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Reduction of Power Quality Issues in Micro-Grid using Neural Network Based DVR

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Abstract: ***As the current vitality situation deals with one serious issue is Power quality. Power quality has been progressively applicable, centered, with the expansion of reasonable hardware, where its conduct is especially critical to the quality of power input supply. Issue due to power quality is a wonder pointed as an uncommon standard current, voltage recurrence that brings about a disappointment of advanced gadgets. The primary matter centers at the voltage enlargement & dips. Here, creators introduce a specific system for the aversion of the voltage enlargement & dips. To amend the matter pointed out above, modified power types of gear are embraced. One of them, Dynamic Voltage Restorer (DVR), the foremost just as exact progressed redid control hardware utilized in power dispersion systems. The favorable circumstances incorporate scaled down value, small scale, with great dynamic reaction with regard to obstructions. Customary type controller like Proportional-Integral one and Neural Network (NN) based DVR Controller are utilized here for examination. In the proposed technique, NN based DVR controllers actualized are supplanted by the regular PI controller to build up the exhibition of the system. The point of the controller is built quicker than customary procedure found controller. By MATLAB reproduction apparatus, the presentation shall be considered.***

Index Terms: ***Dynamic Voltage Restorer, Genetic Algorithm (GA), Neural Network (NN), Solid State Equipments, Power Quality***

I. INTRODUCTION

Nowadays, most recent modern hardware is regularly working on electronic gadgets with power type working. The electronic sort supplies are predominantly dependable on obstructions that can be less average to control grade problems for example voltage enlargements, harmonics interferences & dips. The significant basic obstructions to the modern gadgets are voltage swells [1, 5].

DVRs normally sorts of tweaked control hardware that can have give predictable power quality in the exact place. It uses innovation named increasing of voltage by pay like enlargement by using solid driven electronic equipments [9]. Dynamic Voltage Restorer is the main ordinarily utilized in reacting to small variations in burdens that shall be generally impacted by framework voltage varieties.

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Diverse power quality problems ie .enlargements, dips, sounds and so forth.., in which voltage lists are the primary influenced basic impedances. Utilizing the custom power gadgets, these issues can be corrected. The most and apt progressed redid gadget for power upgrade is the DVR utilized in power appropriation systems , that recently presented fell short circuit in the strong side that add potential difference (pd) into system for mitigating the pds from burden side. This is generally prepared in a circulation system middle of the road at the regular connecting point is the heap feeder and the useable feeder.

Here NN based DVR is proposed to upgrade the power nature of the framework and to offer propelled power stream control under different working states of systems dependent on power framework, for dispose of the disadvantages of the traditional kind DVR. For taking care of complex framework issues easily, NN controllers have the better arrangement in such manner.

Likewise, the NN controller has a unique power stream control under different working conditions and is a straightforward kind controller [10, 11]. IEEE – 14 transport frameworks is considered for test study, so as to clarify the conduct of DVR with NN based controller for upgrading the power nature of the transmission arrange. MATLAB programming has been gotten the reproduction, as it has inability of getting powerfully great and fast estimations for the constraints involved in composite power framework.

NN based Controllers contrasted with the conventional PI Controller which will lift the framework behavior by utilizing DVR. To upgrade the power nature of the system, under significant conditions, the proposed DVR is utilized under major type of faults.

II. ARRANGEMENT OF DVR

The component setup of the DVR have the storing part, injection transformer part, voltage source inverter part and a filtering part [1, 3, 4, 6, 8] as given in Figure: 1.

To restrict the dynamic voltage from input side to output side as well as interference pairing is done with the help of a dedicatedly designed transformer which is the Injection transformer [5].

For the production of injected voltages is done with the help of storage equipment that is to provide the wanted power to the VSC by a dc link [2]. Batteries, Capacitance, and Energy storage equipments, are the Superconductive magnetic energy storage (SMES) [2, 7].

At the output side of inverter, due to non-linearity behavior of semiconductor equipments existing in the inverter may cause contorted graphs deals with oscillations. Filter part is used to get rid of this drawback.

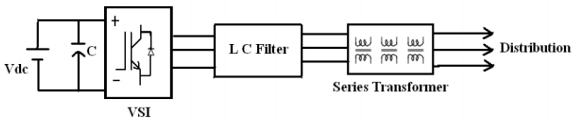

Figure 1: Schematic Layout of DVR.

III. POSITION OF DVR

With respect to the interrelation order to put in cascade with the middle of the transformer at the distribution side and the load, the location the of DVR can be decided as shown in Figure: 2.

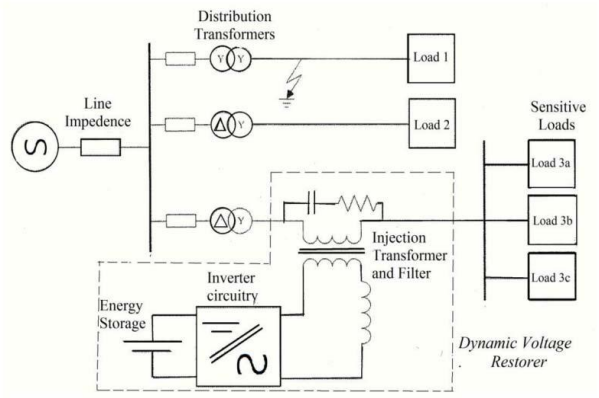

Figure 2: Position of DVR.

IV. OPERATING THEORY

With the help of a booster transformer, the DVR is DC commutated VSC (voltage source converter) which put a transient controlled voltage (VDVR) in cascade to the system voltage. Through the injection transformer, the produced magnitudes of the three inserted phase voltage due to dynamic interferences in the ac line that has been mitigated by the VSC and inserted on the intermediate voltage level as shown in Figure: 3 .

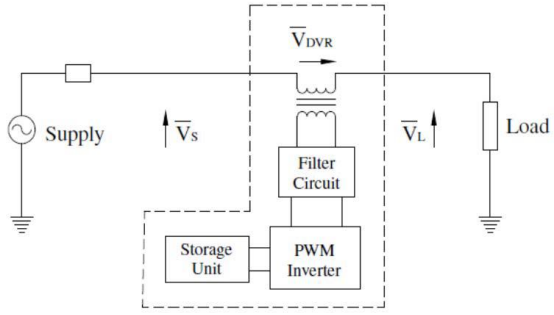

Figure 3: Operation of DVR.

V. CONTROL STRATEGIES

Changjiang Zhan et al recommended the various sorts of control methods proposed for DVR. The intelligent control strategies based tuning calculations for PID controller discussed by Nagaraj et al . The GA tuned PI controller based DVR for micro grid discussed by Thaha H S et al [13]. A most recent strategy for DVR compensating developed by Mostafa I. Marei et al .

Hysteresis voltage control technique for DVR is created by H. Ezoji et al.

VI. PID CONTROLLER GAIN TUNING BASED ON NEURAL NETWORK

A mathematical method or procedure methodology impressed by the architecture which has useful features of biological neural networks, like the brain could be Neural network (NN). In order to solve certain problems, it contains an outsized variety of extremely interconnected process neurons operating in specific union. The structural conFigureuration of a Neural Network in which there is only single input neurons, single output neurons and several other hidden neurons shown in Figure 4. There are specific nodes (neurons) in each layer. The adjacent layer neurons are connected together, while neurons in the same layer are not connected. The Neural Network also can be learned by itself like the biological neural systems. During studies, the weighted connections between neurons are often adjusted by specific algorithms with the help of external as well as internal info that flows through the network.

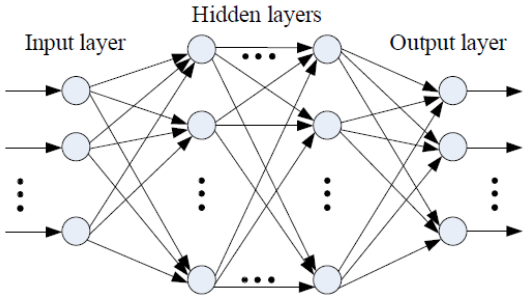

Figure 4: The structural architecture of a Neural Network.

The important merit of Neural Network is the competence selected utilizes the same as a whimsical function estimation technique that gets from practical data set. A lot of outstanding benefits of Neural Network are depicted as follows:

1. Adaptive type learning: Adaptive learning means that a capability to find out however the tasks have been done with the help of the initial experience or data provided for training.
2. Real time operation: A very large data and information can be processed by Neural Network in parallel. Using this advantage, unique hardware equipments get planned and made.
3. Fault tolerance: Few advantages of Neural Network shall be maintained as it is even with large network damage.

BP (Back Propagation) Neural Network (BPNN) is the mainly used common type of neural network for actual works. It uses the back propagation learning rule that comprises of two steps: data feed forward and error back propagation.

1. Data feed forward: Here, the data, like the controlled error system which is given to the input layer and then it is given to the unseen stratum and so finally into the output stratum.

From the output stratum, the output of the Back Propagation Neural Network (BPNN) can be taken where the connection weights between neurons will be in terms of function.

2. Error back propagation: At this stage, the desired value is compared with the real output of the network got in the last step.

The error got is propagated backward. Based on the error, the weighted connections between the neurons are altered by few techniques, such as gradient descent algorithm. Until the performance of the network is satisfied, the above two steps are continuously repeated. In this section, for tuning the parameters online for C-PID controller, Back Propagation Neural Network (BPNN) is utilized. The basic diagram of this I-PID controller called as Neural Network based PID (NNPID) controller gain tuning is given in Figure 5.

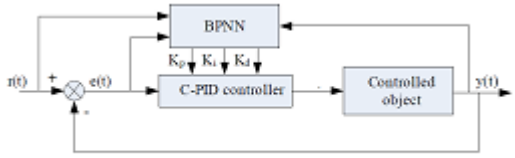

Figure 5: The Basic Diagram of NNPID controller.

The NNPID controller comprises of Back Propagation Neural Network (BPNN) and C-PID controller. Direct plant control is done with the help of C-PID. By fault tolerance, the output, a(t), is got. Back Propagation Neural Network (BPNN) is utilized to fine-tune the three parameter through online for C-PID controller with the help of specified state variables of the system, to optimize the performance criterion of the structure

The architecture for BPNN utilized in the controller type NNPID is depicted below as Figure 6.

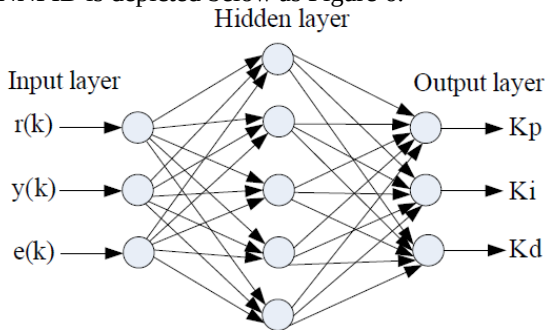

Figure 6: The BPNN architecture utilized in NNPID controller.

By observing the suggested BPNN, it consists of three stratums (layers): one input stratum, one hidden stratum and one output stratum. Three input variables and three output variables are there in the network. The mentioned input of the structure, the actual output of the structure, and the error linking them are represented by r (k), y (k) and e (k) respectively. Kp , Ki and Kd are the three parameters of the C-PID controller. The hidden layer consists of six nodes (neurons). During the working condition, the weighted connection connecting neurons can be robotically altered in the course of knowledge algorithm with help of the input knowledge. By adjusting the connection weights, the three output variables of NN (Kp , Ki and Kd), are changed. At last, the behavior of the system can be increased.

Nodes in the input layer for output is equal to their input as explained by Liu Luoren, and Luo Jinling [12]. The nodes in the hidden layer and output layer for output and input can be expressed as

$$Hidden\begin{cases} in_i^{(2)}(k)=\sum_{j=1}^{3} w_{ij}^{(2)} out_j^{(1)}(k) \\ out_i^{(2)}(k)=f\left[in_i^{(2)}(k)\right] \end{cases} i=1,2,3,4,\&5 \quad (1)$$

$$Output\begin{cases} in_l^{(3)}(k)=\sum_{i=1}^{5} w_{li}^{(3)} out_i^{(1)}(k) \\ out_l^{(3)}(k)=g\left[in_l^{(3)}(k)\right] \end{cases} l=1,2\&3 \quad (2)$$

Where wij(2) is the weight connection between unseen and output stratum (layer), wli(3) is the weighted connection between unseen and output stratum (layer) f[•] and g[•] are activation functions. In this section, a sigmoid type start task of unseen stratum (layer) is used. Due to the output variables of Neural Network, Kp , Ki and Kd cannot be negative, a nonnegative sigmoid type start task of output stratum (layer) is taken represented as:

$$\begin{cases} f(x)=\tanh(x)=\dfrac{e^x-e^{-x}}{e^x+e^{-x}} \\ g(x)=\dfrac{(1+\tanh(x))}{2}=\dfrac{e^x}{e^x+e^{-x}} \end{cases} \quad (3)$$

Then, the output variables of Neural Network are the three online parameter of
C-PID controller which is given by:

$$\begin{cases} out_1^{(3)}(k)=K_p \\ out_2^{(3)}(k)=K_i \\ out_3^{(3)}(k)=K_d \end{cases} \quad (4)$$

With (1) ~ (4), the feed forward of the information is completed by NN. The output of the C-PID controller is obtained simply with the help of the three current parameters, and then the output of the system, y (k), is found. The next procedure is the error back propagation.

To reduce the miscalculation linking y (k) and r (k), a recital indicator task is taken which is represented as:

$$J(k)=\frac{1}{2}(r(k)-y(k))^2=\frac{1}{2}e(k)^2 \quad (5)$$

Generally, the weighted connections are altered by steepest descent method. To maximize the convergence rate, an inertia term is included.

$$\Delta w_{li}^{(3)}(k)=-\eta\frac{\partial J(k)}{\partial w_{li}^{(3)}}+\alpha\Delta w_{li}^{(3)}(k-1) \quad (6)$$

Where η is learning rate, α is inertia constant such that η=0.001 and α=0.05 respectively.

As per the equations (5) ~ (6), the weighted connection can be tuned conventionally. Figure 7 to Figure 13 shows the NN training, testing, validating of data for the NN tuned DVR.

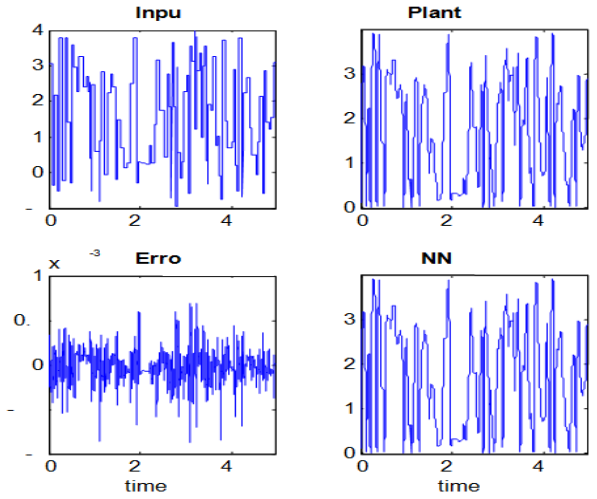

Figure 7: Training Data

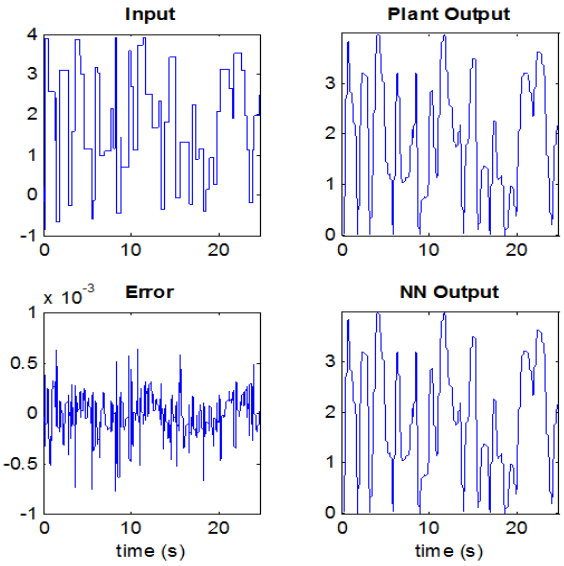

Figure 8: Testing Data

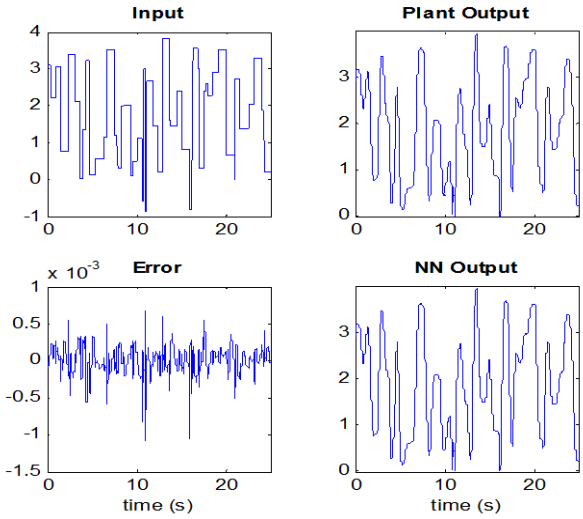

Figure 9: Validating Data

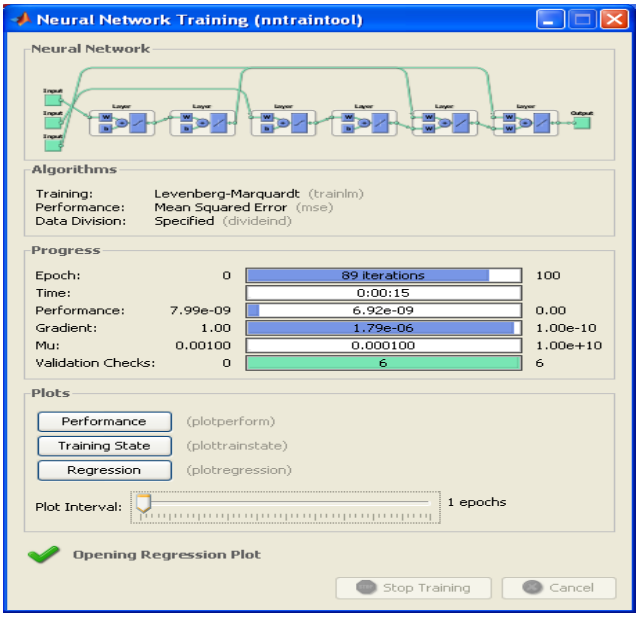

Figure 10: Training tool window of the NN controller model

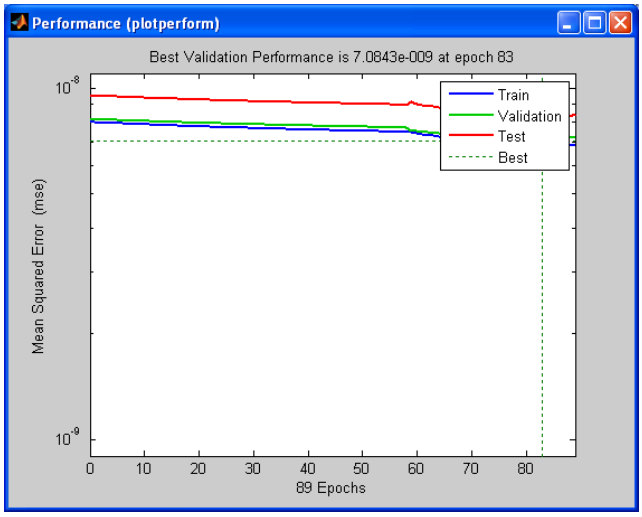

Figure 11: Performance plot of the NN controller

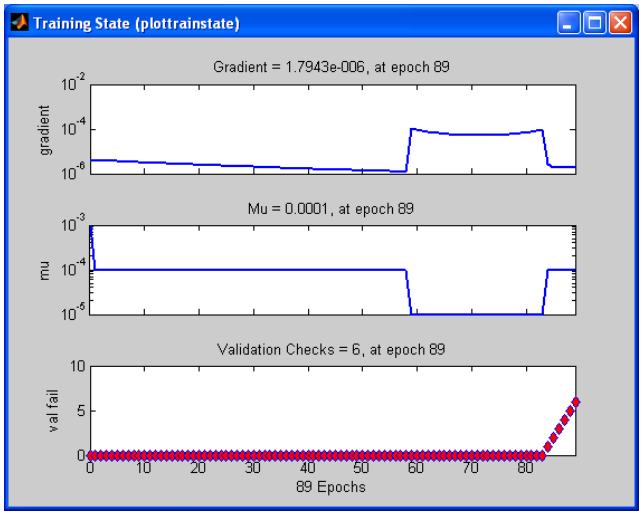

Figure 12: Training State

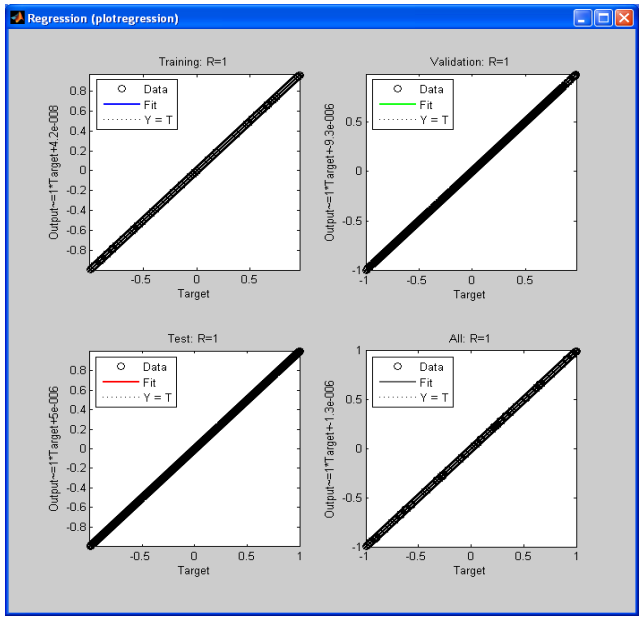

Figure 13: Regression plot

VII. MATLAB SIMULATION OF NN BASED DVR

Matlab model without DVR is shown in Figure: 14. The two control methodologies were displayed to conduct DVR control aspects in various viewpoints.

The test framework suggested in this paper is to simulate the model for DVR with NN Controller (data as in [13]) is shown Figure: 15.

When a three phase fault is provided to the system, the load side voltages are shown in Figure.16. At the point when the NN controlled DVR is in working situation, the voltage unsettling influences are indemnify almost downright and the voltage at the unpretentious burden point is controlled typical circumstance and is appeared in Figure: 18.

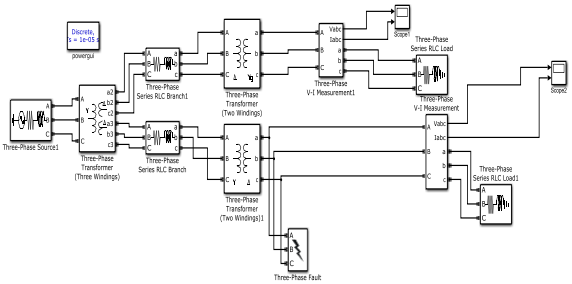

Figure: 14: Without DVR Diagram

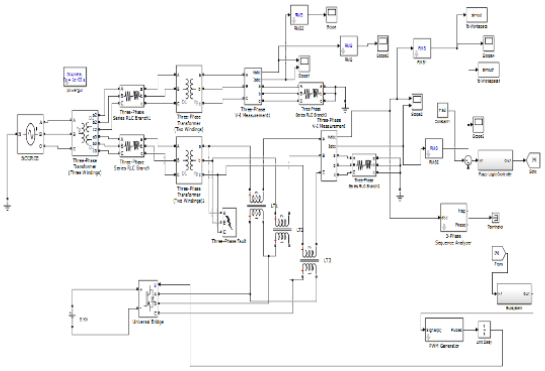

Figure 15: NN Based DVR Diagram

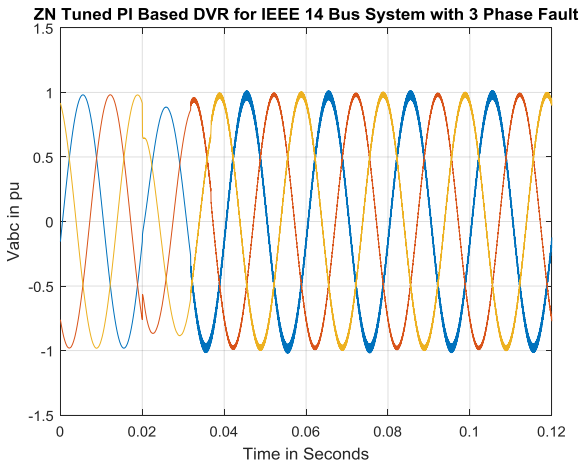

Figure 16: ZN Tuned PI DVR Load Voltage

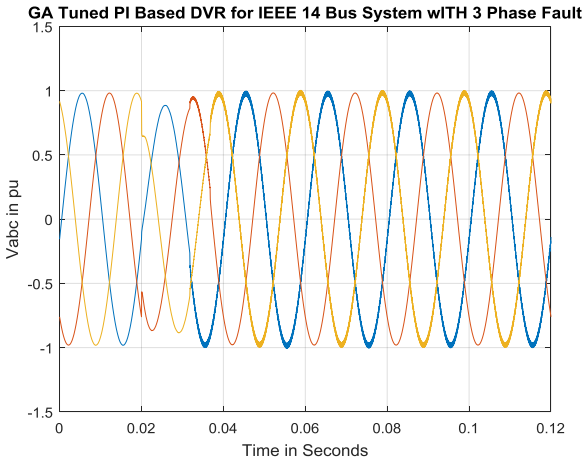

Figure 17: GA Tuned PI DVR Load Voltage

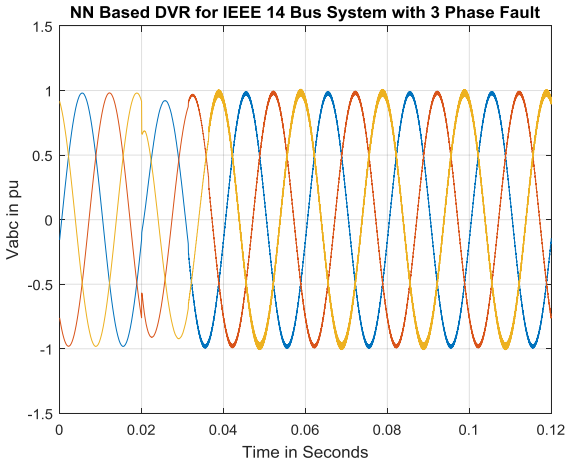

Figure 18: NN Based DVR Load Voltage

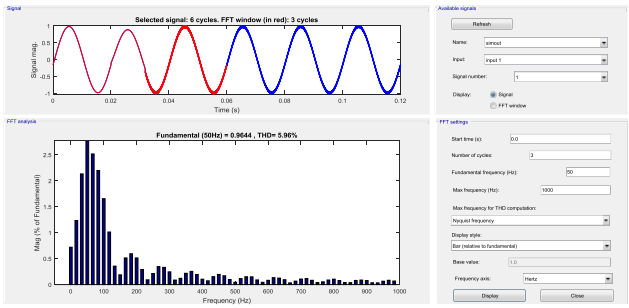

Figure 19: ZN Tuned PID Controlled DVR THD Analysis

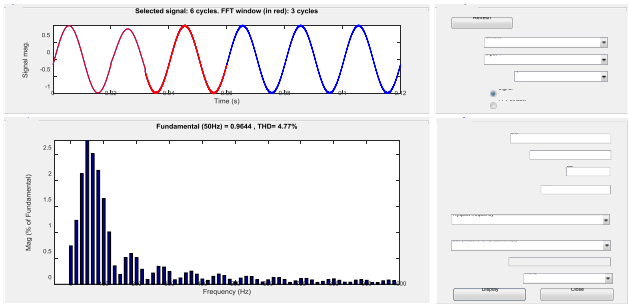

Figure 20: GA Tuned PID Controlled DVR THD Analysis of Population size 40

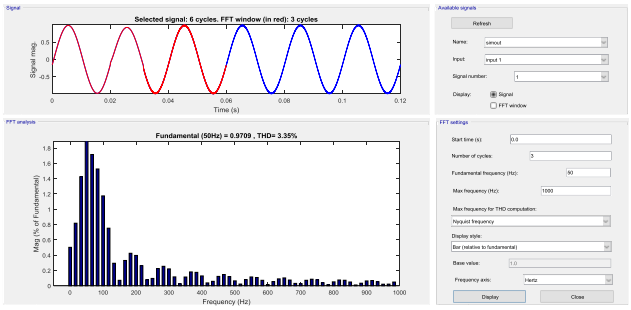

Figure 21: NN Based DVR THD Analysis

Table 3: Control Algorithms Comparison

Type of Control Method	Total Harmonic Distortion (THD) in %
PID Controller	5.96
GA Tuned PID Controller	4.78
NN Tuned PID Controller	3.35

The correlation table is appeared in Table II delineates obviously the viability of ANFIS Based controller in different perspectives. The Total Harmonic Distortion (THD) for every one of the controllers is given in the examination table as well as in Figure 19-21.

VIII. CONCLUSION

DVR is recently proposed cascaded solid state equipment which injects potential differences into the framework, in order to maintain the output side voltage at consistent. At the purpose of basic coupling, DVR is generally united with a distribution framework between the input and the critical load. For THD level reduction in the case of networks that are fixed to the harmonic generated load, DVR is needed. The yields of voltage charts of DVR utilizing NN type Controller with voltage dip and enlargement during three phase fault are applied. NN Controller based DVR performs better among DVR with other types of Controllers. Hence, the suggested NN based DVR has higher level achievements compared to other type of Controllers with regard of enhancement in active and reactive power flow through transmission network lines.

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