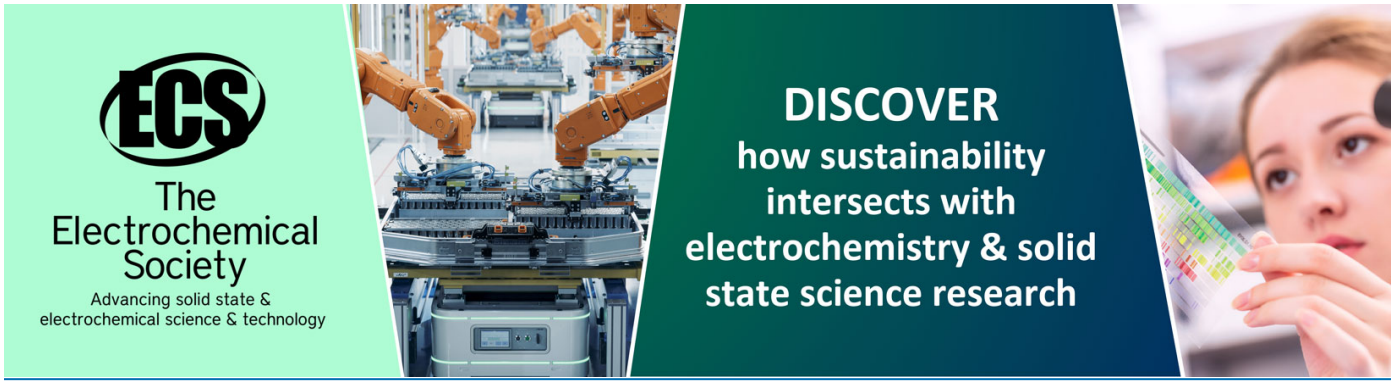
Study on the Interaction Mechanism between Photovoltaic Power Generation and Power Quality



Study on the Interaction Mechanism between Photovoltaic Power Generation and Power Quality

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Abstract: In the microgrid, the voltage of the access point fluctuates due to the PV power plant connected to the grid, and there is a risk of voltage overrun. In this article, the photovoltaic power generation system access to the power grid and the starting point of the impact of the access point voltage deviation mechanism is analysed, obtaining the two major influencing factors including light intensity and ambient humidity.It also analyzes the effect of light and humidity fluctuation on the fluctuation of bus voltage and uses PSCAD to simulate the mechanism of generating harmonics in photovoltaic power generation system.

1. Preface

In today's energy system, the proportion of new energy relative to traditional energy sources is increasing. The new energy is widely distributed and can be used sustainably. It can be connected to the power grid and transmit power to the grid load and also can be operate in isolated islands.[1-2] Due to the wide range of accessing to distributed power supply, it may have a certain impact on the power grid system, such as fluctuations and flicker of the bus of the access point, and some higher harmonics, which affect the power quality of the power grid.[3-4]

In this article, the photovoltaic power generation system access to the power grid and the starting point of the impact of the access point voltage deviation mechanism is analysed, obtaining the two major influencing factors including light intensity and ambient humidity.It also analyzes the effect of light and humidity fluctuation on the fluctuation of bus voltage and uses PSCAD to simulate the mechanism of generating harmonics in photovoltaic power generation system.

2. Photovoltaic power generation causes voltage deviation impact mechanism

When the photovoltaic power plant is integrated into the power grid, the power flow of the power grid system will be changed, so that the voltage of the bus voltage will be biased. Photovoltaic power access is shown in Figure 1. The infinity system bus voltage phasor is $\dot{U}_1$. The voltage phasors of the access point bus before and after PV power is connected to the grid are $\dot{U}_2$ and $\dot{U}_2'$, respectively. The system impedance is R_s+jX_s. The total power on the system side is P_{pv}+jQ_{pv}, and the load size is P_L+jQ_L. It is assumed that the rated voltage phase of the system side line is $\dot{U}_N$.

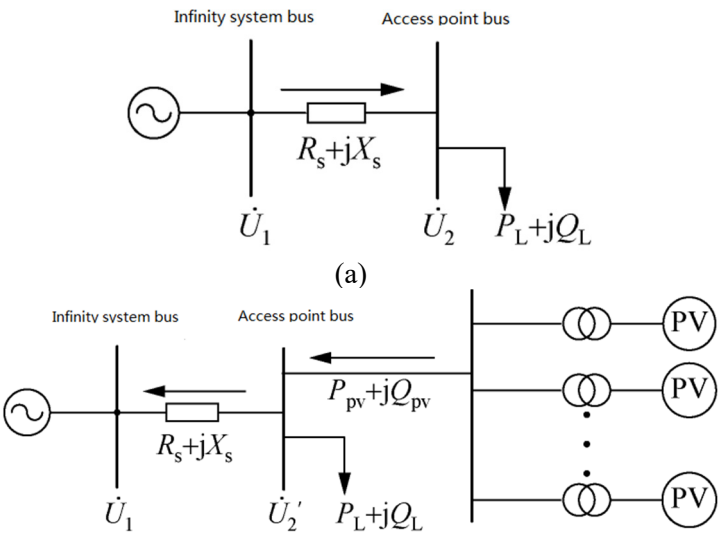

Figure 1 Before and after photovoltaic power generation

The access point bus voltage can be calculated before the PV system is connected to the original power flow.

$$\dot{U}_2 = \dot{U}_1 - \frac{P_L R_s + Q_L X_s}{U_N} - \mathrm{j}\frac{P_L X_s - Q_L R_s}{U_N} \tag{1}$$

The bus voltage after PV power generation is:

$$\dot{U}_2' = \dot{U}_1 + \frac{(P_{pv} - P_L)R_s + (Q_{pv} - Q_L)X_s}{U_N} + \mathrm{j}\frac{(P_{pv} - P_L)X_s - (Q_{pv} - Q_L)R_s}{U_N}. \tag{2}$$

The voltage difference between photovoltaic power generation before and after access to power grid is:

$$\Delta\dot{U} = \dot{U}_2' - \dot{U}_2 = (P_{pv}R_s + Q_{pv}X_s)/U_N + \mathrm{j}(P_{pv}X_s - Q_{pv}R_s)/U_N. \tag{3}$$

Since PV is generally connected to the grid with unity power factor, $Q_{pv}\approx 0$, available:

$$\Delta\dot{U} \approx P_{pv}R_s/U_N + \mathrm{j}P_{pv}X_s/U_N. \tag{4}$$

When the active power generated by the photovoltaic power generation system is injected into the grid, the bus voltage of the access point generates a voltage deviation.

3. Mechanism of photovoltaic power generation leading to voltage fluctuation and flicker

Photovoltaic power plant output caused by voltage fluctuations and flicker due to light and humidity, appeared on the day from 8 to 18 o'clock, as shown in Figure 2.

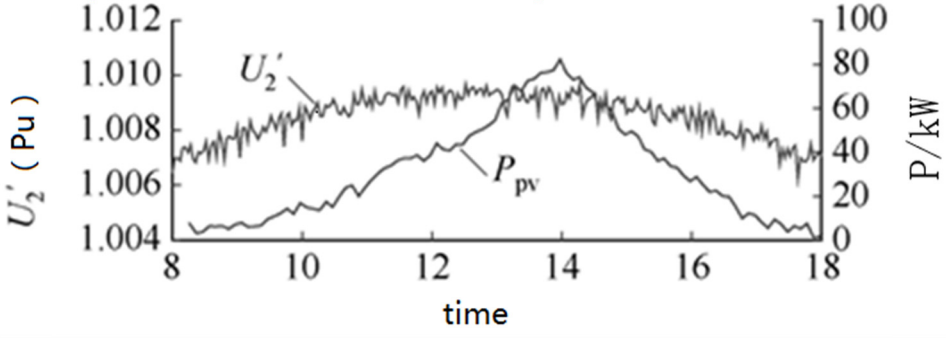

Figure 2 Photovoltaic output and bus voltage fluctuation due to light and temperature fluctuations

In the work of photovoltaic systems, the two major factors affecting the output characteristics of photovoltaic power plants are light and temperature fluctuations. When a photovoltaic power plant is incorporated into a large power grid, environmental factors such as illumination and temperature fluctuations are likely to cause voltage flicker and bus voltage fluctuations.

4. Mechanism of Photovoltaic Power Generation to Harmonic Waves

Photovoltaic generation harmonics are composed of low harmonics and higher harmonics, as shown in Figure 3.

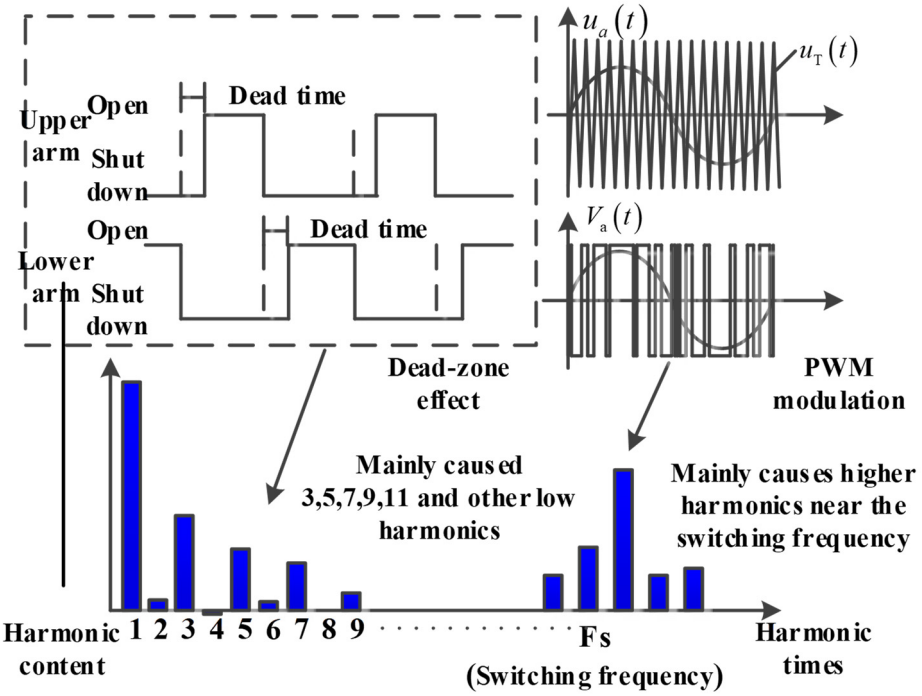

Figure 3 Dead-band effects and harmonics caused by PWM

Pulse deadband forms low harmonics and PWM generates higher harmonics. Due to the improvement of current inverters and related advanced control strategies, higher harmonics can be basically filtered out. For photovoltaic systems, 2 to 25 harmonics are mainly considered.

The maximum power point tracking technology of photovoltaic power generation is the maximum power output of the system in various complex environment conditions (such as light and humidity). The photovoltaic system carries out the maximum power point tracking technology with generating voltage fluctuation on the DC side, which makes the harmonic and interharmonics on the grid side.

Build Simulation Models in PSCAD/METDC

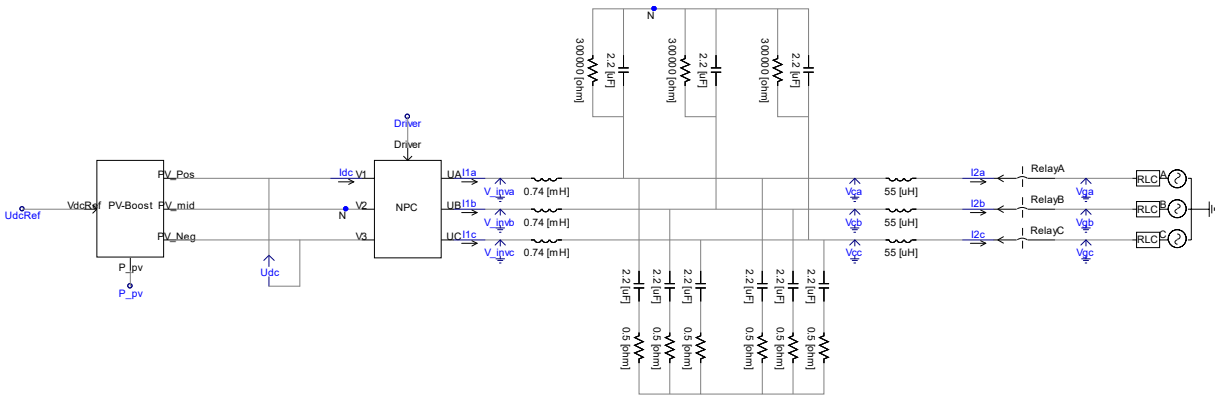

Figure 4 Photovoltaic system simulation model

5. Voltage deviation analysis

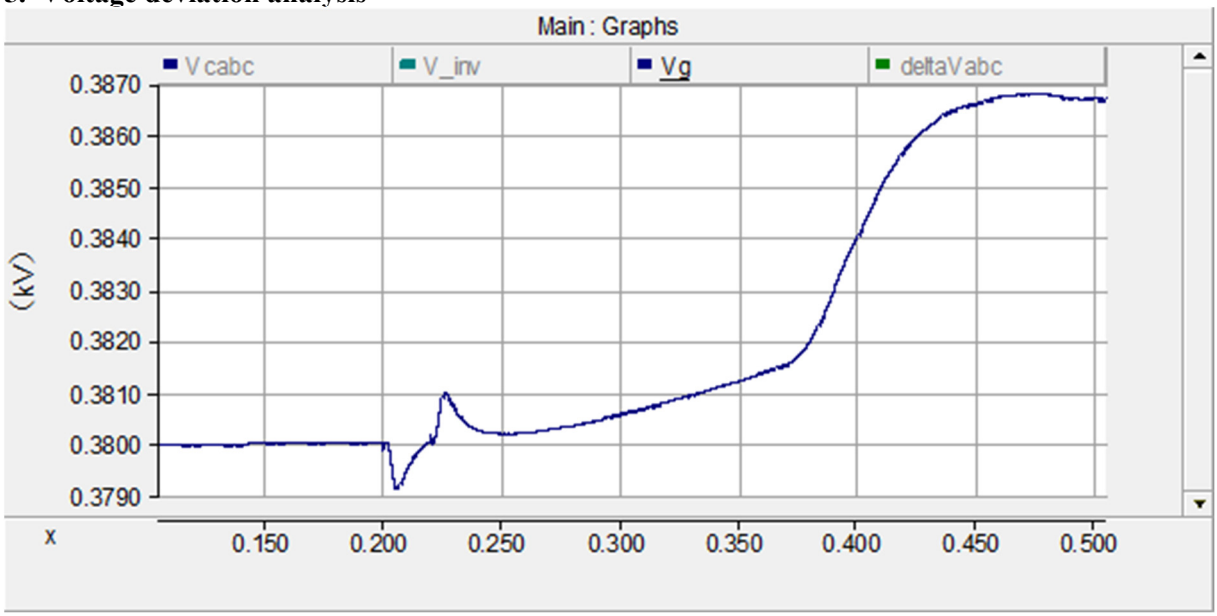

Figure 5 Before and after photovoltaic grid-connected bus voltage

From Fig. 5, it can be seen that at 0.2 s, the grid absorbs the active power generated by the PV and the bus voltage of the outlets will increase, which is consistent with the analysis of the mechanism.

6. Voltage fluctuation and flicker analysis

When a large number of photovoltaics are connected to the grid, according to the following rules, the light changes as the bus voltage changes, as shown in Figure 7.It can be seen that the fluctuation of light is the most important cause of voltage fluctuations. When the power generated by a large-capacity photovoltaic power generation system is injected into the grid, the bus voltage of the access point fluctuates greatly.

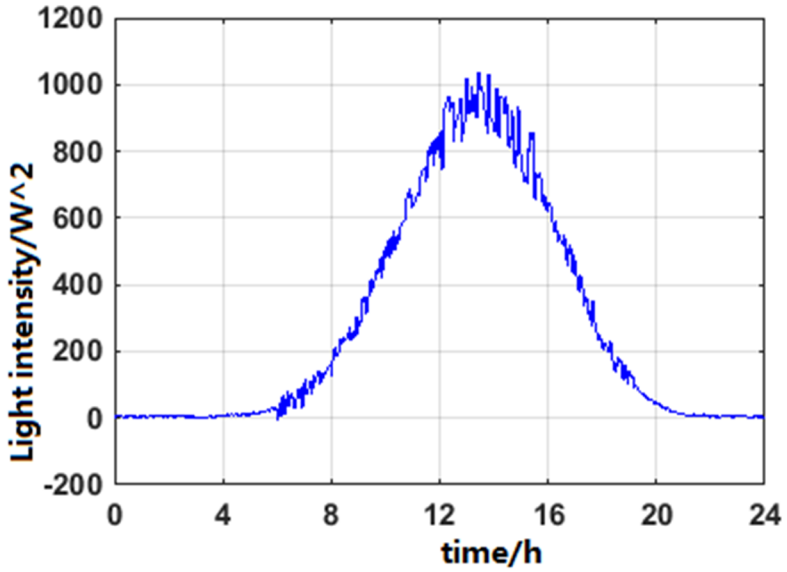

Figure 6 Variation curve of light intensity on a typical day in summer

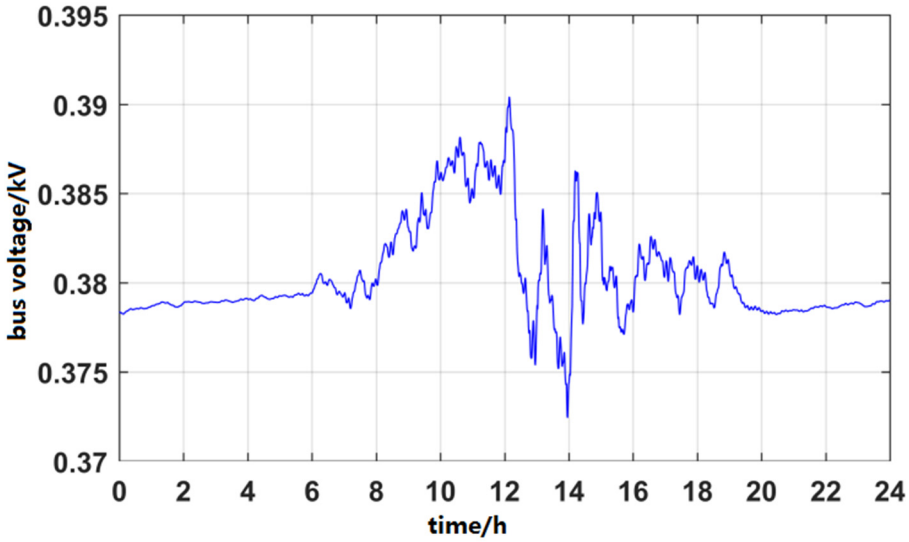

Figure 7 Bus Voltage Variations in One Day

7. Harmonic analysis

The higher harmonics generated by the inverter are mainly 5th harmonic, 7th harmonic, 11th harmonic, etc. Due to the structural characteristics of photovoltaic inverters, it produces few 3, 9 order zero sequence harmonics.

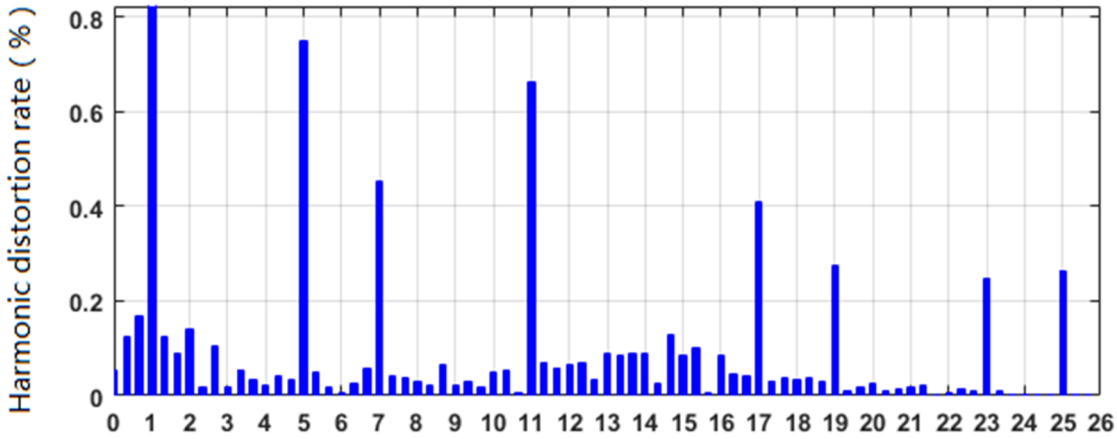

Figure 8 Harmonic Current Distortion Rate of Photovoltaic Power Generation System

8. Conclusions

Through the above analysis we can see:

(1)When the PV system is connected to the power grid, a voltage deviation is generated on the voltage of the access point, and the voltage deviation cannot be ignored.

(2)The two major factors affecting the voltage fluctuation and flicker of the photovoltaic system are light and humidity.

(3)High-order harmonics are generated when the photovoltaic inverter works, mainly 5, 7, 11 equal-order harmonics, and 3 and 9 zero-order harmonics can be filtered out.

References

[1] You Yi,Liu Dong,Yu Wenpeng,et al.Active distribution network technology and its progress[J].Automation of Electric Power Systems,2012,36(18):10-16.

[2] Elkhatib M E,EL－Shatshat R,Salama M M A.Novel coordinated voltage control for smart distribution networks with DG[J].IEEE Trans on Smart Grid,2011,2(4):598-605.
[3] Zhai Sheng,Sheng Yu,Kong Li,et al.Effect and improvement of distributed power supply on distribution network voltage quality[J].Proceedings of the CSEE,2008,28(13):152-157.
[4] Lü Zhisheng, Yan Liwei, Luo Aiqing, Wang Qianggang, Zhou Niancheng. Research on the impact of new energy generation on grid power quality. East China Electric Power, 2012.
[5] Yang Yongbiao, Bai Yongbao, Zhu Jinda, Ding Xiaohua. New technologies for smart electricity use[J].Rural Electrification,2009,11:20-22.
[6] Li Peng,Dou Pengchong,Li Yuwei,et al.Application of microgrid technology in active distribution network[J].Electric Power Automation Equipment,2015,3(4):8-16.