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Control Scheme for a Stand-Alone Wind Energy Conversion System -A Review

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***Abstract** – Wind energy is considered to be one of the proven technologies. In this paper ensure continuous supply of power suitable storage technology is used as backup. A charge controller for battery bank is developed based on MPPT logic control to ensure controlled charging and discharging of battery. The control schemes are integrated and the efficacy is validated by testing it with various load and wind profiles .Present energy need greatly relies on the conventional sources. But the inadequate availability and steady increase in the price of conventional sources has shifted the focus toward renewable sources of energy. The mechanical protection of the WECS is guaranteed by means of pitch control technique. Both the control schemes are integrated and the efficiency is validated by testing it with a variety of load and wind profiles in MATLAB/SIMULNIK.*

***Keywords**: Wind Energy, MPPT, WECS, Stand Alone System.*

I. Introduction

Wind Energy Conversion System (WECS) is one of the most versatile non-conventional resources of energy due to the ever-growing demand of electricity supply. Since wind is a natural source and its utility is based on the climatic variation, it is essential to tap this energy effectively for meeting the demand. Due to the development of technology in the synchronous and asynchronous generators, it is possible to effectively employ these generators in WECS. The wind energy can be used for stand-alone load or connected to grid. ENERGY is considered to be the essential input for development. At present due to the reduction of available conventional resources and concern about environmental degradation, the renewable sources are being utilized to meet up the ever increasing energy demand. Due to a relatively low cost of electricity production wind energy is considered to be one of the potential sources of clean energy for the future, But the nature of wind flow is schocastic. The advent of DC electric power in 1882, and introduction of 3-phase AC power production in the early 1890s, provided a technological basis for constructing wind turbines that generated electricity. The Danish scientist and engineer Poul La Cour is the most widely known pioneer of electricity generation using wind power. In 1891 in Askov, Denmark he introduced a four shuttle sail rotor design generating approximately 10kW of DC electric power. He also applied the DC current for water electrolysis, and utilized the hydrogen gas for gas lamps to light up the local school grounds [3]. La Cour's efforts started research, development and commercialization of wind electricity in Europe and thus Europe gained its leadership role in wind energy electricity generation. Though less recognized than La Cour, Charles F. Brush in 1888 introduced in Cleveland Ohio the first automatically operating wind turbine generator, a 12kW, 17-meter-diameter machine, operated for 20 years [5][6]. So thorough testing is to be carried out in laboratory to build up efficient control policy for wind energy conversion system (WECS). The study of WECS and the related controllers are, thus, becoming more and more important with each passing day. Wind energy has been used for thousands of years for milling grain, pumping water and other mechanical power applications. Today it finds its application both as Grid Connected & Off Grid Electrical Power Source [2].

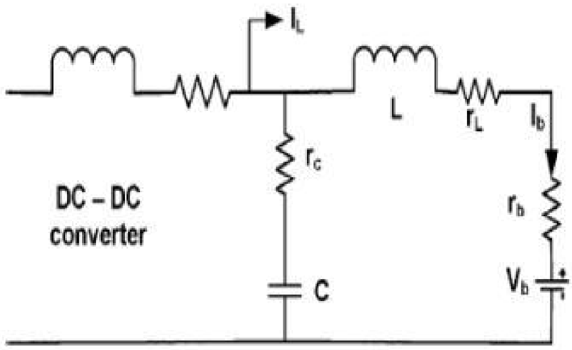

Fig1: Circuit Buck Converter

II. Method

Maximum power conversion of the WECS is obtained by adjusting the generator speed ω_g as wind speed V changes. This is achieved by modifying the equivalent load at the generator terminal via power electronics converters. The equivalent standalone WECS is depicted in Fig. 2 where R_L and L_L are the equivalent load resistance and inductance, respectively. The equivalent load resistance is considered the control input for the control system.

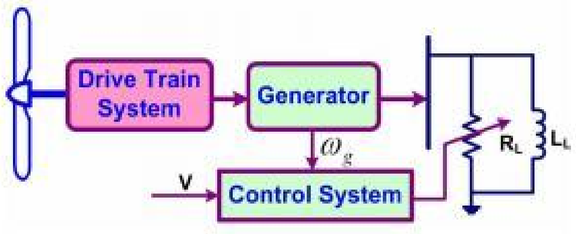

Fig 2: Standalone WECS

II.1. Maximum Power Point Tracker(MPPT)

MPPT or Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting maximum available power from wind module under certain conditions. The voltage at which wind module can produce maximum power is called 'maximum power point' (or peak power voltage). Maximum power varies with wind module produces power with maximum power voltage. A MPPT or maximum power point tracker is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels (and a few wind generators) down to the lower voltage needed to charge batteries.

III. Literature Review

Miguel López et. al. "Stand alone wind energy conversion system with maximum power transfer" in this paper author proposed a controlled wind generation system for a stand alone application is presented in this paper. A cascaded step-up/step-down power electronic converters topology is proposed to control the wind power system in the whole wind speed range. For the low wind speed range, the control strategy is aimed to follow the wind turbine's maximal power coefficient by adjusting the generator's rotational speed. For high wind speeds, the system power regulation is also made by controlling the generator speed. This control is made by the DC/DC power electronic converter, which modifies its input voltage, changing the machine voltage and consequently varying the generator's rotor speed. The proposed system is validated by computer simulation. The proposed control system shows a good performance for its application in autonomous wind energy systems. The wind energy conversion system is validated by computer simulation, using Matlab PowerSym toolbox. With the goal of a correct observation and analysis of the proposed power and control systems behavior, the wind was supposed as a known and controllable parameter.The proposed wind energy conversion system was verified by simulation for a stand alone application.

M. Druga et. al. "Stand-Alone Wind Power System Operating with a Specific Storage Structure" in this paper author analyze a low power wind system operating in autonomous mode. We present a control structure that ensures the maximization of wind energy conversion and the balance between required and produced power. We have studied two stand alone wind system structures based on the capacitor voltage control and the buffer battery operation. The simulation results have been obtained in Matlab/Simulink environment, using PowerSim toolbox. The system is considered operating when the capacitor voltage is controlled by a PI command. This control loop is supposed to reduce the power imbalance in the studied system. The local power network is composed by receivers that must be supplied in priority, by auxiliary controlled loads and by dissipation loads. The wind regime was supposed to be nominal, that is the instantaneous wind speed varies around the nominal value. In the case of considered wind, there is a surplus of produced energy, used for charging the battery.

Hoa M. Nguyen et. al. "Direct Fuzzy Adaptive Control for Standalone Wind Energy Conversion Systems" This paper presents a direct fuzzy adaptive control for standalone Wind Energy Conversion Systems (WECS) with Permanent Magnet Synchronous Generators (PMSG). The problem of maximizing power conversion from intermittent wind of time-varying, highly nonlinear WECS is dealt with by an adaptive control algorithm. The adaptation is designed based on the Lyapunov theory and carried out by the fuzzy logic technique. Comparison between the proposed method and the feedback linearization method is shown by numerical simulations verifying the effectiveness of the suggested adaptive control scheme. The simulation results show that the proposed DFAC (Direct Fuzzy Adaptive Control) is very good in dealing with the time-varying, nonlinear nature of WECS. The DFAC was also proven more effective than the FLC(Feedback Linearization Control) regarding the control performance and power capture.

Nivedita Chakraborty et. al. "Modelling of Stand –Alone Wind Energy Conversion System using Fuzzy Logic Controller" The concern for environment due to the ever increasing use of fossil fuels and rapid depletion of the conventional sources of energy has led to the development of alternative sources of energy. Wind energy, the kinetic energy associated with movement of large masses of air, is an inexhaustible source of energy which generates electricity without harming our environment. But it is unreliable energy source as wind

conditions are uncertain and unpredictable. This paper focuses on developing a fuzzy logic controller based Stand-Alone Wind Energy Conversion System, where this controller manages power production and power storage according to wind conditions & load demand. This proposed system will help us to get a smooth AC output voltage to supply to fixed Load under any wind speed .The effectiveness of the proposed system for its application in autonomous wind energy system is verified with simulation results, which is carried out using MATLAB.
This paper presents a fuzzy power management for electricity distribution for stand-alone system. With information about load and battery state-of-charge, control signals were generated to manage well the power production for any wind conditions in respecting load demand. The simulation results show a good behaviour of our controller.

Mahmoud M. Hussein et. al. "Control of a Stand-Alone Variable Speed Wind Energy Supply System"
This paper presents a simple control strategy for the operation of a variable speed stand-alone wind turbine with a permanent magnet synchronous generator (PMSG). The PMSG is connected to a three phase resistive load through a switch mode rectifier and a voltage source inverter. Control of the generator side converter is used to achieve maximum power extraction from the available wind power. Control of the DC-DC bidirectional buck-boost converter, which is connected between batteries bank and DC-link voltage, is used to maintain the DC-link voltage at a constant value.Control strategy of a stand-alone variable speed wind energy supply system has been presented in this paper, along with a comprehensive analysis and simulation using MATLAB/SIMULINK. From the simulation results, the maximum power extraction control algorithm at the generator side converter has been implemented based on estimating generator speed, using the relation curve between generator speed and mechanical power to adjust the generator speed operation at optimum value through a hysteresis current control for extracting maximum power from the available wind power.

IV. Conclusion

The power available from a WECS is very unreliable in nature. So, a WECS cannot ensure uninterrupted power flow to the load. In order to meet the load requirement at all instances, suitable storage device is needed. Therefore, in this paper, a hybrid wind-battery system is chosen to supply the desired load power. To mitigate the random characteristics of wind flow the WECS is interfaced with the load by suitable controllers. The control logic implemented in the hybrid set up includes the charge control of battery bank using MPPT and pitch control of the WT for assuring electrical and mechanical safety.

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