Encompassing Monte Carlo Estimator with fair division method in determination of best suited methods in photovoltaic systems under partial shading condition

HELENCATHERINE[1], SOUNDARRAJAN[2]
DrMCET[1],PSG college of technology[2], Coimbatore
R L JOSEPHINE[3],
NIT, Trichy
c.catherineclement@gmail.com

Abstract

Solar photovoltaic system is an emerging technology for renewable power source, but some natural and undesirable changes like shadows of tower, trees, buildings, passing clouds, brings major losses in power. In order to overcome this issue, two different interconnection schemes are studied and compared between each other. Minimum distance Average (MDA) is a method based on clustering algorithm used to improve the power loss for different shading conditions. Fair Division Method (FDM) is yet another method which is found to be efficient in partially shaded conditions. These two methods are examined under four shaded patterns, Short narrow (SN), Short wide (SW), Long narrow (LN), Long wide (LW). The performances of each method are studied and compared using Monte Carlo Estimator (MCE) and the results are presented based on the working of proposed methods.

Keywords:*Photovoltaic (PV); Fair division method (FDM); Minimum distance average method (MDA).*

1. Introduction

Many power plants may exist such as Hydro, thermal and nuclear etc but each has its own drawbacks and depends on the resource in which its presence is unpredictable [1]-[4]. But solar energy is the only system which depends on sunlight that exists forever and it is also periodical [5]-[7]. Moreover, Solar system is eco-friendly and does not cause any pollution and environmental hazard, but this system has a major defects due to partial shading, thus to overcome this defect a method is proposed i.e. Fair Division Method (FDM). The content discussed in this paper is the comparison of the different interconnection between Minimum Distance Average and Fair Division Methods.

The MDA is based on the clustering algorithm [8]-[9].The reconfiguration is done by the clustering concept. The minimum distance panels form clusters and these clusters are connected to the cluster head. The minimum distances between the panels are calculated using the analytical concept and solved with the corresponding mathematical equations. The result from the analysis will give us a matrix of PV array module and along with the clustering concept the shade dispersion occurs and the required output is obtained. Section 2 of this paper deals with the FDM based on the mathematical concept [10]-[11]. In this method, the rows of the respective PV matrix are divided partially with shaded panels. The partial division occurs when all the shaded cells are arranged in ascending order irrespective of their irradiation values and these cells are placed in a 1-D array.The cells are now partially divided for every row of the solar panel by fair division method along with its shade dispersion.Section 3 deals with the complete comparison of the two methods MDA and FDM. For this section of comparison Monte Carlo technique is used. The mean and variance are calculated using various mathematical expressions [12]-[13]. The inputs are fed based on different irradiance value to obtain the expected output, this technique is a discrete uniform distribution concept and it uses the probability density function [14]-[17]. From the calculated variance values they are compared with their performance in all the four cases such as short wide, short narrow, long narrow, long wide. Hence the results of comparisons are presented along with their successful working based on the proposed method to improve the efficiency under partial shading condition.

2. Fair Division Method

FDM is the method of dividing "n" number of shaded cells partially to each row. There are many kinds of fair division methods depending on the nature, criteria of fairness and their preferences from that "Method of Makers" is used to reconfigure the PV array in order to get an efficient output [8], [9]. Hence the partial division of shaded cells occurs by the following Equation (1) and (2).

$$V_i(X_i) \geq 1/n \text{ for all } i \quad (1)$$

For the case of the envy free division,

$$V_i(X_i) \geq V_i(X_i) \text{ For all } i \text{ and } j \quad (2)$$

Where i=j=1, 2, 3, 4, 5, 6

The problem of dividing a set of divisible and homogenous items is called fair resource allocation. This concept is applied in the condition of the solar PV array modules under partial shading condition to enhance the power output. The panels are first arranged in the conventional TCT configuration. Now according to the concept of fair division the shaded panels are partially divided to each row, before that the ascending order arrangement according to their irradiance from the right bottom is done. This method is represented for all the four cases LW, LN, SW, and SN in 6x4 and 6x6 PV configuration.

A. Algorithm

Step 1: Initially the PV module with the normal TCT connection is verified for all the four cases.

Step 2: Check the conditions for the fair division allocation using the Equation (1).

Step 3: “n” is the number of shaded cells and the shaded cells are arranged in a 1-D array to differentiate the other cells in each case.

Step 4: Now arrange the cells in the 1-D array in the ascending order from the right bottom of the PV matrix.

Step 5: The process is repeated for all the four cases SN, SW, LN, and LW.

Step 6: The complete reconfiguration based on fair division allocation and it is compared with the TCT configuration.

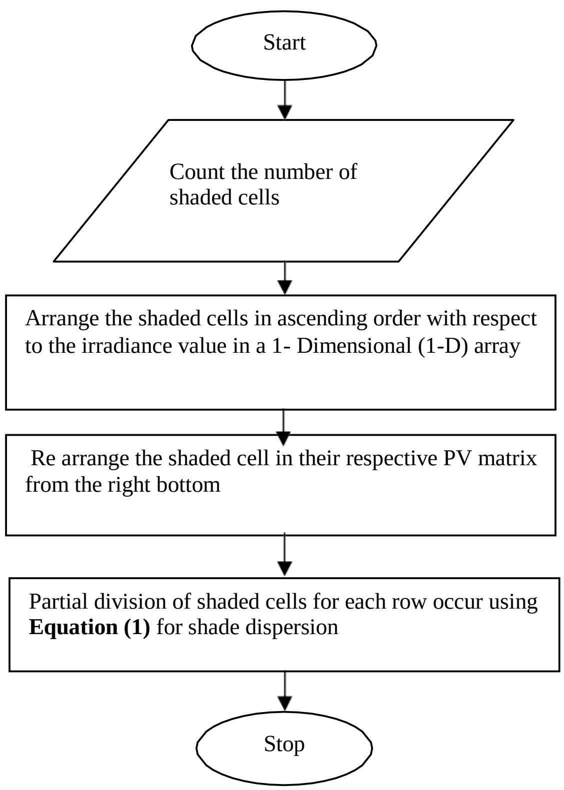

Fig. 1.Flowchart of FDM

B. PV Array module configuration with shade dispersion

This section deals with the array reconfiguration with the help of TCT configuration as shown in Fig 2.(i).the method of fair division i.e. 1-D array representation in Fig. 2.(ii). Fig. 2.(iii) represents the FDM arrangement along with the shade dispersion and Fig. 2.(iv).represents the MDA method with shade dispersion. This is taken for ***6x4 matrices***. In array current equations conventional method represents MDA and after reconfiguration denotes FDM arrangement.

C. Array current equations

Case a: Long Wide (LW)

Under conventional configuration

$I_{R1}=K_1I_1+ K_7I_7 + K_{13}I_{13} + K_{19}I_{19}=2.4I_m$

$I_{R2}=K_2I_2+ K_8I_8 + K_{14}I_{14} + K_{20}I_{20}=3.4I_m$

$I_{R3}=K_3I_3+K_9I_9 + K_{15}I_{15} + K_{21}I_{21}=2.4I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22}=3.0I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23}=2.8I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24}=3.6I_m$

After Reconfiguration

$I_{R1}=K_1I_1+ K_7I_7 + K_{13}I_{13} + K_{19}I_{19}=2.8I_m$

$I_{R2}=K_2I_2+ K_8I_8 + K_{14}I_{14} + K_{20}I_{20}=3.0I_m$

$I_{R3}=K_3I_3+K_9I_9 + K_{15}I_{15} + K_{21}I_{21}=2.8I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22}=3.0I_m$

$I_{R5}=K_5I_5+K_{11}I_{11}+K_{17}I_{17}+K_{23}I_{23}=3.0I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24}=3.0I_m$

Case b: Long Narrow (LN)

Under conventional configuration

$I_{R1}=K_1I_1+ K_7I_7 + K_{13}I_{13} + K_{19}I_{19}=3.2I_m$

$I_{R2}=K_2I_2+ K_8I_8 + K_{14}I_{14} + K_{20}I_{20}=3.4I_m$

$I_{R3}=K_3I_3+K_9I_9 + K_{15}I_{15} + K_{21}I_{21}=3.4I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22}=3.2I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23}=3.2I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24}=3.6I_m$

After Reconfiguration

$I_{R1}=K_1I_1 + K_7I_7 + K_{13}I_{13} + K_{19}I_{19}=3.4I_m$

$I_{R2}=K_2I_2 + K_8I_8 + K_{14}I_{14} + K_{20}I_{20}=3.4I_m$

$I_{R3}=K_3I_3 + K_9I_9 + K_{15}I_{15} + K_{21}I_{21}= 3.4I_m$

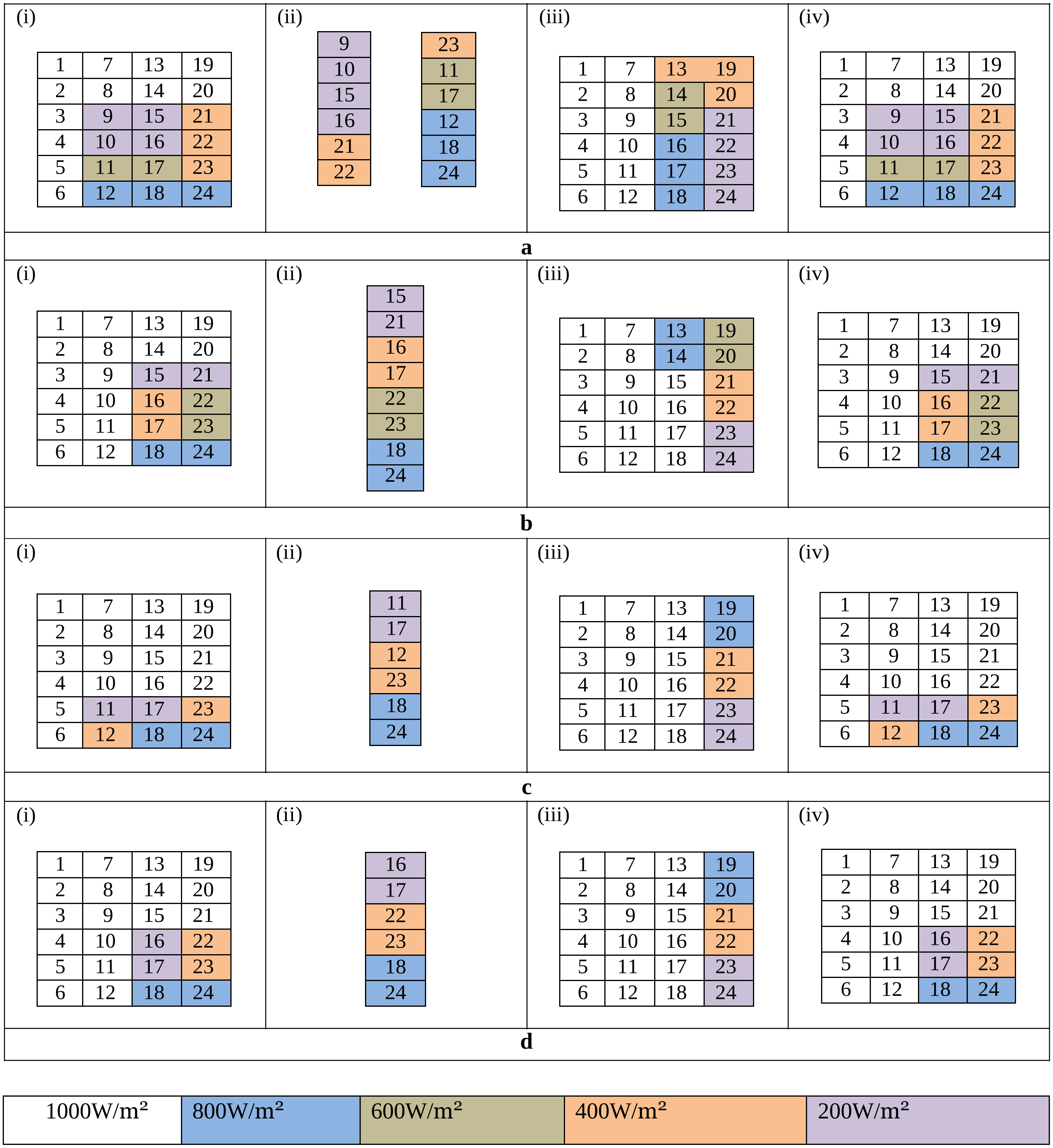

Fig. 2.Shading pattern for 6x4 matrices

Case (a) LW (i) TCT arrangement (ii) 1D array arrangement (iii) FDM arrangement (iv) MDA arrangement with shade dispersion

Case (b) LN (i) TCT arrangement (ii) 1D array arrangement (iii) FDM arrangement (iv) MDA arrangement with shade dispersion

Case (c) SW (i) TCT arrangement (ii) 1D array arrangement (iii) FDM arrangement (iv) MDA arrangement with shade dispersion

Case (d) SN (i) TCT arrangement (ii) 1D array arrangement (iii) FDM arrangement (iv) MDA arrangement with shade dispersion

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22}=3.4I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23} = 3.2I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24}=3.2I_m$

Case c: Short Wide (SW)

Under conventional configuration

$I_{R1}=K_1I_1+ K_7I_7 + K_{13}I_{13} + K_{19}I_{19}=3.2I_m$

$I_{R2}=K_2I_2+ K_8I_8 + K_{14}I_{14} + K_{20}I_{20}=3.4I_m$

$I_{R3}=K_3I_3+ K_9I_9 + K_{15}I_{15} + K_{21}I_{21}=3.2I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22}=3.8I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23}=3.4I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24}=3.8I_m$

After Reconfiguration

$I_{R1}=K_1I_1+ K_7I_7 + K_{13}I_{13} + K_{19}I_{19}=3.8I_m$

$I_{R2}=K_2I_2+ K_8I_8 + K_{14}I_{14} + K_{20}I_{20}=3.8I_m$

$I_{R3}=K_3I_3+ K_9I_9 + K_{15}I_{15} + K_{21}I_{21}=3.4I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22}=3.4I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23}=3.2I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24}=3.2I_m$

Case c: Short Narrow (SW)

Under conventional configuration

$I_{R1}=K_1I_1+ K_7I_7 + K_{13}I_{13} + K_{19}I_{19}=3.2I_m$

$I_{R2}=K_2I_2+ K_8I_8 + K_{14}I_{14} + K_{20}I_{20}=3.2I_m$

$I_{R3}=K_3I_3+ K_9I_9 + K_{15}I_{15} + K_{21}I_{21}=3.4I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22}=3.8I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23}=3.4I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24}=3.8I_m$

After Reconfiguration

$I_{R1}=K_1I_1+ K_7I_7 + K_{13}I_{13} + K_{19}I_{19}=3.8I_m$

$I_{R2}=K_2I_2+ K_8I_8 + K_{14}I_{14} + K_{20}I_{20}=3.8I_m$

$I_{R3}=K_3I_3+ K_9I_9 + K_{15}I_{15} + K_{21}I_{21}=3.4I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22}=3.4I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23}=3.2I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24}=3.2I_m$

D. PV Array module configuration with shade dispersion

This section deals with the array reconfiguration with the help of TCT configuration as shown in Fig 3. (i).the method of fair division i.e. 1-D array representation in Fig 3. (ii). Fig 3. (iii). represents the FDM arrangement along with the shade dispersion and Fig 3. (iv).represents the MDA method with shade dispersion. This is taken for ***6x6 matrices***. In array current equations conventional method represents MDA and after reconfiguration denotes FDM arrangement.

E. Array current equations

Case a: Long Wide (LW)

Under conventional configuration

$I_{R1}=K_1I_1 +K_7I_7 + K_{13}I_{13} + K_{19}I_{19} + K_{25}I_{25}+K_{31}I_{31}=4.4I_m$

$I_{R2}=K_2I_2 + K_8I_8 + K_{14}I_{14} + K_{20}I_{20} + K_{26}I_{26}+K_{32}I_{32}=5.2I_m$

$I_{R3}=K_3I_3 + K_9I_9 + K_{15}I_{15} + K_{21}I_{21} + K_{27}I_{27}+K_{33}I_{33}=3.8I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22} + K_{28}I_{28}+K_{34}I_{34}=4.0I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23} + K_{29}I_{29}+K_{35}I_{35}=4.6I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24} + K_{30}I_{30}+K_{36}I_{36}=5.4I_m$

After Reconfiguration

$I_{R1}=K_1I_1 + K_7I_7 + K_{13}I_{13} + K_{19}I_{19} + K_{25}I_{25}+K_{31}I_{31}=4.4I_m$

$I_{R2}=K_2I_2 + K_8I_8 + K_{14}I_{14} + K_{20}I_{20} + K_{26}I_{26}+K_{32}I_{32}=4.4I_m$

$I_{R3}=K_3I_3 + K_9I_9 + K_{15}I_{15} + K_{21}I_{21} + K_{27}I_{27}+K_{33}I_{33}=4.4I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22} + K_{28}I_{28}+K_{34}I_{34}=4.6I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23} + K_{29}I_{29}+K_{35}I_{35}=4.8I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24} + K_{30}I_{30}+K_{36}I_{36}=4.8I_m$

Case b: Long Narrow (LN)

Under conventional configuration

$I_{R1}=K_1I_1 +K_7I_7 + K_{13}I_{13} + K_{19}I_{19} + K_{25}I_{25}+K_{31}I_{31}=4.4I_m$

$I_{R2}=K_2I_2 + K_8I_8 + K_{14}I_{14} + K_{20}I_{20} + K_{26}I_{26}+K_{32}I_{32}=4.4I_m$

$I_{R3}=K_3I_3 + K_9I_9 + K_{15}I_{15} + K_{21}I_{21} + K_{27}I_{27}+K_{33}I_{33}=4.8I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22} + K_{28}I_{28}+K_{34}I_{34}=4.6I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23} + K_{29}I_{29}+K_{35}I_{35}=4.6I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24} + K_{30}I_{30}+K_{36}I_{36}=5.4I_m$

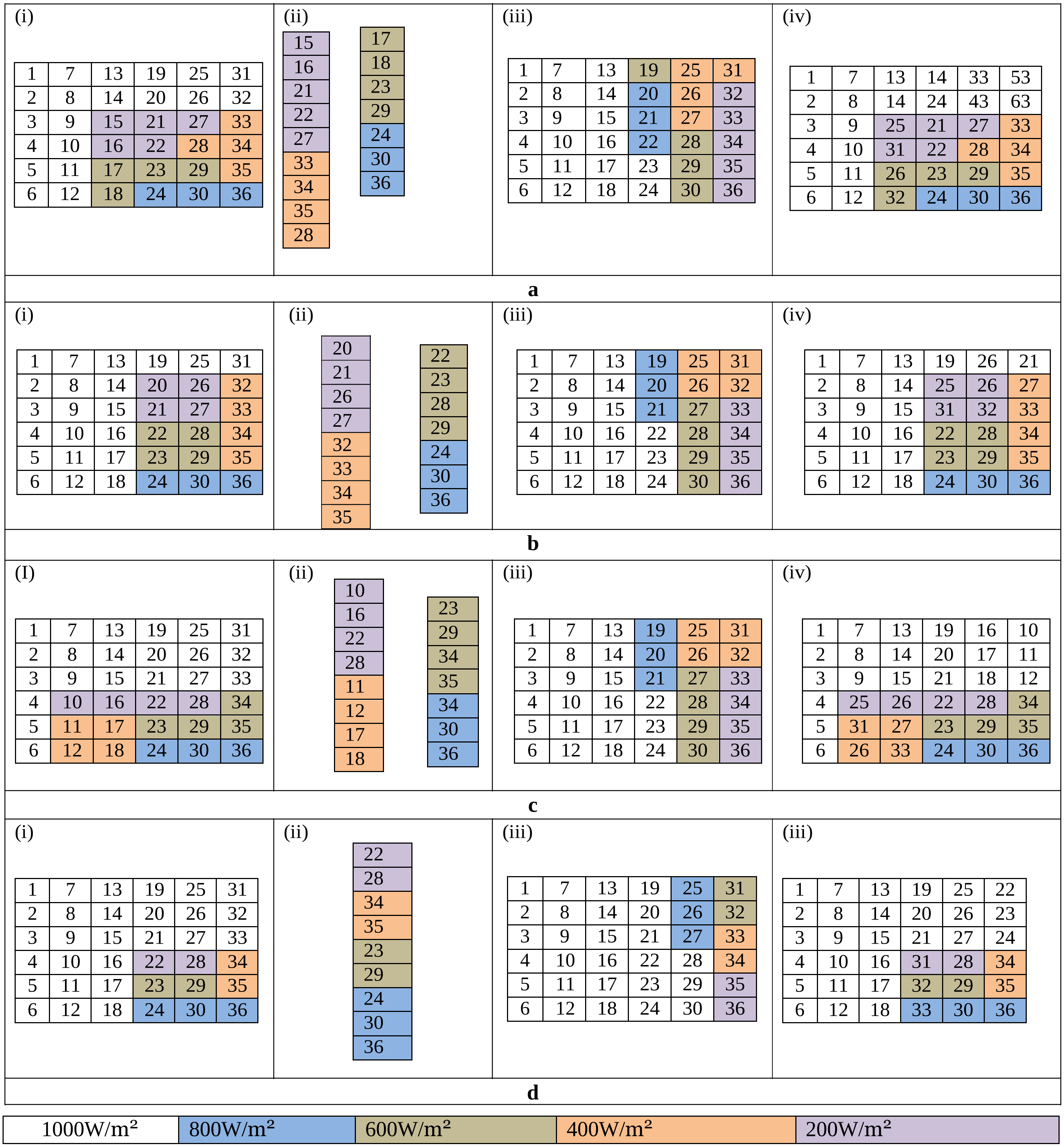

Fig. 3.Shading pattern for 6x6 matrices

Case (a) LW (i) TCT arrangement (ii) 1D array arrangement (iii) FDM arrangement (iv) MDA arrangement with shade dispersion

Case (b) LN (i) TCT arrangement (ii) 1D array arrangement (iii) FDM arrangement (iv) MDA arrangement with shade dispersion

Case (c) SW (i) TCT arrangement (ii) 1D array arrangement (iii) FDM arrangement (iv) MDA arrangement with shade dispersion

Case (d) SN (i) TCT arrangement (ii) 1D array arrangement (iii) FDM arrangement (iv) MDA arrangement with shade dispersion

After Reconfiguration

$I_{R1}=K_1I_1 + K_7I_7 + K_{13}I_{13} + K_{19}I_{19} + K_{25}I_{25}+K_{31}I_{31}=4.6I_m$

$I_{R2}=K_2I_2 + K_8I_8 + K_{14}I_{14} + K_{20}I_{20} + K_{26}I_{26}+K_{32}I_{32}=4.6I_m$

$I_{R3}=K_3I_3 + K_9I_9 + K_{15}I_{15} + K_{21}I_{21} + K_{27}I_{27}+K_{33}I_{33}=4.6I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22} + K_{28}I_{28}+K_{34}I_{34}=4.8I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23} + K_{29}I_{29}+K_{35}I_{35}=4.8I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24} + K_{30}I_{30}+K_{36}I_{36}=4.8I_m$

Case c: Short Wide (SW)

Under conventional configuration

$I_{R1}=K_1I_1 +K_7I_7 + K_{13}I_{13} + K_{19}I_{19} + K_{25}I_{25}+K_{31}I_{31}=4.6I_m$

$I_{R2}=K_2I_2 + K_8I_8 + K_{14}I_{14} + K_{20}I_{20} + K_{26}I_{26}+K_{32}I_{32}=4.6I_m$

$I_{R3}=K_3I_3 + K_9I_9 + K_{15}I_{15} + K_{21}I_{21} + K_{27}I_{27}+K_{33}I_{33}=4.8I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22} + K_{28}I_{28}+K_{34}I_{34}=4.0I_m$

$I_{R5}=K_5I_5+K_{11}I_{11}+K_{17}I_{17}+K_{23}I_{23}+K_{29}I_{29}+K_{35}I_{35}=4.8I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24} + K_{30}I_{30}+K_{36}I_{36}=5.4I_m$

After Reconfiguration

$I_{R1}=K_1I_1 + K_7I_7 + K_{13}I_{13} + K_{19}I_{19} + K_{25}I_{25}+K_{31}I_{31}=4.6I_m$

$I_{R2}=K_2I_2 + K_8I_8 + K_{14}I_{14} + K_{20}I_{20} + K_{26}I_{26}+K_{32}I_{32}=4.6I_m$

$I_{R3}=K_3I_3 + K_9I_9 + K_{15}I_{15} + K_{21}I_{21} + K_{27}I_{27}+K_{33}I_{33}=4.6I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22} + K_{28}I_{28}+K_{34}I_{34}=4.8I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23} + K_{29}I_{29}+K_{35}I_{35}=4.8I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24} + K_{30}I_{30}+K_{36}I_{36}=4.8I_m$

Case c: Short Narrow (SW)

Under conventional configuration

$I_{R1}=K_1I_1 + K_7I_7 + K_{13}I_{13} + K_{19}I_{19} + K_{25}I_{25}+K_{31}I_{31}=5.2I_m$

$I_{R2}=K_2I_2 + K_8I_8 + K_{14}I_{14} + K_{20}I_{20} + K_{26}I_{26}+K_{32}I_{32}=5.6I_m$

$I_{R3}=K_3I_3 + K_9I_9 + K_{15}I_{15} + K_{21}I_{21} + K_{27}I_{27}+K_{33}I_{33}=5.8I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22} + K_{28}I_{28}+K_{34}I_{34}=4.6I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23} + K_{29}I_{29}+K_{35}I_{35}=5.0I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24} + K_{30}I_{30}+K_{36}I_{36}=5.6I_m$

After Reconfiguration

$I_{R1}=K_1I_1 + K_7I_7 + K_{13}I_{13} + K_{19}I_{19} + K_{25}I_{25}+K_{31}I_{31}=5.4I_m$

$I_{R2}=K_2I_2 + K_8I_8 + K_{14}I_{14} + K_{20}I_{20} + K_{26}I_{26}+K_{32}I_{32}=5.4I_m$

$I_{R3}=K_3I_3 + K_9I_9 + K_{15}I_{15} + K_{21}I_{21} + K_{27}I_{27}+K_{33}I_{33}=5.2I_m$

$I_{R4}=K_4I_4+K_{10}I_{10} + K_{16}I_{16} + K_{22}I_{22} + K_{28}I_{28}+K_{34}I_{34}=5.4I_m$

$I_{R5}=K_5I_5+K_{11}I_{11} + K_{17}I_{17} + K_{23}I_{23} + K_{29}I_{29}+K_{35}I_{35}=5.2I_m$

$I_{R6}=K_6I_6+K_{12}I_{12} + K_{18}I_{18} + K_{24}I_{24} + K_{30}I_{30}+K_{36}I_{36}=5.2I_m$

Table 1

Comparison of array currents with proposed and conventional algorithm with different case studies for 6x6 matrices.

Cases	Array Currents	
	MDA	FDM
LW	3.8	4.4
LN	4.4	4.6
SW	4.0	4.6
SN	4.6	5.2

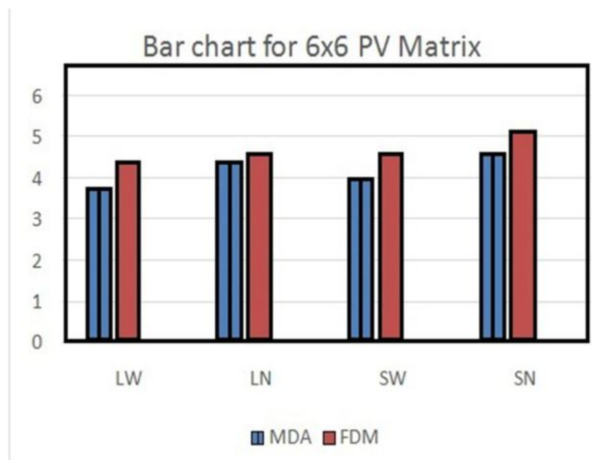

Fig. 4.Bar chart of array current for FDM vs MDA for 6x6 PV matrices.

Table 2

Comparison of array currents with proposed and conventional algorithm with different case studies for 6x4 matrices

Cases	Array Currents	
	MDA	FDM
LW	2.4	2.8
LN	3.2	3.2
SW	3.2	3.2
SN	3.2	3.2

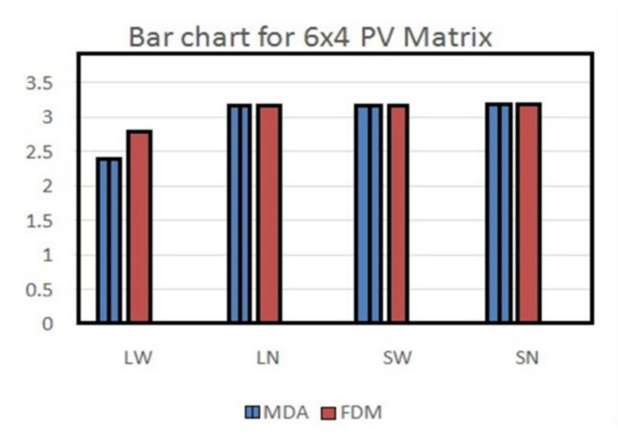

Fig. 5.Bar chart of array current for FDM vs MDA for 6x4 PV matrices.

, 3.Monte Carlo Technique

The Monte Carlo technique is based on the principles of probability and statistics, this method uses random numbers and always gives approximate values but if it is modified with some methods, here we will be using FDM and MDA method, thus, it will improve the approximation. These types of algorithms are useful for solving optimisation problems. This technique provides a useful generic approach to statistical computing. According to this paper this technique is used to compare the performance of MDA and FDM by

$$\mu=1/n\sum_{i=0}^{n} f(Xi) \quad (3)$$

Where μ is called the Monte Carlo Estimator (MCE) of E[f(X)]

F(x) is a sample matrix framed from the array current analysis

N is the number of samples in each matrix

Mean of MCE

$$E[\mu]=1/n\sum_{i=1}^{n} E[f(Xi)] \quad (4)$$

Variance of MCE is V[μ]

$$V[\mu]=1/n^2 \sum_{i=0}^{n} V[f(Xi)] \quad (5)$$

The values of the mean and variance are calculated using (3) and (4) for all the four cases such as SN, SW, LN and LW and the variance values are tabulated in table.

Table 3

Variance of MCE for LW with respect to varying irradiation for 6x6 matrices

Solar Irradiance	LN	
	MDA	FDM
1000	0.0044	0.0018
750	0.0025	0.0008
500	0.0011	0.0004
250	0.0003	0.0001

Table 4

Variance of MCE for LN with respect to varying irradiation for 6x6 matrices

Solar Irradiance	LW	
	MDA	FDM
1000	0.2507	0.0107
750	0.1410	0.0060
500	0.0627	0.0027
250	0.0157	0.0007

Table 5

Variance of MCE for SW with respect to varying irradiation for 6x6 matrices

Solar Irradiance	SW	
	MDA	FDM
1000	0.0124	0.0124
750	0.0070	0.0070
500	0.0031	0.0031
250	0.0008	0.008

Table 6

Variance of MCE for SN with respect to varying irradiation for 6x6 matrices

Solar Irradiance	SN	
	MDA	FDM
1000	0.0124	0.0124
750	0.0070	0.0070
500	0.0031	0.0031
250	0.0008	0.0008

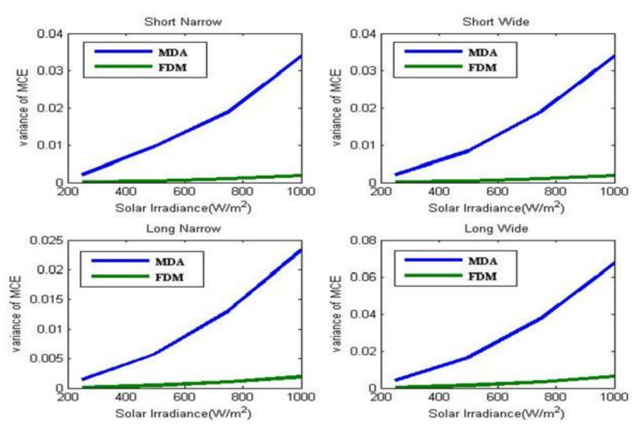

Fig. 6.Variance of MCE with respect to solar irradiance (W/m^2) for 6x6 matrices

Table 7

Variance of MCE for LW with respect to varying irradiation for 6x4 matrices

Solar Irradiance	LW	
	MDA	FDM
1000	0.2507	0.0107
750	0.1410	0.0060
500	0.0627	0.0027
250	0.0157	0.0007

Table 8

Variance of MCE for LN with respect to varying irradiation for 6x4 matrices

Solar Irradiance	LN	
	MDA	FDM
1000	0.0044	0.0018
750	0.0025	0.0008
500	0.0011	0.0004
250	0.0003	0.0001

Table 9

Variance of MCE for SW with respect to varying irradiation for 6x4 matrices

Solar Irradiance	SW	
	MDA	FDM
1000	0.0124	0.0124
750	0.0070	0.0070
500	0.0031	0.0031
250	0.0008	0.0008

Table 10

Variance of MCE for SN with respect to varying irradiation for 6x4 matrices

Solar Irradiance	SN	
	MDA	FDM
1000	0.0124	0.0124
750	0.0070	0.0070
500	0.0031	0.0031
250	0.0008	0.0008

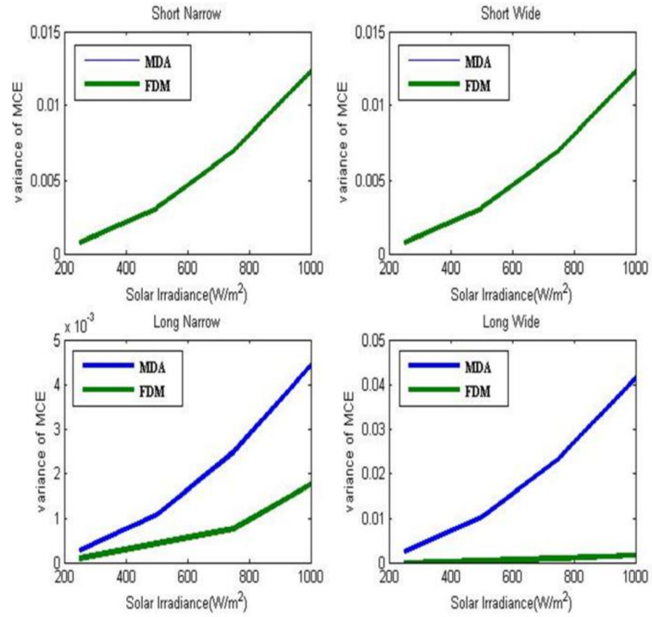

Fig. 7.Variance of MCE with respect to solar irradiance(W/m^2) for 6x4 matrices

Table 3 to 6 and table 7 to 10 gives the variance values for all the four cases such as LW, LN, SW and SN. From the analysis it's clear that in Table 9 & 10, FDM and MDA matches each other in SW and SN cases and in the other two cases (LN and LW) FDM is efficient. Thus, from Fig 6, 7. It is clear that FDM is efficient in almost all the four cases.

4.Conclusion

The performance of FDM and MDA are compared based on two criteria, First the array current is compared for all the four cases such as SN, SW, LN and LW in that array current values of FDM is greater than MDA four cases such as SN, SW, LN and LW in that array current values of FDM is greater than MDA. Secondly, by using Monte Carlo Analysis the variance of the methods are analysed. And according to this analysis method with least variance value has better performance. Hence from the above table it's clear that FDM has least variance value when compared to MDA. Thus the above two criteria justifies that FDM performs better than MDA.

5 References

[1]. Josephine Rathinadurai Louis., SujaShanmugam., KarunabikaGunasekar., *et al*.: 'Effective utilization and efficient maximum power extraction in partially shaded photovoltaic systems using minimum-distance-average based clustering algorithm', *IET Renew. Power Gener.*, 2015., vol.10, no.3, pp. 1-8.

[2]. L.F.L. Villa., D.Picault, B., Raison S, Bacha., A. Labonne.: 'Maximizing the power output of partially shaded photovoltaic plants through optimization of the interconnections among its modules', *IEEE Journal of Photovoltaics*., vol.2, no.2, pp. 154-163, 2012.
M. Z. Shams El-Dein., Kazerani., M. M. A,Salam.:

[3]. M. Z. Shams El-Dein., Kazerani., M. M. A,Salam.: 'Optimal photovoltaic array reconfiguration to reduce partial shading losses', *IEEE Trans. on sustains. Energy*.,vol 4, no 1, pp. 145-153, January 2013.

[4].Patnaik, B., Sharma, P., Trimurthulu, E., Duttagupta, S.P., Agarwal, V.: 'Reconfiguration strategy for optimization solar photovoltaic array under non-uniform illuminationconditions'. Proc. Photovol. Special. Conf. (PVSC), Jun. 19-24, 2011, Vol. 56, pp. 1859-1864.

[5].Velasco-Quesada, G., Guinjoan-Gispert, F., Pique-lopez, R., *et al*.: 'Electrical PV array reconfiguration strategy for energy extraction improvement in grid connected systems', *IEEE Trans. Ind. Electron*., 2009, 56, (11), pp. 4319-4331.

[6].JazayeriMoein., UysalSener., JazayeriKian.: 'Comparative study of different photovoltaic array topologies under Partial Shading Conditions'. IEEE Conference on PES T&D, Chicago, IL USA, 2014, pp. 1-5.

[7].Ibraheem, S Khatoon., Jalil, M.F.: 'Feasibility Analysis of Solar Photovoltaic Array Configurations under Partial Shading Conditions'. IEEE India Conference (INDICON), New Delhi, India, 2015, pp. 1-6.

[8].Kamimura, J., Wakamiya, N., Murata, M.: 'A distributed clustering method for energy-efficient data gathering in sensor networks', *Int. J. Wirel. Mob. Comput.*,2006, 1, (2), pp. 113-120.

[9].Jadidoleslamy, H.: 'A novel clustering algorithm for homogenous and large scale wireless sensor networks: based on sensor nodes deployment coordinates', *Int. J. Comput. Sci. Netw. Secur*, 2014, 14, (2), pp. 97-109.

[10]. Aumann, R., Dombb, Y.: 'The Efficiency of Fair Division with Connected pieces'. 6th International workshop, Stanford University, pp. 26-37, Springer, Verlag, 2011.
of Photovoltaics., vol.2, no.2, pp. 154-163, 2012.

[11]. A, Alkan., G, Demange., D, Gale.: 'Fair allocation of the indivisible goods and criteria of justice', Econometrica, 59, pp. 1023-1039, 1991.

[12]. S.J Brams., A.D Taylor.: 'An Envy free cake Division Algorithm', Journal of Mathematics, pp. 9-18, 1992.

[13]. Rubinstein, R.Y., Dirk, P.: 'Simulation and the Monte Carlo method' (John Wiley & Sons, New York, 2nd edn, 2007.)

[14]. Fishman, G.S.: 'Monte Carlo: concepts, algorithms and application' (Springer-Verlag, New York, 1996, 1st edn.)

[15]. Hammersely, M., Handscomb, D, C.: 'Monte Carlo Methods' (1975, 2ndedn.)

[16]. Doucet., Arnaud., Freitas., Nando de., Gordon, Neil.: 'Sequencial Monte Carlo Methods in Practice' (Springer, 2001.)

[17]. Paul Glasserman.: 'Monte Carlo methods in Financial engineering' (Springer, New York, 2003.)