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# Voltage Control Strategy of AC-DC Hybrid Generation System for Uninterrupted Supply of Power

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**ABSTRACT**:This Paper is an attempt to develop a hybrid generation System, which utilizes the six-phase induction generator for the purpose of conversion loss reduction in a AC-DC Micro grid. This hybrid generation system, which is the combination of wind energy conversion system (WECS), and voltage source converter, which supplies both DC and AC load and the battery energy storage system (BESS). The WECS would be able to supply both AC and DC load while it is working with good speed, while it supplies only the DC load when it is working in low speed condition. But when the WECS does not supply any power BESS would supply AC grid by the use of bypass switches called the static excitation converters (SEC). The six phase induction motor and the inverter model is developed for the AC-DC hybrid generation system .The comparison of the control system using the PI and the fuzzy controller is developed for the PWM control of the voltage Source Converter model which is the cause of overall control of the system. The Matlab based implementation is carried out for the AC-DC hybrid generation system and the performance comparison of both PI and Fuzzy controller is analysed.

**KEYWORDS:**Battery Energy Management System. Wind Energy Conversion System, AC-DC Hybrid Systems, Control Winding Voltage Oriented Control.

## I.INTRODUCTION

Operation ofmicro grid requires implementation of high performance power control and voltage regulation algorithm [1]-[5]. This concept permits high penetration of distribution generation without considering redesign of the distribution system itself [7]. In case of disturbances on the main network, micro grid could potentially terminate and continue to operate individually, which helps in improving power quality to the users [8]. The micro source thus appears as a controlled voltage source, whose output should rightfully share the load demand with the other sources. The sharing should preferably be in proportion to their power ratings, so as not to overstress any individual entity [9].

The problem that is faced by use of the AC-DC-AC systems is that there would be lot of losses in the conversion process .The cost and the size of the system would become uneconomical while the AC-DC-AC conversion system is developed.In this paper the implementation of the AC-DC hybrid system which involves modeling of DWIG(dual stator winding induction generator) and fuzzy logic controller. The DWIG which is a special type of a generator which has two windings in its stator, one three phase winding is referred as power winding which will supply the AC loads and other one is referred as control winding which will take care of the generator excitation and also feed the DC loads. This system would reduce the conversion losses along with the reduction of the size and the capital cost of the implementation, And also efforts are made to reduce the hormonics.

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## II.SYSTEM MODEL

The AC-DC hybrid generation system is described in the Figure 1 depicting the overall block diagram of the implementation thus developed.

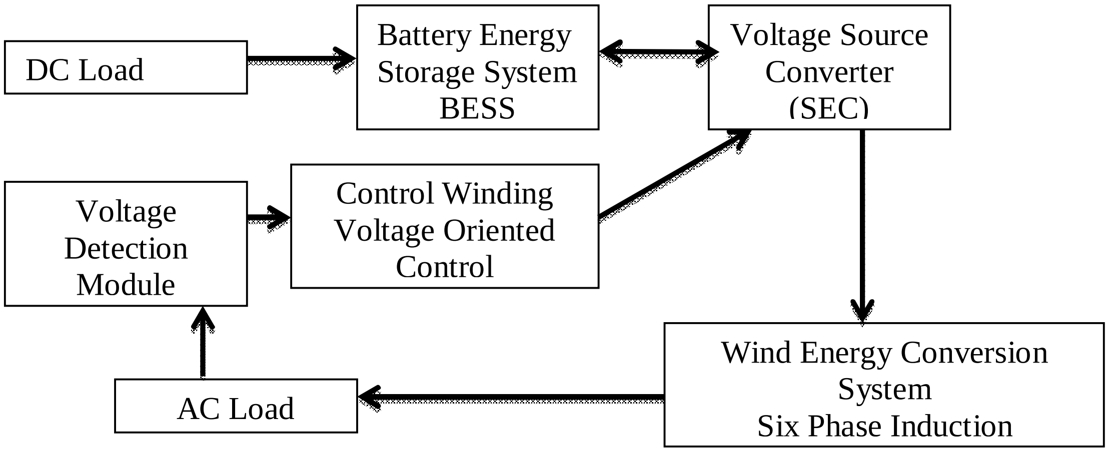


Figure 1.Overall Block Diagram of AC-DC Hybrid Generation System.

The AC-DC hybrid generation system would be able to supply both DC and AC grid by means of BESS and SEC systems. There are two portions of the winding in the Six Phase Induction generator, which is called as the control winding and the power winding. The control winding is the one, which connects SEC and WECS; the power winding is the one, which connects WECS and AC load.

The control of SEC is carried out by the use of the voltage detection module. The Voltage detection module would convert the three phase instantaneous voltage to the orthogonal components in order to have a better control of the variable ,that is voltage. The orthogonal component is the direct and the quadrature component of the three-phase voltage supplied to the AC load. As the grid voltage is taken for the reference current calculation, it means the shape of the reference must be pure which is desirable to be fed from the voltage source controller. The reference current would be obtained after regulating the direct axis and the quadrature voltage through PI controller. The conversion of the three-phase voltage to the orthogonal portions of the voltage is as shown in the Figure 2.

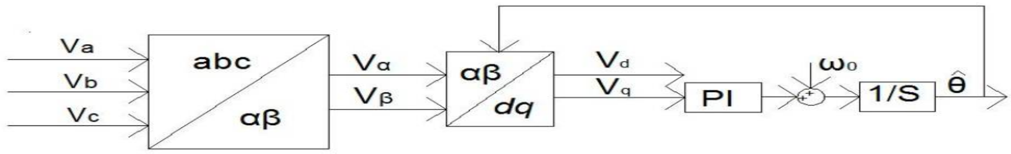


Figure 2.The ABC to dq conversion

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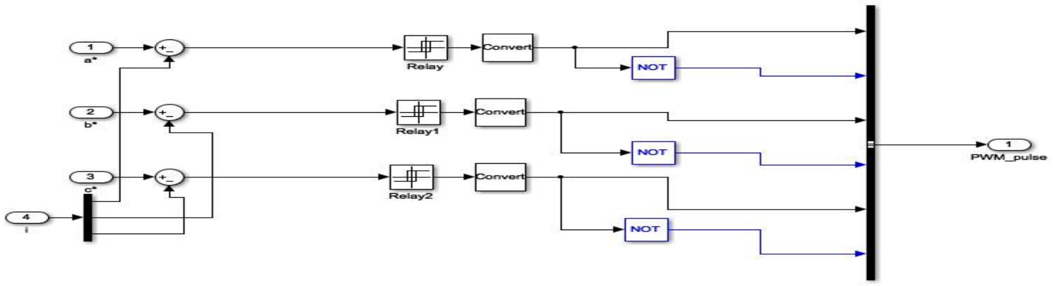


Figure 3. Hysteresis Controller

The direct and quadrature current thus generated would be compared with the current generated from the output of the voltage source converter which would be sent to hysteresis controller as shown in the Figure 3.The PWM generation for the SEC is as shown in Figure 3, using the hysteresis controller. The PWM thus generated would be given to the converter, which would develop a voltage from the inverter, which is able to maintain a constant voltage in the input side of the converter, and also voltage in phase to the load.

## III. CONTROLLERS USING PI AND FUZZY CONTROLLER:

The PI controller used in the Figure 2 would be replaced by the Fuzzy logic controller, which would be used to develop a better control of the voltage control in the SEC. The PI controller thus used would have the proportional and the integral constants as Kp=1 and Ki=1 with the upper and the lower limit of the regulator to be .52 and .49 respectively. The Fuzzy controller is developed with the two inputs of error and change in error of the direct and the quadrature voltage and the output is the reference direct and quadrature current. The two inputs have seven membership functions each making it to have 49 rules. The ratings of the power system thus considered is as depicted in the Table 1.

| SLno. | Voltage rating | Power Rating |
|---|---|---|
| WECS | 425 V (600/sqrt(2)) | 200 kW |
| BESS | 600V | 90 KVA |
| SEC | 425 V | 200 kW |

Table 1.specification of the system.

The table Below shows the fuzzy rules.

| Error/Changein Error | MF1 | MF2 | MF3 | MF4 | MF5 | MF6 | MF7 |
|---|---|---|---|---|---|---|---|
| MF1 | MF1 | MF1 | MF1 | MF4 | MF4 | MF4 | MF4 |
| MF2 | MF5 | MF1 | MF1 | MF1 | MF1 | MF1 | MF4 |
| MF3 | MF4 | MF3 | MF1 | MF1 | MF1 | MF1 | MF4 |
| MF4 | MF4 | MF4 | MF7 | MF2 | MF1 | MF1 | MF4 |
| MF5 | MF1 | MF1 | MF4 | MF4 | MF7 | MF3 | MF1 |
| MF6 | MF3 | MF1 | MF4 | MF4 | MF7 | MF3 | MF1 |
| MF7 | MF4 | MF4 | MF4 | MF4 | MF7 | MF7 | MF7 |

Table 2. 49 fuzzy rules used for fuzzy controller.

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## IV. RESULT AND DISCUSSION

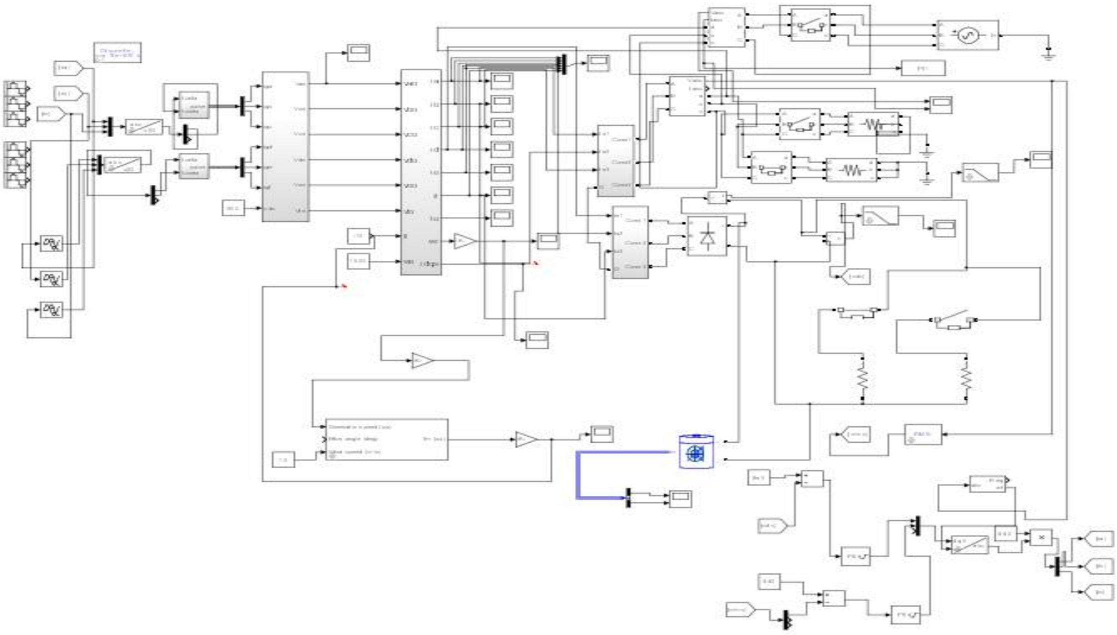

Figure 4:Simulink model of the hybrid AC/DC generating system.

The simulation model of AC&DC hybrid generating system in MATLAB which has three parts: DWIG, the SEC and controller. DWIG is a new generator with unique structure, so its simulation model must be built on the basis of the mathematical model. The SEC is connected with control winding which provides excitation reactive power for generator to maintain stability of the system and produce DC power while the power winding gives AC power directly. The simulation model of controller is set up with the Simulink modules in MATLAB according to the proposed control algorithm. The controller has the mainrole of tracking and evaluating reactive power, sending out PWM signals to drive the SEC and maintaining the stable operation of the generating system.
Here PI controller is replaced with fuzzy controller to reduce the harmonics.

**PI controller results:**

**Steady state simulation:**

In the generating system model, adding 4KW DC load in the control winding side while adding 8KW three-phase AC load in the power winding side at the same time. The operation process can be observed and the simulation waveforms are shown below.

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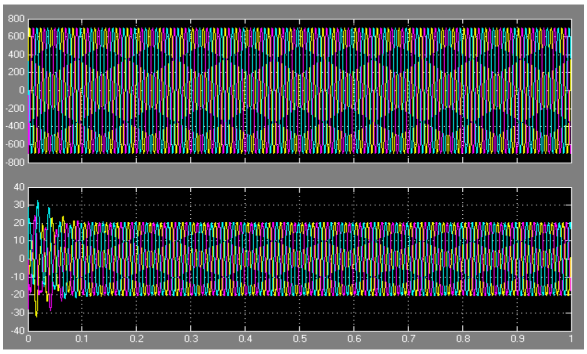

Fig 5: AC output voltage and current.

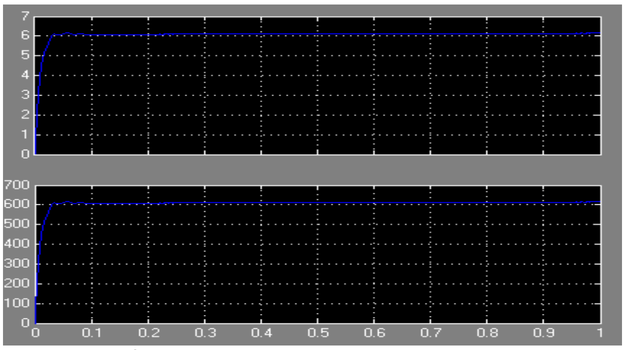

fig 6: DC output voltage and current.

Above figures shows that DC voltage continues to rise until 600V and has remained at around 600V. The amplitude of three phase AC line voltage can finally remain at 700V.

**Dynamic Simulation:**

**Case 1:** Adding 8KW three-phase AC load at 0.7 sec in the power winding side.

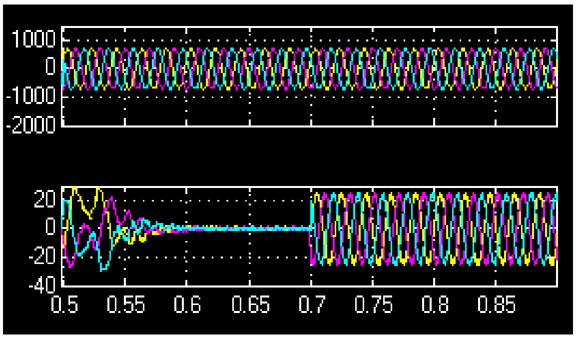

Fig 7:AC output voltage and current.

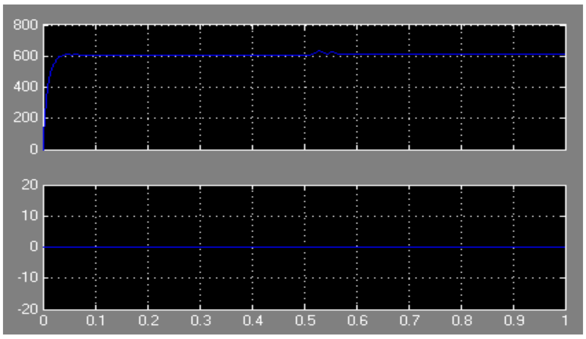

Fig 8:DC output voltage and current

Above figures shows that when AC load of 8KW is added at 0.7 sec the AC current increases at that instant and DC current will remain at zero.

**Case 2:** Adding 4KW DC load at 0. 7sec in the control winding side

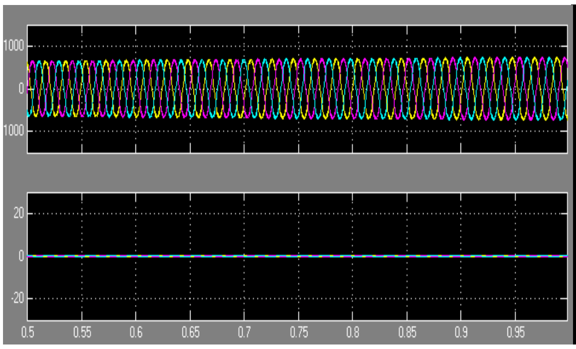

Fig 9: AC output voltage and current

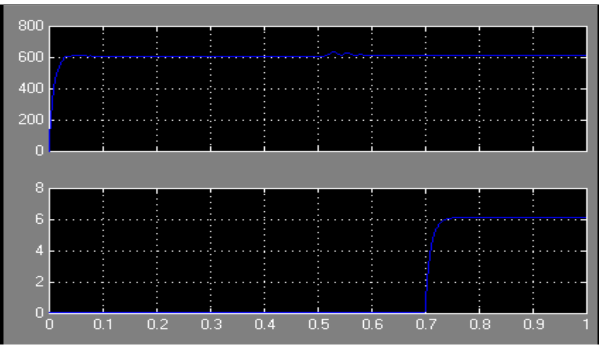

fig 10: DC output voltage and current.

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Above figures shows that when DC load of 4KW is added at 0.7 sec, DC current increases and AC current remains at zero.

**Case 3:**Adding 8KW three-phase AC load in the power winding side and 4KW DC load in the control winding side simultaneously at 0. 7s.

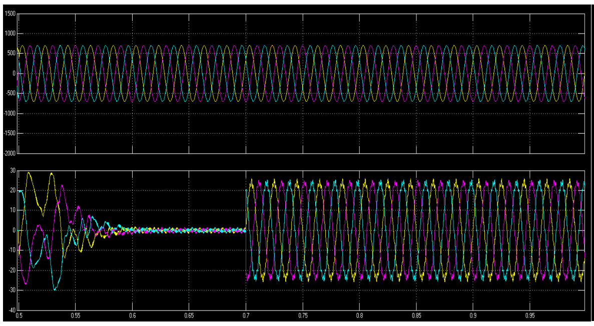

Fig 11:AC output voltage and current.

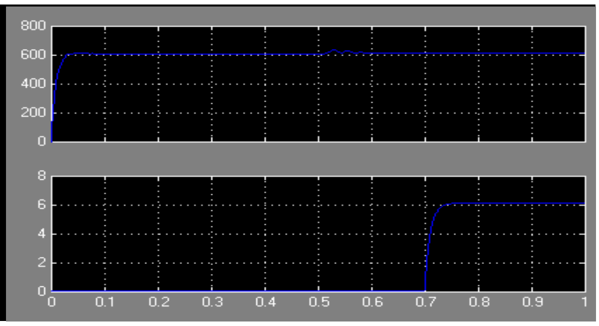

Fig 12:DC output voltage and current.

Above figure shows that when both AC and DC loads are added simultaneously at 0.7 sec both AC and DC current starts to increase simultaneously at the same instant.

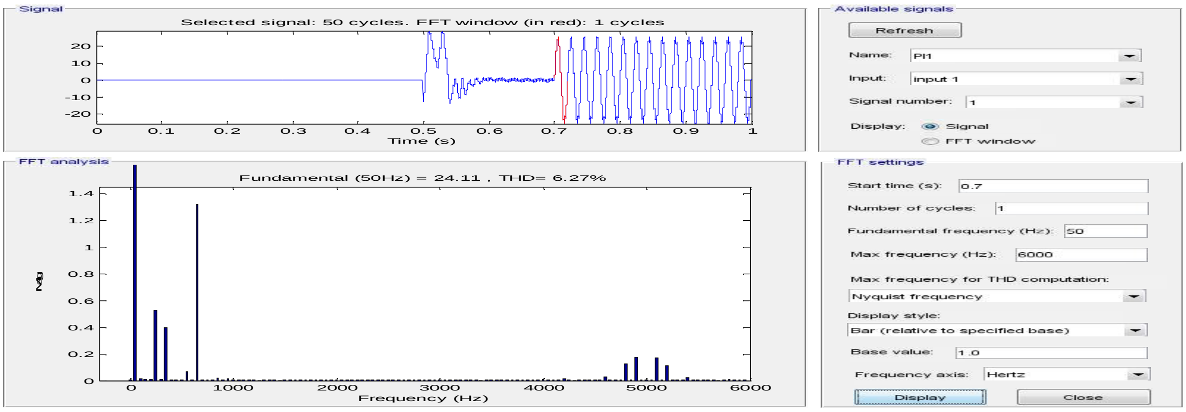


Figure 13:THD analysis using FFT

PI controller is replaced by **fuzzy controller** for better dynamic performance and hormonic reduction.

**Steady state simulation:**

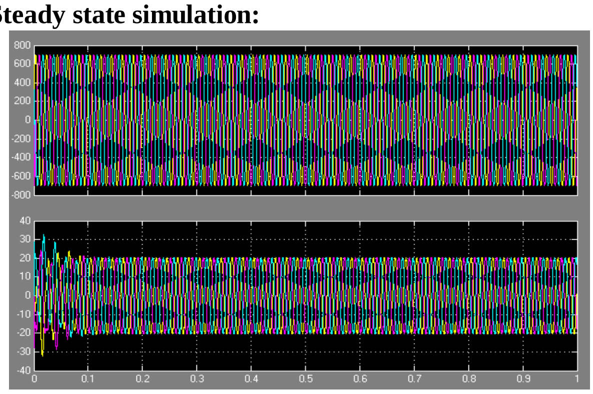

Figure 14.AC Voltage and current.

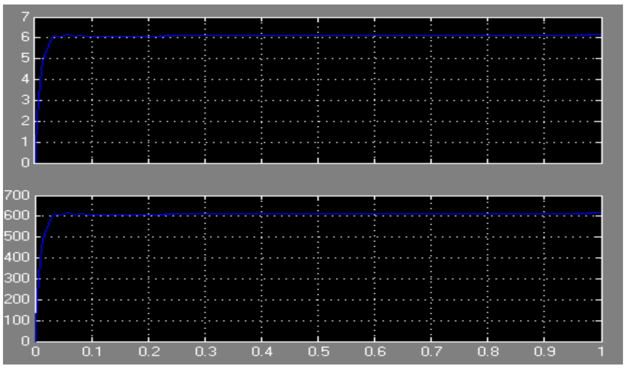

Figure 15. DC voltage and current.

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**Dynamic Simulation:**

**Case 1:** Adding 8KW three-phase AC load at 0.7 sec in thepower winding side

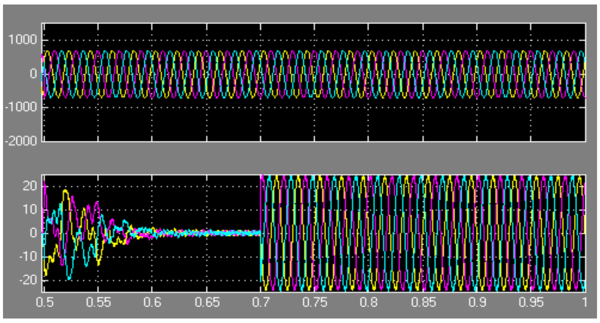


Figure 16: AC output voltage and current.

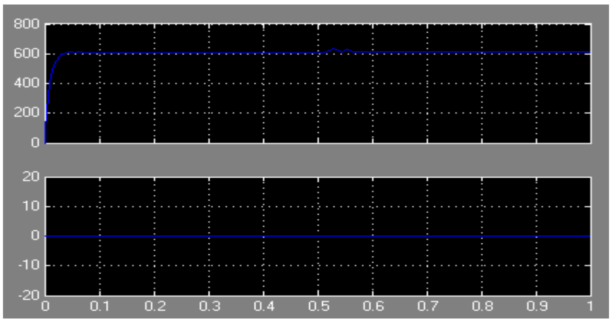


Figure 17: DC output voltage and current.

Above figures shows that when AC load of 8KW is added at 0.7 sec the AC current increases at that instant and DC current will remain at zero.

**Case 2:** Adding 4Kw DC load at 0.7 sec in the control winding side.

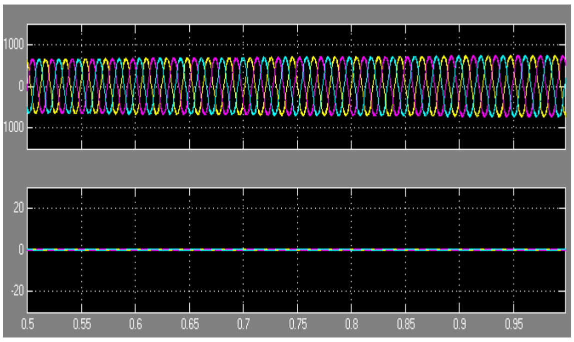

Figure 18: AC output voltage and current.

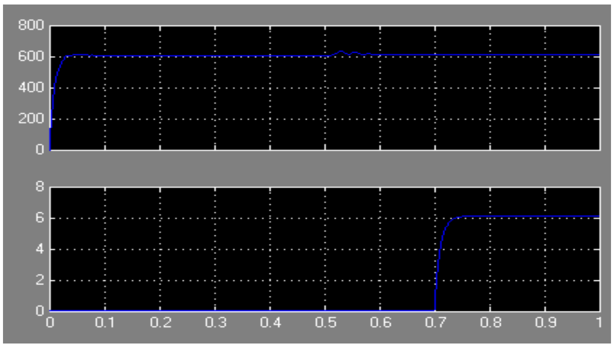


Figure 19: DC output voltage and current.

Above figures shows that when DC load of 4KW is added at 0.7 sec, DC current increases and AC current remains at zero.

**Case 3:** Adding 8KW three-phase AC load in the power winding side and 4KW DC load in the control winding side simultaneously at 0. 7s.

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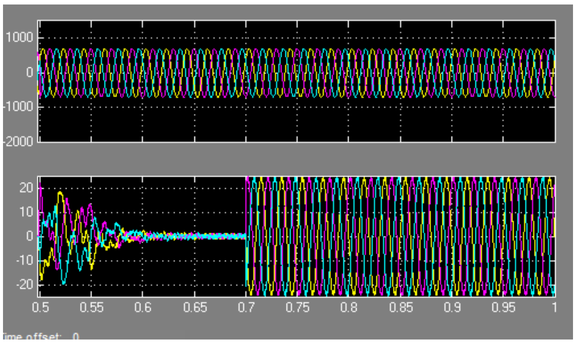

Figure 20:AC output voltage and current

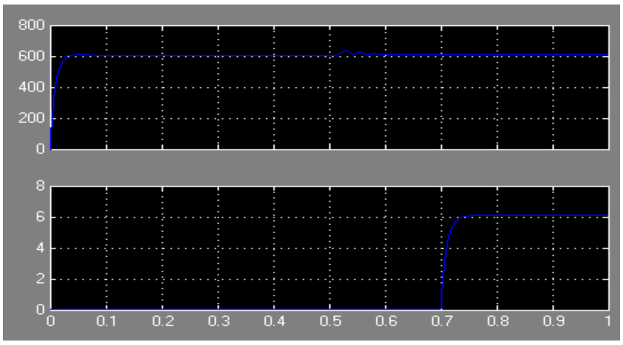

figure 21: DC output voltage and current.

Above figure shows that when both AC and DC loads are added simultaneously at 0.7 sec both AC and DC current starts to increase simultaneously at the same instant.

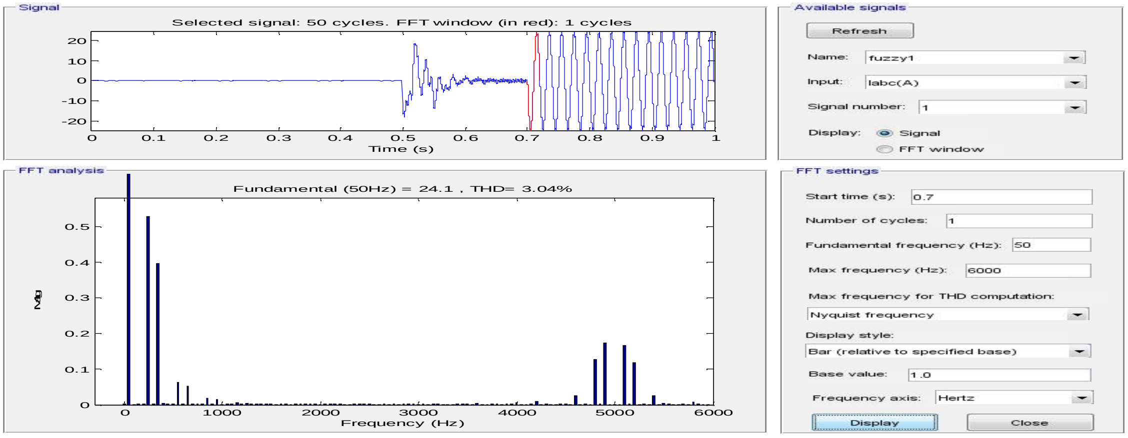


Figure 22: THD analysis using FFT

The THD value of 6.37% is observed with pi controller implementation and the THD value is reduced to 3.04% with the fuzzy controller implementation

## VI.CONCLUSION

The Matlab based simulation is developed for the AC-DC hybrid generation system, which controlled by both PI and Fuzzy controller and the performance of the control winding based voltage oriented control is developed. The inference of the implementation suggest that the fuzzy controller has performed better as compared to the PI controller while controlling the SEC.

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