MULTIDISCIPLINARY INTERNATIONAL RESEARCH JOURNAL OF GUJARAT TECHNOLOGICAL UNIVERSITY

Gujarat Technological University

An International Innovative University

Accredited with A+ grade by NAAC

About GTU

Gujarat Technological University is a premier academic and research institution which has driven new ways of thinking and working, since its inception in 2007, by Government of Gujarat vide Gujarat Act No. 20 of 2007.Today, GTU is an intellectual destination that draws inspired scholars to its campus, keeping GTU at the nexus of ideas that challenge and change the world. GTU is a State University with 430+ affiliated colleges operating across the state of Gujarat through its six zones at Ahmedabad, Gandhinagar, Vallabh Vidyanagar, Rajkot, Surat and Bhuj. The University caters to the fields of Engineering, Architecture, Management, Pharmacy and Computer Science. The University has about 2,25,000 students enrolled in a large number of Diploma, Under Graduate, Post Graduate programs along with the robust Doctoral program.

VISION:
To be a global university for the creation and dissemination of knowledge and Innovation in Science & Technology, Humanities and Multidisciplinary domains for sustainable development and enrichment of human life.

MISSION:
1. To develop centres of academic excellence at university premises and at affiliated colleges in domains of science, engineering, technology, management, and environment for imparting comprehensive education, training, and research infrastructure as per the nation's requirements.

2. To build resources, facilities, proficiencies and other related infrastructure of global standard for the development of knowledge, skills, and competencies in the various educational domains.

3. To develop research-oriented pedagogy for flourishing ideas and to nurture innovators, entrepreneurs and professionals of tomorrow

4. To build and enhance collaborations with other academic, research, industry, and government organizations as well as NGOs across the globe so that education, training and research at university and its affiliated colleges become aligned with national and global level requirements.

5. To encourage multidisciplinary research and develop flexible learning ecosystem.

GTU has emerged as an International Innovative University in its pursuit of bringing innovation and internationalization in professional education. Within a really short span it has achieved several national accolades for its endeavor in bringing excellence in professional education. GTU is a pioneer in introducing some innovative learning methodology like "Active Learning", a classroom created online. GTU has the largest International Experience Program in collaboration with the universities of US, Canada, Bulgaria and Germany, which offers a unique opportunity to the students to enhance their capabilities and capacities in a global perspective. GTU's Research Week, a unique concept, is an evaluation process of dissertations of Master's and Doctoral Program students involving experts from the Universities across the globe.

From the Desk of Editor-in-Chief

MESSAGE

I feel pride in publishing the ninth issue of 'Multidisciplinary International Research Journal of Gujarat Technological University'.

This issue concentrates on Engineering, Management and Pharmacy disciplines in which articles are written in different areas such as customers' awareness about internet banking, isolation and characterization of selective herbal markers from Garcinia Indica extract, performance analysis of PV panel under partial shading condition and minimizing energy with high-speed WDM optical grid networks.

I hope all these articles will be useful for their range of applications and will also open up new directions for further research.

I take this opportunity to thank the GTU editorial board members & international editorial board members for their efforts in upgrading the articles in this issue.

Dr. Pankajray Patel
(I/C) Vice Chancellor
Gujarat Technological University, Ahmedabad

INDEX

CUSTOMER AWARENESS ABOUT INTERNET BANKING: IN CONTEXT OF SMALL FINANCE BANK IN AHMEDABAD

Ms. Snehal Vaghela

B.K. School of Business Management

Gujarat University

Dr. Ismail Bootwala

K. S. School of Business Management

Gujarat University

Abstract

Small Finance banks play an important role to achieve financial inclusion. The usage of Internet banking is termed as a delivery channel over a period of time which provides competitive advantage to the small finance banks. Customer can easily enjoy banking services with the help of internet banking. The present study is based on the responses of 92 respondents in Ahmadabad city from different small finance banks to understand customer awareness towards usage of internet banking, purpose, pros & cons of internet banking. To achieve the objectives of the study a questionnaire with different scales consisting of various aspects related to internet banking was framed. Random sampling method was used to collect the responses. The result of the study indicates that there is moderate level of awareness among the customers of SFB. Small Finance banks need to focus on hassle free procedure.

Keywords: Internet Banking, Small Finance Bank, Customer Awareness

Introduction:

Small Finance banks are at the rising stage of evolution. Small Finance banks is a specific segment of banking created by Reserve Bank of India under guidance of the government of India with an objective of widening financial inclusion by primary undertaking basic banking activities to un-served and underserved sections of the society including small business unit, small and marginal farmers, micro and small industries and unorganized entities. After the announcement during union budget for the year 2014-15, RBI issued guidelines of Small Finance banks in November, 2014. Across the country 72 different entities applied for the license of while only 10 of these entities got the license of Small Finance bank as on 24th November, 2014.The Primary objective of launching SFB was to achieve height of financial inclusion through an effective deployment of deposits and extension of credit facilities to micro, small and unorganized entities at low processing cost (RBI 2014). The word "small "in Small Finance Bank refers to give importance of serving to those people who are excluded. It does not indicate the size of the bank. The main reason for establishing SFB is to finance Micro, Small and Medium Enterprises (MSMEs).Adoption of technology has brought a revolutionary change in the traditional banking process. Banking services are available 24 hours which does not matter working hours. There are many pros & cons of Internet banking. Being a positive side, Internet banking helps banks to serve customers round the clock effectively and efficiently, whereas, being a negative side, customers are facing lots of problem while using internet banking due to changes in technology. Because of very high level of competition in banking industry, it becomes very difficult to understand perception of the customer. SFBs are mainly serving to the un-banked section of the society. So it is interesting to study awareness about it, how internet banking is useful to them and which problems are there for its usage.

Literature Review

There view of past researches helps to find the research gaps in the vast area of knowledge. The past research gives direction and basis for the new research area. Hereby it is the summary of the existing literature. A good number of articles have been reviewed. Some of the important studies are:

1. **Sonu Garg & Dr. Parul Agarwal (2014)** mentioned in their article that, "The concern of banks about profitability is to be addressed by the regulators as the entire process of financial inclusion would be a kind of social work in the first few years. The concern of the government about the reach, feasibility and implementation of government polices to the last mile needs to be addressed. The bank's concern can be addressed by leveraging information and communication technology, designing new innovative products and services models. A structured expansion and appropriate regulatory norms addressing the bank's concern. Thus, Innovative products, out of the box service model, effective regulatory norms and leveraging technology together could change the landscape of the current progress of the much needed and wanted, financial inclusion program.

2. **Kamal Kishore (2015)** stated in his article that, "Despite of many concerns and challenges, new differentiated banks along with earlier announced payments banks, represent a good strategy to deepen the financial inclusion agenda. However, looking at the size of the country, ten numbers of such banks may not be adequate and need to be expanded substantially if financial inclusion has to get real and substantial push on nationwide scale. RBI has announced its intention to allow more such banks in future after watching experience of first lot.

3. **Jaydev M, Himanshu Singh &Pawan Kumar (2017)** explained challenges of small finance bank. They stated that, "the new small finance banks are likely to redefine the banking sector in India with more number of players competing in the rural financial services landscape. The immediate challenges for these banks are building the liability product portfolio, meeting the mandatory norms on statutory norms of cash reserve ratio, improving the digital connectivity with the large scale rural customer base, and designing cost effective banking solutions.

4. **P. Dhanya and Dr. P.B Banudevi** mentioned in their article which talks about threats & challenges to small finance banks with special reference to Coimbatore city. In this article they explained," Small finance banks will help bring a revolutionary change in the Indian Banking System. It will help in making banking more competitive and more inclusive for both borrowers and depositors, making banking more affordable to the common man. In dynamic economy banks either emerge or collapse in the upcoming year.

5. **Khan Firdaus Masarrat Rashid (2019)** written article "Banking for the poor: A GLM study on Small Finance Banks in India". In this article he mentioned that banking business got affected by demonetization. It is early to judge the performance of SFBs in banking sector, there is justifiable optimism emerging from the empirical analysis that financial inclusion is being implemented and bearing some fruit. SFBs have a very important role to play in financial inclusion imperative.

6. **T. Ravikumar (2019)** found in his article "Small Finance Banks and Financial inclusion in India "that the small finance banks are meant to promote financial inclusion in India. These banks are performing considerably well and they have good potential all over India as financially excluded people are at large in India.

Methodology of the Study:

Objectives

1. To study the level of awareness and knowledge about various aspects of internet banking among the customers of all small finance bank.
2. To study pros & cons of usage of internet banking for customers.

Data Collection and Sampling

In statistical analysis both Primary and secondary data have been used to achieve the objectives. After literature review structured questionnaire is prepared to collect primary data. There are different components in questionnaire. i.e. Demographic profile of the respondent, Awareness about internet banking usage of small finance bank, different purpose of using internet banking, Different benefits of Internet banking, List of problems while using internet banking. Random sampling method is used to collect data from customers of Small Finance banks in Ahmadabad. The sample size of 100 was determined. 125 questionnaires were distributed among the customers of different small finance banks. From that 92 customers gave proper response.

Statistical Tools

The Descriptive statistics percentage and mean values were used to analyze collected primary data. F test have been used to test the hypothesis and variation in mean values. Levene's test was used to test equality of variance in different ways considering like it was assumed and it was not assumed. This section talks about analysis part of the research. Here 4 tables are there to show statistical analysis. The discussions of the tables are as follow:

Level of Awareness and Knowledge

Table1. Demographic Profile of Respondents-

Variables		Frequency	Percentage of Respondents
Gender	Male	59	64.13
	Female	33	35.87
Total		92	100.00
Age	20-29	30	32.61
	30-39	40	43.48
	40-49	6	6.52
	50-59	12	13.04
	60& Above	4	4.35
Total		**92**	**100.00**
Marital status	Married	68	73.91
	Unmarried	24	26.09
Total		**92**	**100.00**

Annual Family Income	Below2,50,000	25	27.17
	2,50,000-5,00,000	32	34.78
	5,00,000-10,00,000	29	31.52
	Above10,00,000	6	6.52
Total		**92**	**100**
Occupation	Government Service	31	33.70
	Private Service	46	50.00
	Professional	7	7.61
	PSU	2	2.17
	Student	6	6.52
Total		**92**	**100.00**
Highest Educational Qualification	Secondary	8	8.70
	Diploma/ITI	8	8.70
	Graduation	32	34.78
	Post-Graduation	42	45.65
	Ph.D.	2	2.17
Total		**92**	**100**
Family Type	Joint	74	80.43
	Nuclear	18	19.57
		92	**100.00**

Explanation of Table1:

According toTable1, out of 92 respondents, 33 respondents are female which around 36% of the total population is. Rest of that is male i.e. 64%. Further in terms of Age, we found that age group of 30-39 is highly aware about Usage of Internet Banking of Small Finance bank. There is very low level of awareness among age group of 40-49 and 60 & above. Under category of annual family income, income group of 2, 00,000 to 10, 00,000 are moderately aware about usage of internet banking of SFB. Under category of occupation, Private sector employees are highly aware about usage of Internet banking of Small Finance Bank and in comparison of that employees of PSU are very less aware about it. Next category is highest educational qualification, Graduates and Post graduates customers are moderately aware whereas there is lack of awareness among rest of the customers. Another category is family type, in which customers from Joint family are highly aware about usage of Internet banking of SFB.

Table 2: Independent T test of customer awareness about Small Finance bank

Awareness about usage of Internet Banking of SFB	Levene's Test for equality of variance		t test for Equality of Means
	F	Sign.	t

Are you aware about Internet banking services provided by your Small Finance bank?	Equal variances assumed	1.51	1.03	
	Equal variances Not assumed			1.230769231
				1.01
Do you know about various rules & regulations regarding Internet Banking?	Equal variances assumed	1.07	0.13	
				1.032258065
	Equal variances Not assumed			0.362095876
Are you aware about fund transfer through Internet Banking?	Equal variances assumed	1.00	0.00	
				1
	Equal variances Not assumed			0
Are you aware about how to manage Debit card & Credit Card through Internet Banking?	Equal variances assumed	1.31	-0.69	
				1.142857143
	Equal variances Not assumed			0
Do you have knowledge about online complaint procedure and online grievance handling?	Equal variances assumed	1.78	-0.22	
				1.333333333
	Equal variances Not assumed			0

Explanation of Table2:

It is observed from the above table that the Levene's test for Equality of variance results the table value of the T test from the public view on Small Finance bank. (F= 1.51 and P>0.05)and F Values are1.07 and1.00 for awareness about rules and regulations of usage of internet banking of SFB and Fund transfer through internet banking of SFB. It also states that there is significance for another factor like how to manage debit card and credit card through internet banking and knowledge about online complaint procedure and grievance handling.

Purpose and Pros & Cons of Internet Banking

Table3: Purpose of using Internet Banking of SFB.

Sr. No.	Purpose of using Internet Banking	Frequency	N	Mean	Standard Deviation	Std. error	95% Conf. interval for mean	
1	To view account balance and statement	Very often	48	0.52	31.11	3.243723	Column1	
		Often	20	0.22	50.91	5.30791		
		Sometimes	18	0.20	52.33	5.455352	Conf. Level (95.0%)	13.76
		Never	6	0.07	60.81	6.340004		
		Total	**92**		**9.59**			

2	To enquire about cheque status	Very often	22	0.24	49.50	5.160468	Column1	
		Often	24	0.26	48.08	5.013027		
		Rarely	6	0.07	60.81	6.340004	Conf. Level (95%)	13.76
		Sometimes	32	0.35	42.43	4.423259		
		Never	8	0.09	59.40	6.192562		
		Total	**92**		**9.59**			
3	To give request For cheque book	Very often	16	0.17	53.74	5.602794	Column1	
		Often	27	0.29	45.96	4.791864		
		Rarely	8	0.09	59.40	6.192562	Conf. Level (95.0%)	15.42
		Sometimes	35	0.38	40.31	4.202096		
		Never	6	0.07	60.81	6.340004		
		Total	**92**		**9.59**			
4	To inquire about fixed deposit	Very often	22	0.24	49.50	5.160468	Column1	
		Rarely	9	0.10	58.69	6.118841		
		Often	28	0.30	45.25	4.718143	Conf. Level (95.0%)	10.48
		Sometimes	23	0.25	48.79	5.086747		
		Never	10	0.11	57.98	6.04512		
		Total	**92**		**9.59**			
5	For online trading with Demat services	Very often	28	0.30	45.25	4.718143	Column1	
		Often	22	0.24	49.50	5.160468		
		Sometimes	14	0.15	55.15	5.750236	Conf. Level (95.0%)	8.123
		rarely	12	0.13	56.57	5.897678		
		never	16	0.17	53.74	5.602794		
		Total	**92**		**9.59**			
6	To update your profile	Very often	24	0.26	48.08	5.013027	Column1	
		Often	19	0.21	51.62	5.381631		
		Rarely	12	0.13	56.57	5.897678	Conf. Level (95.0%)	9.15
		Sometimes	27	0.29	45.96	4.791864		
		Never	10	0.11	57.98	6.04512		
		Total	**92**		**9.59**			

7	To inquire about different products & rates of Interest	Very often	22	0.24	49.50	5.160468	Column1	
		Often	22	0.24	49.50	5.160468		
		Rarely	12	0.13	56.57	5.897678	Conf. Level (95.0%)	7.325
		Sometimes	24	0.26	48.08	5.013027		
		Never	12	0.13	56.57	5.897678		
		Total	**92**		**9.59**			
8	To download application form	Very often	12	0.13	56.57		Column1	
		Rarely	12	0.13	56.57	5.897678		
		Often	26	0.28	46.67	4.865585	Conf. Level (95.0%)	8.718
		Sometimes	36	0.39	39.60	4.128375		
		Never	6	0.07	60.81	6.340004		
		Total	92		9.59			
9	To give request for stop payment of cheque.	Very often	20	0.22	50.91	5.30791	Column1	
		Often	12	0.13	56.57	5.897678		
		Sometimes	29	0.32	44.55	4.644422	Conf. Level (95.0%)	8.718
		Rarely	12	0.13	56.57	5.897678		
		Never	19	0.21	51.62	5.381631		
		Total	92		9.59			
10	To apply for loan & other services	Very often	17	0.18	53.03	5.529073	Column1	
		Often	16	0.17	53.74	5.602794		
		rarely	16	0.17	53.74	5.602794	Conf. Level (95.0%)	4.695
		Sometimes	25	0.27	47.38	4.939306		
		Never	18	0.20	52.33	5.455352		
		Total	92		9.59			
11	To calculate loan payment information	Very often	30	0.33	43.84	4.570701	Column1	
		Often	12	0.13	56.57	5.897678		
		Rarely	13	0.14	55.86	5.823957	Conf. Level (95.0%)	9.15
		Sometimes	21	0.23	50.20	5.234189		

		Never	16	0.17	53.74	5.602794		
		Total	92		9.59			
12	To transfer funds between two accounts	Very often	30	0.33	43.84	4.570701	Column1	
		Often	29	0.32	44.55	4.644422		
		Rarely	7	0.08	60.10	6.266283	Conf. Level (95.0%)	13.68
		Sometimes	18	0.20	52.33	5.455352		
		Never	8	0.09	59.40	6.192562		
		Total	92		9.59			
13	To transfer funds to third party	Very often	24	0.26	48.08	5.013027	Column1	
		Often	28	0.30	45.25	4.718143		
		Rarely	12	0.13	56.57	5.897678	Conf. Level (95.0%)	9.521
		Sometimes	18	0.20	52.33	5.455352		
		Never	10	0.11	57.98	6.04512		
		Total	92		9.59			
14	To pay utility bills	Very often	32	0.35	42.43	4.423259	Column1	
		Often	28	0.30	45.25	4.718143		
		Rarely	8	0.09	59.40	6.192562	Conf. Level (95.0%)	13.87
		Sometimes	16	0.17	53.74	5.602794		
		Never	8	0.09	59.40	6.192562		
		Total	92		9.59			
15	To shop online	Very often	44	0.48	33.94	3.538607	Column1	
		Often	14	0.15	55.15	5.750236		
		Rarely	6	0.07	60.81	6.340004	Conf. Level (95.0%)	19.59
		Sometimes	22	0.24	49.50	5.160468		
		Never	6	0.07	60.81	6.340004		
		Total	92		9.59			
16	To create & renew fixed	veryoften	26	0.28	46.67	4.865585	Column1	
		Often	26	0.28	46.67	4.865585		

	and recurring deposits	Rarely	6	0.07	60.81	6.340004	Conf. Level (95.0%)	10.59
		Sometimes	20	0.22	50.91	5.30791		
		Never	14	0.15	55.15	5.750236		
		Total	92		9.59			
17	To give request for Demand draft & pay orders	Very often	20	0.22	50.91	5.30791	Column1	
		Often	20	0.22	50.91	5.30791		
		Rarely	12	0.13	56.57	5.897678	Conf. Level (95.0%)	4.777
		Sometimes	22	0.24	49.50	5.160468		
		Never	18	0.20	52.33	5.455352		
		Total	92		9.59			
18	To pay credit card bill	Very often	30	0.33	43.84	4.570701	Column1	
		Often	23	0.25	48.79	5.086747		
		Rarely	9	0.10	58.69	6.118841	Conf. Level (95.0%)	11.06
		Sometimes	10	0.11	57.98	6.04512		
		Never	20	0.22	50.91	5.30791		
		Total	92		9.59			
19	To subscribe for mobile banking services (Debit cards & credit cards)	Very often	38	0.41	38.18	3.980933	Column1	
		Often	21	0.23	50.20	5.234189		
		Rarely	5	0.05	61.52	6.413725	Conf. Level (95.0%)	15.42
		Sometimes	16	0.17	53.74	5.602794		
		Never	12	0.13	56.57	5.897678		
		Total	92		9.59			
20	To pay insurance premium	Very often	32	0.35	42.43	4.423259	Column1	
		Often	26	0.28	46.67	4.865585		
		Rarely	10	0.11	57.98	6.04512	Conf. Level (95.0%)	12.47
		Sometimes	14	0.15	55.15	5.750236		
		Never	10	0.11	57.98	6.04512		
		Total	92		9.59			
21	To pay online tax	Very often	34	0.37	41.01	4.275817	Column1	
		Often	20	0.22	50.91	5.30791		

			N	Mean	Std. Dev.	Std. error	95% Conf. interval for mean	
		Rarely	10	0.11	57.98	6.04512	Conf. Level (95.0%)	11.83
		Sometimes	16	0.17	53.74	5.602794		
		Never	12	0.13	56.57	5.897678		
		Total	92		9.59			
22	To recharge mobile prepaid plans	Very often	38	0.41	38.18	3.980933	Column1	
		Often	22	0.24	49.50	5.160468		
		Rarely	12	0.13	56.57	5.897678	Conf. Level (95.0%)	15.04
		Sometimes	12	0.13	56.57	5.897678		
		Never	8	0.09	59.40	6.192562		
		Total	92		9.59			

Explanation of Table3: According to above table, it seems that Main Purpose for using Internet banking of SFB is to view account balance and statement with mean value of 0.52. Most of the respondents use internet banking for the purpose to subscribe for mobile banking services (Debit cards & Credit Cards).

Table4: Benefits of using Internet Banking of SFB.

	Benefits of Internet Banking		N	Mean	Std. Dev.	Std. error	95% Conf. interval for mean	
1	Online banking makes banking cheaper	Strongly Agree	36	0.39	39.60	4.128375	Column1	
		Agree	30	0.33	43.84	4.570701		
		Moderate	16	0.17	53.74	5.602794	Conf. Level (95.0%)	17.68
		Disagree	6	0.07	60.81	6.340004		
		Strongly Disagree	4	0.04	62.23	6.487446		
		Total	92		9.59			
2	it gives account access 24*7	Strongly Agree	44	0.48	33.94	3.538607	Column1	
		Agree	36	0.39	39.60	4.128375		
		Moderate	4	0.04	62.23	6.487446	Conf. Level (95.0%)	24.8
		Disagree	6	0.07	60.81	6.340004		
		Strongly Disagree	2	0.02	63.64	6.634888		
		Total	92		9.59			
3	It saves time	Strongly Agree	48	0.52	31.11	3.243723	Column1	
		Agree	34	0.37	41.01	4.275817		

		Moderate	2	0.02	63.64	6.634888	Conf. Level (95.0%)	26.36
		Disagree	4	0.04	62.23	6.487446		
		Strongly Disagree	4	0.04	62.23	6.487446		
		Total	92		9.59			
4	it is secure way of dealing with bank	Strongly Agree	38	0.41	38.18	3.980933	Column1	
		Agree	36	0.39	39.60	4.128375		
		Moderate	12	0.13	56.57	5.897678	Conf. Level (95.0%)	21.61
		Disagree	4	0.04	62.23	6.487446		
		Strongly Disagree	2	0.02	63.64	6.634888		
		Total	92		9.59			
5	it checks balance of account and records of transaction	Strongly Agree	40	0.43	36.77	3.833491	Column1	
		Agree	37	0.40	38.89	4.054654		
		Moderate	9	0.10	58.69	6.118841	Conf. Level95%	23.04
		Disagree	2	0.02	63.64	6.634888		
		Strongly Disagree	4	0.04	62.23	6.487446		
		Total	92		9.59			
6	it pays bills automatically each month with easy to step up auto payment	Strongly Agree	42	0.46	35.36	3.686049	Column1	
		Agree	32	0.35	42.43	4.423259		
		Moderate	8	0.09	59.40	6.192562	Conf. Level (95.0%)	21.61
		Disagree	6	0.07	60.81	6.340004		
		Strongly Disagree	4	0.04	62.23	6.487446		
		Total	92		9.59			
7	it transfers funds between two accounts	Strongly Agree	46	0.50	32.53	3.391165	Column1	
		Agree	28	0.30	45.25	4.718143		
		Moderate	8	0.09	59.40	6.192562	Conf. Level (95.0%)	22.72
		Disagree	2	0.02	63.64	6.634888		
		Strongly Disagree	8	0.09	59.40	6.192562		
		Total	92		9.59			
8	to open a new account	Strongly Agree	42	0.46	35.36	3.686049	Column1	
		Agree	25	0.27	47.38	4.939306		

easily	Moderate	16	0.17	53.74	5.602794	Conf. Level (95.0%)	19.68
	Disagree	7	0.08	60.10	6.266283		
	Strongly Disagree	2	0.02	63.64	6.634888		
	Total	92		9.59			

Explanation of Table 4: As per the according table , it reveals that services provided by SFB of Internet Banking round the clock 24*7, time saving, transfer fund between two accounts, to open a new account easily are the main benefits of using internet banking as per their mean values. And it also states that majority of the customer are likely to use internet banking as it is a secure way of dealing with bank, it check balance of accounts and records of transaction, easy to step-up auto payment.

Table5: List of problems while using Internet banking of SFB

	List of Problems		N	Mean	Std. Dev.	Std. error	95% Conf. interval for mean	
1	Inadequate knowledge	Strongly Agree	18	0.20	52.33	5.455352	Column1	
		Agree	42	0.46	35.36	3.686049		
		Moderate	22	0.24	49.50	5.160468	Conf. Level (95.0%)	18.95
		Disagree	4	0.04	62.23	6.487446		
		Strongly Disagree	6	0.07	60.81	6.340004		
		Total	92		9.59			
2	Poor Network	Strongly Agree	18	0.20	52.33	5.455352	Column1	
		Agree	42	0.46	35.36	3.686049		
		Moderate	22	0.24	49.50	5.160468	Conf. Level (95.0%)	19.01
		Disagree	7	0.08	60.10	6.266283		
		Strongly Disagree	3	0.03	62.93	6.561167		
		Total	92		9.59			
3	Lack of technological requirement	Strongly Agree	16	0.17	53.74	5.602794	Column1	
		Agree	44	0.48	33.94	3.538607		
		Moderate	18	0.20	52.33	5.455352	Conf. Level (95.0%)	18.86
		Disagree	6	0.07	60.81	6.340004		

		Strongly Disagree	8	0.09	59.40	6.192562		
		Total	92		9.59			
4	Time consuming	Strongly Agree	14	0.15	55.15	5.750236	Column1	
		Agree	36	0.39	39.60	4.128375		
		Moderate	22	0.24	49.50	5.160468	Conf. Level (95.0%)	14.09
		Disagree	14	0.15	55.15	5.750236		
		Strongly Disagree	6	0.07	60.81	6.340004		
		Total	92		9.59			
5	Hanging websites	Strongly Agree	22	0.24	49.50	5.160468	Column1	
		Agree	32	0.35	42.43	4.423259		
		Moderate	26	0.28	46.67	4.865585	Conf. Level (95.0%)	14.73
		Disagree	6	0.07	60.81	6.340004		
		Strongly Disagree	6	0.07	60.81	6.340004		
		Total	92		9.59			
6	Complex process	Strongly Agree	20	0.22	50.91	5.30791	Column1	
		Agree	32	0.35	42.43	4.423259		
		Moderate	22	0.24	49.50	5.160468	Conf. Level (95.0%)	12.09
		Disagree	10	0.11	57.98	6.04512		
		Strongly Disagree	8	0.09	59.40	6.192562		
		Total	92		9.59			
7	Frequent change in password	Strongly Agree	20	0.22	50.91	5.30791	Column1	
		Agree	44	0.48	33.94	3.538607		

		Moderate	16	0.17	53.74	5.602794	Conf. Level (95.0%)	19.43
		Disagree	4	0.04	62.23	6.487446		
		Strongly Disagree	8	0.09	59.40	6.192562		
		Total	92		9.59			
8	Delayed complaint handling process	Strongly Agree	12	0.13	56.57	5.897678	Column1	
		Agree	42	0.46	35.36	3.68604		
		Moderate	24	0.26	48.08	5.013027	Conf. Level (95.0%)	18.53
		Disagree	8	0.09	59.40	6.192562		
		Strongly Disagree	6	0.07	60.81	6.340004		
		Total	92		9.59			
9	Lack of security	Strongly Agree	18	0.20	52.33	5.455352	Column1	
		Agree	32	0.35	42.43	4.423259		
		Moderate	24	0.26	48.08	5.013027	Conf. Level (95.0%)	12.59
		Disagree	6	0.07	60.81	6.340004		
		Strongly Disagree	12	0.13	56.57	5.897678		
		Total	92		9.59			
10	hacking of password is possible	Strongly Agree	22	0.24	49.50	5.160468	Column1	
		Agree	40	0.43	36.77	3.833491		
		Moderate	18	0.20	52.33	5.455352	Conf. Level (95.0%)	17.77
		Disagree	10	0.11	57.98	6.04512		
		Strongly Disagree	2	0.02	63.64	6.634888		
		Total	92		9.59			
11	lack of clarity in procedure	Strongly Agree	26	0.28	46.67	4.865585	Column1	
		Agree	37	0.40	38.89	4.054654		

		Moderate	12	0.13	56.57	5.897678	Conf. Level (95.0%)	15.72
		Disagree	8	0.09	59.40	6.192562		
		Strongly Disagree	9	0.10	58.69	6.118841		
		Total	92		9.59			

Explanation of Table 5: As per above calculation it seems that customers are facing problem while using internet banking like lack of clarity in procedure, hacking of passwords, hanging websites, complex process, as per their mean value.

Findings of the study

1.1 **The level of awareness** is good among the customers of SFB for the usage of Internetbanking.CustomersalsohavegoodidearegardingrulesandregulationsforofInternet Banking. And in addition to that customers have also good awareness about Fund transfer through internet banking. People also aware about how to manage debit cards & credit cards through internet banking and good knowledge about online complaint procedure and online grievance handling.

1.2 **Purpose of using internet banking –** The main purpose of using internet banking is to shop online, to shop online. To give request for cheque book, to inquire about fixed deposit, to trade online for Demat services are also important purpose for using internet banking services.

1.3 **Benefits of using Internet banking-** As Internet banking gives 24*7 services is the most important benefit of using internet banking.   It also saves time, check balance of accounts and records of transaction.

1.4 **List of Problems for using Internet banking-** the lack of adequate knowledge of using internet banking, Poor network are main problems for using internet banking.

Conclusion

Toconcludethestudy,CustomersofSmallfinancebankhavemoderatelevelofawarenessforusinginternetbanking services.Themainpurposeforusinginternetbankingistocheckaccountbalance,topayutilitybillsandtoshoponline .Asinternetbanking gives 24*7 services, time saving is the main benefits of using internet banking. As per research, complex procedure for using internet banking is the common problem faced by users of internet banking. Hence, Small Finance banks need to focus on complex procedure and try to make it somewhat easier for general people.

Limitations

There are some limitations of the research. In this research demographic variable on awareness level and knowledge of the respondents regarding various aspects of internet banking across the different small finance bank are not considered.

Future Research

The result of this research can be used by Different Small Finance Banks to improve their services and it can be also helpful to improve low level of awareness. They may go for different campaign for

improvement of their services. Therefore the result highly reveals that there is significant difference between Equal variance assumed and Equal variance not assumed for the given factors.

References

1. Banudevi, P. D. (2019). A Study on customer's awareness and perspective towards selected small finance banks in Coimbatore city. International Journal of Applied Research, 50-53.
2. C Paramasivan, V. (2013). Overview of Financial Inclusion in India. International Journal of management and development studies, Volume no.2 (2013) issue no.3 (March).
3. Dhanya, P. (2019). An empirical study on the threats and challenges to small finance banks with special reference to Coimbatore city. Coimbatore: EPRA International journal of Research and Development.
4. G, V. P. (2019). Impact of Capital Structure on financial performance of Small Finance Banks. International Journal of Research in Business studies and management, volume 6 issue 4, page 29-35.
5. Journal of Emerging Technologies and Innovative Research (JETIR), Volume6, Issue6.
6. Kishore, K. (October December 2015). Small Finance Banks: New category of Differentiated Banks. FIIB Business Review, Volume4, Issue4.
7. Mohanty, J. J. (February 2018). Leveraging Small Finance Bank in Achieving Financial Inclusion in India. International Journal of Business and Management Invention, Volume 7 Issue 2 Version III page 08-18.
8. P, P. e. (2019). Customer perception towards Small Finance Banks with special reference to ESAF Small Finance bank. International Journal of Management and Social Sciences, Volume 8 (2.1) page 41-46(2019).
9. Radicular, T. (2019). Small Finance banks and financial inclusion in India. Research Review journals, Volume4, issue-03, March 2019.
10. Rashid, K.F. (June2019).Banking for the poor: A GLM study on Small Finance Banks in India.
11. S. Kangayan, K. (July 2020).A Study on Review of Sustainability of Small finance banks in India.
12. Sonu Garg, D. P. (June 2014). Financial Inclusion in India: A Review of Initiatives and Achievements. IOSR Journal of Business and Management, 52-61.
13. UNNAYAN, Volume XII, Issue IIpage125-140.

ISOLATION AND CHARACTERIZATION OF SELECTIVE HERBAL MARKERS FROM GARCINIA INDICA EXTRACT

Monika Sorathiya	Dr. Sanjay Chauhan	Udaykumar Vegad	Mohammdhassan Harsoliya	Bhavinkumar Gayakvad*

*Bhavinkumar Gayakvad

Graduate School of Pharmacy**,** Gujarat Technological University Gandhinagar Campus, Nr. Government Polytechnic K-6 Circle,E-4 Electronic Estate G.I.D.C, Sector 26, Gandhinagar 382028, Gujarat.

Abstract

As the market for herbal goods grows, it will be necessary to build trustworthy, cutting-edgetechnical interventions to find fake, mislabeled, and contaminated products. In this case, we have established cutting-edge technical ways to test the Garcinia indica (G. indica) which is a member of the Kokum-related Guttiferae family. It prevents obesity and functions as anantioxidant and digestive tonic, and treats liver conditions, sunstroke, cancer, and heartconditions. Garcinol, citric acid (CA), hydroxycitric acid (HCA), hydroxycitric acid lactone (HCAL), tannins, carbs, fiber, lipids, proteins, and anthocyanin pigments are some of thephytoconstituents discovered in it. Garcinol isolation by vacuum column chromatography andsize exclusion chromatography is performed after dichloromethane: methanol (1:1) extraction ofdried fruit rinds. Toluene, ethyl acetate, and acetic acid (7:3:0.2 v/v/v), used as the mobile phase,were used to develop the high-performance thin layer chromatography (HPTLC) method. Thehigh-performance liquid chromatography (HPLC) method was established using C_{18} (250mm x4.6mm, 5 m) as the stationary phase, 0.01M potassium dihydrogen phosphate (KH_2PO_4) as themobile phase A, and acetonitrile: 0.01M KH_2PO_4 (90:10 v/v) as the mobile phase B. Thesamples were then detected at 215nm and 276nm. Garcinol had a 0.69 retention factor (Rf) according to the HPTLC technique. HCAL, HCA, CA, and Garcinol all had HPLC retentiontimes that were, respectively, 2.941, 4.25, 8.666, and 18.467 minutes. This study may aid in theprevention of adulteration as well as quality assurance, standardization, and phytoconstituentidentification in G. indica formulations.

Keywords: Garcinia Indica extract, Herbal Markers, HPTLC, phytochemicals constituents

1. INTODUCTION

1.1 Introduction to *Garciniaindica*

Kokum derived from *G. indica*, a member of the Guttiferae family. The western ghats of maharashtra, goa, karnataka, and kerala are its typical habitat. And eastern India, which comprises the states of west bengal, assam, and the north eastern ill area. Between the months of march and may, the summer season exists. The tree consistently produces fruit during the warm months of march to may.

Kokum syrup, Kokum agal (Kokum juice concentrate), Kokum sarbat, Kokum solkdhi, Kokum amsul (dried salted rind), Kokum butter, and Kokum beverages are among the various products available on the market that contain kokum fruits, rinds, and fat. Rinsings are dried and stored so they can be used to manufacture reconstituted beverages during the off-season.

The fruit rind of *G. indica* has been utilized as a source of pink and purple food coloring, as it contains 2% to 3% water-soluble red pigments. The principal coloring components are the anthocyanin pigments cyanidin-3-glucoside and cyanidin-3-sambubioside, which are typically present in a ratio of 4:1. The variation in color tones of kokum fruits is due to the replacement of hydroxyl and methoxyl groups onto the anthocyanin structural skeletons. *G. indica's* radical scavenging capacity is determined by the 3' and 4'-OH in the B-ring with a saturated 2, 3-double bond, whereas the 3' and 4'-OH in the B-ring determine the radical scavenging capacity with a saturated 2, 3-double bond. The below**Figure 1**isthe key phytochemicals derived from *G. indica*, as well as their structures. [1]
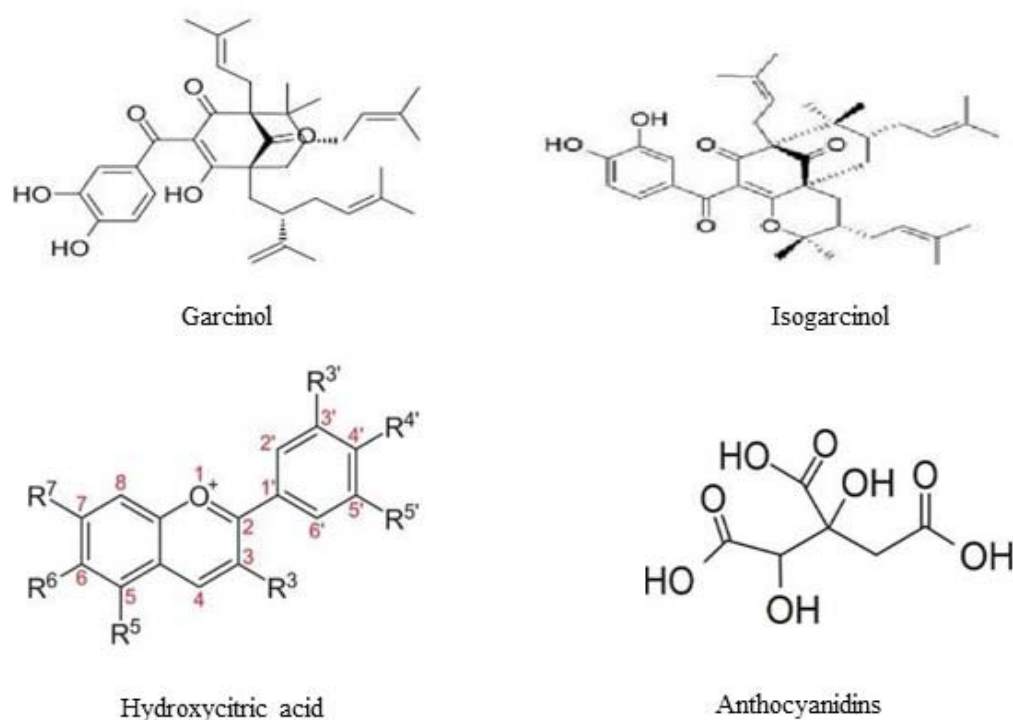
Figure. 1 Structure of chemical constituent present in kokum fruit rinds

1.1.1 Chemical Constitution

Kokum rind has three important chemical compounds: garcinol, hydroxycitric acid, and anthocyanin colors. Garcinol is a fat-soluble yellow pigment, while hydroxycitric acid is a chemical with established weight loss benefits. Kokum's anthocyanin pigment acts as a natural antioxidant. [2-5]

1.1.2 Traditional Uses

Garcinia Indica has many types of medicinal properties, it studies and investigated for the activities like, Anticancer activity, Antioxidant activity, Ant obesity activity, Antifungal activity and Antiulcer activity.[6]

2. OBJECTIVES

This study was planned to isolate the garcinol and HCL lactone from the Garcinia Indica by vacuum chromatography and characterization of garcinol by LC-MS, HPTLC and HPLC. Along with that to develop a single method to identify the selective herbal markers such as a HCA lactone, HCA, CA, Garcinol from the plant extract.

3. MATERIAL AND METHODS

3.1 Extract preparation and isolation of Garcinol from *G. indica*

3.1.1 Plant material

FruitrindsofG. indicawerecollectedfromlocal market in Ahmedabad.

3.1.2 Extraction from plant

Shade-dried pulverized *G. indica* fruit rinds (1 Kg) were prepared. Following this, the dried fruit rinds

were macerated in a mixture of dichloromethane and methanol (1:1) for three separate sessions totaling 24 hours at room temperature. The solvents were recovered using a rotary evaporator, and the extract was dried using a high-vacuum evaporator at 40 degrees Celsius to produce 150 grams. Put 10 grams' worth onto a petri dish, and then dry it in a 40 degrees Celsius high-vacuum oven. Place the dry yield in a separating funnel and fill it with a solvent, like n- Hexane. Acetic acid, ethyl: A mixture of methanol and water with a (1:1:1:1). To divide the organic phase into an upper and lower layer (aqueous phase). The TLC fingerprint for mobile-phase Garcinol is a Toluene: ethyleneaminoacetylene (EA: AA) mixture (7:3:0.2). The top layer was then concentrated in a 40 degree C high vacuum to produce 5 grams. Then, a vacuum column chromatography separation of the garcinol compound is performed.

3.1.3 *EvaluationofConcentratebyThinLayerChromatography*

Thin-layer chromatography (TLC) is a powerful tool in the scientific community. TLC is a rapid and inexpensive approach for determining how many different substances are present in a solution, finding the best solvent for flash column chromatography, and keeping tabs on how a reaction is going.

To establish how many chemicals are in *G. indica* extract, TLC was used with a variety of solvent/mobile phase combinations of decreasing polarity. Ethyl acetate/n-Hexane (9:1), ethyl acetate/n-hexane (9.5:0.5), ethyl acetate/n-hexane (9:1), ethyl acetate/n-hexane (8.5:1.5), Ethyl acetate/n-Hexane (8:2), Ethyl acetate/n-Hexane (7.5:2.5 (7:3). The results show that flash chromatography must use all of these solvent mixtures to successfully isolate garcinol from *G. indica* Extract.[8]

3.1.4 *SeparationofextractbyVacuumColumnChromatography*

Vacuum column chromatography is an excellent method for separating complex chemical mixtures into their individual components. The experiment was conducted using Aldrich Chemical Company-supplied silica gel (60-120 mesh) in a column of 60 cm in length and 3 cm in diameter. After suspending the mixture of around 5.0 g silica gel and 20 mL ethyl acetate, the ethyl acetate was extracted under vacuum using a high vacuum oven set to 40°C, and the *G. indica* extracts were fed into the column as a solid mixture with some silica. First, low-polarity pure hexane was used for the separation, followed by 1% ethyl acetate-containing hexane, then ethyl acetate at increasing concentrations up to 50%, then pure ethyl acetate, and lastly 100% methanol for the column flush. [9-10]

3.1.5 *Size exclusion chromatography*

Proteins and other macromolecules can be separated according to their molecular size using a technique called size-exclusion chromatography, commonly known as gel filtration chromatography. Size-exclusion chromatography is commonly utilized because to the diverse protein molecular weights present in biological tissues and extracts. The fundamental idea of size exclusion chromatography is that different sized solutes will be separated in different fractions of the column. Large molecules are eluted by the void volume (V0), while small molecules are eluted by the total volume (Vt). Now that garcinol has been successfully extracted from *G. indica*, we may move on to isolating other compounds. And HPTLC, HPLC, and HPLC all confirm the presence of garcinol. [11-13]

3.2 Extract preparation and Isolation of Hydroxycitric acid from *G.indica*

3.2.1 *Plantmaterial*

Commercially available in India, the acid is found in quantities of 20-30% in the dried fruit rinds of *Garcinia cambogia, Garcinia atroviridis,* and *G. indica*. Provide details on how hydroxycitric acid was extracted from *G. indica* here. Mix the rind of two hundred grams of *G. indica* fruit with six hundred milliliters of water and let it sit out at room temperature for 24 hours.

3.2.2 ExtractPreparation

After the extract has cooled, it is passed through several layers of muslin before being filtered through a Buchner funnel (Whatman No. 1 paper) and the residue is rinsed with water. The dark brown filtrate (originally 600 mL) is concentrated to around 100 mL by adding 200 mL of ethanol while being stirred over a water bath. Pectineus material is removed using centrifugation, followed by filtration. When adding 40% KOH to the acidic filtrate, it should be done so slowly and with careful stirring to maintain a constant pH of 7. Soaked in 500 mL of acetone in a 1 L flask overnight. Again, it was extracted in the same manner, this time with an equal amount of acetone. Acetone is evaporated off of the combined extracts using a rotary evaporator. The reddish-brown filtrate (80-90°C) is heated with activated charcoal (approximately 20 g) and reduced to a thick syrup in a water bath (light brown in color). The output is roughly 150 g. The material is extracted using 1 liter of ether (ten 300 mL sections), and the combined extracts are then dried over anhydrous sodium sulfate. Much of the pigment cannot be broken down by ether. After that, the extract is decolored with activated charcoal. After the ether has been distilled out, the extract material is dried off by heating it in a thin layer on a water bath for 10 to 15 minutes. So, having a pure white color. About 80 grams can be harvested.[14-15]

3.2.3 Purificationofisolatedconstituent

After obtaining lactone using either of the aforementioned methods, further purification is accomplished by repeatedly extracting it with diethyl ether (1g/20 mL). An equivalent volume of dry chloroform (chloroform passed from anhydrous sodium sulfate) is added to the concentrated substance soluble in diethyl ether and the mixture is stirred. When left exposed to air, the lactone crystallizes. After that, it was gathered and dried in a vacuum oven.However, HPLC validation showed that only 60% of the HCA was recovered using these isolation procedures.

3.2.4 IdentificationofisolatedcompoundAPI

HPTLC, LC-MS, and HPLC were all utilized in the identification of Garcinol. There were six visualizations of the datawhich are mentioned in result part. Melting point analysis and high-performance liquid chromatography were utilized to positively identify hydroxy citric acid lactone and hydroxy citric acid. In result part mention the data. The melting point, FTIR, and ultraviolet spectrum were used to positively identify citric acid.

3.3 PreparationsofsolutionforHPLC andHPTLCmethod

3.3.1 StandardStockSolution(SSS)

An accurately weighed 10 mg of Garcinol was placed in a 10 mL volumetric flask, then roughly 10 mL of methanol (HPLC) was added and sonicated for five minutes to dissolve adequately, yielding a standard stock solution of isolated garcinol (1000 g/mL). The final volume of the standard stock solution, 1000 g/mL, was adjusted to the correct level using the same diluent.

3.3.2 Preparation of 0.01M KH_2PO_4

Weigh 680 mg of KH_2PO_4 and put it in 500 mL of water. Then, sonicate it for 3 minutes. Use orthophosphoric acid to set the PH to 2.50 after measuring it. Then, a vacuum filter with 0.45 membrane filter paper was used to filter the solution that had been made.

3.3.3 Preparation of sample solution

G. indica fruit was bought from local market in Ahmedabad. The fruit rinds, which weighed 5 gm, were put in a 50 mL volumetric flask and diluted with water and MEOH to make 100000 g/mL. (Milli- Q and HPLC). Then, 0.2 mL of this solution was taken out and put into a 10 mL volumetric flask, where it was diluted with diluent to make 2000 g/mL.

3.4 RP-HPLCmethoddevelopment

3.4.1 Establishmentoftheoptimumconditionsof themethod

The HPLC method is chosen based on the type of sample (ionic, non-ionic, or neutral molecule), its molecular weight, and how well it dissolves. Reversed phase chromatography can be used to study the parts used in this study because they are both polar (HCA, CA) and nonpolar (Garcinol). Reversed phase chromatography is not only easy and convenient, but it is also more effective, stable, and repeatable. The C18 column is less polar than the C4 column and the C8 column. For better separation of the three analytes, a Waters Sunfire C18 250mm x 4.6mm column with 5 m particle packing was chosen. Gradient mode because it makes it easy to tell the peaks apart.

3.4.2 Selection of wavelength

The wavelength used to detect in an HPLC method that uses UV light showed how sensitive the method was. The best wavelength is the one that gives the best response when drugs are being looked for. In this study, drug solutions of Garcinol, HCA, and CA (1000 ppm) were made. The UV range of 190-400 nm showed that this medicine solution absorbed the lightest. The spectrum of a 1000 ppm solution shown the wavelengths where Garcinol (276 nm), HCA (215 nm), and CA (215 nm) are the strongest. Since the drug absorbs well at 276 and 215 nm for Garcinol and HCA, CA, respectively. For detection, these wavelengths were chosen.

3.4.3 Selection of Column

A review of the literature led to the choice of the C18 column for the trial. The study was first done on a C18 column, which helps separate things better. So, the C18 column was chosen to be looked at.

3.4.4 Selection of Mobile phase

Varying mobile phases, including methanol, water, acetonitrile, and KH_2PO_4 buffer, were evaluated in different quantities, volumes, and flow rates in a series of experiments. Based on numerous tests, the 0.01 M KH_2PO_4 (A) and ACN: 0.01 M KH_2PO_4 (90:10) (B) gradient modes, at a flow rate of 1.2 mL/min and a pH of 2.50, give superior peak form, theoretical plate, and asymmetry. We attempted various flow rates and proportions of mobile phase in isocratic and gradient modes, but the peaks of three analyzers could not be separated. To solve this issue and assure complete resolution, gradient elution was utilized, beginning with a low fraction of mobile phase B (ACN: 0.01 M KH_2PO_4 (90:10)). Several gradient programs were tested, but the greatest balance between adequate resolution, tolerable retention times, and acceptable peak shape was found with the gradient program utilizing solvent (A) 0.01 M KH_2PO_4 and mobile phase B with ACN: 0.01 M KH_2PO_4 (90:10). Various mobile phase check and mention in **Table 1**.

Table1.Initial HPLCOptimizedchromatographiccondition and mobile phase trials

Parameters	Chromatographiccondition
Chromatographicmode	Reversedphase
Modeofelution	Gradient
Column	WatersC18(250mmx4.6mm,5µm)
Flowrate	1.2 mL/min
Columnoven temp.	25°C
Run time	30 min.
Injectionvolume	10µl

Detectionwavelength	210and 276 nm		
Mobilephase	Buffer0.01MKH$_2$PO$_4$		
	Time(min.)	A(Buffer)	B (ACN: Buffer90:10)
	0	100	0.0
	3	100	0.0
	6	90	10
	8	90	10
	12	0.0	100
	25	0.0	100
	30	100	0.0

4.4.1 Flow rateoptimization

Initiallyworkwasperformedwith 1.0mL/min, and1.2mL/minwerealsotried.atFlowrate of 1.2 mL/min was finalized for analysis as it gave reasonable analysis time andgoodseparation.

4. RESULT AND DISCUSSION

4.1 Identification ofDrug

UV spectra of *G.indica* extract in methanol demonstrate that the medication absorbs significantly at 224 and 282 nm for Garcinol, and HCA lactone -HCA, respectively. Consequently, the wavelengths 224 and 282 nm were chosen for detection as shown in **Figure 2.**
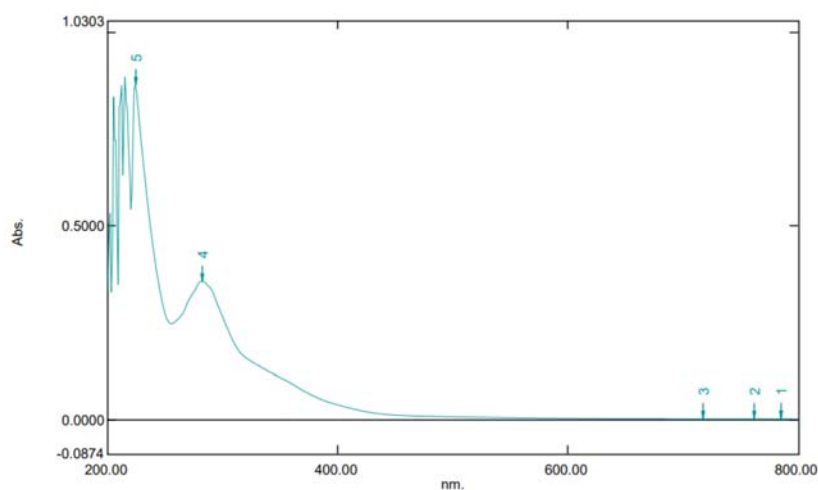
Figure. 2 UV spectrum of Garcinia indica extract

4.2 Determination of Solubility

According to the literature review and the nature of the constituents, Garcinol was found to be soluble in methanol and HCA lactone, HCA, and CA were found to be soluble in water. Different trials in water and methanol in different ratios were conducted, and the water: methanol (70:30) ratio was chosen based on UV absorbance.From the trials, HCAL, HCA and CA were soluble in in 100:0 (water:methanol) and garcinol was insoluble, another trial of 50:50 ration of water: methanol have shown the solubilty of all the constituents but peak sharpness was not achieved. While, 70:30 ratio of water:methanol have shown solubility with sharp peak.

4.3 Confirmation of isolated Garcinol

4.3.1 *IdentificationbyHPTLC*

Extract of *G. indica* in water: methanol (70:30) 10 µl spot on TLC, it given 7different band of compound in mobile phase is toluene: EA: AA (7:3:0.2). The rf value was found 0.69 of garcinol. (**Figure.3**)The band is then dissolved in methanol, and recollected using mass interference. Then confirmation of mass of garcinol by LC-MS**.**[8]
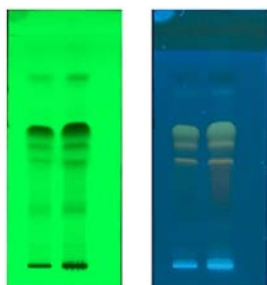
Figure. 3 HPTLC chromatogram of garcinia indica extract at 254 nm and 366 nm

Isolated Garcinol 10µl, 1000 ppm in mobile phase toluene: EA: AA (7:3:0.2)were tried but band having tailing effect. Then various combination of mobilephase was tried. In toluene: methanol: AA (7:3:0.2 v/v/v) band was sharp atsatisfactoryRf which is 0.76 andwas selectedas mobilephasein the method.(**Figure. 4**)
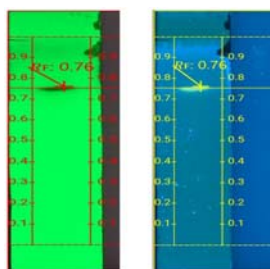
Figure. 4 HPTLC chromatogram of isolated Garcinol at 254 nm and 366 nm

4.3.2 Identification of Garcinol by LC-MS

 The molecular weight of the isolated garcinol was confired by the LC-MS technique. 601.0 gm/mol of molecular wt. was observed by LC-MS and it was found nearer to the theoretical molecular wt. about 602.8 gm/mol.(**Figure. 5**)
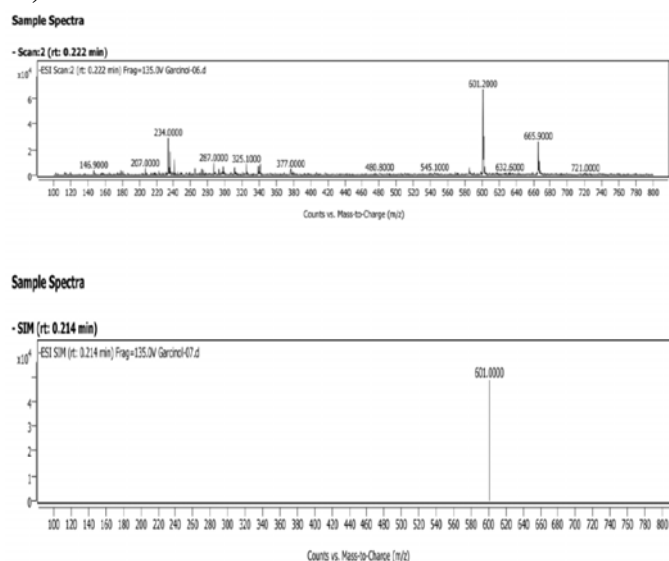
Figure. 5 LC-MS chromatograms of extract isolated Garcinol

4.3.3 Identification ofGarcinolbyHPLC

A number of mobile phase combination were tried**.** But isolated garcinol wasgiven sharp peak at RT 18.46 min, in mobile phase such as a ACN: $0.01MKH_2PO_4$(90:10)(PH 2.50). With other chromatographic conditions like flow rate of 1.0mL/min, peak area of 100%, tailing effect of 1.267 and Plates USP about 11181.041.**(Figure. 6)**
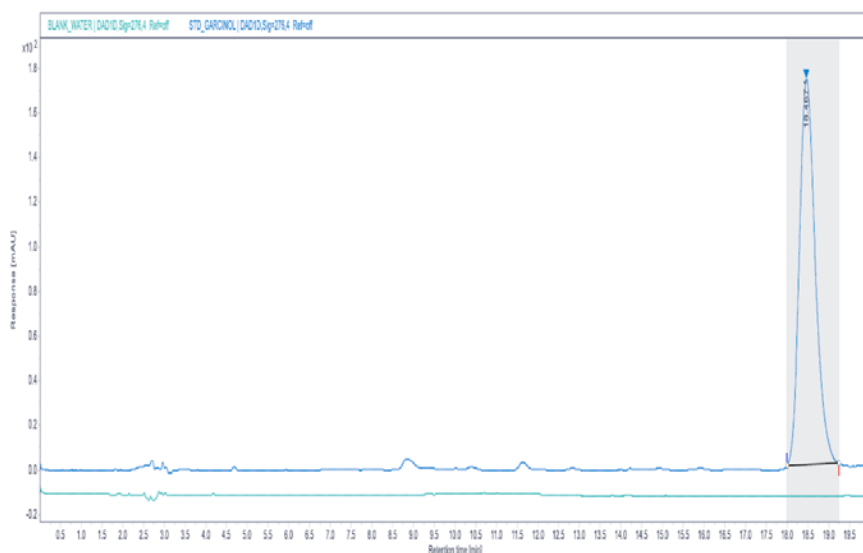
Figure. 6 HPLC chromatogram of isolated Garcinol

4.4 Identification of HCA lactone and HCA

4.4.1 Identification of isolated HCA lactone, HCA by Melting point

Thesamplewastakenincapillaryandplaceintotheheatedliquidparaffinbath. Observed melting point was found around 190-195 °C, which is nearer to >188 °C of reported value.

4.4.2 Identification of isolated HCA lactone, HCA byUVspectroscopy

UV spectra of HCA lactone or HCA in water, it is revealed that at 220 nm, drughavesignificanceabsorbance.Hence,220nmwavelengthwasselected for detection.**(Figure. 7)**
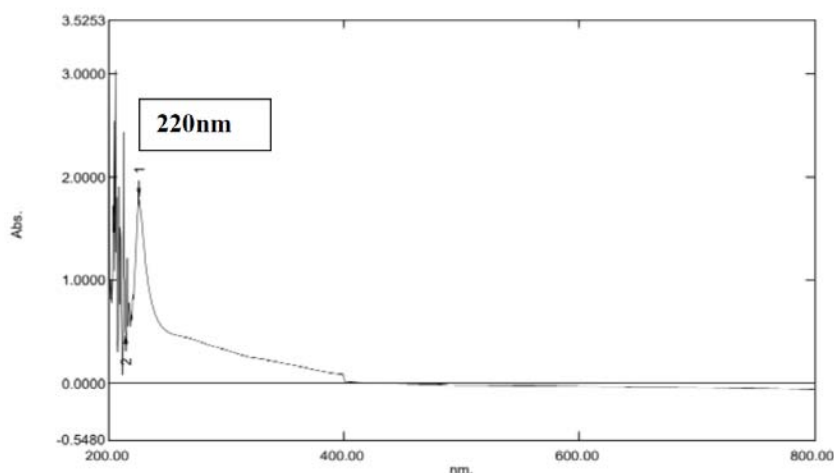
Figure. 7 HPLC chromatogram of isolated Garcinol

4.4.3 Identification of isolated HCA lactone,HCAbyHPLC

A variety of mobile phase combinations were tried, but extracted HCA lactone andHCA shows good peaks at RT 2.971 and 4.25 min, respectively, in a 0.01M KH_2PO_4(90:10)(PH 4.75)mobilephase. (**Figure. 8**)
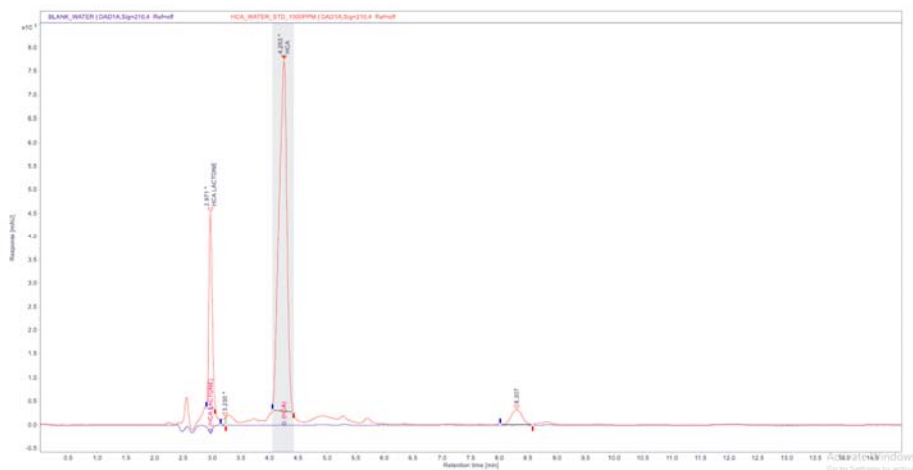
Figure. 8 HPLC chromatogram of isolated HCA lactone and HCA

4.5 Identification of citric acid

4.5.1 IdentificationbyUVspectroscopyforcitricacid

From UV spectra of citric acid in water, it is revealed that at 235 nm, drug have significant absorbance. Hence, 235nmwavelengthwasselected fordetection.(**Figure. 9**)
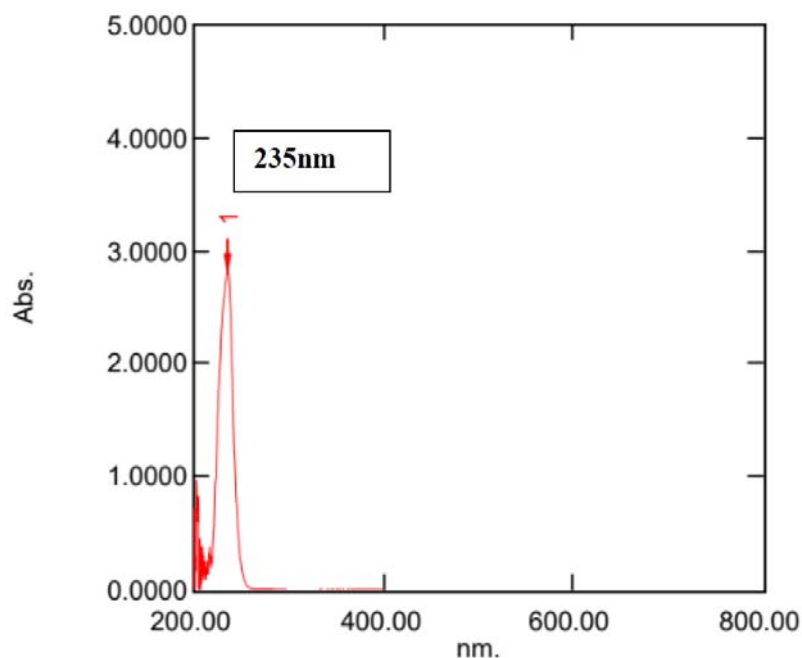
Figure. 9 UV spectra of citric acid

4.5.2 Identification by IR for citric acid

Citric acid standard was scanned in the region of 4000-400 cm-1 in FT-IR andobtainedIR

spectrumwas compared withthereferencespectrum. All the predicted standard frequencies were observed and confirmed the functional groups for citric acid. (**Figure. 10**)
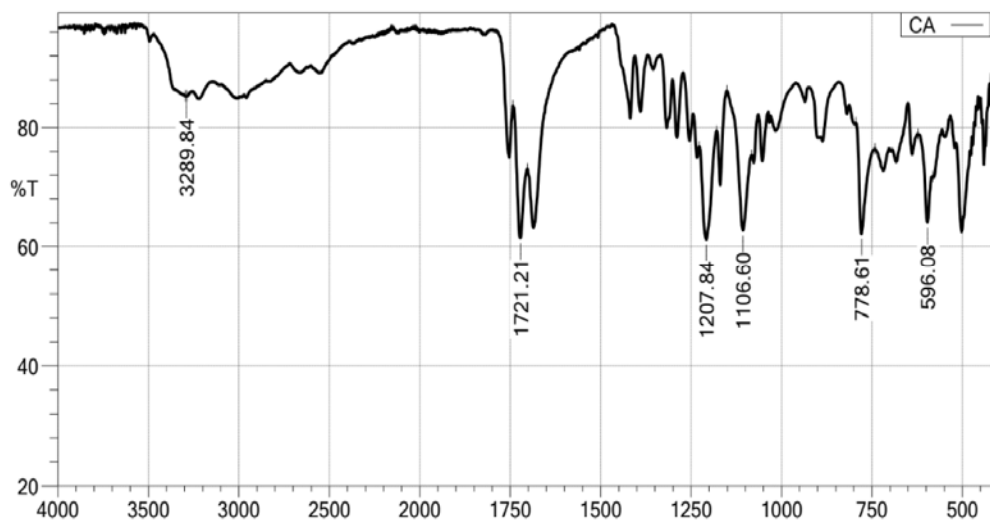
Figure. 10 IR spectra of citric acid

4.5.3 Determination of Melting point for citric acid

The sample was taken in capillary and place into the heated liquid paraffin bath.Observedthe meltingpoint which is 159-160°Cand comparedwith thereference which is 153°C.

4.5.4 Optimized chromatographic condition

Final HPLC chromatographic conditions for the detection of targeted constituents. Which found almost similar to the initially optimized HPLC method. Which can be used to detect the targeted molecules from any marketed herbal formulation.

Table2.Final HPLCOptimizedchromatographiccondition

Parameters	Chromatographiccondition
Chromatographicmode	Reversedphase
Modeofelution	Gradient
Column	WatersC$_{18}$(250mmx4.6mm,5µm)
Flow rate	1.2 mL/min
Columnoventemp.	25°C
Runtime	30 min.
Injectionvolume	10µl
Detectionwavelength	210and 276 nm

5. CONCLUSION

HPTLC analysis confirmed the presence of garcinol in a *G. indica* extract. Utilizing mass interference and mass spectroscopy, scrape the band. Garcinol was then recovered from *G. indica* extract utilizing chromatography techniques such as vacuum column chromatography and size exclusion chromatography. Garcinol was validated through the use of HPTLC, HPLC, and LC-MS methods.

According to a review article, the *G. indica* extract contains HCAL and HCA. After isolating the ingredient and validating it with HPLC, we were able to separate HCAL and HCA from *G. indica* extract, however we were unable to separate HCAL and HCA using this isolation strategy. The developed HPTLC, HPLC, and LC-MS techniques for the confirmation of the isolated compound Garcinol, as well as the HPLC, IR techniques for the confirmation of the isolated compound. This designed and developed approach can be used to detect and identify the proposed target constituents from the marketed formulations to check the authenticity of the product.

REFERENCES:

1. Jagtap P, Bhise K, Prakya V. A Phytopharmacological Review on *Garcinia indica*. Int J Herb Med. 2015;3(4):2–7.

2. Nayak CA, Rastogi NK, Raghavarao KSMS. Bioactive Constituents Present in *Garcinia Indica*Choisy and its Potential Food Application 2010 May 13(3):441–53.

3. Garcinol | 78824-30-3https://www.sigmaaldrich.com/IN/en/product/sigma/g5173 (Last accessed 12/01/2023)

4. Hydroxycitric acid | 6205-14-7https://www.sigmaaldrich.com/IN/en/search/6205-14-7 (Last accessed 12/01/2023)

5. Citric acid anhydroushttps://www.sigmaaldrich.com/IN/en/product/sial/c3674 Last accessed 12/01/2023)

6. Lim SH, Lee HS, Lee CH, Choi CI. Pharmacological Activity of *Garcinia indica* (Kokum): An Updated Review. Pharmaceuticals. 2021 Dec 1 [cited 2022 Apr 24];14(12).

7. High Performance Liquid Chromatography (HPLC) – Methods, Benefits and Applications | https://www.elgalabwater.com/high-performance-liquid-chromatography. (Last accessed 12/01/2023)

8. Bharate JB, Vishwakarma RA, Bharate SB, Thite TB, Kushwaha M, Gupta AP. Quantification and Validation of Two Isomeric Anticancer Compounds, Garcinol and Isogarcinol, in Ultrasound-Assisted Extracts of *Garcinia indica* Fruits Using HighPerformance Thin-Layer Chromatography. J Planar Chromatogr - Mod TLC. 2013;26(6):480–5

9. Pressure PA, Roge AB, Nagar S. Roge et al. ,. 2011;2(8):1930–7.

10. Price KR, Curl CL, Fenwick GR. Flash chromatography-A simple technique of potential value to the food chemist. Food Chem. 1987;25(2):145–53.

11. Sheet TD. Cellufine ® GH-25. :2–8.

12. Pedersen DS, Rosenbohm C. Dry column vacuum chromatography. Synthesis (Stuttg). 2001;(16):2431–4.

13. Issa D, Hassan M, Hamed O. STUDIES TOWARD ISOLATION AND IDENTIFICATION OF BIOACTIVE SUBSTANCES FROM MEDICINAL PLANTS Derar Issa " Mohammad Hassan " Smadi. 2011;

14. Fallis A. Estimation of (-)-Hydroxycitric Acid (HCA) In Garcinia LanceaefoliaRoxb. Using Novel HPLC Methodology. J Chem Inf Model. 2013;53(9):1689–99.

15. Lewis YS. [77] Isolation and properties of hydroxycitric acid. Methods Enzymol. 1969;13(C):613–9.

PERFORMANCE ANALYSIS OF PV PANEL UNDER PARTIAL SHADING CONDITION

Mr. Pranay Dattani

Shantilal Shah Engineering Collage

Mr. Munjal Bhatt

Shantilal Shah Engineering Collage

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.

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

$$V_T = \frac{KT}{q} * nl * Ncell$$
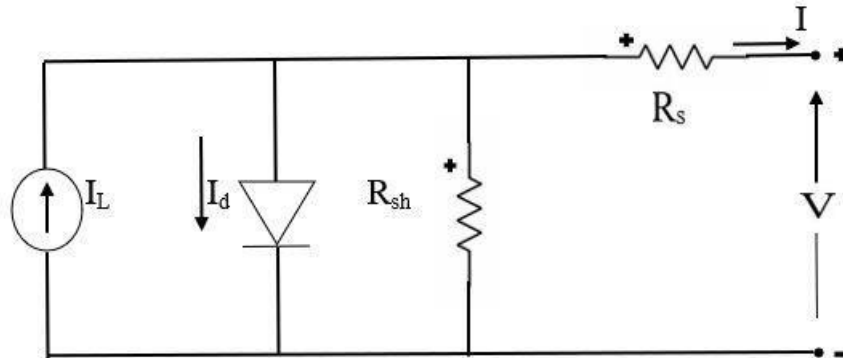
I_d	Diodecurrent(A)
V_d	Diodevoltage(V)
I_0	Diode saturation current(A)
nI	Diode ideality factor, a number close to 1.0
k	Boltzmann constant=1.3806e-23J.K-1
q	Electron charge =1.6022e-19 C
T	Cell temperature(K)
Ncell	Number of cells connected in series in a module
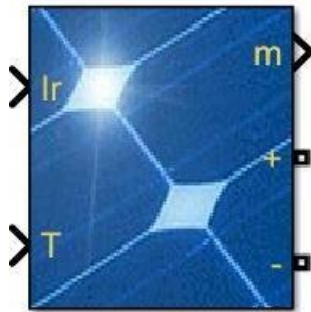
Parameter	Value
Pmax	249.952 W
V_{oc}	50.93V
I_{sc}	6.2A
V_{mp}	42.8V
I_{mp}	5.84A
Ncell	72
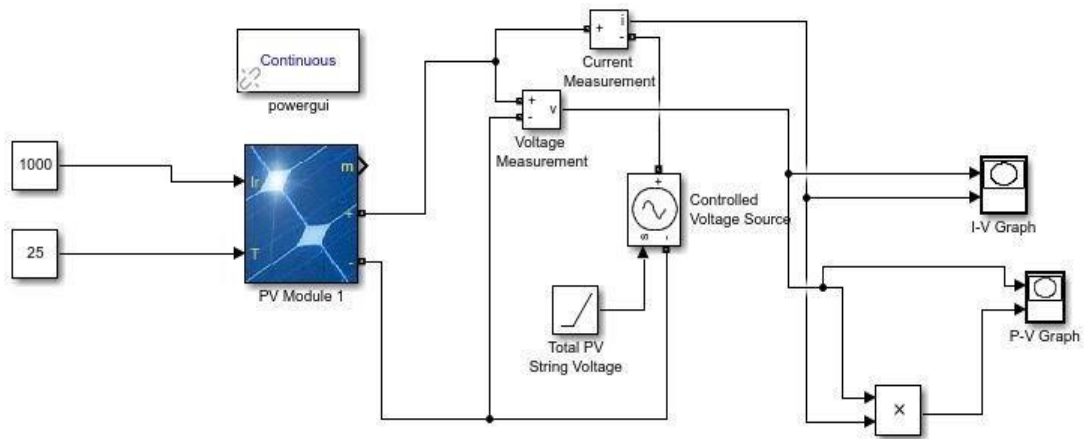
Fig IV graph of generalized Solar panel.
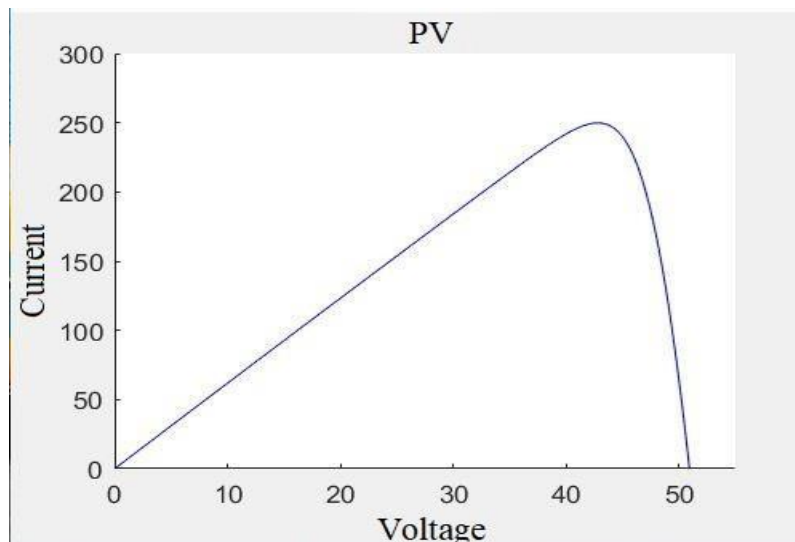
Fig PV graph of generalized Solar panel.

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.
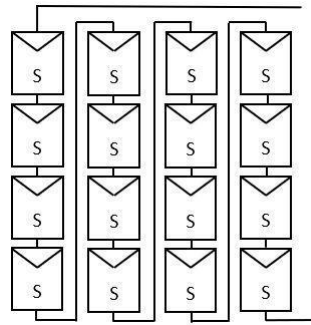
Fig Series (S)

- 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.
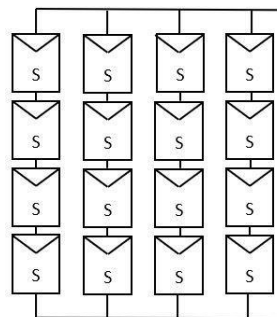
Fig Series Parallel (SP)

- 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.
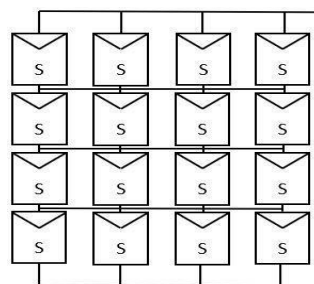
Fig Total cross tide (TCT)

- _ 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.
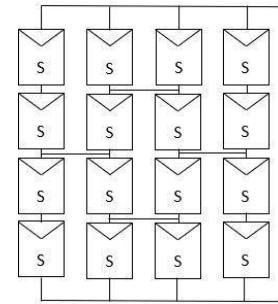
Fig Bridge link (BL)

- 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.
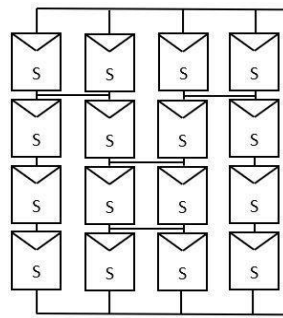
Fig Honeycomb (HC)

- 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.
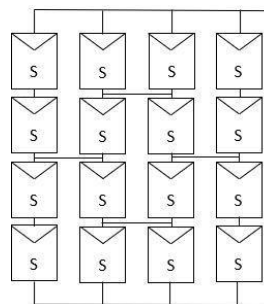
Fig Bridge link (BL)

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 1 Case 2 Case 3 Case 4

Case 9 Case 10 Case 11 Case 12
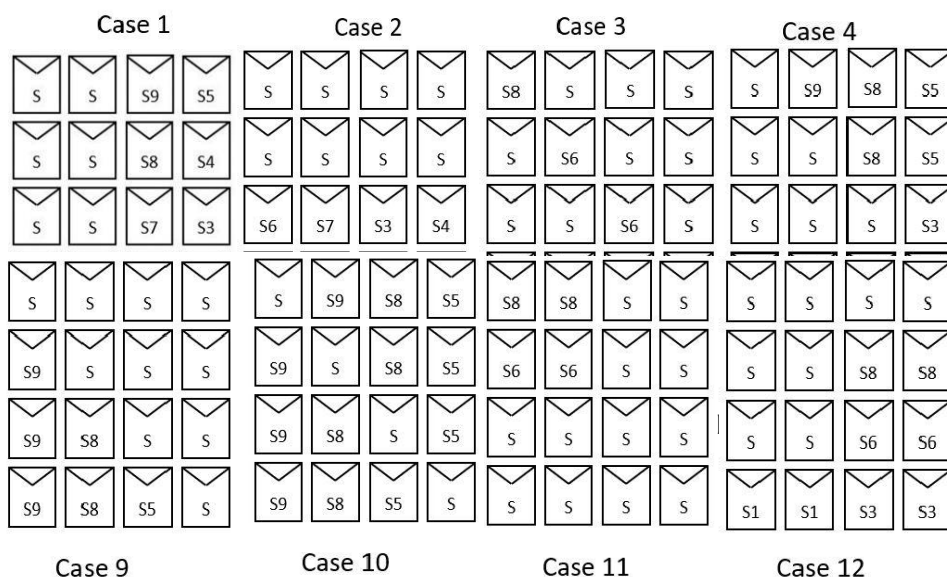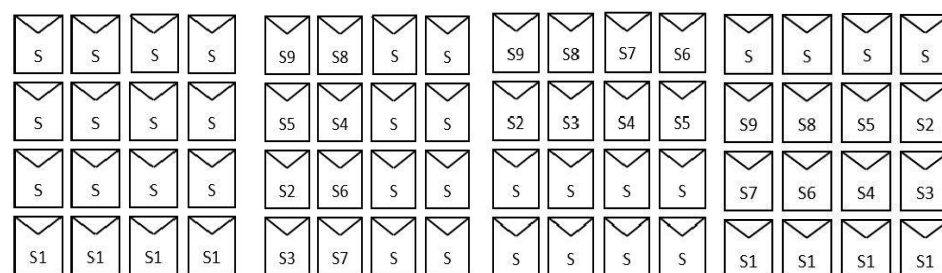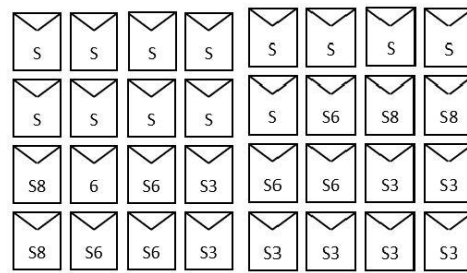
Case 13   Case 14

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:-**
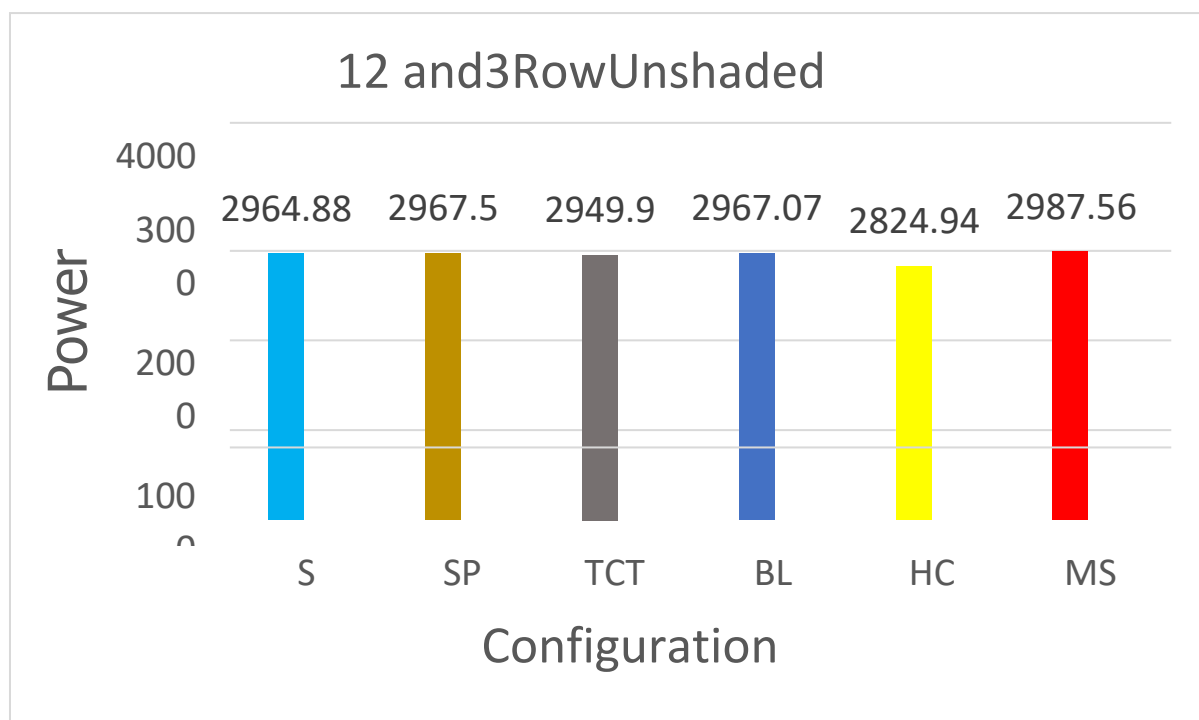
Case2:-

Case3:-

Case4:-

Case5:-

Case6:-

3 and 4 Row Shaded

Case7:-

Diagonal Shaded

Case 8:-

LSOD Unshaded

Case9:-

RSOD Unshaded
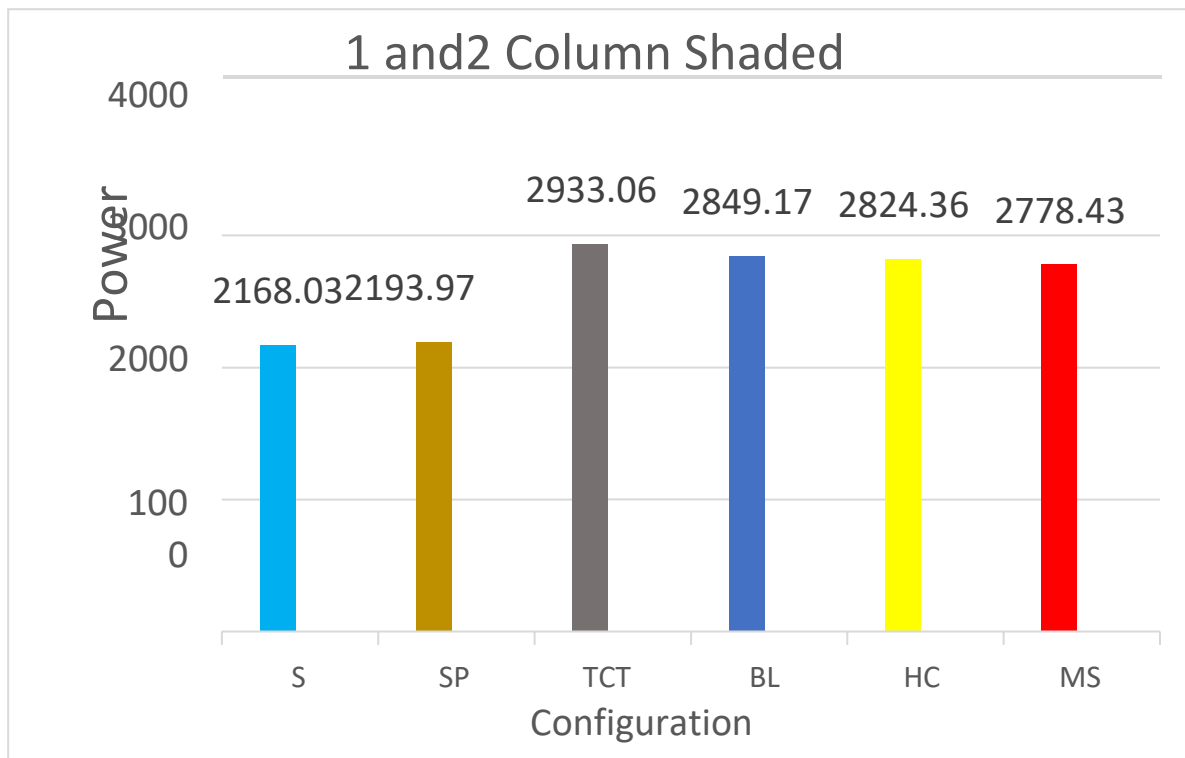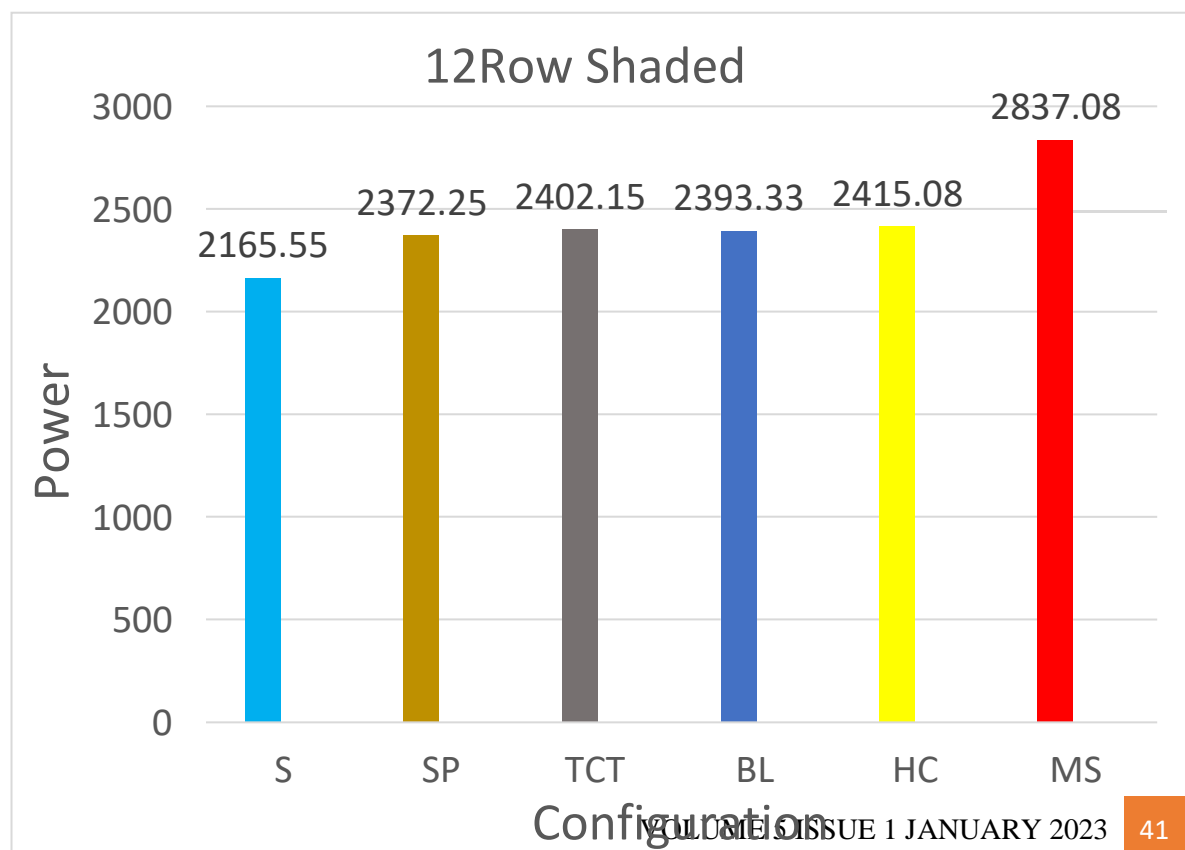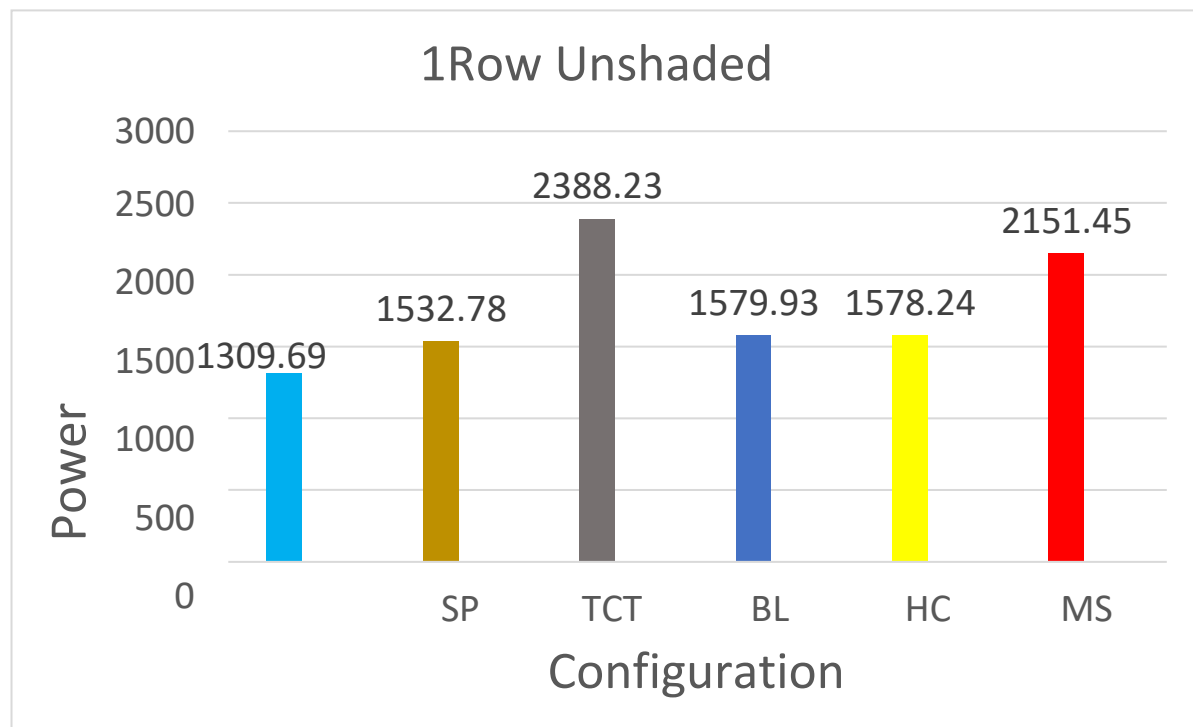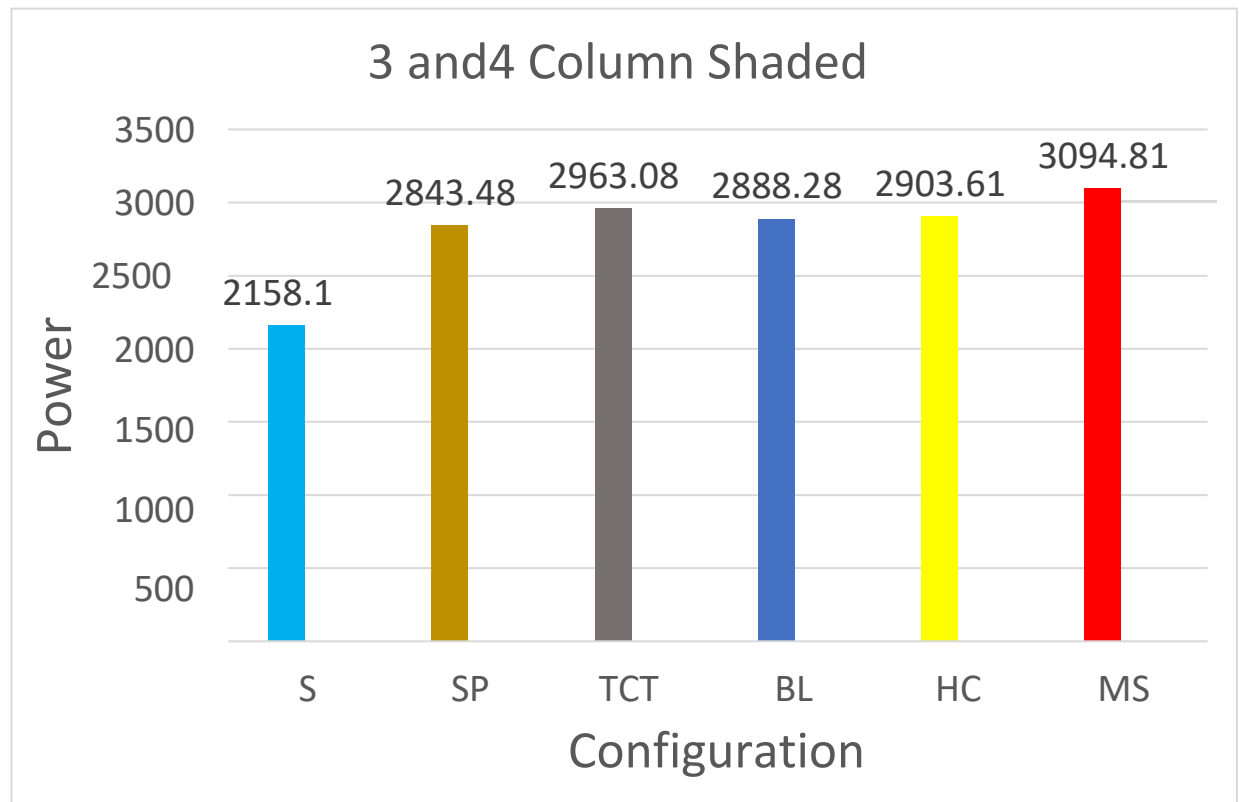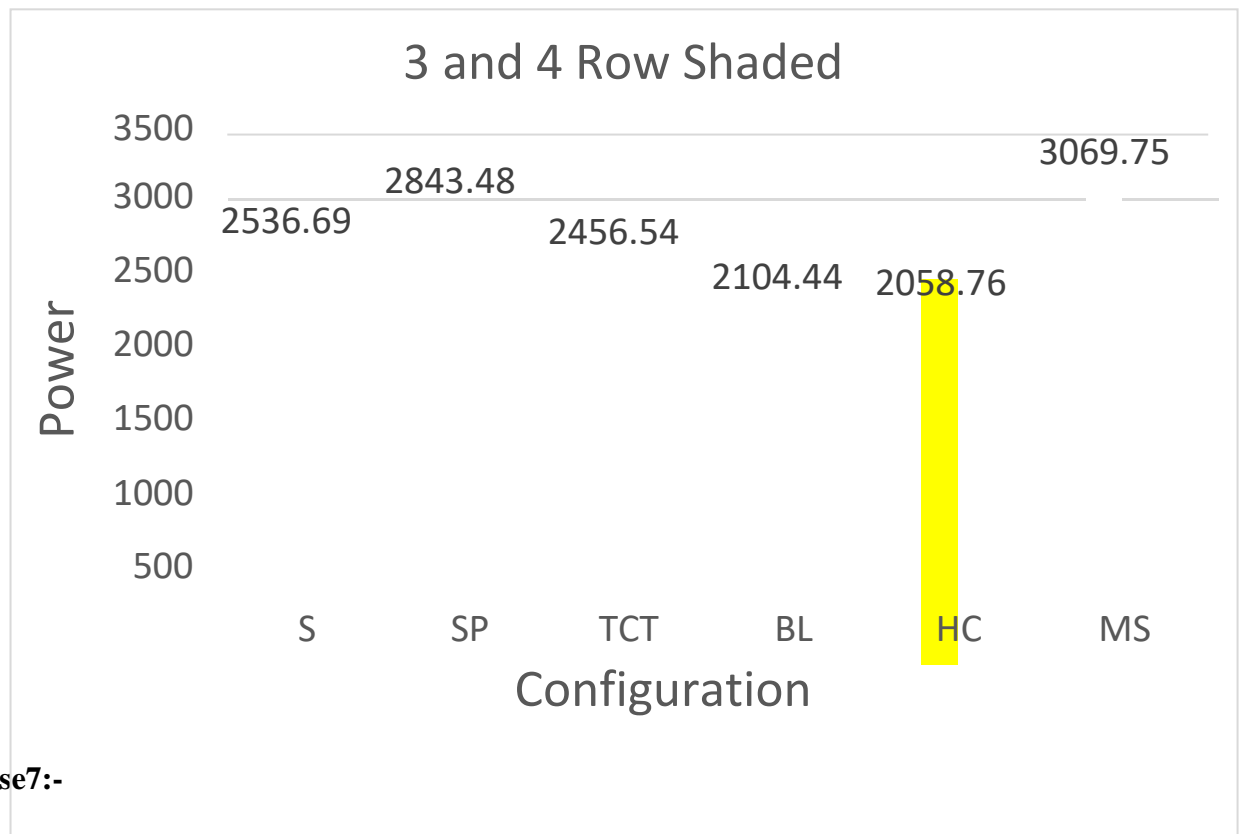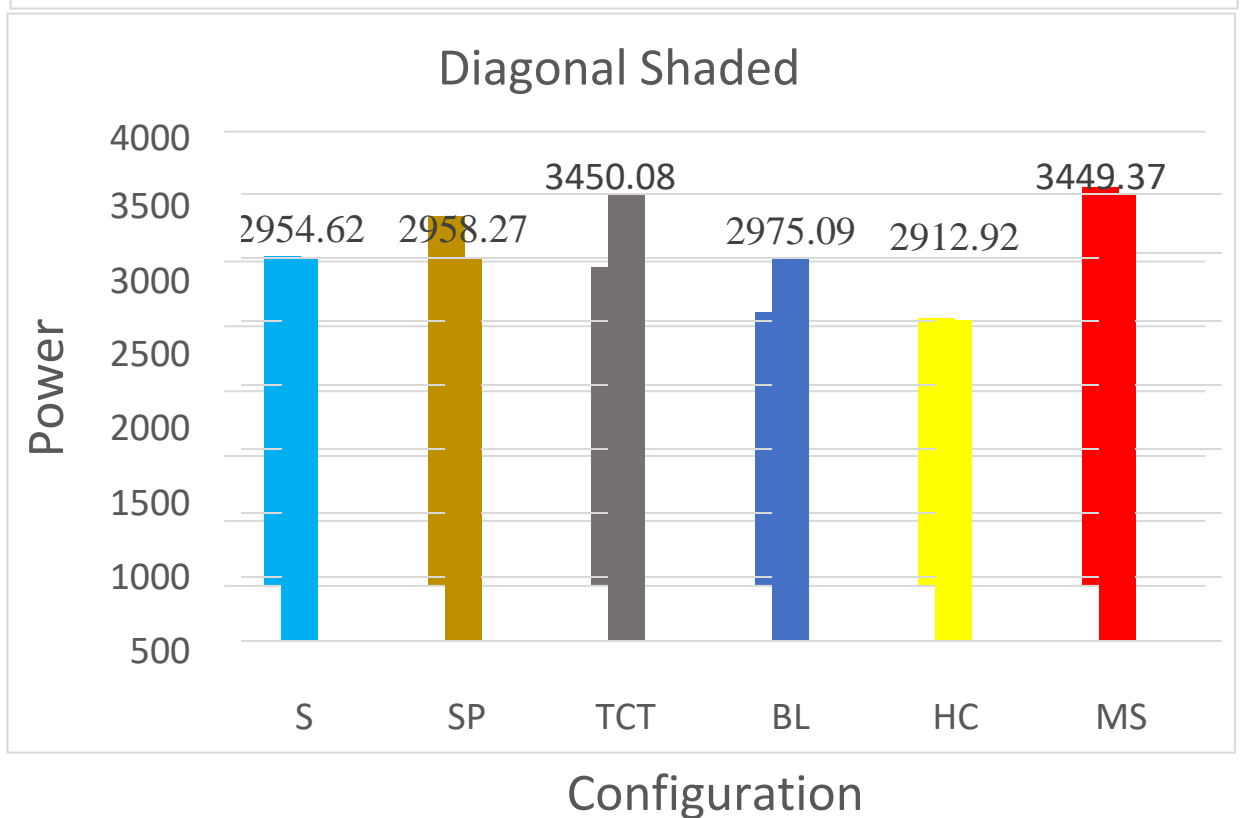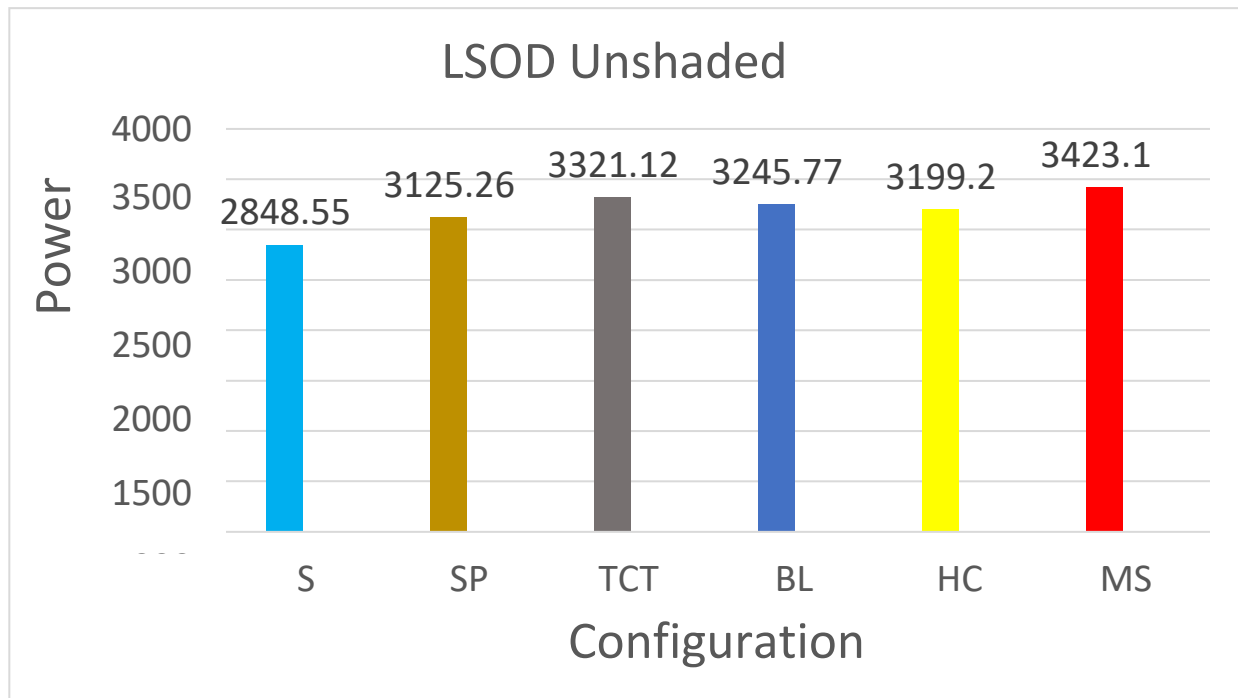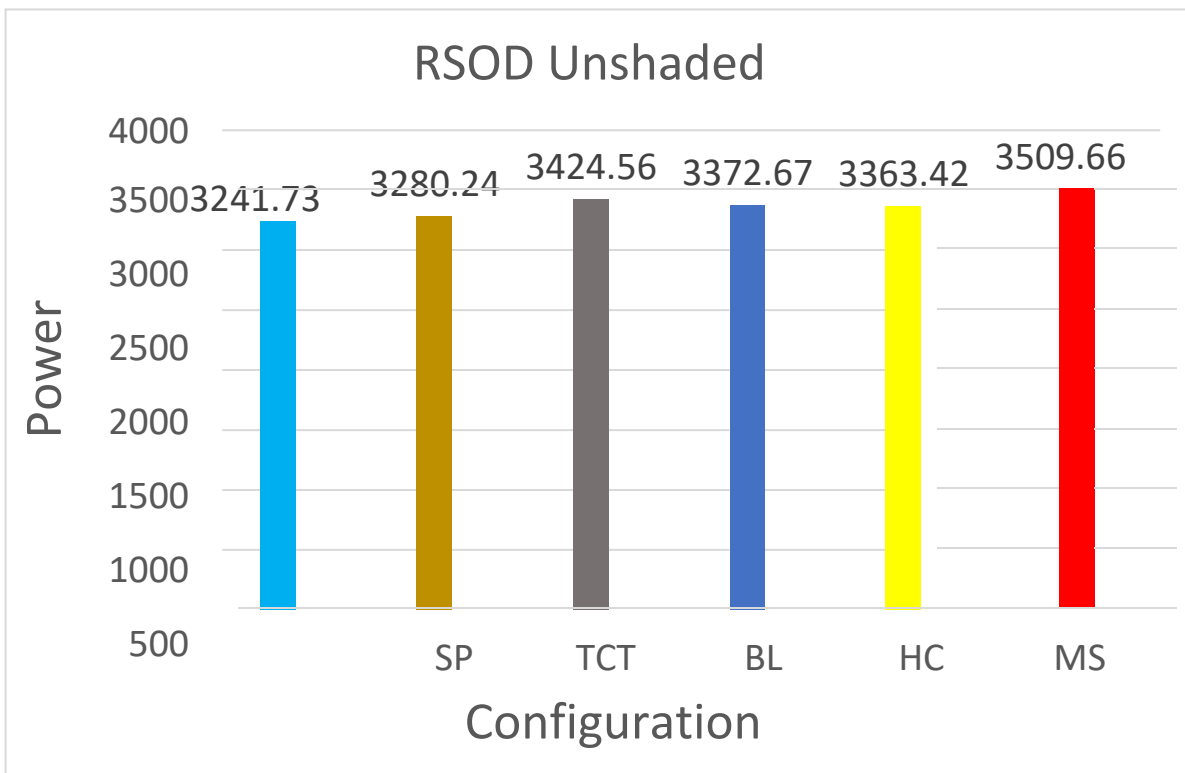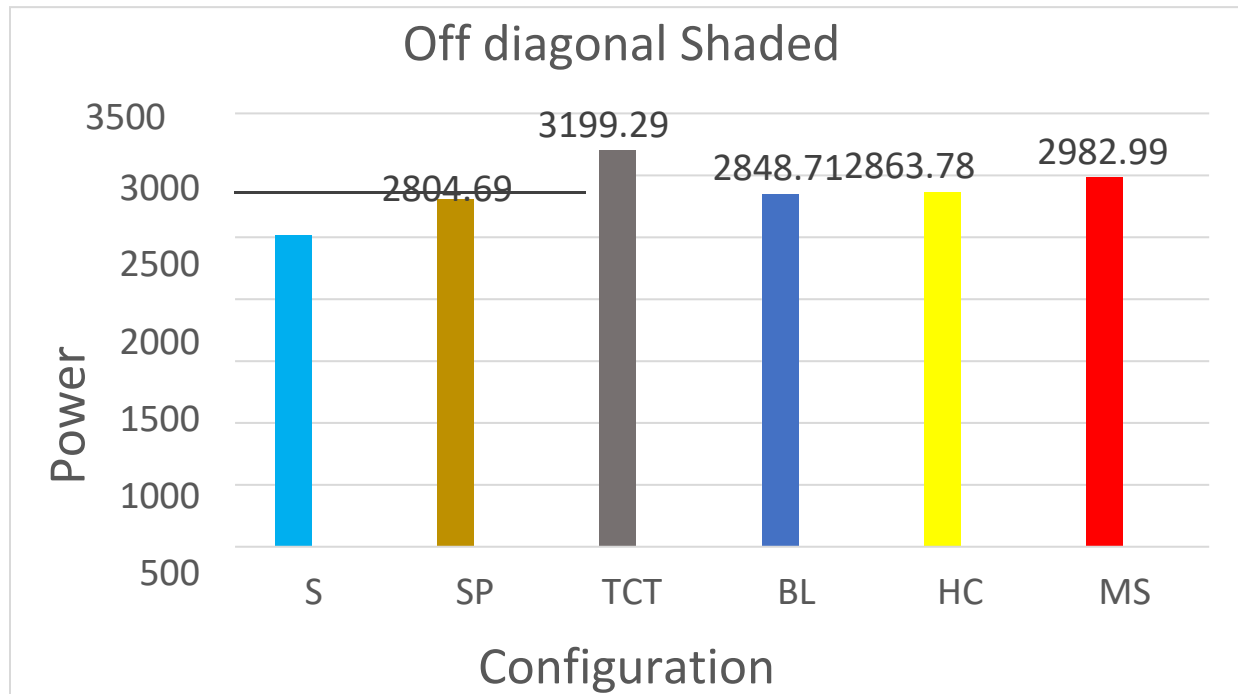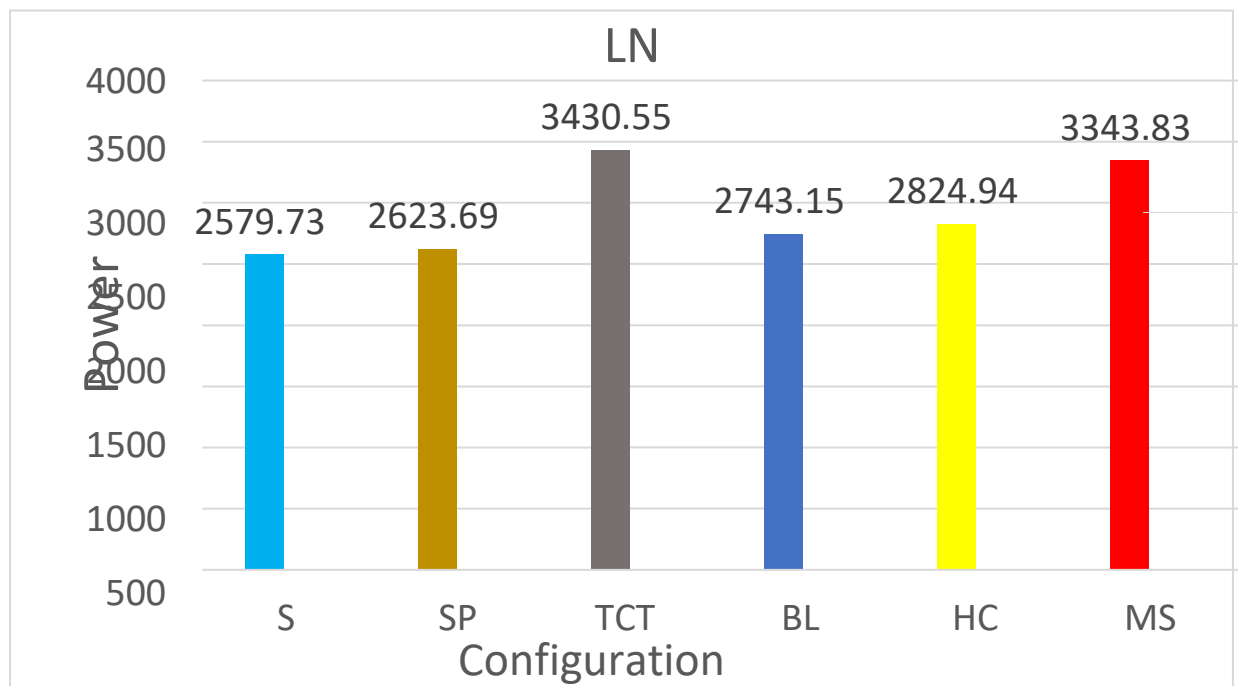
Case10:-
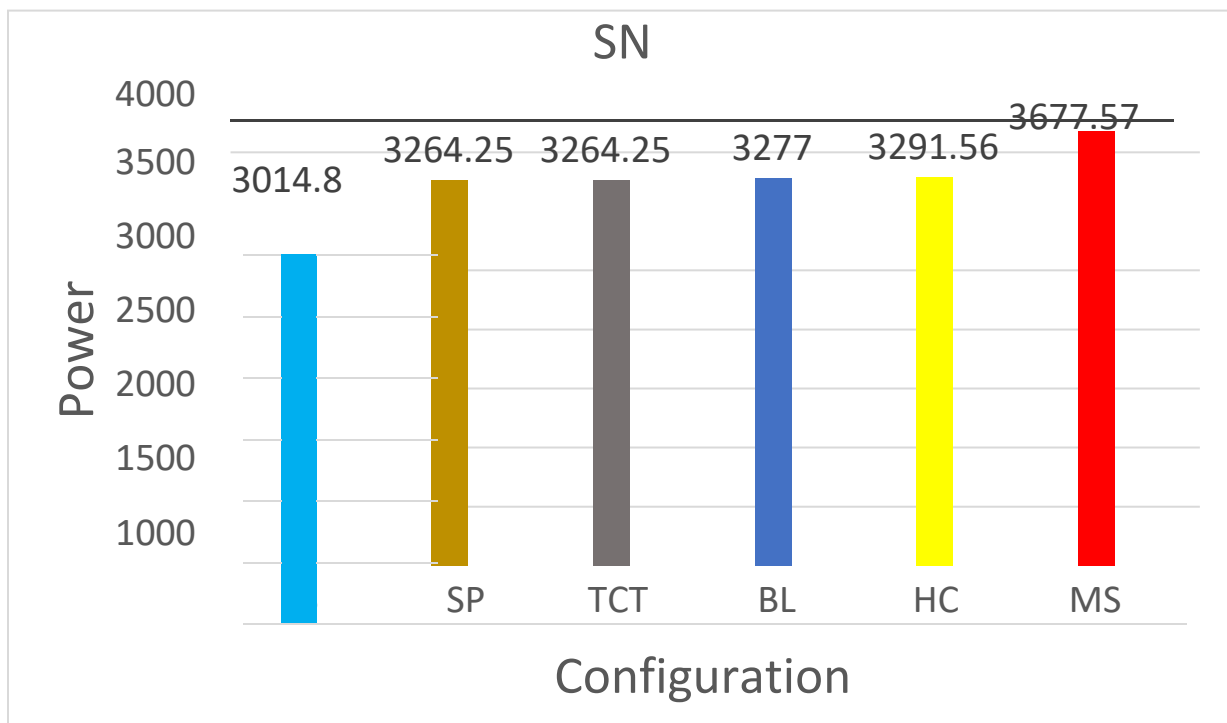
Case11:-
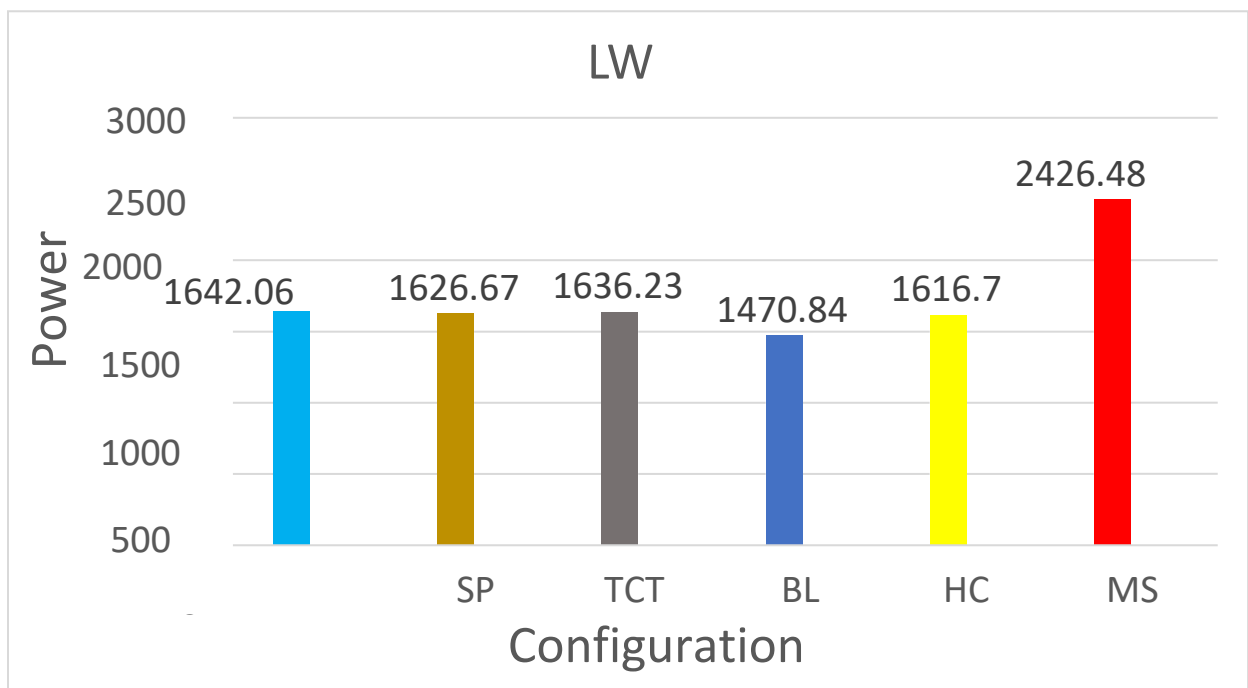
Case12:-
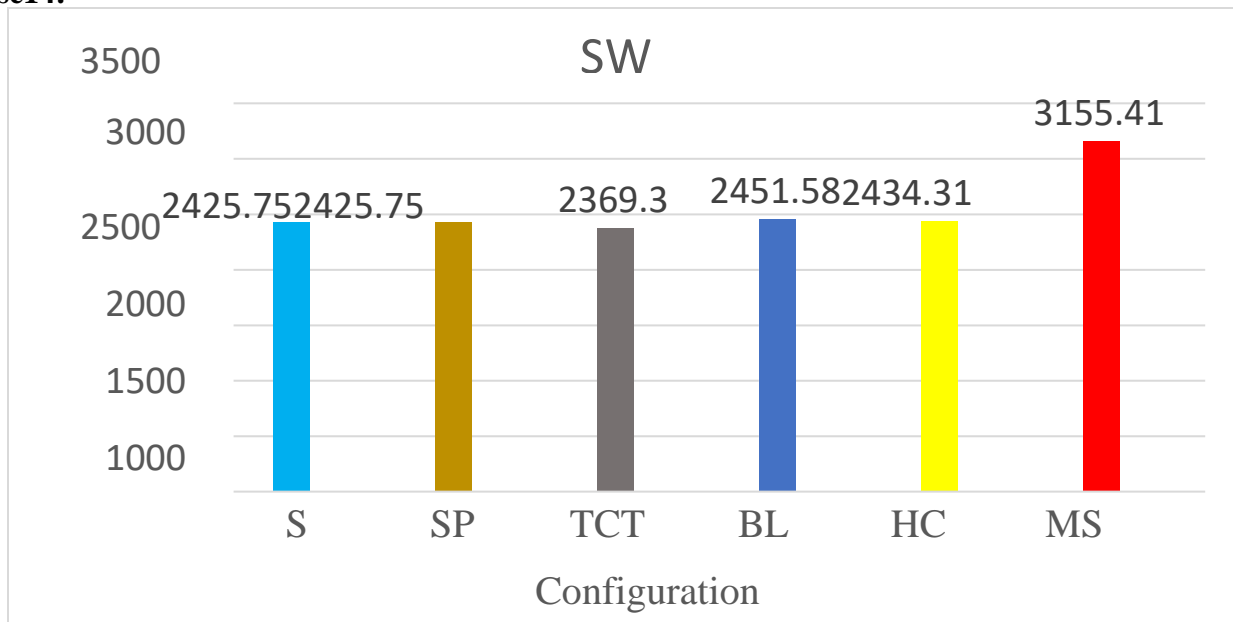
Case13:-

Case14:-

Generate Losses under shading condition:
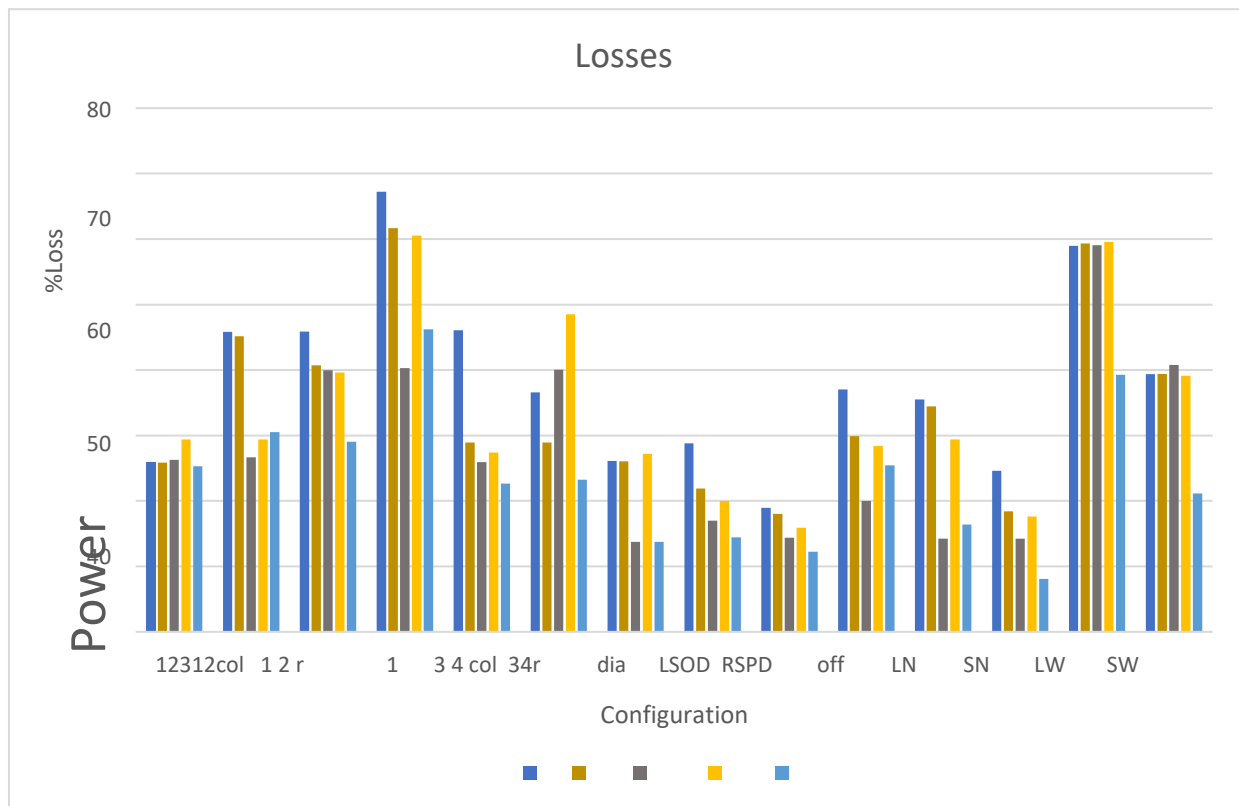
1. **Comparison of all configurations**

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 (%)

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)
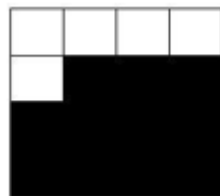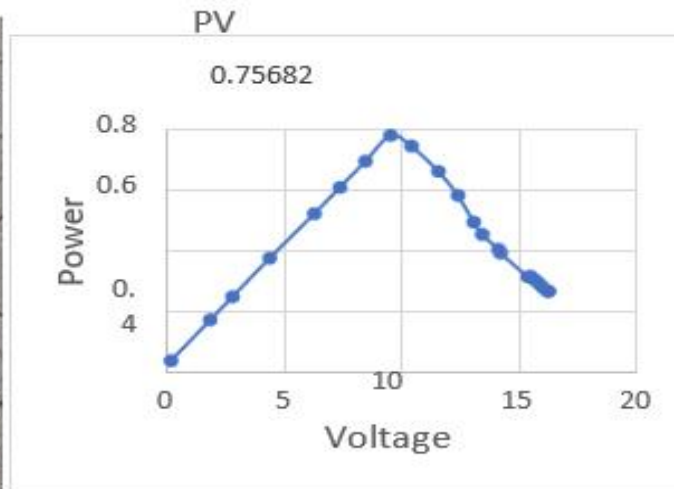
Fig 6.1 LW shading on SP configuration

Power(W)

0.75682

6.1.2 Bridge link (BL)

Fig 6.2 LW shading on BL

Configuration
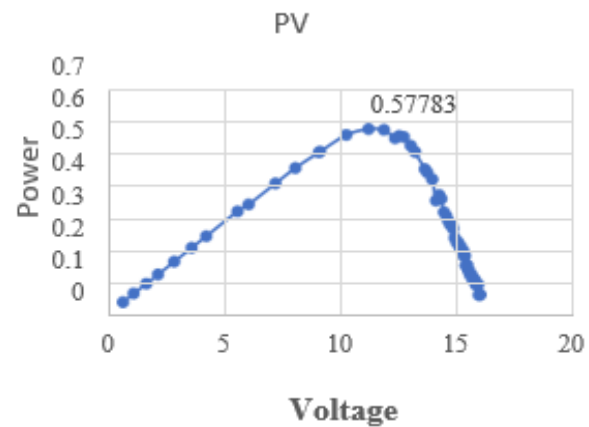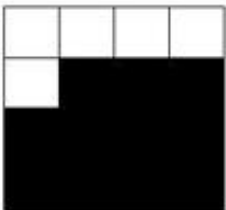
Power(W)

0.577

6.1.3 Honeycomb (HC)

Power(W)

0.694

Fig 6.3 LW shading on HC configuration

PV

0.6944
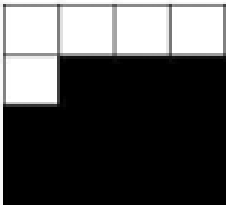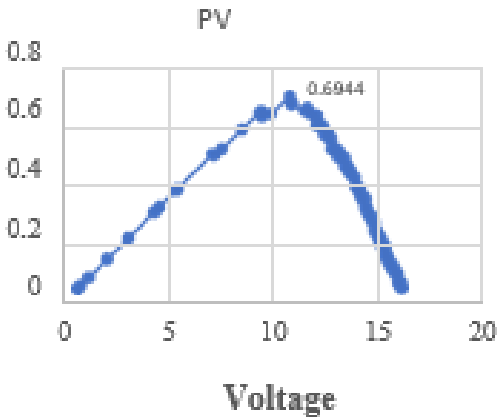
6.1.4 Total Cross tide (TCT)
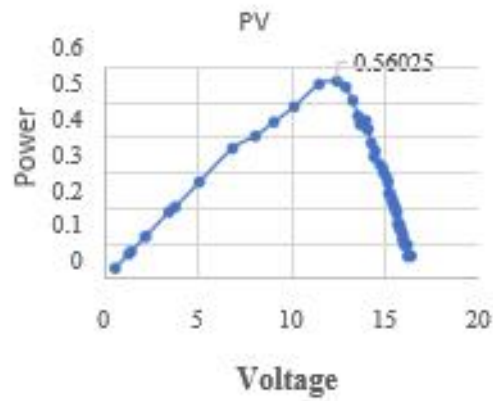
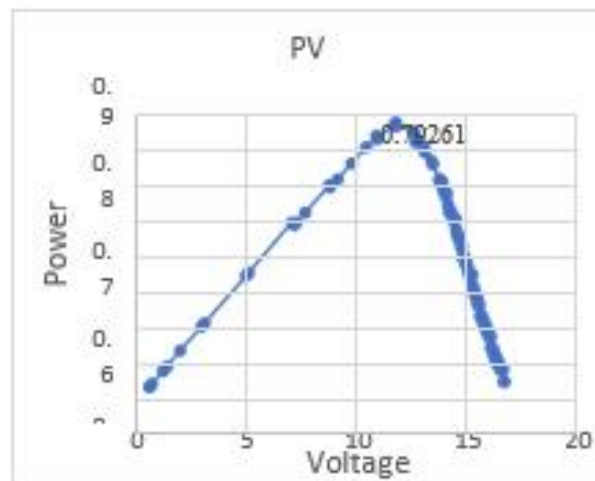Fig 6.4 LW shading on TCT configuration.
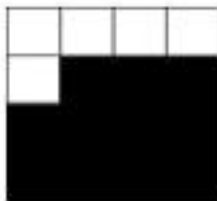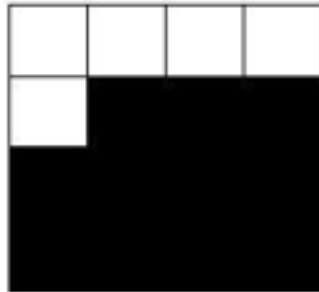

Power(W)

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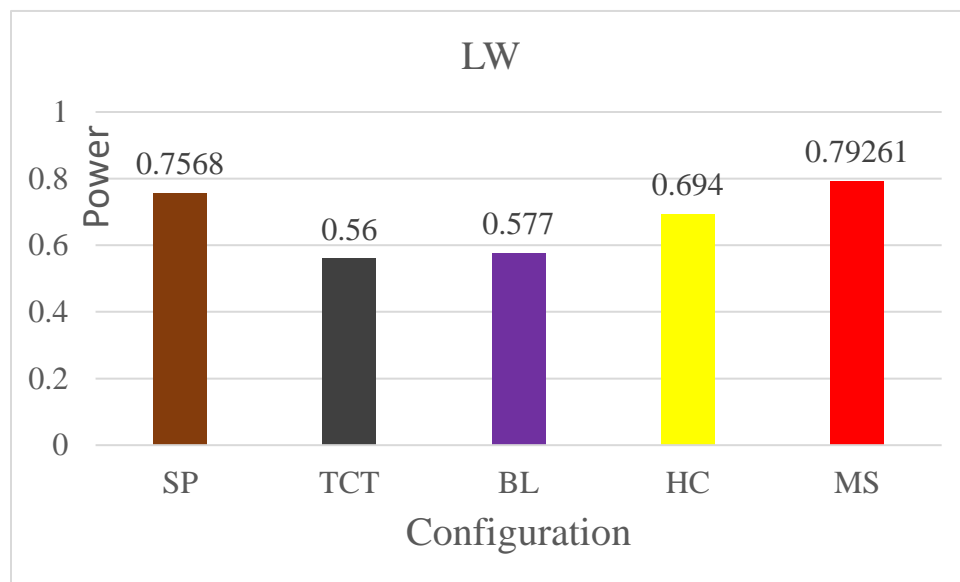
- After major shading pattern apply on the different configuration and we analyze the MS configuration is delivered higher power (3.88W) in all apply shading pattern compared to another configuration.

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.

References:-

1. Abri, W. Al, Abri, R. Al, Yousef, H., & Al-hinai, A. (2021). A simple method for detecting partial shading in PV systems. Energies, 14(16), 1–12.
2. Ali, B. S., Benalia, N., & Nora, N. Z. (2018). Effect of partial shading on the PV system performances. 2018 6th International Conference on Control Engineering and Information Technology, CEIT 2018, October 1–4.
3. Alves, T., Torres, J. P. N., Marques Lameirinhas, R. A., & Fernandes, C. A. F. (2021).Different techniques to mitigate partial shading in photovoltaic panels.Energies,14(13).
4. Anand, V. P., Ameen, E., & Pesala, B. (2014). Experimental investigation of the shading losses on solar module system performance. 2014 International Conference on Advances in Electrical Engineering, ICAEE2014.
5. Arun, P.S., & Mohanrajan, S.R. (2019).Effect of Partial Shading on Vehicle Integrated PV System. Proceedings of the 3rd International Conference on Electronics and Communication and Aerospace Technology, ICECA 2019, 1262–1267.
6. Chinyoka, S., Ncube, T., Iroegbu, M., & Alarefi, S. M. S. (2020). Partial Shading Performance Evaluation of Bifacial PV Array Configurations. Proceedings of 2020 IEEE International Women in Engineering (WIE) Conference on Electrical and Computer Engineering, WIECON-ECE 2020, 485–488.
7. Deshpande, V. P., & Bodkhe, S. B. (2017). Analysis of Various Connection Configuration of Photovoltaic Module under Different Shading Conditions.12 (16), 5715–5720.
8. Giyantara, A., Wisyahyadi, Rizqullah, R. B., & Kusuma Priyanto, Y. T. (2021). Analysis of Partial shading Effect on Solar Panel Power Output. Journal of Physics: Conference Series, 1726(1).

9. Ibrahim, H., &Anani, N. (2019). Variation of the performance of a PV panel with the number of bypass diodes and partial shading patterns. 5th International Conference on Power Generation Systems and Renewable Energy Technologies, PGSRET 2019, 2(c), 1–4.

10. Kumar, T., Kumar, B., & Jha, S.K.(2017). MATLAB/ Simulink model to study solar cell characteristics under partial shading. Proceedings of the International Conference on Electronics, Communication and Aerospace Technology, ICECA 2017, 2017-January (1),642–646.

11. Ma, J., Bi, Z., Man, K. L., Dai, H., & Wu, Z. (2018). Identification of Partial Shading in Photovoltaic Arrays Using Optimal Sensor Placement Schemes. 7th International IEEE Conference on Renewable Energy Research and Applications, ICRERA2018, 5, 458–462.

12. Mohammad nejad, S., Khalafi, A., & Ahmadi, S. M. (2016). Mathematical analysis of total-cross-tied photovoltaic array under partial shading condition and its comparison with other configurations. Solar Energy, 133, 501–511

13. Mukti, R. J. (2014). Maximum Power Point Tracking Technique by Comparing Different Converter Topologies. 235–240.

14. Nadia, B. S. A., Ahmed, M., Nadia, B., & Nora, Z. (2019). Analysis of Solar Photovoltaic Array Interconnection Schemes Working under Partial Shading Conditions.Proceedings-20191stInternationalConferenceonSustainableRenewableEnergySystemsandApplications, ICSRESA 2019, 8–11.

15. Nageswara Rao, M., & Chaitanya, V. S. N. K. (2020). Experimental analysis of partial shading on solar panels with the use of aluminium reflectors. Proceedings of 2020 IEEE International Conference on Advances and Developments in Electrical and Electronics Engineering, ICADEE 2020, Icadee, 3–7.

16. Pendem, S. R., &Mikkili, S. (2018). Modeling, simulation, and performance analysis of PV array configurations (Series, Series-Parallel, Bridge-Linked, and Honeycomb) to harvest maximum power under various Partial Shading Conditions. International Journal of GreenEnergy, 15(13), 795–812.

17. Pendem, S. R., & Mikkili, S. (2018). Performance evaluation of series, series-parallel and honey-comb PV array configurations under partial shading conditions. 2017 7th International Conference on Power Systems, ICPS 2017, 749–754.

18. Pradhan, R., & Kar, S. (2020). A Comprehensive Study of Partial Shading Effect on the Performance of PV array with Different Configuration. Proceedings of the 2020 International Conference on Renewable Energy Integration into Smart Grids: A Multidisciplinary Approach to Technology Modelling and Simulation, ICREISG2020, 78–83.

19. R.Boukenoui, R.Bradai, H.Salhi, A.Mellit IEEE (2015). Modelling and Simulation of Photovoltaic Strings under Partial Shading Condition Using

MATLAB/Simscape. Journal of Scientific research of Algiers.

20. Raju, V. B., & Chengaiah, C. (2019). Power Enhancement of Solar PV Arrays underPartial Shading Conditions with Reconfiguration Methods. 2019 Innovations in Power and Advanced Computing Technologies, i-PACT 2019, 1–7.

21. Ramaprabha, R., & Mathur, B. L. (2008). Modelling and simulation of solar PV array under partial shaded conditions. 2008 IEEE International Conference on Sustainable Energy Technologies, ICSET 2008, 7–11.

22. Saeed,S.,Awan,F.G.,Nasir, M.,Mudassar, M.,Kamran,M.,Nazir,A.,&Nazar,W.(2019). Analysis of interconnection schemes for PV systems operating under shadow conditions. International Journal of Renewable Energy Research, 9(2), 913–922.

23. Saket, R. K., & Member, S. (2021). Performance Enhancement of PV System Configurations Under Partial Shading Conditions Using MS Method. 9.https://doi.org/10.1109/ACCESS.2021.3071340

24. Sharma, A., Venkateswaran, V. B., & Singh, R. (2019). Experimental Analysis of Electrical and Thermal Effects of Various Configurations of Partial Shading on Three Different Solar Module Technologies. Proceedings of the IEEE International Conference on, RTECC 2018, 137–142.

25. Tatabhatla, V. M. R., Agarwal, A., &Kanumuri, T. (2021). Performance Improvement by Mitigating the Effects of Moving Cloud Conditions. IEEE Transactions on PowerElectronics,36(4), 4214–4223

26. Villa,L.F.L.,Picault,D.,Raison,B., Bacha,S.,& Labonne,A.(2012).Maximizing the power output of partially shaded photovoltaic plants through optimization of the interconnections among its modules. IEEE Journal of Photovoltaics, 2(2), 154–163.

MINIMIZING ENERGY WITH HIGH-SPEED WDM OPTICAL GRID NETWORKS

Dr. Mihir K. Patel

Kalol Institute of Technology & Research Centre, Kalol, Gandhinagar

Abstract

In the existing optical network, WDM technology transfers information with different wavelengths. Several researchers previously focused on increased wavelength capacity in optical networks. The optical network of WDM technology ranges from 1 to 2.5 GB/S & 10 to 40 GB/S. with the increasing WDM range level; it can be extended up to 400 GB/S. The previous 100 GHz grid networks used in WDM are not feasible solutions for transceiver applications. The traffic manipulation of multiple signals in WDM will cause lower system efficiency. The key difference is the fast response by transponders which allows high efficiency for spectrum modulation, but it will not fitted within 50GHz slot of frequency modulation spectrum due to large spectrum modulation requirement. The crucial benefit of adopting flex grid network is it will offers spectrum efficient modulation & finer control in spectrum allocation. It also provides better control on WDM network with effective traffic management. In this paper, flex grid & fix grid networks are used for internet networks to minimize energy usage in the system. In this project work, optical network planning & operation control helps with the operation of both grid network configurations.

Keywords—WDM, OFDM, Flex Grid & Fix Grid, etc.

1. INTRODUCTION

In recent time the optical fiber network is operates on WDM technology with information transfer on different range & different wavelengths. I studied that previous researchers have focused the traffic management of WDM & optical network through increasing the wavelength of signals. The increase of wavelength requires wide range receiver with 100 GB/s range & in next few years it will crosses 400 GB/s step with more complex network configurations. This kind of transmission will not fit for 50 GHz wavelength in WDM networks [2-4]. After some of researchers is designed 75 to 100 GHz range for transceivers in optical network. But all of those are very limited solution & not possible to use for wide range of optical network applications. At the other hand WDM network faces low efficiency problem due to coarse granularity of the light paths in optical network operations. Due to this issue optical connections & their operation in WDM network becomes very complex for whole wavelength.

Traffic manipulation at lower capacity levels is performed at the electronic. The traffic manipulation of multiple signals in WDM will cause lower system efficiency. This Paper studied the data records for internet use & Global Internet traffic growth increase in recent years. From that study, I learned that multiple 300 times more GB/s increases GIT growth. Using Flex-gird will help meet the requirements of internet networks for the next generations. While the use of fix grid network provides fixed bit data rate transfer in the communication network in the system. The data patterns are also maintained in the specified manners in the limited grid network, while the data patterns are in unexpected ways in the flex grid network. This paper studied all research materials on flex & fix grid networks for optical internet networks with features of energy use reduction [4].

This Paper characterized the benefits of a flex grid network for managing the flexible operation of internet sources. To increase network capacity, the Flex grid requires a less rigid and fixed approach to wavelength allocation. Flex grid networks can natively support demands greater than 100Gbit/s demands, which is a key benefit and brings significant capacity benefits on both a point-to-point link and in a network context. This Paper is a detailed study of the use of WDM networks for internet use. It helps me to manage the project objectives to carry out during this work [1-2].

- ✓ To study the benefits of Flex grid network compared to fix grid network for WDM network.
- ✓ To carry out the study on the operational block diagram of the project idea.
- ✓ To develop the Matlab coding & implementation for simulation analysis of both types of grid networks.

2. RESEARCH GAP & OBJECTIVES

This work presents the exponential growth of internet in past few years, this large usage of internet leads us to think about grid network operations. This paper work presents the use of fix grid & flexes grid networks in optical network to solve the traffic issues, various wavelength signal modulation, power saving, etc. In this paper the operational structure of fix grid & flex grid network is studied for energy consumption & power saving with analytical model study. I have applied the study of these analytical models for real topologies with internet traffic management. In the previous studies several researchers have proposed CAPEX/OPEX model based solutions with energy optimization algorithms. [1-3]But due to their limitations & complexity for wide range of wavelength modulation control in WDM network, I have focused to extend my work fix grid & flex grid based operation for WDM system with location based energy pricing system. This will helps to significantly monitoring of energy use & adjustment in reducing the power consumptions in optical network system. With the development of technological advancement, internet use is also rapidly increasing. The internet will consume electricity for devices to operate the board band network. The ICT use with telecommunication will control energy consumption under control [2-4]. In the present scenario, in this Paper researcher studied that broadband-enabled countries use around 4% of total energy consumption, and in the optical network, energy consumption is around 12%. This Paper planned to develop a feasible grid network for the internet to reduce energy use in the system. I learned that there are flex grid & fix grid networks are used for internet networks to minimize energy usage in the system. In this project work, optical network planning & operation control helps with the operation of both grid network configurations. The proposed formulation is quite generic and can be used to allocate resources when sliceable transponders are used, but also for fixed transponders of single or mixed line rate and fixed grid switch [4-5]. Using a flexible grid network, I also studied that optical network planning can be implemented with low energy consumption. Appropriately planning the algorithm is essential to develop Matlab coding for the proposed system to check the performance comparison. This Paper studied that still in developing countries, internet speed is deficient. As time goes by, they require high-speed internet in upcoming times for data transfer and reliable operation.

In the future, technological advancement is focused on developing an internet channel for 400 GB/s. An existing fixed grid WDM network can't achieve this internet speed. To enhance the speed level flex grid network is feasible for increasing the internet speed in this research work. This Paper planned Matlab simulation work with coding implementation for flex grid network and studying bandwidth signal multiplexing. This Paper used communication ideas to develop the energy-aware algorithm for a flexible

grid network with SLR & MLR spectrum for transmitting high bit rate data in the channel system. This Paper developed the Matlab coding of the proposed algorithm to test the performance of the fixed grid & flex grid for maximum data transfer. It helps me improve communication network fundamentals for internet networks [6].

3. FLEX GRID & FIXED GRID NETWORKS

3.1 Fixed Grid Network Operations

In the latest, all researchers focused on variable spectrum connections to improve spectral efficiency and large bit rate data transfer in the system. But the existing fixed grid network will not provide such a variable spectrum causing the limited use of optical internet networks [1-2].

This Paper studied the basic operational configuration of a fixed grid network that provides a fixed spectrum frequency for WDM networks. It required modulation & several OFDM techniques for the modulation of channel signals. For the use of fixed grid ROADM operation, they will follow the traditional grid network in communication networks. The conventional networks will provide fixed frequency levels for the operations around 50 to 100 GHz for individual channels. The fixed grid system will use multiple devices for variable spectrum applications at receiving end, including optical switches, multiplexers, transponders, etc. The wavelength spectrum & diagram for the essential operation of the fixed grid network are shown below.
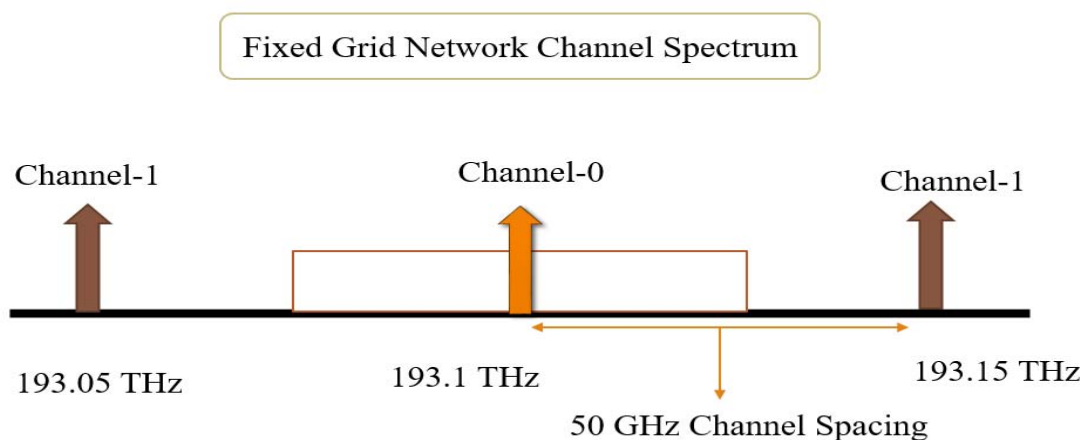
Fig.1 Operational Diagram of Fixed Grid Network

The main drawback of a fixed grid network is the RWA problem which causes the limited bandwidth of the signal. WDM was only designed for SLR with a single transponder for the optical network in a fixed grid network. But the new advancement in transmission technologies is required to adopt multiple transponders to improve efficiency & reduce network costs. These kinds of multiple transponders will be called MLR for the optical network system. This Paper studied that MLR benefits will be focused on the WDM system with flexible grid network use for upcoming times. The flexible grid network provides multiple frequency band signals for modulation and multiplexing of various frequency ranges for signal.

3.2 Flex Grid Network Operations

This Paper specified earlier that a flex grid network has several benefits compared to a fixed grid network. But the only problem with a flex grid network is that establishing a flex grid is more complicated than a fixed grid. Compared with the fixed grid network where a single wavelength is used, the flex grid has spectrum slots with combination forms with different width channels. Therefore, it is also known as RSA for spectrum allocation in the optical system. This Paper also worked on a different range of transmission options & various fields of spectrum use for RWA and RSA spectrum sampling.
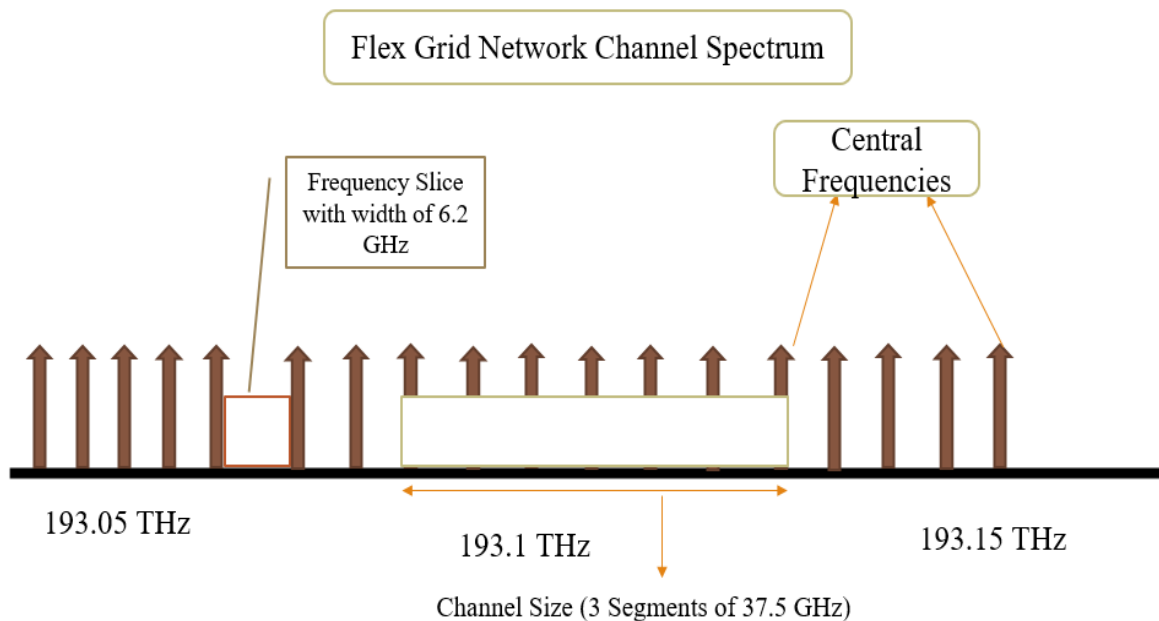
Fig.2 Operational Diagram of Flex Grid Network

WDM transceivers are used for specific signal transmission with other signal interference control with useful OFDM technologies. In the proposed flex grid network, the data transmission rate depends on the configuration of BVT & regenerators in the optical network system. For example, a flexible-grid node uses only 25 GHz spectrum resources instead of 50 GHz to transmit a 40 GB/s signal, which saves spectrum resources. As shown in fig. 3 above, the signal spectrum will show the multiple signal multiplexing & an extensive range of frequencies in the operation of flex grid network operations.

4. SIMULATION & ANALYSIS

4.1 Matlab Coding of Proposed Grid Networks

For developing the WDM optical network model, this Paper worked on tutorial & demo models of Matlab coding to start the communication network work. The optical network coding will include all parameters results analysis like dispersion, intensity, fiber optics efficiency, and many more. As shown in the figure below, in this Paper calculated the modal dispersion in the fiber network concerning the signal's wavelength. All the other case studies and results are carried out in the below section. The diameter is considered with various ranges to calculate the modal dispersion η_{eff} for the different wavelengths of signals [1-3].

This Paper tested multiple ranges of applications for the proposed WDM network in this Matlab coding. It helps me characterize the optical network's performance with results analysis. This Paper also prepared different tutorial models in Matlab coding for this project which is also helpful in developing the comparative study of flex grid & fixed grid performance.
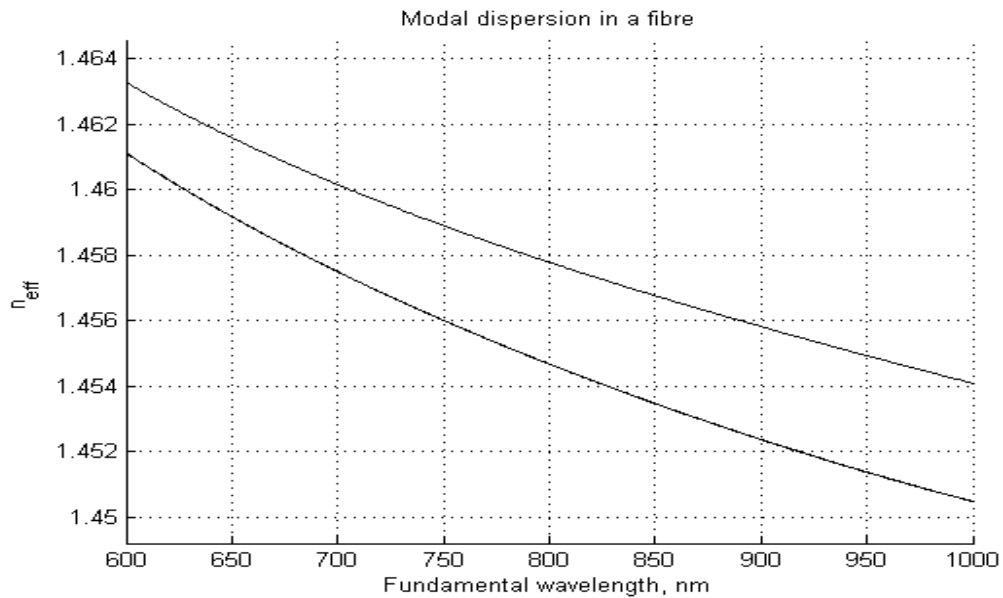

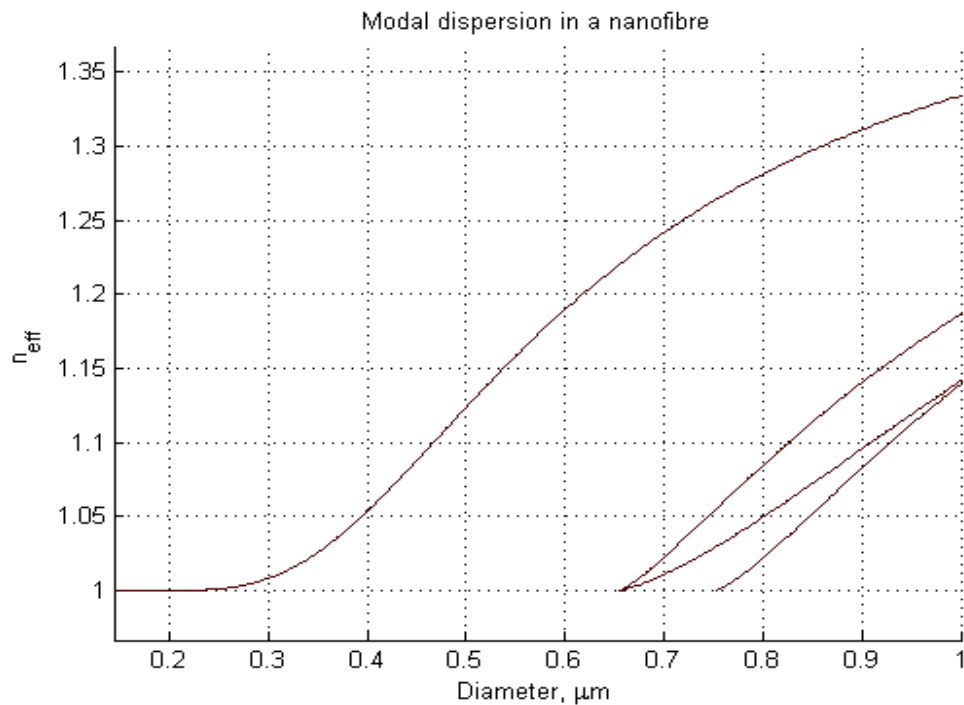Fig.3- Modal Dispersion in Optical fiber network w.r.t wavelength
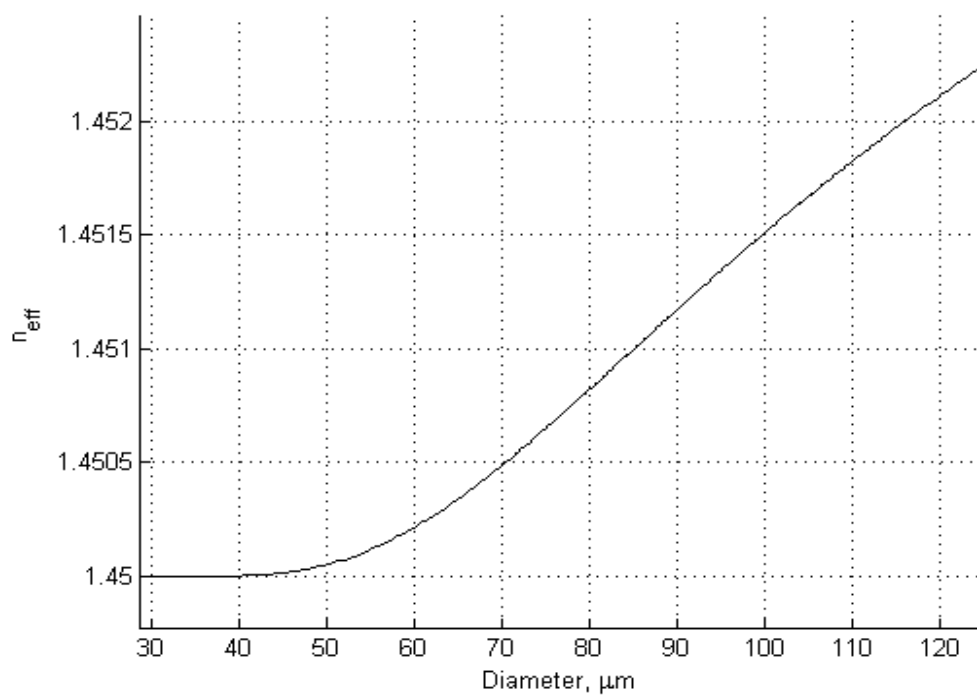

Fig.4- Change in Modal dispersion with diameter change

Fig.5- Results of η_{eff} with the fiber diameter range
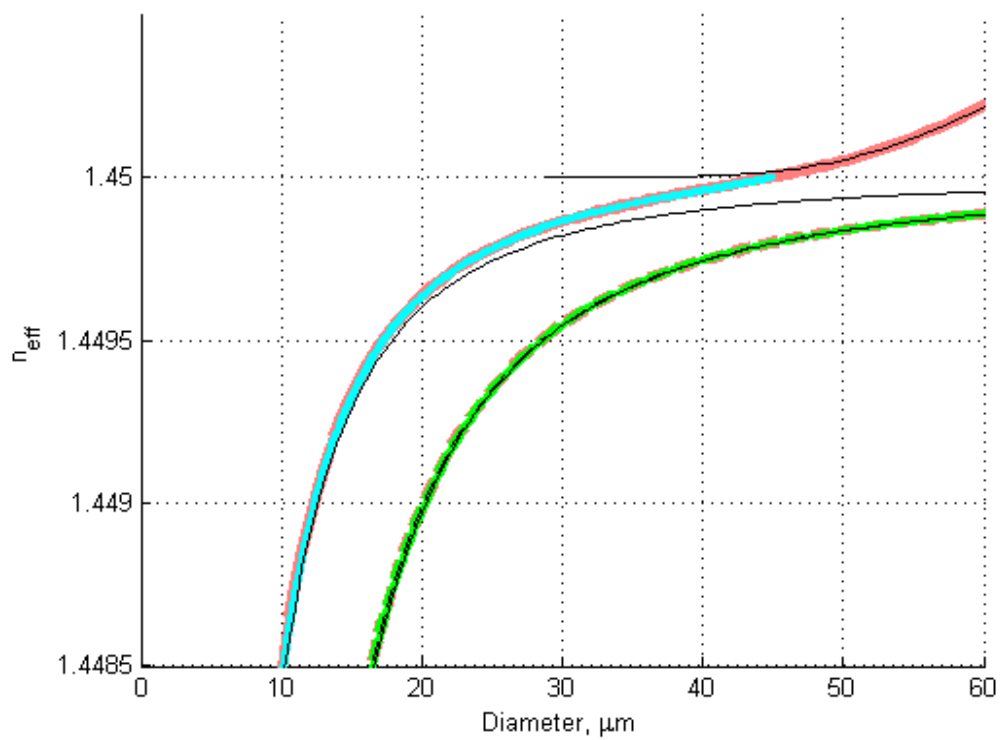
Fig.6- various signals modal dispersion η_{eff} with fiber diameter range in WDM
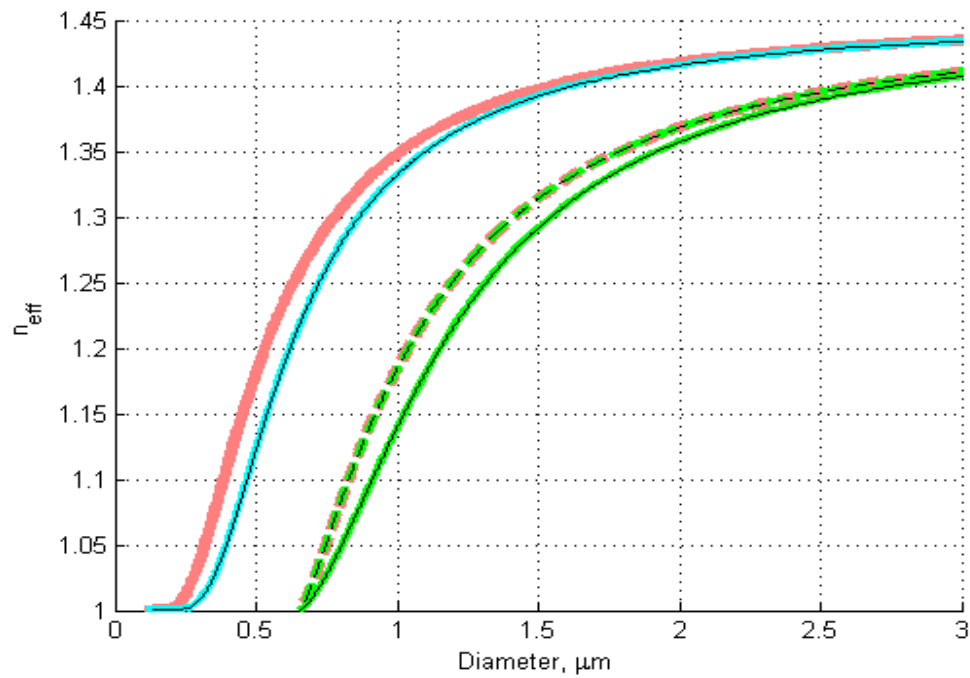
Fig.7- various signals modal dispersion η_{eff} with fiber diameter range in WDM Case study-I
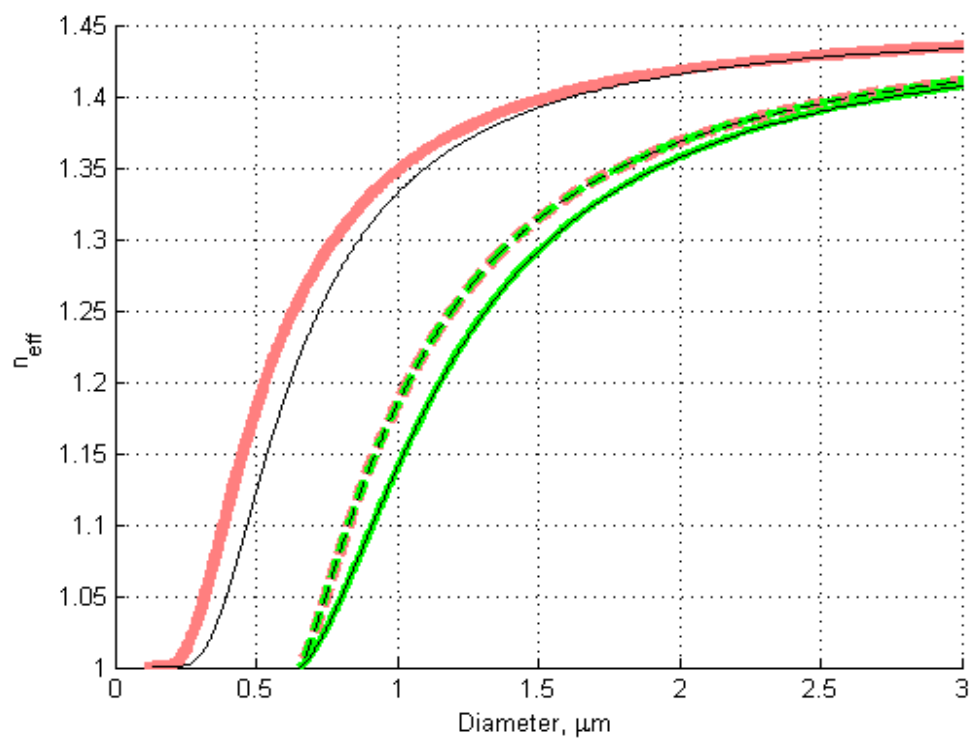
Fig.8- various signals modal dispersion η_{eff} with fiber diameter range in WDM Case study-II
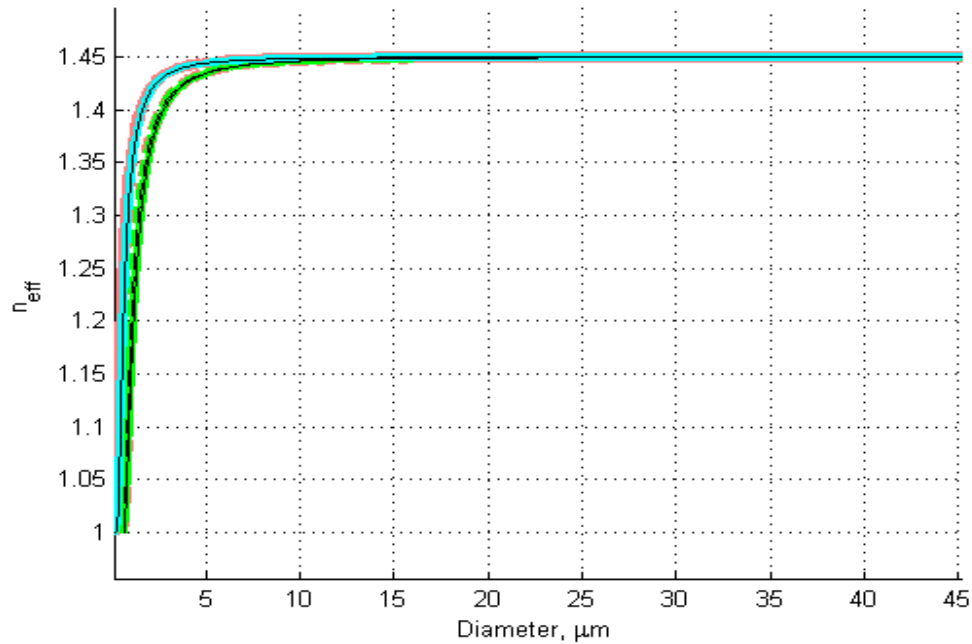
Fig.9- various signals modal dispersion η_{eff} with fiber diameter range in WDM Case study-III

4.2 Performance Comparison

For the comparative analysis of both types of grid network configurations, in this Paper performed the simulator model developed for the WDM network model. Various nodes are used to multiplex the signals in flexible mode, shown in the results below.
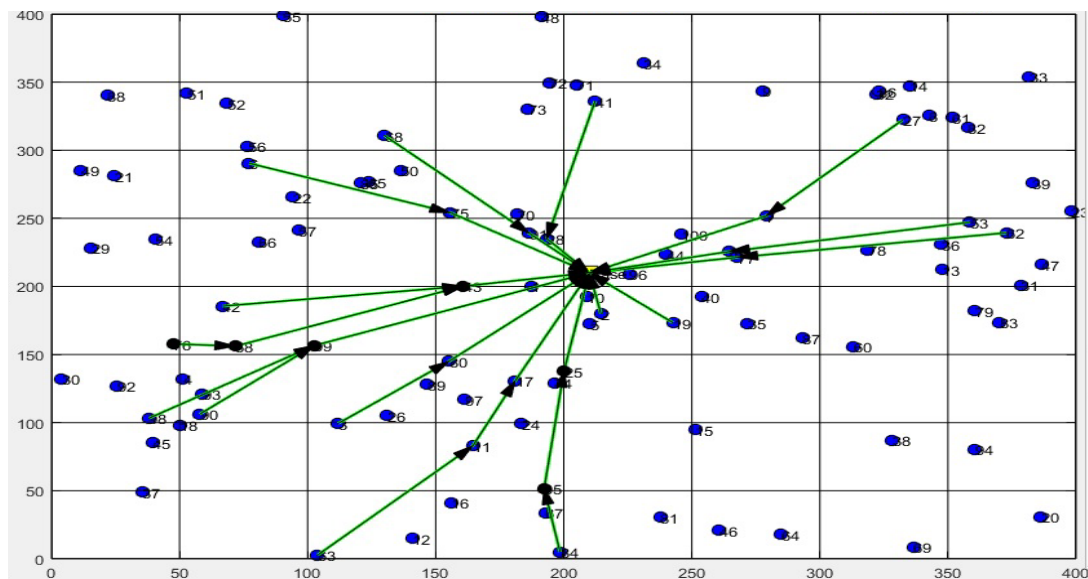
Fig.10 Flex Gird multiplex with the number of nodes in the simulator
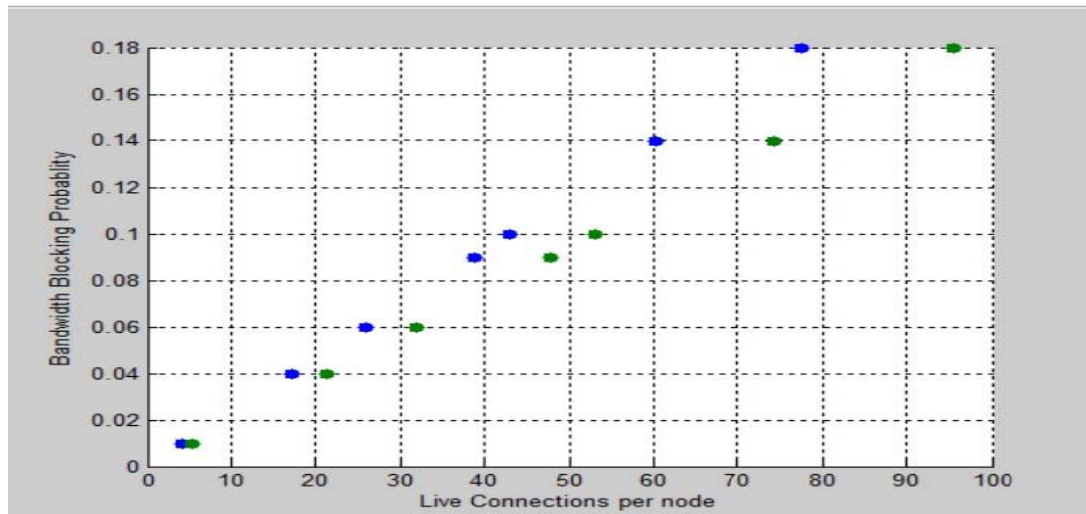
Fig.11- Comparison of Flex grid to Fixed Grid

The above-shown fig.11 compares the Flex grid to the fixed grid, in this idea I have develop the poison process with negative exponential algorithm to create these both gird networks. In this Matlab system design I have use frequency slot for 12.5 GHz with variable range of 1 to 12 GHz in the flex grid network. While for fixed grid network I have maintained frequency level for 8 GHz for the WDM operation. At the same time for performance comparison I have adopted frequency range for 12.5 GHz slot even in the Fix grid. This will helps us compare both grid network methods easily. I have discarded the option of 50 GHz because it won't be a modern approach wherein we are trying to use a frequency slot of only 12.5 GHz. As seen from the above figure, the Green dots are of the Flex grid network, which shows that we can provide more live connections using the flex grid method. Loads on the network include inter-arrival time, Holding time, live connections & other random parameters that come with a grid network. The comparison shows us that the Flex grid better utilizes provided frequency slots.
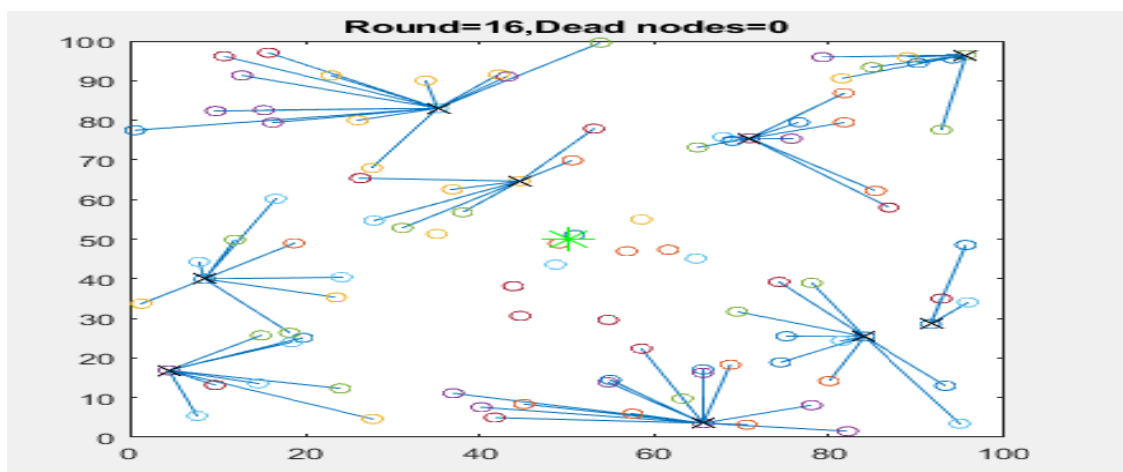

Fig.12- Test results of flex grid with multiple nodes for 16 Rounds

Conclusion

The continuous growth of the internet will focus on research on the energy consumption of internet devices & infrastructures. The broadband networks & optical networks are consumed 4% to 12% of total

energy consumption. If any effective grid network is not developed for the WDM network, then the efficiency level & performance level of internet speed is deficient. This Paper studied multiple ideas to achieve in this work, including high-speed internet and reduced energy use with a flex grid network. In this project, this Paper managed network performance with individual power consumption control with analytical models of flex grid models. This Paper performed the Matlab coding & simulation of the WDM network for the energy consumption of a fixed- or flex-grid optical layer proposed in this work. It will summarize that adopting a fixed-to-flex grid model will help increase internet speed with multiple node frequency modulations. It will also help to reduce the energy levels in the WDM network. The work expansion of this flex grid network adoption can be added in terms of SNR with amplifiers use. It will reduce the noise ratio & signal disturbances in the network, ultimately enhancing the proposed system's efficiency level.

REFERENCES

1. 'Cisco visual networking index: Forecast and methodology, 2012–2017,' Cisco White Paper. (May 2013).
2. 'SMART 2020: Enabling the low carbon economy in the information age,' Global e-Sustainability Initiative Report. (November 18, 2008).
3. 'Spectral grids for WDM applications: DWDM frequency grid,' ITU-T Recommendation G.694.1, July 15. (2012).
4. Bolla, R., Bruschi, R., Davoli, F., & Cucchietti, F. (2011). Energy efficiency in the future Internet: A survey of existing approaches and trends in energy-aware fixed network infrastructures. IEEE Communications Surveys and Tutorials, 13(2), 223–244. https://doi.org/10.1109/SURV.2011.071410.00073
5. Caria, M., Chamania, M., & Jukan, A. (February 8–10, 2011). Trading IP routing stability for energy efficiency: A case for traffic offloading with optical bypass. In Proceedings of the IEEE International Conference Optical Network Design and Modeling.
6. Coiro, A., Listanti, M., Valenti, A., & Matera, F. (2011). Reducing power consumption in wavelength-routed networks by selective switch off of optical links. IEEE Journal of Selected Topics in Quantum Electronics, 17(2), 428–436. https://doi.org/10.1109/JSTQE.2010.2052791
7. Gerstel, O., Jinno, M., Lord, A., & Yoo, S. J. B. (February 2012). Elastic optical networking: A new dawn for the optical layer? IEEE Communications Magazine, 50(2), s12–s20. https://doi.org/10.1109/MCOM.2012.6146481
8. Hasan, M. M., Farahmand, F., Patel, A. N., & Jue, J. P. (May 23–27, 2010). Traffic grooming in green optical networks. In IEEE international conference on Communications (ICC). https://doi.org/10.1109/ICC.2010.5502230
9. Idzikowski, F., Orlowski, S., Raack, C., Woesner, H., & Wolisz, A. (February 1–3, 2010). Saving energy in IP-over-WDM networks by switching off-line cards in low-demand scenarios. In the 14th conference on Optical Network Design and Modeling. https://doi.org/10.1109/ONDM.2010.5431569
10. Stern, T., Ellinas, G., & Bala, K. (2008). Multiwavelength optical networks: Architectures, design, and control (2nd ed). Cambridge University.
11. Tucker, R. S., Parthiban, R., Baliga, J., Hinton, K., Ayre, R. W. A., & Sorin, W. V. (2009). Evolution of WDM optical IP networks: A cost and energy perspective. Journal of Lightwave Technology, 27(3), 243–252. https://doi.org/10.1109/JLT.2008.2005424

Author Guidelines

1. Every author has to register himself /herself on givenwebsite
2. After Registration, author will be allotted unique author code (e.g. AM0003) which will be author's identification number for furthercorrespondence.
3. All fields in the registration are compulsory, and no changes in the details will be allowed once the author hasregistered.
4. If, there are multiple authors for a single manuscript then every author has to register separately. All the authors will be given a unique author code which they have to use for further correspondence.
5. This unique Author Id will be communicated to authors by their registered e-mail only. Hence it is mandatory to provide correct mailid.

For more information click on below link:
http://www.researchjournal.gtu.ac.in/ImpPdf/GuidelinestoAuthors.pdf

Disclaimer

Contact Person

DR. PANKAJRAY PATEL
Director & Managing Editor
Graduate School of Management Studies
Gujarat Technological University

DR. SARIKA SRIVASTAVA
Assistant Professor & Section Editor
Graduate School of Management Studies
Gujarat Technological University

Correspondence Address

Gujarat Technological University

Published by

Gujarat Technological University

📍 Nr. Vishwakarma Government Engineering College,
Nr. Visat - Gandhinagar Highway,
Chandkheda, Ahmedabad - 382424, Gujarat (India)

🌐 www.researchjournal.gtu.ac.in

✉ researchjournal@gtu.edu.in