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Analysis of 132kV Transmission Line Using Static Load Model

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ABSTRACT: The benefits for a comprehensive analysis for the improvement of the performance of 132kV transmission line are well addressed as data collected and the ones realized mathematically served as input data for the analysis. Static load model as a method was employed in the modelling of 3-bus 132kV transmission lines 1 and 2 in ETAP 12.6 software. This was performed to analyze the performance of the transmission line. The transmission lines were subjected to load flow analysis with static load of 350KVA for each of buses 17 and 19. The load flow analysis showed that buses 4, 21 and 23 have voltage magnitudes of 99.902, 99.897 and 99.897. These represent 131.87kV, 131.86kV and 131.86kV as against 132kV for buses 4, 21 and 23. Also, reactive powers available are 0.278MVAr, 0.138MVAr for each of buses 21 and 23.

KEYWORDS: Static Load Model, Transmission Line, Load Flow, Load Bus, Reactive Power, Voltage Magnitude.

I. INTRODUCTION

Transmission systems are undergoing continuous changes and restructuring. They are becoming more heavily loaded and are being operated in ways not originally envisioned. The economical utilization of transmission system assets is of vital importance to enable power supply providers in industrialized countries to continuously remain in business.

The power system operating environment of today has substantially increased the difficulty of maintaining an acceptable system voltage profile. Problems associated with the steady state stability and voltage collapse of electric power systems have become increasingly important. It is common to associate steady-state stability with the ability of the transmission system to transport real power to necessary locations within the system [1].

Due to insufficient generation, inadequate transmission lines, and the slow response of conventional means of control through the use of reactors, capacitor banks and tap changing transformers (phase shifters) to regulate power flows, there has been an overloading and stressing of the operational network of the power transmission systems beyond their thermal limit just to meet the increasing load demand.In any power system, the creation, transmission, and utilization of electrical power can be separated into three areas, which traditionally determine the way the electric power supply provider had been organized [2].

II. RELATED WORKS

There is high demand on transmission network in recent years and therefore, it is important to study the network adequately to address the challenges. While the challenges persist, it is necessary to examine the other possible options of increasing the transmission capability on present sites and making maximum use of existing transmission systems [3].

The demand for electricity is increasing due to the fast growth of industries, household, etc. The need to generate and transmit bulk power to address the demand of electricity becomes inevitable. It is possible to detect network challenges when load flow study is performed. If it is known that the existing transmission line falls short of adequate power transmission capability, then installation of new transmission infrastructure is encouraged. Then, it is necessary to improve the maximum limit of power transfer of an existing power transmission system to overcome the challenges

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related to constructing new transmission infrastructure [4]. The Power transmission capability can be improved directly by using series compensation [5].

An electric transmission system must provide power transmission within voltage limits at safe and high-quality conditions by industrial development, demand of electrical energy has become harder to provide acceptable voltage profile in power transmission system. Voltage stability and voltage collapse studies have become increasingly important.

Many are making concerted efforts to fully utilize the installed facilities of power systems as energy demand is increasing, thus creating security challenges for power systems [6]. It therefore calls for urgent attention to carry out study that will provide sufficient information regarding the power transmission line. The study will resolve very pertinent issues. Static load model can provide solution to the problem of network loading as it represents on the average maximum allowable network load. The power utility is probably the largest and most complex industry in the world. The electrical engineer, who researches in this industry, will encounter challenging problems in designing future power systems to deliver increasing amounts of electrical energy in a safe, clean, and economical manner.

According to Onahet al. [7], power flow analysis of the transmission grid revealed that the existing condition of the Nigerian 330kV transmission network is very unsatisfactory. Ravilla&Ramamohan, [8] asserted that contingency analysis carried out on the network to verify the effect of losing any line in the system also indicates a total of 208 violations. There is no line in the network that does not result in at least 2 violations. Increase or decrease in loading conditions further force more buses to be out of tolerance. Unnecessary voltage drops lead to huge losses which require to be supplied by the source thereby leading to faults in the line because of increased stress on the system.

It is important to carry out adequate study of the network because several scenarios that might lead to fault exist. The maximum transmissible power is that of the weakest section, but since this is necessarily shorter than the whole line, an increase in maximum power and, therefore, instability can be expected [9].For a long power transmission line, the ratio of reactance to resistance is very high. Load flow through alternating current transmission line is a function of line impedance, the magnitude of sending and receiving end voltages, and phase angle between the two end voltages [10]. Load flow study is an important part of the power system studies. Load flow is a vital tool for power system analysis and design Inadequacy in the reactive power leads to voltage drop to some extent and if continues in the same state and the tripping is not achieved properly in the system connected then the generator will go out of step and finally it leads to blackout in the power system. Consequently, system operators do not know what the voltage magnitude is on the other side, usually the transmission side. Moreover, long transmission lines are normally subjected to over-voltages. Over-voltages are the highest either in the middle of the line because of Ferranti effect or on the line end when one line end tripped.Hence, it becomes difficult for the operators to find the problems and their impact to take necessary actions. Based on economic and environmental limitations, always the consumers are located far from the power stations. It is also not possible to extend the network which results the system to operate closer to the permissible limits. As the load varies, voltage at the substation buses and the load buses varies. Switching can be based on timing if load variation is predictable, or can be based on voltage power factor, or line current.

III. MATERIALS AND METHOD

Research materials such as transmission line data, bus data, station data and other relevant data were obtained at the Afam Power Station and Port Harcourt Mains Transmission Station. Others were computed for the purpose of the analysis. The network for this study was the medium transmission line since it measured up to 100km. Static Load Model was used to model the network and load flow conducted on the network to ascertain the network's real power, reactive power, voltage magnitude and voltage angle with reference to Afam/Port Harcourt 132kV transmission lines 1 and 2 .

To this study, Afam/Port Harcourt, 3-bus 132kV transmission network comprising of two lines (lines 1 and 2) has been designed as a test case for the analysis using static load model.

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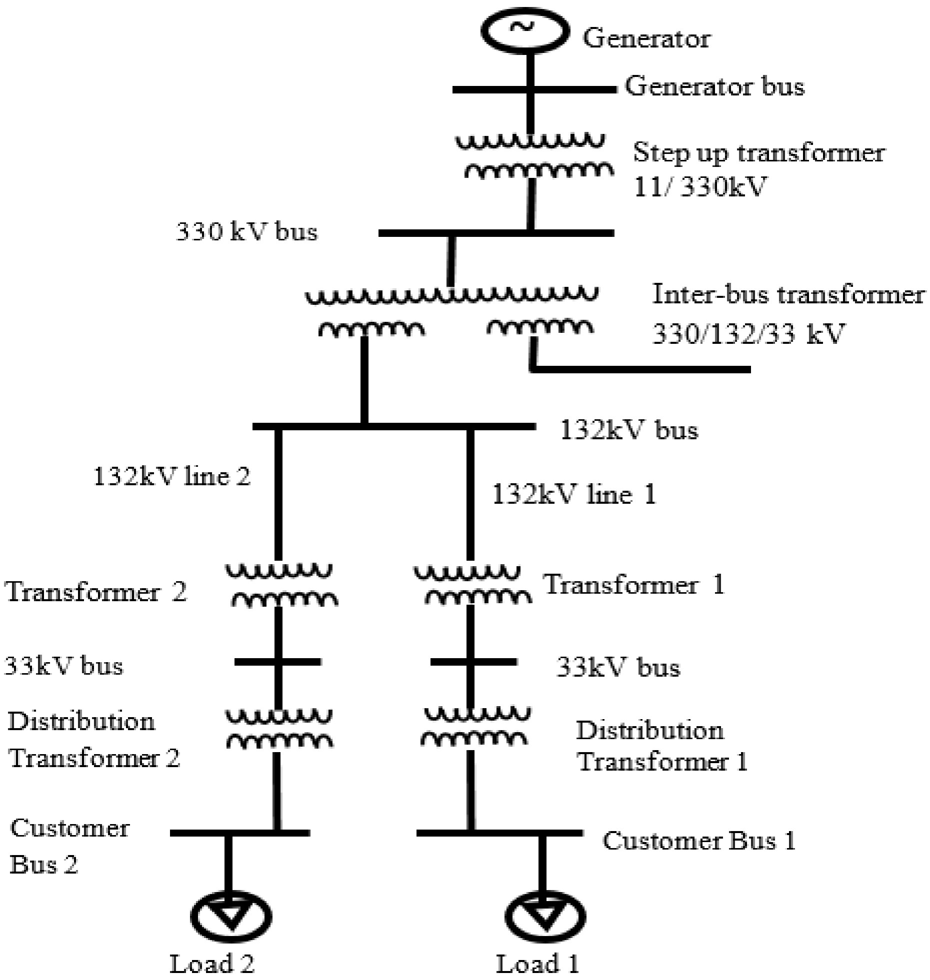

Fig.1 Single Line Diagram of Afam/Port Harcourt, 3-Bus 132kV Transmission

Static load model calculation on 3-bus 132kV transmission lines 1 and 2 becomes:
BUS 21
Following that

$$P = P_0\left(\frac{V}{V_0}\right)^{np}$$

Where
P_0=350KVA

$np = 1$
$V = 0.415KV$ for bus 14
$V = V_O$ at unity pf for power distribution
Then,

$$P = 350\left(\frac{0.415}{0.415}\right)^1$$

$P = 350KVA$
BUS 23
Following that

$$P = P_0\left(\frac{V}{V_0}\right)^{np}$$

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Where
P_0=350KVA

$np = 1$
$V = 0.415KV$ for bus 13
$V = V_O$ at unity pf for power distribution
Then,

$$P = 350\left(\frac{0.415}{0.415}\right)^1$$

$P = 350KVA$

After realizing all the data required using static load model, load flow analysis was conducted on the 3-bus 132kV transmission lines 1 and 2 in ETAP 12.6 software environment as the data were used as input data.

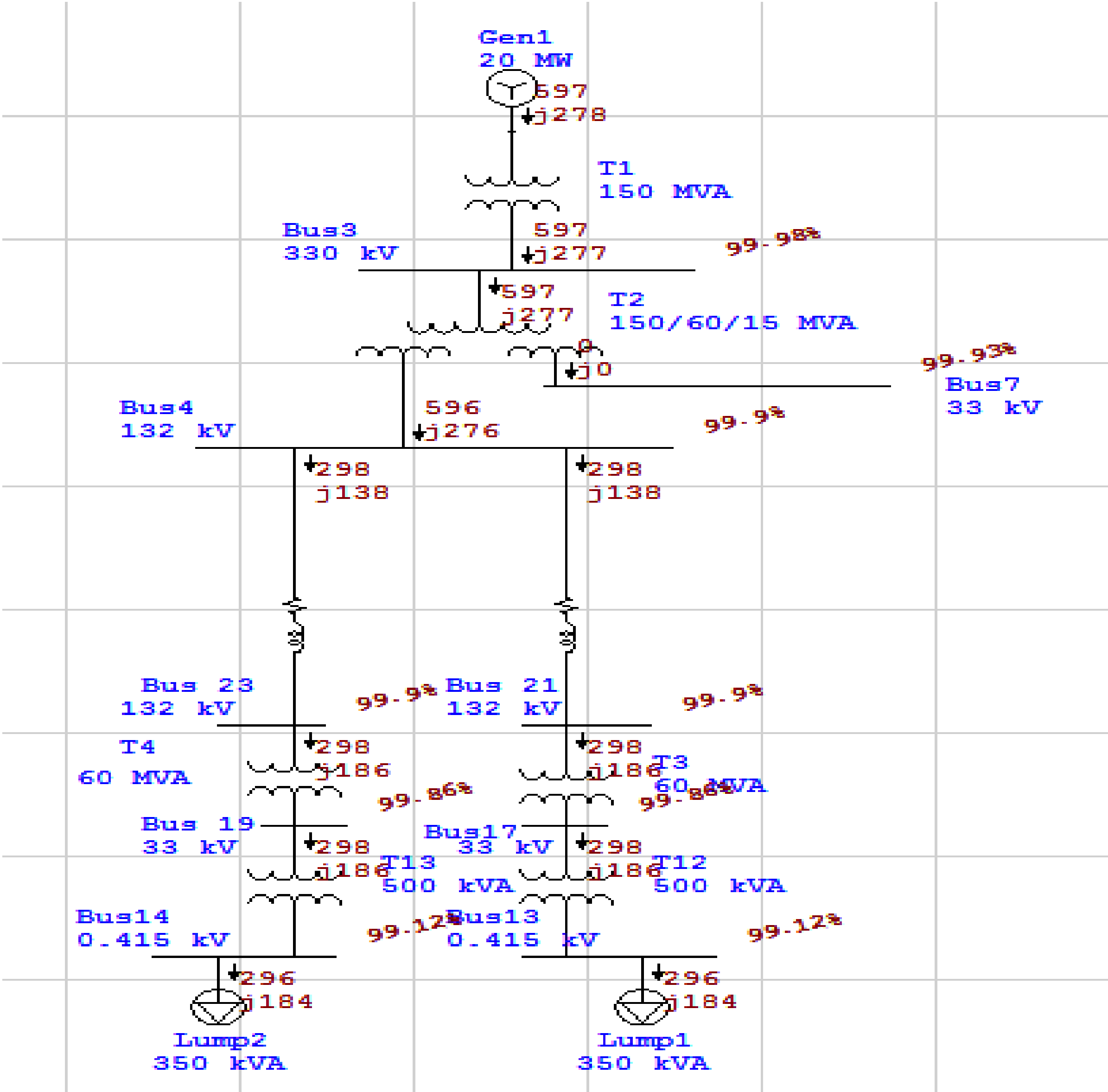

Fig. 2 3-Bus 132kV Transmission Lines 1 and 2 Modelled in ETAP 12.6 Software

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IV. RESULTS AND DISCUSSION

Results realized from the load flow are indicated in Tables 1-2 and Figs. 3-4.

Table 1 Summary of Voltage Magnitude

Buses	**Voltage Magnitude (%)**
4	99.902
21	99.897
23	99.897

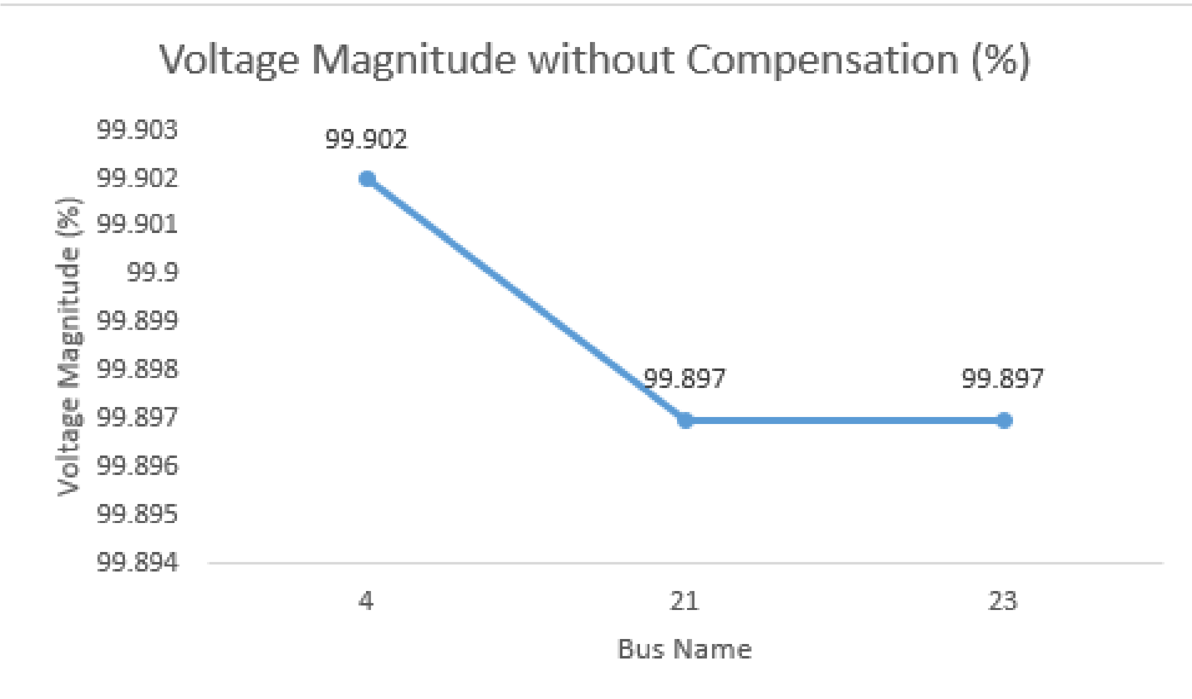

Fig. 3 Plot of Voltage Magnitude Without Compensation

Table 2 Summary of Reactive Power

Buses	**Reactive Power (MVAr)**
4	0.278
21	0.138
23	0.138

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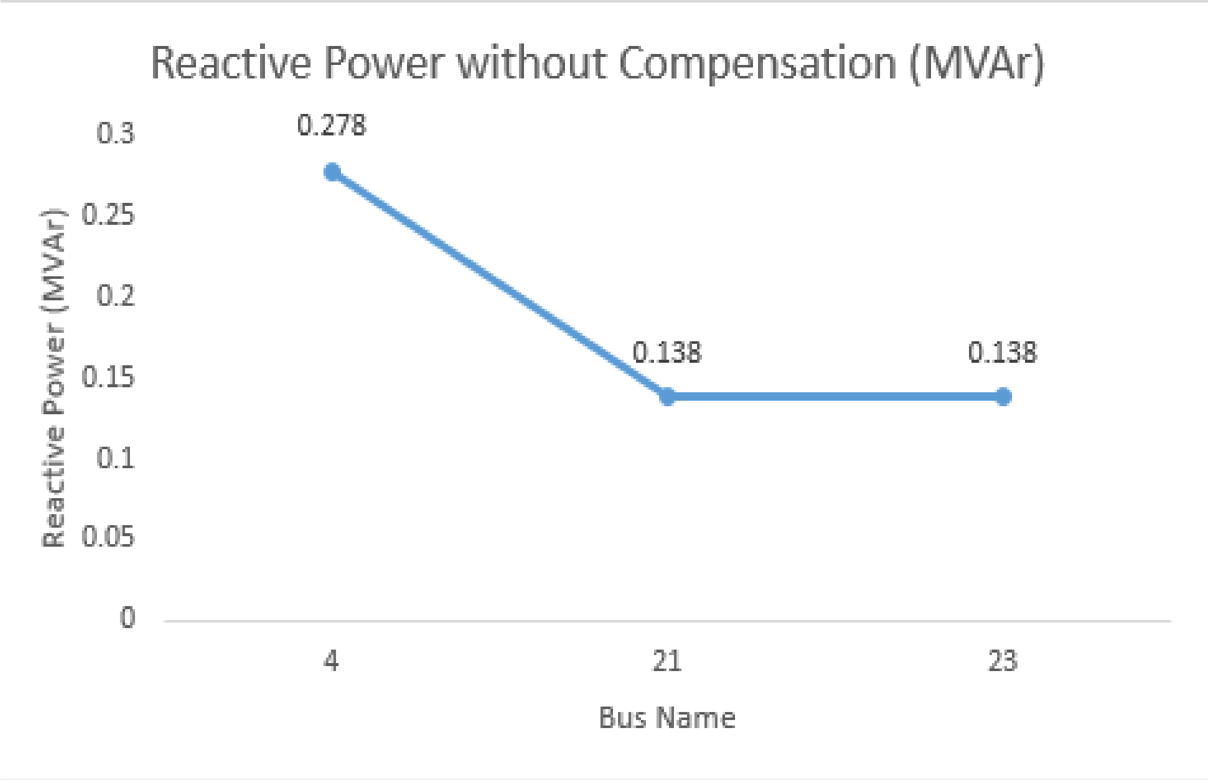

Fig. 4 Plot of Reactive Power

V. CONCLUSION

Static load model was used in the modelling of 3-bus 132kV transmission lines 1 and 2 in ETAP 12.6 software. This was performed to analyze the transmission lines as the transmission lines were subjected to load flow analysis with static load of 350KVA for each of buses 17 and 19. The load flow analysis indicated that buses 4, 21 and 23 have voltage magnitudes of 99.902, 99.897 and 99.897 which represent 131.87kV, 131.86kV and 131.86kV as against 132kV for buses 4, 21 and 23.

Also, reactive powers available are 0.278MVAr, 0.138MVAr for each of buses 21 and 23. This is an indication of reactive power and how it affects the line performance.

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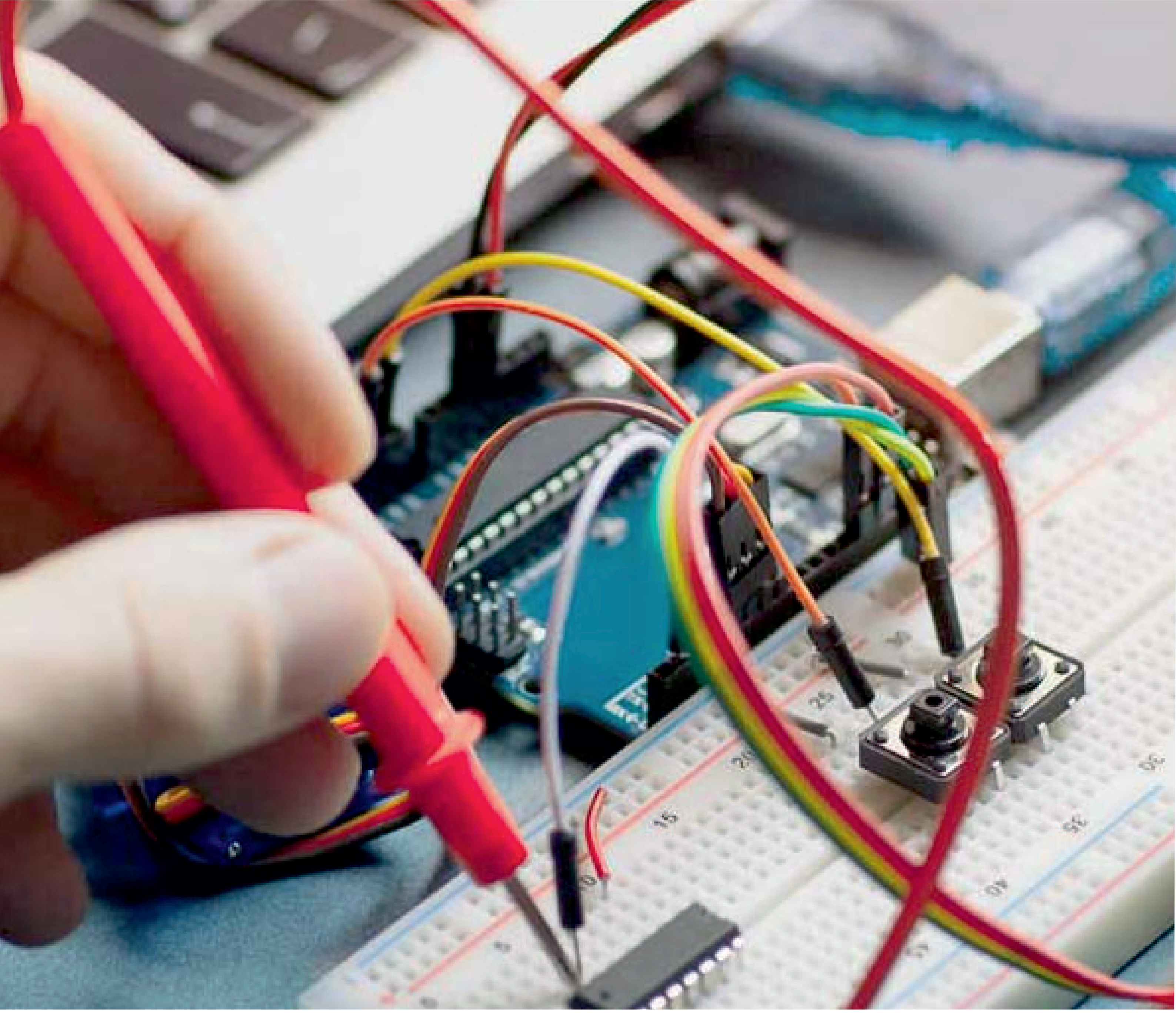

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