Experiment on Power Quality of PV-grid System at FKEE UMP

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Abstract— **This paper presents experiments of PV-grid system operation for a day light consisting of Photovoltaic (PV) – Inverter system as the renewable source connected to a network of induction motor as the load. A small-scale laboratory consists of Photovoltaic, Inverter, and loads system was setup. One power supplies from PV and grid were connected to single phase induction motors. In the experiment, both energy supplies from the grid and photovoltaic system were connected to the loads. Measurements have been done at both side of power transformer to analyze power quality in the system.**

Keywords— **Grid-connected PV, Power quality.**

1. Introduction

Renewable energy is no longer just an option nowadays. The renewable energy plays an important role in our live due to rise demand for electrical power. Photovoltaic is one of the renewable energy that has been used for about decade ago. The word "photovoltaic," first used in about 1890, is a combination of the Greek word for light and the name of the physicist and electricity pioneer Allesandro Volta. So, "photovoltaic" can be translated literally as "light-electricity." Photovoltaic or known as solar energy is a renewable resource that is vast and is locally available. It is a clean energy source that allows for local energy independence. The sun's energy flow reaching the earth is typically about 1,000 Watts per square meter (W/m2), although ease of use varies with location and time of year. Simple PV systems provide power for many small consumer items, such as calculators and wristwatches. More complicated systems provide power for communications satellites, water pumps, and the lights, appliances, and machines in some people's homes and workplaces. Many road and traffic signs along highways are now powered by PV. In many cases, PV power is the least expensive form of electricity for performing these tasks [1].

Photovoltaic produce DC voltage to the load. The voltage can be converting to AC by using DC-AC converter which is commonly known as inverter. The inverter conversion process with power electronics is generally known as the switched-mode inversion. One major application of switched-mode is Adjustable Speed Drive (ASD). Adjustable Speed Drives (ASDs) are power electronic circuits used to control the speed of motors. In practice, many ASDs are connected together to form a network of adjustable speed drives to control the speed of motors in manufacturing lines, buildings (for HVACs), agricultural sectors (for irrigation pumps), and house-hold applications (such as those found in energy-saving washers and dryers). Today, 55% of the total electrical power in the US is consumed by the motor drives industry. Due to the advent in power electronics, adjustable speed drives employing solid-state switches have become popular in motor applications due to the significant energy saving that they offer. It has been estimated that the widespread use of adjustable speed drives causes as much as 20% reduction in energy consumption. This is equivalent to the total electric energy produced by about 162 power plants.

So, in this project, PV system and ASD will be used and connected to each other to see how it can save the energy usage and although to see their efficiency. Further, the results of this project, henceforth, will be useful in developing a smart or innovative load management PV-inverter-ASD system that ensures maximum system efficiency at any given time. This, in turn, will result in significant energy savings, suppression of operating cost, and provision of efficient planning tool for future expansion of PV system as the alternate source of energy.

Power quality is an aspect of power engineering that has been with us since the inception of power systems. However, topics in power quality have risen to the forefront since the advent of high power semiconductor switches and networking of transmission and sub-transmission systems. Also, the trends in modern power engineering have been extracting the most from the existing installed system, and this has placed stress on issues of sinusoidal waveform fidelity, absence of high and low voltage conditions, and other ac waveform distortion.

It is estimated that industrial and digital economy companies collectively lose $45.7 billion a year to outages and another $6.7 billion each year to power quality phenomena [1]. Harmonic distortion is the most common power quality problem and it is found in both the voltage and the current waveform [2]. Current harmonic cause increased loses to customer and utility power system, they produce poor power factor, distorted voltage waveform (causing voltage harmonics)

and they could produce dangerous resonant oscillations in the utility power supply.

Previous studies have shown that the drive load factor and the system impedance at the drive are the two factors impacting the input harmonic distortions in ASD. The current harmonic distortion and lower order harmonic currents in percent of the fundamental vary significantly with the drive load factors. However, the higher order harmonic currents above the 17th do not change much with the drive loading and system impedance [3]. Harmonic currents in Amps will increases with the increase of drive load factors.

One common application for ASD is for variable torque loads under different loading conditions. With multiple drives and multiple motors operating in the system, the harmonics created from various loads could crosstalk and could further positively or negatively affect the magnitude of distortion. However, little has been known about the harmonic interaction between these drives on a single point of common coupling (PCC). There has been a few of attempts done in the past to investigate harmonic distortions. As an example, previous research has been done for a single drive with two induction motors connected to the drive [4]. Besides that, there were also experiments for network of two drive system and two motors connected to each drive [5], network that contain different types of ASD with one motor connected to each drive [6], and system with mixture of ASD and loads connected together at PCC [7].

In this paper, an experiment on power quality will be analysis of a network of one motor connected to PV and grid system. System impedance at the drive input is considered to be constant and the input harmonic distortions are determined by drive load factors only. Experimental results from this research will be important to further understand the interaction and hence reveal how the drives interact with each other.

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2. Experiment Setup and Procedure

The diagram in Figure 1 shows that operation of the system for a day light start from morning till evening. This experiment starts at 11 am and end at 6 pm. In this experiment, both supply which is supply from PV and grid was used. PV array 1.5 kW was used and motor 0.7 hp used as load and this motor was setup at 1500rmp. The measurement was recorded at the measurement points which shown in Figure 1. Data Total Harmonic Distortion(THD) for voltage and current was measure by using fluke power quality analyser. In PV supply side, the measurement point is situated between inverter and switch box. Meanwhile, in Grid supply side, the measurement point is situated between main supply and switch box. The points were view in Figure 1:

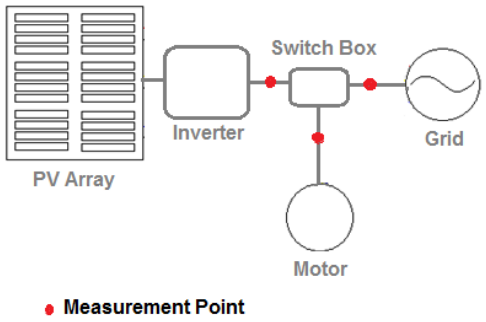

Fig. 1 Measurement point in diagram system

3. Results and Discussion

The Graphs in Figure 2, Figure 3 below show the result of experiment that was conducted at room temperature.

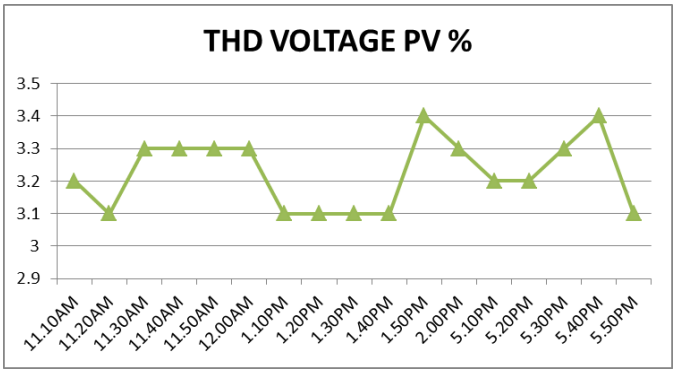

Figure. 2 Total Harmonic Distortion(THDv) at PV side

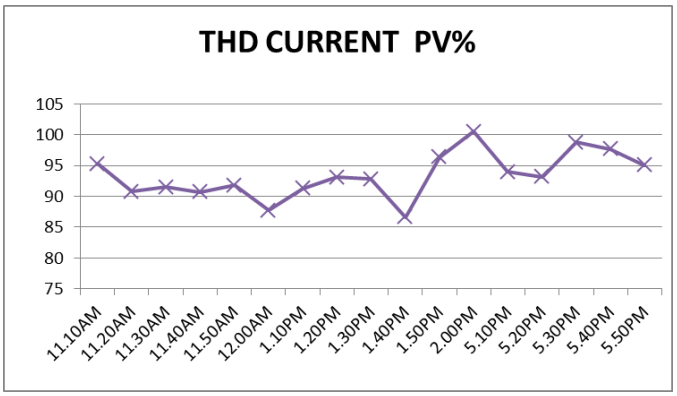

Figure. 3 Total Harmonic Distortion(THDi) at PV side

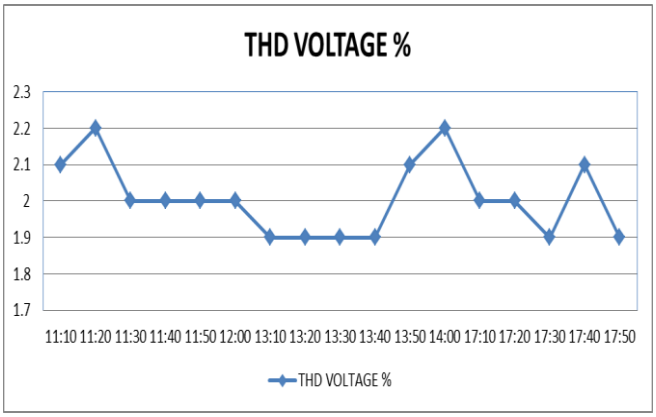

Figure. 4 Total Harmonic Distortion(THDv) at Grid side

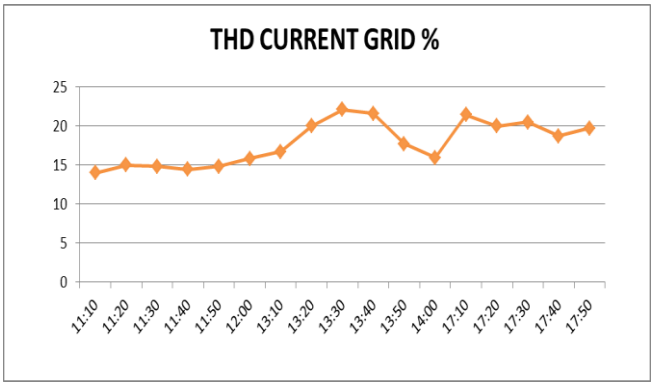

Figure. 5 Total Harmonic Distortion(THDi) at Grid side

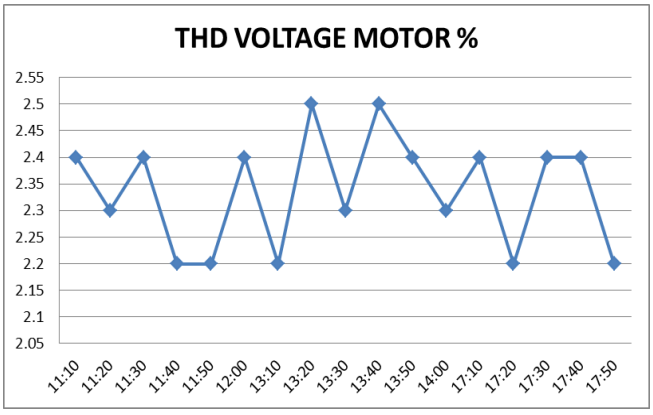

Figure. 6 Total Harmonic Distortion(THDv) at Motor side

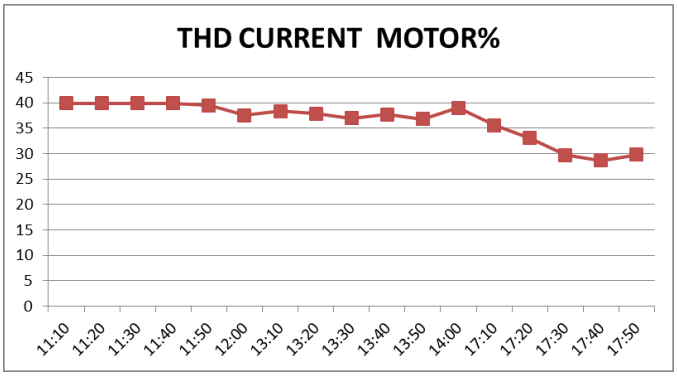

Figure. 7 Total Harmonic Distortion(THDi) at Motor side

The graph in Figure 2 to Figure 7 above shows the characteristic of Total Harmonic Distortion(THD) for this experiment. This graph is the function of Total Harmonic Distortion(THD) in percentage versus time. The measurement was conducted for 7 hours started from 11 am till 6.00 pm on 10/3/2012.

Analysis of Voltage Distortion

In this experiment, THDv for PV-Grid Connected with motor as a load is shown in graphs as in figure 2, 4, and 6. In general, for measurements at each measurement point show all result not more 4%. THDv for PV system is high compare to THDv grid and THDv motor. This is because by power electronics equipment which generates more harmonic distortion. The equipment such as inverter will produce harmonic distortion to the system.

Analysis of Current Distortion

The analysis of current distortion is important, especially since the power quality issues relating to harmonic distortion of the current waveform are the responsibility of the customer compared to voltage distortion in which much of the responsibility of maintaining a clean voltage waveform lies on the utility [3]. For analysis of the current distortion, the THDi for grid connection is shown in graphs as in figure 3, 5 and 7. In general, THDi PV is higher compare to THDi Grid and THDi Motor. This scenario happens because of power electronic equipment at PV which produce more harmonic compare to grid and motor.

4. Conclusion

In this paper, an efficiency analysis of PV-inverter system connected to a motor as a load has been presented. As results, the optimum operating condition based on the worst and best case operating scenarios has been obtained. The analysis of the data shows trends in the harmonics behavior in the system which connected to induction motors and can be used to analyze power quality impact to the grid system. Additionally, this research can be used to reduce the higher total harmonic

distortion in power system with a network of adjustable speed drives based on worst case operating scenarios.

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