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Research Article

A Novel Approach Using Adaptive Neuro Fuzzy Based Droop Control Standalone Microgrid In Presences of Multiple Sources

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ABSTRACT. In this paper, a novel Q/P droop control strategy for regulating the voltage and frequency in Standalone micro grid with multiple renewable sources like solar and wind is presented. The frequency and voltage control strategy is applied to a Standalone micro grid with high penetration of intermittent renewable generation system. Adaptive Neuro-Fuzzy logic Interface system (ANFIS) controller is used for frequency and voltage control for Renewable generation system. Battery energy storage system (BESS) is used to generate nominal system frequency instead of using the synchronous generator for frequency control strategy. A synchronous generator is used to maintain the state of charge (SOC) of the BESS, but it has limited capacity. For Voltage control strategy, we proposed reactive power/active power (Q/P) droop control to the conventional reactive power controller which provides voltage damping effect. The induced voltage fluctuations are reduced to get nominal output power. The proposed model is tested on different cases and results show that the proposed method is capable of compensating voltage and frequency variations occurring in the micro grid with minimal rated synchronous generator.

Keywords: Adaptive Neuro-Fuzzy Interface System (ANFIS), Battery energy storage system (BESS), State of Charge (SOC), Frequency control, Q/P Droop control, standalone microgrid, voltage damping effect, voltage control

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1. Introduction

Micro-grids operating in standalone mode are more commonly exposed to variation in voltage and frequency. The grid becomes weaker than a conventional power system due to an isolated system. In recent years, dependence on renewable energy sources like solar and wind generation system (Park & Yu, 2001; Velasco de la Fuentev *et al.* 2013) has increased the instability of grid due its varying input nature. In case of isolated networks diesel based synchronous machines are used for voltage and nominal frequency control. the pattern recognition and decision making are done by mapping input points to the output using fuzzy logic interface. Mostly in an isolated power system, the diesel generator based on a synchronous generator which is used to generate nominal system frequency and voltage with the help of Adaptive Neuro-Fuzzy Interface system (ANFIS). The mapping point of an input to the output using Fuzzy Logic interface provides a basis from which decisions can be made and the patterns discerned. The SIMULINK software system can access the Fuzzy logic test system in a block diagram (Sumina, Erceg and Idzotic. 2005). It describes all membership functions, logical operators and If-Then rules. This control strategy is applied specially to penetrate the intermittent Renewable power generation to control the frequency and voltage for stable operation of the system. Several methods are being examined to support frequency control.

The strategies are enabling to dispatch wind power to operate in a similar manner of a conventional power plant. Wind power is a fluctuating motive source, the effectiveness of active power control of wind turbine generators (WTG) will depend upon wind speed (Keung *et al.* 2009). WTG's are supplemented with doubly fed induction generator (DFIG) to expand the flexibility of wind power procurement and enhance the controllability (Ekanayake, Holdsworth and Jenkins, 2003). The control approach of DFIG is to set a point of active power at fixed pitch angle (Ekanayake and Jenkins. 2004). With the proper reference frame, I_{dr} will come up with the electromagnetic torque (T_{em}) against turbines mechanical torque (T_{mech}) at some rotor speed. Consequently, the torque difference between T_{mech} and T_{em} can make rotor to accelerate / decelerate.

$$J\frac{dw_r}{dt} = T_{mech} - T_{em} \qquad (1)$$

$$\frac{dw_r}{dt} = \frac{1}{2H}(Tm - T_e) \qquad (2)$$

Where, w_r - Rotor speed, J - Inertia of motion, H -Inertia constant (s).

The primary frequency support from de-loaded wind turbines using variable droop was developed (Diaz et

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al. 2010). In micro-grids with high penetration of wind energy, the fluctuations in the wind form output due to variations in wind speed cause frequency disturbances. A frequency droop control was applied to PV power generation (Lalor. Mullane and O'Malley. 2005). Even though the fuel cost is free but its cost of installation is high. PV's operate in the maximum power point tracking (MPPT) model to generate maximum income. However, as penetration of PV's increase the frequency regulation capability (mainly provided by synchronous generators) and inertia from synchronous generators decrease which leads to severe frequency fluctuations under some disturbances.

Moreover, load changes can lead to some significant frequency deviations if PVs don't have frequency regulation capability. To avoid this, the PVs are designed with a virtual governor to have frequency droop characteristics similar to that of the synchronous generator. However, frequency control strategies using intermittent renewable generation are not beneficial economically. There are various ways to control voltage drop by installing regulators in substations, using online transformer tap changers, shunt capacitors, increasing the size of conductors etc. Some sensors, such as smart meters (SM) measure voltage in reference and current at each branch send this information/recorded data to the control center (Carvalho et al, 2008; Schlabbach, Blume & Stephanblome, 2001).

Decentralized voltage control is another method which uses local data to control voltage issues. But this device operates independently and there is no communication between loads and the substation. The effect and the reliability must be maintained for these methods. The linear quadratic tracking method is one of the voltage control method used to obtain desired results. The voltage is considered at each node then the controller increases / decreases voltage to minimize the error. The monitoring of controller is based on entire system conditions. This process can be categorized as decentralized control, but it increases system complexity and it needs more study. Analyzing and modeling of power distribution would become more complex and time taking. Most control strategies have applied optimization algorithms to meet specific objectives, such as minimizing loss, improving voltage profile, mitigating voltage fluctuation, maintaining voltage within regulated limits (Kim 2010). However, these methods will never be perfectly accurate, since they are based on forecasting load demand, wind speed and solar irradiance. The voltage compensator, shunt capacitors, LQT methods which lead to increased additional cost. Q/V droop control is widely used for voltage compensation, but the compensation is triggered by sensing the voltage deviation. Section 2 describes about proposed methodologies and the control strategy which includes Q/V droop control and ANFIS controller are explained in Section 3. The test system operation and its simulation results are observed in different cases in Section 4.

2.Proposed Methodology

In a remote power system, the Active power/frequency (P/F) and Reactive power/voltage (Q/V) droop control are used to generate nominal system frequency, voltage and some voltage compensation devices are used for control strategy. If the generating system units' droop is increased, it's response to the system frequency deviation diminishes. However, frequency control strategies using intermittent renewable generation are not beneficial, because they cannot make the most of their ability to utilize free energy. BESS is used to support the frequency of micro-grid. The system stability and operational security can be improved by using BESS (Divya and Ostergaard 2009). By improving the controllability of RES generators, BESS provides a resolution to overcome the frequency control issues. Q/V droop control is widely used for voltage compensation, but the compensation is triggered by sensing the voltage deviation. The recommended strategies include

1. BESS is used to generate small system frequency instead of using diesel generators which does not depend on the mechanical inertia of a synchronous generator.
2. SOC (state of charge) of the BESS is used by the diesel generator at a convinced value and the reference significance of the SOC is adjusted to limit the output power of the diesel generators to within a permissible range.
3. Q/P droop power is added to the renewable generation which has damping effect to avoid voltage fluctuations induced by its active power fluctuations.
4. Adaptive Neuro-fuzzy logic controller reduces the frequency and voltage fluctuations and improves the system performance.

3. Control Strategies

To maintain frequency and voltage control, there are many strategies to a conventional power plant. A frequency control droop was added to PV generation. But these control strategies are not economically beneficial, since they cannot, maximize their usage of free energy. So, by adopting BESS (Battery energy storage system) the control strategies enabling to support system frequency deviating from its nominal value (Shayeghi, Shayanfar and Jalili 2009). With the aid of Active power/frequency (P/F) and Reactive power/voltage (Q/V) droop control and voltage compensation devices are applied to the isolated power system. The Q/V droop control is widely used for mitigating voltage fluctuations, since the voltage fluctuations are triggered by sensing the voltage deviation.

a. Test System configuration

The proposed control strategy with ANFIS (Adaptive Neuro-Fuzzy Interface system) is tested on the below test system as shown in Fig 1, location of loads and power generation system are also indicated. The distance. The ratings of the power generation using different sources considered in this analysis are given in Table 1 (Rana, Singh and Mishra, 2017).

Table 1.
Power ratings of different sources considered for analysis

No	Name of source	Rating(MW)
1	Diesel generator	14
2	Wind generator	9.1
3	PV System	1
4	BESS	15

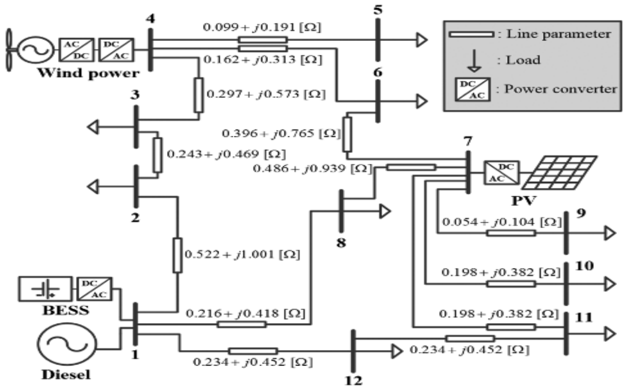

Fig.1 Power System configuration block diagram.

The nominal system frequency and voltage considered in this study are 50HZ and 11KV respectively and the change in load during the day and night are shown in the table 2. The inverters are modeled as two level and the gate signals to the inverter switches are generated using conventional sinusoidal pulse width modulation.

Table 2
System Load Demand

BUS NUMBER	DAY(MW)	NIGHT(MW)
2	3	1.5
3	2	1
5	1	0.5
6	1	0.5
8	2	1
9	0.2	0.1
10	0.2	0.1
11	0.1	0.05
12	0.5	0.25
TOTAL	**10**	**5**

b. Frequency Control Strategy

Battery system is used to deliver power at nominal frequency instead of using synchronous machine. As the frequency of the system is depending on the generator speed and inertia BESS rather than diesel generator is adopted to overcome this weakness to control the system frequency (Scott, Wilreker and Shaltens, 1984). The BESS controls the nominal system frequency by adopting relevant switching mechanism based on the control scheme designed. Chargeable characteristic of BESS is used to the execute frequency control strategy which enables battery system to take twice the amount of change in load value than any other devices with same rate of power. The rapidly changing charging and discharging abilities of BESS make it to respond quickly to the fluctuations in output power of renewable generation system (Senjyu, Miyazato and Yona 2008). However, SOC and implementation of control scheme using frequency droop in Figure 2 is not achieved by the BESS alone.

BESS should work in synchronization with Diesel Generator where the frequency, voltage and phase are to be matched. To generate nominal system frequency, the diesel generator should be controlled (Serban, Marinescu 2011). During normal operation of diesel generator in Fig.3, the switch is moved to node A to control the power output diesel generator reducing the discharge from BESS and hence maintaining SOC at the desired value SOC_{ref}. SOC load control is same as the conventional load frequency control and SOC_{ref} is chosen as 0.5PU. The charge and discharge cycle of the BESS is controlled by the operator depending on the requirement.

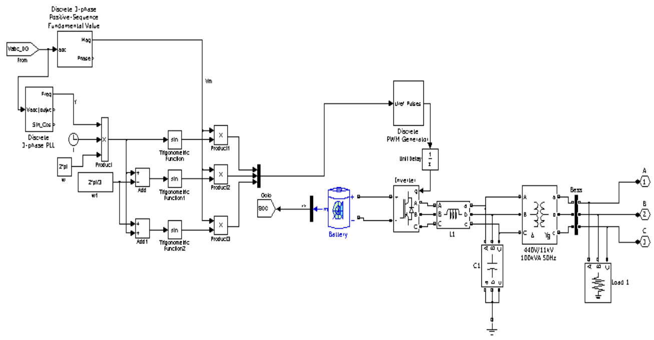

Fig.2 Implementation of the rid-side inverter control scheme

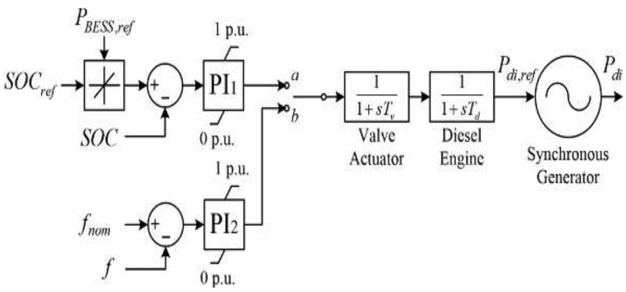

Fig.3 Proposed SOC based scheme for control of diesel generator

The diesel generator output active power of is maintained within specified value ranging from 0 p.u to 1 p.u by adding the anti-windup function and output limiter value at the output of the PI-controller. The frequency of the system is mostly depending upon the effective implementation of BESS control strategy. To overcome the reliability problem that may arise due to tripping action of BESS, the switch is connected to node B, when the BESS is isolated from the network due to reduction in SOC value. During the node B connection of switch, the diesel generator is controlled same as conventional one. The $P_{di,ref}$ is obtained from the output of the PI controller, it adjusts the valve actuator of diesel engine there by increasing the mechanical input to the synchronous generator, where T_v is the valve actuator time constant 0.05s and T_d diesel engine time constant 0.5s. P_{di} is the output active power of the diesel generator. The diesel generators acting as auxiliary source for SOC control which resembles the frequency control and its priority is changed to control SOC of the BESS rather than frequency control.

c. Voltage control strategy

The excitation of the diesel generator helps in maintaining its nominal voltage with in the specified limits. In contradictory to frequency control which can be done in central control, the voltage control should be done locally. the Control algorithm for grid side inverter control of the wind generator is shown in Fig.4. To solve these voltage variations caused by the renewable system, a new Q/P droop strategy for voltage control is applied to the distributed generators (S, R, Jang 1993).

$$K_{QV} = \frac{\frac{Q}{P_{rate}}}{\frac{\Delta V_{bus}}{V_{base}}} \quad (3)$$

Where v_{id} is the d-axis component of inverter voltage and v_{iq} q-axis component of inverter voltage. i_{id} and i_{iq} are the d- and q- components of the inverter currents, w_s represents the angular frequency of the system voltage, L_f represents the inductance of the filter, K_{QP} and K_{QV} are the droop coefficients of Q/P and Q/V, operating points of active and reactive power are represented by P_o and Q_o, V_{bus} is the voltage at generation bus.

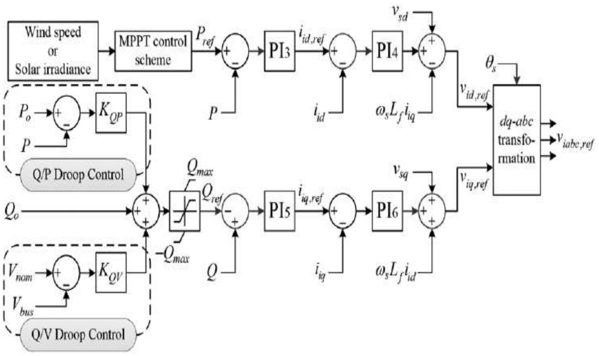

Fig. 4 Grid-side inverter control of the wind/solar system

When voltage droop is not activated the generating system is made to operate at unity power factor when Q_o K_{QV} is varied from 0 to 25 depending on the ability of power generation. MPPT control is applied by giving Wind speed or solar irradiance as inputs to generate reference active power value (P_{ref}). P_{ref}, P measured value are given to PI controller converting it to $i_{id,ref}$. i_d which is parks transformation value. The error obtained by comparing $i_{id,ref}$ and i_{id} is fed to PI controller generating V_d^*. It can be written as,

$$V_{id,ref} = V_{sd} + V_d^* - \omega_s L_f i_{iq} \quad (4)$$

Q/P droop control is the comparison of active power whereas Q/V droop control is the comparison of voltage control. K_{QP}, K_{QV} are the Q/P and Q/V droop coefficients respectively. K_{QP} and K_{QV} convert the error to reactive power component.

$$Q_{ref} = Q_o + Q_P + Q_V \quad (5)$$

Where Q_o is the operating point of reactive power and is set to zero. Again Q_{ref} and Q are given to PI controller and generates $i_{iq,ref}$. $i_{iq,ref}$ are compared with i_q in the PI controller generating an error V_q^*.

$$V_{iq,ref} = V_q^* + V_{sq} + \omega_s L_f i_{id} \quad (6)$$

Therefore, $V_{id,ref}$ and $V_{iq,ref}$ are fed as input to the dq-abc transformation and is converted into $V_{iabc,ref}$ using inverse parks transformation for sinusoidal pulse width modulation which generates six pulses for the inverter. The speed of the generator is taken as 1.2 P.U, pitch angle is 0 and the speed of the wind is 11m/s. Instead of using PI controller in the control schemes, Adaptive Neuro fuzzy logic controllers are used to improve stability and performance of the system. Solar irradiance is about 660W/m^2. By adding MPPT control scheme and Boost converters to maximize the utilization of free energy and to maintain constant output power.

d. Adaptive Neuro-Fuzzy interface system (ANFIS)

The Effective technique called ANFIS (Adaptive Neuro-Fuzzy Interface system) which was developed by Dr. Roger Jang. Apart from various optimizing methodologies in soft computing, the fuzzy logic and Neuro computing has visibility, which leads to Neuro-fuzzy systems. The combination of Artificial Neural Network (ANN) and Fuzzy Interface systems (FIS) has attracted the interest of researchers in various applications. Fuzzy logic interface system is a mapping point to map an input space to output space from starting point to the ending for all. Fuzzy logic is an intriguing area of research because it has a premium quality of trading off among significance and precision. Neuro adaptive learning methods similar to methods used for training neural networks is used for tuning parameters of fuzzy membership functions. This methodology is called as adaptive neuro-fuzzy inference system (ANFIS) . The backpropagation (BP) algorithm is used to trine the adaptive Neural network and 7*7=49 rule based fuzzy Logic command-line functions are used for training SUGENO-type fuzzy inference systems using given input/output training data (Jang 1993; Srinivas Singirikonda, Sathish Goud, & Harika Reddy, 2014).

4. Result and Discussion

To establish the effectiveness of the proposed control strategies, simulation results are observed during the day time in the standalone micro-grid with high penetration of renewable generation system. Voltage waveforms of PV, wind power, BESS and diesel generator are clearly presented in MATLAB simulation. The MATLAB simulation diagram for Adaptive Neuro Fuzzy Control Strategy for Standalone Micro Grid System with Multiple Renewable Sources show in Fig.5.

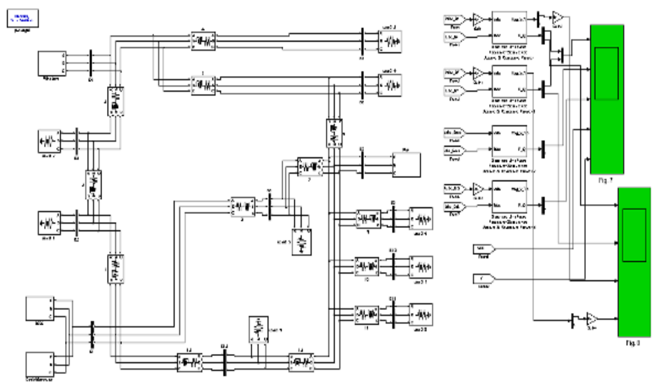

Fig.5 MATLAB simulation diagram of adaptive neuro fuzzy control strategy for standalone micro grid system with multiple renewable sources

Case I: Day time

During the day period, the speed of the wind is considered to be varying from 10.5 to 11.5 m/s and set to an average of 11m/s, the solar irradiance ranges at 660W/m^2. The active and reactive power of wind, solar are set at 0.413 and 0.495 respectively. The BESS come into action during voltage variations whereas the duty of the diesel generator is to support BESS by maintaining SOC.

There are some oscillations of SOC at diesel generator due to inertia of the machine leading to slow system Dynamics and output variations in active power of renewable generation systems. Without droop control, filter and inverter switching losses may lead to slight reduction in SOC Using droop control method SOC fluctuations are reduced with the support of diesel generation, even though the fluctuations in SOC is maintained at desired value. The frequency also fluctuates from its desired value without droop but the deviations are reduced with proposed droop method.

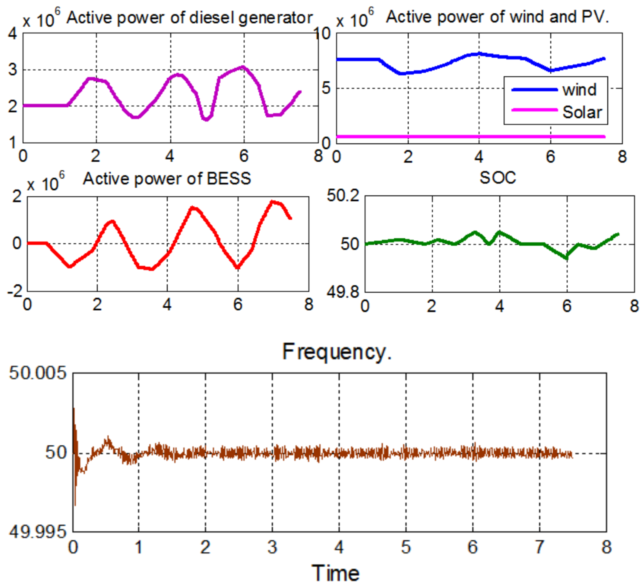

Fig.6 Frequency control results for case I: (a) Active power of wind and PV (b) Active power of BESS (c) Active power of diesel generator (d) SOC (e) Frequency

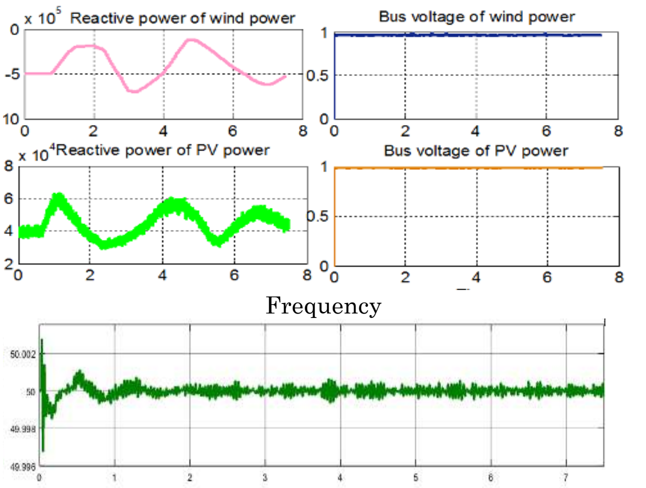

Fig.7 Voltage control results for case I: (a) Reactive power of wind power (b) Reactive power of PV power (c) Bus voltage of wind power (d) Bus voltage of PV (e) Frequency

Fig.6 shows the output active power of PV and wind, and active power flow characteristics of diesel generator BESS. the results show that the diesel generator takes full response in the absence of droop control, for the output fluctuation of the renewable generation system with droop control, BESS supports diesel generator to meet the power demand with P/F droop control method. Fig.7 shows the variation of reactive power of wind and solar power respectively without implementation of droop control, the renewable generation system has same power factor, but by applying Q/V droop control, the reactive power is controlled by compensating voltage deviation. By implementing the proposed method, the reactive powers of solar and wind are controlled, also mitigates the voltage fluctuation.

The bus voltage of PV and wind are kept near to nominal value using Q/V droop control. Even though, the fluctuations are not effectively prevented. There is a considerable reduction in voltage fluctuations when Q/P droop control is implemented.

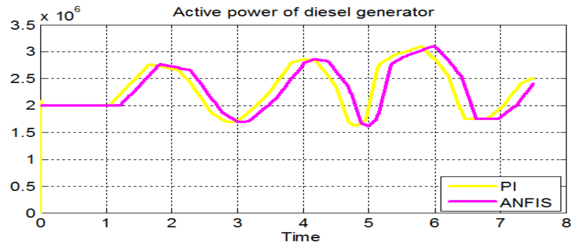

Fig.8 Comparison of Active power with Adaptive Neuro Fuzzy logic controller and PI-controller during Day time

The Fig 8 shows simulation results for Adaptive Neuro Fuzzy interface system (ANFIS) and PI-controller. ANFIS response rate is faster than PI controller and the simulation time to get output is less and easy to access and also the participation of DG id reduced to some extent giving optimal solution.

Case II: Night time

At night time, the solar irradiance is 0 W/m² and speed of the wind varies from 7.1 to 10.2 m/s and set to an average of 8.5 m/s. The reactive power value K_{QP} are set as 0.473 for wind and 0.514 for PV power. Fig.10 shows the power output from PV and wind, also the output active power of diesel generator as well as Battery system. The output power response is like that of day time but the diesel generator output power is reduced and it is observed from the simulation results, accordingly SOC_{ref} is to be increased. The diesel generator is made to generate active power within allowable range. It is also observed that the frequency deviation during the night is more compared to day time, but frequency is maintained at 50 Hz during the proposed method.

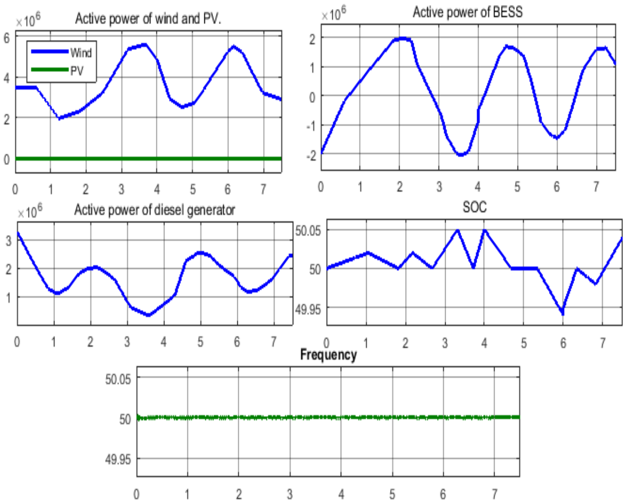

Fig.9 Frequency control results for case II: (a) Active power of wind and PV (b) Active power of BESS (c) Active power of diesel generator (d) SOC (e) Frequency.

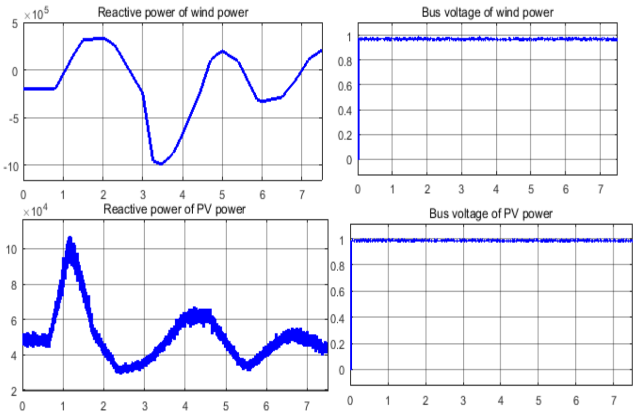

Fig.10 Voltage control results for case II: (a) Reactive power of wind power (b) Reactive power of PV power (c) Bus voltage of wind power (d) Bus voltage of PV

The Fig.10 shows that during voltage control mode the output power fluctuation of wind generator is greater than that in day case. The more compensation of reactive power has led to more wind power output power fluctuation of during the day. Since there is no solar irradiance, the voltage fluctuations are prevented. The change in voltage of the PV during the droop and proposed method is less.

In Fig.11, the violet color indicates the ANFIS controller output whereas the blue color denotes the PI controller. More over the bus voltages are maintained at a constant rated value even though the solar PV is not able to produce active power. The active participation of DG in compensating load power requirement makes the system to operate at constant frequency. The below figure 11 show that, the system operation with fuzzy control gives fast response in case of network variations.

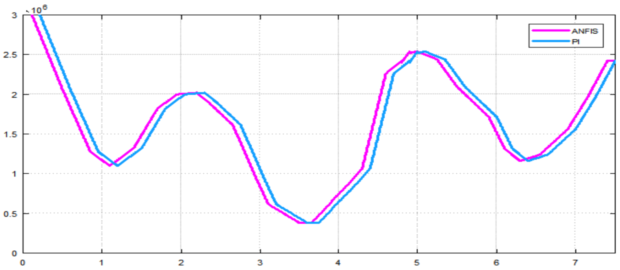

Fig.11 Comparison of Active power with Adaptive Neuro Fuzzy logic controller and PI-controller during Night time.

Case III: Worst Case (When there is no solar irradiance and wind speed)

To study the robustness of the proposed method the absence of both solar and wind is considered as worst case. In this case, solar irradiance has to be varied, and the load demand is same as day time. Hence the K_{QP} is set as 0.413 for wind and 0.495 PV based on day time data. Fig.12 shows active power response of the of wind and PV power generation systems. However, frequency remains unchanged.

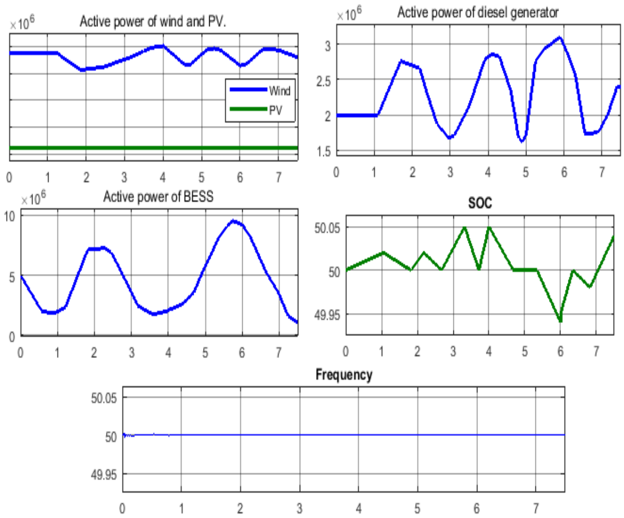

Fig.12 Frequency control results for case III: (a) Active power of wind and PV (b) Active power of BESS (c) Active power of diesel generator (d) SOC (e) Frequency

The Fig.13 represents the voltage control simulation results. As a result, there are some deviations around some points but the proposed method performs better than others. It is observed that the participation of BESS and DG is more in this case and the reactive power requirement of the load, Wind generator are compensated by the solar inverter setup. The bus voltages are also maintained at constant rated value even in the worst-case operation. The simulation results of Fig.14 show the comparison of both PI and Adaptive Neuro-fuzzy logic controllers even in worst case has better performance.

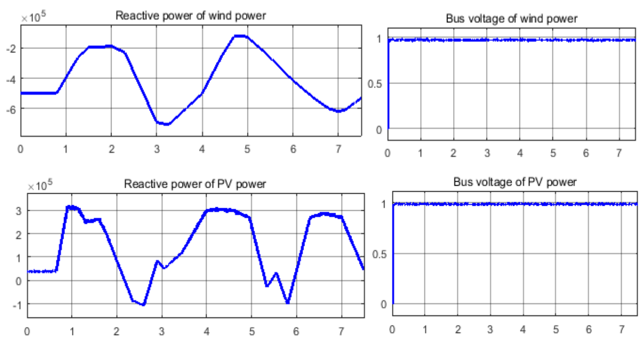

Fig.13 Voltage control results for case III: (a) Reactive power of wind power (b) Reactive power of PV power (c) Bus voltage of wind power (d) Bus voltage of PV

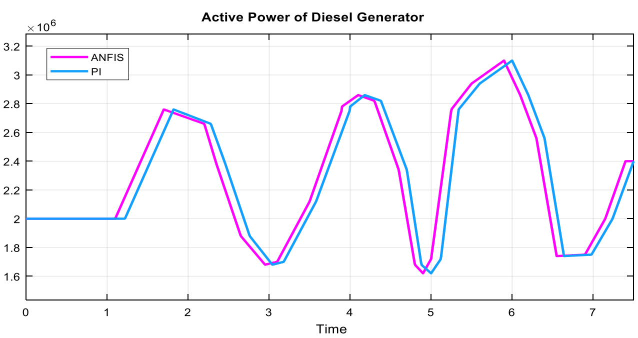

Fig.14 Comparison of Active power with Adaptive Neuro Fuzzy logic controller and PI-controller during Worst case

Case IV: Effect of Load change and BESS Tripping on the system performance.

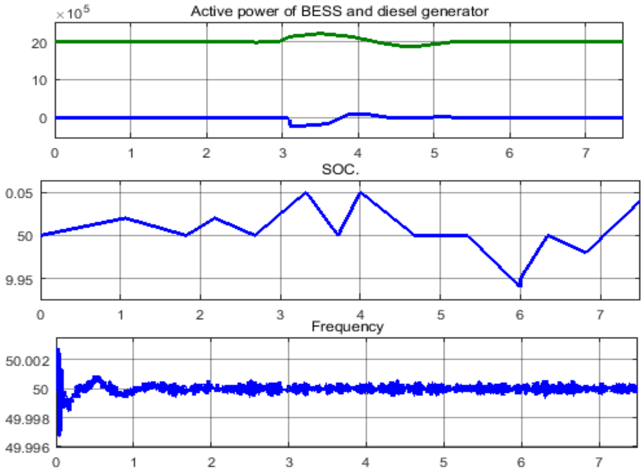

Fig.15 Load change simulation results for case IV: (a) Active power of BESS and diesel generator (b) SOC (c) Frequency

Here consider two cases (i) Load change (ii) Tripping of BESS for the frequency control strategy. Fig.15 shows the load change in day time. There is a load decrement at 0.5MW at 3sec of time. SOC and frequency are maintained same as previous cases. The Fig.16 shows the load change simulation of Adaptive fuzzy controller scheme and PI controller. Taking Time (sec) on X-axis and Active power (MW) on Y-axis. Fig.17 represents the results for the case of while battery system is tripped. The BESS is tripped out of the system due to fault maintenance etc. The diesel generator operates by changing its switch position to 'b' when BESS trips out of the system. Fig.18 shows the Tripping of BESS simulation results of Adaptive fuzzy controller and PI controller scheme.

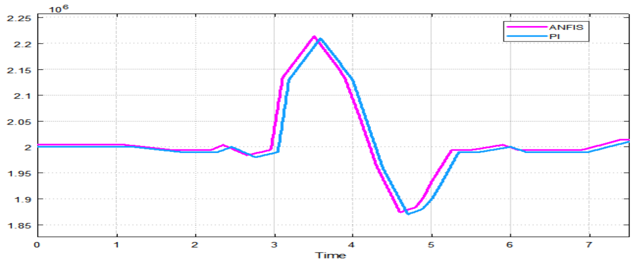

Fig.16 Comparison of Active power during load change with Adaptive Neuro Fuzzy logic controller and PI-controller

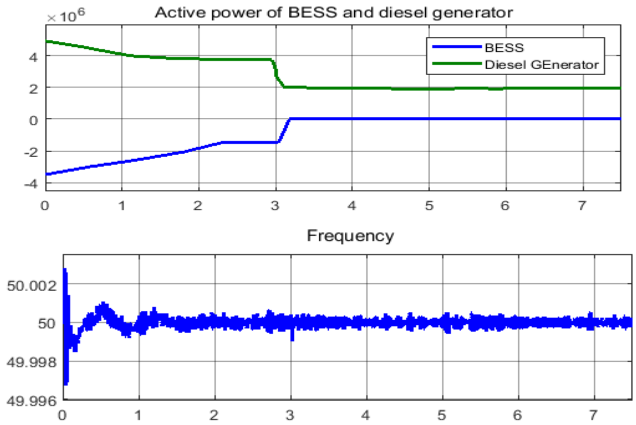

Fig.17 BESS tripping simulation results for case IV: (a) Active power of BESS and diesel generator (b) Frequency

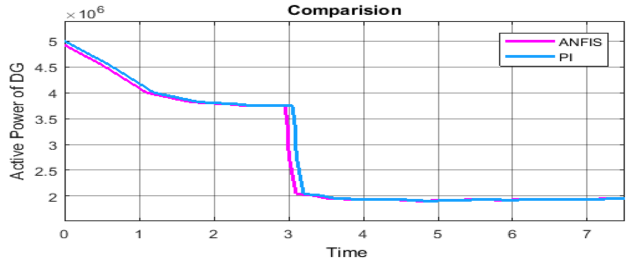

Fig.18 Comparison of Active power with Adaptive Neuro Fuzzy logic controller and PI-controller during BESS tripping

Case V: Considering PV bus only

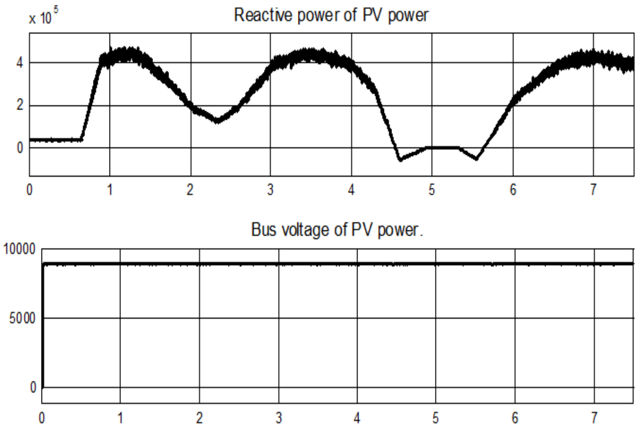

Fig.19 Simulation results for case V: (a) Reactive power of PV power (b) Bus voltage of PV power

In this case, the output of wind power system is kept constant and active power fluctuation of the PV system is considered and the effect of voltage control strategy on PV power system bus are observed. The PV power system shows results in fig 19 and the reactive power is limited.

Case VI: Adjusting charge/ discharge of BESS

BESS should be controllable for the energy efficiency perspective. By varying the slope of the ramp of SOC, BESS is controlled to output the desired level of active power. Fig.20 shows charging of SOC at 1MW and active power of Battery storage system and diesel generator.

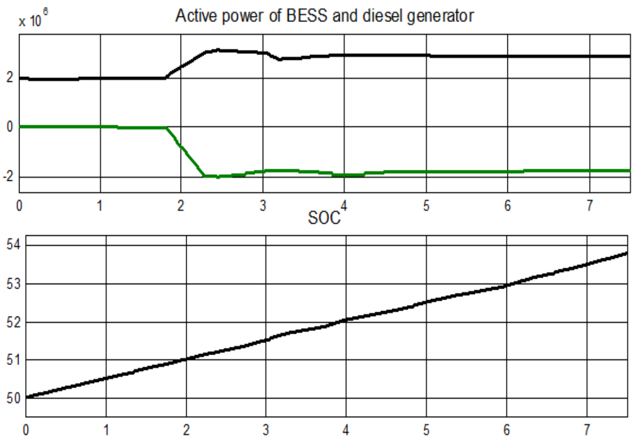

Fig.20 Simulation results for case VI: (a) Active power of BESS and diesel generator during charging (b) SOC during charging

BESS is consequently adjusted such a way to discharge if the power output of the diesel generator varies at t ramp rate and the effect is shown in Fig.21. The BESS is controlled in this manner, to discharge active power required by adjusting ramp rate of SOC which includes the controller of diesel generator.

By comparing with different cases, the system performance in case-1 with ANFC is better when compared to all other cases because, all sources are active at day time and whereas solar energy is limited in night time. With the use of Adaptive Neuro fuzzy controller, the output active power wind and PV are 7MW and 50KW.Frequency and SOC are maintained as 50HZ and 0.5P.U.

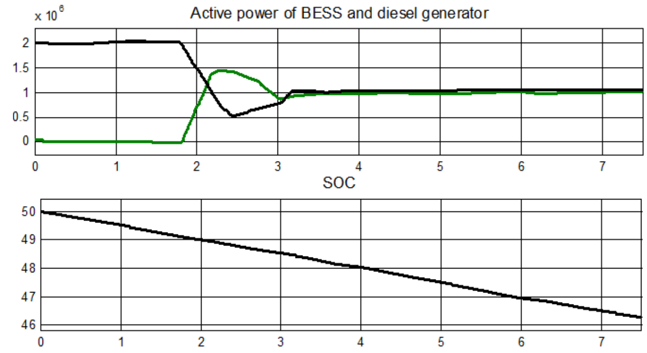

Fig.21 Simulation results for case VI: (a) Active power of BESS and diesel generator during discharging (b) SOC during discharging.

Table 3
Comparison of results with and without controller

Cases		Without controller (PI controller)	With Adaptive Neuro fuzzy logic controller
1.	Day time	Active power is 2.7MW at 1.4sec. Frequency is 49.8HZ with some oscillations. SOC is 0.48 P.U	Active power is 2.8MW at 1. 2sec.The frequency is maintained 50HZ constant. SOC is 0.5P.U with less damp of oscillations and settles faster than PI
2.	Night time	Active power of wind and PV are 3.8MW, Diesel generator is 3MW.Reactive power of wind is 0.48 and PV is 0.52. Bus voltage of wind and PV are 0.97 and 0.98 P.U	Active power of wind and PV are 4MW, Diesel generator is 3.2MW Reactive power of wind is 0.473 and PV is 0.514. Bus voltage of wind and PV are 0.98 and 0.99 P.U
3.	Worst case (No solar irradiance and wind speed)	Active power is 2.6MW at 1.8sec time. Reactive power of wind and PV are 0.413 and 0.495MVAR	Active power is 2.8MW at 1.5sec time. Reactive power of wind and PV are 0.5and 0.8MVAR
4.	i) Load change	Active power is 4.9MW at 3.1sec of time	Active power is 4.9MW at 2.8sec of time
	ii) Tripping of BESS	Active power is 2MW at 3.1sec of time	Active power is 2MW at 2.8sec of time and the frequency is maintained constant as 50HZ.

5. Conclusion

To mitigate the problems of diminishing voltage and frequency fluctuations, Adaptive Neuro Fuzzy Interface system is used, which has quick response rate compared to PI-Controller. The implementation of BESS leads to stable operation of the system maintaining the frequency at nominal value of 50Hz. without any deviation. For this reliable voltage control a novel Q/P droop is introduces into the control scheme for controlling the reactive power flow in test system with multiple Renewable generators. The active power fluctuations are effectively prevented by damping voltage fluctuations in the renewable generation. The output Active power of PI and Adaptive Neuro fuzzy controllers are compared and simulation results are observed on the graph during different cases. Simulation results are observed in MATLAB software by using these control strategies. The ANFIS controller improves system stability without any interruptions and produces effective performance.

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