DOI: 10.21917/ijme.2021.0182

DESIGN OF DYNAMIC VOLTAGE RESTORER USING OPTIMISED PSO - ANFIS CONTROLLER FOR POWER QUALITY IMPROVEMENT

B. Karthik[1] and M. Priyanka Gandhi[2]

[1]*Department of Electrical and Electronics Engineering, Sona College of Technology, India*

[2]*Department of Electrical and Electronics Engineering, Government College of Engineering, Bargur, India*

Abstract

With fast trends in the industry, electricity pleasant turns into very important. Power quality is described as any electricity trouble manifested in the voltage, current or frequency deviations that bring about failure or mal characteristic of the purchaser equipment. Power quality problems may be categorized as quick period voltage variations, lengthy period voltage variations, waveform distortions, transients, voltage imbalance and voltage flicker. Among the numerous electricity pleasant problems, voltage sag, voltage swell and harmonics are extra dominant in the distribution system. To compensate those problems, Dynamic Voltage Restorer (DVR) is used. DVR is a sequence compensating device to mitigate voltage sag and voltage swell. It is likewise used as collection active filter to mitigate harmonics. In this work, Modeling of the DVR collectively with optimized ANFIS controller, have been evolved below the Matlab/Simulink surroundings to mitigate Voltage sag and harmonics in the electricity system. PSO tuning topology is followed for optimizing the ANFIS controller.

Keywords:

Dynamic Voltage Restorer, ANFIS Controller, Voltage Sag, Power Quality, Voltage Sag and Voltage Swell

1. INTRODUCTION

. In recent years, the application of nonlinear loads such as adjustable-speed drives, switched mode power supplies and electronic fluorescent lamp ballasts etc., in industries, residential applications and in commercial establishment has created a hazard to power system in terms of power quality issues such as harmonics. This led to have more emphasis on the quality of power delivered to the customer.

Any kind of power problem which causes any deviation in the voltage, current / frequency and in turn results in equipment failure /fail to function normally is characterized as Power quality. Similarly, the implementation of high efficiency adjustable speed drives with power factor correction tools such as shunt capacitor can also raise the harmonic levels of the power systems, even though the losses in the system gets reduced [1] [8].

The demand for trustworthy, clean and uninterrupted electrical energy is ever increasing and at the same time, end users are also concerning more about the quality of the electric power in order to ensure the life span of the power electronics based equipments. Hence the term Power Quality maintenance has become one of the foremost slogans among the end users. Thus, the influence of these issues in relations to cost and the quality of the products, have made the engineers to gaze towards the new technologies to overcome power quality problems [9].

In the present network industrial scenario, even if a minor failure created by the power fluctuations, then it will lead to have heavier consequences. Hence it is compulsory to monitor the quality of the power across the entire network continuously and in case of a power quality issues, speedy measures should be taken.

Power quality issues such as short duration voltage variations, long duration voltage variations, waveform distortions, transients, voltage imbalance and voltage flicker plays a vital role in a power system. Amongst the numerous varieties of quality issues, voltage sag, voltage swell and harmonics are the more foremost concern in the distribution system.

2. LITERATURE SURVEY

Designed a repetitive control for DVR. This system is mainly suitable for medium voltage applications. This control strategy simultaneously cancels the voltage sags, voltage imbalances and voltage harmonics [1].

Dynamic voltage restorer for fault compensation schemes. In this work, the synchronous reference frame controller is introduced for DVR and a better compensation in sag, swell and harmonics is obtained [2].

Analysed a control structure for controlling the DC-link capacitor, phase jump up and sag depth up to 50%. In traditional method, it is very tedious to control the maximum depth of sag. However, this proposed scheme overrides the problem of traditional method by implementing phase jump technique using minimum active power mode of enhanced control schemes. From the results, it is proven that the proposed system has better performance [3].

Evaluated an auxiliary control strategy for radial distribution line using Dynamic Voltage Restorer (DVR). A Fast least error squares digital filter technique is proposed to find out the impact of faults. This technique accurately measures the power quality issues such as real, reactive, power factor correction etc. [4].

Hosted a proportional resonant control in rotating frame to control the DVR. This proposed methodology proposes a better performance under sudden voltage sags condition [5].

Endorsed a hysteresis voltage manipulate method for DVR primarily based totally on bipolar and unipolar Pulse Width Modulation (PWM). In this method, it is easy to regulate the hysteresis bandwidth and switching frequency in accordance with system parameters [6].

Fast control dynamic scheme for capacitor supported single phase DVR. Thus the proposed scheme comprises boundary control method to control the gating signals of the switches present in the DVR. This forms inner loop of this scheme. The outer loop was formulated to generate reference voltage for the inner loop. This proposed methodology maintains output voltage at nominal value during occurrence of voltage sag [7].

3. PROPOSED SYSTEM

The idea of compensation strategies in DVR may be divided into categories which are as follow: Active and reactive power compensation

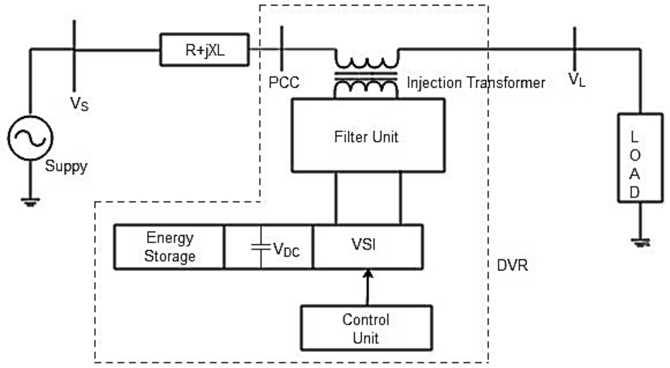

Fig.1. Schematic illustration of a DVR

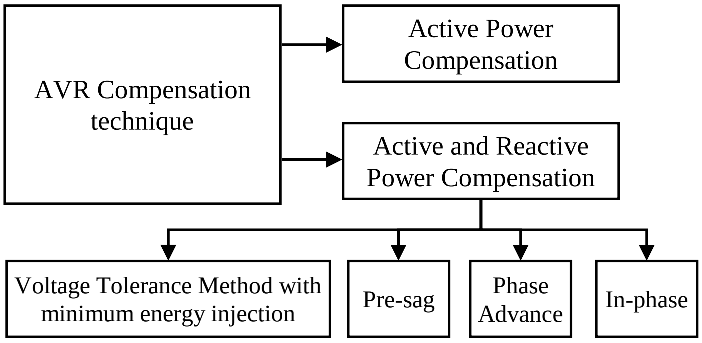

Fig.2. Compensation Techniques of a DVR

3.1 ANFIS DESIGN

This section introduces the fundamentals of ANFIS network structure and its hybrid studying rule. ANFIS is an affiliation of Fuzzy and Neural Network. In ANFIS, Neural Network learning methods enhance the parameters of a Fuzzy Inference System (FIS). The ANFIS network structure comprises five discrete layers and it contains of inputs and one output.

3.2 PROPOSED PSO-ANFIS METHOD

The proposed hybrid method was a combination of PSO optimization algorithm and ANFIS. Here PSO was used to optimize the ANFIS parameters. The Fig.3 shows the flow chart and detail working of the proposed hybrid method.

The *f*(.) indicate the training function. After getting ready data set, form of membership characteristic and neuro-fuzzy inference system changed into optimized through the PSO. PSO is used to optimize the parameters associated with the fuzzy inference system membership functions.

4. ANFIS OUTPUT

In the last stage-trained ANFIS model parameters were updated by the optimized parameters of PSO. After updating the optimized ANFIS parameters, updated ANFIS method was used to control DVR.

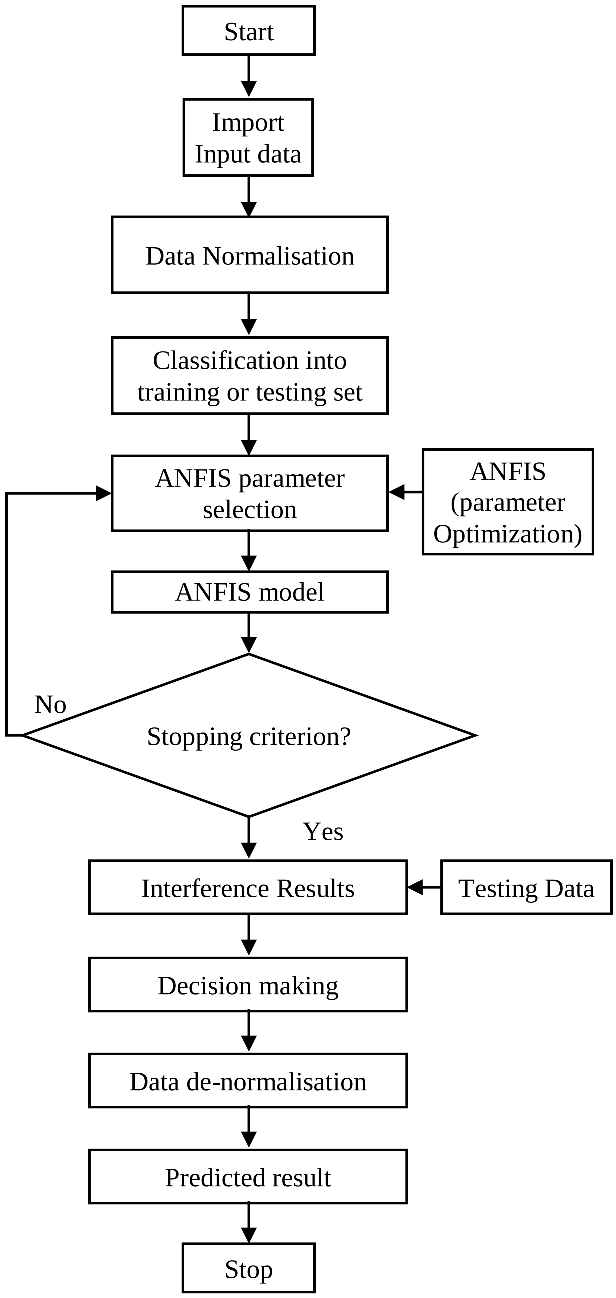

Fig.3. Flow chart of the proposed model

To verify the effectiveness of the proposed DVR, it is subjected to single line to ground fault introduced in the system and evaluated using MATLAB. The design parameters of the proposed system is depicted in Table.1.

Table.1. System and DVR parameters

Parameter	Value
Line resistance (X) and Inductance (mH)	1.0 and 5.0
System voltage (V) and line frequency	400 V and 50 Hz
Carrier wave frequency (Hz)	5500
Filter series inductance (mH) and Series resistance (X)	80 and 0.1
Filter shunt capacitance (lF) and Shunt resistance (X)	6 and 60

Two cases are considered for studying the performance of the proposed DVR. The case below examine may be summarized as follows

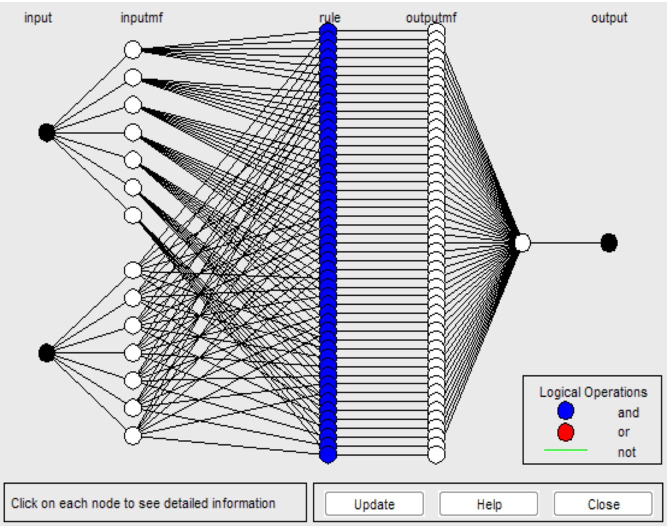

Fig.4. ANFIS Structure

4.1 UNDER BALANCED SAG

Thus, three different sag condition (ie.75%, 50% and 25%) were introduced by varying the load. The voltage sag is introduced in the system between the time interval t = 0.1s and 0.3s. At that time of sag occurrence, the performance of the uncompensated system is depicted in Table.2.

Table.2. Performance of the uncompensated system

%Sag	THD	Power Factor
75	9.86	0.67
50	7.41	0.70
25	6.14	0.63

From the table, it is observed that the THD of the system increases thereby reducing the power factor. Hence, the system retains instability condition. Thus as a result DVR is incorporated.

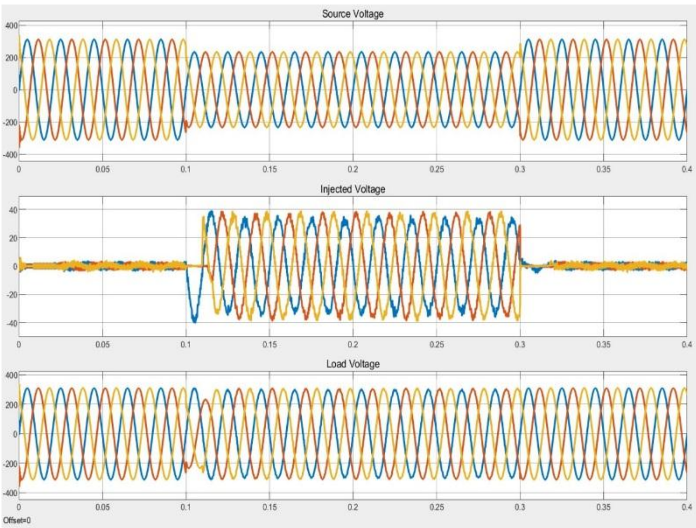

Fig.5. Performance of the system after compensation

The Table.3 represents the results of compensated system with proposed DVR under balanced condition

Table.3. Performance of the compensated system

%Sag	THD	Power Factor
75	5.81	0.86
50	5.06	0.87
25	3.91	0.86

From the Table.4, it is proven that the DVR improves the power quality of the system by reducing harmonics and by improving power factor under different sag condition.

Table.4. Comparison of Distorted voltage, Injected voltage and Load voltage for different level of inverters (Fault compensation)

Type of Controller	% sag	Distorted Voltage (V)			Injected Voltage (V)			Load Voltage (V)		
		A	B	C	A	B	C	A	B	C
PI controller	50	225	415	350	165	0	40	390	415	390
ANFIS Controller		225	415	350	185	0	61	410	415	411
PSO tuned ANFIS Controller		225	415	350	190	0	65	415	415	415

The DVR is capable of produce the specified voltage components for specific stages unexpectedly and assist to keep a balanced and steady load voltage. As a result, the performance of DVR under the proposed PSO tuned ANFIS controller in mitigating voltage sag and voltage unbalance is evident.

5. CONCLUSION

In this dissertation, DVR has been shapely and simulated in Matlab surroundings. The performance of DVR has been found to regulate voltage under varying load condition and load unbalancing. It is obvious that DVR reduces harmonics from load voltage very efficiently and makes it smooth. Hence, it's far concluded that DVR has a large scope in enhancing electricity quality in distribution systems.

The work may be improved with inside the following area: Other advanced optimization controllers, SVPWM Technique can be employed with DVR to increase the effectiveness of DVR in distribution networks. Dynamic loads can be considered in future work and then the effect of DVR can be studied.

REFERENCES

[1] D. Tien, R. Gono and Z. Leonowicz, “Advanced Control of the Dynamic Voltage Restorer for Mitigating Voltage Sags in Electricity Systems”, *Advances in Electrical and Electronic Engineering*, Vol. 16, No. 1, pp. 36-45, 2018.

[2] Y. Li, T. Wang and Y. Li, “Analysis on Manage Method of Dynamic Voltage Restorer”, *Proceedings of International Conference on Electricity Distribution*, pp. 1-5, 2016.

[3] A.M. Rauf and V. Khadkikar, “An Enhanced Voltage Sag Compensation scheme for Dynamic Voltage Restorer”,

IEEE Transactions on Industrial Electronics, Vol. 62, No. 5, pp. 2683–2689, 2015.

[4] R. Pal and S. Gupta, "State of the Art: "Dynamic Voltage refinisher for Power Quality Improvement", *International Journal on Electrical and Engineering*, Vol. 4, No. 2, pp.79-98, 2015.

[5] S. Jothibasu and M.K. Mishra, "A Control scheme for Storage much Less DVR Based on Characterization of Voltage Sags", *IEEE Transactions on Power Delivery*, Vol. 29, No. 5, pp. 2261-2269, 2014.

[6] Mohammad Reza, Mohammad Ali Shamsi Nejad and Mohammad Hassan Khooban, "Dynamic Voltage Restorer Control the Usage of Bi-Goal Optimization to Enhance Electricity Quality's Indices", *IET Science, measure and Technology*, Vol. 8, No. 4, pp. 203-213, 2014.

[7] Alfonso Parre, "Generalized Proportional- Integral Control for Voltage-Sag Compensation in Dynamic Voltage Restorers", *Proceedings of International Conference and Workshop on Compatibility and Power Electronics*, pp. 1-6, 2011.

[8] T. Jimichi, H. Fujita and H. Akagi, "A Dynamic Voltage Preserver Equipped with a High-Frequency Isolated DC–DC Device", *IEEE Transactions on Industry Applications*, Vol. 47, No. 1, pp. 169-175, 2011.

[9] T.I. El-Shennawy, A.M. Moussa, M.A. El-Gammal and A.Y. Abou-Ghazala, "A Dynamic Voltage Refinisher for Voltage SAG Mitigation all Through a Plant with Induction Vehicles Loads", *American Journal of Engineering and Applied Sciences*, Vol. 3, No. 1, pp. 144-151, 2010.