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Power Quality Improvement by Using PEMFC Based Quasi Y-Source DVR

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Abstract
Power quality has an important role in modern grids. Voltage sag and swell are one the major issues for poor power quality in distribution side of power system. There are different custom power devices available for power quality improvement. DVR (Dynamic Voltage Restorer) is one of the best economic, fast and popular custom power device for mitigation of voltage sag and swell. In this paper, A DVR is modelled with PEMFC and Quasi Y-source inverter and Hybrid controller is proposed. Proton Exchange Membrane Fuel Cells (PEMFCs) as a promising clean energy source for DVRs. Present the Quasi Y-Source inverter as a suitable topology for DVR applications due to its buck-boost capability and single-stage power conversion.

Keywords: DVR, PEMFC, Ultra-capacitor, fuzzy logic controller, NeuroFuzzy controller, Quasi Y source inverter.

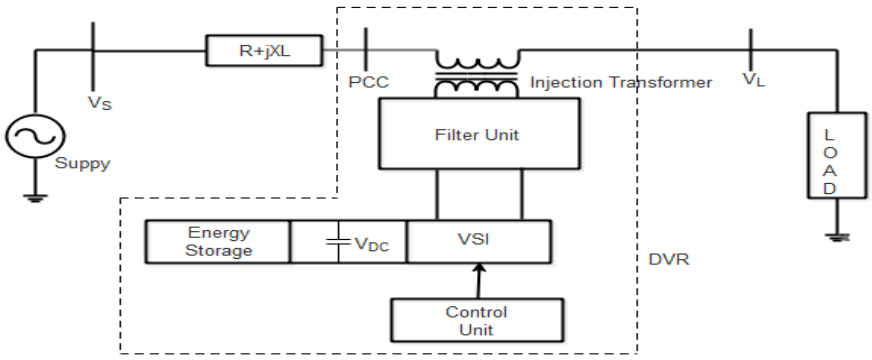
1. INTRODUCTION

There are too many complex networks in power systems. So there are many power quality problems takes place due to introduction of sensitive loads and usage of power electronic devices in industries or commercial sectors etc. Problems are categorized as short interruptions, voltage sags and swells, voltage flickers, voltage unbalance, voltage and current transients etc. There are many causes for these problems. The primary causes for short interruptions in distribution systems are switching of capacitors, lighting and transmission line disconnections etc. [Ajay Kumar,Dr. Geena Sharma, Er. Mahender Pal, December 2023] and Short circuit fault in the distribution side is mainly causes Voltage sag and swell, momentarily impulses and jerk. Voltage sag and swell are most common problem of power quality in distribution side. [Geena Sharma & Mahender Pal, August 2019] To minimize these problems reactive power compensation must be required. These problems can be minimized by using custom power device DVR (Dynamic Voltage Restorer).[[Geena Sharma & Mahender Pal, August 2019]. DVR is fast, dynamic and economic device as comparison to other custom power devices. Here, in this paper we used PEMFC (Proton Exchange Membrane Fuel Cell) as DC source and an Ultra-capacitor is connected along with it to increase storage capacity of the system. Here Quasi Y -Source inverter and Hybrid controller is used. Hybrid controller is better than other conventional controller. It increases the stability of the system.

I.I. Basic DVR Configurations

DVR is a series connected voltage controlled custom power device which is designed to maintain a constant voltage across a sensitive load [Ashish Kumar and Mrs. Geena Sharma, October-December 2023]. The DVR mainly consists of: Injection transformer for voltage ejection or injection to the Circuit to maintain a constant voltage, Filters for harmonic reduction, voltage source inverter for DC to AC conversion, DC source or DC storage device and a control system as shown below in Fig.1

Fig. 1 Basic DVR Model



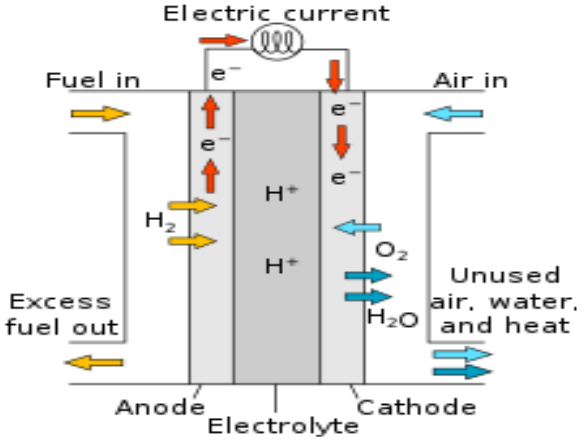
I.2. PEMFC

PEMFC (Proton Exchange Membrane Fuel Cell) is also called Polymer electrolyte membrane fuel cell. PEMFC consists of three main components: A negatively charged electrode (cathode), a positively charged electrode (anode). And a solid polymer electrolyte membrane for proton exchange. Hydrated hydrogen ions are supplied at the anode and air is supplied at the cathode [Geena Sharma & Mahender Pal, August 2019]. At the anode, Hydrogen gas is ionized in the presence of platinum catalyst into positive and negative ions.

$H2 = 2H+ + 2H-$ . . . . . (1)

The proton exchange membrane permits only the positive hydrogen ions to flow from anode to cathode as shown in the fig.2 [Geena Sharma & Mahender Pal, August 2019].

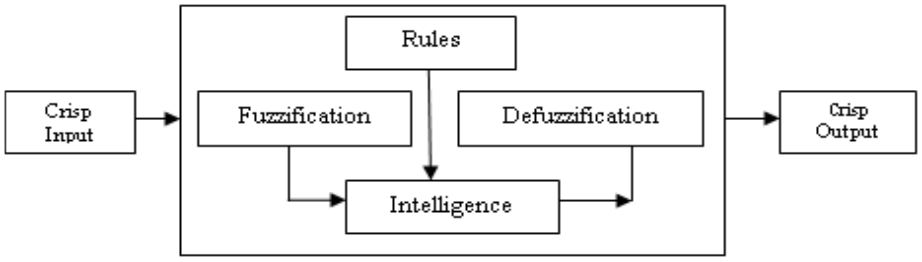
Fig.2. Basic operation of PEMFC



I.3. Fuzzy Logic Controller

PI controller is commonly used controller in DVR. So to Increase the efficiency or stability of the system Fuzzy logic controller is introduced. Fuzzy logic controller increases the efficiency and reliability of the system to greater extent. In basically Fuzzy logic controller has three main elements: Crisp input, membership function and crisp output as shown in figure below. The main functions of membership function is Fuzzification, Intelligence, Defuzzification [Geena Sharma & Bhupender, September 2019].

Fig.3 Basic Fuzzy logic controller



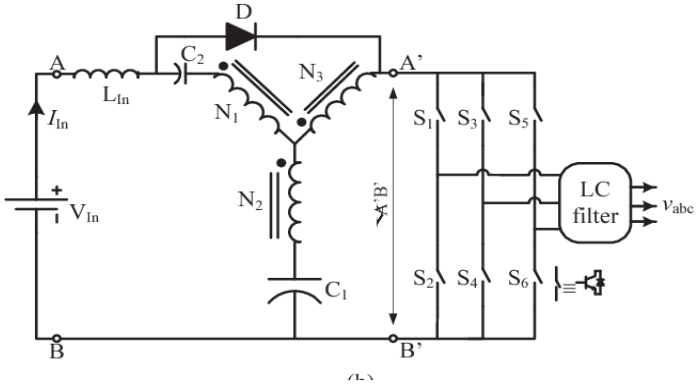
I.4. Neurofuzzy controller:

Neurofuzzy controller is a hybrid control system that combines the learning capabilities of neural networks with the reasoning capabilities of fuzzy logic. They are used in applications such as robotics, process control, and power systems, particularly in highly nonlinear systems where traditional methods may not be effective. The neural network adapts to changing conditions, while the fuzzy logic component interprets the output and generates appropriate control actions. This approach provides robust and effective control in complex and dynamic environments. [Ajay Kumar,Dr. Geena Sharma, Er. Mahender Pal, December 2023]

I.5. Quasi Y-Source Inverter

Simple Y-source inverter consists of Y-source network on the input side and a three phase bridge inverter at the output side of inverter. Filter is also connected at the output side with the three phase bridge inverter. The Simple Y-source network consists of a passive diode D, and a capacitor C1 and a Three winding transformer (N1, N2, N3) for introducing a high boost at a small duty ratio. The transformer is connected directly to the Inverter Bridge as shown in Fig.3.[Geena Sharma & Mahender Pal, August 2019].

Fig.4 Quasi Y-source inverter

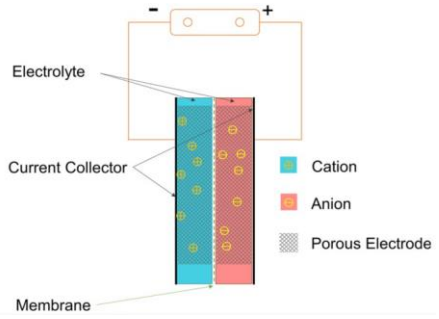


Quasi Y-source inverter is the modified version of Y-source Inverter. All advantages of simple Original Y-source Inverter are already presented in the Quasi Y-source inverter. But Quasi Y-source inverter has few additional advantages as continuous input current, Reduce source stress, and lower component ratings as compared with Y-source inverter. So the Quasi Y-source inverter is best suitable for renewable power conditioning systems. The Quasi Y-source inverter consists of two capacitors as C1, C2 and it preserves three winding coupled inductors. I.e. The two capacitors placed such as they block DC current which flowing to the coupled inductor and hence preventing its core from the saturation. C2 is paced in the simple Y-Source network and additionally DC blocking capacitor C1 and Input Inductor L1 are added. The Diode D is made to switch between the negative polarity of input capacitor C1 and positive rail of the Inverter Bridge.

I.6. Super Capacitor

Batteries can hold very large amount of power but it takes hours to charge up. But capacitors, charge almost at instant and store only little amount of power. If we need large amount of storage and very fast charging then we have to turn to super capacitor. Super capacitor is also known as Ultra-Capacitor. In batteries electricity stores by conversion of chemical energy into electrical energy [Jaydeep Chakarvorty, Geena Sharma& Vinay Bhatiya, March 2017]. But capacitor uses static electricity i.e. inside a capacitor; there are two conducting metal plates, with an insulating material called dielectrics between them. Positive and negative electrical charges build up on the plates and the separation between plates prevents them coming into contact. I.e. charge stores. And the dielectric strength allows a capacitor of a certain size to store more charge at the same voltage. Because its plates have much bigger area and the distance between them is much smaller because the separator between them works in a different way to a conventional dielectric.

Fig.5 Schematic diagram of Super capacitor



2. Proposed Model

The Proposed DVR model for Voltage sag Compensation is shown in Fig.6 and proposed DVR model for Voltage swell compensation is shown in Fig.7. In this proposed DVR model PEMFC is used as a DC source and Super capacitor is connected with it to Increase the storage capacity of the system. Quasi Y-source Inverter is used with Passive filter and Controller is AI based i.e. neurofuzzy controller.

Fig.6 Proposed DVR model for voltage sag/ Swell Compensation.

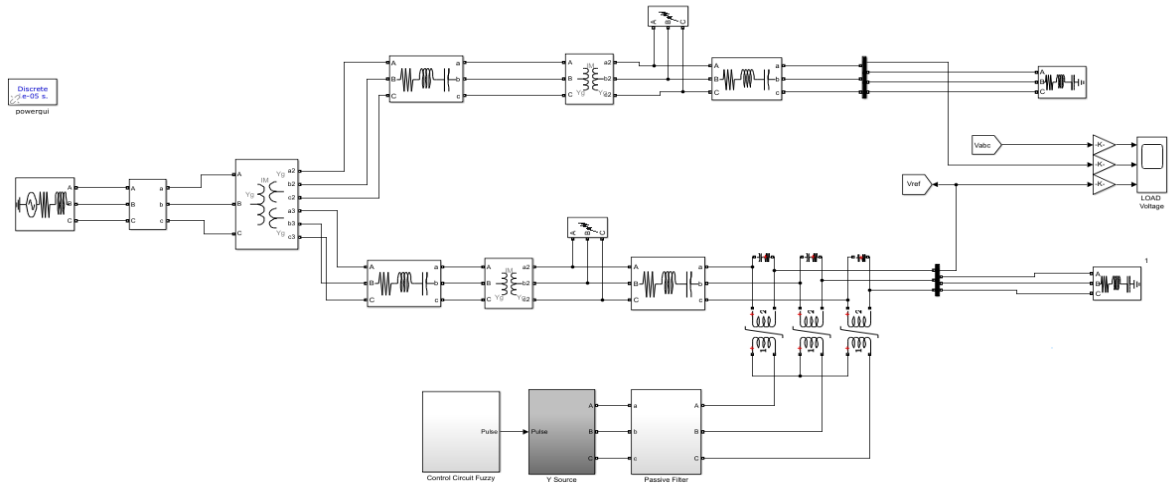
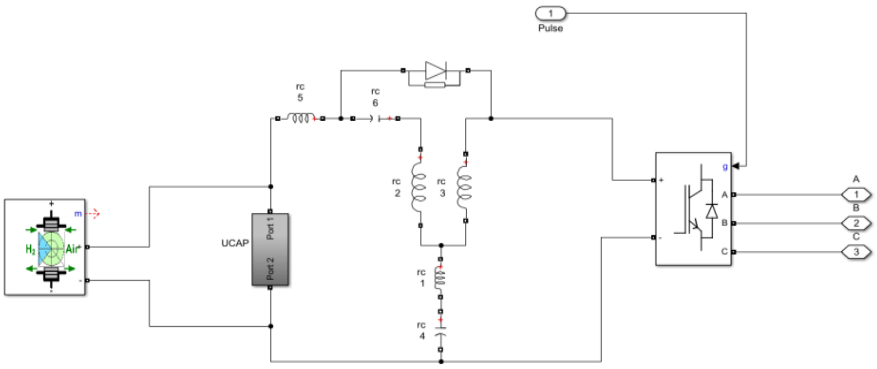


Fig.7 Quasi Y-source Inverter in DVR with PEMFC and Supercapacitor.



3. Simulation Results

The comparison of this proposed Quasi Y-source DVR model with neurofuzzy controller & Quasi Y source DVR model with only fuzzy logic controller as shown below in Tabular form in Table1 and Table11. In Table 1 the Comparison of Voltage sag compensation and in table 11 Voltage swell.

Table 1 Comparison Table for voltage Sag compensation

Fault	Phase	Voltage Sag	Quasi Y Source DVR with Fuzzy logic controller	Quasi Y Source DVR with Neurofuzzy controller
Single Line to Ground	R	240	240	240
	Y	240	240	240
	B	120	228	240
Double Line to Ground	R	240	240	240
	Y	120	228	240
	B	120	228	240
Tripple Line to Ground	R	120	228	240
	Y	120	228	240
	B	120	228	240

Table II Comparison Table for voltage Swell compensation

Fault	Phase	Voltage Swell	Quasi Y Source DVR with Fuzzy logic controller	Quasi Y Source DVR with Neurofuzzy controller
Single Line to Ground	R	240	240	240
	Y	240	240	240
	B	300	255	240
Double Line to Ground	R	240	240	240
	Y	300	255	240
	B	300	255	240
Tripple Line to Ground	R	300	255	240
	Y	300	255	240
	B	300	255	240

4. Conclusion

This Proposed Model is simulated in MATLAB. In this DVR, A Quasi Y-Source Inverter with Hybrid Controller gives Improved results in Voltage sag and swell compensation as comparison with existing Quasi Y source DVR with Fuzzy logic controller. This inverter is able to produce very high voltage gain while simultaneously operating at high modulation index. Hence it has been observed that A DVR with PEMFC, Super capacitor and Quasi Y-source inverter with Hybrid Controller is very efficient and reliable as compared to Quasi Y-source Inverter with fuzzy logic controller for power quality improvement

References

1. Ajay Kumar,Dr. Geena Sharma, Er. Mahender Pal," Analysis of power quality improved by DVR with Neuron Fuzzy Logic", IRJMETS, Volume:05/Issue:12/, ISSN: 2582-5208,December 2023, impact factor- 7.868
2. Ajay Kumar,Dr. Geena Sharma, Er. Mahender Pal,"Review and Analysis of power quality improvement by neural and optimization approaches", IRJMETS, Volume:05/Issue:12/, ISSN: 2582-5208,December 2023, impact factor- 7.868
3. Geena Sharma & Mahender Pal "Power Quality Improvement using PEMFC based Z-source DVR with fuzzy logic controller" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol.8, Issue8, August 2019 P(2083-2092), Impact Factor 7.282
4. Geena Sharma & Mahinder Pal "PEMFC based Quasi Y-Source DVR for Power Quality Improvement" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol.8, Issue 8, August 2019P(2116-2129), Impact Factor 7.282
5. Geena Sharma,Sandeep Sharma,' Improvement of Power Quality by fuzzy rules using Particle Swam Intelligence' in International Jounal of Advanced Research ,Idea and Innovation in Technology (IJARIIT), Jan – Feb 2021, Volume 7, Issue 1, impact factor 6.081
6. Ashish Kumar and Mrs. Geena Sharma, —," Review on Power Quality Improvement by Optimization and Conventional approaches" published in the International Journal of research in electronics and computer engineering (IJRECE) Vol. 8, Issue 4, Oct – Dec 2020, p ISSN: 2393 –

9028,7.23
7. Geena Sharma,Sandeep Sharma,' Review on DVR Power Quality of Sag and Swell' in International Jounal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), August 2020, Volume 9, Issue 8, impact factor 7.122
8. Jaydeep Chakarvorty, Geena Sharma& Vinay Bhatia "Analysis of a DVR with Molten Carbonate Fuel Cell and Fuzzy Logic Control" Engineering Technology & Applied Science Research, Vol. 8, No. 2, March 2018, Scopus Indexed, impact factor 1.4
9. Jaydeep Chakarvorty, Geena Sharma "DVR With Modified Y Source Inverter And MCFC" Engineering Technology & Applied Science Research , Jan 2019, Scopus Indexed, impact factor 1.4
10. Geena Sharma & Bhupender "Harmonic reduction using passive filter based Z-Source DVR" in International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 8, Issue 8, August 2019 P(2109-2115), Impact Factor 7.282
11. Geena Sharma & Bhupender "Power Quality Improvement using Active Filter Based Z-Source DVR" in International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 8, Issue 9, September 2019 P(2166-2174), Impact Factor 7.282
12. Geena Sharma & Vijeta "Modelling & Simulation of DVR With Active Filter" International Journal of Advance Research in Electrical Electronics & Instrumentation Engineering, Volume:6 Issue:6, June-2017.ISSN: 2277 – 9655, Impact factor 4.116
13. Geena Sharma & Vijeta "Modelling And Simulation of Dynamic Voltage Restorer" International Journal of Advance Research in Electrical Electronics & Instrumentation Engineering, Volume:6 Issue:6, June-2017, Impact Factor 4.116
14. Rajbir & Geena Sharma "THD Reduction & Power Quality Improvement in Grid Connected PV System" in International Journal of Trend in Scientific Research & Development Volume: X, June-2017, Impact Factor 6.4
15. Rajbir & Geena Sharma "Different Strategies for Power Quality Improvement in Off Grid Renewable Energy Based Power System" in International Journal of Trend in Scientific Research & Development Volume:X, June-2017, Impact Factor 6.4