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A Single Phase 15-Level Inverter with Reduced Number of Components for Solar PV Applications

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ABSTRACT: In this paper work a single phase fifteen level inverter with reduced number of components for solar PV application is proposed. The proposed inverter fed with boost converter, and boost converter connected to the PV module. PV System is the best renewable energy resources among all the renewable sources. The output obtained by the PV system is unregulated and DC but our transmission system uses AC. So here conversion is very important. In this proposed system boost converter regulates and produce high voltage and proposed inverter produces 15 level output with high efficiency. The proposed inverter have reduced number of components so complexity get reduced. The solar PV with MPPT (P&O) method is carried out, boost converter boost the output voltage to maximum voltage. The work presents the efficiency on different load conditions. The entire work simulating using MATLAB/ SIMULINK software.

KEYWORDS: MLI(Multi level inverter), PV(photo voltaic system), THD(Total harmonic distortion), DC(direct current) AC(alternating current). MATLAB/SIMULINK.

I. INTRODUCTION

In this present world increase in population and advance technology entire world looking towards the high power applications.by demand of power sources world trying to shift towards the renewable energy sources. Solar PV system is best renewable energy resource among all existing sources. The power output obtained by the PV system is DC, so conversion is needed in this process. Power electronic converters are plays a best role in the conversion and controlling process. Integration of power electronic technology with solar PV will give a best result. The output power obtained by PV module is not regulated and fluctuated, so DC-DC boost converter plays role here to reduces the complexity. Inverter is the device which converts DC power to AC power. For high power applications with better efficiency MLI are required because they increases the output voltage without using the transformers.

In this proposed system solar PV produces output voltage with MPPT. MPPT carried out by using P&O method based on duty ratio. Output voltage is fed to DC-DC boost converter and boost converter triggered by MPPT technique. DC-DC boost converter produces high output voltage and this produced output voltage gives to inverter circuit with dc link capacitor. The proposed 15- level inverter have8-switches along with 3 dc sources. DC input voltage is given by 1:2:5 ratio, V1=57.15v,V2=114.3v,V3=285.75v respectively. gate pulses is produced by SPWM technique. The MLI is operated in 15 modes of operation with different 15 level output voltages. The MLI is operated with high voltage with low THD. Losses and efficiency is carried out in this work. Output voltage is stable in both R and RL load conditions. The MLI is integrated boost converter to enhance high DC-link Voltage for solar PV applications. The proposed inverter suits for grid –connected and FACTS.

II. PROPOSED SYSTEM AND DISCUSSION

Proposed System: the proposed system shown in fig (1). PV system output voltage is fed to DC-DC boost converter along with MPPT. Boost converter produces high voltage output and fed to 15-level inverter then inverter produces AC voltage with high efficiency. MPPT is carried out by using (P&O) method by considered duty ratio.the MPPT flowchart of (P&O) method is shown in figure (2).

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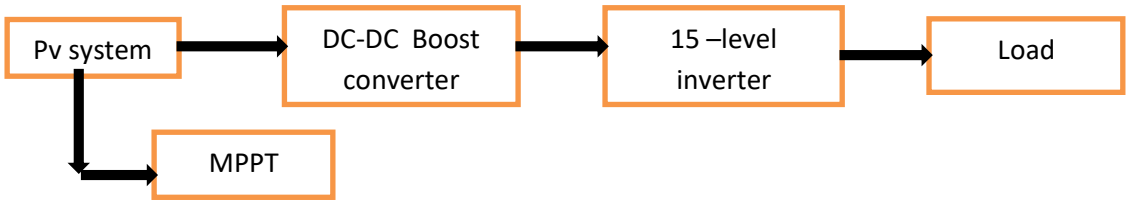

Fig (1) Block diagram of proposed system

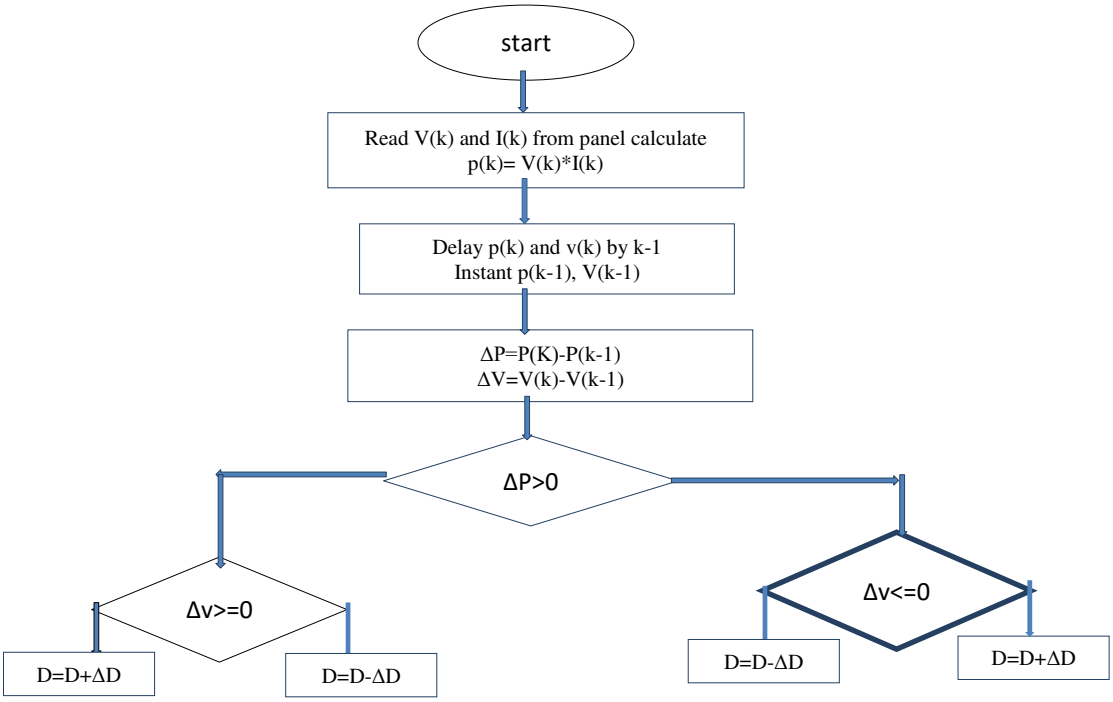

Fig (2) MPPT flow chart of P&O method

Topology: The figure(3) and (4) shows the circuit and Simulink model of the proposed 15 level inverter respectively. Proposed inverter consists of 8 switches along with the 3 DC sources.Voltage sources are given in the form of 1:2:5 ratio.V1=57.15V,V2= 114.3V, V3=285.75 respectively. Table 1 is the switching sequences of the 15-level inverter with 15 levels of output voltage.

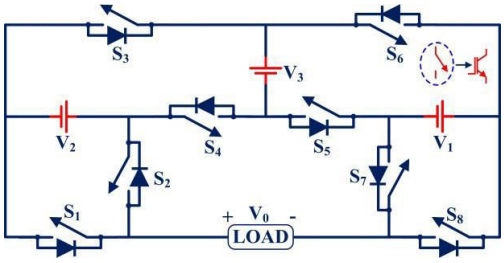

Fig (4) circuit diagram of proposed system

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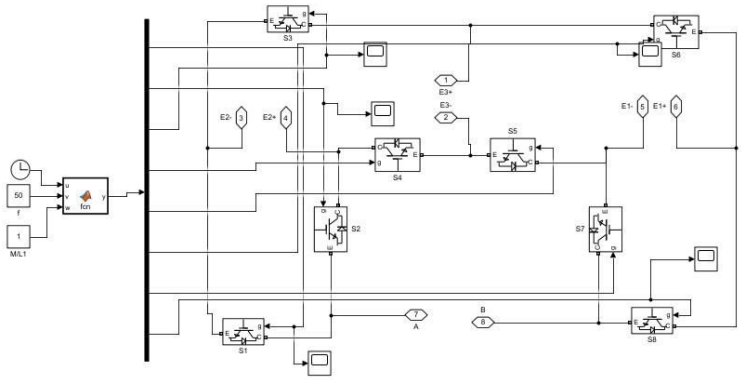

Fig (3) Simulink model of proposed 15 level inverter

Table 1.Switching States Of 15-Level Inverter Along With Output Voltage Level

states	S1	S2	S3	S4	S5	S6	S7	S8	Vout
1	0	1	1	0	1	0	1	0	V2+V3
2	0	1	1	0	1	0	0	1	-V1+V2+V3
3	1	0	1	0	1	0	1	0	V3
4	1	0	1	0	1	0	0	1	-V1+V2
5	0	1	1	0	0	1	1	0	V1+V2
6	0	1	1	0	0	1	0	1	V2
7	1	0	1	0	0	1	1	0	V1
8	0	1	0	1	1	0	1	0	0
9	0	1	0	1	1	0	0	1	-V1
10	1	0	0	1	1	0	1	0	-V2
11	1	0	0	1	1	0	0	1	-(V1+V2)
12	0	1	0	1	0	1	1	0	-(-V1+V3)
13	0	1	0	1	0	1	0	1	-V3
14	1	0	0	1	0	1	1	0	-(-V1+V2+V3)
15	1	0	0	1	0	1	0	1	-(V2+V3)

Design Parameters: for 15-Level inverter power output considered is 800watt for R load and 1500 watt for RL load.Vm=400V.Vrms= 282V. P = Vrms*Irms, I=P/V, Irms=2.88A, R=V/I, R=97.91ohm.

For RL-load, P=1500 watt,; pf = 0.8, I = P/ V*cosϕ =6.75A,Z = (Vrms/Irms) = 41.1ohm, from cosϕ=R/Z

R = 32.8ohm,from impedance triangle, XL can be calculated. XL = 2*pi*f*L, L = 24.76/(2*PI*50) = 0.078H.

For boost converter and solar PV: Vpv =110V, f_s=100KHz, C=1.104mF, L=0.0273H, duty ratio =70%.

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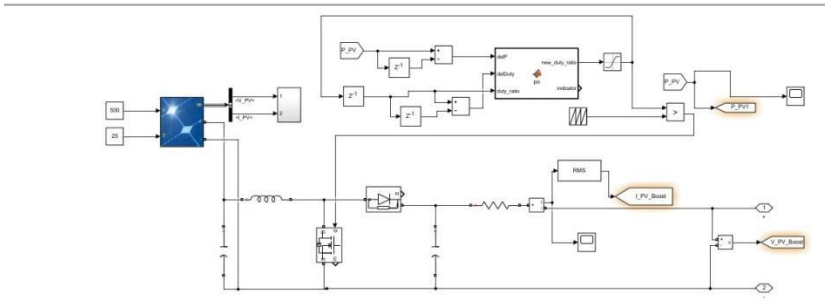
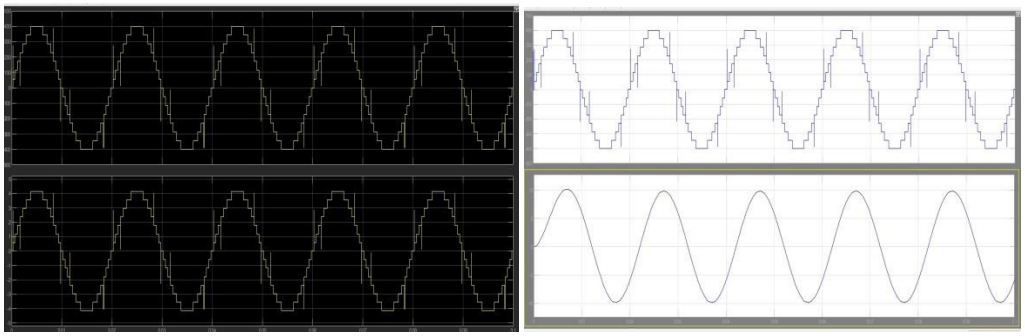


Fig (4) Simulink model of solar PV with MPPT and boost converter

Fig (4) shows the Simulink model of solar PV system with MPPT and boost converter. Boost converter triggered by MPPT method and MPPT is carried out by P&O method by considering duty ratio. Change in power and voltage get compared with previous value and maximum power will obtained. Output of boost converter fed to MLI as a source.

III. SIMULATION RESULTS

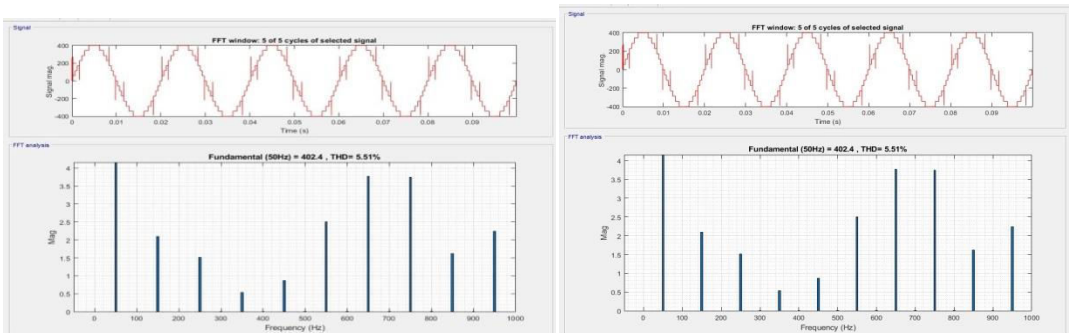
Simulation results of 15-level inverter with reduced number of components



(a)R-load (b) RL-load

Fig (5) out put volatge and current waveforms of 15 MLIwith R and RL load

The figure 5(a&b) shows the output volatge and current waveforms of the fifteen level inverter with R and RL load respectively. The output voltage is stable in both load conditions.current waveforms get changed according to load changes. Vm = 400V and Im=4A(R-load) , Im=10A (RL-load).



6(a) 6(b)

Fig 6. THD of 15-level inverter with R(a) and RL(b) load

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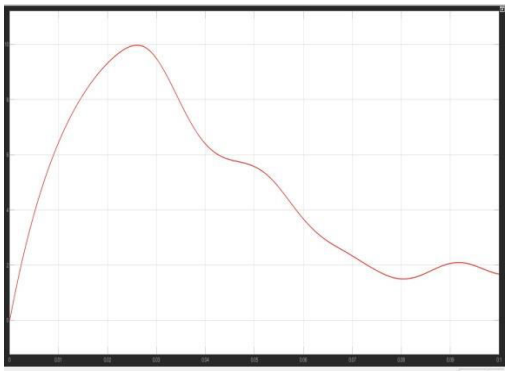
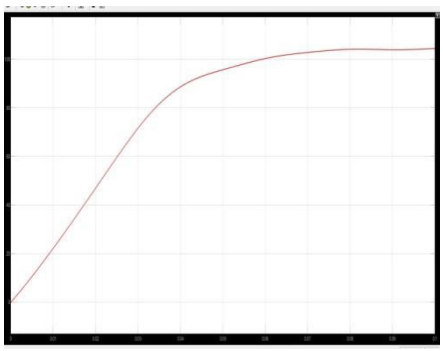
Fig 6(a&b) shows the THD of the output volatge waveform with R and RL load respectively . hormonics of the inverter is not increased even load changes.THD of the inverter is 5.51% and stable in both load comnditions and obtained THD is low with this reduced number of components and compared to other topology inverters.

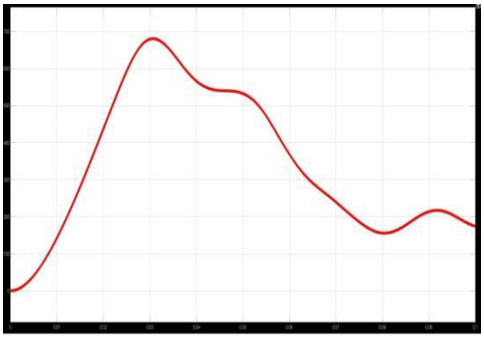


7(a)

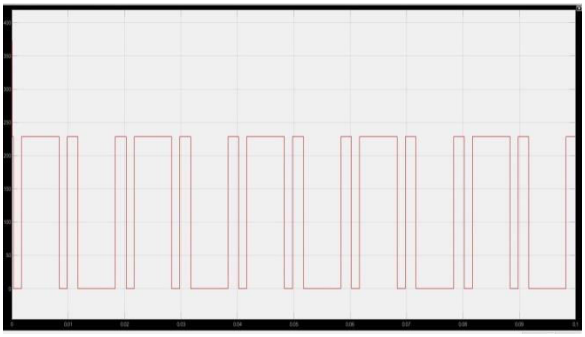


7(b)

Figure 7(a&b) shows the output current and volatage of PV system respectively.Ipv obatained is 10A and Vpv is 110V. output of PV system fed to boost converter to increase the volatage level and for stabel regulated voltage.



7(c)



7(d)

Fig 7(a) output current waveforms of PV, 7(b) output voltage waveforms of PV, 7(c) output power of PV, 7(d) output of boost converter. The maximum power obtained by PV system is 690watt for 500 w/m^2 of irradiance. Boost converter output voltage is 228V.

Table.2.output of solar PV and boost converter

Vpv	110V
Ipv	10A
Ppv	690watt
Vout of boost converter	228V

Table (2) shows the Output of solar PV and DC-DC boost converter , the obtained output voltage from solar PV system is get boosted to high voltage and power.so MPPT and boost converter works well in this proposed system.

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Table.3.simulation output parameters of 15-level inverter with different load conditions.

Parameters	R-load	RL-load
Vrms	282V	282V
Irms	2.88A	7.07A
Pcon	14.52W	37.52W
Psw	0.154W	0.38W
Total losses	14.67W	37.90W
Output power	800W	1500W
Efficiency	98.19%	97.53%
THD	5.51%	5.51%

Table (3) shows the output parameters of the proposed system. Obtained Output voltage is stable in both load conditions. THD is not varied when load changes, efficiency of the system is above 95% in both load conditions. Both conduction and switching losses are calculated, and losses are less compared to other topology inverters.

IV. CONCLUSION

A 15-level inverter with reduced number of components simulation work is carried out in this paper. The MLI inverter consists of only 8 switches with 3 dc sources along with the absence of inductors and capacitors, so cost and complexity get reduced in the proposed system. Because of reduced number of switches switching losses is less and achieved high efficiency with lower THD. The Conventional boost converter produces high voltage and fed to MLI. Mainly renewable sources get used in this proposed work. Conduction and switching losses are calculated. The inverter provides high output voltage and stable in both load conditions. The inverter can be connected to grid and FACTS applications.

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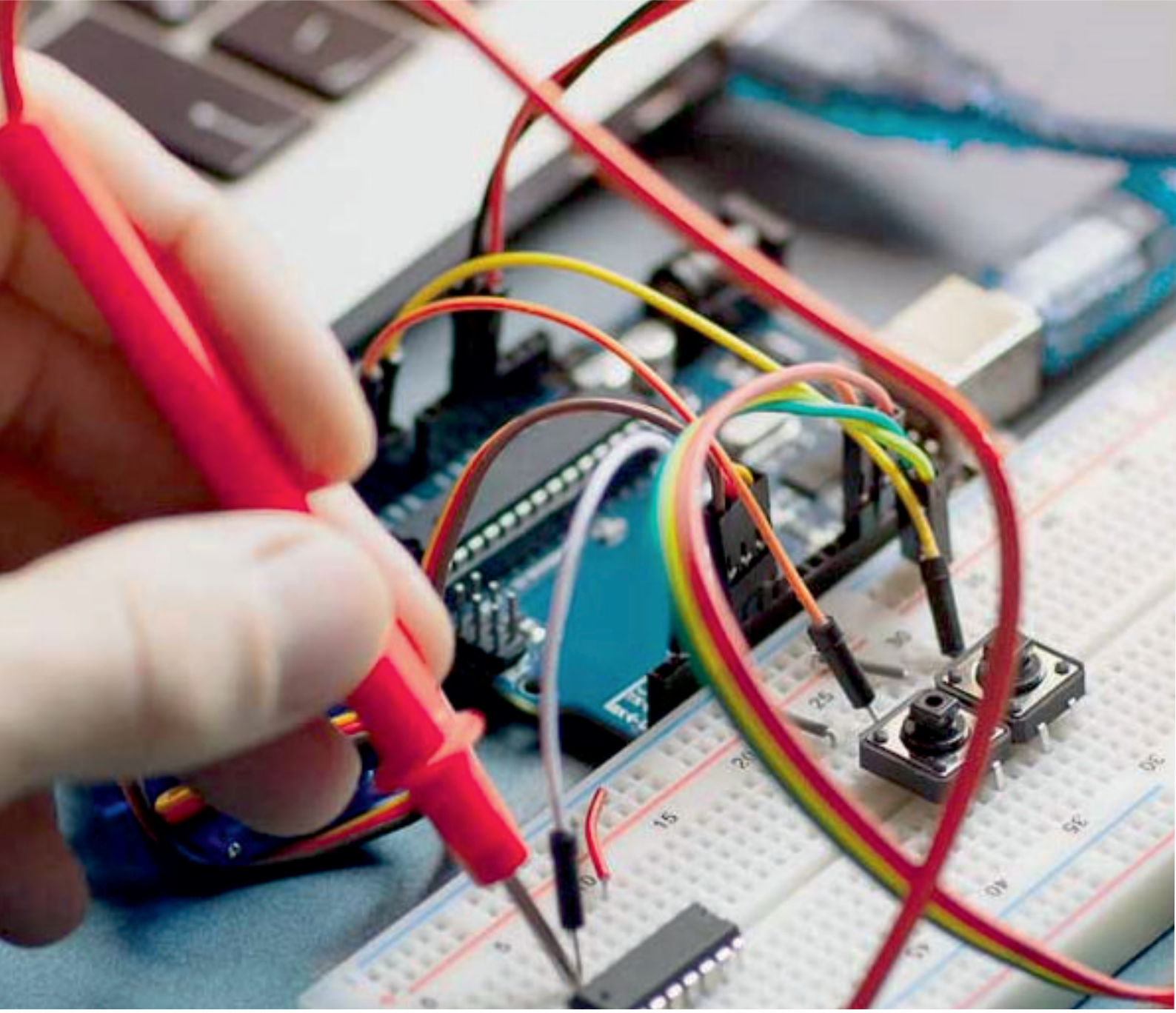

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