Charging Electric Vehicles with Energy from Wind, Photovoltaics and Hybrid Energy Storage System

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Abstract

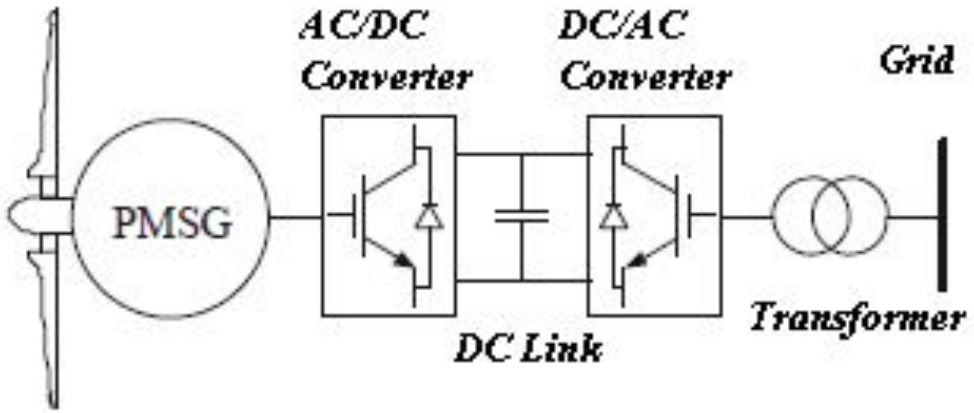
- As there is a rise in both population and pollution and depleting the natural resources, renewable energy systems are used for the eco friendly usage of power.
- In this project, renewable sources like wind and solar power are used to supply the load.
- Hybrid Energy Storage System (HESS) is implemented to have a look at the working of the battery in case there are any emergencies.
- All these 3 systems are implemented to observe the working of the load in different systems that are modelled and simulated.

- **KEYWORDS**: Electric Vehicles (EVs), DC Micro-grid, Hybrid Energy Storage Systems (HESS), Solar energy, Wind energy, MPPT algorithm, rectifier, inverter, chopper

Introduction

- New challenges to the stability, integrity and reliability of the utility grid arise because of the limited resources which comprise an increasing percentage of system generation capacity as compared to the traditional hydraulic and thermal synchronous generation.
- These adverse effects on the utility grids can be reduced by combining energy storage with renewable sources .
- Hybrid and hybrid electric technologies are performing a key role in increasing the fuel efficiency and declining the outflows of new EVs. In all these technologies, energy storage systems are an integral part.
- Because of their relatively higher capacity, long lifetime, high energy, less cost and environmentally friendly nature, NiMH batteries have become the most desirable storage systems.
- The proposed system is a combination of photovoltaic solar power, wind power and NiMH battery energy storage into a DC microgrid–based charging station for EVs(or a generalised load).

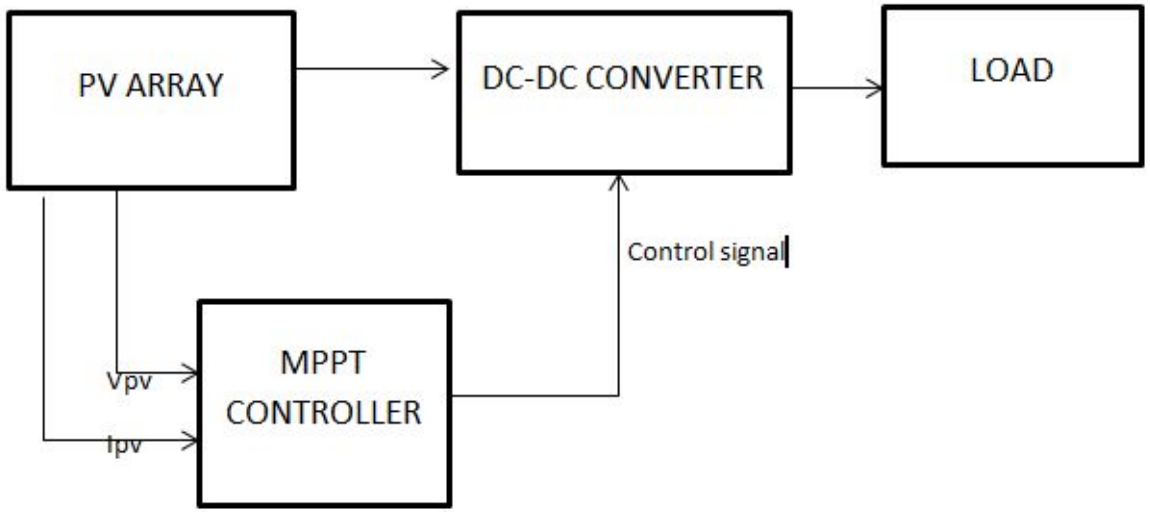
Methodology

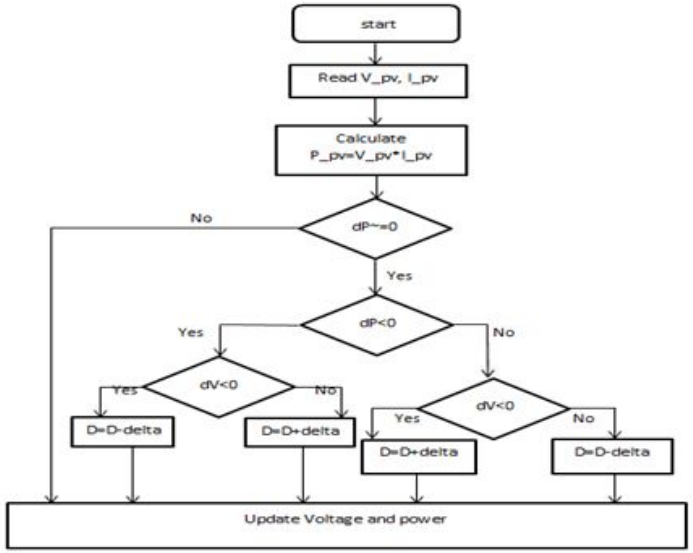


❖ Wind Energy Harvesting

1. Harvested via a combination of turbine and generator.
2. Power generated depend on: turbine's performance coeff., density of air, tip speed ratio, blade pitch angle , and velocity of wind.
3. Safe mode of operation, wind speed between cut in and cut out speeds.
4. PSMG: Permanent magnet synchronous generator, high efficiency
5. 3 Phase AC output rectified to DC. Can be boosted to higher voltage and fed to grid via a three phase inverter.

Methodology



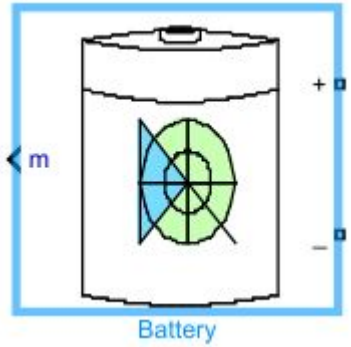


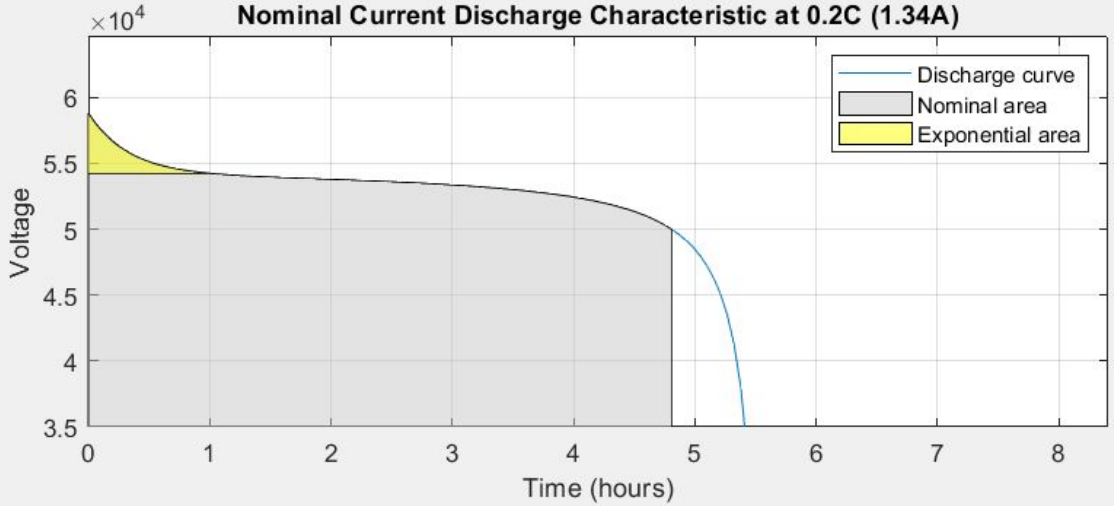
❖ PV model

1. The model consists of PV array, DC-DC converter, MPPT controller as shown in the schematic.
2. PV array depends on Irradiance and temperature parameters.
3. DC-DC converter is used as an interface to transfer power from the source to load.
4. MPPT controller is used to transfer maximum power as possible from PV array. Through we can reduce the use of non renewable sources for generation
5. The algorithm implemented to design the MPPT controller is Perturb & Observe algorithm.

(flowchart)

Methodology

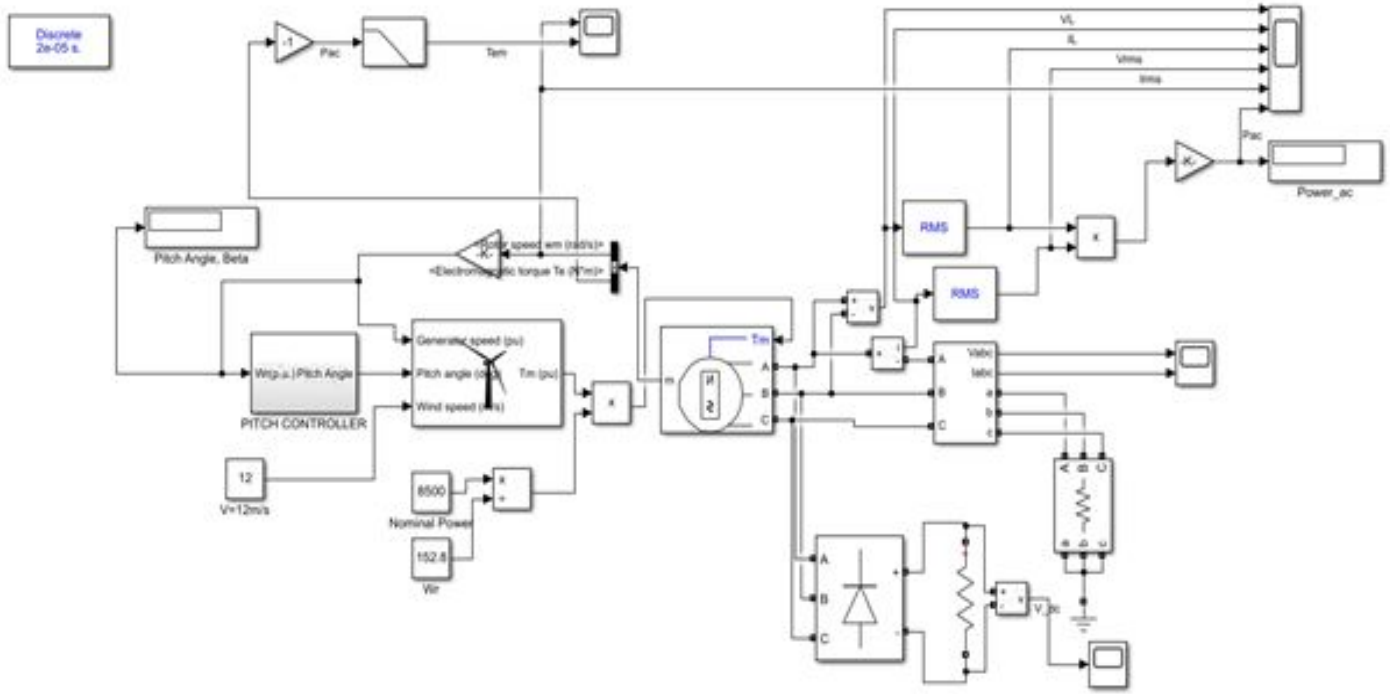




HESS:

- HESS is defined as at least two energy storage systems with similar properties that are integrated together in a circuit or grid as a source
- The objective is to compensate the drawbacks of one ESS with the other and add the advantages of the two together
- In previous studies, battery was found out to be a promising storage device due to its fast charge and discharge cycle and is suitable for long and short storage storage cycles.
- We used two Nickel metal hydride batteries to maintain the power delivered to load and improve the lifecycle of the system

Modelling and simulation



Wind Energy Harvesting

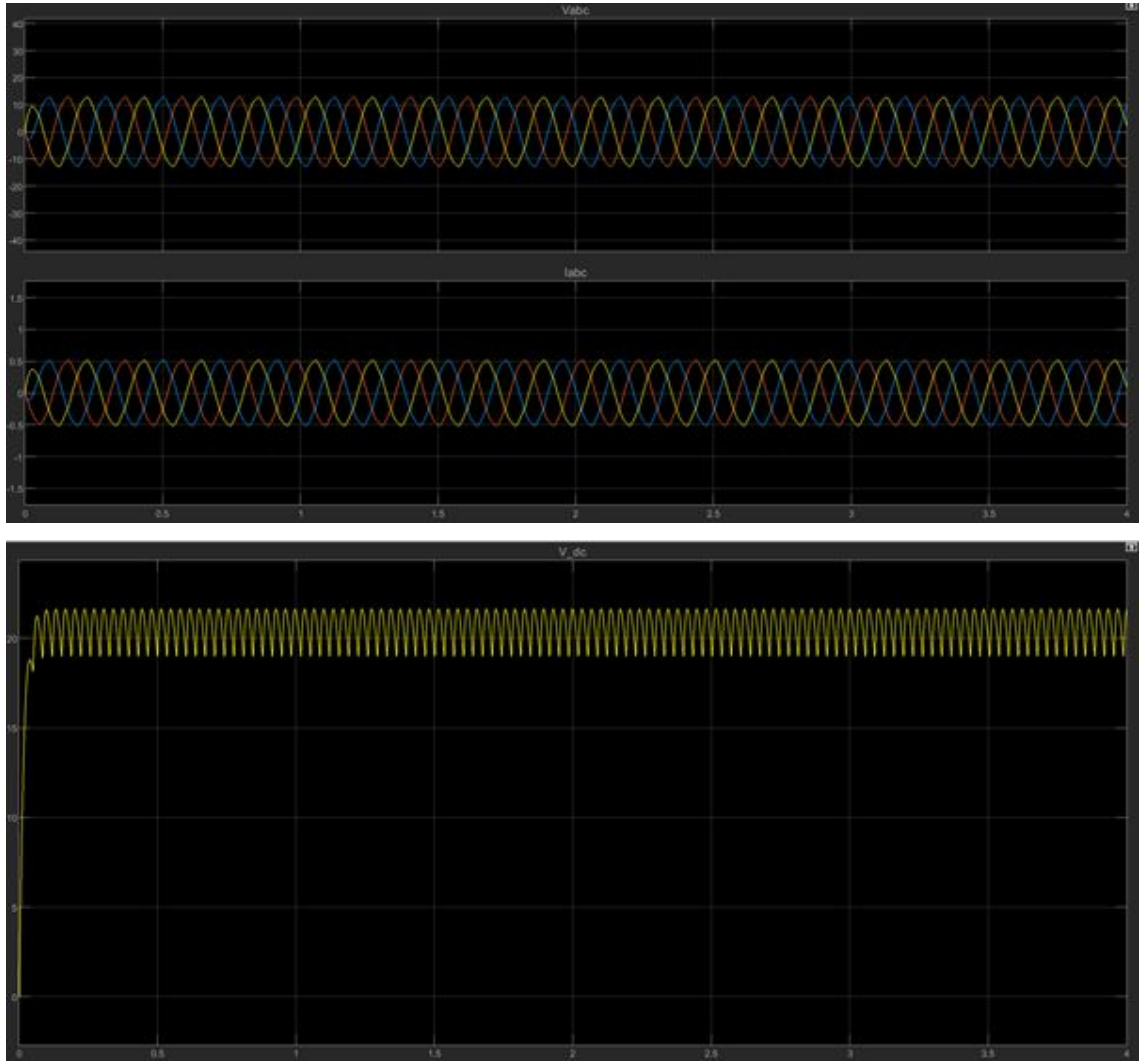
Components:

- Discrete Powergui Block
- Pitch Controller
- Wind Turbine
- PMSG Machine
- Rectifier- Universal Bridge

Conditions:

- 12 m/s constant wind speed
- Nominal Power O/p=8500 W
- 3 Phase Wye load of 25 Ω

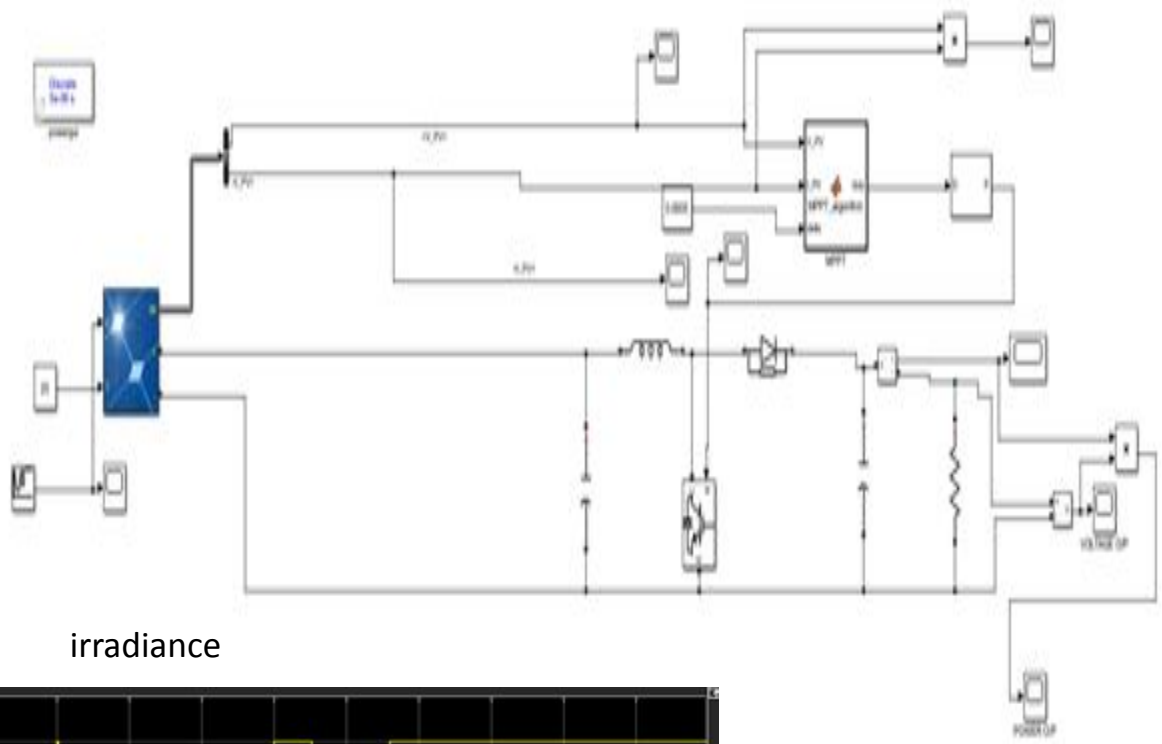
Results



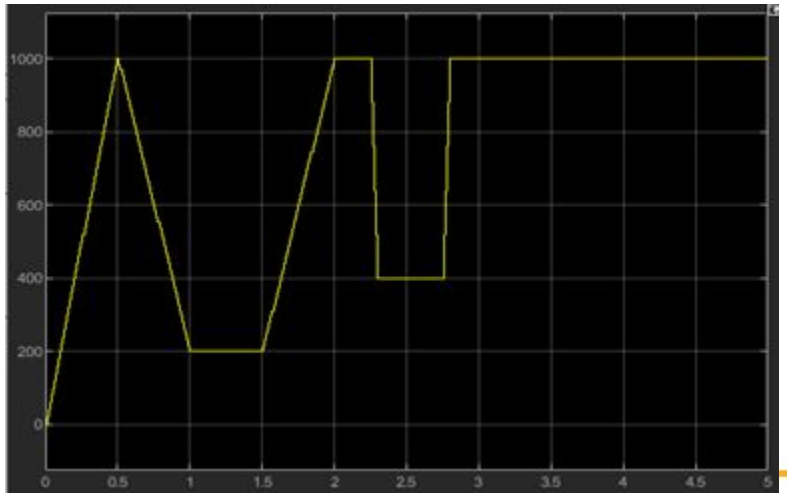
❖ Wind Energy Harvesting

1. Pitch angle between 0.035-0.04 deg.
2. 3 Phase Voltage and current generation
3. Rectified Voltage plot

Modelling and simulation



irradiance



- **Solar array**

Components:

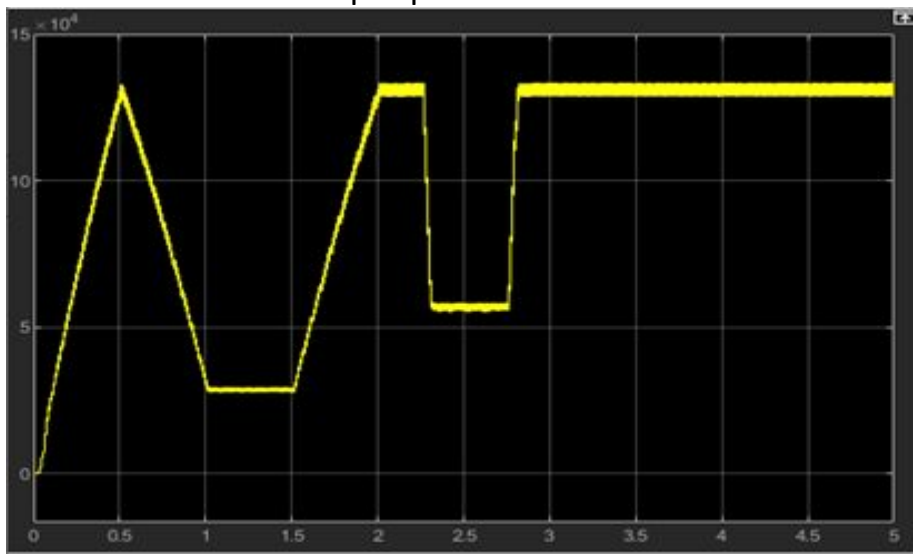
PV array (264 in parallel and 7 in series)
MPPT controller
DC-DC converter (boost)

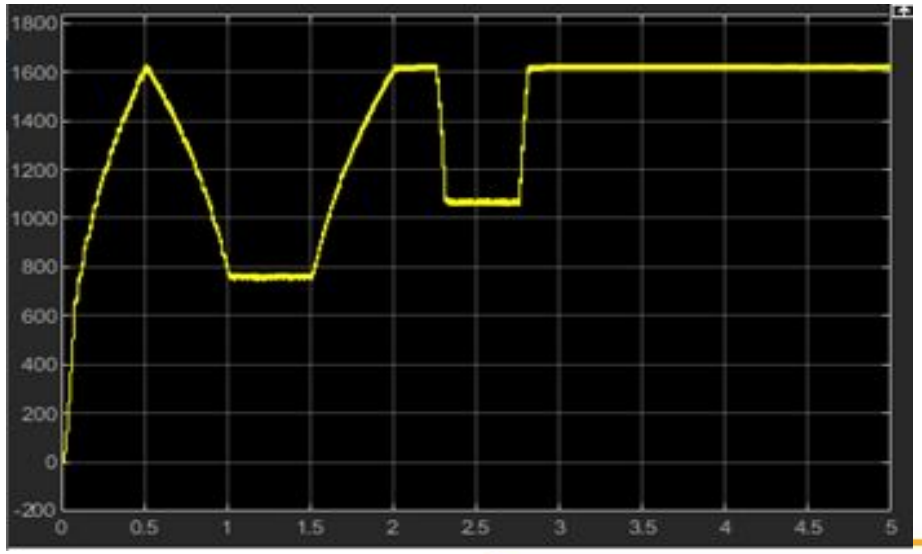
Conditions:

Temperature 25 degrees
Irradiance (varying between 0 and 1000W/m^2 for 5 seconds as shown in figure)

Results

output power



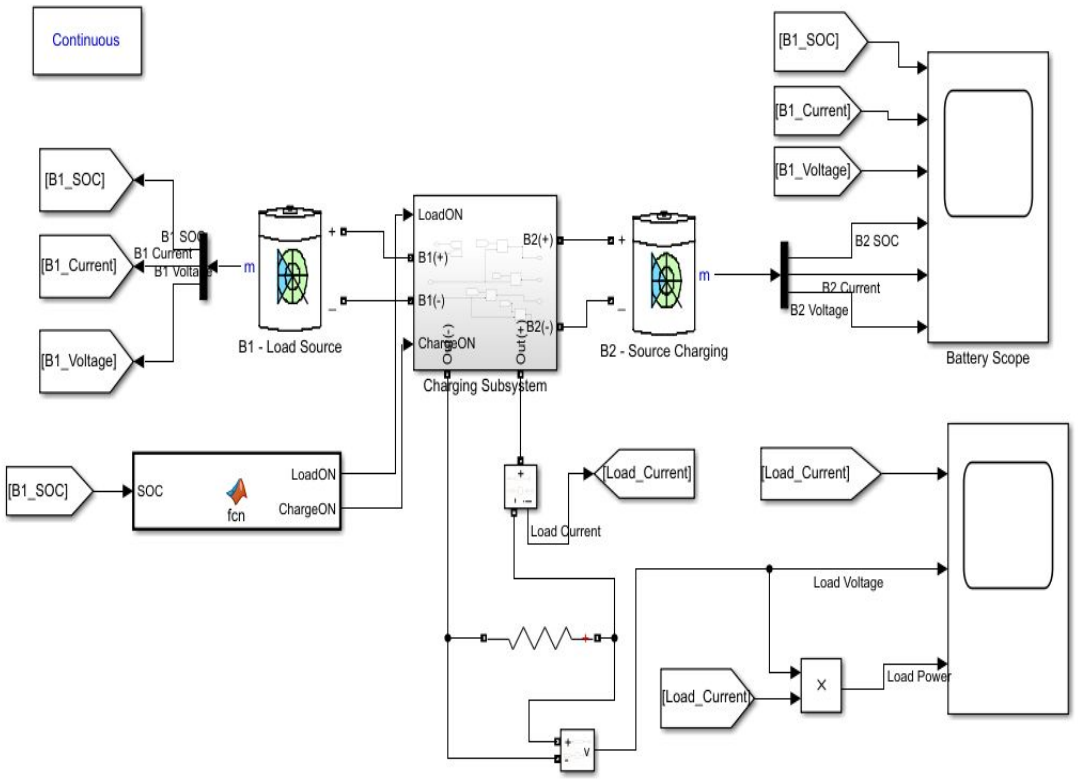


- **Solar array**

1.Output power for different conditions of irradiance and temperature.

2. Output voltage

Modelling and simulation

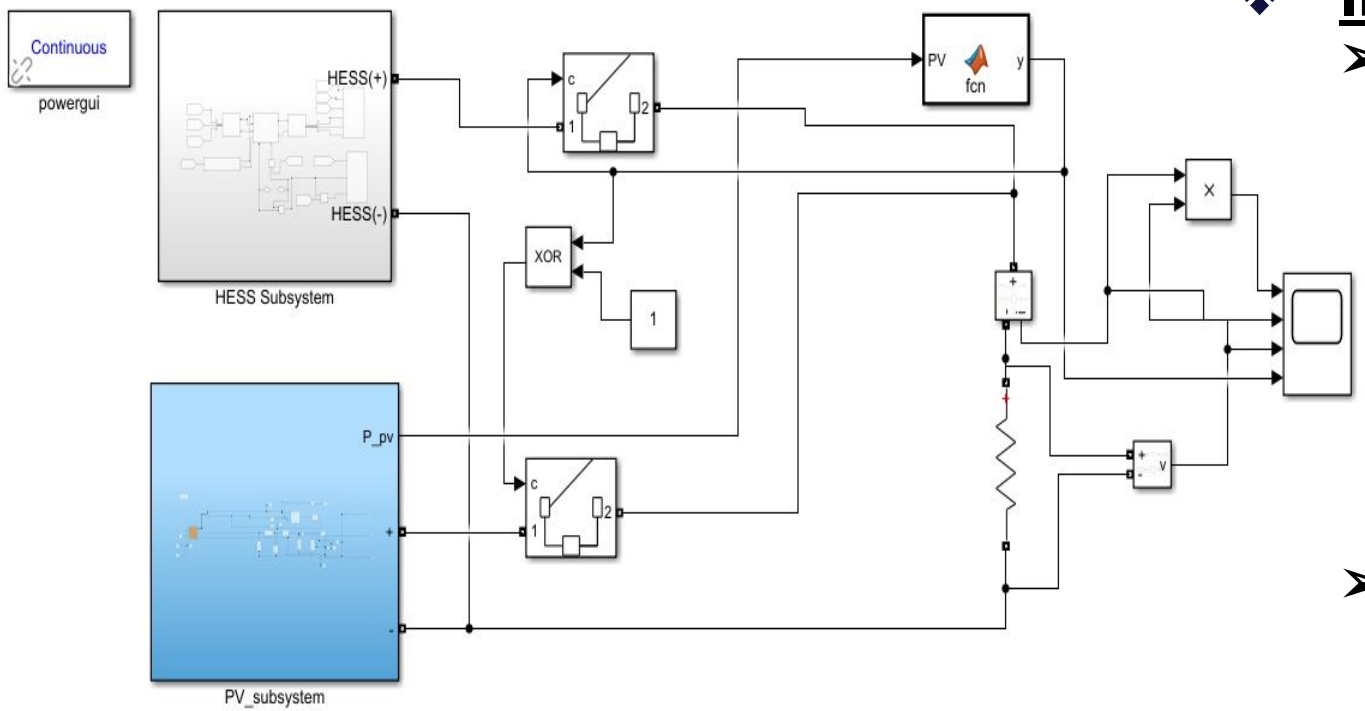


Hybrid Energy Storage System

- Components:
  - Batteries B1 (Source) and B2 (to charge the source)
  - Matlab function to control switching
  - Circuit breakers
  - R load

- Circuit Characteristics:
  - When B1 SOC drops to 40% which is the minimum efficient SOC, B1 starts charging from B2
  - Once B1 charges to 100% SOC, it disconnects from B2
  - B1 charges while still delivering power to load

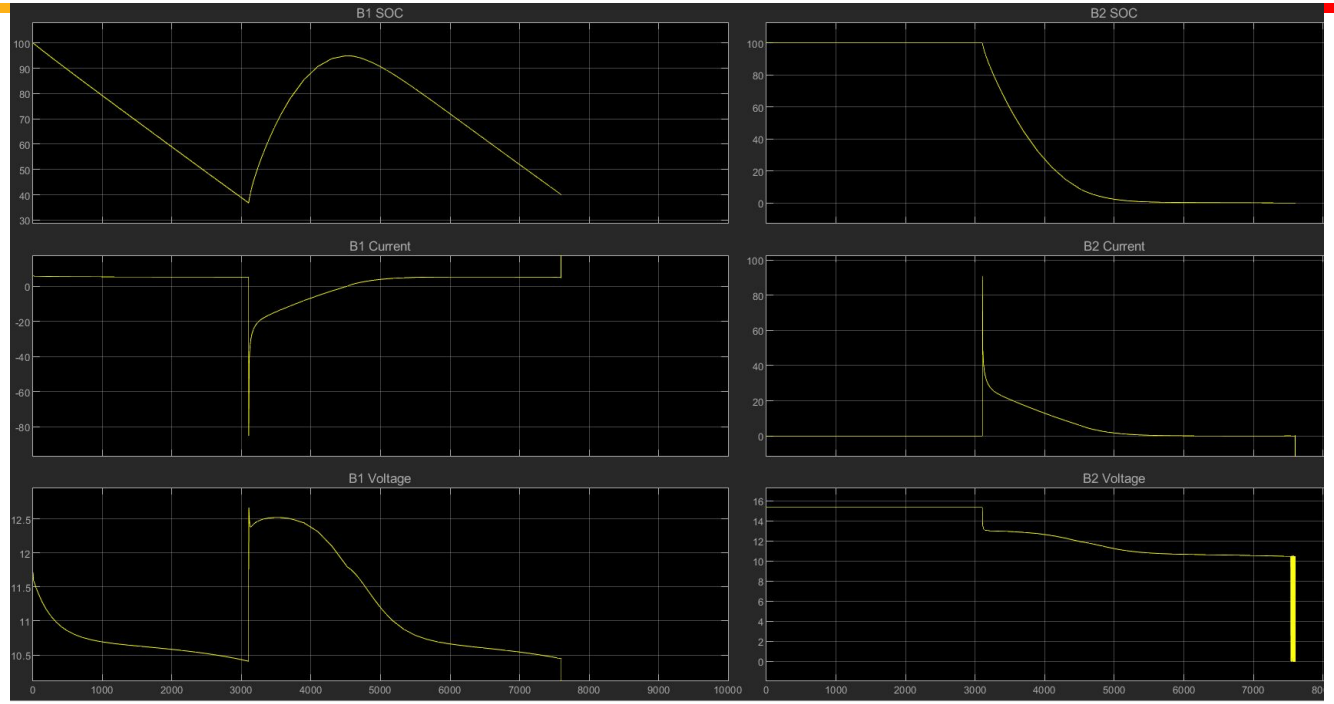
Modelling and simulation

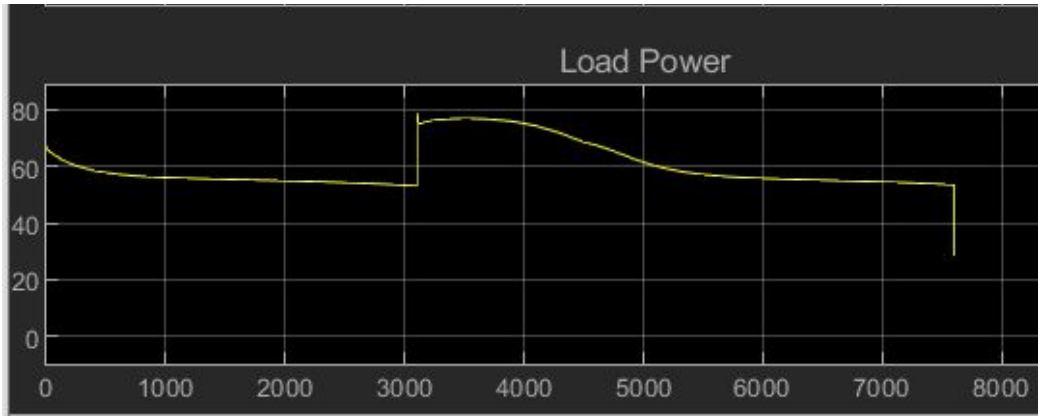


Integrated Circuit:

- **Circuit Design:**
  - Integrated HESS and PV Subsystems
  - The circuit switches to HESS as a source when PV's power supply drops below threshold
  - Introduced error in PV power generation to simulate random cloudy weather
- **Components:**
  - PV subsystem
  - HESS Subsystem
  - Circuit breaker
  - Matlab function
  - R load

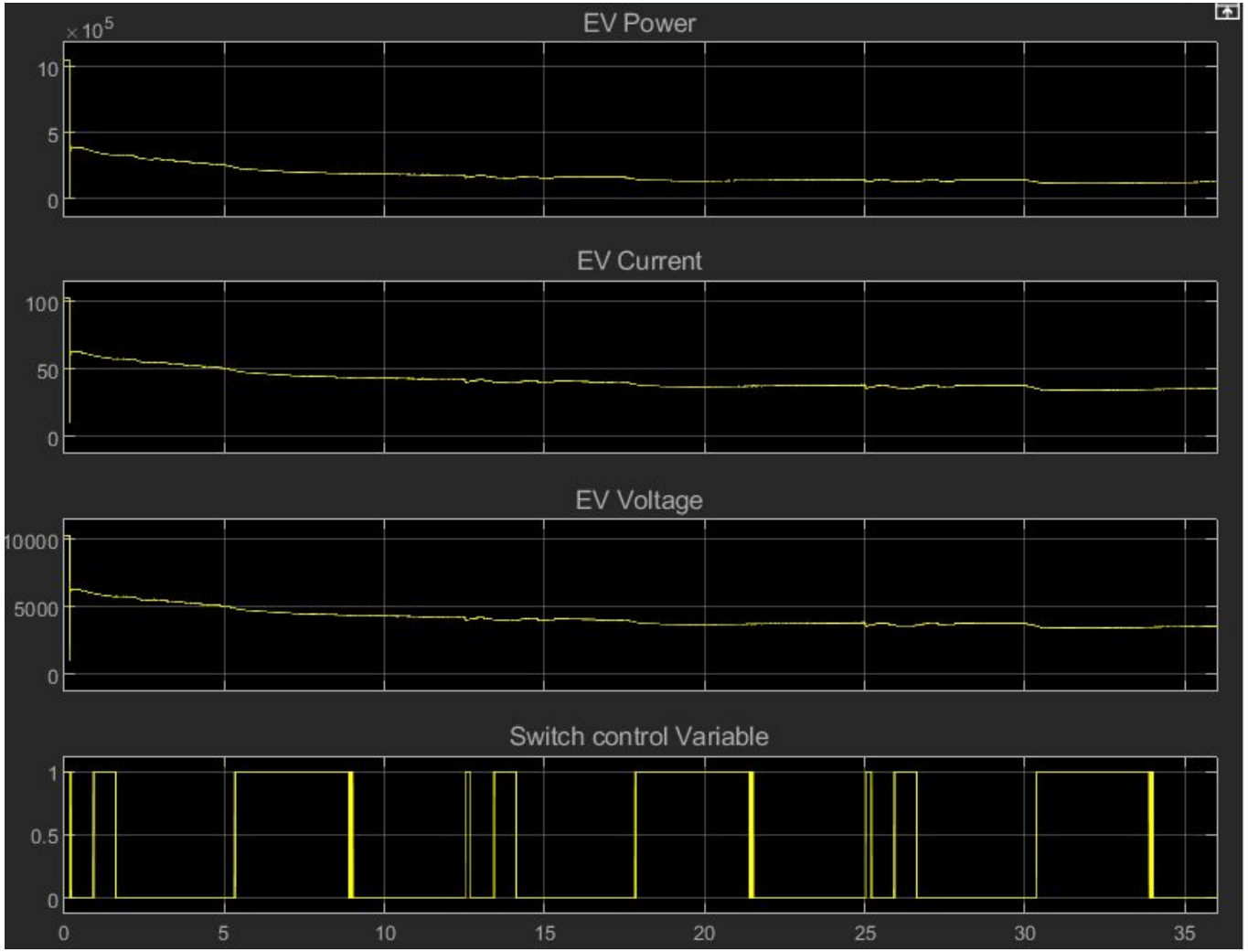
Results





- **HESS:**
  - Battery B1 charged from B2 until B2 SOC dropped to 0
  - The power delivered to load is sustained
  - Performance of the source is maintained and prolonged

Results



Integrated Circuit:

- Power delivered to load is maintained
- This circuit can be further modified to include wind subsystem and supply power to a grid
- The HESS subsystem can be modified to be charged from other renewable energy generators when not in use

Conclusion

- This study proposes a hybridization of the traditional fossil-fuel based power generation systems by integrating them with renewable energy resources like wind and solar power, thereby providing a simple and cost-efficient solution to the problem of energy shortage.
- The excess power generated by these sources is stored in a hybrid battery storage system to ensure continuity of power supply to the load in case of emergencies.
- The project fulfil the aim of maximising delivered power of Renewable Energy resources like wind and solar energy to the grid while still having a reliable power supply, an Energy Storage System(ESS).
- When the renewable energy sources produce excess power, it is stored in the hybrid batteries and when they fall short of the energy demand, energy is supplied to the load by the power stored in the hybrid batteries.
- The design and comprehensive modelling and simulation results of various components of the Hybrid Renewable Energy System like wind, solar photovoltaic, and Energy Storage Systems with their corresponding control functions and algorithms have been described and presented in detail.

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