International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 03, 2021

Design and Implementation of Integration of Potovoltaic Systems with Existing Power Grids

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Abstract: Over the past two decades, political and scientific leaders from all over the world have worked hard to meet the growing demand for energy while also improving energy security and reducing greenhouse gas emissions (GHG). Because of what they are doing, it will soon be necessary to add large-scale RER to the electricity networks that are already in place. Due to their intermittent nature, the most common renewable energy sources, like solar photovoltaic (PV) and wind systems, can be hard to integrate in a way that is both technically and operationally sound. This makes the network less reliable and stable. This page gives a summary of the known problems with adding solar photovoltaic systems to the grid and talks about some possible solutions. Integration of solar PV plants into the grid is discussed, as well as a number of technical issues, such as non-dispatchability, power quality, angular and voltage stability, reactive power support, and fault ride-through capabilities. It also talks about important issues in the fields of economics, ecology, and the electrical industry. Lastly, it talks about ways to fix the problems that were already pointed out, such as grid codes, better control methods, energy storage devices, and policies that encourage the use of renewable energy sources. Academics and researchers who study power systems can use the article's findings as a starting point for their own research. It also helps decision-makers choose the best ways to deal with the problems that are likely to come up when PV systems are added to the grid.

Keywords: solar power, electrical grids, and PV systems.

1. INTRODUCTION

Integration Studies of Solar Energy and Infrastructure for Electricity Because renewable energy systems have so many benefits, this part of the energy industry is a top choice for grid investments. One of the benefits of renewable energy is that it helps keep the environment clean, which is a big part of the fight against environmental damage. It's important to keep these resources safe for future generations because supplies of things that don't grow back are limited. So, it can be kept up with a relatively small amount of money. Depending on the source and location, these plants can make small amounts of energy or a lot of energy, and they can usually be built quickly.
The need to find new ways to turn energy from renewable sources into something else comes from the things that have already been talked about. In the near future, it's possible that solar energy will take the place of other ways to make energy. The most important benefit of

renewable energy sources is that they can be used forever without hurting the environment. Fossil fuels, which have always been thought of as the main source of energy, are becoming less and less available around the world.Not only the unavailability of the fossil fuels is the reason behind switching to
But renewable sources of energy have been linked to more pollution in the air. When these fossil fuels are burned, they give off chemicals that are bad for people and the environment. Because of this, every country must work to improve methods and tools for making energy that is clean and good for the environment. Renewable energy, which is important for saving lives, is now acceptable because the current environmental crisis has forced us to move toward green energy. When these sources of energy are used to make a lot of power, there are a number of problems, such as inefficiency and storage issues (due to the lack of availability of energy storage devices with a sizable capacity). The most difficult problem to solve when connecting to the ON grid is that the input source is always changing. This is especially true for solar energy, because the sun's light changes all the time. Problems with synchronisation between the ON grid and the power plant's output can explain why it doesn't work as well as it could.
If something isn't very efficient, it takes a long time for it to pay off. Because operating costs will go up if energy-saving measures are put in place, it is possible that the plant will no longer be able to be run.
Recent research has shown that India will need more electricity in the coming years because of its large population growth. This discovery comes from India, which has a large number of people. Studies have shown that by 2025, Indians will have used 2.25 times as much electricity as they do now. Based on this, it's safe to say that the demand requirement is almost exactly twice as high as the current requirement). Renewable energy sources are very important in today's world because they give people the energy they need to live. Fossil fuels are being used less and less as these other types of energy take their place.
We can use these energies to make clean energy that is reliable and will last for a long time. They are also good for the whole planet and can be used forever without running out of resources. In Hong Kong, the qualities of solar energy that make it good for widespread use were found. Facilities that use photovoltaic (PV) and water heating using sun energy (WHUSE) are common and could be useful ways to convert solar (sun) energy. Everyone knows that compared to other countries, India's fossil fuel reserves are quickly running out. So, it's important to focus on growing options like solar power that use different kinds of energy. This is even more true for countries.

Related work

Y. Bao et al [1] Virtual power plants (VPPs) combine parts of the distribution network and study how photovoltaic, energy storage, electric vehicles, and other resources work in the VPP and the distribution network as a whole. The end goal of the process is to make better use of the resources already in the distribution network. In this work, we present a distributed resource control method for VPPs and distribution networks, as well as an optimization model for choosing VPP members that takes into account both their economic value and the security of the network as a whole. The enhanced IEEE33 node system is used as a case study to show that the proposed strategy works.

G. Missrani, et al [2] ETAP was used to model the investigation, and simulations focused on the 150 kV buses at the Kuta, Sengkol, and Paokmotong substations. When four PV modules of different capacities were connected and a bus voltage of 150 kV was used, the measured short circuit currents went up a little bit from 2.806 kA. The results show that the amount of solar PV plants has almost no effect on how often and how bad short circuits happen.

Z. Yang et al[3] The "life cycle cost" (LCC) theory is used, and a planning scheme is laid out for when the amount of power that can be used from photovoltaics is more than what the distribution network can handle. This model tries to minimise total life-cycle costs by analysing and evaluating the economics of the distribution network construction planning scheme when high permeability distributed photovoltaic power generation is connected. This is done to improve the way solar power is distributed even more. An example is given to show how the proposed method works and how realistic it is. Distributed solar systems with high permeability that are part of distribution networks can use this example as a reliable guide for operating and planning.

S. M. Said et al [4] By using the suggested method, the energy efficiency of the electric system can be improved. The way reactive power is shared between interface inverters needs to be changed to account for the power losses that are expected. The proposed method also reduces the amount of heat stress on smart inverters, which makes them more reliable. This is done by making use of smart inverters' ability to share reactive power to make up for expected power losses. As a case study to test the new reactive power dispatch strategy, we chose hybrid photovoltaic (PV) generation with superconducting magnetic energy storage (SMES) systems.

S. Yazdani et al [5] The parallel operation of a photovoltaic (PV)-based GF inverter with a modified virtual synchronous machine control and a battery-supported inverter with an improved droop control is studied. A photovoltaic synchronous generator and a nonlinear feedback linearization current-limiting control with voltage ride-through are part of the control scheme. Even when the grid is out of balance, they let the grid-following PV inverter and the grid-following battery inverter send active and reactive power to the load.

G. Hua et al[6] In this article, we talked about the quick frequency response performance needs of new energy power stations and gave an example of a quick frequency response strategy for wind farms and solar power stations that are already up and running or are in the planning stages. After it was built, a solar power plant was used as a test site for a new energy power plant's integrated control system. It is now possible for new energy power plants to actively support the frequency and voltage of the power grid because the AGC/AVC and rapid frequency response functions have been integrated.

2. PROPOSED METHODOLOGY

If a PV system that is connected to the grid doesn't have an MPPT controller, it can cause a number of serious problems. The problems, such as wasted energy, that mean more money needs to be spent on buying more solar panels to make the same amount of power. If you don't have an MPPT controller [7], you're wasting electricity, so you need to add more PV panels to make up for it. In an off-grid photovoltaic (PV) system, the same problem makes the battery and other parts break down much sooner than they should. For both on-grid and off-grid use, it is important to install an MPPT controller. In the last chapter, we talked about the many ways to improve the performance of a PV system that is connected to the grid. The effects of each strategy talked about in the last chapter were also talked about. found that while every strategy has pros and cons, different situations call for different approaches, and vice versa. The simulation results are used to analyse and improve the overall techniques in terms of how well they track maximum power, how well the devices in the system work, how much power is lost at different stages, the THD level, how stable the system is, and so on. This can be done with THD, stability, and other metrics. In this chapter, we present a new hybrid algorithm that combines two classic ones and can switch between them automatically, one for each step size

There are a number of new algorithms for techniques that can be used instead of or in addition to the standard algorithms. "Model reference automatic control," which is what MRAC stands for, is one of these. The main benefit of this method [8] is that it creates transfer functions with stable responses. As soon as the instant duty cycle is added to the system, the output voltages will start to drop in oscillations at the designated transient periods, eventually reaching the nominal voltage level of the maximum power point condition.

On the other hand, it can only work in steady state mode for systems with very high damping, which limits how often it can be used. This makes it less useful. If the system is affected by damping, then this method cannot be used to reach steady state.

The standard MPPT algorithm approach is used, but soft computing methods are also used to improve performance. In the real world, fuzzy MPPT, particle swarm optimization, and an MPPT based on a genetic algorithm have all been used. As a bonus, these soft computing techniques work well with systems that don't follow a straight line.

For the fuzzy MPPT [9] algorithms to give accurate results, they need a precise model. You can't just tell it the right things and expect it to work. Even with these improvements, the system is harder to run because there are more ways to control it.

The idea of "survival of the fittest" is at the heart of the genetic algorithm. This makes the system's ability to learn or the quality of the information it gets better. This method, like the ones that came before it, requires complicated coding and makes both the hardware and the cost of computing more complicated.

The particle swarm optimization (PSO) method [10] can work with systems that don't follow a straight line. For this kind, you need computers with a lot of power and fast processors. Soft computational techniques, which we talked about above, allow tracking to be more responsive and accurate.

But each of these types needs, among other things, a powerful computer, advanced hardware, and complicated software. As an alternative to the soft computing techniques of MPPT algorithms, you can get the best results by combining classical algorithms with smart switching behaviour. The results may be almost as accurate. There are two different ways to use the MPPT technique, and both are considered to be excellent ways to use the traditional approach. The perturb and observe method and the incremental conductance method are two examples of these. Most of the time, the step size of these more traditional algorithms is used to describe and implement them [11].

The step size is usually 0.5, and the algorithm keeps changing it based on how much sunlight hits the solar PV. This is done by adding or taking away the 'D' change or modification symbol.

In the hybrid-based algorithm approach, two or more algorithms run at the same time, and which ones run depends on how big the step is. Maximum Power Point Tracking (MPPT) is a standard way to make sure that you get the most out of your solar panels.
Each algorithm has its own advantages and disadvantages that come from how it works. In this chapter, we'll look at how to make a hybrid algorithm by combining two or more existing algorithms. By combining the best parts of each strategy, we can improve tracking and efficiency.
Using a hybrid method like this one will give you the most accurate results[12] and give you the best chance of measuring the maximum power accurately. This chapter uses the Incremental Conductance (INC) and Perturb and Observe (P&O) techniques. Both of these methods are examples of basic algorithms that have been used for a long time. To combine the two technologies into a single hybrid system, a smart switching algorithm based on the size of the solar radiation step is used.
This chapter is made up of these parts. a brief summary of the Perturb and Observe method, how it works, and the results of simulations are given. The incremental conductance[13] approach and simulation results are talked about in the paper. In the next section, we'll look at the hybrid technology, its benefits, and how they compare to the simulation results.

Due to how difficult the required method is, the PV system strongly suggests that the switching you want to happen happen within the P&O method[14] and the IC method (method). This makes it easier to keep an eye on the maximum amount of power while still letting a high level of efficiency be kept. By improving the tracking of the maximum power point, the level of ripple at the output can be lowered. The changes that were made to the ripple content definitely made the electricity better.

The pulse width of the (dc-dc) converter can be changed more easily with the help of the MPPT's output signal. The pulse signal is sent to the DC-DC converter's ZETA part, which uses it to make the switching happen[15]. As far as we know, a dc-dc converter takes in direct current that is not continuous and turns it into a different kind of direct current that is. The output of the dc-dc converter is hooked up to the inverter circuit.

So, it's important that the dc-dc converter's output stays the same. For the dc-dc converter's output to work with the inverter circuit, it needs to have a steady and steady output, or a fixed output. A constant output is another name for this. The last step in the inverter process is to connect the inverting circuit directly to the commercial grid. Within the framework of the classical method, there are different ways to use algorithms. Throughout this investigation, the "perturb and observe strategy" and the "Incremental conductance method" have been seen as important methods. So, to get the benefits of both methods, the two traditional methods were put together to create the hybrid algorithm technology. Because of this, it is important to have a good understanding of how each technique works[16]. Techniques of disturbance and observation

First, we will look at the P&O method of the MPPT algorithm. The P&O algorithm is a one-of-a-kind method that is rarely used because it doesn't depend on changing conditions or the elements. The duty cycle is the most important part of this method. At first, it was thought that the duty time period of cycle value was 0.5, but after the perturb action, this thought started to change. After the perturb action has been run, this procedure keeps going so that the results can be checked at every level of time and space. At each time step, the ratio of output

power to peak power is calculated. From this, the disturbance's path is figured out. Once the system gets used to the new conditions, the duty cycle time length or width must be changed.
If the steps are followed and, for the sake of argument, the amount of power goes up by a certain amount, the action of perturbation will keep the amount going in the same direction as before. But if the power starts to go down, the so-called perturbation action will switch to the other (opposite) direction[17]. This was used as a standard when the algorithm was being made.
Since this is the case, the algorithm is made by following the steps above
This process is done as many times as needed for it to work as well as it can. There are some problems with this approach. Because of fixed disturbances, this strategy doesn't always give the same result. One of the many problems with this strategy is that the system's operating point tends to move around the area around the maximum power point. This method loses some of its usefulness for monitoring peak power levels in some situations because it can't adapt to different step sizes.

The absolute maximum amount of power that can be used is set, but it can be changed as needed. In the perturb and observe (P&O) method, the algorithm for how the MPPT works is based on the calculation of power and the change in power over time. The voltage and current of the PV module are used to figure out how much power it can produce. Depending on the level of output needed, the tracking point can be changed periodically (on a set schedule) by using increment or decrement operations. Here is a timeline that shows how the actions taken in response to the Perturb and Observe commands changed over time. By multiplying the instantaneous voltage (potential drop) and current of the PV, the instantaneous power is calculated or estimated, and actions are taken based on the result. The first step in this method is to multiply the instantaneous voltage and current of the PV. The same thing is done over and over until the maximum amount of power is reached. If the system is oscillating around its maximum power point, you can gain control by changing the step size of the perturbation. According to this P&O strategy[18], the sign of the most recent action caused by a power shift and the sign of the most recent action caused by a perturbation are the two most important factors in determining whether or not the next perturb action will happen. When we look at the algorithmic flowchart of the Perturb and Observe method of MPPT, we can see that the algorithm of the perturb and observe action keeps changing the operational point of the PV system. Because of this, the voltage will always change at the maximum power point, even if the solar system's temperature and brightness stay the same.

When the voltage changes, the way the current flows changes, and so does the amount of power that comes out. Before the perturbation procedure was done and after it was done, these parameters moved between two different ranges. The size of the steps is another important thing that affects whether or not there is noise and oscillation. When the size of each step changes, the other parts of the circuitry are told to start switching. Once the switching process has begun, the power output of the PV array will change. This change in the power of the PV array also affects other parts of the system and should be taken into account when designing and putting the system together.

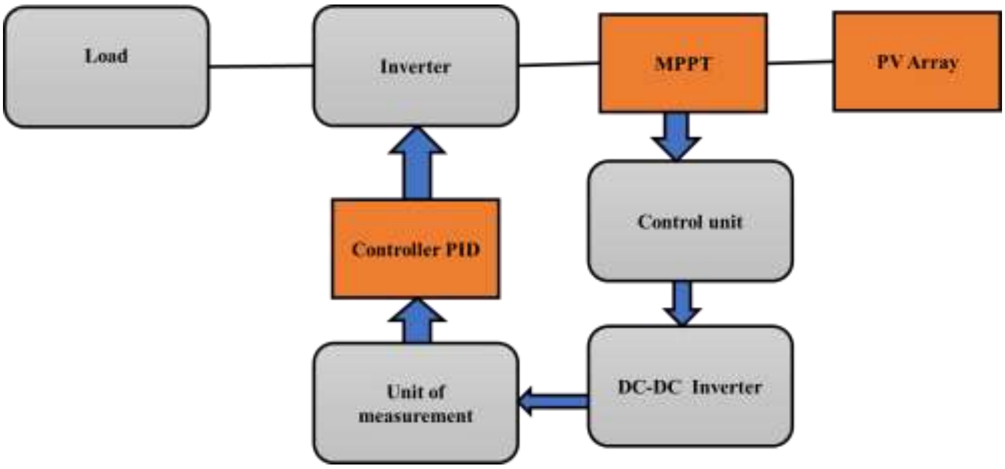

Figure 1: A flowchart that shows the Block Diagram of the P&O Algorithm

This is a block diagram showing how the P and O algorithm works in real life.
With the help of PV panels, the perturb and observe algorithm's MPPTT (Maximum level of Power Tracking or sucking technique) lets you track the maximum amount of power. At this point in the dc-dc conversion process, a measuring device is used to check the MPPT output. The (dc-dc) converter makes sure that the output stays the same. A dc-dc converter takes alternating current (AC) power and turns it into a steady stream of direct current (DC). This gets rid of the source of the fluctuations. Many different topologies can be used to get the (dc-dc) converter to line up in different ways.
So, any topology that seems best for the PV application can be chosen. Before the MPPT output is turned into AC power, the dc-dc converter topology is used to stabilise it. A dc-dc converter sends the signal it makes into the circuit of an inverter. After that, the output of the inverter is hooked up to the public power grid. Because of this, the energy that is made can be used to meet the expected demand. The energy won't be sent to the grid until it's been used to meet the needs of the household or someone else who can use it. It's important for everyone that this is done.

3. RESULTS ANALYSIS

The study shows the results of simulations done with the suggested comprehensive simulation model and the best way to use a mix of skillful approaches in many phases of the PV-based power plant. The GRID-integrable photovoltaic panel has a ZETA dc-dc converter, a Thirteen Level inverter with a current-regulated hysteresis control technique, and a phase-locked loop. The five main parts of the system are shown by the five main subsystems in the MATLAB simulation. The core subsystem of the 8-kilowatt solar array is a set of Zeta dc-dc converters, and the maximum power point tracking (MPPT) circuitry uses soft switching. The second part of the system is an inverter that has 13 stages and a clamped neutral point. This subsystem is part of the multi-level inverter.
The third and final part of the system is the LOAD configuration. It uses two separate loads of 13 KW and 24 KW to show how stable the system is under different loads. The GRID's energy supply is the fourth part of its system.

The phase lock loop (PLL) is used to find out the phase and magnitude of the GRID, so that the PV system can work in sync with it. The fifth subsystem, the control technique, tunes the

Vdc and syncs it with the GRID using a proportional integral derivative (PID) and a hysteresis current regulated method. To do this, the inverter needs to get enough gating pulses. A three-phase power supply is used to build the Grid system in MATLAB Simulink. People often think that the Grid can provide an endless supply of power. The Phase Locked Loop (PLL) is used to get information about the Grid's three-phase current. The control method uses the sin and cosine angles from the Grid to better match the inverter's Iabc&Vabc with the Grid's Iabc&Vabc.
In the simulation, there are two loads, and each of them has a different capacity.
From 0 milliseconds to 330 milliseconds, a 24-kilowatt load is put on the system. Before turning on the 24 kilowatt load again, the system gives you 0.3 to 0.5 seconds to use the 13 kilowatt secondary load. the inverter has always given the system exactly 8 KW over the course of the simulation. the rest of the electricity comes from the grid. the power curve from zero seconds to three and a half seconds, when the grid is giving the last 16 kW. In addition, the remaining 5 kW of power is sent to the load for an extra 0.3–0.5 seconds. The mechanism is listed so that you can see it in

Table 1: Grid electricity plus a photovoltaic inverter that can adapt to different loads

Time (Sec)	Grid Power (KW)	Inverter power (KW)
0-0.4	15	7
0.4-0.6	6	7
0.6-0.7	15	7

4. CONCLUSION

In this chapter, simulations are used to find the most practical way to combine the different ways to build the PV power system. These ways had already been explained in earlier chapters. Each technique is added to the whole so that the goals can be met and the most is made of the resources that are available. Total harmonic distortion (THD) levels of 4.96% on the current side of the inverter and 1.24% on the voltage side of the inverter were reached, showing that the alternating current that was made was stable. The system was set up so that energy from renewable sources would be used first. If that wasn't enough, the system would use energy from the grid. To figure out the system's dynamic stability, the load needs to be changed in real time and the necessary load needs to be increased while keeping the PV system in sync with the grid.

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