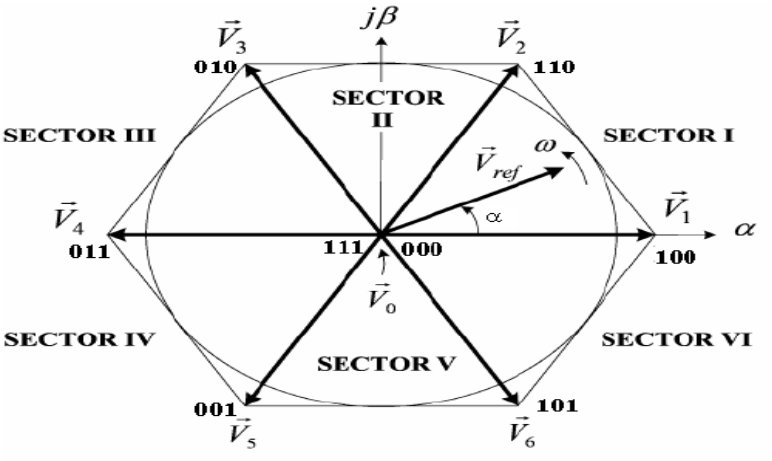

Figure 2.2 Space vector diagram for two-level inverter.

Three phase sinusoidal voltage component **be** **Va =Vmsinϙt**

Vb = Vm (sinϙt -2π/3) **(3.2)**

Vc= Vm (sinϙt -4π/3)

When 3-phase voltages are applied to AC machine, they produce a rotating flux inair gap of the AC machine. Rotating flux component can be shown as a single rotating voltage vector. Magnitude & angle of rotating vector can be found by the mean of Clark's Transformation

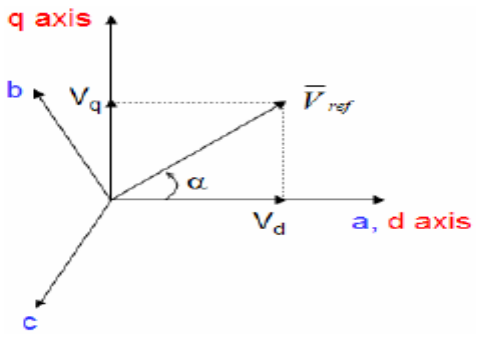

Figure 2.3 Voltage Space Vector and its components in (d,q)

$$V_{ref} = V\alpha + j\,V\beta = 2/3\,(Va + aVb + a^{2}Vc) \quad (3.3)$$

where

$$V\alpha = 2/3\,(V_a + \cos 2\pi\, V_b + \cos 2\pi/3\, V_c) \quad (3.4)$$

$$V\beta = 2/3\,(0V_a + \sin 2\pi\, V_b - \sin 2\pi/3\, V_c) \quad (3.5)$$

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$$\begin{bmatrix} V_d \\ V_q \end{bmatrix} = \frac{2}{3} \begin{bmatrix} 1 & \cos\frac{2\pi}{3} & \cos\frac{2\pi}{3} \\ 0 & \sin\frac{2\pi}{3} & -\sin\frac{2\pi}{3} \end{bmatrix} \cdot \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}$$

(Equation 3.6)

Voltage Vd, VqVref and angle α are calculate by using above equation.

IV. EXPERIMENTAL SETUP AND RESULTS

The experimental setup consists of ,converter and an Inverter circuit. Converter comprise brigerectifier and capacitor where 100 microfarad 450 v capacitors which is used as filter. Boost converter comprises of an,Capacitor of 100 microfarad,450 volts and an IGBT of 1200V,43A which is used as the switching device. Inverter section is a six leg inverter, in which 6 IGBT of 1200V,43A is used. IGBT IR2101 driver is providedfor the proper gating pulses of inverter circuits.12V supply for driver circuit is given from 230/12 volt,2A transformerand is rectified using 1A bridge rectifier. Rectified dc is filtered using 100 microfarad capacitor and constant DC voltage of 12 volt is taken out using MC7805 voltage regulator.

Figure4.1 Experimental setup of designed system

Three phase 1 HP ,415V,50Hz induction motor load tested on experimental setup .figure 4.1 shows experimental setup for designed system. Input voltage ,Output voltage and Speed of motor recorded by multimeter and tachometer.

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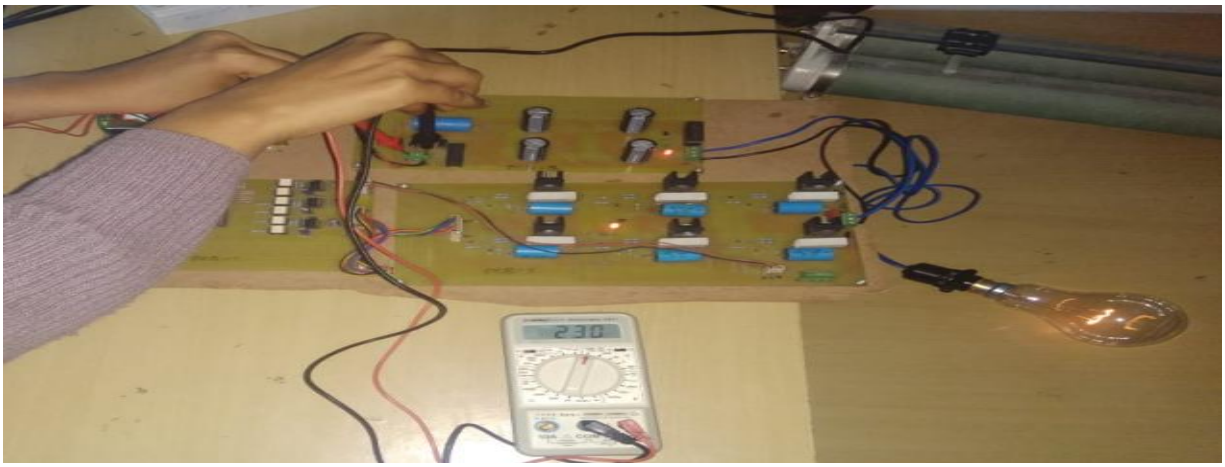

Figure 4.2 Input single phase ac voltage

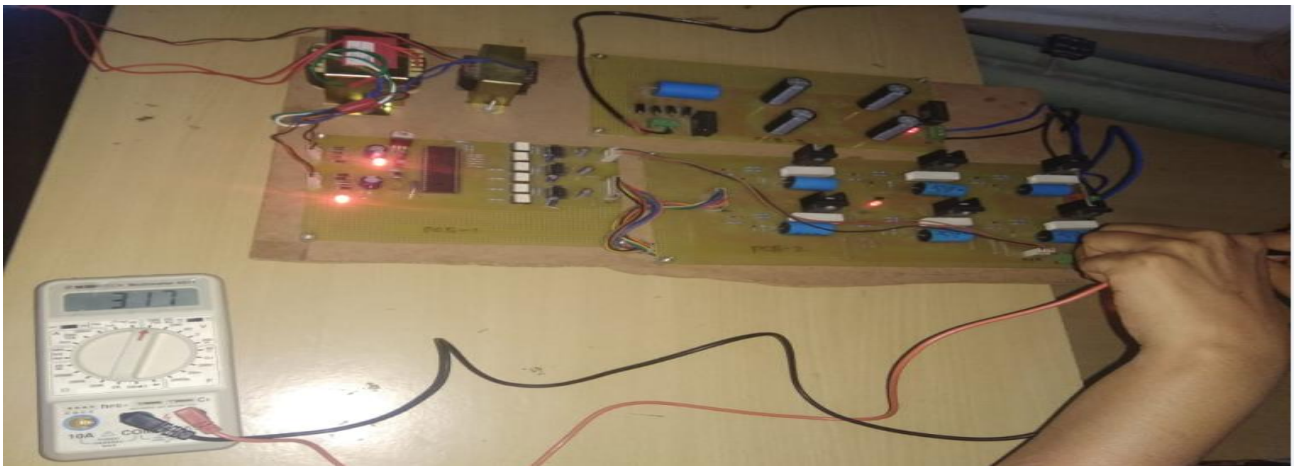

Figure 4.3 Three phase output ac voltage

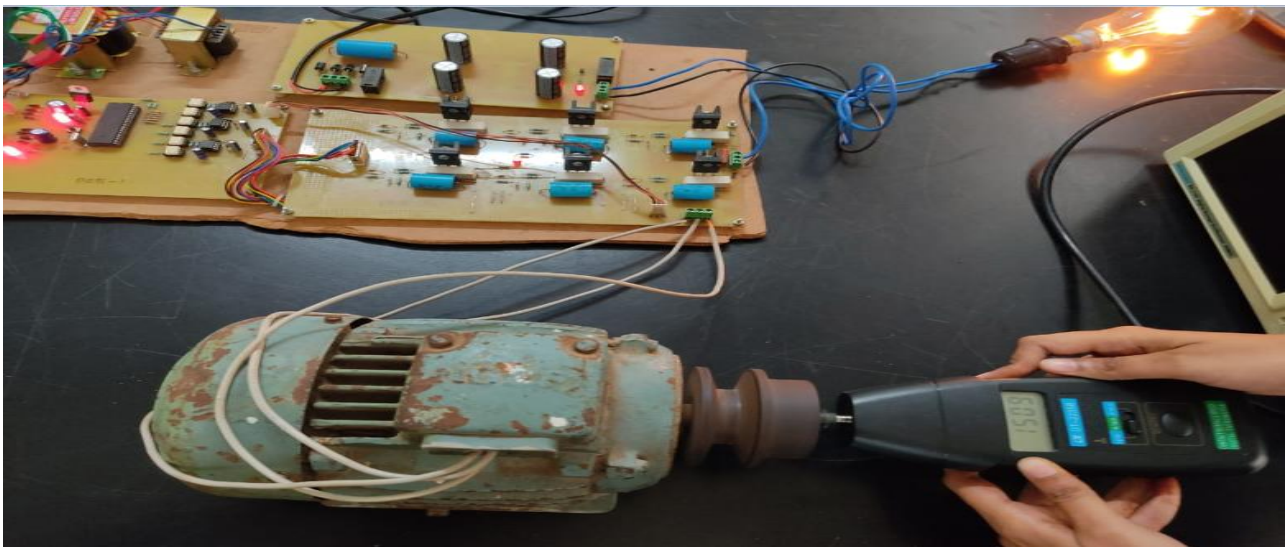

Figure 4.3 Three phase induction motor speed

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The Output Line to Line voltage waveforms for six switch inverter using space vector modulation technique captured by DSO (Digital storage oscilloscope DX-1101)

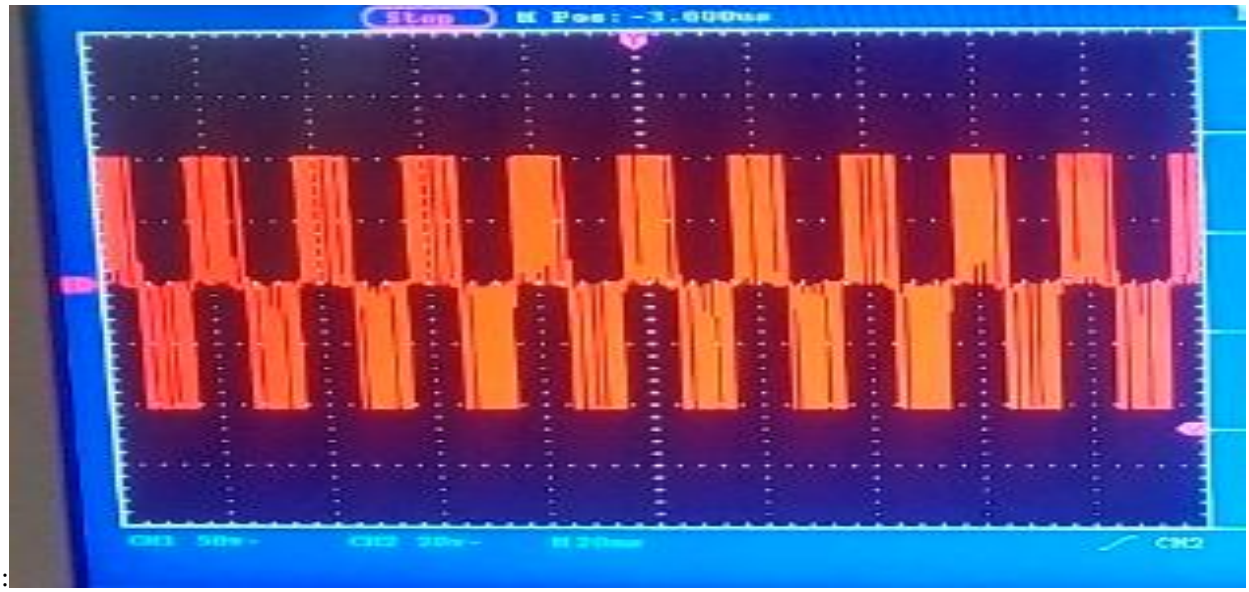
: 

Figure 4.4 Line voltage waveform

VI.CONCLUSION

A novel design of 1 ph. to 3 ph. converter study has been proposed. Proposed converter is capable of powering a three phase adjustable speed ac motor drives from a 1ph. ac mains while maintaining sinusoidal input current at near unity power factor. This method is more capable and economical as compared to other methods . This system is also advantageous to user to drive a three phase motor when only single phase supply is available, especially in rural area.

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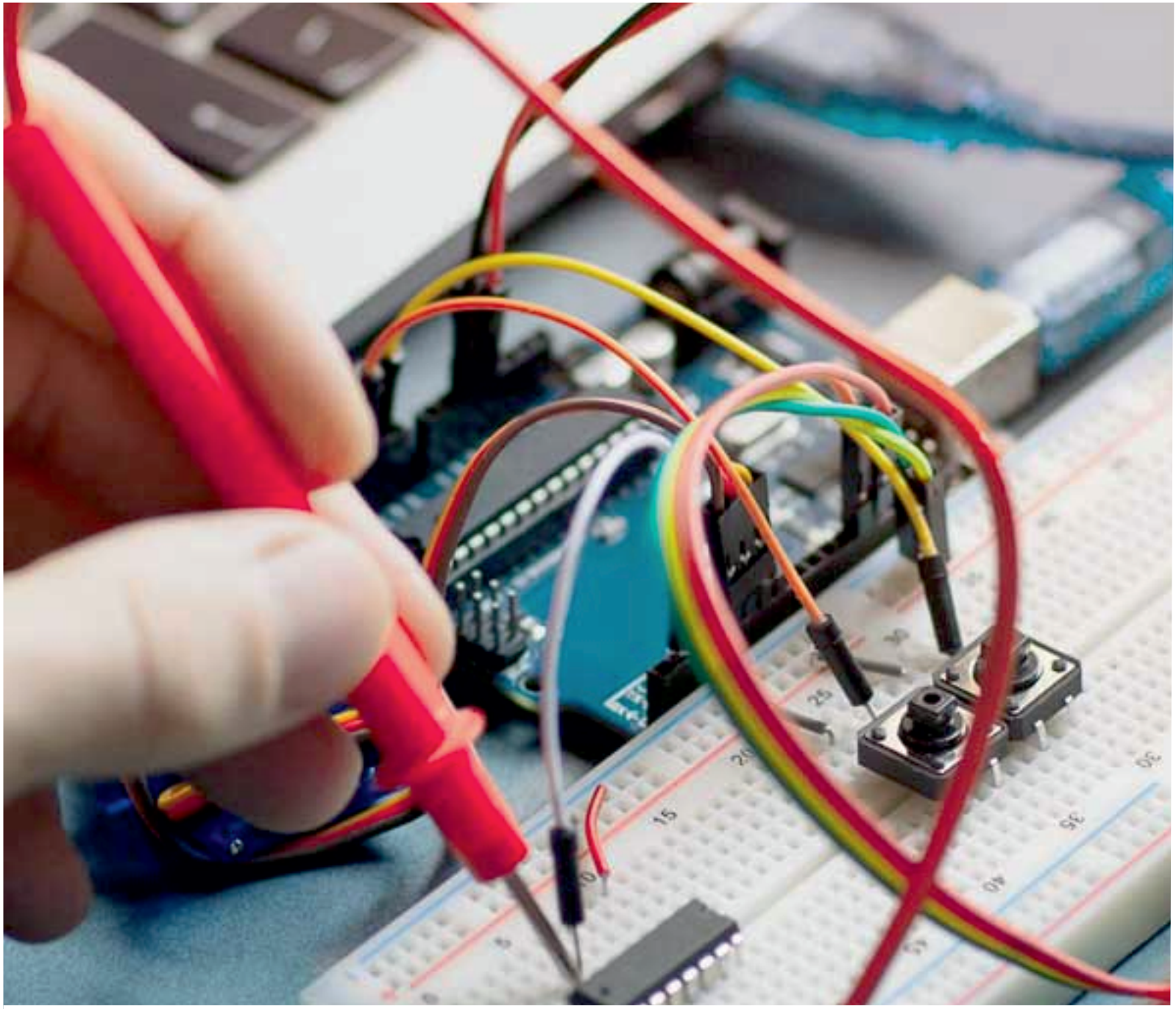

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