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A four-leg Voltage-source inverter using Predictive Control Scheme in Renewable energy systems


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Abstract:

The increasing energy demand, increasing costs and exhaustible nature of fossil fuels, and global environment pollution have generated huge interest in renewable energy resources. Hybrid photovoltaic and wind energy system has higher dependability to give steady power than each of them operating individually. Other benefit of the hybrid system is that the amount of the battery storage can be decreased as hybrid system is more reliable compared to their independent operation. The Problems due to Harmonics and reactive power loses has been pertaining from the decades. Since many methods are proposed to reduce those above mentioned problems. one of the best method is employing Active Filters for the elimination of Harmonics and compensation of reactive power problems. In this paper An active power filter is implemented with a four-leg voltage-source inverter using a predictive control scheme is presented. The use of a four-leg voltage-source inverter allows the compensation of current harmonic components, as well as unbalanced current generated by single-phase nonlinear loads. The compensation performance of the proposed active power filters.

Keywords: Power Filter, Renewable energy, four-leg converters, PV Cells, Hybrid systems.

Introduction:

Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves, and geothermal heat.

Renewable energy replaces conventional fuels in four distinct areas: electricity generation, air and water heating/cooling, motor fuels, and rural (off-grid) energy services. Renewable energy resources and significant opportunities for energy efficiency exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency, and technological diversification of energy sources, would result in significant energy security and economic benefits.

Photovoltaic Systems:

Converting solar energy into electrical energy by PV installations is the most recognized way to use solar energy. Since solar photovoltaic cells are semiconductor devices, they have a lot in common with processing and production techniques of other semiconductor devices such as computers and memory chips. As it is well known, the requirements for purity and quality control of semiconductor devices are quite large. Solar photovoltaic modules, which are a result of combination of photovoltaic cells to increase their power, are highly reliable, durable and low noise devices to produce electricity. The fuel for the photovoltaic cell is free. The sun is the only resource that is required for the operation of PV systems, and its energy is almost inexhaustible.

Functioning Of The Photovoltaic Cells:

The word "photovoltaic" consists of two words: photo, a greek word for light, and voltaic, which defines the measurement value by which the activity of the electric field is expressed, i.e.

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the difference of potentials. Photovoltaic systems use cells to convert sunlight into electricity. Converting solar energy into electricity in a photovoltaic installation is the most known way of using solar energy.The light has a dual character according to quantum physics. Light is a particle and it is a wave. The particles of light are called photons. Photons are massless particles, moving at light speed. The energy of the photon depends on its wavelength and the frequency, and we can calculate it by the Einstein's law, which is:

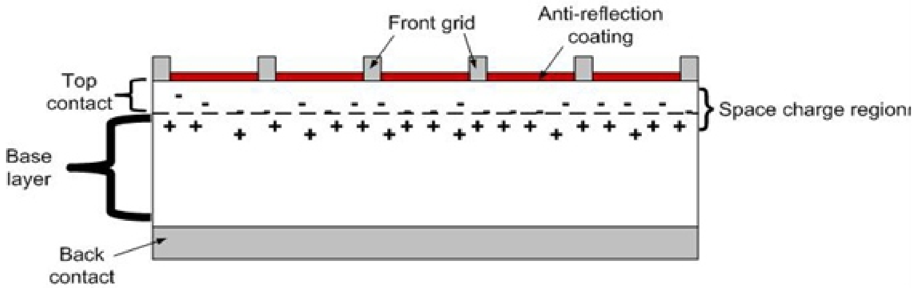
E = h V

where:

E - photon energy

h - Planck's constant h = 6.626×10 – 34Js

V - photon frequency



Structure of a PV cell

Pv-Hybrid Systems:

In cases where it is not feasible economically or practically to supply the requisite energy from PV modules other means are used. In most cases the PV system is used in conjunction with a Diesel generator. Such a hybrid system ensures that energy demands are met while fully utilizing the PV supply. A typical hybrid system is shown in Figure.

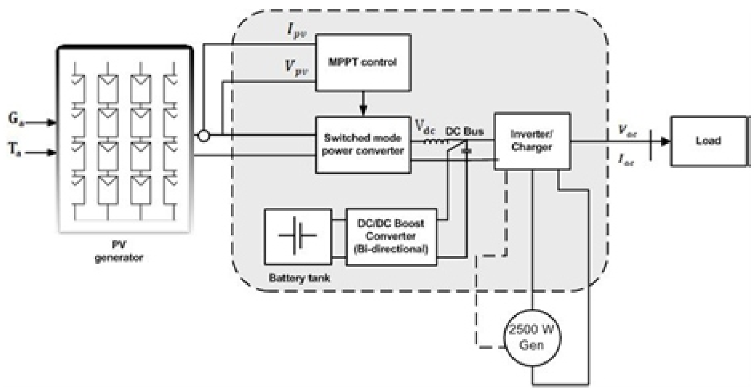


Figure 1.5: Hybrid stand-alone PV system

Active Power Filters:

Active power filter (APF) can solve problems of harmonic and reactive power simultaneously. APF's consisting of voltage source inverters and a dc capacitor have been researched and developed for improving the power factor and stability of transmission systems. APF have the ability to adjust the amplitude of the synthesized ac voltage of the inverters by means of pulse width modulation or by control of the dc-link voltage, thus drawing either leading or lagging reactive power from the supply.

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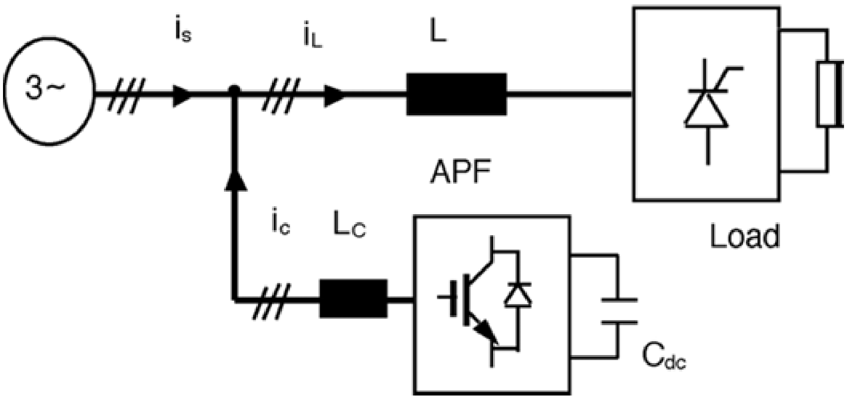
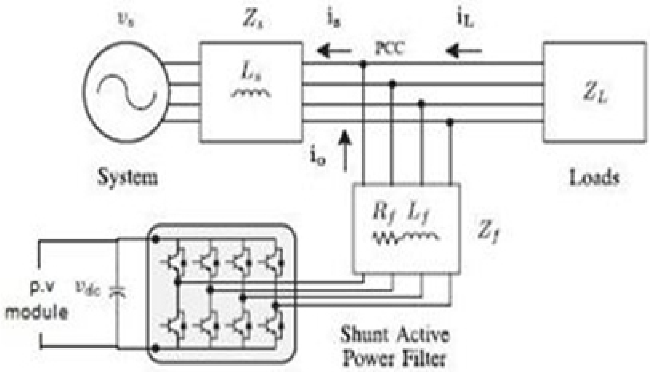


Block diagram of APF

Proposed Model:
FOUR-LEG INVERTER MODEL:

Renewable sources, such as wind and sunlight, are typically used to generate electricity for residential users and small industries. Both types of power generation use ac/ac and dc/ac static PWM converters for voltage conversion and battery banks for long-term energy storage.These converters perform maximum power point tracking to extract the maximum energy possible from wind and sun. The electrical energy consumption behaviour is random and unpredictable, and therefore, it may be single- or three-phase, balanced or unbalanced, and linear or nonlinear. An active power filter is connected in parallel at the point of common coupling to compensate current harmonics, current unbalance, and reactive power.



Three-phase equivalent circuit of the proposed shunt active power filter.

DIGITAL PREDICTIVE CURRENT CONTROL:

The block diagram of the proposed digital predictive current control scheme is shown in Fig. below. This control scheme is basically an optimization algorithm and, therefore, it has to be implemented in a microprocessor. Consequently, the analysis has to be developed using discrete mathematics in order to consider additional restrictions such as time delays and approximations.

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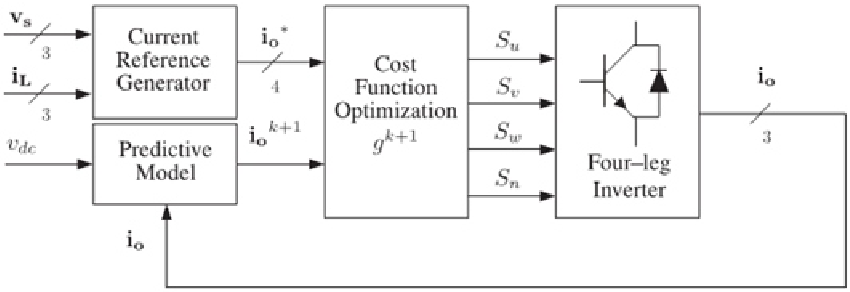
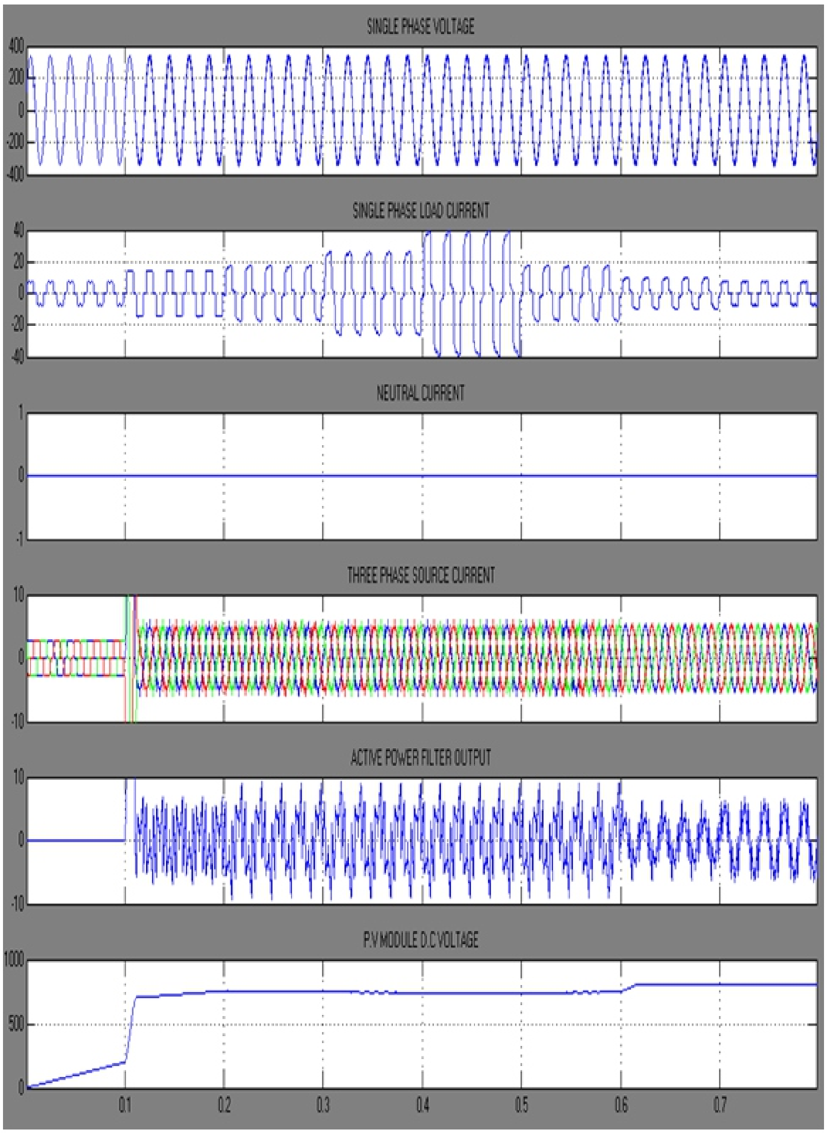


Proposed predictive digital current control block diagram.

The main characteristic of predictive control is the use of the system model to predict the future behaviour of the variables to be controlled. The controller uses this information to select the optimum switching state that will be applied to the power converter, according to predefined optimization criteria. The predictive control algorithm is easy to implement and to understand, and it can be implemented with three main blocks, as shown in Fig. above.

MATLAB/SIMULINK OUTPUT:



PROPOSED MATLAB/SIMULINK OUTPUT

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CONCLUSION:

Improved system performance is observed after the introduction of P.V module as an input to active power filter which includes the compensation of reactive power, and current harmonics by numerically reducing the total harmonic distortion of the source current from 30% to 6% on average. Resulting in surge of the quality of power in distribution system to a good extent. The predictive algorithm is proved a better alternate to conventional converters in handling non linear and unbalanced load because of its simplicity.

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