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Optimization of Total Transfer Capability using Allocation of FACT devices and Genetic Algorithm

Shivansh Dwivedi[1], Devendra Dohare[2]

PG Student, Department of Electrical Engineering, Maharana Pratap College of Technology, Gwalior, Madhya Pradesh, India

Assistant Professor, Department of Electrical Engineering, Maharana Pratap College of Technology, Gwalior, Madhya Pradesh, India

ABSTRACT: Energy power flows are an important factor to be calculated and, thus, are needed to be enhanced in an electrical generation system. It is very necessary to optimally locate the Flexible Alternating Current Transmission Systems (FACTS) devices and improve the Available Transfer Capability (ATC) of the power transmission lines. It relieves the congestion of the system and increases the flow of power. This research study has been accomplished in two stages: optimization of location of FACTS device by the novel Sensitivity and Power loss-based Congestion Reduction (SPCR) method and the calculation of ATC using the Genetic Algorithm technique. The Thyristor Controlled Series Capacitor (TCSC) is used as a FACTS device to control the reactance of power transmission line. The effectiveness of the proposed methods is validated, utilizing the 14 bus system. The acquired outcomes are contrasted with conventional ACPTDF and DCPTDF procedures. These values are determined with the assistance of MATLAB version 2020a on the Intel Core i7 framework.

KEYWORDS: Transmission system, FACTS devices, Genetic algorithm, Congestion Reduction, Available Transfer Capabilities

I. INTRODUCTION

The power system has gone through a significant change in the most recent many years. Previously, the electric industry has been either an administration controlled or an administration directed industry, which existed as syndication in its administration area. The huge element of these progressions is to take rivalry among generators of power into account and to make an economic situation in the businesses, which are viewed as important in expanding the proficiency of electric energy creation and appropriation, and to offer lower costs, higher caliber, and safer item. In the monopolistic structure, the generation, transmission, distribution, and control in a region are overseen by one organization or office that offered electric force and offered types of assistance to all clients, for example, the power is considered as an energy flexible area. While, in the emerging restructured competitive market, the different under taking are isolated and they must be independently paid by the executing parties, for example, the power is treated as an assistance area and it is to be advertised as another normal ware. The transmission of power itself can be treated as a particular assistance. There are qualifications in the deregulated structure and, along these lines.

A significant increase in power transfers involves non-discriminatory open access to transmission networks and it has resulted in a range of technological challenges, including the evaluation of the optimal Available Transfer Capabilities (ATC), to ensure safe transactions.
The ATC indicates the power system's ability to efficiently increase the transferred power for commercial trading between two zones or two points.

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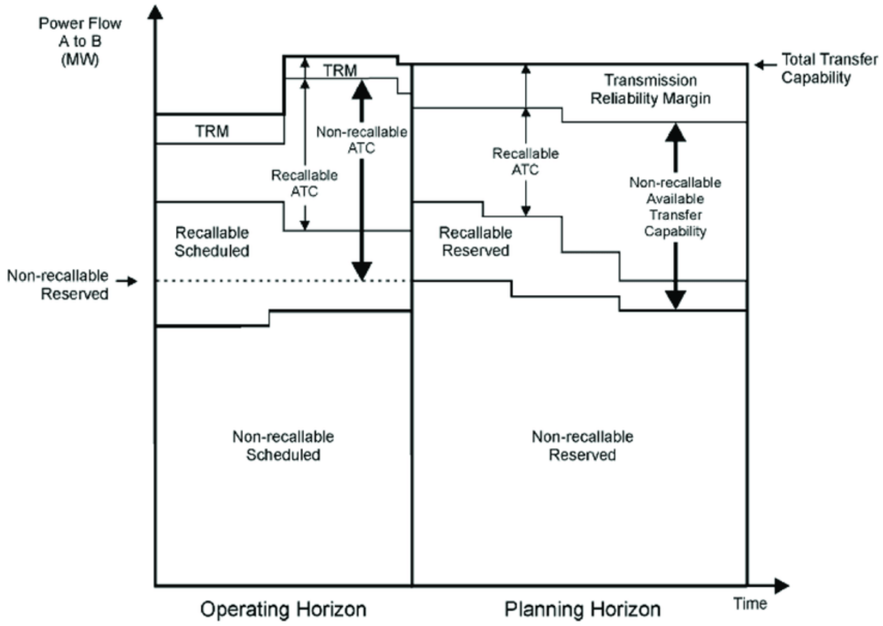

Fig. 1: Various terms for scheduling the transmission service

The transfer capability refers to the unutilized transfer capability of a transmitting network that is available for transactions to the participants in the market. Its accurate and fast estimation, including margins of transmission, remains the key factor in congestion management and its planning [1].

Because power transmission amenities have some physical constraints, entire power transactions cannot be acknowledged. Further, the expansion of new generation and trans- mission facilities become hindered due to ecological constraints and economic contemplated- tions.Various methods have been reported earlier to estimate ATC based on conventional power system equations. The methods that are based on DC load flow [2] involve less computation complexity and are faster.

The Continuation Power Flow methods (CPF) and Repeated Power Flows(RPF)repeat a full-scale AC load flow solution per increment (over the basic case value) of the load at the sink until any line in the system becomes over-loaded. In these methods, the impact of voltage and reactive power has been accounted for. Although accurate computation complexity is more while being implemented on a large system, and the optimal generation is ignored. The methods that are based on optimal power flow (OPF) provide the optimal settings of controllable variables by optimizing the objective function subjected to equality and inequality constraints. The methods that are based on distribution factors [3] can accommodate the scenarios that are near to the base case. For this purpose, the factors based on power transfer/outage are derived. The linear ATC method [4] that is based on linear distribution factors provides the approximate ATC value. The methods using sensitivity indices [5] can quickly calculate ATC. However, accuracy cannot be maintained when there are significant changes in the system. ATC can be estimated based on probabilistic methods [6].

After going through all these research works, we came to know that there is a lack of methods that can imbibe the quality of sensitivity factors and, at the same time, prove that the reactive power losses are reduced and congestion is minimized by reduction of real power [11,13 ,14].

II. IEEE 14 BUS NETWORK SYSTEM

The IEEE 14 bus system is shown in figure 2. The system data is takenfrom [9]. The data given in the following tables is on 100MVA base.The minimum and maximum limits of voltage magnitude and phase angle areconsidered to be 0.95p.u. to 1.05p.u. and -45° to +45° respectively.

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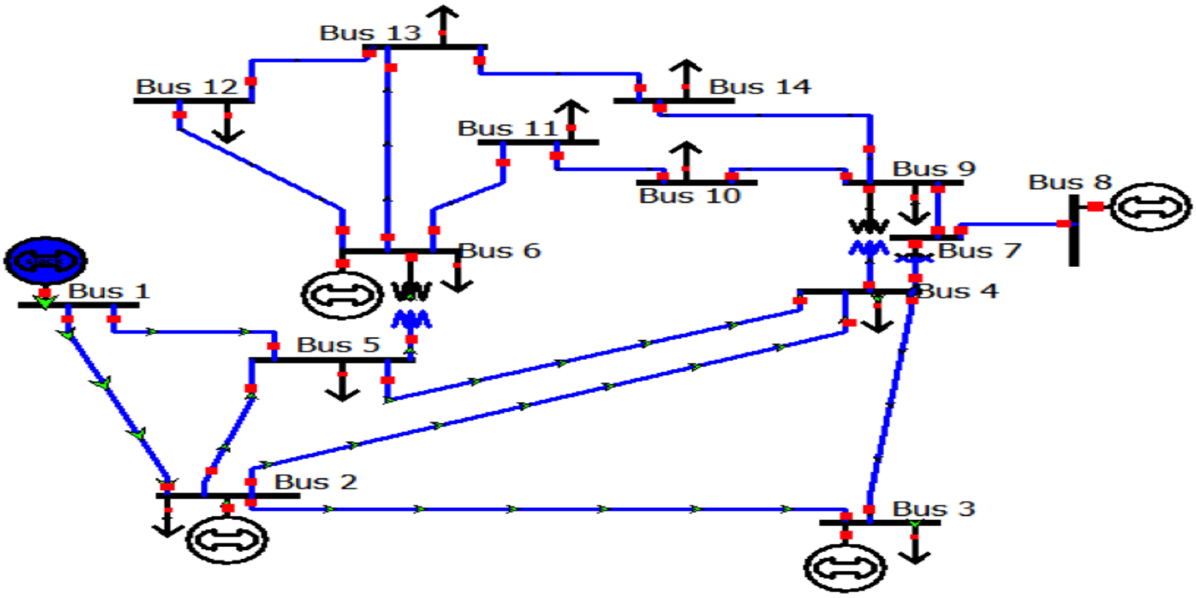

Fig. 2: IEEE 14 Bus network system

Table 1: Line data IEEE 14 bus system

Line number	From bus	To bus	Line impedance ($p.u.$)		Half line charging susceptance ($p.u.$)	MVA rating
			Resistance	Reactance		
1	1	2	0.01938	0.05917	0.02640	120
2	1	5	0.05403	0.22304	0.02190	65
3	2	3	0.04699	0.19797	0.01870	36
4	2	4	0.05811	0.17632	0.02460	65
5	2	5	0.05695	0.17388	0.01700	50
6	3	4	0.06701	0.17103	0.01730	65
7	4	5	0.01335	0.04211	0.00640	45
8	4	7	0	0.20912	0	55
9	4	9	0	0.55618	0	32
10	5	6	0	0.25202	0	45
11	6	11	0.09498	0.1989	0	18
12	6	12	0.12291	0.25581	0	32
13	6	13	0.06615	0.13027	0	32
14	7	8	0	0.17615	0	32
15	7	9	0	0.11001	0	32
16	9	10	0.03181	0.0845	0	32
17	9	14	0.12711	0.27038	0	32
18	10	11	0.08205	0.19207	0	12
19	12	13	0.22092	0.19988	0	12
20	13	14	0.17093	0.34802	0	12

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III. MATERIAL AND METHODS

The genetic algorithm (GA), developed by John Holland and his collaborators in the 1960s and 1970s (Holland, 1975; De Jong, 1975), is a model or abstraction of biological evolution based on Charles Darwin's theory of natural selection. Holland was probably the first to use the crossover and recombination, mutation, and selection in the study of adaptive and artificial systems. These genetic operators form the essential part of the genetic algorithm as a problem-solving strategy. There are many advantages of genetic algorithms over traditional optimization algorithms. Two most notable are: the ability of dealing with complex problems and parallelism. Genetic algorithms can deal with various types of optimization, whether the objective (fitness) function is stationary or non-stationary (change with time), linear or nonlinear, continuous or discontinuous, or with random noise. Because multiple offspring's in a population act like independent agents, the population (or any subgroup) can explore the search space in many directions simultaneously. This feature makes it ideal to parallelize the algorithms for implementation. Different parameters and even different groups of encoded strings can be manipulated at the same time. In this work Genetic Algorithm is used to optimize the placement location on FACTS devices for getting the maximized transfer of power through a transmission line. The various steps of the GA is given in the chart below:

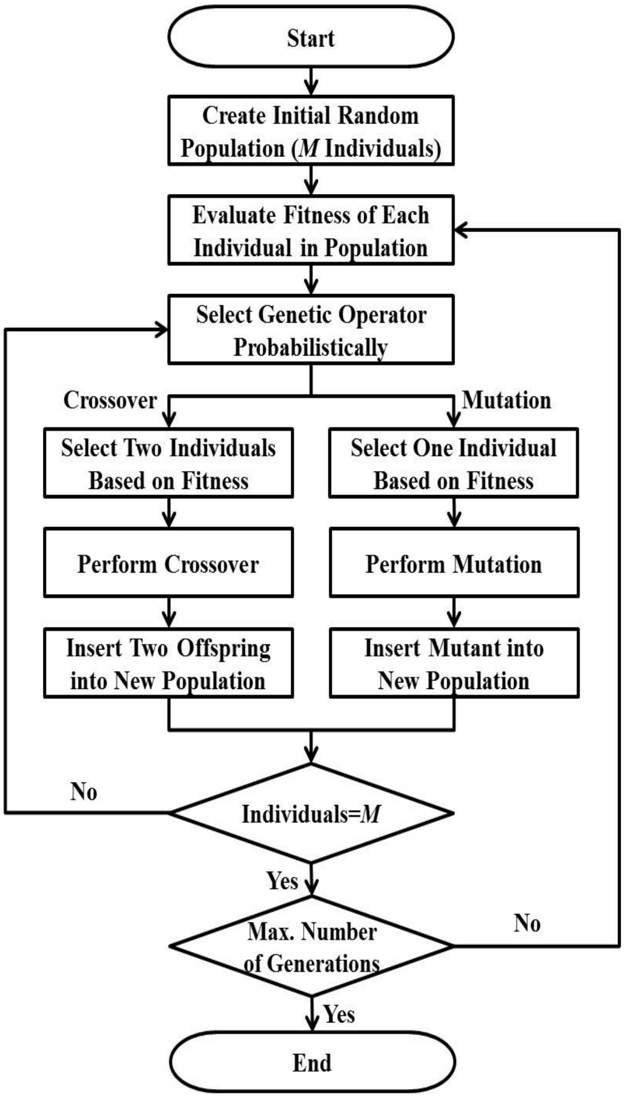

Fig. 3: Flow diagram of GA

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IV. SIMULATION RESULTS

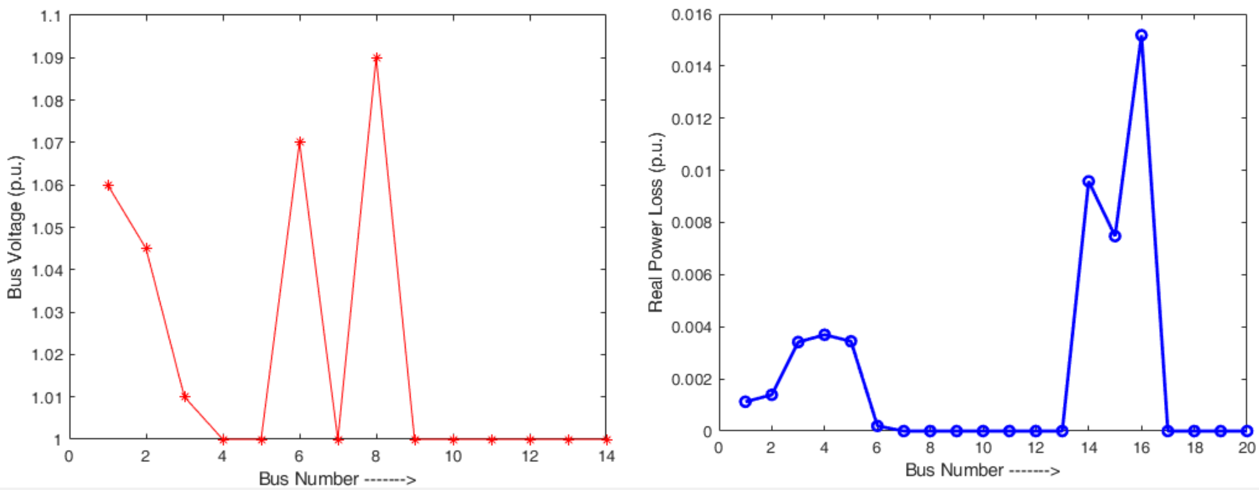
After successful implementation, we have simulated the proposed method in MATLAB and the obtained results are presented in this section.

4.1 Bus voltage profile with incorporation of SVC and TCSC

Bus voltage magnitude during transaction T1 with incorporation of SVC and TCSC is presented in Fig. 4(a). TCSC maintains bus voltage magnitude throughout the transaction. However, network bus voltage between bus number 8 and 14 experienced a slight improvement with incorporation of SVC. A similar scenario was experienced during simultaneous transaction T2 as indicated in Fig. 6 in which voltage at buses numbers 16 to 30 were slightly increased with SVC. Still, TCSC incorporation maintained bus voltage magnitude for all buses. In multilateral transaction T3, a slight voltage dip occurred from bus number 6 to 14 with placement of TCSC for ATC enhancement.

4.2 Real power losses with incorporation of SVC and TCSC

The response of the test system real power loss to ATC enhancement consequent of FACT amalgamation is shown in Figs. 4(b). Placement of TCSC and SVC maintains system real power loss without further provocation during transactions T1 and T2. Notwithstanding, a critical look at Figs. 4(b)reveals the variation of system loss with FACTS for different transmission lines. Arising from Fig. 10, TCSC placement reduced system loss from 0.0081 p.u to 0.005p.u on transmission line 14-16where it was incorporated but increased losses slightly on line 2-6, 14-16 and 16-18 during multilateral transaction T3. However, for all these mentioned lines, SVC maintained and slightly reduced losses on line 6-8.



(a) Bus voltage profile (b) Power loss profile

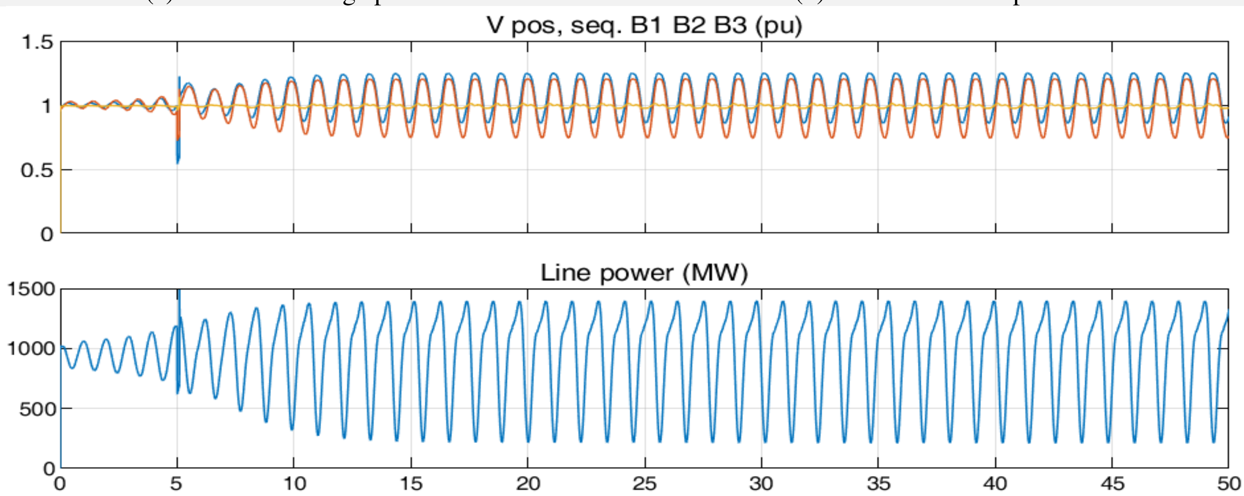


Fig. 5: Line Power and Bus Voltage Transient Analysis.

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V. CONCLUSION

From all the test cases, it is clear that with incorporating FACTS controllers the ATC can be enhanced and also it is noticed that the TCSC gives more ATC when compared to SVC. i.e., with TCSC, enhancement of ATC is better than with SVC. The result indicates that use of the FACTS devices could increase the ATC approximately 1000 MW for large power systems. The results obtained on test systems reveal that the ATC values are enhanced with suitable parameters of TCSC and SVC using CSO which gives the better enhancement of ATC under normal as well as line outage case. Also, it is clear that the ATC is high within FACTS case-3 and low in case-4 for 14-bus system. The contingency based on the performance based index gives the most accurate contingency cases in all line outage as well as the significance of data change case. For very large systems the number of population must be increased.

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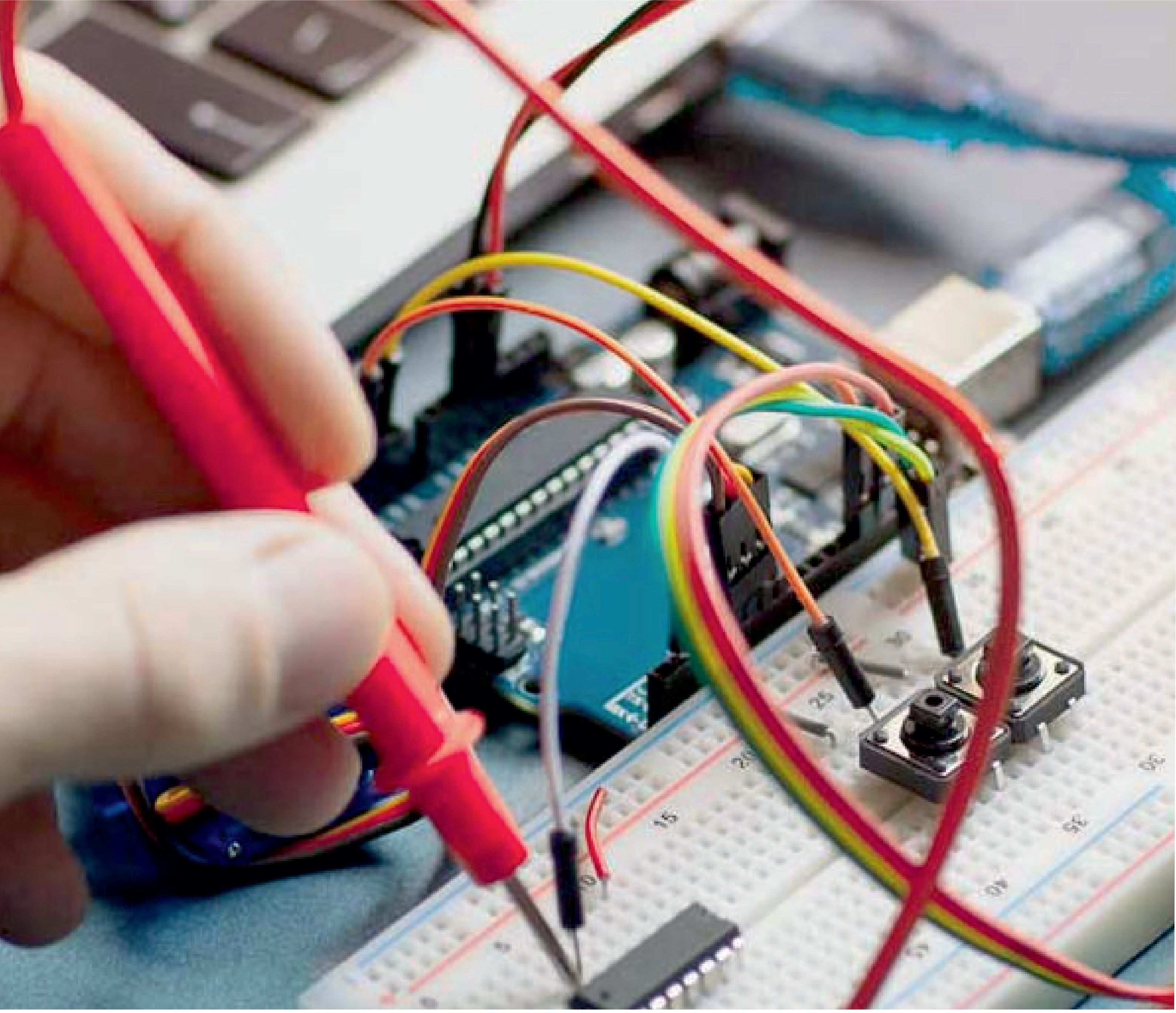

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