Power Quality Analysis for PV Grid Connected System Using PSCAD/EMTDC

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Abstract- Power quality is the main concern in power distribution systems. Poor power quality could cause disturbance and financial losses to consumers. It may also cause electrical appliances to overheat, damage and operate in undesired regions. Other than that, power distribution components such as transformers could also experience core saturation and overheating to the winding. This paper investigates potential power quality issues in a photovoltaic-grid connected power system. A real-life power distribution system is first modelled in PSCAD and it is then integrated with a photovoltaic system to form a micro-grid power system. Several case studies are conducted to identify any potential power quality issues with the micro-grid power system. The simulation results shows that the micro-grid power system experiences various power quality issues, such as inrush current, power fluctuation, frequency fluctuation, harmonic distortion and low power factor.

Keywords: Photovoltaic, Power Quality, Total Harmonic Distortions, Grid

1. Introduction

Micro-grid power system is sourced by distributed generation (DG) where electric power is supplied to local loads and it could be isolated from a traditional grid system. DG has the benefits of reducing transmission cost, less capital investment, reduced line loss and increased reliability of the grid [1]. DG that uses renewable energy to generate electricity is classified as Distributed Energy Resources (DER). Solar Photovoltaic (PV) is one of the DER technologies with the most potential as it solely requires sunlight to generate electric power, where this source is free and clean. However, with the increase usage of the DER, the centralized power plant might need to increase the reserve power for the grid to prevent power outage issues. Besides, the growth of PV penetration might create power quality issues to the system [1].

In power distribution systems, power quality is the most important element. It is defined as the ability of the utility to supply a noise-free and stable power to the consumers. Poor power quality would cause damage to electrical appliances and power distribution component as frequency fluctuations would cause operation in undesired regions. To generate more power, it is unavoidable to have higher penetration of DER. However, this also means an imbalance between electric power and load could occur anytime [2]. As a result, frequency could vary largely and cause overheating to the motor and transformer.

United States, Europe, Canada and Japan built test sites for micro-grid experimental purpose. Consortium for Electric Reliability Technology Solutions (CERTS) from United States developed a micro-grid test-bed in Columbus, Ohio. Main objective was to analyse the effects of high penetration of DER with appropriate control and protection. Different topologies of micro-grid experiments were carried out by the European Union. The power quality issues that occur during the interface of micro-grid with the grid were their main concerns. BC Hydro and Hydro Quebec, the utilities companies in Canada were focusing on the possibility of intentional islanding for micro-grid. The aim of the experiment was to enhance the distribution system reliability on rural feeders [3] [4].

Other than hardware facilities, simulation software has been used to analyse the power quality issues in micro-grid system. A group of researchers used PSCAD simulation software to model a micro-grid for the Jeju Island, Korea. In that project, three distributed generations were used to identify the possible power quality that might occur due to high penetration of DGs [5]. Beside Korea, China had done many researches on simulation for islanding purpose of micro-grid [6].

In [12], researcher designs a PV grid-tied system to monitor the effect of irradiance to the total harmonic distortion of voltage and current. Result from the designed PV system shows voltage and current at the point of common coupling have total harmonic distortion issue. However, since designed PV grid-tied system does not have load, power quality events from consumer or load are unable to be reflected on the system.

The present paper aims to model a real-life modern university power distribution system and a photovoltaic system by using PSCAD simulation software. After that, both systems are integrated to form a real-life micro-grid power system. The aims of this paper are twofold: 1) to investigate the power quality of the designed micro-grid power system under Malaysia weather conditions by using real-life temperatures and solar irradiation data, and 2) to investigate the effects of high PV penetration to power quality in the micro-grid power system.

In this paper, chapter 2 describes the fundamental components of the solar photovoltaic system with detail descriptions for the chosen parameters. Chapter 3 shows the designed photovoltaic system with controller units in PSCAD. Chapter 4 displays the result of the photovoltaic system which being tested under various conditions. Finally, chapter 5 concludes the paper.

2. Solar Photovoltaic System Model

The designed PV system in this paper is improved on Kalbat's PV system [12]. Connection of the electrical devices in the developed PV system can be seen from figure 1. A capacitor is connected in between the maximum power point tracker and photovoltaic array. It is used as an energy buffer for the transient. To fully utilise the photovoltaic energy and connect to the grid, it has to be connected with other electrical devices such as DC-DC converter, DC-AC inverter, filter and transformer. The following sections describe the details on these devices.

2.1 Photovoltaic (PV) Array

The fundamental unit of a PV array is the PV cell. By connecting many PV cells in series-parallel manner, a PV module can be formed. A PV module provides more power than the PV cell. In this paper, 108 (series) by 4 (parallel) configuration for the PV module is used. Figure 2 shows the power generated by a single PV module in PSCAD. Other than the PV configuration, parameters such as the series resistance, shunt resistance, ideality factor and band gap energy are needed to be set correctly. These parameters are set to moderate levels as shown in Figure 3.

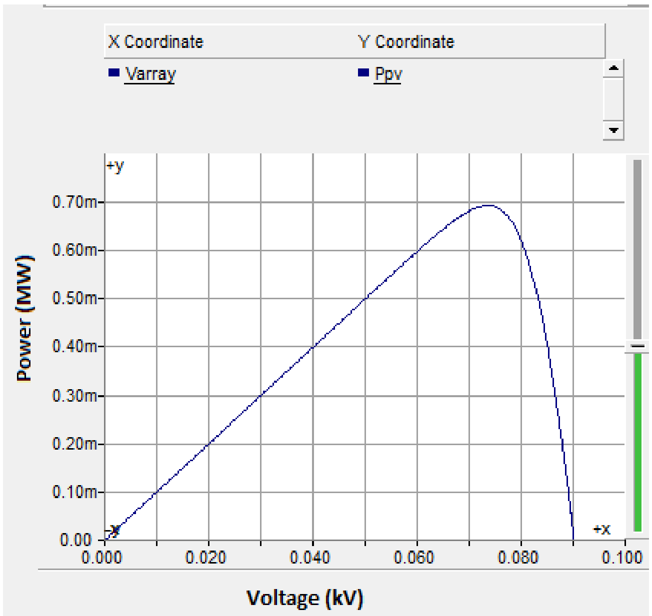

Fig. 2. Power versus Voltage Graph for Single PV Module

General	
PV array name (optional)	PVarray1
Number of modules connected in series per array	20
Number of module strings in parallel per array	20
Number of cells connected in series per module	108
Number of cell strings in parallel per module	4
Reference irradiation	1000 [W/m^2]
Reference cell temperature	25 [oC]
Effective area per cell	0.01 [m^2]
Series resistance per cell	0.02 [ohm]
Shunt resistance per cell	1000 [ohm]
Diode ideality factor	1.5
Band gap energy	1.103 [eV]
Saturation current at reference conditions per cell	1e-12[kA]
Short circuit current at reference conditions per cell	0.0025[kA]
Temperature coefficient of photo current	0.001 [A/K]

Fig. 3. PV Array Configuration

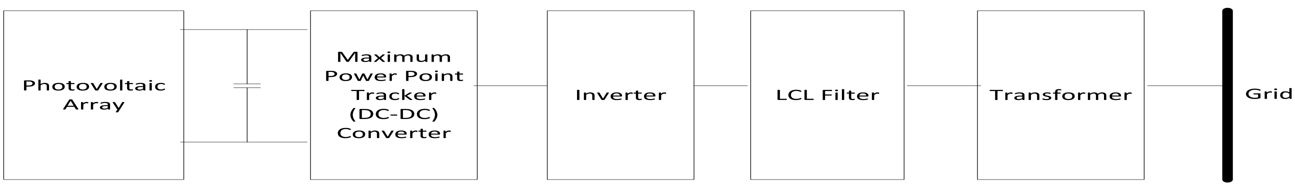

Fig. 1. PV System

As shown in Figure 2, the power generated by a single module is about 700W which is insufficient to aid the grid. A combination of PV modules can solve this issue. By increasing the number of cells connected in series, the voltage increases. On the other hand, by increasing the number of cells connected in parallel, the current increases. It is important to know that both methods do provide the same amount of maximum power. However the maximum power point voltage ($Vmpp$) will vary according to the PV array configuration. PV array is configured in 20-by-20 to provide 270kW power during the standard test conditions (STC). This configuration is made to ensure the PV system able to aid the grid in a detectable manner.

2.2 DC Link Capacitor

DC link capacitor is an important component to reduce output power ripple. Capacitance's equation of the DC link capacitor is available in [7]. To consider the worst scenario occurs during STC, the minimum capacitance value has to be 0.5mF. Hence, the DC link capacitor is set to be $1.25mF$ to minimise the ripple output power.

2.3 Maximum Power Point Tracker (MPPT)

MPPT is used to force the PV array to operate to the maximum power point. A DC-DC converter is used to vary the voltage level to the knee point to drive the PV array to work at the optimum point. The available DC-DC converters are buck converter, boost converter and buck-boost converter. A buck converter is used in the PV system. Figure 4 shows the buck converter that is used in the simulation. An IGBT is chosen as the switch for the buck converter because of its lower on-state voltage and switching loss as compared to the MOSFET.

Among MPPT techniques, Perturb & Observe (P&O), and Incremental Conductance (InC) are techniques that being researched and used mostly. These two techniques are the only available techniques in PSCAD software. The reason of InC technique is chosen because P&O technique can be failed under rapid changing atmospheric condition [11].

2.4 MPPT Controller

Figure 5 shows the configuration of the MPPT. The difference between the instantaneous maximum power point voltage (V_{i-mpp}) and the instantaneous voltage of PV array (V_{ins}) is fed to a PI controller. The output of the PI controller will be compared with a high frequency saw tooth waveform to generate a high frequency duty cycle. The frequency is set as $1kHz$. The effect of using a lower switching frequency is that the converting process will be slower and the component value has to be larger. The V_{i-mpp} is used as a reference to force the PV array to operate at its voltage by changing the duty cycle. Figure 6 shows the controller of the MPPT.

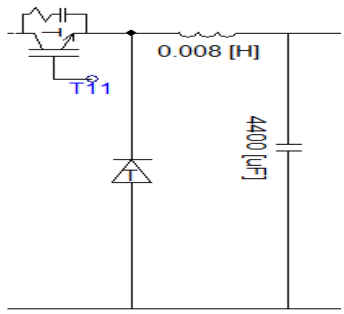

Fig. 4. Buck Converter Schematic

General	
PV Array Short Circuit Current	0.2 [kA]
PV Array Open Circuit Voltage	1.8 [kV]
Sampling Interval	0.1 [s]
Initial Value of Vmpp	1.5 [kV]
Tracking Algorithm	Incremental Conductance

Fig. 5. Configuration of MPPT

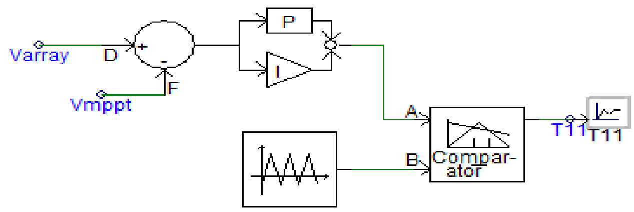

Fig. 6. MPPT Controller

2.5 Inverter

Three phase inverter is chosen as the inverter for the PV system. To construct a three phase inverter, three pairs of power electronic switches are used. A snubber circuit is given to both the diode and switch to protect these devices from damage [8]. The switch will be turned on while the controller assigns an on-state to a particular switch. The modulation index is varied in between 0 to 1 to avoid over-modulation or under-modulation. To model a three phase inverter in PSCAD, three sine wave generators and three triangular waveform generators are required to compare with each other to determine the on-off state of the switches.

Sine wave generator is available in PSCAD. The amplitude, frequency and phase angle are manipulated to suit the user's requirements. The frequency and phase angle of the sine wave generators are set to 50 Hz and 120° apart from each other. The amplitude and the phase of the inverter will be described later in the control unit because the modulation index and the phase angle have to be varied in real-time situation in order to have the optimum effect. The frequency and amplitude of the triangular waveform is set to be 5kHz and 1kHz, respectively. The sine waveform is used to assign an on-state signal to the switch. A NOT gate is used to change the state of the signal. Signal generator for the inverter is shown in Figure 7.

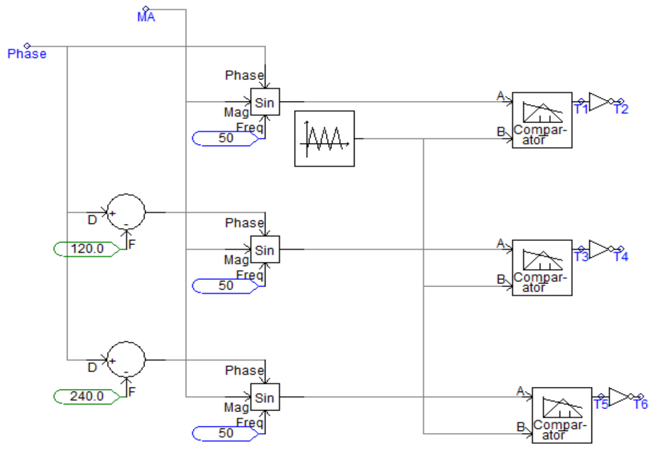

Fig. 7. Signal generator for the inverter

2.6 Filter

A third order LCL filter is designed according to [14]. It is used to remove the high order harmonic and also comply with the IEEE 519-1992 standard (PV grid-tied system can have a total harmonic distortion of less than 5% for current and 3% for the voltage). The capacitor is used to confine the variation of maximum power factor within 5%. By considering the worst scenario which occurs during STC, the maximum filter capacitance is calculated as $120\mu F$; therefore, $60\mu F$ is reserved to have a range for adjustments. The inverter's and grid's inductance are calculated as $1.361mH$ and $0.1mH$, respectively. The resistance of the suppress resistance is 0.415Ω. With these values, the resonant frequency is found on 2.128 kHz.

2.7 Transformer

A transformer is used in the PV system to step-up the filtered voltage to 11kV. The turns ratio, winding type for primary and secondary sides and power rating have to be determined. The power rating of the transformer is designed according to the capacity of generated power from the PV array which has a peak generation of 0.27 MW. Taken the reactive power generation and absorption into account, 0.5MVA rating is selected for the transformer.

Among the winding connection types, delta-wye is chosen for the transformer, where the lower voltage from the inverter connects to the delta and the wye side connected to the grid [9]. Besides, the wye side of transformer can be grounded to reduce the insulation requirements to the high voltage side [9]. In addition, the delta-wye configuration eliminates the third order harmonic effectively. This is because the zero sequence current, which cause triple harmonic is trapped in the delta connection of the transformer. In order to control the inverter, the primary winding of the transformer has to be chosen as the modulation index operates in between 0 to 1. From STC, the PV array operates at $1.5kV$ due to the MPPT effect. The primary side voltage winding is designed as 600V. Therefore, the modulation index of the inverter under normal operation is 0.653.

3. Complete System and Control Unit

PI controller is being used frequently in this paper. It is because the cheap and robust function of the PI controller. If output of controller does not match with desired value, it will tune the controller to output a chosen value. In addition, advanced control technique is not being used because actual performance of a PV grid-tied system is the concern of this paper.

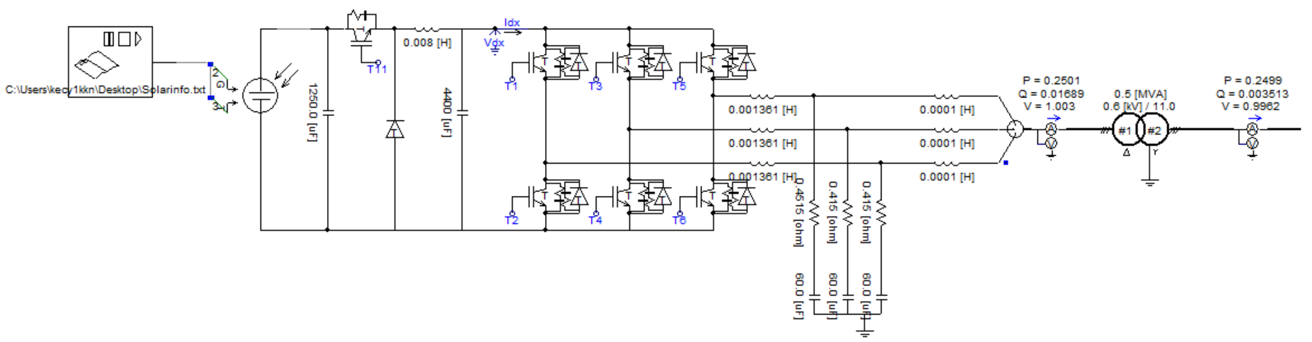

Fig. 8. Complete modelled PV System

Real and reactive power of PV system is being controlled by power flow equation of a two port network as in Eq.2 and 3 respectively.

$$P_{12} = \frac{V_1 V_2}{X_{12}} \sin\theta \quad (2)$$

$$Q_{12} = \frac{V_1 V_2}{X_{12}} \cos\theta - \frac{V_2^2}{X_{12}} \quad (3)$$

Where P_{12} and Q_{12} are real power and reactive power flowing from PV system to grid. X_{12} is equivalent system impedance between two voltage and theta is phase difference between PV output voltage and grid voltage.

Analysing the variables in (2), the system impedance is a fixed parameter, V_1 is slightly variable, and V_2 is usually fixed at its nominal value. The last variable parameter, phase difference is known as power angle, will use to control the output power of the PV system. Since the grid's phase angle is a constant quantity that controlling the power angle; therefore, by manipulating the PWM phase angle will able to control the power delivered from the PV system.

It is important to know that, if the power angle is greater than the generated power, the DC bus voltage would collapse due to the PV array is not working on the operating curve. However, if it is too low, the system is working in inefficient mode because it is not operating on the MPP. To solve this problem, the difference between the RMS line to line voltage of the inverter and the DC bus voltage is fed into a proportional integral (PI) controller to generate the phase angle of the inverter.

In order to maintain the inverter's output voltage, the nominal 11kV, grid's voltage is used to subtract the inverter's output voltage. The difference will be used as the input of a PI controller, and output the amplitude of the SPWM inverter. By modulating the modulation index, the output voltage of the inverter will be under controlled.

The PV grid-tied system is derived and controlled by the sinusoidal pulse width modulation (SPWM) inverter control, second stage MPPT algorithm and basic power flow equations. With these control units, the system would be able to operate under an ideal environment. The complete modelled PV system in PSCAD is shown in Figure 8.

4. Results and Discussion

To demonstrate the power quality issues that occur in the PV grid-tied system, several test cases such as the steady-state environment, transient operation, islanding and load-changing environment are developed in the PSCAD. With these test cases, the potential power quality issues will be identified. Point of Common Coupling (PCC) is being used in this section to determine the injected real and reactive power, voltage and harmonic content by the PV system. It is a point where the grid and the PV system connected and being used widely in the industry as a reference of connected point. Since high frequency is being used, the switching, time step and the plot step of the PSCAD have to be small to determine any small changes. However, if the time step and plot step are too small, it will cause the computer to run out of memory and terminate the simulation. In this paper, the time step and plot step is set to be 25µs and 50µs respectively.

4.1 Steady-State Analysis

This section tests the ability of the PV system to track the MPP, operate within the IEEE 519-1992 regulation and inject the appropriate power to the grid. To conduct the simulation for steady state analysis, the load is set to be 1MVA with power factor 0.8. The test conditions are listed in Table 2.

In this paper, inverter controller is being configured to output unity power factor. It is because unity power factor ease the process of islanding detection [13]. Figure 9 shows the inverter controller. The per unit system is implemented into the PV grid-tied system to ease the analysis process. Table 1 shows the per unit base value.

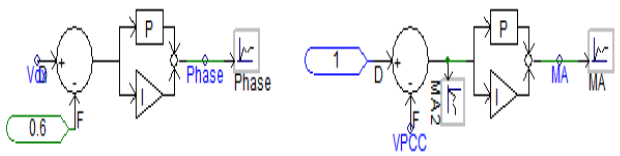

Fig. 9. Inverter Controller

Table 1. Per Unit Base Value

Base	PV System	Grid
Apparent Power, S	0.27 MVA	0.27 MVA
RMS Voltage, V	0.6 kV	11 kV
Current, I	259.8 A	14.17 A
Impedance, Z	1.33 Ω	448.15 Ω

Table 2. Environmental Input

Second	Irradiance (Wm^{-2})	Temperature (°C)
$0 < t < 3$	1000	25
$3 < t < 6$	800	30
$6 < t < 9$	600	50
$9 < t < 11$	400	40
$11 < t < 13$	200	50
$13 < t < 15$	1000	40

Figure 10 shows that the PV array slightly fluctuates at 1.5kV, which is the maximum power point voltage. Figure 11 shows the frequency at the PCC. It illustrates that the maximum variation of load is about 0.03%, which is within the confined limit. In addition, a drastic change in the environment will cause a spike to the frequency as shown in figure 11. Figure 12 and 13 illustrate the PV system and grid real and reactive power, respectively. From the figures, the PV system effectively injects maximum available power to the grid. Besides, the control units of inverter modulate the inverter according to the environment changes. While the PV system injects inadequate power to the load, the grid takes the responsibility to supply required power to the load as displayed in figure 12.

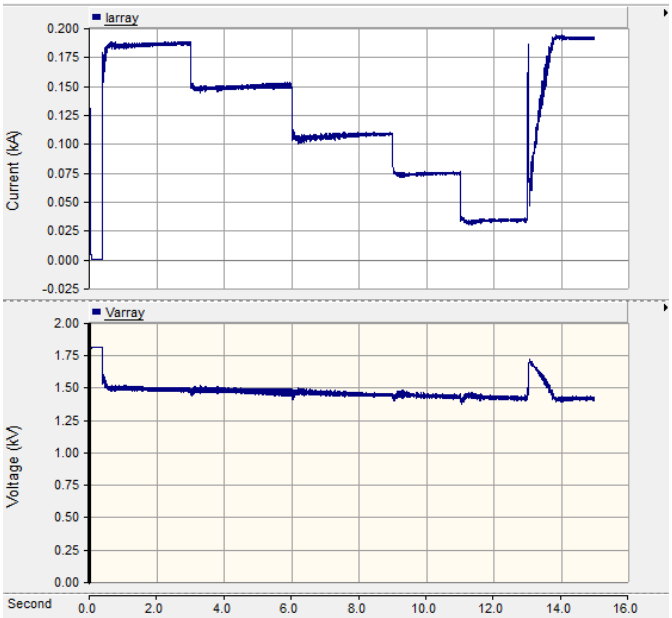

Fig. 10. PV Array's Current and Voltage

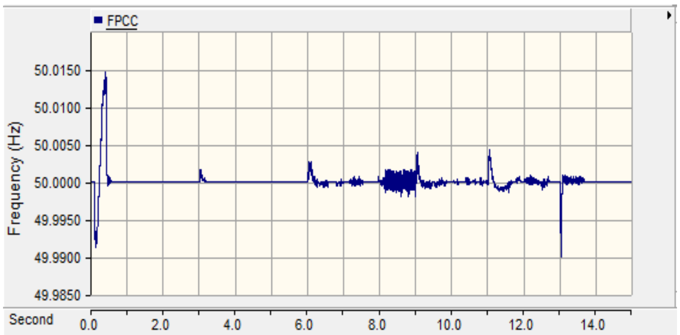

Fig. 11. Frequency of the PCC

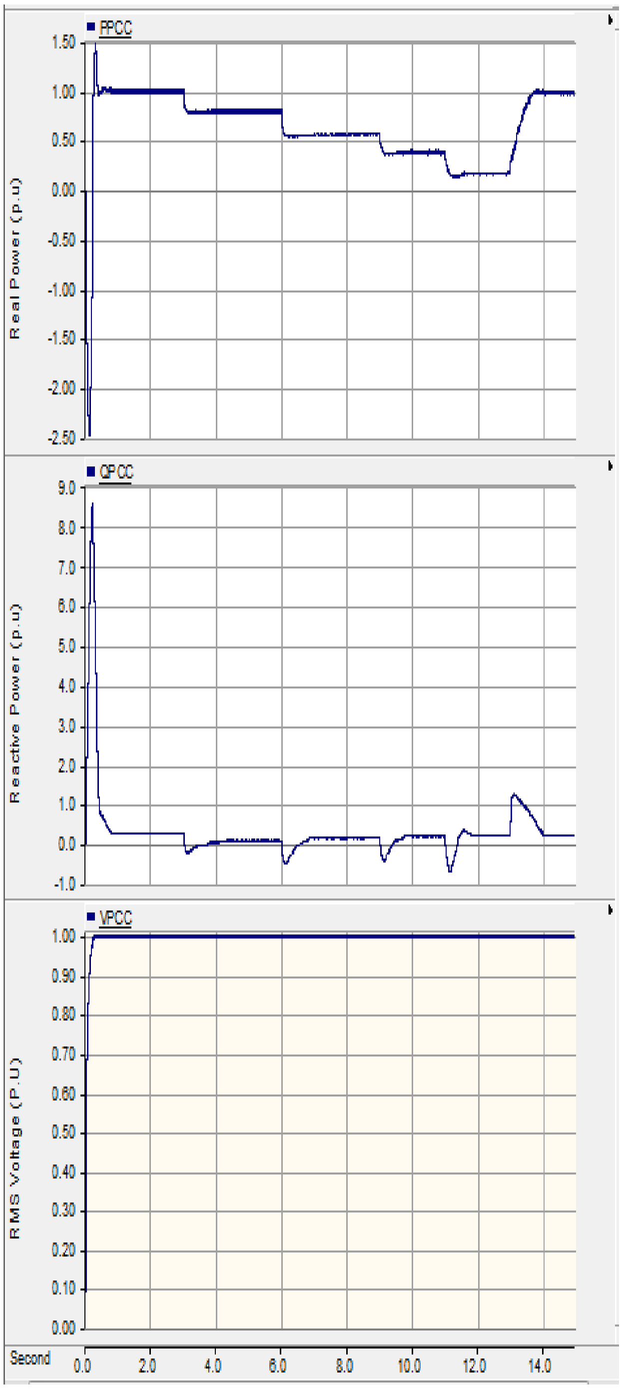

Fig. 12. Real and Reactive Power, RMS Voltage of PCC

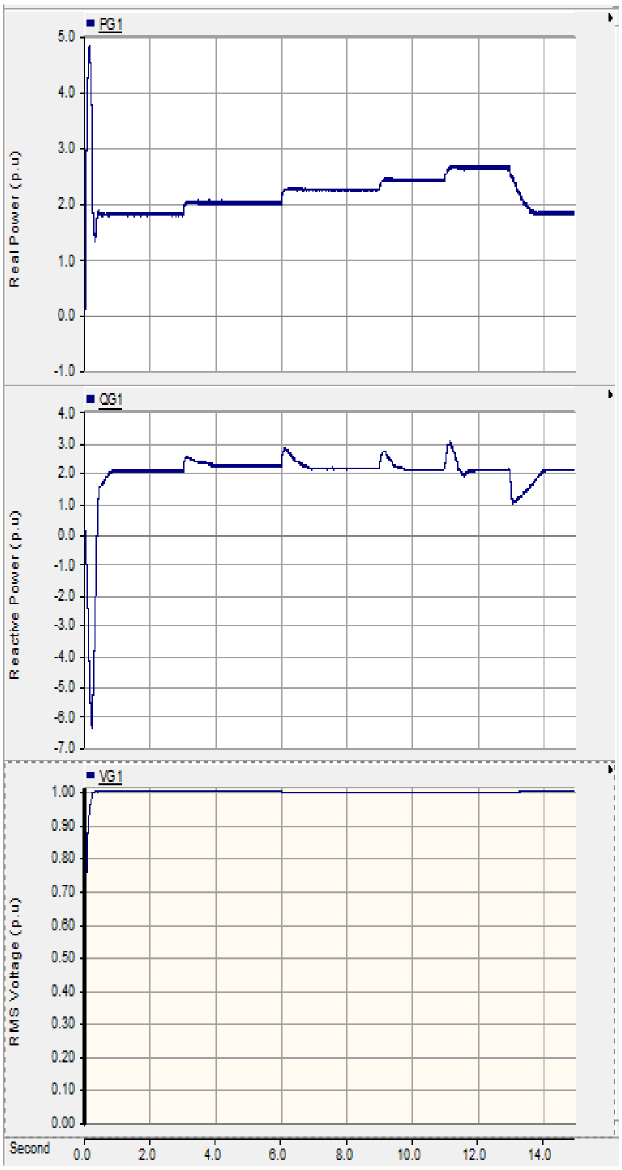

Fig. 13. Real and Reactive Power, RMS Voltage of Grid

Other than the normal operations, the harmonic distortion of voltage and current are also being investigated. Figure 14 and 15 show the total harmonic distortion for current and voltage, respectively. From the figures, the total harmonic distortion (THD) for voltage is maintained at a very low value, approximately 0.03%. However, the THD for current is approximately 8. Further analysis of the harmonic content of current and its frequency is illustrated in figure 15.

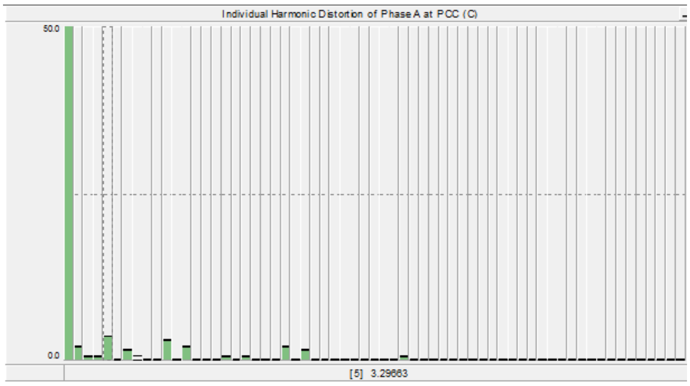

Fig. 15. Inverter Controller

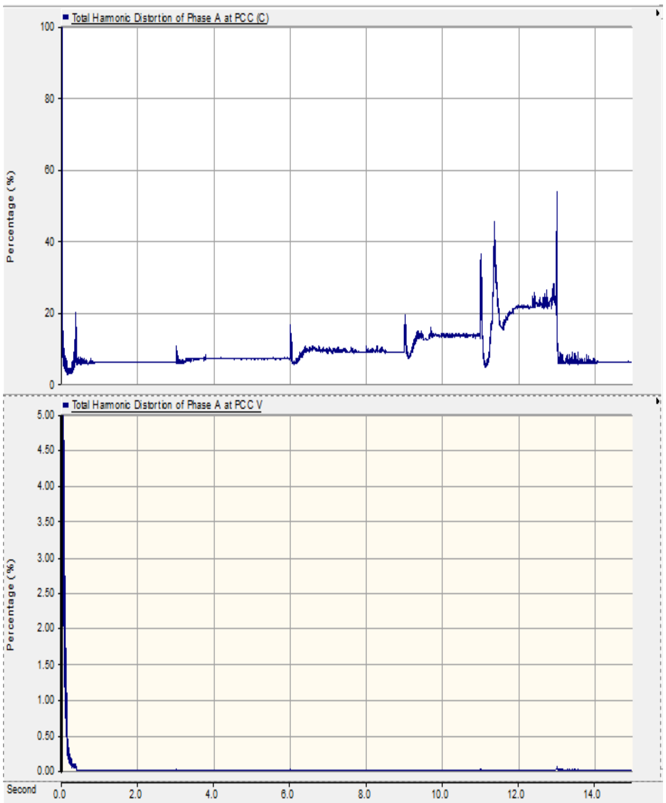

Fig. 14. THD for Current and Voltage

The unit that is being used in figure 15 is in percentage. According to the IEEE 519-1992 standards [10], the THD of the voltage is under the maximum limit (<3%) all the time. On the other hand, the current exceeds the maximum limit (5%). It is because other than the fundamental frequency, the other harmonic content value in current is high. Therefore if the PV system injects power to the grid, it will distort the load and grid current. It is believed that the LCL filter in the PV system is unable to suppress the low order harmonic content of current effectively.

4.2 Transient Analysis

In this section, the potential power quality issues of high penetration of PV system will be investigated. In order to identify the power quality issues, the modelled PV system is being tested under different environment situations and different penetration level.

For environment settings: 1) high and low irradiance, and 2) unexpected increase and decrease of irradiance as illustrated in figure 16 are tested. These environmental situations will be fed into the PV array. Three sets of PV systems are used to test the high penetration effect of PV system to the grid. Since the penetration effect is the aim of this experiment, 27%, 54% and 72% of PV penetration are used in the experiment. The PV systems are connected to the grid in 2 second in order to allow the grid to run smoothly. Figure 17 and 18 illustrate the RMS voltage of grid and the real and reactive power, and the RMS voltage of the PCC respectively (red, green and blue are displaying three PV systems, two PV systems and one PV system that is used in the experiment). Figure 19 and 20 show the power factor and instantaneous current of PCC respectively.

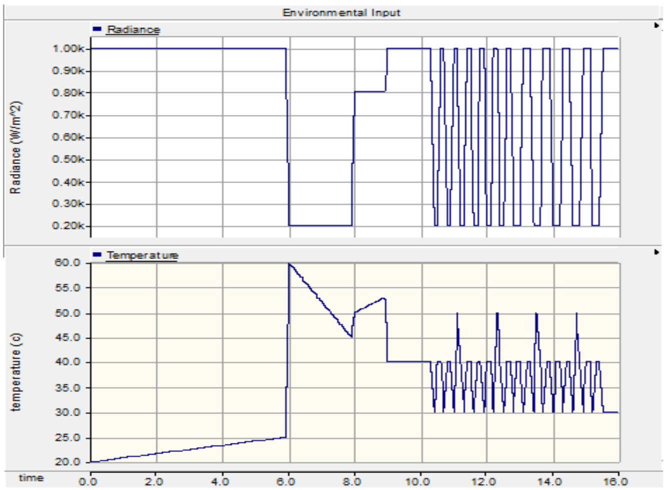

Fig. 16. Irradiance and Temperature

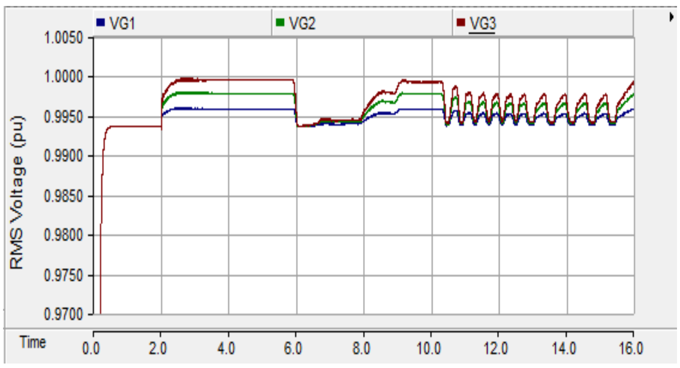

Fig. 17. RMS Voltage of Grid

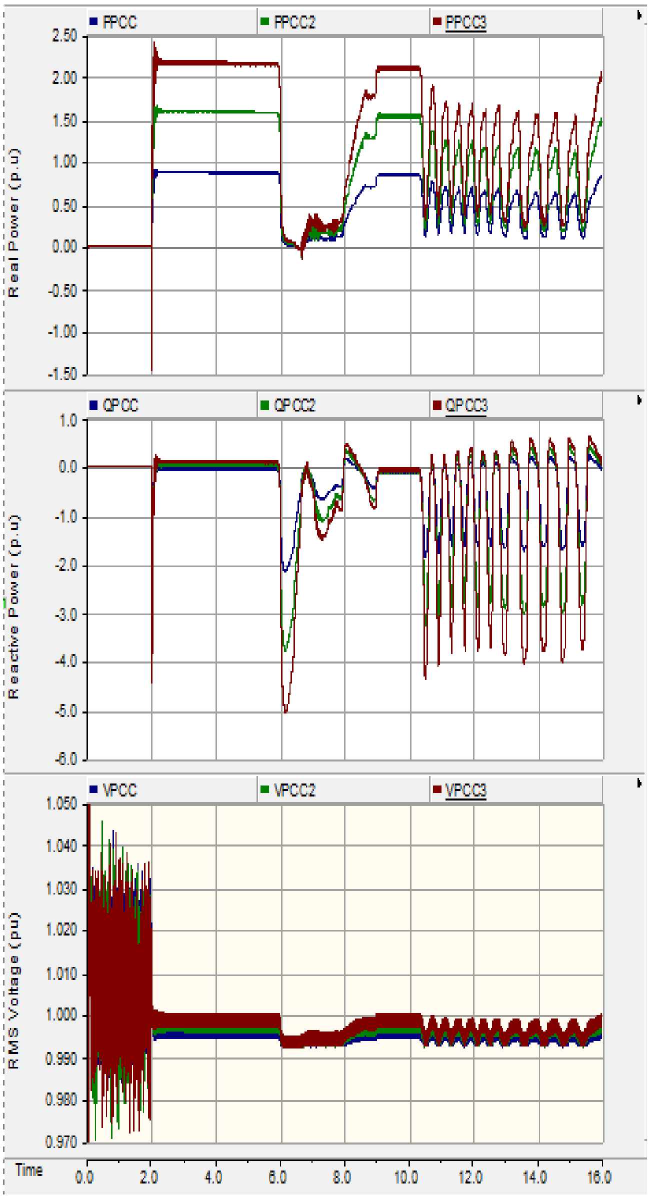

Fig. 18. Real and Reactive Power, RMS Voltage of PCC

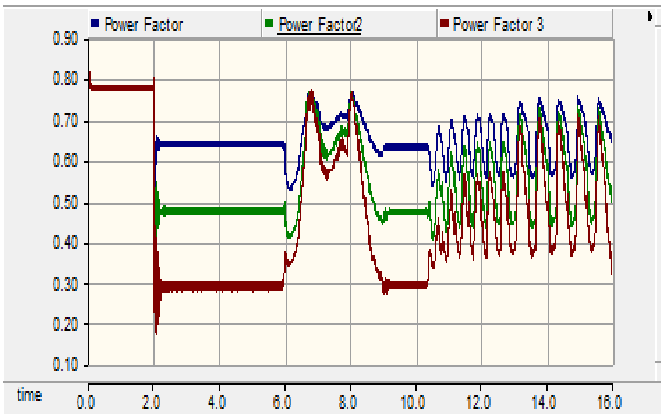

Fig. 19. Power Factor

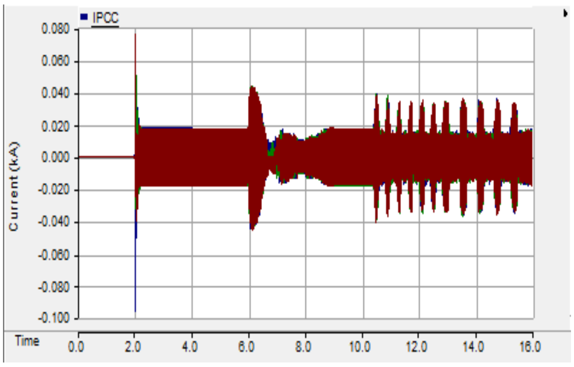

Fig. 20. Instantaneous Current of PCC

Penetration of the PV system is directly proportional to the output power is shown in figure 18. When the irradiance drops to $200Wm^{-2}$, the PV system active power drop to 0 and its reactive power is absorbing 5 p.u for the highest penetration. When the irradiance is having a sudden increase and decrease phenomenon, the output power fluctuates. This indicates a power quality issue where the higher the penetration the stronger the fluctuation. Besides, when the power fluctuates, the RMS voltage of the PCC slightly fluctuates as well. However, it is in an acceptable level.

With the penetration of PV system, the RMS voltage of the grid is slightly increased as shown in figure 17. Thus, with higher penetration level of the PV system, the grid might experience over-voltage. However, due to the controller has limited the RMS voltage in PCC, the controller mitigates the over-voltage issue. Not only the RMS voltage of the grid is affected by the penetration of PV system, the power factor is varied as well (as shown in figure 19). The penetration of the PV system causes the power factor to drop to a very low value as the PV system is running in unity power factor mode. This reduces the real power but maintains the reactive power from the grid. Even though the PV system is able to decrease the real power demand effectively, the apparent power does not decrease visibly. Consequently, it might cause the utility to have extra charge on the user due to low power factor.

Inrush current is another issue with the PV system as displayed in figure 20. While the PV system connects to the grid, the current is approximately four times to the usual value in transient and it is known as the inrush current. Without appropriate protection circuit, it could damage the electrical appliance with high current flow. Moreover, the sudden increase and decrease of irradiance double the current flow as well.

In this section, several power quality issues from PV system are investigated, which are, power fluctuation, over voltage, low power factor and inrush current. Either one of these power quality issues would be able to cause damage to electrical appliances from minor to severe effects. Among these issues, the over voltage and inrush current are the most severe power quality problems for the high penetration of the PV system.

4.3 Islanding

Apart from the power quality, islanding is another concern for micro-grid. Islanding is defined as the DER continuously supplying power to the off-grid area. It might cause risk to the technicians due to the high voltage from the DER. The possibility that islanding will happen is investigated in this section. The circumstance when this happens is when the load is greater than the capacity of the PV. This is to test whether the PV is able to supply power out of its capacity and its ability to be islanded and de-islanded (reconnect to the grid). The grid is switched off at the 5th second and reconnected at the 12th second. The real and reactive power and the RMS voltage of the PCC is illustrated in figure 21. Figure 22 shows the frequency at the PCC.

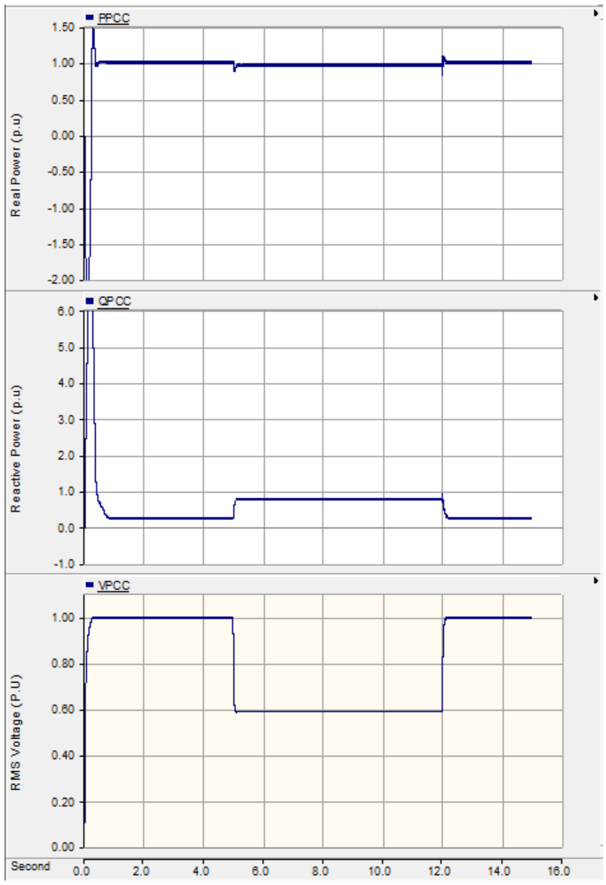

Fig. 21. Real and Reactive Power, and RMS Voltage of PCC

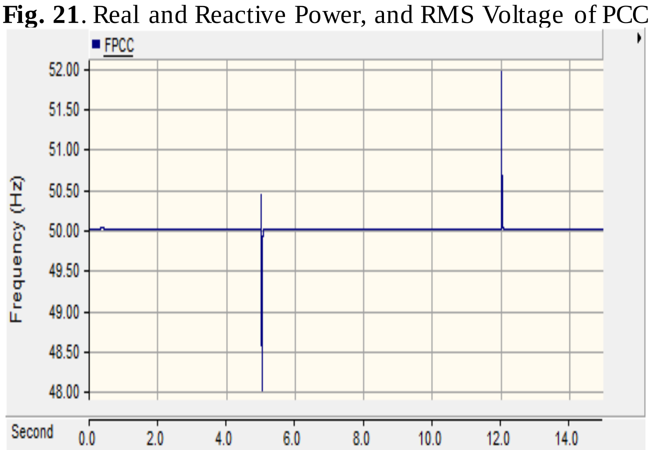

Fig. 22. Frequency of PCC

While the grid is turned off, the load to power ratio of the PV system is increased. Therefore, the frequency at the PCC is decreased to $48Hz$ in transient as shown in figure 22, which is about 4% of changes. This is a type of power quality issue known as the frequency fluctuation. When the grid is reconnected, the frequency raises to $52Hz$, which is about 4% as well. Therefore, any changes in load to power ratio could trigger the frequency to fluctuate. From figure 21, the RMS voltage of the load and PCC drops to 0.5 p.u. This phenomenon is called under voltage. If electrical appliances operate under this voltage, it will undergo overheating. The next observation is that the PV system would try to supply the reactive power to the load when the grid is turned off. However due to insufficient capacity of generated power, the demand of the load cannot be satisfied. Furthermore, when the grid is being reconnected to the load, the real and reactive powers fluctuate. This is known as the power fluctuating phenomenon. In conclusion, that the PV system is unable to island the load if the load demand is greater than its capacity.

4.4 Micro-Grid Analysis

This section presents the performance of the modern university micro-grid power system. The modelled load is being designed according to a modern university's electrical schematic. In order to model a real-life situation, the real-life data of irradiance and temperature is used as the environmental input for the photovoltaic system and it is available in figure 23. Due to limited memory of the 32-bit computer, the 24 seconds of simulation result is corresponding to one day result. This micro-grid power system uses the modelled PV system as the DER.

To analyse the power quality issue, the instantaneous current of PCC and power factor are investigated and shown in figure 24 and 25, respectively. In addition, the total harmonic distortion against time and individual harmonic content for current are available in figure 26 and 27, respectively. Besides, figure 28 displays in figure 28.

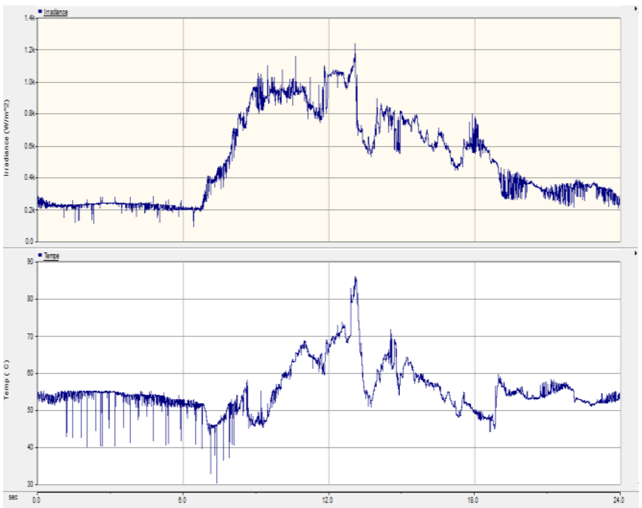

Fig. 23. Real-life Irradiance and Temperature Data

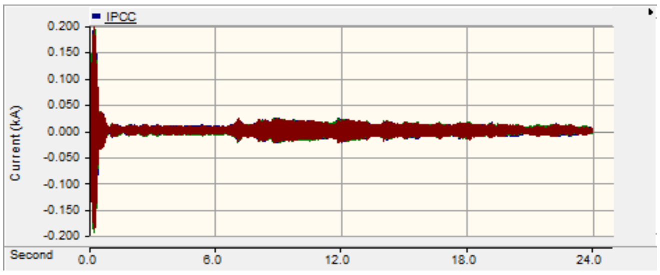

Fig. 24. Instantaneous Current of PCC

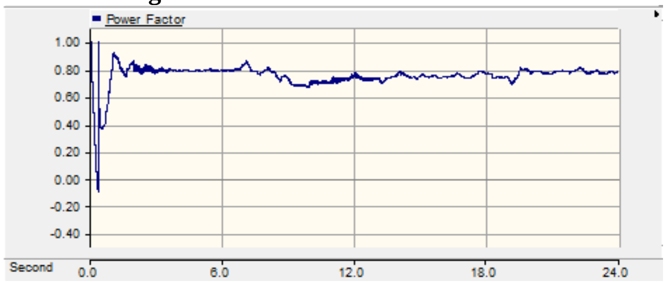

Fig. 25. Power Factor

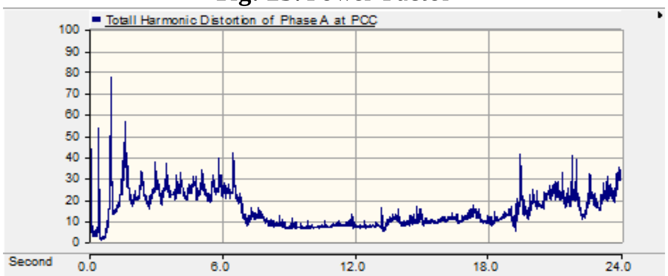

Fig. 26. Total Harmonic Distortion of Current

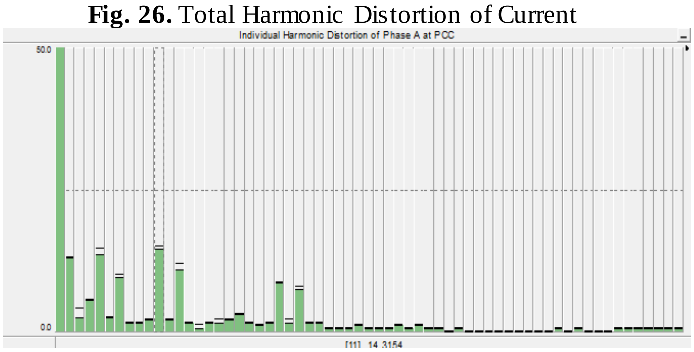

Fig. 27. Harmonic Content of Current

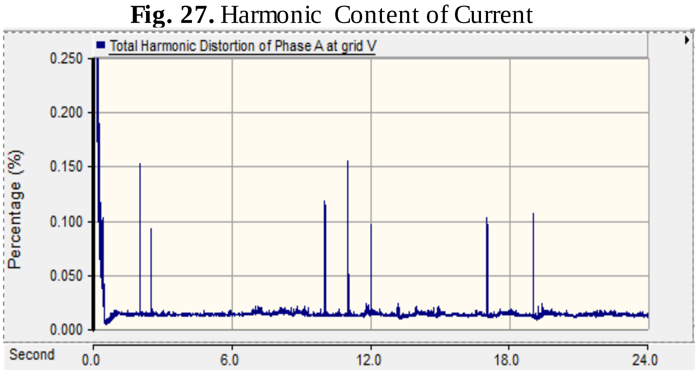

Fig. 28. Total Harmonic Distortion of Voltage

Similar to the transient analysis, inrush current arises while the PV system is connected to the grid, which is in 0 second for this experiment. From figure 24, it indicates inrush current able to rise up to 200 A within a second. This high current is sufficient to interrupt power supply of a particular region due to fuse blowing. Besides, the current raises and falls gradually according to the environmental changes.

After the PV system is connected to the grid and operates in a stable region, the power factor maintains at 0.8. It is different from transient analysis because during the real-time situation, the strong irradiance occurs on daytime, which requires more power and low irradiance occurs during the night time, which requires less power. Another explanation of high power factor is that the penetration of the PV system is low in this experiment, which is about 10% only. As a result, a high power factor is able to be sustained. It is important to know that, with low power factor, utility has to generate more power for consumer. In consequence, it increases stress of distribution line which opposes to the idea of micro-grid.

The harmonic distortion is a severe power quality issue of this micro-grid. Figure 26 shows that a high level of total harmonic distortion of current occurs in the micro-grid power system at all times, where these values exceed the IEEE 519-1992 standard. From figure 27, it shows high order of current are within the current waveform. This phenomenon increases temperature in transformer, motor and conductor, decreases lifespan of electronic devices, and interrupts the operation of communication transmission. High harmonic distortion issue become worse during the night time from figure 26. It is believed as a result of sharply decrease in fundamental element. In contrast to figure 26, total harmonic distortion of voltage is about zero as shown in figure 28. It indicates LCL filter able to perform well in removing high order of voltage, but weak in high order of current.

5. Conclusion

In order to identify potential power quality issues, fundamental power distribution components and a photovoltaic system are developed using PSCAD software. Both systems are integrated to form a micro-grid power system. To increase the reliability of the PV system, maximum power point tracker, inverter and LCL filter are used in the PV system. The power rating from the distributed energy resource is 0.27MW. Basic power flow equation is used in the inverter controller. Several case studies are conducted. The simulation results show that, various power quality issues such as over-voltage, under-voltage, power fluctuation, inrush current, low power factor and current harmonic distortion could occur in the micro-grid power system.

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