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Hybrid DC Microgrid System for Electric Power Distribution

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ABSTRACT: This paper proposes a Novel DC Micro-grid System for smart Energy distribution. The power send to the System from five different sources which from DC micro grid, The Sources are wind, solar, Battery, ac source, and ultra-capacitor all together, form DC micro grid for smart energy delivery. DC micro grid are use to provide output power to three different load namely single-phase output, 100V DC output and 48V DC output,. The grid is at 230Vrms with 50Hz connected to a isolator in connection with the DC bus.The MOSFET switch provide in the ZETA converter switches according to the duty ratio given by the Fuzzy controller for which the input is given from the error value of the reference and measured output DC value of the ZETA converter. It a closed loop control system with feedback fuzzy controller circuit and the switching frequency of the ZETA converter is 45kHz. The converted DC voltage form the ZETA converter is fed to the DC bus where all the other modules are connected.Overall system run using MATLAB 2016 A

KEYWORDS –PV Array, Zeta Converter, Wind system, Ultracapacitor, Inverter..

I. INTRODUCTION

In present, the idea of Smart Grid (SG) turns out to be increasingly significant and recognizable to various territories, which covers the conventional force topology, renewable electrical power source topology, electric vehicles, energy generation stockpiling innovation, correspondence innovation, etc [1]-[4]. The DC Micro-grid (MG) topology, as a subnetwork of the SG topology, can likewise join the smart idea into the DC electrical power dispersion for smart energy generation distribution [5], [6]. Nonetheless, since the smart idea for present day grid is being worked on, the DC MG topology actually restricts in the conventional design. Additionally, there are not many reports on the new DC MG for practical application. In spite of the fact that the reference [7] presents another DC MG for high force quality dissemination, the renewable electrical power source isn't demonstrated into the grid topology. Henceforth, it is as yet a conventional model for the DC grid topology. In this topology, another DC MG topology is introduced for the smart energy generation distribution. The introduced MG topology is associated with the 230V AC electrical power source, and coordinates the renewable electrical power energy of wind electrical power and PV electrical power, just as the electric vehicle together. What's more, the introduced DC grid topology emgrids the battery, UC and EV for the energy generation stockpiling. Henceforth, the introduced DC MG topology can not just give the top notch capacity to three sorts of DC and AC loads, yet in addition accomplish numerous unique highlights and attributes for smart energy generation distribution. In this, it will give a detail discussion of the topology design, topology control technique for smart energy generation distribution, and the comparing reproduction execution.

II. PROPOSED METHODOLOGY

The grid is at 230Vrms with 50Hz associated with an isolator regarding the DC bus. The Three stage generation output of the grid is changed over to undulated DC by the utilization of DBR (Diode connect rectifier) The changed over DC voltage generation is taken care of to ZETA topology which is a DC-DC topology, making the undulated DC to consistent DC with the utilization of a buck inductor. The MOSFET switch give in the ZETA topology switches as per the obligation proportion given by the PI regulator for which the info is given from the blunder estimation of the reference and estimated output DC estimation of the ZETA topology. It a shut circle control network with input PI regulator circuit and the exchanging signal of the ZETA topology is 45kHz.

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The changed over DC voltage generation structure the ZETA topology is taken care of to the DC bus where the wide range of various units are associated. On the load side we have three loads, one AC load which must be 110Vrms and 50Hz. Second 100V DC load, and third is 48V DC load. The AC load comprises of a PWM inverter utilizing Simple sinusoidal PWM method changing over DC to PWM AC with 110Vrms 50Hz output thusly associated with an AC load. The 100V DC load is associated with a DC-DC buck help topology with two MOSFET switches each working with NOT activity. The exchanging signal is 20kHz and the obligation proportion is 0.2 The 48V DC load is associated with another DC-DC buck-help topology with two MOSFET switches each working with NOT activity. The exchanging signal is 20kHz and the obligation proportion is 0.1 In both the DC-DC buck help topologys when the MOSFET Q1 is OFF Q2 is ON charging the inductor. After a pattern of time-frame 50usec the MOSFET Q1 is ON and Q2 is OFF and the charge present in the inductor releases through the MOSFET Q1

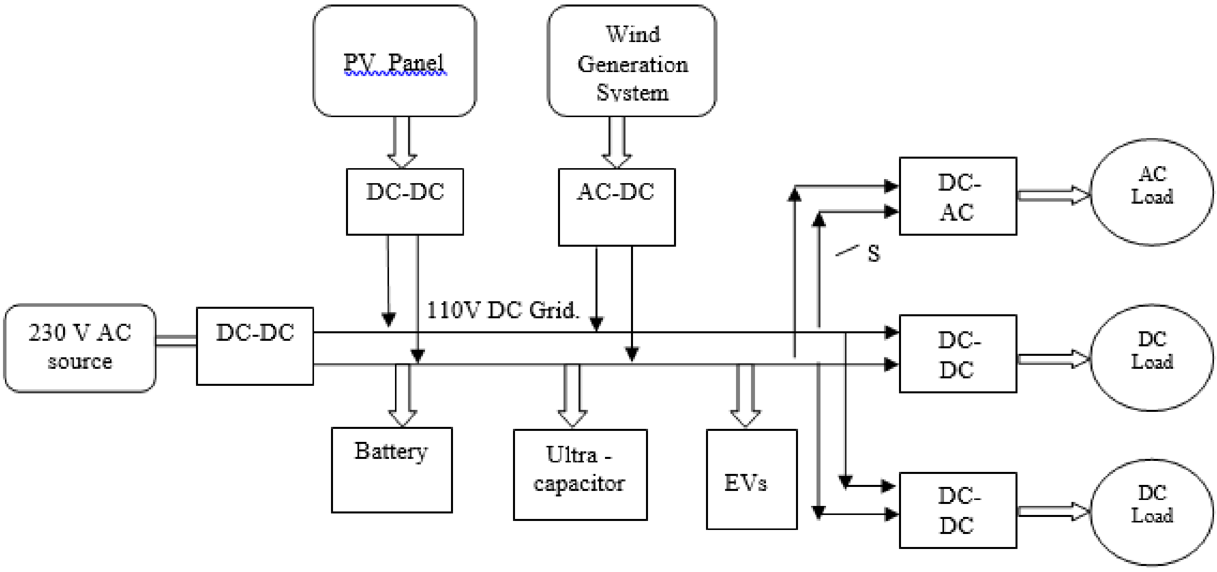

Fig -1 Block diagram of Proposed System

III. MODELING OF PVA

Voltage generation of PVA totally relies upon sunlight based light (Sx) and surrounding temperature (Tx). PVA (Photo voltaic exhibit) is a mix of arrangement and equal sunlight based cells masterminded in a cluster to produced the necessary voltage generation and current. Every arrangement blend of cells can be considered as photograph voltaic unit. Increment in arrangement cells expands the voltage generation and increment in equal cells builds the current limit. Plan for voltage generation of every cell is given beneath

$$V_C = \frac{AkT_C}{e} \ln\left(\frac{I_{ph} + I_0 - I_C}{I_0}\right) - R_S I_C$$

Where, k = Boltzmann consistent (1.38 × 10-23 J/°K).
Ic = cell output current, Amp.
Iph = photocurrent
I0 = turn around immersion current of diode
Rs = arrangement obstruction of cell
Tc = reference cell working temperature
Vc = cell voltage generation, V.

For productive renewable electrical power generation PVA is utilized to create electrical power from sunlight based light. As the load request is expanding step by step the electrical power generation additionally must be expanded, however because of the conventional method of electrical power generation is causing a dangerous atmospheric

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devation. Because of this the productivity of the PVA must be expanded by including silicon surface panel. And furthermore utilize MPPT schemes to follow most extreme electrical power during any light and air conditions. The plan of PVA is done in MATLAB with Simulink block, with numerical portrayal.

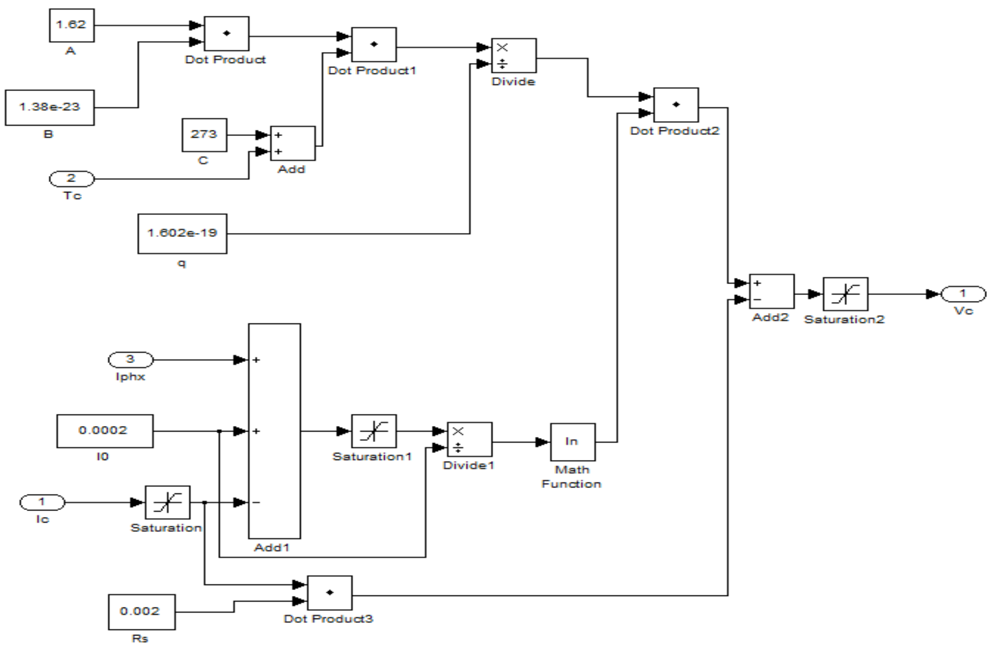

Fig. 2: Simulink Model of Vc

The above plan is for a solitary cell voltage generation, so as to expand the voltage generation of the PVA the phone voltage generation must be duplicated to an ideal qualities considering every phone voltage generation as 0.4V. Along these lines, the quantity of arrangement associated cells (Ns) can be determined as

Ns = Vo/0.4

To get every cell current, the all out current output from the reliable source must be isolated by number of equal associated cells (Np). Thusly, equal associated cells are considered as

Np = Io/Icell

The representation in simulink is taken as

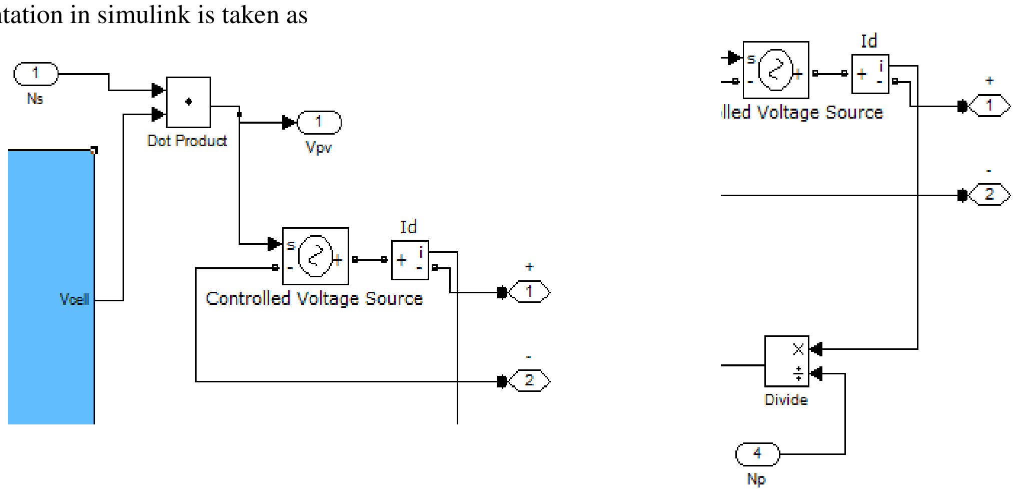

Fig. 3: Simulink modeling of Ns &Np

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For the calculation of V_{cx} (cell voltage generation) and I_{phx} (Photocurrent) we need correction factors C_{TV} C_{TI} C_{SV} C_{SI}. The formulation is given as

$$V_{CX} = C_{TV} C_{SV} V_C$$

$$I_{phx} = C_{TI} C_{SI} I_{ph}$$

The correction factors are given as

$$C_{TV} = 1 + \beta_T (T_a - T_x) \; C_{SV} = 1 + \beta_T \alpha_S (S_x - S_C)$$

$$C_{TI} = 1 + \frac{\gamma_T}{S_C}(T_x - T_a) \; C_{SI} = 1 + \frac{1}{S_C}(S_x - S_C)$$

Where, βT = 0.004 and γT = 0.06

Ta = reference temperature

Tx = ambient temperature

Sc = reference solar irradiation

Sx = ambient solar irradiation

The estimations of Tx and Sx changes relying on the Sun beams which change ceaselessly and eccentrically. The impact of progress in solar irradiation light shifts the cell photocurrent and furthermore the cell.

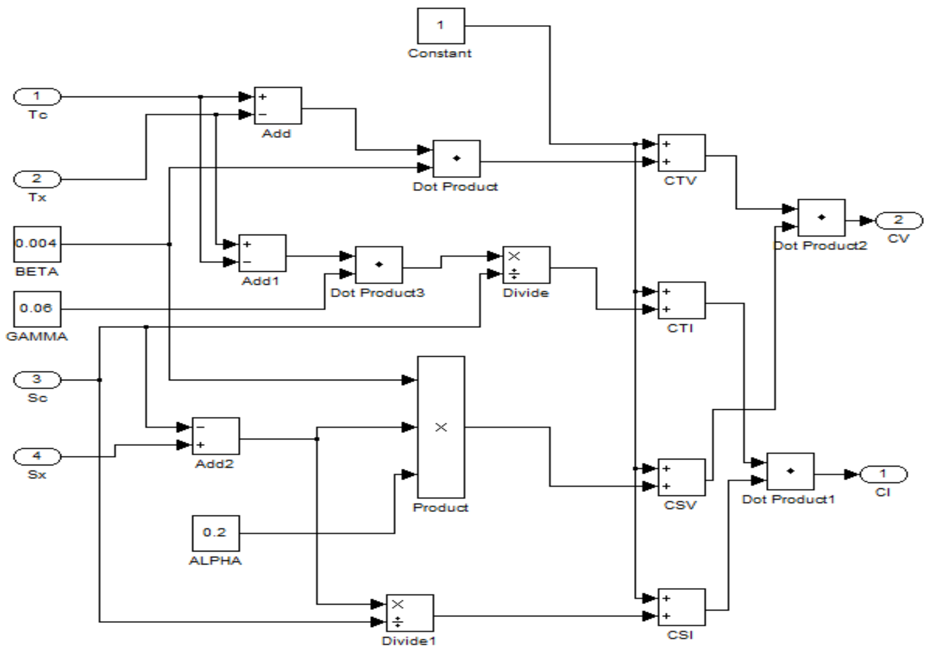

Fig. 4. Modelling

Contingent on the sun electrical powered illumination and temperature the estimations of CV and CI are determined which is taken care of to Vc square to get the cell voltage generation esteem as demonstrated as follows

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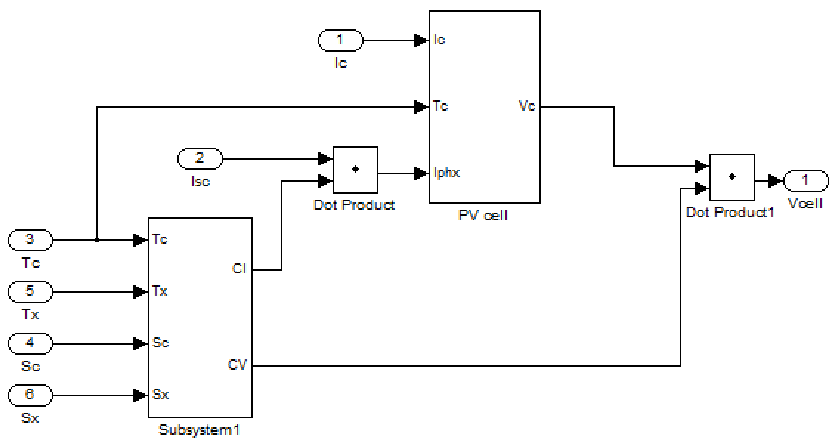

Fig . 5 : Combined diagram of CV CI &Vc mathematical models

The complete network chart of the PVA with the entire numerical detailing are placed into a subnetwork to make it understood and reasonable. The output of the Vc duplicated with the Ns steady square characterizing the absolute voltage generation of the consolidated cells of the PVA is taken care of to the voltage generation controlled voltage generation source block to produce the necessary voltage generation. A diode is associated in arrangement at the positive terminal of the PVA to keep away from turn around currents passing into the PVA. To lessen the waves a capacitor can be included later after the diode in equal as the capacitor doesn't permit unexpected difference in voltage generations dV/dt. The total PVA unit with inside square development is appeared in the fig. beneath

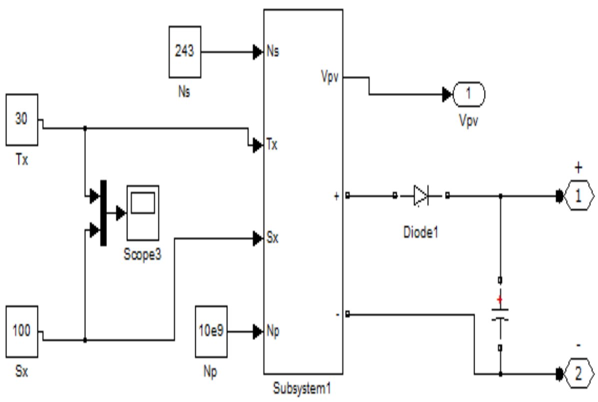

Fig. 6: Complete diagram of PVA

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IV. PROPOSED ZETA TOPOLOGY

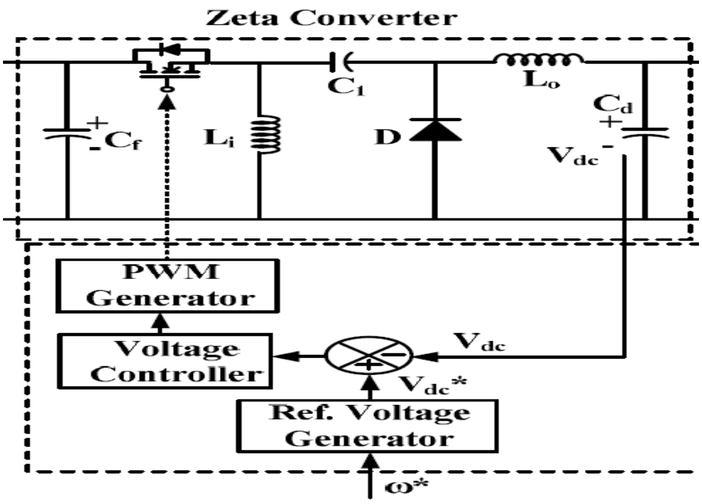

Fig.7. : Zeta topology circuit

The normal output voltage generation after the rectifier is given as

Vin = 2√2 . Versus/π… … ..   (1)

Where Vs is the AC flexibly RMS voltage generation

In the introduced geography a solitary switch (MOSFET) [3] is utilized to control the output voltage generation of the topology. The switch ON schedule and OFF controls the output voltage generation of the topology. A unique obligation proportion (D) must be produced for the activity of the switch at a particular exchanging signal taken as 45kHz. The Duty apportion of the PFC Zeta topology is given as

D = Vdc/(Vin + Vdc)… … ..…. …   (2)

To decrease the current waves in the info current and output current of the introduced topology two inductors Li (input inductor) and Lo (output inductor) [4] are utilized and the estimations of these components is given as

Li = D x Vin/{fs x (ΔiLi)}… …   (3)

Lo = (1-D) x Vdc/{fs x (ΔiLo)}… … ...   (4)

Where, fs = exchanging signal

ΔiLi = change in input current

ΔiLo = change in output current

A middle of the road capacitor (C1) and a DC connect capacitor (Cd) are taken to decrease voltage generation swell brought about by exchanging. Also, these qualities are given as

C1 = D.Idc/{fs. (ΔVC1)}… …   (5)

Cd = Idc/(2.w.ΔVdc)… … ..….   (6)

Where, Idc = output DC current

ΔVC1 = change in voltage generation across capacitor C1

w = precise signal (2. Π. fs)

ΔVdc = Change is DC voltage generation output

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Taking the source voltage generation of 220V as thought and exchanging signal as 45kHz referenced beforehand the estimations of the aloof components are determined as Li = 2.463 mH, Lo = 60 µH, C1 = 330 nF and Cd = 2500 µF [5]. The adjustment in input current ΔiLi and change in output voltage generation ΔVdc are taken as 10% and 4% separately.

V. CONTROL STATERGY

After the demonstrating of the topology with the above qualities the obligation proportion regulator is displayed to control the exchanging of the MOSFET switch in the topology. As found in the fig.8 beneath the voltage generation situated control conspire with PI regulator can be watched.

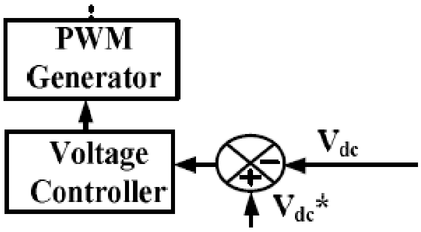

Fig. 8: Voltage generation oriented control of PFC Zeta topology

The voltage generation regulator in ordinary network is viewed as PI (Proportional Integral) gain regulator which will be supplanted with fluffy rationale regulator [8] for better activity of the Zeta topology. The mistake from the comparison of the reference DC voltage generation and estimated DC voltage generation is taken care of to the voltage generation regulator to create obligation proportion. The created obligation proportion (which is dynamic as for change in estimated voltage generation) is compared with a saw tooth or three-sided waveform producing pulses for MOSFET. Increment in obligation proportion builds the conduction of MOSFET thus expanding the output voltage generation, and this impact is the other way around to diminish the voltage generation.

The Zeta switch have an obligation proportion during exchanging which can be constrained by input circle regulator. This obligation proportion can be set by PI regulator or Fuzzy regulator taking mistake sign of output DC voltage generation comparison with reference signal. In the control structure it very well may be unmistakably seen that the PI or Fuzzy regulators [6] produce obligation proportion which is taken care of to PWM generator creating a heartpulse given to switch. The relative and basic addition esteems are taken as Kp = 1e-3, Ki = 10-4 individually. The fluffy structure is planned with seven information and seven output participation capacities with an aggregate of 49 principles as per the standard base demonstrated as follows.

Table-1 Rule table for fuzzy structure

de ↓ / e →	NB	NM	NS	EZ	PS	PM	PB
PB	**Z**	PS	PM	PB	PB	PB	PB
PM	NS	**Z**	PS	PM	PB	PB	PB
PS	NM	NS	**Z**	PS	PM	PB	PB
EZ	NB	NM	NS	**Z**	PS	PM	PB
NS	NB	NB	NM	NS	**Z**	PS	PM
NM	NB	NB	NB	NM	NS	**Z**	PS
NB	NB	NB	NB	NB	NM	NS	**Z**

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The control structure block diagram is given below.

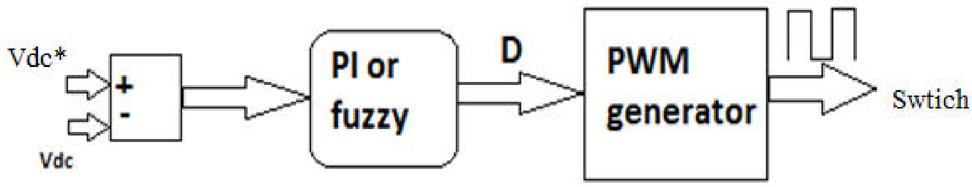

Fig. 9: Control block diagram of Fuzzy or PI controllers

VI. RESULT ANALYSIS

Considering the fig. test network the modelling of the DC micro grid network with PVA, wind farm, loads and Zeta topology is designed in MATLAB Simulink environment. The modelling of the introduced network is shown below.

In the model there are three loads connected in which the first load is an AC load with inverter and other two loads are low voltage generation DC loads. The low voltage generations (100V and 48V) is generated using conventional buck topologys. The simulation is run out for 0.1sec and voltage generations of all devices are recorded in graph using GUI environment available in MATLAB. All graphs are plotted with respect to time.

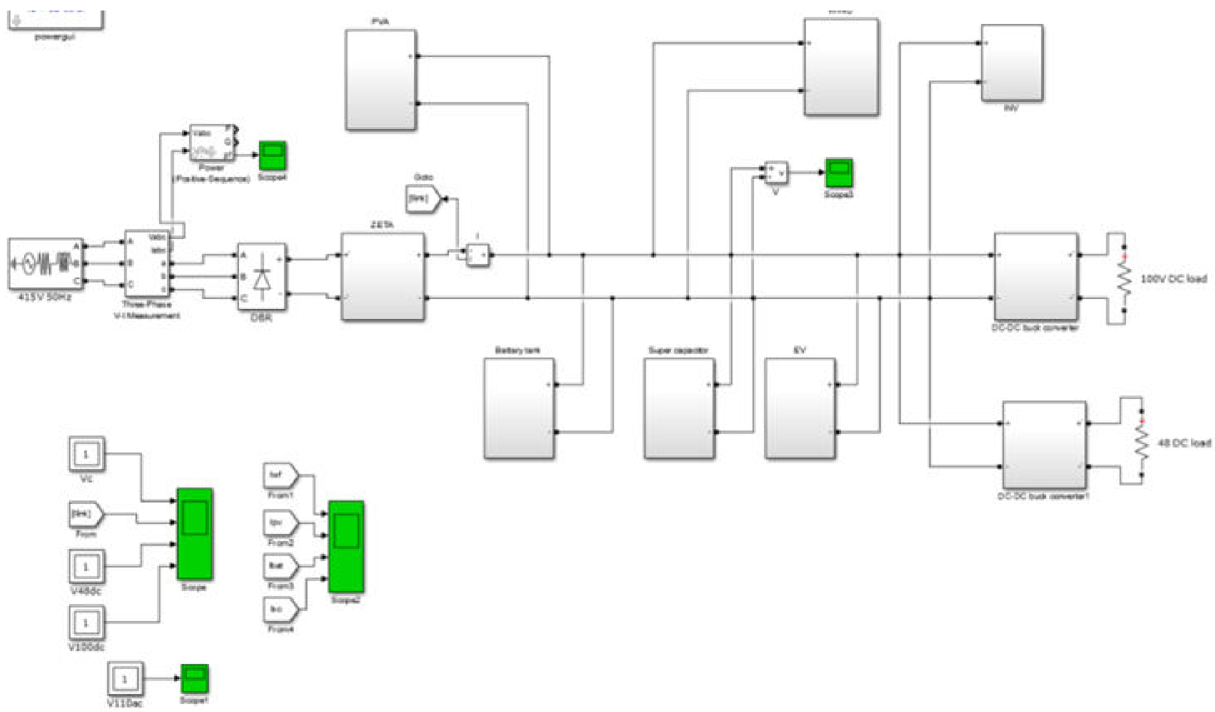

Fig. 10: MATLAB modeling of introduced test network with Zeta topology at grid

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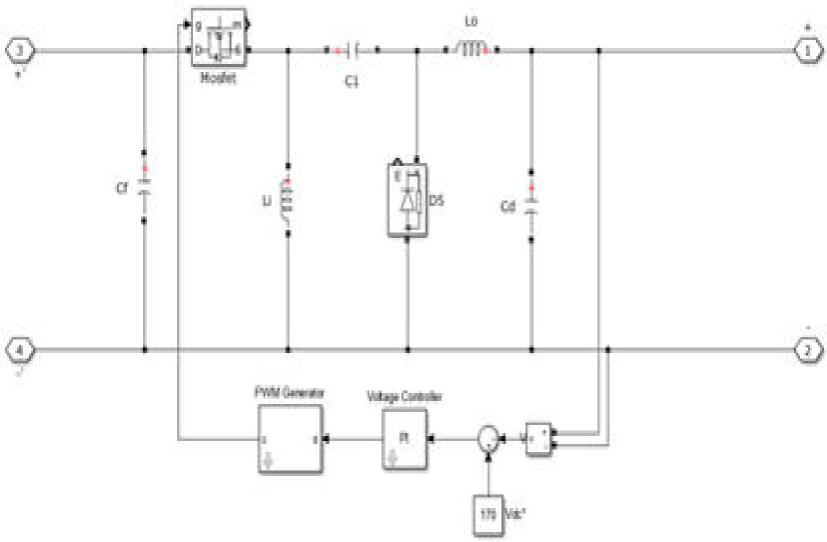

Fig 11: Introduced Zeta topology

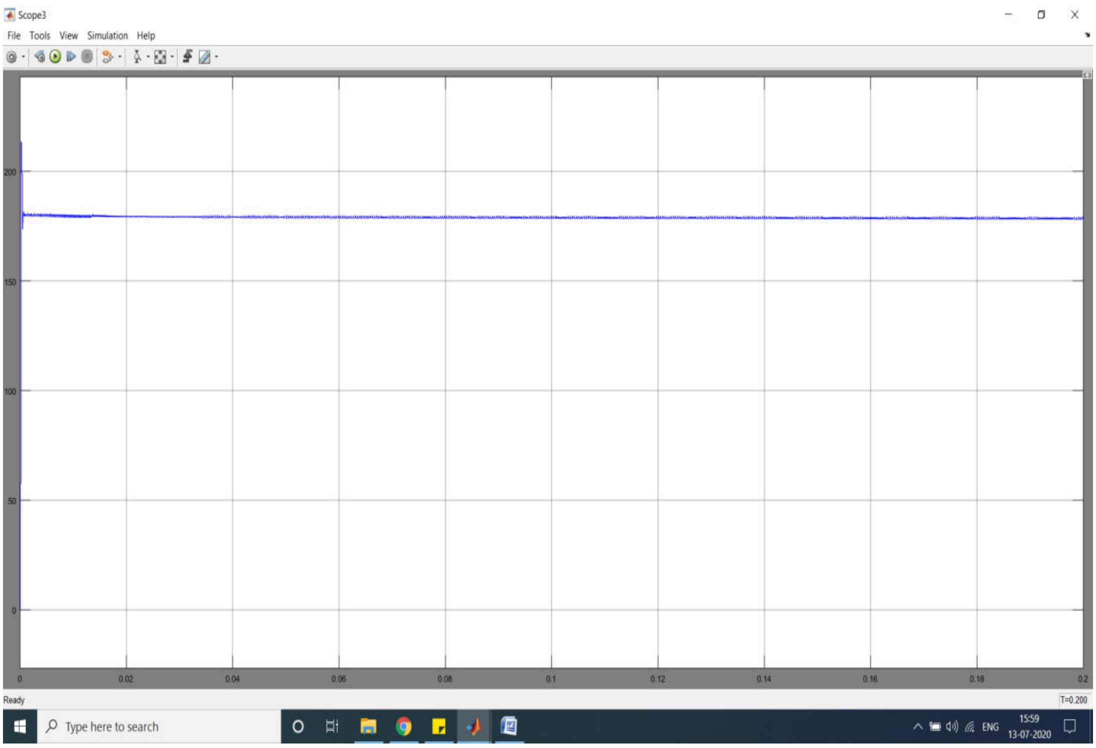

Fig.12 : DC link voltage generation at PCC with Zeta topology

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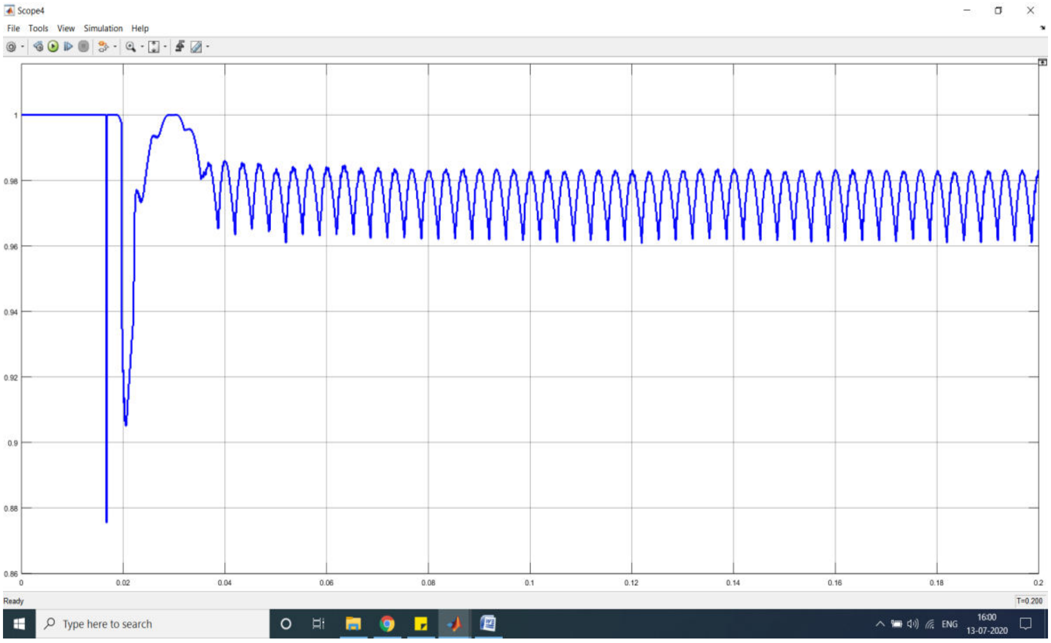

Fig.13 : Electrical power factor of three phase source with Zeta topology

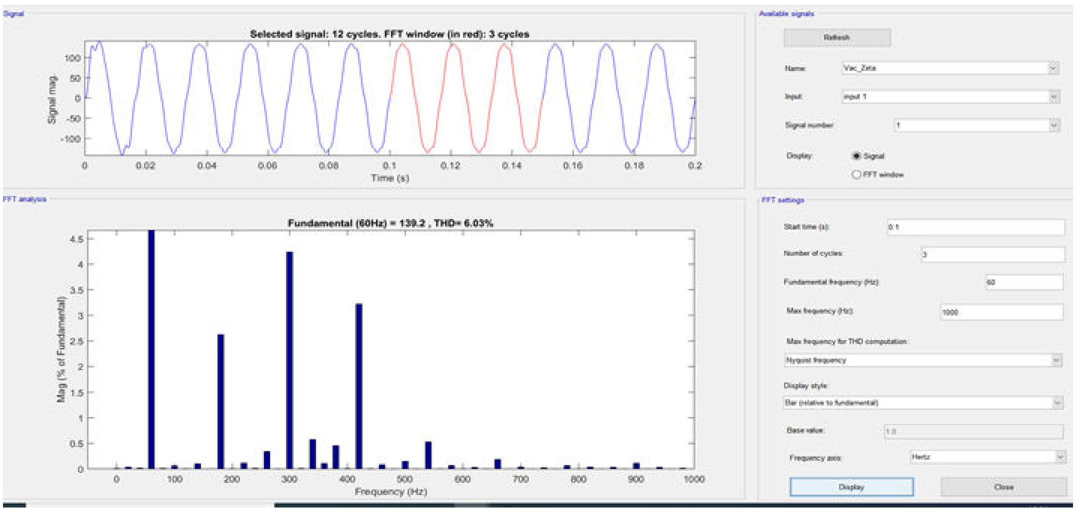

Fig-14 THD of AC load Voltage generation With fuzzy Controller.

The ripple in the DC link voltage generation at PCC is less in Zeta topology with Fuzzy controller in the range of below 1% along with improved electrical power factor.. For AC load voltage generation with Fuzzy controller THD is 4.03 %.With Fuzzy controller reducing the harmonics in the voltage generation waveform.

VII. CONCLUSION

As seen in the given graphs and FFT analysis f the fuzzy controller for Zeta topology Controller connected to the three phase grid, and it observed that Zeta Topology with Fuzzy network show better performance. The ripple in the DC link voltage generation at PCC is less in Zeta topology with introduced controller in the range of below 1% along with improved electrical power factor of the three phase source maintained above 0.96. Harmonics at output voltage generation comparatively less with introduced network also dc output of zeta topology show better output.

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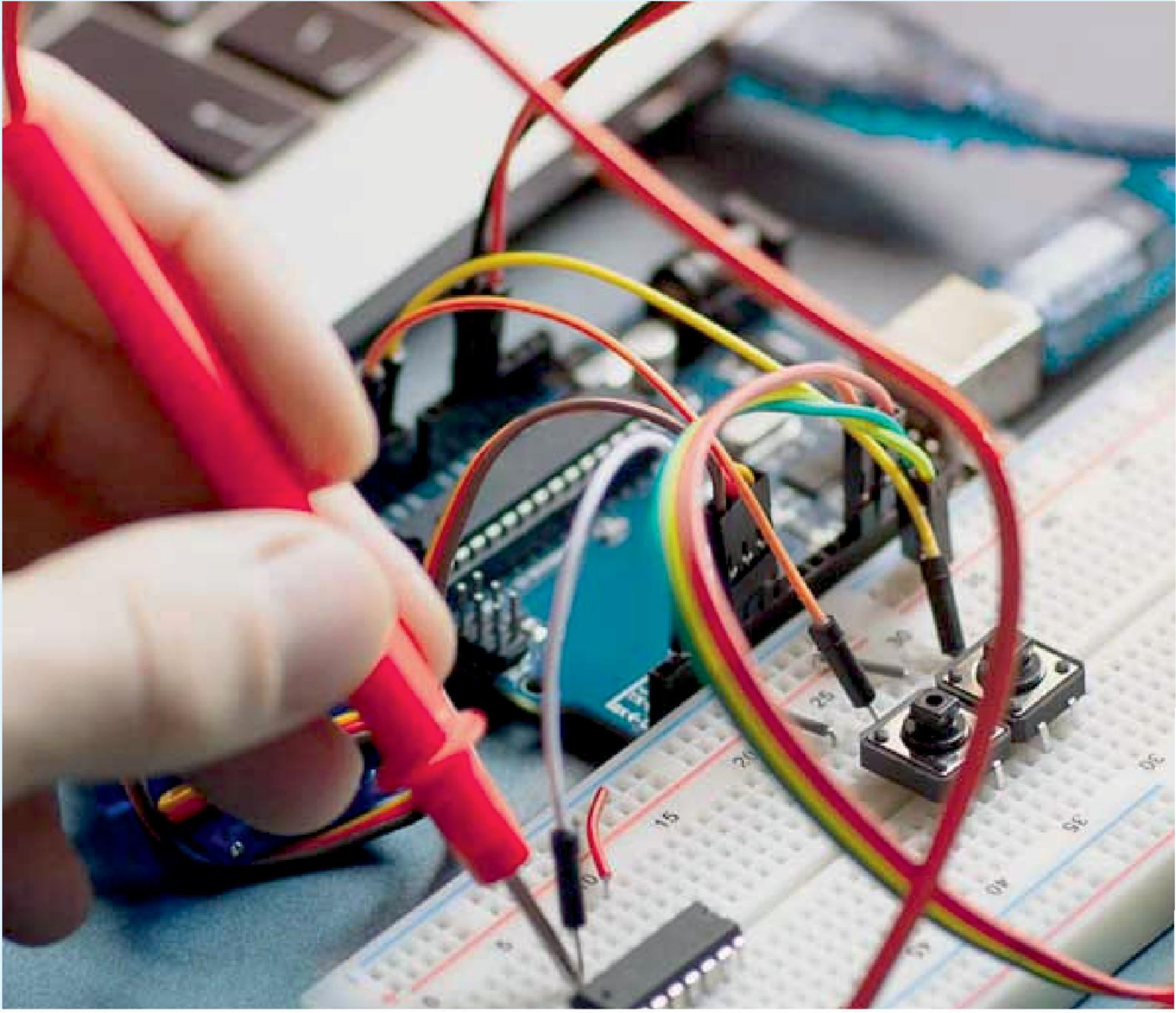

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