HYBRID POWER SYSTEM WITH INTGRATION OF WIND AND SOLAR PV SYSTEM

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ABSTRACT

Renewable energy resources such as solar and wind energies are becoming advantageous compared to the conventional sources of power production in many ways like they are eco-friendly, available in a huge amount, non-deplorable, etc. But the only drawback is that their outputs depend upon the climatic conditions. Wind-Photovoltaic Hybrid System (WPHS) utilization is becoming popular due to the increasing energy costs and decreasing prices of turbines and PV panels. However to make up for the drawbacks back-up power is often necessary.

This paper presents a renewable energy hybrid power system that based on photovoltaic (PV) and wind, and equips with cuk DC-DC converter, three phase inverter and LC filter. The wind and PV energy are suitable for hybrid system because they are environmental friendly and widely available in India. However, the hybrid power system that solely depends on the intermittent renewable energy sources will generate a fluctuating output voltage that leads to damage to the machines that operate on a stable supply. The modeling of the hybrid system with cuk converter, three phase inverter and LC filter is build using MATLAB Simulink.

Blocks such as wind model, photovoltaic model, cuk converter, inverter and LC filter are built separately before combining into a complete DC voltage hybrid system with main grid of power system. Different irradiance value and varying wind speed are the input parameters for the project simulation. The results show that hybrid system has greater reliability in terms of output voltage generation as compared to standalone system. In addition, cuk DC-DC converter, three phase universal bridge based inverter and LC filter that installed in the hybrid system is able to reduce the fluctuation output voltage.

Keyword: - *Hybrid power system, PV cell, wind energy, Battery, Converter.*

1. INTRODUCTION

Energy, a word everybody is well acquainted with, mathematically means power consumption in a certain span of time. From the first hour of the day till the last hour the daily needs of a man start consuming energy in one form or the other. Nowadays people can't even imagine their lives without energy. A man without a major body part is called to be handicapped; likewise a world without energy is like a crippled world.

Mankind is getting developed year by year and the total population of the world is also increasing as years are passing. As a result, the total energy requirement is also increasing rapidly to keep pace with the rapid modernization of mankind and with the rapid increase in population. According to a survey the primary energy demand is increasing by 1.5% per year and by 2030 the total energy demand will be 16,800Mtoe, with an overall increase of 40% [1].

According to BP Statistical Review of World Energy, world energy consumption got increased by 2.5% in 2011, less than 5.1% in 2010 but well in coordination with the historical average till date [2].

In figure 1, it is seen that the GDP (Gross Domestic Product) has increased to a higher value from 1970 till 2010 and will be even more in 2030. But population is decreasing and is estimated to decrease more in the coming years. It can be observed that energy is decreasing but energy per capita in increasing by a marginal value. Lastly energy per GDP is estimated to decrease more and more up to 2030.

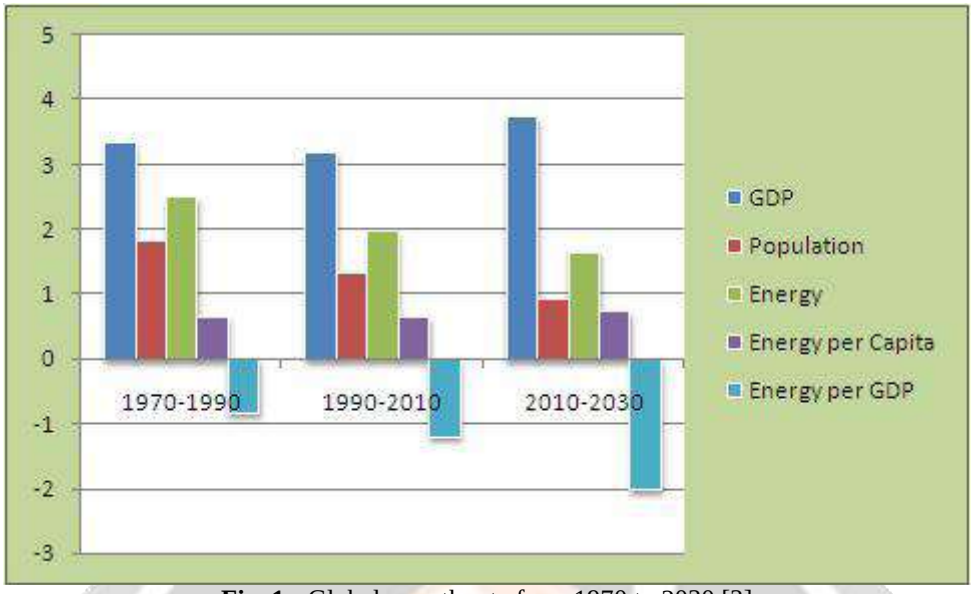

Fig. 1:- Global growth rate from 1970 to 2030 [3]

India, a developing country, nowadays is enlisted as one of the strong economy countries. In 2011, India's 121 crores population comprises of 17% of the world's total population. From 2001 to 2011 there has been a percentage growth of 17.64% in the population of India [3]. With this continuous increase in population, the electricity consumption of India will grow at an average rate of 3.3% per year through 2035 and to meet this increasing demand the total generation capacity of India should be increased by 235 MW [4]. Presently India's per capita electricity consumption is 531.34 kWh, which is presumed to increase day by day with more and more modernization [5]. The imbalance between the demand and supply of electricity in India needs major attention now.
In the above figure, Figure 2, it can be observed that the maximum power generated in India comes from coal-based thermal power plant. 57% of the total power developed is dependent on coal as a fuel, whereas 1% and 9% are generated from oil and gas. Renewable energy sources generate very less power in India, about 12% only, and rest 19% and 2% are developed from hydro-power and nuclear power.

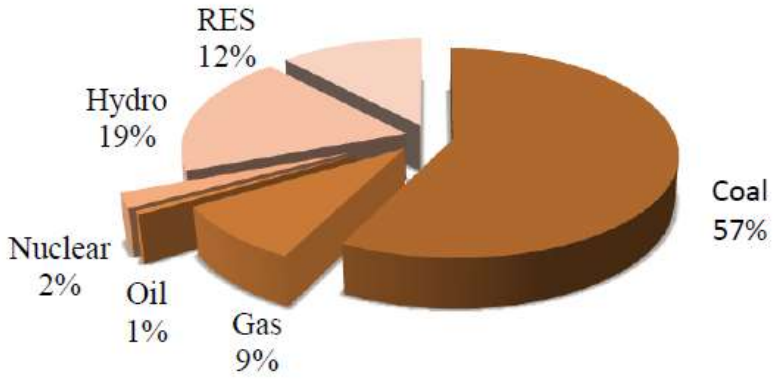

Fig. 2:- Fuel-wise installed capacity in India [6]

2. PROPOSED METHODOLOGY

The proect implementation will be done using MATLAB simulink software. The major blocks will be design in MATALAB as:

1) Simulation of wind energy system using application library in sim power system toolbox.
2) Simulation of solar PV system and MPPT (maximum power point tracking) algorithm using sim power system and commonly used simulink blocks.
3) Simulation of inverter circuit using power electronics library.

4) Simulation of power system and grid using sim power system toolbox.
5) Simulation of common coupling point for syncronisation of wind/solar system to main power system grid.
6) Simulation of infinite bus and LC filter using sim power system toolbox.

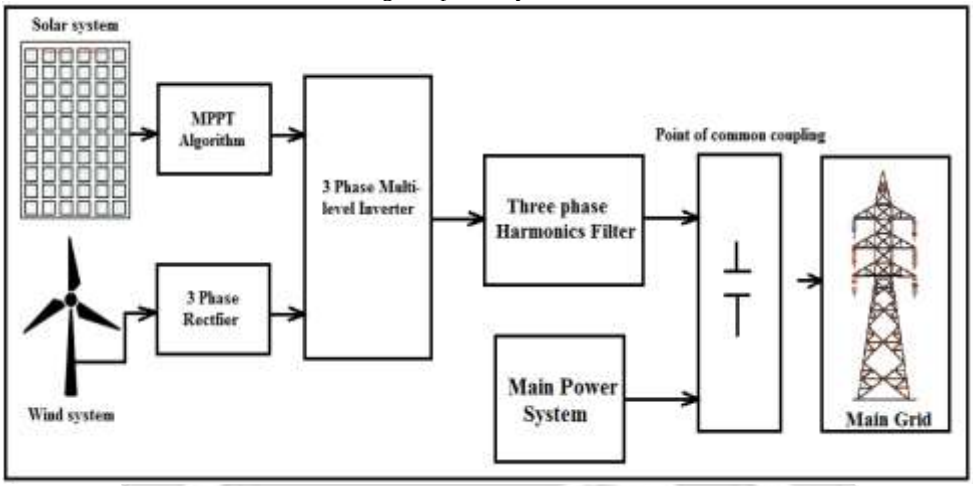

Fig.3:- Block diagram of proposed hybrid power system.

3. MATLAB SIMULATION MODEL

In this section, proposed methodology shown in figure 3 implemented using MATLAB Simulink software in which Sim power system toolbox utilized for hybrid power system design, wind energy system design, solar pv system, battery energy system and dc to dc converter subsystem design. Figure 4 shows the complete MATLAB simulation model of proposed approach.

3.1 Hybrid power system model

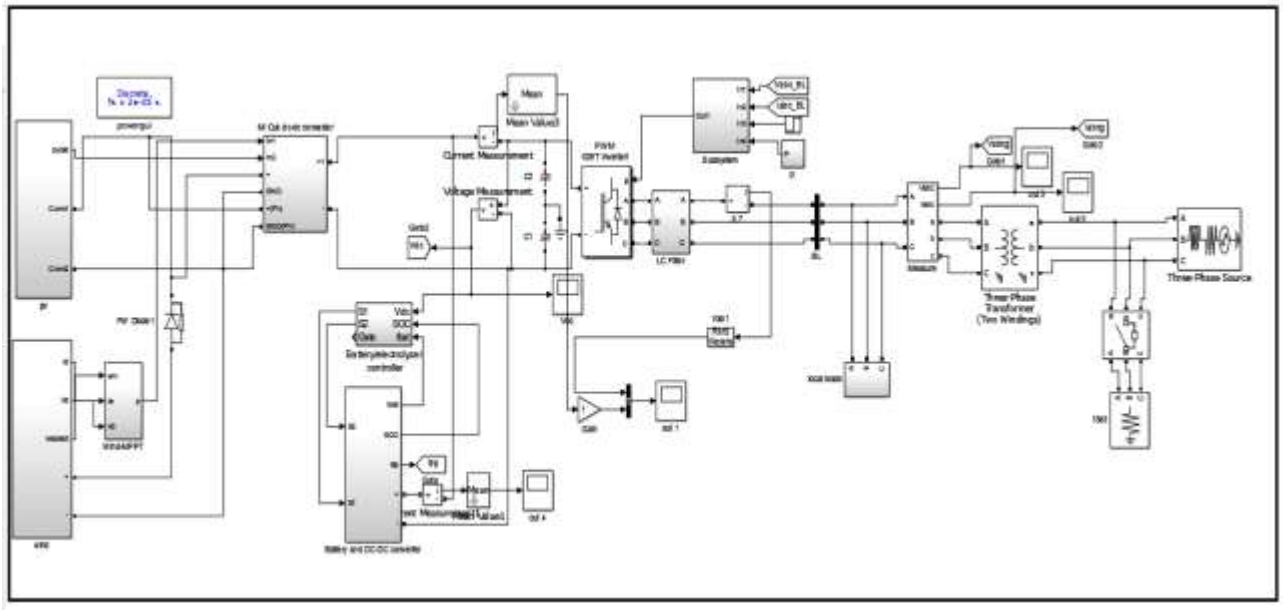

Fig 4:- Complete MATLAB simulation model of proposed hybrid power system.

Table 1:- MATALB Simulation model parameter for hybrid power system model.

Sr No	MATLAB simulation block	Parameters Specification
1	Solar PV system	Power output = 1KW

2	Wind energy system	Output dc current =50 Amp; Output ac power = 1000 W
3	Battery energy system	Voltage = 200V; Ampere hour rating = 6.5 Ah.
4	Universal bridge (Inverter)	Snubber resistance = 5000 Ohm; Ron = 1 mOhm.
5	Three phase transformer	Nominal power = 73 KVA; Frequency = 50 Hz; Primary voltage = 75 Kv; Secondary voltage = 2.4 Kv.
6	Three phase source (Alternator)	Phase to phase Rms voltage = 2.4 KV; Frequency = 50Hz; Short circuit level = 25 KVA; X/R ratio = 7.
7	Local three phase load	Nominal phase to phase voltage Vn= 420V; Nominal frequency = 50 Hz; Active power = 10 KW; Inductive reactive power = 100 VAr.

3.2 Solar PV subsystem model

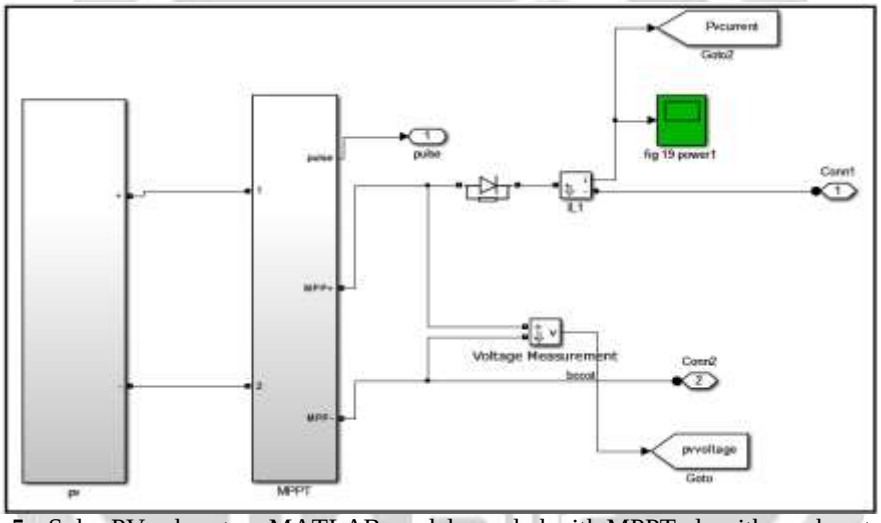

Fig.5:- Solar PV subsystem MATLAB model coupled with MPPT algorithm subsystem.

Figure 5 shows the solar pv subsystem in which solar pv cell output dc terminal connected with maximum power point tracking (MPPT) algorithm block for calibrating or tracking maximum solar dc output voltage according to irradiation available at atmospheric condition.

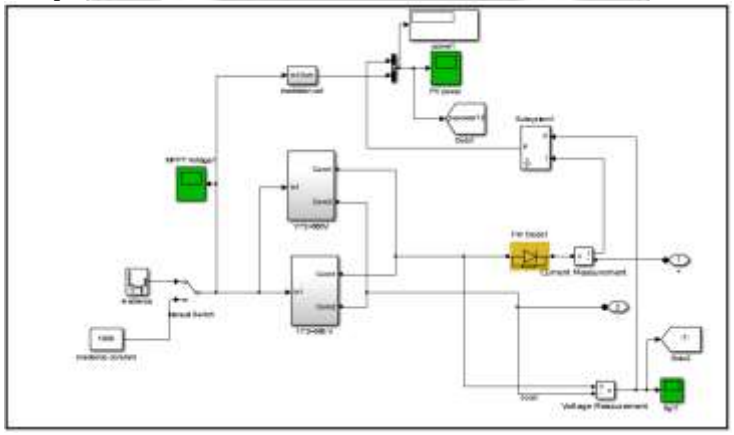

Fig.6:- Solar PV cell interconnected subsystem MATLAB model.

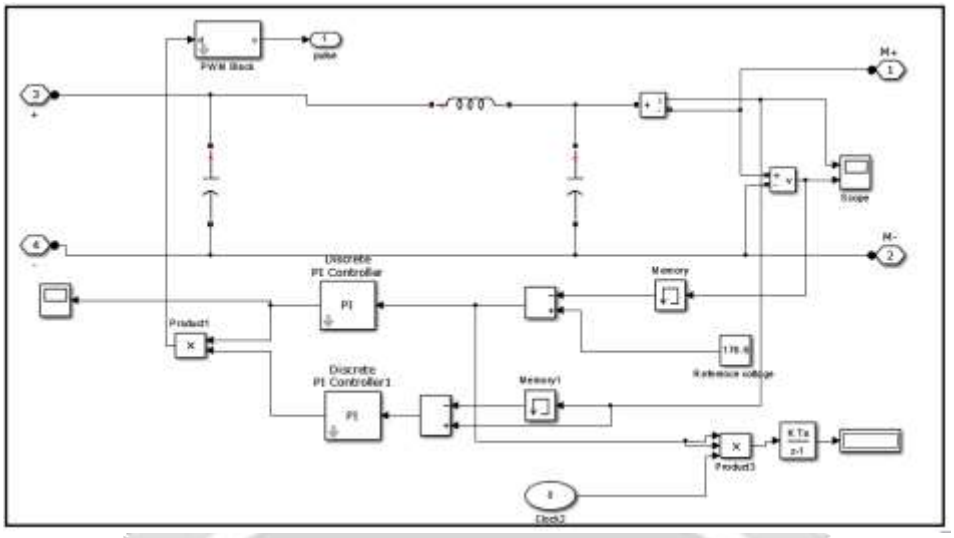

Fig.7:- MPPT algorithm subsystem MATLAB model.

3.3. Wind energy subsystem model

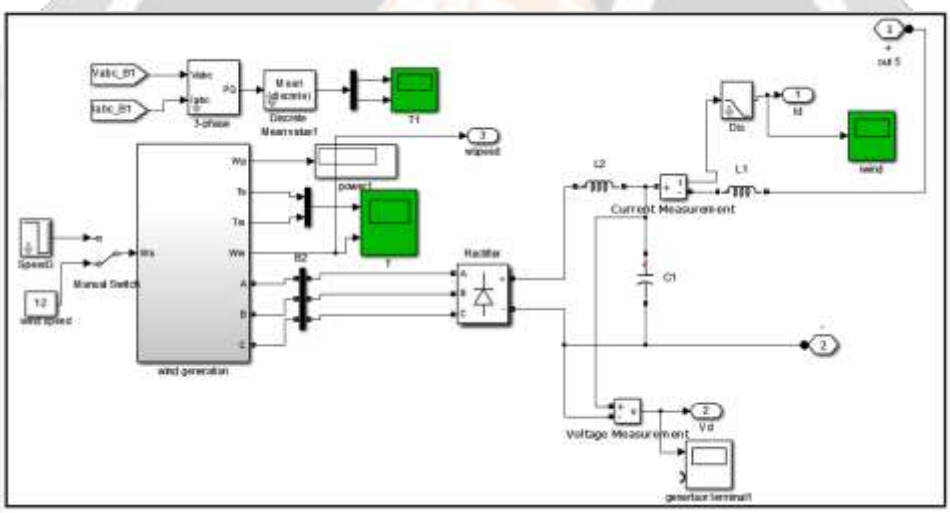

Fig.8:- Wind energy MATLAB subsystem model.

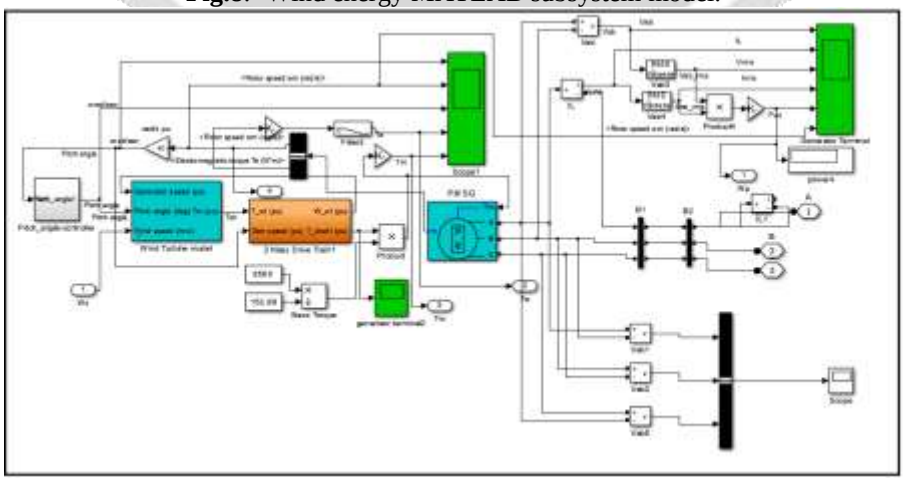

Fig.9:- Wind energy controller subsystem, generator, and mechanical subsystem.

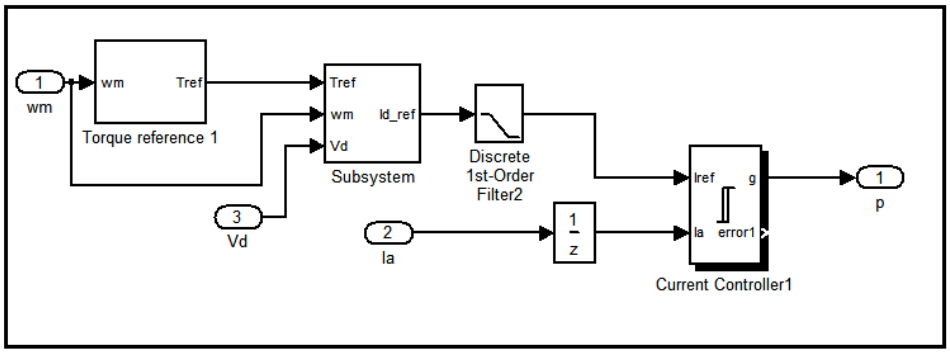

Fig.10:- Wind energy MPPT subsystem MATLAB model.

Figure 8 shows that wind energy turbine system in which wind turbine generates the AC three phase power then transfer to rectifier circuit for conversion of AC power to DC power. Because solar power system output becomes in DC form but wind energy generator power in AC form then for coupling both the solar and wind energy system we need to convert wind energy AC power into DC power with equal magnitude.
Figure 9 shows the controlling mechanism for wind energy system which control the wind turbine wind speed, mechanical torque, mechanical input, speed of turbine. Also wind turbine consist of three phase AC alternator which generates the AC power also control by controller circuit.

3.3. Cuk DC-DC convertor subsystem model

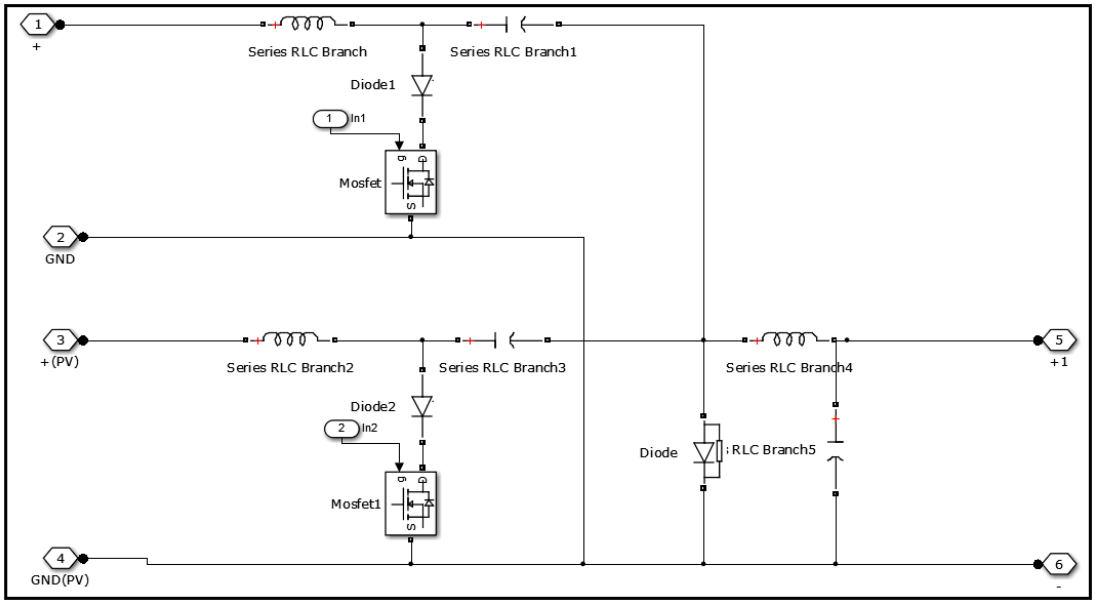

Fig.11:- Cuk DC-DC convertor MATLAB subsystem model.

Figure 11 shows that DC-DC cuk converter which convert variable DC input in constant DC output. That convertor coupled both solar power and wind energy system with same amount of DC power magnitude. This variable dc power received from solar and wind system then convert into constant DC power. This constant dc power then fed to inverter for generation of three phase power which coupled with main power system.

3.4. Battery subsystem model

Figure 12 shows the battery subsystem MATLAB model, which coupled with main power system using three phase inverter circuit. That battery system stored the energy during normal power system operation and utilize this stored power during abnormal atmospheric condition at which wind or solar pv system not available.

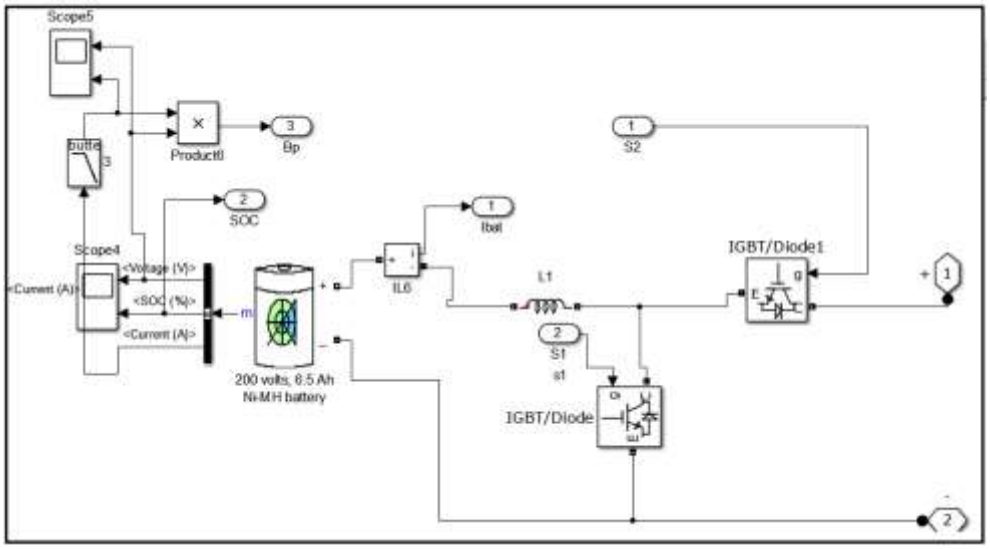

Fig.12:- Battery subsystem MATLAB model.

3.5. LC filter subsystem model

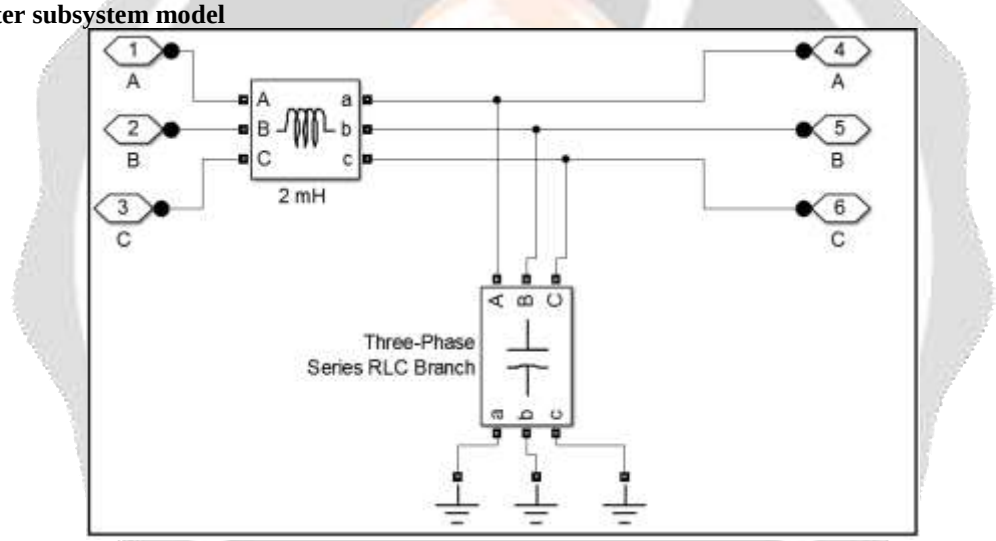

Fig.13:- LC three phase filter bank.

Figure 13 shows the three phase LC filter circuit for removing harmonics and flickers from inverter output. That output voltage then coupled with main power system.

4. MATLAB SIMULATION RESULTS

In this section we discuss the power system parameter for coupling solar pv cell and wind energy system with power system. Also analyzed the effect of solar system and wind energy system on different power system parameters. The different power system parameters shown as follow:

4.1. Power system voltage and current

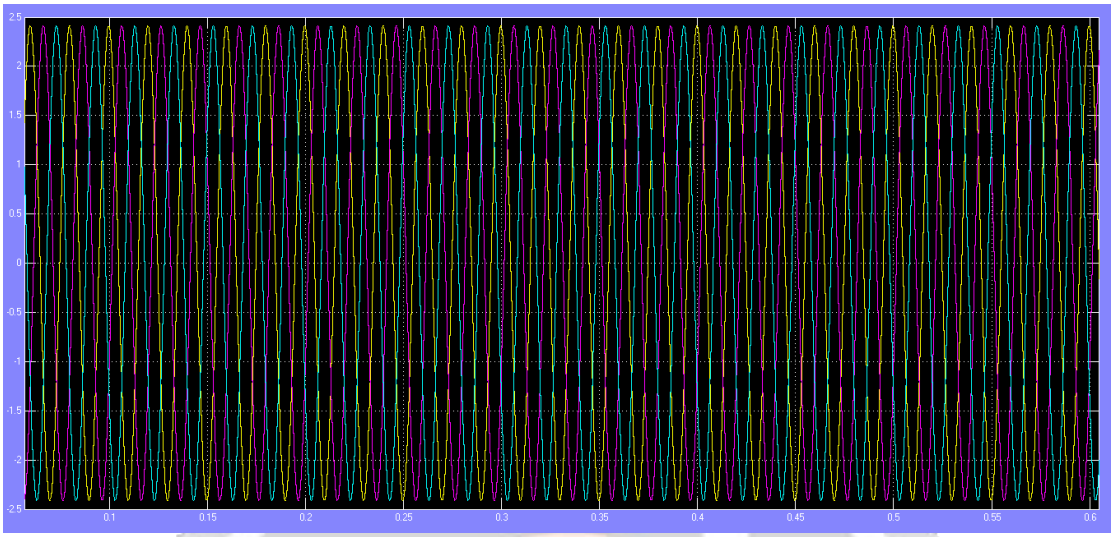

Fig.14:- Power system three phase current with integration of wind and solar system without interruption.

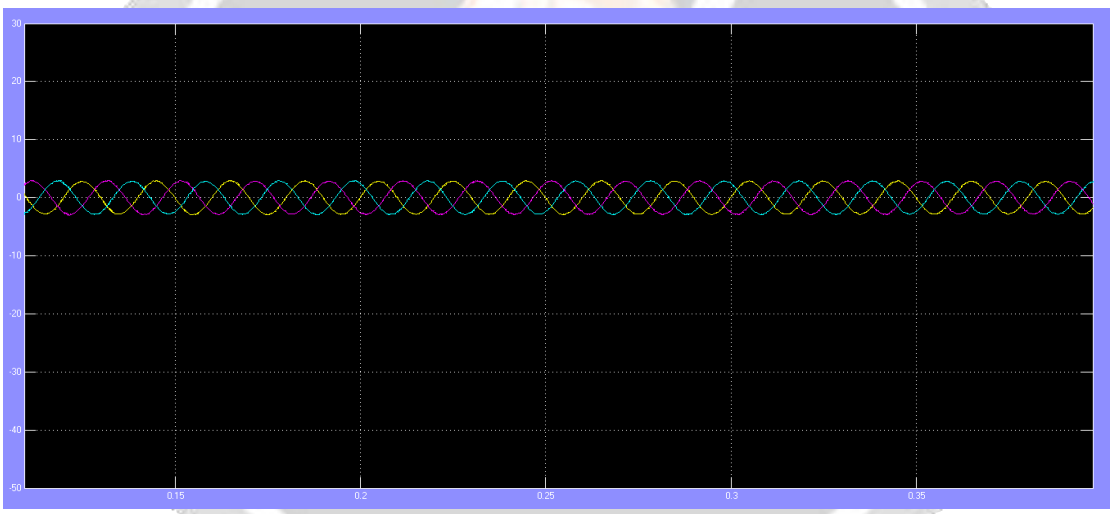

Fig.15:- Power system three phase voltage with integration of wind and solar system without interruption.

4.2. Solar PV system parameters

Fig.16:- Solar pv system constant power output waveform.

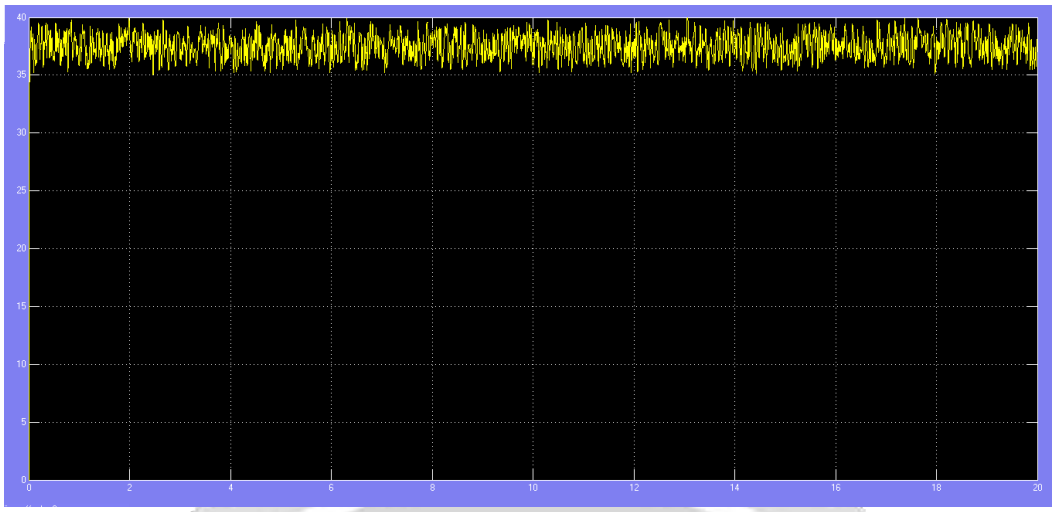

Fig.17:- Solar pv system load current.

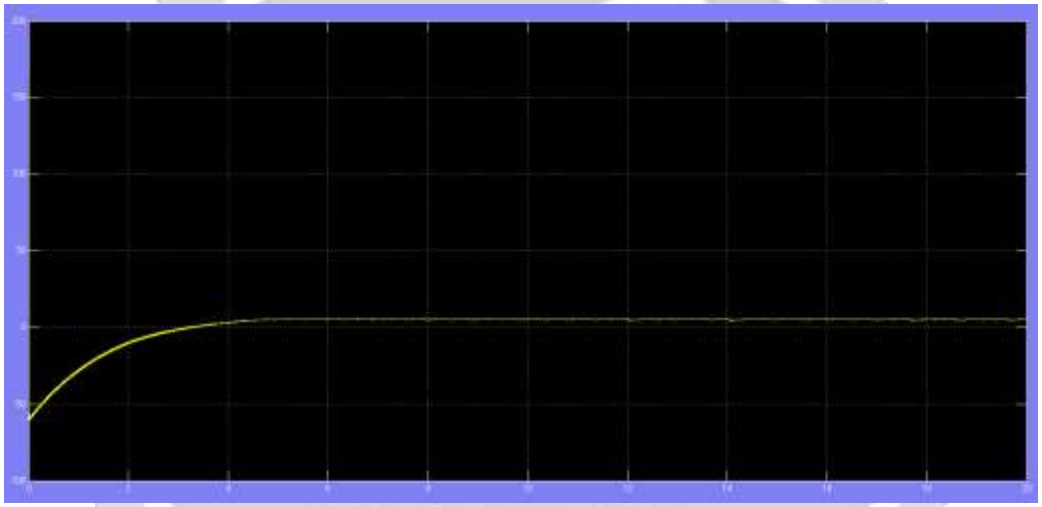

Fig.18:- Solar pv system output voltage.

4.3. Wind energy parameter

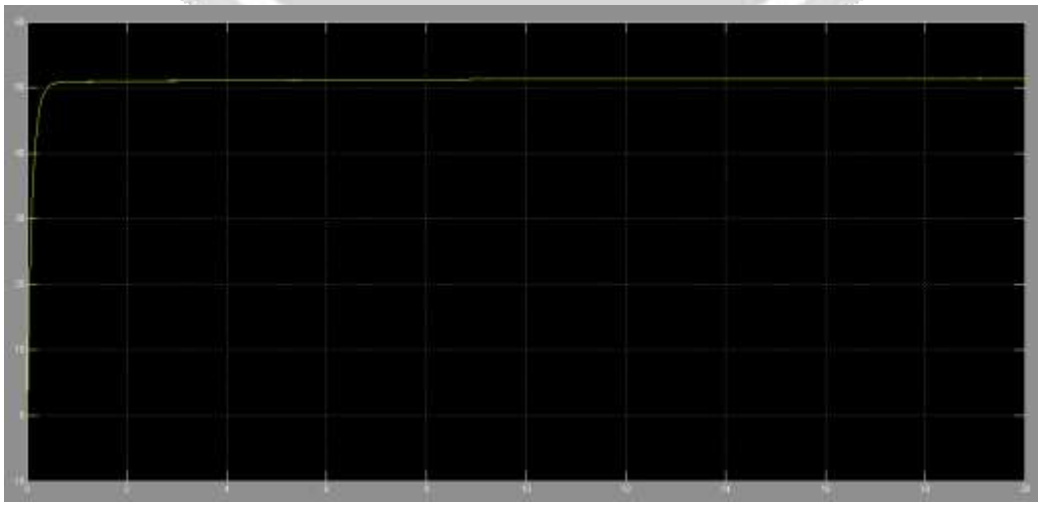

Fig.19: Wind energy power system output current.

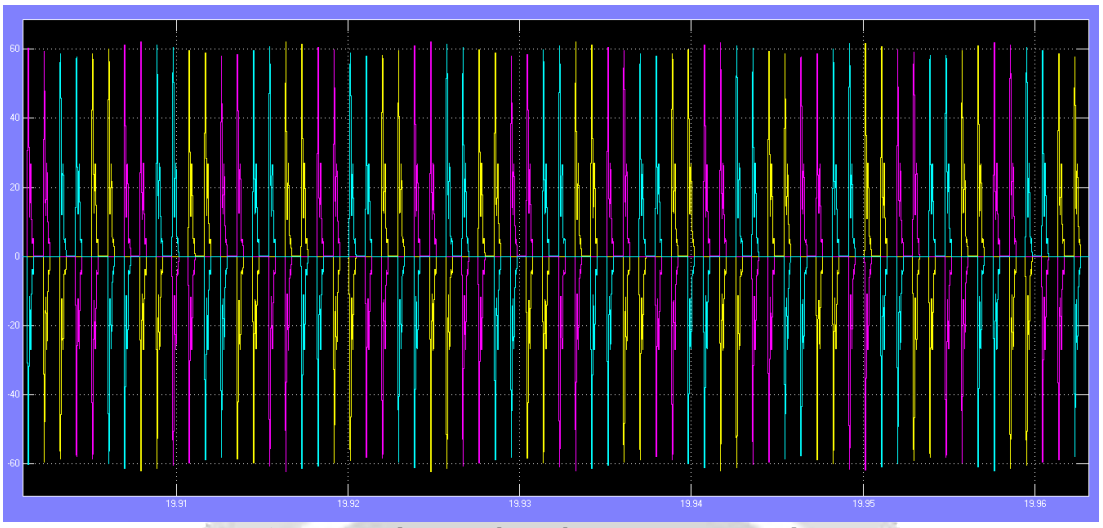

Fig.20:- Wind energy three phase power output voltage.

4.4. Battery parameter

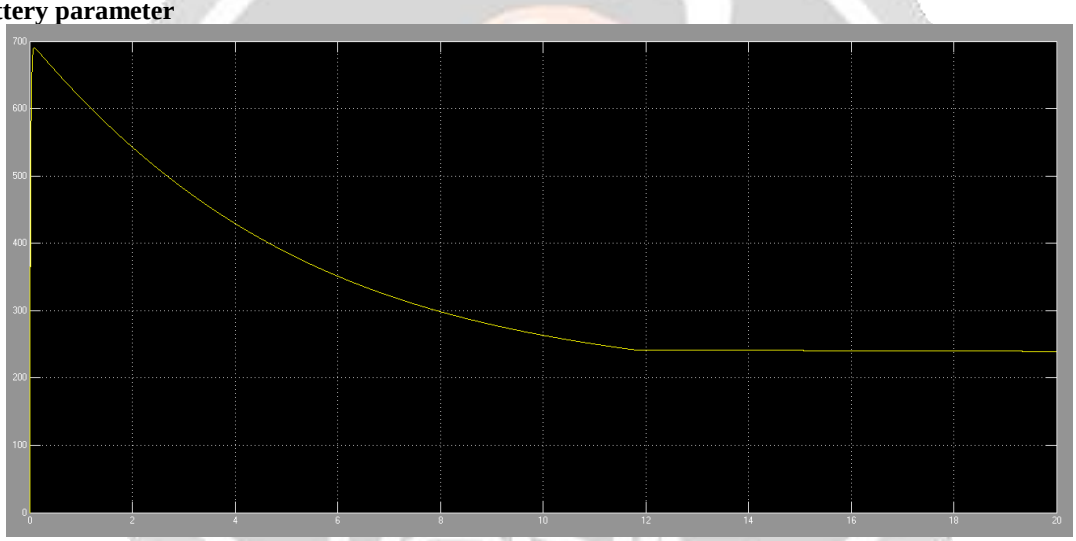

Fig.21:- Battery system output dc power.

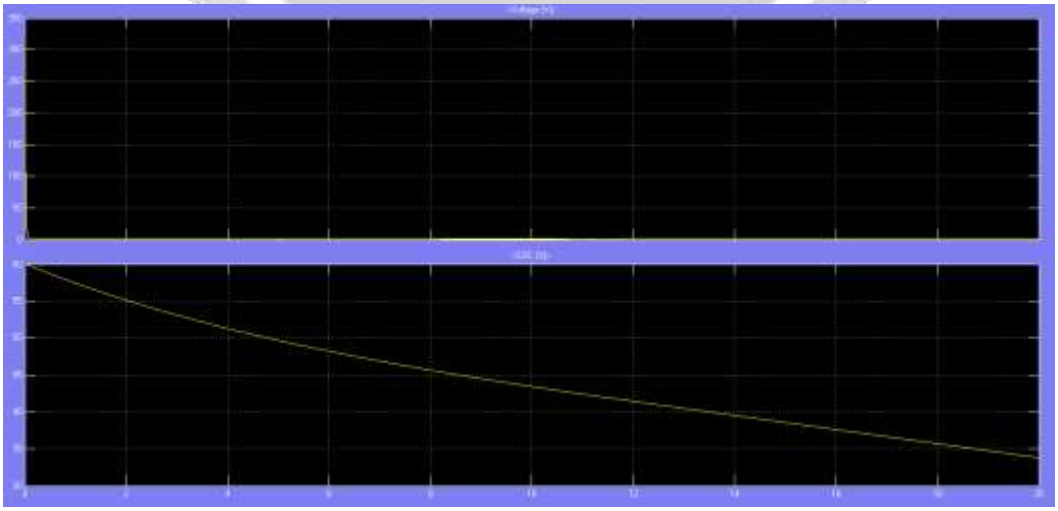

Fig.22:- Battery output dc voltage and battery state of charging (SOC).

5. CONCLUSION

This paper presents a renewable energy hybrid power system that based on photovoltaic (PV) and wind. The wind and PV energy are suitable for hybrid system because they are environmental friendly and widely available in India. However, the hybrid power system that solely depends on the intermittent renewable energy sources will generate a fluctuating output voltage that leads to damage to the machines that operate on a stable supply. The modeling of the hybrid system with cuk converter, three phase inverter and LC filter is build using MATLAB Simulink.

Different irradiance value and varying wind speed are the input parameters for the project simulation. The results show that hybrid system has greater reliability in terms of output voltage generation as compared to standalone system. In addition, Diode Clamped Multi-Level Inverter and LC filter that installed in the hybrid system is able to reduce the fluctuation output voltage.

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