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Modelling of Series Active filter to mitigate power quality of distribution network

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ABSTRACT: In industries and commercial consumers category the major problem is power quality due to extensive use of nonlinear loads in industries and commercial buildings. The harmonics present in the system is the main reason of system less efficiency. The harmonics produced by the simple device that produce harmonics will not impact but due to these large number of devices in the system the harmonics generated has a huge impact at the point of common coupling. These harmonics can be prevented by the use of series active filters. We have done a modelling of a distribution network connected with the nonlinear loads and a series active filter is connected in the model to reduce the effects of harmonics in the system. The main aim is to bring the harmonics values in a minimum range near about the defined scale to reduce the losses incurred due to all these harmonics to the devices as well as system.

KEYWORDS: Total harmonic distortion, non-linear loads, passive power filter, active power filter, facts devices.

I. INTRODUCTION

Broad utilizations of nonlinear loads have caused alarming power quality issues, notably current harmonic contamination to the electrical power system. Generally, the injected harmonic currents deteriorate power quality by increasing total harmonic distortion (THD) of a power system. Moreover, they are also the main culprit to reduction of overall power system efficiency (indicated by low power factor), overheating of equipment, failure of sensitive devices, and even blown capacitor [1,2,3]. As a result, it is obligatory to limit harmonic contents in power system and maintain it within an acceptable level.

In conjunction with the mitigation efforts, IEEE standard 512-1992 has been formulated (presently revised as IEEE standard 519-2014 [4]) to strictly limit level of harmonic distortion within 5% THD and also harmonic filters are installed in the polluted power system to minimize power quality issues due to harmonic currents. Conventionally, the harmonic filters are developed based on passive elements such as inductors and capacitors to deal with specific harmonic issues (i.e., they only have fixed mitigation ability) [5]. However, due to their inherent weaknesses of inflexibility, instability, and large size, they are soon replaced by active power filters (APFs) which offer versatile solution to harmonic problems [6,7,8].

The Shunt active power filter is one of the power filter that has a dynamic performance and this needs a better control methodology to provide a better overall performance of the power system. This control techniques are responsible for the generation of reference currents used to trigger the voltage source inverter.

Various Facts devices and filters has been used to neutralise the effects of harmonics and the values to be reduced in the set limit by IEEE for the commercial and industrial consumers as they used large number of devices causes disturbance.

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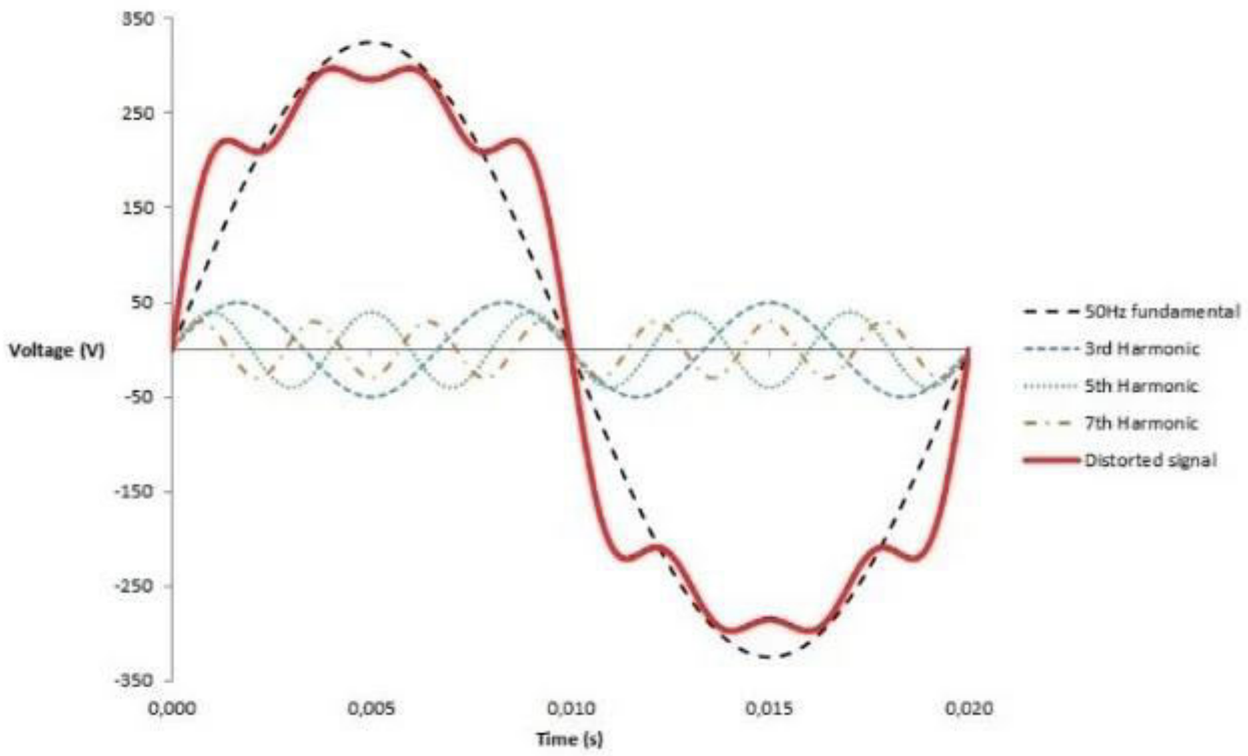

Fig 1 Harmonic effects on waveforms

II. PROPOSED MODEL

A series active filter with hysteresis control technique has been modelled with a simple power system network along with the three phase source and transformers connected with the nonlinear load generating harmonics and filters suppressing it. The whole system derives the system harmonics reduction technique in which various filters and loads are connected with it. A hysteresis control technique uses a hysteresis controller to generate switching signals for voltage source inverter.

- Hysteresis control technique – This technique involves defining upper and lower hysteresis band limits.
- Series active filter – This type of filter acts a voltage regulator and isolator between the utility grid and a nonlinear load. It's often used to compensate voltage sags and unbalance in an AC supply.

The switching frequency of a hysteresis controller can vary widely depending upon the parameters and signals. A smaller or larger hysteresis loop width can shift the amplitude frequency characteristic of the series active power filter.

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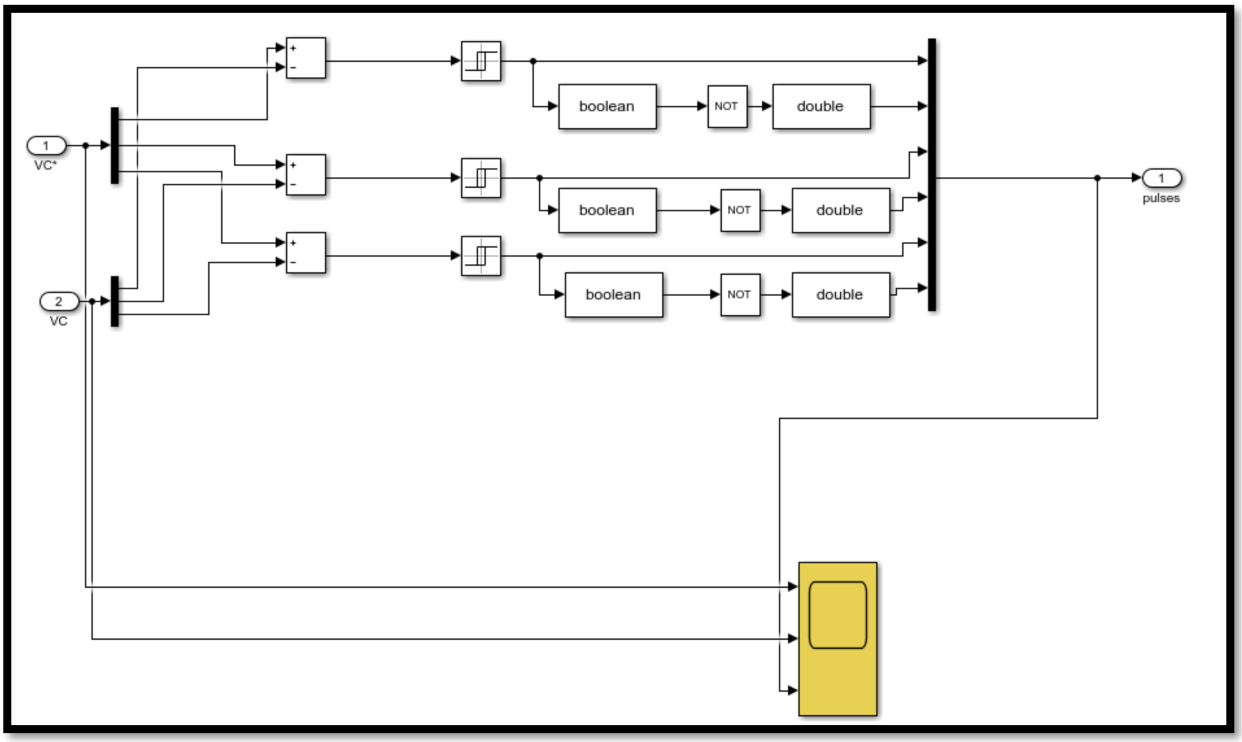

Fig 2 Hysteresis control technique

Non Linear Load- The three phase full bridge rectifier with RL load acts as a non-linear load which distorts line current, source voltage is given by

$$V_{in} = V_m \, Sinwt$$

$$I_{st} = \sum_{h=1}^{\infty} I_h \, Sin \, (h_{wt} + \emptyset_h)$$

$$I_{st} = I_1 \, Sin \, (\omega_{st} + \emptyset_1) + \sum_{k=2}^{\infty} I_k \, Sin \, (h_{wt} + \emptyset_k)$$

Where I_1 is the fundamental current and I_k is the harmonic current, V_{in} is the peak supply voltage, ω_{st} is the fundamental frequency, $\emptyset_k$ is the phase angle between supply voltage and current of the kth harmonic component.

The shunt active passive filter is tuned for the harmonic frequency of line current and this filter will provide reactive power compensation.

The distorted current is given by

$$I_l \, (t) = I_f \, (t) + I_h \, (t)$$

For proper compensation of harmonics and power factor improvement the supply current should have fundamental component and in phase with the supply mains.

$$I_s \, (t) = I_m \, Sin \, (\omega_{st}) = I_f \, (t)$$

Where Im is the maximum fundamental component of current and w is the supply frequency.

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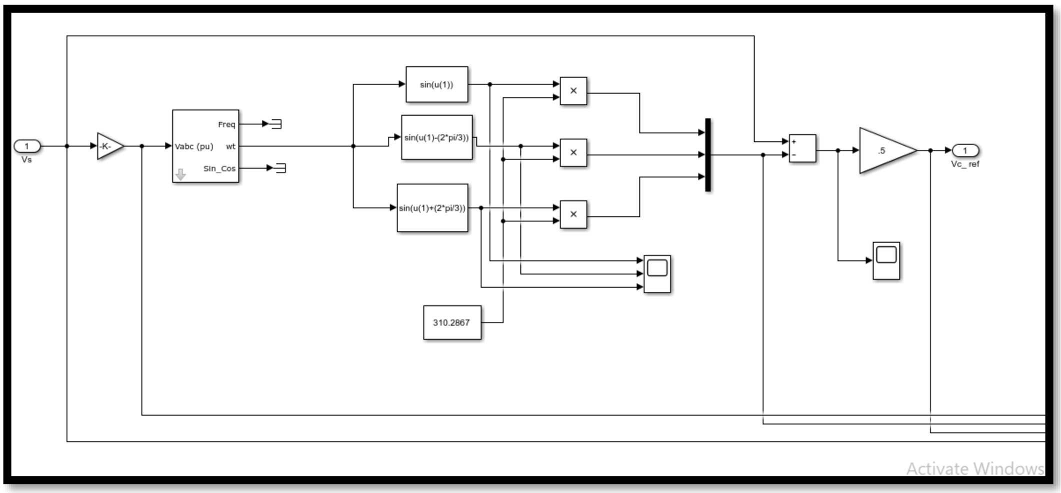

Fig 3 Subsystem for generating reference signal for pulse generation

The series active filter in the proposed model is been connected with the utility grid through. Coupling transformer. By connecting a series active filter between the ac source and nonlinear loads elimination of voltage harmonics can be achieved. This can be achieved by injecting voltage harmonics components across the coupling transformer into utility grid. Series active filters are operated mainly as a voltage regulator and harmonic insulator between nonlinear load and utility grid. This type of approach is generally used for the voltage unbalances and voltage sags from the ac supply. The series active power filter injects a voltage fundamental component in series with the supply voltage.

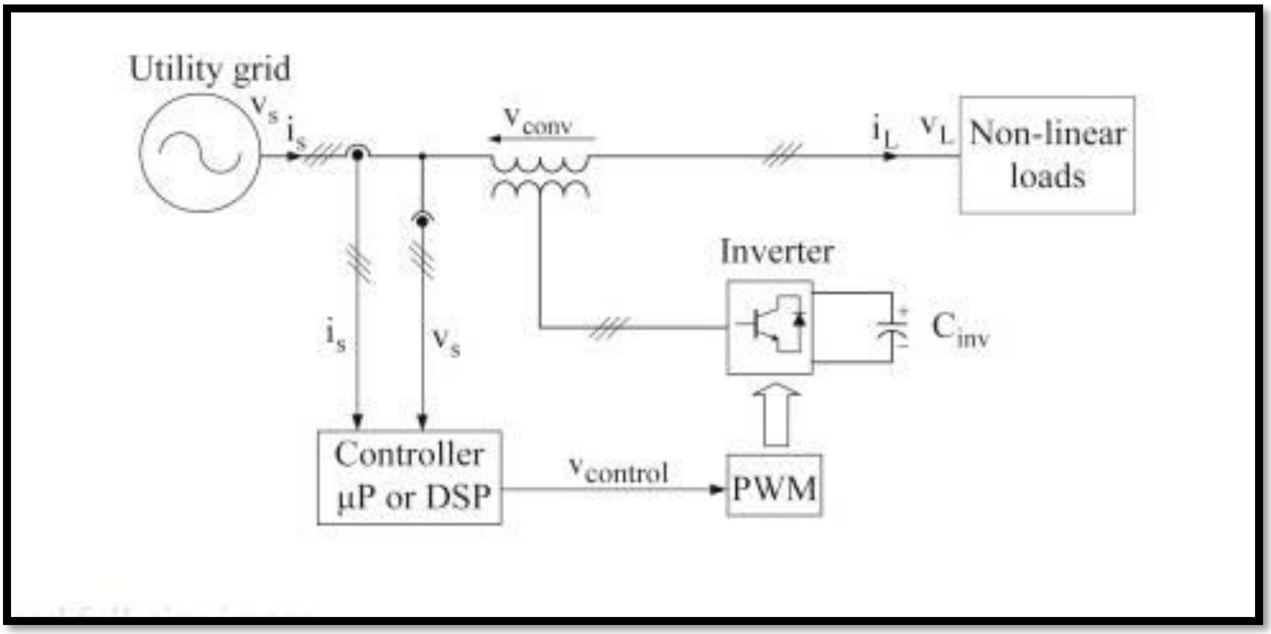

Fig 4 Basic Scheme of series active filter connected with the utility

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III. RESULT AND DISCUSSION

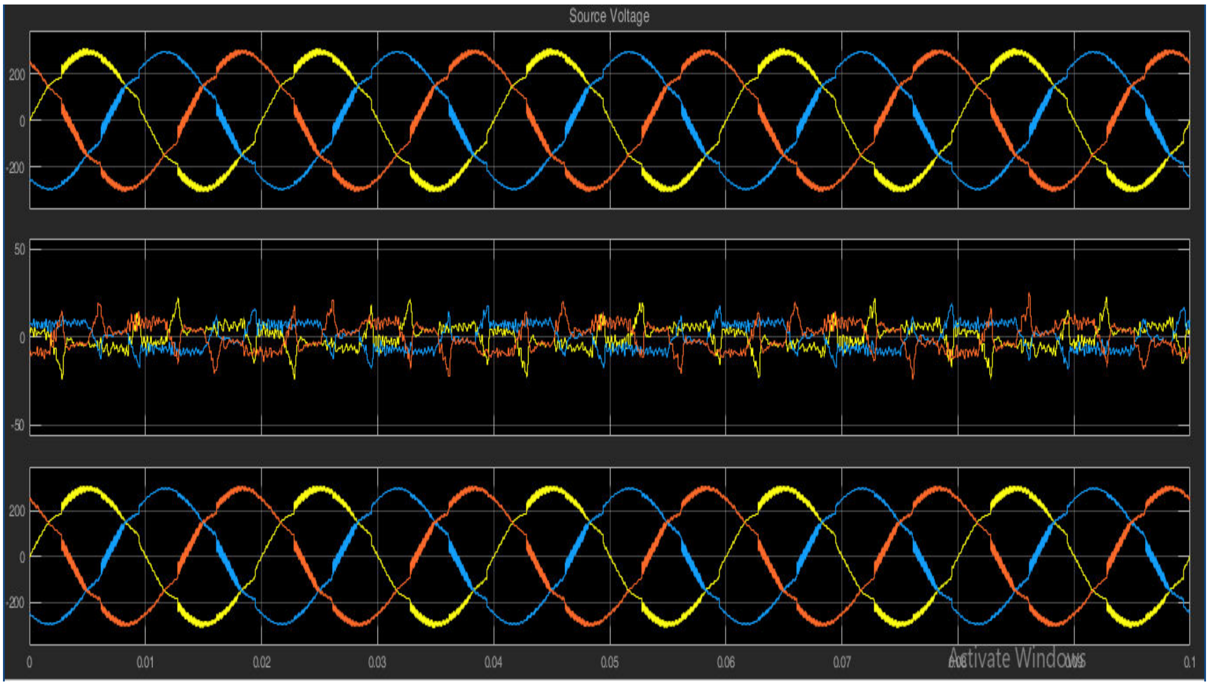

Fig 5 Source voltage, compensatory voltage and load voltage

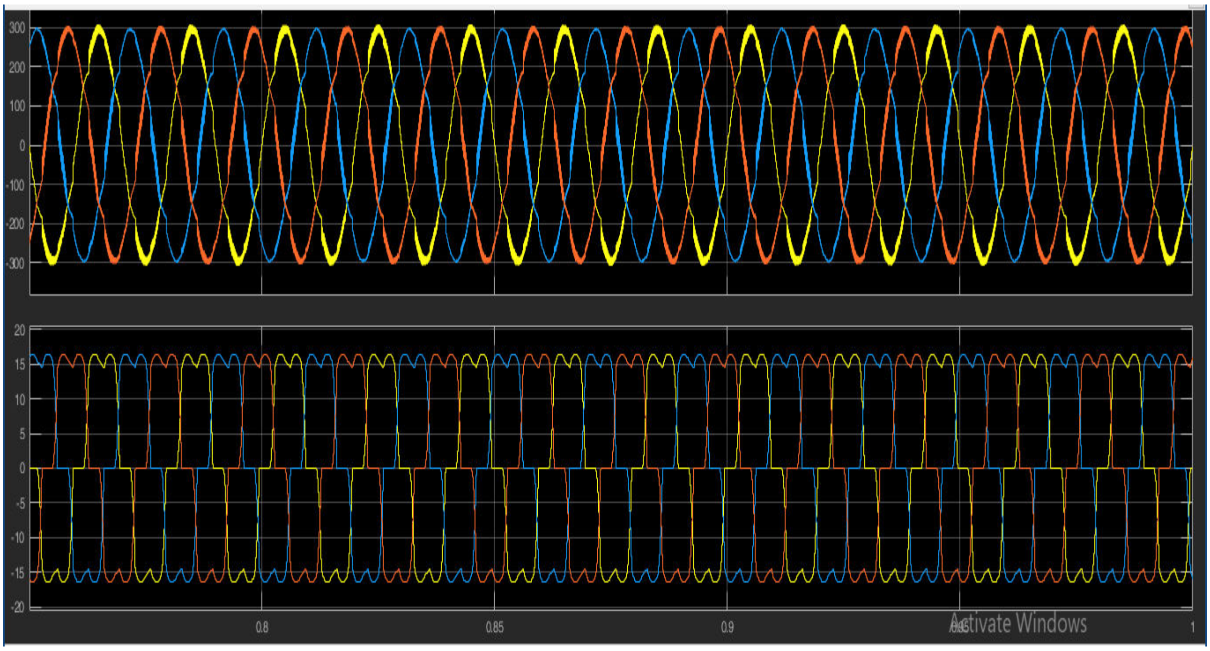

Fig 6 Three phase voltage and current of load

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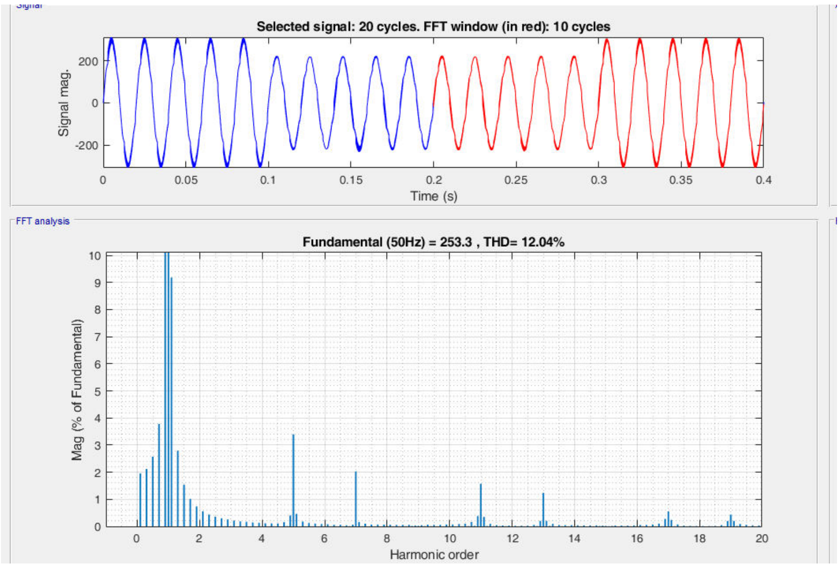

Fig 7 Source voltage harmonics

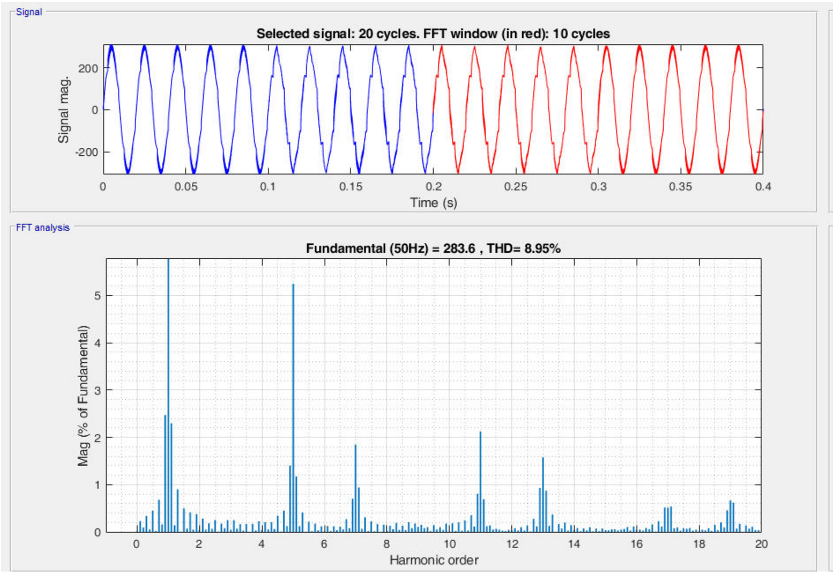

Fig 8 Load voltage harmonics

V.CONCLUSION

A series active filter has been placed between utility and grid load through a coupling transformer for the elimination of harmonics generated due to nonlinear loads. This filter provides a voltage fundamental components in series with the supply voltage. As we can see the results after simulation of the proposed model we can see that the three phase voltage and current containing harmonics due to the load has been compensated and reduced up to 8 % as seen from the FFT analysis all other parameters are considered in the standard and this model conclude that in the case of voltage unbalance and voltage sags this kind of filter with proper configuration will give the better results to achieve the reduction in harmonics.

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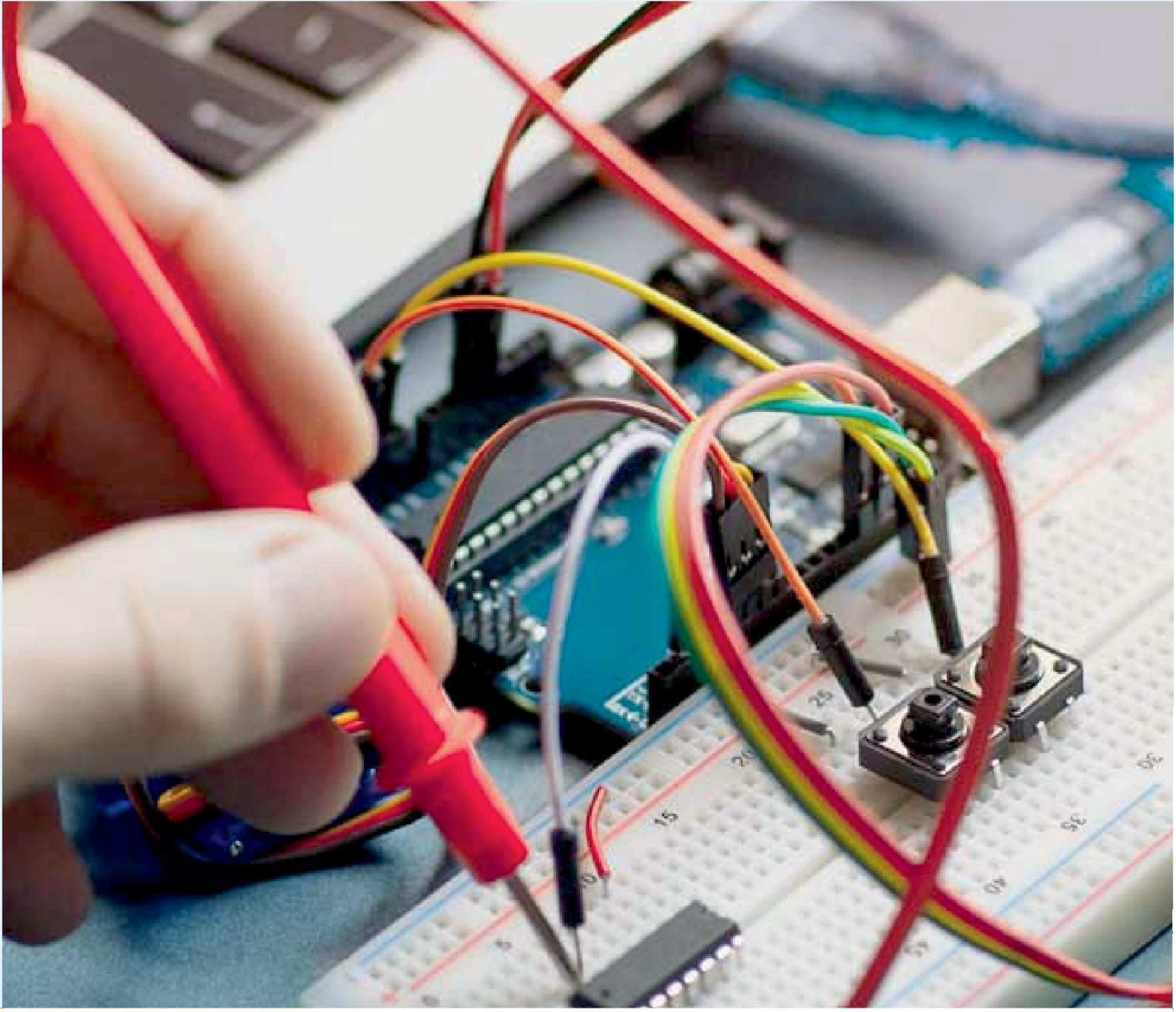

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