RESEARCH ARTICLE OPEN ACCESS

To Improve the Performance Efficiency of AC-DC Converter

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ABSTRACT
This project is about to develop and design the power converter with improved performance with low voltage and high current dc output.One of the application of low voltage,high current dc output is charger of supercapacitors(12V,150A).The need to design the power converter for reduced volume and high efficiency with dc low voltage and high current is the main objective.For high level performance of converter the voltage and current ripples should be low particularly in terms of losses and low component stress.To meet these requirements resonant converter has been used.The high frequency transformer is preferred to obtain the minimum voltage regulation.This paper describes the high frequency transformer and resonant converter intended to obtain a better efficiency by maintaining the constant low voltage and high current dc output.Simulation is performed using PSIM software and also the open loop transfer function are derived.

Keywords - Series Parallel Resonant Inverter, Resonating Components,High Frequency Transformer, Leakage Inductance,TransferFunction

I. INTRODUCTION

Advent of devices with better switching capabilities has enriched the field of power electronics. This enables the development of converter circuits with improved and high performance[1]. The AC-DC converters are characterized so as to obtain low voltage and high current dc output. Conventional converters are most common but they have clumsy structures,slow system responses and high ripples level of voltage and current.

At present there are several types of power supplies to charge supercapacitors but they do not make so convenient solutions for high current low voltage dc output with high performance and low losses.In this study several topologies have been investigated for modelling high current low voltage converter having low current and voltage ripples which is the most crucial point of system design. To improve the power factor of ac input line several topology has been proposed in the literature[3-6].High frequency resonant inverter provides novel solution to the problem offered by conventional inverter and also they can be operated in variable and high frequency mode. Owing to higher frequency of operation component sizes get reduced thereby component stress. On the other hand conventional converter was found to have several disadvantages such as bulky size, heavy weight, high di/dt value,high voltage stress,turn on and turn off losses, low efficiency,etc.The above demerits are overcome by high frequency resonant converter. It has numerous advantages such as light weight,higher frequency of operation,high efficiency,small size,fast response,low component stress,less electromagnetic interference(EMI)etc.

II. AC-DC CONVERTER

The below figure shows the power circuit diagram of AC-DC converter for low voltage/high current dc output application with high performance.Focussing towards the improvement in the performance ,the converter circuit has been divided into five stages.

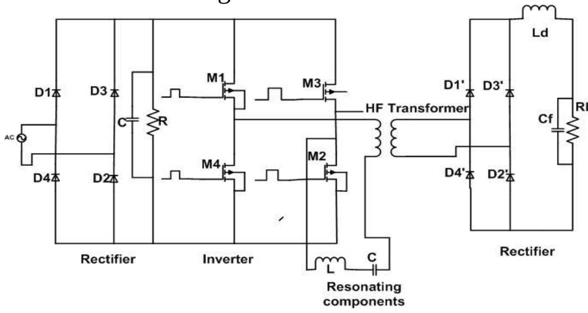


Fig 1.Power Circuit Diagram Of Ac-Dc Converter

The above figure shows the power circuit diagram of AC-DC converter for low voltage/high current dc output application with high performance.Focussing towards the improvement in the performance ,the converter circuit has been divided into five stages.In the 1st stage,when ac supply is fed to the single phase uncontrolled diode rectifier,there is conversion of ac to dc.Filters has been added to avoid ripples and to have constant smooth dc output. In the 2nd stage,output from rectifier is applied to single phase full bridge high frequency inverter circuit.Mosfet switches are used in the inverter circuit as they have fast switching speed and gives better efficiency at high frequency.The switching frequency is 50Khz.The high frequency inverter has numerous advantages such as light weight,better system reliability and efficiency at higher frequency,small size,quick response,low component stress,reduced electromagnetic interference(EMI),etc. The 3rd stage is LC tank resonating circuit.The LC resonating components of high frequency inverter helps to minimize the leakage reactance of the transformer. There are three types of resonant converter

2.1.Series resonant converter

Series Resonant Converter uses a series capacitor,which blocks the dc component avoiding high frequency(HF) transformer saturation. Its part load efficiency is high due to the decrease in device currents with decrease in load.Output dc filter is required to carry high ripple current.

2.2.Parallel resonant converter

Parallel resonant converter works such that the entire current is limited by resonant inductor when the output terminal is short circuited[6].The filter inductor limits the ripple current carried by the output capacitor.

2.3. Series parallel resonant converter

Series parallel resonant converter(sprc)combines desirable features of series and parallel resonant converter[2].Thus the behaviour of series parallel resonant converter was found to be suitable for low voltage dc application and was observed in detail.At light loads it takes the property of parallel resonant converter.The load can be short circuited and light load regulation is possible[1].Current through high frequency switches does not decrease in proportion to decrease in load and hence produces high efficiency.The resonant tank circuit consists of capacitor and inductor which is placed across primary winding of high frequency transformer and thus forms series parallel resonant converter.

In the 4th stage,resonant inverter output is applied to HF transformer. High frequency(HF) transformer specified for low voltage high current output applications have been useful for establishing more advanced power distribution with energy storage systems.The HF transformer non idealities such as leakage inductance and winding capacitance are utilized as a part of resonant tank circuit elements[1].This configuration is well suited for low output voltage giving better performance in terms of efficiency and voltage regulation.The leakage inductance of HF transformer can be used as a part of resonating inductor.Hence the transformer leakage inductance need not be a troublesome parasitic.Thus power loss and voltage spike magnitude will not increase.The HF transformer has several advantages such as low eddy current losses at higher accurate frequency, skin effects are minimized, low leakage inductance, reduction in size, weight and cost etc.Skin effect is the tendency of an AC to become disturbed within a conductor such that the current density is largest near the surface of the conductor[7-9]. It causes the effective resistance of the conductor to increase at higher frequency where the skin depth is smaller,thus reducing the effective cross section of conductor.Hence the transformer output will be low ac voltage and high ac current.

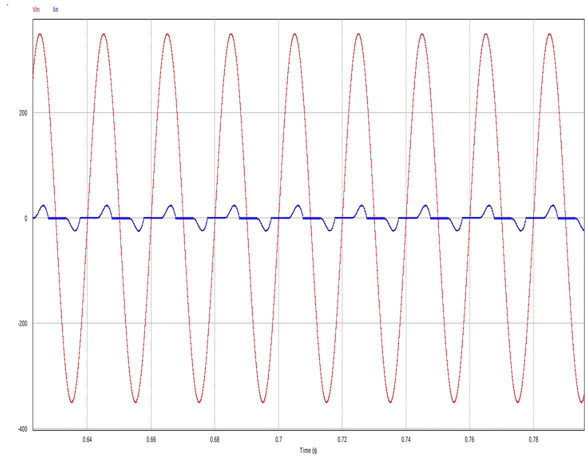
In the 5th stage, output of HF transformer is applied to rectifier circuit to obtain constant low voltage and high current dc output.The diode bridge rectifier connected across the secondary of HF transformer is of schottky type.The feedback loop is used for maintaining the constant voltage output,to obtain minimum voltage regulation and also to meet output ripple specifications.The low voltage,high current dc output has several other applications such as heating of the bearings,short circuit and laboratory testing of circuit breakers(both ac and dc),microcontrollers,electric welding.arc furnace for small industries,etc.As a result of the studies, the ac-dc converter model have been simulated in the PSIM software.

III. SIMULATION PARAMETERS

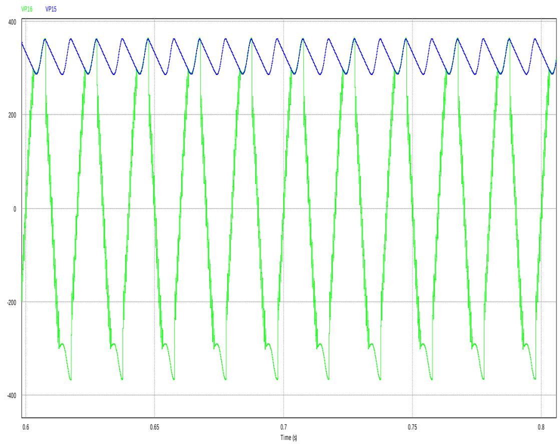
S.N	Parameters of AC-DC Converter		
	Parameters	**Symbols**	**Values(Units)**
1	Applied ac voltage	Vac	325 V
2	Applied ac current	Iac	10A
3	Switching frequency	Sw freq	50 Khz
4	Output dc voltage	Vdc	12V
5	Output dc current	Idc	150A

The above table shows the simulation parameters which were considered while simulating the circuit in PSIM software.

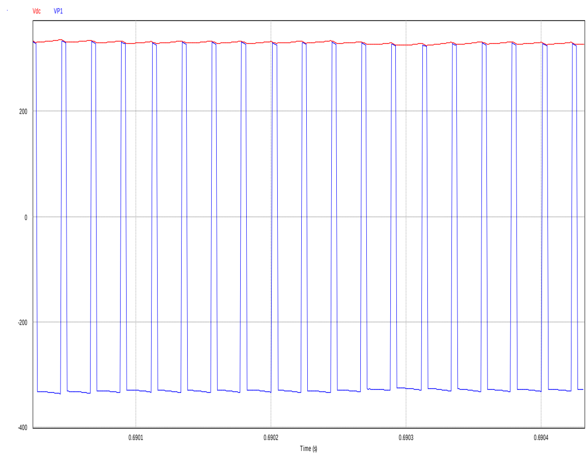
4. SIMULATION RESULTS



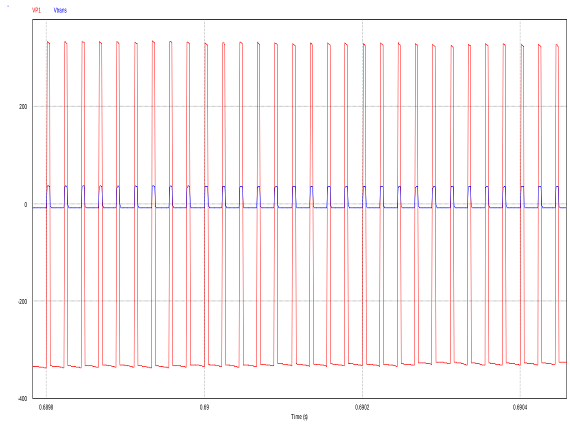
- Input Voltage and Current of AC-DC Converter



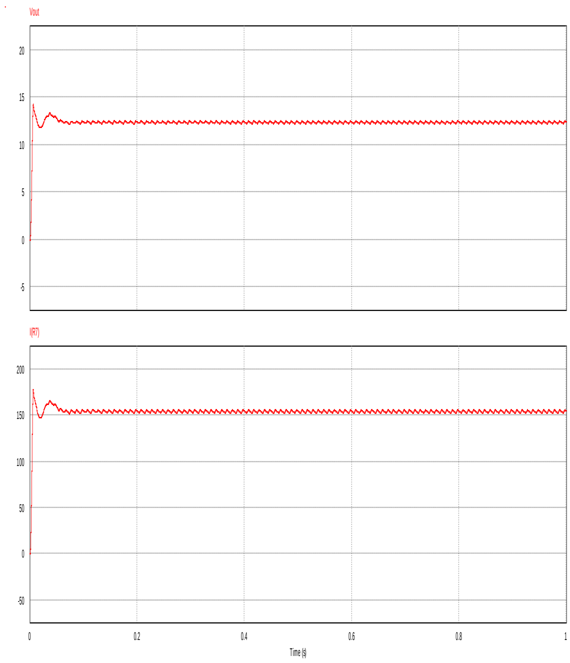
- Input and Output Voltage of Rectifier



- Input and Output Voltage of Resonant Inverter



- Input and Output Voltage of HF transformer.



- Low Voltage and High Current dc Output of Converter
  The above waveforms are the result of the simulation circuit of ac-dc converter in the software.

IV. TRANSFER FUNCTION MODELLING

The following assumptions were considered while deriving the open loop transfer function model of series parallel resonant converter[10].(a)The ideal diodes and switches are used.(b)The effect of snubber circuit on the performance of ac/dc converter is neglected.

(c)The hf transformer is represented by its "T" equivalent circuit(Losses in the hf transformer and distributed capacitance inside and outside the hf transformer are neglected).

(d)Losses in the resonating components and the output filters are neglected.

The below Fig. 2 shows the general block diagram representation of the ac-dc converter shown in Fig. 1.

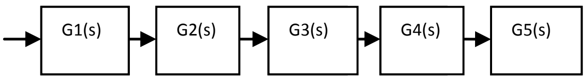


Fig 2. Block Diagram Representation

Here G*fwd*(s)=G1(s).G2(s).G3(s).G4(s).G5(s)
G*fwd*(s) = G1(s) for rectifier,
= G2(s) for inverter,
= G3(s) for resonant tank circuit and hf transformer,
= G4(s) for output filter and load block,
= G5(s) for rectifier.

5.1 Rectifier Block

The transfer function of rectifier block is obtained as[11]:

$$G1(s) = \frac{Vout(s)}{Vin(s)} = \coth\left(\frac{sTs}{2}\right)$$

5.2 Inverter Block

The transfer function of rectifier block is given as:

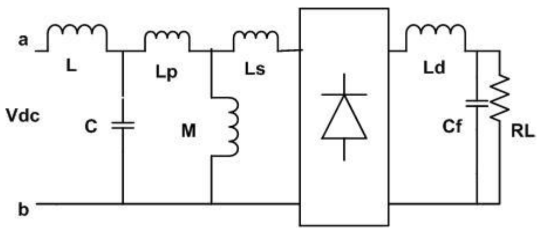
$$G2(s) = \tanh\left(\frac{sTs}{2}\right)$$

Where Ts is the time period of the output square wave.

5.3 Resonating tank and hf transformer circuit

The resonating capacitance and inductance nullifies the effective leakage reactance produced by the hf transformer.The transfer function of this block is given by:

$$G3(s) = \frac{1}{k_2 s^2 + k_4} \text{ where } k_2 = \left(\frac{M+L_p}{M}\right) LC \text{ and } k_4 = \frac{M+L+L_p}{M}$$



5.4 Output Filter and Load Block

The output of the rectifier is filtered by inductor Ld and capacitor Cf and fed into the load resistance,RL.The transfer function of the filter cum load block is given by:

$$G4(s) = \frac{1/T6^2}{s^2 + \left(\frac{s}{T5}\right) + \left(\frac{1}{T6^2}\right)} \text{ where } T6 = \sqrt{L_d C_f} \text{ and } T5 = R_L C_F$$

5.5 Forward Path Transfer Function

The transfer function of input and output rectifier are the same.The total transfer function of the forward path for the SPRC is the cascade of all individual blocks and can be written as:
G*fwd*(s)=G1(s).G2(s).G3(s).G4(s).G5(s)

$$G_{fwd}(s) = \coth\left(\frac{sTs}{2}\right) \cdot \frac{1}{k_2 s^2 + k_4} \cdot \frac{1/T6^2}{s^2 + \left(\frac{s}{Ts}\right) + \left(\frac{1}{T6^2}\right)}$$

V. CONCLUSION

This paper represents low voltage high current capability of AC/DC converter which has minimum ripples,improved performance and high efficiency at the output. The merits of series parallel resonant inverter topology and HF transformer has been examined and the AC-DC converter is simulated in software.Also the open loop transfer function of the converter is discussed.This topology gives high reliability,increased efficiency,improved performance ,reduced cost,etc.

VI. ACKNOWLEDGEMENT

The author would like to express sincere thanks to Department of Electrical Engineering of Shri Ramdeobaba College of Engineering and Management for the encouragement of the work.

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