



SOLAR BASED VOLTAGE REGULATION FOR DC SOURCE USING MACHINE LEARNING

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ABSTRACT

The power generation from renewable power sources is variable in nature, and may contain unacceptable fluctuations. So in current use the renewable energy is stored in the battery or super capacitors to use it later but it requires high maintenance charge. So the main aim of the proposed system is to regulate the renewable power during the fluctuation to give uninterrupted power supply so here we are continuously monitoring the power generation of solar panel and simultaneously load usage. These values are sent to machine learned model to classify the switching status of regulator circuit. All these AI process is done in Python Platform.

Keywords: Renewable power sources, Python Platform and Phasor Measurement Unit

1. INTRODUCTION

Community micro grids are set to change the landscape of future energy markets. The technology is being deployed in many cities around the globe. However, a wide-scale deployment faces three major issues: initial synchronization of microgrids with the utility grids, slip management during its operation, and mitigation of distortions produced by the inverter. The Phasor Measurement Unit (PMU) Assisted Inverter (PAI) that addresses these three issues in a single solution. The proposed PAI continually receives real-time data from a Phasor Measurement Unit installed in the distribution system of a utility company and keeps constructing a real-time reference signal for the inverter. To validate the concept, a unique intelligent DC microgrid architecture that employs the proposed Phasor Measurement Unit (PMU) Assisted Inverter (PAI) is also presented, alongside the cloud-based Artificial Intelligence (AI), which harnesses energy from community shared resources, such as batteries and the community's rooftop solar resources.

One of the solutions that has been visualized for improvement of grid reliability is through implementation of microgrids. The United States Department of Energy (DOE) has defined a microgrid as "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode".

The micro grid allows integration of distributed energy resources to the distribution system. The Distributed Energy Resources (DERs) are defined by federal energy management program as "Small, modular, energy generation (< 10 MW) and storage technologies that provide electric capacity or energy when you need it". The recent surge of DERs at commercial and residential consumer level has been significant, this provides an opportunity to utilize the locally available DERs in the events outage and natural disasters. Hence, including capabilities in the residential level micro/nano-grids to use DERS for providing power to the critical loads during emergencies can alleviate the human and economic damages mentioned. Recent development in microgrid technology has added different functions such as improving reliability, supply demand balance, and economic dispatching to create what has been called Advanced Micro Grid (AMG) Systems by Cheng et. al. According to

Cheng, the key element of the AMG is the underlying Energy Management System (EMS), named Micro Grid Management System (MGMS), which consists of four distinct control principles: Model predictive Control (MPC), multiagent system, distributed network control, and droop control. These control schemes are implemented at different hierarchical levels and have different functionalities targeted towards grid power quality maintenance to economic dispatching depending upon the application. The MPC performs multi-objective optimization with defined constraints, the distributed networks and multiagent system determines the connection to and functionality of each agent based on the result of MPC, and droop controls provides references for fundamental control of Power Electronics Interface (PEI) that generates respective Pulse Width Modulation (PWM) based gate signals for the power switches. These hierarchical levels operate at different speed depending upon their relationship to direct control of the power switches.

The Primary controls are the most fundamental control layer that are directly responsible for controlling the power switches through gate signals, which are most often PWM signals. Although the references required for primary control can be of slower speed, the control signals have to be generated at switching frequencies. The primary controls include protection, converter output control, voltage and frequency regulation, and power sharing. The response time of primary control is in the range of milliseconds. The PWM based converter controls are conventional PID controllers with voltage, current, or cascaded voltage-current control loops. The primary converter control functions are identical for distributed or centralized framework. The Energy Management Systems (EMSs) form the secondary control level. The conventional goals of EMS have been improving cost and reliability. The EMS can be viewed as a multiobjective optimization tool that takes several inputs such as load profiles, generation forecasts, market information and uses them for specified objectives such as cost mitigation, demand response management, and power quality maintenance. Proposed in this study is an EMS targeted towards improving power availability to critical loads during outages and natural disasters. Conventionally, EMSs, like MGMSs, are implemented from a control room together. The power sharing is conventionally performed by establishing a master unit that controls the voltage of the system while the remaining slave units operate in current control mode. In distributed networks, the most popularly used power sharing techniques are droop control based techniques, however, the limitations associated with droop controls have led to numerous improvements. The control room consists of high-performance computing devices that control DERs in a centralized manner. The constrained multi-objective optimization problem are most often mixed-integer non-linear programming problems that have been solved using computation heavy evolutionary algorithms or reduced to linear programming problems and solved by using methods such as Lagrangian relaxation and gradient descent. The distributed EMSs have been modelled using multiagent systems. The multiagent systems relies on the intelligent units to achieve local goals and interact with other intelligent units to cooperatively achieve a global goal. A local and robust P2P connection is required for such multiagent systems. Furthermore, different variations of leaderless consensus and tracking synchronization problems have been suggested to reach global agreement like Distributed Cooperative Control (DCC) suggested in. The schemes such as DCC simplifies communication requirement by enabling global agreement while communicating with immediate neighbors only. This communication diagram is ideal for wireless communication between residential nano-grids in suburban environment.

2. LITERATURE REVIEW

VOLTAGE REGULATION OF SYNCHRONOUS CONDENSERS AND SWITCHING CAPACITORS IN POWER GRIDS WITH A UHV DC/AC SYSTEM

This paper proposes a voltage regulation of synchronous condensers and switching capacitors in the power grids with an ultra-high voltage (UHV) DC/AC system. The control is able to regulate the system voltages in permitted range, reduce the times of switching capacitors, and improve the system dynamic voltage stability. Firstly, the influences of the UHV DC/AC system, switching capacitors, and synchronous condensers on system dynamic voltage stability are estimated. And then, the sensitivity of bus voltages and reactive power is used to select the switching capacitors. A voltage control model with synchronous condensers and switching capacitors is established. Finally, an improved interior point method is applied to solve the voltage control model. An actual power grid with a UHV DC/AC system is used to validate the effectiveness of the proposed scheme.

DC-MICROGRID VOLTAGE REGULATION USING DUAL ACTIVE BRIDGE BASED SVR

This work presents the series voltage regulator (SVR) for DC-microgrid. The SVR consists of two different types of power converters namely, dual active bridge (DAB) and followed by full-bridge dc-dc converter

(FBDCC). DC-microgrid of five buses is considered with the nominal grid voltage of 380V. As transmission line length increases the drop in the line is also increases so it becomes necessity for some type of voltage control device that can compensate for this line voltage drop. The main goal of the SVR is to inject varying voltage in series with the microgrid for voltage regulation. This results the voltage level at different buses becomes independent of the load change and remains within the defined grid voltage limit. The system is modeled and simulated in MATLAB/Simulink environment. Simulation results show that the proposed SVR gives good dynamic performance and voltage regulation under different load conditions.

DISTRIBUTED AUTONOMOUS VOLTAGE BALANCING CONTROL FOR A MODULAR IPOS DC GRID-CONNECTED RENEWABLE POWER SYSTEM

A distributed autonomous voltage balancing control strategy for an input-parallel output-series (IPOS) modular DC grid-connected renewable power system is presented and analyzed in this paper. Autonomous voltage balancing of output voltages and distributed voltage regulation of low voltage DC bus of these IPOS DC-DC modules are achieved by introducing the output voltages of DC-DC modules into the input voltage reference of each module. The information of output voltages of these modules is shared through the low voltage DC bus. Therefore, fully distributed and automatic power balancing control and hot-swap can be realized without information exchange or central controller among these modules. Simple control, easy realization and high reliability can be ensured with the presented control strategy. Experimental results are provided to verify the effectiveness and feasibility of the IPOS system and its control strategy.

LCL IGBT BASED DC/DC CONVERTER PERFORMANCE IN A FIVE TERMINAL MOCK-UP DC GRID

The inductor-capacitor-inductor (LCL) fault tolerant DC/DC converters have shown promising properties in DC voltage stepping using no internal AC transformer. This paper details design and modelling a 5kW, 250V/400V LCL IGBT based DC transformer. The design is to be prototyped at CITCEAUPC in Barcelona and put into a five terminal mock up DC grid located at Electrical Engineering and Power Electronics Laboratory (L2EP) in Lille. Different topologies of DC transformer integration into the mock up are studied and best scenario is identified considering optimized power flow within the grid and DC voltage profile at different bus bars. The embedded converter divides the DC grid into two separate protection zones which results in easier grid protection design. An advanced control method developed in one single synchronous frame linked with central capacitor voltage is also proposed. The whole system including 5 VSC terminals and designed DC transformer is modelled in EMTPRV and the converter performance in DC power flow regulation, DC fault isolation, and DC voltage stepping is demonstrated using simulation results.

DC DYNAMIC VOLTAGE RESTORER (DC-DYR): A NEW CONCEPT FOR VOLTAGE REGULATION IN DC SYSTEMS

Many of the sensitive and high power loads in the AC distribution power system are direct current (DC) loads, which power quality is a fundamental issue in this type of load. There are many factors that affect the issue of power quality. The voltage sag is one of them which is the main factor in reducing power quality of grid. There are many of devices to increase voltage quality in the grid. The dynamic voltage restorer (DVR) is an economical solution to eliminate voltage-related power quality problems. In this paper, a DC dynamic voltage restorer (DC-DVR) is presented to retrieve the voltage drop at sensitive DC loads in the AC power grids. The proposed DC-DVR receives energy from output of the rectifier to maintain the load voltage constant at a nominal value. The proposed DC-DVR is in fact an isolated DC-DC converter fed from the DC bus and its output is series connected to the DC bus. The performance of the proposed DC-DVR is verified via simulations in PLECS software.

3. SYSTEM DESIGN

3.1 EXSISTING SYSTEM

In Existing system experimental set up for closed-loop control of the hardware prototype of the converter has been developed. The project presents a closed-loop control architecture of a grid-tied single-source multilevel inverter (MLI) with reduced switching loss, to control the DC-link as well as the power supplied to the utility system. The converter topology utilizes a diode-capacitor ladder network to facilitate a number of inherently-

balanced voltages, which resolves the predominant constraint of MLIs having several separate dc sources. Furthermore, zero-voltage-switching (ZVS) is achieved for the solitary high-frequency switch, which mitigates the switching losses. High-frequency operation of the switch facilitates the reduced components size resulting in less cost and weight of the converter. The performance of the grid-connected MLI is evaluated in various real-time conditions and the experimental results are presented.

3.2 PROPOSED SYSTEM

In order to increase the integration rate of distributed renewable energy generation, it has become important for the operation of future hybrid systems that the grid side converter be able to limit the influence of faults occurring at the point of common coupling (PCC) control systems should be able to avoid active and reactive double frequency oscillations and to prevent them to propagate through the common DC-bus and even to the generators (PVS and WECS ...). These oscillations harmful to the power system and its control system resulting from the appearance of the negative sequence. In addition, the interaction between the of the positive and negative sequences components leads to an undesired behavior of the electrical power system and even to the activation of the protection circuits to prevent instability

3.3 BLOCK DIAGRAM

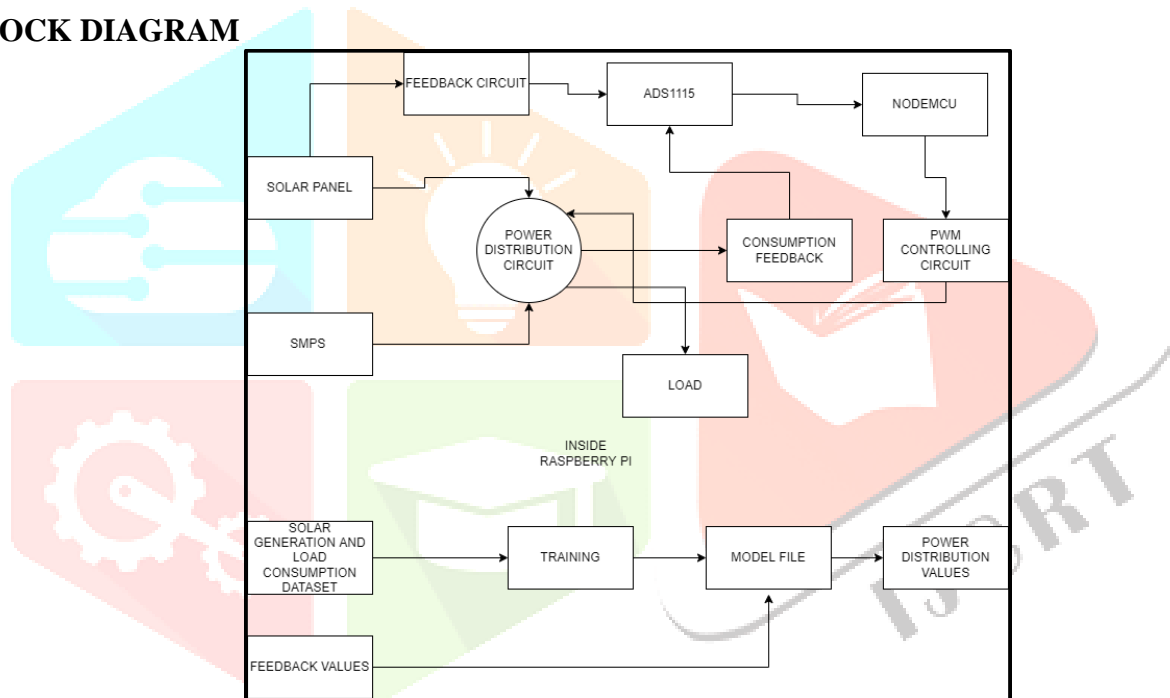


Fig: 1: Block Diagram

3.4 SOFTWARE DESCRIPTION

MATLAB-SOFTWARE DESCRIPTION

MATLAB, software is a technical matrix manipulating based computation software manipulating matrices leads to big data analysis. The things to learn in MATLAB are entering matrices, usage of the: (colon) operator, invoking functions. At the heart of MATLAB is a new high level language due to its multilanguage inheritance fully exploits its power. Matrix manipulation and function working will be the basics of MATLAB and. Users will be rewarded with high productivity, high-creativity, and strong computing power that will change the way us work.

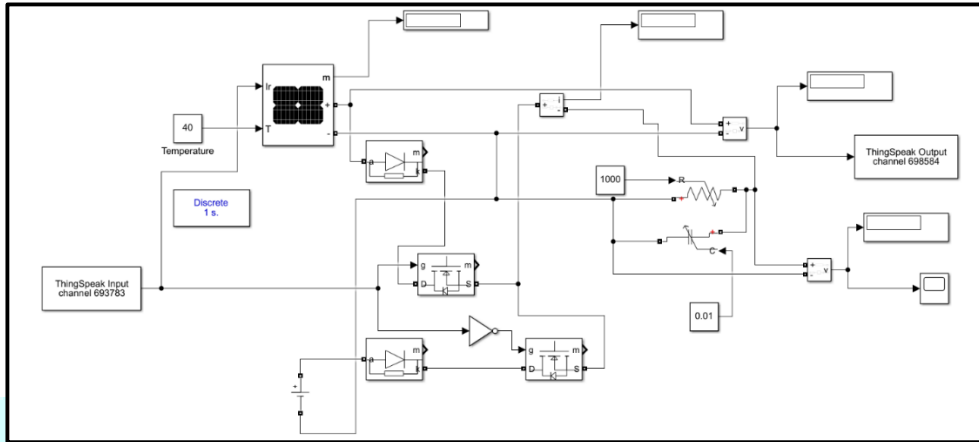
Introduction - describes the basic and commands and components of the MATLAB system.

Development Environment - introduces the MATLAB development environment which is based script making based on our needs, including information about toolboxes and the MATLAB desktop window environment.

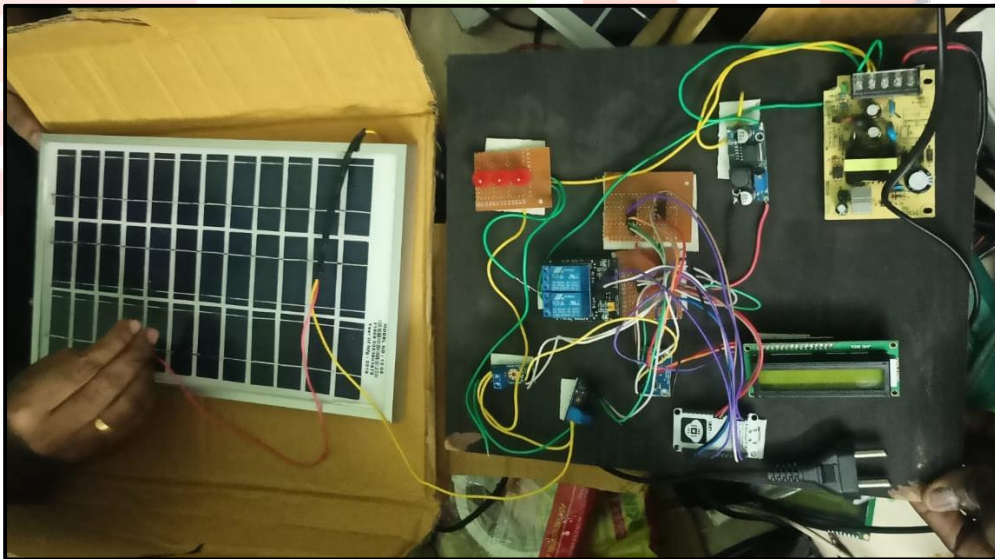
Manipulating Matrices - introduces how to use MATLAB to generate matrices and perform mathematical operations on matrices such addition and various mathematical operations. **Graphics** - introduces MATLAB graphic capabilities, including information about plotting data, annotating graphs, working with large data base and working with images.

Programming with MATLAB - describes how to use the MATLAB language to create scripts and functions based on external calculations, and manipulate data structures, such as cell arrays and multidimensional arrays

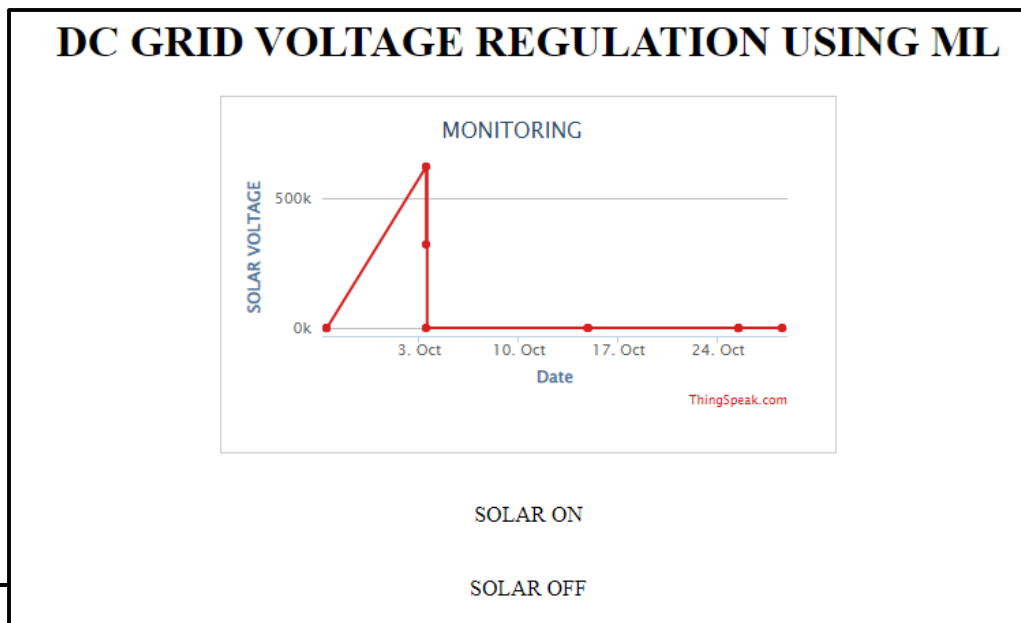
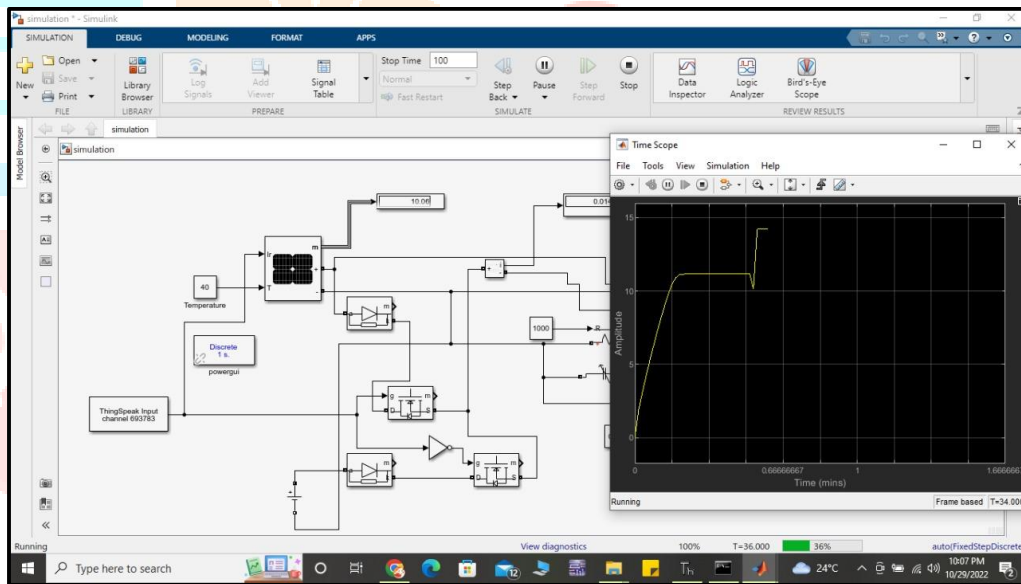
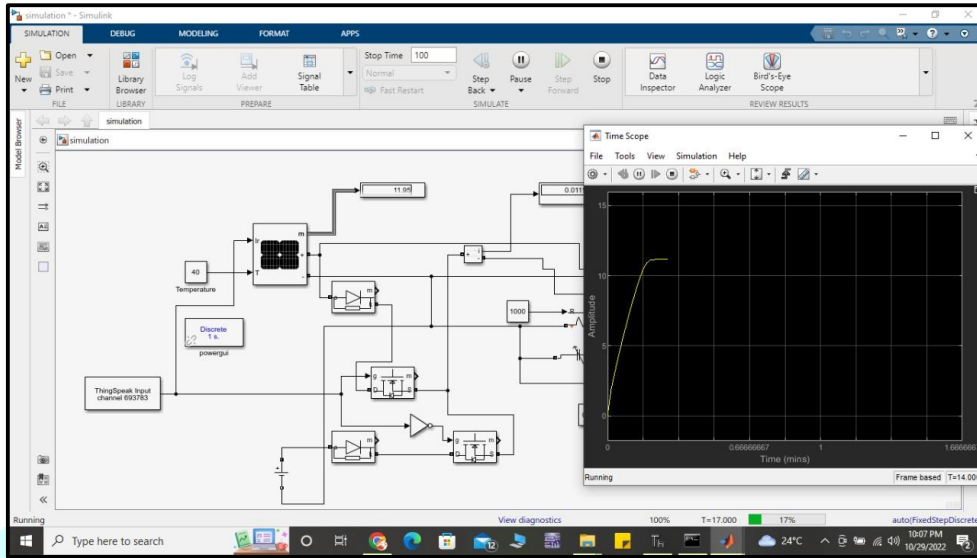
4. WORKING



The output voltage of solar PV always varies according to solar irradiation, temperature, so that it becomes a challenge in modelling DC-DC Converter with constant output voltage to the load. The design consists of switching and driver circuits, and LC filter to generate constant voltage as output to load. To ensure a constant output voltage, the design equipped by a machine learning based feedback switching controller based on voltage control mode.



5. RESULTS



6. CONCLUSION

Though the proposed intelligent DC microgrid commissioned with Phasor Measurement Unit assisted inverter architecture offers several benefits, if not properly cyber secured, it may be prone to cyberattacks. For instance, a disgruntled community resident may conduct a “replay attack” or “false data injection”, into the community-based microgrid and change the set-points. Though addressing cyber-security issues does not fall into the scope of this paper, most of the attacks can be identified through anomalies detection or attack signature detection. An AI Smart Server and Client coupled with machine learning approaches, as discussed in, can detect cyberattack signatures and behaviors from known and new threat actors. It is planned to focus on AI-based Cybersecurity attack detection. The authors also plan to study the application and effectiveness of AI and PMU based DC microgrids for quantifying the Power Quality Limits for distributed generation.

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