PERFORMANCE ANALYSIS OF PV PANEL UNDER PARTIAL SHADING CONDITION

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Abstract

Conditions of partial shadowing lessen the charged energy production of PV arrays. The PV modules in this array get different amounts of solar irradiation, and as a result, the arrays show several peaks in P-V and I-V characteristics, leading to mismatch loss involving the PV modules under situations of partial shadowing. It analyses how changing the layout of the photovoltaic solar PV array might increase performance inside it. All tests have been performed burning up to various shades. We evaluate the effectiveness of various array designs utilizing various shading patterns using MATLAB/ Simulink.

The solar panel is the most efficient way to use solar energy and it generates power, but when a shadow falls on the PV panel, its output is reduced and we do not generate or consume as much electricity as we might. The solar panel's output power is decreased by the shadowing situation, which also has an impact on the panel's effectiveness and lifespan. The effect of partial shadowing reduces and maximum power is obtained under partial shading conditions in this article using several PV panel configurations and MPPT.

Keywords: Partial shading, Maximum power point tracking (MPPT), solar panel, PV configuration, converter.

1. INTRODUCTION

The fast rise in population and economic activity in the emerging world is a major contributor to the globe's rising energy consumption. We must expand the power generation from diverse natural resources in order to satisfy the essential energy demand. The primary energy source for producing electricity is fossil fuels, but as these resources become less abundant, so does the amount of energy produced. As a result, renewable energy sources, particularly solar energy, provide significant benefits over other energy sources. By using the photovoltaic effect, the photovoltaic cells in the modules transform solar energy into electrical energy.

Nonrenewable energy sources are limited in quantity and need millions of years to replenish. Renewable energy sources, on the other hand, are the most practical alternative due to their environmental friendliness and low cost. There are several types of renewable energy resources accessible; however, solar energy is the greatest option for developing nations such as India.

To meet the essential energy demand, we must enhance power generation from natural sources. The primary source of power generation is from fossil fuels; but, when fossil fuels become depleted, power generation declines; thus, renewable energy sources, particularly solar energy, provide significant benefits over other sources. Photovoltaic cells in modules use the photovoltaic effect to transform solar energy into electrical energy.

Structure and topologies of Grid connected and standalone systems; fixed PV array configurations array reconfigurations; global maximum power point tracking algorithms; advanced power electronic converter topologies; generation control circuits and current compensation techniques are the various approaches to harvesting the maximum power from PV systems. PV array arrangement is one of the most important factors to harvesting maximum power in centralized topology. Typically, PV modules are arranged with a power electronic converter.

Solar energy adoption is expanding at the domestic, grid-connected, and off-grid levels since it is a renewable energy source that generates clean energy. As solar radiation strikes the panel, a solar cell generates power. The output power of a PV cell is determined by the amount of solar radiation, the temperature of the solar module, and the amount of shadowing on the solar panel. The shading effect is often caused by trees, neighboring buildings, passing clouds, neighbor solar cell shade, and bird droppings, among other things. When this partial shadowing impact is considered on a wide scale, it reduces the effectiveness of the solar module and also deteriorates the health of PV panels, generating hotspots and eventual degradation in the PV structure, rendering it worthless. Partial shading losses are affected not only by partial shading area, but also by partial shading pattern, array arrangement, and bypass diode integration with Modules. Since partial shade causes several MPPTs on the VI and PV characteristics, complicated global maximum power point tracking systems are required to retrieve the maximum power under shading situations. Several strategies are employed to reduce the negative impacts of shading. The bypass diode is a passive technology in which a diode is connected to the solar photovoltaic module to lessen the effect of partial shadowing. During partial shadowing, the diode shields the solar array from local heating, and the overall efficiency of the module is boosted.

A combination of cascaded H-bridge, clamped capacitor, and diode is utilized in multilevel inverter technology to offset the effect of partial shading by obtaining independent voltage control for each module. Voltage strains and ac harmonics that emerge on the output of the solar photovoltaic module can be eliminated utilizing this approach. This technology employs more complex control and optimization techniques to obtain optimal power point.

As previously stated, many strategies used to reduce the effect of partial shade have a number of drawbacks. In this paper, various possible interconnection schemes such as Series(S), Parallel(P), Series Parallel (SP), Total cross tide (TCT), Bridge link (BL), Honeycomb (HC), and Magic square (MS) are analyzed to determine the output power under partial shading conditions, power loss, and the best PV panel configuration for the various partial shading cases. Choose several various shading situations for this analysis in this article.

Methodology:-

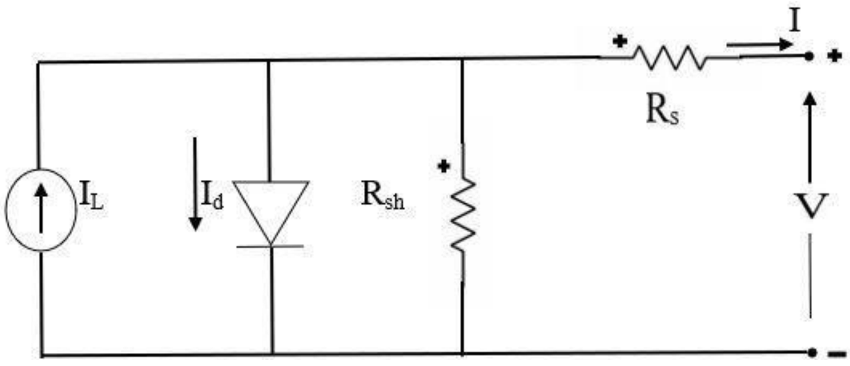
1. Modellingof PVpanel

The photovoltaic solar cell is a device that uses the photovoltaic effect to convert solar energy from the sun into electricity. As sunlight strikes a solar cell, it can be absorbed, reflected, or passed through. Yet only that light creates energy, which is absorbed by the solar cell's surface. When we need to boost their usefulness, we link a large number of individual solar cells together in a sealed and waterproof configuration known as a panel or module. Modules are joined in series and parallel to form a photovoltaic array in order to produce the appropriate current and voltage.

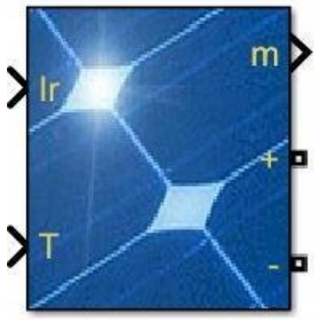
For the building of a photovoltaic cell equivalent circuit, it is required to understand the physical layout of the cell's parts as well as the electrical properties of each cell. The solar photovoltaic cell's single diode equivalent model consists of a current source parallel to the diode and two lumped resistances, parallel resistance, and series resistance.

$$I_d = I_0[\exp\left(\frac{V_d}{V_T}\right) - 1]$$

$$V_T = \frac{KT}{q} * nl * Ncell$$



I_d	Diodecurrent(A)
V_d	Diodevoltage(V)
I_0	Diode saturation current(A)
nI	Diode ideality factor, a number close to 1.0
k	Boltzmann constant=1.3806e-23J.K-1
q	Electron charge =1.6022e-19 C
T	Cell temperature(K)
Ncell	Number of cells connected in series in a module



Parameter	Value
Pmax	249.952 W
V_{oc}	50.93V
I_{sc}	6.2A
V_{mp}	42.8V
I_{mp}	5.84A
Ncell	72

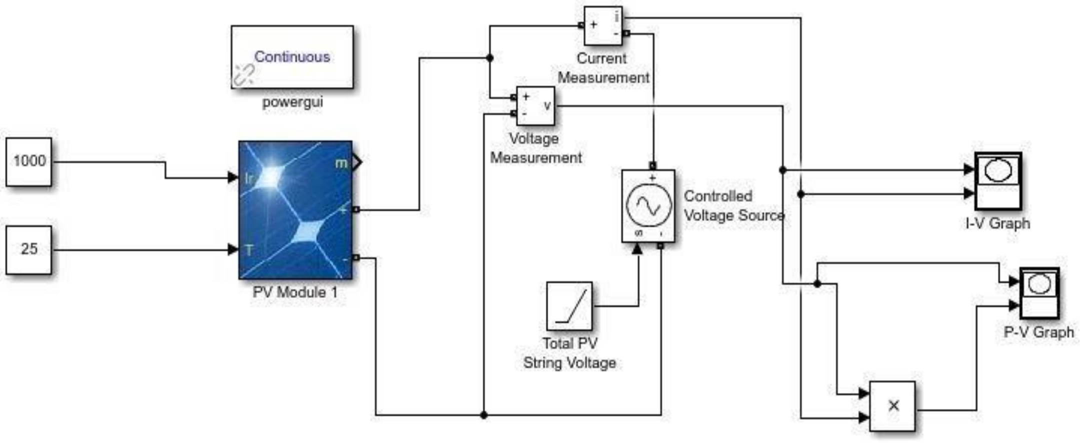


Fig IV graph of generalized Solar
panel.

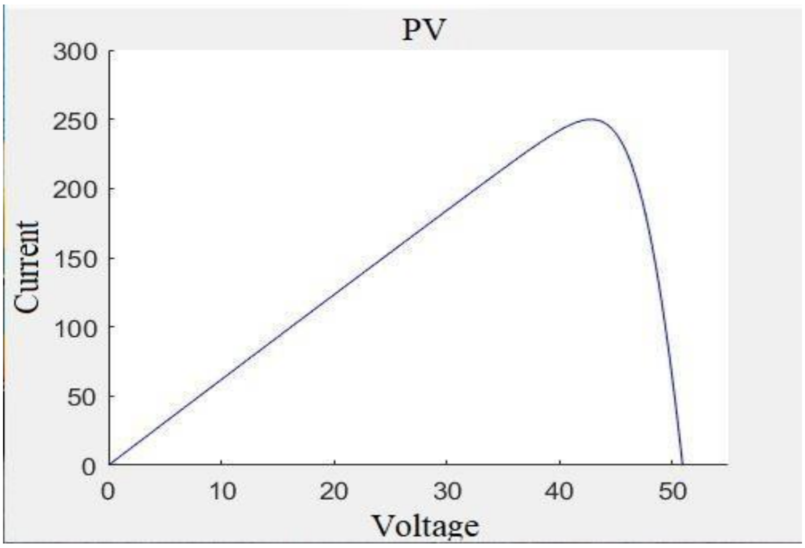


Fig PV graph of generalized Solar panel.

2. Types of Different configuration

The PV panel configuration is the most important for this analysis and in this paper proposed [1],

- Series(S)
- Parallel(P)
- Series Parallel(SP)
- Total Cross Tide(TCT)
- Bridge link (BL)
- Honey comb(HC)
- Magic Square (MS)

- Series(S)

All of the PV modules are linked in series to make a single string. As a result, the total PV array current is equal to the sum of individual PV module currents, and the total PV array voltage is equal to the sum of individual PV module voltages.

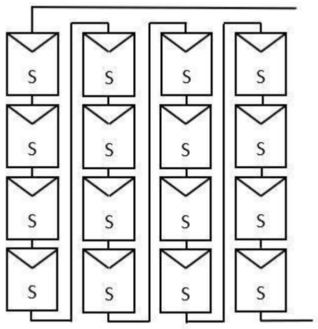


Fig Series (S)

- Series Parallel (SP)

The required output voltage is generated by series connected modules in the array known as strings and to generate required output current by parallel connection of these strings.

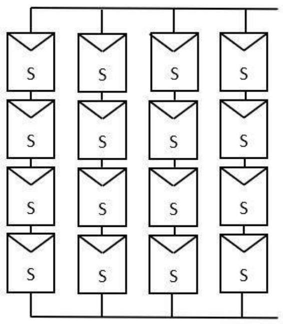


Fig Series Parallel (SP)

- Total Cross Tide (TCT)

In this topology, the output voltage of the arrays sums of the voltages across modules in all the rows of array. The total current of PV array is the sum of currents in the modules in a row of array.

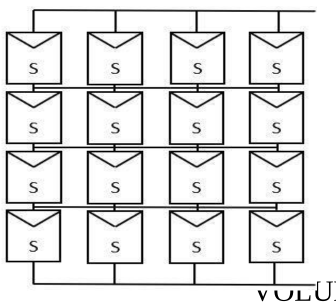


Fig Total cross tide (TCT)

- _ Bridge link (BL)

In this type of topology, all the modules in array are connected in bridge type of architecture. It is obtained from TCT with a benefit of lesser number of ties, less wiring installation time and low cable losses but it adversely affects overall voltage and current under shading conditions.

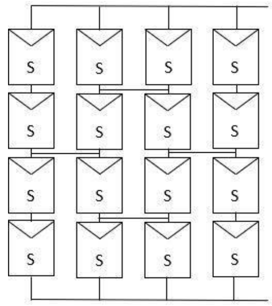


Fig Bridge link (BL)

- Honeycomb (HC)

In this configuration, output power losses can be minimized but it has a limitation that it cannot reduce power losses under all shading conditions. All modules are connected in hexagon shape of architecture.

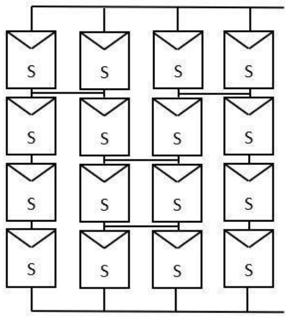


Fig Honeycomb (HC)

- Bridge link (BL)

In this type of topology, all the modules in array are connected in bridge type of architecture. It is obtained from TCT with a benefit of lesser number of ties, less wiring installation time and low cable losses but it adversely affects overall voltage and current under shading conditions.

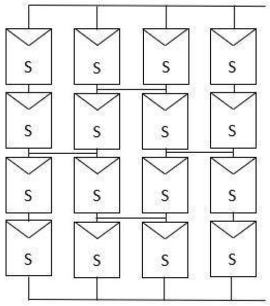


Fig Bridge link (BL)

3. Shading

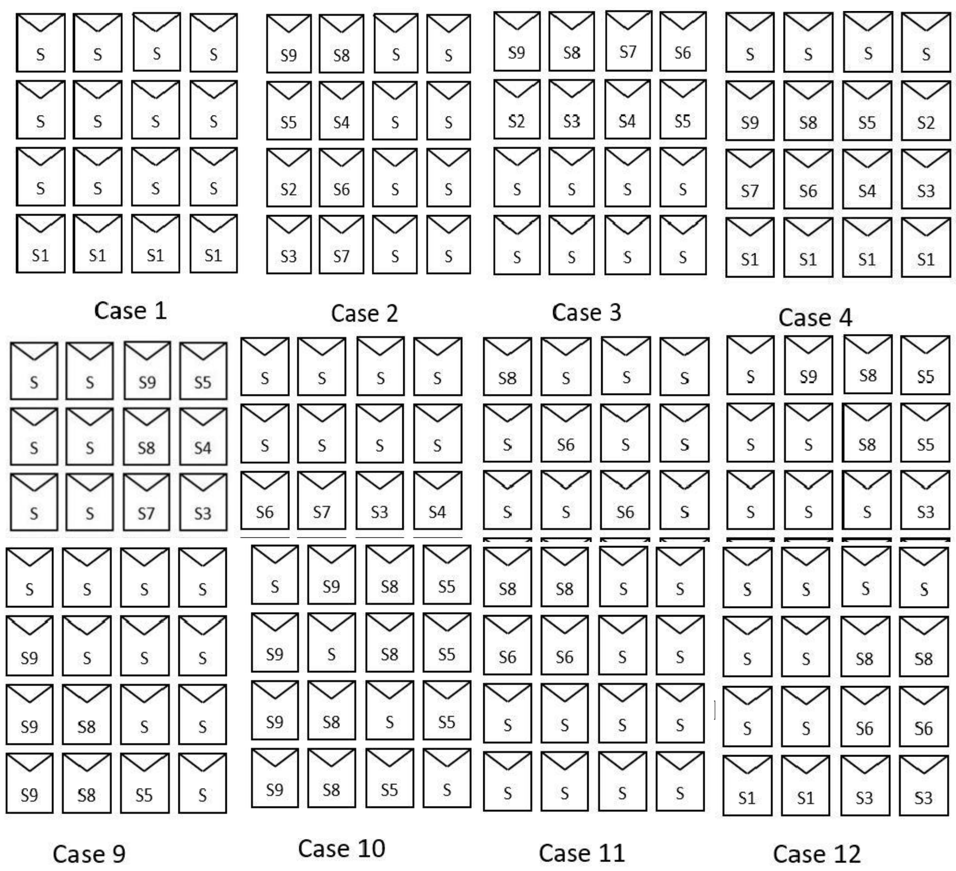
In the partial shading is occurs threw the various shading like, tree shadow, building shadow, bird, moving cloud. For the analysis the various 14 types of partial shading cases are taken.

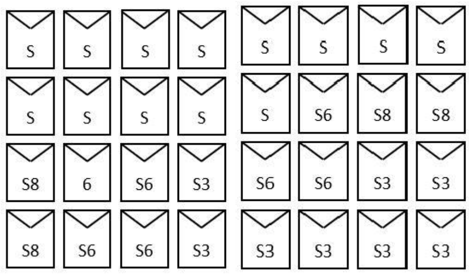
4. Effect of shading

- Reduce power generation from solar panel.
- Mismatch power loss
- Create Hot spot.
- Reduce Efficiency of the PV system

Different cases

Sr no	Case No	Shading name
1	Case1	12and 3RowUnshaded
2	Case2	1and2 Column Shaded
3	Case3	12 Row Shaded
4	Case4	1RowUnshaded
5	Case5	3and4 Column Shaded
6	Case6	3and4 Row Shaded
7	Case7	Diagonal Shaded
8	Case8	Left side off diagonal shaded (LSOD)
9	Case9	Right side off diagonal shaded (RSOD)
10	Case10	Off-diagonal Shaded
11	Case11	Long narrow(LN)
12	Case12	Short narrow(SN)
13	Case13	Long Wide(LW)
14	Case14	Short wide(SW)





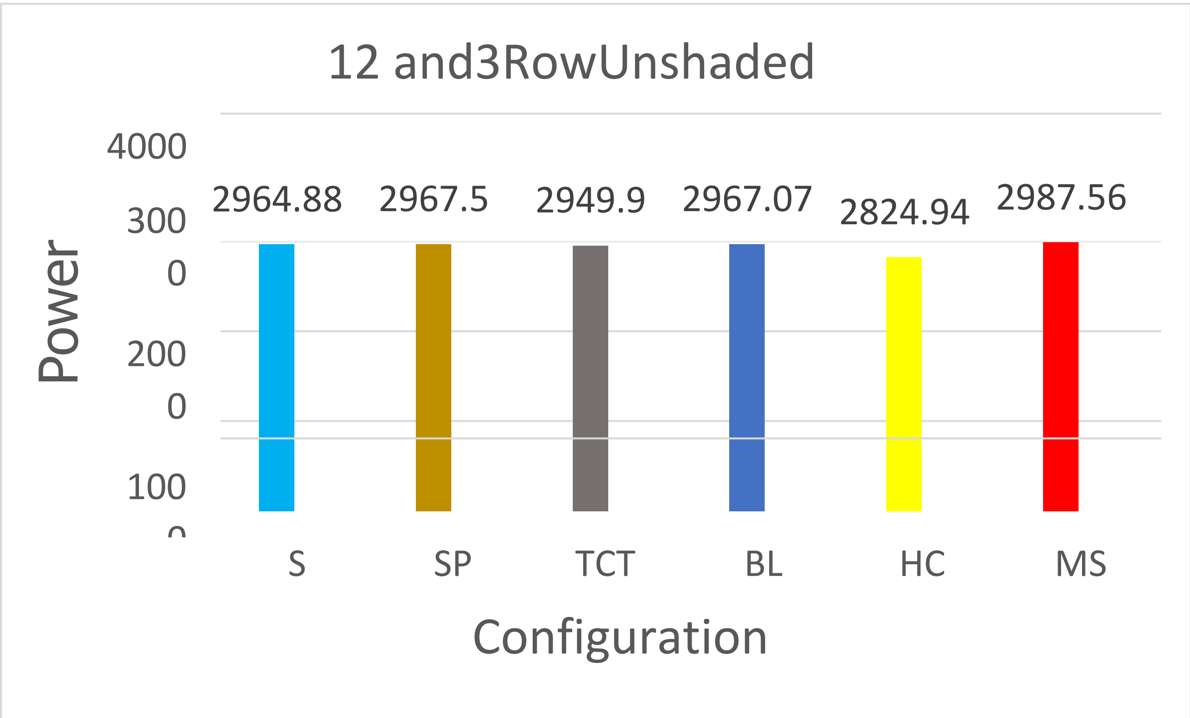
Case 13 Case 14

Intensity w/m^2								
S1	S2	S3	S4	S5	S6	S7	S8	S9
100	200	300	400	500	600	700	800	900

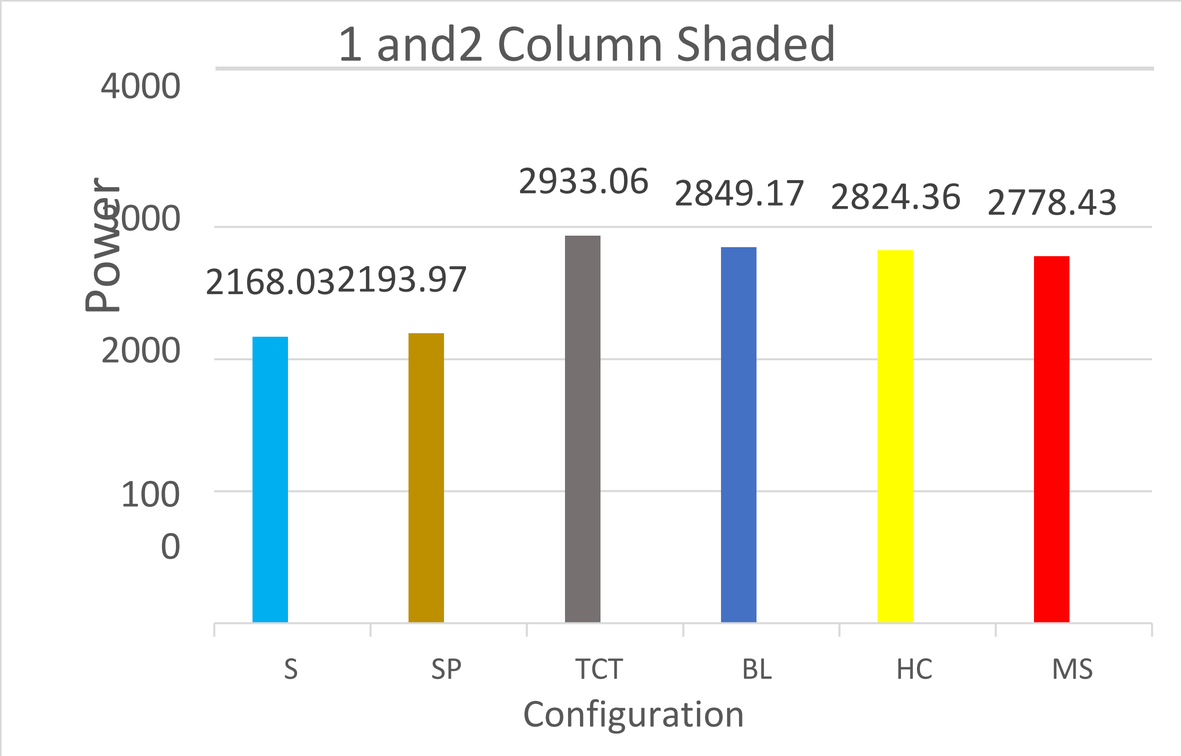
5. Simulation and result:-

1. Different configuration result on different shading

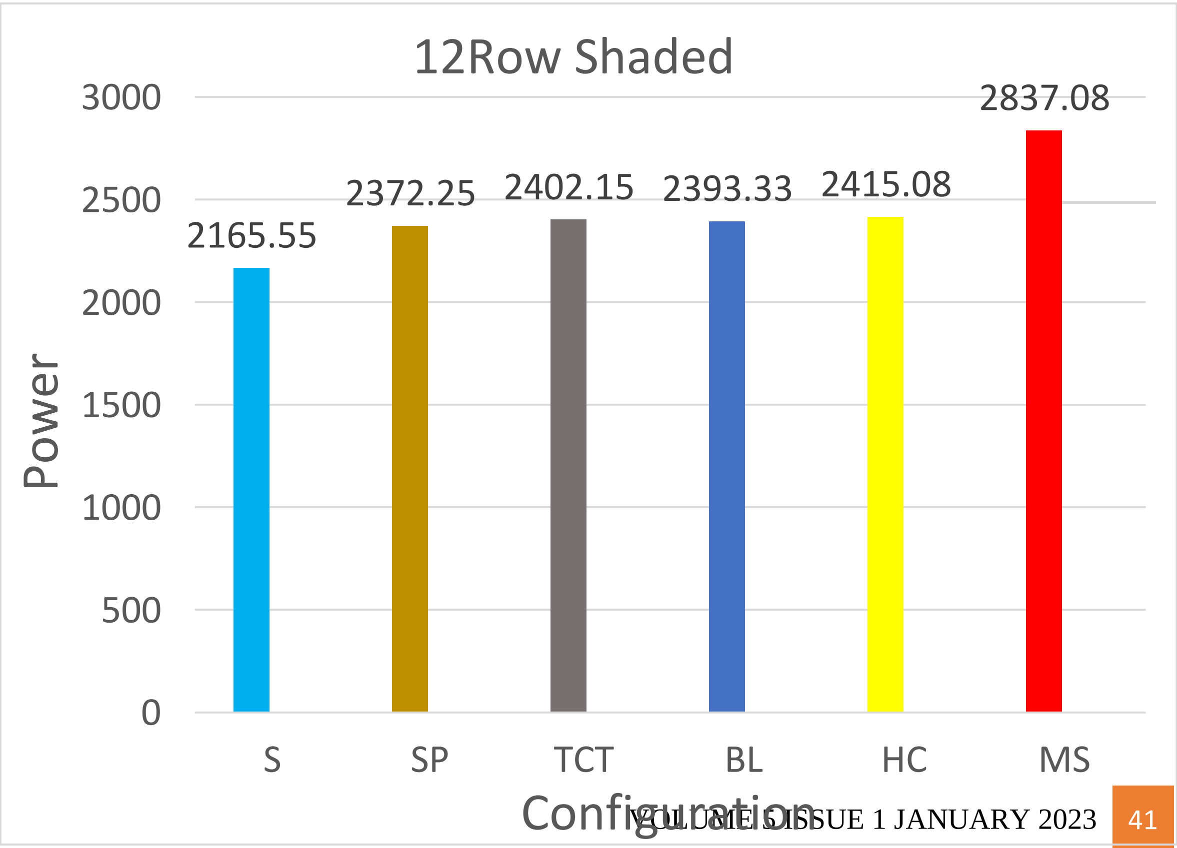
cases**Case1:-**



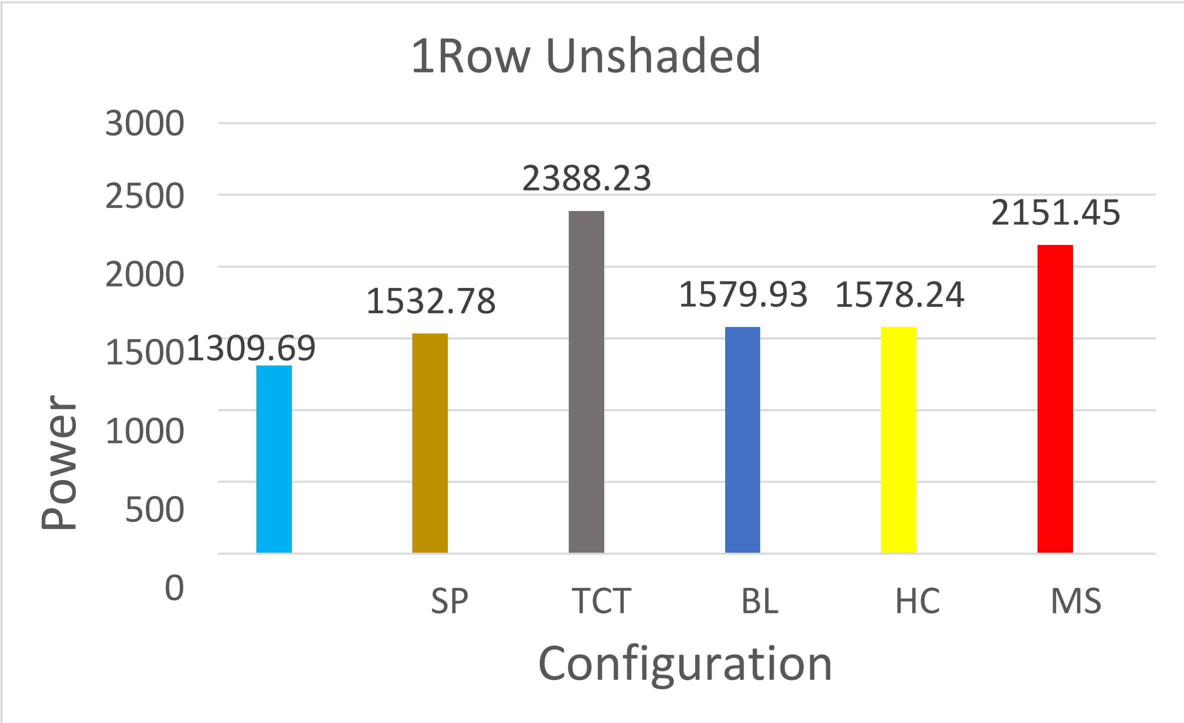
Case2:-


1 and2 Column Shaded
4000
3000
2000
100
0
Power
2168.03
2193.97
2933.06
2849.17
2824.36
2778.43
S
SP
TCT
BL
HC
MS
Configuration

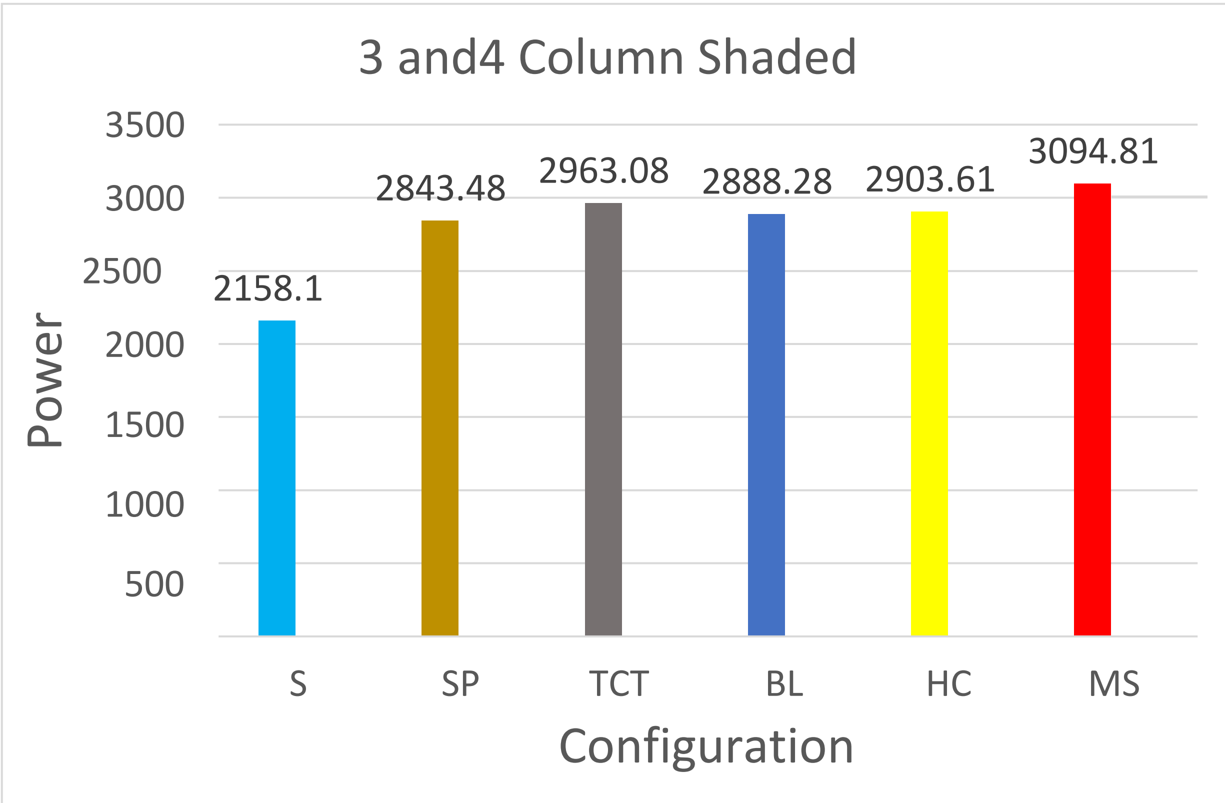
Case3:-


12Row Shaded
3000
2500
2000
1500
1000
500
0
Power
2165.55
2372.25
2402.15
2393.33
2415.08
2837.08
S
SP
TCT
BL
HC
MS
Configuration

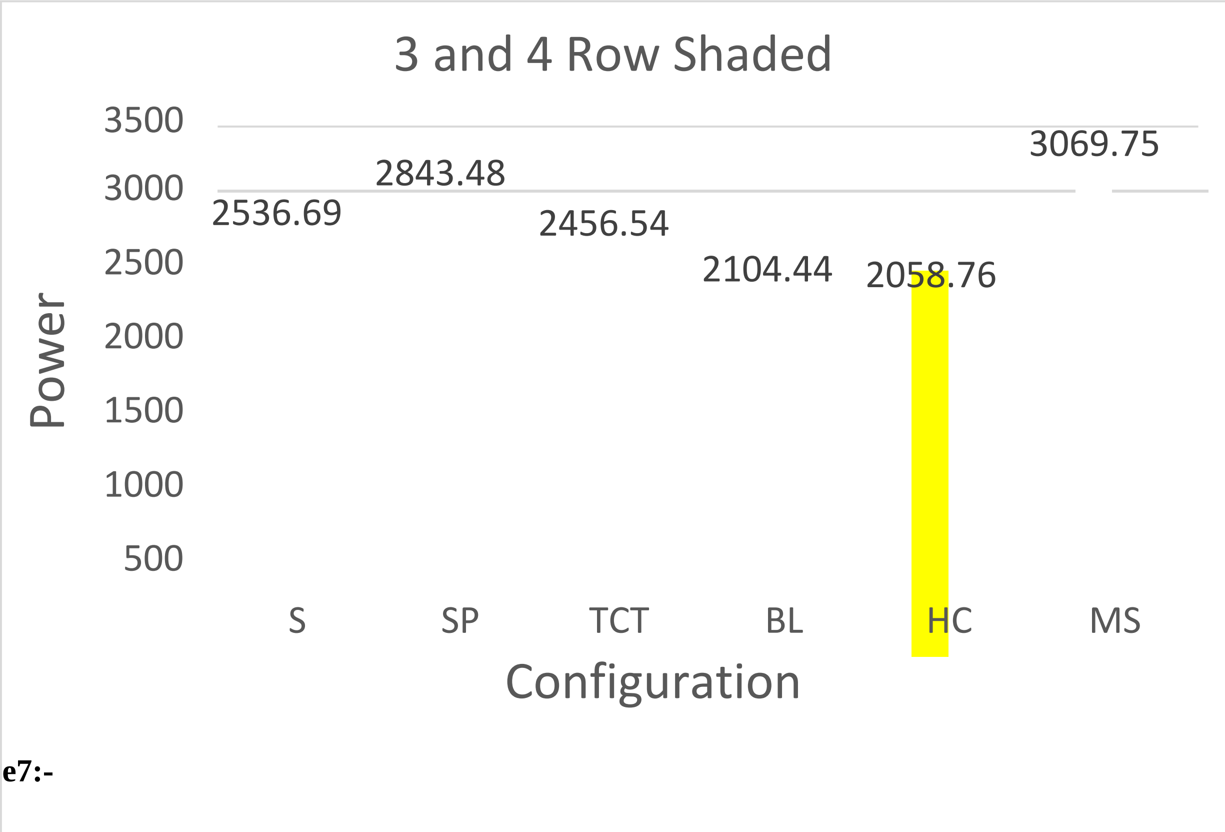
Case4:-


1Row Unshaded
3000
2500
2000
1500
1000
500
0
Power
1309.69
1532.78
2388.23
1579.93
1578.24
2151.45
SP
TCT
BL
HC
MS
Configuration

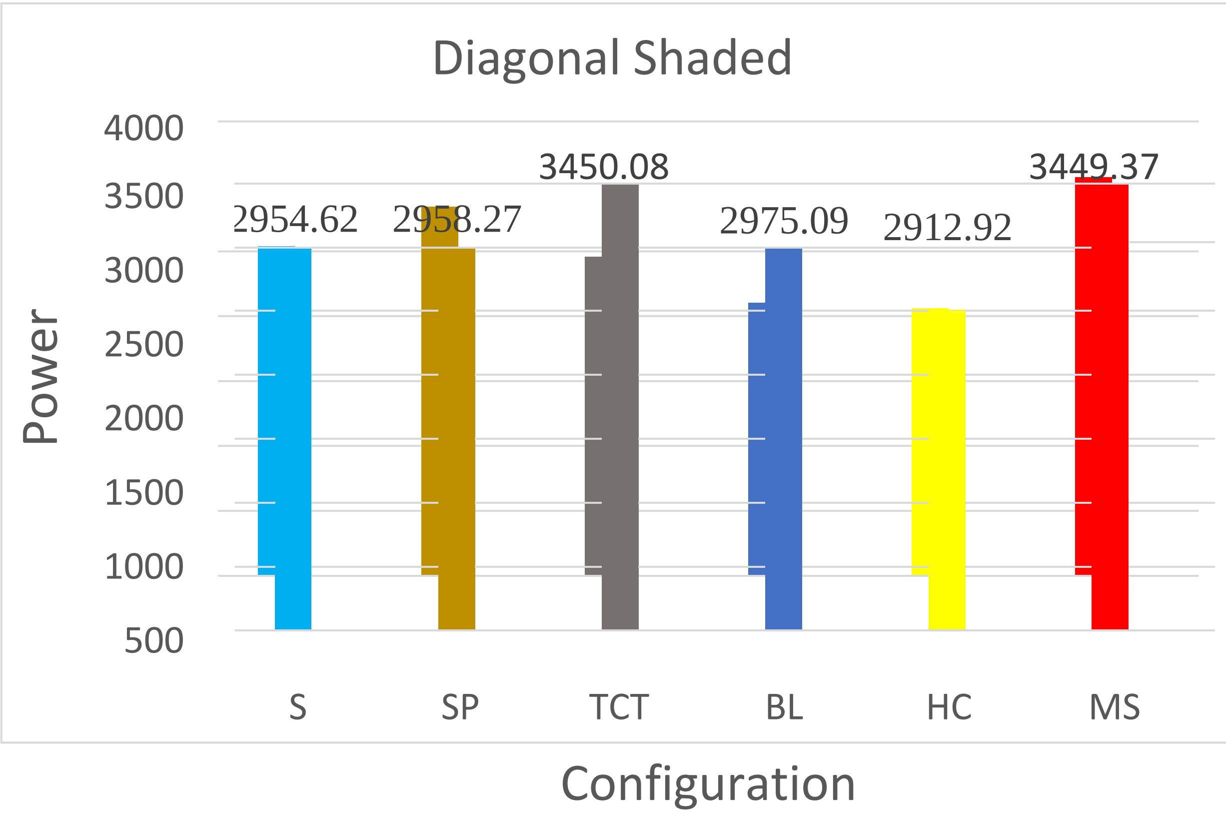
Case5:-


3 and4 Column Shaded
3500
3000
2500
2000
1500
1000
500
Power
2158.1
2843.48
2963.08
2888.28
2903.61
3094.81
S
SP
TCT
BL
HC
MS
Configuration

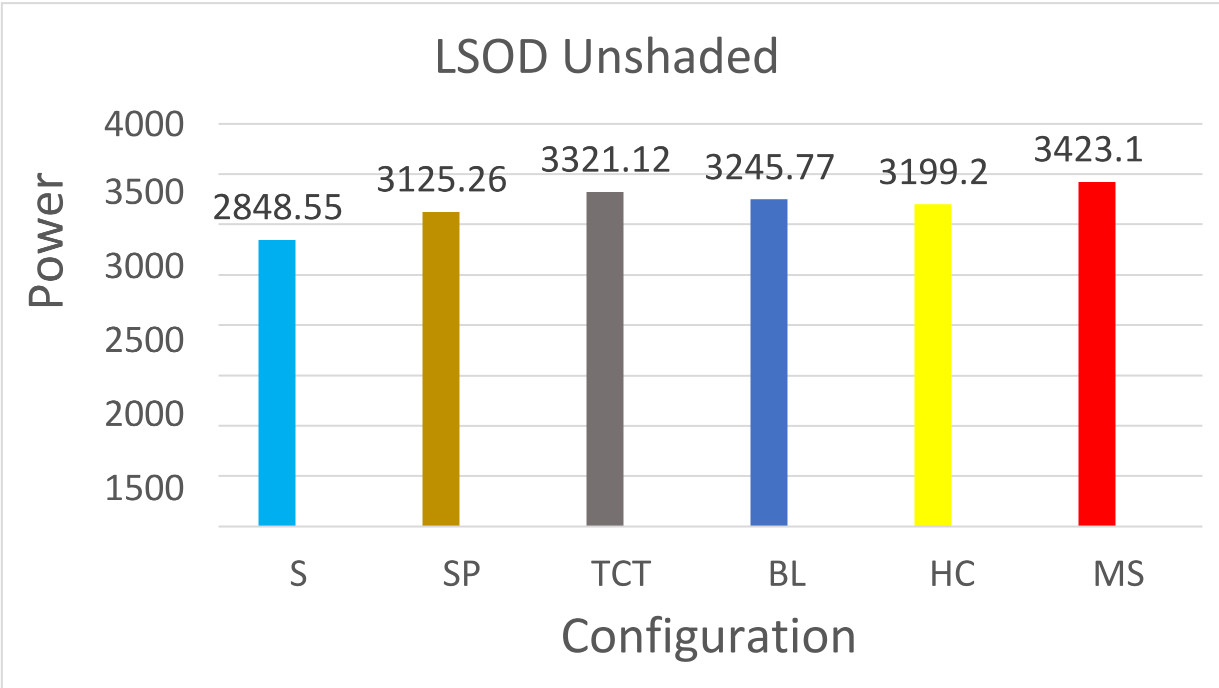
Case6:-


3 and 4 Row Shaded
3500
3000
2500
2000
1500
1000
500
Power
2536.69
2843.48
2456.54
2104.44
2058.76
3069.75
S
SP
TCT
BL
HC
MS
Configuration

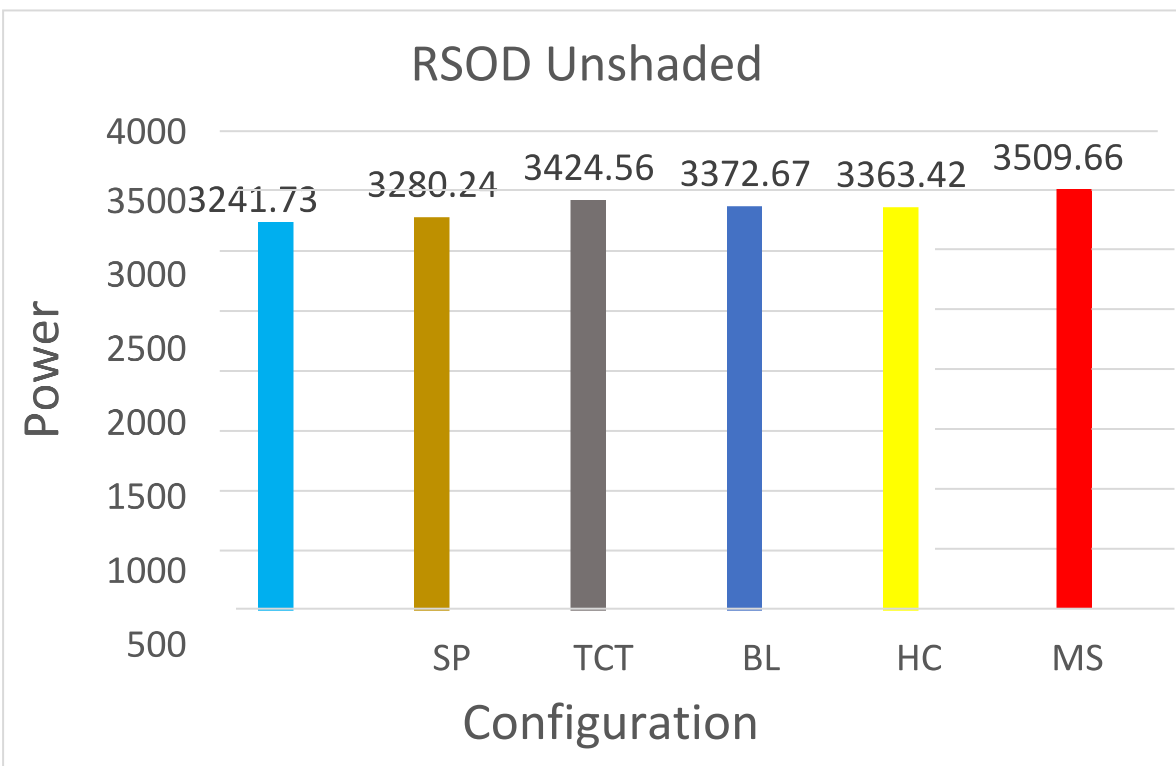
Case7:-


Diagonal Shaded
4000
3500
3000
2500
2000
1500
1000
500
Power
2954.62
2958.27
3450.08
2975.09
2912.92
3449.37
S
SP
TCT
BL
HC
MS
Configuration

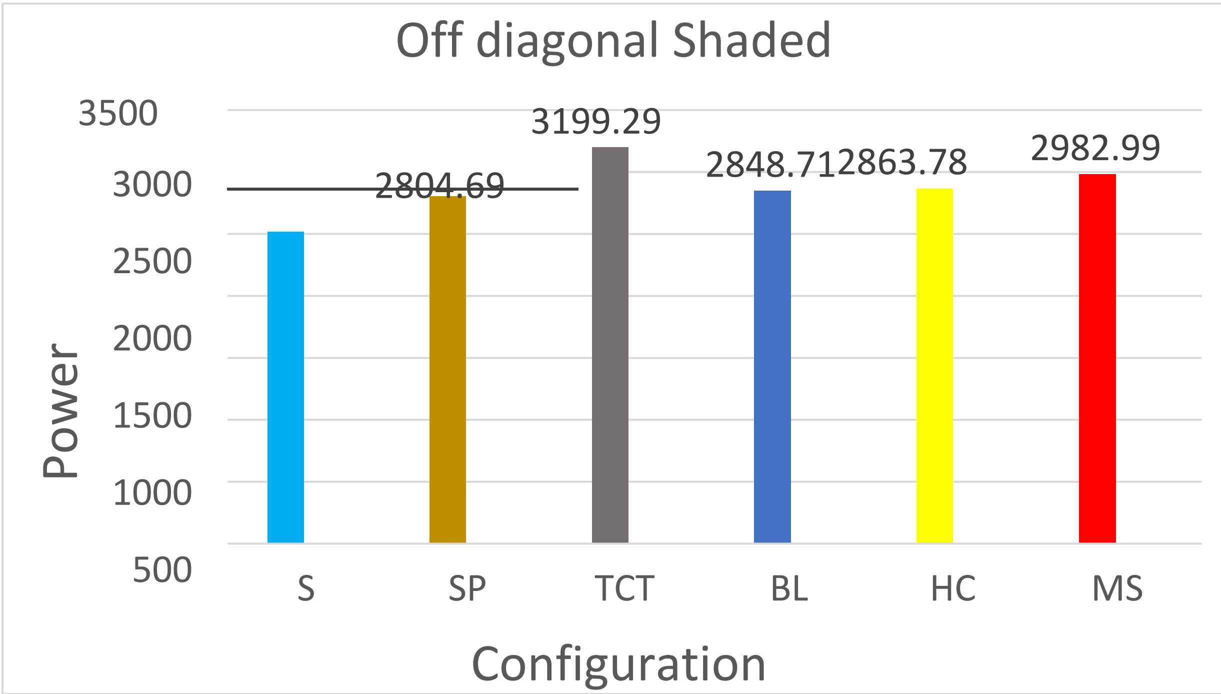
Case 8:-


LSOD Unshaded
Power
4000
3500
3000
2500
2000
1500
2848.55
3125.26
3321.12
3245.77
3199.2
3423.1
S
SP
TCT
BL
HC
MS
Configuration

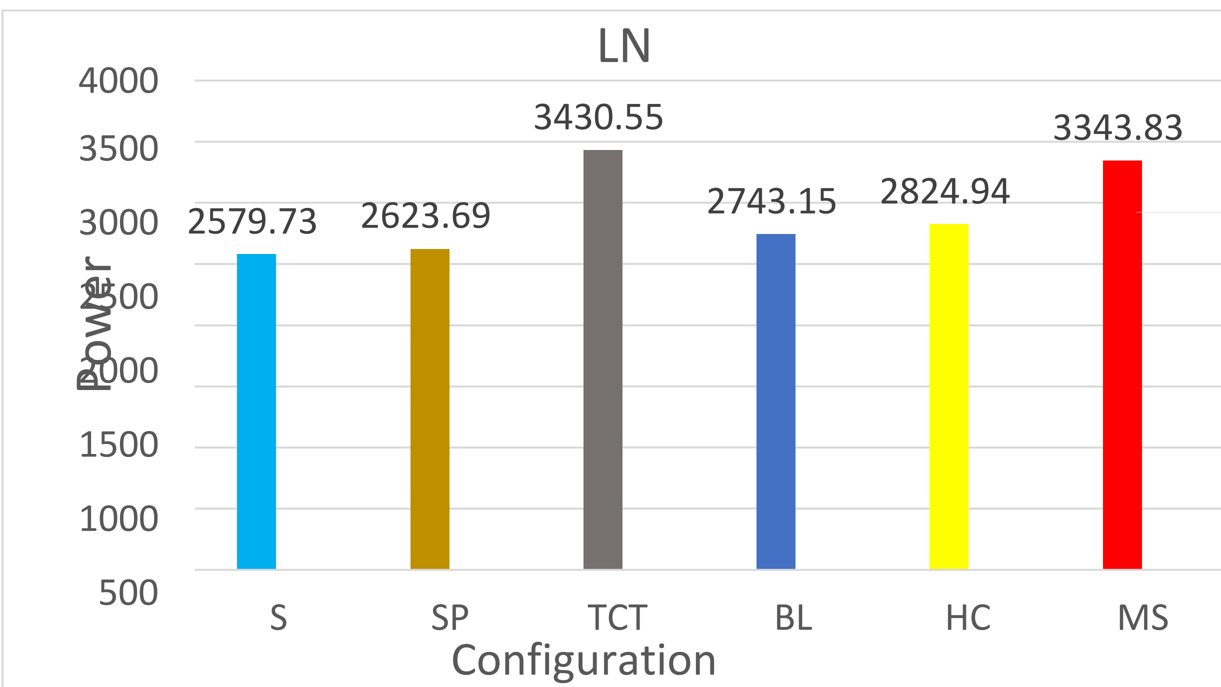
Case9:-


RSOD Unshaded
Power
4000
3500
3000
2500
2000
1500
1000
500
3241.73
3280.24
3424.56
3372.67
3363.42
3509.66
SP
TCT
BL
HC
MS
Configuration

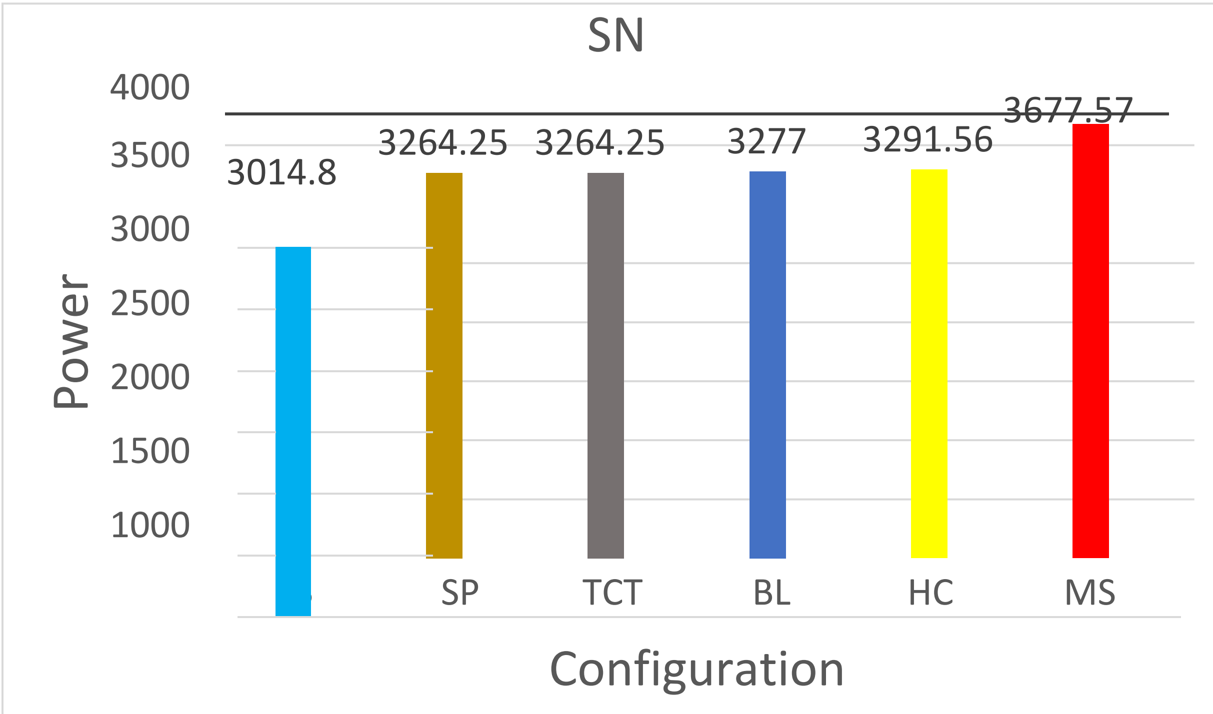
Case10:-



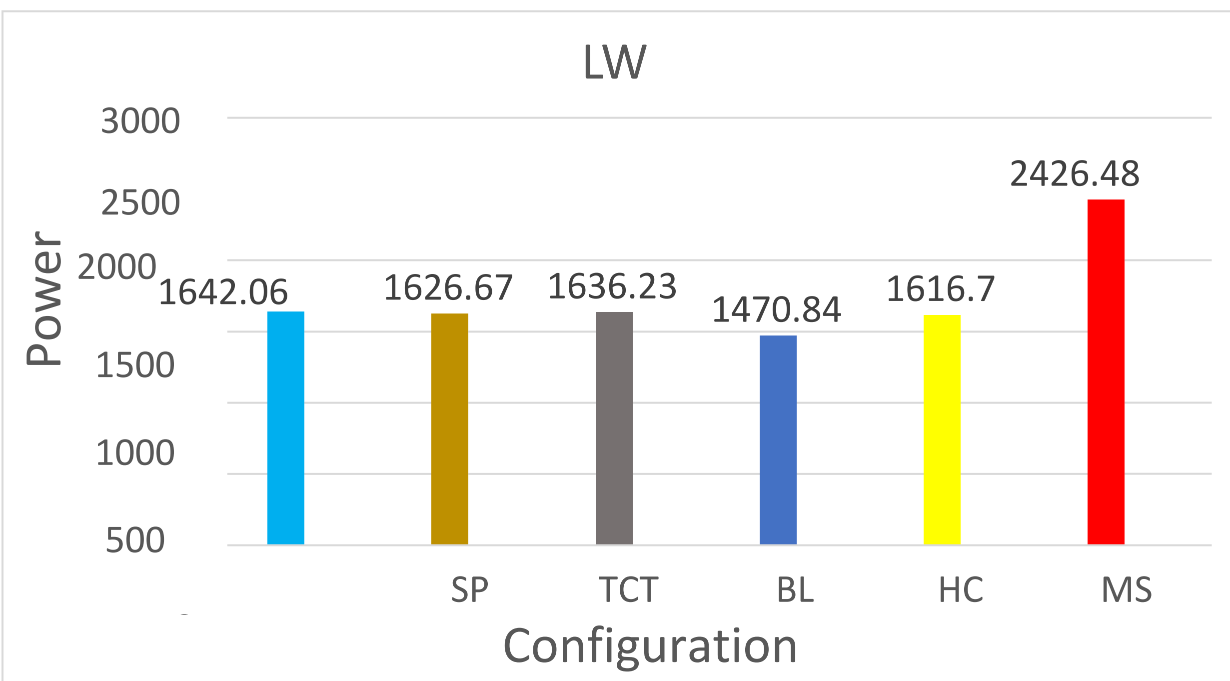
Case11:-



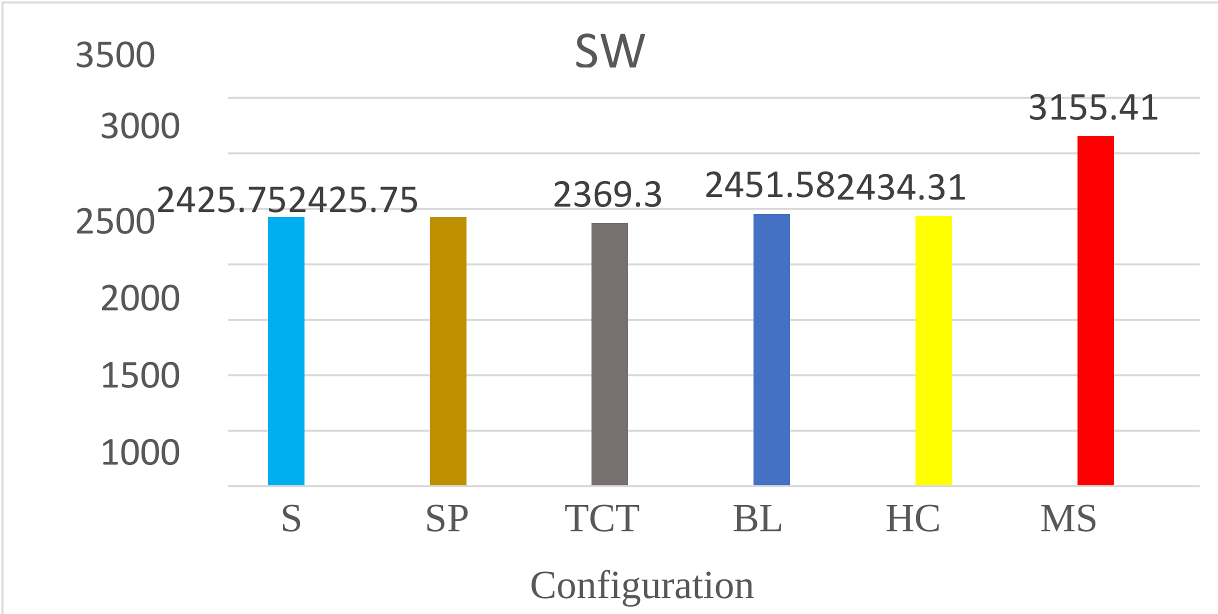
Case12:-



Case13:-



Case14:-



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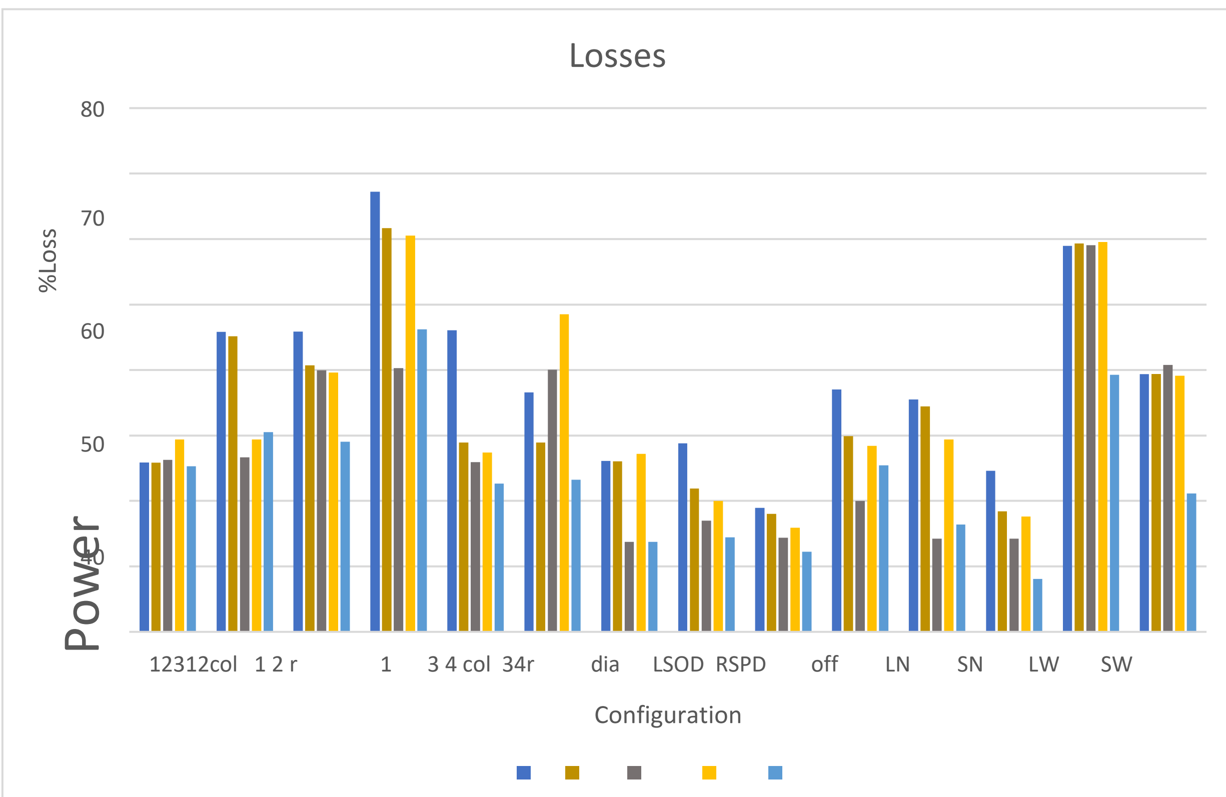
Generate Losses under shading condition:



1. Comparison of all configurations

Case1			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	2964.9	1035.12	25.878
SP	2967.5	1032.5	25.8125
TCT	2949.9	1050.1	26.2525
BL	2967.1	1032.93	25.8232
HC	2824.9	1175.06	29.3765
MS	2987.6	1012.44	25.311
Case2			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	2168	1831.97	45.7992
SP	2194	1806.03	45.15075
TCT	2933.1	1066.94	26.6735
BL	2849.2	1150.83	28.7707
HC	2824.4	1175.64	29.391
MS	2778.4	1221.57	30.53925
Case3			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	2165.6	1834.45	45.86125
SP	2372.3	1627.75	40.69375
TCT	2402.2	1597.85	39.94625
BL	2393.3	1606.67	40.1667
HC	2415.1	1584.92	39.623
MS	2837.1	1162.92	29.073
Case4			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	1309.7	2690.31	67.2575
SP	1532.8	2467.22	61.6805
TCT	2388.2	1611.77	40.29425
BL	1579.9	2420.07	60.50175
HC	1578.2	2421.76	60.544
MS	2151.5	1848.55	46.21375
Case5			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	2158.11	1841.89	46.04725
SP	2843.48	1156.52	28.913
TCT	2963.08	1036.92	25.923
BL	2888.28	1111.72	27.793
HC	2903.61	1096.39	27.40975
MS	3094.81	905.19	22.62975

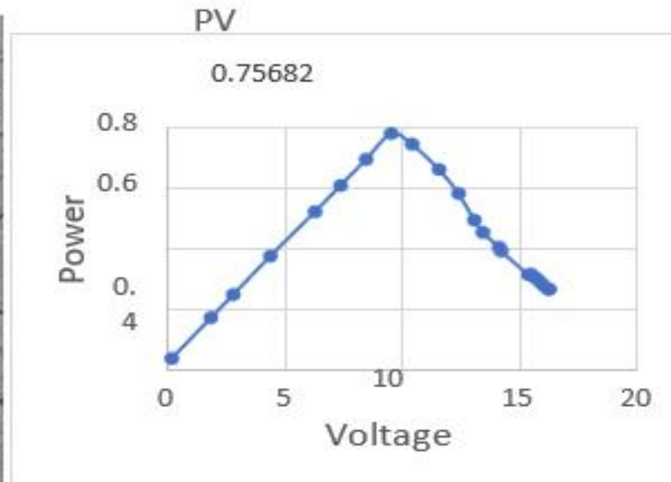
Case6			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	2536.69	1463.31	36.5827
SP	2843.48	1156.52	28.913
TCT	2456.54	1543.46	38.5865
BL	2104.44	1895.56	47.389
HC	2058.76	1941.24	48.531
MS	3069.75	930.25	23.25625
Case7			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	2954.62	1045.38	26.1345
SP	2858.27	1041.73	26.04325
TCT	3450.08	549.92	13.748
BL	2975.09	1024.91	25.62275
HC	2912.92	1087.08	27.177
MS	3449..37	550.63	13.76575
Case8			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	2848.55	1151.45	28.786
SP	3125.26	874.74	21.5685
TCT	3245.77	754.23	18.8557
BL	3321.12	678.88	16.972
HC	3199.2	800.8	20.02
MS	3423.11	576.89	14.42225
Case9			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	3241.73	758.27	17.95675
SP	3280.24	719.76	17.994
TCT	3424.56	575.44	14.386
BL	3372.67	627.33	15.68325
HC	3363.42	636.58	18.9145
MS	2509.66	490.34	12.2585
Case10			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	2815.72	1481.28	37.032
SP	2804.69	1195.31	29.88275
TCT	3199.29	800.71	20.01775
BL	2848.71	1151.29	28.78225
HC	2863.75	1136.22	28.4055
MS	2982.99	1017.01	25.42525
Case11			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)

S	2579.73	1420.27	35.50675
SP	2623.69	1376.31	34.40775
TCT	2743.15	1256.85	31.42125
BL	3430.55	569.45	14.23625
HC	2824.94	1175.06	29.3765
MS	3343.83	656.17	16.40425
Case12			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	3014.8	985.2	24.63
SP	3264.25	735.75	18.39375
TCT	3277	723	18.075
BL	3430.55	569.45	14.23625
HC	3294.56	705.44	17.636
MS	3677.57	322.43	8.06075
Case13			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	1642.06	2575.94	58.9485
SP	1626.67	2373.33	59.33325
TCT	1636.23	2363.77	59.09425
BL	1470.84	2529.16	63.229
HC	1616.7	2383.3	59.5825
MS	2426.48	1573.52	39.338
Case14			
Configuration	P_{MPS}(W)	P_{LOSS}(W)	PL (%)
S	2425.75	1575.25	36.35625
SP	2425.75	1575.25	39.35625
TCT	2363.3	1630.7	40.7675
BL	2451.58	1548.42	38.7105
HC	2434.31	1565.69	39.14225
MS	3155.41	844.59	21.11475

6.1 Result on different constant shading pattern

6.1.1 Long wide (LW)

6.1.1.1 Series parallel (SP)



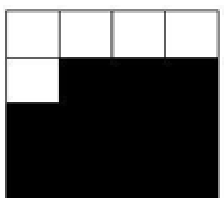
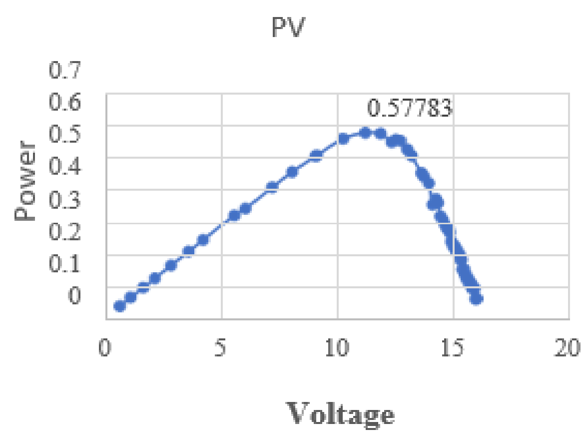


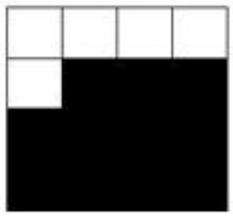
Fig 6.1 LW shading on SP configuration

Power(W)
0.75682

6.1.2 Bridge link (BL)

Fig 6.2 LW shading on BL Configuration



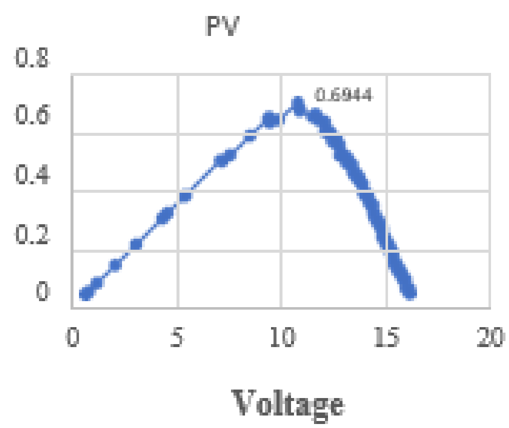


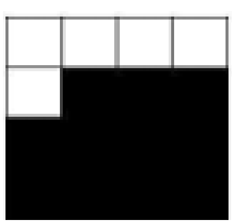
Power(W)
0.577

6.1.3 Honeycomb (HC)

Power(W)
0.694

Fig 6.3 LW shading on HC configuration





6.1.4 Total Cross tide (TCT)

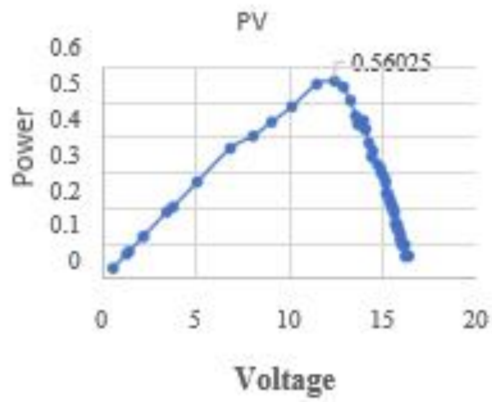
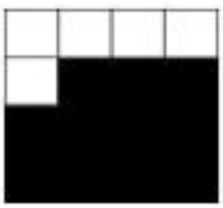


Fig 6.4 LW shading on TCT configuration.



Power(W)
0.560

6.1.1.2 Magic square (MS)

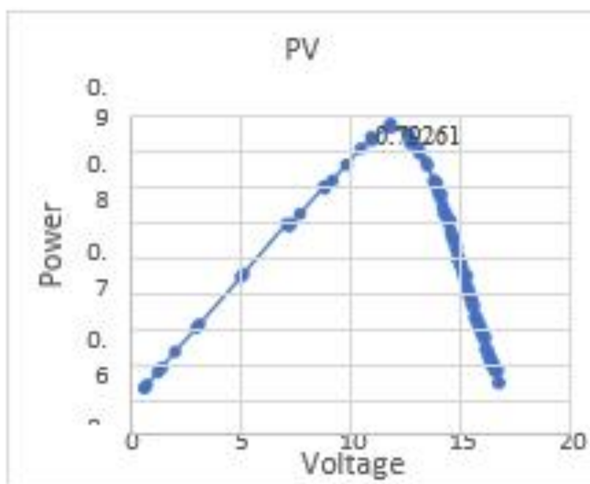
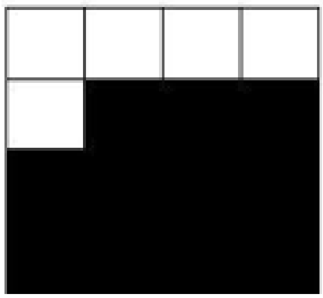


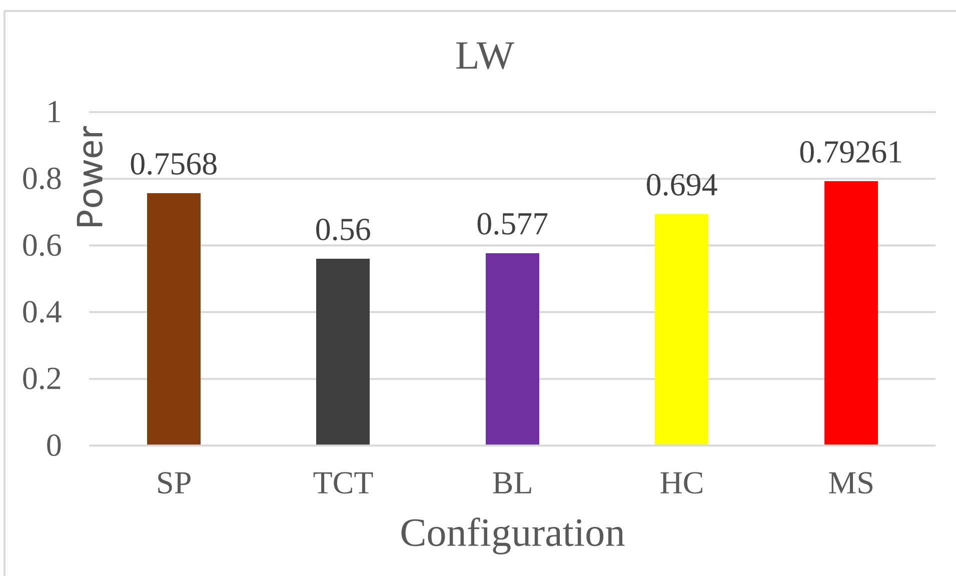
Fig 6.5 LW shading on MS configuration.



Power(W)

0.79261

LW	
Configuration	Hardware result Power (W)
SP	0.7568
TCT	0.56
BL	0.577
HC	0.694
MS	0.79261



- After major shading pattern apply on the different configuration and we analyze the MS configuration is delivered higher power (3.88W) in all apply shading pattern compared to another configuration.

Conclusion:-

An approach for decreasing power losses and improving power has been developed after applying a technique to the various shading scenarios and assessing the system's performance on the shading condition. In the simulation analysis, various types of shading cases are applied to the six different configurations to minimize the shading effect on output power, and the simulation result shows that the magic square technique has the best performance, with the least effect on shading condition when compared to another configuration. When all shading situations are applied to hardware and after analysis, the magic square approach provides the best performance in either constant or changing shading conditions. Average maximum power gets in MS after all shading cases apply to the configuration is 84.53% and after MS the TCT configuration has 69.58% then HC, BL,SP,andSits67.92%,66.53%,65.13%,and58.90%respectively.

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