STABILITY ANALYSIS PV PENETRATION USING POWER WORLD

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical Power)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JANUARY 2018

"Specially dedicated to my beloved father, mother, brothers and sister, lecturers and friends…."

ACKNOWLEDGEMENT

I would like to express my gratitude and appreciation to all those who gave me the possibility to complete this report. A special thanks to my supervisor, Dr. Jasrul Jamani, who always gave advice and for this patience, motivation and immense knowledge to walk me through the completion of the final project.

Deepest thanks and appreciation to my family, friends, and others for their cooperation, encouragement, constructive opinion and full support. Last but not least thanks to all of my friends and everyone, those have been contributed by supporting my work and help myself during the final year project progress.

ABSTRACT

Stability in grid network is important since it will have impact on the sustainability and reliability in delivering power and also limiting the total power losses. It also been used to define system ability turn back to steady state condition when a disturbance occurs within minimum time. Nowadays renewable energy is a main discussion for future energy source. Photovoltaic (PV) is one of common discussion and it is a part of grid connected generation. PV generation is depending on the cloud clearness and the generation will varies accordingly. When it connected to the grid, it has significantly impact on the power system in terms of voltage fluctuation, power quality and power control. For this simulation brief study on the voltage profile in the steady stage and also transient stability using IEEE 9 bus as a test system. Study on the stability of the system when of PV penetration in steady state and fault applied has been presented. Simulation study cases are Case 1: Generator as only source for the test system in steady state and fault condition applied to one of the system bus. Case 2: PV as sole source for the test system except for slack bus in steady state. Case 3: PV and Generator as source except for slack bus with different PV penetration in fault condition applied to one of the system bus. The study of stability in this system has been carried out in short terms disturbance. Rotor angle at generator and the variations of voltage at buses been observed for the maximum PV penetration until the slack bus act as motor instead of reference.

ABSTRAK

Kestabilan dalam rangkaian grid adalah penting kerana ia akan memberi kesan kepada kelestarian dan kebolehpercayaan dalam menyampaikan kuasa dan juga mengehadkan jumlah kehilangan kuasa. Ia juga digunakan untuk menentukan keupayaan sistem berbalik kepada keadaan keadaan mantap apabila gangguan berlaku dalam masa yang minimum. Kini, tenaga boleh diperbaharui adalah perbincangan utama untuk sumber tenaga masa depan. Photovoltaic (PV) adalah salah satu perbincangan umum dan ia merupakan sebahagian daripada generasi sambungan grid. Penjanaan PV bergantung pada kekosongan awan dan generasi akan berbeza-beza mengikutnya. Apabila ia disambungkan ke grid, ia mempunyai kesan yang ketara ke atas sistem kuasa dari segi voltan turun naik, kualiti kuasa dan kawalan kuasa. Untuk kajian ringkas simulasi ini pada profil voltan di peringkat mantap dan kestabilan sementara menggunakan bas IEEE 9 sebagai sistem ujian. Kajian kestabilan sistem apabila penembusan PV dalam keadaan mantap dan kegagalan yang digunakan telah dibentangkan. Kes kajian simulasi ialah Kes 1: Generator sebagai sumber hanya untuk sistem ujian dalam keadaan mantap dan keadaan kesalahan yang digunakan pada salah satu bas sistem. Kes 2: PV sebagai sumber tunggal untuk sistem ujian kecuali untuk bas kendur dalam keadaan stabil. Kes 3: PV dan Generator sebagai sumber kecuali bas kendur dengan penembusan PV yang berlainan dalam keadaan kerosakan mantap yang digunakan pada salah satu bas sistem. Kajian tentang kestabilan dalam sistem ini telah dilakukan dalam jangka pendek gangguan. Sudut rotor pada penjana dan variasi voltan pada bas telah diperhatikan.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	i
	DEDICATION	ii
	ACKNOWLEDGEMENT	iii
	ABSTRACT	iv
	ABSTRAK	v
	TABLE OF CONTENTS	vi
	LIST OF TABLES	viii
	LIST OF FIGURES	ix
1	**INTRODUCTION**	
	1.1 Background	1
	1.2 Problem Statement	4
	1.3 Objective of the Study	5
	1.4 Scope of the Study	6
	1.5 Significant of study	7
	1.6 Report Organization	7
2	**LITERATURE REVIEW**	
	2.1 Introduction	9
	2.1.1 Voltage Stability-Static Condition	10
	2.1.2 Voltage Stability-Transient Condition	10

	2.2 Power Flow	11
	2.2.1 Power Flow Transient Stability Analysis	12
	2.3 Summary	12
3	**DESIGN AND SIMULATION**	14
	3.0 Introduction	14
	3.1 Design and Modeling	14
	3.1.2 Power World Software	15
	3.1.2 Model Test System	15
	3.1.3 Generator Test System	17
	3.2 Design Parameter	24
	3.3 Simulation Flow	26
4	**RESULT AND DISCUSSION**	
	4.1 Steady State Analysis	28
	4.1.1 Generator 1-Slack Bus	28
	4.1.2 Bus System Voltage	28
	4.1.3 Load Bus	31
	4.2 Transient State: Case 1 and Case 2	34
	4.2.1 Generator Rotor (Slack Bus)	34
	4.2.2 Bus System	35
	4.2.3 Load Bus	38
	4.3 Transient State: Case 1 and Case 3	41
	4.3.1 Generator	41
	4.3.2 Bus Voltage	42
	4.3.3 Load Bus	45
	4.3 Summary on Simulation	49
	4.3.1 Steady State	50
	4.3.2 Transient Analysis: Case 1 and Case 2	50
	4.3.3 Transient State: Case 1 and Case 3	51

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion 53

5.2 Future Work 54

REFERENCES 55

LIST OF TABLES

TABLE NO.	TITLE	PAGE
3.1	Combination of Renewable Energy in previous Power World	22
3.2	Data-Bus, Transformer and Load	24
3.3	Parameter Data-Line Bus	25
3.4	Parameter Data-Load Bus	25
3.5	PV Data based 10% Increment	26
4.1	System Bus Voltage Different	30
4.2	Load Bus Voltage Different	31
4.3	Load Bus Voltage. MW and MVar Different	33
4.4	System Bus Voltage Difference	37
4.4	Load Bus Voltage, MW and MVar Difference	40
4.5	Bus System Voltage	43
4.6	Load Bus Voltage Comparison	46
4.7	Load Bus Power(MW)	47
4.8	Load Bus Power(MVar)	49

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Solar PV Global Capacity	2
1.2	Solar PV-Off Grid and Grid connected (2006-2016)	2
1.3	Power System Stability Network	3
2.1	Diagram of the analysis	13
3.1	Single line diagram without PV connected to the system	16
3.2	Single line diagram with PV connected to the system	16
3.3	GENROU Machine model by Power World	18
3.4	Exciter Model	19
3.5	PSSA2 Model	20
3.6	IEEEG! Model	21
3.7	PVD1 Model	23
3.8	Simulation Flow	27
4.1	Generator Bus-Case 1	28
4.2	System Bus Voltage	29
4.3	Load Bus Voltages	31
4.4	Load Bus Active Power (MW)	32
4.5	Load Bus Reactive Power (MVar)	32
4.6	Rotor Angle Slack Bus-Transient (Case 1 and Case 2)	34
4.7	Bus system (Case 1 and Case 2)	35
4.8	Load Bus system (Case 1 and Case 2)	38
4.9	Load Bus system P(MW) (Case 1 and Case 2)	38
4.10	Load Bus system Q(MVar) (Case 1 and Case 2)	39

4.11	Rotor Angle for Generator (Case 1-Transient Case 3-Transient)	41
4.12	Bus system voltage (Case 1-Transient Case 3-Transient)	44
4.13	Load Bus Voltage	45
4.14	Load Bus Power (MW)	47
4.15	Load Bus Power (MVar)	48

CHAPTER 1

INTRODUCTION

1.1 Background of the Problem

Electrical Renewable Energy is one of huge topic that has been discuss as one of renewable energy and can be one of the solution for the climate change situation. Solar and wind energy is the most largely been used as a source and commercially established. There are quite a number of studies for solar and wind technologies and the studies on solar and wind kept on be a main topic to overcome the entire problem that still exist.

As per REN 21 report the solar PV installation has increased from 3MW in 2006 to 303GW in 2016 and Figure 1.1 shows the generation of PV by countries all over the world

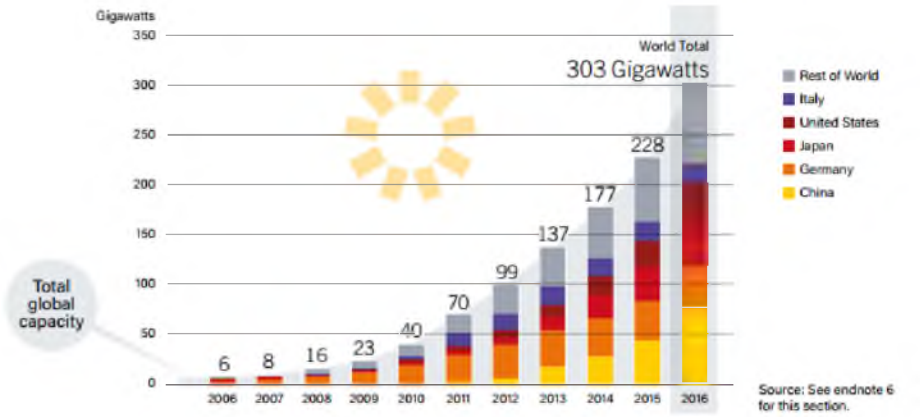

Figure 1.1 Solar PV Global Capacity [1]

The number of installation for the solar PV in 2016 the number of power generation is almost 75GW worldwide and it is also increasing the number over the years from standalone PV generation to the grid connected as it show from the Figure 1.2

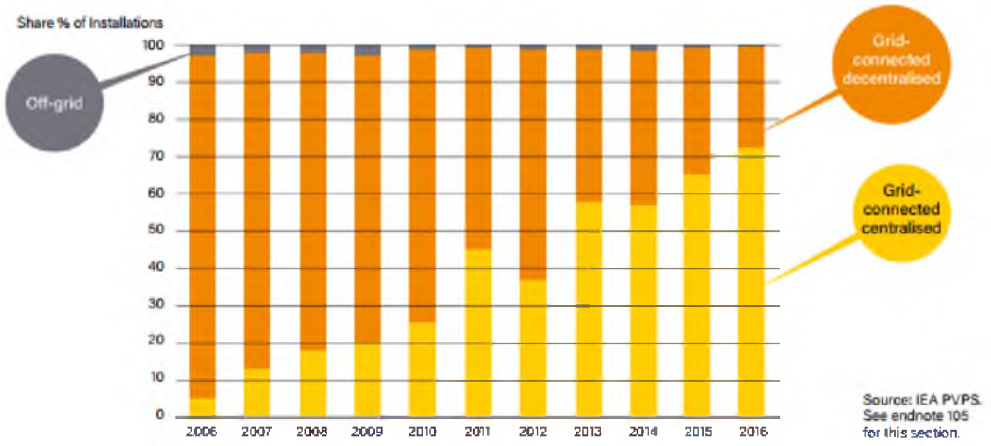

Figure 1.2 Solar PV-Off Grid and Grid connected (2006-2016) [1]

The enhancement of PV installation is due to the technologies advancement in manufacturing and also the design of the system. The technology of the PV is small; installation is much easier, less maintenance and most important there is no mechanical

part. Based on the REN 21 report it shows that there will be more PV implementation in the world.

Power system stability is main aspect of power system network. Stability can be under steady state and transient stability condition. Steady state is used to determine the upper limit before the system losing synchronism. Transient stability is referring to the sudden disturbance which will make system fall out if the disturbance is too large for the system. It normally happen around one second in order for the generator to close the disturbance

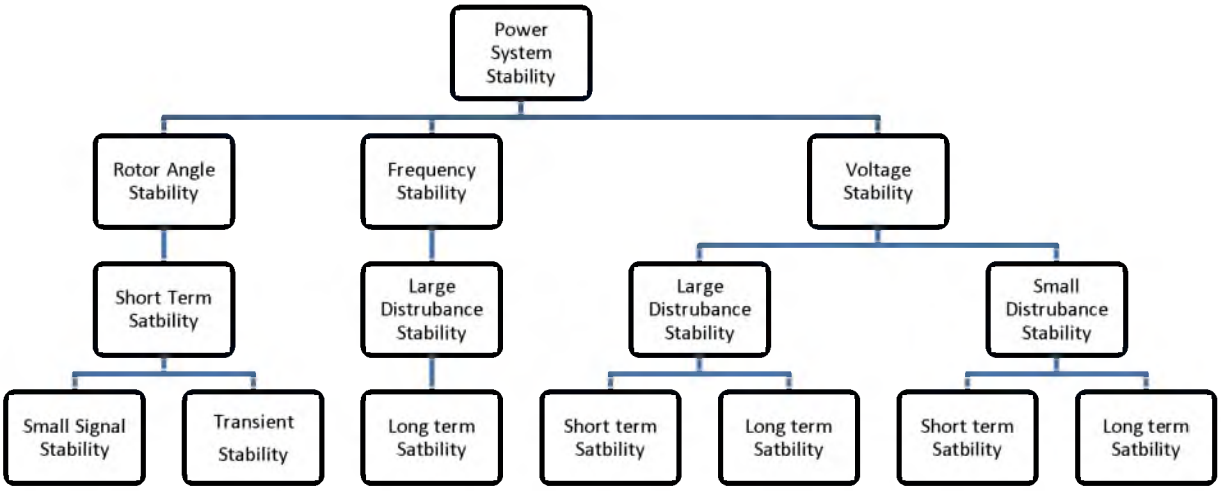

Figure 1.3 Power System Stability Network [2]

Power system stability is depending on the generation of the real (P) and reactive (Q) power to meet the demand. High PV generation connected to grid will cause margin of stability of the voltage been increased which might cause voltage collapse situation. Location of PV generation also will have impact on the transient stability of the system.

High PV penetration which consists of low voltage will have capability have negative affects in the transient stability.

PV penetration also will contribute to the voltage instability due to the solar radiation, inverter dynamic behaviour and also the step-up transformer. This is happen since PV is only adding the active power to the system and mostly the re-active power is been supported by the generator. This situation will cause reverse power flow situation which lead to the dynamic voltage instability. All the affect is due to the PV parameter cohere the PV is depending on the radiation and also temperature. Thus, PV power output will be intermittent and will have issue with voltage especially when it is been connected to grid. Furthermore the power system grid normally had been design for top down flow of energy. The reverse flow of energy in the system due to PV can give a problem in the power system stability.

This project will focus on the stability problem cause by PV that connected to the grid. The analysis will consider the rotor angle analysis and the bus system voltages. The simulation will evaluate condition on steady state and transient state in terms of stability. For steady state, the bus system will have a generator for initial review and then the source will be change from generator to PV generator. For transient state, the system will be compare with generator as a source and combined generator.

1.2 Problem Statement

Voltage is the main aspect in power system stability which it need to be maintain in acceptable voltage range in all bus system during steady state or transient condition.

Instability voltage performance due to uncontrolled disturbance will make the system have a large voltage drops. This situation is due to the system that cannot provide the reactive power.

PV is depending on the climate and this make the input from PV generator will varies accordingly to the climate. This lead to several issues such as voltage regulation, deviation of frequency and islanded grid protection when the PV is connected to the grid.

Furthermore depending on the PV penetration level, part of the power PV generation will be transfer to the other loads which will have modified the amount of power that been supplied. The distribution of the power is limited by the rating of the transmission line and component of transmission which include the transformer. With large penetration level of PV, the system reactive power will be limited and give an impact to bus voltage when disturbances occur. Furthermore, the penetration of PV will also contribute to the rotor angle performance and indirectly give impact to the system stability.

1.3 Objectives of the Study

This study is aim to:

i. Review the different between PV as a sole source compared to the generator

in steady state and transient condition in terms of the bus system and rotor angle for slack bus

ii. Analyze the impact of the PV penetration to grid on transient stability of the bus system for the combined generator and also the rotor angle when fault been trigger in Bus 7

iii. Compare the simulation results based on the scenario that have been chosen

1.4 Scope of the Study

Two conditions of network are considered in this study which is with and without PV connection. The system without connection will become base case. This study will do the comparison of:

i. Case 1: Generator as only source for the test system in steady state and fault condition applied to one of the system bus.
ii. Case 2: PV as sole source for the test system except for slack bus in steady state.
iii. Case 3: PV and Generator as source except for slack bus with different PV penetration in fault condition applied to one of the system bus

The simulation analyse voltage profile of the generator output and bus output when the source had been set as generator and combined PV and generator. Transient stability of the system when there is fault will also been introduced in the analysis and the results in terms of buses voltage and rotor angle for generator source and PV will be discussed in detail

1.5 Significance of the Study

This study will gave the overview of the impact on the bus voltage and rotor angle when PV penetration is beyond the limit system can absorbed during transient or steady state analysis. The comparison between PV installation in the test system versus the conventional generator can give an indicator how the performance of high penetration PV in the network.

1.6 Report Organization

The study is been structured into five (5) chapters. The chapters as below:

i. Chapter 1: Will have the background, problem statement, objective, scope and significant of the study

ii. Chapter 2: Consists of the literature review of the topic and it also will be used as a reference in expected outcome and understand the concept when PV been connected to a grid

iii. Chapter 3: Explanation the method, simulation approach and the data that been used for the study including the software that been used to perform the study

iv. Chapter 4: Simulation results on each of the scenario that has been selected. PV versus conventional generator in steady state been reviewed in terms of voltage. Impacts of PV penetration and comparison between steady state and transient for combined generator been reviewed. Simulation results on the scenario are discuss

v. Chapter 5: Conclusion on the analysis and future work that can be carried out for extended study

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