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**SINGLE STAGE POWER ELECTRONICS CONVERTER USED FOR RENEWABLE  
ENERGY GRID CONNECTED SYSTEM WITH CLOSED LOOP CONTROL**

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**ABSTRACT**

The use of power converters is very important in maximizing the power transfer from renewable energy sources such as wind, solar, or even a hydrogen-based fuel cell to the utility grid. A Cycloconverter is often used to interconnect an AC/AC to the utility grid. Furthermore, there has been a lack of a state-space mathematical modeling approach that considers practical cases of Pulse Generator showing their effects on possible grounding alternatives. This paper describes a design methodology of a Cyclo converter for grid-interconnected converter along with a comprehensive study of how to maintain constant frequency. The procedures and techniques described in this paper may be used in small-scale renewable energy conversion systems and may also be retrofitted for medium and large-scale grid connected systems.

**KEYWORDS:** Cycloconverter, doubly fed induction generator (DFIG), phase-locked loop, simulation.

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**INTRODUCTION**

more and more of distributed generation will be gradually added to the grid as the use of renewable sources such as wind energy system increases. These sources are connected to the distribution grid through cycloconverters. An cycloconverter The existing electric grid was designed for generation by centralized, dispatch able power plants. It is expected that converts the AC power from its generation source to AC power that can be fed into the grid. The cycloconverter must control the amount of active power (P) and reactive power (Q) injected into the grid while matching the grid frequency and phase. The most common type of cycloconverter control system in use grid-tie cycloconverter measures the local grid frequency using a phase-locked loop (PLL) and attempts to output power at this frequency. The cycloconverter also receives an active power set point from its generation source. A simple feedback controller (e.g., a PI) is implemented to adjust the output power until it reaches set point. Of specific interest

in this paper is how power balance and frequency control are maintained in systems as penetration of cycloconverter-connected generation sources increases. In frequency control and stability is discussed for systems with high penetration of wind generation. A system involving energy storage with

fuel cells is proposed to provide primary frequency control.

At current low levels of renewable penetration there are few concerns. Distributed generation is connected to the grid through an cycloconverter with a simple control system. However, the question is whether this will continue to work at higher levels of cycloconverter-connected penetration. The goal of this paper is to establish from a controls perspective if the power stability can be guaranteed as penetration of cycloconverter-connected generation sources increases. We focus on the stability of a distribution system under varying parameters with an cycloconverter-connected generation source controlled using a grid-tie system.

**SYSTEM CONFIGURATION**

**Single Stage Conversion System**

Traditionally, ac-ac conversion using semiconductor switches is done in two different ways: 1-in two stages (ac-dc and then dc-ac) as in dc link converters or 2-in one stage (ac-ac) cycloconverters. Cycloconverters are used in high power conversion system. The cycloconverter minimize the two stage conversion to single stage conversion and vary the frequency. so this converter used to variable input frequency to constant output frequency.

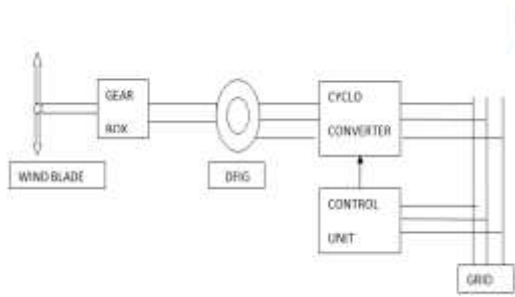


Fig.1 wind Energy conversion system

**SINGLE PHASE TO SINGLE PHASE CYCLOCONVERTER**

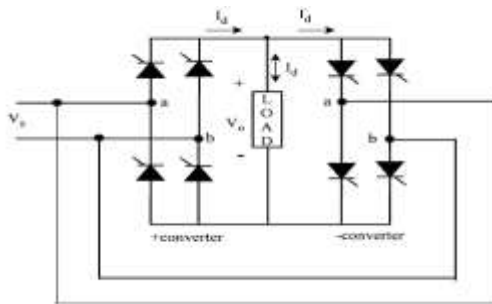


Fig.2 Single phase to Single phase cycloconverter

To understand the operation principles of cycloconverters, the single-phase to single-phase cycloconverter (Fig. 2) should be studied first. This converter consists of back-to-back connection of two full-wave rectifier circuits. Fig 3 shows the operating waveforms for this converter with a resistive load. The input voltage,  $v_s$  is an ac voltage at a frequency,  $f_i$  as shown in fig2. For easy understanding assume that all the thyristors are fired at  $\alpha=0^\circ$  firing angle, i.e. thyristors act like diodes. Note that the firing angles are named as a P for the positive converter and a N for the negative converter. Consider the operation of the cycloconverter to get one-fourth of the input frequency at the output. For the first two cycles of  $v_s$ , the positive converter operates supplying current to the load. It rectifies the input voltage; therefore, the load sees 4 positive half cycles as seen in Fig.3b. In the next two cycles, the negative converter operates supplying current to the load in the reverse direction. The current waveforms are not shown in the figures because the resistive load current will have the same waveform as the voltage but only scaled by the resistance. Note that when one of the converters operates the other one is disabled, so that there is no current circulating between the two rectifiers.

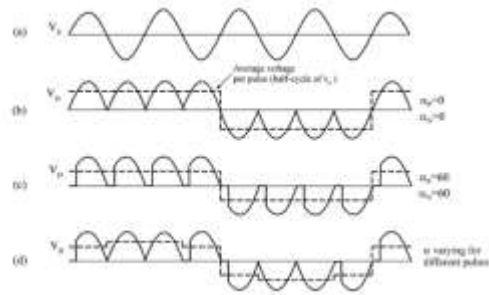


Fig.3 Single-phase to single-phase cycloconverter waveforms (a) Input voltage (b) Output voltage for zero firing angle (c) Output voltage with firing angle  $p/3$  rad (d) Output voltage with varying firing angle.

The frequency of the output voltage,  $v_o$  in is 4 times less than that of  $v_s$ , the input voltage, i.e.  $f_o/f_i=1/4$ . Thus, this is a step-down cycloconverter. On the other hand, cycloconverters that have  $f_o/f_i>1$  frequency relation are called step-up cyclo converters. Note that step-down cycloconverters are more widely used than the step-up ones. The frequency of  $v_o$  can be changed by varying the number of cycles the positive and the negative converters work. It can only change as integer multiples of  $f_i$  in  $1f-1f$  cycloconverters. With the above operation, the  $1f-1f$  cycloconverter can only supply a certain voltage at a certain firing angle  $\alpha$ .

The dc output of each rectifier is:

$$V_D = 2\sqrt{2}(V \cos \alpha) / \pi$$

Where  $V$  is the input rms voltage. The dc value per half cycle is shown in Figure. Then the peak of the fundamental output voltage is

$$V(p) = 4/\pi * \sqrt{2}V/\pi$$

Equation 2 implies that the fundamental output voltage depends on  $\alpha$ . For  $\alpha=0^\circ$ , The more pulses there are with different  $\alpha$ 's, the less are the harmonics.

**SIMULATION CIRCUIT**

**Step Up Cyclo Converter**

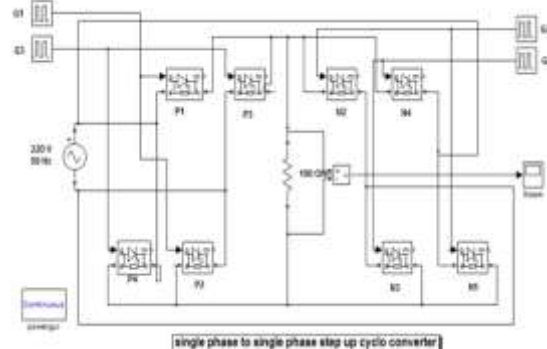


Fig.4 Simulation circuit of single phase step up cycloconverter

**Parameters:**

- Input voltage, Output voltage:220 volt
- Input frequency:50; output frequency:100
- Resistance:100 Ohm
- Time period(T):0.02seconds
- Time duration:
- P1,p2:0; n1,n2:0.005;
- p3,p4:0.01; n3,n4:0.015

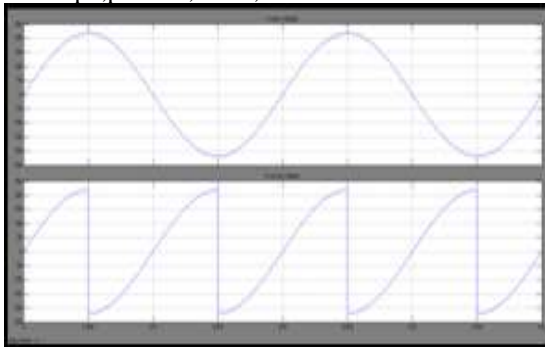


Fig.5 Simulation output of step Up CycloConverter

**Step Down Cycloconverter**

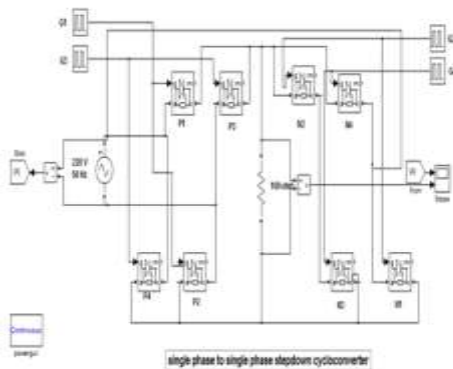


Fig.6 Simulation Circuit of Step Down CycloConverte

**Parameters:**

- voltage,Output voltage:220 volt
- Input frequencInput y:50; output frequency:25
- Resistance:100 Ohm
- Time period(T):0.02seconds
- Time duration:(sec)
- P1,p2:0; n1,n2:0.02;
- p3,p4:0.01; n3,n4:0.03

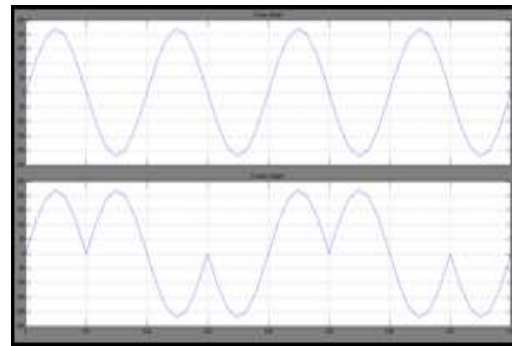


Fig.7 Simulation output of Step Down CycloConverter output

**Closed Loop Control System in Step Up Cycloconverter Simulation Circuit**

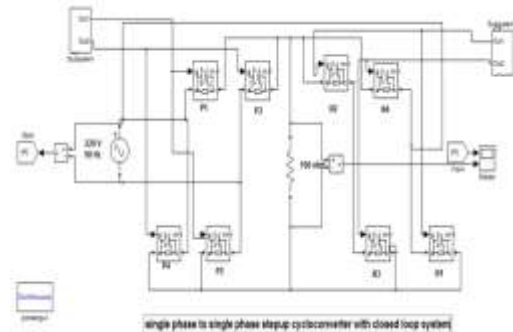


Fig.8 Simulation Circuit of Closed Loop Control System in Step Up Cycloconverter

**Parameters:**

- Sine wave:
- Amplitude 5,
- Frequency 314 Hz
- Signal generator:
- Amplitude 10,
- Frequency 1000
- Constant 5

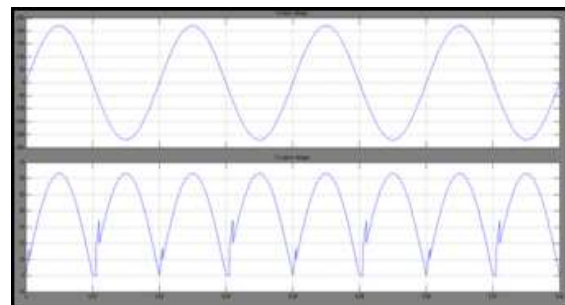
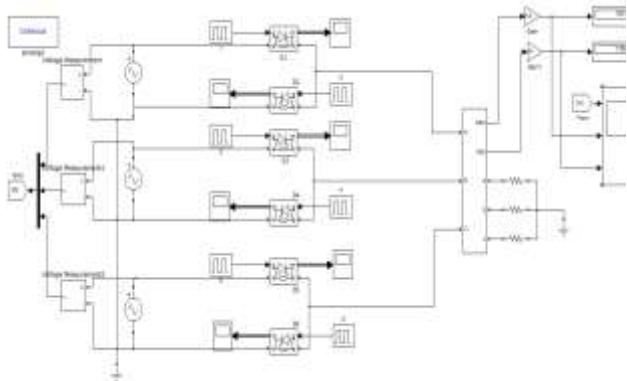


Fig.9Closed Loop System Output Waveform

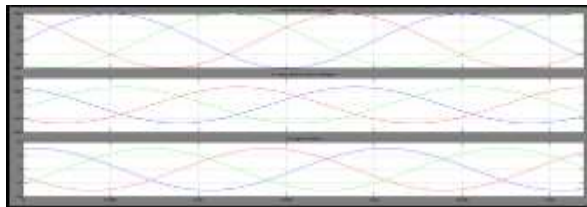
**Three Phase To Three Phase Half Controlled Converter**



**Fig.10 three phase to three phase Half Controlled cycloconverter**

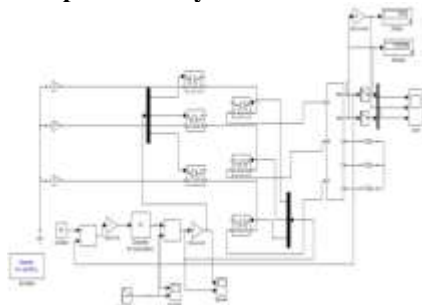
**Parameters:**

- Input voltage, Output voltage: each phase(100) volt
- Input frequency:100Hz; output frequency:150Hz
- Resistance:1000 Ohm
- Time period(T):0.02seconds
- Time duration:
- P1,p2:0; n1,n2:0.005;
- p3,p4:0.01; n3,n4:0.015



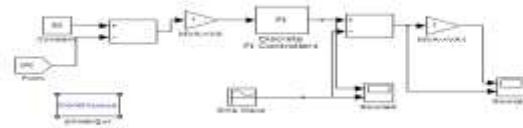
**Fig.11 Three Phase to Three phase Half Controlled Converter output waveform**

**Three Phase Three Phase Cycloconverter With Closed Loop Control System**



**Fig.12 Three Phase Three Phase Cycloconverter With Closed Loop Control System**

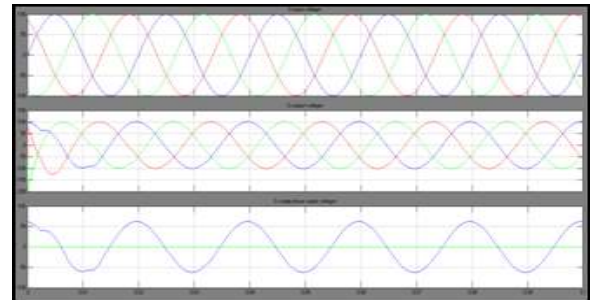
**Closed Loop Control System**



**Fig.13 Closed loop Control System**

**Parameters:**

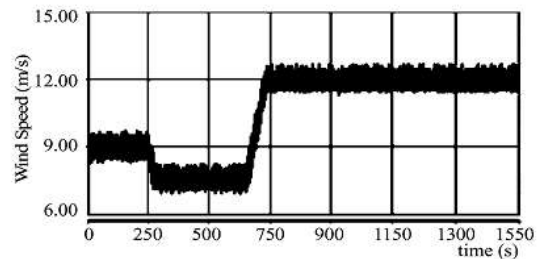
- Sine wave
- Amplitude 5,
- Frequency 314 Hz
- Signal generator:
- Amplitude 10,
- Frequency 1000
- Constant



**Fig.14 Three Phase Cycloconverter With Closed Loop Control System output waveform**

**RESULTS AND DISCUSSION**

Simulations were performed in MATLAB/SIMULINK. Through C++ programming, the design of AFCS was accomplished, converting the simple s of the pi controller, which can be self-tuned online. The objective of simulation is to illustrate interacting phenomena that have not been understood before and verify the control strategies Fig proposed for the new WECS system. The system is simulated under a steady state and two disturbances, a sudden decrease,



**Fig.15 Wind velocity**

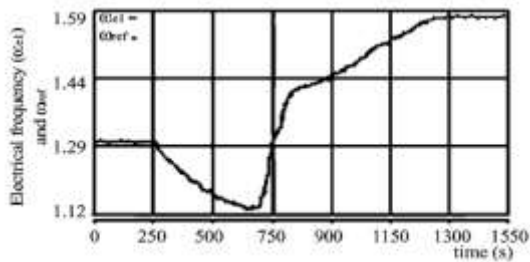


Fig.16 Frequency and reference

and a sudden increase of the wind speed. Response of the system with a wind velocity, which fluctuates with a mean value near 9 m/s and at 250 s, following an almost step change, drops to a mean value near 7.5 m/s see Fig. 15. After a few seconds, the wind velocity rises suddenly up to 12 m/s. With the decreases or increases of wind velocity, the values of output real power from the generator decreases or increases correspondingly as the changes of system frequency are largely constrained and the control system gives an order for corresponding decrease or increase of power. The constant local frequency and voltage are predominantly due to the control effect of PI controller, which adjusts the firing delay angle of Cyclo9 Converter according to the change of system frequency. From Fig. 16. It can be observed that  $\omega_e$  is continuously attached to  $\omega_{ref}$  that keeps on increasing, trying to reach its optimal value for the specific wind velocity. During the disturbance,  $\omega_e$  stays close to  $\omega_{ref}$  and increases until it reaches its optimal value. When this happens, output power and  $\omega_e$  reach a new steady state that corresponds to the maximum absorption of real power from the wind turbines. After the fault, the system enters once again in operation and it has been found that the proposed WECS system regains its operation more quickly as compared to others, which proves the superiority of the proposed WECS system over conventional ones.

## CONCLUSION

It is clear that wind is becoming a staple within world energy production, requiring a continual need for research and development. These next few years will prove to be some of the most important in development of renewable energy, especially wind. In order to fulfill these strong predictions, attention must be paid to increasing the efficiency of wind energy capture, which is what has been researched and presented in this paper. Besides the fact that these types of goals will help reduce the amount of pollutants released into the environment, they also promote energy stability and economic security through the global reduction of reliance on fossil fuels,

the creation of an export commodity, and the expansion of the job market. The work presented in this paper is a great beginning to understanding this type of energy conversion. Further work will lead to a more thorough model for a real world wind farm connected to a supply grid. This can even develop into the modeling and control of wind energy penetration into a smart grid.

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