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Analysis of Transformer and Transformerless DC-DC Converter for Renewable Energy System

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Abstract: ***This paper tells about a comparative analysis of DC-DC converter for renewable energy system. DC-DC converter with transformer has been proved that it is suitable to the electrolysis application. High frequency voltage matching transformer is used in this topology, due to the high input and output voltage difference. In this comparation is done with and without transformer to obtain the stabilized output voltage. The MATLAB simulation result shows that the output voltage with transformer is free from ripples.***

Keywords: MOSFET, High frequency transformer, Diode, capacitors.

I. INTRODUCTION

A. *Renewable Energy Resources*

1)Solar energy: Now a days the solar energy is most commonly used by the consumers, business, organisation. It is one of the most essential sources of renewable energy. It is used to generate the electricity by using solar panels. This technology is used to reduce the electricity bill. It is completely clean, it produces no air pollution, no water pollution, and no green house gas effects. Installation is easy. Low Maintenance Cost.

B. *MOSFET*

MOSFET Stands for Metal oxide Silicon field effect transistor. It works a Switch in Inverter Circuit. It is a 3 terminal device with Drain, Source and Gate. It operates in two modes enhancement mode, depletion mode. It is of two types n-channel, p-channel.

1) *Working:* As soon as drain and source are connected with the DC voltage Source then two p-n junctions is formed. One is between n type drain and p type base and other is between p type base and n type Source. As Drain is connected is Positive Terminal of Source, the Drain is higher Voltage than Base hence this p-n junction is reversed biased. On the other hand as source is connected to negative terminal of the battery the p type base will be at higher potential than n type source. Hence this p-n junction is forward biased as between drain and source, there will be one reversed biased and one forward biased junction. There will be no significant current flowing from drain to source but a tiny current continuous to flow due to minority carriers. We can say that virtually there is no continuous path or channel between drain and source.

C. *High frequency Transformer*

These Transformers are designed to handle high voltages upto15,000 volts safely and accurately. These are widely used in Switched mode power supplies. It is smaller in size and lighter in weight. It has less number of turns on primary and secondary side. It is made up ferrite core. Ferrite material is used to reduce hysteresis losses due to high frequency.

D. *LC Filter*

LC filter is also known as resonant circuit, tank circuit and tune circuit. Capacitor and inductor are connected to form LC filter. Inductor does not allow sudden change of current and capacitor does not allow sudden change in voltage. LC filter does not allow AC voltage and it allow DC voltage. Rectifier output is connected to the inductor, inductor does not allow AC component and allows only DC component from output. Now output DC contains slightly AC component as capacitor allows AC components, and these AC components are grounded. Now pure DC is obtained at the output.

II. BLOCK DIAGRAM

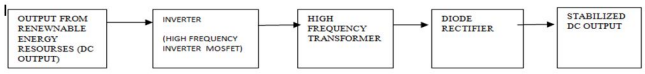

Fig1: Typical Block Diagram

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In the above block diagram the output from the renewable energy resources that is DC output is given to the high frequency inverter. The DC is converted to AC by using this high frequency inverter. The available AC is transferred to the secondary side with the help of high frequency transformer. The AC is again converted back to DC by using diode rectifier. Finally the stabilized DC voltage is obtained.

III. A COMPARATIVE ANALYSIS OF DC-DC CONVERTER RENEWABLE ENERGY SYSTEM

A. Design Parameters

DESIGN PARAMETER	RATING
INPUT VOLTAGE	48V
L1	25mH
L2	50mH
C1	200pF
C2	100pF
C3	100pF
C4	2000pF
Ton	50%
Toff	50%
T	100%
Switching Frequency	50KHz
Transformer Ratio	1:4
Diode	IN4007
MOSFET	IRF840
Output Voltage	200V
Output Current	10A
Output Power	2KW

Table 1: the above values are the specifications of the circuit model.

B. Simulation Link Models

1) DC-DC converter without transformer

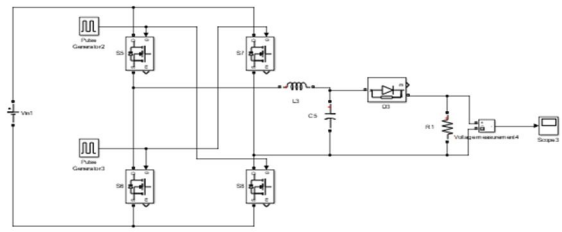

Fig 2: DC-DC converter without transformer

2) Circuit Working: We are using high frequency inverter in which s1, s4 will operate in parallel and s3, s2 will operate simultaneously. In the first half cycle s1 and s4 will turn ON and in second half cycle s3 and s4 will turn ON. In first half cycle when s1 and s2 are in operation the flow of dc will be through supply-s1-L3-c5-s4-back to the supply. In the second half cycle s1 and s2 will turn OFF and automatically s3 and s2 will turn on then the flow of dc will be through supply-s3-c5-L3-s2-back to supply. The DC is converted in AC by using high frequency inverter and is again converted back to the DC by using diode rectifier. The obtain dc voltage is not stabilize one if we give this output voltage to the load it will get damaged. In order to overcome this we are going to DC-DC converter with transformer.

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3) DC-DC CONVERTER with Transformer

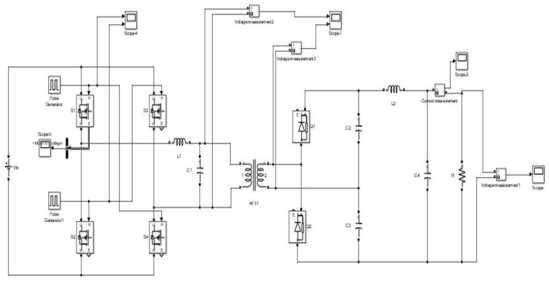

Fig 3 : DC-DC converter with transformer

4) Circuit Working: We are using high frequency inverter where we are using 4 MOSFETS s1, s2, s3, s4. s1 and s4 will operate in parallel and s3 and s2 will operate simultaneously. In first half cycle s1 and s4 will turn ON and in the second half cycle s3 and s2 will turn ON. In the first half cycle s1 and s4 will in operation and the flow of dc will be through supply-s1-L1-primary winding-s4-back to the supply. In the second half cycle s1 and s4 will turn off automatically and s3 and s2 will be in operation then the flow of dc will be through supply-s3-primary winding-L1-s2-back to the supply. Now positive and negative voltage waveforms are generated on primary side of the transformer with the help of high frequency inverter. The high frequency AC voltage is transferred to the secondary side by using high frequency transformer. On secondary side we are using diode rectifier to convert AC voltage into positive waveforms. In the positive half cycle the current flows through d1-L2-R-C2-back to the winding. At this time when the current flows through the d1, d2 will be in reverse bias. In negative direction the current flow through c2-L2-R-d2. At this time diode d1 will be in reverse bias. DC Output voltage is obtained which is stabilized one.C2 and c3 capacitors are used to reduce voltage peak over shoot generated by the high frequency transformer. Capacitor c4 is used to reduce the ripples in the voltage across the resistor.

IV. SIMULATION RESULTS OF DC-DC CONVERTER WITHOUT TRANSFORMER

The simulation is done using MATLAB simulation and the output waveforms are presented. In order to display the output waveforms the scope is connected at the output.

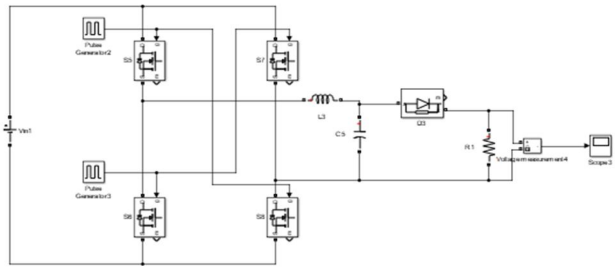

Fig4: Simulation circuit of DC-DC converter without transformer

A. Output voltage

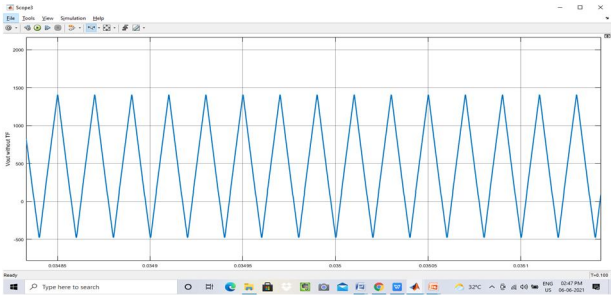

Fig5: Output Voltage Waveforms
(X axis-time (sec), Y axis-Voltage (amplitude))

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V. SIMULATION RESULTS OF DC-DC CONVERTER WITH TRANSFORMER

The simulation is done using MATLAB simulation and the output voltage waveforms are presented. In order to display the output waveforms the scope is connected at the output.

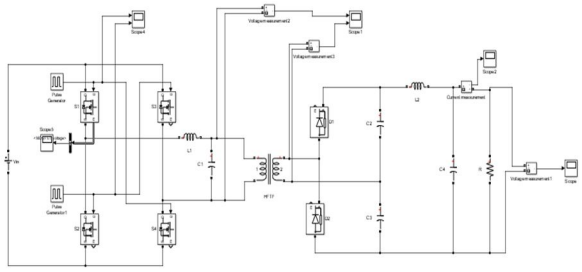

Fig 6: Simulation circuit of DC-DC converter with transformer.

A. Pulses

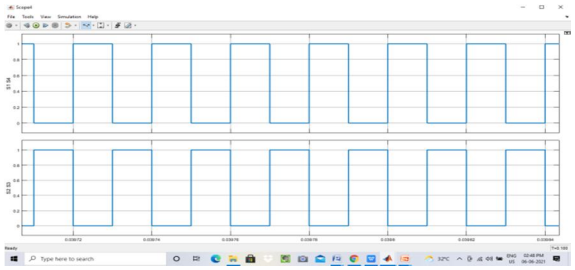

Fig 7: Driving pulses to the MOSFET
(X axis-time (sec), Y axis-amplitude)

B. MOSFET Voltage

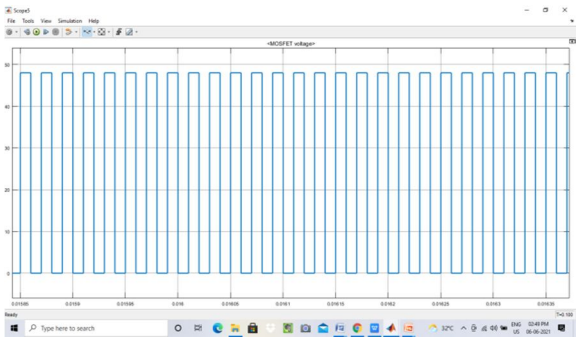

Fig8: MOSFET voltage
(X axis-time (sec), Y axis- amplitude)

C. Primary and Secondary voltage Waveforms of Transformer

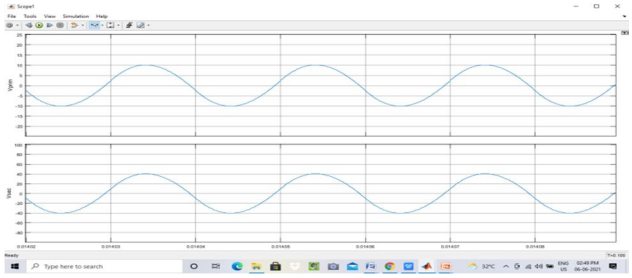

Fig9: Transformer primary and secondary voltage waveforms
(X axis-time (sec), Y axis- Amplitude)

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D. Output Current

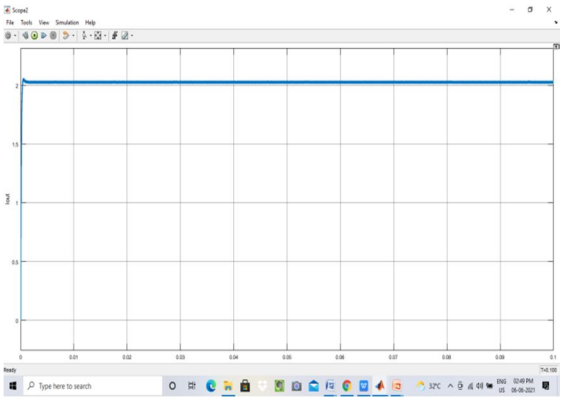

Fig10 :Output current
(X axis-Time (sec), Y axis-Current (Amp))

E. Output Voltage

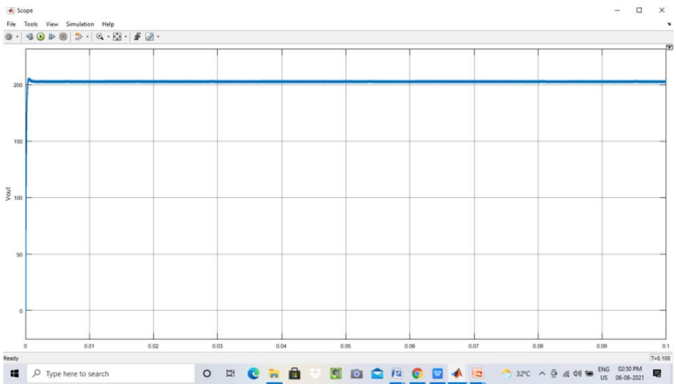

Fig 11: Output Voltage
(X axis- Time (sec), Y axis-Amplitude)

VI. ADVANTAGES, DISADVANTAGES, APPLICATIONS

A. Advantages

Simple Topology.
With the transformer it is used to stabilise the voltage.
High frequency voltages are generated.

B. Disadvantages

Without transformer the output voltage will be unstable.

C. Applications

It is used in electric vehicles to charge the battery in the parking slots, also used at the output of converter stations etc.

VII. CONCLUSION

This paper provides a comparative analysis of DC-DC converters with and without transformer for renewable energy system like wind, solar etc. With transformer configuration we will get a stable output voltage by which loads are protected from over currents and over voltages. LC filter at the output reduces the ripples present in the DC Output voltage. Voltage peak over are reduced by using capacitor. DC-DC Converter with transformer can be used for electrolyser application because of its desirable features. Efficiency of output voltage is increased by 15% by using DC-DC converter with transformer. Simulation results are compared for with and without transformer configurations.

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VIII. ACKNOWLEDGEMENT

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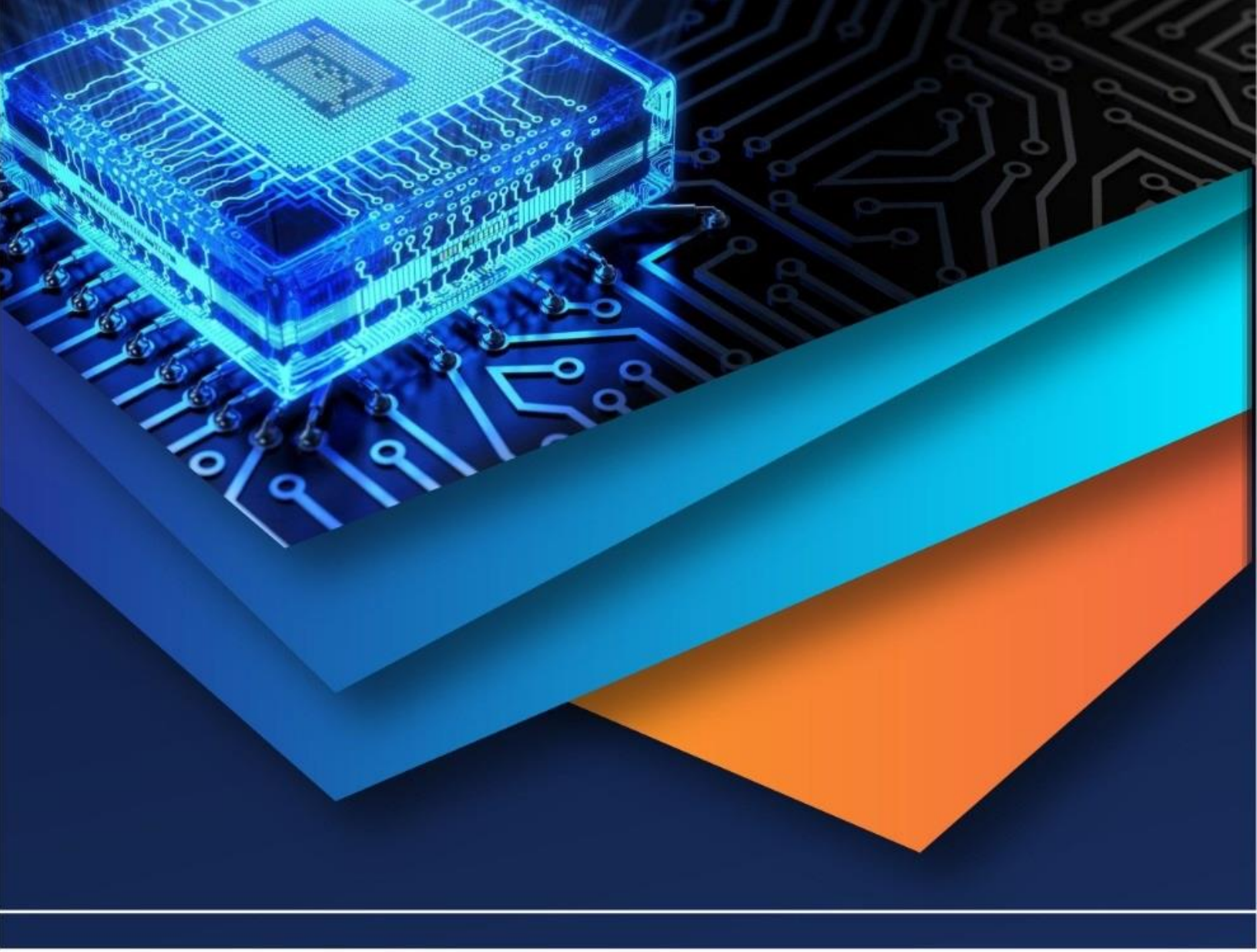

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