ANFIS CONTROL OF ENERGY CONTROL CENTER FOR DISTRIBUTED WIND AND SOLAR GENERATORS USING MULTI-AGENT SYSTEM

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Abstract - *The main objective of this project is to power control of distributed wind and solar generators using multi-agent system by ANFIS controller which reduces transmission, distribution losses, reduces total harmonic distortion and increases system efficiency because of their benefits of extensibility, autonomy, reduced maintenance, etc. Reliable operation of power system requires a control computer architecture that contains hardware and software protocols for transposing system status and control signals. This project presents design of energy control center (ECC) to control DERS using a multi-agent system. The multi-agent system composed of smart grid/load and agents such as user agent, distributed energy resources (DER) agent, database agent, control agent, work in coactions to perform attribute tasks. The DER model is created on the customer side and ECC is created on the server side. The wind power generator and solar power connected with local load and solar contains battery for energy storage, ECC controlled by ANFIS and simulation done in MATLAB/SIMULINK.*

Index Terms: Distributed energy resources (DER) and internet protocol (IP), distributed generators (DGs), energy control center (ECC), Artificial Neuro Fuzzy Interface System (ANFIS).

I.INTRODUCTION

Now-a-days demand for electrical power is increasing, some amount of power loss in transmission and distribution. To reduce the distribution losses in monitoring and control several methodologies used like SCADA. To overcome drawbacks of SCADA, a new technique is used with the help of multi-agent system. Multi-Agent systems (MAS) are composed of multiple intelligent agents that interact to solve problems that may be on the far side capabilities of a single agent or system. With an increase in usage and modeling of distributed energy resources for micro grid applications, MAS are well suited to manage the size and complexity of these energy systems. The recent trend of renewable energy development is a combination of distributed power sources and energy storage subsystems to form a small micro grid that can restrict loss of energy from power transmission lines over long distances. To use renewable energy more with efficiency, dc power should be directly supplied to this loads.In order to have an efficient power system operation and control, various control centers have to be operated in the top to bottom level.

II.VERBAL DESCRIPTION OF ENERGY CONTROL CENTER AND MULTI-AGENT SYSTEM

A multi-agent system is one more effective than SCADA system is used to manage the grid/load. The structure of multi-agent system is shown in block diagram in Fig. 1.The server has a wireless connection with the customer as shown in Fig.1.Interaction between them enables a DER agent (from the customer side) to manage the power that is to be distributed to the necessary loads. DER agent, solar and wind power generator are connected to ECC through the Internet protocol. That data is stored in DB agent in ECC. Here system controlled by ANFIS present in ECC, based on the data from the DER.
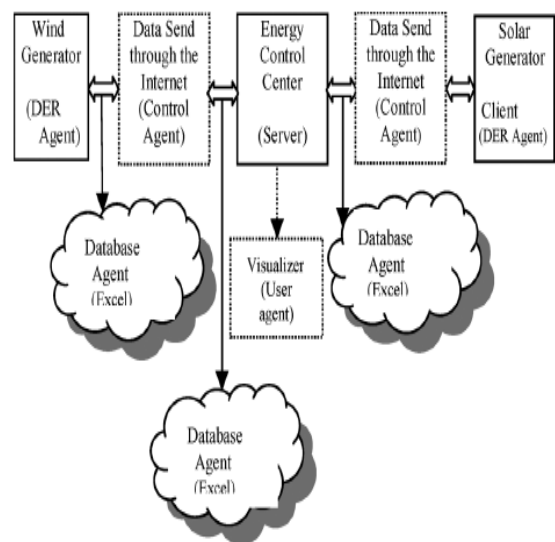

Fig-1. Block diagram of ECC.

Operations of multi-agent system shown in Fig. 2.It consist of User agent, control agent and DER agent communicate with the database agent. This database is sent to the server through a Remote Terminal Unit (RTU) like a conventional SCADA system. RTUs are special purpose computers which contain analog to digital converters (ADC) and digital to analog converters (DAC). In this converter digital inputs are used to get the status and outputs are used to control. The visualizer receives copies of all messages exchanged within the multi-agent system.
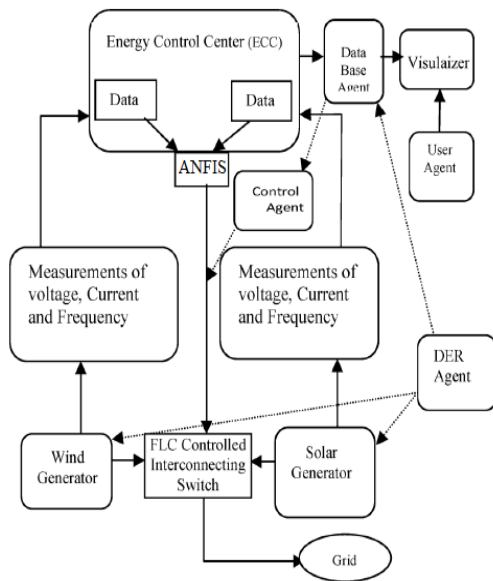

Fig-2. Multi-agent System Operation

Multi-agent system used for monitoring the voltage, load management, energy management, automated meter reading and substation control.

III. BLOCK DIAGRAM OF THE SIMULATION MODEL

Wind power generation composed of a wind mill, induction generator connected to the grid through circuit breaker and the load. Solar power generation consists of solar panel, inverter, transformer connected to the load and circuit breaker. The interconnection of wind power, solar power and grid forms the power system smart grid with DER. Voltages of wind power generator and solar power generator is sent to ECC through the Internet. The Artificial Neuro Fuzzy Interface (ANFIS) present in ECC activates the circuit breaker according to the voltage requirement. The addition/removal of solar panels to the grid is controlled by ANFIS. If solar panel is removed from the grid, it will be connected to charge the battery. Since ANFIS is used for the control, it can be extended to control circuit breaker (CB-1) and circuit breaker (CB-2), as given in

Fig. 3, depending upon the availability of DERs. The block diagram of the multi-agent system simulation model is given in Fig. 3.
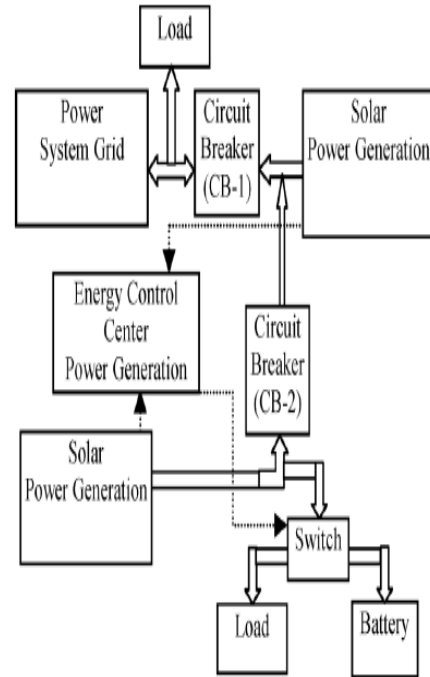

Fig-3. Block diagram of power system interconnected with wind and solar power generation scheme.

Multi-agent system analysis can be done in two computers computer-1 for wind generator, computer-2 for solar generator shown below in fig.4.
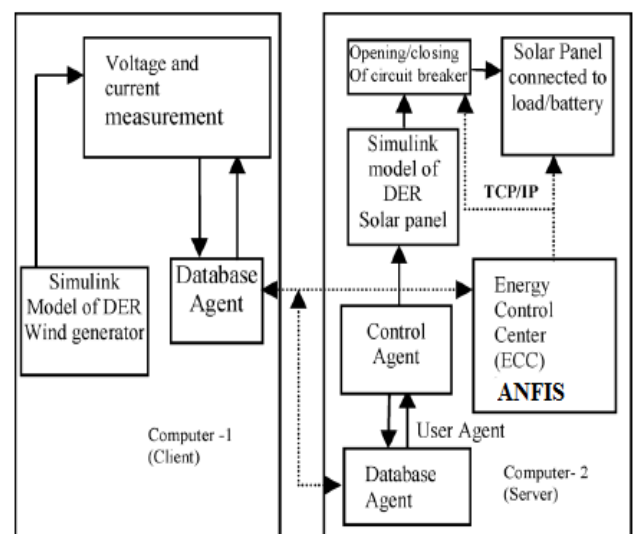

Fig-4: Representation of multi-agent system.

IV. ANFIS ARCHITECTURE:

In general, ANFIS is various layer feed forward network with constant output in which each node performs a particular function (node function) on incoming signals. For easiness, we consider two inputs 'x' and 'y' and one output 'z '. Suppose that the rule base check two fuzzy if-then rules of Takagi and Sugeno type

Rule 1: IF x is A1 and y is B1 THEN f1=P1x+Q1y+R1
Rule 2: IF x is A2 and y is B2 THEN f2=P2x+Q2y+R2

The ANFIS architecture is a five layer feed forward network is given as

Layer 1: Every node in this layer is a square node with a node function (the membership value of the premise part)
Oi=μAi(X)
Where, x is the input to the node i, and Ai is the linguistic label associated with this node function.

Layer 2: Every node in this layer is a circle node labeled which multiplies the incoming signals. Each node output represents the firing strength of a rule.
Oi2=μAi(X) μBi(Y)   where i = 1:2

Layer 3: In this layer every node is a circle node labeled N (normalization). The ith node calculates the ratio of the ith rule's firing strength to the sum of all firing strengths.
Oi3=W= $w1/(w1 + w2)$,where i = 1:2

Layer 4: Every node in this layer is a square node with a node function
Oi4=W (PiX+QiY+Ri)

Layer 5: The single node in this layer is a circle node labeled that computes the overall output as the summation of all incoming signals
Oi5 = System output, where i = 1:2

V. SIMULATION MODEL OF THE MULTI-AGENT SYSTEM

The output of ANFIS is used to control the solar panel. Before simulation, the excel files are converted into database agent in MATLAB command window and loaded to the workspace. Based on the magnitude of voltage received in the inputs, the decision is taken by the ANFIS. The output of ANFIS is constant value (1, 2, 3, 4, and 5) and this is used to drive the multi port switch. Based on the output of ANFIS, the number of panels are added or removed in the model. The wind power generation, solar power generation and grid are connected through the circuit breakers (CB-1) and (CB-2) as shown in Fig.3.These breakers are activated based on the step pulse. In this work, these circuit breakers are controlled by ECC command. The ECC is enabled to monitor the solar voltage and wind voltage magnitude for regular intervals of time to make the decision on number of solar panels connected to the load/grid or battery based on ANFIS output. During simulation of model shown in Fig. 5, the voltage induced in solar panel and wind generators are stored in .mat file and it is converted into excel format using MATLAB commands. The Fig.6. Indicates the simulation of ECC with ANFIS, if it is created in computer 3.

A. Solar Power Generation

In a solar module 36 cells are connected in series the voltage induced in 36 cells is 21.6V. To generate 230 V ac supply with 50 Hz, approximately 11 modules are connected. To convert DC to AC, inverter is used and to increase the voltage, transformer is used. Solar power generation consists of solar panel, inverter, trans-former connected to the load and circuit breaker.

B. Wind Power Generation

In this self excited Induction generator connected in parallel with capacitor bank provides excitation to the generator. When it is connected with grid, it injects power depending upon the speed of the generator. The speed of the generator depends upon the wind speed. Wind power generation consists of a wind mill, induction generator connected to the grid through circuit breaker.
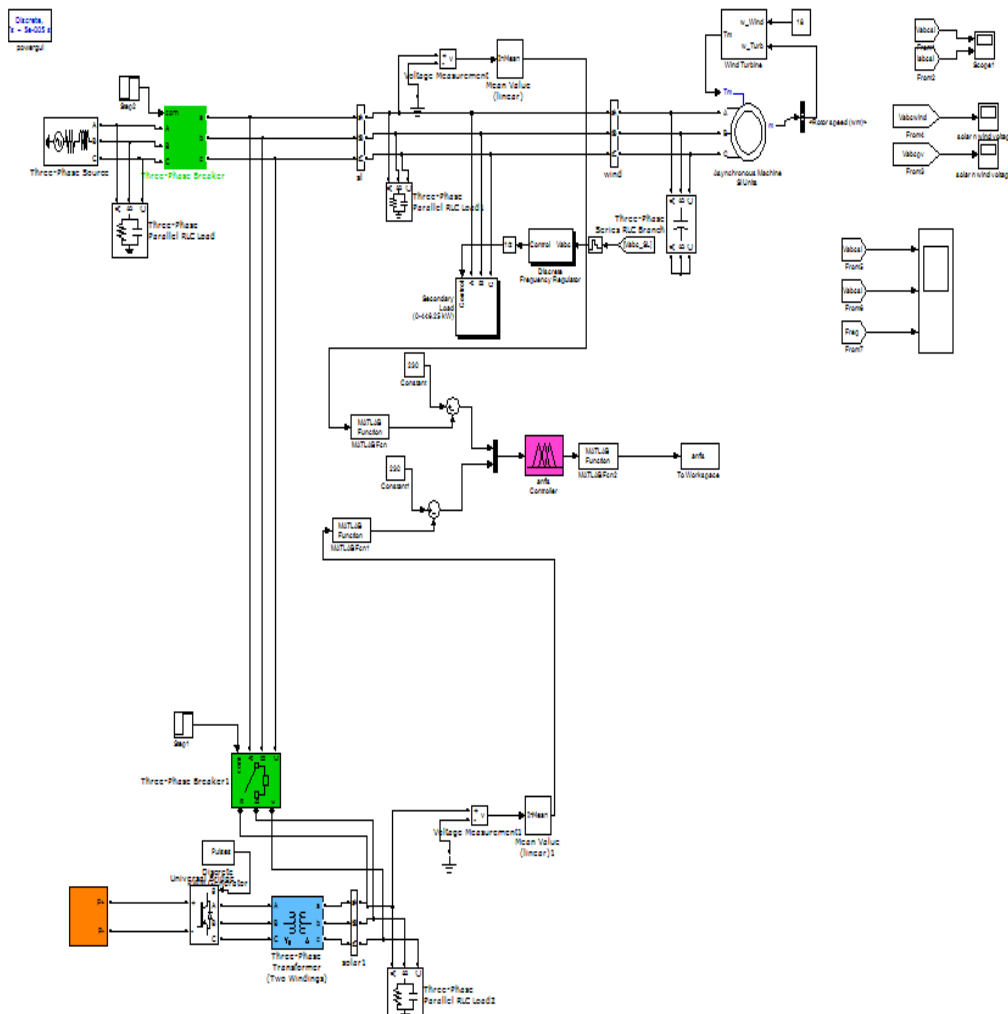
Fig-5. Simulation diagram of distributed wind and solar power generation using Multi-Agent System by ANFIS controller.

VI. RESULT ANALYSIS

Simulation results of solar and wind power generation are mentioned in Fig5. In this project, the irradiation is assumed as 1000 W/m and the voltage generated is 230 V (rms) or 325.2691 V (max). The wind velocity is assumed constant (12 m/s). After the simulation, the results are stored in workspace which is converted into excel sheet using MATLAB command window in the file names "solar" and "wind". To express this circuit breaker (CB-1) is closed after 0.1 s. solar power generator is connected to the grid through the circuit breaker (CB-2) after 0.3 s. The view of DB agent in excels sheets named as "solar" and "wind". This sheet is generated by the simulation model. This sheet is used as

input to fuzzy logic controller during simulation. For the same pretense model, the three phase voltage and three phases current is shown in Fig.6.
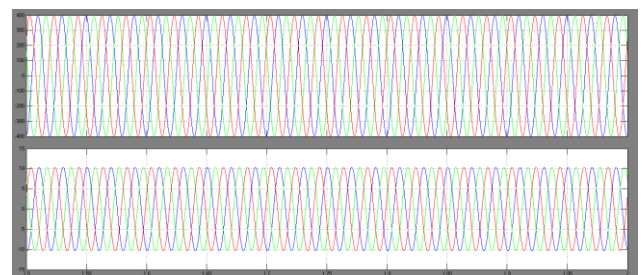
Controlled Voltage and Current:

Fig -6. Voltage and current waveform of wind and solar Power
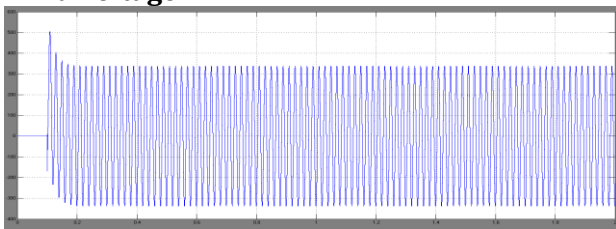
Wind voltage:

Fig-7. Voltage waveform of wind
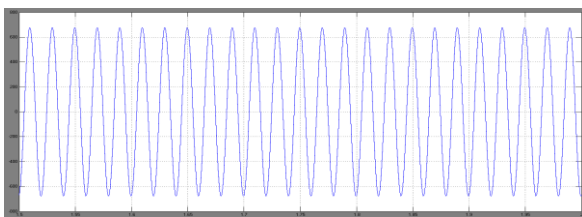
Solar Voltage:

Fig-8. Voltage waveform of solar

Controlled Solar and Wind Voltage and frequency:
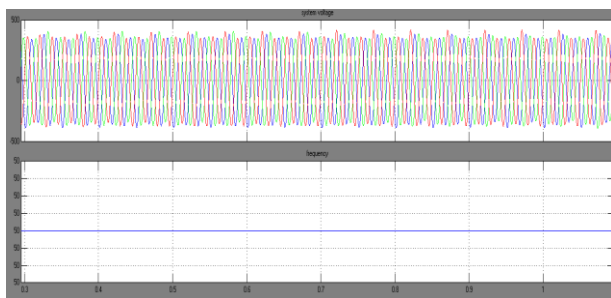

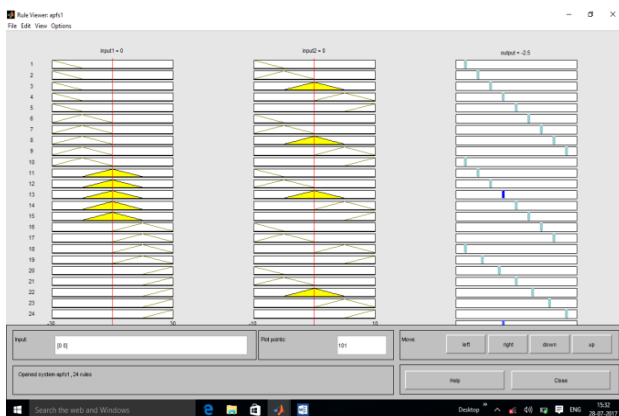Fig-9. System Voltage and frequency

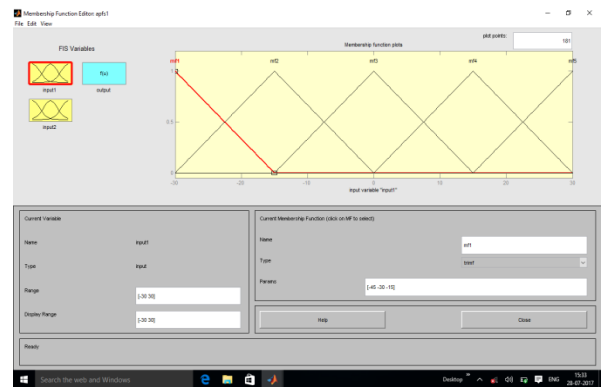
Fig-10.Rule View of Output Energy

Fig-11.Membership Function of Output Energy

Total Harmonic Distortion (THD):

In this project by using Artificial Neuro Fuzzy Interface System (ANFIS) the Total Harmonic Distortion (THD) will be reduced compare to the Fuzzy Logic Controller to about 36.13%.

COMPARISION BETWEEN FLC AND ANFIS:

S.NO	Controller	THD (%)
1	ANFIS	19.98
2	Fuzzy Logic Controller (FLC)	31.28

Table 2.THD comparison

CONCLUSION

By the simulation model of ECC, with ANFIS control can manage power of solar and wind generators by a switch provided in the solar panel to add/remove depending upon the voltage requirements. Above results shows that by using ANFIS frequency oscillations are reduced. By using FLC the THD value is more than ANFIS. The total reduced THD value by using ANFIS compares to FLC is 36.13%.By these results we proved controlling of DER agent can be achieved from the server and customer. In this scenario solar power is used as back up for wind power. By using this control technique we can reduce transmission, distribution losses, reduces THD, complexity and increases system efficiency.

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.BIOGRAPHIES

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