A Novel Intelligent Controller With Dvr Based Hybrid Renewable Fed Grid Tied To Mitigate Voltage Sag

Nalliboina Satya Sai[1] , G. Chitti Babu[2] , Dr. Kiran Kumar Kuthadi[3]

[1]Pg Scholar, Department Of Eee, Sree Vahini Institute Of Science And Technology (Autonomous), Tiruvuru, Andhra Pradesh.
[2]Assistant Professor, Sree Vahini Institute Of Science And Technology (Autonomous), Tiruvuru, Andhra Pradesh.
[3]Associate Professor, Dept Of Eee Sree Vahini Institute Of Science And Technology(A), Tiruvuru, Andhra Pradesh, Orcid: 0000-0003-2375-9776. Kiran9949610070@Gmail.Com

Abstract: Power quality has a significant impact on loads and stability when power equipment is working. Unstable conditions can cause the power system to lose stability due to a variety of defects, fluctuations, and even damage to sensitive loads. Dynamic voltage restorers, which have demonstrated their ability to compensate for distribution side faults and fluctuations notwithstanding the effects of the grid-side system, are a dependable way to counteract these intermediate power occurrences. Fuzzy logic controllers are the controller technology used in DVR simulations, which Favor the new trend of renewable energy sources with hybrid PV and wind systems. In order for the DVR to function as efficiently as possible under ideal circumstances during a voltage sag disturbance, the controller dynamically evaluates the different sag compensation parameters. Matlab is used to systematically model the project's activities while taking into account different situations.

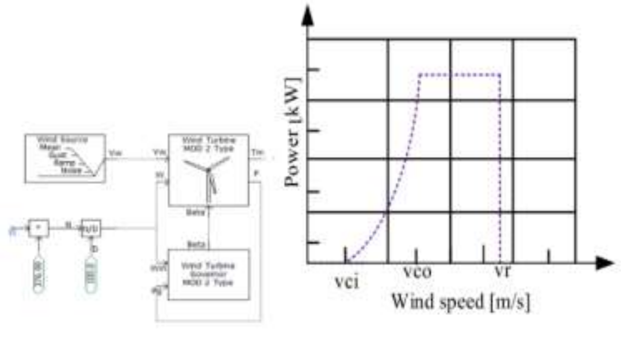
Index Terms Dynamic voltage restorer (DVR), Fuzzy logic controller (FLC), voltage sag compensation.

1. INTRODUCTION:

By 2050, there will be roughly 10 billion people on the planet, which presents a significant obstacle to future energy consumption. "The energy sector is going through an unprecedented period of uncertainty, and demand is only going to rise." There is tremendous strain and difficulty in developing and changing the energy system.[1] The availability, quality, pollution, and prices of fossil fuel extraction limit the use of nonrenewable energy resources [2], making KWH energy more expensive over the long term. Vigorous research in the field of renewable energy resources (RES), including solar, wind, tidal, geothermal, etc., is overcoming these limits. These may have high upfront expenses, but they only generate returns over time with little upkeep, resulting in significant energy resources in the near future. By integrating different power electronic equipment [5-7], power converters that use various AI techniques and algorithms [8,9], etc., the research gap[3] between the production of renewable energy and system stability[4] is filled, making the system more dependable, efficient, and capable of producing the most power possible compared to previous systems. Despite the promising future of hybrid RES in the electricity sector [10,11], improper maintenance could cause the grid as a whole to become unstable during power events [12], such as voltage sags, swells, etc. The local utility is typically held accountable when voltage sags occur. However, the plant's internal gear is responsible for many sag incidents. Problems with power quality [13–15] occur on both sides of the electric meter. Determining the cause of voltage sags or other power quality problems can occasionally be challenging. In fact, even seasoned experts in power quality do not always agree. On the utility side of the power meter, voltage sags can occur for normal reasons or as a result of human activity. Dynamic voltage restorers compensate for such occurrences. Eighty percent of power events caused by sags, swells, dips, etc. are mitigated by DVR [16]. In addition to common issues at distant buses, loads switching, starting high HP motors, transformer energizing, etc., sag in a PV-wind power system may also be caused by intermittent sources. The DVR's operations are connected to a fuzzy logic controller [17–21] that has a set of rules and membership functions in order to get the best performance possible. in order for it to distinguish between symmetrical and non-symmetrical power system failures and respond appropriately. In order to mitigate power quality issues, fuzzy regulators are used to examine the voltage injection schemes for DVR. Control and compensation strategies for DVR geographies are presented. The methods primarily focus on limiting the DC interface capacitor storage limit and DVR-infused transformer ratings. These systems may cause untimely loads to freak out due to their inability to handle phase jumps. Therefore, pre-droop compensation is generally used when taking into account the optimal measurement of the infusion transformer and DC link capacitor capacity limit. Frameworks for wind and photovoltaic electricity are unstable and unable to manage electrical power output. A thorough and detailed explanation of the HES-based FLC integrated DVR framework is provided in this study. The lattice-associated PV-wind hybrid power system's voltage fluctuation enhancement is replicated. A FLC-based DVR is the compensation mechanism used in this analysis, and its control and operating policy are explained in detail. Despite the promising future of hybrid RES in the electricity sector [10,11], improper maintenance could cause the grid as a whole to become unstable during power events [12], such as voltage sags, swells, etc. The local utility is typically held accountable when voltage sags occur. However, the plant's internal gear is responsible for many sag incidents.

1.1 PV WIND BASED HYBRID SYSTEM

In comparison to the non-renewable energy resources of fossil fuels renewable energy resources are promising and reliable with abundant in nature. The global grid connected capacity of solar power is around 600GW as of international renewable energy agency which proves the upcoming future of renewable grid structures. Though the wind and PV output power is dependent on the climatic conditions such as wind power, irradiance patterns, seasonal and monsoon patterns, etc. these conditions can be assessed from the previous data and can be drawn into curves by production companies as shown in fig.1. The output power is nonlinear and must combined with any other resource so as to maintain stability.



(a) Wind turbine system (b) Power curve of wind turbine

Fig.1 Power curve of a wind system

The PV output is calculated based on the pv cell's I-V characteristics shown in fig.2. Voc, Isc,,solar radiance pattern are highly fluctuated with the environmental patterns as shown in fig.3. So the hybrid power generation power plants are bought into picture for specifically meeting the sensitive loads for uninterrupted sustainability.

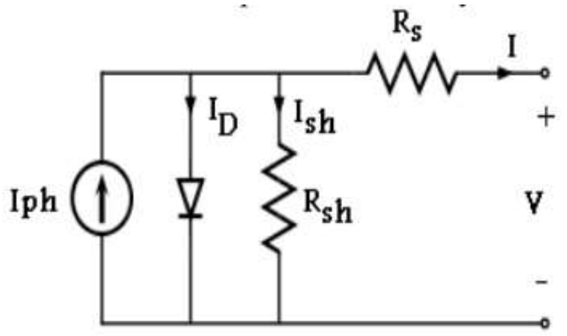


Fig.2 PV cell circuit

The load current (I), mathematically expressed as

$$I = I_{ph} - I_s\left(\exp q\frac{(v + R_s I)}{NKT}\right) - 1 - \left(\frac{v + R_s I}{R_{sh}}\right)$$

Where
Iph= solar current
Rse and Rsh are the series and shunt resistors
q = electron charge
V = voltage available at diode
K = Boltzmann's constant
T = temperature

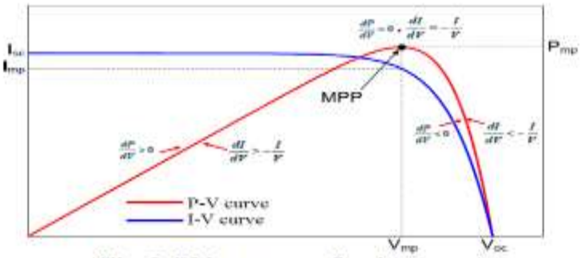


Fig.3 PV curves of solar array

Pmax = Voc*Isc*FF (2) where Pmax = maximum output power Voc= open circuit voltage Isc =short circuit current of the PV cells FF =fill factor. Voc = V∗ oc + βv(T − 25) (3) WhereV∗ oc, βv and T are the Vocof the PV cell under standard conditions, temperature coefficient of PV cells refers to Vocand cell temp. respectively. Isc = (G/ GN) *(I ∗ sc + βi (T − 25)) (4) Where G incident solar irradiance GN =the incident solar irradiance under standard test conditions respectively. I ∗ scPV cell's short circuit current under standard test conditions βi =temperature coefficient referring to the Isc. Ppv= PSTC (G/Gn)*(1 − γ (T − 25)) (5) where PSTC maximum power under standard conditions γ=Pmaxtemperature coefficient. T=Tamb+ (G/GNOCT) *(TcNOCT–TNOCT) (6) Where Tamb= environmental temperature GNOCT= incident solar irradiance at nominal operating cell temperature TcNOCT and TNOCT are nominal operating cell temperature.

From the above equations the solar power generated can be extracted at regulated amount. Solar power has its own limitations, in order to minimize the effects it must be stabilized by other reliable renewable power source making the wind power system an excellent choice. Wind Energy Conversation System (WECS) mainly contains aero dynamics components, mechanical & electrical components. Aero dynamics components contain wind towers and turbine, gear box and generator set up is treat as mechanical components and power electronics components. In wind power production, availability of wind, tower heights this are affect the power generation from windmills. The power generation from the wind is explained as follows: The mechanical wind power can be expressed as [20]

$$P_{wind} = 0.5\rho\pi R^2 \pi v^3_w \qquad (6)$$

Where ρ= air density
R=turbine blade radius
V_w=air flowing speed.

The Power captured by turbine blades is

$$P_{blade}=0.5\rho\pi R^2\pi v^3{}_w C_p(\lambda) \quad (7)$$

Where $C_p(\lambda)$=turbine power coefficient, and in terms of pitch angle β

$$C_p(\lambda, \beta)=0.5176(\frac{116}{\lambda i} - 0.4\beta - 5)^{\frac{-21}{\lambda i}}+0.0068\,\lambda \quad (8)$$

The turbine mechanical torque (T_m) can be expressed as:

$$T_m = 0.5\,\rho\,\pi R^2\pi v^3{}_w\, C_p(\lambda)/w_r \quad (9)$$

This PV-Wind energy sources are operating in two modes one is islanding mode and second one is grid integrated. In islanding mode only single energy is operates to satisfy the load demand. In grid connected RES sources frameworks fig.4, both energy sources are operating and balance the power demand. Mainly the power from wind basically inconstancy in nature so this power may cause the fluctuations in this system. This is maintained by DVR system where the control technique used is fuzzy logic controller.

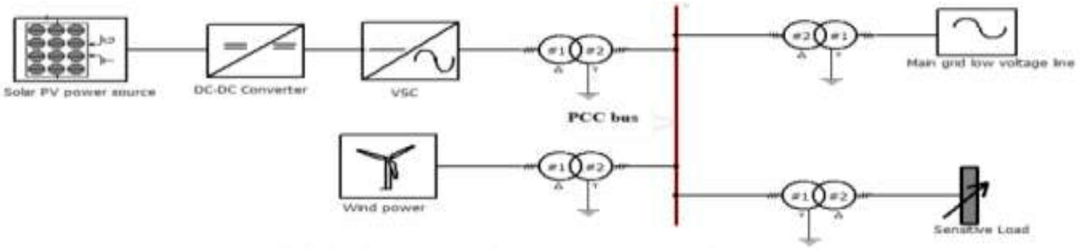


Fig.4 Hybrid PV Wind Energy conversion System

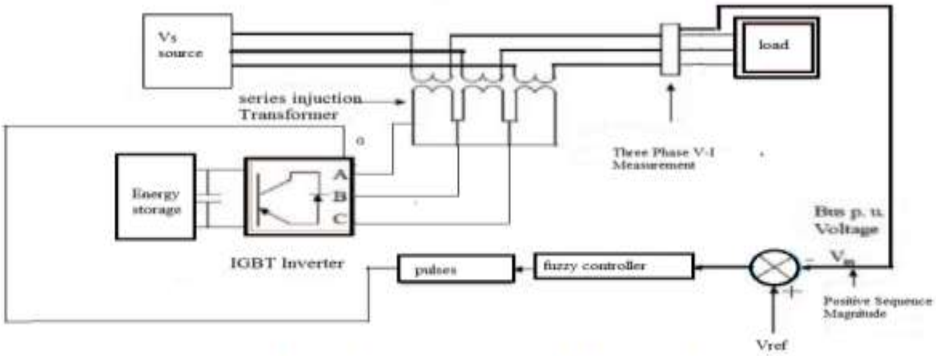


Fig.5 Fuzzy logic controller based DVR

2. FLC BASED DVR

Numerous arrangements and their issues utilizing DVRs are accounted here, for example, the voltages in a three-phase framework are adjusted and an energy advanced control of DVR is examined. Industrial instances of DVRs are given furthermore, extraordinary control techniques are examined for various sorts of voltage lists. A correlation of various geographies and control techniques is introduced for a DVR. The plan of a capacitor-upheld DVR that ensures sag, swell, bending, or unbalance in the voltage source is examined. The presentation of a DVR with the high-frequency-interface transformer. In this paper, the control and execution of a DVR are exhibited with a decreased rating voltage source converter (VSC). The coordinated reference outline (SRF) hypothesis is utilized for the control of the DVR with Fuzzy regulator.fig.5.

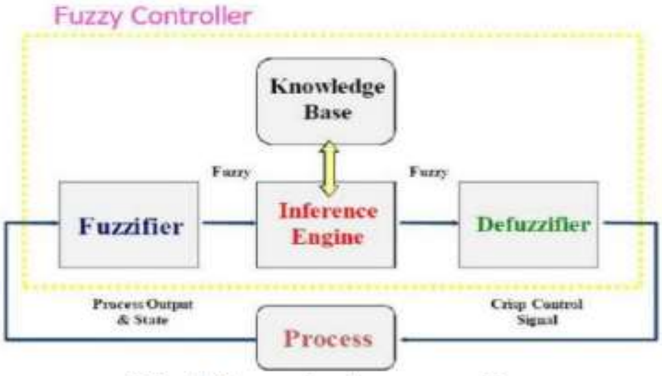


Fig.5 fuzzy logic controller

The schematic of a DVR-associated framework is appeared in Fig. 6. The voltage is embedded to such an extent that the heap voltage is steady and is undistorted from the fig.6 the voltage source inverter in the DVR can be modelled with fuzzy logic controller in contrast to the conventional PI controller and other PWM techniques. The FLC utilizes the feedback functions of the ongoing voltage and current levels in the power loop and the required membership functions are designed and pushed through Fuzzification module. So as to implement the effective calculations of the voltage need to be injected into the power system under disturbances.

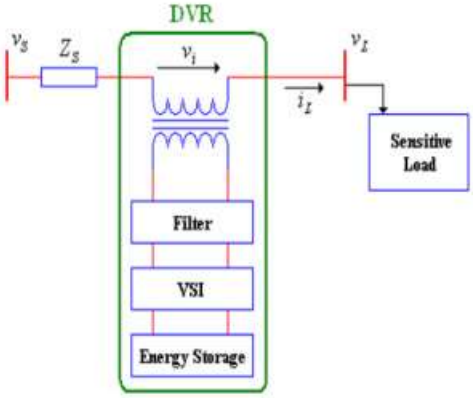


Fig.6 Schematic diag. of DVR

Analysing the aggravations and deciding the reference signal utilized for voltage infusion are the essential pieces of DVR framework. The voltage droop/swell is calculated by estimating in the 3 stage process at the place of regular coupling and utilizing the RMS voltage (Vpu) so the voltage aggravation can be perceived. The assurance of reference signal age is connected to the sort of the pay technique utilized among the notable remuneration techniques, for example, in-stage, presag, energy limited and crossover pay strategies. At the point when Vpu at the coupling is under the notable droop condition, the DVR will infuse and repay the missing voltage utilizing the HES gadgets and during Vpu esteem. the DVR will retain the overabundance voltage to be put away in its HES with the goal that the load voltage will be steady and inside the standard worth.

2.1 FUZZY LOGIC CONTROLLER

The shaggy logic regulator as opposed to customary regulators doesn't need a numerical form of the machine strategy being overseen. Yet, a skill of the framework strategy and the control necessities are fundamental. The fuzzy regulator plans need tolayout what insights measurements streams into the machine (input control variables), how the information measurements is handled (technique and decision) and what insights records streams out of the machine (arrangement yield variables) in this notice, a fuzzy logic regulator is employed for controlling the voltage infusion of the proposed dynamic voltage restorer (DVR). Fuzzy regulator is liked ludicrous hysteresis regulator due to its vigor boundary variants over the span of activity and execution. The proposed FLC regulator plot exploits the effortlessness of the mamdani type fuzzy constructions which may be utilized inside the plan of the regulator and variation component.

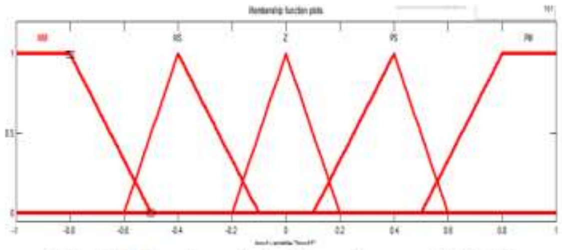


Fig.7 Membership functions of FLC

The fuzzy decision-making ability control plan might be isolated into four major commonsense squares explicitly aptitude base, fuzzification, derivation instrument and defuzzification. The data base is made out of data set and rule based.

E ↓/*Cl*	NB	N M	NS	ZE	PS	PM	PB
NB	ZE	ZE	ZE	NB	NB	NB	NB
NM	ZE	ZE	ZE	NM	NM	NM	NM
NS	NS	ZE	ZE	NS	NS	NS	NS
ZE	NM	NS	ZE	ZE	ZE	PS	PM
PS	PM	PS	PS	PS	ZE	ZE	PS
PM	PM	PM	PM	PM	ZE	ZE	ZE
PB	PB	PB	PB	PB	ZE	ZE	ZE

Table.1 Rule base for fuzzy logic controller

3. SIMULATIONS AND DISCUSSIONS

The proposed system is configured in the MATLAB for various simulations under symmetrical and asymmetrical voltage sags with and without DVR technology. From the fig.8 and fig.13 the load voltage was dropped drastically of its nominal value respectively for 25% and 12% symmetrical sags. By using FLC based DVR, sag was improved to normal as in Fig. 10 and Fig.14wheer the fig.9 and 12 indicate the injected voltage into the system by DVR.

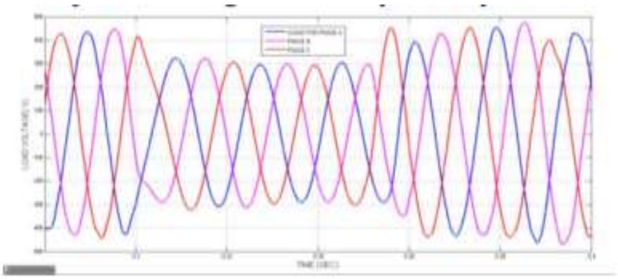


Fig.8 Load voltage response for 25% symmetrical voltage sag without DVR

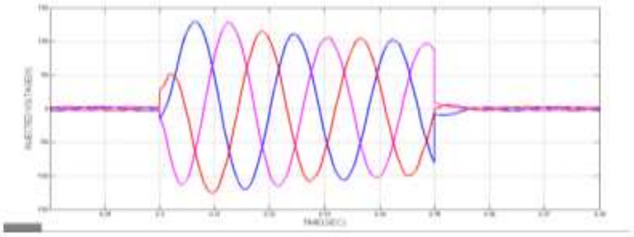


Fig.9 Injected voltage profile for 25% symmetrical voltage sag by DVR

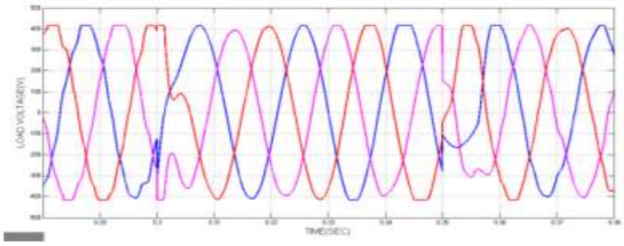


Fig.10 Load voltage response for 25% symmetrical voltage sag with DVR

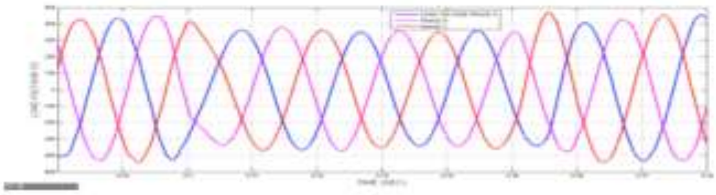


Fig..11 Load voltage response for 12% symmetrical voltage sag without DVR

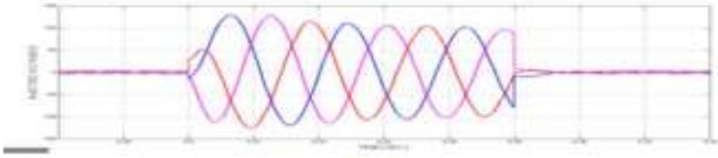


Fig.12 Injected voltage profile for 12% symmetrical voltage sag by DVR

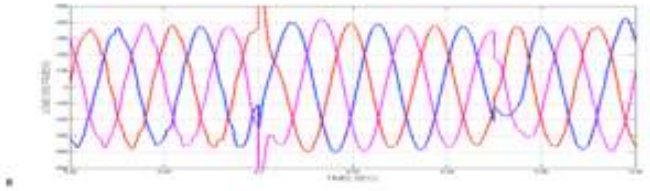


Fig.13 Load voltage response for 12% symmetrical voltage sag without DVR

From the fig.14 and fig.17 the load voltage was dropped drastically of its nominal value respectively for 25% and 35% asymmetrical voltage sags. By using FLC based DVR, sag was improved to normal as in Fig. 16 and Fig.19 where the fig.15 and 18 indicate the injected voltage into the system by DVR.

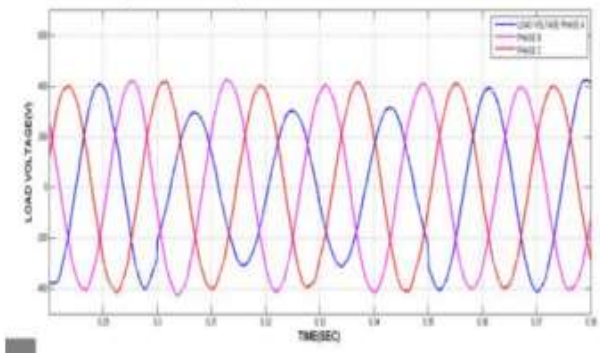


Fig.14 Load voltage response for 25% asymmetrical voltage sag without DVR.

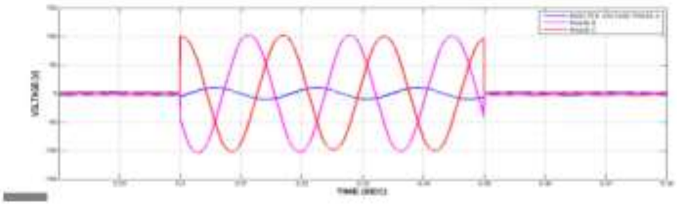


Fig.15. Injected voltage profile for 25% asymmetrical voltage sag by DVR

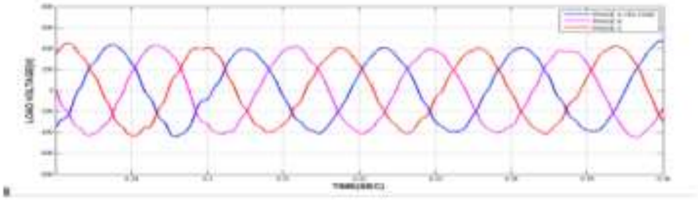


Fig.16Load voltage response for 25% asymmetrical voltage sag with DVR

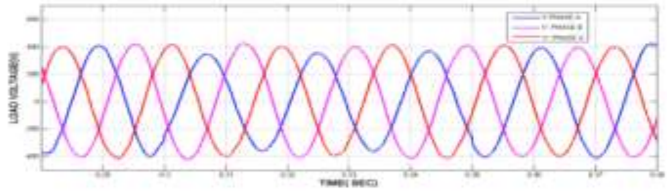


Fig.17Load voltage response for 35% asymmetrical voltage sag without DVR

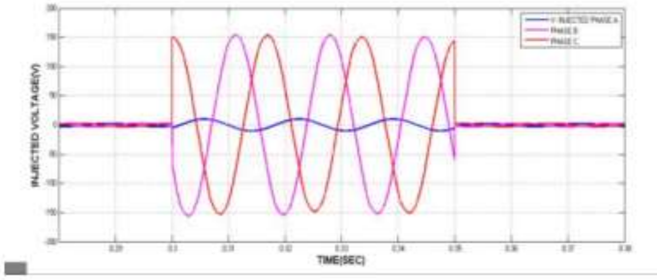


Fig.18Injected voltage profile for 35% asymmetrical voltage sag by DVR

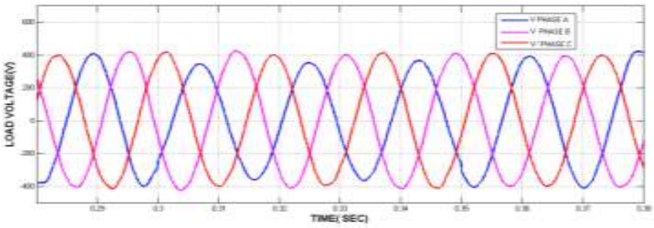


Fig.19Load voltage response for 35% asymmetrical voltage sag with DVR

The harmonic content present in the load voltage is expressed in terms of total harmonic distortion (THD) factor. FFT analysis is employed to calculate the THD. The summarized analyses of THD value present in load voltage with and without DVR for different symmetrical and asymmetrical faults are tabulated in table-1. And its corresponding THD plots are configured in fig.20.

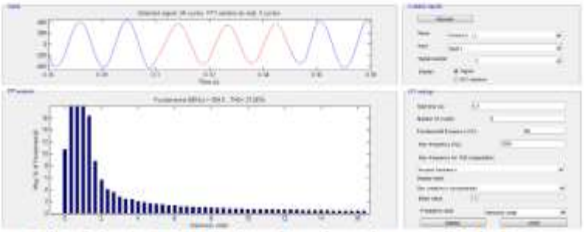


Fig.20 a) THD plot load voltage with PI controller under 12% symmetrical voltage sag.

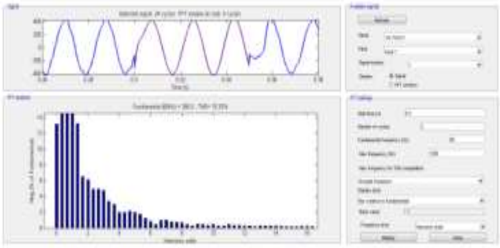


Fig.20 b) THD plot load voltage with fuzzy controller under 12% symmetrical voltage sag.

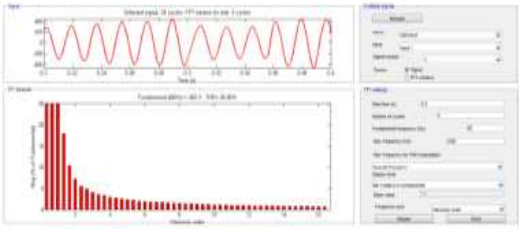


Fig.20 c) THD plot load voltage with PI controller under 25% symmetrical voltage sag.

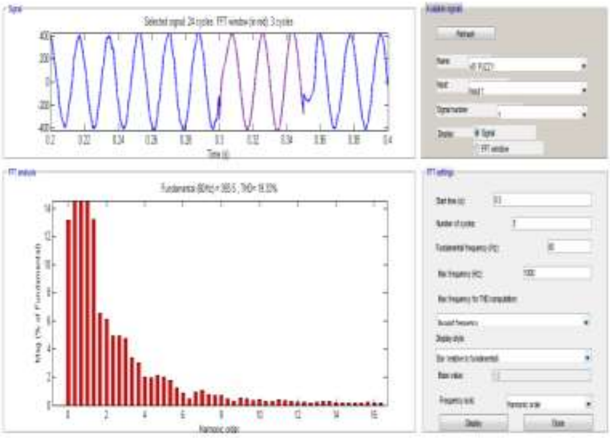


Fig.20 d) THD plot load voltage with fuzzy controller under 25% symmetrical voltage sag.

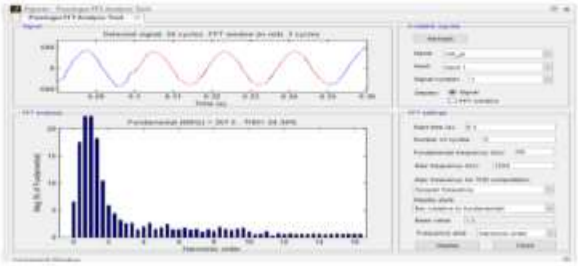


Fig.20 e) THD plot load voltage with PI controller under 25% asymmetrical voltage sag.

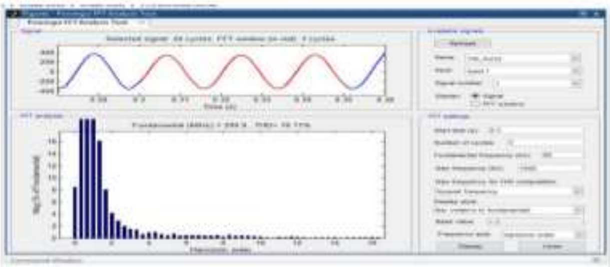


Fig.20 f) THD plot load voltage with fuzzy controller under 25% asymmetrical voltage sag.

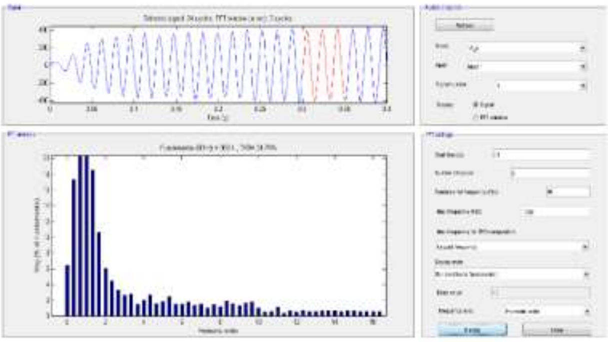


Fig.20 g) THD plot load voltage with PI controller under 35% asymmetrical voltage sag.

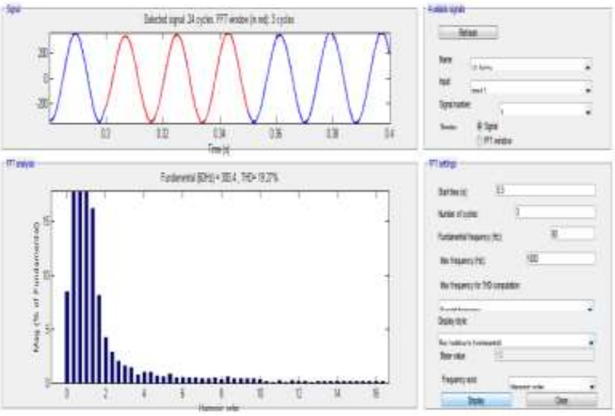
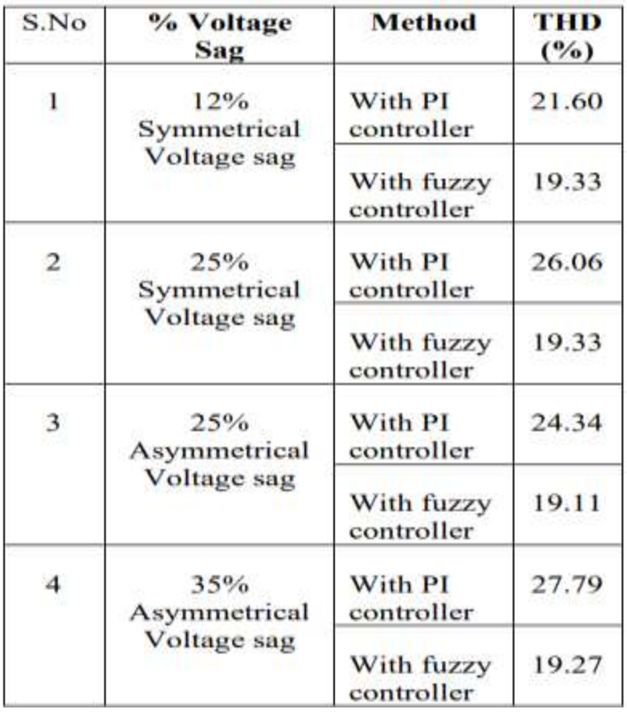


Fig.20 h) THD plot load voltage with fuzzy controller under 35% asymmetrical voltage sag.

4. CONCLUSION

A DVR system based on fuzzy logic is used to create simulations of hybrid PV wind energy conversion systems. Two scenarios with symmetrical voltage sags of 12% and 25%, respectively, and asymmetrical voltage sags of 25% and 35%, respectively, were used in the simulation. Using a DVR based on fuzzy logic control, the feedbacks were used to determine the appropriate voltage that needed to be injected, helping to keep the power system's voltage stable. Matlab simulations for individual scenarios have shown the efficacy of the suggested operating states, demonstrating the superiority of the FLCbased DVR over traditional approaches.



S.No	% Voltage Sag	Method	THD (%)
1	12% Symmetrical Voltage sag	With PI controller	21.60
		With fuzzy controller	19.33
2	25% Symmetrical Voltage sag	With PI controller	26.06
		With fuzzy controller	19.33
3	25% Asymmetrical Voltage sag	With PI controller	24.34
		With fuzzy controller	19.11
4	35% Asymmetrical Voltage sag	With PI controller	27.79
		With fuzzy controller	19.27

5. REFERENCES

[1]. World energy council for sustainable energy. www.worldenergy.org

[2]. O. V. Marchenko, S. V. Podkovalnikov and S. V. Solomin, "Comparison of Competitiveness of Renewable and Non-Renewable Energy Sources in Russia and in East Asian Countries," 2019 International Multi-Conference on Industrial Engineering and Modern Technologies (FarEastCon), 2019, pp. 1-5

[3]. S. Kennedy, "Bridging the gap between energy research and energy development impact," 2011 IEEE Power and Energy Society General Meeting, 2011, pp. 1-1, doi: 10.1109/PES.2011.6039399.

[4]. L. Fanglei, W. Fan, Y. Jiaming, X. Guoyi and B. Tianshu, "Estimating Maximum Penetration Level of Renewable Energy Based on Frequency Stability Constrains in Power Grid," 2020 5th Asia Conference on Power and S.No % Voltage Sag Method THD (%) 1 12% Symmetrical Voltage sag With PI controller 21.60 With fuzzy controller 19.33 2 25% Symmetrical Voltage sag With PI controller 26.06 With fuzzy controller 19.33 3 25% Asymmetrical Voltage sag With PI controller 24.34 With fuzzy controller 19.11 4 35% Asymmetrical Voltage sag With PI controller 27.79 With fuzzy controller 19.27 Electrical Engineering (ACPEE), 2020, pp. 607- 611, doi: 10.1109/ACPEE48638.2020.9136471.

[5].P. K. Steimer, "Enabled by high power electronics - Energy efficiency, renewables and smart grids," The 2010 International Power Electronics Conference - ECCE ASIA -, 2010, pp. 11-15,

[6]. R. Zingel, "Grid Compliance Conditioning of Renewable Power Sources by Means of Modern Power Electronics," 2007 European Conference on Power Electronics and Applications, 2007, pp. 1-8.

[7]. Q. Chen, "Opportunities and challenges to power electronics industry in alternative and renewable energy," 2009 3rd International Conference on Power Electronics Systems and Applications (PESA), 2009, pp. 1-1.

[8]. M. Y. Morgan, M. S. El Sobki and Z. H. Osman, "Matching demand with renewable resources using artificial intelligence technique" Eurocon 2013, 2013, pp. 1011-1019

[9]. B. K. Bose, "Artificial Intelligence Techniques in Smart Grid and Renewable Energy Systems—Some Example Applications," in Proceedings of the IEEE, vol. 105, no. 11, pp. 2262-2273, Nov. 2017

[10]. P. Sharma and Sathans, "Performance analysis of a stand-alone hybrid renewable energy power system- a simulation study," 2015 Annual IEEE India Conference (INDICON), 2015, pp. 1-6,

[11]. Hongshan Zhao, ZengQiangMi and Hui Ren, "Modeling and analysis of power system events," 2006 IEEE Power Engineering Society General Meeting, Montreal, QC, Canada, 2006, pp. 6 pp

[12]. V. Kavitha and K. Subramanian, "Investigation of power quality issues and its solution for distributed power system," 2017 International Conference on Circuit, Power and Computing Technologies (ICCPCT), 2017

[13].P. F. Ribeiro, "Power electronics conditioners: configurations, performance, power quality and cost issues," 10th International Conference on Harmonics and Quality of Power. Proceedings (Cat. No.02EX630), 2002, pp. 587-589 vol.2,

[14]. R. G. Suryavanshi and I. Korachagaon, "A review on power quality issues due to high penetration level of solar generated power on the grid," 2019 2nd International Conference on Power and Embedded Drive Control (ICPEDC), 2019, pp. 464-467