

Analysis based on impacts for grid-connected photovoltaic power station on the distribution network

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Abstract. Photovoltaic power generation, with the advantage of renewable energy and convenient installation, has been widely used in distributed generation in distribution network as the technology gradually developed. Grid-connected photovoltaic power generation station not only changes the structure single terminal power supply distribution network, affect the operation of distribution network due to its fluctuant and intermittent characteristics. As grid-connected photovoltaic power station adopts power electronic converter for the connection to distribution network, the harmonic voltage and current as well as the DC components are inevitable. Therefore, the impact analysis and the comprehensive evaluation of grid-connected photovoltaic power station are studied. The main contents are as follows:

1: Based on the multiple CPUs embedded measurement and evaluation system designed for the grid-connected photovoltaic power generation station, a positive and negative effect index is proposed for its comprehensive evaluation. With FFT as basic power measurement algorithm and adopted DSP computing unit, data manage unit and analysis unit, a real-time calculation of positive and negative effect index is realized.

2: Common weights of the index are determined by DS/AHP method with incomplete information, and then the weight synthesizing of positive and negative effect index are conducted through penalty-incentive balance functions respectively. The comprehensive evaluation results are generated by the method of grey relation analysis.

Introduction

To ensure the maximum utilization of renewable energy, and grid-connected PV systems use appropriate control strategies to achieve maximum active power output of photovoltaic power plants since the dynamic fluctuations of light intensity, photovoltaic grid power station there is a big random fluctuation of output power, intermittent power fluctuations would cause large grid power quality adversely affected [4].

As mentioned above, photovoltaic grid power station pollution power output harmonic and dynamic fluctuations caused photovoltaic inverter, with the normal operation of the power grid will be adversely affected. Given the online measurement and evaluation system at home and abroad we are not against PV grid power stations, also has not been established photovoltaic grid power plant affect the distribution network of the comprehensive assessment and evaluation methods. Therefore, this paper analyzes its impact on aspects of distribution network voltage, frequency and harmonics, etc. Based on the measured data of photovoltaic power stations and networks, and thus for the photovoltaic grid power station on the distribution network to monitor and assess the impact of issues research papers The main work is as follows:

1: research grid-connected PV systems classification and access, re-use 2MW photovoltaic 10kV distribution network access and network data measured power stations, in terms of the distribution feeder voltage, frequency and harmonic analysis of photovoltaic power plants impact on the distribution network.

2: design photovoltaic grid power station on the distribution network impact measurement and evaluation system, consider the requirements of real-time online monitoring of power plants, the use of bimodal spectral correction algorithm and windowing interpolation fast Fourier transform (FFT) calculation Interharmonic and proposed positive and negative effects photovoltaic grid power station indicator system and calculation method of distribution network impacts.

3: incomplete information for empowerment groups using evidence theory Analytic Hierarchy Process (DS / AHP) to determine the index often right, then build photovoltaic power plants on the impact of positive and negative effects of the distribution network integrated assessment models use correlation analysis.

PV Grid Power Station's Impact on The Distribution Network On-line Monitoring and Assessment Index Calculation

PV grid power plant on-line monitoring system hardware design. Grid-connected PV power generation technology platform for measuring the basic requirements to collect real-time frequency, real-time voltage, current real-time to these three parameters as input parameters platform, through a variety of post-processing algorithms to give various monitoring parameters, the output of photovoltaic power plants. Due to the high amount of sampling and measurement technology platform computing requirements for the realization of the aforementioned monitoring requirements and indicators to consider ways to achieve multi-processor, the hardware architecture design and network overall photovoltaic measurement technology platform shown in Figure 3.2, consists of the following 7 parts:

1) power collection unit: Acquisition 4 voltage and 4 current analog, the ARM7 frequency measurement module calculates the 3-phase voltage and current fundamental phase and 3-phase voltage frequency, while photovoltaic power plant monitoring indicators calculated by the DSP processing module;

2) On the unit: Acquisition of photovoltaic power plants and network feeder switch signal, open into the signal by the signal conditioning circuits and opto-isolation for data transmission processing by the DSP chip;

3) takes the unit: DSP receives ARM9 data management and monitoring unit out of signal, out of the relay output control unit;

4) Temperature measurement unit: a temperature sensor converts the temperature signal into a voltage signal, after processing by the A / D data acquisition and data obtained temperature, and then sends the data to the serial port 485/232 ARM9 data management and monitoring unit;

5) illuminance measurement unit: similar unit and temperature measurement, illuminance measurement unit after the measured light intensity data is also used to send to ARM9 485/232 serial data;

6) ARM9 embedded platform: provide photovoltaic power plant monitoring data reading, data unified management, real-time monitoring of photovoltaic power plants evaluation algorithm, complete interactive device, data communication function;

7) CPLD / FPGA interface conversion unit: consider not compatible with ARM9 embedded DSP platform communication interface using CPLD / FPGA as an interface converter, CPLD / FPGA and DSP combination can improve the efficiency of the algorithm is suitable for real-time signal processing

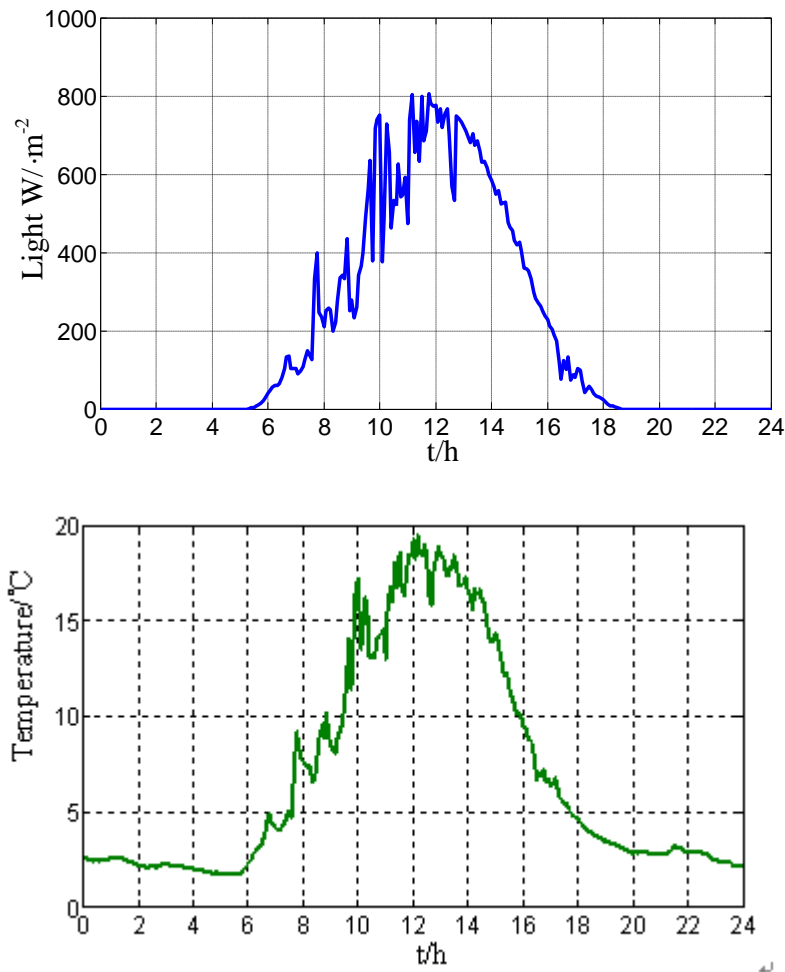


Fig. 1 Light intensity and temperature of PV power station

Comprehensive assessment of the positive and negative effects on the distribution network photovoltaic effects

Weight vectors determined to be an important part of photovoltaic grid power station on a comprehensive assessment of the impact of the distribution network, mainly by using AHP expert or decision-makers for each sub-index pairwise comparison judgment matrix is formed layer by layer, and then by hierarchy single sort, total consistency check and hierarchical ordering finalized constant weighting coefficient; AHP in order to reduce the amount of calculation, scholars have proposed order relation analysis method (G1 method), the method does not construct the judgment matrix and consistency check on the same level There is no limit the number of indicators and the weight vector has rank preservation. Because of the structure of expert knowledge, judgment level, personal preferences and the complexity of objective things, uncertainties and other factors, experts may only be part of the sub-indicators of the importance of the judge, and DS evidence theory can effectively solve the evaluation based on incomplete information the group decision-making problems [54], therefore, the use of evidence theory with incomplete information group weighting method to determine the constant weight vector.

Evidence-based theory of community empowerment method [55] is the sub-index of different experts or decision makers to judge the information regarded as independent evidence, the basic probability assignment weight adjustment by the expert were synthesized Dempster rule, Comprehensive Weight Evaluation of information Decision community empowerment vector form sub-index, the specific process is as follows: The group of experts or decision ① incomplete evaluation information into evidence information to construct evidence and focal element to calculate the basic probability assignment. Let index set is $X = \{x_1, x_2, \dots, x_n\}$, the evaluation group members

$E = \{e_1, e_2, \dots, e_m\}$, the first expert e_i table according to the following scale evaluation x_j ($j = 1, 2, \dots, p$) of the importance of $f_i(x_j)$.

Tab. 1 Graduation reference

Importance	$f_i(x_j)$	Importance	$f_i(x_j)$
Extremely important	9	Somewhat important	3
Highly important	7	Equally important	1
Obviously important	5	Not Evaluated	0

Information e_i expert judgment $f_i(x_j) \neq x_j$ and recognition framework indicators Θ together constitute evidence of expert e_i focal element, wherein Θ expression as an expert reference e_i incomplete information and that the unknown new evidence has in Q equal opportunities, take $f_i(\Theta)=1$. According to sub-indicators of the importance of expert reviews, allocated by the appropriate formula to calculate the basic probability focal element m_i

$$m_i(x_j) = \frac{f_i(x_j)}{\sum_{j=1}^p f_i(x_j) + f_i(\Theta)}, m_i(\Theta) = \frac{f_i(\Theta)}{\sum_{j=1}^p f_i(x_j) + f_i(\Theta)} \quad (1)$$

Similarity index between the expert and the position of the weight vector applied by the expert relative weights, basic probability relative weights to adjust the use of expert evidence allocation. Evaluation of the importance of the expert members of the same information does not correspond to the evidence to support the strength is different, experts should be introduced relative weights ω_i expert e_i basic probability assignment m_i adjusted to obtain basic probability assignment m'_i

$$m'_i(x_j) = \frac{\omega_i m_i(x_j)}{\sum_{j=1}^p \omega_i m_i(x_j) + m_i(\Theta)}, m'_i(\Theta) = \frac{m_i(\Theta)}{\sum_{j=1}^p \omega_i m_i(x_j) + m_i(\Theta)} \quad (2)$$

According to expert personal judgment information and community input to determine how close the relative weights of experts, for groups of expert opinion closer to giving greater weight. Due to the importance of the degree of similarity of views between the experts do not affect, and therefore the use of basic probability assignment before adjustment similarity similarity, experts α and β computing expert among experts as among.

$$c_{\alpha\beta} = 1 - \sqrt{\frac{1}{2} \left[\sum_{j=1}^p (m_\alpha(x_j) - m_\beta(x_j))^2 + \frac{p-2}{p} (m_\alpha(\Theta) - m_\beta(\Theta))^2 \right]} \quad \alpha, \beta = 1, 2, \dots, t \quad (3)$$

Dempster rules apply basic probability assignment synthesis expert group, the expert group on synthetic weighting vector. Because experts focal element contains only $f_i(x_j) \neq x_j$ and recognition framework indicators Q 0 can be derived synthetic basic probability expert group was assigned as

$$m'_{1-t}(x_j) = \frac{1}{K} \left[\prod_{i=1}^t (m'_i(x_j) + m'_i(\Theta)) - \prod_{i=1}^t m'_i(\Theta) \right] \quad j = 1, 2, \dots, p$$

$$m'_{1-t}(\Theta) = \frac{1}{K} \prod_{i=1}^t m'_i(\Theta)$$

$$K = \sum_{j=1}^p \left[\prod_{i=1}^t (m'_i(x_j) + m'_i(\Theta)) \right] - (p-1) \prod_{i=1}^t m'_i(\Theta) \quad (4)$$

This could be a function of have to trust each focal element x_j and the likelihood function composition confidence interval $[m'_{1-t}(x_j), m'_{1-t}(x_j) + m'_{1-t}(\Theta)]$, according to Smets gambling

probability based decision rules that are consistent with the probability of identifying frame Θ elements appear, calculate expert group Integrated weights

$$\omega_j = m'_{1-t}(x_j) + \frac{1}{N} m'_{1-t}(\Theta) \quad (5)$$

Thereby calculate the level of the index system weight vector a set of indicators index to its upper right, from the bottom layer by layer weights weighted index of the target to get the lowest layer of the overall constant weight vector.

Conclusions

Based on a comprehensive analysis of the measured data with the impact of photovoltaic power plants access to the grid, photovoltaic power plants constructed considering the impact of positive and negative effects on the distribution network indicator system and assessment model, the main results are analysis of the operating characteristics of centralized and distributed large and small-scale photovoltaic power generation systems, and photovoltaic power stations incorporated into the distribution network access. Measured data network utilizing photovoltaic power stations, the steady-state voltage deviation from the terms of the feeder, voltage fluctuations and flicker, harmonics and other frequencies and systematically analyze the impact of the distribution network of photovoltaic power plants. Grid-connected PV simulation examples when combined analysis of different power station power fluctuations caused by the penetration ratio of the grid frequency fluctuations, as well as the asymmetric distribution network failures of the PV inverter generated additional harmonic currents.

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