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INCREASING GRID EFFICIENCY BY INTERFACING PV & FUEL CELLS THROUGH AQUA MEDIUM

Mattapudi Jo Babu
Prasad V Potluri Siddhartha Institute of Technology

ABSTRACT
1. The grid efficiency depends on the efficiencies of energy sources and transmission losses. Feeding of the grid takes place by different energy sources like Photovoltaic cells, Thermal & Hydraulic power plants. In conventional grid, during peak load PV modules supply energy to loads & during off peak loads energy is stored using batteries. For greater energy storage batteries like lithium-ion is inefficient, costlier & not compact in nature. The Idea is to replace the convention batteries with fuel cell. The fuel cell having 80% efficiency, compact & reliable. The fuel cell generates the electrical energy by taking hydrogen & oxygen (atmospheric air) as input. During off peak time the photovoltaic cell generates electrical energy from sunlight & convert it into hydrogen gas using electrolysis process. The generated hydrogen at daytime using electrolysis by utilizing solar energy, is stored in hydrogen cylinders & this hydrogen gas is supplied to fuel cells whenever energy deficiency occurs in grid during daytime or night time. The fuel cell consumes supplied hydrogen & atmospheric oxygen, generates Electrical energy & water as by-product. The water generated at fuel cell again supplied to electrolysis chamber at photovoltaic cell it is known as PVFC Aqua Cycle. So using this method there is no need of battery usage. In MATLAB, electrolysis simulation is done by the current signal from solar panel, current signal is used as the control signal for hydrogen fuel at fuel cell. The PVFC Aqua Cycle system reduces water consumption. We can also extract the hydrogen using Photo catalytic paint which takes solar energy & water moisture in air as input to produce hydrogen. The efficient method for generating hydrogen in environmental friendly is by using electrolysis which provides high molar rate of production. The main advantage of the energy storage system it can store large quantities of energy which is fictional normal conventional batteries. The maintenance cost of the system is also less, compact in nature.

2.1 HYDROGEN TANK

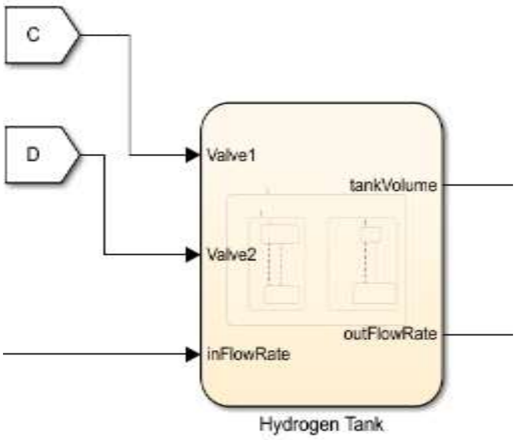


Fig2.1(a) Hydrogen tank.

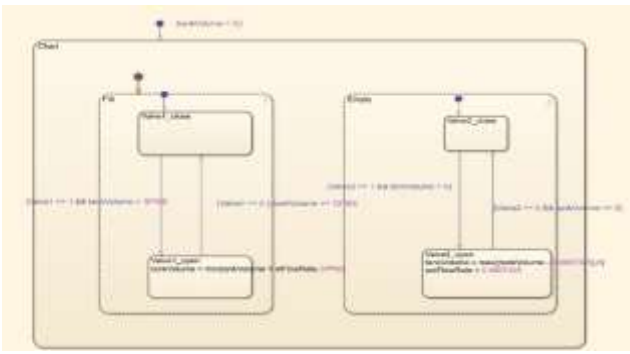


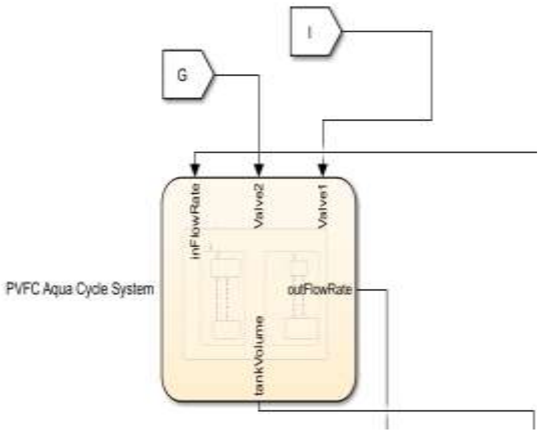
Fig2.1(b) Hydrogen tank LM

2.1.1 Function of the Hydrogen tank : The hydrogen tank is driven by the inflow & Outflow regulators & valve commands taken from energy regulatory switch. It will collect the hydrogen from the Electrolysis chamber through inflow regulator & stores the hydrogen in the scale of litres per minute. The stored hydrogen us supplied to the fuel cell. The storing of hydrogen starts at off peak load valve one opens & hydrogen supplies if valve one is closed & valve two is open as shown in figure 2.1(a) The A tag represent the command input for valve one & similarly for valve 2.

2.1.2 Logical Implementation: The hydrogen tank takes three inputs & two outputs. The three inputs are Valve one, valve two on & off, Inflow rate is also as input. The outputs are the outflow rate & tank volume. Valve one operation if the input is one & tank volume is less than the 1000Lites then valve one will open. Valve two operation is that if valve two input equals one and tank volume will be greater than zero than the valve two will open. The Inflow rate will works as tank volume is equals to tank volume plus inflow rate. The outflow rate works as tank volume is equals to the tank volume minus outflow rate. The Inflow rate is input from the Electrolysis chamber whereas outflow rate is input to the fuel cell. The outflow rate is defined based on the requirement of the fuel call input. Which is provided constantly until the volume is less than the Outflow rate, the job is done by the outflow regulator. The Electrolysis chamber gives output of hydrogen in the form the moles but the hydrogen takes the input as litres, the job is done by the inflow regulator. The entire system is regulated & operated by the energy regulatory switch without manual operation such that the volume is initialized as zero.
Two parallel states fill & empty, the input for the fill State are Valve one on& off & inflow rate, the input for the empty state is valve two on & off & output for the empty state is outflow rate. The output for the chart state is the tank volume. The logic is derived at the transition between two states. Transition will automatically switches the State based on the logic written.
The valve one & valve two on & off tapping inputs are taken from the energy regulatory switch, Inflow rate is taken from the Electrolysis chamber, Ouflow rate is given to the fuel as it's input which is regulated by the outflow regulator.

2.2 PVFC AQUA CYCLE SYSTEM

2.2.1 Function of PVFC Aqua cycle System : The function of the PVFC Aqua cycle system is to collect the water generated at the fuel cell & supplies it to the Electrolysis chamber. Electrolysis chamber requires water during its Electrolysis and water is produced as byproduct after reacting hydrogen with the atmospheric oxygen at fuel cell. So these water is again circulated to the Electrolysis chamber for reducing water consumption. It is driven by the Inflow regulator which deals GC deficiency factor, Valve one & Valve two operations for Inflow & outflow is done by the energy regulatory switch. The outflow regulator is connected between the Electrolysis chamber & the PVFC cycle system.



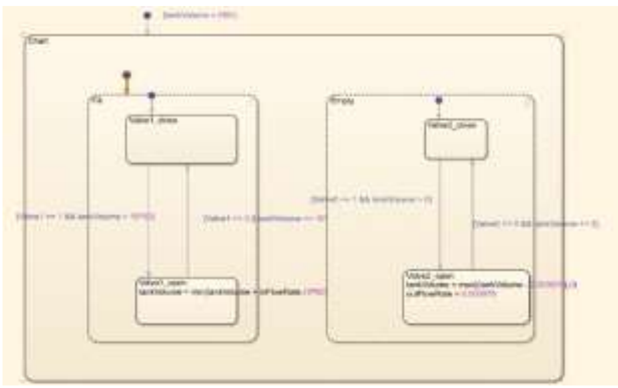


Fig2.2.1(a) PVFC Aqua Cycle System. **Fig 2.2.1(b) PVFC -LI**

2.2.2 Logical Implementation : The valve one & Valve two on & off tapping from the energy regulatory switch controls the inflow & Ouflow rates of PVFC Aqua Cycle System. The inputs for the PVFC Aqua cycle system is water input from the fuel cell & water outlet to the Electrolysis chamber. Valve one operation if the input is one & tank volume is less than the 500Lites then valve one will open. Valve two operation is that if valve two input equals one and tank volume will be greater than zero than the valve two will open. The Inflow rate will works as tank volume is equals to tank volume plus inflow rate. The outflow rate works as tank volume is equals to the tank volume minus outflow rate. Here the 500 Litres indicates the capacity of the tank. Increasing the tank capacity is also possible. It will take water input from the fuel cell & stores the water during the peak time by collecting the water from the fuel cell & sends to Electrolysis chamber during the peak time. The outflow rate is provided as constant until the volume of the tank is greater than the outflow rate this job is done by the outflow regulator. The GC constant is determined at Inflow regulator to fix the Generation consumption deficiency. Energy regulatory switch operates the entire peak & off peak conditions by giving tap command to the valves of the PVFC Aqua Cycle System.

Two parallel states fill & empty, the input for the fill State are Valve one on& off & inflow rate, the input for the empty state is valve two on & off & output for the empty state is outflow rate. The output for the chart state is the tank volume. The logic

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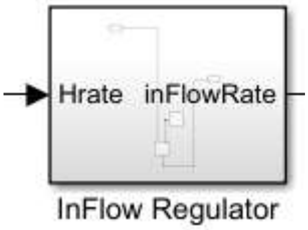
is derived at the transition between two states. Transition will automatically switches the State based on the logic written. The above figure 2.1.1b shows the transistor implementation.

The valve one & valve two on & off tapping inputs are taken from the energy regulatory switch, Inflow rate is taken from the Fuel cell, Ouflow rate is given to the Electrolysis chamber as it's input, which is regulated by the outflow regulator.

2.3 INFLOW REGULATOR- HYDROGEN TANK



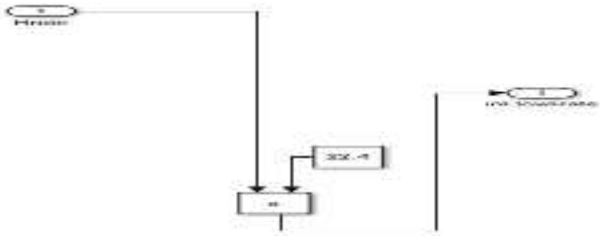


Fig2.3(a) Inflow Regulator. **Fig2.3(b) Inflow Regulator LI**

2.3.1 Description : The Inflow regulator of the hydrogen tank converts moles into the litres. The input of the Electrolysis chamber to hydrogen tank is in moles but the tank stores volume litres. The conversation constant is 22.4

2.4 OUTFLOW REGULATOR OF HYDROGEN TANK

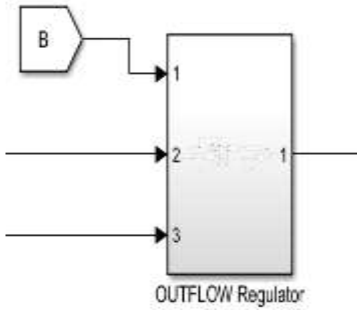


Fig2.4(a) Outflow Regulator

2.4.1 Description : The outflow regulator of hydrogen tank will provide constant fuel flow rate & time conversion between Electrolysis chamber & the fuel cell. The fuel cell stack consumption is in litres per minute but Electrolysis chamber production of hydrogen us moles let second it will convert the entire system scale to seconds by taking the input in litres per second & providing output as Litres per minute.

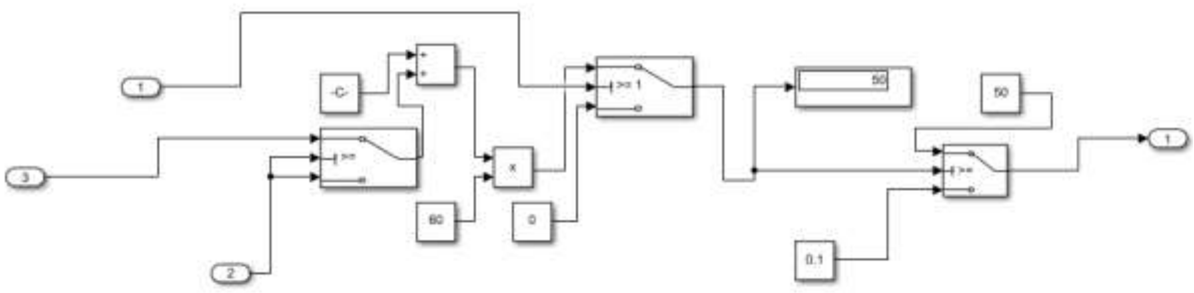


Fig2.4(b) Outflow Regulator LI

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2.4.2 Implementation of constant outflow rate: The outflow rate from the hydrogen tank is 0.0007325. then it finds the required Generation & consumption deficiency constant which is given by((lpm/60) -0.0007325) the value equals 0.8326008. The constant is added to the outflow rate to get required output for the produced hydrogen. Then the tank volume is given to switch threshold value. It gives constant outflow rate until the tank volume is less than the outflow rate if tank volume is less than outflow rate than tank volume appears as output. But the outflow is continuous at off peak time means valve 2 is closed but it can be rectified by taking valve command separately for controlling the outflow rate.

2.4.3 Implementation of time conversion : The input from the Electrolysis chamber is in moles per second after Inflow regulator it converts litters per second but the consumption of the fuel cell is at litres per minute. The output of the outflow of the tank is in litres per second & it is converted it into the litters per minute by multiplying with 60 and then the output bus supplied to the fuel cell.

2.5 INFLOW REGULATOR- PVFC AQUA CYCLE SYSTEM :

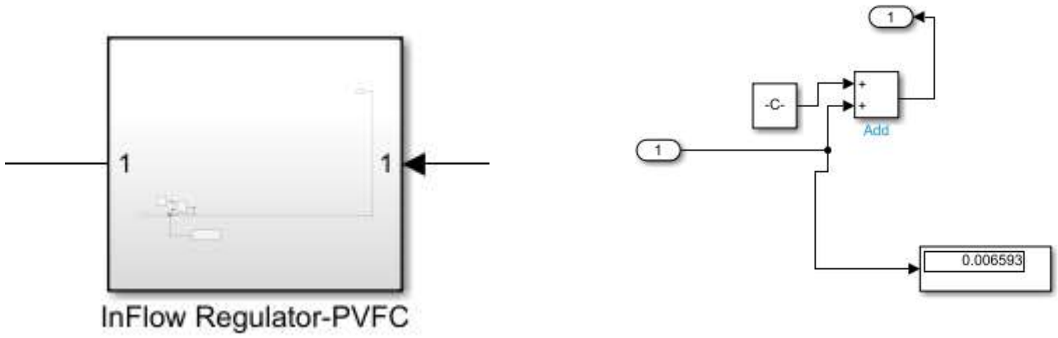

Fig2.5(a) Inflow Regulator PVFC Fig2.5(b) Inflow Regulator PVFC-LI

2.5.1 Function of Inflow Regulator PVFC : The inflow Regulator of the PVFC Aqua cycle system takes input of water from the fuel cell then it calculates Generation consumption deficiency factor and add it to the inflow rate such that the water is added to the PVFC Aqua Cycle System through the inflow rate regulator. The GC constant is 0.0042

2.6 OUTFLOW REGULATOR- PVFC AQUA CYCLE SYSTEM

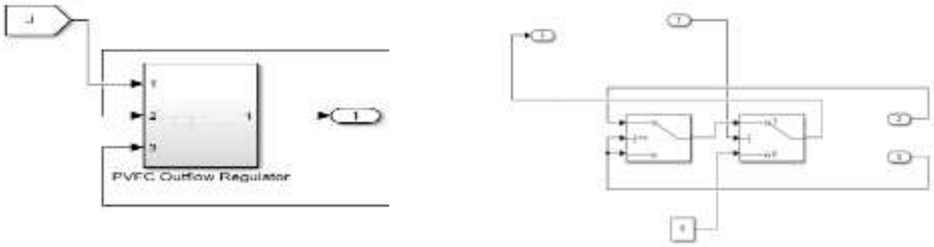

Fig2.6(a) Outflow Regulator -PVFC 2.6(b) Outflow Regulator-PVFC LI

2.6.1 Function of outflow regulator PVFC Aqua Cycle System : The outflow rate from the hydrogen tank is 0.003978 It is calculated how much water is required for the output of hydrogen and Simulated the water is using switch case if required water is getting or not the calculation is available at Chapter -3. The tank volume is given to switch threshold value. It gives constant outflow rate until the tank volume is less than the outflow rate if tank volume is less than outflow rate than tank volume appears as output. But the outflow is continuous at off peak time means valve 2 is closed but it can be rectified by taking valve command separately for controlling the outflow rate. It also takes command from the energy Regulatory Switch to control the flow.

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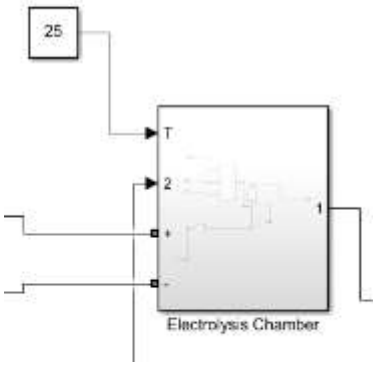
2.7 ELECTROLYSIS CHAMBER



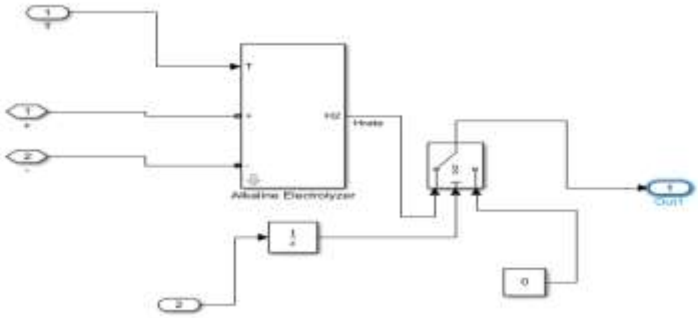


Fig2.7(a) Electrolysis Chamber. Fig2.7(b) Electrolysis chamber LI

2.7.1 Description of Modelling Electrolysis Chamber : Water can only be split into hydrogen and oxygen When a minimum electrical voltage is applied. Ideally the Cell voltage is equal to this minimum voltage, called Reversible voltage, but due to irreversibility, the cell Voltage is always higher. The extra voltage present in the cell is called Overvoltage and is composed of ohmic, activation and Diffusion overvoltages. Ohmic overvoltage is the Overvoltage due to overall resistance of all components of The electrical circuit, while the activation overvoltage is the Overvoltage related to extra energy required to start the Oxygen and hydrogen formation process in the electrodes Diffusion overvoltage only takes precedence at high Current densities when the reaction changes from Electronic transfer to matter transfer. An empirical model involving ohmic and activation Overvoltages the Model has six different parameters to characterize the Logarithmic response of an electrolyser cell voltage in Terms of current and temperature.

$$V = V_{rev} + \frac{r_1 + r_2 T}{A} I + s\log\left(\left(t_1 + \frac{t_2}{T} + \frac{t_3}{T^2}\right)\frac{I}{A} + 1\right) \qquad (1)$$

Where: T is the temperature of the cell, A is the area of the Electrodes, r1 and r2 are the ohmic overvoltage parameters, And t1, t2, t3, and s are the activation overvoltage Parameters. Is the reversible voltage of the cell and is Temperature and pressure dependant with a value of 1.229V at standard conditions (1 bar, 25 oC). For low Temperature ranges of up to 100 0C, voltage variation is Small and can be considered constant. Production rate of hydrogen can be related to the input Current using Faraday law. An empirical expression for the Hydrogen production efficiency is called Faraday Efficiency.

$$\dot{n}H_2 = \left(\frac{(I/A)^2}{f_1 + (I/A)^2} f_2\right)\frac{I}{zF}$$

Where: f1 and f2 are parameters related to Faraday Efficiency, z is the number of electrons transferred in the Reaction (2 electrons for water electrolysis), F is Faraday Constant and is the molar flow rate per second F1 and f2 are usually considered constant for the overall Model. However, they vary with temperature. The Assumption of linear relation with temperature. Depends on the temperature range of operation. In this Research, a linear expression only applies for f1 whereas for F2 a limit value must be set to guarantee a range value Between 0 and 1 . Note that an extra point was added to f2 at 0 oC to Guarantee a limit value of 1.

$$f_1 = 2.5T + 50 \qquad (3)$$

$$f_2 = 1 - 6.25x10^{-6}T \qquad (4)$$

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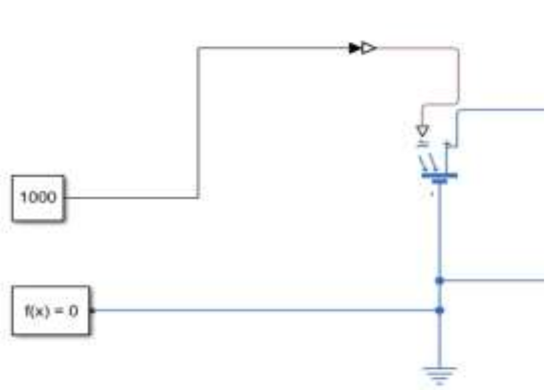
A unit conversion is needed for the flow rate in Eq. (2) to obtain a rate in kilograms rather than moles. This Will facilitate comparisons in the result section. Using the Volume of an ideal gas at standard conditions , the Volumetric flow rate and the mass flow rate is given by Eq. (5).[1]

$$\dot{V} = \dot{n} v_{std} \rightarrow \dot{M} = \dot{V} c \qquad (5)$$

where: v_{std}= 0:0224136 m^3/mol and c = 0.08988 kg/m^3.

3.1 SOLAR CELL



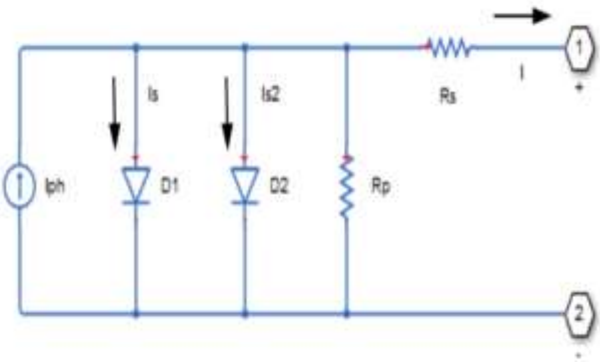
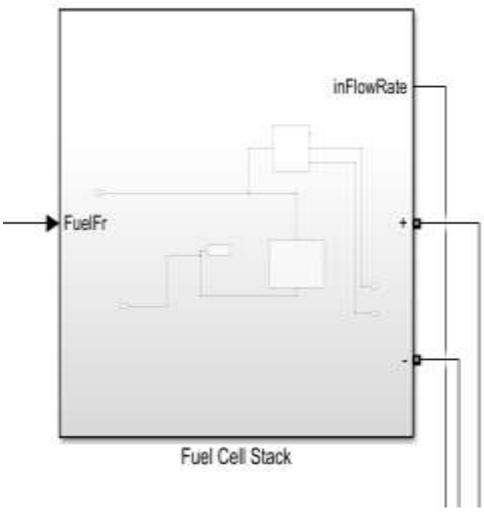


Fig 3.1(a) PV cell. Fig 3.1(b) PV cell Equivalent circuit

3.1.1 Function of the Solar cell : The solar cell takes irradiance input as 1000 & Number of cells connected in series is 130 & the output voltage is 79.2 approximately 80. During peak time it is connected to load & during off peak time it is connected to Electrolysis chamber through the valve operation is controlled by energy regulatory switch. The solar cell is simscape but the entire model is Simulink it can be converted to Simulink by PS to Simulink converter.

3.2 Fuel cell



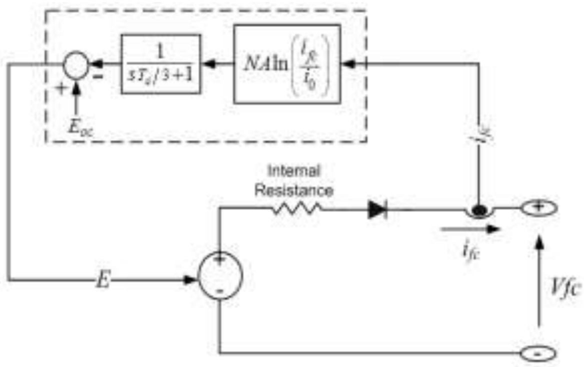


Fig3.2(a) Fuel cell Fig3.2(b). Equivalent Circuit of Fuel cell

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3.2.1 Fuel cell nominal parameters

Stack Power: Nominal = 5998.5 W, Maximal = 8325 W, Fuel Cell Resistance = 0.07833 ohms, Nerst voltage of one cell [En] = 1.1288 V, Nominal Utilization: Hydrogen (H2)= 99.56 %, Oxidant (02)= 59.3 %, Nominal Consumption: Fuel 60.38 slpm, Air = 143.7 slpm, Exchange current [i0] =0.29197 A &Exchange coefficient [alpha] = 0.60645

3.2.2 Manual water Simulation of the Fuel cell

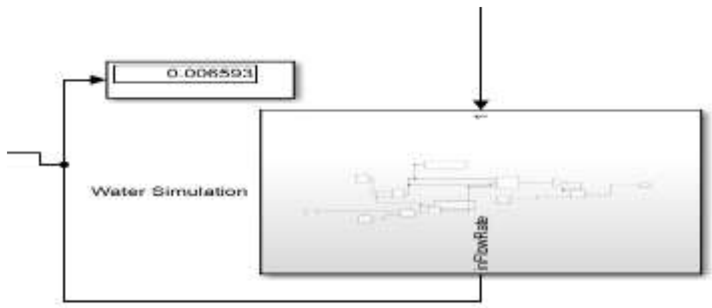

Fig 3.3.2(a) Manual water Simulation

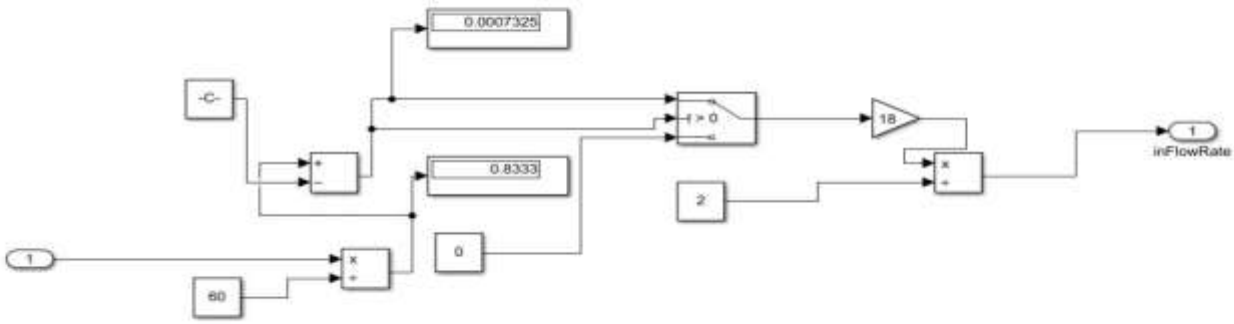

Fig3.2.2(b). Manual water Simulation LI

The generic Fuel cell stack didn't provide output of the water it only provides electrical energy by taking hydrogen gas as input in litres per minute. So the water is Simulated manually by taking same hydrogen input of the fuel cell.

3.2.2.1 Logical Implementation of water Simulation

Water Simulation Calculation for Fuel cell :
First it will take same fuel input of fuel cell convert it into litres per second from litres per minute the reverse process of outflow regulator and follow the below steps for calculating the water in litres per minute.
Molecular weight of water = 18grams
Every 18grams has 2 grams of hydrogen
1kg of water consists of =(1000*2)/18 = 111.11 grams of hydrogen
Let's consider H2O as X liters
Water released at Fuel cell = (x*18)/2 = YLitres.

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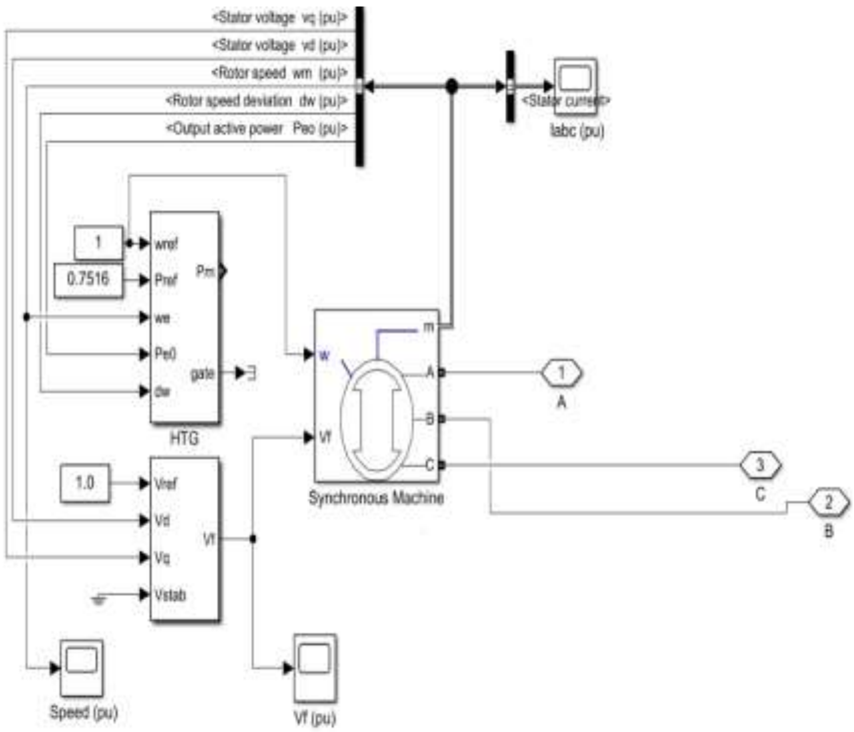
3.2.3 Functions of the fuel cell : The function of the fuel cell is it will supply power to the load during the peak time & it will be off in off peak time. The fuel cell starts supplying the power to the whenever the fuel input(hydrogen) is given to the fuel cell the supply bus controlled by outflow regulator. The Ouflow rate take the command from energy regulatory switch. The fuel will take inputs oxygen and hydrogen but we are only supplying hydrogen as input to the fuel cell because the oxygen will be taken directly from the atmospheric air so the necessity of providing oxygen to the fuel cell is not required.

3.3 Power Plant Simulation



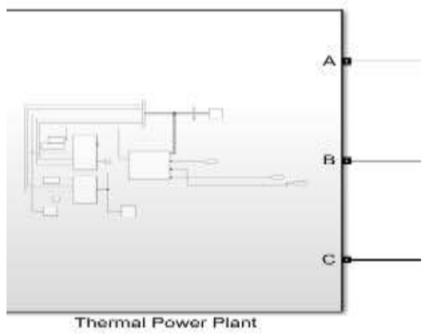


Fig 3.3(a) Power Plant Simulation LI. **Fig3.3(b) Power Plant**

3.3.1 Excitation System

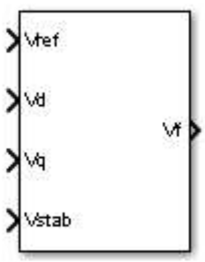


Fig : 3.3.2(a) Excitation System

3.3.2Function of the power plant : The function of the power plant it has to supply 15MW power constantly during peak & off peak time. The power plant is considered as the base plant. The system is three phase the Three phase transformer is connected to the Synchronous machine to give desired output voltage (415V).

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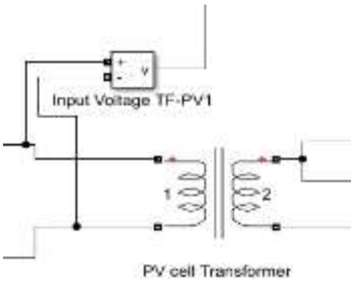
4.1 TRANSFORMERS



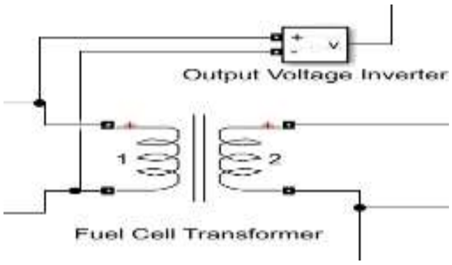


Fig 4.1(a) PV cell Transformer **Fig 4.1(b) Fuel cell Transformer**

4.1.1Three phase transformer Block Description

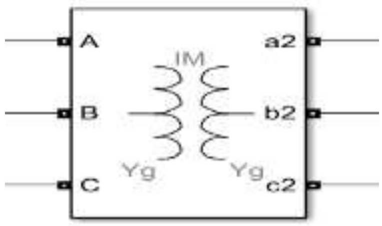
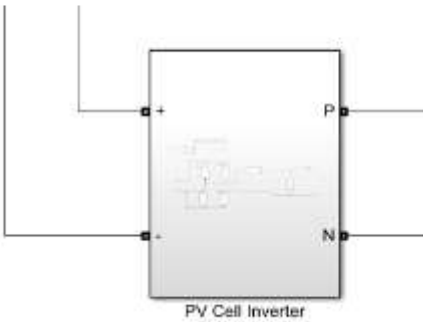


Fig 4.1.2(a) Three Phase Power plant transformer

4.1.2 Presence of single phase Transformer & it's function : The function of the single phase transformer is to step-up the voltage & it is present across the fuel cell & photovoltaic cell. The Inverter is placed after the photovoltaic cell and the fuel cell the inverter converts DC to AC and the output voltages of the inverter is step-up to 230v & supplied to the load. The two transformers having the rating of 5KW & 50HZ frequency and the values considered for ideal case.

4.1.3 Presence of Three phase Transformer & it's function : The function of the three phase transformer is to step-down the voltage coming from the alternator and it's is present in between three phase load & Alternator. The output voltage of the three phase transformer is 415V the capacity of the transformer is 20KW & frequency of the transformer is 50Hz. It is considered for the ideal condition.

4.2 Inverters :



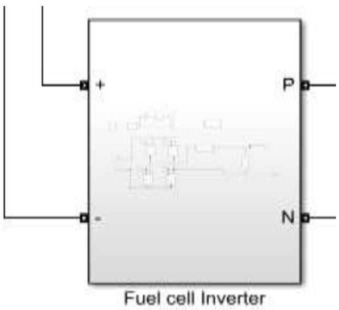


Fig 4.2(a) PV cell Inverter. **Fig 4.2(b) Fuel cell Inverter**

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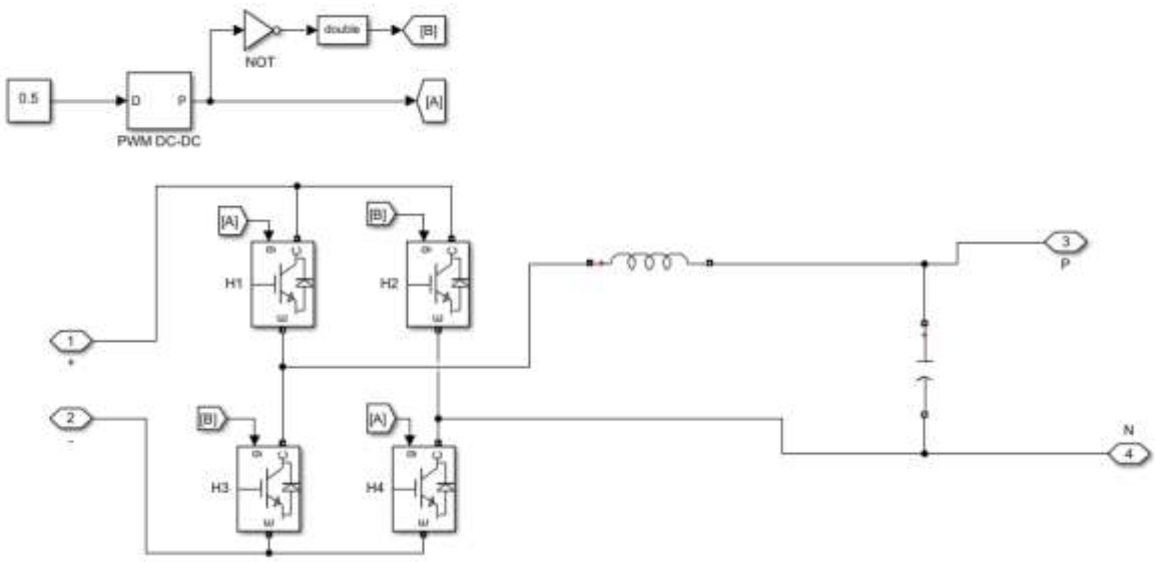


4.2(c) Circuit diagram of Inverter

4.2.1 Function of Inverter : The function of the inverter is to convert DC of PV & Fuel cells Output to AC then it will be connected to the transformer to give the specified voltage to load(230V). The duty cycle is provided as 0.5 such that output frequency is 50HZ with respect to the below specified filter values.

4.2.2 Filter values of the Inverters :

Device	**Inductor value**	**Capacitor value**
PV Cell Inverter	21.0466e-4	6.36e-4
Fuel cell Inverter	20.0466e-4	22.36e-4

5.1 ENERGY REGULATORY SWITCH

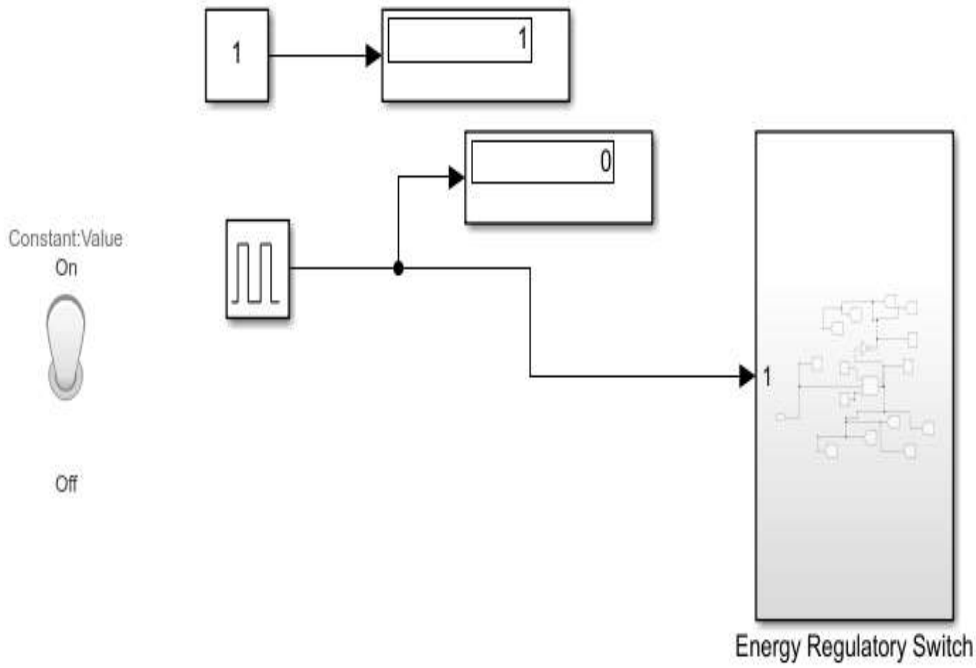


Fig5.1(a) Energy regulatory switch

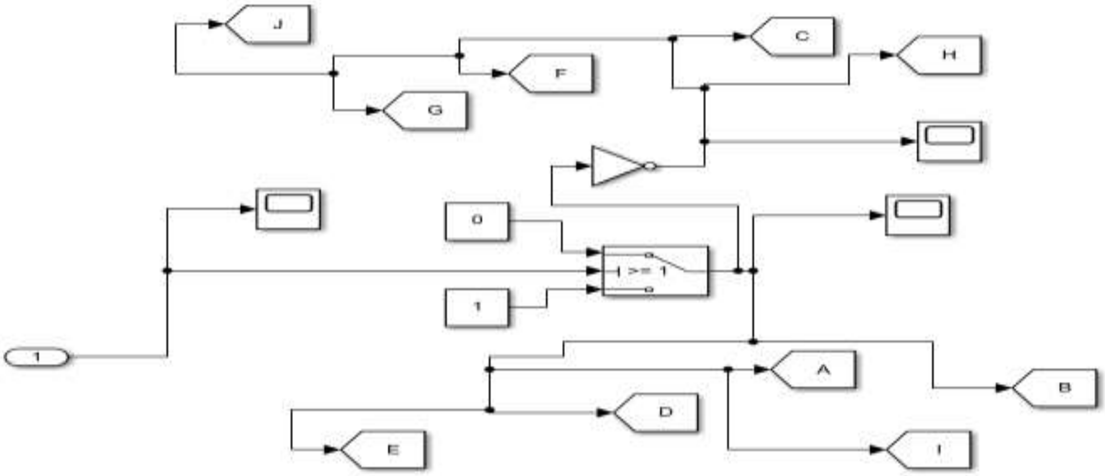


Fig5.1(b) Energy regulatory switch LI

5.1.1 Energy regulatory switch description : The energy regulatory is said to be heart of the system it controls the entire system by stimulating peak & off peak load condition. During off peak load it will give command to the solar cell valve operator to connect the solar cell to Electrolysis chamber, gives input to the hydrogen tank to open the valve and accept the inflowrate and also sends commands to the valve two of the hydrogen tank, Outflow Regulator to stop the outflow rate. It also sends the commands to the PVFC Aqua cycle system to open the valve two and send water to Electrolysis chamber. Here the hydrogen tank is initialized with 0 volume and PVFC Aqua Cycle System water tank is initialized with 250Litres of volume. During peak time the it will give command to the solar cell valve operator to connect the solar cell from the Electrolysis chamber to load, by closing valve one of hydrogen tank and opening valve two of the hydrogen tank & sending command to outflow regulator of hydrogen tank will hydrogen gas is supplied to fuel cell and fuel cell is also starts generating electricity which is already connected to the load. It also opens valve one of PVFC Aqua Cycle System and closes the valve two of the PVFC Aqua Cycle System such outflow rate of the water is stopped & Inflow rate is passed to the PVFC Aqua Cycle System then the water from the fuel cell is collected and stored. The Energy regulator switch is a subsystem such that all the tag variables of from us considered as Global.

5.2 Photovoltaic cell valve operation :

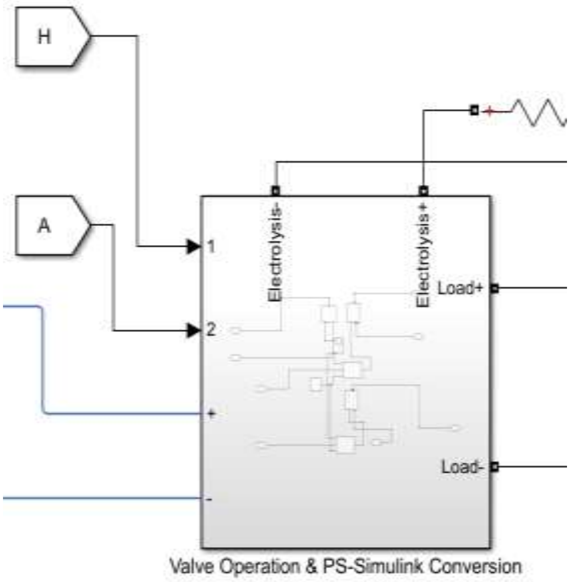


Fig 5.2(a) photovoltaic cell valve operation

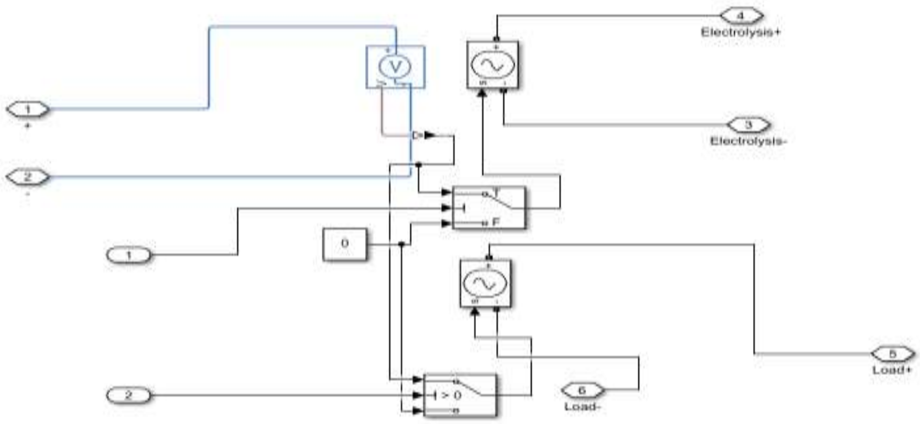


Fig 5.2(b) photovoltaic cell valve operation LI

5.2.1 Description of photovoltaic cell Valve operation : The photovoltaic cell is Simscape so that voltage signal is converted into the Simulink and given it to the controlled voltage source. The controlled voltage source signal is connected & disconnected by using the switch case the switch threshold takes input from the energy regulatory switch. If the command is one then it will connect to voltage signal else it will connects to the constant zero.

6.1 SIMULATION IMPLEMENTATION PROCEDURE

The Simulation implementation procedure deals with the working Procedure & connections.

6.1.1 Connections based on Sources

6.1.1.1 Photovoltaic cell : The photovoltaic cell is Simscape component and it converted into the Simulink by using PS-simulink converter. The positive and negative terminals of the Solar cell is connected to Conversion and Valve operation subsystem. The subsystem converts the Simscape to Simulink and it will take commands from energy regulatory switch to connect with the load and Electrolysis chamber. During off peak time it is connected to the load using the inverter and transform, The Photovoltaic cell is connected to the valve operation during peak time it is directed connected to the Electrolysis chamber. During peak time it is connected to the Inverter which converts the DC to AC. The output frequency of the inverter voltage is 50Hz. The output of the inverter is(79.2V) connected to the transformer primary it is stepped up to the 230V and supplies to the load.

6.1.1.2 Fuel cell : The fuel cell supplies DC voltage and it will takes the input from the Hydrogen tank through outflow regulator. During off peak time the fuel supplied to the fuel cell is negligible (zero,). Such that Electrical generated is also. Whenever the peak time appears the Fuel is supplied to the fuel cell through the outflow regulator by taking command from the Energy regulator switch. The output of the Fuel cell is connected to the Inverter which converts DC to AC. The output voltage of the Inverter(55V) is connected to the Transformer and step-up to produce the 230V and supplies to the load.

6.1.1.3 Thermal power plant : The thermal power plant is base plant. It will supply the power continuously in both peak and off peak the phase alternator with 20KW 50Hz frequency is connected to the three phase transformer which will step down the voltage from the alternator to the 415V and supplies it to the three phase load of 15KW.

6.1.2 Connections based on non electrical apparatus :

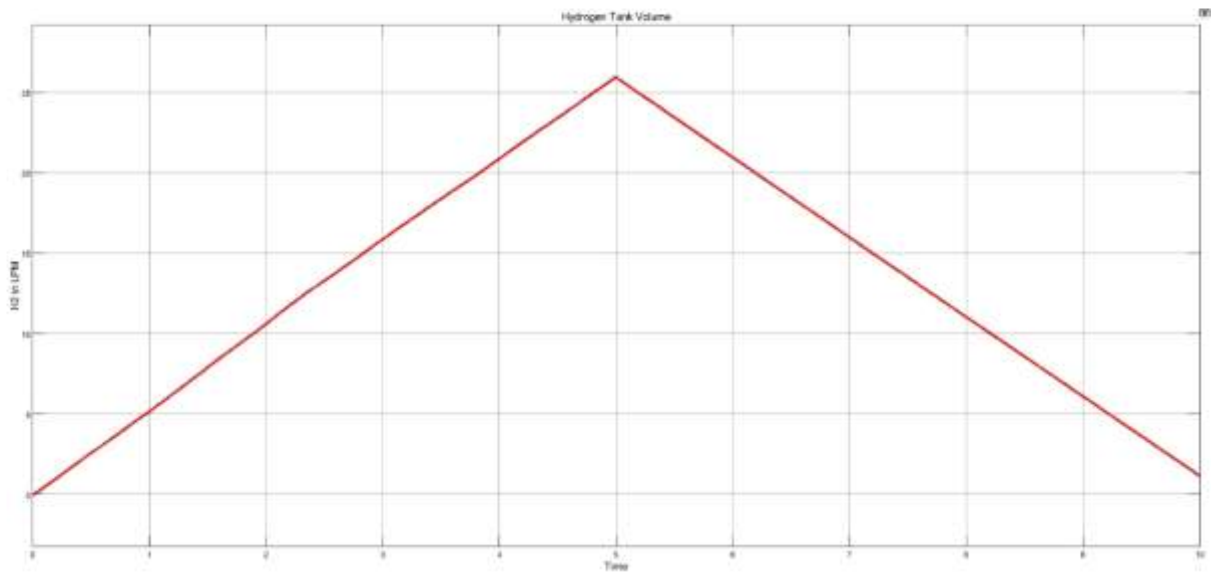
6.1.2.1 Hydrogen Tank : The hydrogen tank is connected to the Electrolysis chamber and fuel cell. The Electrolysis chamber is connected to the Hydrogen tank using the Inflow regulator. The output of the Electrolysis chamber is hydrogen gas in molar rate and the hydrogen tank stores the hydrogen in the form of litres, such that the moles is converted into the litre by using the inflow rate regulator .The outflow rate of the Hydrogen tank is connected to the fuel cell through the outflow regulator. The outflow regulator takes three inputs one is command input from the energy regulatory switch, the other two are outflow rate of the hydrogen tank and volume of the hydrogen tank. The hydrogen tank also takes input for valve 1 & valve 2 opening and closing operation from energy regulatory switch.

6.1.2.2 PVFV Aqua Cycle System: The PVFC Aqua Cycle System is connected to the to the Electrolysis chamber through outflow regulator of the PVFC Aqua Cycle System. The outflow regulator will take two input one is outflow rate of the PVFC and other one is volume of the PVFC & provides output to the Electrolysis chamber. It will also connected to the fuel cell through inflow rate regulator using GC constant. The PVFC Aqua cycle System is connected to the energy regulatory switch for on & off of the inflow and outflow valves (Valve-1&valve-2).

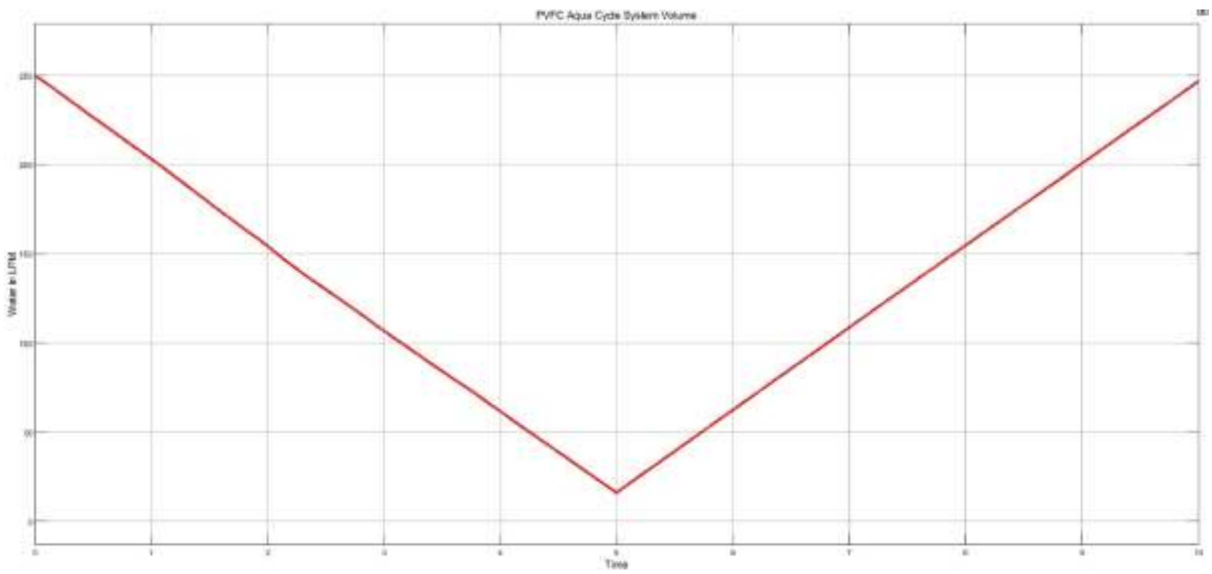
6.1.2.3 Electrolysis chamber : The Electrolysis chamber is connected to hydrogen tank and it is connected in between the PV cell valve operator & hydrogen tank. It will take the Electrical energy from the PV cell during the off peak time and converts it into hydrogen gas by splitting the water. The PVFC Aqua Cycle System supplies the water to the Electrolysis chamber. The static water constant is calculated and assigned to switch case to stimulate the water consumption at Electrolysis chamber. The inflow rate of the Electrolysis chamber is connected to the hydrogen tank through in flowrate regulator for converting moles into the litres.

6.2 Working Procedure : They are two types of Simulation one is peak load Simulation and other one is off peak load Simulation it is controlled by energy regulatory switch. The energy regulatory switch will connect to either pulse generator or toggle switch toggle switch for manual operation and pulse generator for automation. In this pulse generator is connected to the energy regulatory switch such the simulation time is 10sec first 5 sec is off peak load condition and next 5 sec is peak time. During peak condition the hydrogen generation at Hydrogen tank and water consumption from the PVFC Aqua cycle system is observed, the hydrogen inflow rate and water outflow rate is also displayed. The voltage of the power plant is also measured. During the peak time the solar cell is connected to the inverter through Valve operator the Output voltages of the inverter and transform is measured and power supplied to the load is measured using the PQ block. The hydrogen is supplied to the fuel through outflow Regulator and the fuel cell generates the electrical energy Output voltages of the inverter and transform is measured and power supplied to the load is measured using the PQ block. Hydrogen consumption and water generation is also measured. The base plant Voltage levels also measured at the peak time here base plant terms to the thermal power plant.

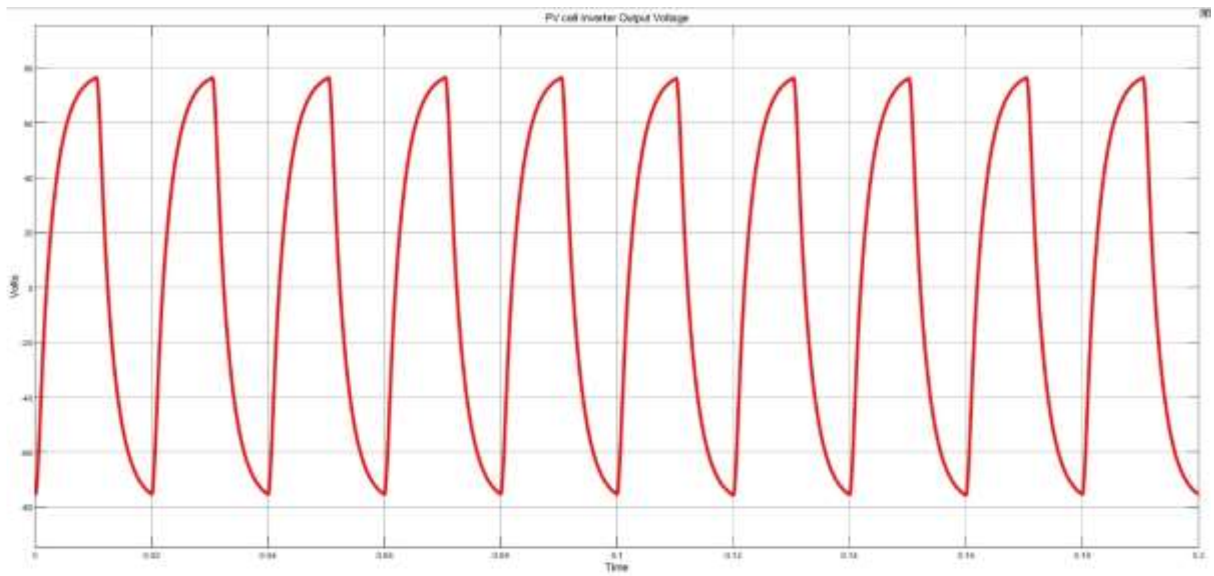
6.3 Outputs :
Hydrogen tank output :



PVFC Aqua Cycle System :



PV-Cell Inverter output voltage :



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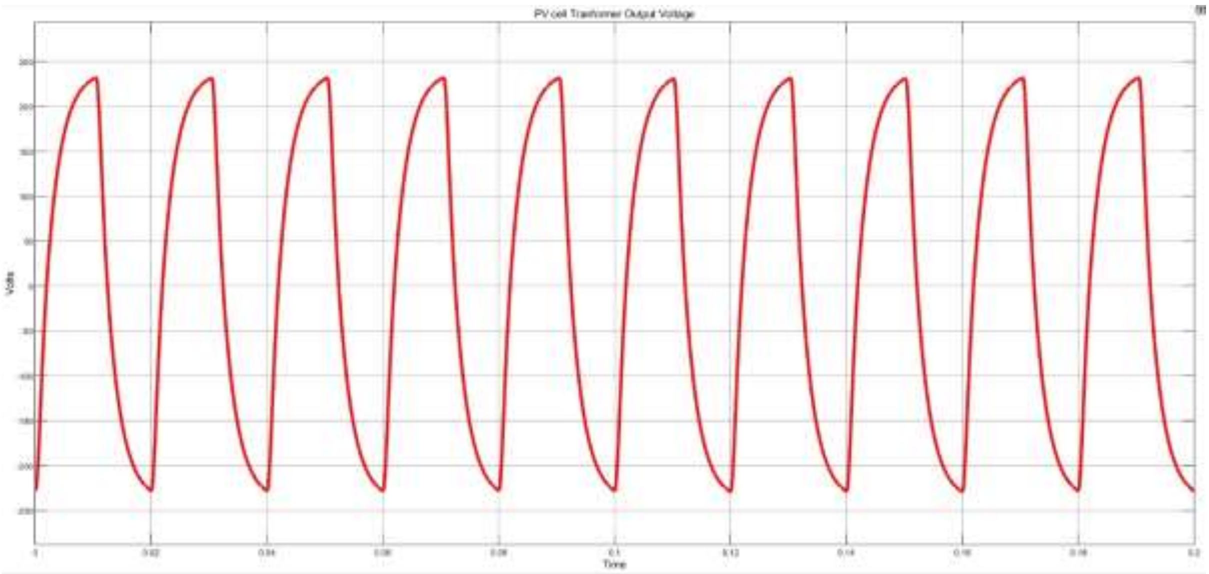
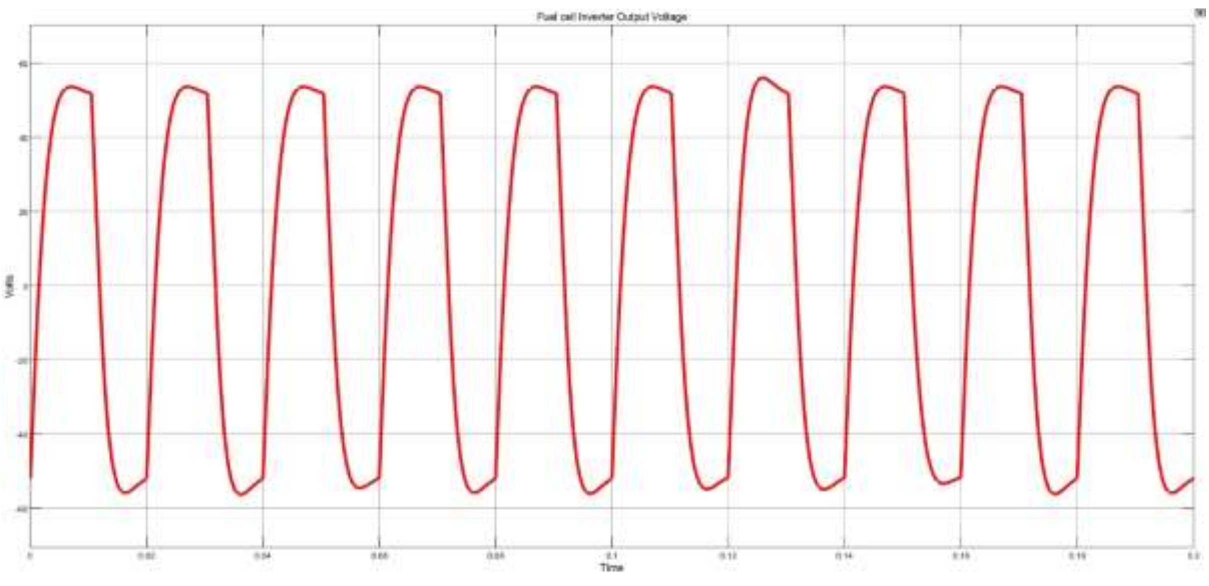
PV cell transformers output voltage :



Fuel cell Inverter output voltage :



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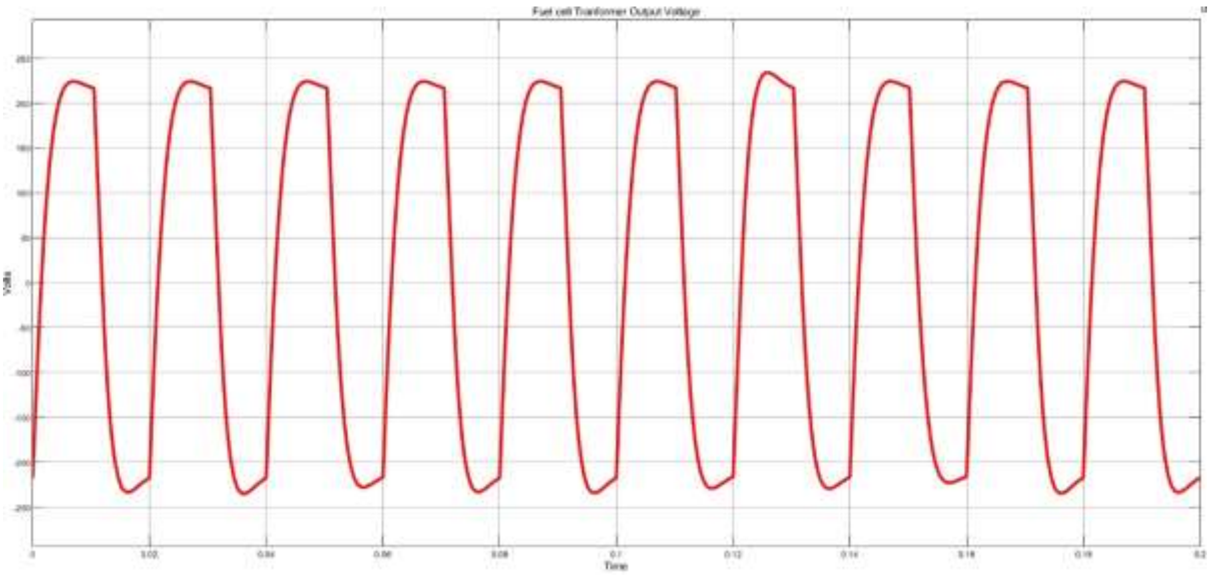
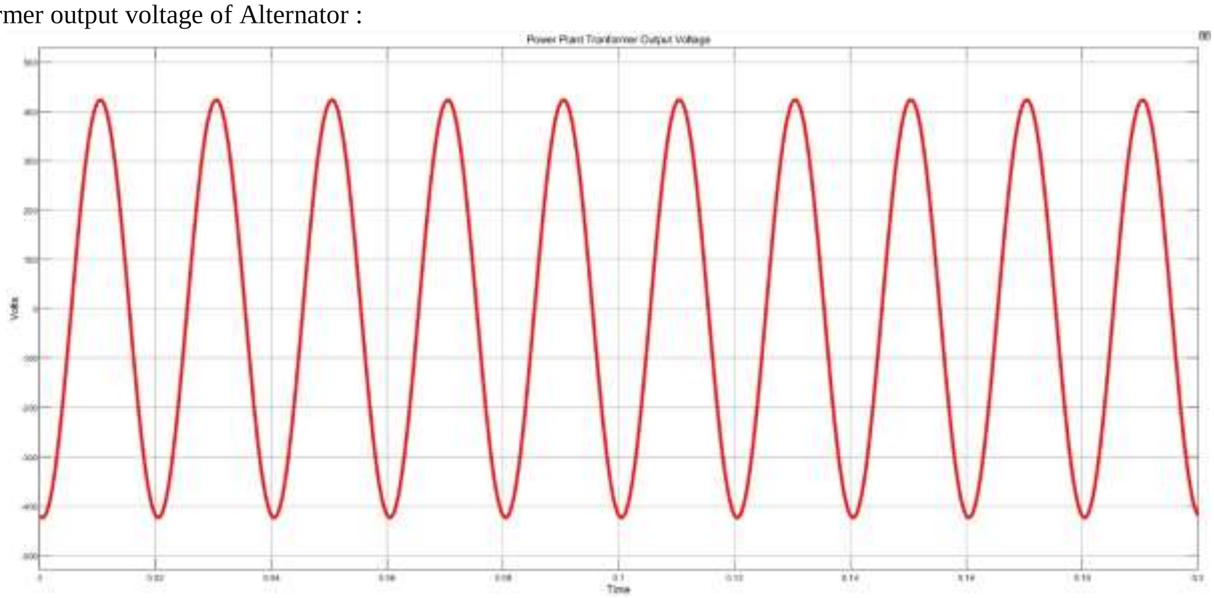
Fuel cell Transformer output voltage :



Transformer output voltage of Alternator :



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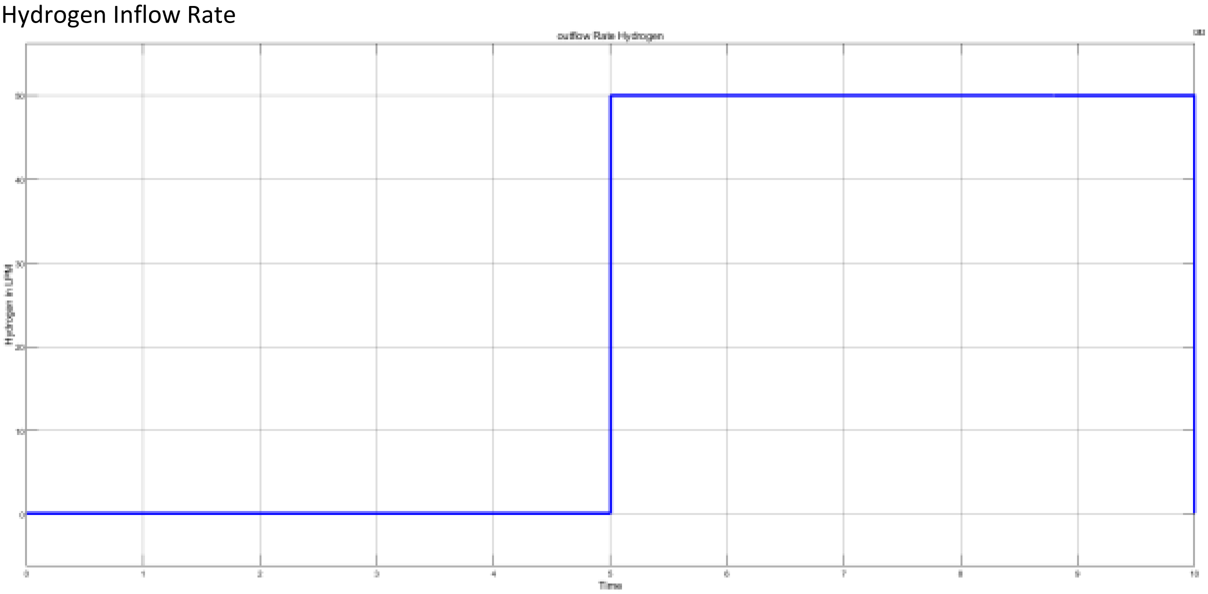
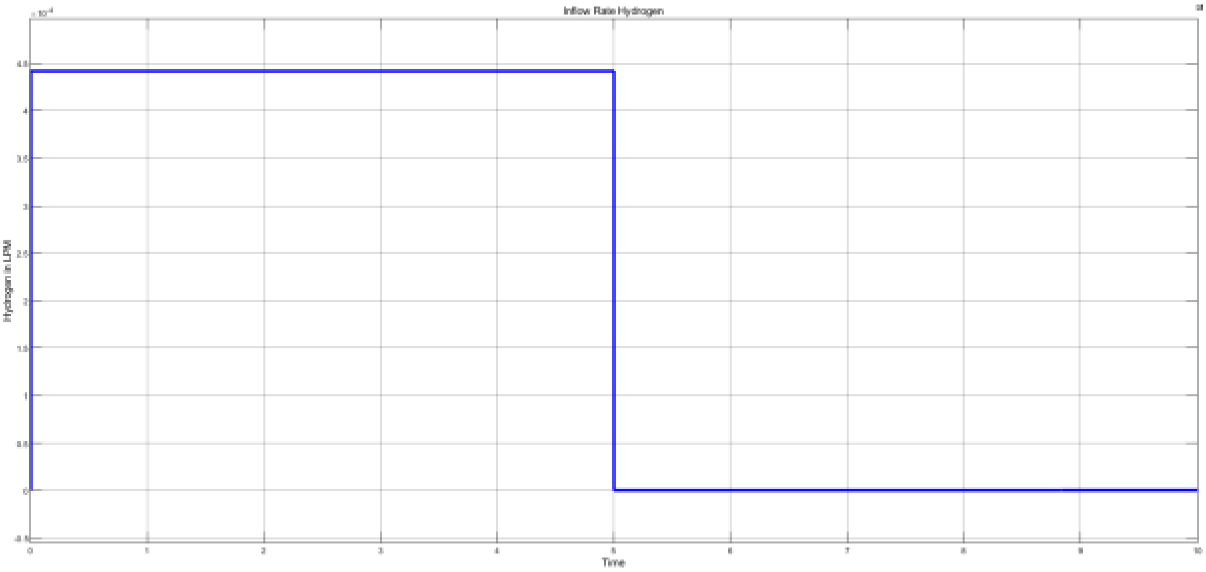
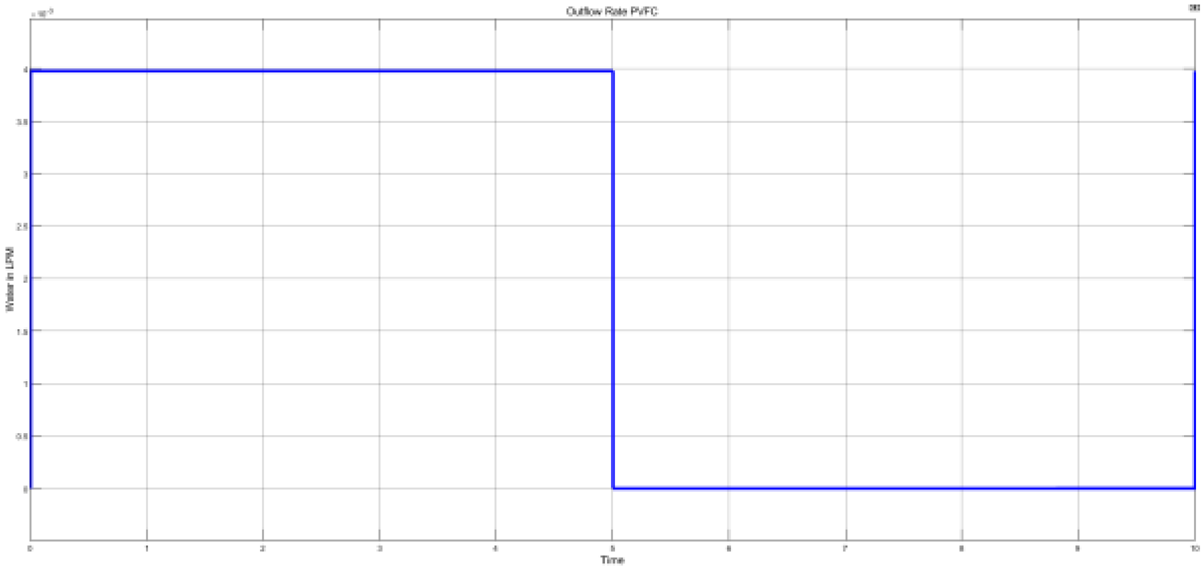
Hydrogen Inflow Rate



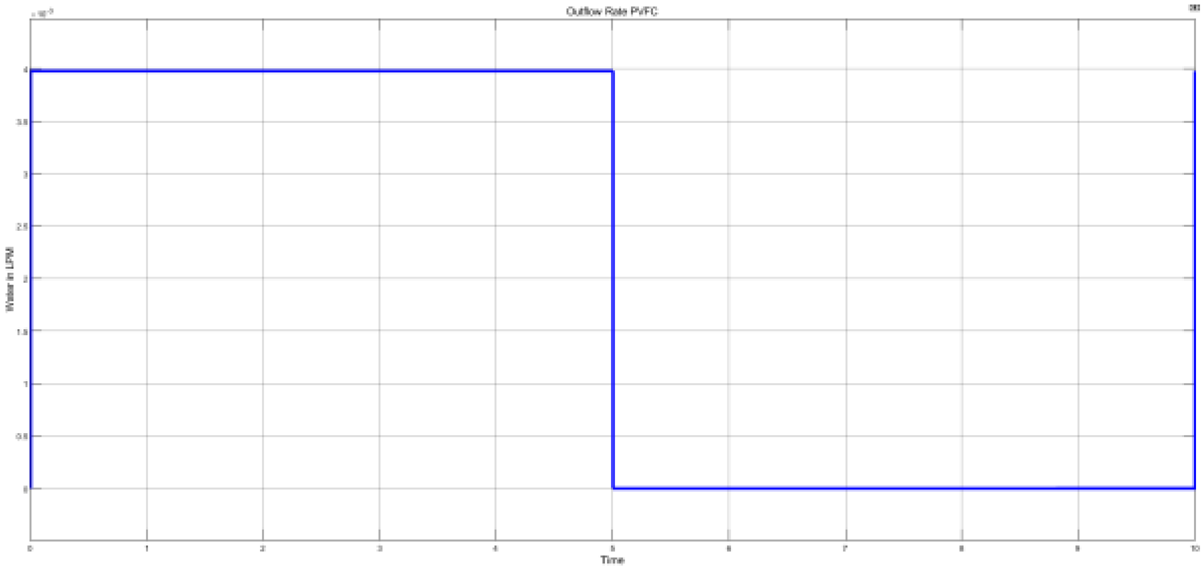
Hydrogen Outflow Rate



PVFC Outflow Rate :



PVFC Inflow Rate :



CONCLUSION

The project finally reduces the water consumption at the Electrolysis chamber When electrical energy is stored in the form of hydrogen gas. The water collected from the fuel cell is again send back to the Electrolysis chamber. It increased the overall efficiency of system. Decreased the dependency on continuous water supply & small water resources is quite enough to Store large quantity of the power in the form of hydrogen gas. The continuous circulation of water (Aqua cycle) in the closed system will reduce the contamination ratio of the fluid which is directly exposed to the atmosphere In such a way the life Span of the Fuel cell & Electrolysis chamber also increases. It reduces the maintenance cost because the System is automated. Future Scope : It is also used by the vehicles in future. The PVFC Aqua cycle system plays key role at fuel stations to reduce the cost of the fuel. Means the vehicle dumps water from PVFC Aqua Cycle System to the Fuel station and fills the hydrogen.

1. Bulk power stored using the fuel cells in future. The PVFC Aqua System gives solution at water scarcity areas.
2. The system is compact and compatible with any other devices like grid using synchronisation such that at future fuel cells are available in grid.
3. It also helpful in production of rocket fuel for cryogenic engines with less cost and less power utilisation.
4. It also useful in hydrogen production industries for managing water quantity.

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