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Harmonic Minimization for Cascade Multi Level inverter based on Differential Evolutionary Algorithm

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ABSTRACT: A new topology of cascaded multilevel converter is proposed. The proposed to is predicated on a cascaded connection of single-phase sub multilevel converter units and full bridge converters. Compared to standard multilevel converter, the amount of DC voltage sources, switches, installation area, and converter cost is reduced as number of voltage steps increases. structure of proposed topology is optimized so as to utilize a minimum number of switches and DC voltage sources, produce a high number of output voltage steps. The H-bridge based multilevel inverter increase the amount of output voltage levels by adding switch components and DC input voltage sources. lower number of conducting switches which reduces the switching losses. Comparison study is presented between the proposed inverter and other recently presented toapologies

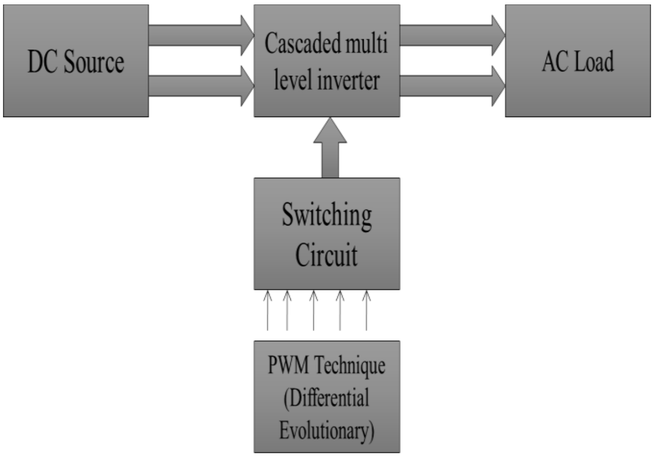
I. INTRODUCTION

Multilevel inverters are more advanced and latest type of power electronic converters that synthesize a desired output voltage from several levels of dc voltages as inputs. By taking sufficient number of dc sources, anearly sinusoidal voltage waveform are often synthesized.

In comparison with the hard-switched two-level pulsewidth modulation inverters, multilevel inverters offerseveral advantages including their capabilities to workat high voltage with lower voltage stress per switching,high efficiency and low electromagnetic interferences [1],[3] etc.To synthesize multilevel output ac voltage usingdifferent levels of dc inputs, semiconductor devices must

be switched on and off in such how that desiredfundamental is obtained with minimumharmonicdistortion. There are different approaches for theselection of switching techniques for the multilevelinverters [4]-[9], one among the important techniques isselective harmonic elimination (SHE) method. In SHEtechnique, certain predominating lower order harmonicsare eliminated whereas higher order harmonics arefiltered using suitable filter. Switching angles arecomputed by solving the SHE equations, but it's difficultto solve SHE equations due to their nonlinearcharacteristics. thanks to nonlinear nature, solution ofthoseequations could also be simple, multiple or maybe no solution fora particular value of modulation index (m). an enormous task ishow to get all possible solutionsonce they exist usingsimple andfewer computationally complex method. Oncethese solutions are obtained, the solutions having leastTHD are selected for switching purpose.In [4], [5], iterativenumerical techniques likeNewton- Raphsonmethod are implemented tosolve the SHE equations producing just one solution set,and even for this a correct initial guess and starting valueof m that solutions exist are required. Sometechniques as discussed in [6], [7], here SHE equationsare first converted intopolynomial equations, and thenthe resulting polynomial equations are solved usingtheory of resultants of polynomials and therefore the theory ofsymmetrical polynomials, producing all possiblesolutions. an issue with these approaches is that forhigher levels of multilevel inverter the order ofpolynomials becomes very high, thereby making thecomputations of solutions of those polynomial equationsvery complex. Optimization techniques supported GeneticAlgorithm(GA)and Differential evolutionary Algorithm are discussed in [8], [9] for computingswitching anglesjustfor7levelmultilevelinverters.Theimplementationofthose approachrequiresproperselectionofcertainparameters like population size,mutation rate, initial weight etc. It becomes difficult toselect these parameters for higher level multilevelinverters. to bypass above mentionedproblems,asimpleoptimizationtechnique supported sequentialquadratic programming (SQP) is proposed during this paper tosolve SHE equations which produces all possiblesolutions. The proposed technique is implemented insucha way that each one possible solutions for any number of Hbridges connected serial are computed by using anyarbitrary initial guess with negligiblecomputationaleffort. an entire analysis for an 11-levelinverter usingfive H-bridges per introduce series ispresented, and it'sshown that for a variety of m,switching angles are oftencomputed to supply thespecified fundamental voltagealong with elimination of 5th, 7th, 11th, and 13th orderharmonic components. The computational results arevalidated through experiments.

BLOCK DIAGRAM:



II. CASCADE MULTILEVEL INVERTER

Cascade Multilevel Inverter (CMLI) is one among theforemostimportant topology within the family ofmultilevel inverters.It requires least number of components with compare todiode-clamped and flying capacitors type multilevelinverters. it's modular structure with simple switchingstrategy and occupies less space [1] - [3].

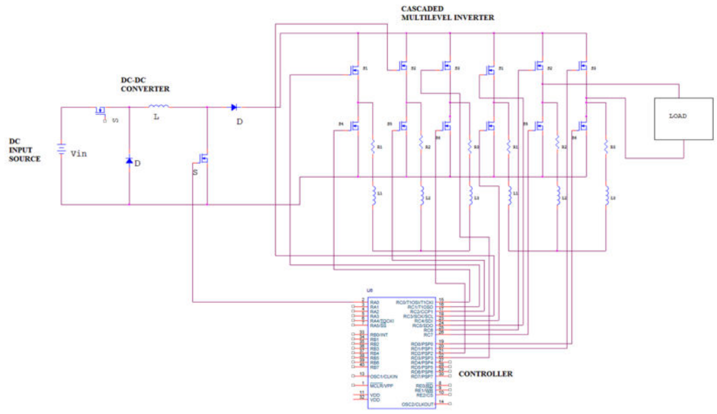
The CMLI consists of variety of H-bridge inverterunits with separate dc source for every unit and isconnected in cascade or series as shown in Fig. 1. EachH-bridge can produce three different voltage levels: +Vdc,0, and –Vdc by connecting the dc source to ac output sideby different combinations of 6switches S1, S2, S3,S4, S5 and S6. ac output of every H-bridge is connected serialsuch that the synthesized output voltage waveform is that thesum of all of the individual H-bridge outputs.

cascade and using proper modulation scheme, a nearlysinusoidal output voltage waveform are often synthesized.The number of levels within the output phase voltage is 2s+1,where s is that the number of H-bridges used per phase. Fig. 2shows an 11-level output phase voltage waveform usingfive H-bridges. The magnitude of the ac output phasevoltage is given by

van = va1+va2+va3+va4+va5 [2].

In general, when s number of H-bridges per phase isconnected in cascade, the Fourier series expansion of thestaircase output voltage waveform is given by (1).

CIRCUIT DIAGRAM:



III.HARMONIC ELIMINATION CONTROL TECHNIQUE USING EVOLUTIONARY ALGORITHMS USING GA & DEA

Harmonic Elimination pulse width modulation (HEPWM)method has been widely applied to remove harmonics due to its superior frequency spectra. It requires the answer of a set of transcendental nonlinear equations. Softcomputing(SC) methods are extensively employed to unravel thisproblem due to their effective global search ability.Genetic Algorithm (GA) and Differential evolution (DE) has surpassed most of the SC methods in diverse fields butit has never been utilized to unravel this problem. In thiswork. GA and DE is employed to unravel the HEPWMproblem for eleven level cascaded multilevel voltage source inverter (MVSI). Simulation results have shownthat the discontinuities of the HEPWM angle trajectories are nullified and a wider over-modulation range has beencovered, enhancing the use of DC link voltages and extending the appliance of HEPWM for top powerapplications.

IV.FORMULATING THE MATTER

The step- by- step procedure to unravel the SHE problem with unequal dc sources using GA isas follows.

i) Get the info for the system. At the primary step, therequired parameters of the algorithm likepopulation size, modulation index (M), NominalVoltage, Number of Inverter level, max iterationnumber are determined.
ii) Random population generation.
iii) Fitness function – the fitness evaluation evaluatethe population using the fitness function given byequation .
iv) Parent Selection – Best parents of generation areselected supported the rouleete. Wheel selectionfor creating next generation.
v) Crossover – the crossover operator creates thetwo new child vector by mating the 2 bestparents using arithmetic crossover method.
vi) Mutation – the mutation operator mutates a toddlerby changing any of it's genes.
vii) Survival Selection – the survival selectionoperator chooses the vectors that are getting tocompose the population within the next generation.

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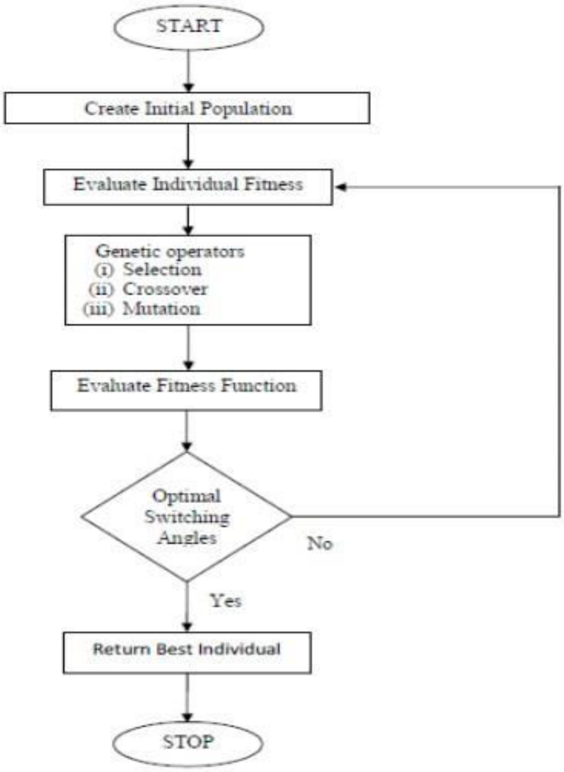
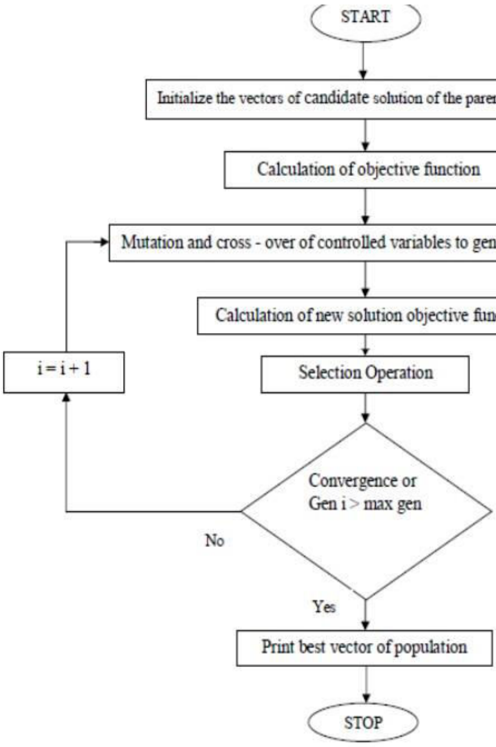
V. FLOW CHART OF GENETIC ALGORITHM



VI. DIFFERENTIAL EVOLUTION ALGORITHM

The DE algorithm may be a population based algorithm likegenetic algorithms using the similar operators; crossover,mutation and selection. the most difference in
constructing better solutions is that genetic algorithms on crossover while DE relies on mutation operation. This main operation is predicated on the differences of randomly sampled pairs of solutions withinthe population. The algorithmuses mutation operation as an enquiry mechanism and selection operation to direct the search toward theprospective regions within the search space. The Differential Evolutionary algorithm
also uses a non-uniform crossover which will take childvector parameters from one parent more often than it doesfrom others. The recombination (crossover) operator
efficiently shuffles information about successful combinations, enabling the look for a far better solutionspace. An optimization task consisting of D parameters canbe represented by a D-dimensional vector. In DE, a population of NP solution vectors is randomly created at the start. This population is successfully improved by applying mutation, crossover and selection operators.

FLOW CHART DEA



VII. STEPS OF DIFFERENTIAL EVOLUTION

The main steps of the DE algorithm are given below:
• Initialization
• Mutation
• Crossover
• Selection

Mutation

For each target vector $x_{i,G}$,i= 1,2,3,…..,NP, a mutant vector is produced by

$$v_{i,G+1} = x_{r1,G} + F \cdot (x_{r2,G} - x_{r3,G})$$

withrandom indexes *r1, r2, r3* {1,2,….,NP}, integer, mutually different and $F > 0$. The mutation factor *F* is a constant from [0,2] which controls the amplification of the differential variation

$$(x_{r2,G} - x_{r3,G}).$$

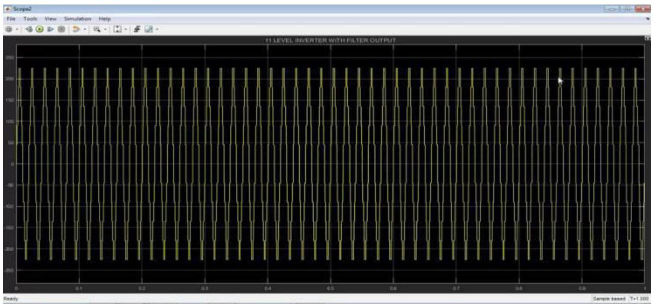
Crossover

In order to increase the diversity of the parameter vectors, crossover is introduced. To this end¸ the trial vector:
$u_{i,G+1} = (u_{1i,G+1}, u_{2i,G+1},\ldots,u_{Di,G+1})$
is formed, where

$$u_{ji,G+1} = \begin{cases} v_{ji,G+1} & \text{if } (rand_j \leq CR) \text{ or } j = I_{rand} \\ x_{ji,G} & \text{if } (rand_j > CR) \text{ and } j \neq I_{rand} \end{cases}$$

Selection

To decide whether or not it should become a member of generation *G*+1, the trial vector *ui,G*+1 is compared to the target vector *xi,G* using the greedy criterion. If vector *ui,G*+1 yields a smaller cost function value than *xi,G,* then *xi,G*+1 is set to *ui,G*+1*;* otherwise, the old value *xi,G* is retained.



Output wave form

VIII. CONCLUSION

The selective harmonic elimination method atfundamental frequency switching scheme has beenimplemented using the optimization technique thatproduces all possible solution sets once they exist. Incomparison with other suggested methods, the proposedtechnique has many advantages such as: it can produce allpossible solution sets for any numbers of multilevelinverter without much computational burden, speed ofconvergence is fast, it can produce continuous solutionsfor the entire range of modulation index therebygiving more flexibility on top of things action etc. The proposed

technique was successfully implemented for computingthe switching angles for 11-level CMLI. an entireanalysis for 11-level inverter has been presented and it'sshown that a big amount of THD reduction can beattained if all possible solution sets are computed.

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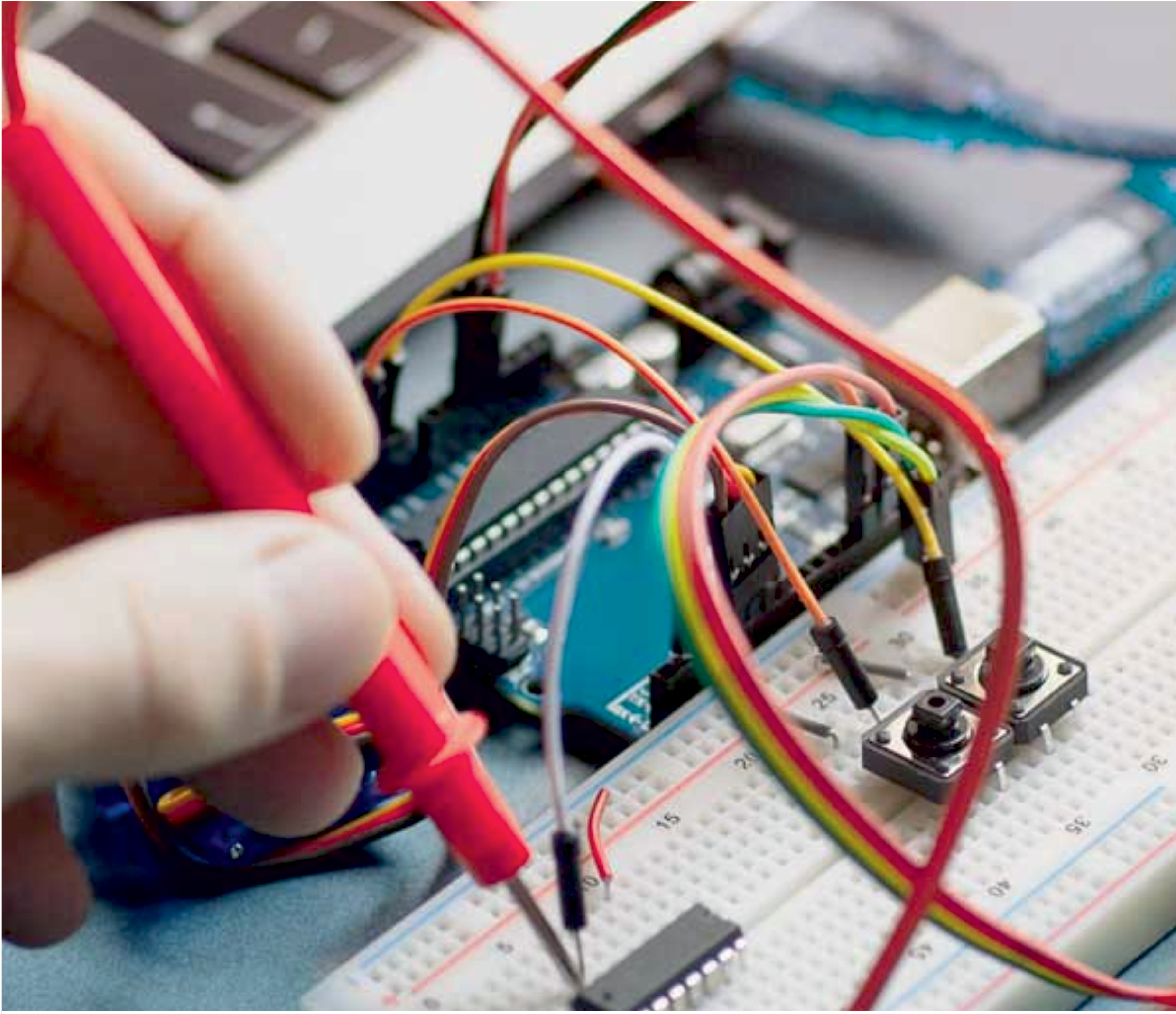

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