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A High Efficiency And High Voltage Gain Step UP DC-DC Converter for DC Micro Grid Applications

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Abstract : A high gain step up DC-DC converter with IC MPPT algorithm, solar & wind as inputs in conjunction with this converter are presented in this paper. Recently, due to increase in the green energy demand the renewable energy resources are widely used. Now-a-days DC micro grid gets major importance because of the increase in DC loads and demand of high power quality. These DC loads require different voltage levels based on their power ratings. Therefore, the proposed step up DC-DC converter posses a high voltage gain characteristics with optimum duty ratio. Along with this, it results an additional advantage of supplying power at two different voltage levels which is more suitable for DC micro grid applications and all the switches are controlled using single control signal which reduces complexity. The proposed converter is implemented and theoretically verified in SIMULINK MATLAB software for two different load power ratings of 100W and 200W.

Keywords : DC-DC Boost Converter; Voltage gain; DC-Microgrid; Duty cycle;Maximum Power Point Tracking (MPPT);

1. INTRODUCTION

In recent years, due to severity of global energy crisis and environmental issues the concern towards green energy has been increased rapidly. This leads to exploration of the use of renewable energy sources such as solar energy, fuel cells etc, will generate DC power [1]. DC Micro-Grids prove to a natural option for integration of green energy [2]. The other important aspect is, most of the consumer loads are DC based or adaptable to DC like, TV, LED lights, ceiling fans, Computers etc. which require different voltage levels based on their power ratings [1]. Solar energy is one of major renewable energy source because of their merits like absence of fuel cost, no noise and little maintenance etc [12]. The output from PV resource is essentially a low signal voltage due to this drawback there is a need for boost converter as an interface between the source and the load. The conventional boost converter like, cascaded boost converter, switched capacitor converter etc. offers high gain at extreme duty ratios which results in severe voltage stress at power switches, reverse recovery problems, electromagnetic interference etc [2]. To overcome those problems high gain step up DC-DC Converter is used. Fig. 1(a) shows the block diagram of DC Micro-Grid.

Because of the non-linear characteristics of PV array the maximum power can be extracted under particular voltage conditions [12][11]. In this regard MPPT techniques are used in PV generating system

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to maximize the output power. Therefore, the dynamics of PV array is simulated various solar irradiance and cell temperature. So as to control the output voltage, the IC MPPT technique is used [11]. In this paper a High efficiency high voltage gain step up DC-DC converter with IC MPPT method and conjunction of solar and wind energy is proposed to serve as inputs.

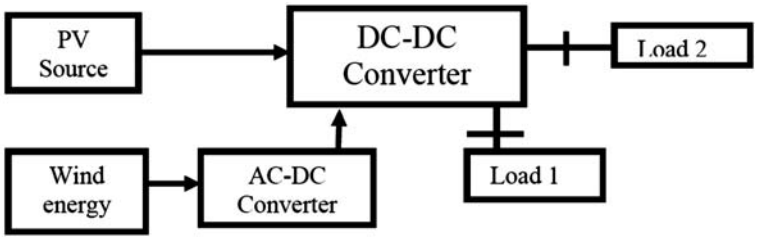

Fig. 1(*a*). Block Diagram of DC Micro-Grid.

2. CIRCUIT CONFIGURATION OF PROPOSED CONVERTER

The Converter is capable of maintaining two different Voltage levels. This Converter uses two high voltage Capacitors namely C_1 and C_2 ,two Inductors L_1 and L_2, three Diodes represented as D_1,D_2 and D_3, and also controlled power Switches S_1, S_2, S_3 which are taken as high frequency MOSFETs to maintain two Voltage levels and Vs is the low voltage PV source .Based on the duty cycle the controlled switches are operated at two different voltage levels. As this converter requires only one control signal to operate all the controlled power switches. This circuit operates in two modes that is when all switches are turned off and in mode2 all the switches are turned on which are shown in the figures 1(*b*) and 1(*c*).

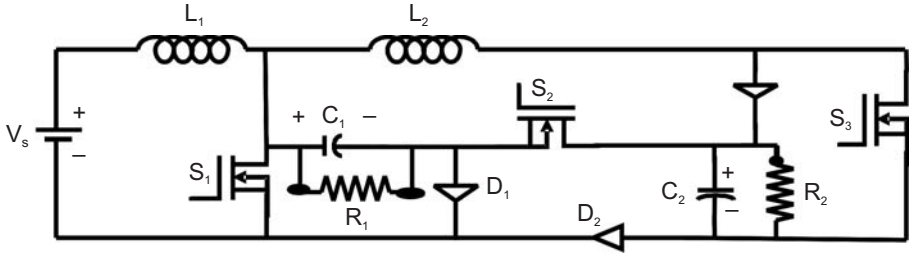

Fig. 2(*a*). Circuit diagram of high gain step up DC-DC Converter with loads are replaced with resistances.

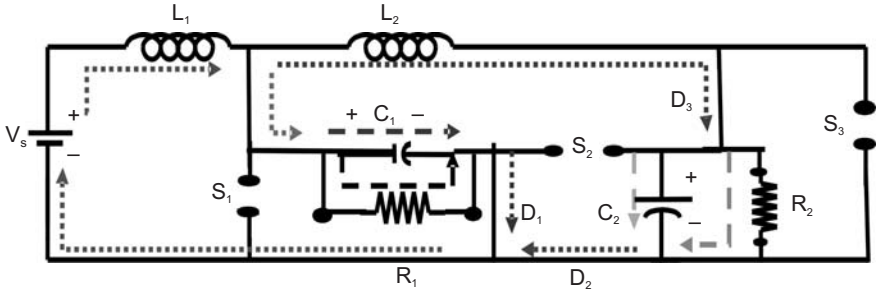

Fig. 2(*b*). High Voltage gain step up DC-DC Converter when all controlled switches are turned off.

Designing Specifications	Values
Switching frequency	10KHZ
Source voltage	48V
Power at load1, load2	100W,200W
Duty ratio	0.369
R1,R2	57.76 Ω, 420.5 Ω
L1,L2	4.8mH, 36.6mH
C1,C2	48.5μF, 25.6μF

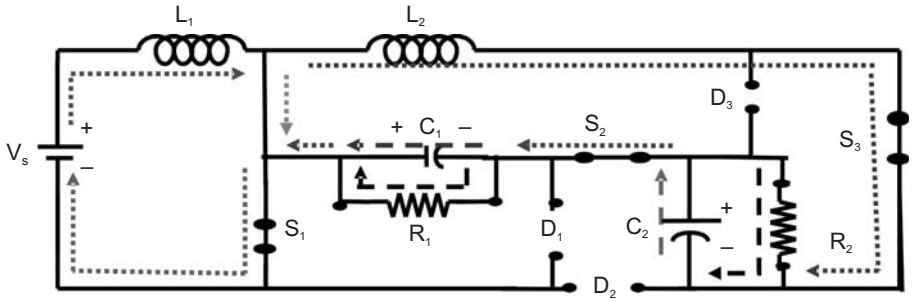

Fig. 2(*c*). High Voltage gain step up DC-DC Converter when all controlled switches are turned on.

3. MPPT ALGORITHM

As the PV module possess Non-linear characteristics, so the maximum power can be extracted only under specific conditions. Therefore, maximum power point tracking (MPPT) algorithms Such as incremental conductance method is used in PV array to maximize the output power. IC technique can track even with rapidly varying irradiance conditions with high accuracy.

4. SIMULATION RESULTS OF IC MPPT METHOD

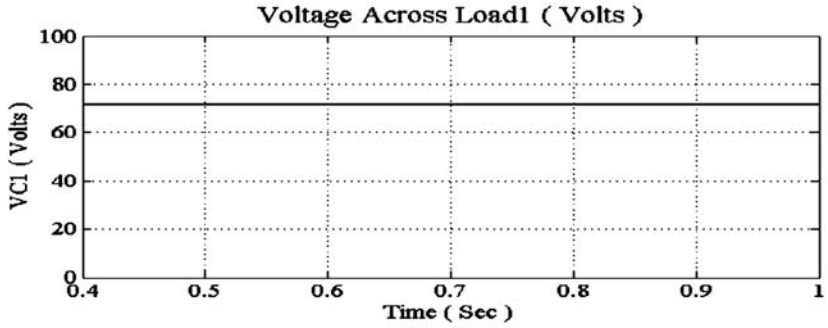

Fig. 3(*a*). Voltage across Load$_1$ (V_{C1}).

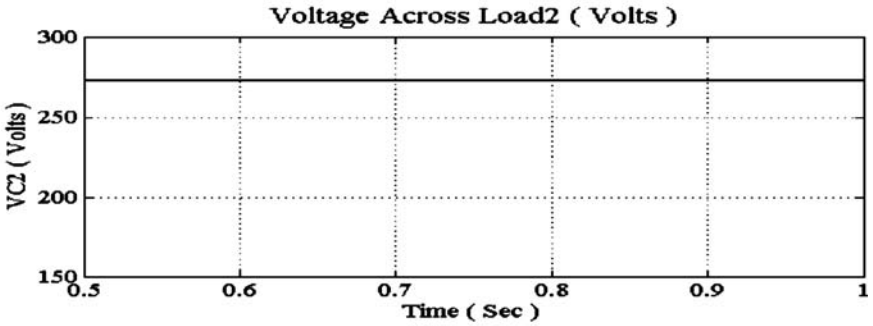

Fig. 3(*b*). Voltage across Load$_2$ (V_{C2})

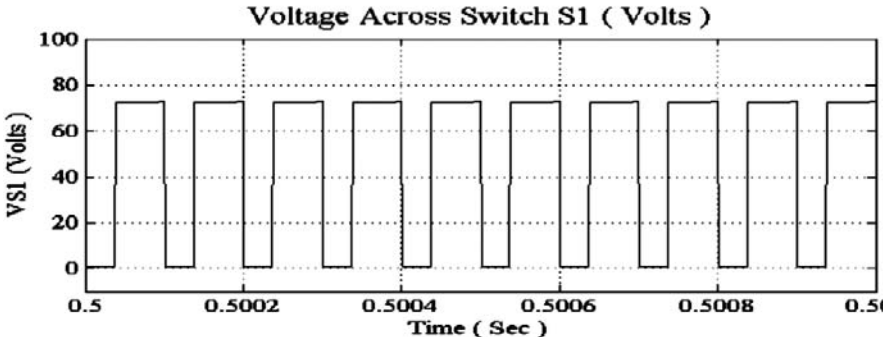

Fig. 3(*c*). Voltage stress across Switch S$_1$ (V_{S1})

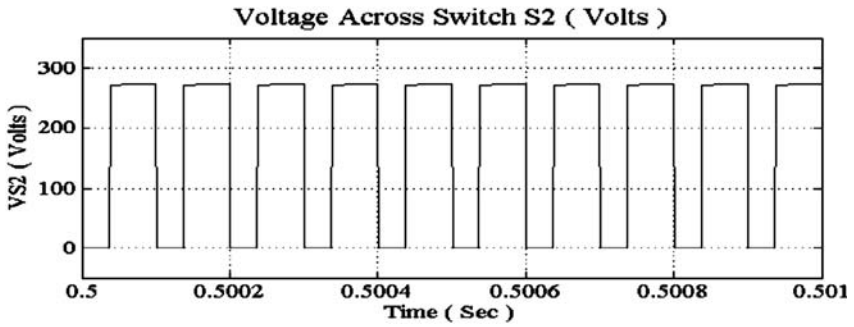

Fig. 3(*d*). Voltage stress across S_2 and similar to S_3.

5. SIMULATION RESULTS OF IC METHOD AND WIND ENERGY

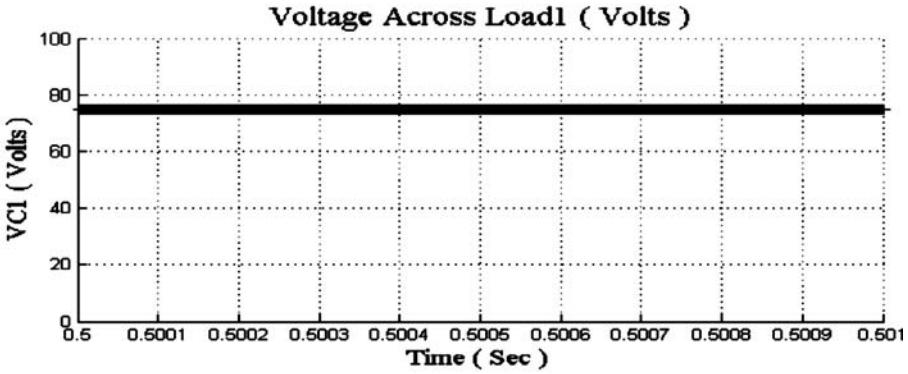

Fig. 4(*a*). Voltage across $Load_1$ (V_{C1})

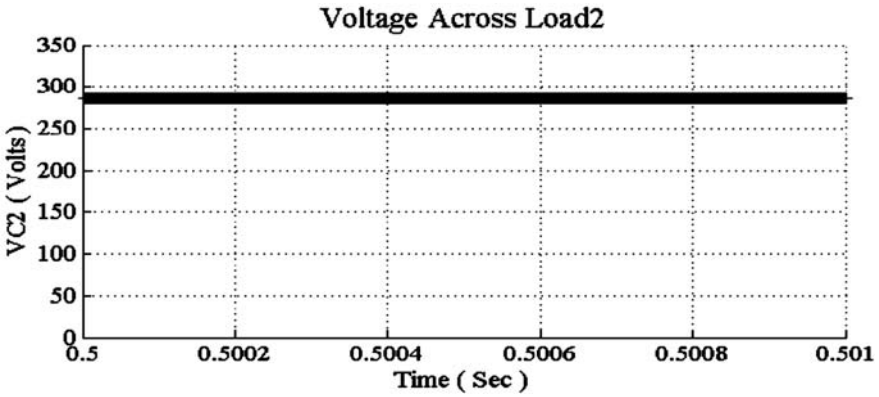

Fig. 4(*b*). Voltage across $Load_2$ (V_{C2})

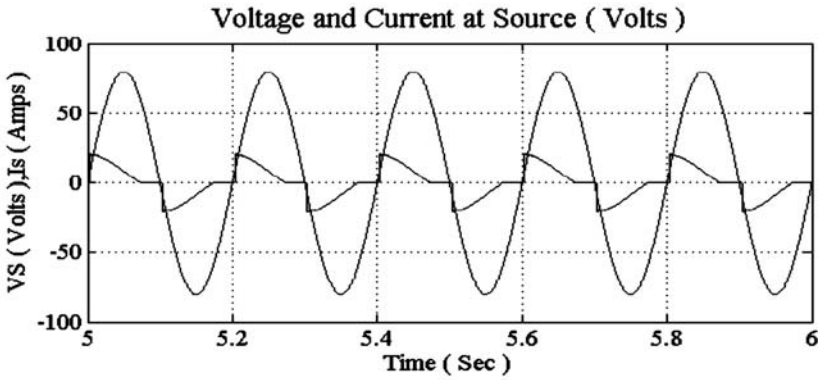

Fig. 4(c) Input current and voltage waveform & P.F =0.9

6. COMPARISON TABLE

Type of converter	T_s (Sec)	Ripple voltages (V) and currents (A)				Voltage stress (V)	η (%)	ΔI_{L1} (A)	V_{s1} (V)	V_{S2} (V)	ΔI_{L2} (A)	M_p (%)	PF
		ΔV_{C1}	ΔI_{O1}	ΔV_{C2}	ΔI_{O2}								
Converter without MPPT	0.6	2	0.035	5	0.01	74	76%	0.1	73	700	0.25	19.2	-
Converter with MPPT	0.37	0.4	0.007	0.75	0.0015	72	70.8%	0.1	72.5	273	0.1	-	-
Solar and wind as input	0.37	0.4	0.02	0.8	0.0018	76	67.5%	0.4	73	288	0.1	-	0.9 lag

7. CONCLUSION

By this experimental work, the simulation of the high voltage gain step up dc-dc converter with incremental conductance MPPT algorithm has been successfully implemented in MATLAB/SIMULINK. As it can able to maintain a high voltage with smaller duty cycle and also overcomes the limitations of extreme duty ratios. It is able to maintain two different dc bus voltages for high power applications and for low power applications due to which it is more suitable for DC-Micro Grid applications. As a result, the developed system has many advantages over individual step up DC-DC Converter such as reduced switch stress, reduced settling time and the output voltage ripple and current ripple has decreased. Further we can design this converter with perturb and observe MPPT algorithm or any other advanced MPPT algorithms.

8. REFERENCES

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