*A mid-sem project progress report*

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##### INTRODUCTION

The usage of the DVR with rechargeable energy storage at the dc-terminal to meet the active power requirements of the grid during voltage disturbances. In order to avoid and minimize the active power injection into the grid -----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Of all the rechargeable energy storage technologies, UCAPs are ideally suited for applications which need active power support in the ***milliseconds* to *seconds***timescale. Therefore, UCAP-based integration into the DVR system is ideal, as the normal duration of momentary voltage sags and swells are in the ***milliseconds* to *seconds***range. UCAPs have low-energy density and high-power density ideal characteristics for compensating voltage sags and voltage swells, which are both events that require high amount of power for short spans of time. UCAPs also have higher number of charge/discharge cycles when compared to batteries and for the same module

size, UCAPs have higher terminal voltage when compared to batteries, which makes the integration easier. With the prevalence of renewable energy sources on the distribution grid and the corresponding increase in power quality problems, the need for DVRs on the distribution grid is increasing. Supercapacitor-based energy storage integration into the DVR for the distribution grid is proposed in [16] and [17]. However, the concept is introduced only through simulation and the experimental results are not presented.

In this project, UCAP-based energy storage integration to a DVR into the distribution grid is proposed and the following application areas are addressed.

1. Integration of the UCAP with DVR system gives active power capability to the system, which is necessary for independently compensating voltage sags and swells.
2. MATLAB simulation of the UCAP, dc–dc converter, and inverter.



Fig. 1. One-line diagram of DVR with UCAP energy storage.

##### THREE-PHASE SERIES INVERTER

##### Power Stage

The one-line diagram of the system is shown in Fig. 1. The power stage is a three-phase voltage source inverter, which is connected in series to the grid and is responsible for compensating the voltage sags and swells; the model of the series DVR and its controller is shown in Fig. 2. The inverter system consists of an insulated gate bipolar transistor (IGBT) module, its gate-driver, *LC* filter, and an isolation transformer. The dc-link voltage *V*dc is regulated at 260 V for optimum performance of the converter and the line–line voltage *Vab* is 208 V; based on these, the modulation index *m* of the inverter is given by

|  |
| --- |
| ***m* = (2\**√* 2\**Vab*(rms))/( *√3*\**V*dc*∗n)-------------------(1)*** |

where *n* is the turns ratio of the isolation transformer.

Substituting *n* as 2.5 in (1), the required modulation index iscalculated as 0.52. Therefore, the output of the dc–dc convertershould be regulated at 260 V for providing accurate voltage compensation. The objective of the integrated UCAP-DVR system with active power capability is to compensate for*temporary* ***voltage sag***(0.1–0.9 p.u.) and ***voltage swell***(1.1–1.2p.u.), which last from 3 s to 1 min

1. **Controller Implementation**

There are various methods to control the series inverter to provide dynamic voltage restoration and most of them rely on injecting a voltage in quadrature with advanced phase, so that reactive power is utilized in voltage restoration [3]. Phase advanced voltage restoration techniques are complex in implementation, but the primary reason for using these techniques is to minimize the active power support and thereby the amount of energy storage requirement at the dc-link in order to minimize the cost of energy storage. However, the cost of energy storage has been declining and with the availability of *active power support* at the dc-link, complicated phase-advanced techniques can be avoided and voltages can be injected *in-phase* with the system voltage during a voltage sag or a swell event. The control method requires the use of a PLL to find the rotating angle. As discussed previously, the goal of this project is to use the *active* *power capability* of the UCAP-DVR system and compensate temporary voltage sags and swells.

Fig. 2. Model of three-phase series inverter (DVR) and its controller with integrated higher order controller.

1. **SOLAR PV SYSTEM**

The solar photovoltaic cell (PV) converts the solar energy into electrical energy directly with the help of solar PV modules or solar PV arrays. --------------------------------------------------------------------------------------------

1. **DC-DC BI-DIRECTIONAL CONVERTER**

Bidirectional converter is the modified version of conventional DC-DC converter with anti-parallel diode connected with MOSFET/IGBT. -----------------------------------------------------------------------------------------------

1. **BATTERY STORAGE SYSTEM**

Battery storage systems are devices that allow renewable energy sources such as solar and wind to be stored and released when the power generated by the grid is less that the requirement. ----------------------------------------------------------------------------------------------------------------------------------------------------

A picture containing text, sport

Description automatically generated

Fig. 1. CC-CV modes of battery charging

##### LITERATURE REVIEW

For the task to be implemented, a thorough literature review has been conducted and is given below.

The authors of [1]elaborates the interest and potential significance of recent technology related to renewable energy sources. -----------------------------------------------------------------------

The Battery Charging Methods of Micro-Grid Photovoltaic Systems has been elaborated in [2]. ------------------------------------------------------------------------------------------------------------------------------

In [3], the authors haveproposed a bidirectional DC–DC converter for an energy storage system with galvanic isolation. -------------------------------------------------------------------------------------------------------------

**------------------------there must be at least 15 articles/papers/book/book chapters used for the literature survey------------------**

##### PROBLEM FORMULATION

Renewable energy technology is well known around the world, but the difficulties and obstacles encountered in implementing renewable energy technologies, particularly in tribal and rural regions, are the main concerns. ---------------------------------------------------------------------------------------------------------------------------

##### MOTIVATION

Renewable energy technologies are rapidly evolving, and engineers must be familiar with the installation and maintenance of these technologies. --------------------------------------------------------------------------------------------

##### OBJECTIVES

* + To design the model and simulate photovoltaic system using P&O algorithm in MATLAB Simulink.
  + To design the model and simulate battery controller design in MATLAB Simulink.
  + To design the model and simulate PV integrated battery system in MATLAB Simulink using isolated DC-DC bi-directional converter.

##### PLAN OF ACTION

---------------write here how are you going to achieve your objectives mentioned above – from where to get the information/data? which software to use? How to evaluate/test the proposed work? how would you implement it? add a timeline (Gantt chart, etc.) -----------------------------------------------------

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