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Multiport DC-DC Converter for Different Renewable Energy Sources

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Abstract– *According to previous approaches multiport dc–dc converter for concurrent power management of several renewable energy sources which can be of similar types. The introduced dc–dc converter uses only one controllable switch in each port to which a source is connected. It has simple configuration and minimum number of power switches. The introduced converter is applied for simultaneous maximum power point tracking (MPPT) control of a wind/solar hybrid generation system consisting of one Wind Turbine Generator (WTG) and two different Photovoltaic (PV) panels. With the world oil crisis, dangers of overdependence on oil pushed for the development of alternative energy sources. Current international trend in electricity generation is to utilize renewable energy resources. Solar, wind, biomass, micro hydro systems can be seen as suitable alternatives to conventional power. So far these vast renewable energy resources, wind and solar, are not sufficiently harnessed for power generation. Thus, in this dissertation a hybrid renewable power generation system integrating the available solar wind and hydro resources will be investigated in detail for a specific location.*

Keywords— Multiport Converter, Maximum Power Point Tracking (MPPT), Solar Energy, Wind Energy, Hydro Energy, Matlab.

1.Introduction

Due to geo-climatic conditions, several forms of renewable energy resources. Some of them are widely used and developed to supply the energy requirement of the country. Others have the potential for development when the technologies become mature and economically feasible for use. Renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, tides and geothermal heat. These resources are renewable and can be naturally replenished. Therefore, for all practical purposes, these resources can be considered to be inexhaustible, unlike dwindling conventional fossil fuels. The global energy crunch has provided a renewed impetus to the growth and development of Clean and Renewable Energy sources. Clean Development Mechanisms (CDMs) are being adopted by organizations all across the globe. Apart from the rapidly decreasing reserves of fossil fuels in the world, another major factor working against fossil fuels is the pollution associated with their combustion. Contrastingly, renewable energy sources are known to be much cleaner and produce energy without the harmful effects of pollution unlike their conventional counterparts. Following are the main renewable resources:

1) Biomass
2) Hydro Power
3) Solar
4) Wind

In addition to the above indigenous renewable resources, the availability of petroleum within the country territory is being investigated. Petroleum, Coal, Natural Gas, Nuclear Energy are the most common energy sources globally available for electricity supply purposes.

1.1Biomass

Large quantities of firewood and other biomass resources are used for cooking in rural households. Even though the majority of energy needs of the rural population are fulfilled by the use of firewood, there are possibilities of further increasing the use of biomass for energy purposes in the country, especially for electricity generation.

1.2 Hydro Power

Hydro Power is a key energy source used for electricity generation. Better part of the major hydro potential has been already developed and they are delivering valuable low cost electricity. Currently, hydro power stations are operated to supply both peaking and base electricity generation requirement.

Apart from the grid connected large hydro power stations, many small scale hydro power plants are in operation serving off-grid loads and grid connected loads. A substantial number of small scale hydro power stations have been already connected to the national grid and many more is expected to join in.

1.3 Wind

Wind power is the use of air flow through wind turbines to mechanically power generators for electricity. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, uses no water, and uses little land.[2] The net effects on the environment are far less problematic than those of non-renewable power sources.

Wind farms consist of many individual wind turbines which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electricity, competitive with or in many places cheaper than coal or gas plants.[3][4][5] Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electricity to isolated off-grid locations.[6] Wind power gives variable power which is very consistent from year to year but which has significant variation over shorter time scales. It is therefore used in conjunction with other electric power sources to give a reliable supply. As the proportion of wind power in a region increases, a need to upgrade the grid, and a lowered ability to supplant conventional production can occur.[7][8] Power management techniques such as having excess capacity, geographically distributed turbines, dispatch able backing sources, sufficient hydroelectric power, exporting and importing power to neighboring areas, using vehicle-to-grid strategies or reducing demand when wind production is low, can in many cases overcome these problems.[9][10] In addition, weather forecasting permits the electricity network to be readied for the predictable variations in production that occur.

1.4 Solar

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic convert light into an electric current using the photovoltaic effect. The International Energy Agency projected in 2014 that under its "high renewable scenario, by 2050, solar photovoltaic and concentrated solar power would contribute about 16 and 11 percent, respectively, of the worldwide electricity consumption, and solar would be the world's largest source of electricity. Most solar installations would be in China and India.

2.Multiport Converter

Nowadays, there is a growing interest in generating electricity from distributed renewable energy sources. In numerous applications, it is required to connect multiple renewable energy sources of different types to a power grid or load. The multiport DC-DC converter has been proposed to efficient power management and grid integration for the multiple origins and development in a new era in a demand quality power in remote communities[8][9]. The isolated dc–dc converter has multiple input ports for connecting different sources, such as photovoltaic (PV) panels, wind turbine generators (WTGs), fuel cells, etc., The multiport dc–dc converter not only regulates the low-level dc voltages of the sources to a constant high level required by the inverter but also provides other important control functions, such as maximum power point tracking (MPPT).

The review on multiport dc–dc converter for simultaneous power management of multiple renewable energy sources uses only one power electronic switch in each input port connected to a source. The introduced converter does not use any controllable switch on the secondary side of the transformer [2]-[4]. The proposed converter has the least number of switches and thereby a lower cost. The newly introduced converter is applied for power management of a wind/solar hybrid generation systems, which consists of a WTG and two varied PV panels. The power generation from solar and wind energy are designed using perturbation and observation (P&O) MPPT algorithm, in which the WTG and PV panels can be controlled at the same time and extract the maximum power. The Figure 1 shows the block diagram of the introduced multiport DC-DC converter. It consists of PV Panels, Wind turbine generator, Boost converter, MPPT controller, High frequency transformer and an inverter.

3.Energy Supply

Energy is a vital input to our day to day life in the households, industry and commercial sector. To understand the status of the energy sector of a country, what is more important is not the availability of different energy resources, but the extent of use of these resources. Availability of a resource within a country does not guarantee its utilization. Therefore, it is more important to analyze the resources which are actually being used to meet the energy demand of the country. Following are the main energy supply forms in Sri Lanka.

1) Biomass
2) Petroleum
3) Electricity

Energy needs of the country are fulfilled either directly by primary energy sources such as biomass and petroleum or by secondary sources such as electricity produced using petroleum, hydro and biomass.

4.Methodology

According to new proposed approach power generation system and analysis using hybrid wind, solar and hydro system. There are following steps as follow as:

Step 1: Establish three renewable (wind, solar and hydro) power generation system.
Step 2: Connect MPPI with wind power generation system.
Step 3: Apply PI based controller for controllable hybrid power generation system.
Step 4: Apply conditioner for DC-to-DC converter.
Step 5: Connect inverter circuit for AC loads.
Step 6: Analysis on the basis of AC load three renewable (wind, solar and hydro) power generation system.

5.Maximum Power Point Tracking

A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. Maximum power point tracking technique is used to improve the efficiency of the solar panel. According to Maximum Power

Transfer theorem, the power output of a circuit is maximum when the Thevenin impedance of the circuit (source impedance) matches with the load impedance. Hence our problem of tracking the maximum power point reduces to an impedance matching problem.

In the source side we are using a boost convertor connected to a solar panel in order to enhance the output voltage so that it can be used for different applications like motor load. By changing the duty cycle of the boost converter appropriately we can match the source impedance with that of the load impedance.

5.1Different MPPT Techniques

There are different techniques used to track the maximum power point. Few of the most popular techniques are:

5.1.1Perturb and Observe (hill climbing method)

5.1.2Incremental Conductance method

5.1.3Fractional short circuit current

5.1.4Fractional open circuit voltage

5.1.5Neural networks

5.1.6Fuzzy logic

6.Wind-Solar-Hydro Hybrid System

The hybrid power generation concept is a system aimed at the production and utilization of electrical energy coming from more than one source within an integrated arrangement.

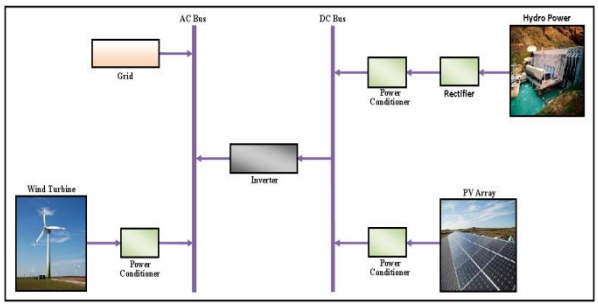

Figure- 1: Hybrid Power Generation System.

The hybrid system studied in this thesis is one combining solar PV and wind turbines with power conditioning units such as inverters. Hybrid wind turbine and solar PV modules offer greater reliability than any one of them alone, because local energy supply cannot depend entirely on any one of these sources. Other advantages of the hybrid system are the stability and reliability of the system and the lower maintenance requirement thus reducing downtime during repairs and routine maintenance. In addition to this, as well as being indigenous and free, renewable energy resources also contribute to the reduction of pollution emissions.

In this paper, the proposed hybrid power generation system makes use of solar PV and wind turbine to produce electricity and supply the load by connecting to the grid. A schematic of a typical grid connected wind-solar hybrid system can be shown in Figure 1.

7.Simulated Results

In this section, the proposed hybrid power generation system is evaluated via computer simulation using Simulink (MATLAB simulator). All simulation results are obtained by using solar, wind, hydro power generation system. The simulation study of system parameters are presented below and to predict their actual characteristics three energy sources are modelled accurately in Simulink. Figure 2 show the simulation model for hybrid system with solar, wind and hydro systems.

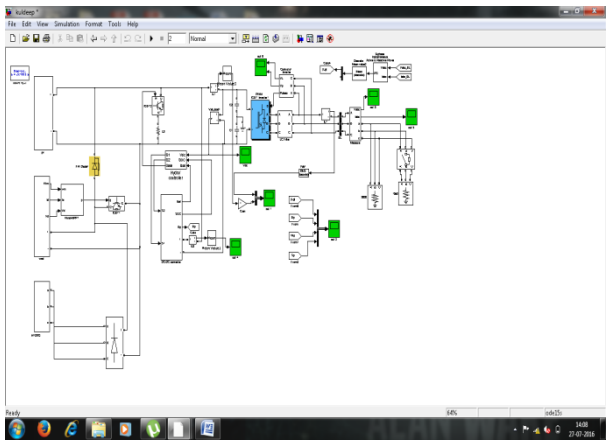

Figure- 2: Simulink Model for Hybrid System.

Figure 3 the simulation result for output voltage across load terminals. From this result it observed that the voltage changes with respect to change in the wind, solar and hydro plants.

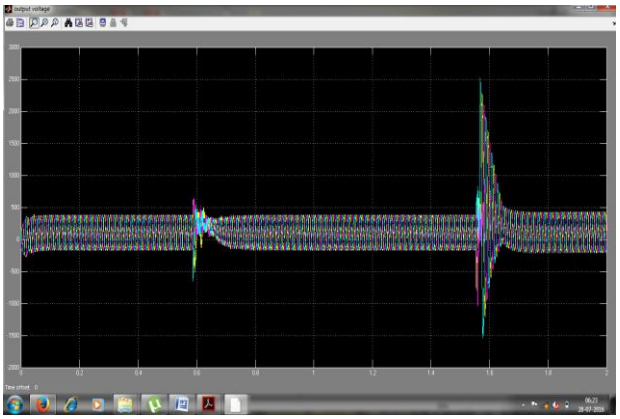

Figure- 3: Output Load Voltage.

Figure 4 show the simulation result of output current through the load. If the load is changed or suddenly extra load applied to the system then changes occur in the load current

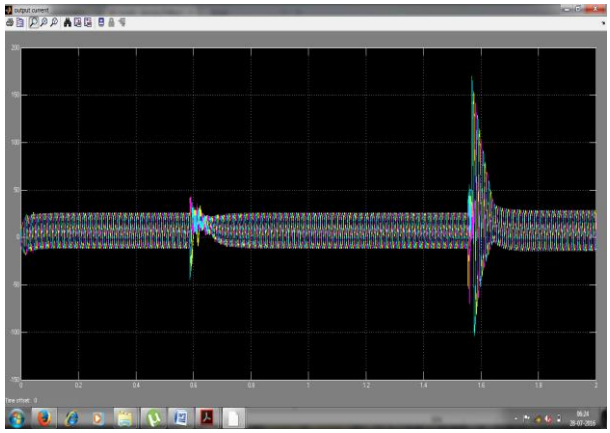

Figure- 4: Output Load Current.

Figure 5 shows the wave form for powers which are obtained from the solar plant, wind energy system.

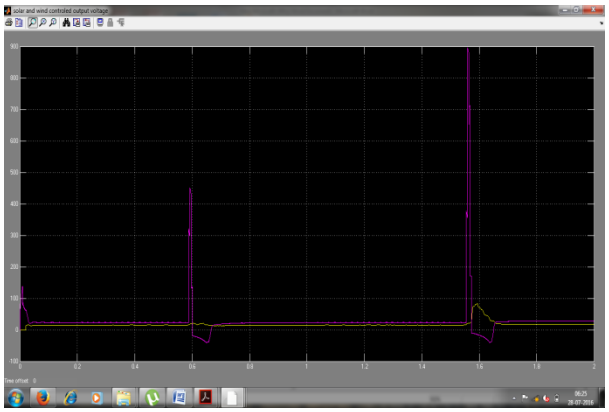

Figure- 5: Output Voltage from Solar and Wind System.

Figure 6 shows PI controlled hydro output voltage.

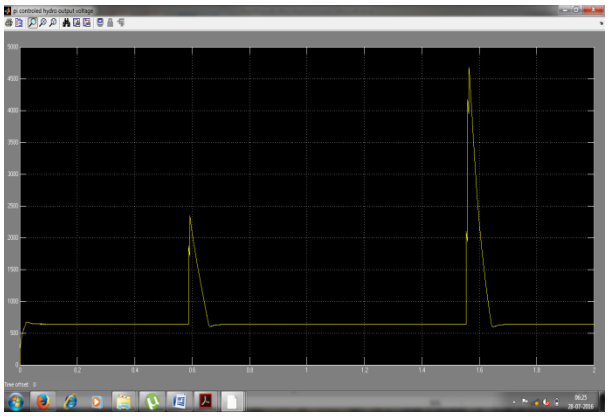

Figure- 6: PI Controlled Hydro Output Voltage.

Figure 7 show output voltage from solar, wind and hydro system.

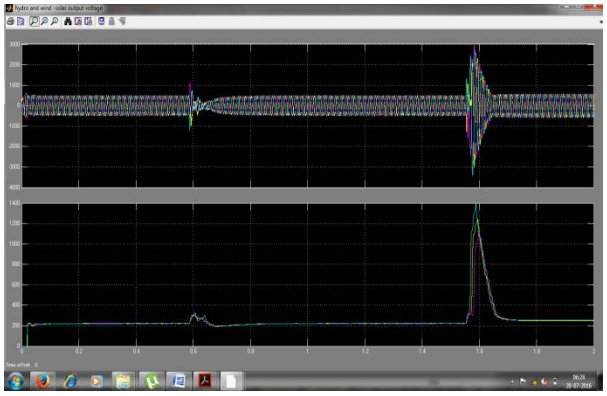

Figure- 7: Output Voltage from Solar, Wind and Hydro System.

8.Conclusion

The present worldwide trends concern energy security and sustainable development across the globe. The role of renewable energy has therefore become ever more significant. The developed world is already on the track for walking out from the fossil fuel era and involving mainly the areas of renewable energy technologies and energy efficiency. The proposed system is implementable to those areas where the solar wind and hydro energies are available at moderate nature such as Indian circumstance. The nature of the solar wind and hydro energies is intermittent. Hence, using the individual system the continuous power generation is not possible, and it will also increase burden to the grid. The proposed system is able to supply the community in all seasons. The proposed hybrid system reduces the complexity of the electrical system, having less cost as compared to other renewable energy sources and reliable operation. The obtained results show that the proposed system has the potential to supply the local community.

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