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Anfis Based Mppt Control Of A Stand - Alone Hybrid Power Generation System

T.Karthic, A.Rathinam
[1]Student, [2] Professor,
[1]Power System engineering,
[1]Paavai Engineering College, Namakkal, India

Abstract—**This research study presents the fuzzy space vector pulse width modulation (FSVPWM) method of current control for three-phase voltage source inverter. The hybrid fuzzy particle swarm optimization-based maximum power point (MPP) tracking algorithm has been employed to obtain high tracking efficiency as well as optimal MPP under adverse operating states. The FSVPWM technique provides less current harmonic content, fixed switching pattern, protection from over current, low switching losses and able to handle the non-linearity's and uncertainties of the photovoltaic-wind grid integrated system. Grid synchronization with sinusoidal current injection is achieved using the inverter controller. Most studies on tuning of fuzzy inference are concerned with numerical inputs and outputs only, and very few research has been done on tuning of fuzzy inference with fuzzy inputs and outputs. Moreover, in many cases the object of tuning are fuzzy predicates only, apart from the other factors intervening in fuzzy inference. In this paper we propose a method to tune the fuzzy inference when inputs and outputs are given as fuzzy sets. This method is similar to back propagation and tunes the parameters of aggregation operators, implication functions and combination functions as well as the fuzzy predicates which appear in the nodes of the network representing the calculation process of thc fuzzy inference Fuzzy logic controller-based SVPWM controller compensates current error and provides DC-link utilization with high efficiency. The experimental responses have been validated using MATLAB/Simulink interfaced real-time SPACE DS 1104 controller. Irrespective of solar irradiance and wind velocity, the proposed hybrid system obeys MPP accurately with high performance.**

I. Introduction (Heading 1)

A hybrid system is a dynamical system that exhibits both continuous and discrete dynamic behavior – a system that can both flow (described by a differential equation) and jump(described by a state machine or automaton). Often, the term "hybrid dynamical system" is used, to distinguish over hybrid systems such as those that combine neural nets and fuzzy logic, or electrical and mechanical drivelines. A hybrid system has the benefit of encompassing a larger class of systems within its structure, allowing for more flexibility in modeling dynamic phenomena.

In general, the state of a hybrid system is defined by the values of the continuous variables and a discrete mode. The state changes either continuously, according to a flow condition, or discretely according to a control graph. Continuous flow is permitted as long as so-called invariants hold, while discrete transitions can occur as soon as given jump conditions are satisfied.

II. SOLAR

III. WIND

2.HYBIRD SYSTEM

2.1 SOLAR

In this project Solar cells, also called photovoltaic (PV) cells by scientists, convert sunlight directly into electricity. PV gets its name from the process of converting light (photons) to electricity (voltage), which is called the *PV effect*. The PV effect was discovered in 1954, when scientists at Bell Telephone discovered that silicon (an element found in sand) created an electric charge when exposed to sunlight.

Traditional solar cells are made from silicon, are usually flat-plate, and generally are the most efficient. Second-generation solar cells are called thin-film solar cells because they are made from amorphous silicon or non silicon materials such as cadmium telluride. Thin film solar cells use layers of semiconductor materials only a few micro meters thick. Because of their flexibility, thin film solar cells can double as rooftop shingles and tiles, building facades, or the glazing for skylights.

Third-generation solar cells are being made from a variety of new materials besides silicon, including solar inks using conventional printing press technologies, solar dyes, and conductive plastics. Some new solar cells use plastic lenses or mirrors to concentrate sunlight onto a very small piece of high efficiency PV material. The PV material is more expensive, but because so little is needed, these systems are becoming cost effective for use by utilities and industry

Solar photovoltaic modules are where the electricity gets generated, but are only one of the many parts in a complete photovoltaic (PV) system. In order for the generated electricity to be useful in a home or business, a number of other technologies must be in place.

2.2.1MOUNTING STRUCTURES

PV arrays must be mounted on a stable, durable structure that can support the array and withstand wind, rain, hail, and corrosion over decades. These structures tilt the PV array at a fixed angle determined by the local latitude, orientation of the structure, and electrical load requirements. To obtain the highest annual energy output, modules in the northern hemisphere are pointed due

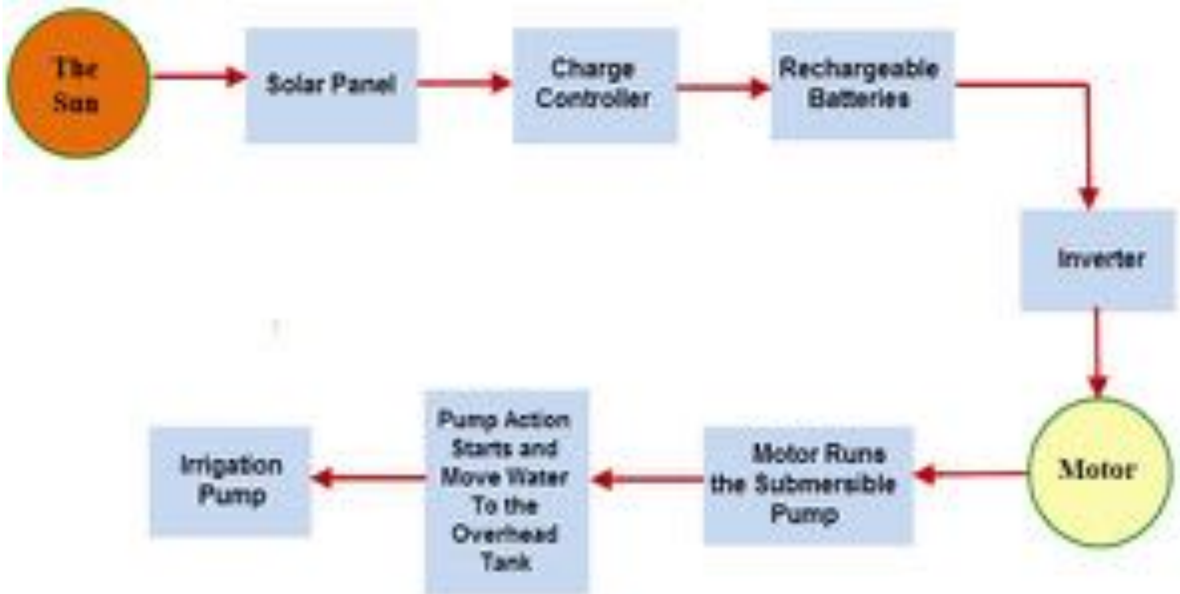
south and inclined at an angle equal to the local latitude. Rack mounting is currently the most common method because it is robust, versatile, and easy to construct and install. More sophisticated and less expensive methods continue to be developed.
For PV arrays mounted on the ground, tracking mechanisms automatically move panels to follow the sun across the sky, which provides more energy and higher returns on investment. One-axis trackers are typically designed to track the sun from east to west. Two-axis trackers allow for modules to remain pointed directly at the sun throughout the day. Naturally, tracking involves more up-front costs and sophisticated systems are more expensive and require more maintenance. As systems have improved, the cost-benefit analysis increasingly favors tracking for ground-mounted systems.

2.2.2 INVERTERS

Inverters are used to convert the direct current (DC) electricity generated by solar photovoltaic modules into alternating current (AC) electricity, which is used for local transmission of electricity, as well as most appliances in our homes. PV systems either have one inverter that converts the electricity generated by all of the modules, or microinverters that are attached to each individual module. A single inverter is generally less expensive and can be more easily cooled and serviced when needed. The microinverter allows for independent operation of each panel, which is useful if some modules might be shaded, for example. It is expected that inverters will need to be replaced at least once in the 25-year lifetime of a PV array.
Advanced inverters, or "smart inverters," allow for two-way communication between the inverter and the electrical utility. This can help balance supply and demand either automatically or via remote communication with utility operators. Allowing utilities to have this insight into (and possible control of) supply and demand allows them to reduce costs, ensure grid stability, and reduce the likelihood of power outages.

2.2.3 STORAGE

Batteries allow for the storage of solar photovoltaic energy, so we can use it to power our homes at night or when weather elements keep sunlight from reaching PV panels. Not only can they be used in homes, but batteries are playing an increasingly important role for utilities. As customers feed solar energy back into the grid, batteries can store it so it can be returned to customers at a later time. The increased use of batteries will help modernize and stabilize our country's electric grid.



2.1 BLOCK OF DIAGRAM SOLAR PANEL CRICUIT

2..1.3 Advantages of Solar Energy

1. Renewable Energy Source

Among all the benefits of solar panels, the most important thing is that solar energy is a truly renewable energy source. It can be harnessed in all areas of the world and is available every day. We cannot run out of solar energy, unlike some of the other sources of energy. Solar energy will be accessible as long as we have the sun, therefore sunlight will be available to us for at least 5 billion years when according to scientists the sun is going to die.

2. Reduces Electricity Bills

Since you will be meeting some of your energy needs with the electricity your solar system has generated, your energy bills will drop. How much you save on your bill will be dependent on the size of the solar system and your electricity or heat usage. Moreover, not only will you be saving on the electricity bill, but if you generate more electricity than you use, the surplus will be exported back to the grid and you will receive bonus payments for that amount (considering that your solar panel system is connected to the grid). Savings can further grow if you sell excess electricity at high rates during the day and then buy electricity from the grid during the evening when the rates are lower.

3. Diverse Applications

Solar energy can be used for diverse purposes. You can generate electricity (photovoltaics) or heat (solar thermal). Solar energy can be used to produce electricity in areas without access to the energy grid, to distill water in regions with limited clean water supplies and to power satellites in space. Solar energy can also be integrated into the materials used for buildings. Not long ago Sharp introduced transparent solar energy windows.

4. Low Maintenance Costs

Solar energy systems generally don't require a lot of maintenance. You only need to keep them relatively clean, so cleaning them a couple of times per year will do the job. If in doubt, you can always rely on specialised cleaning companies, which offer this service from around **£25-£35**. Most reliable solar panel manufacturers offer **20-25 years** warranty. Also, as there are no moving parts, there is no wear and tear. The inverter is usually the only part that needs to changed after **5-10** years because it is continuously working to convert solar energy into electricity (solar PV) and heat (solar thermal). Apart from the inverter, the cables also need maintenance to ensure your solar power system runs at maximum efficiency. So, after covering the initial cost of the solar system, you can expect very little spending on maintenance and repair work.

5. Technology Development

Technology in the solar power industry is constantly advancing and improvements will intensify in the future. Innovations in quantum physics and nanotechnology can potentially increase the effectiveness of solar panels and double, or even triple, the electrical input of the solar power systems.

2.1.4 Disadvantages of Solar Energy

1. Cost

The initial cost of purchasing a solar system is fairly high. Although the UK government has introduced some schemes for encouraging the adoption of renewable energy sources, for example, the Feed-in Tariff, you still have to cover the upfront costs. This includes paying for solar panels, inverter, batteries, wiring, and for the installation. Nevertheless, solar technologies are constantly developing, so it is safe to assume that prices will go down in the future.

2. Weather Dependent

Although solar energy can still be collected during cloudy and rainy days, the efficiency of the solar system drops. Solar panels are dependent on sunlight to effectively gather solar energy. Therefore, a few cloudy, rainy days can have a noticeable effect on the energy system. You should also take into account that solar energy cannot be collected during the night. On the other hand, if you also require your water heating solution to work at night or during wintertime, thermodynamic panels are an alternative to consider.

3. Solar Energy Storage Is Expensive

Solar energy has to be used right away, or it can be stored in large batteries. These batteries, used in off-the-grid solar systems, can be charged during the day so that the energy is used at night. This is a good solution for using solar energy all day long but it is also quite expensive. In most cases, it is smarter to just use solar energy during the day and take energy from the grid during the night (you can only do this if your system is connected to the grid). Luckily your energy demand is usually higher during the day so you can meet most of it with solar energy.

4. Uses a Lot of Space

The more electricity you want to produce, the more solar panels you will need, as you want to collect as much sunlight as possible. Solar panels require a lot of space and some roofs are not big enough to fit the number of solar panels that you would like to have. An alternative is to install some of the panels in your yard but they need to have access to sunlight. If you don't have the space for all the panels that you wanted, you can opt for installing fewer to still satisfy some of your energy needs.

5. Associated with Pollution

Although pollution related to solar energy systems is far less compared to other sources of energy, solar energy can be associated with pollution. Transportation and installation of solar systems have been associated with the emission of greenhouse gases. There are also some toxic materials and hazardous products used during the manufacturing process of solar photovoltaics, which can indirectly affect the environment. Nevertheless, solar energy pollutes far less than other alternative energy sources.

2.2 WIND ENERGY

Wind is caused by the uneven heating of the atmosphere by the sun, variations in the earth's surface, and rotation of the earth. Mountains, bodies of water, and vegetation all influence wind flow patterns. Wind turbines convert the energy in wind to electricity by rotating propeller-like blades around a rotor. The rotor turns the drive shaft, which turns an electric generator. Three key factors affect the amount of energy a turbine can harness from the wind: wind speed, air density, and swept area

Regulator regulates the output voltage constant depends upon the regulator.

2.2.1 Equation for Wind Power

$$P = \frac{1}{2}\rho A V^3$$

- **Wind speed**

  The amount of energy in the wind varies with the cube of the wind speed, in other words, if the wind speed doubles, there is eight times more energy in the wind ($2^3 = 2x2x2 = 8$). Small changes in wind speed have a large impact on the amount of power available in the wind.

- **Density of the air**

  The more dense the air, the more energy received by the turbine. Air density varies with elevation and temperature. Air is less dense at higher elevations than at sea level, and warm air is less dense than cold air. *All else being equal*, turbines will produce more power at lower elevations and in locations with cooler average temperatures.

- **Swept area of the turbine**

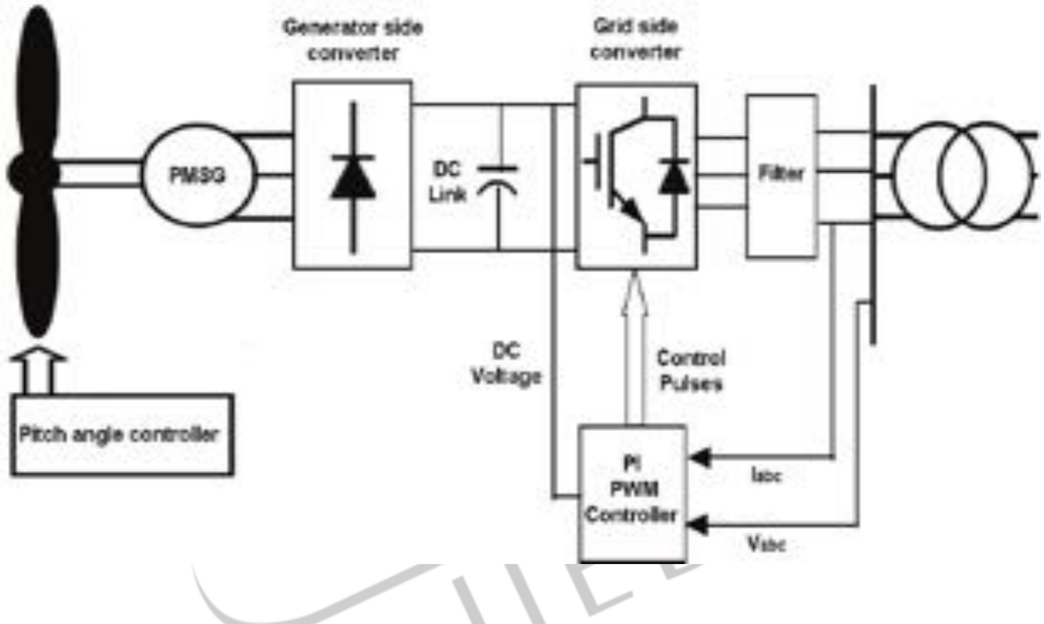
  The larger the swept area (the size of the area through which the rotor spins), the more power the turbine can capture from the wind. Since swept area is , where r = radius of the rotor, a small increase in blade length results in a larger increase in the power available to the turbine $A = pir^2$

2.2.2Worldwide Installed Capacity

Country	Total Capacity, end of 2014 (MW)[8]	Total Capacity, June 2010 (MW)[9]	Total Capacity, end of 2009 (MW)[10]
U.S.	65,900	36,300	35,159
China	114,600	33,800	25,853
Germany	40,000	26,400	25,813
Spain	23,000	19,500	18,748
India	22,500	12,100	10,827
France	9,300	5,000	4,775
U.K.	12,200	4,600	4,340
Portugal	4,953	3,800	3,474
Denmark	4,883	3,700	3,408

Wind power is the use of air flow through wind turbines to provide the mechanical power to turn electric generators. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land

2.3 BLOCK DIAGRAM OF WIND MILL



2.2.3.Advantages of Wind Energy

Wind energy has numerous benefits. It has helped to provide a source of clean and renewable electricity for countries all over the world. This section takes a look at the different advantages of wind energy.

- **Renewable & Sustainable**

Wind energy itself is both renewable and sustainable. The wind will never run out, unlike reserves of fossil fuels (such as coal, oil, and gas.) This makes it a good choice of energy for a sustainable power supply**.**

- **Environmentally Friendly**

Wind energy is one of the most environmentally friendly energy sources available today. This is based on the simple reason that wind turbines don't create pollution when generating electricity.

Most non-renewable energy sources need to be burnt. This process releases gases such as carbon dioxide (CO_2) and methane (CH_4) into the atmosphere. These gases are known to contribute to climate change. In contrast, wind turbines produce no greenhouse gases when generating electricity.

We should note that both noise and visual pollution are environmental disadvantages of wind turbines. However, these factors don't have a negative impact on the earth, water table or the quality of the air we breathe**.**

- ***Reduces Fossil Fuel Consumption***

Generating electricity from wind energy reduces the need to burn fossil fuel alternatives such as coal, oil, and gas. This can help to conserve dwindling supplies of the earth's natural resources. As a result, they will last longer and help to support future generations.

- ***Low Maintenance***

Wind turbines are fairly low in maintenance. A new wind turbine can last a long time prior to it requiring any maintenance. Although older turbines can come up against reliability issues, technological advancements are helping to improve overall reliability**.**

- ***Low Running Costs***

As wind energy is free, running costs are often low. The only ongoing cost of wind energy is for the maintenance of wind turbines, but they are low maintenance in nature anyway.

2.2.4 Disadvantages of Wind Energy

- ***Wind Fluctuates***

Wind energy has a similar drawback to solar energy in that it is not constant. Although wind energy is sustainable and will never run out, the wind isn't always blowing. This can cause serious problems for wind farm developers. They will often spend a significant amount of time and money investigating whether a particular site is suitable for wind power.
For a wind turbine to be efficient, it needs to have an adequate supply of wind energy. For this reason, we often find wind turbines on top of hills or out at sea. In these locations, there are fewer land obstacles to reduce the force of the wind.

- **Installation Expensive**

Although costs are reducing over time, wind turbines are still expensive. First, an engineer must carry out a site survey. This may involve having to erect a sample turbine to measure wind speeds over a period of time. If deemed adequate, a wind turbine then needs to be manufactured, transported and erected on top of a pre-built foundation. All of these processes contribute to the overall cost of installing wind turbines.
When we take the above into account for offshore wind farms, the costs become much greater. Installing structures out at sea is far more complex than on land. Some companies have even commissioned bespoke ships capable of transporting and installing wind turbines at sea.

Conclusion

In my project the conventional converters are replaced by proposed back to back connected diode clamped converters for alternating current application such as variable speed industrial electric drives, electric vehicles, reactive power compensation in large distribution and transmission systems interfacing of renewable energy sources with the utility.So,as to gives better performance like unity input power factor, negligible input current THD, reduced rippled regulated dc load voltage at a lower switching frequency and reduced voltage stress of the power semiconducting devices. The operation of the back to back connected diode clamped five level converter is developed and output is verified by using hardware implementation and also MATLAB/SIMUINK model.

The proposed topology is verified through the result obtained. The proposed topology is very suitable for ac motor drive and utility application. In this proposed work maintained power quality improvement like total harmonic distortion (THD) and power factor and balanced the neutral point potential voltage due to back to back connected diode clamped five level converters. Also, it gives fault tolerance capability. THD value is decreased from 35.78% to 10.68% and thus efficiency is increased.

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