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ACTIVE POWER CONTROL WITH IMPROVED P&O METHOD FOR WIND- PV-BATTERY BASED STANDALONE GENERATION SYSTEM

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Abstract: This paper presents study of hybrid power system.A solar-wind hybrid system is a reliable alternative energy source because it uses solar energy combined with wind energy to create a stand-alone energy source that is both dependable and consistent. Solar power or wind power alone can fluctuate, when used together they provide a reliable source of energy. In this paper the modelling and simulation of active power control (APC) with anti-windup PI controller (AWPI) and improved perturbation and observation (P&O) method with sliding mode control (SMC), are investigated to get high level of performance with reduced number of sensors for a stable operation of a wind-PV-battery based hybrid standalone power generation system (HSPGS). The SMC approach with boundary layer, is used to have an optimum trajectory of the system as sliding manifold of surfaces, under variable operating conditions of many power converters operated in simultaneously. The effectiveness and robustness of HSPGS and their respective control strategies are validated by simulation using Matlab-Simulink.

I. INTRODUCTION

Rapid depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to cater to the present days' demand. . Therefore, it is imperative to find alternative energy sources to cover the continuously increasing demand of energy while minimise the negative environmental impacts Recent research and development of alternative energy sources have shown excellent potential as a form of contribution to conventional power generation systems. There is a huge potential for utilizing renewable energy sources, for example solar energy, wind energy, or micro-hydropower to provide a quality power supply to remote areas. The abundant energy available in nature can be harnessed and converted to electricity in a sustainable way to supply the necessary power demand and thus to elevate the living standards of the people without access to the electricity grid. The advantages of using renewable energy sources for generating power in remote islands are obvious such as the cost of transported fuel are often prohibitive fossil fuel and that there is increasing concern on the issues of climate change and global warming. The electric power generation system, which consists of renewable energy and fossil fuel generators together with an energy storage system and power conditioning system, is known as a hybrid power system. A hybrid power system has the ability to provide 24 hour grid quality electricity to the load. This system offers a better efficiency, flexibility of planning and environmental benefits compared to the diesel generator stand-alone system. The maintenance costs of the diesel generator can be decreased as a consequence of improving the efficiency of operation and reducing the operational time which also means less fuel usage. The system also gives the opportunity for expanding its capacity in order to cope with the increasing demand in the future. This can be done by increasing either the rated power of diesel generator, renewable generator or both of them.The disadvantage of standalone power systems using renewable energy is that the availability of renewable energy sources has daily and seasonal patterns which results in difficulties of regulating the output power to cope with the load demand. Also, a very high initial capital investment cost is required. Combining the renewable energy generation with conventional diesel power generation will enable the power generated from a renewable energy sources to be more reliable, affordable and used more efficiently.Solar and wind energy systems are being considered as promising power generating sources due to their availability and topological advantages for local power generations in remote areas. Utilization of solar and wind energy has become increasingly significant, attractive and cost-effective, since the oil crises of early 1970s. This Paper focuses on the combination of solar wind systems for sustainable power generation. The solar energy also varies with the hourly, daily and seasonal variation of solar irradiation. The wind turbine output power varies with the wind speed at different conditions. However, a drawback, common to solar irradiation and wind speed options, is their unpredictable nature and dependence on weather and climatic changes, and the variations of solar and wind energy may not match with the time distribution of load demand. This shortcoming not only affects the system's energy performance, but also results in batteries being discarded too early. Generally, the independent use of both energy resources may result in considerable over-sizing, which in turn makes the design costly. It is prudent that neither a stand-alone solar energy system nor a wind energy system can provide a continuous power supply due to seasonal and periodical variations for stand-alone systems.Thus wind system is hybridized with solar systemto maximize use of renewable energy generation system while minimizing the total system cost.

II. CLASSIFICATION OF ENERGY RESOURCES

Energy resources are classified into non-renewable and renewable resources

Non-renewable Energy Resources

Non-renewable energy resources are the ones which are limited and become extinct with the time, such as oil, coal and coal derivatives, natural gas, wood and radioactive material (uranium, plutonium) and also produces a lot of harmful waste.

Renewable Energy Resources

Renewable energy resources are the ones that are continously available and renewing itself with the time.Industrialization and ever increasing world population need the use of renewable energy resources. Solar energy, wind energy, biomass, tidal energy, wave energy, geothermal power are popular.

1) Solar power

Solar panel is a device that converts solar energy directlyinto electrical energy. Solar panel is made up off photovoltaic cells which are made by semiconductor. When sun beam is fall on the PV cell they absorb the heat and electron are emitted from the atom. Due to the movement of the electron current is generated. With this process solar panel, convert solar energy directly into the electric energy. Photovoltaic is known as theprocess between radiation absorbed and the electricity induced. Solar power is converted into the electric power by a common principle called photoelectric effect.

The basic unit of aphotovoltaic power system is the PV cell, where cells may be grouped to form panelsor modules. The panels then can be grouped to form large photovoltaic array thatconnected in series or parallel. Panels connected in parallelincrease the current and connected in series provide a greater output voltage.

Fig. PV Cell, PV Module, PV Array

The energy generated by the sun radiation is calculated bythe formulae:

$P = A \cdot x^2 + B \cdot x + C$ (in Watts)

Where,

X = Solar radiation

P= Power Formation

And A,B,C are constant

By the above formula, we can calculate the amount of power generated by the Sun.

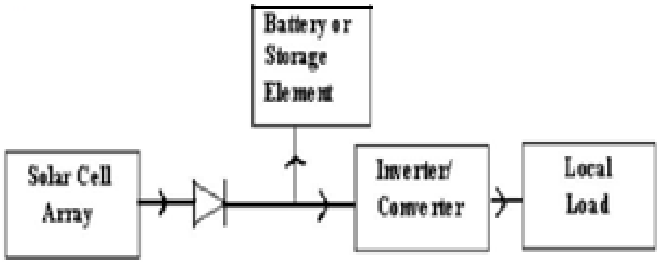


Fig. Basic PV System

Storage batteries as shown in Fig. provide the backup power during cloudy weather to store the excess power or some portion of power from the solar arrays. This solar power generating system is used for domestic power consumption, meteorological stations and entertainment places like theatre, hotel, restaurant etc.

2) Wind Power

The wind energy is a renewable source of energy. Wind power involves converting wind energy into electricity by using wind turbines. A wind turbine is a machine that converts the kinetic energy in wind into mechanical energy. The energy production by wind turbines depends on the wind velocity acting on the turbine. Wind power is able to feed both energy production and demand in the rural areas.The main drawback of this system is that as the wind speed or velocity is not constant with respect to time i.e.fluctuating, hence the electric power thus obtained is also does not have a fixed value i.e. varying nature. Thus, it is better to feed the wind electricity to the battery or any power storage device, which supply the load consecutively, rather than directly supply to the load as shown.

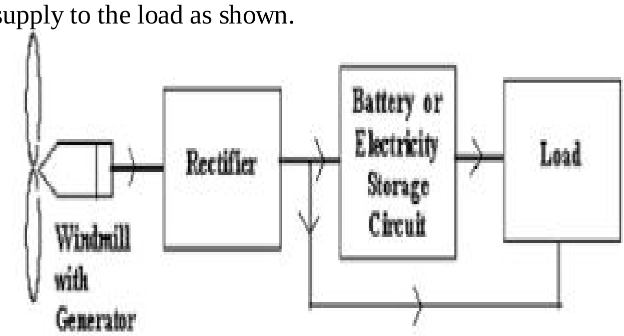


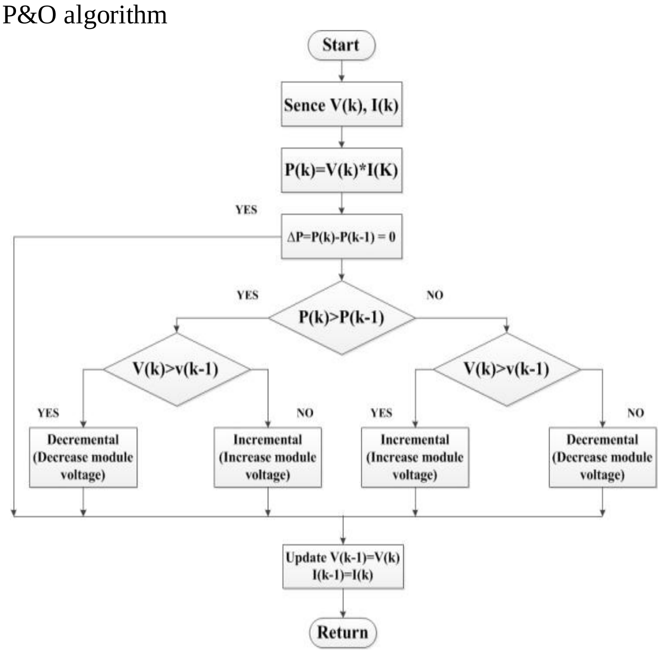
Fig. Basic Wind Power System

The power output of a turbine is a function of the cube of the wind speed, so as wind speed increases, power output increases dramatically. Areas where winds are stronger and more constant, such as offshore and high altitude sites are preferred locations for wind farms. We cannot convert all the wind energy into electricity: we can convert only 59%, according to Betz limit. The output equation for a wind generator is given by:

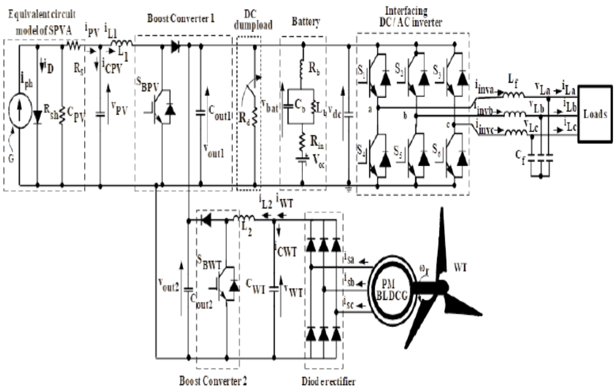
$P = (1/2) \times \rho \times A \times v^3$(in Watts)

Where, A=area perpendicular to the direction of flow (in m^2), v=wind velocity (ms^{-1}), ρ =density of air (in Kgm^{-3}) and P=power generation.

P&O algorithm



Improved P&O Method for Wind- PV-Battery based Standalone Generation System



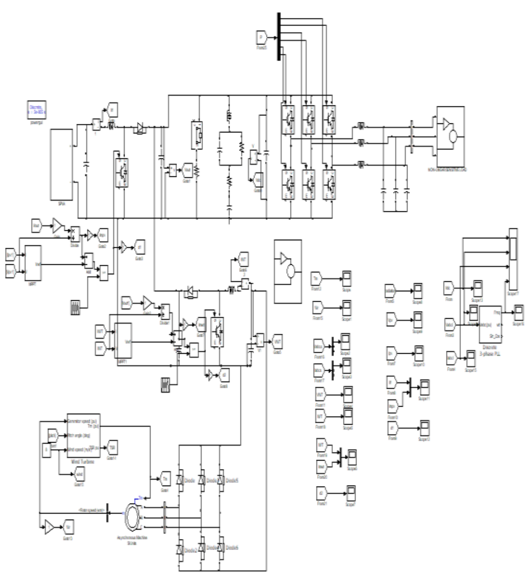
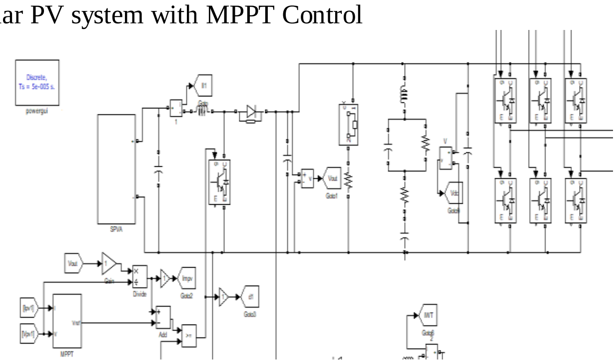
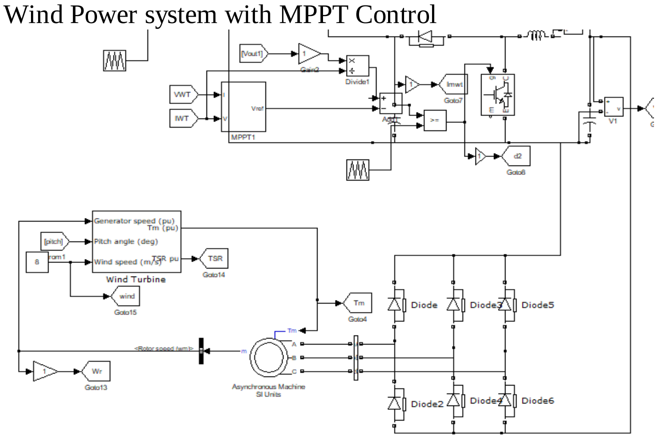


Fig. 1. HSPGS Matlab Model

Solar PV system with MPPT Control



Wind Power system with MPPT Control



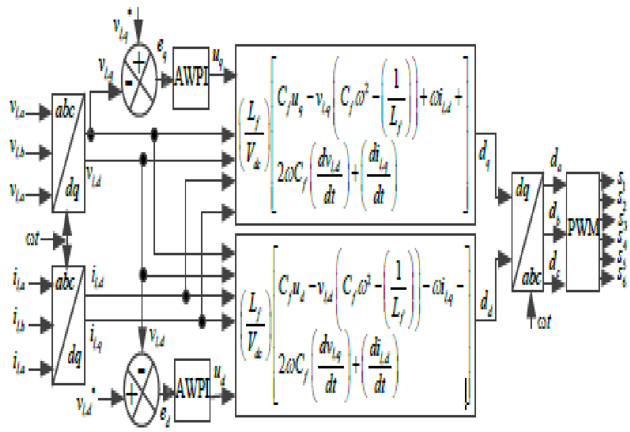


Fig. APC based AWPI controller for DC-AC interfacing inverter

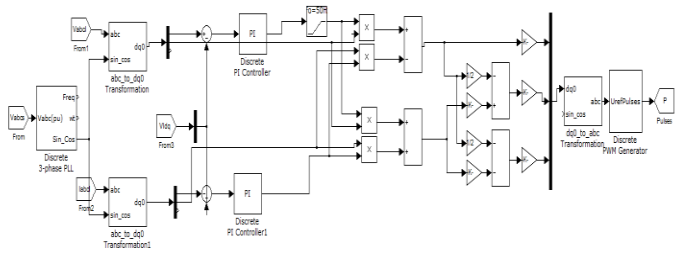
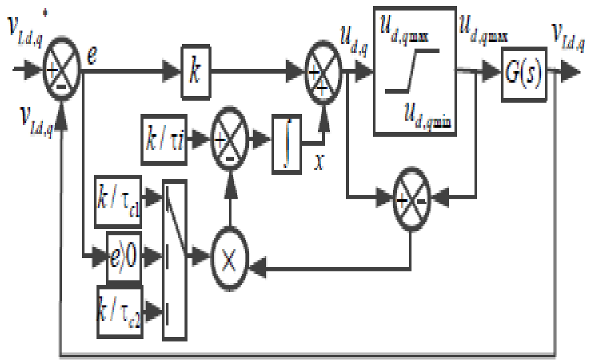
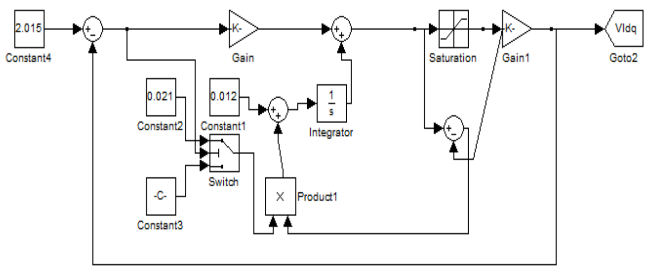


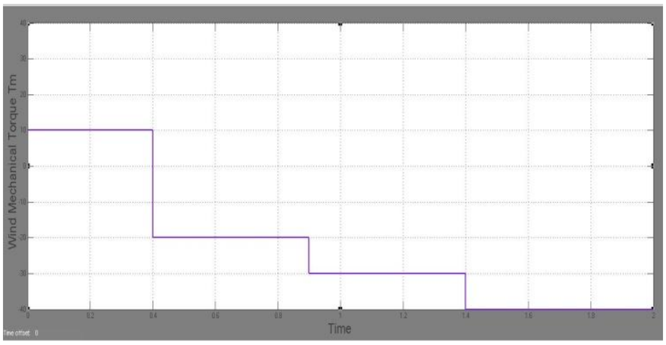
Fig. APC based AWPI controller for DC-AC interfacing inverter

Block diagram of the AWPI controller with feedback path control for d and q axis

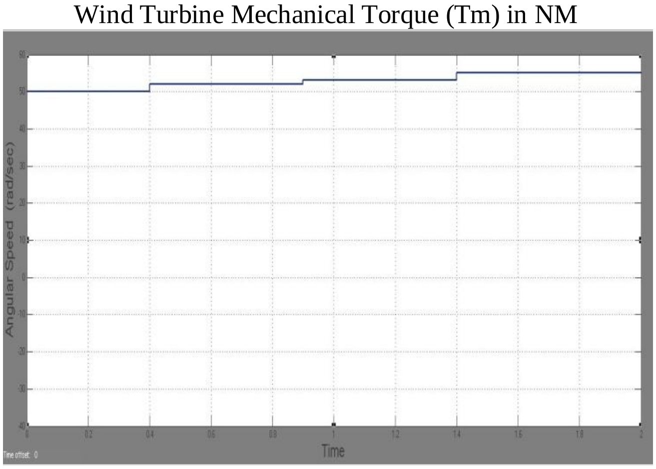




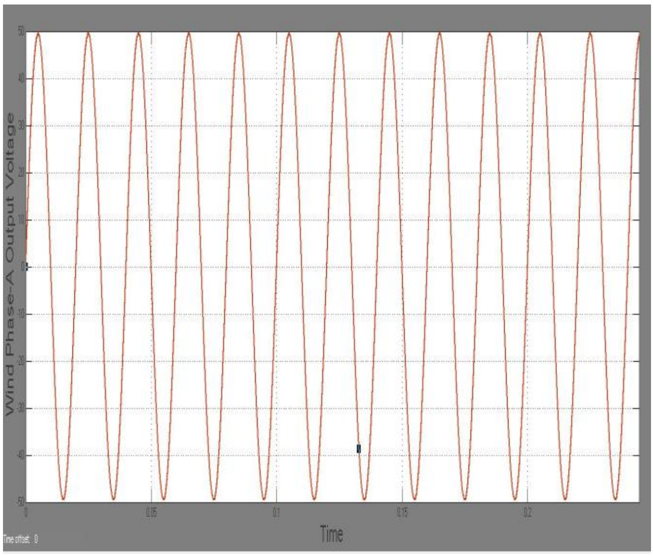
Wind Output Parameters



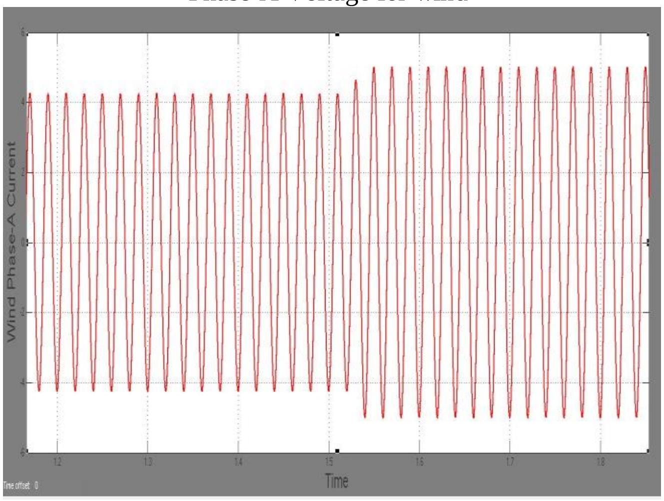
Wind Turbine Mechanical Torque (Tm) in NM



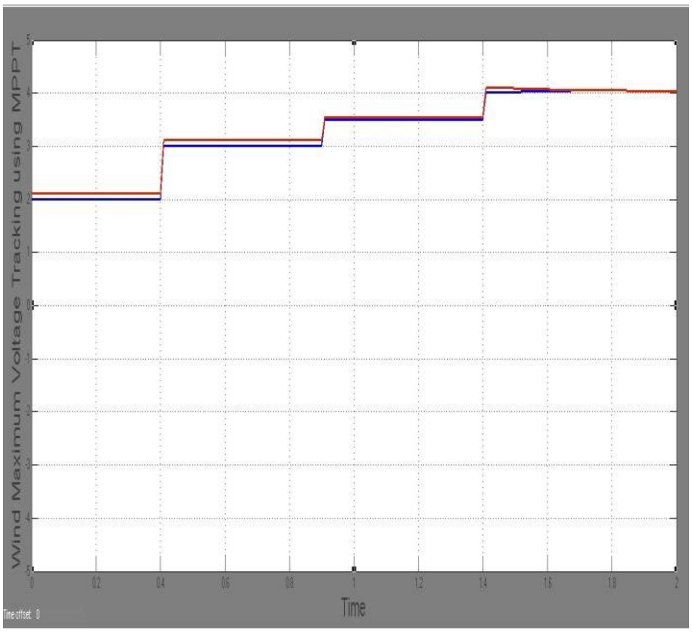
Angular Speed in rad/sec



Phase-A Voltage for wind

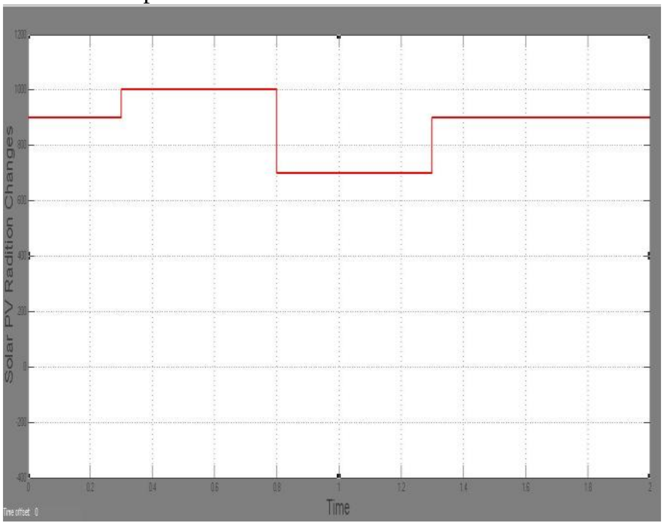


Phase-A Current for wind

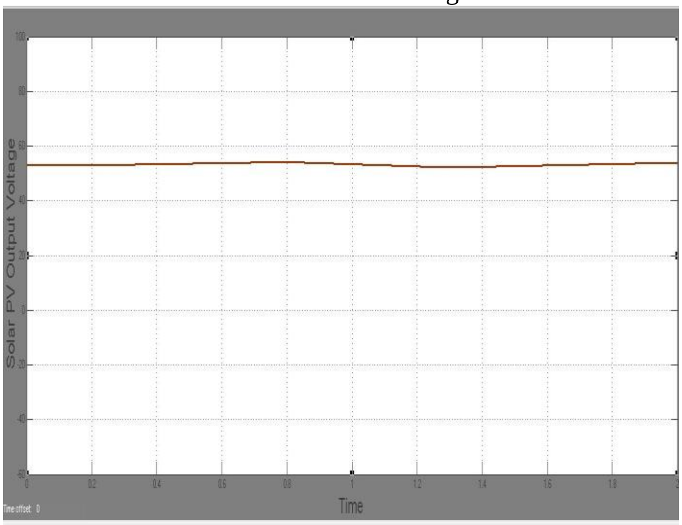


Wind Maximum Current Tracking (Imwt)

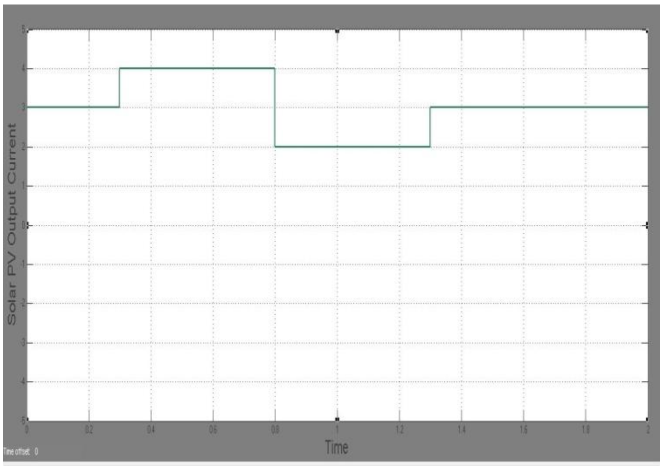
Solar PV Output Parameters



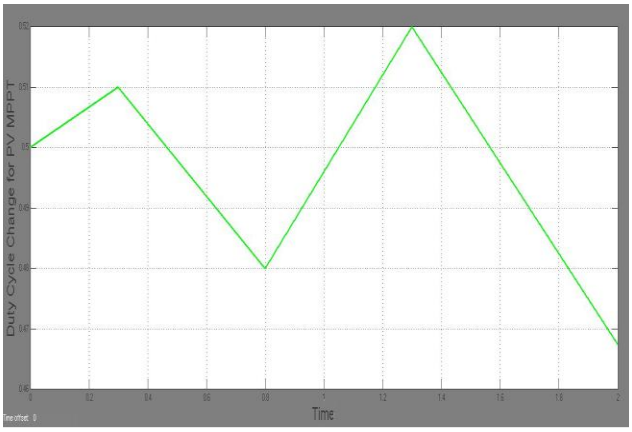
Solar PV radiation change



Solar PV output voltage

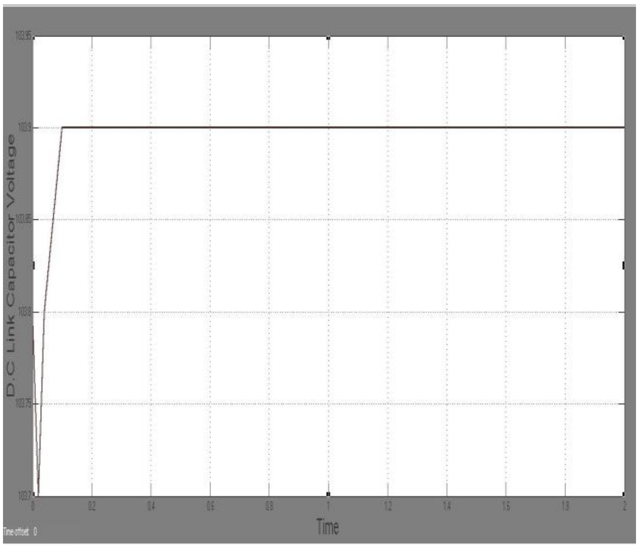


Solar PV output Current

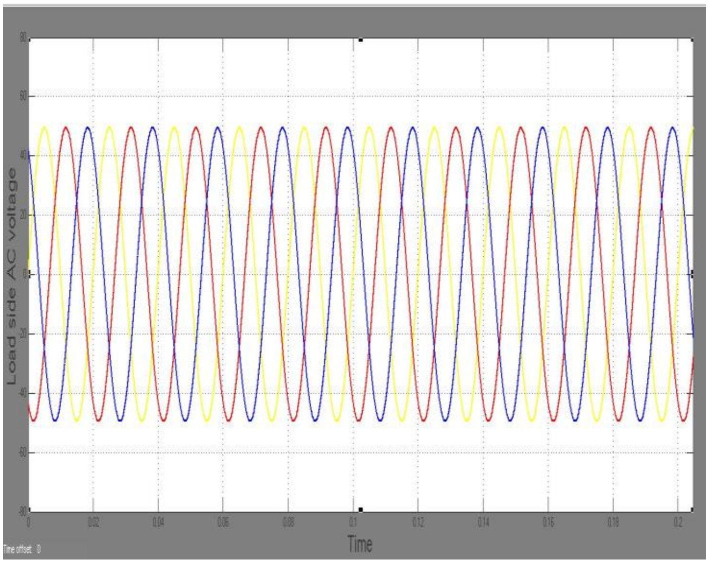


Duty Cycle for Solar PV MPPT Controller

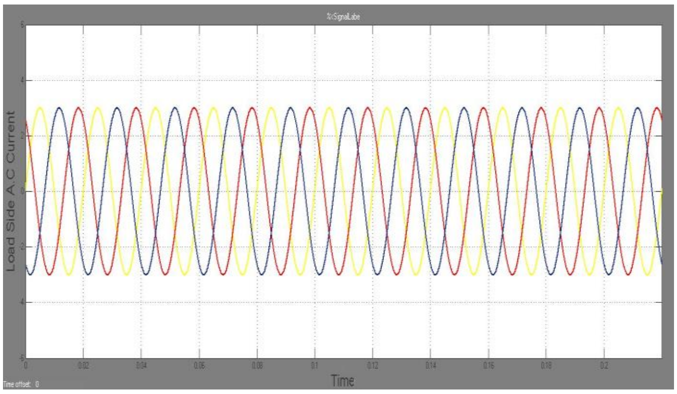
Load Side Parameters

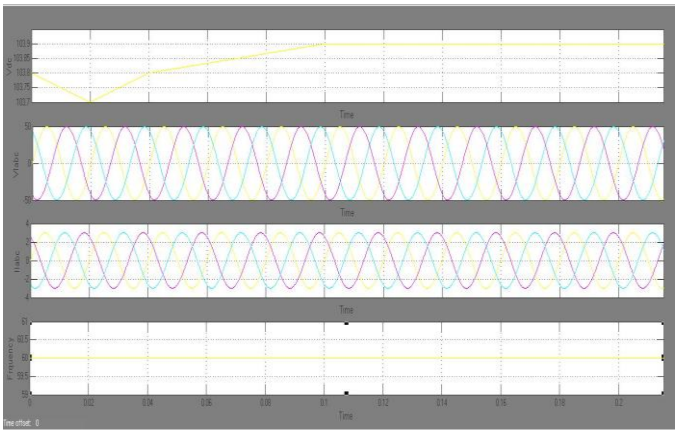


Common D.C link Capacitor Voltage



Load side A.C output Voltage


Load side A.C output Current


Load side all Parameters

III. CONCLUSION

This paper presents a hybrid wind/PV energy system for standalone system. The standalone hybrid system is better than a single energy source. The wind energy systems may not be technically viable at all sites because of low wind speeds and being more unpredictable than solar energy. Modeling, control design, and stability analysis have been presented in detail. Simulated performance of the system has been obtained with an improved P&O method for MPPT in Solar PV. This Project also represents the modelling and Simulation of Solar PV System using MATLAB-SIMULINK software. It has been demonstrated that theimproved P&O based MPPT is more reliable and efficient during weather changes in presence of many power converters operated simultaneously. Further, it has been demonstrated that the APC with AWPI voltage controller regulates constant and sinusoidal AC voltage without any saturation and overshoot during transients. Simulated performance has been validated on real-time laboratory prototype for improved P&O based SMC with boundary layer and the APC with AWPI controller with reduced number of sensors and hardware complexity.

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[7] Optimal Energy Management of Building Microgrid Networks in Islanded Mode Considering Adjustable Power and Component OutagesVan-Hai Bui 1 , Akhtar Hussain 1, Hak-Man Kim 1,* and Yong-Hoon Im 2,*1 Department of Electrical Engineering, Incheon National University, 12-1 Songdo-dong, Yeonsu-gu, Incheon 406840, Korea; buivanhaibk@inu.ac.kr (V.-H.B.); hussainakhtar@inu.ac.kr (A.H.) 2 Korea Institute of Energy Research, 152 Gajeong-ro, Yuseong-gu, Daejeon 34129, Korea.
[8] Optimal Energy Management of Building Microgrid Networks in Islanded Mode Considering Adjustable Power and Component OutagesY. Nian*, S. Liu*, D. Wu*, J. Liu**North China Electric Power University, Beinong Road 2th , Changping District, Beijing, Chinanianyue90@126.com

