POWER SHARING STRATEGY USING H$^{\infty}$ CONTROLLER BETWEEN TWO DISTRIBUTED GENERATION SOURCES IN ISLANDED MODE

ERUM

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To my beloved Dad, Mom, Brother, Father in law, Husband, Daughter and Sisters

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ABSTRACT

This project addresses the problem of the primary controller of parallel-connected inverters in AC microgrid, which is operated in islanded mode. Voltage and frequency power sharing controller techniques are commonly used for sharing loads. However, this non-communication power sharing control technique has a disadvantage, where the frequency and voltage deviations are severe during a sudden load change. Currently, it can be fixed by using the communication-based secondary level. Therefore, the concept of non-communication network is needed for the DGs with fast restoration of voltage and frequency in order to maintain the stability and sensitivity of the islanded system. This project aims to develop a robust distributed H^{∞} power sharing strategy to overcome the problem of restoration. The new controller would be able to enhance the performance and give a more reliable performance for power sharing, voltage and frequency restoration. Moreover, this project mainly focuses on the mathematical modelling of parallel-connected inverters, where the eigenvalues technique of the electric network is used to predict the stability of the islanded condition by applying eigenvalue technique. The proposed H^{∞} power sharing control has established a condition for power sharing among the DGs and restores the voltage and frequency. This controller has shown the robustness effect in order to restore voltage and frequency and to satisfy the system performance. Finally, this H^{∞} controller with robust and dynamic response is tested in islanded mode configuration, which has two DGs with identical power ratings connected to several local loads at the point of common coupling. The proposed robust controller's theoretical concept is validated by using MATLAB Simulink, and it is compared with the conventional and existing secondary power sharing strategies that are also applied at the same electrical system. As result, the proposed controller can achieve better steady state performance and fast restored frequency within 0.002 s with rise time 0.05s while compared to 0.13 s rise time for existing secondary controller. Maximum overshoot is also reduced during the sudden

load changed and good tracking performance efficiency by 95% as compared to the 90% efficiency of existing secondary controller and 85% conventional controller. Thus, it is able to restore voltage and frequency to nominal values and enhances power sharing according to inverter rating.

ABSTRAK

Projek ini menangani masalah pengawal utama penyongsang yang disambungkan secara selari dalam mikrogrid AC, yang dikendalikan dalam mod *islanded*. Teknik pengawal perkongsian kuasa voltan dan frekuensi biasanya digunakan untuk perkongsian beban. Walau bagaimanapun, teknik kawalan perkongsian kuasa bukan komunikasi ini mempunyai kelemahan di mana sisihan voltan dan frekunsi adalah tidak berkesan apabila perubahan pada beban secara tiba-tiba. Pada masa ini, ia boleh diperbaiki dengan menggunakan komunikasi berasaskan tahap kedua untuk menanggapi perubahan ini. Oleh itu, konsep rangkaian bukan komunikasi diperlukan di kalangan DGs dengan pemulihan pantas voltan dan frekuensi untuk mengekalkan kestabilan dan kepekaan sistem islanded. Projek ini adalah untuk membangunkan strategi perkongsian kuasa H^{∞} teragih yang mantap mengatasi masalah penstoran semula. Pengawal baru dapat meningkatkan prestasi dan memberikan prestasi yang lebih dipercayai terhadap perkongsian kuasa, voltan dan frekuensi. Selain itu, projek ini terutamanya tertumpu kepada pemodelan matematik terbadap penyongsang yang disambungkan secara selari, di mana teknik nilai eigen bagi rangkaian elektrik digunakan untuk meramalkan kestabilan keadaan kawalan perkongsian kuasa H^{∞} yang dicadangkan telah mewujudkan satu keadaan untuk perkongsian kuasa antara DGs dan memulihkan voltan dan frekuensi. Pengawal ini telah menunjukkan kesan yang mantap untuk baik pulih voltan dan frekuensi dan untuk memenuhi prestasi sistem. Pada akhirnya, pengawal H^{∞} ini yang mantap dan tindak balas yang dinamik diuji dalam konfigurasi mod *islanded* yang mempunyai dua DG dengan kadar kuasa yang sama disambungkan kepada beberapa beban tempatan pada titik gandingan yang biasa. Konsep teori pengawal yang dicadangkan telah disahkan dengan menggunakan MATLAB Simulink, dan ia juga telah dibandingkan dengan strategi perkongsian kuasa sekunder konvensional yang sedia ada dan telah digunakan pada sistem elektrik yang sama. Akibatnya , pengawal yang dicadangkan dapat mencapai prestasi keadaan mantap yang mantap dan frekuensi pemulihan yang cepat dalam

0.002 s dengan masa naik 0.05 s berbanding dengan lenaikan masa 0.13 s untuk pengawal menengah sedia ada. Penyungkiran maksimum juga dikurangkan semasa behan tiba-tiba berubah dan lecelapan prestasi penjejakan yang baik sebanyak 95 % berbanding dengan kecekapan 90% pengawal menengah yang sedia ada dan pengawal konvensional 85%. Oleh itu, ia dapat mengembalikan voltan dan kekerapan kedada nilai nominal dan meningkatkan perkongsian kuasa mengikut penarafan inverter.

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LIST OF SYMBOLS AND ABBREVIATIONS

A	-	Ampere
AC	-	Alternating current
DC	-	Direct current
DG	-	Distributed generation
d	-	Disturbance signal
G	-	System plant
H	-	Low pass filter
Hz	-	Frequency
kW	-	kilo Watt
LFT	-	linear fractional transformation
LMI	-	Linear Matrix Inequalities
MG	-	Micro Grid
m	-	Frequency power sharing coefficient (rad/W. s)
m_d	-	Adaptive frequency power sharing coefficient
n	-	Voltage power sharing coefficient (V/VAR)
n_d	-	Adaptive voltage power sharing coefficient
P	-	Augmented plant
PCC	-	Point of common coupling
PI	-	Proportional Integral
PLL	-	Phase Lock Loop
P_L	-	Load active power
P_n	-	Inverter active power (n=number of inverter)
PV	-	Photovoltaic
ΔP_{MG}	-	Microgrid active power deviation
Q_L	-	Load reactive power
Q_n	-	Inverter reactive power (n=number of inverter)
ΔQ_{MG}	-	Microgrid Reactive power deviation

RMS	-	Root mean square
r	-	Reference signal
ρ	-	Dynamic phasor domain
s	-	Second
V	-	Voltage
V_{dc}	-	Input voltage
V_g	-	Microgrid output voltage
V_o	-	Nominal output voltage
V_{sec}	-	Secondary controller Voltage
W	-	Watt
W_n	-	No of weighted function
ω	-	Exogenous inputs
ω_o	-	Nominal angular frequency
ω_{sec}	-	Secondary controller angular frequency
δ	-	Voltage phase (°)

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The conventional power systems are changing globally and a large number of distributed generation (DG) sources are being integrated into complex power distribution systems to reduce the emission of greenhouse gases, increase the reliability of the system and alleviate the pressure on power transmission. These DGs may be photovoltaic arrays, winds turbines, fuel cells and energy storage devices such as batteries and supercapacitors, etc. A cluster of interconnected DGs is known as a microgrid. As known, the microgrid has been proposed to integrate DGs to the local loads. The primary function is to facilitate the penetration of DGs, hence enhancing the persistence of power supply [1], [2], [3]. The load connected to the grid may be critical or non-critical but it should provide reliable energy and demand rigorous power quality. Therefore, the DGs need power converter mechanisms of control interface to be connected to the microgrid. Consequently, inverters and converters are adapted to connect the DGs to the microgrid, as shown in Figure 1.1.

A microgrid can be operated in two modes, grid-connected and islanded mode, to provide reliability and power quality. When a microgrid is operated in grid-connected mode, the voltage and frequency are fixed by the stiff grid and the DC/AC inverters are connected parallel with the utility grid, whereas in islanded mode of operation, multiple parallel DGs are required to stabilise voltage and frequency. Thus, the main aim is to share the power load properly. Proper power sharing is crucial as per the stability, disturbance, sensitivity and load requirement; hence, a modern control strategy is needed to share the power as per the required load as well

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