ANALYSIS OF FLUCTUATION CHARACTERISTICS OF PV SYSTEM ACCORDING TO THE ARRAY CONFIGURATION

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ABSTRACT

Short time fluctuations of solar irradiance will become an important issue with regard to future embedded photovoltaic (PV) systems. However, when a large number of systems introduce in certain area intensively, the output of the systems will be stable by the equalization of irradiance fluctuation. This phenomenon is called "the smoothing effect" by the authors. There are three factors to which the smoothing effect smoothes the fluctuation; number of PV systems, area of installed PV systems, and PV array configuration. In this time, authors report on result of analyzing the fluctuation characteristics of each array configuration.

1. INTRODUCTION

An output of PV systems has a short-term fluctuation due to weather fluctuation. It may give undesirable effects on an individual power system, and it makes the capacity value (kW value) of the PV system lower. For resolution of those problems, authors have studied "the smoothing effect [1]" which is smoothed total irradiance in the area. The purpose of this study is quantification of the smoothing effect [2], [3], [4]. Therefore, authors developed an evaluation method of fluctuation of PV output. There are three factors to which the smoothing effect smoothes the fluctuation; number of PV systems, area of installed PV systems, and PV array configuration. In this paper, fluctuation characteristics of PV system according to the array configuration are analyzed by using this evaluation method. Especially, the result concerning short-term fluctuation is described.

2. APPROACH

2.1 FLUCTUATION ANALYSIS METHOD [4]

In an evaluation of fluctuation characteristics of PV output, it is necessary to know the relation between speed of fluctuation and magnitude of fluctuation.

Then, analytical data is prepared in the beginning, and the power spectrum (PS) is calculated from this data by using the Wavelet transform. "Haar" has been chosen as a wavelet function. Next, the peak of PS is detected for each range of fluctuation time. An evaluation window is prepared centering on the peak of PS as shown in Fig. 1, and the difference between the maximum value and minimum value in the window is calculated. This difference is defined as Maximum Magnitude of the Fluctuation (MMF). MMF shows the biggest magnitude of fluctuation during a day for each range of fluctuation time. In other words, this is the worst case in the fluctuation. MMF is calculated from every hour in this time though MMF is originally obtained from a whole day. Because there is a possibility that the detection time of MMF is different depending on the array configuration.

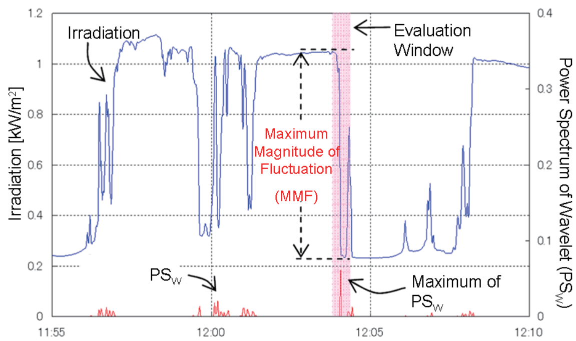

Fig. 1 Calculation image of MMF.

2.2 ANALYSIS CONDITION

An analytical period is from 1st May 2007 to 4th June 2007. Among these, 30days that was able to be analyzed was used. The data used for the analysis is PV array output (normalized by PV array capacity) measured every second. The array configuration of the analytical object is single array oriented east (I), single array oriented south (II), and single array oriented west (III) as shown in Table I.

Table I. Array configuration of PV systems used for the analysis.

System No.	Azimuth [deg]	Tilt angle [deg]
I	-85 (East)	26.57
II	0 (South)	26.57
III	84 (West)	45

3. ANALYSIS RESULT

Analysis results of from two to four seconds fluctuation time are shown in Fig. 2, 3, 4 with box-whisker chart. 30days results are plotted in one box.

The lower boundary of the box indicates the 25th percentile, a line within the box marks the median, and the upper boundary of the box indicates the 75th percentile. Whiskers above and below the box indicate the 90th and 10th percentiles respectively. Black points indicate outlier. 50% of all data is included in the box.

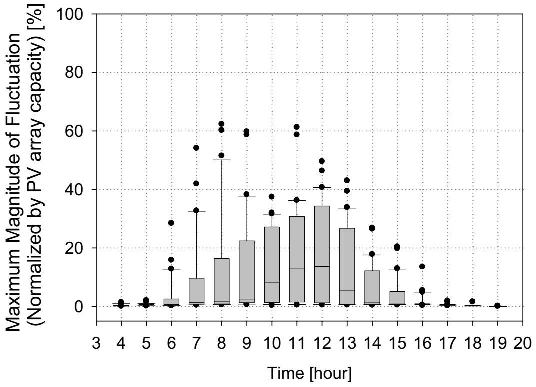

Fig. 2 MMF of System I (single array oriented east) of from two to four seconds fluctuation time.

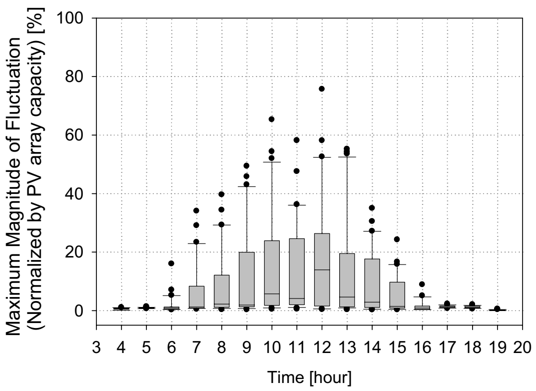

Fig. 3 MMF of System II (single array oriented south) of from two to four seconds fluctuation time.

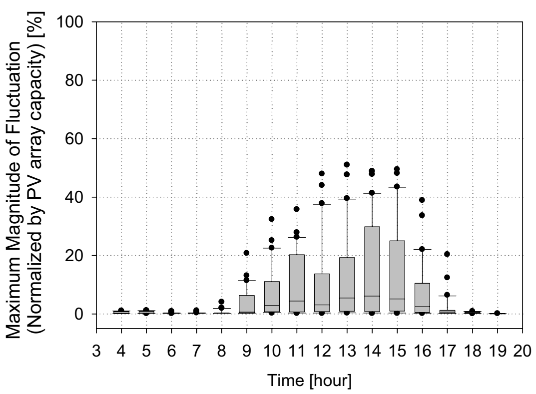

Fig. 4 MMF of System III (single array oriented west) of from two to four seconds fluctuation time.

From these analysis results, the detection time of maximum of MMF for above outlier is different depending on the array configuration; System I is eight, System II is noon, and System III is fifteen. If the azimuth of the PV array is different, it is known that the peak of the power generation electric power of PV system shifts; especially, this is about long-term fluctuation. According to this analysis, it was clarified to the short-term fluctuation that the MMF and time zone were different depending on the array configuration. This means that fluctuation is large near the peak of PV output.

4. CONCLUSIONS

MMF every one hour was calculated by applying the evaluation method that authors had developed. Then, fluctuation characteristics of PV system according to the array configuration for a short-term fluctuation were analyzed, and these features were understood.

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