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Design and simulation of front end power converter for a microgrid with fuel cells and solar power sources

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Abstract. The need for Renewable Energy Sources (RES) is increasing due to increased demand for the supply of power and it is also environment friendly.In the recent few years, the cost of generation of the power from the RES has been decreased. This paper aims to design the front end power converter which is required for integrating the fuel cells and solar power sources to the micro grid. The simulation of the designed front end converter is carried out in the PSIM 9.1.1 software. The results show that the designed front end power converter is sufficient for integrating the micro grid with fuel cells and solar power sources.

1. Introduction

In the recent years, Microgrids are animportant part of the smart grids. The necessity of electric power is increasing every day. The generation of power from the conventional sources is limited due to the decrease in the resources and also its impact on the environment. The generation of power from solar power sources, wind energy along with fuel cells, generator turbines and power plants are going to play important role in the future [1] [2].

The energy obtained from the solar power sources and fuel cells are environment friendly and also does not cause any pollution. In general, a fuel cell produces a maximum of 1 V. The combination of many fuel cells in series can produce a maximum of 40 V and normally a photovoltaic module can produce up to 24 V which are not sufficient for the grid connected applications. Therefore a power converter is needed to boost voltage for integrating solar power sources and fuel cells to the grid [3,4].

2. Converter Topology

The proposed front end power converter circuit will provide an electric isolation between the sources and load with the help of transformer. The transformer turns ratio is 1:4 which helps in boosting the input voltage. For minimizing the input ripples and switching losses in the MOSFET, two parallel inverters with 90 degree phase shift are used.

The switching frequency of the circuit is 100 kHz which reduces the size of magnetic components used and increase the reliability of the circuit.

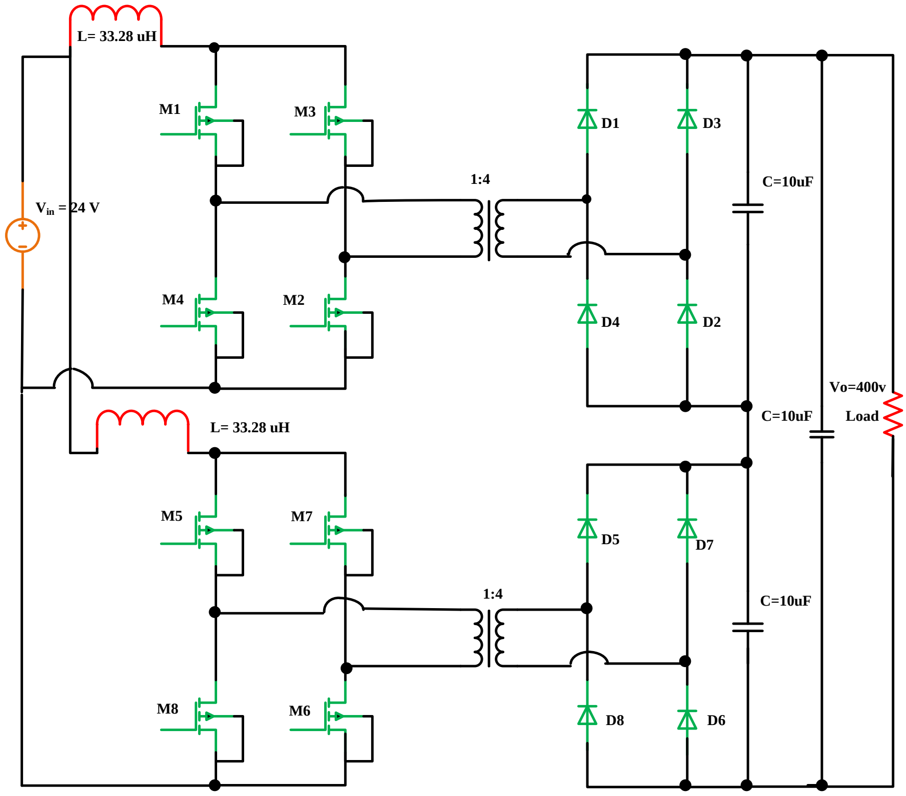

Figure 1. Proposed Converter topology

3. Principle of Operation

FIRST MODE: In this mode, M_1, M_2 are ON in the upper leg. The interleaved inverters are having 90 degree phase shift M_7, M_8 are conducting in the second leg simultaneously. At the output side the voltage across transformer secondary side the diodes D_1, D_2, D_7, and D_8 are conducting and D_3, D_4, D_5, D_6 are non-conducting diodes. The path of the conduction is shown in Figure 2. The circuit of the first mode is shown in Figure 2.

SECOND MODE: In this mode, all M_1 to M_8 are conducting together. Due to this inductance stores energy and therefore there will be no output in this mode. The circuit diagram of the mode 2 is shown in Figure 3.

THIRD MODE: In this mode, M_3, M_4 are conducting in the first leg and M_5, M_6 are conducting in the second leg simultaneously.so this combination occurs which is acompliment of the mode 1. The path of the conduction is shown by arrows in the Figure 4.The circuit diagram of the mode 3 is shown in Figure 4.

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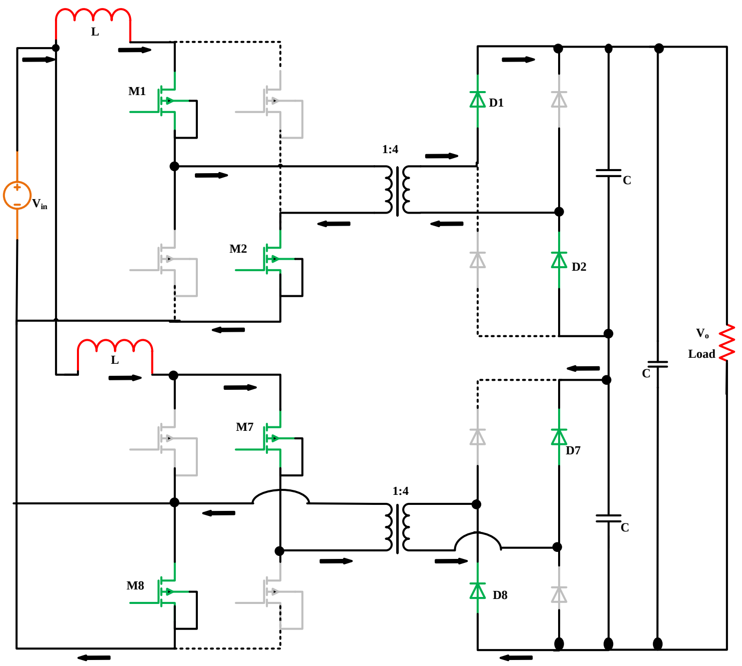

Figure 2. First Mode

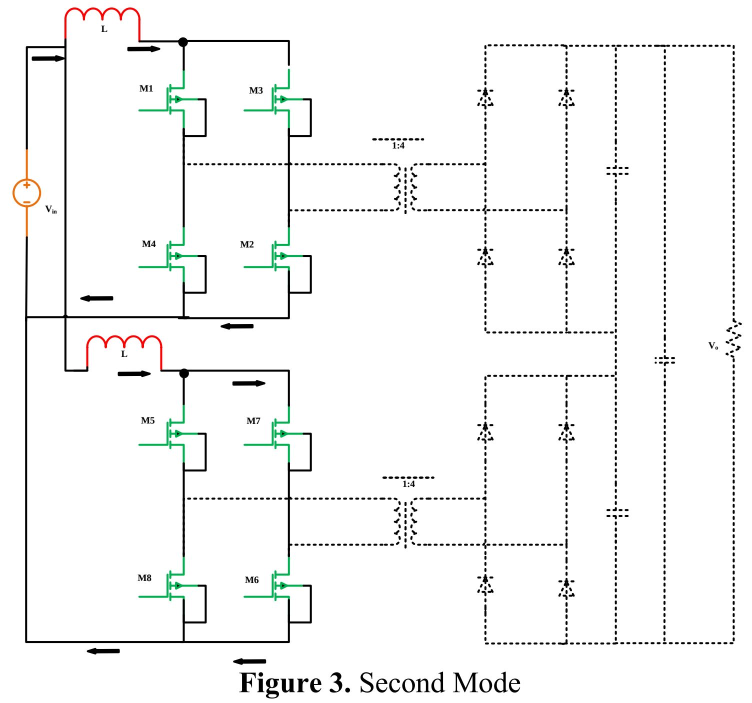

Figure 3. Second Mode

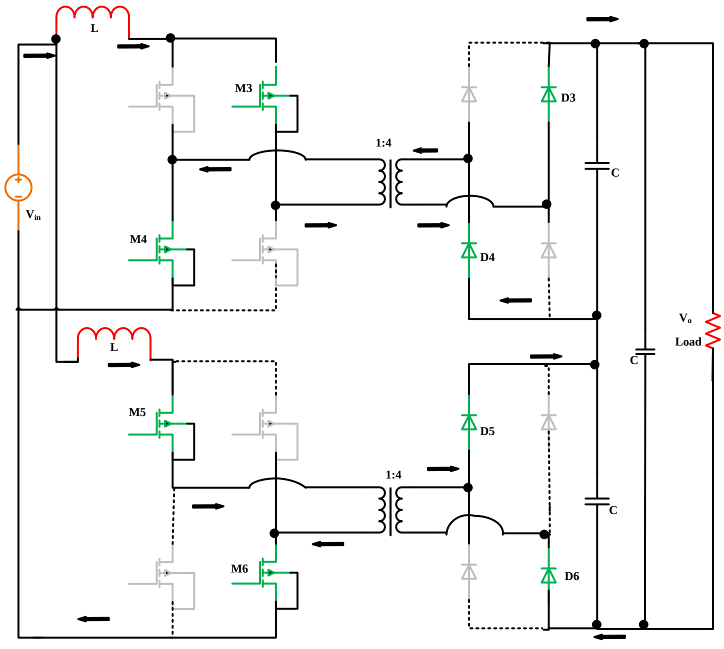

Figure 4. Third Mode

4. Simulation Results

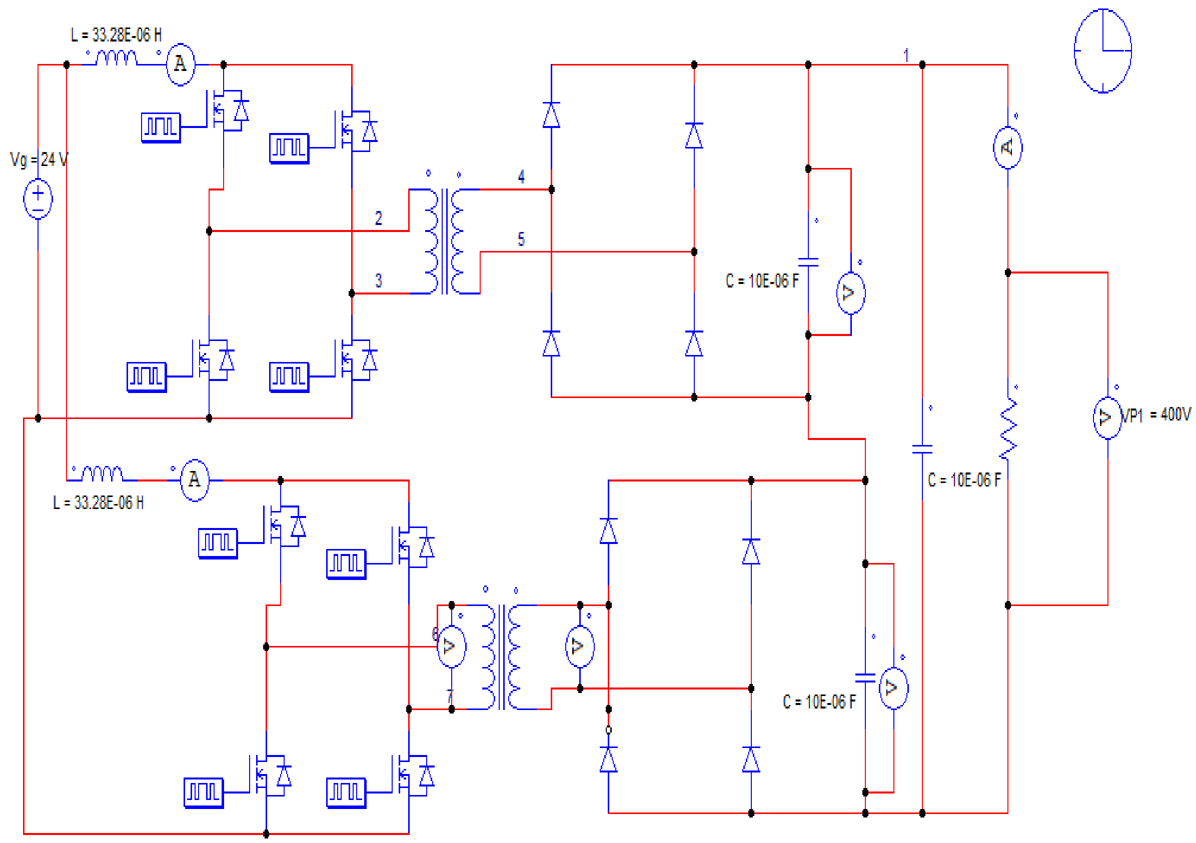

Figure 5. Simulation Circuit

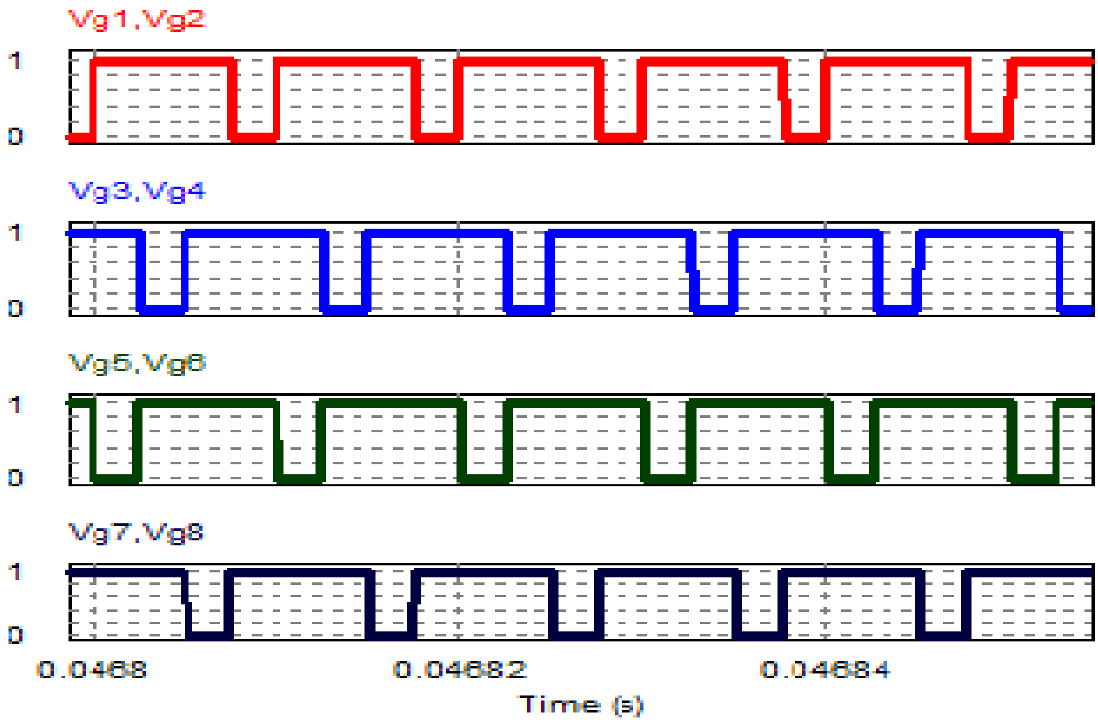

Figure 6. Triggering Pulses for the Switches

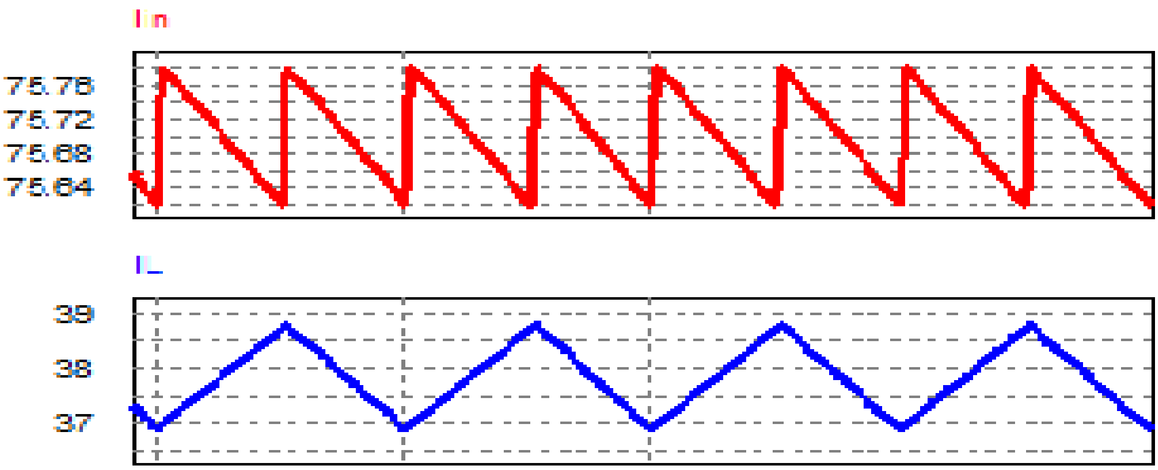

Figure 7. Input Current and Inductor Current.

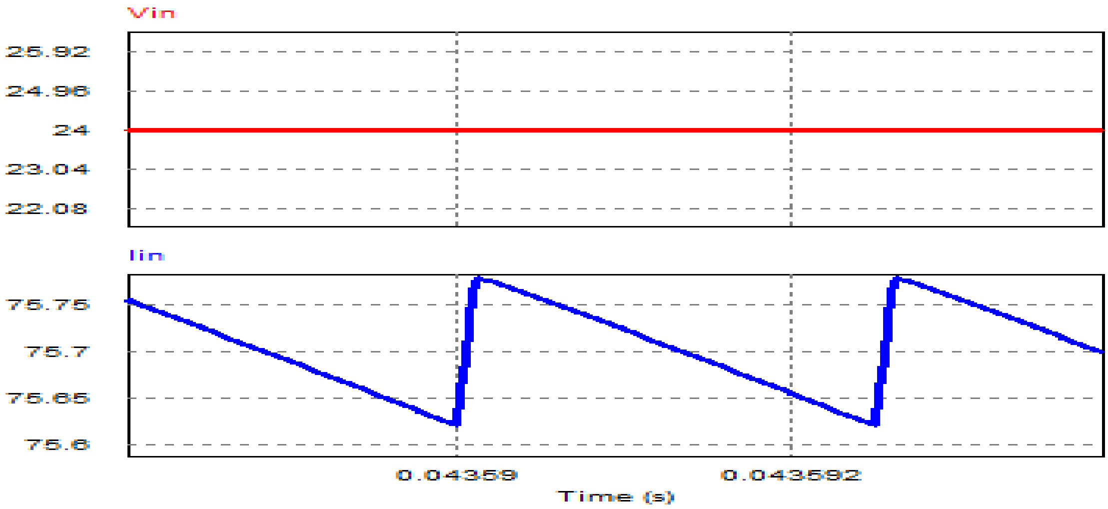

Figure 8. Steady State Input Voltage and Current.

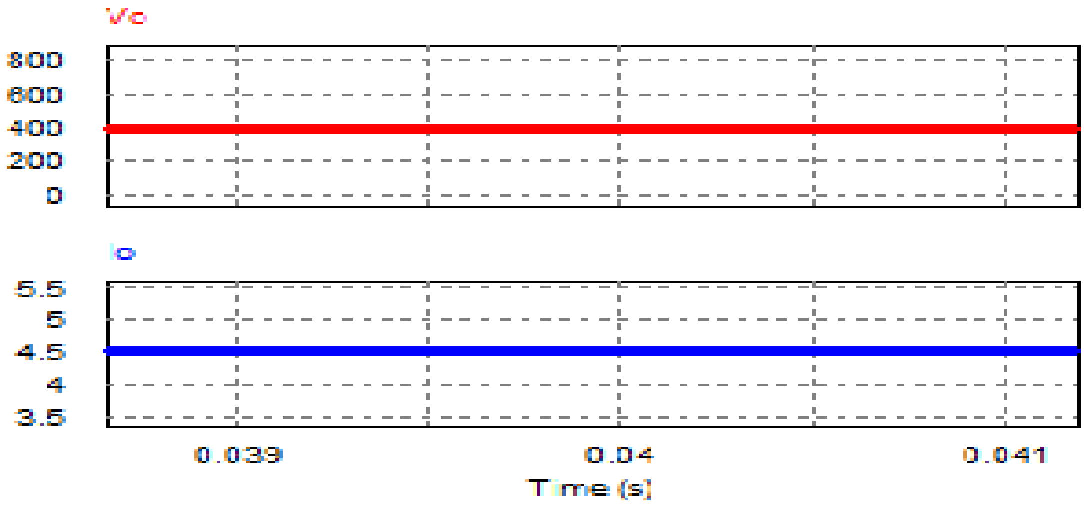

Figure 9. Output Voltage and Current

5. Specifications of Design

Table 1. Design Specifications for the Circuit

Parameters	Values
Input voltage	24 V
Output voltage	400 V
Power	1800 W
Resistance	88.88 Ω
Frequency	100 kHz
Duty cycle	76%
Filter capacitors	10 µF
Boost Inductors	33.28 µH

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6. Conclusion

The front end converter for integrating the solar power sources and fuel cells to the grid applications is implemented. The designed converter reduces the input ripple and also shares the load current equally as the input sources are connected in parallel which minimizes stress on switches.

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