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Research on New Energy Power Grid-Integration on Grid Power Quality

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Abstract

Distribution network is an important part of the power system which delivers the electric power to consumers. With the increasing attention to the new energy power generation, more and more distributed photovoltaic power systems are connected to the distribution network. In this paper, it researches on new energy power grid-integration on grid power quality. First, the technologies of wind and solar power are introduced. Second, the concepts of power quality and evaluation index are introduced. Finally, voltage deviations and harmonics are mainly elaborated.

Keywords*: DG, Wind Power, Solar photovoltaic systems, power quality*

1. Introduction

With the development of science and technology and the national economy, electricity is an important resource for people's lives. The coal, oil and other fossil fuel bear 90% of the traditional power load [1-3]. Entering the new century, we should pay attention to energy and environmental issues. On the one hand, with the start of the industrial revolution, the consumption of traditional energy sources rapid increases and traditional energy is non-renewable resources. Excessive development and using will eventually lead to depletion of resource [4]. On the other hand, a large number of traditional energy which use makes ecological deterioration. Especially the emissions of carbon dioxide cause the greenhouse effect. Human living environment is threatened. In this context, China has proposed the scientific concept of development and taken the road of sustainable development. National advocate and develop "clean, green, efficient" renewable energy development and utilization and this is seen as the energy strategy. The National Development and Reform Commission develop a "long-term renewable energy development plan.

Currently, researching on new energy generation has made breakthrough progress and increased the share of electricity production. New energy generation technologies extensive application will have a huge impact in entire power system including grid power quality, system stability, protection measures [3]. Among them, people constantly improve the power quality requirements to prompt new energy sources.

2. New Energy

With the advancement of technology and social development, the demanding for electricity is increasing, while the traditional energy shortage and environmental protection make people have an urgent requirement for to promote electricity sectors and continue to strengthen the development of new development and using, which formed a new power mode.

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2.1 Distributed Generation

Internationally, distributed generation can also be referred to a embedded generation [5]. It can be described the image which distributed power is embedded into distribution system. It stressed the difference among the traditional centralized power.

Currently, the definition of distributed generation is still no uniform criterion. A common understanding is something which distributed generation is an independent power supply that meets certain requirements of the end user and the power of small modular from tens to hundreds compatible with the environment [5]. The independent power supply can be connected directly to the distribution network. Distributed generation has the advantage of less investment, small footprint, short construction period, highly energy efficiency, energy saving and environmental and so on. Because the distributed power closes to the load, it can reduce the distance of the power output and transmission losses. Although there are many advantages of distributed generation, distributed power entering grid also causes many problems.

Overall, distributed generation technologies have made a wealth of experience and achievements in some Western countries which contain from the independent operation of DG to the parallel distributed power runs with the big grid. The domestic research on DG is still in its early stages [6]. At present, domestic research on distributed generation technologies are mostly concentrated in the power supply. The efficiency for power generation DG and the stability DG operation is increasing [7]. DG entering the big grid brings up many problems such as the power system planning, operation and power quality which mostly concentrated at the level of qualitative analysis [8-9].

2.2 Wind Power

Wind power is a clean green renewable energy and widely distributed. It is currently the development of new energy technologies which is the most sophisticated kind of power generation technology [10]. With the emergence of the energy crisis and environmental issues and other issues, more and more countries are studying and constructing the wind power. Along with the development of wind power technology promotes its lower costs. So, we will pay more and more attention to wind power. It is estimated that the global cumulative installed capacity of wind power will exceed 126 MW by 2020 and it can meet 12% of global electricity consumption [11].

Wind power technology is a generation technology which can turn the wind energy into mechanical energy by gearing, and then turn the mechanical energy into electrical energy generation technology by the generator. The output power of wind power is mainly determined by the wind energy.

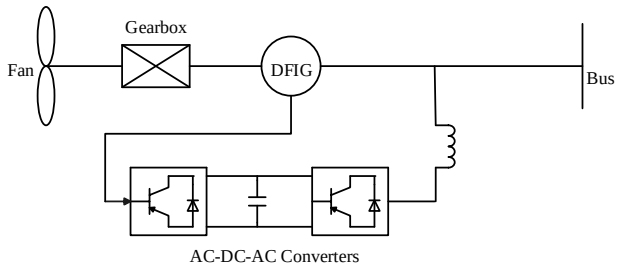

Figure 1. Principle of Wind Power Generation System

Wind power operation mode can be divided into independent operation, and network operation, and combining with other complementary power generation operation [12-13].

The first one runs independently. The output power of wind turbine was used by people through battery energy storage. The way of power grid is adjusted some place where the power can not reach the remote rural and pastoral areas and islands and other regions. This pattern of wind power installed capacity is typically from several hundred to several kilowatts

The second is the wind power in connection with a big grid. Network operation runs in the region where the resource of wind is rich. According to a certain arrangement of the installation of wind power group, it can become wind power plants. It can send electricity to the grid by transformer transported .This is a major wind power form.

The third is complementary operation which combines the other ways of power. such as wind-diesel hybrid power generation group, the wind-a fuel cell power generation group, wind power-solar photovoltaic power generation group, This approach can not only compensate the amount of electricity which the wind speed changes and it can ensure a balanced supply throughout one year. And you can also extend the battery life, while it also can reduce electricity costs of off-grid small users and the natural resources are fully utilized. This approach is mainly used as a virtual extension of the grid.

At present, China's wind farms are mostly located in some place where it distances from the main system and the load centers, and connection with the relatively weak grid [12].

2.3 Solar Photovoltaic

Solar energy is the energy which the sun inside continuously generated by nuclear fusion. It generates tremendous energy and wide coverage to become human development and utilization of new energy sources in nearly 20 years. Solar photovoltaic power generation system is the use of the photovoltaic effect generated electromagnetic by semiconductor materials [14]. It is a new generation which directly conveys the solar energy to electrical energy. Because of the abundant of solar energy resources, it has no territorial restrictions, no pollution, flexible scale, and simple maintenance. The power generation capacity of Solar photovoltaic can be composed in any ways. So it is an important supplement of today's traditional centralized power and an important part of the new energy [15].

At present, solar photovoltaic have two major forms [16]:

1) A Stand-alone PV System

Independent photovoltaic power generation system is the only rely on solar-powered photovoltaic system. As is show Figure. 2: a stand-alone PV system.

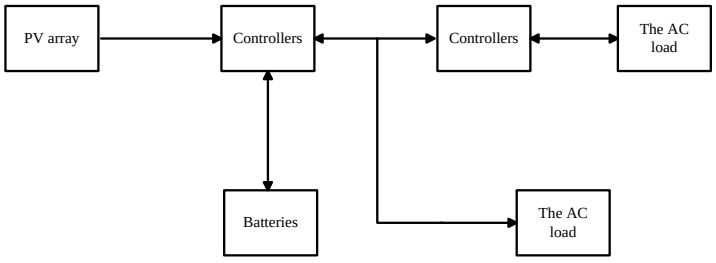

Figure 2. A Stand-Alone PV System

Currently, the main form of generate electricity is solar photovoltaic in New Energy in China. Independent photovoltaic power generation system is mainly used in some place, such as no electricity or power grid unstable places and so on. The photovoltaic system which provides electricity has many benefits, such as easy to use, safe, reliable, and easy maintenance and so on. PV systems can be locally powered and without long-distance transmission to save investment and reduce the power loss. Accordance with the requirements of the load power supply, the local weather conditions and geographical conditions design the control system ensure the reliability of the local power supply and economy.

2). Grid-Connected PV System

Grid-connected photovoltaic power generation system is that a solar cell matrix issued DC turn into alternating current through the inverter, and in parallel with the grid. Structure is as follows in Figure. 3.

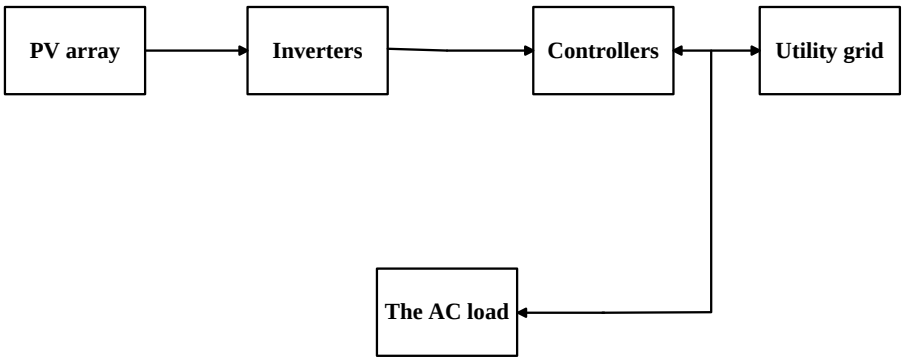

Figure 3. Grid-Connected PV System

Grid-connected photovoltaic power generation system is the main trend of the world's photovoltaic power generation and can provide active and reactive power of the power system. Grid-connected photovoltaic power generation system can be divided into two categories which contain residential grid-connected PV systems and centralized grid-connected photovoltaic power generation system. The characteristic of former is that the PV systems send power directly to the user load, excess or shortage of electricity through the grid to adjust. The characteristic of latter is that the power of PV systems sent power directly to the big grid. Currently, residential PV system has been vigorously promoted in foreign countries, while the applications of centralized grid-connected PV system still develop. Both have little difference on the system architecture.

Solar photovoltaic power generation, as a new form of energy has broad prospects for development and a better future.

3. An Overview of Power Quality

Different people have different attitude towards power quality. Studies of power quality have been sustained for decades. So far, power quality has not given precise definitions. From common sense, power quality refers to the quality of power supplied by the public grid alternating current client [16-18].

3.1 The Concept of Power Quality

In practice, because the different power users and electrical equipment for power quality requirements are different. Describing the quality of power in the current which can has important implication in the power system. Therefore, from a

practical point of engineering view, the concept of power quality for further elaboration [19, 20].

1) Current Quality

So as to improve the efficiency of power transmission, we need not only ensure requirements of electric current users who get a single frequency sine wave but also should also try to maintain the same supply voltage and sine wave phase. Current issues include the quality of the current phase of the lead and lag, harmonics, noise.

2) The voltage quality

A bias was found by comparing actual voltage and the ideal voltage. It can reflect the electrical power of the sector provided. Voltage quality problems include voltage deviation, frequency deviation, under voltage and over voltage.

3) The power quality

Quality of supply includes non-technical part and the technical part. Non-technical part refers to the quality of the supply of services, including transparency of electricity price and the electricity sector reflects the speed of customer complaints. The part of technical mainly refers to the quality and reliability of power supply voltage.

3.2 The Indicators of Power Quality

The standard of power quality is the basic technical specifications which can ensure the safe operation of the power grid, electrical environment protection, safeguard the normal using of electric power users. It can finish the supervision of the power quality and promote control. It provides a nominal environment, the definition of technical terms, quantitative quality indicators, recommended a unified measurement and evaluation methods. . Many agencies have developed evaluation index to reflect the power quality and in order to represent and measure the characteristics of different power quality [21].

3.2.1 The Voltage Deviation

Voltage deviation is indicator which can measure the normal operation of the power supply system. In the normal operation of the power supply system, There is a difference between a voltage measurements of a node and system voltage and then divided system voltage. The percentage of known is the node voltage deviation. The mathematical expression is following.

In the formula: (1)

——system voltage deviation;

——system operating voltage;

——system rated voltage;

Currently, the national standards for allowable limits: the absolute value of bias between the positive supply voltage users and the negative supply voltage users do not exceed more than 10% of rated voltage in 35kV. The three-phase supply voltage tolerance of the rated voltage of ± 7% in 20kV and below [21].

When the voltage is lower than the rated voltage, the torque of the motor becomes smaller and the speed will drop. Then the current and the motor temperature will increase. The coil will heat and the life of the motor will be shorted. When the power is running in low pressure, it may cause the collapse of the system voltage and power outages.

3.2.2. Harmonic: Harmonic refers to a sinusoidal voltages and currents which has frequencies of integer multiples of frequency. Internationally recognized harmonics defined something that "harmonic sinusoidal component is a cycle electrical quantities, and its frequency is an integer multiple of the fundamental frequency"[22]. The harmonic of power system is composed of the nonlinear device of power network, the distortion of system voltage and harmonic currents. The measurement parameters of harmonic typically contain harmonic amplitude and phase, the distortion of total harmonic, harmonic power, and so on.

Currently, there are many ways to measure harmonics. You can use the FFT and DWT. In the steady-state of harmonic, you can be used the improved of the FFT algorithm and wavelet transform algorithm in transient harmonics. Currently, the restrictions of harmonic voltage specified in the Table 1.

Table 1. The Restrictions of Harmonic Voltage Specified

Voltage(KV)	THD	Odd	EVEN
0.3	5	4.0	2.0
6	4	3.2	1.6
35	3	2.4	1.2
110	2	1.6	0.8

Harmonic harms to the power system: ①it makes the reactive power compensation capacitor bank resonate and the amplification of harmonic current can cause the capacitor overload and damage. ②it makes the measuring instruments especially inductive meter errors in measurement. ③it makes the power of cable damage in over-voltage and over-load. ④it makes interference and errors for protection devices and automatic control devices. ⑤it will interfere with communications.

3.2.3 The Frequency Deviation: Frequency is one of the most important power quality indicators for power system. In the normal operating conditions of Electric power system, the difference between the actual value of the system frequency and the nominal value of the system frequency is called frequency deviation.

In the formula: (2)

——the frequency deviation;

f——actual deviation;

——the nominal frequency of system;

The frequency of the national standards for allowable limits: The restriction of frequency deviation is ± 2HZ under normal operating conditions for the power system. When the system capacity is small, the restrictions of deviation can be relaxed to ± 5HZ. The change of System frequency which caused by the impact load is 0.2Hz. Currently, the method of measuring the frequency, there are three main methods.

(1) The Cycle method: frequency is calculated by measuring the signal wave form successive crossing zero.
(2) By observing the signal wave, establishing the mathematical model and mathematical transformation, and an explicit function was estimated to the sample.
(3) It can use error minimization algorithm principle [24].

The influence of system frequency:

(1) The diversification of frequency caused the asynchronous motor and the transformer magnetizing current increasing and the reactive power will increase. This will influence of the voltage level of the power system.

(2) It can lead to reduced motor speed and power and result in reduced mechanical efficiency.

(3) It can reduce the accuracy of monitoring and control equipment related to the frequency.

(4) It can cause the filters of system detuned and the variations in reactive power of capacitor bank.

3.2.4. Three-Phase Voltage Unbalance

The three-phase equilibrium refers to voltage or current value of three-phase are equal, the same frequency of three-phase and phase difference of 120 degrees. If it can not meet the above conditions and then it become unbalance.

Three-phase voltage imbalance generally represents by fundamental negative sequence components and positive sequence component. Known for three-phase power, symmetrical component analysis can be used to solve the problem. When excluding zero sequence, we can take the root mean square value between the fundamental negative sequence voltage and the positive sequence voltage to represent Three-phase voltage imbalance. Formula (2-3). If it contains zero-sequence component, you can add style (2-4) will be described

In the formula: (2-3)

(2-4)

——the fundamental positive sequence component;

——the fundamental negative sequence component;

——the fundamental zero sequence component;

It produced many impact on power system. ①synchronous motor generates electricity harmonic and synchronous motor generates electricity harmonic and pollute the power system operating environment. ②It can result the malfunction between the negative sequence current protection device and automatic device. ③It can affect people's normal work and life.

3.2.5 Other Indicators: In addition to the above assessment of power quality indicators, including voltage sags, voltage fluctuations and flicker, voltage swells and so on [23-25]. At present, these indicators have not yet enacted relevant standards, with the development of social and technology, especially the development of the power sector. This will pay people's attention to these indicators and it also will be refined.

4. Impact of Distributed Power for Power Quality

The system of distributed generation was added in the distribution system. It is main trend for the development of distributed power generation. However, with the penetration of DG in power systems increasing, it have an influence on the power system, including the power system power quality, load forecasting, system planning, system flow, system failure and protection devices [26]. This section will study the impact of power quality, and analyze the deviation of the voltage and harmonic for power quality.

4.1 New Energy Power Grid-Integration Have a Beneficial Effect on Power Quality

(1) When the system load become large, distributed power source can provide power quickly and timely, so that the system can reduce failures and improve the stability of the system.

(2) Accessing to distributed power, it can increase the short circuit capacity of the access point, increasing the strength of the grid, reducing the voltage fluctuation and flicker and reduce transmission power feeders. While also saving investment.

(3) The electronic converter device of distributed generation power can not completely replace and improve power quality equipment and technology of the traditional power grid .It can apply the distributed power generation equipment to DFACTS technology [27]. It not only improves the power quality level but also reduces the investment in equipment.

4.2 New Energy Power Grid-Integration Have an Adverse Impact on Power Quality

(1) A large number of power electronic converters and switching devices applied to the system. It prone to harmonics and harmonic pollutes the grid.

(2) The distribution network of traditional centralized power generally exhibit radial. The voltage decreases along the direction of the trend feeder under steady operating state. After access DG, the transmission power of the feeder will decrease and DG provide reactive power so that the node voltage of each load along the feeder increasing. It may lead to the deviation of some voltage excessive and stability of the system [27].

(3) Distributed power operation and decommissioning are related to many factors which contain natural condition, user requirements, geographic location, and so on. Starting and stopping irregularly distributed power easily lead to power output fluctuations. This causes voltage fluctuations and harmonics and then cause significant voltage fluctuations.

(4) Distributed power and the load of distribution network uncoordinated operation. This will also affect the quality of power in distribution network. In addition, the distributed power supply capacity and control often choose unreasonable, it will make large changes on the trend line and cause the voltage fluctuations [28].

4.3 New Energy Power Grid-Integration Have Impact on the Voltage Deviation

The distribution network of traditional centralized power generally exhibit radial. The voltage decreases along the direction of the trend feeder under steady operating state. After a large number of distributed powers added to the grid, electricity networks will change and it will inevitably lead to change in active and reactive power of feeder, thereby affecting the steady-state voltage. This will change the network topology of distribution network and cause voltage deviation [26].

As shown in Figure.4. When not connected DG, the voltage of the line satisfy the following relation.

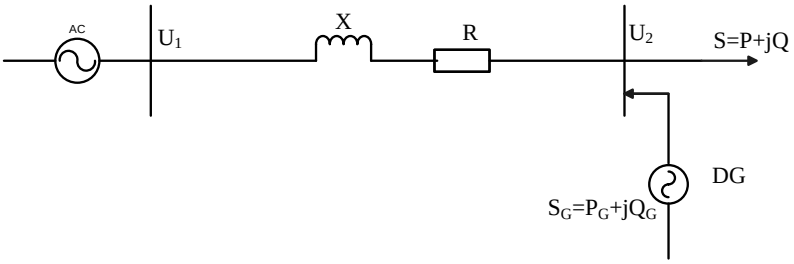

Figure 4. Power Lines

$$\nabla U= \tag{2-5}$$

In general, the phase angle change is small across the line, ignoring transverse component of voltage drop losses. Therefore, the vertical component of the voltage approximated as a voltage loss.

$$\nabla U \tag{2-6}$$

When DG Grid-Integration, it can be expressed as:

$$\nabla U \tag{2-7}$$

Apparently, the detected power level of the bus will be less than without accessing to distributed power. Based on this information, the system bus side voltage is set lower than the actual needs of the user and this will make voltage of part of the user is below a certain standard. When DG access to the distribution system at the end line and it will reduce line losses and raise the terminal voltage. Meanwhile, in case of failure needs to remove DG, it will make part of the node voltage is below the lower limit prescribed.

4.4 New Energy Power Grid-Integration have Impact on the grid harmonics

With the development of new energy technologies, New Energy has been widely distributed applications. The power generation equipments of wind and solar is used in some low-voltage distribution network. The output power is generally not in the power frequency, and the power delivered to the grid by power electronic devices. Therefore, the grid has a large number of non-linear load and power electronics equipment which constitutes a potential source of harmonics. Meanwhile, the distribution network capacity is generally small and harmonic prone to low voltage grid [29]. For these reasons, we should study the influence of harmonic.

1. Harmonic Problems of Wind Power

The topology of Wind Power Grid-Integration is as follows. In this system, the wind generator side converter main control wind power generation. By generator torque adjusted to meet the maximum power point of wind turbine operation. The grid side converter complete and control the feed of grid.

There are two main harmonics which bring wind power bring to the system. One is that the power electronic devices equipped with wind power brings harmonic. Another is that between the parallel compensation capacitors of wind power and line impedance can happened resonance and cause the grid harmonic problems [30].

2. Harmonic Problems of Solar Photovoltaic System

The topology of solar photovoltaic Grid-Integration is as follows:

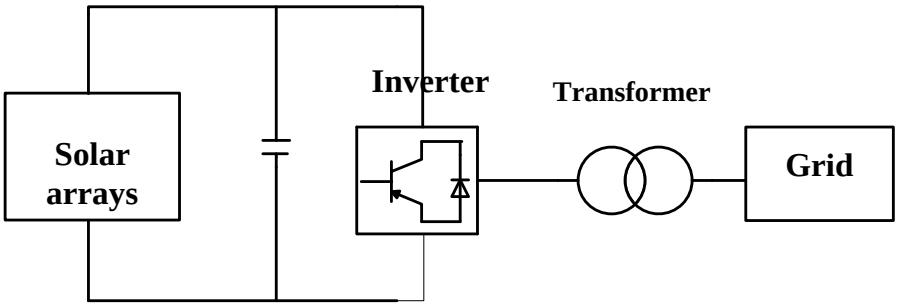

Figure 5. Solar Photovoltaic Grid-Integration

In this system, solar photovoltaic power generation system consists of solar cell and inverter device component [31].

When the photovoltaic cells have the power output, the inverter can export active power by MPPT [32] and provide the power to the power grid by unity power factor. The switching frequency of Inverter, the control strategy of network, the selection of DC capacitor, AC side filter inductor and capacitor and other factors will cause harmonic problems. Meanwhile MPPT algorithm may cause harmonic problems. When the output of the PV system has no power or energy output does not meet the criteria, and inverter stop working, it will make the distribution network voltage fluctuates. So it can cause a series of other power quality problems [33].

5. Conclusion

With the development of new energy technologies and power generation technologies, distributed generation will become competitive power generation and play important roles in modern power system. In this paper, it interprets the new energy power grid-integration on grid power quality and explains the beneficial effects of distributed energy and cause adverse effects by distributed energy. It provides a theoretical guidance. Combined with the trend of smart grid development and increasing levels of distributed power, it will occupy a very important position in energy utilization. The power quality issues of wind power grid, such as the voltage deviation, voltage fluctuations, harmonics and three-phase imbalance, give a serious impact to the safe and stable operation of the grid. The power quality issues of wind power grid involve technical problems and management challenges of power grid in our country, thus the search subjects about the wind farm power quality assessment and control measure sown important theoretical and practical significance.

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References

[1] E. Santacane, G. Rackliffe, L. Tang, J. Getting Smart. vol.8, no. 41 **(2010)**.
[2] M. Kezunovic, V. Vittal, S. Meliopoulos, J. “Research for Large Scale Integrated Smart Grid Solution”. vol. 10, no. 22 **(2012)**.
[3] Q. Lu, S. W. Mei, J. “Major Power System Research Toward the 21st Century”. vol. 10, no. 870, **(2000)**.
[4] X. Yang, Y. Song, G. Wang, J., “Comprehensive Review on the Development of Sustainable Energy and Implementation in China”. vol. 1, no. 57, **(2010)**.
[5] T. Ackermann, G. Andersson, L. Soder, J. Distributed Generation: a definition. vol. 57, no. 195 **(2001)**.

[6] S. Y. Chen, S. F. Song, J. "Overview of Smart Grid Technology", vol. 33, no.1, **(2009)**.
[7] Z. Xiang, "Research on Multi-Objective Power Dispatch in Future Smart Grid". Shanghai: Shanghai Jiaotong University. **(2010)**
[8] J. A. P. Lopes, N. Hatziargyriou, J. Mutale, J. , "Integrating Distributed Generation into Electric Power Systems: A Review of Drivers Challenges and Opportunities". vol. 77, no. 1189 **(2007)**.
[9] C. S. Wang, S. X. Wang, J. "Study on Some Key Problems Related To Distributed Generation Systems". vol. 32, no. **(2008)** .
[10] R. S. Diao, Z. Xu, Y. Chang, J. "Technical Comparison between Several Common Wind Power Generation Systems" vol. 2, no. 20, **(2006)**.
[11] X. Y. Yang, G. S. Liang, J. "Development of Wind Power Generation and Its Market Prospect". vol.27, no. 78, **(2003)** .
[12] Z. Q. Long, J. Green Energy of 21 Centuries. vol. 23, no. 32 **(2006)**.
[13] X. Y. Chen, M. J. Liu, Y. D. Shan, J. Application of Super Conducting Magnetic Energy Storage System—SMES in Wind Power System of Network-Forming. vol. 12, no. 63, **(2001)**.
[14] N. R. Chenni, M. Makhlouf, T. Kerbache, A. Bouzid, J. A Detailed Modeling Method for Photovoltaic Cells. vol.32, no. 25 **(2007)**.
[15] R. Lasseter, J. Models for Micro-turbines and Fuel CellsPower Engineering Society Summer Meeting, Canada **(2001)**.
[16] S. Naka, J. Y. Gen, Y. Fukuyama. C. Practical Equipment Models for Fast Distribution Power Flow Considering Interaction of Distributed Generators, IEEE Power Engineering Society Summer Meeting, Vancouver, Canada, (**2001)**.
[17] IEC60050-161. Disturbances in Supply Systems Caused by Household Appliances and Similar Electrical Equipment: Part 1 Definitions, (**1990)** .
[18] IEEE Std 100-1996. The IEEE Standard Dictionary of Electrical and Electronics Term.6th ed. New York: IEEE Press, 78 **(1997).**
[19] J. Stones, A. Collinson, J. Power Quality. Power Engineering. vol. 15, no. 58 **(2001)**.
[20] X. G. Hou, Z. G. Wu, J. Winding Fault Diagnosis Method of Induction Motor Based on Coherence Analysis. vol. 25, no. 83, **(2005)** .
[21] IEC Standard 61000-4-15 Ed. 1.1**(2003)**, "Electromagnetic compatibility (EMC)-Part4: Testing and measurement techniques - Sectionl5: Flickermeter – Functional and design specifications", **(2003)** .
[22] A. Bertola, G. C. Lazaroiu, M. Roscia, D. Zaninelli, C. A Matlab-Simulink Flickermeter Model for Power Quality Studies, IEEE PES 11th International Conference on Harmonics and Quality of Power, Lake Placid, **(2004)**.
[23] C. Wei, M. X. Han, W. L. Yan, C. Voltage Fluctuation and Flicker Assessment of A Weak System Integrated Wind Farm, Power and Energy Society General Meeting, **(2011)** .
[24] G. Carpinelli, P. Caramia, A. Russo, P. Verde, C.**(2004)** New System Harmonic Indices for Power Quality Assessment of Distribution Networks,39th International (Jnversities Power Engineering Conference(UPEC), Bristo; (UK), September
[25] M. Fei, H. Chen, J. Survey of Power Quality and Its Analysis Methods. vol. 24, no. 36 **(2000)**
[26] Q. Xun, Effects and Assessment on Power Quality of Distribution Network with Distributed Generation. Beijing: North China Electric Power University. **(2012)**.
[27] G. Carpinelli, P. Caramia, A. Russo, P. Verde, **(2005)** New System Power Quality Indices for Distribution Networks in the Presence of Embedded Generation.CIGRE Symposium on Power Systems with Dispersed Generation, Athens(Greece), April.
[28] S. Q. Sun, X. R. Li, the Research of Power Quality Comprehensive Evaluation Method. Hunan: Hunan University. **(2013)**.
[29] W. Liu, Y. Zhou, "Evaluation and Control Measures on Power Quality of Wind Power Grid", Beijing: Beijing Jiaotong University. **(2014)**.
[30] A. E. Feijoo, J. Cidras, J. Modeling of Wind Farms in the Load Flow Analysis. vol.15, no. 110 **(2000)**.
[31] T. V. Gestel, J. A. K. Suykens, G. Lanckriet, J. Bayesian Framework for Least Squares Support Vector Machine Classifiers, Gaussian Processes and Kernel Fisher Description Analysis. vol. 15, no. 1115 **(2002)**.
[32] S. Liu and R. A. Dougal, J. Dynamic Multiply Models for Solar Array. vol. 17, no. 285, (**2002)**.
[33] K. Ishaque, Z. Salam, H, Taheri, J. "Accurate Matlab Simulink PV System Simulator Based on a Two-Diode Model". vol. 11, no. 179, **(2011)**.

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