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IoT Enhanced Real Time Monitoring and Optimization for Wind Power Generation

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ABSTRACT: The Internet of Things (IoT) has revolutionized various industries by enabling real-time monitoring and control of systems. In the field of renewable energy, loT-based solutions have gained prominence in enhancing the efficiency and reliability of wind power generation. This research project focuses on the development of an IoT-based real-time monitoring system for wind power generation. The system integrates various sensors, communication protocols, and data analytics tools to collect, transmit, and analyze data from wind turbines, enabling operators to optimize performance, ensure reliability, and reduce maintenance costs. This paper presents the key points and methodologies of this project, highlighting its significance in advancing wind energy generation and promoting sustainable energy sources.

KEYWORDS: Internet of Things (IoT), Renewable Energy, Wind Turbine, Optimization.

I.INTRODUCTION

This thesis deals with developing energy management strategies (EMSs) that dynamically optimize the operation of stand-alone dc micro grids, consisting of wind, converters (DFIG), and battery branches, to coordinately manage energy flows and regulate dc bus voltage level of micro grids. The proposed strategies are novel constrained and multivariable maximum power point trackers (MPPTS) that employ renewable energy systems as flexible generators which means that their generated powers are optimally curtailed. The presented EMSs are developed using non-linear model predictive control (NMPC) technique and dynamically extract the optimal control signals with respect to the battery bank and wind turbine operations. In order to develop these NMPC-based strategies, this dissertation work also involves the mathematical modeling of wind standalone dc micro grids as a complementarily system (CS) of type which is applicable to both the NMPC strategies, as well as for the long-term simulation purpose. As parts of the modeling efforts, a stochastic model is also presented to simulate hourly wind speed and wind irradiance for locations across the UK. Furthermore, a novel algorithm is proposed to identify an accurate equivalent electrical circuit for DFIG modules. The remainder of this chapter reviews the notion of sustainable micro grids and briefly describes three wind, wind, and battery branches.

Renewable energy sources like wind, sun, and hydro are seen as a reliable alternative to the traditional energy sources such as oil, natural gas, or coal. Distributed power generation systems (DPGSS) based on renewable energy sources experience a large development worldwide with Germany, Denmark, Japan, and USA as leaders in the development in this field. Due to the increasing number of DPGSS connected to the utility network, new and stricter standards in respect to power quality, safe running, and islanding protection are issued. As a consequence, the control of distributed generation systems should be improved to meet the requirements for grid interconnection. A fast maximum power point tracking (MPPT) control algorithm for the converters (DFIG) in a hybrid wind-DFIG system, in which the DFIG generator may also need to work in a reduced power mode (RPM) to avoid dynamic overloading. The two control modes, MPPT and RPM, are inherently compatible and can be readily implemented, without the need of a dumping load for the RPM. Following the establishment of a dynamic system model, the study develops the guidelines to determine the variables of a direct hill-climbing method for MPPT: the perturbation time intervals and the magnitudes of the applied perturbations. These results are then used to optimally set up a variable-step

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size incremental conductance (VSIC) algorithm along with adaptive RPM control. The power tracking performance and power limiting capability are verified by simulation and experiment. Then, the proper switching sequence is chosen based on an analysis of the predicted voltage unbalance. The independent phase duty ratios are calculated through complex calculations.

Using these, the control signals of the 12 switches are generated. These methods are complex to use and can increase the switching frequency and output THD. The small voltage vectors of an NPC inverter affect the neutral-point voltage. The N-type small switching state decreases the neutral-point voltage, and the P-type small switching state increases the neutral-point voltage when the inverter is in normal operation (inverting mode). Hence the dwell time of a small voltage vector should be divided equally. Conversely, if the dwell times of the P-type and N-type small voltage vectors are adjusted when the neutral-point voltage is unbalanced, the neutral-point voltage can be balanced.

Power electronics has progressively gained an important status in power generation, distribution, and consumption. With more than 70% of electricity processed through power electronics, recent research endeavors to improvethe reliability of power electronic systems to comply with more stringent constraints on cost, safety, and availability in various applications. This paper serves to give an overview of the major aspects of reliability in power electronics and to address the future trends in this multidisciplinary research direction. The ongoing paradigm shift in reliability research is presented first. Then, the three major aspects of power electronics reliability are discussed, respectively, which cover physics-of-failure analysis of critical power electronic components, state-of-the-art design for reliability process and robustness validation, and intelligent control and condition monitoring to achieve improved reliability under operation. Finally, the challenges and opportunities for achieving more reliable power electronic systems in the future are discussed. . The elementary DFIG device is the DFIG cell. A set of connected cells form a panel. Panels are generally composed of series cells in order to obtain large output voltages. Panels with large output currents are achieved by increasing the surface area of the cells or by connecting cells in parallel.

This paper presents a method to estimate the inverter lifetime so that we can predict a failure prior to it actually happening. The key contribution of this study is to link the physics of the power devices to a large scale system simulation within a reasonable framework of time. By configuring this technique to a real system, it can be used as a converter design tool or online lifetime estimation tool. In this paper, the presented method is applied to the grid side inverter to show its validity. A power cycling test is designed to gather the lifetime data of a selected insulated gate bipolar transistor (IGBT) module (SKM50GB123D). Die-attach solder fatigue is found out to be the dominant failure mode of this IGBT module under the designed accelerated tests. Furthermore, the crack initiation is found to be highly stressing dependent while the crack propagation is almost independent with stress level. Two different damage accumulation methods are used and the estimation results are compared. The neutral-point voltage is balanced by adding a time-offset to the turn-on time of the switches. If an inaccurate time-offset is added, the neutral-point deviation still remains. An accurate time-offset is obtained through the proposed time-offset estimation scheme. This method is implemented without additional hardware, complex calculations, or analysis. The effectiveness of the proposed method is verified by experiments. The small voltage vectors of an NPC inverter affect the neutral-point voltage. The N-type small switching state decreases the neutral-point voltage, and the P-type small switching state increases the neutral-point voltage when the inverter is in normal operation (inverting mode). Hence the dwell time of a small voltage vector should be divided equally.

A converters (DFIG) generator is internally a power-limited nonlinear current source having both constant-current- and constant-voltage-like properties depending on the operating point. This paper investigates the dynamic properties of a DFIG generator and demonstrates that it has a profound effect on the operation of the interfacing converter. The most important properties an input source should have in order to emulate a real DFIG generator are defined. These properties are important, since a power electronic substitute is often used in the validation process instead of a real DFIG generator. This paper also qualifies two commercial wind simulators as an example in terms of the defined properties. Investigations are based on extensive practical measurements of real DFIG generators and the two commercial wind simulators interfaced with dc-dc as well as three- and single-phase dc-ac converters. In case of nearest three vector (NTV) approach, the first step of SVPWM is to confirm a sub-section that reference vector located in, and the second step is calculation of the dwell time. As the number of level of inverters increasing, the sub-section is very small, so the completion of the algorithm of sub-section is not impossible in one sample period, if traditional SVPWM for multi-level inverters. In this section, a novel SVPWM method for multi-level inverters is proposed. As the number of level increasing, the SVPWM method becomes more and more complex. An intrinsic relationship between multi-level and two-level is developed and by using a linear transformation, the switching time of vectors for two-level

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inverter can be transformed for multi-level inverter. A novel classification of voltage vectors is proposed to determine switching sequence.

II. EXISTING SYSTEM

The stability of a dc micro grid is measured in terms of the stability of its dc bus voltage level which is one of the main control objectives. The grid voltage source converters (G-VSCs) are the primary slack terminals to regulate the voltage level of grid-connected micro grids. Battery banks, on the other hand, are effective slack terminals for wind standalone micro grids their energy absorbing capacities are limited regarding a number of operational constraints. The single-phase two-stage configuration is preferable for residential PV applications. The control structure of a two-stage single-phase PV system with the proposed control concept is which indicates that the hybrid control strategy is implemented in the control of the boost stage depending on the instantaneous available power of the PV panels, the actual output power of the PV panels can be expressed as where $Po\ (t)$ is the output power of the PV panels (i.e., input power of the power conversion stage), $P\text{PV}(t)$ is the available maximum power of the PV panels, and Limit is selected by taking into account the tradeoffs among the thermal performance (lifetime) of power devices, the PV inverter utilization factor, and the annual energy yield. As the available PV power is weather-dependent, the operation modes will alter accordingly with the wind irradiance and ambient temperature. Exemplifies different operation regions for a single-phase PV system during a day with the proposed control strategy the operation principle of the proposed hybrid MPPT-CPG control can be described as follows. When $\text{PPT}(t) \geq \text{P limit}$, the system enters into CPG operation mode and the MPPT control is deactivated.

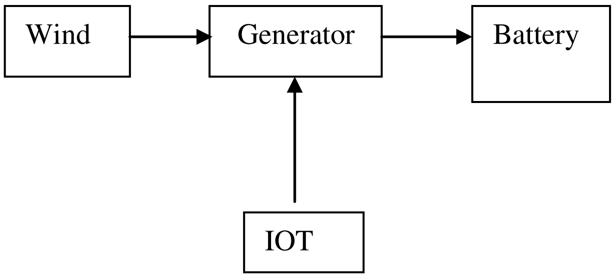

Figure.1. Block Diagram

III. PROPOSED SYSTEM

The main objective of this system is to design DC-DC MPPT circuit using chaotic pulse width modulation to track distributed maximum power from wind DFIG module for space application. The direct control method of tracking is used to extract maximum power. The nominal duty cycle of the main switch of DC-DC LUO converter is adjusted so that the wind panel output impedance is equal to the input resistance of the LUO converter which results better spectral performance in the tracked voltages when compared to conventional PWM control. The conversion efficiency of the proposed MPPT system is increased when CPWM is used as a control scheme. The single-phase two-stage configuration is preferable for residential DFIG applications. The control structure of a two-stage single-phase DFIG system with the proposed control concept is which indicates that the hybrid control strategy is implemented in the control of the boost stage depending on the instantaneous available power of the DFIG panels, the actual output power of the DFIG panels can be expressed as where Po (t) is the output power of the DFIG panels.

Cordeiro estimates the absolute position of the robot based on odometry. Besides odometry, Santos uses computational vision for the same purpose. Regarding the use of computational vision, Bessa et al. use pattern recognition techniques in omnidirectional images to estimate the localization of the robot. In sensor networks, multisensory data fusion usually can provide more accurate perception about the environment through sensor data fusion than using data individually. In this work, due to the availability of different amount of information at different locations, the SN has different levels of confidence about its position. The SN would be more confident about its position estimates in the coverage of a RN than those obtained out of the coverage of any RN. In this sense, the pipe sections within the communication coverage of a RN are considered as high- confidence zones, and the pipe sections out of the coverage of a RN as low-confidence zones, as labelled in Figure. In this work, algorithms.

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Generator

In electricity generation, a generator is a device that converts motion-based power (potential and kinetic energy) or fuel-based power (chemical energy) into electric power for use in an external circuit. A generator is a machine that turns mechanical energy into electrical energy. It provides electricity to devices and appliances when you are not connected to the power grid.

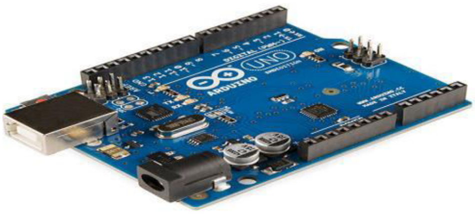
Figure.2. Generator

DISPLAY (LCD)

Figure.3. Display

Power generators are small, self-contained power plants built around a reciprocating engine and an alternator. The engine and the alternator are usually combined into a single enclosure, which can be as big as a tractor trailer, or as small as a suitcase, depending on how much electricity is needed.

ARDUINO UNO R3 MICROCONTROLLER



Arduino Nano controls the other components Raspberry Pi, motors, motor driver module, ultrasonic sensor. LCD screen is more energy efficient and can be disposed of more safely than a CRT. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically modulated optical device made up of any number of segments filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome. Liquid crystals were first discovered in 1888. By 2008, worldwide sales of televisions with LCD screens exceeded annual sales of CRT units; the CRT became obsolete for most purposes.

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IV.HARDWARE RESULTS

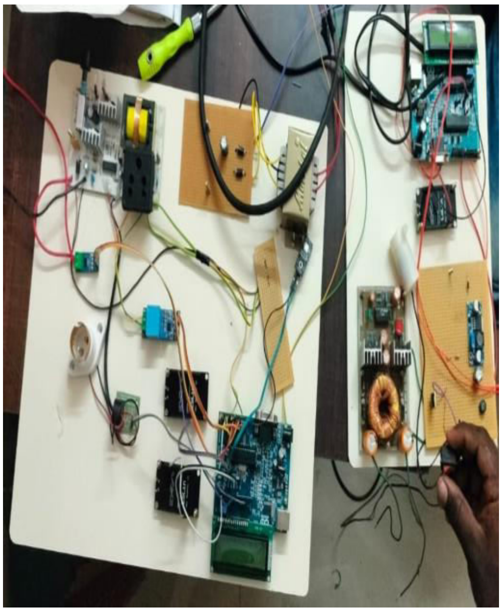

Figure.5.Hardware Result

Real-time monitoring and data analysis optimize operations, ensuring resources are allocated effectively and processes run smoothly. Predictive maintenance and energy optimization strategies minimize downtime and expenses, leading to significant cost savings over time. Enhanced monitoring ensures adherence to regulations and promotes a safer work environment, reducing risks and liabilities associated with industrial operations.

V.CONCLUSION

APFC based BL-DC-DC converter fed BLDC motor drive has been proposed for a wide range of speeds and supply voltages. A single voltage sensor- based speed control of the BLDC motor using a concept of variable dc-link voltage has been used. The PFC BL-DC-DC converter has been designed to operate in DICM and to act as an inherent power factor pre regulator been designed and its performance is simulated in MATLAB/Simulink environment for achieving an improved over equality over a wide range of speed control. Finally, the performance of the proposed drive has been verified experimentally on developed hardware prototype. A satisfactory performance of the proposed drive has been achieved an desire commended solution for low-power applications.

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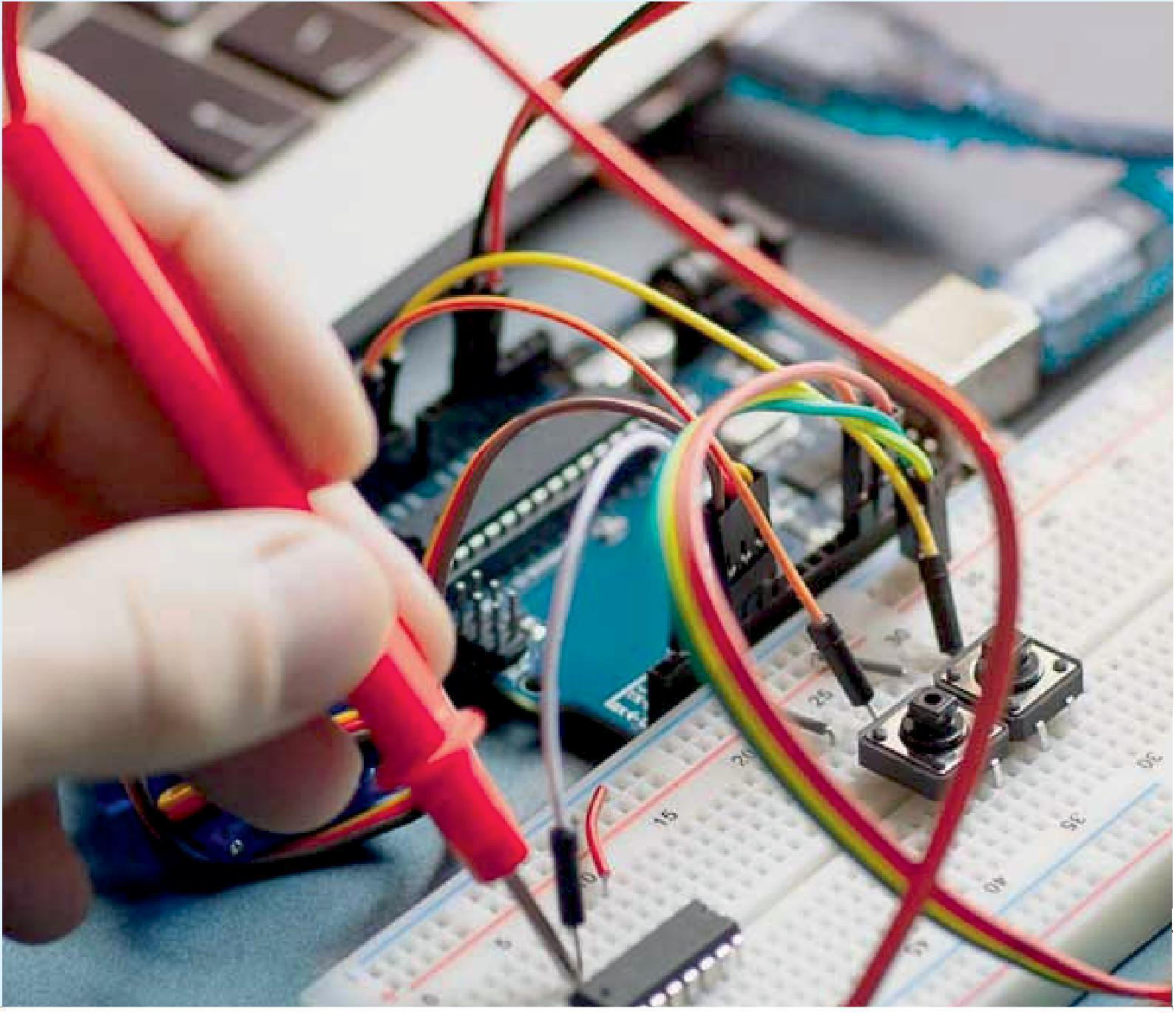

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