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# Multi Cell Boost Topology-Based Charger for Plug-In Electric Vehicle

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**ABSTRACT**:A sufficient charging infrastructure is required to support the increasing number of electric cars (EVs). The cutting-edge EV charging infrastructure with an emphasis on the XFC technology, which is required to meet both the present and future EV refilling requirements.The typical power electronics converter topologies analysed with appropriate to supply extreme fast-charging (XFC) technology and present the design considerations for the extreme fast-charging (XFC) technology stations.

The aim of this article is to design and analyse the multi cell boost topology-based charger for plug in electric vehicle. The Multi-Cell Boost (MCB) topology with three input-series output-parallel (ISOP)-connected dc/dc converter modulesis finally adopted for implementing the fast charger due to its high-power density, high efficiency, low cost, low number of switches, and anticipated high reliability.

This charger is 3-level charger with 2.4 kV input voltage also we can vary from 1 kV to 3 kV voltage as we know 3-level charger gives output voltage up to 400 V, this DC fast charger also gives voltage up to 416 V. This charger consists full wave rectifier ,3-level boost converter, neutral point clamped (NPC)inverter, high frequency transformer and battery. This MCB topology with one module gives high-efficiency up to 96.1%. When we used three modules, then efficiency increased up to 96.6%.

**KEYWORDS*:***DC/DC power converter, ISOP connection, Plug-in ElectricVehicle,Three-level boost converter

## I.INTRODUCTION

Now days, transportation system is major part of our busy life. Fossil fuels like petrol, diesel is the main source of transportation system. As growing pollution due to fossil fuels cars and increasing cost of fossil fuels the new transportation system is comes into picture that is Electric Vehicle.Butelectric vehicle requires battery capacity which fulfil daily needs. Main challenge is more time required for charging of battery and for longer trips electric vehicle had some limitations related tobatteries. In past few years, Li-ion battery technology has evolved substantially, increasing the affordability and usefulness of EVs. The batteries are now less than $120/kWh in price[1]– [3]. But there is requirement to improve the Li-on batteries discussed and reviewed in [4]. The battery management system, which is also known as a battery pack assembly, is thought of as the brain of the electric vehicle system. This provides a thorough analysis of the two components of battery management systems, including mechanical designs and control through battery modelling. Thedifficulties and potential for creating battery management systems reviewed in [5]. To minimize these limitations chargers that charges these batteries with less time required.

There are different chargers with different specifications. Generally, Level 1 charger operates on 120V with average power as 1.3 kW to 2.4 kW, charge vehicle up to 9-10 hrs and this charger adds 5miles per over hour charge. Level 2 charger operates on240V with average power as 3.7kW TO 7.7 kW, require to charge up to 5-6hrs and this charge adds 20-60 miles per hour charge. Level 3 charger operates on 400 V to 480V with average power as 50 k W, charge vehicle up to 30 mins minimum and this charger adds 60-100 miles per 20 minutes of charge. This 3-level charger uses extreme fast charging topologies that discussed in [6].A sufficient charging infrastructure is required to support the increasing number of electric cars (EVs). A refuelling experience is that of gasoline vehicles may be offered by the newly developed extreme fast-charging (XFC) technology.Due to high power DC load demand, thecompact power supply unit is required. Type 3-level charger with 400 V is standard voltage level and charge the battery by using DC microgrids.

Some topologies use low frequency transformers to increase efficiency but low frequency transformers are bulky in nature. Some new proposed system consists single-phase solid-state transformer.

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The different solid-state transformer (SST) architectures that have been suggested in the literature [7]-[9],following are the single-phase SST topologies -

1) Five-level AC to DC topology
2) Modular multilevel converter (MMLC) topology
3) Multicell boost (MCB) topology

These topologies have generally 6.6 kV at AC side. These topologies are used for high voltage applications.Variousunidirectional solid-state transformer (SST) topologies are reported in literature in that MCB topology is best in unidirectional SST topologies [9]. Sic (Silicon Carbide) semiconductors are used for optimized power density and better efficiencies.

## II.MULTICELL BOOST TOPOLOGY

Simulation of multi cell boost (MCB) topology is done on MATLAB (Simulink), three modulesused to increase efficiency of this topology. The fig 1.is showsMulti Cell Boost (MCB) topology and fig.2. shows the control strategy used in the Multi Cell Boost (MCB) topologyreferred from [10]. At first, connect full bridge rectifier with 1.2 kV as input AC supply. Here, all three modules are connected in input series output parallel (ISOP) manner.Significant scalability in the input voltage and output power ratings is offered by the ISOP design of the MCB architecture modules. After full wave rectifier three level boost converter is connected then next neutral point clamped inverter is used. That neutral point clamped (NPC)inverter connected to high frequency transformer this transformer gives isolation and operate at high frequency up to 6 kHz. After that full wave converter is connected to battery. Three PI controller control loops are employed. The dc bus main loop controls the overall voltage of the split dc bus, the voltage balancing loop balanced the capacitor voltages, and the closed loop of neutral point clamped (NPC)inverter regulates the output voltage. The full wave bridge rectifier then after that another two modules also comes into picture and all modules input is connected in series

and output

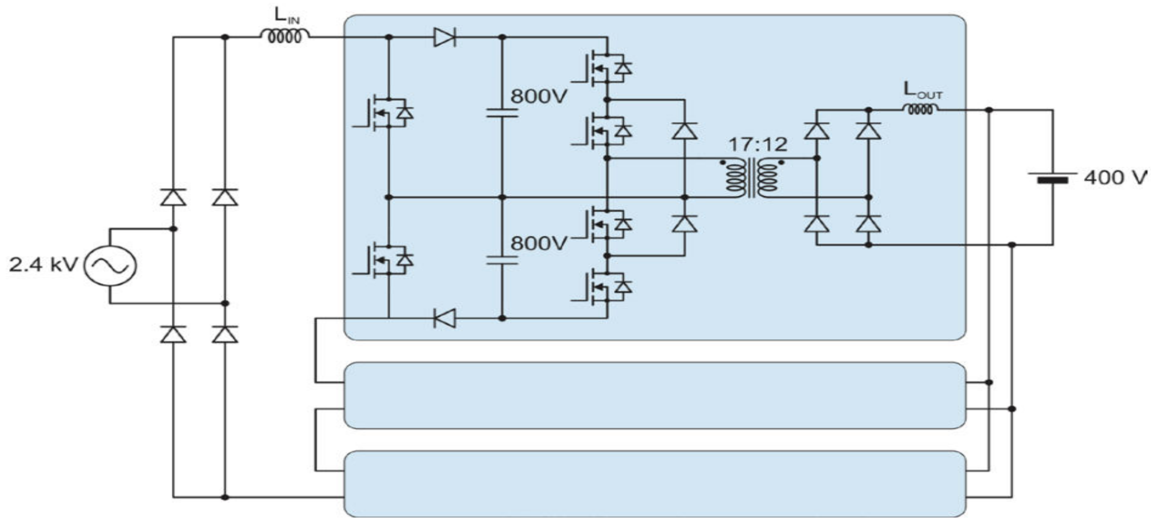


Fig. 1. Multi Cell Boost (MCB) topology

is connected in parallel.Inputis connected in series with input voltage given 2.4 KV is distributed in three modules. For each module input voltage given up to 800V.

The bridge rectifier at input side converts AC into DC. This DC voltage given to three level boost converter and it boost the voltage up to 1400 to 1600 V.Input DC voltage 800 V is boosted up to 1500 V

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DC voltage by using three-level boost converter. This DC voltage converted to AC voltage by neutral point clamped diode rectifier. The NPC loop also connected and one high frequency transformer is used for high voltage application that is most suitable. After that AC voltage again converted into DC voltage by full wave bridge rectifier. Then all modules are connected in parallel. At last, we have to check the battery and their output voltage which gives up to 415 to 417V. That makes this is the three-level charger withgood efficiency. If we use one module topology the efficiency gives up to 96.15% but if we use three same modules with input series and output parallel connection (ISOP) then it gives up to 96.62% efficiency.

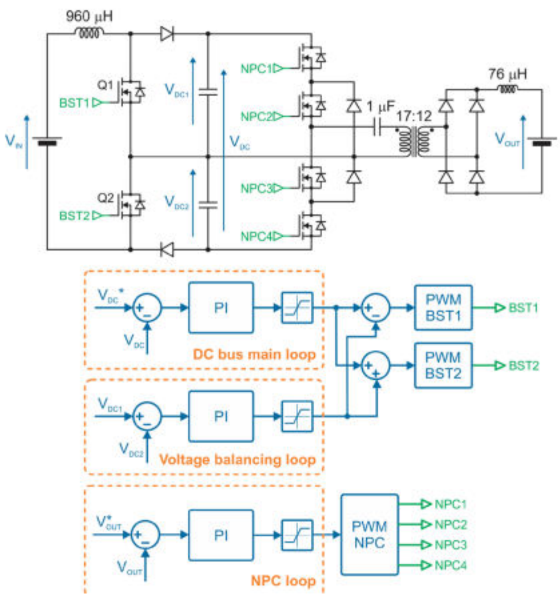


Fig.2.Multi Cell Boost (MCB) topology control strategy

The voltage is balanced by using three level boost converters by using PI controller. The main purpose of using three level boost converter is to increase the voltage capability, reduces current ripple and uses a smaller number of switches. The NPC inverter is used for voltage balancing purpose in MCB topology. When there are more than three levels in an NPC inverter, the neutral point voltage is managed by employing an SPWM method to balance the upper and lower group capacitor voltages with regard to the neutral point. However, the voltage of each capacitor is not properly balanced. Here, three levels of NPC inverter used and for high voltage application it can controlled circuit by using closed loop control. Here, PI controller for controlling the circuit.

## III. RESULT AND DISCUSSION

The simulation done on MATLAB (Simulink) and following are the results-

1) Input voltage and output current sharing by each module
2) Load sharing of each module under varying load condition

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**Table 1- Input voltage vs output current of each module**

| Sr.no. | Input Voltage (resistive load=15 ohm) | Input Voltage of module one | Output current of module two | Input Voltage of module two | Output current of module two | Input Voltage of module three | Output current of module three | Total output current | Output voltage |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 1000 V | 400 V | 8 A | 400 V | 8 A | 400 V | 8 A | 24 A | 439 V |
| 2. | 1500 V | 495 V | 8 A | 495 V | 8 A | 495 V | 8 A | 25 A | 331 V |
| 3. | 2400 V | 800 V | 16 A | 800 V | 16 A | 800 V | 16 A | 48 A | 416 V |
| 4. | 2500 V | 832 V | 16 A | 832 V | 16 A | 832 V | 16 A | 48 A | 421 V |
| 5. | 3000 V | 1000 V | 17 A | 1000 V | 17 A | 1000 V | 17 A | 51 A | 422 V |

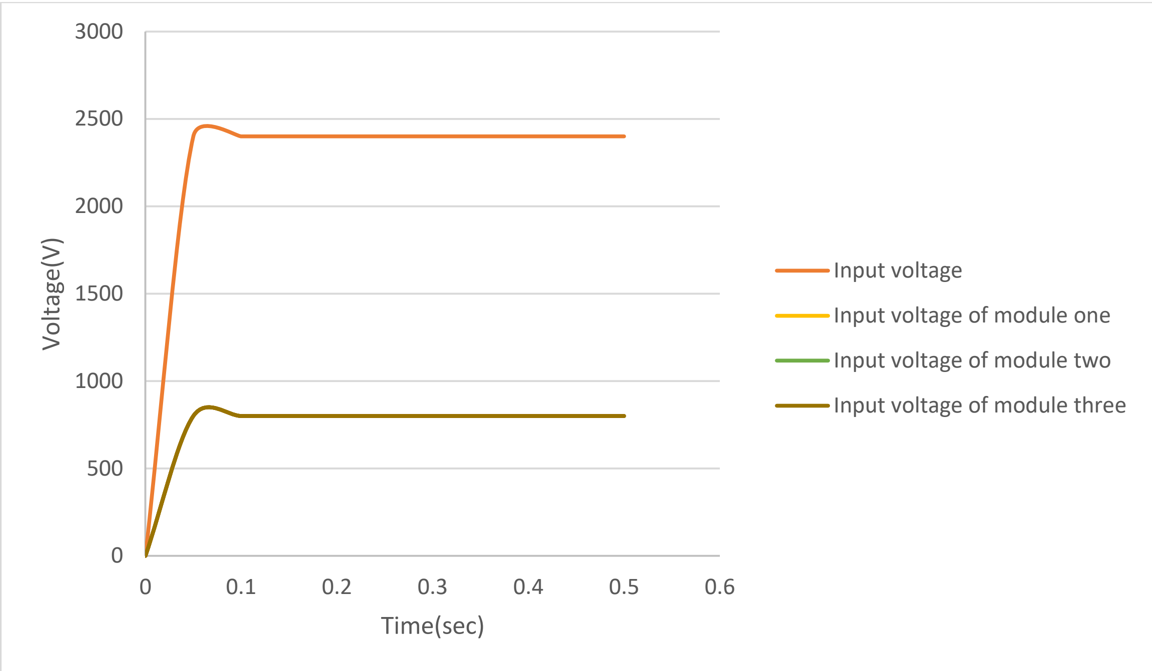


Fig.3.Input Voltage of module one, two and three

From the table 1, input voltage varied from 1000 V to 3000 V and check the input voltages with respect to all modules.The reference voltage is considered as 2400V, all modules share same voltage as 800 V. Input side is connected in series and output is connected in parallel. From the fig.3. shows that voltage is shared equally in each moduleas up to 800V.

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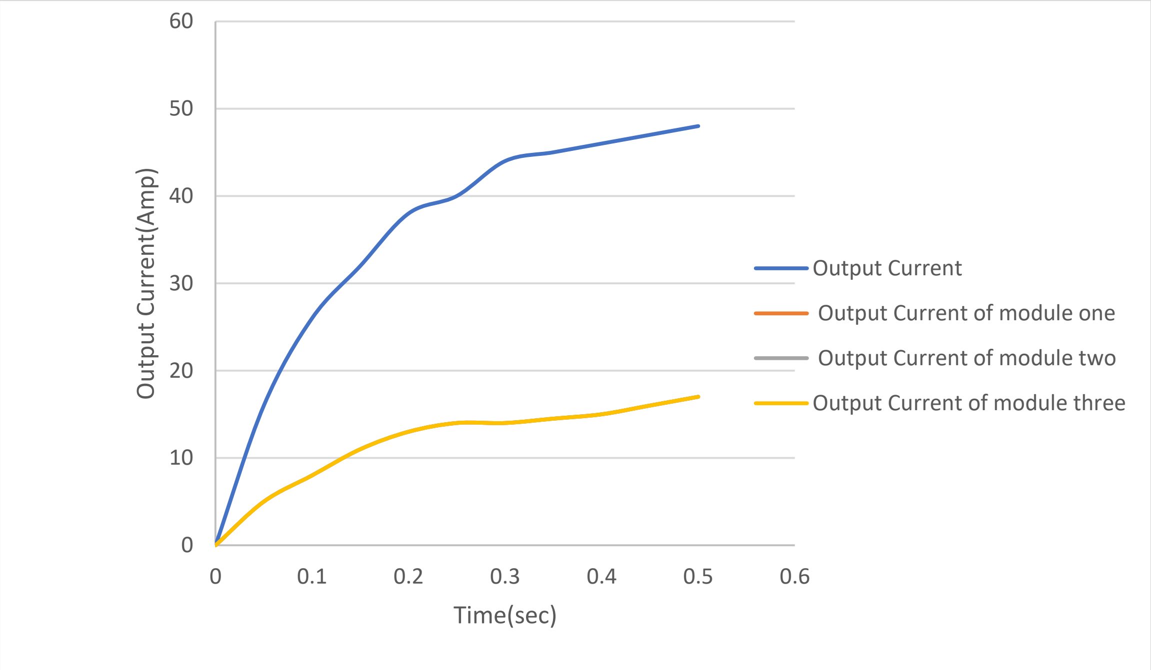


Fig.4.Output current of module one, two and three

From the table 1, The input current gives up to as 16 A for each module as input voltage is 2.4 kV is considered for all results and the output current gives up to 48 A. From fig.4 shows that output current is sum of current of each module and current also shared equally.

**Table 2- Input voltage vs output current of each module**

| Sr.No. | Resistive Load (Input voltage= 3000v) | Output current of module one | Output current of module two | Output current of module three | Total output current | Output voltage |
|---|---|---|---|---|---|---|
| 1. | 10 ohm | 13A | 13A | 13A | 40A | 439 V |
| 2. | 15 ohm | 9A | 9A | 9A | 28A | 331 V |
| 3. | 20 ohm | 7A | 7A | 7A | 21A | 416 V |
| 4. | 25 ohm | 7A | 7A | 7A | 21A | 421 V |

From table 2,The resistive load is taken from 10 ohm to 25 ohm with taking as constant input voltage as 2400 V. From this after changing resistive load also the current shares equally for each module.

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## IV.SIMULATION STUDYAND RESULTS

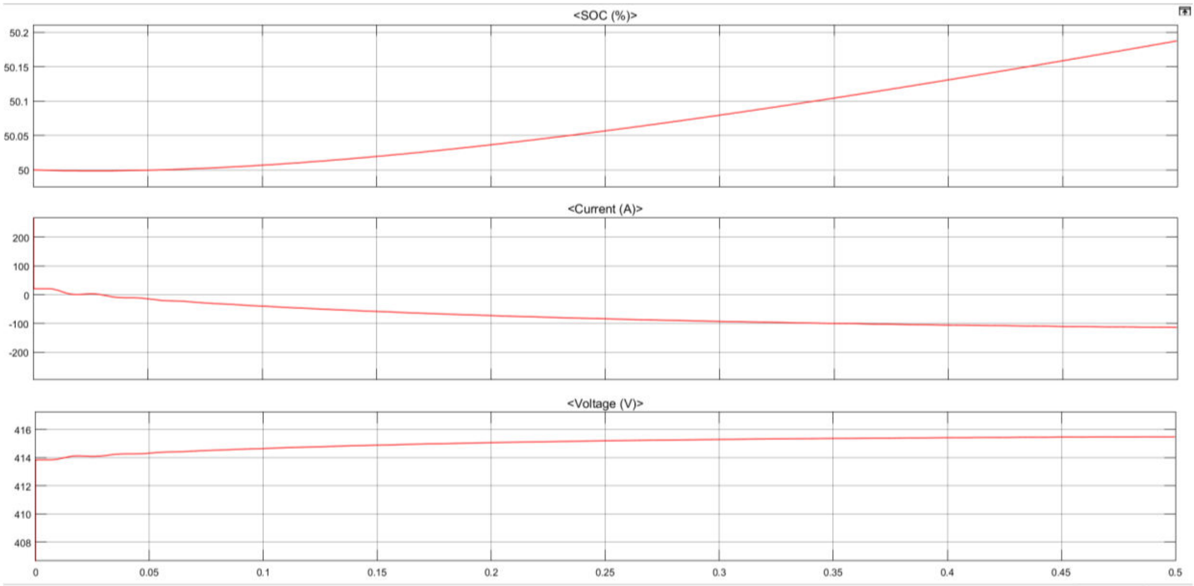


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Fig.5. Result of battery SOC vs Current vs Voltage

Complete MCB topology simulated in MATLAB(Simulink). Fig.5.shows simulation of three-level charger. The result shows of charging battery. Maximum capacity of battery is 5.4 Ah and rated capacity is used is 50.4 Ah. Simulation result shows that SOC (state of charge) changed from 50% to 50.2%, current changed from 0 A to 120 A and voltage changed from 413 V to 415 V.

## V.CONCLUSION

Literature review shows that MCB topology is best in unidirectional SST topologies. This topology implements the fast charger due to its high-power density, high efficiency, low number of switches, and anticipated high reliability.Here, ISOP connection used as input side is connected in series and output connected in parallel. All modulesshareinput voltage and outputcurrent equally by each module. From this topology, the extremely fast charger made by using XFC technology. The output voltage is up to 416 V so this charger considered as Three level charger.

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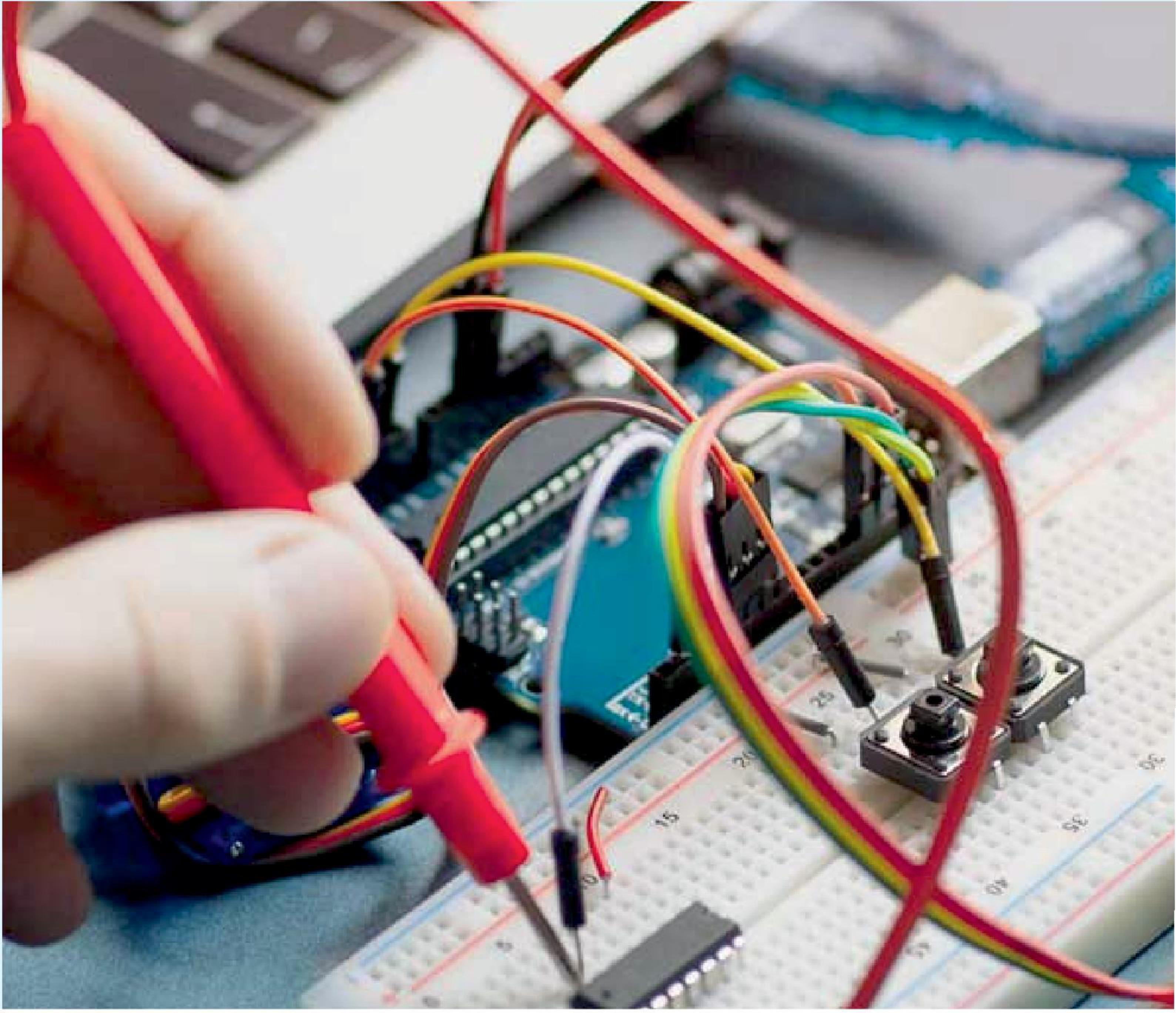

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