STABILITY IMPROVEMENT OF DC BUS IN MULTIPLE INPUT DISTRIBUTED POWER SYSTEM USING PASSIVE DAMPING CIRCUIT

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DEDICATION

This thesis is dedicated to my mother, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my father and my wife, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

Direct current (DC) technologies have drawn more consideration because of the expanding use of (DC) energy sources, energy storages, and loads in power systems. The integration of renewable energy sources into distributed power systems (DPS) usually requires a power converter which can deal with a widely varying input voltage. DPS consist of large complex system build up from many power electronic converters which have internal voltage control process that can regulate the output voltage. Tightly regulated converters, however may cause instability in such systems due to the negative incremental input impedance of constant-power loads (CPLs). Although there is various research for this topic, there still have some limitations regarding on the performance of DPS in term of DC bus voltage fluctuation and damping circuits. In this project, multiple input PV source consists of various series array strings with different (V-I) characteristics distributed power system connected to passive damper circuit was designed and simulated in MATLAB/SIMULINK program. The modelling of passive damper circuit was designed as series (RL), parallel (RL), and (RC) networks and the best performance among the structures was selected. The system is tested to three different values of CPL power which are (2.5, 5, 8 kW) respectively. It was noticed that, the installation of RC damper has shown good results in reducing the CPL effect. Moreover, the effect of combine both damping network and (LC) filter capacitor also discussed. In addition, the selected model was simulated with several filter cut-off frequency and the results were also analysed and explained. Furthermore, the improvement on the performance of the damper was also observed in this project. In conclusion, this project was examined directly the issue in power quality and stability along the distributed power system design and development.

ABSTRAK

Teknologi arus terus (A.T) telah mendapat lebih banyak pertimbangan kerana penggunaan sumber tenaga arus terus (A.T) yang semakin meluas, storan tenaga dan beban dalam sistem kuasa. Penyepaduan sumber tenaga boleh diperbaharui ke dalam sistem kuasa teragih (DPS) biasanya memerlukan penukar kuasa yang boleh menangani perubahan besar voltan input. DPS terdiri daripada sistem kompleks besar yang terbina daripada banyak penukar elektronik kuasa yang mempunyai proses kawalan voltan dalaman yang boleh mengawal voltan keluaran. Walau bagaimanapun, penukar kuasa yang dikawal ketat boleh menyebabkan ketidakstabilan dalam sistem sedemikian disebabkan oleh galangan tambahan masukan negatif beban kuasa malar (CPL). Walaupun terdapat pelbagai kajian untuk topik ini, masih terdapat beberapa batasan mengenai prestasi DPS dari segi turun naik voltan bas A.T dan litar redaman. Dalam projek ini, sumber PV berbilang input terdiri daripada pelbagai rentetan tatasusunan siri dengan ciri (V-I) yang berbeza sistem kuasa teragih yang disambungkan kepada litar peredam pasif telah direka bentuk dan disimulasikan dalam program MATLAB/SIMULINK. Pemodelan litar peredam pasif telah direka bentuk adalah jenis siri RL, selari RL, dan RC dan prestasi terbaik antara struktur ini telah dipilih. Sistem ini diuji kepada tiga nilai kuasa CPL iaitu (2.5, 5, 8 kW) masing-masing. Kajian yang dibuat menunjukkan, pemasangan peredam (RC) menghasilkan hasil yang memuaskan dalam mengurangkan kesan CPL. Selain itu, kesan kedua-dua kapasitor penapis redaman dan penapis pemuat (LC) juga dibincangkan dengan lebih lanjut. Di samping itu, model peredam RC telah disimulasikan dengan beberapa nilai frekuensi pemotongan penapis pemuat dan hasilnya dianalisis dan dijelaskan. Sebagai rumusan penyelidikan yang diterangkan dalam projek ini secara langsung sangat penting untuk kualiti dan kestabilan kuasa terhadap reka bentuk dan pembangunan sistem kuasa teragih.

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LIST OF ABBREVIATIONS

AC	-	Alternative current
C	-	Capacitor
C_d	-	Damping capacitor
C_f	-	Filter capacitor
CPL	-	Constant power load
EMI	-	Electromagnetic interference
DC	-	Direct current
DPS	-	Distributed power system
FF	-	Fill factor
G	-	Gain
G_{mlg}	-	Gain of minor loop gain
$I_{s.c}$	-	Shot circuit current
L	-	Inductor
mlg	-	Minor loop gain
NIR	-	Negative incremental resistance
PV	-	Photo-voltaic
R	-	Resistor
R_s	-	Series resistance
R_{sh}	-	Shunt resistance
RAS	-	Region of asymptotic stability
STC	-	Standard condition
$V_{o.c}$	-	Open circuit voltage
A.T	-	Arus terus

LIST OF SYMBOLS

Ω	-	Ohm
μ,u	-	Micro
A	-	Ampere
v	-	Voltage
H	-	Henry
Hz	-	Hertz
I	-	Current
P	-	Power
rad/sec	-	Radian per second
ω	-	Omega
kW	-	Kilo watts
F	-	Farad
Z	-	Impedance

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The photovoltaic (PV) system is growing rapidly in the energy market in this decade. This technology converts sunlight directly into electricity and become desirable for reducing electricity bills, diverse applications, availability and low cost maintenance. The world has turned to this technology because its benefits have outweighed its disadvantages. Moreover, the positive impact on the environment especially global warming problem because it reduces greenhouse gases emission [1]. The widespread use of solar PV offers significant technological issues for the operation and performance of traditional energy distribution networks in AC and DC applications, which were previously designed and operated as passive circuits with a single-direction power flow feed. High PV penetration imposes significant challenges on the control and operation of distribution systems. Therefore, many methods were adopted to integrate the PV system with the power grids to avoid violating a significant parameter that is system security, reliability and stability which are the probability of the system's operating point remaining within acceptable ranges [2], [3].

System stability is an importance issue to evaluate the power system, since the photovoltaic PV system can affect negatively many substantial elements in that system. In any power network, the quality of power supply is critical, especially for electricity consumers. The term "power quality" refers to the supply's availability, frequency, and voltage magnitude, as well as the waveform characteristics of the power supply. If the power supply is continuous at appropriate steady values of voltage and frequency, and has a smooth waveform, it is said to be of good quality. Poor power quality is a major issue for residential, commercial, and industrial customers. For example, several domestic appliances and gadgets may not function properly if the voltage is below or beyond a permissible level, thereby causing harm to the appliance.

Poor power quality can cause bulbs and electrical equipment to malfunction or stop working altogether, resulting in premature failure. Low power quality in industry is an issue for increasingly automated sensitive manufacturing machinery. Inverter-based generators are represented by photovoltaic systems. They are made up of photovoltaic panels that generate direct current (DC) power and an inverter that converts the DC power into alternating current (AC) power on a continuous basis [4].

The photovoltaic system can be connected to an AC electrical system relying on inverters or DC bus through converters. Since photovoltaic systems are made up of a DC power source and electronic equipment, they can produce power quality concerns such residual DC current, harmonics, unbalanced loads, and negative incremental impedance. Recently, direct current (DC) micro-grids have drawn more consideration because of the expanding use of direct current (DC) energy sources, energy storages, and loads in power systems. Two main operation models which are grid-connected mode, and off-grid mode including the islanded and isolated modes. Figure 1.1 shows the block diagram for DC micro-grid system [5].

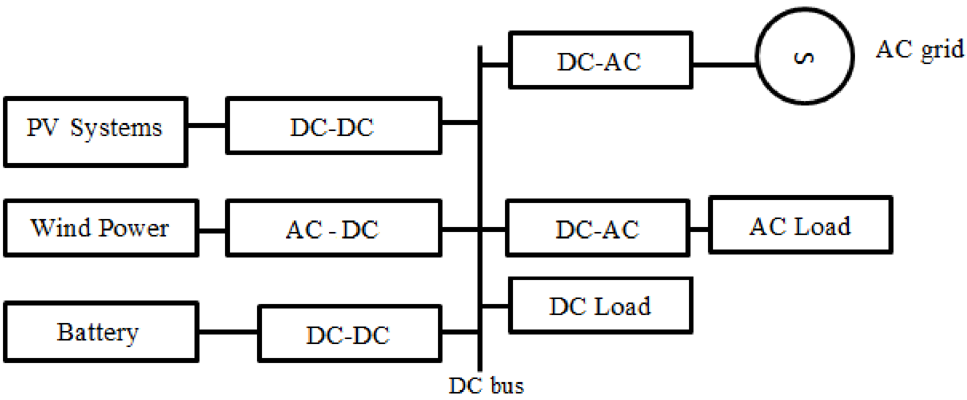

Figure 1.1 The block diagram of DC micro gird system [6]

When the electronic components that comprise the distributed power system are tightly controlled, these electronic components tend to consume a constant power. As a result, when multiple subsystems are coupled to a single common DC bus bar, the interactions between these subsystems may disrupt the performance of a system.

Because each converter in the network has its own internal control mechanism to manage its output voltage, such converters tend to require constant power. As a result, inside its closed loop bandwidth, the power converter creates negative incremental input impedance. CPLs degrade the power quality of the electric system and cause instability, leading current to decrease as voltage fed to it increases and vice versa on the DC bus [6].

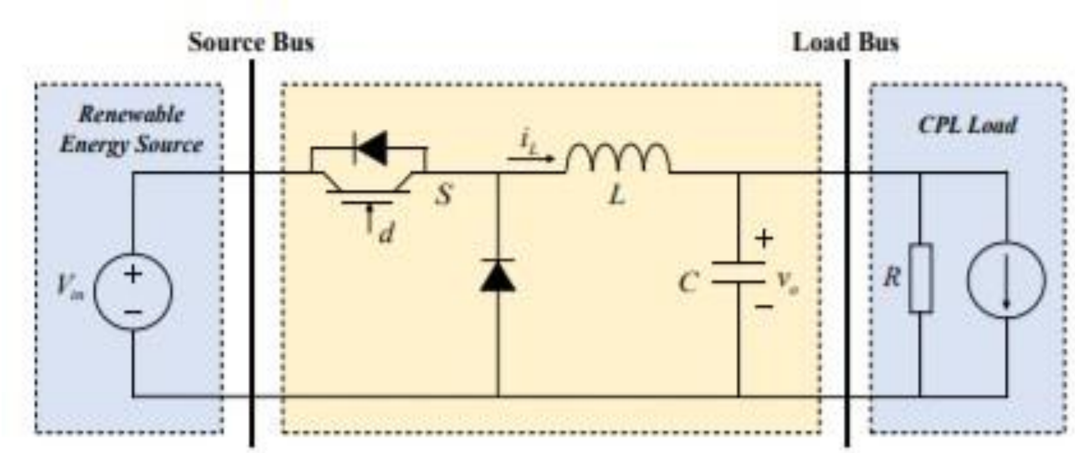

Figure 1.2 The simplified buck converter in DC-DPS with CPL[7].

Figure 1.2 illustrates a basic DC micro-grid including one buck converter to obtain DC voltage supply from the source bus. The load bus is linked in parallel with the constant voltage and constant power loads.

1.2 Problem Statement

Solar photovoltaic (PV) generation systems has become a crucial element in energy generation industry. This power electronic based system integration with DC-micro-grid via converters has a major drawback which is creating a constant power load phenomenon. Loads in power system can be divided into two basic categories. First is constant voltage load, which maintains a constant voltage drop and the equivalent resistance of this kind of load remains constant, and second is the constant power loads, represented in power electronics based devices such as converters and inverters which have internal voltage control process that can regulate the output voltage, leading to experiencing negative impedance characteristics. Therefore, negative impedance of constant power loads causes a destabilizing effect on micro-grids leading to voltage level oscillations. Thus, this problem of instability deserves to be studied because of its importance in the field of DC power generation system and DPS integration technology.

1.3 Research Objectives

The purpose of this study is to mitigate the power oscillation and maintain on the voltage level unaffected on the DC bus. The objectives of this project are:

(a) To design a passive damping network to mitigate power oscillation problem in DC bus bar.

(b) To investigate the stability parameter of multiple input photovoltaic with different characteristics connected to DC bus with passive damping network.

(c) To simulate the constant power load effect on stability with different characteristics PV input source in DPS with MATLAB SIMULINK program.

1.4 Scopes of Study

The goal of this research is to examine the stability of various PV sources coupled in a DC bus system with different (V-I) characteristics. Many researchers have tackle the issues of power stability in photovoltaic DC micro-grid tied system that concentrate on a major part which is power oscillation. In order to overcome the system's instability, the passive damping network is chosen as the stabilizing strategy. This approach has various benefits over active damping networks, including the fact that it does not require external power sources or an extra sensing circuit. Moreover, this method is less expensive and less complicated than an active damping network. A photovoltaic system that generates renewable energy also contributes to the input sources. Multiple characteristics PV sources are supplied into the DC bus through power converters, and the constant power load (CPL) can be directly connected to the DC bus. The damping circuit, however, will be situated between multiple (PV) energy sources and the constant power loads. The proposed system will be tested and simulated through MATLAB SIMULINK to inspect and analyse the instability mitigation method.

1.5 Hypothesis

In this research we assume a (115 V) DC bus is fed from a multiple photovoltaic power system with different (V-I) characteristics throughout buck converter with power oscillation elimination circuitry by using passive damper to improve power stability on the DC bus have the following hypothesis:

(a) By mitigating the effect of constant power load in distributed power system the power instability losses will be decreased.

(b) Improvement of power stability mean the transferred power through the grid will have a high quality.

1.6 Significance of Study

The aim of the research is to minimise the negative impedance effect in a DPS system when integrating two or more direct current subsystems. This research also delivers a suitable voltage profile and a stable DC bus system. Nonetheless, this research expands on the passive damping method's application to the stability of a DC bus system with multiple input (PV) sources.

1.7 Research Outline

The outline of this research is as follow: Chapter 1 briefly discusses the planned work's history and general concept. This chapter also covered the problem statement, the objectives, the importance of study, and scope of study. The literature studies in Chapter 2 covers the fundamental aspect of a distributed power system (DPS) for direct current distribution. A short introduction of filter architecture, constant power load, distribution system instability, negative incremental resistance, the stabilization approach, and the relationship of load-sources is also provided in this chapter. For the methodology chapter, the fundamental modelling of a DC source with a constant power load is covered in Chapter 3. It includes a work flow chart as well as a study Gantt chart and theoretical design chart. In addition, it depicts a simulation with a (DC) direct current source and a constant power load. For chapter 4, the simulation results for four conditions are illustrated in this chapter. Finally, the conclusion and recommendations is the last part in this project.

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