

Article Info

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Renewable Energy Fed DC Microgrid: An Overview

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ABSTRACT

This paper lays emphasis on need of renewable energy sources for power due to increase in the demand for energy and depletion of conventional sources of energy. We propose to integrate the renewable energy with our DC Micro grid. In this paper we study the interfacing of the Solar P-V, Wind Turbine with the DC Micro grid through the rectifier, Buck Boost and Fly back converter respectively. We present a model of a wind turbine using a Fly back converter as it can provide isolation due to the use of high frequency transformer in its design. This isolation provides the advantage of protection of the DC link from any fault on the wind turbine or synchronous generator side. The emphasis is to investigate performance of P-V with Buck Boost converter. We also apply the Perturb and Observe MPPT tracking technique on the respective converters at varying operating points to extract the maximum power and keep the DC-link voltage constant. Further the model of wind generator and solar energy performance on the MATLAB/SIMULINK environment is investigated..

Keywords: Solar P-V; Wind Turbine; DC Microgrid; Flyback Converter; Buck-Boost Converter; MPPT.

1.0 Introduction

Due to increased exhaustion of the conventional energy resources we are trying to switch to non-conventional sources of energy which are renewable immaculate and ecological.

They have several other advantages which includes (a) reduced transmission losses, (b) power quality improvement (c) improved reliability (d) reduction in emissions (e) provisions for heterogeneous power quality [1]. Systems should be installed according to the geographical parameters. Places where wind speed is high will benefit from the installations of wind turbines like the coastal regions of Tamil Nadu, Karnataka, Andhra Pradesh and Gujrat of the Indian subcontinent.

Likewise Rajasthan, Punjab, Uttar Pradesh and Haryana and few amongst the many places benefitting from the solar power installations.

However accounting globally, Hydropower has the largest installations with total installation capacity being more than 1000GW which alone is 16% of the total energy used for electrification [2]. Also we see the performance of Solar P-V with Buck-Boost.

2.0 Wind Energy Conversion System Description

The system consists of a wind turbine connected to a synchronous machine which supplies AC power to a diode bridge rectifier which converts it to DC which is fed to a fly back converter which performs MPPT operation and maintains the constant grid voltage as shown in Fig.1

2.1 Wind conversion system model

In the wind energy conversion system we obtain electrical energy from rotational energy obtained by the wind speed. The output power or torque of a wind turbine will depend on several factors like wind velocity, size and shape of the turbine, etc. [3]. A dynamic model of the wind turbine, governed by these parameters, is necessary to understand the behaviour of a wind turbine over its region of operation. Therefore by analysing its modelling, it is possible to control a wind turbine's performance to meet the desired operational characteristics [3]. Further the different performance characteristics and variables that play an important role in wind power generation, by deriving the speed and power relations are investigated [3].

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$$E = \frac{1}{2}mv^2 \quad \dots(1)$$

Here, m= mass of air; v= velocity of wind;
mass is obtained by:

$$m=\rho Ad \quad \dots \quad (2)$$

Here, ρ = air density, A= rotor blade swept area, d= covered distance by wind
mechanical power as-

$$P=\frac{E}{t} = \frac{\frac{1}{2}\rho Adv^2}{t} = \frac{1}{2}\rho Adv^3 \quad (3)$$

The wind turbine is used to deliver the maximum mechanical output power for corresponding wind velocity to track maximum power present in wind [4]. Fig 1 depicts that for tracking the maximum attainable power present in wind, the wind generator system rotor speed is varied widely[4]. This is performed using MPPT technique.

2.2 Maximum power point tracking technique

Fig 1: Block Diagram of Wind Connected DC Microgrid

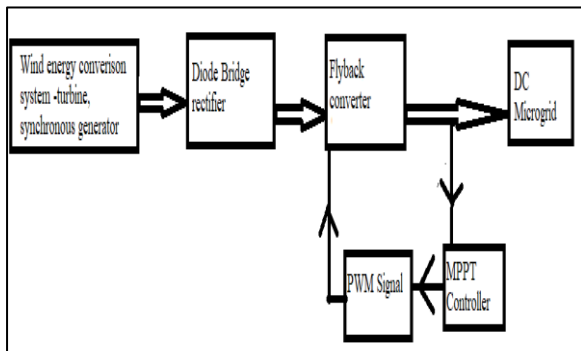
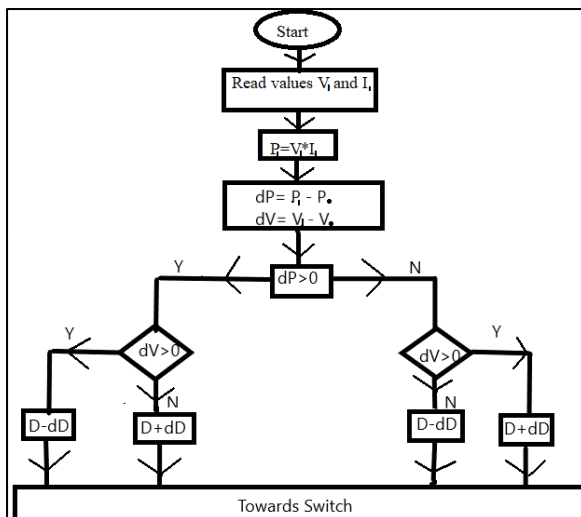


Fig 2: P & O Flowchart MPPT



In the MPPT technique duty cycle of the converter is varied to keep the operating point, in this case the voltage of the generator so as to extricate maximum power. The grid voltage is kept constant and the current is varied. The MPPT controller senses the increment or decrement and a comparison is made with the previous values. The duty cycle of the converter is adjusted accordingly to keep the operating point so that maximum current is maintained and maximum power can be exploited as shown in the flowchart. The rotor velocity of the wind turbine system is also changed according to the duty ratio in accordance with the voltage of generator, current and power as in figure 2.

3.0 Verification of Applicability of Buck Boost Converter for MPPT

A model of Solar P-V was formed in MATLAB/SIMULINK as shown in Fig 4. Voltage, Current and Power at various duty cycle was noted and found that the Power Vs duty cycle characteristics matched to the Solar P-V and Wind characteristics.

4.0 Simulink Models

A model is designed in MATLAB/SIMULINK for Flyback converter shown in Fig 3. Input voltage is considered 25V. Output voltage at various duty cycles is simulated and the result is obtained.

Fig 3: Flyback Model Simulation

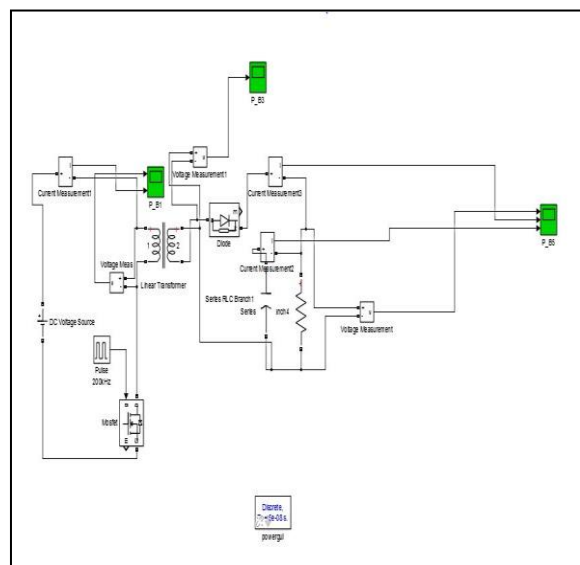


Fig 4: Simulation of Solar with Buck Boost

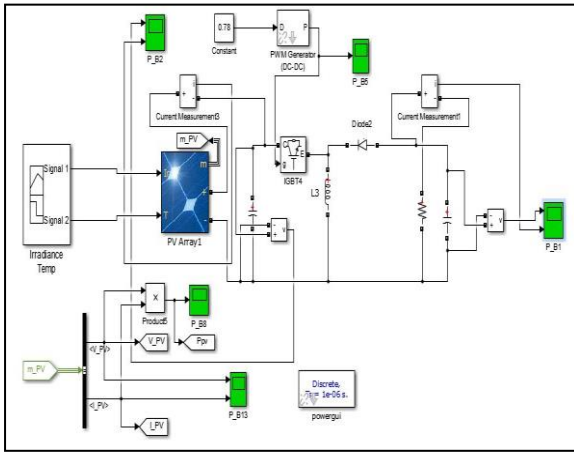


Fig 5: Various Measurements

Duty Ratio	Vin	Iin	Pin	Vout	Iout	Pout
0.05	114.7	0.02	2.294	-7.5	-0.15	1.125
0.1	114.65	0.03	3.44	-14	-0.28	3.92
0.15	114.6	0.054	6.1884	-22	-0.45	9.9
0.2	114.55	0.165	18.9	-30.6	-0.62	18.97
0.25	114.23	0.4	45.692	-40	-0.8	32
0.3	114.2	0.55	62.81	-49	-1.1	53.9
0.35	114.17	0.8	91.2	-62.5	-1.3	81.25
0.4	114.05	0.98	111.72	-79.5	-1.57	124.815
0.45	114	1.75	199.5	-96.5	-1.92	185.28
0.5	113	2.5	282.5	-117	-2.5	292.5
0.55	112.5	4	450	-143	-3	429
0.6	111	6	666	-173.5	-3.47	602
0.65	110	8	880	-210	-4	840
0.7	106	12.5	1325	-260	-5.5	1430
0.75	100	20.5	2005	-312	-6.5	2028
0.77	92	22	2024	-330	-6.7	2211
0.78	88	24.9	2195	-331	-6.63	2194.53
0.79	80	25.7	2056	-322	-6.45	2076.9
0.8	70	26	1820	-305	-6	1830
0.85	35.5	26.1	926.55	-212.5	-4.3	913.75
0.9	12.5	26.16	327	-129.5	-2.6	336.7

The curves obtained were as follows

Fig 6: Power input Vs Voltage Input

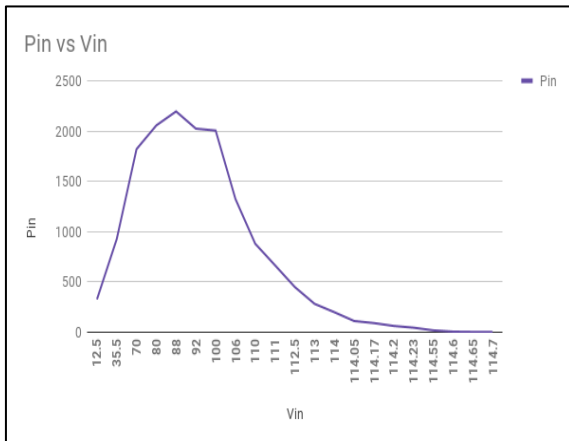


Fig 7: Current input Vs Voltage Input

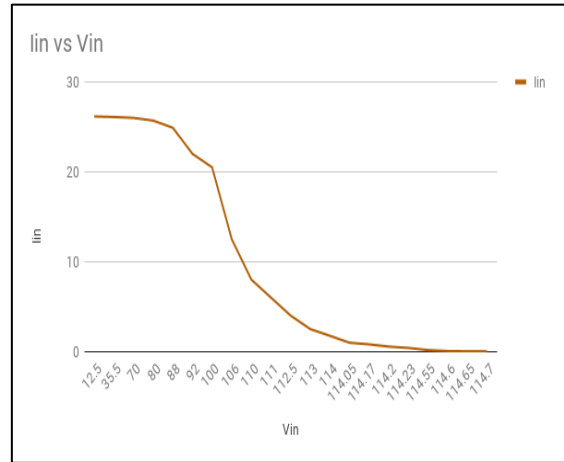


Fig 8: Power output Vs Duty Ratio

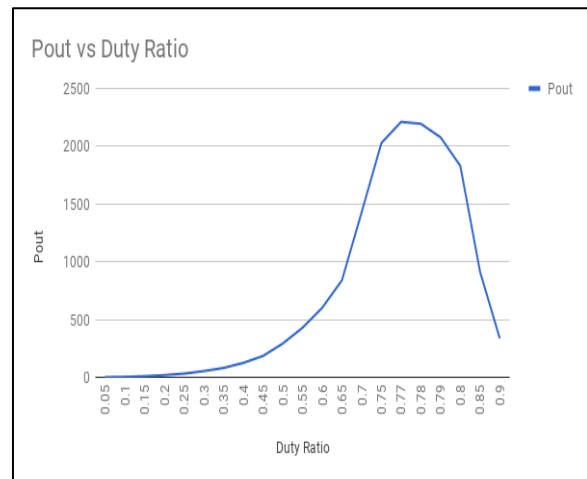


Fig 9: Power input Vs Duty Ratio

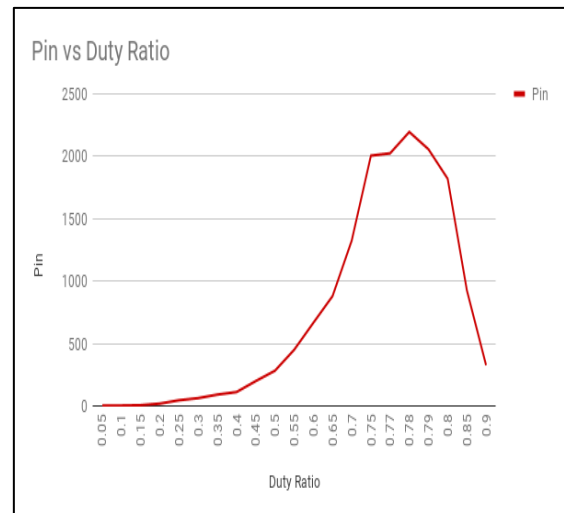
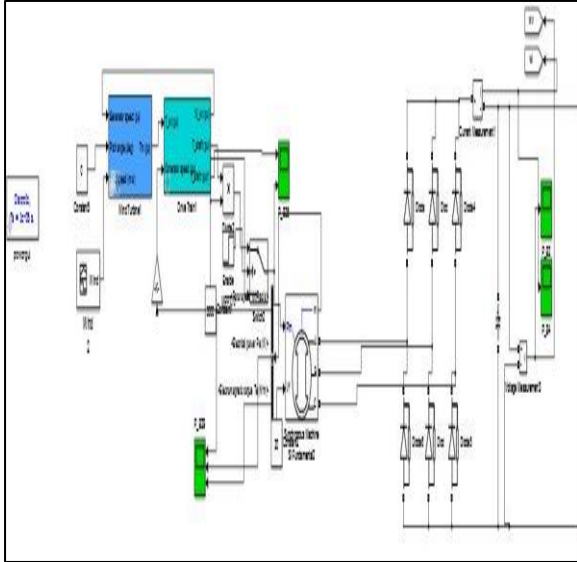
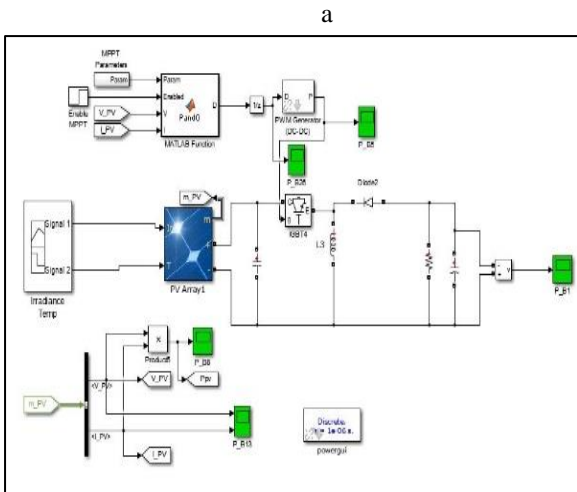


Fig 10: Complete Simulation of the Wind System with Flyback Converter and MPPT



Specifications of the wind turbine system are Synchronous Generator: 3 kVA, 415V, 50Hz. Figure 5 is the various measurements taken at various duty cycles and Figures 6,7,8,9 are the various characteristics plotted from the measurements. Further it is verified in the results section with output waveforms.

Fig 11: Solar MPPT Simulation



The parameters for this simulation were Solar Irradiation: 1000 W/meter square Temperature: 25 degree Celsius, Solar PV: $W_p = 245$ W, $V_{oc} = 38.23$ V, $I_{sc} = 8.67$ A, $V_{mp} = 29.9$ V, $I_{mp} = 8.2$ A.

5.0 Results

Fig 12: D-45% Input Voltage Waveform for Fig 4.

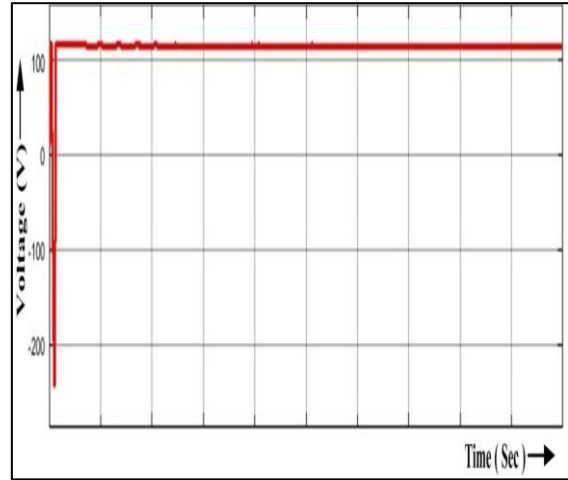


Fig 13: D-45% Input Current Waveform for Fig 4.

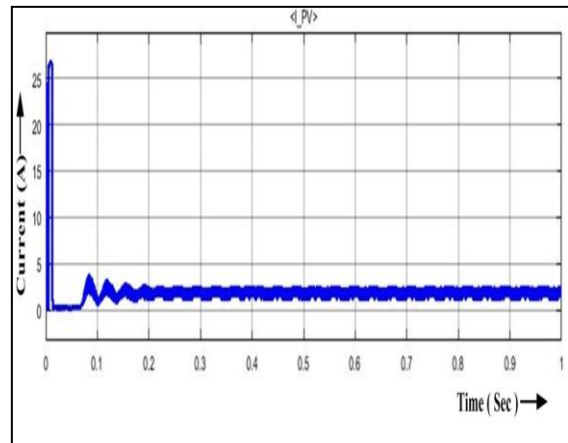


Fig 14: D-78% Input Voltage Waveform for Fig 4.

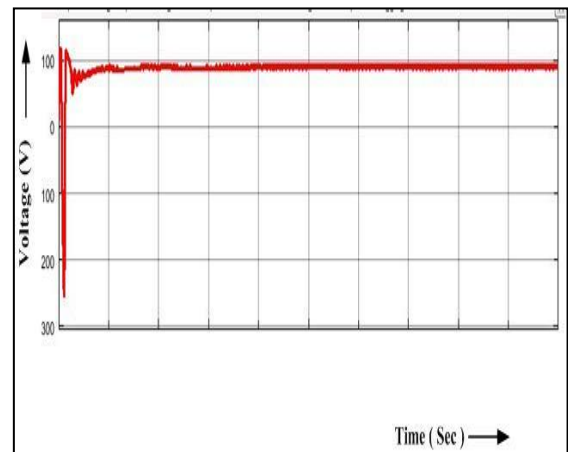


Fig 15: D-78% Input Current Waveform for Fig 4

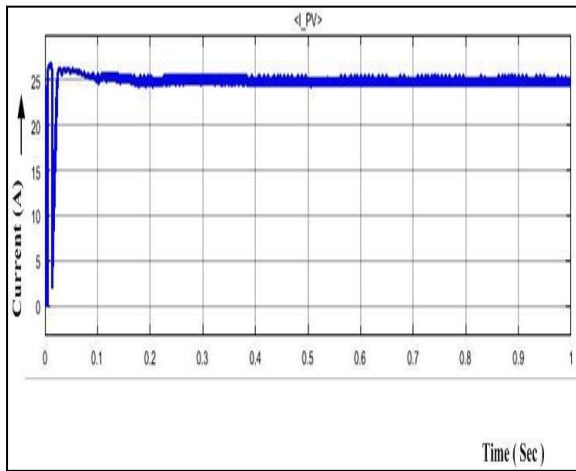


Fig 18: Input Voltage Waveform for Fig .11 with Complete Solar MPPT.

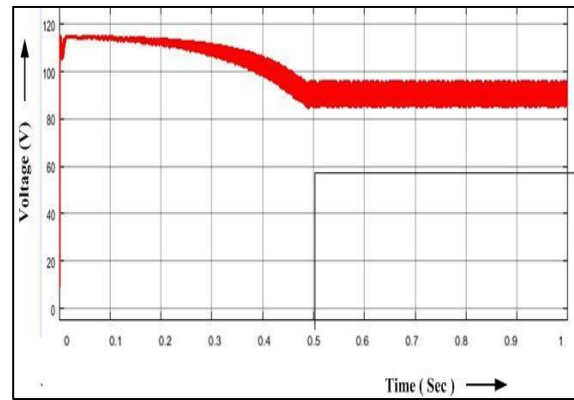


Fig 16: D-80% Input Voltage Waveform for Fig 4

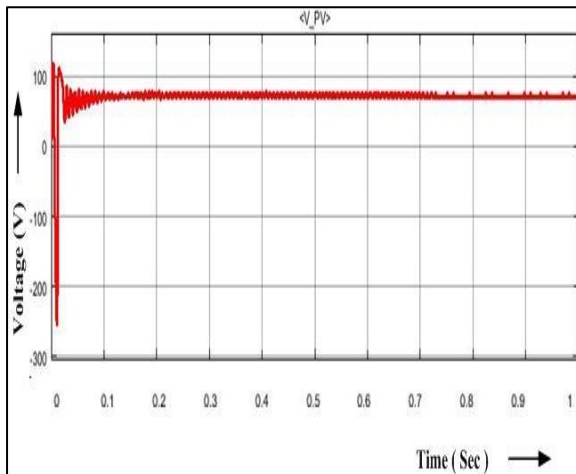


Fig 19: Input Current Waveform for for Fig .11 with Complete Solar MPPT.

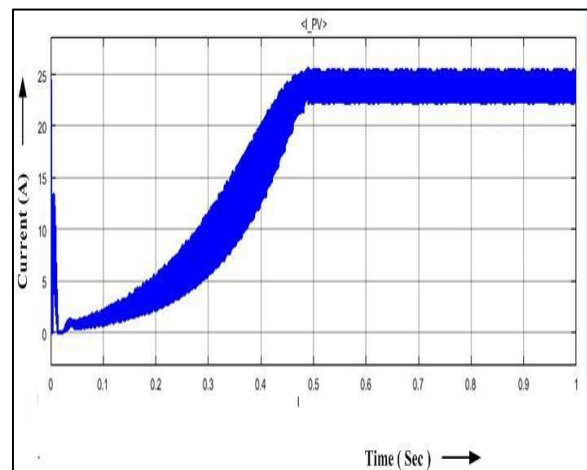


Fig 17: D-80% Input Current Waveform for Fig 4

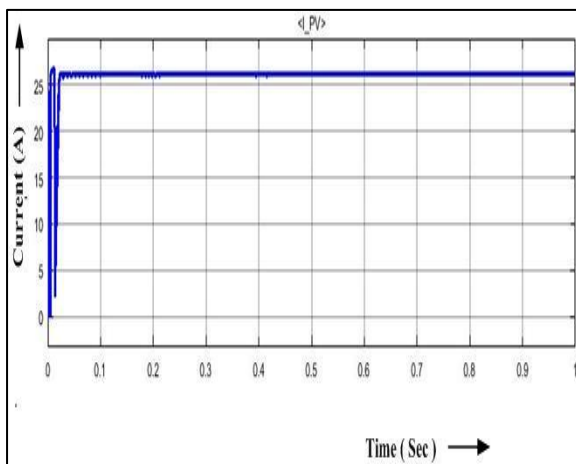


Fig 20: Output Voltage Waveform for Fig .11 with complete Solar MPPT.

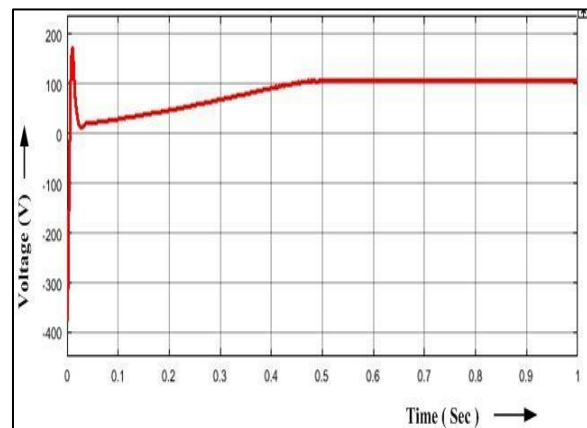


Fig 21: Output Voltage Waveform of Fig 10. Wind Turbine with Flyback Converter

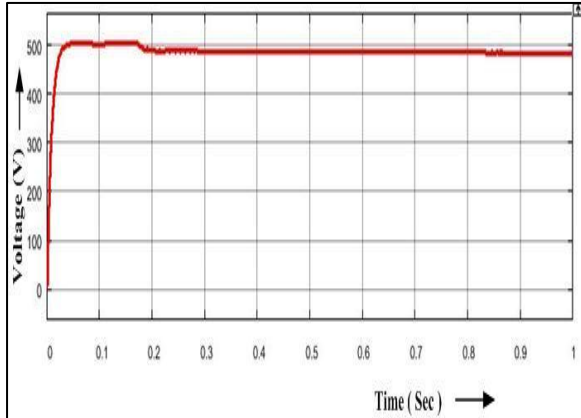
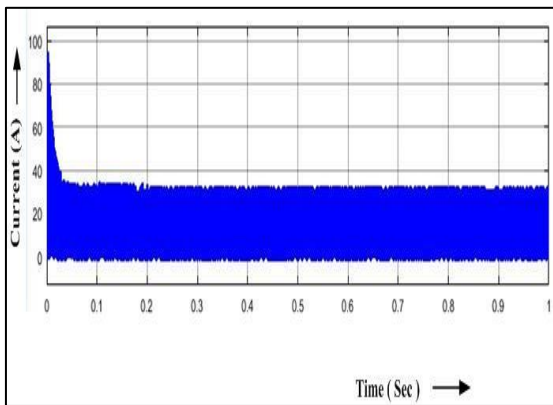


Fig 22: Output Current Waveform of Fig 10. Wind Turbine with Flyback Converter



6.0 Conclusions

In this study after analysing a lot, we found that the buck boost converter is applicable for MPPT as its Power Vs Duty Ratio graph and Power input Vs Voltage input graph is identical to the P-V

characteristics of the solar panel and Power-speed characteristics of the wind system. It is also suggested to use Flyback Converters for MPPT as they are buck boost converters with isolation. This isolation provides the advantage of protection of the DC link from any fault. Fly back converters with higher turns ratio has application in higher power generation.

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