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Review on Inverter Controller in saps system for grid connected load

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Abstract

This paper proposes a unique standalone hybrid power generation system, applying advanced power control techniques(APC), fed by four power sources: wind power, solar power, storage battery, and fuel cell, and which is not connected to a commercial power system One of the primary needs for socio-economic development in any nation in the world is the provision of reliable electricity supply systems. This work is a development of an indigenous technology hybrid Solar –Wind and fuel cell Power system that harnesses the renewable energies in Solar- Wind and fuel cell to generate electricity. Here, electric DC energies produced from photovoltaic and wind turbine systems are transported to a DC disconnect energy Mix controller. The controller is bidirectional connected to a DC-AC float charging-inverter system that provides charging current to a heavy duty storage bank of Battery and at the same time produces inverted AC power to AC loads. This paper focuses on the modeling and simulation of solar – photovoltaic, wind, fuel cell and battery hybrid energy systems using MATLAB/simulink.

Keywords – SAPS , PLL , controller , multilevel inverter

Introduction

Hybrid renewable energy system combines two or more energy sources, usually solar and wind power. The main advantage of hybrid system is the enhancement of reliability of the hybrid generation system used. Also, the battery size can be reduced as the Solar and Wind energy sources are complementary in nature .The surge for suitable alternative energy sources is growing more intense than ever in order to reduce the heavy dependence on fossil fuels. Fuel cells are another rapidly developing generation technology. Fuel cells have high efficiency, low carbon emissions, high reliability due to the limited number of moving parts and longer life than batteries.

Solar panels generate the electricity from the sun, which is either used by the household at the time or stored in the battery to be used when it is dark or when demand exceeds what is being produced by the panels. The inverter converts the DC electricity from the solar panel and battery to AC which can be used by the household. In some cases when the battery has been completely discharged and the sun is not shining, the generator will start up to cover the household needs. The size of the system can be matched to the use of the household, so that most days of the year the battery and panels meet the electricity needs of the household, only on rare occasions would the generator be required.

SPS are a good solution in instances where the household is isolated and serviced by very long transmission and distribution electricity lines. Long lines in country areas are more exposed to wind, rain, vegetation and lightning,

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and are more likely to experience interference and customers to have a less reliable service. While the cost of an SPS is still quite high, in remote locations, they can be cheaper than moretraditional methods of supplying electricity.

Stand alone power supply system

Structure of Power SystemA well-defined framework of a hybrid system is vital, as various energy sources may have different operating characteristics. In an optimal framework, the renewable energy sources, energy storage, and loads are integrated and capable of operating autonomously as a unit . A robust system should also have a "plug-and-play" capability which renders the system capable of integrating any number of devices without system re-configuration [2].There are various ways to integrate different energy sources and storage to form a hybrid power system. Among them, dc-coupled, ac-coupled and hybrid-coupled are the most popular options [3]-[5], which outlined as below

Need for stand alone power system

If connecting to the grid is too expensive for you, a stand alone power system (SAPS) is a good alternative. SAPS generally use a combination of renewable generation sources (such as solar PV, wind turbine or micro-hydro), a battery bank, smart controller/inverter and a back-up

When to use SAPS

If you live in a remote area and are not already connected to the electricity grid - a stand alone power system could be a good way to get your electricity.

If there is no connection to the electricity network - micro-generation, control and storage technologies are often used together as stand alone power systems.

Connecting your rural property to the electricity network can be expensive - costing as much $25,000 per kilometre. So you don't have to be far from the nearest electricity lines for a stand alone power system to be a better alternative.

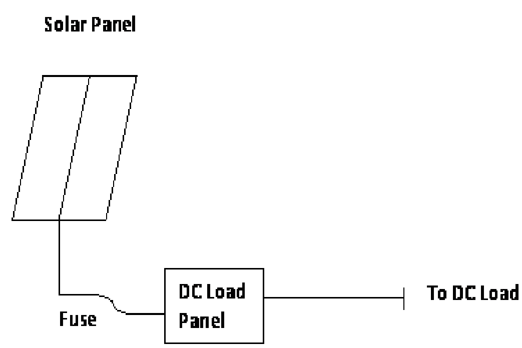
Electricity is typically generated by one of the following method

1 Photovoltaic system by using solar panel
2 Wind turbine
3 geothermal source
4 diesel or bio fuel generator

Here we are using PV system for generating electricity by using solar panels.

Working

The simplest type of stand-alone PV system is a **"Direct-coupled system"**, where the DC output of a PV module or array is directly connected to a DC load. Since there is no electrical energy storage (batteries) in direct-coupled systems, the load only operates during sunlight hours, making these designs suitable for common applications such as ventilation fans, water pumps, and small circulation pumps



Matching the impedance of the electrical load to the maximum power output of the PV array is a critical part of designing well-performing direct-coupled system. For certain loads such as positive-displacement water pumps; a type of electronic DC-DC converter, called a maximum power point tracker (MPPT) is used between the array and load to help better utilize the available array maximum power output.

DC loads can also be connected directly to the battery bank. A more common type of the standalone system is where the PV system with a battery bank powers the AC loads

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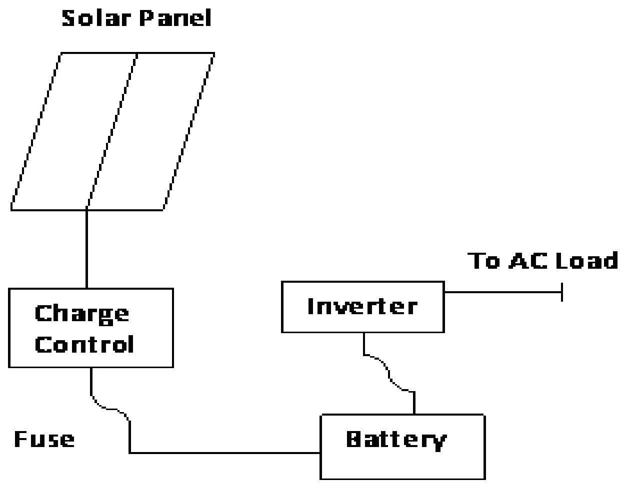

The **“Small stand-alone"** system is an excellent system for providing electricity economically. These systems are used primarily for RV power, lighting, cabins, backup and portable power systems. The size of the photovoltaic array (number of solar panels) and battery will depend upon individual power requirements. The solar panels charge the battery during daylight hours and the battery supplies power to the inverter as needed. The inverter changes the 12 volt batteries DC power into 230V volt AC power, which is the most useful type of current for most applications. The charge controller terminates the charging when the battery reaches full charge, to keep the batteries from "gassing-out", which prolongs battery longevity.

Grid synchronization techniques

Zero Crossing Detector (ZCD):

Zero-crossing detector is an applied form of a comparator. Either of the op-amp based circuits discussed can be employed as zero-crossing detector. In some applications the input signal may be low frequency one (i.e. input may be a slowly changing waveform). In such a case output voltagemay not switch quickly from one saturation state to another. Because of the noise at the inputterminals of op-amp, there may be fluctuation in output voltage between two saturation states (+Vsatand – Vsatvoltages) . Thus zero crossing may be detected for noise voltages as well as input signal. Both problems can be overcome if we use regenerative or positive feeding causing the output voltage to change faster and eliminating the false outputtransitions that may be caused due to noise at the input of the op-amp. Thus we prefer PLL based methods for the detection of Phase angle when compared to Zero Crossing Detector.

Phase Locked Loop (PLL):

A phase-locked loop is a control system that generates an output signal whose phase is related to the phase of an input "reference" signal .This circuit compares the phase of the input signal with the phase of the signal derived from its output oscillator and adjusts the frequency of its oscillator to keep the phases matched. The output signal from the phase detector is used to control theoscillator in a feedback loop. Frequency is the time derivative of phase. Keeping both the input and output phase in lock step implies keeping the input and output frequencies in lock step. Consequently it can track an input frequency or it can generate a frequency that is a multiple of the input frequency.

Synchronous Reference Frame (SRF) PLL:

In the conventional PLL, three-phase voltage vector is translated from the abc natural reference frame to the αβ stationary reference frame by using Clarke’s transformation, and then translated to dq rotating frame by Park’s transformation]. The angular position of this dq reference is controlled by a feedback loop which makes the q-axis component equal to zero in steady state. Therefore, under steady state condition, the d-axis component will be the voltage vector amplitude.

Double Synchronous Reference Frame (DSRF) PLL:

This method utilizes two synchronous reference frames similar to i.e., the voltage vector v is decomposed into positive sequence phasor v+and negative sequence phasor$v$ In the general equation of $V\alpha\beta$, α- and β-axis components both contain the information of thepositive sequence and negative sequence which makes it difficult to detect the positive sequencecomponent. A synthesis circuit,, is used to separate them. Then like two independent

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PLLs, the two synchronous reference frames rotating with the positive direction and negative direction respectively and detect the positive sequence and negative sequence components simultaneously.PLL

The basic phase locked loop (PLL) concept was originally published by Appleton in 1923 and Bellescize in 1932, which was mainly used for synchronous reception of radio signals . After that, PLL techniques were widely used in various industrial fields such as communication systems , motor control systems, induction heating power supplies and contactless power supplies . Recently, PLL techniques have been used forsynchronization between grid-interfaced converters and the utility network. An ideal PLL can provide the fast and accurate synchronization information with a high degree of immunity and insensitivity to disturbances, harmonics, unbalances, sags/swells, notches and other types of distortions in the input signal. This paper aims at presenting a comprehensive survey on various PLL synchronization techniques to facilitate the proper selection for specific applications.

PLL Structure

The basic structure of a phase-locked loop (PLL) is shown in Fig. 1. It consists of three fundamental blocks as: Phase detector (PD): This block generates an output signal proportional to the phase difference between the input signal, *v*, and the signal generated by the internal oscillator of the PLL, *v'*. The type of PD decides high-frequency AC components appearing together with the DC phase-angle difference signal. Loop filter (LF): This block presents a low-pass filtering characteristic to attenuate the high-frequency AC components from the PD output. Typically, this block is constituted by a first-order low-pass filter or a PI controller. Voltage-controlled oscillator (VCO): This block generates at its output an AC signal whose frequency is shifted with respect to a given central frequency, ωc, as a function of the input voltage provided by the LF.

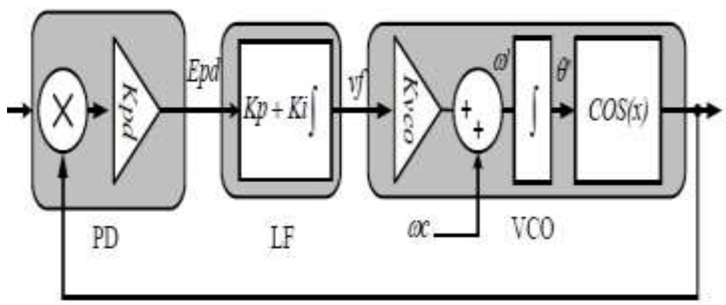

Fig. 1. Block diagram of basic PLL structure

Advantage of PLL

The **advantage of phase-lock loops** is that they receive an input signal, compare this to the feedback of their internal clock generated by a voltage-controlled oscillator (VCO), and adjust the VCO by way of the charge pump to match the new input frequency and synchronize the internal and external clocks.

Three-phase PLL design

A block diagram displaying the functional components of a generic PLL is shown in Figure 3. For small deviations, standard simplifying assumptions [8] allow the PLL to be modeled according to the linear block diagram of., where _*t* is the phase of the measured voltage and _*p* is the phase estimate given by the PLL. In order to establish the PLL error signal _*t*□_*p* for phase tracking in a three-phase system, we have adopted an approach suggested by [9]. The first step in this process is to express the measured three-phase voltages in the stationary reference frame. This is achieved through the

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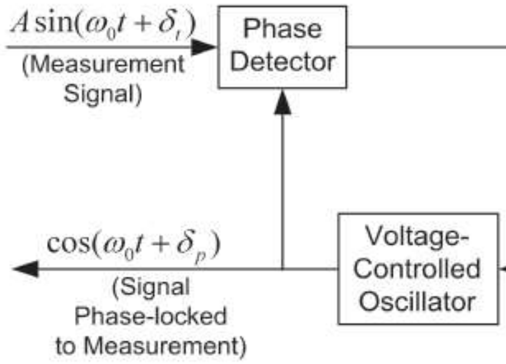


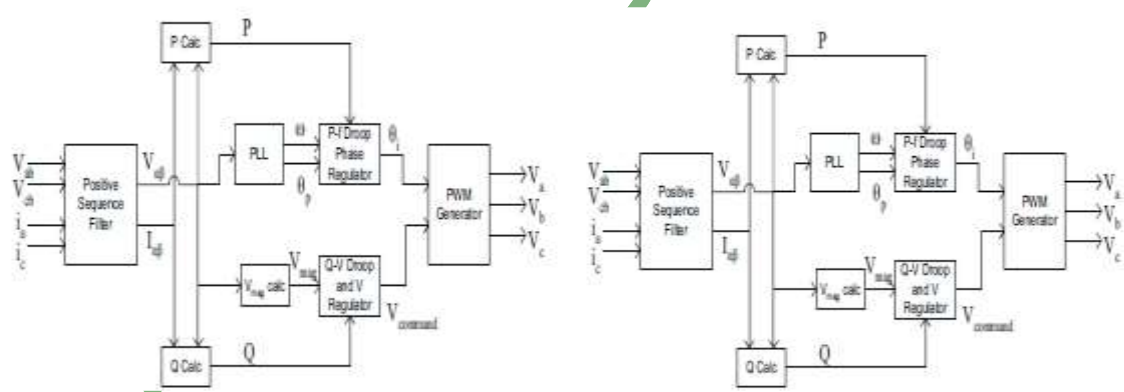
Generic PLL block diagram

Inverter controller

PID controller for inverter

There are basically two categories of micro sources in a micro grid, inverter-based and synchronous generators. Inverter based sources are those that do not generate power at the grid frequency, and thus need an inverter to interface with the microgrid [11], Such sources include photovoltaic panels, fuel cells, wind power, microturbines, and batteries.Synchronous sources, such as diesel gensets, are currently more common, though inverter-based generation is steadily growing. Microgrids offer improved reliability through their ability to island. Islanding means that the microgrid continues to operate autonomously when disconnected from the grid. Islanding provides microgrid customers with greater reliability because power can continue to be supplied when the utility system is interrupted. [12]A microgrid is generally connected to the utility grid through a single connection point, so it is easily islanded by opening the circuit breaker at that point. After islanding, the microgrid should continue to serve its loads without disruption. The microgrid must also be able to resynchronize with the grid when the condition that initiated islanding has been corrected.

This paper presents an inverter control scheme that achieves these islanding requirements.[13]



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Conclusion

The proposed SAPS system for purpose of rural area is designed in MATLAB simulinkenviornment with PID controller is implemented for inverter control and PLL method is adopted for grid synchronization

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