# Proportional Resonant Controlled High Gain Step-up Converter System with Improved Response

**G.Hemavathi, S.Maheshwaran**

***Abstract*****:** ***In recent days the step up converters used for commercial & industrial applications should produce high gain with ripple free output voltage. The step up converters are connected between PV and DC loads, these should have capacity to produce high gain, and it serves as a good interface between load and source. In our work a suitable methodology is adapted to reduce the ripple in output voltage. The proposed method uses the Closed Loop system (both PI and PR controller) with coupled inductor and a switched High gain step up Converter with Cascade filters. The results of PI and PR controllers are compared to find best output.***

***Index Terms*****:** ***Proportions controller, High step up converter, Proportional Resonant controller***

## I. INTRODUCTION

The power module is appropriate as power supplies for vitality source applications. As a rule, an ordinary energy component control supply system containing a high advance up converter. To get high voltage for applications like DC micro grid, inverter, or battery etc. the step up converter is used, because due to low voltage produced by the power module. High voltage gain with outrageous duty cycle is accomplished by boost converter but in normal operations which is limited by impacts of rectifier diode and protections of capacitors and inductors.

By modifying the turns proportion of the transformer winding, a fly back converter can achieve high voltage gain but still this high voltage spike leakage vitality may cause damage to the main switch. In order to avoid above problem, a high voltage rated switch with drain-source on resistance and snubber circuit are installed in fly back converter, however the voltage spike leakage vitality still consumed. The above discussed techniques will tend to reduce the efficiency.

To get high voltage gain, we are using some methods like switched capacitor and voltage-lift techniques, even though switches will affect by high current and conduction losses.

Here we are presenting how the anticipated high step-up converter is planned for fuel cell energy source applications. Usually the main source used for the applications should have the capacity to do adapt the changes caused by load dynamics.

But main source does not have this capacity, so lithium iron phosphate acts as a auxiliary source is utilized to adapt all changes(to fast dynamics and contribute to load peaking).

For continuous conduction mode ,fuel cell based source is adapted for our methodology. Since the intermittent conduction mode operation results in high peak current and large input current ripple, which create the fuel cell stacks hard to afford.

## II. HIGH GAIN STEP UP CONVERTER SYSTEM WITH REDUCED RIPPLEVOLTAGE

Recently, the cost increment of non-renewable energy source and novel bearings of $CO_2$ emissions have unequivocally expanded interests in sustainable power sources. Hence, sustainable power sources like wind energy, fuel cells and solar energy have been esteemed and utilized.

For conventional gasoline vehicles and crisis power sources, fuel cell acts as an excellent alternate source. Which produce clean energy without carbon di oxide emissions. Due to its sustainable fuel supply and stable operation, fuel cells has been progressively acknowledged as alternative source for the future.

By changing the turns proportion of the transformer winding, high voltage gain can be accomplished by fly back converter.

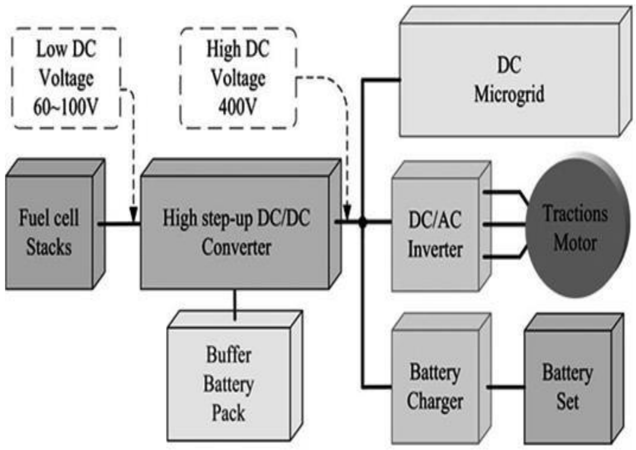


**Fig. 2.1 High Step-Up Converter based Power Supply System**

The existing system is shown in Fig 2.2. Here boost converter is used to stepup the DC voltage to the rated level and applied to the load.

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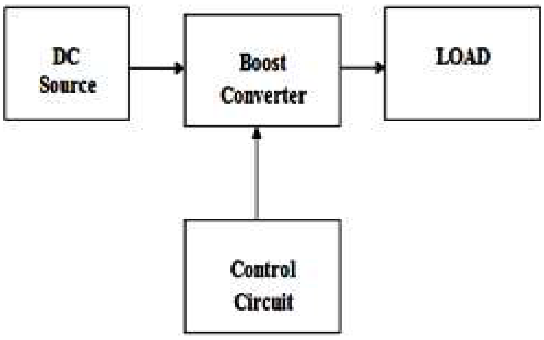



**Fig. 2.2 Existing System**

The proposed HGSC system is shown in Fig 2.3. The DC input is stepped up with a HGSC by employing suitable PWM Technique and suitable Filters are provided before connecting it to the Load such as Cascaded Filters are employed so as to reduce the ripple.

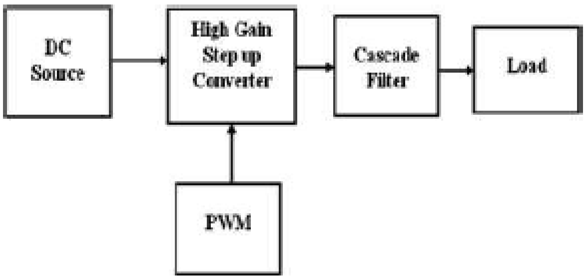



**Fig. 2.3 HGSC System**

### A. Operation of High gain Step-Up Converter

For obtaining high step-up conversion ratio the proposed methodology utilizes voltage-doubler circuit and switched capacitors. Thus by changing the number of turns ratio of coupled-inductor, the output voltage will be improved with help of the voltage-doubler circuit.

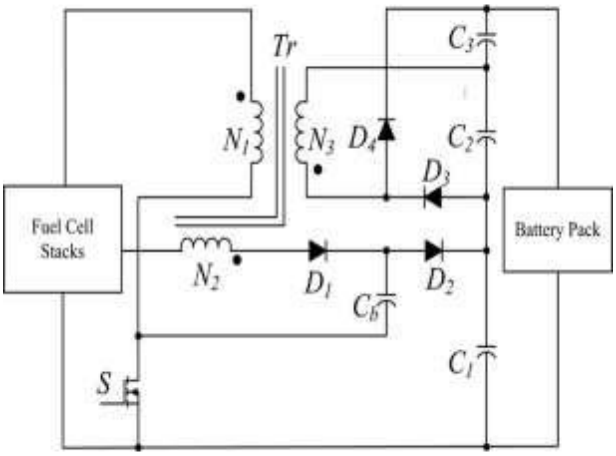



**Fig. 2.4 High gain Step-Up Converter**

### B. Modes of operation

Mode I [t0, t1]:

- During this mode current in the primary leakage inductor will be increasing linearly.
- The stored energy in magnetizing inductance will be transferred to the load

Mode II [t1, t2]:

- The series LC circuit charges the switched capacitor $C_b$.
- Secondary side of the coupled inductor obtains energy from the available source. Which charges capacitor $C_{3.}$

Mode III [t2, t3]:

- The parasitic capacitor get charged with the help of magnetizing current and LC series current.

Mode IV [t3, t4]:

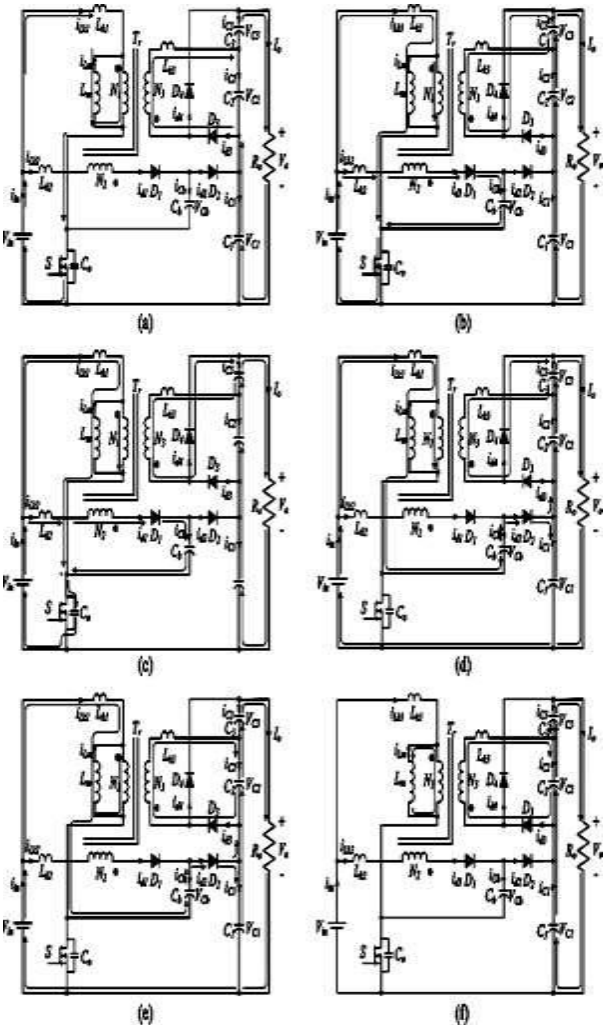
- The load gets partial energy due to the obtained voltage ($V_{in}$+$V_{Lm}$+$V_{Cb}$) and the remaining energy is utilized to charge the clamped capacitor $C_1$.

Mode V [t4, t5]:

- Current flowing in the diode $D_3$ will be increased linearly.

Mode VI [t5, t6]:

- The capacitor and leakage inductor ($L_{K3}$)continuously gets energy from magnetizing inductor.
- This energy gets discharge from capacitor 1&3 to load
- The diode (D-3) current will charge capacitor2 and supply sufficient current to load.




(a)Mode I [t0, t1], (b)Mode II [t1, t2], (c) Mode III [t2,t3],(d)Mode IV [t3, t4], (e)Mode V [t4,t5], (f) Mode VI [t5, t6]

**Fig. 2.5 CCM Operating Modes of the Proposed Converter**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The design of proposed high step up converter converts dc voltage from fuel cell stacks into 400 V. The maximum conversion ratio is 6.7.Duty cycle should be lowered upto 0.5 In order to reduce the conduction losses.

## III. SIMULATION RESULTS

HGSC systems with C, π, T and cascaded filters are modeled and simulated with the help of simulink. The results of these systems are presented in this section. Fig 3.1 shows HGSC system with C-Filter. The PWM produces updated pulses for the main switch of HGSC. The Fig 3.2 shows the input voltage form the DC is 24V. The switching pulse for M1 and Vds is shown in Fig 3.3. The output current of HGSC with C-Filter is shown in Fig 3.4 and its value is 0.65 A. The output voltage of HGCS with C-Filter is shown in Fig 3.5 and its value is 170 V. The output ripple voltage of HGSC with C- Filter is shown in Fig 3.6 and its value is 169.42 V. The output power of HGSC with C- Filter is shown in Fig 3.7 and its value is 110W.

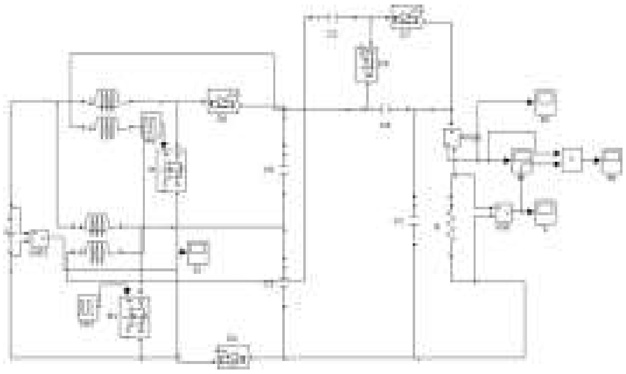

**Fig. 3.1 HGSC System with C-Filter**

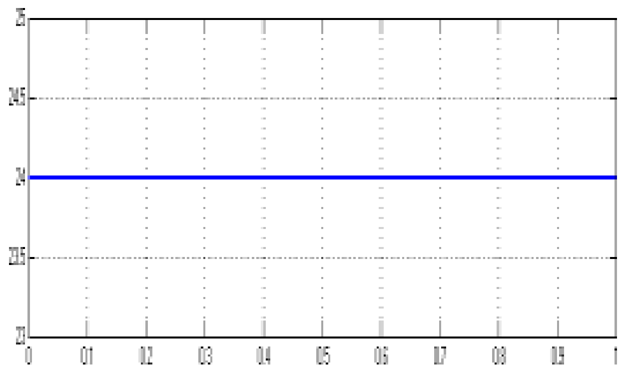

**Fig. 3.2 Input Voltage**

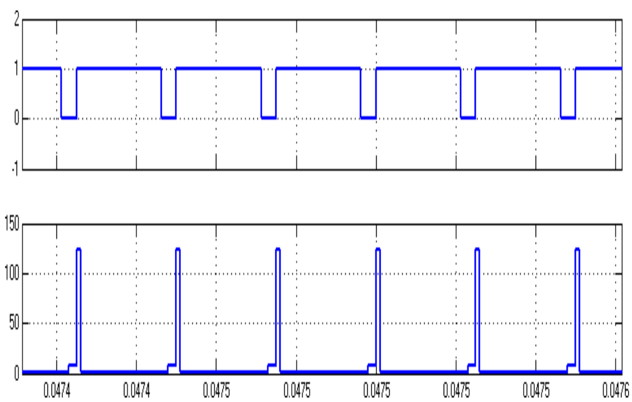

**Fig. 3.3 Switching Pulse for M1 &Vds**

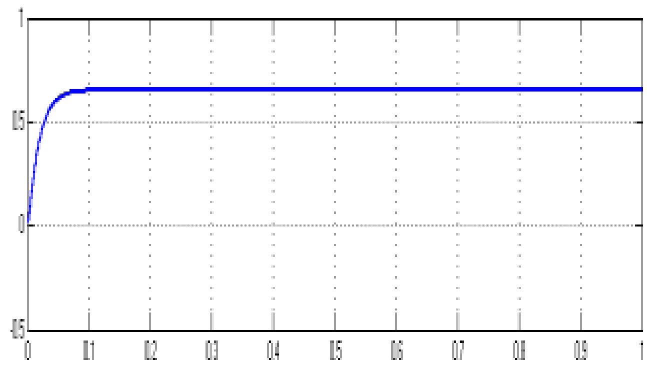

**Fig. 3.4 Output Current of HGSC with C-Filter**

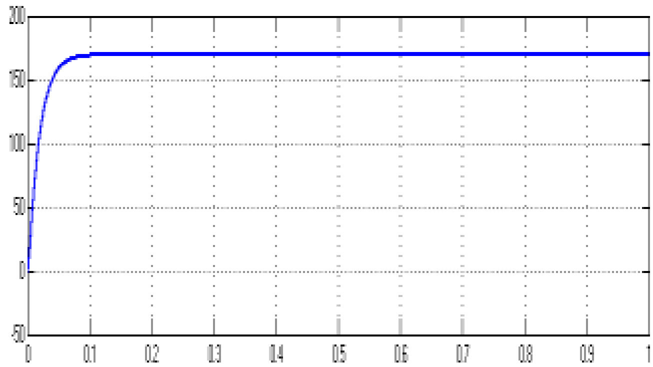

**Fig. 3.5 Output Voltage of HGSC with C-Filter**

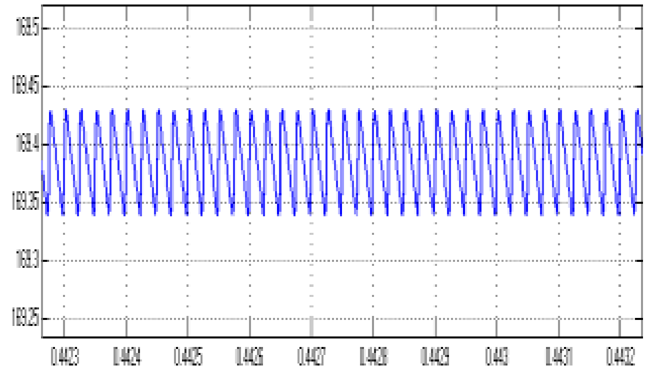

**Fig. 3.6 Output Ripple Voltage of HGSC with C- Filter**

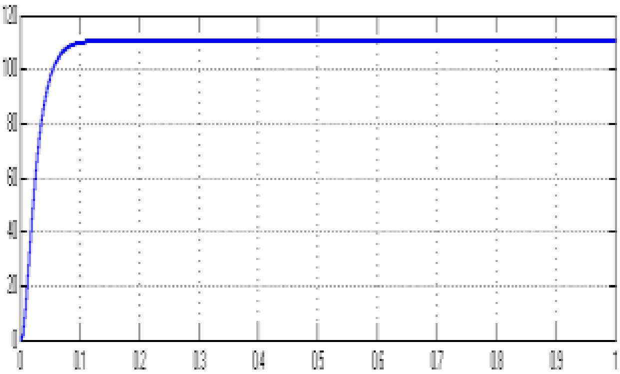

**Fig. 3.7 Output Power of HGSC with C-Filter**

Fig 3.8 shows HGSC system with ∏-Filter. The Output voltage (170V) of HGSC with ∏-Filter is shown in Fig 3.9. Fig 3.10 shows the Output ripple voltage of HGSC with ∏-filter and its peak value is 170.33 V.


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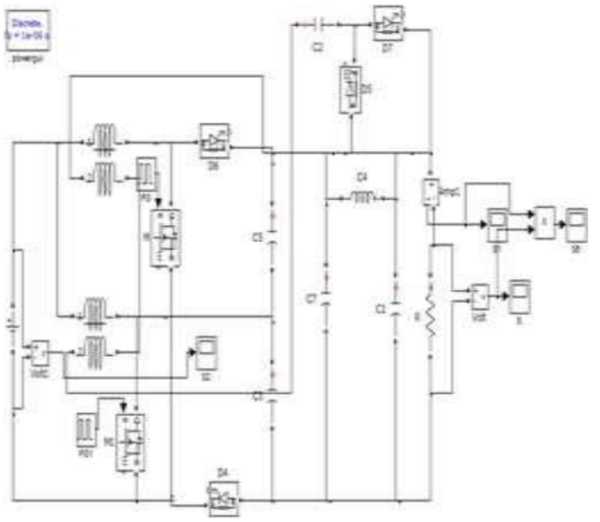

**Fig. 3.8 HGSC System with ∏-Filter**

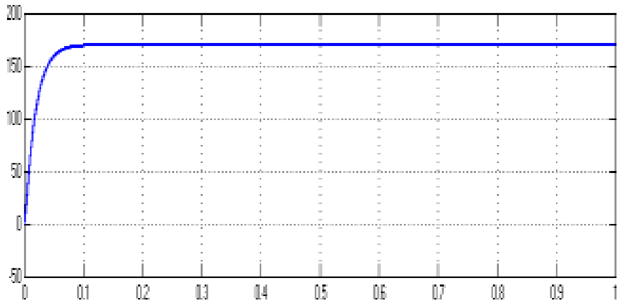


**Fig. 3.9 Output Voltage of HGSC with ∏- Filter**

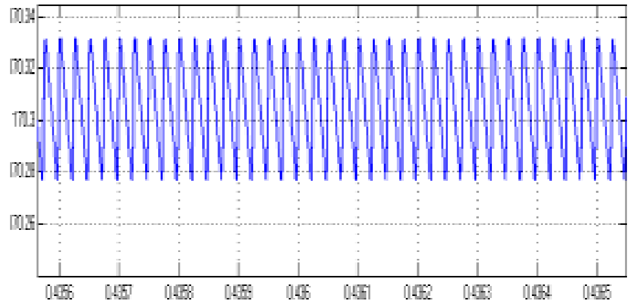

**Fig. 3.10 Output Ripple Voltage of HGSC with ∏- filter**

The HGSC system is shown in Fig 3.11. The Output voltage of HGSC is shown in Fig 3.12 and its value is 170 V. The Output current of HGSC is shown in Fig 3.13 and its peak value is 170.05A.

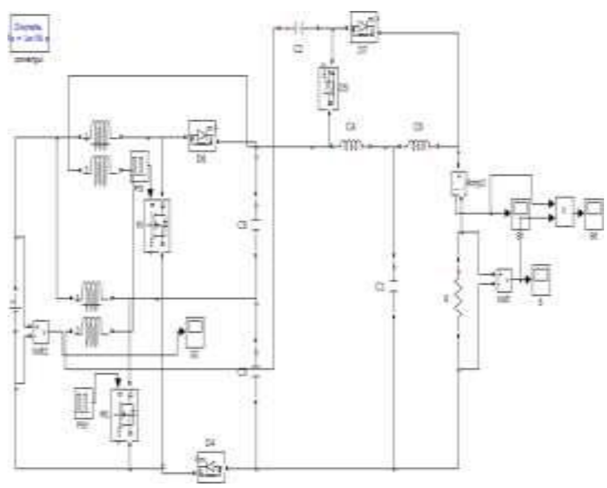

**Fig. 3.11 HGSC System**

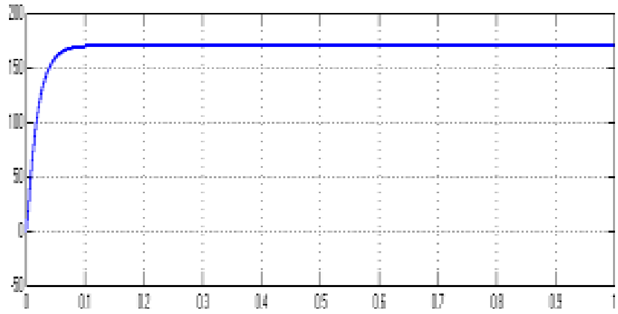


**Fig. 3.12 Output Voltage of HGSC**

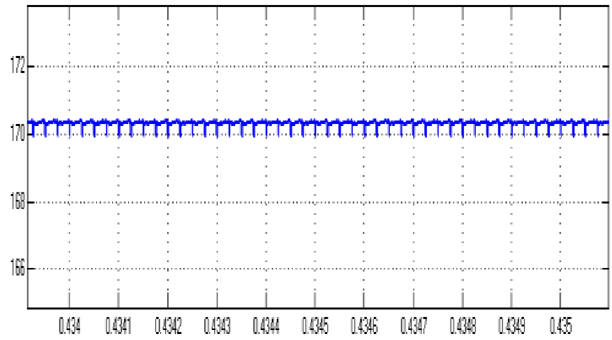


**Fig. 3.13 Output Current of HGSC**

The HGSC system with Cascaded-Filter is shown in Fig 3.14. The Output voltage of HGSC with Cascaded- Filter is shown in Fig 3.15 and its value is 170V. The Output ripple voltage of HGSC with Cascaded- Filter is shown in Fig 3.16 and its peak value is 173.02 V.

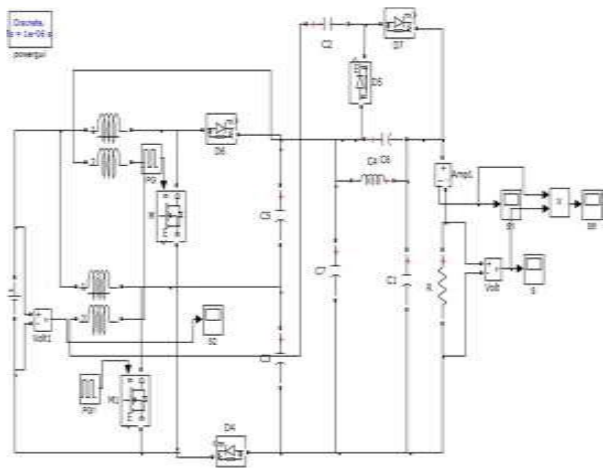

**Fig. 3.14 HGSC System with Cascaded-Filter**

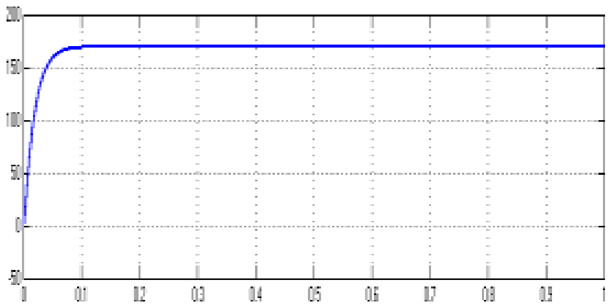


**Fig. 3.15 Output Voltage of HGSC with Cascaded- Filter**


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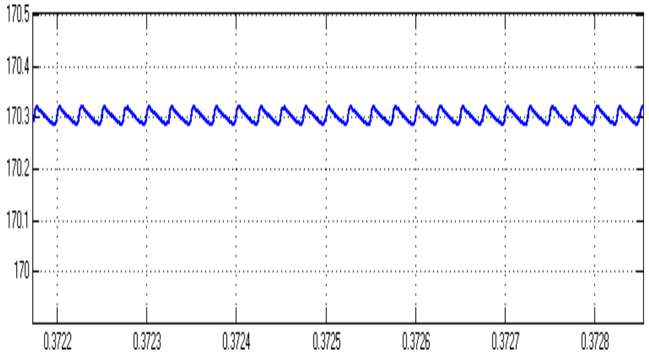

**Fig. 3.16 Output Ripple Voltage of HGSC with Cascaded- Filter**

The comparison of different Filters with various output ripple voltage is shown in Table-1. The C-Filter Ripple voltage is 0.08v, ∏-Filter Ripple voltage is 0.05v, T-Filter Ripple voltage is 0.04v and Cascaded-Filter Ripple voltage is 0.003v. C-Filter is 0.08v and Cascaded-Filter is 0.003v. It is observed that the ripple in voltage is minimum with cascaded Filter.

**Closed Loop with PI and PR controller**

The Open loop with disturbance circuit diagram is appeared in Fig 3.17.The Input voltage is shown in Fig 3.18 and its value is 30 V. The Output voltage is shown in Fig 3.19 and its value is 220 V. The Output current is appeared in Fig3.20 and its value is 0.8 A. The Output power is shown in Fig 3.21 and its value is 175 Watts.

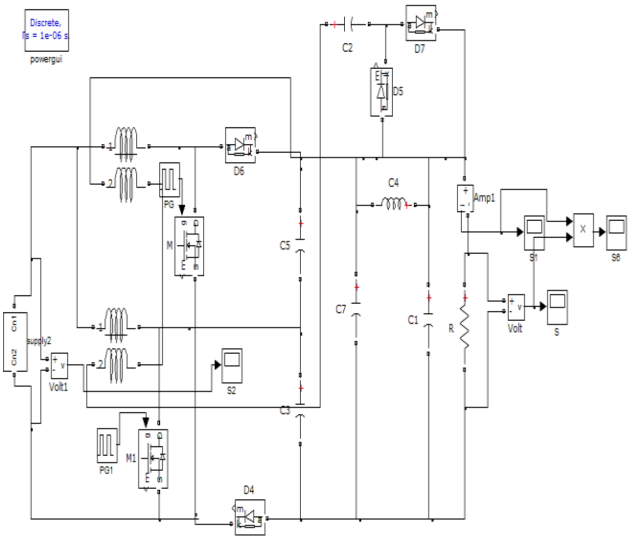

**Fig. 3.17 Open Loop System with Change in Input Voltage**

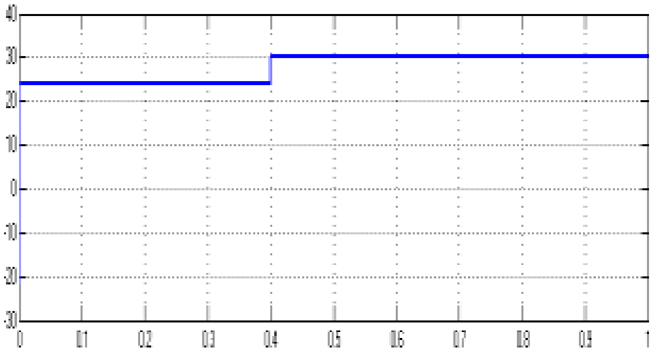

**Fig. 3.18 Input voltage**

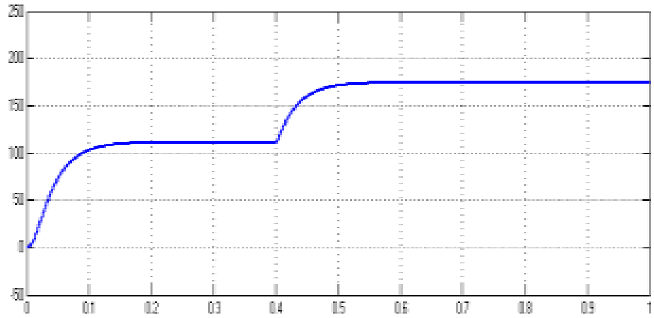

**Fig. 3.19 Output voltage**

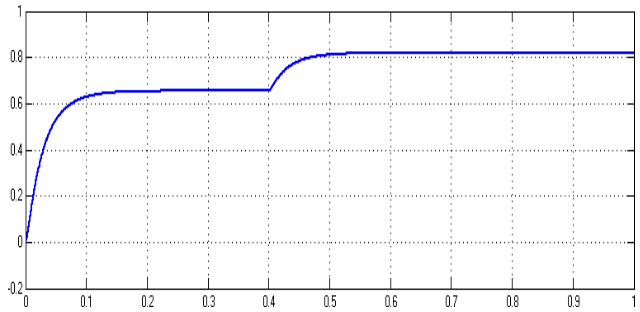

**Fig. 3.20 Output current**

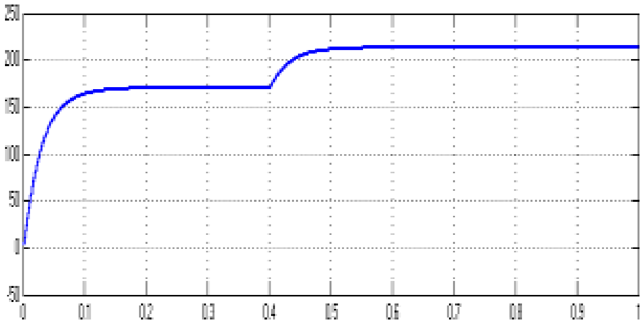

**Fig. 3.21 Output power**

The Closed loop with PI controller is shown in Fig 3.22. The input voltage is appeared in 3.23 and its value is 30 V. The output voltage is appeared in Fig 3.24 and its value is 165 V. The current is shown in Fig 3.25 and its value 0.65 A. The output power is shown in Fig 3.26 and its value is 105 watts.

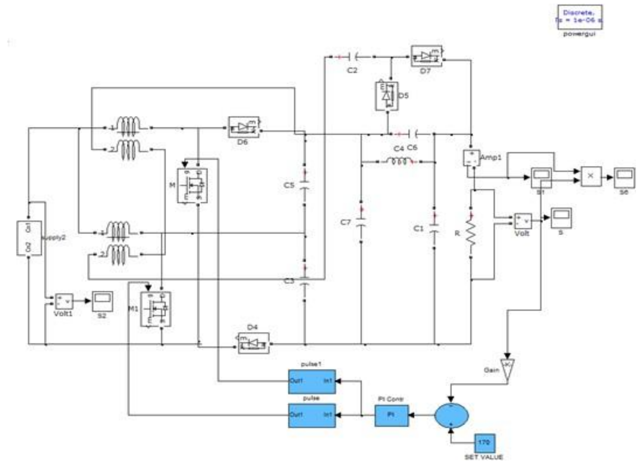

**Fig. 3.22 Closed loop with PI controller**


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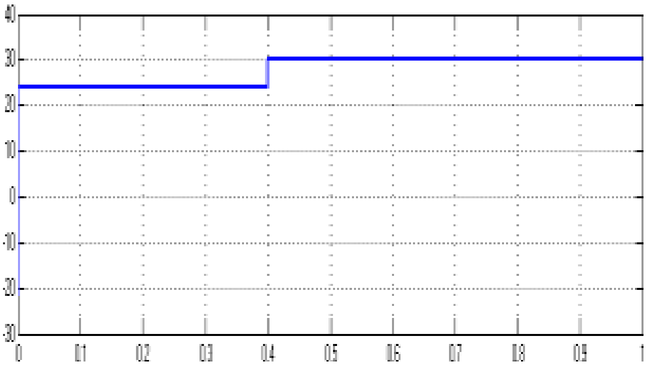

**Fig. 3.23 Input voltage**

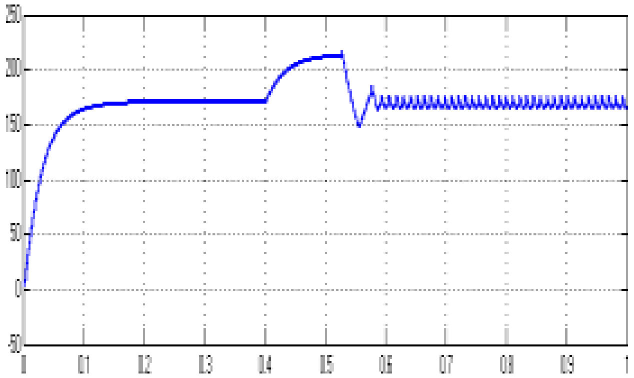

**Fig. 3.24 Output voltage**

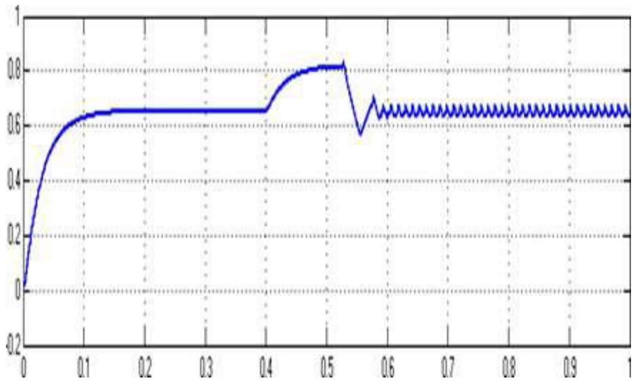

**Fig. 3.25 Output current**

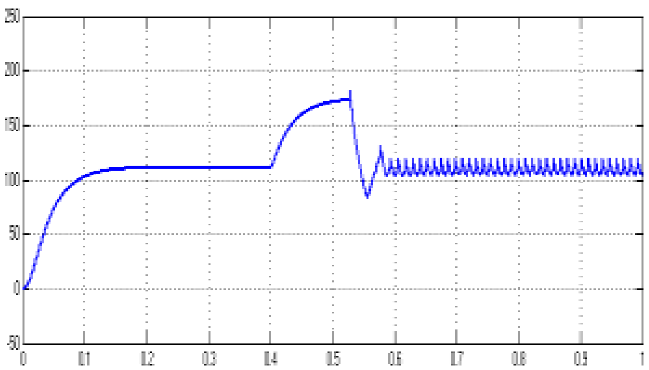

**Fig. 3.26 Output power**

Closed loop with PR controller is appeared in Fig 3.27. The output voltage is appeared in Fig3.28 and its value is 80 V. The current is shown in Fig 3.29 and its value 0.07 A. The output power is shown in Fig 3.30 and its value is 100 watts.

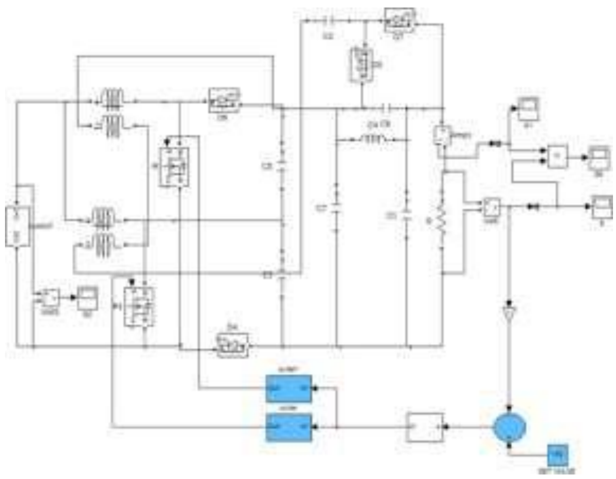

**Fig 3.27 Closed loop with PR**

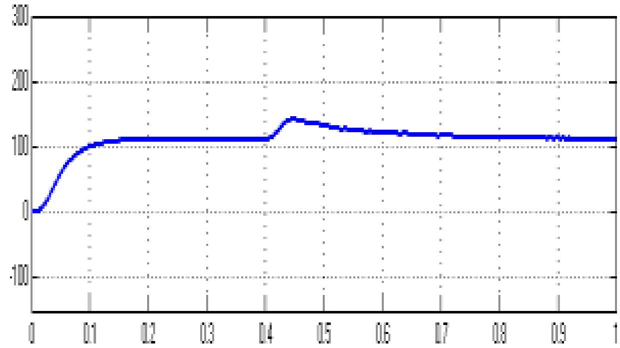

**Fig 3.28 Output voltage**

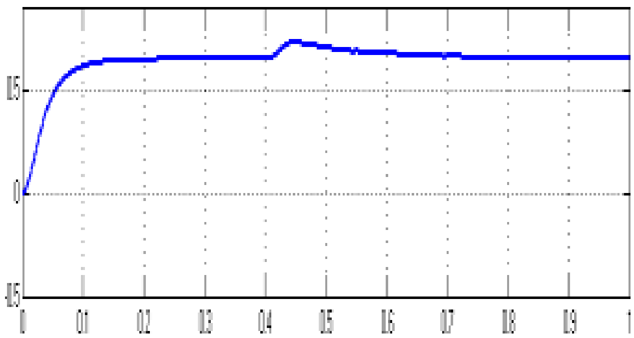

**Fig 3.29 Output current**

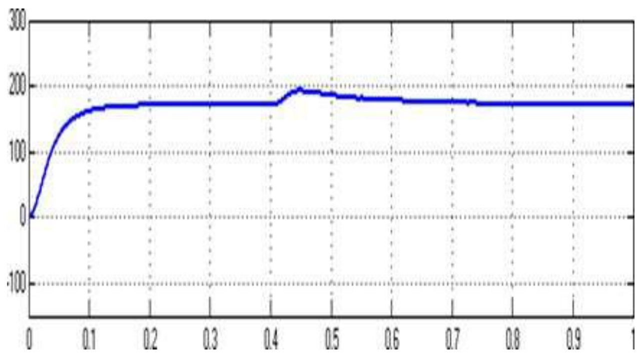

**Fig 3.30 Output power**

The Evaluation of Time Domain Constraints are depicted in above figure. Peak time of the voltage is considerably reduced from 0.6 to 0.5 sec., similarly resolving time is brought down from 0.5 to 0.43 sec and steady state error is brought down from 2.2 to 1.3 volts with the help of PR controller. Therefore dynamic response is enhanced using PR controller.

## IV. CONCLUSION

Simulation for the proposed High Gain Step-up Converter with PI and PR controllers has been done. Comparison of both PI and PR controlled High Gain Step-up Converter are also carried out. Analysis of hydroid electric vehicle has been done successfully which effectively uses the High Gain Input-Parallel Output-Series DC/DC Converter with Dual Coupled Inductors. High step- up conversion is obtained effectively with the use of voltage doubler circuit, three-winding coupled inductor and switched capacitor. The efficiency of the total system is improved by reducing the leakage voltage and spikes in voltage.

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