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Voltage and Frequency Mitigations for Solar PV-Mini Micro Hydel Power Plant in Hybrid Microgrid System

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ABSTRACT
A large proportion of the world's sparsely populated, and geographically isolated remote areas have lack of central grid connection. To facilitate these areas with proper uninterrupted power supply, microgrid is one of the possible solutions. Research works on microgrid system with renewable energy sources are getting importance nowadays. In this paper a review on how the intermittent nature of renewable energy sources is affecting the power quality is discussed. Artificial Intelligence based techniques are used for resolving these problems are also reviewed and analyzed. This paper tries to review different control strategies which are adopted to overcome these mitigations.

KEYWORDS
Artificial Intelligence; Microgrid; Mini-micro hydel; Solar Photo-Voltaic system; Voltage and frequency mitigations.

1. INTRODUCTION

For the economic growth of society, energy requirements are increasing continuously. But for the remote areas where grid supply is challenging, and costly renewable energy sources can be introduced in addition to the conventional one to make hybrid generating system. Microgrid employs hybrid generating systems like PV-Diesel, Wind-Diesel, PV-Micro hydro system etc. [1-2] Microgrid is electrical power small subsystems with a few numbers of distributed generating sources. This system may include renewable and conventional energy sources like photovoltaic, wind power, hydro, internal combustion engine, gas turbine and micro-hydro-turbine together with loads. A microgrid is a decentralized group of electricity sources and loads that normally operates with synchronous grid but able to operate autonomously in 'islanded mode'. Photovoltaic source is a very reliable and renewable energy source. PV system consists of PV modules which converts sunlight into electricity. Solar PV system output is dc in nature, so inverter is required to supply electrical energy to grid. Inverter does not have any rotating mass so it cannot provide mechanical inertia which makes the system frequency instable during large disturbances.

The capacity of hybrid system with PV-hydro is always small, on kW-scale. The output of the system in different condition like change in irradiation in PV system or lack of water in hydro generating system may become unstable and inconsistent. In the solar PV-Mini micro hydel power system, hydro generating system works for constant voltage and frequency control and solar PV system works for fixed active and reactive power output control. PV generation is maximum during daytime when solar insolation level is appropriate. Simultaneously hydel power resources which generate power are conserved for power management in the peak hours. During day-time surplus electrical energy is stored in battery storage system which is used to meet the power demand of evening hours [3]. Generating energy mostly depends on flow and the head of the stream or river in case of mini-micro hydel power plant [4]. Solar PV with mini-micro hydel system is the most cost effective and suitable reliable energy source for their complementarity to each other for the remote rural areas, those are not connected with the grid [3-4].

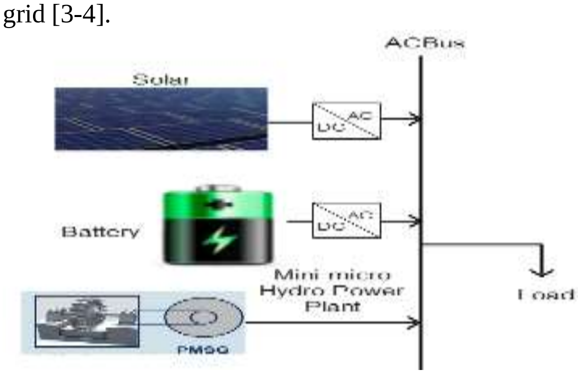

Fig. 1 Hydro-PV Microgrid System

It is required to get maximum power output from the microgrid keeping the voltage and frequency stable. Micro grids employ distributed energy resources and require smooth transition between operating modes of grid-connection and islanded mode for different operating conditions. So, energy management is very complex. Many artificial intelligences (AI) based techniques are adopted as control strategies in both voltage and frequency mitigations under steady state and transient state conditions for microgrid control applications.

Providing reliable and secure power supply to the consumers with balanced load sharing the regulation of voltage and frequency in microgrid is very much challenging. Apart from these, weather conditions also play an important role in which instability in the system may occur. The unpredictable and intermittent nature of renewable energy can lead to deterioration of power quality. This may lead to variation in system frequency and voltage. This paper reviews these strategies and tries to identify the short falls and suggests areas of improvements. Here in this paper a comprehensive review of voltage and frequency instability of microgrid system is discussed. Different techniques are used to achieve stability in hybrid microgrid system, where the voltage and frequency mitigations are addressed by conventional control techniques as well as artificial intelligence techniques. In conventional control technique, classical control based on Proportional and Integral controller or linear controller is used. But these are not capable of addressing all the system dynamics. Therefore, Artificial Intelligence based controller can play an important role as it can be considered a powerful tool for different purposes like estimation and control of different variables in power applications.

2. MICROGRID STABILITY

2.1 Detection of Fault in Microgrid

Faults may be observed in microgrid components as well as in the grid. These faults are vulnerable to the generating and battery storage system shifting their operating condition which in turn unable to fulfill power requirements. These faults may include shading fault or inverter fault in the solar system, battery fault, ground fault, ground fault and converter switching faults. Islanding fault is required to be detected within 2s [44-46]. Islanding means disconnection from utility grid. There are two types of islanding, one may be intentional which is required for general maintenance and budget constraints and another type is unintentional which may be because of uncertainties occurred in the utility grid, which is known as islanding fault. Islanding fault creates hazard to personnel, instabilities and anomalies are observed voltage and frequency of the output signal range, microgrid gets disconnected from the main grid when that goes out of phase. Then circuit reclosures are used to reconnect with main grid. Two common techniques are utilized for detecting Islanding faults, remote technique, and local technique [38-39]. There are three common remote techniques available, like Transfer trip, Power line carrier communication, System state monitoring. Transfer trip scheme and intercropping [40] is utilized for monitoring of all switching operation and sends command to control unit to run in islanding mode after detecting disconnection. In power line carrier communication two types of devices are applied. Transmitter which uses the power line to send a low energy communication signal known as anti-islanding signal and receivers those are installed at microgrid side. System state monitoring is a SCADA based method utilized to detect islanding faults created due to voltage and frequency mismatch where the microgrids are adequately equipped with communication device. Local technique is of three types like Passive, Active and Hybrid. Passive techniques monitor frequency, voltage, harmonics and compare them with the predefined threshold values for detecting islanding fault. Under passive technique nine very common techniques are utilized:

• Rate of change of output power- fault detected by monitoring the change ingenerated power for a finite time

• Rate of change of frequency- the islanding fault can be located by continuous tracking of the change of frequency for time span

• Rate of change of frequency over output power- change of frequency over change of output power of the generation units is used to detect the islanding fault

• Change of impedance- connected microgrid is required to have low impedance islanded one. • Voltage unbalance- output voltage should not be more than the threshold voltage 3

• Harmonic distortion- islanding fault can be detected by measuring total harmonic distortion and by comparing with the reference values in voltage and current

• Phase jump detection- for detecting zero crossing of PCC at the generating unit PLL is connected. The voltage at PCC deviates during faulty condition. But inverter output current remains same as that is obtained from PLL. With that there will phase displacement among the current and voltage at the next stage. If this deviation is more than the preset threshold value, the islanding fault occurs.

• Under/over voltage and under/over frequency- when voltage or frequency at PCC does not exceed certain level power flow to utility grid is restricted.

• Rate of change of voltage and change of factor- power factor change is an indication of islanding fault.

Active techniques are the method where some perturbations are injected into the system which causes more imbalances when system is in islanded mode rather than connected to grid. Under this technique there are several methods like impedance measurement, phase, or frequency shift method, slip mode frequency shift, active frequency drift, Sandia frequency shift, Sandia voltage shift, Automatic phase shift, Reactive power export error detection, frequency jump, variation of active and reactive power, Negative sequence current injection, High frequency signal injection, virtual capacitor, virtual inductor, virtual resistor, Phase PLL perturbation methods are applied. Chances are there to be unstable system output for application of perturbations. Hybrid technique utilizes both the active and passive techniques mentioned above. Initially passive techniques are utilized for primary detection and after that by active technique accurate islanding fault detection is done. Five hybrid techniques are there, they are voltage unbalance and frequency set point, voltage change and power shift, voltage fluctuation injection, hybrid Sandia frequency shift Qg-f method, rate of change of reactive power and load connecting strategy. Hybrid technique has very small non-detection zone. Since less perturbation is applied there is less chance of system degradation [38]. A new islanding detection method (IDM) is used to deal with the fault caused due to self-excited induction generator driven by mini-hydro turbine with two stage fault detection process, active and passive. When at one stage the ROCOF is more than the threshold value, at next stage the power reference is changed to alter the governor gate position. This algorithm ensures zero NDZ and 373ms average detection time [41]. PV modules are generally installed with the tracking system to get the maximum insolation position which may become faulty for many reasons. Image processing algorithm based principal component analysis (PCA) is used for the purpose. PV module slopes are determined and compared with the threshold value. A deviation index is also proposed to identify the faulty panels [42].

2.2 Techniques to Stabilize Voltage and Frequency mitigation.

Microgrid with a greater number of micro sources may suffer from reactive power oscillation that can be controlled by voltage reactive power droop controller. In microgrids, there is a link between system variables like active-reactive power, voltage and frequency for high R/X ratio and feeder length. For regulating the output active power flow in different system hierarchical control is proposed for restoring frequency of PV-hydro microgrid system [5]. The rapid changes in output power of distributed generations create frequency instabilities which cannot be solved by Droop controllers only. Here for maintaining the active power balance, additional controllers are required which will control frequency [6]. Mode transition of the microgrid system introduces a huge number of transients. An additional pole-placement-based output feedback controller is applied during transitioning of modes for reducing transients [7]. For utilizing the micro-hydro and solar system in combination with battery bank the required design sizing is mentioned here [8]. In paper [9] network reconfiguration approach is applied which can estimate better dynamic response in case of variation in line admittance, node current and frequency and voltage variation. In paper [10] an auto tuning PI controller is used with on-off relay for regulating turbine valve of micro hydro system to maintain voltage and frequency constant keeping maximum efficiency with changing load. In islanded hybrid renewable energy system, for compensation of a load voltage and current deformities dynamic voltage restorer is applied for ac non-linear load. The output of photovoltaic is variable and for that hydropower is applied in hybrid generating system [11]. An hourly based optimized model was developed to smooth solar generation and insert more than one turbine for ensuring more flexibility and proper utilization of water resources [12]. Between DC hybrid system and ac non-linear load inverter is connected in combination with LCL filter. In islanded MG voltage source converter is used to improve power quality and maintain voltage and frequency by providing reactive power compensation. The fundamental component of load current of VSC can be estimated by third order sinusoidal integrator (TOSI) based control algorithm is discussed [13]. In paper [14] power management of a standalone MG is done by Voltage Source Converter (VSC) and a bidirectional DC-DC converter (BDDC). Here a hydro-PV microgrid is implemented with an adaptive filter based on LMF (Least Mean of Fourth) and a battery unit is 4 employed. In this battery unit maximum power is injected by BDDC. Regulation of voltage and frequency, improvisation of power quality can be achieved by this adaptive control technique. With a control algorithm Virtual inertia is developed keeping maximum power point tracking during the operating condition [15]. In paper [16] two high level algorithms are applied, namely MFO (Moth-Flame Optimization) and WCA (Water Cycle Algorithm). These two methods are tallied with GA (genetic algorithm). With that the optimal design of a hybrid power generating station is developed for radio transmitter station. In case of islanded Microgrid the decentralized control is used for balancing generated energy and demand maintaining voltage and frequency with required power quality [17]. PI controller is used to regulate the speed of synchronous generator. Regulation of frequency can also be obtained by a feedback signal resulting from the adjustment of load and speed variation [18]. The stability of a system primarily depends on the loading and their sudden changes. Frequency instability occurs due to mismatch of generation and demand of active power. Due to low system inertia of RE based system the system frequency fluctuates but inverter can emulate virtual inertia for its fast and better controllability. Two novel methods are introduced to imitate variable inertia while another one to support the MPPT operation continuously [19]. The PV inverters are designed in a way that the chosen DC link capacitor and inductor can be utilized to make up the reactive power of islanded microgrid. This can reduce voltage fluctuation with load and solar radiation change [20-21]. In paper [22] an analytical model is developed for obtaining accurate estimation of voltage and frequency variation which is caused due to network reconfiguration. Switching and scheduling are done to reduce power losses. With the network reconfiguration the variation of voltage and frequency responses can be analyzed. This model improves the model predictive control of a reconfigurable Microgrid. In this paper scheduling is done in respect of load requirement which may be followed in our work to meet the voltage and frequency requirement. These issues are more obvious during the presence of fluctuating load conditions and poor weather conditions. With the implementation of suitable control design, virtual inertia units and energy usage reduction these challenges can be met in further work. The challenges that we can find in Microgrid are:

a. Maintaining voltage, current and frequency within desired range

b. Maintaining active and reactive power sharing and balance

c. Transitioning between various modes of operation maintaining system stability

2.3 Artificial Intelligence Based Techniques for Instability Analysis

Artificial intelligence techniques can be applied for instability analysis of microgrid. Microgrids are generally affected by the intermittent nature, nonlinear response, and the large amount of input and out data of renewable energy source which can be dealt with the Artificial Intelligence technique. In hybrid microgrid system the PV is controlled by three stage hierarchical theory, primary control, secondary control, and tertiary control as observed in Figure 2. Primary controller relates to voltage, current control loop, virtual impedance control and active reactive power control loop. For recovering voltage, amplitude, frequency, and grid synchronization at the point of common coupling, secondary control is applied. Tertiary control is for getting PV system response and injecting power into the grid utility. There are different types of AI techniques like Deep learning, hierarchical deep reinforced learning which are suitable mostly for optimization problem in case of non-linear fields like line parameters based on frequency and load based on voltage. Artificial neural network composed of nodes or a group of joined units which are known as artificial neurons similarly like human brain neurons. In Figure1. The nodes are elaborated, and artificial neurons are shown. The Arrow shows the direction of connection from one neuron output going to input of another neuron. The study of artificial neural networks works like biological systems, which is like the human nervous cell with the capability of learning. The learning process of neural network is done with proper training samples. The training samples may be of the output of previously worked tests or associated data. With Neural network similar problems can be solved after proper training with samples. With this, the system becomes more robust to the noisy input signals with neural networks [23]. Machine learning can spontaneously frame the rules and irregularities with experience from collected data or by trial-and-error. Machine learning (ML) is a subset of AI, mainly consisting of supervised learning (SL), unsupervised learning (USL), and reinforcement learning (RL) Deep Learning (DL), and deep reinforcement learning (DRL) [34].

There are several methods for voltage regulation like using k-means AI algorithm techniques which are unsupervised learning for solving clustering data. Power systems can be separated into smaller regions which can be called pilot buses. The pilot buses are subjected to many variations. Required reactive power

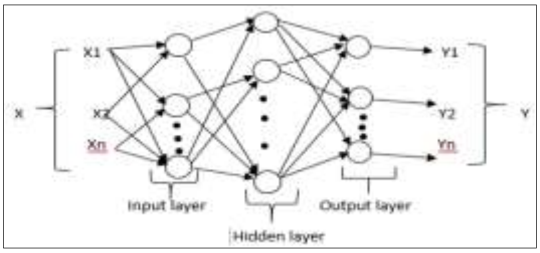

Fig. 2 Neural Network Strategies

into the pilot buses can be injected by individually designed ANN. Designing such ANN for individual region, offline learning algorithm is used, and estimation of nonlinear system is done utilizing load disturbances as inputs and bus voltage as outputs [35] between IIDG (Inverter interfaced distributed generation) and load. In wide-reaching MGs with inverter interfaced distributed generation (IIDC), equivalent line parameter calculation is tough and establishing GDC is difficult. For this reason, an adaptive neuro-fuzzy inference system (ANFIS) is developed. This ANFIS drop controller is trained with the previously given data set which can make the whole system independent of microgrid model loop, virtual impedance control and active reactive power control loop. For recovering voltage, amplitude, frequency, and grid synchronization at the point of common coupling, secondary control is applied. Tertiary control is for getting PV system response and injecting power into the grid utility. There are different types of AI techniques like Deep learning, hierarchical deep reinforced learning which are suitable mostly for optimization problems in case of non-linear fields like line parameters based on frequency and load based on voltage. Artificial neural network composed of nodes or a group of joined units which are known as artificial neurons similarly like human brain neurons. In Figure1. The nodes are elaborated, and artificial neurons are shown. The Arrow shows the direction of connection from one neuron output going to input of another neuron. The study of artificial neural networks works like biological systems, which is like the human nervous cell with the capability of learning. The learning process of neural network is done with proper training samples. The training samples may be of the output of previously worked tests or associated data. With Neural network similar problems can be solved after proper training with samples. With this, the system becomes more robust to the noisy input signals with neural networks [23]. Machine learning can spontaneously frame the rules and irregularities with experience from collected data or by trial-and-error. Machine learning (ML) is a subset of AI, mainly

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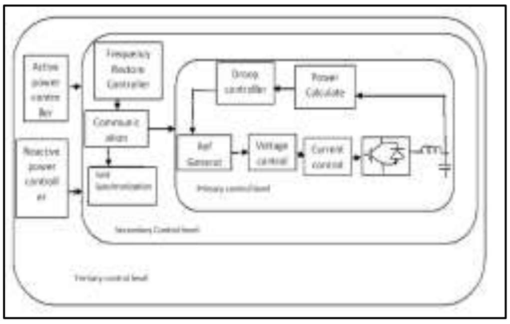

Fig. 3 Block Diagram of the Conventional Hierarchical Control of PV

Figure 3 shows Block Diagram of the Conventional Hierarchical Control of PV. Supervised learning (SL) can set up the mapping and working relationship within input-output with previously inserted data set. Unsupervised Learning (USL) is not required for studying target during the process used mainly for data clustering and data compression. Reinforcement learning (RL) does not require training dataset. It is suitable for finding strategies to maximize output for a particular task mostly suitable for the system with lack of previous information or challenging to formulate model [24- 26]. To meet the demand load requirement, controllable sources are applied where delay in output characteristics may create frequency oscillations. For proper utilization of energy, control of real and reactive power can be achieved by the Automatic generating controllers (AGC). Tuning of controller parameters is generally done with Ziegler's- Nichol's method but in practical cases these are not feasible for generating rate constraint and saturation. For such cases some powerful mathematical optimization techniques are present in Genetic Algorithm like PSO (Particle Swarm Optimization), BFO (Bacteria foraging Optimization) are very much applicable for tuning the parameters. BFO Artificial Intelligence technique is a suitable technique for this case for its lesser numerical iteration [27]. AI-based sensor less control is introduced to DC microgrid structure with the help of non-linear input-output neural network eliminating the effect of communication delay caused by sensors boosting up the system's reliability. ANNs are utilized to lower the quantity of sensors. Here multilayer feed-forward neural network is used for its less complexity. For implementing this ANN model, it is well-tuned to compute optimized results and exact values. Weight factors and bias factors are obtained first and then ANNs are applied to the system. Satisfactory results are obtained from trained ANN which is related to selection of proper data. Accurate data selection is necessary for training of ANN. When required training results are obtained the calculated sensor data are disabled and the outputs of Arithmetic Neural Networks (ANN) are linked to the controllers for utilizing. There the number of sensors is reduced whose data are estimated by ANNs. The proposed controller can provide the loads with fast response, lesser oscillations, and higher tolerance than cascaded PI controller [28]. For applying AI, it is required to take care of power demand of the locality depending on population density, weather condition, commercial activities etc. and the prediction of energy generation capacity. AI can be applied for efficient use of available data and can help make decisions. Estimation of energy savings, loss and stored charge in batteries can be predicted by Deep Learning strategies [29-30]. A time varying load is considered for a hybrid microgrid system consisting of hydro-wind-PV. The power flow of wind energy system is controlled by doubly fed Induction generator. This induction generator is controlled by fuzzy logic. The fuzzy logic-based Grid Side Converter-I controls the power flow of PV and Grid Side Converter-II compensates for the load current. GSC-II acts like a STATCOM as it supplies both active and reactive power of load [31]. Deep Learning algorithms has multiple perception layers, and the layers are utilized for learning a representation with different level. There will be a loss function at output layer and activation function in the hidden layer. DL is suitable for its ability of feature extraction and representation from high dimensional data and DRL can be applied for decision making process by utilizing that information. The difficulties in deciding strategies after each control command may create hazards and cascading failure which can easily be solved by inverse reinforced learning (IRL) [32]. Microgrid failure due to its small inertia can be prevented by ANN control approach and by adaptive method of re-dispatching of power which makes the system robust and more reliable. The pattern recognition ANNs use a scaled conjugate gradient back propagation training function and fitting ANN with Levenberg-Marquardt Back Propagation (LMBP) training method. With LMBP, convergence speed can be increased with reduced training time [33]. An ANN method based on the Multi-Layer Perceptron (MLP) with back-propagation to predict the solar radiation is proposed in [34]. There are several methods for voltage regulation like using k-means AI algorithm techniques which are unsupervised learning for solving clustering data. Power systems can be separated into smaller regions which can be called pilot buses. The pilot buses are subjected to many variations. Required reactive power into the pilot buses can be injected by individually designed ANN. Designing such ANN for individual region, offline learning algorithm is used, and estimation of nonlinear system is done utilizing load disturbances as inputs and bus voltage as outputs [35] between IIDG (Inverter interfaced distributed generation) and load. In wide-reaching MGs with inverter interfaced distributed generation (IIDC), equivalent line parameter calculation is tough and establishing GDC is difficult. For this reason, an adaptive neuro-fuzzy inference system (ANFIS) is developed. This ANFIS drop controller is trained with the previously given data set which can make the whole system independent of microgrid model and structure. So, this is suitable for working with a wide range of microgrids. In this case the GDC is applied on a simple microgrid. The input and output data at different load condition of that test was saved as training data to train the ANFIS unit. Imposing training ability

3. Case Study

One of the workers with MG system used system droop characteristics to improve voltage and frequency stability [36]. In the case of inductive MGs reactive power/voltage (Q/V) droop control and in resistive microgrids, active power/voltage(P/V) droop control is applied. Instability of frequency is caused due to deviation of real power, there active power/frequency droop control methods are used. Since a strong linkage exists between reactive power and grid frequency, the droop techniques are applied for MGs frequency control design.

Table. 1 Cross platform comparative performance

S.N.	Control technique Methods used	Findings	Conclusion
1.	Electronic load controller (ELC) [4]	Electronic load controller (ELC) is used to maintain load balance. During low load condition dump load is provided by ELC	Maintain the output voltage and frequency stable.
2.	Frequency restorer technique [5]	For regulating active power an active power controller is inserted in tertiary control level of photovoltaic system	System output may be able to regain its frequency response and improves power output.
3.	Voltage based frequency controller [6]	To maintain active power balance and frequency additional controller along with Droop controller is used which consist of PI controller with a lag-lead block to detect the frequency deviations and act accordingly.	Regulation of frequency response is possible.
4.	Pole placement-based output feedback controller [7]	Transients can be removed	Provides much stable voltage output
5.	TOSI based control Algorithm [13]	A third order sinusoidal integrator (TOSI) based control algorithm is applied for estimating fundamental component of load current for VSC control and elimination of harmonics.	Able to regulate the voltage and frequency of the MG with improved power quality.
6.	Adaptive filter based voltage source converter (VSC) is used. [14]	This controller is capable of harmonics mitigations, reactive power compensation and load balancing. Adaptive filter (belongs to least mean square and least mean of fourth)	Track the ambient condition changes and self-tune the filter parameters on that basis.
7.	Automatic generation control (AGC) [27]	Controller gain tuning, frequency bias, drop in the presence of generation rate constraint in microgrid is done.	large number of parameters tuning can be done

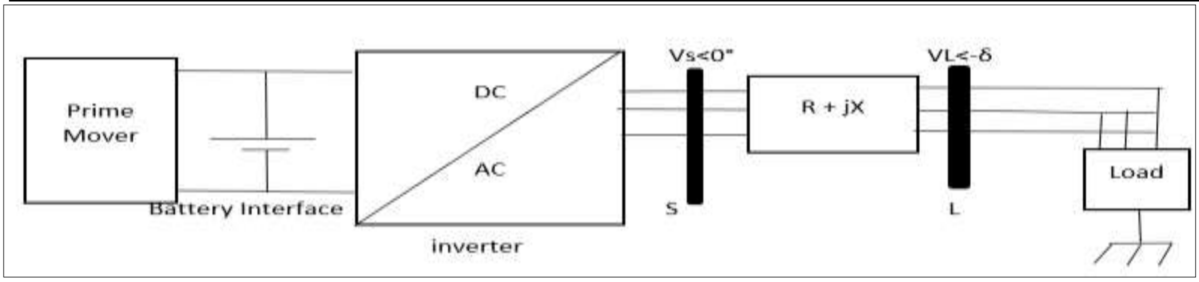

Fig. 4 Simple MG with an Interfaced Inverter System

Figure 4 shows Simple MG with an Interfaced Inverter System. A generalized droop control (GDC) is applied to separate the active and reactive power impacts on the voltage and frequency and is highly dependent on the line parameters to the fuzzy logic creates new hybrid technique called ANFIS [37], which is capable of learning data set information with proper training and can work as dynamic generalized droop controller. Based on fuzzy If-Then rules are applied to the I/O pairs are generated which creates an appropriate mapping with membership functions (MFs) and input/output (I/O)., a hybrid learning algorithm is utilized to determine the parameters. In this technique, the training of system can be done with ANN. After the training there is no requirement of the knowledge of MFs the fuzzy rules. The construction of MFs is dependent on the parameters.

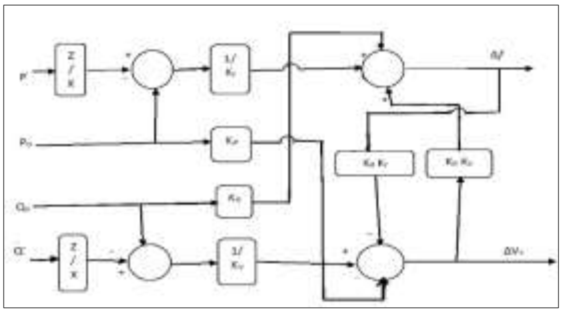

Fig. 5 Block Diagram of GDC

ANFIS can select those parameters accordingly. Figure 5 shows Block Diagram of GDC. Fuzzy interference system (FIS) can be built with input-output data. The Back propagation (BP) algorithm and least square error (LSE) method are applied to settle the parameters. Active and reactive powers are the two inputs which are injected at the fuzzy interference system. The output is voltage and frequency. In Layer1 input parameters are applied to get fuzzy sets proportional to the inputs. The second layer represents the multiplication of input signals, activity level of each rule is determined in layer3 and is accurately determined in layer3, and number of layers is equal to number of rules. Layer 4 represents the partial output values and finally Layer 5 provides the final output of ANFIS. Initially the GDC is used to simple MG modeled by ANFIS then after assuring model validity proposed ANFIS-based controller is used instead of GDC. With the severe changes of active and reactive loads the system voltage and frequency responses are compared [36]. With this intelligent technique the requirement of detailed microgrid structure is not necessary. Thus, it is suitable for a wide range of microgrids. From the discussion and the detailed elaboration in the above papers we have observed that the stability of a system primarily depends on the loading and their sudden changes. Apart from these, weather conditions also play an important role in which instability in the system may occur. The unpredictable and intermittent nature of renewable energy can lead to deterioration of power quality. This may lead to variation in system frequency and voltage.

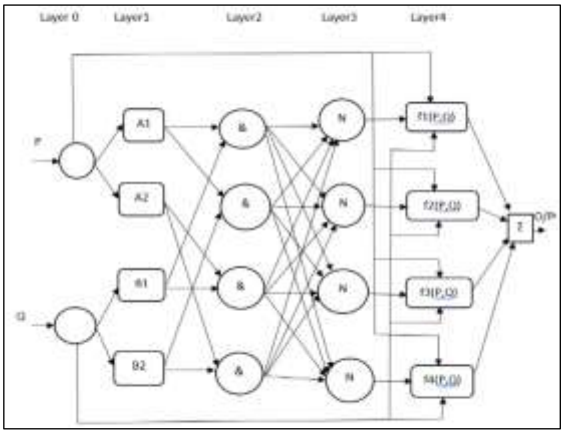

Fig. 6 Typical Structure of ANFIS

Voltage fluctuations, voltage notching transients, harmonic distortions, limited short circuit capacity etc. create serious effects in sensitive end users. Figure 6 shows the typical structure of ANFIS. Microgrid with a greater number of micro sources may suffer from reactive power oscillation that can be controlled by voltage reactive power droop controller. In microgrids, there is a connection between system variables like active and reactive power flow, voltage, and frequency etc. due to feeder length and system parameter ratios (X/R) and these are more frequent when system becomes instable with different situations. With the enhanced control mechanism these problems can be resolved and many of the challenges can be addressed in further work with Artificial Intelligence (AI) techniques. AI techniques are applied to predict the microgrid energy production capability considering the surrounding weather conditions and make the optimization of battery energy storage and discharge advantageous than the grid supply. AI predictive technique can be utilized to reduce consumption of energy for meeting the demand.

4. Identification Of Shortfalls and Area of Contribution of research

In Table 1. the control strategies are compared where conventional control techniques are adopted to get rid of the problems of intermittencies of renewable energy sources but to get fast response and decision-making capabilities, AI based techniques are adopted in Grid connected & Islanded mode for Voltage and frequency mitigation. Therefore, research work on the instability analysis with the help of a generalized AI based control algorithm may reduce harmonic components, DC offset values and any such parameters leading to Instability for the system under consideration. Learning of reactive power compensation to prevent voltage deviation, harmonic distortion etc. may be considered in our research work area and for that deep learning methodology may be a suitable way to provide the details at distinct stages and bring out the important information from high dimensional data.

5. Conclusion

Different conventional and advanced methods of voltage and frequency mitigation in solar PV and Mini-micro hydel microgrid have been reviewed in this paper. From this discussion we can conclude that shortcomings like voltage-frequency fluctuation, poor power quality, low inertia, harmonic distortion, instability for mode transitioning may be the major cause of inconsistency and instability of the system. These uncertainties and instabilities can be reduced by controlling active and reactive power, decision making capabilities of system to remove cascading failure, introducing virtual inertia, removing, or reducing transients etc. These can be achieved in more stable and reliable setup using AI based control techniques. Regulation of voltage and frequency instability of hybrid microgrid system can be obtained and thus the dependability on such renewable energy sources may increase.

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