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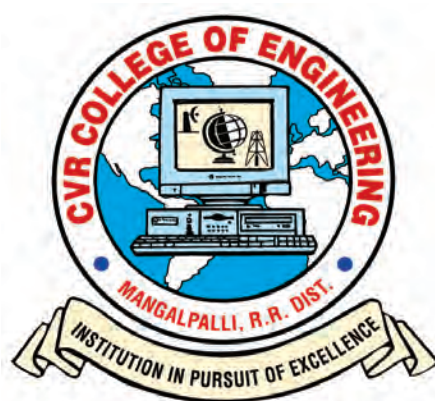
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EDITORIAL

It is with immense pleasure that we bring out Volume – 16 of the Biannual Journal- CVR Journal of Science and Technology, due in June 2019. This is the first Volume carrying DOI number and e-ISSN number along with print ISSN number on the cover page. Every research article published is given DOI number and they can be accessed on- line. On line portal is also created for the Journal. This Volume is also brought out in time, with the co-operation of all the authors and editorial team. We are thankful to the Management for supporting this activity, and permitting to publish the journal in colour print, using quality printing paper.

In this issue, an interesting article regarding durability studies on glass fibre reinforced self compacting concrete is published. Also, an article on comparative study of Green Building rating system in India, in terms of energy and water is published. Some other articles are on Industrial IOT Gateway configurator, Optimized Fast Walsh Hadamard Transform, ASIC implementation of Various Sorting Techniques for image processing application, Personalized Medicine in Health care using Data Mining Techniques etc.

We are encouraging PG students also to publish papers based on their one-year project work and wish that the quality of their project works and that of the M-Tech programme will improve, by this.

The Volume covers research articles in the branches of engineering and Mathematics. The breakup of papers among various branches is:

CIVIL – 4, ECE –5 , EEE – 3, EIE – 1, CSE– 4, IT- 3, MECH- 2 ,H & S (Maths)-1.

In this issue, total number of research articles published is increased to 23.

The college has many accomplishments and to name a few, it obtained **NBA Tier 1 accreditation for its UG Programs,   NAAC 'A' grade**, **UGC autonomous status**, **National Employability Award** for seventh year in a row and received a very high rating by several ranking agencies including the most recent Education World ranking of third best college in Telangana and Outlook magazine, rating CVR CE, one among the **top 100 colleges in the country**, and **AAAA grade** from careers 360. The college received the **ISTE Best Engineering College award** and, the Director Dr. K. Rama Sastri, the ISTE Lifetime Achievement Award in 2017.

The college has been creating records year after year. With more than 100 companies visiting CVR and more than 650 placements for the 2017-18 academic year, it is the highest among the peer group of colleges. The highest offer is Rs. 24 Lakhs and close to 40 students got offers higher than Rs. 7 Lakhs. About 75 offers are higher than Rs. 5 Lakhs. With this, CVR becomes the leading college in entire Telangana in terms of the offers with higher salaries. CVR has made huge progress in a short span of time and is preferred by the students and parents during the EAMCET counseling this year and is among **the top 3 colleges** in the state.

I am thankful to all the members of the Editorial Board for their help in reviewing and short listing the research papers for inclusion in the current Volume of the journal. I wish to thank **Dr.S. Venkateshwarlu, HOD, EEE and Dr. R. Ponnusamy, Professor of CSE, Associate Editors** for the effort made in bringing out this Volume. Thanks are due to **HOD, H & S, Dr. G. Bhikshamaiah** and the staff of English Department for reviewing the papers to see that grammatical and typographical errors are corrected. I am also thankful to **Smt. A. Sreedevi**, **DTP Operator** in the Office of Dean Research for the effort put, in the preparation of the papers in Camera Ready form.

For further clarity on waveforms, graphs, circuit diagrams and figures, readers are requested to browse the soft copy of the journal, available on the college website **www.cvr.ac.in** wherein a link is provided. Authors can also submit their papers through our online open journal system(OJS) **www.ojs.cvr.ac.in** or **www.cvr.ac.in/ojs**

Prof. K. Lal Kishore
Editor

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Durability Studies on Glass Fibre Reinforced Self Compacting Concrete

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Abstract: **The paper presents durability properties of Glass Fibre Reinforced Self Compacting Concrete (GFRSCC) of different grades. The durability of Glass Fibre Reinforced Self Compacting Concrete (GFRSCC) using anti-crack highly dispersible glass fibres is reported in terms of acid resistance, surface absorption and sorptivity. The mixes were designed using rational mix design procedure for SCC satisfying the EFNARC (2005) guidelines. In the first phase the mechanical properties of different grades are studied. In the second phase durability properties like Acid attack factors, Acid-Durability factors, sorptivity are studied for the Plain SCC(SCCP) and Glass Fibre Reinforced SCC(GFRSCC) and a comparison is made. Based on the studies it is observed that the compressive strengths of the GFRSCC were found to be about 10% more compared to SCCP. With the increase in the grade of concrete, the sorptivity of GFRSCC is found to be reducing. With the increase in duration of exposure to the acidic environment the ASLF increased. SCCP and GFRSCC have shown more or less similar percentage loss in strength for the same grade of concrete. With increase in period of immersion of the concrete in various solutions (acids and sulphates), there was a considerable damage of concrete near the corners of the standard cube and such disruption in GFRSCC was less than in SCCP. Overall, the GFRSCC was found to be more durable against both acids and sulphates.**

Index Terms: Glass Fibres, Durability, Sorptivity and, Self Compacting Concrete, Acid attack factor, Acid durability factor

I. INTRODUCTION

Self compacting concrete is a self consolidating concrete defined as a Concrete which is able to flow under its self weight and to fill the formwork in complete, even in the presence of dense reinforcement, without using any vibration, whilst maintaining homogeneity. Self-compacting concrete is not affected by the shape and quantum of reinforcing bars. Professor Hajime Okamura (1997) proposed the concept of self compacting concrete in 1986, but the prototype was first developed in 1988 in Japan, by Professor Ozawa (1989). This concrete was developed to improve the durability characteristics of concrete structures. However, the Bureau of Indian Standards (BIS) has not brought out any standard mix procedure although number of agencies and researchers carried out extensive investigations to establish rational mix design procedures and testing methods in fresh state. SCC consists of materials like in conventionally vibrated concrete, which are cement, aggregates and water, with the addition of mineral and chemical admixtures in suitable proportions.

Usually, the chemical admixtures such as high-range of water reducers (Super Plasticizer) and Viscosity Modifying Agents, which change the rheological properties of concrete are used. Mineral admixtures are used as an extra fine material besides cement. In this study cement content was partially replaced with fly ash. In this study anti crack highly dispensable glass fibres are mixed to make GPRSCC and its strength and durability properties are investigated.

II. LITERATURE REVIEW

W Zhu *et al.* [1] discussed about Durability of Self Compacting Concrete. In his study, gas permeability, capillary water absorption and chloride diffusivity, which are important indicators for concrete durability performance of SCC and vibrated concrete mixes were obtained and compared.

Self compacting concrete mixes have shown low values of coefficient of permeability and sorptivity, when compared to the normal mixes of the same grade. SCC have mixes also shown chloride diffusivity similar to that of vibrated concrete mixes.

The chloride diffusivity was found to be dependent on the different types of powders used in concrete. Among the different mixes of SCC, the mixes containing less powder along with VMA to maintain stability of fresh mix have shown more permeability, chloride diffusivity and sorptivity showing less resistant for the ingress of fluids.

S Venkateswara Rao *et al.* [2] studied the durability performance of Self-compacting concrete. A total of three grades of concrete ie.M20, M30 and M70 grades, representing ordinary, standard, and high strength concrete, respectively were investigated.

In this study, the durability aspects of NC and SCC like acid attack, acid durability factors, thermal cycle effect, test for corrosion resistance, tests for sorptivity were investigated and concluded that with the increase in duration of exposure to the acidic nature, the ASLF was increased for both NC and SCC. With increase in period of immersion of concrete in various solutions (HCL, H2SO4), there was a considerable disruption of the concrete near the corners of the standard cube and such disruption in SCC was less than to NC. The

thermal studies indicates that fly ash based SCC mixes of higher grades are performed better compared to NC The corrosion performance was better in SCC when compared to the NC.

SCC and NC showed more or less similar percentage loss in strength for the same grade of concrete. The weight loss was greater in NC than in SCC. The average ADLF is greater in NC for all grades than in SCC mixes. Average ADLF may be considered a unified parameter to quantify Thermal studies indicated that the fly ash-based SCC mixes of higher grades performed better than NC of identical grade.

K Rajesh Kumar *et al.* [3] investigated the experimental Studies on the Strength, durability and structural behaviour of beam specimens of SCC incorporating E-Glass Fiber Strands**.**

N Venkat Rao *et al..* explained about an Experimental Study on Durability of High Strength Self Compacting Concrete (HSSCC). The test specimens of 10cm × 10cm × 10cm cubes were immersed in 5 % of Sodium Sulphate solution over a period of time. The performance and properties of concrete can be affected by Sulphate attack was identified. The intensity of attack by H_2SO_4 is comparatively more than the attack of HCL and Na_2SO_4 on the specimens.

V Karthik *et al.* [4] presented the study on Durability Properties of Self Compacting Concrete with Copper Slag Partially replaced for Fine Aggregate. In this investigation one control and five SCC mixes with various proportions of fine aggregate partially replaced by copper slag were prepared as per EFNARC guidelines. From the experimental results it may be concluded that copper slag at 60% replacement for fine aggregate gives the optimum results for strength and durability.

S Shrihari et *al.* [5] developed Strength and Durability properties of SCC with GBFS and Meta Kaolin. In this paper apart from mechanical properties, rapid chloride ion permeability and water absorption were conducted by using Meta Kaolin, GBFS and increasing percentage of fly ash with. An improvement in the impermeability, compressive and split tensile strengths were reported. Percentage of water absorption gradually decreases with the use of GIBFS with Meta Kaolin. The replacement of cement by MK leads to decrease in pore space

III. EXPERIMENTAL PROGRAMME

The experimental programme consisted of casting and testing SCC specimens. The mixes were designed with rational mix design method and several trials were made in producing SCC satisfying the mixes satisfying EFNARC specifications (EFNARC, 2005). A total of four grades of concrete was investigated: M20, M30, M40 and M60 grades, representing ordinary, standard and high strength concrete, respectively according to IS 456-2000 (BIS, 2000). A total of 40 standard cubes of size 150mmX150mmX150mm for SCCP, 40 standard cubes for GFRSCC for acid attack, sulphate attack and eight specimens each for SCCP and

GFRSCC of size 100mm×100mm for sorptivity studies, were cast and tested.

IV. MATERIALS AND PROPERTIES

Cement
OPC of 53 grade is used in the investigation. The Cement used was tested as per IS 4031-1988 and found to be satisfying the specifications of 12269-1987.The specific gravity was 3.1 and fineness was 2.37%.

Coarse Aggregate
Crushed granite metal of 10 mm size from a local source was used as coarse aggregate. The specific gravity and fineness modulus were 2.64 and 6.6 respectively.

Fine Aggregate
River sand was used as fine aggregate. The specific gravity is 2.59 and fineness modulus is 2.83.

Fly Ash
Type-II fly was used in the investigations. The properties of fly ash is confirming to I.S. 3812 – 1981.

Glass Fibres
Anti Crack High Dispersion glass fibres were used in the investigation. The glass fibres have aspect ratio of 857:1, filament length of 12mm and filament diameter of 14 μm were used.

Super Plasticizer
Super Plasticizer having Relative density 1.08 ± 0.01 and pH value as 7 ± 1 with Chloride Content nil was used.

Viscosity Modifying Agent
Viscosity modifying agent used is colourless, free flowing liquid. It is a having Specific of gravity 1.01 ± 0.01 @ 25^0C and apH value as 8 ± 1 with no Chloride Content.

Acids and sulphates
The properties of the constituent acids and sulphate used in the present investigation are LR (laboratory grade) hydrochloric acid 35–38% with specific gravity 1.18 kg/l, LR sulfuric acid 98%, 98.07 g/mol with specific gravity 1.835 kg/l and sodium sulphate with specific gravity of 1.464, molecular weight 142.036 g/mol were used in this study at concentrations of both acids and sulphate is 5%.

V. MIX PROPORTIONS

The Rational mix design methods was used (SV Rao et al., 2010). The details of the mix proportions are shown in Table 1, The fresh properties of the four grades of concrete and the compressive strength of the four grades of concrete were shown.

VI. DURABILITY STUDIES

Tests for acid attack and sorptivity were conducted for different grades of SCCP and GFRSCC.

Tests for acid attack on SCCP and GFRSCC

After 28 days of water curing, each cube was tested for weight and compressive strength. The cured specimens of different grades viz. M20, M30, M40 and M60 concrete specimens were kept exposed to 5% solutions of Sulfuric acid, Hydrochloric acid and Sodium Sulphate. Cubes were immersed for 28 days and 56 days. The response of the specimens to the solutions was evaluated through change in appearance, weight, compressive strength and dimensions of solid diagonals. Before testing, each specimen was removed and brushed and cleaned with water. For determining the resistance of concrete specimens to aggressive environment such as acid attack, durability attack factors such as acid strength loss factor (ASLF), acid attacking factor (AAF), acid weight loss factor (AWLF) and acid durability loss factor (ADLF) (Venkateswara Rao, 2010) are evaluated as per ASTM C 666–1997 (ASTM, 1997).

ASLF gives relative performance of concrete before and after immersion in different of acids and Sulphates. The factor also depends on the period of immersion of the specimen in solution. ASLF can be calculated as

Acid strength loss factor (ASLF) = Sr ×(N/M)

Where Sr is relative strength at N days (%), N is number of days at which the durability factor is required; M is number of days at which the exposure is to be terminated. A lower value of ASLF indicates greater stability towards acid attack.

AAF is meant to determine indirectly the disruption of concrete near the corners of the cube by way of measuring the change in the length of diagonal (referred to as diagonal loss) in a typical concrete cube after immersion in acids and Sulphate for a certain period of time. The extent of loss is determined as

Acid attack factor (AAF) =

$$\frac{Loss\ of\ acid\ diagonal\ after\ immersion}{Acid\ diagonal\ before\ immersion} \times 100\%$$

A higher value of AAF indicates that the dimensional stability is lower.

AWLF is calculated follows after immersing the cubes in different solutions for different periods.

Acid weight loss factor (AWLF) =

$$\frac{Loss\ of\ weight\ of\ specimen\ after\ immersion}{Original\ weight\ of\ specimen\ before\ immersion} \times 100\%$$

A higher value of the AWLF indicates that the weight loss is greater.

In order to have a unified factor describing durability, these factors are combined to derive a factor termed the ADLF.

$$ADLF = ASLF \times AAF \times AWLF$$

Test for Sulphate Attack on SCC and GFRSCC

Resistance of concrete to the attack has been tested by immersing concrete cubes in the solution of 5 % Sodium Sulphate. The effect of chemical attack has been determined by measuring change of mass in to consideration. The test specimens of 100mm×100mm×100 mm were immersed in 5 % of Sodium Sulphate solution for different periods ie.28 and 56 days and the effect of Sulphate attack on performance properties of concrete are obtained. The resistance of concrete to the Sulphate attack has been estimated by considering changes in their dynamic modulus of elasticity. Even from the visual observation also the intensity of Sulphate attack on disintegration is noticed.

Tests for Sorptivity

Sorptivity is transport of moisture into unsaturated specimens. Sorptivity is as an important index of concrete durability because the test method used for the determination of Sorptivity reflects the way in which different solutions will penetrate into the concrete. Sorptivity tests were carried out on cubes of size 100 mm × 100 mm × 100 mm on the basis of Hall's method (Hall, 1989).

The Sorptivity Co-efficient (s) was obtained from the expression

$$S = i/t^{1/2}, i = \Delta W/Ad$$

Where ΔW is the amount of water absorbed (kg)[1]; A is the cross-section of specimen that was in contact with water (m^2); d is the density of the medium in which the specimen was dipped (d = 1, as the medium used was water); t = time (min). The unit of s is kg/(m^2 min$^{1/2}$).

The variation of i against t$^{1/2}$ was plotted.

VII. TEST RESULTS AND DISCUSSIONS

The durability of different grades SCC and GFRSCC was studied. A total number of 80 cubes were casted and after 56 days of acid environment curing with distilled water. The cubes were tested for compressive strength. From the studies on acid effect on SCC and GFRSCC specimens, it was noted that most of the GFRSCC specimens performed well compared with SCC specimens. To estimate the effects of acid on SCC and GFRSCC, certain factors are determined, as explained in the following paragraphs.

ADLF for SCC and GFRSCC

When the specimens were kept in an acid environment, the net loss in strength, physical change in the dimensions of the cube and weight loss were noted. All of these can be considered to derive a unique factor typically depicting the various losses due to acid attack and termed as ADLF

(Venkateswara Rao, 2010). The different losses are individually quantified in terms of different factors.

Acid Strength Loss Factor

The ASLF indicates the variation in the compressive strength of SCC and GFRSCC when kept in different acidic environments, namely HCl and H_2SO_4 at 5 % concentrations. Figure 1 shows the variation of ASLF in SCC and GFRSCC for56 days of immersion in acids. The figure indicates that the SCC and GFRSCC showed more or less similar percentage loss in strength for the different grades of concrete. Furthermore, it is observed that as the strength grade increased there is a slight increase in percentage loss of strength in both SCC and GFRSCC. This can be justified by the notion that increase in strength may not bring increase in durability, as interpreted from the loss of strength. Because, it can be based on performance design rather than the strength-based design of concrete. The ASLF is less for GFRSCC than SCC for 5% HCl and the rate of increase of ASLF is greater in sulfuric acid solution.
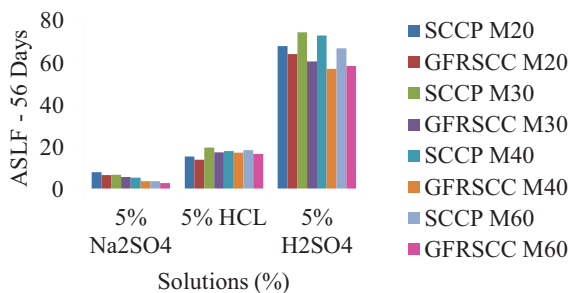
Figure 1. Acid Strength Loss Factors (ASLF) for SCCP and GFRSCC at 56 Days

Acid Attacking Factor

The AAF gives an idea of the disruption in the geometry of the specimen due to an acidic environment. This is determined by measuring the loss in the diagonals of standard test specimens. The average loss in the diagonals was measured for all the specimens immersed in acid at the end of 28 days and 56 days. Again a comparison for all the grades of concrete between SCC and GFRSCC revealed that GFRSCC specimens performed better than SCC specimens. Figure 2 shows the variation of AAF in SCC and GFRSCC for 56 days of immersion in acids. This indicates that there is less loss of diagonal (i.e. greater dimensional stability) in GFRSCC mixes than in SCC mixes. When the specimens were subjected to H_2SO_4, there was a greater loss of dimensional stability with H_2SO_4 than with HCl.
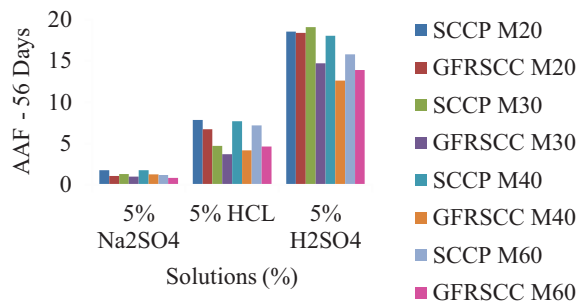
Figure 2. Acid Attack Factors (AAF) for SCC and GFRSCC at 56 days of immersion

Acid Weight Loss Factor

Because of the acidic environment, the pH of the concrete decreases; at the same time the cement and the mortar part in the interstices will be completely eaten away by the acid. This results in decrease in the weight of the specimen. It can be noted in general that the loss is greater with 5% H_2SO_4 than with HCl. Figure 3 shows the variation of AWLF in SCC and GFRSCC for 56 days of immersion in acids.
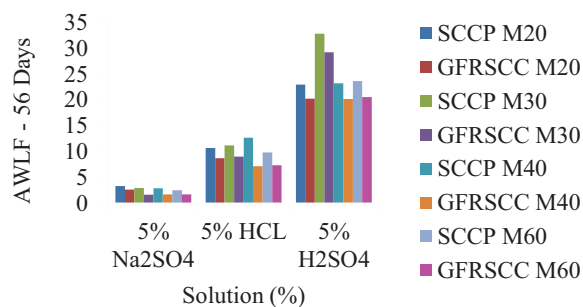
Figure 3. Acid weight loss factors (AWLF) for SCC and GFRSCC at 56 days of immersion

Acid Durability Loss Factor

The above losses in strength, weight and geometry are combined to obtain a durability factor termed ADLF. Figure 4 shows the variation of ADLF in SCC and GFRSCC for 56 days of immersion in acids. It can be noted that the losses are greater in SCC specimens than in GFRSCC specimens. Hence, it can be said at this stage that the GFRSCC specimens are more durable compared to SCC. In the present study, four grades of concrete and two types of acids (HCl and H_2SO_4) and one type of Sulphate with concentration of 5% were considered. The ADLF values were calculated from the loss factors of ASLF, AAF and AWLF. The average ADLF values are given in Table 2. Figure 4 shows the variation in average ADLF with acid concentration for both SCC and GFRSCC. The figure reveals that for HCL and Na_2SO_4 concentrations the SCC and GFRSCC behaved similarly, but as the H_2SO_4 concentration increase the SCC showed higher damage levels than GFRSCC. This indicates that the performance of GFRSCC is better than that of SCC under acidic and Sulphate environmental conditions. It also supports the use of GFRSCC in acidic and Sulphate environments.
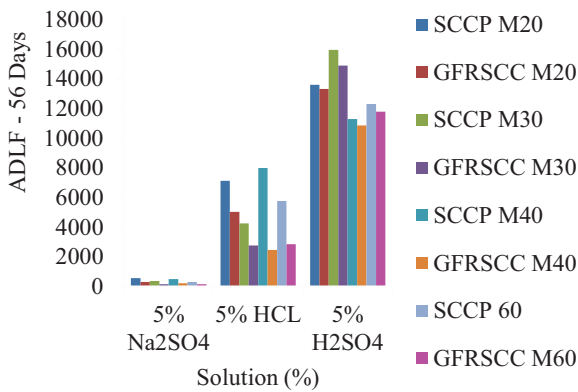
Figure 4. Acid Durability Loss Factors (ADLF) for SCCP and GFRSCC at 56 Days of immersion
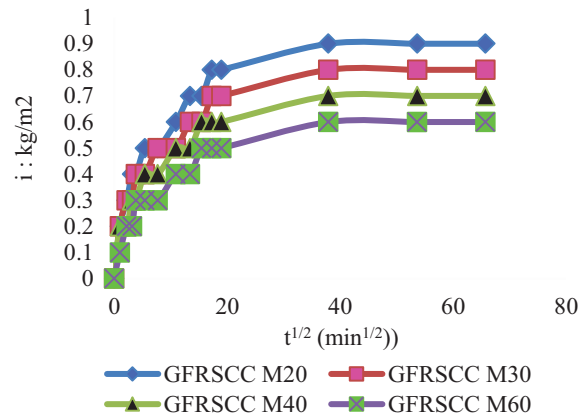
Figure 6. Absorbed water per unit area (i) against time ($t^{1/2}$) for GFRSCC

Sorptivity Studies on SCP and GFRSCC

Sorptivity is the absorption and transmission of water by capillary action (Pereira de Oliveira et al., 2006). Table 3 shows the details of the water absorbed due to capillary action and Sorptivity coefficient for SCC and GFRSCC. Figures 5 & 6and show the variation of absorbed water per unit area, i against $t^{1/2}$: The cumulative water absorption was less for GFRSCC than for SCC with increasing time. This is true for all grades of concrete. For the Sorptivity coefficient, asymptotic behaviour was observed for both SCC and GFRSCC mixes. It can be noted from the above tables and figures that as the grade of concrete increases the water absorption decreases. Also, the values of water absorption in SCC are much lower than in GFRSCC.
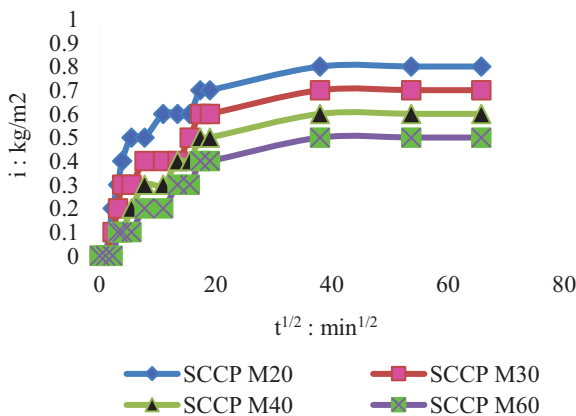
Figure 5.Absorbed water per unit area (i) against time ($t^{1/2}$) for SCCP

VIII. CONCLUSIONS

Based on the studies on SCC and GFRSCC mixes of different grades, the following conclusions are drawn

1. Fibre reinforced self-compacting concrete can be produced by adding glass fibres to improve its performance. However, the use of super plasticizer and viscosity modifying agent are essential to obtain the fresh properties of SCC.

2. In the case of high dispersion of glass fibres, a dosage of 600 grams of fibres/m^3 of concrete is used as optimum dosage by suitably adjusting the dosage of admixtures.

3. In different grades of the concrete i.e., M20, M30, M40 and M60, the compressive strength of the Glass fibre reinforced Self-compacting concrete was found to be more, ranging from 2% to 10%, when compared to plain self-compacting concrete.

4.The increase in the grade of concrete, the Sorptivity of Glass Fibre Reinforced SCC is found to be reducing. This is same in plain SCC.

5. With the increase in duration of exposure to the acidic environment the ASLF increased. This was true for both SCCP and GFRSCC. SCCP and GFRSCC showed more or less similar percentage loss in strength for the same grade of concrete.

6. With increase in period of immersion of the concrete in various types (Na_2SO_4, HCl and H_2SO_4) and 5% concentration of acid and Sulphate, there was a considerable damage of concrete near the corners of the standard cube and such disruption in GFRSCC was less than in SCCP, indicating superior durability of GFRSCC.

7. The GFRSCC has shown 3% more resistance to weight loss, compared to plain SCC.

8. When compared to the plain SCC, the GFRSCC was found to be more durable against both acids and Sulphates.

TABLE I.
QUANTITIES PER 1 CUM OF SELF COMPACTING CONCRETES

Grade of Concrete	Cement (kg/m³)	Fine aggregate (kg/m³)	Coarse Aggregate (kg/m³)	Fly ash (kg/m³)	Water (kg/m³)	SP % bwcf	VMA % Bwcf	Glass Fibre % Volume	Designation
M 20	258	900	685	309	240	1	0.05	-	SCCP
	258	900	685	309	240	1	0.05	0.024	GFRSCC
M 30	360	885	700	345	210	1.5	0.05	-	SCCP
	360	885	700	345	210	1.5	0.05	0.024	GFRSCC
M 40	468	884	700	350	240	1.5	0.05	-	SCCP
	468	884	700	350	240	1.5	0.05	0.024	GFRSCC
M 60	660	850	730	310	260	1	-	-	SCCP
	660	850	730	310	260	1		0.024	GFRSCC

TABLE II.
ACID DURABILITY LOSS FACTORS OF SELF COMPACTING CONCRETE MIXES

Type of Concrete	Grade of Concrete	Acid Durability Loss Factors					
		Na_2SO_4		HCL		H_2SO_4	
		28 Days	56 Days	28 Days	56 Days	28 Days	56 Days
SCCP	20	65.93	552.30	634.84	7114.6	2422.26	13598.2
	30	42.27	362.89	657.37	4246.55	2044.65	15955.0
	40	67.74	494.21	1227.23	7996.1	2544.9	11298.1
	60	48.21	297.71	900.93	5768.76	3422.86	12300.6
GFRSCC	20	40.25	272.71	495.83	5023.14	2463.6	13322.6
	30	19.82	160.25	294.68	2756.48	2397.41	15896.1
	40	33.33	218.84	364.66	2472.27	3071.15	10868.1
	60	11.97	144.07	382.14	2846.06	2577.07	10794.2
SCCP	Average ALDF	56.03	426.77	855.09	6281.5	2608.66	13287.9
GFRSCC		26.34	198.96	384.32	3274.48	2452.3	12220.2

TABLE III.
SORPTIVITY FOR SCCP AND GFRSCC

Time (min^1/2)	Absorption (i) kg/m²							
	SCCP M20	GFRSCC M20	SCCP M30	GFRSCC M30	SCCP M40	GFRSCC M40	SCCP M60	GFRSCC M60
0	0	0	0	0	0	0	0	0
1	0	0.2	0	0.2	0	0.2	0	0.1
2.23	0.2	0.3	0.1	0.3	0	0.2	0	0.2
3.16	0.3	0.4	0.2	0.3	0.1	0.3	0.1	0.2
3.87	0.4	0.4	0.3	0.4	0.1	0.3	0.1	0.3
5.47	0.5	0.5	0.3	0.4	0.2	0.4	0.1	0.3
7.74	0.5	0.5	0.4	0.5	0.3	0.4	0.2	0.3
10.95	0.6	0.6	0.4	0.5	0.3	0.5	0.2	0.4
13.41	0.6	0.7	0.4	0.6	0.4	0.5	0.3	0.4
15.49	0.6	0.7	0.5	0.6	0.4	0.6	0.3	0.5
17.32	0.7	0.8	0.6	0.7	0.5	0.6	0.4	0.5
18.97	0.7	0.8	0.6	0.7	0.5	0.6	0.4	0.5
37.94	0.8	0.9	0.7	0.8	0.6	0.7	0.5	0.6
53.66	0.8	0.9	0.7	0.8	0.6	0.7	0.5	0.6
65.72	0.8	0.9	0.7	0.8	0.6	0.7	0.5	0.6

Figure 7. After Immersion of Specimens in Acids and Sulphate

Figure 8. Testing of SCCP and GFRSCC Specimens for Sorptivity

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Stiffness Contributed by Infill to RC Frames using Finite Element Method Approach

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Abstract: Natural Calamities such as Earthquakes and cyclones cause lateral forces in buildings. Tall Buildings are highly vulnerable to these lateral forces. Designing such buildings to withstand the lateral forces which occur occasionally is considered very expensive. The lateral strength contributed by the infill wall elements is considered to be substantial. Many researchers have adopted different methods to evaluate the lateral strength contributed by wall panels, as on today no complete method has been evolved successfully. In the present work, the lateral strength contributed by the infill panels is explored making use of Finite Element concept. The general purpose of Finite Element package by name MSC NASTRAN is used for the needful calculations. Essentially the Strain Energy contributed by the infill panel in the composite frame structure is equated to the strain energy contributed by an equivalent diagonal strut replacing the infill panel together with bounding frame. Width of such strut is evaluated analytically using MSC NASTRAN. The calculations for strain energy with equivalent diagonal struts is taken-up using STAAD Pro for comparison.

Index Terms: Infill, Infill wall, Diagonal Strut, Equivalent Strut, Strain Energy and Lateral Strength.

I. Introduction

From time immemorial, nature's forces have influenced human existence. Even in the face of catastrophic natural phenomena, human beings have tried to control nature and coexist with it. Seismic actions are accidental actions which, depending on the seismicity of the location, rarely occur in the building's design life.

However, because of the destructive power of earthquakes, the stability and safety of buildings located in earthquake-prone areas should be verified for seismic loads. Such verification is based on the results of geological and seismological studies, which provide data on the seismic activity of the location and recommend the values of parameters to be used in the assessment of the expected seismic actions.

It is because of the increased urbanization that a large number of high-raised buildings have appeared. Due to Lack of space, environmental concerns, high cost of manpower, land and architectural constraints, there is need for new and improvised designs for high raised buildings. Natural calamities like earthquakes, typhoons and tsunamis cause a major concern for the stability of these buildings.

In addition, there can also be man-made calamities like accidents and blasts. Thus high-raised buildings are subjected to large shear forces and over turning moments at the base. So now there is a need to not only design the structures to bear vertical loads like Gravity and Imposed loads but also need to take into consideration the different loads due to calamities to avoid loss of life and property.

Shear wall is a vertical plate like RC Walls which starts at foundation and goes through the height of the building. They generally counter the effect of Lateral forces. The specifications are generally developed using design codes. They occupy space and cannot provide parking lots, doors, windows or other functional utilities as the shear wall needs to be a complete vertical wall without any openings.

Thus, we observe reduction in usable area on the shear wall. They are generally not preferred unless necessary for building. So, there is a need for an alternative which performs both as a substitute for shear wall and still has openings required. One such attempt is Infill wall.

Infill frame construction has been in use for more than 200 years. Infill frames are basically associated with the construction of high rise building with the frames carrying the gravity loads. The infill is a means of providing enclosure and internal partitioning to the building. The infill panels were invariably considered to be non-structural. But the behavior of masonry infill frames has been extensively studied in the last five decades in attempts to develop a rational approach for design of such frames.

Infill wall is a wall panel which is bounded by the frame members consisting of beams and columns all around it. Infill concrete frame is the one which includes the infill wall. Infill walls are not only used as partition but also as external walls of the building. It is also used to fill the gap between RC frames. Infill walls are constructed to partition the interior area of buildings to enhance the lateral stiffness of complete structure.

In general infill is considered to be a non-structural element and thus their influence was neglected. The calculation of buildings by modeling of infill walls is complicated. Thus, they are generally ignored during design state. Infill walls are modelled as mass and weight which are

then applied to floors or beams as a static vertical load and then their effects are calculated. The bearing functionality is achieved by Structure frame while separation of inner and outer space as well as filling up the boxes of the outer frame is achieved by infill. It reduces the probability of collapse due to following reasons

- Lateral deflection of the building.
- Type of Displacement.
- Bending moments in frames.
- Increasing axial forces in columns

II. LITERATURE REVIEW

As early as 1960s, studies have been carried out to investigate the influence of infill on the beam column frames under lateral loads induced by earthquakes, wind and blasts. Numerous experimental and analytical investigations have been carried out for the purpose. Nevertheless, a comprehensive conclusion has never been reached due to the complex nature of material properties. Even the infill effect is seen widely but it is not considered explicit in the modern codes.

Sachanski (1960) had considered that the action of infill in an infill frame could be affected by transmitting two components of forces - normal and shear - at a finite number of connecting joints, along the frame/infill interface. He had suggested a theoretical solution considering it as a plane stress problem. [1]

Smith (1962), who had adopted the equivalent diagonal strut concept, had assumed the strut thickness to be the same as that of the infill. He had applied finite difference method to biharmonic equations (expressed in terms of Airy's stress function) to obtain expressions for the Airy's stress function and using the stress-strain plots which help to derive the diagonal stiffness of the infill. [2]

Haroon and Karadi (2012) have performed seismic analysis using Equivalent Lateral Force Method for different reinforced concrete (RC) frame building models that include bay frame, infill frame and open first storey frame. The parameters such as base shear, time period, natural frequency, story drift and bending moments were studied. Here the consideration is done as there is no bond between frame and infill. Equivalent diagonal Strut method is used in modelling the masonry infill panels and ETABS software was used for the analysis of all the frame models. [3]

Stavridis and Shing (2012) presented a simplified analytical method of the seismic performance of masonry infill reinforced concrete frames based on results of an extended analytical and experimental study. The results were used for the validation of finite element model which was able to predict the behavior of the structure. [4]

Akmaluddin et.al. (2012) has done an investigation on the behavior of hybrid reinforced concrete frame with brick masonry infill under static lateral loading. Precast block masonry unit and cast in-place reinforced concrete beams are now termed as hybrid. In this study of frame opening, representing doors and windows are commonly used parameters in the wall system. [5]

Jagadish and Renukadevi (2013) have studied the variation of lateral stiffness and principal compressive diagonal strut width with modulus of masonry infill, with and without openings. In this study non- linear analysis is performed. It was also seen that in case of two frames with equal area of openings, the frame with larger width of opening, exhibits slightly more initial lateral stiffness. [6]

Niranjan C.B et.al. (2013) has observed the changes or variations of stiffness and diagonal strut width with and without openings. As per ANSYS Version 10.0 analysis it is seen that linear analysis of the infill frame over-estimates the lateral stiffness of the infill frame. [7]

K. Lin et al., (2014) developed a new infill masonry system at the University of Newcastle. It uses dry-stacked interlocking bricks. The finite element model for this new system has been developed using the DIANA program. [8]

Lavanya, N. Murali Krishna et.al. (2015) in their paper discussed that the contribution offered from infill walls to the lateral strength of the building is evaluated using a combination of FEM approach and Neural Networks. [9]

Since the integral action of the wall panels with the bounding frame is considered in this approach, the frame is called as infill frame. In this study instead of the infill wall, they considered two diagonal struts joining the opposite corners of the frame.

Ovidiu Bolea (2015) the influence of masonry on global response of reinforced concrete frames is analyzed by using dynamic nonlinear analyses for several structures in the Bucharest area. The results are then discussed with respect to the displacement demand of the elements and masonry behavior. [10] Akash D. Mundaware et.al. (2016) presents that a soft storey of a building frame is analyzed using software package ANSYS. [11]

Narendra A. Kaple et.al. (2016) presents a comparative study on RC building. Spectrum analysis is carried out on a G+6 RCC framed building with bare frame and frame with infill wall using the software ETABS. [12]

Bhavani Shankar et.al. (2016) in his study, has modelled infill wall using interlocking blocks and analyzed the structure using ANSYS software. [13] M.Pradeepkumar (2016) has observed and reviewed from the various research works that there is no doubt that the infill walls contribute in enhancing the structural strength.[14]

In this project, Criteria for earthquake resistant design of structures (IS 1893 (Part 1):2016 and Explanatory handbook on Indian standard code of practice for plain and reinforced concrete (IS 456: 2000) are used as reference for properties.

III. Methodology

The infill frame that is considered here for developing the flexibility matrix consists of a one bay one storey frame, extending to the left and right by one span and extending to the top and bottom by one storey. The frame members are fixed at their farther ends as shown in the Figure 1.
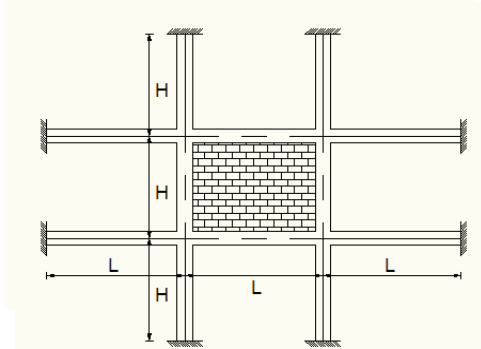
Figure 1. One Bay One Storey Infill frame.

The infill frame is assumed to be made-up with three different materials. While RCC is used for modelling the beam and column members (two-node 3-D frame elements), brick masonry is used to model the infill wall panel (four-node, plane stress quadrilateral elements). The interface between the frame and infill wall panel is modelled with cement mortar (two-node 3-D frame elements).

The infill wall panel is meshed into four-node quadrilateral plane stress elements. The bounding frame members all around the infill have been discretized into number of frame elements to facilitate the connectivity with the corresponding nodes of infill panel. The elements connecting the nodes on infill panel boundary with nodes on the bounding frame elements are called link elements.

While the properties of concrete are taken from IS-456:2000 and experiments, the properties of mortar and masonry are taken from different research papers. A unit force is applied in horizontal direction at the top left-hand corner of the infill frame and the linear elastic static analysis module of MSC NASTRAN is run.
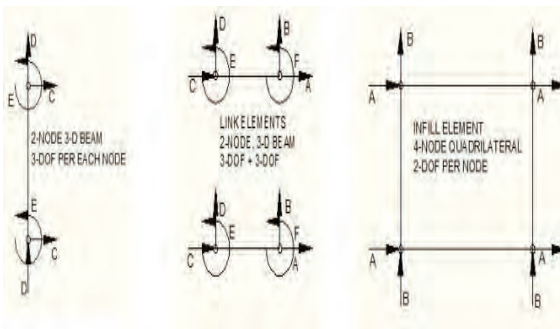
Figure 2. Frame Element, Link Element and Infill Frame (left to right).

The displacements corresponding to three degrees of freedom at the top left-hand corner, top right-hand corner,

bottom right hand corner and the bottom left- hand corner are recorded in order, which forms the first column of the flexibility matrix.

The same process is repeated by applying a unit load in turn, corresponding to each degree of freedom. All twelve displacements corresponding to each force application are recorded systematically to form the flexibility matrix of the corresponding frame.

Now the obtained flexibility matrix (12*12) is inverted to get the stiffness matrix (K). A displacement vector (d) is defined with unit displacements corresponding to the horizontal force applied at first beam column joint which represents the 1st column of flexibility matrix. The strain energy for the infill frame (U) is calculated by the expression given below. MATLAB is used for the mathematical Matrix Calculations

$$U = \tfrac{1}{2} * d^T * K * d. \tag{1}$$

Modulus of Elasticity is denoted by E

TABLE I.
MATERIAL PROPERTIES

Modulus of elasticity of Concrete	22360 N/mm2
Modulus of elasticity of Masonry	4170 N/mm2
Modulus of elasticity of Cement mortar	2958 N/mm2
Poisson's ratio of Concrete	0.15
Poisson's ratio of Masonry	0.14
Poisson's ratio of Cement mortar	0.13

This analysis using MSC NASTRAN is performed for different sizes, specifically 1200mm*700mm, 900mm*700mm and 700mm*1200 mm in this project and considering various frames as given hereunder
1. Bare Frame
2. Infill Frame
3. Infill Frame with Window Opening
4. Infill Frame with Door Opening
5. Infill Frame with Window and Door Opening.

Same analysis to obtain flexibility matrix using MSC NASTRAN and MATLAB for obtaining Stiffness matrix and Strain Energy are used. Strain Energy values obtained is used for our results and inferences discussed in Section V.

Thickness	- 100mm
Beam	- 100mm*100mm
Column	- 100mm*100mm
The Size of Openings	
Window	- 0.36m* 0.36m
Door	- 0.36m*0.525m

The infill wall is next replaced with two diagonal struts connecting the opposite corners of frame made in RCC of arbitrary width as shown in the Figure 3. The same process as described above is adopted for

obtaining the flexibility matrix, stiffness matrix and the strain energy expression. The flexibility influence coefficients are founding using both MSC NASTRAN and STAAD Pro. MATLAB is used for the mathematical Matrix Calculations to obtain stiffness and Strain Energy.
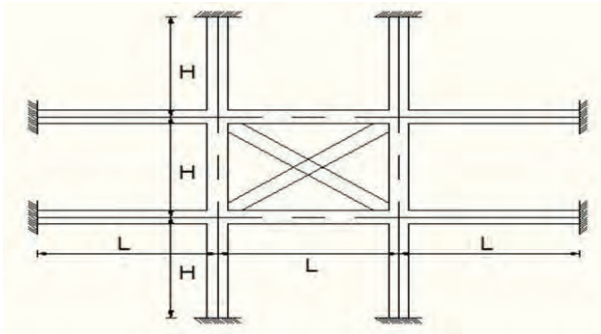
Figure 3. Infill Frame replaced with equivalent diagonal struts.

In general, the value of strain energy obtained is compared with strain energy obtained for the frame with infill. The width of strut is altered depending on the difference in magnitudes of the strain energy with strut until such time that both values of strain energies are matching.
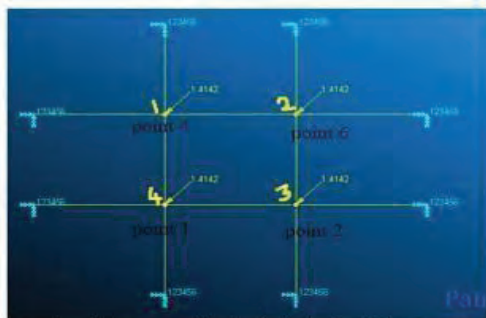
Figure 4. Point of application of loads.

IV. FEM MODELLING

Frames are analyzed as follows

1. Modelling
2. Creating and Assigning Material Properties
3. Creating and Assigning Support Conditions
4. Creating and Assigning loads
5. Creating the load cases
6. Meshing
7. Analyze
8. Check output files & Plotting results

Following Frames are analyzed using above method

1. Bare frame subjected to the following loads at all beam column junctions
2. Infill frame subjected to the following loads at all beam column junctions
3. Infill Frame with Window Opening is subjected to the following loads at all beam column junctions
4. Infill Frame with Door Opening is subjected to the following loads at all beam column junctions
5. Infill Frame with Window & Door Opening is subjected to the following loads at all beam column junctions
   - Horizontal point loads
   - Vertical point loads
   - Rotational point loads

The following pictures are the analytical modelling using MSC NASTRAN which includes five frames with all modelling steps with a clear picture of the mesh seed, mesh and element division. We require only compression members. So we delete all the tension link elements
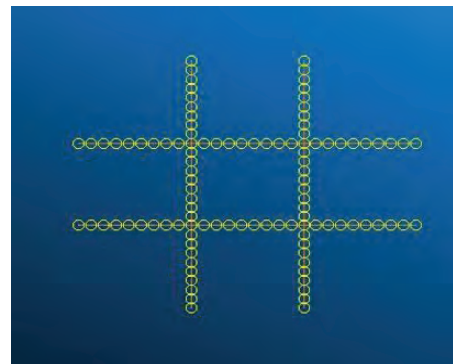
Figure 5. Bare Frame
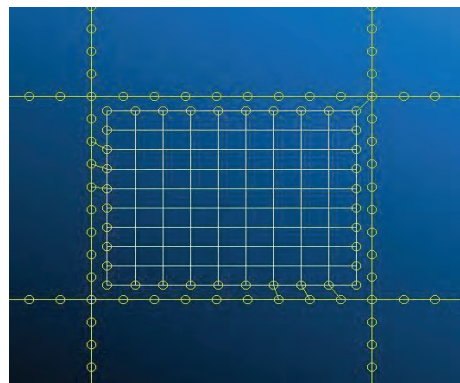
Figure 6. InfillFrame
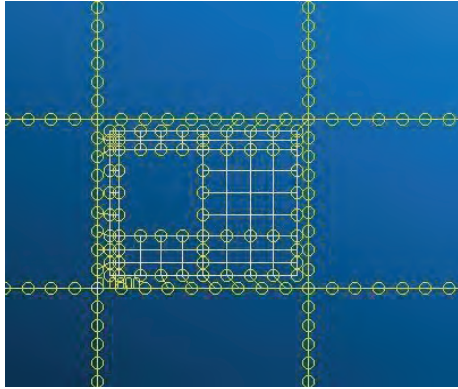
Figure 7. Infill Frame with Window Opening

Figure 10. Equivalent Diagonal Strut Frame

Figure 8. Infill Frame with Door Opening
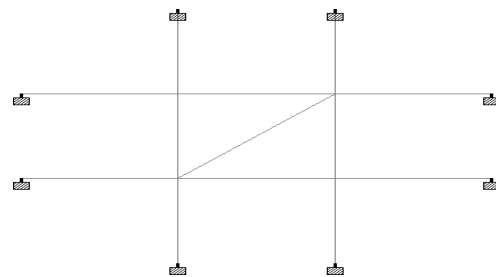
Figure 11. Equivalent Diagonal Strut Condition with Compression Only

As explained in method of study we model the frames and apply loads and obtain a 12 *12 Flexibility matrix. For the aspect Ratio 1200*700 and Bare frame a sample 12 * 12 Flexibility matrix is given below in Table 2

This Flexibility matrix is inversed using MATLAB software where 12*12 Numeric matrix is defined using displacement values obtained from analysis of MSC NASTRAN or STAAD Pro. Then the First column of the flexibility matrix is defined as d which is 12*1 matrix (Column matrix). Transpose of this matrix is d^T which is obtained using MATLAB and then calculate strain energy using the equation

$$U = \tfrac{1}{2} * d^T * K * d. \qquad (1)$$

For the case of the Equivalent Diagonal Strut first perform MSC NASTRAN analysis for the bare frame and Infill frame for the aspect ratio required. Then using results, calculate Strain Energy as explained above. Then for the same aspect ratio, material properties we perform analysis using STAAD PRO and again calculate Strain Energy as same as above method to observe the results.

Figure 9. Infill Frame with Window & Door Opening

Use STAAD Pro for modelling and analysis of Equivalent Diagonal Strut frame which is used to replace the infill and same loading and property conditions are used as in MSC NASTRAN to obtain flexibility matrix. Treating the 2-diagonal strut as truss element.

But it is observed that on application of load, one component is in tension and other is in compression. Delete Tension strut and perform analysis with only compression strut.

Note down the strain energy value and compare that with the infill strain energy which is calculated through NASTRAN package. The requirement here is to equate the infill frame strain energy with the equivalent diagonal strut. By using trial and error method increase or decrease of width (W) of diagonal strut is performed in order to have the same strain energy as that of infill frame.

TABLE II.
12*12 Flexibility Matrix For Bare Frame – 1200*700 Aspect Ratio

1.297E-06	-5.214E-09	1.145E-08	1.141E-06	2.276E-08	1.159E-09	8.486E-07	-1.519E-07	1.696E-09	6.682E-07	1.500E-07	-5.284E-09
2.080E-08	1.723E-06	7.395E-10	1.954E-07	1.639E-07	-1.097E-09	-1.539E-07	1.310E-07	-1.210E-09	-5.357E-08	1.376E-06	-4.305E-10
-2.504E-09	-1.136E-09	-1.209E-11	3.385E-10	1.070E-09	-5.393E-12	8.024E-10	6.581E-10	-4.045E-12	1.400E-09	-6.958E-10	-1.902E-11
9.997E-07	-1.416E-07	8.432E-09	1.073E-06	1.818E-07	1.126E-10	9.481E-07	-2.679E-08	7.564E-10	9.393E-07	-2.155E-08	-9.152E-09
3.004E-08	1.590E-06	6.133E-10	1.822E-07	1.608E-07	-1.109E-09	-1.952E-07	1.409E-07	-1.346E-09	1.158E-09	1.497E-06	-1.807E-09
-2.103E-09	-3.712E-11	-1.725E-11	-8.206E-10	7.005E-10	-4.721E-12	-2.252E-11	7.904E-10	-7.063E-12	3.174E-09	-1.719E-09	-4.809E-11
1.679E-06	1.714E-07	1.225E-08	1.103E-06	-1.442E-07	2.044E-09	6.769E-07	-2.468E-07	2.213E-09	4.934E-07	2.407E-07	-3.527E-09
-1.334E-07	1.939E-06	2.617E-09	1.947E-07	1.094E-07	-5.357E-10	-4.381E-08	6.534E-08	-5.145E-10	5.415E-09	1.280E-06	-6.698E-10
-5.214E-09	-5.087E-10	7.063E-11	9.337E-10	9.041E-11	5.127E-12	2.705E-09	-6.003E-10	9.213E-12	2.182E-09	1.204E-09	-1.876E-11
1.410E-06	4.911E-07	1.210E-08	1.074E-06	-3.604E-07	3.971E-09	8.708E-07	-4.602E-07	4.283E-09	5.994E-07	3.262E-07	-4.182E-09
-1.502E-07	1.930E-06	2.324E-09	2.010E-07	1.084E-07	-4.975E-10	-4.081E-08	6.245E-08	-4.790E-10	1.160E-08	1.290E-06	-7.746E-10
2.171E-09	-3.579E-09	-3.521E-12	4.523E-10	2.424E-09	-2.050E-11	-1.810E-09	2.287E-09	-2.167E-11	-8.668E-10	-9.097E-10	4.467E-12

V. Results and Discussions

In this Project, the Analysis is performed on three different sizes as specified below
  a. 1200mm*700mm
  b. 900mm*700mm
  c. 700mm*1200mm

For each of the above aspect ratios, the different frames are analyzed in MSC NASTRAN

  1. Bare Frame
  2. Infill Frame
  3. Infill Frame with Window Opening
  4. Infill Frame with Door Opening
  5. Infill Frame with Window and Door Opening

The results of the analysis are tabulated in Table III.

For the above different sizes, define two frames in STAAD PRO and the results are tabulated in the Table IV just for the purpose of reference.

  1. Bare Frame
  2. Equivalent Diagonal Strut Frame

Thus, it can be concluded that the width of the equivalent diagonal strut is found to replace the infill in the frame. Width of such strut is calculated in this analysis for different sizes.

The perfect analysis and exact equivalent diagonal strut can be calculated through neural networks concept while generating a C++ program by giving the inputs required to perform and analyze and finally get the required output. That is the width of the equivalent diagonal strut. The abbreviations are defined below

TABLE III.
MSCNASTRANANALYSISRESULTS–STRAINENERGYFORFIVE FRAMES

	Strain Energy Values		
Stiffness	Frame 1	Frame 2	Frame 3
	1200*700	900*700	700*1200
K	1.390E-06	1.333E-06	1.568E-06
KE	1.358E-06	1.285E-06	1.452E-06

TABLE IV.
Staad Pro Analysis Results – Strain Energy for the Frames

	Strain Energy Values		
Stiffness	Frame 1	Frame 2	Frame 3
	1200*700	900*700	700*1200
K	1.390E-06	1.333E-06	1.568E-06
KE	1.358E-06	1.285E-06	1.452E-06

K: Strain energy of open frame

KI: Strain energy of frame with full infill

KE: Strain energy of frame with infill replaced
        with Equivalent diagonal struts.

VI. CONCLUSIONS

- The lateral deflection recorded for RC frame with infill panel was found to be far too less as compared to the lateral deflection without infill. This shows that the lateral stiffness is greatly enhanced due to the presence of infill.

- For the aspect ratio of 1200*700, Strain Energy of Frame model with infill is found to be nearly forty times more than the corresponding frame without infill.

- For the aspect ratio of 700*1200, Strain Energy of Frame model with infill is found to be three times more than the corresponding frame without infill.

- The present methodology presents a rational method for determining the width of the diagonal strut instead of the earlier methods, which are mostly empirical in nature.

- The replacement of the equivalent strut in place of the infill Panel greatly simplifies the structural analysis of buildings with infill wall panels.

- More elaborate studies are needed to be carried-out for the determination of diagonal strut width, so that it improves the structural analysis. More rational and the seismic performance of the buildings also improves.

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Studies on Influence of Admixtures and Aggregate Curing Conditions on the Strength of Lightweight Expanded Clay Aggregate Concrete

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Abstract: Lightweight concrete can be produced by replacing the normal aggregate with lightweight aggregate either partially or fully, depending upon the requirements of density and strength. The present study covers the influence of different aggregate curing conditions and admixtures on the strength of lightweight expanded clay aggregate concrete under normal curing and vacuum curing with and without addition of silica fume. The grade of the concrete is M40. The lightweight aggregate used is LECA, an expanded clay aggregate. Investigations were carried out up to a replacement of 50% of coarse aggregate. The workability and strength at different ages are presented.

Index Terms: Lightweight Expanded Clay Aggregate (LECA), Admixtures, Density, workability, Compressive strength

I. INTRODUCTION

Concrete is one of the most widely used construction material in modern constructions and infrastructure needs. It is used as a construction material because it can be moulded into any structural form and shape. The density of normal concrete ranges from 2200 to 2600 Kg/m^3, self-weight occupies a very large load coming on the structures critically in cases such as weak soils and tall structures.

Lightweight concrete plays a major role in reducing the density of the concrete. It is used worldwide in many construction projects where soil is weak and heavy constructions are to be done, Lightweight concrete density varies from 300 to 1800 Kg/m^3. LWC can be produced by using lightweight materials like Lightweight Expanded Clay Aggregate, Pumice stone, expanded shale, Perlite etc.

Structural lightweight aggregate can be produced naturally or from environmental waste. Use of these aggregates can reduce the density of concrete, the self-weight of the structure and it helps to construct larger precast unit.

The main objective of the present experimental study is to investigate the properties of lightweight expanded clay aggregate concrete (LECAC) under normal curing conditions and vacuum curing.

II. LITERATURE REVIEW

R.N.Rajprakash, A.Krishnamoorthi [1] studied the effect of partial replacement of coarse aggregate (Jelly) in concrete by Light weight coarse aggregate (LECA). They have partially replaced natural aggregates by using LECA by 20%, 40%, 60%, 80% and 100%. Compressive strength of 29.85 N/mm^2 at 20% LECA replacement for a water curing for a period of 28 days.

M.MAHDY [4] investigated the Mechanical properties, workability of lightweight concrete using LECA as lightweight aggregate. High strength concrete is achieved by treating LECA with Silica fume solution of different concentrations (10% & 20%) by weight of mixing water. Three silica fume levels of different percentage's (5, 10, and 15 %) and two coarse to total aggregate content (0.48, 0.65) by volume were used. Results showed that use of cured LECA increased the compressive strength and flexural strength.

N.Sellakkannu and C.Tamilarasan [6] examined the properties of concrete which were determined by tests conducted on concrete such as Concrete Density, Porosity, Ultrasonic pulse velocity and Compressive & Split tensile strength. The test results and examination of the concrete samples using Optical Microscope shows that there is a strong bonding between the cement paste and LECA.

Serkan Subasi [12] studied the effect of fly ash in High strength light weight aggregate concrete produced with LECA. The Physical and Mechanical properties of the concrete were investigated. Concrete mixes with 350, 400 and 450 kg/m^3 cement content and with 0%, 10%, 20% and 30% flyash as replacement of cement content were casted. They found that Physical and Mechanical properties are enhanced by adding mineral admixtures, Ultrasonic pulse velocity is increased by 3%, Compressive strength is increased by 8%; and Split tensile strength is increased by 9% for the concretes with various cement contents.

III. EXPERIMENTAL STUDY

A. Materials

This section gives the details of the characteristics of the different materials used in this experimental study.

Cement

Cement is used as a binding material. In this experimental study Ordinary Portland Cement of Grade 53 is used. The cement is found to be conforming to various specifications of IS 12269-1987.The physical properties of cement are tested and the results are tabulated in the Table I as per IS 4031-1998.

TABLE I.
PHYSICAL PROPERTIES OF CEMENT

Test	Result
Specific gravity	3.10
Standard consistency	34%
Initial setting time	45 minutes
Final setting time	489 minutes
Bulk density	1440 kg/ m^3
Fineness of cement	2.4 %

Aggregates

Aggregates are the inert granular materials such as sand, gravel, or crushed stone that are mixed along with water and Portland cement to make concrete. They are essential ingredients in making concrete.

Coarse aggregate (Gravel)

In present experimental work coarse aggregate passing through 12mm IS sieve and retaining on 10mm IS sieve is used. Certain care is taken while choosing coarse aggregate and it is seen that it is free from impurities. Characteristic Tests are conducted to find out the properties of the coarse aggregate and are tabulated in the Table II.

Coarse aggregate (LECA)

Lightweight expanded clay aggregate (LECA) is used as the lightweight aggregate which is of size 8 to 12mm. LECA is free from impurities. Characteristic tests are also performed on LECA and the results are tabulated in Table II.

Figure 1. Lightweight expanded clay aggregate

TABLE II.
PHYSICAL PROPERTIES OF COARSE AGGREGATE

Property	Coarse aggregate	LECA
Fineness modulus	6.41	5.84
Specific gravity	2.43	0.71
Bulk density	1420 kg/ m^3	410 kg/m^3
Water absorption	0.6 %	30 %

Fine aggregate

Fine aggregate used in this experimental work is locally available river sand, care is taken to see that the sand is free from impurities, waste stones and to remain clean. Sand used is confirming to the requirements of IS: 383-1970. Characteristic tests are conducted on fine aggregate and the properties of fine aggregate are tabulated in Table III.

TABLE III.
PHYSICAL PROPERTIES OF FINE AGGREGATE

Test	Result
Fineness modulus	3.085
Specific gravity	2.59
Bulk density	1570 kg/ m^3
Water absorption	1%

Mineral Admixture

Micro silica, as a replacement to the cement, is used as the mineral admixture in order to improve the strength of the lightweight concrete and also to avoid segregation of concrete.

Chemical Admixture

Admixtures, natural or manufactured chemicals, are added to the concrete before or during concrete mix. Admixtures are used in the tests have the qualities of air-entraining, water reducers, water reducing accelerators or retarders. Use of admixture will improve the workability of the concrete strength.

In the present study, CONPLAST SP 430 is used. It is used to improve the workability of the concrete and also specially formulated to give high water reductions upto 25% without loss of workability and also reduce permeability to give high quality concrete.

Water

Water is the most important ingredient of concrete which helps to bind the cement content and aggregates. Clean potable water is used for concrete mixes.

B. Mix Design

In the present study, the mix design of the Lightweight expanded clay aggregate concrete (LECAC) was done using the code IS:10262-2009 and IS:456-2000. In the coarse aggregate content of the mix, 50% of the normal aggregate is replaced with LECA to obtain lightweight concrete in the present studies. The chemical admixture i.e. SP 430 is used in order to improve workability and mineral admixture

(Micro silica) is added in addition to cement in strength development of LECAC.

Vacuum curing of Coarse aggregate (LECA)

The amount of water absorbed by LECA while curing is less as it floats in the water. In order to improve the water absorption and fill the air voids, LECA is placed in the vacuum chamber and the moisture is removed by passing vacuum through the clay aggregate. This vacuum curing is done for 24 hours and the air voids present in the clay aggregate is filled with the water which results in the increase in the water absorption there by increasing the compressive strength of the LECA concrete.
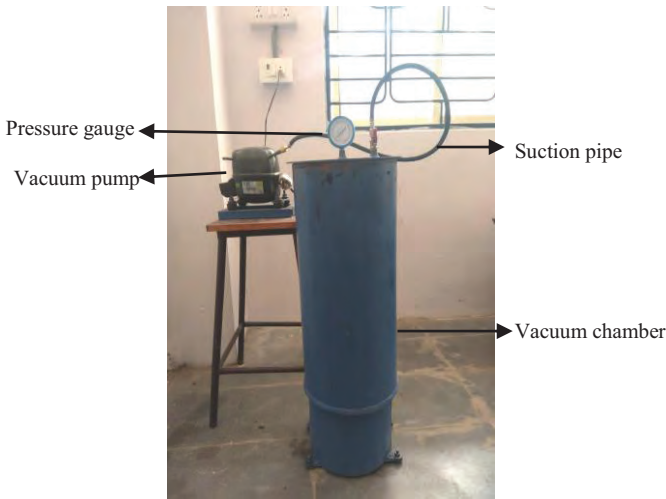
Figure 2. Vacuum curing chamber

Casting of specimen

The fresh concrete was casted using different water-cement ratio i.e. 0.35, 0.40, 0.45 and different super plasticizer dosage for each w/c ratio. For each mixture, cube cylinder and prism specimens of size 150x150x150mm, 150x300mm and 100x100x500mm were casted respectively. The composition of LWC mixtures are represented in Table IV.

Figure 3. Casting of cube specimens

Curing of specimens

All the casted concrete specimens were cured by placing the specimens in the curing tank containing water for a period of 28 days. The LECA was also cured using vacuum curing method by placing it in a vacuum chamber for 24 hours and then used in casting of LWC.

Figure 4. Curing of cube specimens

TABLE IV.
COMPOSITION OF LIGHTWEIGHT EXPANDED CLAY
AGGREGATE CONCRETE MIXTURES

Mix No.	W/C ratio	Cement (Kg/m³)	MS (Kg/m³)	Water content (Kg/m³)	C.A (Kg/m³)	LECA (Kg/m³)	F.A (Kg/m³)
M1	0.35	450	0	157.5	534.60	156.20	614.01
M2	0.40	425	0	170	523.66	153.00	627.42
M3	0.45	400	0	180	513.94	150.16	642.99
M4	0.35	405	45	157.5	534.60	156.20	614.01
M5	0.40	382.5	42.5	170	523.66	153.00	627.42
M6	0.45	360	40	180	513.94	150.16	642.99

IV. EXPERIMENTAL METHODOLOGY

The casted concrete specimens are tested as per standard testing procedures. The Experimental Results of the Lightweight expanded clay aggregate concrete such as Workability, Unit weight, water absorption of LECA, compressive strength, split tensile strength, Flexural strength of the LECA Concrete (LECAC50) is represented in this section.

A. Water absorption of LECA

The water absorption of LECA aggregate is found out by using water curing, vacuum curing. The results are given in table V.

Figure 5. LECA Water absorption test

B. Workability

The workability of the LECAC50 is measured by conducting the Slump cone test using standard Procedure prescribed in IS: 1199 - 1959 and given in Table VI.

Figure 6. Workability test of LECAC50 using Slump cone test

C. Compressive Strength

Cubes of size 150x150x150mm were casted and allowed for curing in curing tank for 28 days and 56 days. And tested in Automatic compression testing machine of 2000KN capacity.

Figure 7. Compressive strength test and Split tensile test of LECAC50 cube and cylindrical specimen respectively with Automatic compression testing machine of 2000kN capacity

D. Flexural strength

Prisms of size 100x100x500mm were casted and allowed for curing in curing tank for a period of 28 days and tested in flexural testing machine.
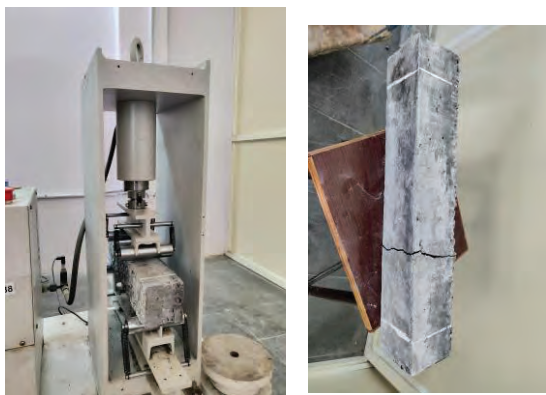
Figure 8. Flexural strength of LECAC50 prism along its failure

E. Split tensile strength

Cylinders of size 150x300mm were casted and allowed for curing in curing tank for 28 days and tested in the

Automatic compression testing machine of 2000KN capacity.

V. EXPERIMENTAL RESULTS

TABLE V.
COMPARISION OF WATER ABSORPTION OF LECA

Property	Normal LECA	Partially saturated surface dried LECA	Vacuum cured LECA
Water absorption	0.85%	14%	75%

TABLE VI.
WORKABILITY OF LECAC50

Trial Mix No.		W/C ratio	Slump(mm)
Partially Saturated Surface Dried LECA	M1		60
	M2		63
	M3		78
Partially Saturated Surface Dried LECA with Micro Silica	M4		48
	M5		52
	M6		58
Vacuum Cured LECA	M1		52
	M2		69
	M3		92
Vacuum cured LECA with Micro Silica	M4		46
	M5		60
	M6		95

The compressive strength of various proportions of LECAC50 for different curing periods such as 28 days and 56 days are analyzed. The results are tabulated in the Table VII. The split tensile and flexural strength results are tabulated in Table VIII, Table IX respectively.

TABLE VII.
COMPRESSIVE STRENGTH OF LECAC50

LECA TYPE	Mix	Compressive strength (MPa)		% increase in strength
		28 Days	56 Days	
Partially Saturated Surface Dried LECA	M1	33.40	35.82	5.13%
	M2	29.59	31.09	5.06%
	M3	27.30	28.54	4.54%
Partially Saturated Surface Dried LECA with Micro Silica	M4	36.20	37.92	4.75%
	M5	31.92	33.21	4.04%
	M6	29.86	31.04	3.95%
Vacuum Cured LECA	M1	36.95	39.62	7.22%
	M2	32.84	34.87	6.18%
	M3	29.36	31.11	5.98%
Vacuum cured LECA with Micro Silica	M4	39.94	43.21	8.18%
	M5	35.14	37.74	7.39%
	M6	32.79	34.95	6.58%

TABLE VIII.
SPLIT TENSILE STRENGTH OF LECAC50

Design Mix No.	Split tensile strength (MPa)	
	With Microsilica	Without Microsilica
M1	8.4	7.2
M2	8.7	7.7
M3	9.9	8.4

TABLE IX.
FLEXURAL STRENGTH OF LECAC50

Design Mix No.	Flexural strength (MPa)	
	With Microsilica	Without Microsilica
M1	6.24	6.15
M2	6.20	6.02
M3	5.93	5.79
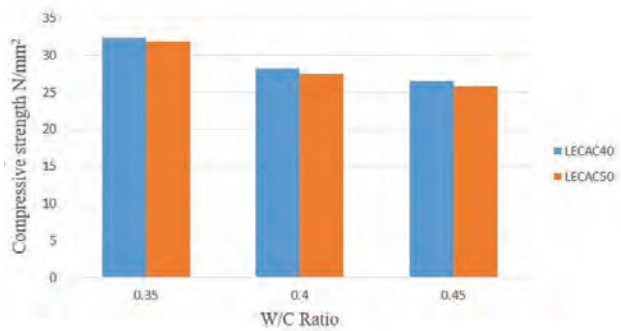
Figure 9. Comparison of compressive strength for LECAC40 and LECAC50 Mix at age of 28 days

Figure 10. Compressive Strength of LECAC50 Trial Mixes for different W/C ratio and chemical admixture dosage

Figure 11. Variation of compressive strength of LECAC50 mix with Partially saturated surface dried LECA with and without addition of 10% Microsilica at age of 28 days

Figure 12. Variation of compressive strength of LECAC50 with Partially saturated surface dried LECA and vacuum cured LECA at age of 28 days

Figure 13. Variation of compressive strength development of LECAC50

Figure 14. Variation of Split tensile strength of LECAC50
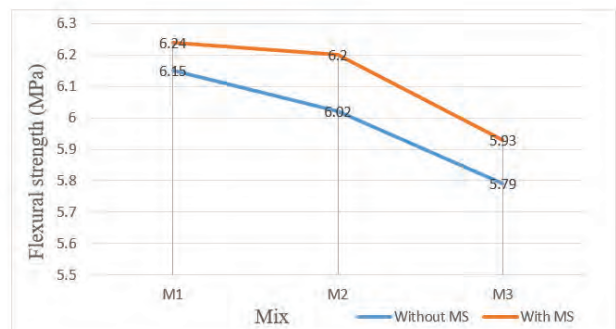
Figure 15. Variaiton of Flexural strength of LECAC50

VI. CONCLUSIONS

The following conclusions are drawn from the Experimental Investigation

- The unit weight of LECAC50 mix was found to be in the range of 1700 Kg/m^3 to 1780 Kg/m^3 which was less than the conventional concrete density.
- The addition of Conplast SP 430 to the LECAC50 improved its workability & strength. The optimum dosage of chemical admixture obtained for water-cement ratios 0.35, 0.40, and 0.45 are 1.5%, 1%, and 1% respectively.
- The addition of conplast SP 430 exhibits increase in the compressive strength by 6.13% for LECAC50.
- The vacuum cured LECA has a water absorption of 75%, whereas the water absorption of partially saturated surface dried LECA for 1 day is 15%, which shows an increase in water absorption with vacuum curing.
- The compressive strength of LECAC50 with vacuum cured LECA increased by 9.83% compared to partially saturated surface dried LECA.
- The addition of 10% Microsilica to LECAC50 with partially saturated surface dried LECA improved the compressive strength by 8%.
- The addition of 10% Microsilica to LECAC50 with vacuum cured LECA increased the compressive strength by 10.33%.
- The addition of 10% Microsilica has shown improvement in Split tensile strength and flexural strength of LECAC50.
- The development of compressive strength of LECAC50 at age of 56 days with vacuum cured LECA is increased compared to the partially saturated surface dried LECA as Micro silica reacts with the water available in the pores of the vacuum cured LECA.

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A Comparative Study on Green Building Rating Systems in India in terms of Energy and Water

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Abstract: Construction Industry has many adverse effects on the environment. Few non-profit organizations have been educating people about the ill-effects of construction activities to bring awareness among people. This awareness among the general public will mandate the builders to choose alternative materials and methods in construction related activities which have less adverse effects on the environment. In order to achieve this, few organizations have setup standards for various materials and procedures in construction to reduce the load on the environment. Two such organizations in India are Indian Green Buildings Council abbreviated as IGBC and Green Rating for Integrated Habitat Assessment abbreviated as GRIHA . IGBC certifies / ratifies buildings like educational, residential, commercial, etc. Out of several criterion mentioned in their respective manuals, energy and water are the most important criteria. In this paper, an attempt is made to compare the two green building rating systems in India for existing buildings in terms of energy and water.

Index Terms: Alternative materials, Environmental load, Rating systems, Energy, Water

I. INTRODUCTION

In the present world, there is a dearth for energy. Many investigations are taking place for alternative ways of generating energy. The alternative ways should be environment friendly i.e. in the process of generating energy, the environment and the limited resources should be least affected. Abanda and Byers (2016) have investigated that the buildings utilized 32 % of global energy and responsible for 19 % energy related green house gases [16]. Waidyasekhara, De Silva and Rameezdeen (2013) have stated that at present, construction industry is one of the industries that talk more on sustainable and environmental performance [1]. Organizations in India like IGBC and GRIHA have set some standards, by following which, the burden on the environment can be reduced. Both the ratification systems have published their respective manuals on certification of green schools, green campuses, green homes, etc., for new and existing structures after a thorough research by respective organizations. Similarly different countries have their own rating systems. Vierra (2011) mentioned that there are about 600 rating systems in the world [12]. The following table gives the rating systems followed by different countries.

TABLE I.
RATING SYSTEM OF DIFFERENT COUNTRIES

S.No.	Country	Name of the Ratings System
1	USA	LEED
2	UK	BREEAM
3	SINGAPORE	BCA GREEN MARK
4	CHINA	GBCI
5	AUSTRALIA	GREEN STAR – AUS
6	MALAYSIA	GBI
7	INDIA	IGBC / GRIHA

Marjaba and Chidiac (2016) have stated that the widely used ratification system is BREEAM – Building Research Establishment Environmental Assessment Method because of its flexibility in assessing local codes and its application in international buildings [15]. Bourdeau, Huovila, Lanting and Gilham (1998) have mentioned that due to different ideas of sustainable construction in different countries there are different sustainable practices [14]. Dat Daon et al., (2017) have stated that due to need to report concerns in local conditions of different countries or regions, different rating systems have different weightages [10]. As there are two certification / ratification systems in India, construction industry often gets into dilemma about the usage and execution of the systems.. Out of the several criterions in both the systems, energy and water constitute to almost 50% of the points. Rebecca (2008) have mentioned that the building valuation systems focus on different areas but most of the systems have water conservation and energy efficiency in common [2]. This paper focuses on the differences in the rating systems in India. It is done in terms of energy and water for existing buildings.

II. GREEN BUILDING CERTIFICATION

A green building is the one, which minimizes the negative impacts of construction right from its design stage to its operation and maintenance stage. It also uses the scarce resources like sand, gravel, raw materials, energy and water effectively. Joseph and Tretsiakova-McNally (2010) have stated that the construction industry is accountable for consumption of large portion of raw materials usage, exploiting 25 % of wood harvest [17]. Gupta and Kumar (2010) have mentioned that the building construction industry exploits 40 % of stone, sand and gravel globally [19]. Attom, Abed, Elemam, Nazal and ElMessalami (2016) have highlighted that buildings consume 16 % of water globally [18]. Yu and Tu (2011) have stated that those

buildings which are certified by rating systems are assumed to consume relatively less enegy and water [13]. A green building is also known as sustainable building. Boonstra and Pettersen (2003) have highlighted the necessity of environmental assessment methods. This can respond to environmental issues and define sustainable levels [3]. Fowler and Rauch (2006) have explained that sustainable building rating systems are used to test the performance or expected performance of the whole building. It translates performance assessment into a tool that can be used to compare the building performance or a performance standard [4]. Sev (2009) documented that the environmental valuation tools have become common in recent times and fascinated the stake holders of construction [5]. The cerfication will be done by IGBC and GRIHA in India. There will be certain procedures to be followed for certification process. Green building certification for existing buildings give a scope to reduce water and energy requirements. Buildings should continously monitor the environmental performance of the existing buidings and improve them if required to obtain resource efficient habitats. Both the rating systems have certain mandatory requirements, without meeting these requirements, the buildings are not eligible for certification.

III. ABOUT IGBC & GRIHA

IGBC was established by the CII – Confederation of Indian Industry in 2001. It is a research institute, head office located in CII Sohrabj Godrej Green Business Center. IGBC has licensed the LEED green building standard from USGBC. LEED – The Leadership in Energy and Environmental Design is the rating system developed by USGBC - United States Green Building Council (USGBC). It is the organization encouraging sustainability through green buildings. It is a structure for gauging building performance compared to set criteria and customary points of reference. The LEED rating system standards were framed in 2000. It ratifies existing and new buildings. Some examples of LEED certified buildings in India are ABN Amro Bank (Ahmedabad) – LEED Platinum rated, American Embassy School (Delhi) – LEED Gold rated, Anna Centenary building (Chennai) – LEED Gold rated etc.

GRIHA was established by TERI – The Energy and Resource Institute. GRIHA is an abbreviation for Green Rating for Integrated Habitat Assessment. The word GRIHA has originated from Sanskrit language, which means 'Abode'. Buildings communicate with environment in many ways. Buildings consume resources in the form of construction materials, waters, energy, etc. Once the buildings are possessed, they effuse waste directly or indirectly. As an old proverb goes, things which can be measured can be managed. GRIHA tries to measure things like energy consumed, waste generated, adoption of renewable energy to manage, regulate and reduce them to least possible extent. Some examples of GRIHA certified buildings in India are ZED Earth villa (Bangalore), Indra Paryavaran Bhavan (New Delhi), IOCL office (Indore) etc.

Both IGBC and GRIHA are ratification tools which helps the construction industry to reduce the harmful effects of construction on the environment thereby promoting sustainable development.

IV. METHODOLOGY

The content mentioned in this paper is through survey of published papers and manuals available in the respective websites of GRIHA and IGBC. In this paper, a comparison is made between IGBC and GRIHA rating systems for existing buildings in terms of energy and water criterion. The reason for considering only these two criterions is that they contribute to the majority of points though there are other parameters also to be considered for certification.

V. CRITERIA AND THEIR WEIGHTAGE
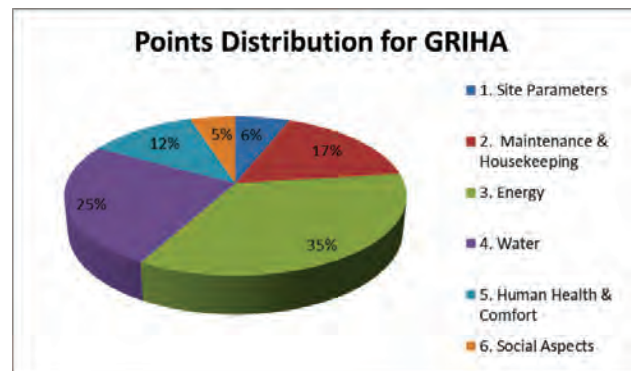
Figure 1. Points Distribution for GRIHA rating system

TABLE II.
LEVELS OF CERTIFICATION BASED ON POINTS EARNED

POINTS	RATING
25-40	ONE STAR
41-55	TWO STARS
56-70	THREE STARS
71-85	FOUE STARS
86 and above	FIVE STARS
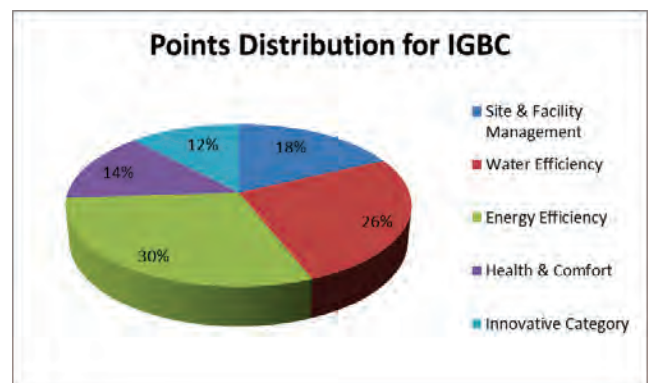
Figure 2. Points Distribution for IGBC rating system

TABLE III.
LEVELS OF CERTIFICATION BASED ON POINTS EARNED

POINTS	RATING
50-59	BEST PRACTICES
60-69	OUTSTANDING PERFORMANCE
70-79	NATIONAL EXCELLENCE
80-100	GLOBAL LEADERSHIP

GRIHA certification is done for a total of 100 points which excludes bonus 4 points. This bonus points are for adoption and implementation of innovative strategies in improving the sustainability of the project. In GRIHA, the site parameters criteria is given 12 points, maintenance and housekeeping criteria is given 17 points, energy criteria is given 35 points, water criteria is given 25 points, human health and comfort is given 12 points and social aspects criteria is given 5 points. These entire criterions have sub criterions. The validity of ratification for GRIHA certified buildings is five years.

IGBC certification is also done for 100 points which includes 12 points for innovative category. There is no such provision for bonus points as it is done in GRIHA. In IGBC, site facility and management is given 18 points, water efficiency is given 26 points, energy efficiency is given 30 points, health & comfort is given 14 points and innovative category is given 12 points. The validity of IGBC certified buildings is only three years.

VI. IMPORTANCE OF ENERGY & WATER CONSERVATION IN SUSTAINABLE DEVELOPMENT

Buildings contribute to 18 % of total emissions globally which is equal to nine billion tons of carbon dioxide every year. The main aim of a sustainable / green building is to reduce the greenhouse gas emissions and promote energy and water conservation. Building construction involves the use of energy and water directly or indirectly. Generation of energy from non-renewable sources requires consumption of fossil fuels by which greenhouse gases are emitted. These are harmful for the environment. It may have side effects like acid rains. Guggemos and Horvath have (2006) have stated that the construction industry is one of the largest users of energy and water [6]. Fawcet et al., (2012) have stated that the main objective of sustainability is to reduce any damaging upcoming consequences from present usage activities [7]. In green / sustainable buildings, importance is given for energy generation from renewable sources like solar, wind etc. These don't emit greenhouse gases. Though it requires huge initial investment, it is one time investment. The rate of return will be very high. Different rating systems around the world have given different weightage for energy criteria.

Another important aspect of sustainable building is water which includes water conservation and water use efficiency. Water is a limited resource in many countries in the world. The availability of potable water is not sufficient and is decreasing day by day. Waidyasekara , De Silva and Rameezdeen (2012) highlighted the importance of addressing pollution caused by water because of construction works and the necessity of instigating rules and regulations towards water monitoring and management at construction areas [1]. Water is required right from the beginning of construction to its operation and maintenance phase. David Langdon (2007) reported that scarcity in water means, the cost increases [8]. Reduction in water consumption means reduction in Life Cycle Cost (LCC) of the building. Using good quality water in construction is also important for attaining maximum strength of structures. Utraja (2010), mentioned that the quantity & quality of water also has a greater effect on the strength of concrete and mortar used in construction work [9]. Different weightage is given by different rating systems for water parameter.

VII. ANALYSIS OF ENERGY PARAMETER IN IGBC & GRIHA RATING SYSTEMS
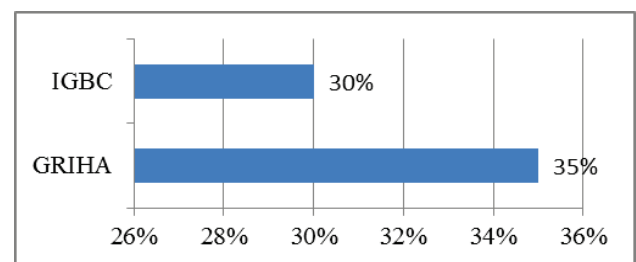
Figure 3. Weightage (%) for energy criteria for IGBC & GRIHA

A. Sub criterion in energy for IGBC

TABLE IV.
POINTS FOR SUB CRITERION

S.No.	Sub criteria	Points
1	Energy performance	14
2	On-site renewable energy	6
3	Off-site renewable energy	6
4	Energy metering	4
	TOTAL	30

B. Sub criterion in energy for GRIHA

TABLE V.
POINTS FOR SUB CRITERION

S.No	Sub criteria	Points
1	Energy efficiency	20
2	Renewable energy utilization	15
	TOTAL	35

VIII. ANALYSIS OF WATER PARAMETER IN IGBC & GRIHA RATING SYSTEMS
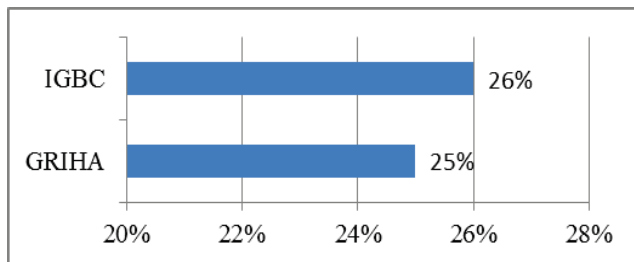
Figure 4. Weightage (%) for water criteria for IGBC & GRIHA

A. Sub criterion in water for IGBC

TABLE VI.
POINTS FOR SUB CRITERION

S.No	Sub criteria	Points
1	Water efficient fixtures	6
2	Rain water harvesting	4
3	Waste water treatment	4
4	Waste water reuse	4
5	Water metering	4
6	Turf area	4
	TOTAL	26

B. Sub criterion in water for GRIHA

TABLE VII.
POINTS FOR SUB CRITERION

S.No	Sub criteria	Points
1	Water footprint	15
2	Reduction in cumulative water	10
	TOTAL	25

IX. DISCUSSIONS & CONCLUSIONS

Construction Industry is one such industry which is responsible for consumption of natural and scarce resources. It is also responsible for global warming. Few organizations have set up some standards. Following these standards, though ill-effects of construction cannot be completely eliminated but can be minimized. Such organizations also certify / ratify buildings based on the methods and materials used right from the beginning of the construction. There are two ratification systems in India namely IGBC and GRIHA. The builder or contractor who would like to go for ratification will be in a state of dilemma on which system they should opt for. In order to avoid this confusion, there should be only one ratification system for a country.

In IGBC, the energy performance sub criteria have a total of 14 points (Table 4) whereas GRIHA has 20 points (Table 5). In this sub criteria, IGBC has given two methods to calculate energy savings and it has also given values for different climatic conditions (composite, warm & humid and hot & dry temperature) for different types of buildings (day time office building, shopping malls, BPOs). The points are awarded based on the energy savings percentage. In case of GRIHA, there is not much of ambiguity in calculating reduction in energy consumption. Based on the percentage reduction in energy consumption, points are awarded for residential and non-residential / commercial buildings respectively. GRIHA calculations are easy to understand and execute when compared to that of IGBC.

In IGBC, 6 points each are awarded for on-site and off-site renewable energy based on the percentage of on-site and off-site renewable energy production. Similarly, 20 points are given for on-site and off-site renewable energy which is based on the percentage usage of renewable energy. In both the ratings systems the calculations are simple and can be easily understood. Energy metering has allotted 4 points for IGBC. In case of GRIHA 3 points are under different criteria, Metering & Monitoring. If this can be included in energy criteria section, then all the energy related criteria can be found in a single place.

Comparing the water criteria, total points are 26 and 25 for IGBC and GRIHA respectively, which means equal importance is given for water in both ratification systems. Using water efficient fixtures are a mandatory requirement in IGBC; water efficient fixtures are given 6 points based on the percentage of potable water savings over baseline. The baseline details are mentioned in the IGBC manual, whereas there is no such mandatory requirement in case of GRIHA but reduction in building water consumption by 30% below the base case through water efficient fixtures is given 3 points. The methodology for calculating water consumption and water use reduction is little complicated but can be simplified to a certain extent. In IGBC, rain water harvested on site from roof and non-roof areas are given 4 points based on the percentage of rain water harvested on site. In places where the state / central ground water board don't recommend artificial rain water recharge or if the groundwater table is less than 4 m, the projects can show nominal compliance by collection and reuse. The points are given based on percentage rainwater harvesting system from roof and non-roof areas. In case of GRIHA, minimizing lawn area and restricting it to 25 % of total landscaped area gives 2 points. Use of water efficient irrigation fixtures to decrease the water requirement by at least 50 % from GRIHA base case (mentioned in the GRIHA manual) gives 2 points. Use of water efficient irrigation fixtures isn't mentioned in the IGBC manual.

If 100 % of waste water is treated on site for reuse of safe disposal to avoid polluting streams, it can fetch 4 points in case of IGBC. Further 4 points are awarded based on the percentage of treated water reuse. Treated water can be used for irrigation or flushing requirements which reduce the dependence on potable water. GRIHA assigns 10 points for this sub criteria depending upon the percentage of reuse of treated water.

IGBC and GRIHA assign 4 points for water metering. IGBC gives 4 points for minimizing the turf area whereas GRIHA gives 2 points based on the percentage reduction.

By the differences observed, it is always better to have a common system of ratification. The procedure for ratification shouldn't be cumbersome. Another important aspect is that the cost of ratification for both the ratification systems is very high. Government of India should provide good incentives for ratified buildings to encourage sustainable buildings. The incentives provided are very less.

It is also observed that both the rating systems have addressed the benchmarks for energy and water for buildings during the operation & maintenance stage, but the limits for activities during the construction period have not been mentioned. With the fast moving pace of technology, a need for automation has arisen. For efficient energy management, automation is necessary, but nothing is mentioned in both the rating systems regarding automation. It is therefore recommended to include automation related parameters in the rating systems.

After the building gets certified, there should be periodical inspections during the certification period from the certification agencies to monitor the maintenance of the building. This should be done to avoid the misuse of the certification. Due to the increased awareness of the sustainable buildings, few builders may rent / lease / sell the certified buildings to a higher price.

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Enhanced Range Free Localization in Wireless Sensor Networks

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Abstract: Node localization is one of the most crucial issues for wireless sensor networks (WSNs), as many applications depend on the precise location of the sensor nodes. In last two decades, a number of range-based and range-free localization algorithms have been proposed. Range-free techniques are relatively more efficient but have poor localization accuracy. One of the most widely used range-free techniques is Distance Vector Hop (DV-Hop) algorithm which attracted more attention of researchers due to its stability, feasibility and less hardware cost. To achieve higher accuracy in range free localization algorithms, an Improved DV-Hop algorithm based on Teaching Learning Based Optimization (IDV-Hop based on TLBO) is proposed. In the proposed algorithm, average hop size of the anchor node is modified by updating a correction factor in traditional DV-Hop algorithm. For further improvement of the accuracy, TLBO technique in IDV-Hop is used. With the help of bounded population feasible region, IDV-Hop using TLBO locates the unknown nodes more accurately and achieves higher convergence rate relatively. Simulation results show that the proposed algorithm is efficient and more accurate in terms of localization accuracy compared to DV-Hop, DV-Hop based on Genetic Algorithm (GADV-Hop) and DV-Hop using PSO (Particle Swarm optimization) algorithms.

Index Terms: Wireless sensor networks, Localization, DV-Hop Algorithm, Optimization, TLBO.

I. INTRODUCTION

Recent advancements in wireless communication and micro electromechanical systems (MEMS) technology have led to the development of small, smart and cost effective nodes for sensing physical phenomenon known as Sensor Nodes (SNs). These tiny sensor nodes comprise of processor, dedicated memory, transceiver, actuator, sensor(s) and power module [1]. Due to size and cost constraint, SNs have limited power and low computational capabilities. SNs are deployed manually or randomly in the area of interest to monitor the physical phenomenon such as temperature, pressure, sound, velocity, light, humidity, etc. Depending upon the applications, a collection of hundreds or thousands of nodes may be deployed, which are capable of communicating with each other through a wireless medium and form a network called wireless sensor network (WSN). Nodes can sense the desired data, exchange this data among each other, perform some computational tasks on that and transmit this data to a centralized unit called sink node or base station.

WSN has a number of prospective applications in various areas such as surveillance, habitat and environmental monitoring, military applications, healthcare, structural monitoring and disaster management [3]. Among all these, many applications depend on the accurate positions of the nodes to report sensed data meaningful.

Since sensed data without location information is of no use for the user as it is necessary for the user to know the event as well as the location of the event. Manual deployment of nodes is one of the easy ways for location estimation but it is not feasible for a large scale network and in inaccessible areas. Addition of Global Positioning System (GPS) [4] receiver to the node is also another possible way for node localization. But unfortunately, it is not viable for such a large sensor network as it adds up to the size, power consumption and cost of network deployment and having imprecision in non-line of sight (NLOS) environments etc. [6]. One possible solution is to equip only small number of nodes with GPS known as *anchor nodes (ANs)* or *beacon nodes* and localize remaining nodes with the help of these anchor nodes through any localization algorithm.

Localization algorithms can be broadly categorized as: range-based and range-free localization. Range-based algorithms need to calculate the distances between ANs and SNs based on the actual range or angle information and use this information to determine the coordinates of unknown nodes [5]. These schemes show good localization accuracy but need an extra hardware for actual range determination and are easily affected by the multipath fading [2]. In contrast, range-free schemes use connectivity information and hop values between ANs and SNs to estimate the position of location unaware nodes but show relatively poor localization accuracy. Due to some limitations in range-based schemes, range-free schemes have attracted worldwide researchers' interest because these are the cost effective alternate solution without any extra range determination hardware.

Distance Vector Hop (DV-Hop) [6, 13] is one of the most widely used range-free localization algorithms that has poor localization accuracy which will be discussed thoroughly in the next section. To achieve desired localization accuracy, an improved Distance Vector Hop (IDV-Hop) localization algorithm based on Teaching Learning Based Optimization (TLBO) [10], [11] is proposed in this paper; IDV-TLBO, which is a range free distributed scheme. TLBO is used to improve the localization accuracy of the DV-Hop algorithm.

The remaining paper is structured as follows: Basic DV-Hop algorithm and some modified DV-Hop algorithms are presented in Section II. In Section III, proposed algorithm (IDV-TLBO) is presented. Then the simulation parameters

and experimental results are discussed in Section IV. Finally, the whole paper is concluded in Section V.

II. RELATED WORK

In literature, a number of range-free localization algorithms have been proposed during last two decades such as Centroid [7], Distance Vector Hop (DV-Hop) [6,13], Approximate Point In Triangle (APIT) [9], Convex Position Estimation (CPE) [8], Multidimensional Scaling (MDS) [12] and many more. But among all these range-free algorithms, DV-Hop has attracted more attention of researchers due to its simplicity, stability, feasibility and less hardware requirement. However, DV-Hop has poor localization accuracy and needs an improvement in it. Basic DV-Hop localization algorithm and some improved versions of DV-Hop are presented in the next part of this section.

A. DV-Hop Algorithm

DV-Hop localization algorithm was first proposed by Dragons Niculescu et al. [13]. Many range-free and range-based localization algorithms work for those unknown nodes which have at least three neighbour anchor nodes for position estimation. But DV-Hop algorithm can also work for those unknown nodes which have few or even no anchor at their neighbour. Since in real time scenarios, anchor nodes are deployed in a very small quantity as compared to normal nodes. Generally, DV-Hop algorithm works into following three steps [13, 14]:

Step 1 Estimation of minimum hop counts between every unknown node and anchor nodes.

First of all, every anchor node A_i broadcasts a packet containing the location of A_i and hop count field starting with 0. These packets are broadcasted throughout the network. During broadcasting of packets, hop count field is increased by 1 with every hop. That means, on reception of this packet, every node J (here, J can be either normal or anchor node) records the location of A_i and initializes $hop_{i,J}$. Here $hop_{i,J}$ is the minimum hop count between J and A_i. The value of hop count field varies according to the packets received by anchors with different hop counts. Suppose the received packet is having the lower hop count value than $hop_{i,J}$, then J will update hop_i according to this lower hop count value, otherwise, J will ignore the packet. By this process, every node gets the minimal hop counts to all anchors in the network.
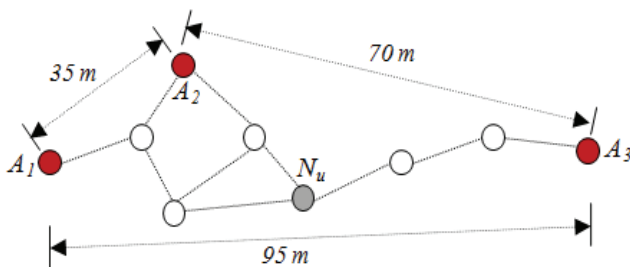
Figure 1. An example of DV-Hop Algorithm

Figure 1 shows an example of a DV-Hop algorithm, in that A_1, A_2 and A_3 are the anchor nodes and remaining nodes are location unaware nodes. The actual distance between A_1 and A_2 is 35m, A_2 and A_3 is 70m and A_1 and A_3 is 95m. Dotted lines show the connectivity between nodes. At a moment, N_u is taken as the unknown node to describe the process clearly. From the step 1 of the algorithm, N_u has the hop counts 3, 2 and 3 to the anchor node A_1, A_2, and A_3 respectively.

Step 2 Estimation of average hop size of every anchor.

From step 1, every anchor A_i has received the coordinates of other anchors and its minimal hop count values to other anchor nodes. Now A_i calculates its average distance per hop or hop size denoted as $HopSize_i$ in the following expression.

$$HopSize_i = \frac{\sum_{i \neq j} \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{\sum_{i \neq j} hop_{ij}} \qquad (1)$$

where (x_i, y_i) and (x_j, y_j) are the coordinates of anchor nodes i and j respectively. hop_{ij} denotes the hop counts between anchor i and j ($i \neq j$). For example in Figure 1, average distance per hop or hop size of anchors can be calculated as follows:

$HopSize_1 (A_1) = (35+95) / (2+6) = 16.25\ m$
$HopSize_2 (A_2) = (35+70) / (2+5) = 15\ m$
$HopSize_3 (A_3) = (95+70) / (5+6) = 15\ m$

Once average distance per hop is calculated, it is broadcasted through the network by A_i.

Step 3 Calculation of coordinates of unknown nodes.

After receiving the average distance per hop, a node can calculate the distance d_{ij} from the anchor nodes by multiplying the $HopSize_i$ to the hop count from that particular anchor as follows:

$$d_{ij} = HopSize_i \times hop_{ij} \quad , \text{where } i \neq j \qquad (2)$$

For an example in Figure 1, node N_u can obtain the approximated distances from each anchor node by formula (2) as: $d_1 = 3 \times 16.25 = 48.75m$, $d_2 = 2 \times 15 = 30m$, $d_3 = 3 \times 15 = 45m$

After calculating the estimated distances d_i from each anchor A_i, $i \in \{1, 2, 3.......k\}$ where k is the total number of anchors, normal nodes can use trilateration or multilateration techniques to calculate their coordinates. Therefore, the following equations can be derived, where (x,y) is the estimated coordinate of an unknown node.

$$\begin{cases} (x - x_1)^2 + (y - y_1)^2 = d_1^2 \\ (x - x_2)^2 + (y - y_2)^2 = d_2^2 \\ \quad \vdots \\ (x - x_k)^2 + (y - y_k)^2 = d_k^2 \end{cases} \qquad (3)$$

Equation (3) can be expressed as:

$$\begin{cases} 2(x_k - x_1)x + 2(y_k - y_1)y = d_1^2 - d_k^2 - x_1^2 + x_k^2 - y_1^2 + y_k^2 \\ 2(x_k - x_2)x + 2(y_k - y_2)y = d_2^2 - d_k^2 - x_2^2 + x_k^2 - y_2^2 + y_k^2 \\ \qquad\qquad\qquad . \\ \qquad\qquad\qquad . \\ \qquad\qquad\qquad . \\ 2(x_{k-1} - x_k)x + 2(y_{k-1} - y_k)y = d_{k-1}^2 - d_k^2 - x_{k-1}^2 + x_k^2 - y_{k-1}^2 + y_k^2 \end{cases} \qquad (4)$$

Equation (4) can be expressed in the linear form as:

$AX=B$; where

$$A = -2 \times \begin{bmatrix} x_1 - x_k & y_1 - y_k \\ x_2 - x_k & y_2 - y_k \\ & . \\ & . \\ & . \\ x_{k-1} - x_k & y_{k-1} - y_k \end{bmatrix} \qquad (5)$$

$$B = \begin{bmatrix} d_1^2 - d_k^2 - x_1^2 + x_k^2 - y_1^2 + y_k^2 \\ d_2^2 - d_k^2 - x_2^2 + x_k^2 - y_2^2 + y_k^2 \\ . \\ . \\ . \\ d_{k-1}^2 - d_k^2 - x_{k-1}^2 + x_k^2 - y_{k-1}^2 + y_k^2 \end{bmatrix} \qquad (6)$$

$$X = \begin{bmatrix} x \\ y \end{bmatrix} \qquad (7)$$

After solving equation (4) based on least square estimations; unknown node can obtain its estimated coordinate as follows:

$$X = (A^T A)^{-1} A^T B \qquad (8)$$

where A^T is the transpose of the matrix A, and A^{-1} is the inverse of matrix A.

Since the DV-Hop algorithm is simple to implement and can localize the nodes which have a few or even no neighbour anchors but its localization accuracy needs to be improved. Many improved versions of DV-Hop algorithm have been proposed in the literature, some of them are discussed here.

An improved DV-Hop algorithm is proposed for WSNs by Dengyi et al. [18]. In this, localization accuracy is improved by two methods throughout the whole process. Firstly, normal node refines the average distance per hop by taking the mean of anchor node's hop size. Secondly, the anchor nodes also refine the average distance per hop with the angle information between normal and anchor node. Calculating angles between normal and anchor nodes make this algorithm more complicated and energy inefficient.

Chen et al. [17] proposed an improved DV-Hop algorithm based on Particle Swarm Optimization (PSO). There are mainly four steps to describe the algorithm. In step 1, few anchors are deployed on the boundary of the sensing field. In step 2, anchors refine the average distance per hop of themselves and broadcast this throughout the whole network. In step 3, distance is calculated by normal nodes and position is estimated using 2-D hyperbolic location algorithm [16].

Finally in step 4, PSO is used to enhance the accuracy of the algorithm. However, anchor nodes placement at the boundary of the sensing field is not a feasible for inaccessible terrain area.

Bo Peng et al. [15] proposed genetic algorithm (GA) based DV-Hop algorithm. The whole algorithm has six steps to perform in which starting three steps are same as for traditional DV-Hop algorithm and last three steps are for the process of genetic algorithm. Though GADV-Hop algorithm improves the localization accuracy up to an extent but by using genetic algorithm, there are some control parameters (crossover, selection and mutation) to be tuned correctly for getting better results.

From the above review, it can be concluded that localization is the optimization problem and its overall estimation error needs to be minimized. This encourages us to propose an Improved DV-Hop algorithm based on Teaching Learning Based Optimization (TLBO). The full process of TLBO is given in [10, 11].

III. PROPOSED ALGORITHM

It is well known that DV-Hop algorithm is based on Distance Vector (DV) routing. The distance between the nodes is estimated by the hop count value multiplied by the hop size of the anchor. But there is a large amount of error between the calculated and actual value when there are two or more hop counts between anchor node and normal node. The deviation created by anchors is not considered in the typical DV-Hop algorithm. The improved algorithm implements the revised hop size in the network to calculate the distance between the normal node and anchor node and uses the teaching learning based optimization (TLBO) to estimate the correct location of the nodes.

In the proposed algorithm, starting two steps are same as described in DV-Hop algorithm of section 2. In step 3, calculated distance is modified. Consider D_{ij} is the distance between two anchors i and j, calculated according to equation (2), as follows:

$$D_{ij} = HopSize_i \times hop_{ij} \quad \text{, where } i \neq j \qquad (9)$$

The actual distance between two anchor nodes can be calculated by their coordinates, as follows:

$$D'_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \text{, where } i \neq j \qquad (10)$$

where (x_i, y_i) and (x_j, y_j) are the coordinates of anchors i and j respectively. Now from equation (9) and (10), difference between the estimated distance and actual distance; d_{ij}^e (distance error) can be calculated by the following relationship.

$$d_{ij}^e = |D_{ij} - D'_{ij}| \qquad (11)$$

Now this distance error value is used to modify the average distance per hop value of ANs by adding the

correction factor ψ to the previous hop size value of the particular anchor. This correction factor is used to refine the average distance per hop deviation of the anchor node. ψ_i is the correction factor of an anchor i and can be calculated using formula (12).

$$\psi_i = \frac{\sum_{i \neq j} d_{ij}^g}{\sum_{i \neq j} hop_{ij}} \quad (12)$$

Finally the particular distance between normal node and anchor node can be determined by adding the correction factor into the average hop size of the anchor and multiplied by the hop counts between normal node and that particular anchor node as shown in the formula (13), which is the modification of formula (2).

$$d'_{ij} = (HopSize_i + \psi_i) \times hop_{ij} \quad \text{, where } i \neq j \quad (13)$$

Still the modified distance value calculated from (13) is not so much accurate because it is a calculated value, there may be error. For that reason, a very efficient optimization technique viz. TLBO is used to improve the localization accuracy in WSN. Therefore, the localization problem can be expressed in terms of objective function as:

$$f(x_u, y_u) = Min \left(\sum_{\substack{i=1,2...k \\ u=k+1...n}} \left| \sqrt{(x_u - x_i)^2 + (y_u - y_i)^2} - d_{iu} \right| \right)$$

$$(14)$$

where (x_i, y_i) is the coordinates of anchor nodes, $i=1,2...k$. (x_u, y_u) is the estimated coordinates of unknown nodes, $u=k+1, k+2....n$ and d_{iu} is the distance between anchor nodes and normal nodes, calculated according to formula (13). There are total N sensor nodes in the network i.e. $N = k + n$.

Although TLBO is free from the algorithm parameters unlike other optimization techniques yet creation of initial population is necessary for the further process.

IV. SIMULATION PARAMETER AND RESULTS

In this section, the simulation of proposed algorithm viz. IDV-Hop using TLBO in MATLAB 7.10 is presented to evaluate the performance in terms of localization errors with different parameters and also make comparisons with some other existing algorithms viz. DV-Hop [13], GADV-Hop [15] and DV-Hop based on PSO [17] under the same scenario.

In the simulations, 100 sensor nodes (anchor nodes (k) and unknown nodes (n)) are distributed randomly in two-dimensional fixed square area of 100×100 m^2 as shown in Figure 2, where anchor nodes and unknown nodes are represented by red pentacles and black dots respectively. Communication radius of each node is set to be $25m$. Simulation parameters are shown in Table I.

In TLBO, there is no need to set any algorithm parameters since it is free from these parameters. Therefore, the convergence rate of TLBO is higher than other optimization algorithms [19], as it is achieved the best solution in 15.02 seconds. Convergence curve for the proposed algorithm is shown in Figure 3.
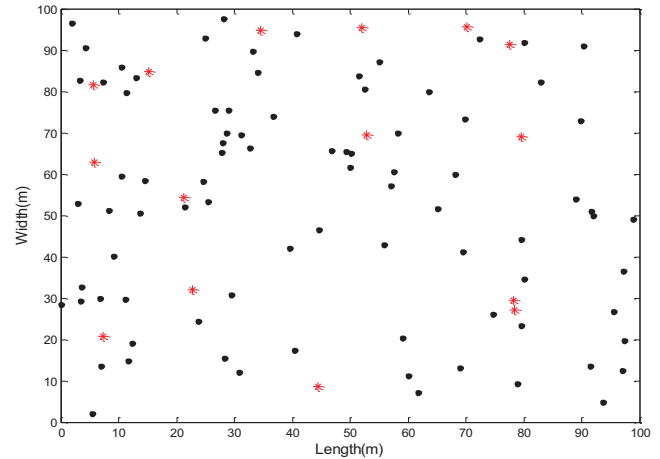
Figure 2. Nodes Distribution
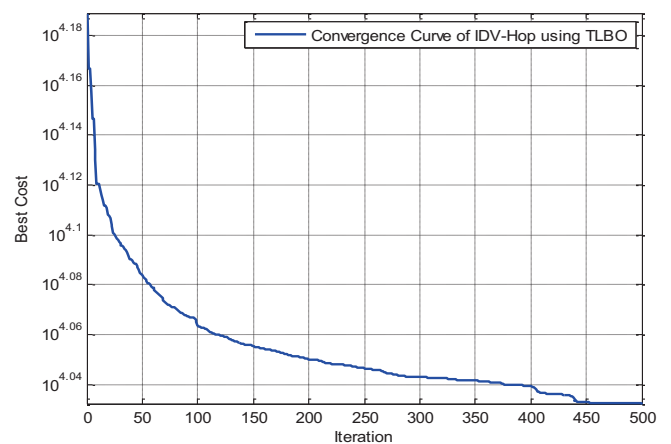
Figure 3. Convergence Curve of proposed algorithm for single simulation run

TABLE I.
SIMULATION PARAMETERS

Parameters	Values
Total number of nodes	100
Area	100×100 m^2
Communication Range	25 m
Number of anchor nodes	15%
Initial Population	50
Maximum Iterations	500

It needs to set the optimum value of initial population because there are not any specified rules or formulas to set it. As there is a trade-off between small and large population size because it is considered that small population size leads the algorithm to poor solutions and large population size makes the algorithm to expend more computation time to find the optimum solution [32]. When there is no information regarding a possible solution, then it could expect, that the more diverse the initial population is, the greater the possibility to find an optimum solution is. So, initial population is taken as 50 after 30 simulation runs to find the optimum value of it by considering above factors. From Figure 3, it can be seen that best solution is achieved in around 450 iterations; therefore, 500 iterations are taken throughout the whole experiments. As Figure 3 shows the convergence curve of the proposed algorithm for single simulation run at any instant.
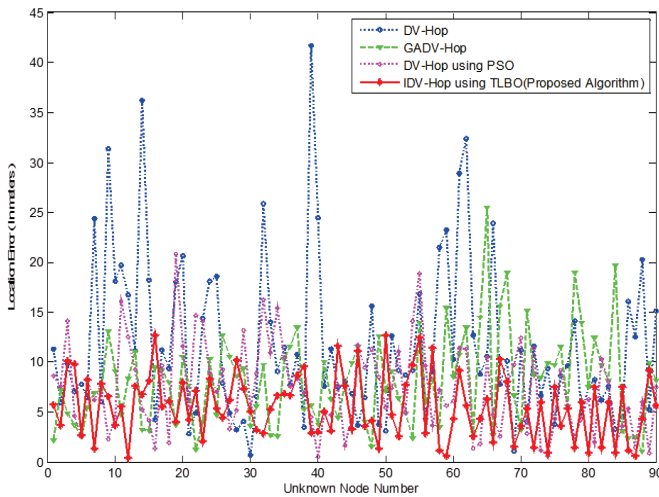
Figure 4. Localization error of each unknown node of single simulation run at any instant (R=25 m, Anchor Node Ratio=10%)

To compare the performance of proposed algorithm with other existing algorithms, the localization error is calculated of each normal node; mathematically it can be expressed by the following formula:

$$Localization\ Error = \sqrt{(x_u - x_a)^2 + (y_u - y_a)^2} \quad (15)$$

where (x_u, y_u) is the estimated coordinate and (x_a, y_a) is the actual coordinate of the unknown node.

The estimated localization error shows the measure of accuracy of the algorithm. Accuracy is better when the estimation error is smaller. Figure 4 shows the location error of each unknown node of four algorithms at communication radius of 25*m* and when anchor node ratio is 10 % in the network. As shown in Figure 4, proposed algorithm is more stable comparatively and has lower localization error than other three variants of DV-Hop algorithms.

To compare the performance of proposed algorithm with existing techniques, the mean error is calculated of each algorithm with different parameters under the same scenario. Mean error can be determined as the ratio of total localization error to the number of unknown nodes (n) and can be expressed as follows:

$$Mean\ Error = \frac{\sum_{a,u=1}^{n} \sqrt{(x_u - x_a)^2 + (y_u - y_a)^2}}{n} \quad (16)$$

Figure 5 shows the estimated localization mean error of these algorithms with a different number of anchor nodes deployed. It can be seen from the results that proposed algorithm performs better than existing three algorithms of [13], [15] and [17]. It is observed from the Figure 5 that when the number of anchor nodes increases, mean localization error of four algorithms decreases.

This is due to the reasons that minimum hop count value between the unknown nodes and anchor nodes decreases with increasing the number of anchor nodes. Also, for accurate hop size of an anchor, more accurate distance between normal node and anchor node is obtained and hence localization error decreases.

The result data of each algorithm is taken as the average of 200 independent simulation experiments.

Figure 6 shows the mean localization error with different communication ranges of the sensor nodes. The communication radius of the sensor nodes is tuned from 15 to 45 *m* and ratio of anchor nodes is taken 15% in the network of 100 sensor nodes. It is observed from the Figure 6 that after the communication range of 25 *m*, the mean localization error increases gradually of all the algorithms. It is due to the reasons that with the increase of communication range, average hop size of anchor nodes also increases and estimated distance between unknown nodes and anchor nodes also increases, thus affecting the localization accuracy of all algorithms.
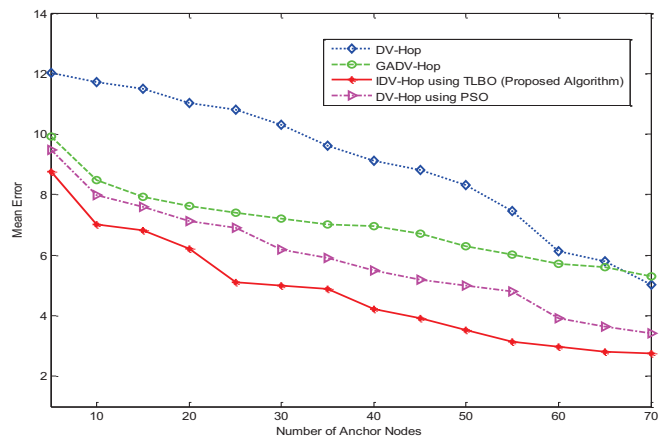
Figure 5. Mean localization error with a different number of anchor nodes.
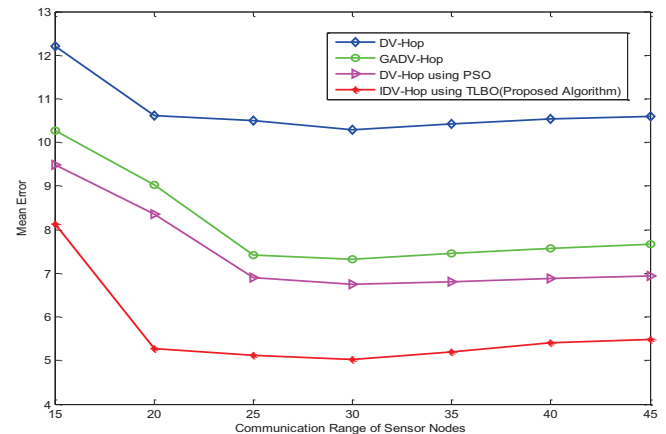
Figure 6. Mean Localization error with the change of communication range of sensor nodes

It can be seen from the simulation results of Figures 4, 5, and 6, the proposed algorithm viz. IDV-Hop using TLBO outperforms than some existing three algorithms of [13], [15] and [17]. The localization error of the proposed algorithm is smaller than these three algorithms with different parameters (variation of anchor nodes, communication radius, and node density) under the same scenario.

V. Conclusions

Localization is a crucial issue in WSNs, because various applications depend on the accurate localization of the

nodes. To minimize the localization errors of the range-free algorithms, IDV-Hop using TLBO technique for WSNs is proposed. In proposed scheme, average hop size of an anchor is modified using correction factor and the distance between the unknown nodes and anchors is calculated based on modified hop size. This calculated distance is closer to the actual distance. Since localization is an optimization problem, which needs to be minimized the localization errors in WSN. To achieve this, an efficient optimization technique viz. TLBO is implemented in this paper, which is free from the algorithms parameters. The proposed algorithm bounds the feasible region of initially generated population. With the help of bounded population feasible region, IDV-Hop using TLBO locates the unknown nodes more accurately and achieves higher convergence rate relatively. Simulation results show that the proposed algorithm has better accuracy as compared to DV-Hop, GADV-Hop, and DV-Hop using PSO algorithms.

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Fault Tolerant Design using 5-Modular Redundancy Configuration with Different Voter Circuits

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Abstract: In the current situation, the reliability of a complex digital system is indigent owing to large amount of components, transistors, Integrated Circuits (ICs), etc. As a result the claim to design a good system with reliability is crucial. Such systems are frequently used in very critical applications such as bank transactions, defense communications, aerospace applications, etc. If these systems fail in the field, then the loss will be massive. The circuit designers carry on research to enhance the reliability of a system by adding redundancy like in hardware, software, information and time. The hardware redundancy is proposed to improve the reliability of the system. At present the Triple Modular Redundancy (TMR) is the most common technique used in the field of microelectronics to improve the reliability. This TMR system can tolerate one error for the correct output of the system. This paper primarily focuses on the 5MR scheme for the betterment of reliability which can tolerate two errors. The TMR in the 5MR system is implemented using FPGA Altera board with various voter circuits and ASIC implementation is carried out using ISCAS'85 and ISCAS'89 benchmark circuits. This paper analyze the 5MR system in detail using different majority computation circuits with TMR portion and convey the optimum circuit which will be suitable for low power, less area overhead and lesser delay.

Index Terms: Fault-tolerant, Majority voters, NMR, TMR, VLSI

I. INTRODUCTION

In the recent microelectronic circuit design scenario, the significance of reliability is to be addressed carefully, otherwise the system may fail due to the reduced supply voltages, higher operating frequencies, lower internal capacitances, and low noise margins. A self checking fault tolerant circuit was designed to improve the reliability in a nanoscale FPGA [1]. A self checking circuit for different voter circuits is designed for error detection. This investigates about the reduction of power, area and delay. Here five inputs are taken for the voter circuits and results are compared with respect to its performance [2]. Many researchers investigated the reliability improvement by considering the voter circuits. A high reliable low cost fault tolerant circuit was designed to gain the reliability in an efficient manner rather than conventional TMR system.

Moreover most of the TMR systems focused on the redundancy methodology [3].

To design a system to withstand more than one error, the N-modular redundancy (NMR) approach can be deployed in real time. Here N is any odd number which can withstand the error upto (N-1)/2 errors. For example, the 5MR system can tolerate two errors; the 7MR system can tolerate three errors and so on [4–6]. The noticeable shortcoming with this NMR system is area and power consumption overhead. This study focuses mainly on the hardware redundant logic techniques using 5MR approach with tolerance of two errors.

II. MATERIALS AND METHODS

The reliability of the system can be improved by implementing 5MR rather than TMR system at the rate of area and power consumption.

A. The existing 5-MR configuration

The 5MR system is shown in Figure 1. The inputs A, B, C, D and E are applied to the circuit and the output (V) is obtained as calculating the majority among the inputs [4]. This system works as follows:
i) If D = 0 and E = 0, results in the majority output (V) as "ABC".
ii) If D ≠ E, then the voter output becomes as the majority among the inputs A, B, and C. That is the voter output make use of the TMR configuration along with the inputs A, B, and C.
iii) If D = 1 and E = 1, the majority output (V) becomes as "A+B+C".This is apparent with reference to the given Fig. 1.
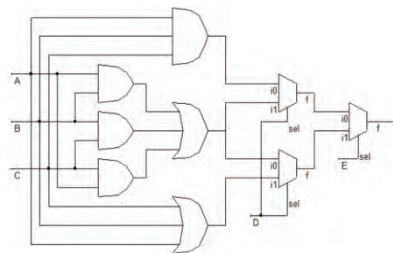
Figure 1. The 5MR system

The TMR subsystem which is available in the 5MR system can be built using different voters [7]. This is the motivation to construct different 5MR systems with various kind of voters and the simulation results with performance comparison are obtained with few industry standard benchmark circuits. The TMR subsystem used here is shown in Fig.2. Here, the TMR output is obtained as "AB+BC+CA" as a carry output of a full adder [8–9]. This subsystem can tolerate only one error.
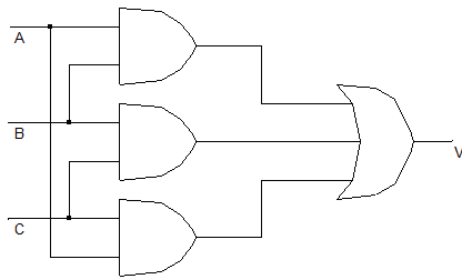
Figure 2. Conventional voter with TMR

B. A 5-MR system using different voters

The voting section, that belongs to TMR is involved in the 5MR is replaced with many voters for performance comparison. Some voters may contain less layout area at the cost of power; few others may dissipate low power consumption at the cost of area. This kind of analysis would help the engineers to choose the optimum design for the system with better power and area metrics.

C. Voter using NAND and NOR gates

In a CMOS VLSI design approach, the NAND and NOR gates play a most vital role due to the unique behavior as universal gates. They may dissipate less power and contains low layout area. The Fig. 3 contains the voter using NAND and NOR gates [8].
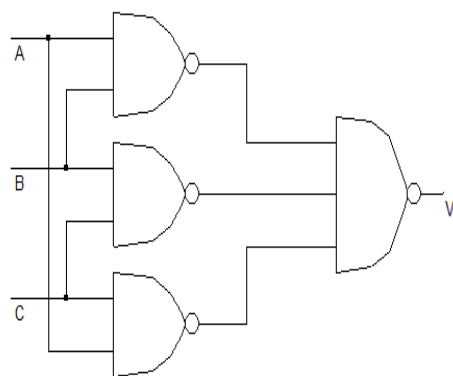
Figure 3(a) Voter circuits using NAND gates
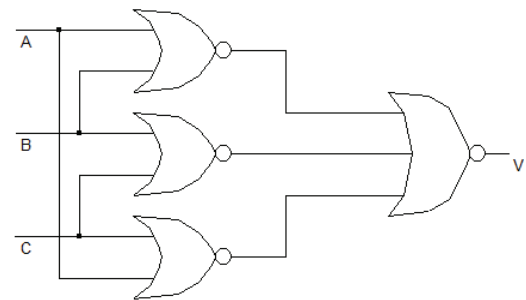
Figure 3(b). Voter circuits using NOR gates

D. Modified voter using carry look-ahead adder principle

The majority function can also being implemented as $\{(A \oplus B)C\} + \{AB\}$ using the concept of CLA (Carry Look-ahead Adder) circuit [8]. This circuit works as follows:

i) If A = B = 1, then the majority output becomes 1.

ii) If A ≠ B, then the majority output follows the third input C.

The modified function $\{(A+B)C\} + \{AB\}$ also produce the majority among the three inputs. These circuits are shown in Fig. 4.

(a)

(b)
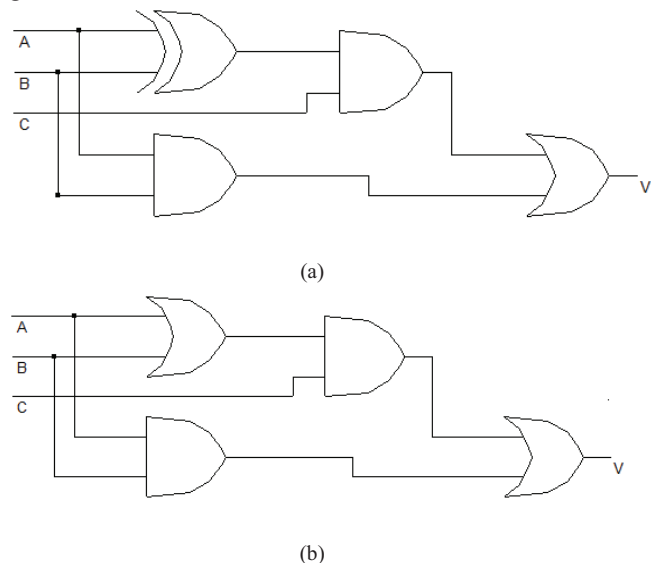
Figure 4. Voter circuits using CLA concept

E. Modified voter usingMux1 approach

The voter output here is calculated using a 2-to-1 multiplexer in which the input A act as a select signal; the inputs B and C are applied as data inputs to the multiplexer. This circuit is shown in Fig. 5 and works as follows:

i) If A = 0, the majority function obtained as "BC".

ii) If A = 1, then the output V will be "B+C".
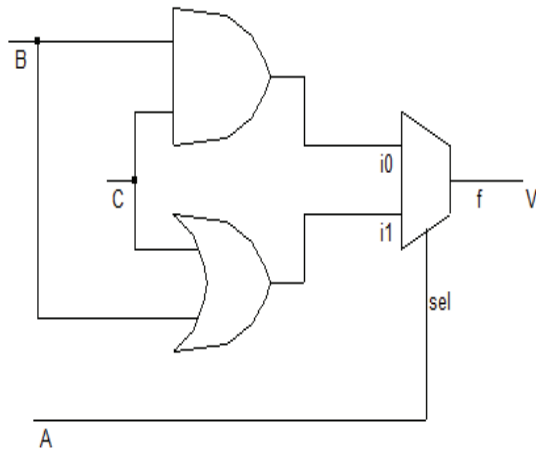
Figure 5. Voter circuit using Mux1 approach

F. Voter using Mux2 approach

The voter output is obtained using one 2-to-1 multiplexer and one XOR gate. This principle looks similar to the CLA subsystem discussed earlier but with modification in the schematic. The $\{B \oplus C\}$ signal act as a select signal to the multiplexer; the A and B inputs can act as data inputs to the multiplexer. This circuit is shown in Fig. 6 and works as follows:

i) If $\{B \oplus C\} = 0$, the majority function becomes as B.

ii) If $\{B \oplus C\} = 1$, then the voter output becomes as A.
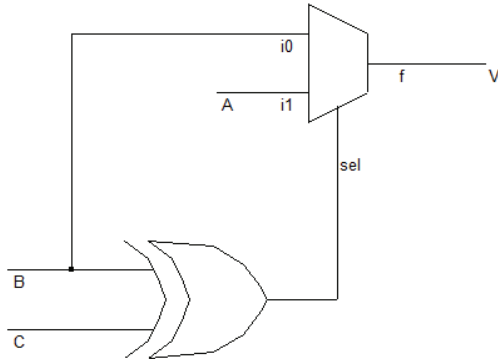
Figure 6. Voter circuit using Mux2 approach

G. The complete 5-MR system

The Fig. 7 shows the complete 5MR system in which the TMR portion is replaced with Mux2 approach. In this study, this TMR portion is replaced with the all above said various voter circuits to obtain the majority functions among the five inputs A, B, C, D, and E.
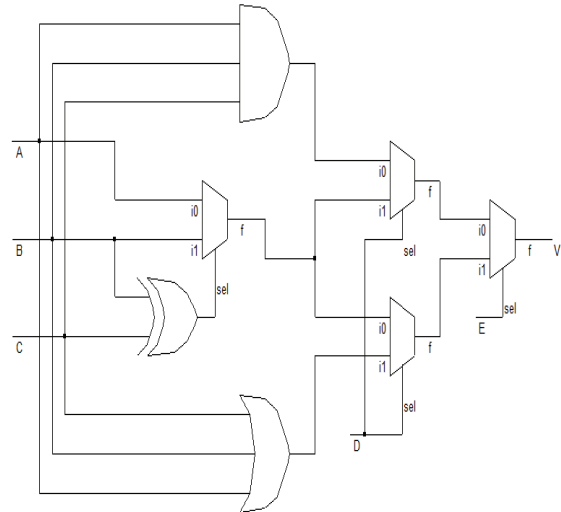
Figure 7. 5MR system using Mux2 approach as TMR

III. RESULTS AND DISCUSSION

The performance comparison of 5MR systems using difference voter circuits is done with few test circuits. The FPGA implementation was carried out with Quartus II 13.1 synthesis tool with Altera FPGA device EP4CE115F29C7.74X-series circuits like 4-bit magnitude comparator, 4-bit carry look-ahead generator and 4-bit adder are used as benchmark circuits. Table.I to Table.V depicted about this simulation. The Electronic Computer Aided Design (ECAD) tools like DSCH and Microwind are also used to test 5MR systems with ISCAS'85 combinational circuit (C17) and ISCAS'89 sequential circuit (S27) [12] with 120nm technology for ASIC implementation and Table.VI and VII showed this simulation. The Figure-Of-Merit (FOM) is computed as the inverse of the product of power, delay, and area (PDA) [4]. For a better design this FOM must be high.Tables I, II, III, IV, and V show the results of 5MR system with the test circuits like 8-bit Ripple Carry Adder (RCA), 4-bit RCA (74283), 8-bit magnitude comparator, 4-bit magnitude comparator (74L85) and a 4-bit carry look-ahead generator (74182) respectively. From the TableI, the Mux1 approach occupies only 94 Logic Elements (LEs), lower delay is obtained with NOR gates method as 17.710 ns, the Mux2 approach dissipates lower power dissipation as 133.91mW. It is apparent by referring other tables that the Mux1 and the Mux2 approaches are optimum as compared with the other style methods.

TABLE I.
SIMULATION RESULTS OF AN 8-BIT RCA USING 5MR WITH VARIOUS VOTERS

Metrics	Voter using different Majority function computations							
	K-map	Existing	NAND	NOR	$(a \oplus b)c+ab$	$(a+b)c+ab$	Mux1	Mux2
LEs	123	115	97	95	115	115	**94**	97
Delay (ns)	21.811	18.537	17.694	**17.710**	25.381	25.381	30.111	17.643
Power (mW)	139.38	133.92	140.42	140.42	154.61	154.61	137.54	**133.91**

TABLE II.
SIMULATION RESULTS OF A 4-BIT RCA USING 5MR WITH VARIOUS VOTERS

Metrics	Voter using different Majority function computations							
	K-map	Existing	NAND	NOR	$(a \oplus b)c+ab$	$(a+b)c+ab$	Mux1	Mux2
LEs	38	63	42	42	41	41	**34**	**34**
Delay (ns)	8.143	8.535	8.377	8.377	8.415	8.415	**8.044**	**8.044**
Power (mW)	132.27	139.96	139.94	139.09	142.98	144.35	**131.31**	**131.30**

TABLE III.
SIMULATION RESULTS OF AN 8-BIT COMPARATOR USING 5MR WITH VARIOUS VOTERS

Metrics	Voter using different Majority function computations							
	K-map	Existing	NAND	NOR	$(a \oplus b)c+ab$	$(a+b)c+ab$	Mux1	Mux2
LEs	109	113	115	111	108	109	**107**	**107**
Delay (ns)	22.395	**15.807**	17.309	18.338	16.893	18.972	20.711	17.862
Power (mW)	168.74	159.79	138.37	137.05	131.74	161.07	142.53	**129.97**

TABLE IV.
SIMULATION RESULTS OF A 4-BIT COMPARATOR USING 5MR WITH VARIOUS VOTERS

Metrics	Voter using different Majority function computations							
	K-map	Existing	NAND	NOR	$(a \oplus b)c+ab$	$(a+b)c+ab$	Mux1	Mux2
LEs	60	61	67	61	61	61	**53**	69
Delay (ns)	8.749	8.1	8.823	8.763	8.621	8.621	8.351	**8.044**
Power (mW)	133.04	133.27	130.09	134.66	134.77	134.60	137.95	**130.01**

TABLE V.
RESULTS OF A 4-BIT CARRY LOOK AHEAD GENERATOR USING 5MR WITH VARIOUS VOTERS

Metrics	Voter using different Majority function computations							
	K-map	Existing	NAND	NOR	(a $\oplus$ b)c+ab	(a+b)c+ab	Mux1	Mux2
LEs	39	41	42	42	41	41	**34**	**34**
Delay (ns)	7.905	8.469	12.013	12.013	**7.717**	**7.717**	8.125	8.125
Power (mW)	143.46	142.71	140.81	140.95	131.55	**130.66**	131.58	131.58

TABLE VI.
SIMULATION RESULTS OF A C17 CIRCUIT USING 5MR WITH VARIOUS VOTERS

Metrics	Voter using different majority function computations					
	NAND	NOR	(a $\oplus$ b)c+ab	(a+b)c+ab	Mux1	Mux2
Delay (ns)	0.870	0.870	0.930	1.170	0.870	0.870
Power (mW)	0.361	0.361	0.136	0.27	0.132	0.065
Area (μm^2)	1674.2	1674.2	3611.1	1300.8	4120.3	2004.9
FOM $\times 10^4$	19.0	19.0	21.89	24.07	21.13	**88.17**

TABLE VII.
SIMULATION RESULTS OF AN S27 CIRCUIT USING 5MR WITH VARIOUS VOTERS

Metrics	Voter using different majority function computations					
	NAND	NOR	(a $\oplus$ b)c+ab	(a+b)c+ab	Mux1	Mux2
Delay (ns)	1.740	1.755	1.920	3.5	1.740	1.740
Power (mW)	0.379	0.379	1.673	1.761	1.688	0.16
Area (μm^2)	2375	2352.2	2364.4	2180.3	2468.2	2468.2
FOM $\times 10^4$	6.37	6.39	1.31	0.74	1.37	**14.55**

Simulation results with ISCAS'85 (C17) and ISCAS'89 (S27) benchmark circuits are obtained as in tables VI and VII respectively. One combinational circuit (C17) and one sequential circuit (S27) are taken as test benchmark circuits to compare the performance of different voters with 5mr system. The FOM and PDA are inversely proportional to each other, and the PDA is calculated as Figure-of-Merit (FOM). Since the optimum designs look for lower delay, less area, and low power consumption, the product term (PDA) will be a low value and hence the higher FOM. It is apparent that from tables, Mux2 approach produces better FOM as compared with the other methods.

IV. CONCLUSIONS

This study analyses the 5MR system in detail using different majority computation circuits in combination with TMR circuit and produced the optimum circuit which will be suitable for low power, less area overhead and lower delay. This kind of study helps engineers a lot in the current microelectronics trend of to choose the optimum circuits for the critical applications with more reliability. This work can be further extended to 7MR, 9MR and 11 MR circuits too with appropriate circuit intelligence.

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Design of Inexact Speculative Adder for High Performance Applications

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Abstract: **The low power and less area are equally vital in the implementation of high speed adders. The response time as the key point is also considered and focused for the optimization and considered for real-time interfaces. The general block schematic of the ISA consists of a carry speculation (SPEC) block, an addition block (ADD) and an error compensation (COMP) block. The Inexact Speculative Adder (ISA) design therefore, improves speed, reduces power consumption, propagation delay and accuracy management due to a short speculative path and to an error compensation technique. This technique allows to precisely controlling errors. The simulation and synthesis is carried out using CADENCE tools in 90nm CMOS technology. The power consumption and area occupied by the design is presented.**

Index Terms: **Compensator, Adder, Carry propagation, Speculator, ISA, CMOS Technology, delay, short speculative path and compensates erroneous sum.**

I. INTRODUCTION

The optimized adders are mostly required for many digital processing applications [2]. In many computers and other kinds of processors adders are used in the ALU. These adders are the most commonly used blocks in multipliers, dividers and subtracters. Addition is one of the fundamental arithmetic operations. Adders decide the efficiency of the digital system. The optimized adder always gives accurate work
. The CLA adders basically operate by generating two signals (Propagate and generate signals) for each and every position of the binary digit. The basic principle of operation is based on whether the carry bit is propagated from an LSB or absent in the binary digit position. In many situations the propagate binary digit is sum output of half adder circuit and generate binary digit is the carry output of the half adder. The carry for each and every bit position are invoked after the propagate bit and generate bits are created. By combining multiple CLA adders, even larger adders can be created.

Applications are aimed on providing sensing and actuating operation where the primary component is the response time which needs optimization for real time application. Hence the design of this High speed adder which is very important mainly when it comes to speed play. The inexact speculative adder designed using CLA adder. The ISA adder circuit design is a new approach with improved speed, power and area in the deep sub micron, scaled technology version. This approach is applicable for error- tolerant applications to get statistical results.

In this paper, the idea of Inexact Speculative Adder with highly optimized hardware efficiency and precision techniques of compensation using error correction or results. The area, power and propagation delay are important measuring factors of the adder. The powerful and highly optimized adders are required for the implementation of present multipliers and other digital systems.

There are various kinds of adders. The binary adders are half adder, full adder, ripple- carry adder, carry- save adder, carry-look ahead adder etc. Among these adders, ripple-carry adder, carry-save adder, Carry skip adder [3], Carry Look Ahead (CLA) adder supports multiple bits.

The block based addition may be designed using carry skip and carry select adders also. But, in these adders area is the penalty. In an adder circuit which focuses on carry save, it is more beneficial not to propagate the carry bit, in case the adder circuit needs to compute the sum of the numbers which contains three bits or more bits. Hence this adder provides a reduction in the number of bits. A better solution to this problem is to employ three bit adders at the input, which generates sum and carry as the output without waiting for the subsequent carry bit propagation. The sum and carry bits can be applied to the two inputs of the three bit carry save adder. Once the adding of the bits is complete for all the stages we may use CLA adder to super impose the final result of sum and carry bits.

To reduce the computation time and area, CLA adders were designed, implemented and are used for ISA in this

error reduction technique is presented. A greater control over accuracy can be obtained and improved by the Inexact Speculative adder which employs a specific topology.

II. SYSTEM OVERVIEW

In this section, the overview of the ISA is presented. The Inexact and approximate circuit design [1] is a better approach for enhancing the performance and saving in energy in low power VLSI design systems. The conventional topology of speculative adders improves performance and enables precise accuracy control.

As wireless devices become ubiquitous, the primary concern of digital systems is power efficiency. Grievously, obtaining low-power and Process-Voltage-Temperature robustness needs elaborate and contradictory design restrictions and reliability. Particularly, IC's are make-up to incessantly guarantee meticulous operation. In order to circumvent error results, they accomplish the majority of calculations earlier than the worst case acceptable delay or with a greater precision essential for typical operations. This culminate failing to make the best utilization of resources and leads to "over-engineered circuits.

- Inexact and approximate circuit design is a very good approach to transfer this counterproductive quest for process of improving substantial rate in power and speed. The preliminary objection is to determine where and how to forbid an error or an approximation take place in the circuits without conciliate the functionality. With increscent quantity of data being processed, a broad range of applications could tolerate in erroneousness. Consider an example, in multimedia processing inadequate percentage of faults is not appreciable to humanoids, and in highly precision data processing algorithms such as data mining, recognition.

A new approach to design inexact circuits is to use speculation in order to improve power and speed such circuits can be used to implement energy efficient and high-performance DSPs and hardware accelerators. It also lowers integration cost along with higher speed or duty cycling.

A new speculative adder is proposed in this paper called ISA. This ISA gives advantages of energy efficient, error management and improves performance through an optimized speculative path. It also comprises the versatile dual-direction error compensation technique.

Speculative adders use the truth that a normal carry propagation adder will not reach the entire length of the adder, thereby making it more convenient to have an estimation of the in-between carry bit using a fixed number of antecedent stages. In this way the carry propagate chain can be divided into two or more short distance paths in the path of the adder there by providing more relaxation in the entire design process and reducing the undesirable glitching power and improving the Energy-Delay-Area Product beyond the normal bounds of the traditional adders.
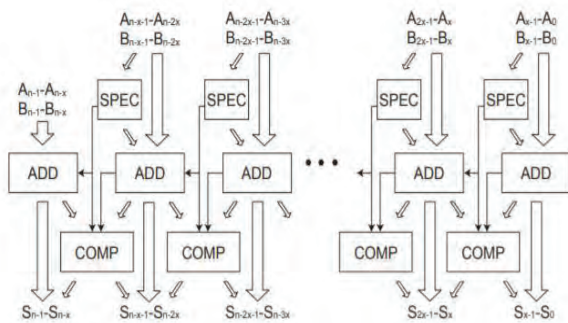
Figure 1. General block diagram of the Inexact Speculative Adder

Many speculative adders have been suggested in literature in order to lower error frequency or magnitude .The ETE2 adder consists of sub-adder blocks along with input carries speculated from carry-look-ahead blocks with same length. To increase accuracy many of the most significant carry-look-ahead adder blocks are chained in the ETA2M version. To lower the relative errors the ETA2B adder adds variable speculation signs and sub adder sum balancing multiplexer (MUX) blocks. N. Zhu et al. and Y. Kim et al. have proposed adders with improved accuracy by taking it into account two prior

speculation blocks instead of one along with carry select or carry skip technique.

The existing speculative adders can be improved, in which the circuit hardware is not utilized efficiently. The overhead due to carry speculation is large and entirely lies in the critical path. The sum balancing blocks consist of parallel multiplexers also contribute to the critical path, have large fan-outs. This ISA architecture that I have proposed greatly improves hardware efficiency to lower the control errors.

III. PROPOSED VLSI ARCHITECTURE OF ISA

In this section, the block diagram of proposed VLSI architecture for ISA and modified internal blocks are discussed. The block diagram of n bit ISA is shown in the figure 2.
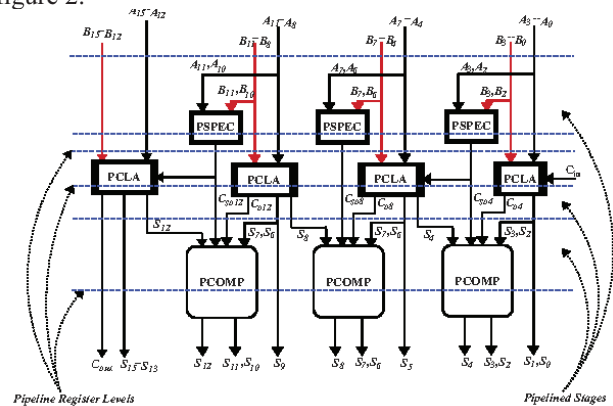
Figure 2. 4-bit VLSI architecture of ISA

The proposed architecture comprises of pipelining SPEC, pipelining CLA and pipelining COMP blocks. From the n number of inputs, 4 inputs are applied to each PCLA and PSPEC blocks simultaneously [6]. Here, the PCLA is used to enhance the speed of the operation. The analysis of an individual blocks are presented in the further sub sections.

A. Speculator and Adder Block:

The inputs for the addition, the operands are represented as A = $\{A0, A1, ...An-1\}$ and B = $\{B0, B1, ...Bn-1\}$ and carry input as Cin; whereas, the carry and sum outputs are represented as S = $\{S0, S1, ...Sn-1\}$, and $Cout$ respectively. The figure 5 shows the implementation diagram of modified speculator, which is in the proposed architecture. The CLA adder is used internally to implement this speculate carry output of each of the four input blocks [7]. The speculation process carried out for r number of MSB bits of each and every block. The size of the r is selected as les than to the input block size x=4. Subsequently, each speculator block carry input is 0 or 1, which creates +ve and –ve errors respectively. Each speculator block carry out (Cso) is applied as input carry for the succeeding adder blocks as shown in the figure 1. Then, each four bit block never waits for the input carry of the preceding 4-bit adder block. Here, all the adder blocks are parallel or simultaneously perform the addition process on relieving input carry bits from the concerned speculator blocks

[10]. The SPEC block produces a speculated internal carry from very short number of input bits. The ADD block computes a local sum from the carry speculated in the SPEC block. If the carry propagation spans the entire SPEC block, it cannot predict exactly the carry and a wrong guess could lead to a speculative error. The COMP block detects those incorrect speculations and compensates erroneous sum. Speculator block computes carry based on the equation shown below:

$$P_i = A_i \oplus B_i \qquad (1)$$

$$G_i = A_i B_i \qquad (2)$$

$$C_{i+1} = G_i + (P_i . C_i) \qquad (3)$$

The P_i, G_i and C_i are necessary to compute the C_{i+1}^{th} bit. The C_{i+1}^{th} bit is located in the critical path of Inexact Speculative Adder and the delay produces very small as we need to calculate the carry bit only for small numbers of bits. Whereas the adder block performs the sum of inputs from 4 bit blocks at the input. CLA adder is based on the equation given below.

$$S_i = P_i \oplus C_i \qquad (4)$$

The above work uses CLA in the suggested hardware since the amount of signal delay in the propagation process is less when compared to traditional methods. As the adder operation is done by making use of the speculated carry bits at the inputs, the sum which is calculated in parallel from each of the blocks of the adder does not resemble the expected output. The sum value correction and balancing is carried out by the compensator block. Adder and compensator blocks are the ones which consume maximum delay along the critical path of the architecture.

B. Compensator Block

The compensator circuit in the ISA adder circuit differentiates the carry output from each of the four binary digits hardware adder circuit with speculated carry bit using EX-OR gate. An error flag is produced from the EX-OR gate output which initiates any one of the compensation techniques: error correction and error reduction to get activated. If the output of EX-OR gate is LOW (logic 0) then the local sum is passed directly to the last output. In the same style, if the EX-OR gate output is '1', that means the error may be positive or negative. The positive error represents a speculation of '0' instead of '1'. Hence, it induces lower sum value too. Albeit a negative error indicates a speculation of '1' instead of '0' which induces higher sum too. Based on the direction of potential error (very high error is solved by a '-1' and very low error is solved by a '+1') an unsigned increment or decrement for the group of LSBs is carried out by compensator block. If the result gets overflowed this correction cannot be possible. Then, the compensator block balances the group of MSB bits of the preceding sub adder block in the reverse direction of the error. The following equation is used for the balancing process;

$$2^n > \{ 2^n + 2^{n-1} + 2^{n-2} + \ldots .. + 2^0 \} \qquad (5)$$

Whenever a 2^n error is found in the sum bit then it could be redressed by producing LSB errors for the sum bit in the direction opposite. The error reduction of unity can be achieved by balancing all the LSB's in the reverse direction as given by:

$$\{ 2^n - 2^{n-1} - 2^{n-2} - \ldots .. - 2^0 \} = 1 \qquad (6)$$

Generally, the p numbers of bits are used for the correction and hence p numbers of LSBs for each 4 input adder block are passed to the compensation block. Then that block checks the overflow condition. The correct compensation technique which provides balancing will be selected. This process is carried out before getting the sum of all other bits from the adder block. For the optimum result, the p value is usually selected as unity. Neither the pre-computing of error correction nor the compensation choice lies in the critical path of the ISA adder is the significant feature of the proposed architecture. The EX-OR gate, MUX and De-MUX of compensator block are only involved in the critical path of the ISA.

The pipelining process of proposed architecture is explained using 16 bit ISA. Here the n=16 can be increased, and which will not affect the critical path because of x is always 4 only. Due to these 4-bits as constant, the adder, compensator and speculators are not changed. In the proposed 32-bit ISA architecture, all the conventional blocks are replaced with pipelining blocks, such as PSPEC, 4-bit PCLA and PCOMP blocks. The individual blocks are internally consists of 2 stage pipelining. The entire architecture is designed using pipelining blocks and corresponding levels of registers, which retains the critical path delay.

The schematics and test-benches of sub blocks have been presented in further sub sections. From the observation of those sub blocks, the critical path is expressed in (7) and it can be used to determine the maximum clock frequency of proposed ISA.

$$\delta_{crt\text{-}prop} = \delta_{clk\text{-}Q(ff)} + \delta_{xor} + 3\ \delta_{and} + \delta_s \qquad (7)$$

Where, $\delta_{clk\text{-}Q(ff)}$ is clock to Q delay and $\delta_{clk\text{-}Q(ff)}$ setup time flip-flops respectivelly. Then the maximum clock frequency can be evaluated by ISA is given as,

$$F_{max} \leq 1/\{\delta_{crt\text{-}prop} - \delta_{skew}\} \qquad (8)$$

Where, δ_{skew} represents the clock skew which may occur in such scenario.

C. Power and Area Analysis

In the VLSI system design, pipelining is the activity of diminishing the critical path at the trade off but increasing the cost of area and the hardware. The hardware is increased due to the insertion of the registers for the pipelining process. Because of the deep pipeline

process the numbers of registers are more for the proposed structure than the conventional ISA. The proposed ISA structure [9] in to several stages by pipelining it is segregated. So, this architecture is more compatible for the clock gating which is used to reduce the power consumption in the VLSI structures. In the proposed design, the clock signal that is fed into every stage is gated.

The active blocks and ideal blocks are differentiated in this architecture and hence clock switching which significantly reduces the power consumption. The clock gating process is only valid for the beginning and ending of the overall process. For the addition, at the very starts the later pipeline stages are ideal stages. These stages can be pipelined. At the ending process of addition, starting or earlier stages are clock gated.

For example: pipeline stages five, four, three and two are ideal while the process is being carried out in the first stage when the addition begins. Similarly, first stage will be ideal while rest keeps processing data when addition is towards the completion. However, the clock gating cannot be applied for the middle of the addition process, because all the blocks are busy by involving in the computation of the addition process.

IV. RESULTS

In this section, the implementation of 32- bit ISA and the corresponding internal blocks are presented and analyzed. The figure 3 represents the schematic of 32-bit ISA adder created using Virtuoso Schematic editor. The simulation of adder using proper testing inputs is carried out in the CADENCE tools.

The ADEL (Analog Design Environment) Editor is used to simulate the ISA adder schematic for the test bench shown in figure 4 and corresponding simulation results shown in figure 11 and figure 12.
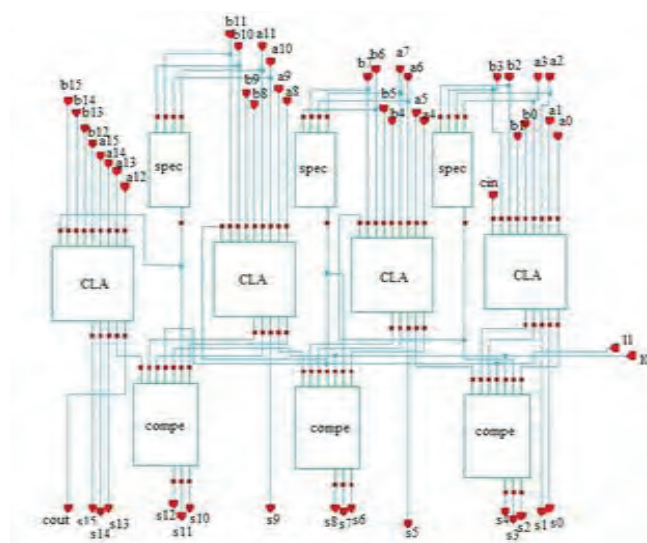
Figure 3. Schematic of 32- bit ISA in schematic editor
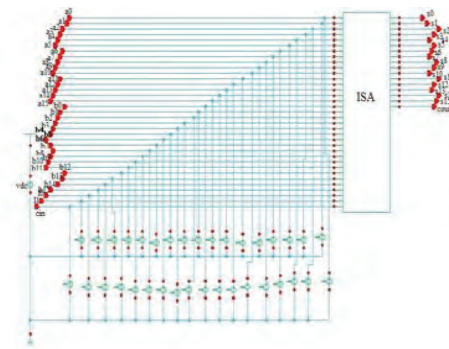
Figure. 4. Test bench of 32-bit ISA

The figure 5 represents the schematic of Speculator block which is used in the ISA. It consists of five AND gates and three OR gates. The schematic of Speculator block is implemented in the Virtuoso schematic editor and test bench for Speculator shown in figure 6.
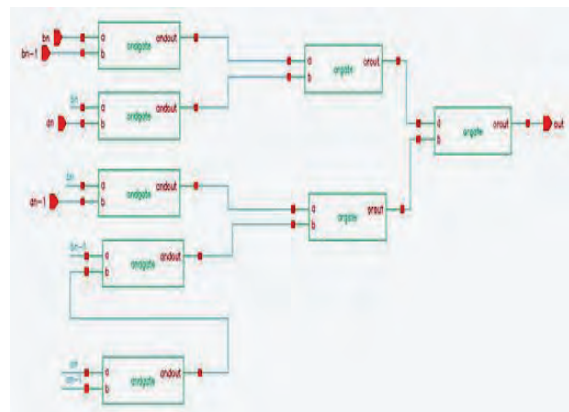
Figure 5. Schematic of speculator of ISA
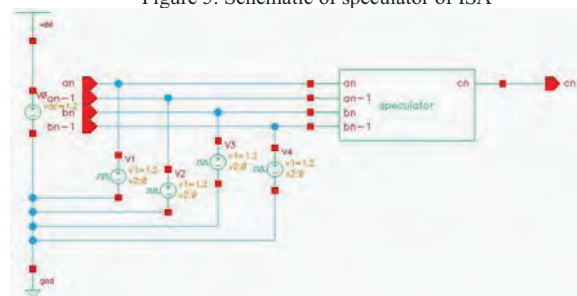
Figure 6. Test bench of speculator of ISA

The figure 7 represents the compensator block which is used in ISA adder. The compensator block designed with 9 AND gates, 3 OR gates, 3 NOT gates and 2 XOR gates. This block is implemented in Virtuoso Schematic Editor and simulated in ADEL using the Test bench shown in figure 8.
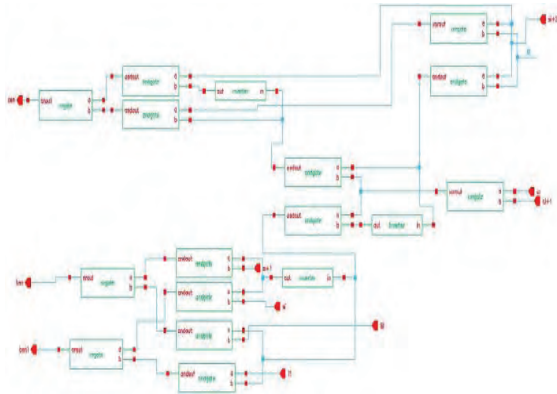
Figure 7. Schematic of Compensator of ISA

The power consumption and delay of the 32-bit ISA adder are shown in the table.1. The entire power for the 32-bit ISA is 36.94µW and the delay for the 32-bit ISA is estimated as 78.38ps.
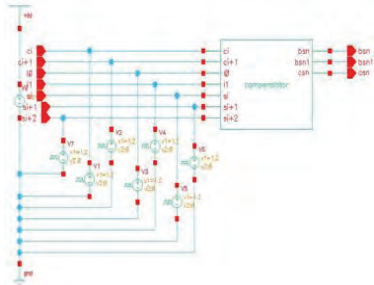
Figure 8. Test bench of Compensator.

The figure 9 represents the CLA circuit which is used in ISA adder design. The carry look adder designed with 23 AND gates, 10 OR gates and 8 XOR gates. This design is implemented in Virtuoso Schematic Editor. This block is simulated in ADEL using the Test bench shown in figure 10.
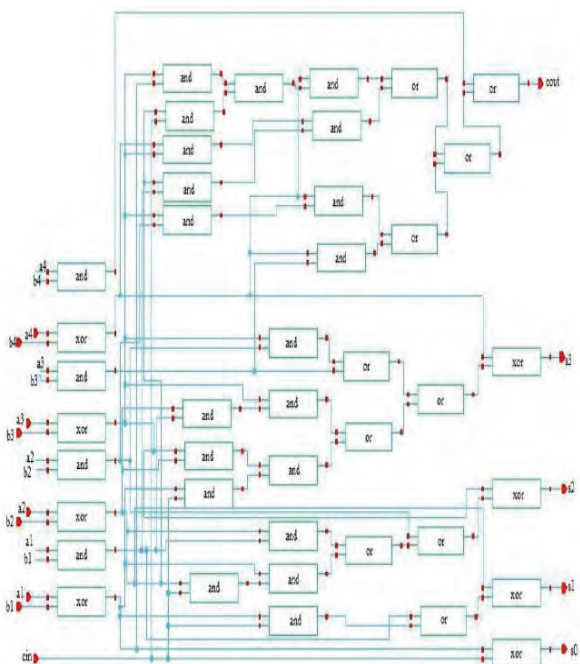
Figure 9. Schematic of Carry-look-ahead adder
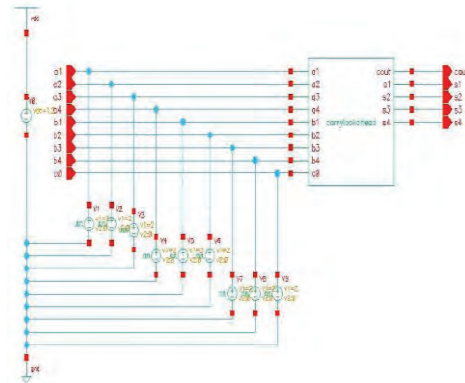
Figure 10. Test Bench of Carry-look-ahead adder

TABLE I.
POWER AND DELAY OF PROPOSED ISA

Parameter	Value
Power	36.94µW
Delay	78.38ps

The figure 11 and figure 12 represents the simulated output wave forms of the two different test inputs for the 32-bit ISA adder.
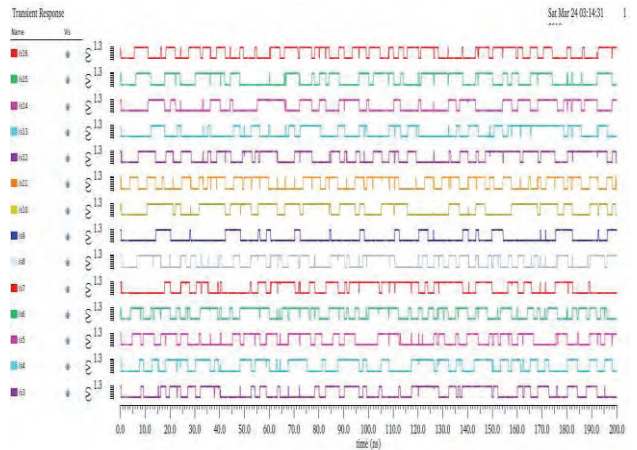
Figure 11. Simulated output waveforms of 32-bit ISA
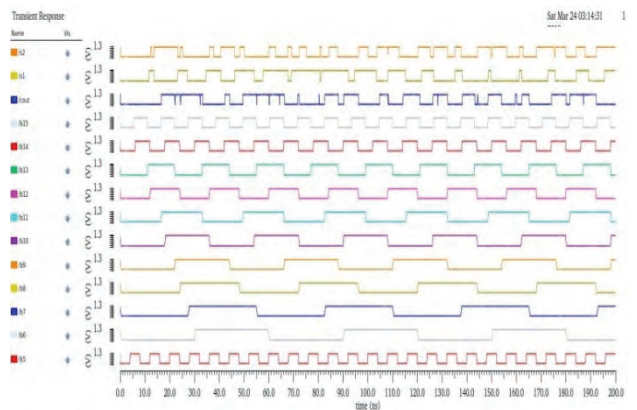
Figure 12. Simulated output waveforms of 32-bit ISA

The power and delay values of 32 bit ISA adder are compared with the existing different types of 32 bit adders [5]. The delay and power are much improved. The comparison of various adders with ISA power and delay values are shown in the table II. The power is saving up to 43% and delay reduced to 40%.

TABLE II.
COMPARISON OF VARIOUS ADDERS WITH ISA

TYPE OF ADDERS	POWER	DELAY
ISA	36.94μW	78.38ps
Parallel Adder using 10T full adder	110μW	4.24ns
Carry look ahead adder	84.90μW	3.1ns

IV. CONCLUSIONS

A conventional architecture of Inexact Speculative Adder (ISA) with hopped-up performance and a versatile precision is presented. In this architecture a novel error correction and error reduction method is used. This process enhances the overall worst case accuracy. The overhead speculative hardware is removed from the critical path of the structure. The ISA architecture allows precise tuning of multiple error characteristics and enhances the interpretation to a large extent the design of inexact speculative adder produced lesser delay compared to the parallel adders designed. It has been proved that ISA, due its low delay contributes a higher speed of operation.

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ASIC Implementation of Various Sorting Techniques for Image Processing Applications

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Abstract: **The direct implementation of parallel algorithms in hardware is possible with the help of current VLSI technology. The process of arranging the items systematically is known as Sorting. Different meanings of sorting are: ordering: items arrangement in a sequence ordered by using some criterion; categorizing: similar property items grouping. The latest VLSI model analyses the complexity of time. The novel model makes a distinction between "processing" circuits and "memory" circuits; the latter are less important since they are denser and consume less power. This paper addresses the design and analysis of various sorting algorithms, and its VLSI implementation based on a sorting network. The various sorting algorithms are Sinking sort, Merge sort and Library sort; all the three sorting algorithms are compared in terms of area, power and timing with a complete comparison table. Mainly these types of sorting algorithms are used in a real time system; signal processing, image and video processing applications. All the blocks were designed using Verilog HDL, simulated using ncvlog simulator, synthesized in cadence-RTL Compiler and finally implemented in ASIC Encounter using GPDK 45nm technology libraries.**

Index Terms: **Sinking sort, Merge sort, Library sort, RTL compiler and ASIC encounter.**

I. INTRODUCTION

In order to obtain high throughput [1] rate, current computers perform several operations simultaneously. Here both the I/O operations and the multiprocessors several computing operations are done concurrently. Such design has to connect various parts of system together (ALU, memory and processor) with a high speed data transferring units. Generally cross-bar switching is used for this, but for large number of inputs (m X n matrix) requires large hardware and power. This paper describes the fast ordering networks. As the new generation computing systems are having high performance, the basic elements like Algorithm-structured chips are helpful for better performance.

- While fabricating the VLSI circuit, the cost effective factors like silicon area places an important rule.
- The circuit area always depends on the logic size and also the architecture modularity;
- The main parameter which effects the network is the circuit speed;
- When talking about different types of sorting algorithms [3], the other parameters like area of the chip and sorting time are also need to be considered.

- Here various sorting techniques are discussed and compare them in various aspects like time, area, power and complexity;

The major contribution of this paper is to describe the basic approach of VLSI sorting device. The main aim is to reduce the complexity in all aspects.

II. SORTING TECHNIQUES

A. Introduction

In ASICs, there are more traditional approaches to perform sorting to achieve high throughput and low latency. Sorting networks became more popular and impressive due to the following reasons. First one is pairs are not required for branch type instructions i.e. loop instructions. The other one is due to the concept of instruction level parallelism. Mainly, these types of networks are performed when their data size or bus width size is less. Mostly in Intel or Pentium processors, these types of networks generally use Vector primitives which have been studied from distributive computing[10].The circuit is mainly designed using horizontal intersection or inter connective wires and vertical elements. i.e. comparators. Knuth notation is mainly used and focused to design each element in the comparator[3].The unsorted elements are applied at the left, one element per wire as shown in Figure 1. It describes various sorting techniques separately by its pictorial representation. The extreme right side of the design represents sorted output. Compare and swap stages of the network are connected through intermediate wires. m-bit number of sorted elements of data are transferred through the intermediate wires. The two element sort is performed to the compared elements in which the smaller values left on the right side and the larger values left on the lower side.
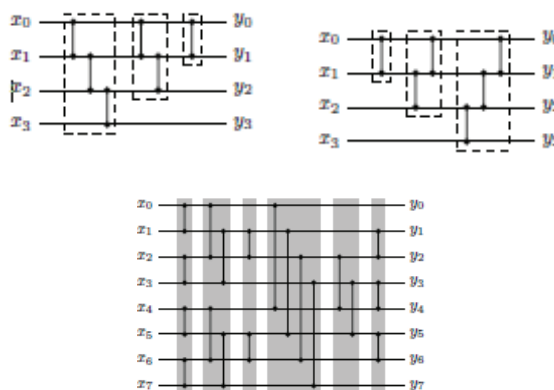
Figure 1. Sinking Sort, Library Sort and Merge Sort

B. Time Complexity

By comparing various sorting algorithms, the choosing of prescribed sorting algorithms or network for a dedicated application makes the network simpler. The throughput of a sorting network is analyzed mainly due to the timing factor of the algorithm. The Robustness of a network reflects the relative throughput and it is usually given in the form of notation Big-D. Here, D represents the network Robustness and p represents the size of the pair of the network. Table I represents and gives a basic idea about the robustness of multiple sorting networks.

TABLE I
COMPLEXITIES OF VARIOUS SORTING ALGORITHMS

Types of sorts	Time Complexity		
	Average	Best	Worst
Sinking Sort	$D(p^2)$	$D(p^2)$	$D(p^2)$
Selection Sort	$D(p^2)$	$D(p^2)$	$D(p^2)$
Library Sort	$D(p^2)$	$D(p)$	$D(p^2)$
Merge Sort	$D(p \log(p))$	$D(p \log(p))$	$D(p \log(p))$

C. Sinking Sort

It is a simple sorting algorithm. The other name of sinking sort is **Bubble sort.** This is also referred to as Comparison sort as it compares smaller and larger elements in the list. In this type of sorting, it continuously goes through the sorting list, where each pair of the adjacent list is compared. If they are in the correct order, it would not change the list and if the order is wrong, the items will be swapped. The same process is repeated until the items are in the same order. i.e. until further swapping is not required. The advantage of this type of sorting technique is very simple and the drawback is slow and practically not useful for most of the problems compared to insertion sort. Practical implementation of bubble sort is possible when the input is generally in sorted order but may usually have some out-of-order elements nearly in position. [5]

Algorithm

```
Procedure sinking sort (S: sortable elements list)
p=length (S)

repeat
        swapped = false
        for k=1 to p-1 inclusive do
                if  S[k-1]> S[k] then
                        swap (S[k-1], S[k] )
                        swapped =true
                end if
        end for
        until not swapped
end procedure
```

Among all the sorting algorithms, sinking sorting is the simplest one in understanding and implementation point of view. But even compared to the Library sort, it is inefficient

as the efficiency decreases adequately due the complexity of $D(p^2)$

D. Library Sort

The other name of Library sort is Insertion sort. Always iteration is done on one input element, and growing a sorted output list. In this type of sorting, one element is removed from the input data at each iteration and after finding the location of the current element it places the element in that respective position within the given sorted list[6]. This process is repeated until there are no such elements to sort. The current value is always compared with the largest value in the sorted list. The position always depends on whether the element is smaller or larger. If the elements value is small, it searches for its correct position and places it in the particular place within the sorted list. Otherwise it ignores that element and moves to the next element [6].

Algorithm

Based on the insertion sort algorithm only, the proposed sorting is done. In this algorithm, always it searches for the correct position of elements and it inserts all the input elements in the correct order. The pseudo-code representation of this algorithm is as follows:

Algorithm

```
Function Insert Sort
        for each unsorted C{
        k=0;
                while (k<p) and (C>M[k]) ) {
                        M[k]=M[k+1];
                        k=k+1;
                }
        [k-1]=C;}
end function;
```

The vector M whose length is infinite is considered and the input data is entered into this vector. But generally it is not possible. So that the option deletion have to be used [8]. Every time, the smallest value in that list is eliminated, meanwhile [9], the data which is going to be deleted should be indicated by the outer input signal.

E. Merge Sort

A Merge sort follows divide and conquer algorithm conceptually and the working procedure of it is as follows:
1. The unsorted list is divided into p sub lists and each sub list containing one element (only one element list is taken and sorted).
2. Every time it combines sub lists so that new sorted list is generated until there is only one sub list left in the given list [7].

Algorithm

It divides input array in two halves, calls itself for the two halves and then merges the two sorted halves. The merge function is used for merging two halves. The merge (arr, 1, a, q) is key process that assumes that arr [1..a] and

arr [N+1..q] are sorted and merges the two sorted sub-arrays into one. [7, 8]

Merge sort(arr [],1,q)
If q>1
Find the middle point to divide the array into two halves:
    Middle a= (1+q)/2.
Call merge sort for first half:
    Call merge sort (arr, 1 ,a).
Call merge sort for second half
    Call merge sort (arr,a+1,q)
Merge two halves sorted in step 2 and step 3
    Call merge (arr,1,a,q)
Merge Sort is a recursive algorithm and time complexity can be expressed as following recurrence relation.
$T(p) = 2T(p/2) + D(p)$.
The above recurrence can be solved either using Recurrence Tree method or Master method. It falls in case II of Master Method and solution of the recurrence is $D(p \log p)$. [9]
Time complexity of Merge Sort is $D(p \log p)$ in all 3 cases (worst, average and best) as merge sort always divides the array in two halves and take linear time to merge two halves.

III. IMPLEMENTATION AND RESULT ANALYSIS

A. Sinking Sort
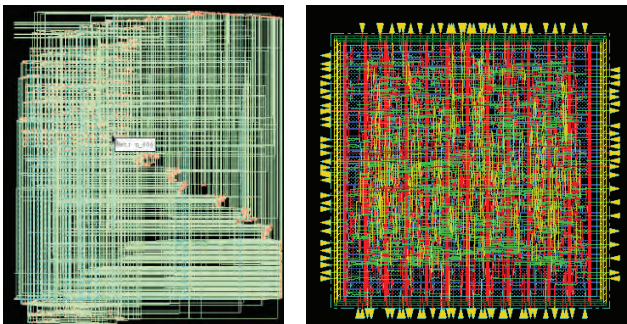
Figure 2 (a), (b). RTL Schematic and ASIC Implementation of Sinking Sort

B. Library Sort
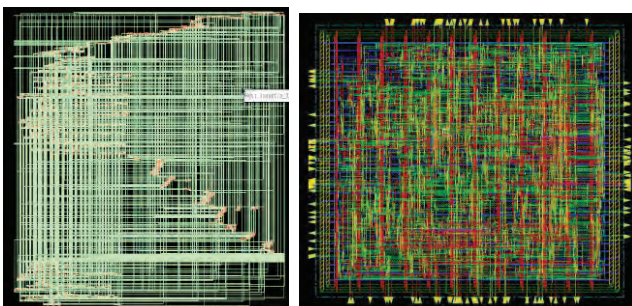
Figure 3 (a), (b). RTL Schematic and ASIC Implementation of Library Sort
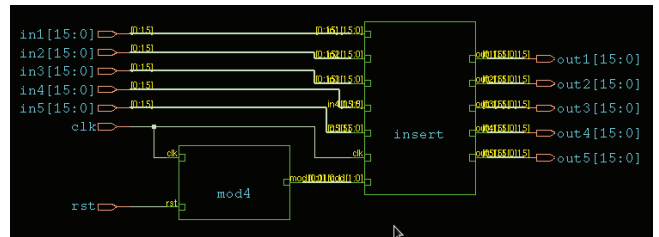
Figure 4. Top Level Design of Library Sort

C. Merge Sort
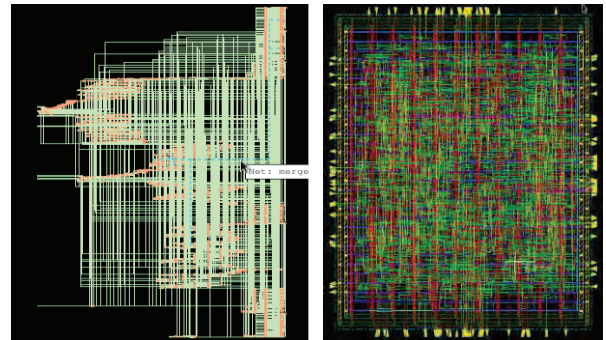
Figure 5 (a), (b). RTL Schematic and ASIC Implementation of Merge Sort
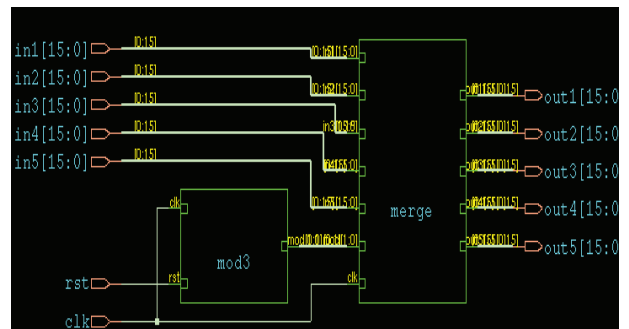
Figure 6. Top Level Design of Merge Sort

Section III mainly deals with the Implementation and Result Analysis of various sorting techniques. The HDL language used and tools used are mentioned below.
HDL Language Used: Verilog HDL
Simulation Tool: Ncvlog Simulator
Synthesis Tool: RTL Compiler
Physical Design Tool: ASIC Encounter
Figure 2(a), (b) represents the RTL Schematic and ASIC Implementation of Bubble Sort. It is very flexible to design on an IC due to its sorting network. Figure 3(a),(b) describes the implementation of Library sort based on its sorting technique. Internally Library sort consists Mod-4 counter to count the number of moves or paths of the respective node in the network which is shown in the figure 4. Figure 5 (a), (b) gives implementation results of Merge Sort. Merge sort internally consists of Mod-3 counter to count the number of elements replaced or eliminated from the sorting newtork respectively as shown in the figure 6. All the sorting networks are taken in the form of m * n matrix only to have equal distribution in the network. Timing of the network is calculated interms of nanoseconds and power is calculated

interms of nanowatts and area is explained and derived interms of cells which are occupied on an IC. The Table II gives the comparative analysis of various sorting techniques i.e., Sinking Sort, Library Sort and Merge Sort in the respective aspects such as Area, Timing and Power. Power analysis is furthur calculated interms of Internal Power, Switching Power and leakage power. Compared to all the above mentioned Sorting Techniques [9] Merge Sort will be more efficient in all the aspects and it is most preferred. Arrangement or ordering of elements in the network will be performed very fastly compared to Sinking sort, Selection Sort and Library Sort.

IV. COMPARISON BETWEEN SORTING TECHNIQUES

A. Area, Speed and Complexity

- To compare different VLSI algorithms and architectures for sorting, it is of great interest to take a look at the lower bounds of area or speed, in the sense that, cannot solve a given VLSI problem using less than a lower bound of silicon area, or less than in a given amount of time. Because of the trade-off between area and speed, it is also important to consider lower bounds of the product ST, or of ST^2.
- Computational Complexity [10](worst, average and best behavior) in terms of the size of the list (p). For typical serial sorting algorithms, good behavior is D(p log p), with parallel sort in D($\log^2$p), and bad behavior is D(p^2). Ideal behavior for a serial sort is D(p), but this is not possible in the average case. Optimal parallel sorting is D(log p). Comparison _based_ sorting algorithm need at least Ω(p log p) comparisons for more inputs.

B. Comparison Table

TABLE II.

COMPARISON OF SINKING SORT, LIBRARY SORT AND MERGE SORT IN TERMS OF SETUP TIME, HOLD TIME, AREA AND POWER FROM THE ANALYSIS OF ASIC IMPLEMENTATION.

Parameters		Bubble Sort	Insertion Sort	Merge Sort
Timing Analysis	Slack (ns)	7923	7464	5184
Total Area	Top Module	1254 Cells, 2678.89 area	937 Cells, 1951.79 area	1000 Cells, 2302.69 area
Total Power	Internal Power	50.8644%	49.4750%	57.1171%
	Switching Power	49.1194%	50.4689%	42.8407%
	Leakage Power	0.0463%	0.0561%	0.0422%

V. CONCLUSIONS

This paper gives the importance of SoCs /ASICs to accelerate ordering. It presents the various ways to fabricate sorting networks on ASICs and briefly explains the on-die resource utilization. For synchronous fally-pipelined

implementation, the flip-flop and LUT utilization of a circuit shows more impact and complexity on the hardware. In the aspect of multi core systems, ASIC shows how the data can be accessed internally at each coprocessor stage. This paper also gives various types of data processing operations where ASICs have multiple advantages i.e. parallelism-pipelining and low latency. Many ways are discussed in which ASICs /SoCs can be embed into a large system so that the performance can be increased rapidly. This type of approach leads to high performance on ASICs in terms of efficiency and latency. Moreover, the main agenda is to achieve high performance of the network. It is challenging to maintain this performance, once the hardware implementation of the algorithm is integrated into a full system. Next to raw performance, these experiments also show that ASIC brings additional advantage in terms of power consumption. Because of these things, ASIC plays an important role in heterogeneous - core architectures. The work reported in this paper is to incorporate the capabilities of ASICs into data processing engines in an efficient manner.

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Bus Identification Device for Blind People using Arduino

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Abstract: **Generally, journey in bus is a safe and comfort factor, but due to increase in number of buses and passengers it's going to be tougher now-a-days and it will be even more difficult for blind people to travel in bus. This paper presents a low cost and easy to build and use system for blind people to identify which bus is approaching the bus stop. The main purpose is to provide a bus detection system for blind people by assigning different tags to different buses with the help of Radio Frequency Identification (RFID) technology. In the experiment set-up, Arduino, RFID reader and tags, bluetooth module for voice announcement and Mobile phone with Serial Monitor App which gives voice commands are used. Whenever the bus comes to the stop, the RFID reader will be reading the tag (which is given to every bus for particular route) depending upon the tag it will give voice intimation so that blind people can know the bus number and related information about bus.**

Index Terms: **Bus identification device, Blind people, RFID, Bus, Bus station, Voice message.**

I. INTRODUCTION

Today, one of the most worldwide occupation is helping and supporting visually impaired person. In most physical environments, the visually impaired have difficulty in accessing information about transport, stops, terminals, vehicles, schedules, maps and directories which prevent them from using public transport effectively. Hence, there is a need to make their lives more comfortable by introducing a system that helps them enjoy transportation services independently and freely like ordinary people, without relying on others. [5] This paper focuses on a bus identification system using Radio Frequency Identification (RFID) technology. The RFID system uses tags, through which information embedded on the tags are read by RFID readers. The proposed system eliminates the need for help on whom the blind people relies for guidance to board the required bus to reach destination. [6] The problems that surfaced during the project were selecting the right kind of device and interfacing these devices appropriately. The approach used was to minimize costs and complexity.

Over the years, there have been comparable research endeavors to create implanted gadgets to mitigate issues. The Talking Signs distinguishing proof framework [6] comprises of infrared (IR) transmitters fused in the target boards of transports that transmit route data. This method is difficult because, an IR beam is exceptionally directional, the person must point the receiver towards the transmitter on the bus. Exact bus location is unknown for the blind person.

Broadcasting bus- is a GPS based framework reporting the bus number upon arrival at the bus stop. These smart bus stops are not satisfactory when outfitted just with the voice detailing framework since voice data is hard to interpret when numerous buses simultaneously arrive at the similar terminal. [3]

II. PROPOSED METHOD

This system is designed to provide information for blind assisting with voice command signals utilizes RFID technology for task of identification. [2] In this system, a RFID reader is installed in every bus near driver which is integrated with Arduino Uno with bluetooth module. Voice assistance equipment like loud speaker is installed in every bus stop. Also, a mobile phone is used with an application- Serial Monitor, which will give voice commands. The block diagram is shown in following figure 1.
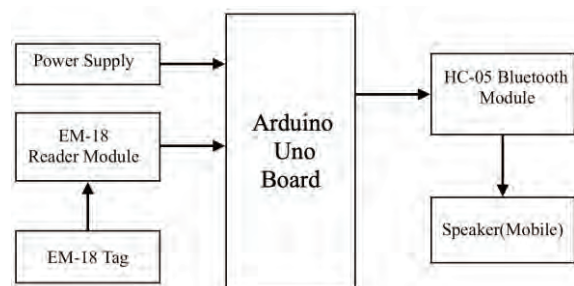
Figure 1. Block Diagram of Bus Identification Device for blind people using Arduino

The key steps of this implementation are

• Placing the RFID tag in front of RFID reader.

- RFID reader provides a signal to Arduino Uno about the detection of RFID tag which contains information about the bus.

- Then, Arduino Uno sends signal to Bluetooth module which is connected to mobile(here) with bluetooth.

- The application will produce a voice message.

A. Methodology and Working

The bus drivers are equipped with a unique RFID tag. When a bus approaches a bus stop, the driver will be place the RFID tag given to that person, near the RFID reader. RFID reader receives the information of the bus through a unique identification code. [8] This reader also detects RFID tag which consists of information related to the bus like bus number and places. The RFID reader acts as a transmitter and transmits to Arduino, [1] the identification code of the bus and with the program dumped in Arduino with the unique identification code the Arduino will be send signals to the bluetooth module.

Now, Bluetooth module acts as receiver and receives the signals from Arduino. [1] The voice-based play back system is already fed the information and is transmitted out through speaker.

B. Hardware Resources

The main hardware resources in this implementation are Arduino Board, Bluetooth module, RFID reader and tags.

i) ARDUINO UNO

The Arduino is a group of smaller scale controller sheets to disentangle hardware plan, testing and prototyping for craftsmen, programmers, and numerous experts. It can be used it as brain for robots, to assemble new advanced music instruments, or to manufacture a framework that lets home plants tweet once they're dry. Arduinos (Arduino Uno is utilized) are worked around an ATMEGA microcontroller- basically a total PC with all the components on a solitary chip. Unlike, say, a Raspberry Pi, it's designed to attach all kinds of sensors, LEDs, small motors and speakers, servos, etc. directly to these pins, which can read in or output digital or analog voltages between 0 and 5 volts. Figure 2 demonstrates the Arduino Uno board. Using USB, the Arduino board is associated with the PC. The program is written in a basic language like C, C++, or Java on Arduino IDE by transferring accumulated code to the board. [1] The Arduino can keep run with the USB connected back to the computer, or remain solitary without it. No console or screen required, simply power when the code is modified.

The Arduino Uno can be powered via the USB connection or with an external power supply. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

Figure 2. Arduino Uno Board

ii) BLUETOOTH DEVICE

HC-05 module is used as a Bluetooth Serial Port Protocol-SPP module. It is designed for transparent remote serial connection setup. It can be utilized as master or slave arrangement. The features of this module-

- Bluetooth V2.0+EDR.
- 3 Mbps Modulation with complete 2.4 GHz
- CSR Blue center 04-External single chip Bluetooth framework with CMOS innovation and with AFH- Adaptive Frequency Hopping feature.

By default, the module is used as slave. The role of the module (Master or slave) can be designed just by AT directions. The HC-05 is a cool module which can include full duplex remote usefulness. It can be used between two Arduinos to communicate with each other.
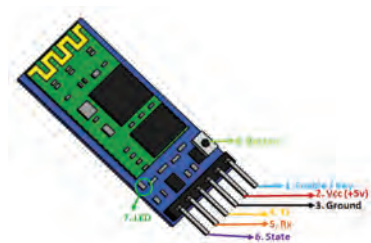
Figure 3. Bluetooth module-HC 05

HC-05 operated in modes- i) Data mode, ii) AT command mode. In data mode, data is transmitted and received from one Bluetooth device to another. In second mode, the default device settings are changed. By using pin number 1 (i.e. Enable/Key), it can be operated in any one the two modes.

This module operated using SPP protocol, it is easy to pair with microcontrollers. Connect the Rx pin (pin number 5) to the Tx pin of microcontroller, Tx pin (pin number 4) to the Rx pin of microcontroller and power the module with 5 volts.

iii) RFID READER AND TAGS EM-18

RFID is used to characterize the system by sending a unique serial number of an object wirelessly using RF waves.

RFID empowers distinguishing proof from a separation and dissimilar to prior standardized tag innovation, it does so without requiring a viewable pathway. RFID labels bolster a bigger arrangement of one of the kind IDs than standardized identifications and can fuse extra information, for example, maker, [4] item type and even measure natural factors, for example, temperature.

EM18 module emanates out 125KHz through the curls. At the point when a 125KHz RFID latent tag is purchased to the field module will get empowered from the field. By the adjustment in balance current through the loops, the label will send the data back to the program memory exhibit.
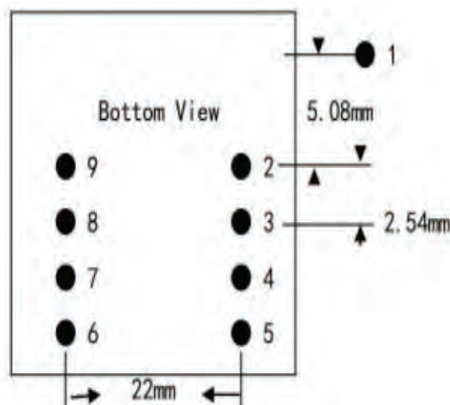
Figure 4. EM-18 Reader Module

Data is stored in any one of two types of memory. One is ROM- read only memory another one is RAM-random access memory. In ROM, once the data is placed, it cannot be modified whereas in RAM, data can be changed. RAM is also called Read/Write Memory.

Connections among the above hardware resources is shown in figure 5.
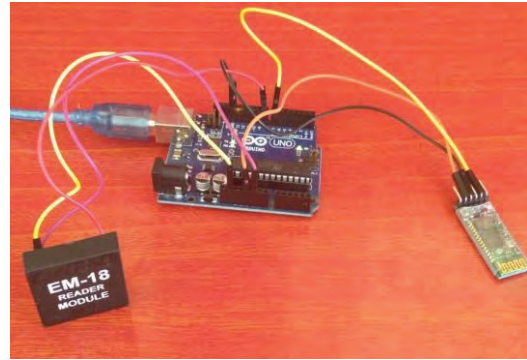
Figure 5. Arduino Board connections to Bluetooth and RFID reader

C. Arduino Software

The IDE of Arduino makes it simple to compose code and transfer it to the different boards. It works on Windows, Mac OS X, and Linux. Java is used in the environment and dependent on processing and another open-source programming. This product can be utilized with any Arduino board. Arduino is an open-source prototyping stage dependent on simple to utilize equipment and programming. [1] Arduino can peruse inputs- light on sensor, a finger on a catch, or a message- and transform it into a yield- initiating an engine, turning on a LED, distributing something on the web and some more. To do as such utilize the Arduino programming language (in the view of wiring), and the Arduino software (IDE), based on processing.
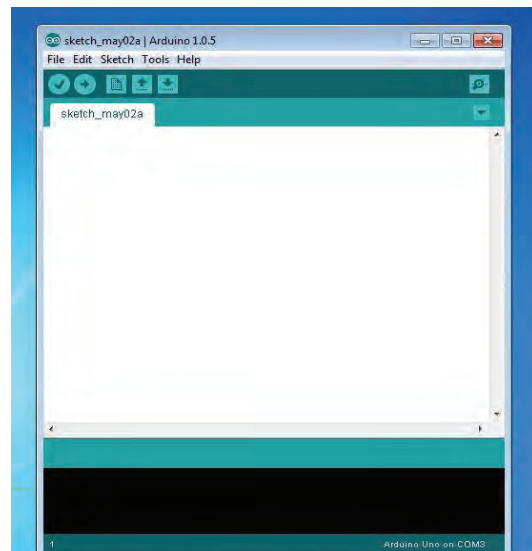
Figure 6. Arduino IDE

Features of Arduino IDE

Inexpensive: Arduino boards are relatively inexpensive compared to other microcontroller platforms.

Cross-platform: The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.

Simple, clear programming environment : The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of it as well.

Open source and extensible hardware/ software: The Arduino boards have common license, so experienced circuit designers can make their own version of the module, extending it and modifying it.

It is an open source and libraries are written in C++.

D.   Flow Chart
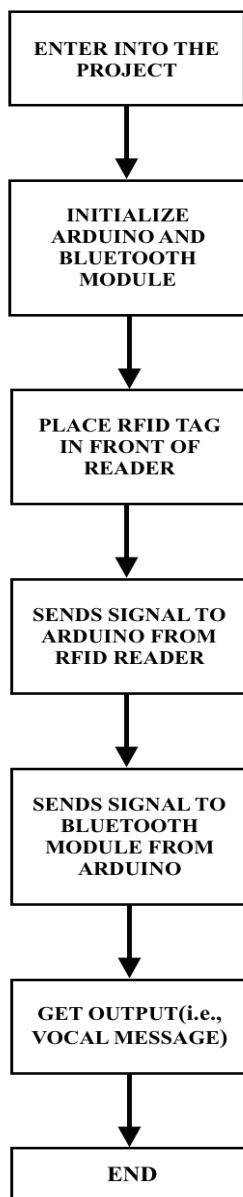
Figure 7. Flow chart of Bus Identification Device for blind people using Arduino

III. RESULTS

The below figures show the output after placing the card for five times. Each time by placing the card, the output gets in both Arduino serial monitor, and serial monitor app related to the information stored about the bus. By placing the card again i.e. 6th time, the information will be given in reverse order. When the bus starts again from the end location, now it becomes the starting location.
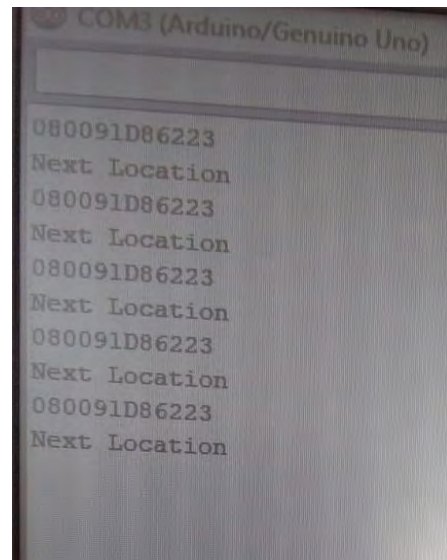
Figure 8. Output after placing the card for five times on Arduino serial monitor
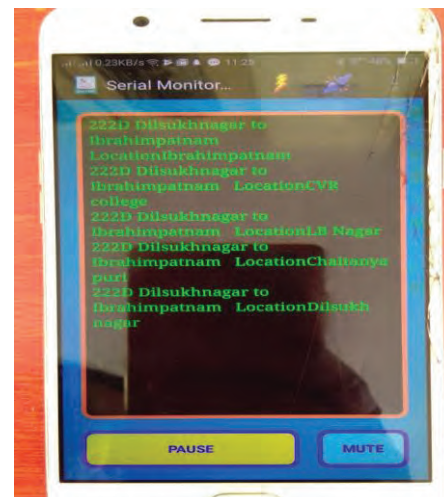
Figure 9. Output after placing the card for five times on Mobile app

When placed the card for sixth time, the ending location now became the starting location and the journey becomes reverse.
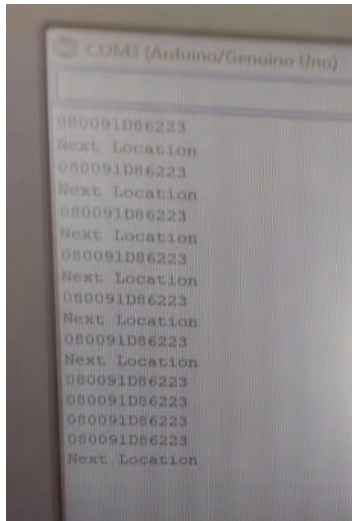
Figure 10. Output after placing the card for five times on Arduino serial monitor
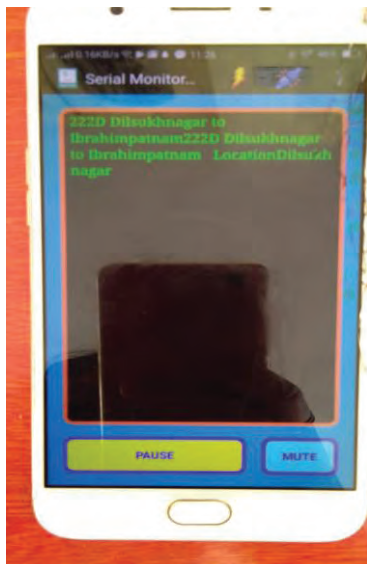
Figure 11. Output when Placed for Sixth Time on Mobile app

IV. CONCLUSIONS

In this paper, the bus identification system for blind people using RFID was successfully implemented. The proposed technique is more suitable for blind passengers. When the blind passenger reaches the bus station, with the help of voice synthesizer can find the buses that pass through a location.

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Simulation of Standalone Solar PV System using Incremental Conductance MPPT

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Abstract: **This paper presents the PV system consisting of PV panel, DC-DC booster Converter, Maximum Power Point Tracking (MPPT) which is fed to the stand-alone DC loads. An analysis is done in order to know the electrical behavior of the PV system with the parameter variations such as temperature, irradiance and the environmental conditions. It has been observed that the behavior of PV panel using Shockley diode is nonlinear in nature. So, a new method known as Incremental Conductance Method (ICM) is proposed based on MPPT. A proper duty cycle is designed to convert variable DC output into constant DC voltage. The results are justified comparing with the existing standard system.**

Index Terms: **Incremental Conductance Method (ICM), Maximum Power Point Tracking (MPPT), Photovoltaic systems (PV), DC-DC Boost Converter.**

I. INTRODUCTION

The amount of pollution producing by the fossil fuels into the environment is increasing day-by-day which is taking us into the state of Global Warming. India is having a huge amount of renewable energy sources. The energy demand is increasing in a greater extent with the increase in the population. Every application needs energy to process. The generation of energy using various fuels is given as 40% is produced by coal and 27% is produced by renewable combustible and other sources such as wind, solar nuclear and oil contribute to 33%. These lead us to generate the increase in demand by using renewable sources. Our country has abundant solar energy which should be trapped to convert solar energy into electrical energy using PV systems. It has many advantages such has free from pollution and very cheap [1]-[4].

The sun energy is tapped by the PV system and it is converted it into Electrical energy using PV cells. PV cell plays very important role in tapping the energy from sun. These cells are connected into different forms from PV panel. When we group all these panels, a PV array is formed. The energy generated by the PV arrays depends on sunlight and also on various other conditions such as temperature, Irradiance and environmental conditions [5]-[7]. The output of the PV array changes depending on temperature and irradiance. To overcome this a circuit should be designed to track maximum power from the PV array. This circuit is called MPPT circuit which increases the efficiency of the PV system. This may increase the cost of the system [8]-[10]. The methods which give maximum power from the PV array are, electronic method and other one is mechanical method of tapping. Many methods are there which are proposed by

various authors to tap maximum power from the PV array. The basic method is Perturb and Observe (P&O). The other methods are Incremental Conductance Method (ICM) and intelligent methods. Every method has advantages and disadvantages but depending upon the application the best method is used. ICM is better method when compared to P&O in terms of MPPT considering all the conditions such as temperature, Irradiance and Environmental condition [11]-[12]. ICM is best method for long run based which is controlled by DC-DC boost converter.

This paper presents the analysis of the PV stand-alone system using ICM with MPPT. The results obtained are compared with the basic P&O method to justify. A proper circuit is designed to generate duty cycle for DC-DC boost converter based on MPPT. The ultimate aim is to generate constant DC output voltage which is fed to the DC loads.

II. SYSTEM CONFIGURATION

A. System Configuration

Sunlight is directly collected with the help of PV cells and is directly converted into DC output. PV cell plays a very important role in collected energy from the sun. These PV cells work under photoelectric impact. At the point when sun-based cells are presented to daylight, it changes over sun powered vitality into electrically oriented vitality. The framework arrangement for the theme is as indicated Fig.1 Here the PV exhibit is a mix of arrangement and parallel sun powered cells. This exhibit builds up the power from the sun-oriented vitality straight forwardly and it will be switched depending upon the temperature and sun based irradiances. This is controlled in order to keep up most extreme power at yield side. Using PI controller voltage boosting is done using current cluster. By relying on the lift converter yield voltage, this AC voltage might be changed lastly. It interfaces with the utility lattice that is only of a heap for different applications. Five-level H-Bridge Cascade multilevel inverter is used to acquire AC yield voltage from the DC support yield voltage.
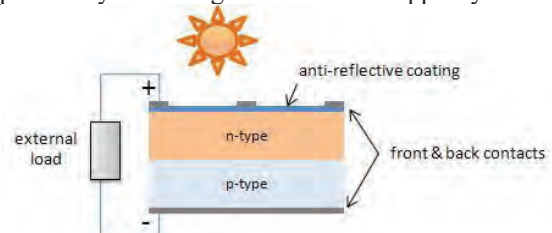
Figure1. Structure of a PV cell

B. Solar PV system Components

A PV system mainly consists of solar cell, solar array, solar panel, charge controller, batteries, inverter and the Load. Block diagram is shown in Fig.2.

i. Charge Controller

Every battery needs a charge controller, which controls the voltage developed. When the sunlight is bright more voltage is developed which will damage the battery if it is not controlled. The charge controller optimizes the required voltage and saves the battery from damage.
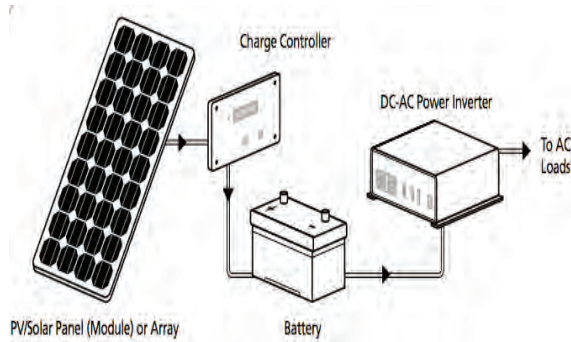
Figure2. Components of PV

ii. Batteries

Batteries plays very important role in storing the energy. There are many batteries available in the market but all are not suitable for solar PV. The most appropriate batteries which can be used for solar PV system are Nickel/Cadmium. Also there are few high quality batteries such as Sodium/sulfur, Zinc/Bromine batteries. For medium size there is Nickel/metal hydride battery. For long run iron/chromium redox and zinc/manganese batteries are used. The outstanding battery is Ingested Glass Mat battery (AGM).

iii. Inverter

Sun oriented board produces DC power yet the greater part of the family unit and mechanical apparatus require air conditioning current. Inverter changes over the DC current of board or battery to the air conditioner current.

C. Characteristics of Solar Module

Recently, photovoltaic (PV) frameworks have gotten remarkable consideration because of the worries about unfriendly impacts of broad utilization of non-renewable energy sources on the earth and vitality security. The photovoltaic vitality is a perfect vitality, with long-life expectancy and a high unwavering quality. In this way, it can be considered as a standout amongst the most reasonable of the sustainable power sources. These frameworks can be situated where ever it is required, which stays away from the misfortunes of transmission and decreases the contribution of CO_2 outflow. The PV module is the group of PV cells connected in series and parallel connections with their assurance gadgets. The vitality depends upon the temperature of the PV cell, sun-based radiation and the voltage delivered by the PV module.

The main structure of the PV cells is based on p-type semiconductor which consists of small quantity of boron particles as the substrate. For this small portion of phosphorous particles are added to form p-n intersection using high temperature dissemination strategy. This p-n intersection creates opening for the electrons for the free movement of the charges. When this takes place p-n structure gets illuminated by the sunlight, and produces photons which will energize electrons and deliver electron sets. These electrical charges get isolated due to the potential obstruction of the p-n intersection. The electrons start moving towards the n-type semiconductor and the protons will move towards the p-type semiconductor. When the p-type and n-type PV cells are associated with outside circuit then the electrons of the n-type semiconductor will move to the opposite side through the outer circuit to consolidate the gaps in the p-type semiconductor.
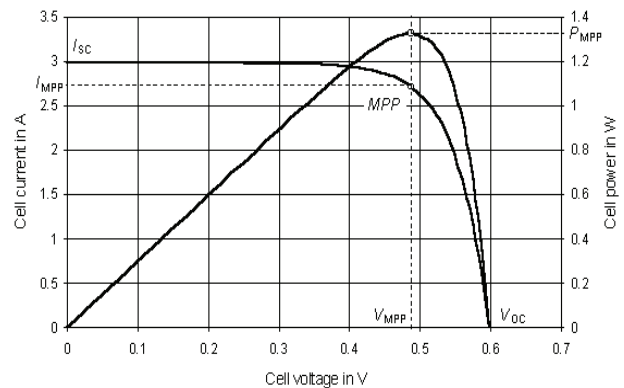
Figure 3. VI and PV characteristics of PV array

III. ROLE OF MPPT IN THE PV SYSTEM

PV systems uses maximum power point tracking to give the better constant output, irrespective of the temperature, irradiance and the environmental conditions. The age of the PV system is continuously indispensable as an economical source as it offers central focuses, securing no fuel cost, not being dirty, requiring little maintenance and not releasing bustle among others. Pv modules have low change in efficiency, controlling most extraordinary MPPT. MPPT is the structure which uses electronic circuit to isolate extraordinary essentials from the PV system. The PV control has expanded more due to various purposes such as free fuel and requires beside unkeep characteristics of interest. To enhance the productivity, it is more important the PV system to work with MPPT. The accessible method with variable ecological conditions is used for MPPT. In this paper MPPT uses open circuit voltage and short-circuit current for P&O and ICM.

The fundamental I-V equation fro PV module is given as:

$$I = I_L - I_0 \left(e^{\frac{q(V-IR_S)}{AkT}} - 1 \right) - \frac{V+IR_S}{R_{sh}} \qquad (1)$$

A PV cell is a p-n semiconductor intersection, which produces dc current when subjected to sunlight. The produced differs based on temperature and irradiance. The standard circuit is shown in Fig.4
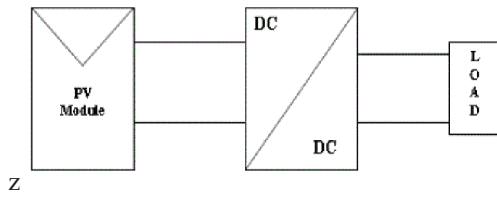
Figure 4. Block diagram of PV MPPT system

A. Maximum Power Point Tracking System

A maximum power tracking system is used to get the maximum possible power from the PV system for given ecological conditions. It is an electro-mechanical device, which undertakes MPPT and which uses circuit-based re-enactment in order to ensure the maximum power from the PV source at various environmental conditions.
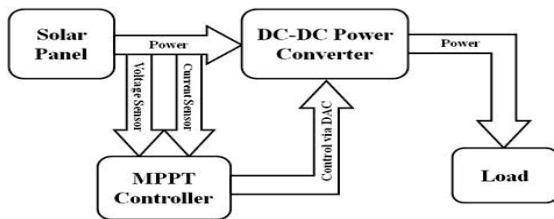
Figure 5. MPPT with DC-DC boost converter

The main aim of MPPT is to control the real working voltage of PV board. For this reason MPPT modifies the yield intensity of inverter as per the heap for the framework. If the PV yield votlage is higher then MPP votlage, at that time the exchanged capacity to the heap is expanded, if not it will decrease.

B. Modelling of a DC-DC Boost Converter

A DC-DC converter is used to lift the voltage to the higher level as required. The unbalance voltage from the solar PV can be converter into balanced output voltage using Boost converter. The circuit diagram shows the used Boost converter Fig.6. when the switch is closed the source will charge the inductor and when the diode is turned on, then the power goes to output. Again when the switch is opened, inductor and the power supply is exchanged to the heap.
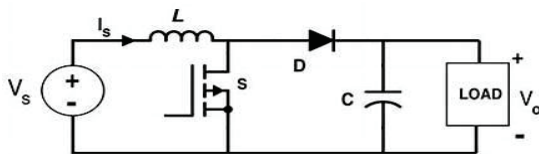
Figure 6. DC-DC Boost Converter

The votlage output of converter is shown bleow

$$\frac{V_{out}}{V_{in}} = \frac{1}{(1-D)} \qquad (2)$$

The output current is given by the following equation assuming the converter as ideal.

$$I_{out} = I_{in} \times (1 - D) \qquad (3)$$

From the above equations it deduced that:

$$\frac{V_{out}}{I_{out}} = \frac{V_{in}(1-D)}{I_{in}(1-D^2)} \qquad (4)$$

$$R_{out} = \frac{R_{in}}{(1-D^2)} \qquad (5)$$

$$R_{in} = R_{out} \times (1 - D^2) \qquad (6)$$

C. Effects of Temperature

The main important parameter in PV system is the temperature, particularly in hot atmospheres. The intensity and the coefficient of temperature is very high. PV cell execution decays as the temperature increases. For example, in brilliant daylight, cell temperatures can reach more than 70ºC, though the PV modules are evaluated at a cell temperature of 25ºC. The influence yield at 70ºC is estimated as (70-25)*temperature coefficient. Most of the PV cells have lower negative temperature coefficient contrasted with crystalline advancements. At the end of the day, they have a tendency to lose less of their appraised limit as temperature rises. Thus, under climatic condition, thin film innovations will create around 10% greater power for each year.

D. P & O MPPT Method

In P&O system sunlight is trapped directly and it is computed. Whenever there is an increase in power due to increase in voltage, then care is taken to increase the voltage additionally. When the power decreases with the increase in voltage then the voltage is also decreased. The calculations depend mainly on hunting process it has broad control around MPP. This is a basic method which uses 3 stages to track MPP. It is a tedious method and needs many calculations which increase the competency of the method. P&O also does not include increase in temperature and the irradiance. To overcome this entire short comes, a new method called Incremental Conductance Method (ICM) is used which takes all the constraints into account and tracks maximum power from the PV system. ICM is a very useful and convenient method to track MPPT from the PV system which also reduces the complexity involved in calculations as in P&O.

IV. ICM MPPT SYSTEM

The ICM is the best method with MPPT to give maximum DC constant output from the variable DC using proper duty cycle with DC-DC boost converter. This method can overcome all the drawbacks of P&O method. The output voltage can be maintained constant and directly given to the DC load with the help of this method. It mainly depends upon the incremental and prompt conductance of the PV module. The main conditions are:

dI/dV= -1V at MPP $\qquad (7)$
dI/dV>-1V left of MPP $\qquad (8)$
dI/dV<-1V Right of MPP $\qquad (9)$

When we maintain the operating region within the constant current area, then the output is proportional to the terminal voltage. The output power increases linearly with respect to the terminal voltage. When the slope is positive, then the operating point of PV passes through MPPT and produces constant DC output voltage. When the slope is negative, the output power decreases linearly with the increase in the terminal voltage. When the operating point is exactly on the MPP, the slope of the curve is zero, which is expressed as:

$$\frac{dP}{dV} = \frac{d(VI)}{dV} = I\frac{dV}{dV} + V\frac{dI}{dV} = I + V\frac{dI}{dV} \qquad (10)$$

dI/dV=-I/V   (11)

dV is the voltage error and dI is the current error before and after incremental conductance.
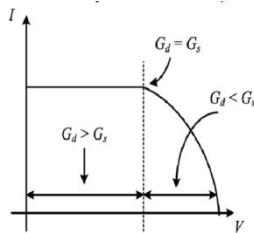
Figure 7. Illustration of ICM MPPT

A. Incremental Conductance Flowchart
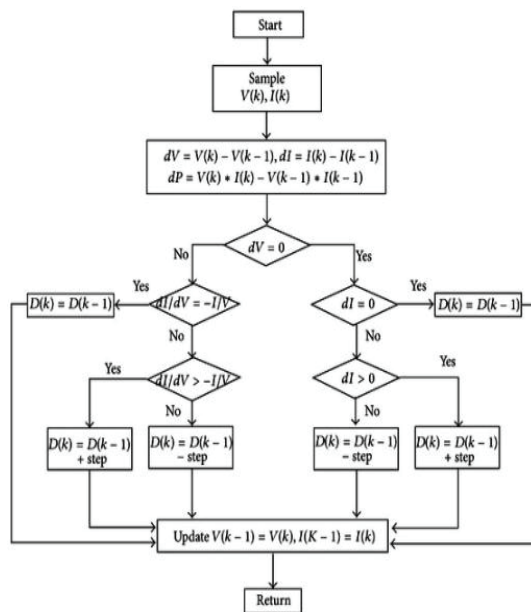
Figure 8. Algorithm of ICM MPPT

B. Modeling and Simulation of stand-alone PV system

The simulation of PV system is done in MATLAB-SIMULINK. The PV sytem gives an output of 18V which consists of total 36 cells, each cell can produce a voltage of 0.5V. the simulation also includes incremnetal conductance MPPT model which track the maximum output from the system. To balacne the output votlage fluctuations a DC-DC boost converter is designed with propoer duty cycles.
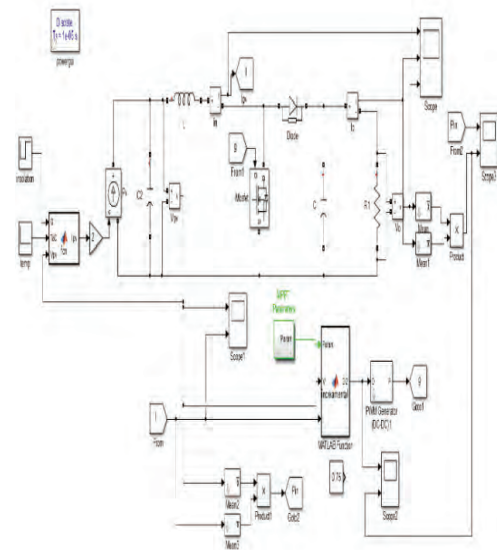
Figure 9. Simulation of ICM MPPT

V. RESULTS ANALYSIS

PV systems with different PV arrays are used in this paper. The temperature of about 25°C and an irradiance of about 1000w/m² is used to get the maximum output with and without MPPT controller. The results are shown below:
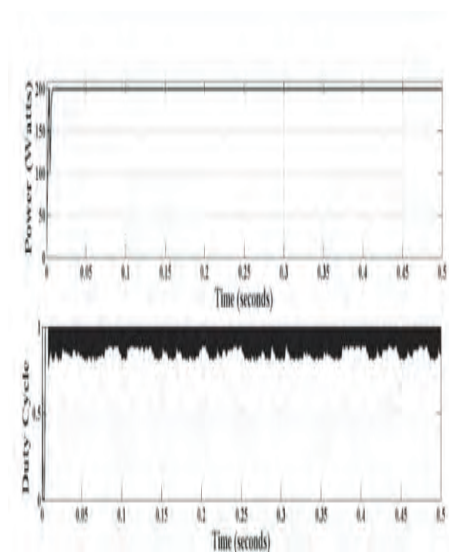
Figure 10. – Output power and duty cycle using P&O
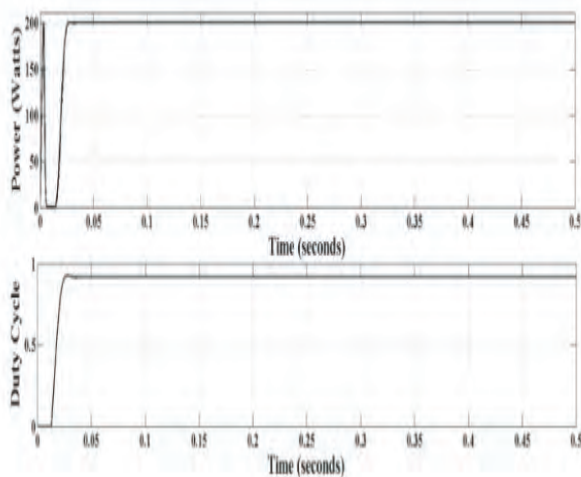
Figure 11. PV panel Power and Duty cycle control using IC at STC

With constant irradiance, a comparison is done using P&O and IC. In Fig.10 output power and duty cycle using P&O is shown and in Fig 11 output power and duty cycle using IC MPP is shown. P&O uses MPP but it has some waver, whereas IC uses MPP at the appropriate time with all constraints. In Incremental conductance method the duty cycle is smooth without any transients whereas P&O the duty cycle is irritate persistently. By fine controlling the duty cycle, one can get the maximum output from the PV system. Here the obligations of temperature, irradiance and the environmental conditions are considered which gives constant output at all the possible conditions.

A. P&O Simulation Output
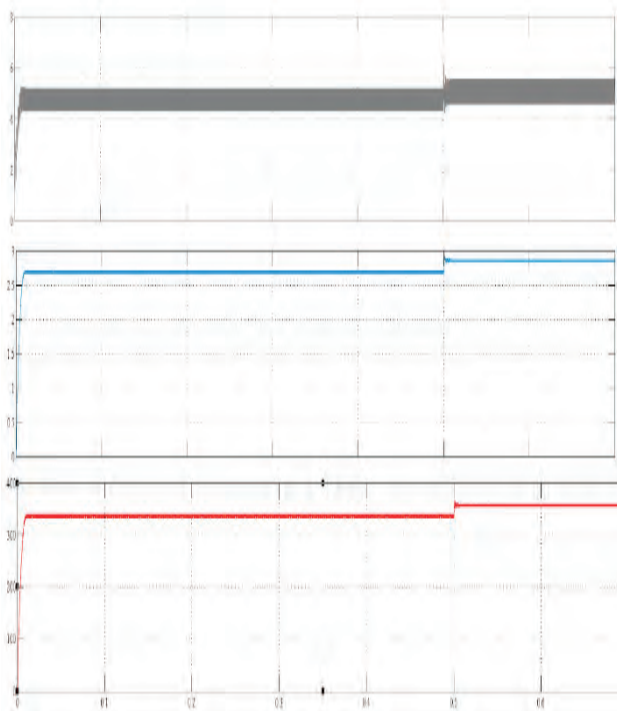
Figure12. Simulation output of P&O MPPT algorithm

B. IC Simulation Output
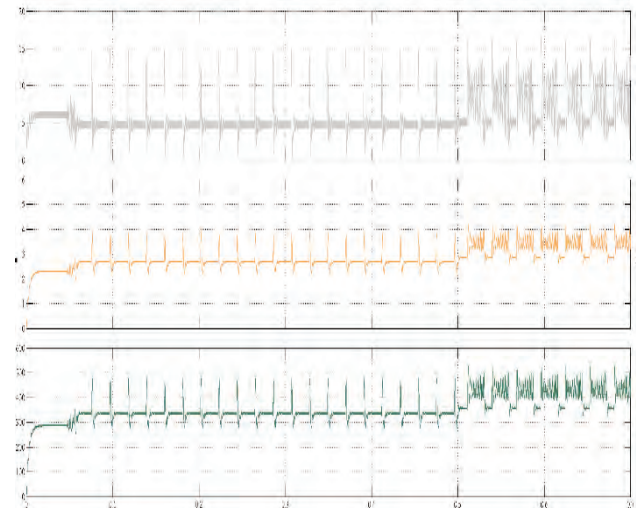
Figure.13 Simulation output of incremental conductance MPPT Algorithm

Where in figures 12 & 13, x-axis represents time and y-axis represents input current, output current, and output voltage respectively.

In general, the advantages of the 'incremental conductance' method over the 'perturb and observe' method are:

➢ Incremental strategy can compute the bearing, for which the cluster's indicate changed all together achieve the MPP,
➢ Incremental method should not oscillate about the MPP once it reaches it,
➢ Incremental method does not go on the wrong direction when conditions in the system changed rapidly.

VI. Conclusions

This paper presents the simulation analysis of stand-alone PV system with two methodologies. First one is Perturb & Observe and the second one is Incremental Conductance method. P&O can give reasonable output voltage including constant temperature and irradiance parameters, but this method does not include environmental conditional variations continuously. Even the duty cycle of P&O is poor compared to IC method. IC method uses all the constraints for getting maximum output voltage using MPPT. This method also uses environmental conditional changes at every instant of its operation. A DC-DC boost converter is used to get the smooth DC output voltage.

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Performance Analysis of Three Level Diode Clamped Inverter fed Induction Machine using Multicarrier PWM Techniques

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Abstract: **The Utilization of multilevel inverter technology in induction machine applications is attaining highest interest in the last two to three decades. Out of the three classical multilevel inverter topologies, diode clamped multilevel inverter topology is widely used due to its high efficiency, minimized stress on power switching devices and decreased number of capacitors. This paper presents the performance analysis of three phase, three level diode clamped inverter fed induction machine in open loop operation, as well as closed loop operation with proportional integral controller using different multi carrier pulse width modulation techniques.**

Index Terms: **Diode Clamped Multilevel Inverter (DCMLI), Multi carrier pulse width modulation, Total harmonic distortion (THD) , Phase Disposition (PD), Phase Opposition and Disposition(POD)**

I. INTRODUCTION

Multilevel inverter fed induction machines tends to gain continuous interest in R&D and industrial sector as they have a quite number of applications in both drives and utility sectors. Initially induction motor drives were employed in constant speed applications. Due to advent of new semiconductor switching devices, power electronic converters and developments in the controllers, induction motor drives are employed in variable frequency applications also. Nearly 80% of the ac motor drives used in industries are induction motor drives only. The major advantage of inverter fed induction motor drives is its ability to synthesize the control voltage vectors for different applications. Usage of Multilevel inverter fed induction machines (induction generators) in wind power generation is gaining tremendous interest both in R&D sector as well as power system sector [1]. Multilevel inverter fed induction machines driven by wind turbines are used in wind power generation both in squirrel cage induction generators and doubly fed induction generators [2]. These induction machines can be either operated in islanding mode or grid connected mode, depending on type of induction machine used.

Invention of vector control or Field Oriented Control (FOC) of induction motors in early 70s by F.Blaschke, led to the tremendous development in the AC motor drives [3]. Later technologies like Sine Pulse Width modulation (SPWM) and Space Vector Pulse Width Modulation (SVPWM) were introduced to control the effective on period of the semiconductor switches [4-6]. Direct Torque Control (DTC) of induction motors was discussed in [7]. Sensor less control of induction motors using vector control is discussed in [8]. In [9], hybrid DTC of induction motor drives was discussed

Block diagram of diode clamped inverter fed induction machine is shown in Figure 1. The input to the diode clamped inverter can be either dc link capacitor or dc voltage source. Induction machine can be either operated as induction motor (as in case of motor drives) or induction generator (as in case of wind generators) depending on load torque. A PI controller is used in the feedback mechanism. However, this controller can be replaced by many of the artificial controllers like neural network controller, fuzzy logic controller or combination of fuzzy-neuro controller, depending on requirement.

This paper is organized as follows. Importance of multilevel inverters and their classification is discussed in section II. Multi carrier PWM techniques are discussed in section III. Simulation studies and results are presented in section IV and conclusions are in section V.
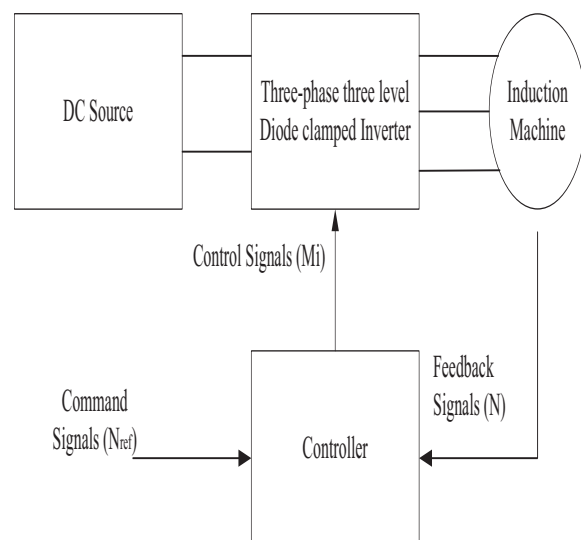
Figure 1. Block diagram of inverter fed induction machine

II. MULTILEVEL INVERTERS

The major limitation of conventional two-level Voltage Source Inverter (VSI) is that it's output voltage has only two levels i.e. $+V_{dc}$ or $-V_{dc}$, where V_{dc} is the input dc voltage of the Inverter. As a result, rate of change of output voltage dv/dt is very high, and is about 10000 V/sec. One more major drawback is presence of harmonics in the output voltage. High winding losses will occur if the output voltage of two level VSI is fed to the induction motor. To overcome the above-mentioned limitations, multilevel inverters are generally used in place of two-level inverters.

A multilevel inverter may be defined as power electronic converter which converts fixed DC to variable ac having more than two levels in its pole voltage using low rating power semiconductor switching devices [10].

The major advantages of multilevel inverters are

- Lower common mode voltages
- Lower harmonic distortion
- Generation of higher voltages using low rating switching devices
- Can operate at low switching frequency
- Suitable for medium power, high voltage applications

Multilevel inverters can be broadly classified into three types. They are
1. Diode Clamped multilevel inverter
2. Flying capacitor multilevel inverter
3. Cascaded H bridge multilevel inverter

A. Diode Clamped Multilevel Inverter

It is the most commonly used and popular topology of multilevel inverter. Diodes are used as clamping devices to clamp different levels of voltages, hence named as diode clamped multilevel inverter (DCMLI). At the input side of the inverter the dc bus capacitance is split into two equal capacitances providing a neutral point 'O'. When the middle switches of any leg of the inverter are turned on, the respective phase is connected to the neutral point 'O' through one of the clamping diodes. As a result, the voltage is clamped to either $+0.5V_{dc}$ or $-0.5V_{dc}$ depending on direction of current through the load. When top two switches are turned on, the output voltage is $+V_{dc}$ and when bottom two switches are on, the output voltage is $-V_{dc}$.

The formulae for number of active switching devices, clamping diodes and dc bus capacitors is given by $6(m-1)$, $3(m-1)(m-2)$ and $(m-1)$ respectively , where m is the level of the inverter. Thus a 3-level diode clamped inverter requires 12 active switching devices, 6 clamping diodes and 2 dc bus capacitors [11].

Advantages of Diode clamped multilevel inverter

- Maximum voltage across any switch is half the value of dc source voltage
- When leakage current of top and bottom switches is greater than leakage current of inner switches, there is no need for additional components to achieve static voltage equalization.
- As the number of levels increases, THD decreases.
- For a given fundamental frequency, efficiency is higher.

Disadvantages of Diode clamped multilevel inverter

- Uneven loss distribution in the devices (Inner switching devices are overloaded compared to the outer switching devices).
- Number of clamping diodes increases as the level increases hence the complexity of the circuit increases
- Active power flow is very difficult
- Voltage imbalance across the dc bus capacitors
- Complexity of the triggering circuit increases with increase in number of levels

The circuit diagram of a three phase, three-level diode clamped multilevel inverter is shown in the Figure 2.
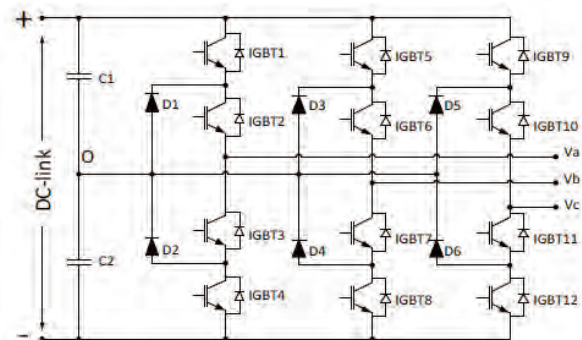
Figure 2. Three phase, three level diode clamped multilevel inverter

B. Flying Capacitor Multilevel Inverter

If the clamping diodes in DCMLI are replaced by capacitors, the resulting topology is called flying capacitor multilevel inverter (FCMLI). The flying capacitor topology is relatively newer compared to diode clamped topology. The process of synthesizing output voltage is more flexible in flying capacitor multilevel inverter compared to the diode clamped multilevel inverter.

Advantages
- No voltage imbalance problems across the dc bus capacitors
- Both active and reactive power flow control can be achieved

Disadvantages
- Requirement of large number of capacitors makes the converter bulky and expensive.
- Switch utilization and efficiency is poor, especially for real power transmission.

A three phase, three level flying capacitor inverter is shown in figure 3.
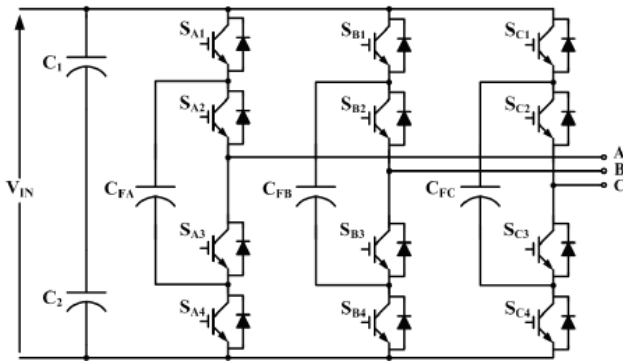
Figure 3. Three -phase, three level, flying capacitor multilevel inverter

C. Cascaded H-Bridge Multilevel Inverter

A cascaded H bridge multilevel inverter is constructed by connecting large number of single-phase H bridge cells in cascade at ac side. This topology requires large number of dc sources at input side unlike that of Diode clamped and Flying capacitor multilevel inverters

Advantages
- Less number of switching devices compared to DCMLI and CCMLI
- More number of levels can be synthesized when input dc sources have different magnitudes
- Doesn't require any additional capacitors or clamping diodes for voltage balancing

Disadvantages
- Needs separate dc sources

Cascaded H-Bridge multilevel inverters are now gaining high interest in the field of Distributed generation and solar photo voltaic inverters.

A single leg of a three-phase three-level cascaded, H bridge multilevel inverter is shown in figure 4.
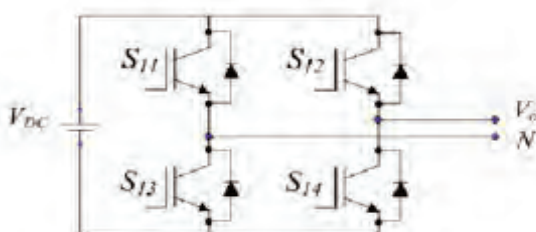
Figure 4. One leg of a three- phase cascaded H bridge three level Inverter

A detailed comparison table on basic multilevel inverter topologies in terms of number of power semiconductor switches, clamping diodes and DC bus capacitors is given in Table I.

TABLE I.
COMPARISON TABLE OF DIFFERENT MULTILEVEL INVERTER TOPOLOGIES

S.No	Topology	Diode Clamped	Flying Capacitor	Cascaded H-Bridge
1	Power Semiconductor Switches	2(m-1)	2(m-1)	2(m-1)
2	Clamping Diodes per phase	(m-1)(m-2)	0	0
3	DC bus Capacitors	(m-1)	(m-1)	(m-1)/2
4	Balancing Capacitors per phase	0	(m-1)(m-2)/2	0

III. Multi Carrier PWM Techniques

For controlling the induction motor parameters like speed etc., carrier based PWM techniques are used in control circuit of inverter. Multi carrier based PWM techniques can be broadly classified into two types. They are [12].
- Level shifted modulation
- Phase shifted modulation

Level shifted modulation is further classified into
- Phase Disposition (PD)
- Phase opposition disposition (POD)
- Alternative phase opposition disposition (APOD)

A Level Shifted Modulation

In level shifted modulation scheme, (m-1) triangular carrier wave forms are required, that have same magnitude and frequency. The frequency of the carrier wave decides the switching frequency of the inverter whereas frequency of the sinusoidal reference waveform is as that of   desired output frequency of the inverter.

In phase disposition level shifted modulation method all the carrier waves are in phase with each other, where as in phase opposition and disposition, the carrier waveforms above reference are in phase, but they are in phase opposition with carrier waveforms which are below reference.

In alternative phase disposition, all carrier waveforms are in opposition disposition. For a five-level diode clamped inverter, number of carrier waveforms required are (5-1) four.

Level shifted multi carrier modulation scheme for five-level inverter is shown in Figure 5. The x axis parameter in figure 5 is time in seconds.

B . Phase Shifted Modulation

In phase shifted multi carrier modulation scheme all carrier waveforms will have same switching frequency and magnitude but these carrier waveforms are adjacent to each other displaced by a phase shift given by $\theta = (360^0$ /m-1) where m is the level of the pole voltage of   the inverter [13].

The peak to peak value of the reference sinusoidal waveform must be same as the peak to peak value of the triangular carrier waveforms. For a 3-level diode clamped

multilevel inverter, number of carrier waveforms required are 2 and phase shift angle is 180^0 . For a five level diode clamped inverter ,number of carrier waveform required are 4 and phase shift angle between carrier waveforms is 90^0
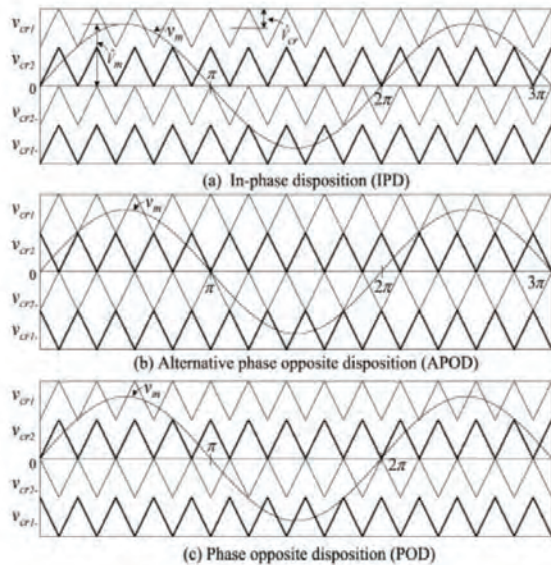
Figure 5 Carrier waveforms for different types of level shifted Modulation

The carrier waveforms for phase shifted modulation shown in figure 6.
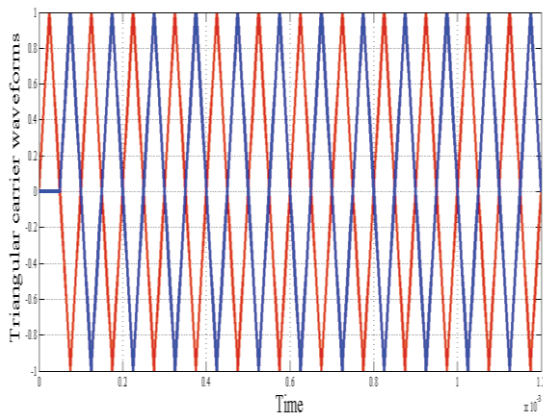
Figure 6. Carrier waveforms for phase shifted modulation

IV. SIMULATION STUDIES AND RESULTS

The three-level diode clamped inverter is fed from a constant DC source of 817V. Output of the inverter is given to 4kW, 400V, 1430 rpm three-phase induction motor. Simulation is performed in MATLAB/SIMULINK software. The rating of the induction motor is chosen based on its suitability towards wind generation. Diode Clamped multilevel inverter is chosen for simulation since it is having high efficiency and practically used in most of the power system applications. The main objective of the paper is to track the speed of induction motor for different load changes in open loop system and in closed loop system using PI

controller. PWM techniques like Phase disposition, Phase opposition and disposition and Phase shifted modulation are considered for controlling inverter, for each of these techniques Total Harmonic Distortion in the stator current of induction motor is calculated [14]. Half load torque and full load torque are applied at 1 sec and 2 sec respectively.

The MATLAB SIMULINK diagram is shown in   figure 7.
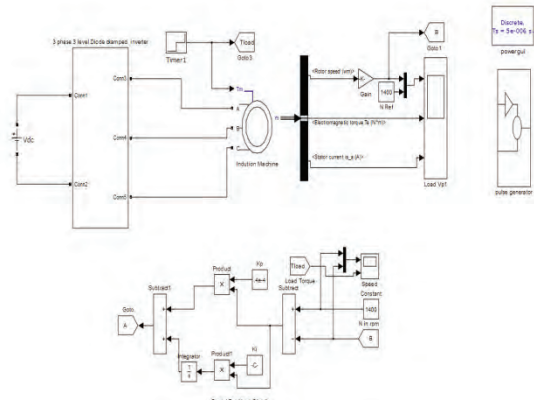
Figure 7. SIMULINK model of three level diode clamped inverter fed induction motor

Induction motor is fed by three level diode clamped inverter in open loop is simulated using SIMULINK. The frequency of the triangular carrier wave forms is 10050 Hz and the reference sinusoidal wave form is 50Hz. Amplitude modulation index is considered as 0.8.The wave forms of speed , electromagnetic torque and stator current of induction motor in phase disposition technique are shown in figure 8.The output line voltages of the inverter are shown in figure 9.It can be clearly shown that the line voltages are having the amplitudes of +Vdc.+0.5Vdc,0,-0.5Vdc and -Vdc and these voltages are displaced by a phase shift of 120^0.
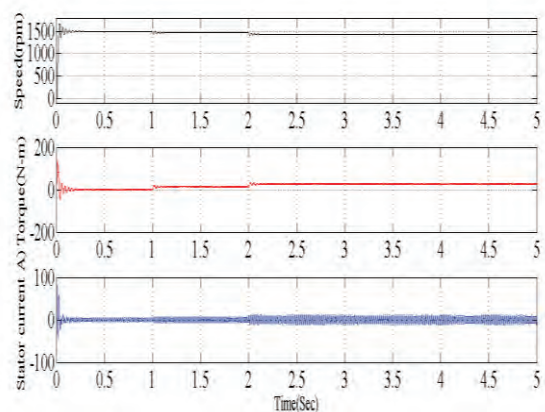
Figure 8. Speed, torque and stator current of induction motor in open loop, Phase disposition technique

At starting of the induction motor, under no load conditions, the speed reached its rated value within 0.05 seconds, At t=1 second, when half full load torque is applied, the speed dropped to 1470 rpm. At t= 2 seconds when full load torque is applied the speed further dropped to 1435 rpm. Ripple in motor speed is less than 1% in steady

state conditions. At starting of the induction motor the starting torque is very high at 130N-m which is nearly 5 times of the rated torque. The oscillations are present in the torque for 0.05 seconds and steady state is reached. The starting current under no load conditions is 80A, which is nearly 7 times the full load current. Steady state is reached within 0.05 seconds.

Total Harmonic Distortion (THD) of stator current for multicarrier SPWM techniques like phase disposition, phase opposition disposition and phase shifting technique is calculated for different carrier frequencies. It has been found that THD decreases with increase in switching frequency of the carrier wave. THD in stator current is very high in phase shifting carrier waveform technique at both switching frequencies. For this reason, Phase shifting carrier technique is not preferred in diode clamped inverter topologies. However, this technique is preferred in cascaded H-Bridge inverters, especially in the applications of solar photo voltaic inverters
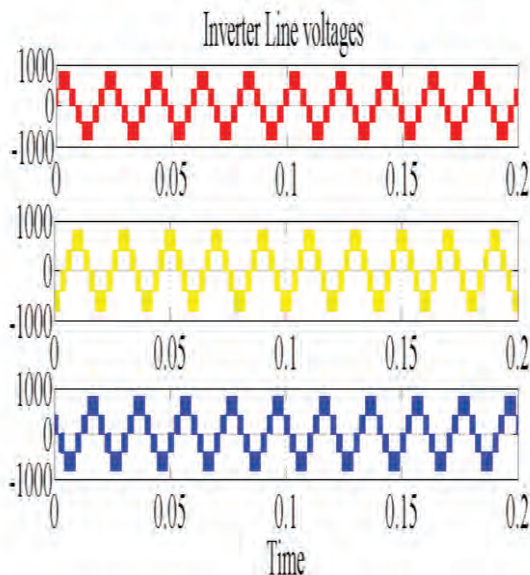
Figure 9. Line voltages of inverter in open loop Phase disposition Technique

The reference and actual speed of induction motor along with electromagnetic torque and stator current in phase 'A' for phase disposition level shifted PWM technique are shown in figure 8. The gains of the proportional (K_P) and integrator (K_I) of PI controller are chosen to be 0.0004 and 0.0015 respectively so that actual speed can track the reference speed under load disturbances accurately. Here the gains K_P and K_I are tuned in randomly using trial and error method.

TABLE II.
THD IN STATOR CURRENT OF INDUCTION MOTOR FOR DIFFERENT TYPES OF MULTICARRIER SPWM TECHNIQUES IN OPEN LOOP SYSTEM

S.No	Name of the SPWM technique	% THD in stator phase current of induction motor
1	Level Shifted Phase Disposition Method (PD)	3.29
2	Level Shifted Phase Opposition Disposition Method (POD)	3.87
3	Phase Shifted Modulation technique	20.24

TABLE III.
THD IN STATOR CURRENT OF INDUCTION MOTOR FOR DIFFERENT TYPES OF MULTICARRIER SPWM TECHNIQUES IN CLOSED LOOP SYSTEM

S.No	Name of the SPWM technique	% THD in stator phase current of induction motor
1	Level Shifted Phase Disposition Method (PD)	3.81
2	Level Shifted Phase Opposition Disposition Method (POD)	4.02
3	Phase Shifted Modulation technique	9.36

To track the speed, closed loop PI controller method is adopted. The reference and actual speed of induction motor along with electromagnetic torque and stator current in phase 'A' for phase disposition level shifted PWM technique are shown in figure 10. The switching frequency of the triangular carrier wave is taken as 10050 Hz with a modulation index of 0.8
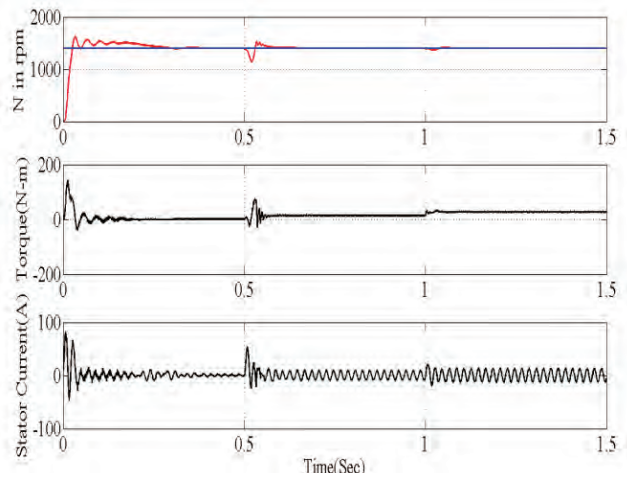
Figure10. Speed, torque and stator current waveforms of induction motor for Phase disposition technique in closed loop

Total harmonic distortion for stator current of the three-phase induction motor is calculated using phase disposition level shifted PWM technique and its harmonic spectrum is shown in figure 11.
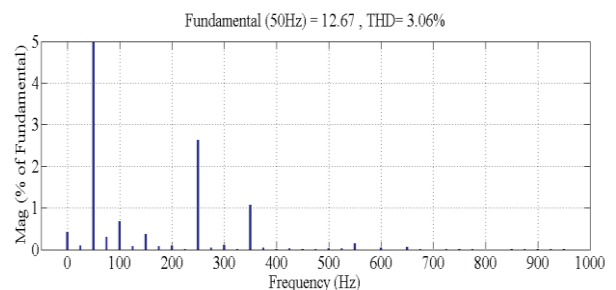
Figure11. Harmonic spectrum of stator current with PD technique

Harmonic spectrum of stator current of the three-phase induction motor for phase opposition disposition (POD)

level shifted PWM technique and phase shifted PWM technique are shown in figure12 and figure 13 respectively
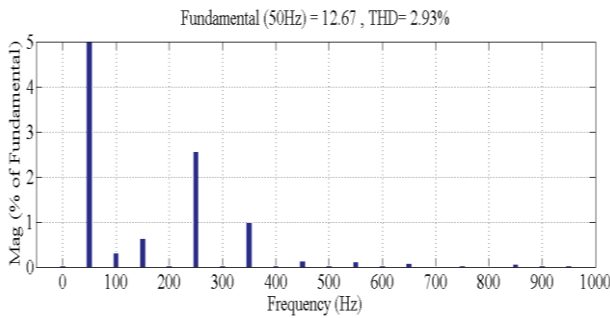
Figure 12. Harmonic spectrum of stator current with POD technique
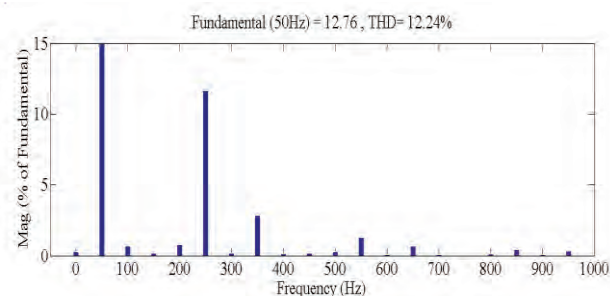
Figure 13. Harmonic spectrum of stator current with Phase shifting PWM technique

Gate pulses for the switching devices of leg1 of 3-level diode clamped inverter are shown in Figure 14.

Total Harmonic Distortion in stator current of induction motor is calculated using FFT analysis for different sinusoidal pulse width modulation (SPWM) techniques such as Phase disposition (PD), phase opposition disposition (POD) and Phase shifted modulation for switching frequency of 10050Hz and 2450Hz are listed in the Table II and Table III. respectively. It has been found that level shifted phase disposition method is giving less THD compared to the other methods like level shifted phase opposition disposition and phase shifted modulation. In Fast Fourier Transform (FFT) analysis, the stator current is considered under steady state conditions and FFT analysis performed at 2.7 sec and for a single cycle.
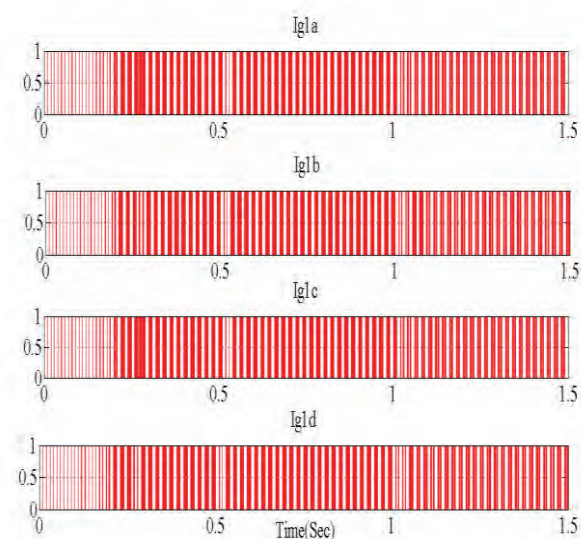
Figure 14. Gate pulses for devices of single leg of three-level diode clamped inverter

Since IGBTs are having low conduction and switching losses, they are used as active switches in the three phase three level diode clamped multilevel inverter. Energy loss calculation for leg1 of three phase, three level diode clamped inverter in PD, POD and Phase shifted multicarrier SPWM techniques is carried out in SIMULINK and the losses of the switches are tabulated in Table IV, Table V and Table VI respectively. The results show that the top and bottom switches are loaded less compared to the middle switches in all the multi carrier SPWM techniques.

TABLE IV.
ENERGY LOSSES IN SWITCHES OF LEG1 OF THREE-PHASE, THREE- LEVEL DIODE CLAMPED INVERTER IN PD MULTI CARRIER SPWM TECHNIQUE

S.No	Name of the switch	Energy loss in mW
1	Qa1	71
2	Qa2	131
3	Qa3	83.7
4	Qa4	48

TABLE V.
ENERGY LOSSES IN SWITCHES OF LEG1 OF THREE- PHASE, THREE- LEVEL DCMLI IN POD MULTI CARRIER SPWM TECHNIQUE

S.No	Name of the switch	Energy loss in mW
1	Qa1	71.8
2	Qa2	131.1
3	Qa3	84
4	Qa4	48

TABLE VI.
ENERGY LOSSES IN SWITCHES OF LEG1 OF THREE- PHASE ,THREE-LEVEL DCMLI IN PHASE SHIFTING MULTI CARRIER TECHNIQUE

S.No	Name of the switch	Energy loss in mW
1	Qa1	181.9
2	Qa2	232.2
3	Qa3	225.5
4	Qa4	177.4

V. CONCLUSIONS

The performance analysis of three-phase, three- level diode clamped inverter fed induction machine is presented for various SPWM techniques. The simulation is performed in MATLAB/SIMULINK software. Speed response for various load conditions like half load and full load torque conditions is analyzed and found that the system is reaching its desired speed with in short duration of time with small

overshoots. Total Harmonic Distortion (THD) in stator current of the induction motor is calculated for various multi carrier SPWM techniques and found that Phase disposition multi carrier SPWM technique gives much superior performance compared to the remaining SPWM techniques. Energy losses in the switches of 3 phase, 3 level diode clamped inverter are calculated and found that innermost switches are overloaded compared to the top and bottom switches.

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All - Silicon Carbide Power Modules Based High Performance Inverter for Traction Applications

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Abstract: The Silicon (Si) IGBT was an enormous positive disruption to the area of Power Electronics in the 1980s. It has been the workhorse of the industry ever since. It is currently available in its 7th generation. The next revolutionary technology is power semiconductor devices made with wide bandgap materials like Silicon Carbide (SiC). SiC devices have higher critical breakdown strength, wider bandgap, thinner drift layer and better heat conductivity when compared to Si devices. A traction inverter using SiC devices will have low value of conductivity loss, lower values of switching and recovery losses, increased range in terms of switching frequency and temperature with better heat dissipation. The converter will be smaller and lighter due to less cooling requirements. A study was done on various options available. Efficiency was compared using an improved model of SiC MOSFET.

Index Terms: SiC, traction inverter, compact, efficient, SBD

I. INTRODUCTION

A conventional IGBT power module is shown in Fig.1 below. In a Hybrid SiC power module, the anti-parallel diode is replaced by a SiC Schottky Barrier Diode (SBD). High speed switching is possible with Hybrid – SiC module as the SBD does not have accumulation carriers. All SiC power module has a SiC MOSFET with SiC SBD connected in anti-parallel. Higher efficiency and faster switching will be possible with all SiC power module. [2][6]
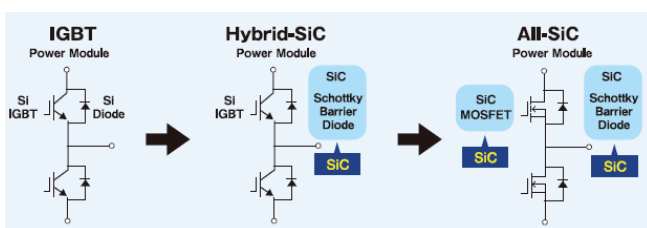
Figure 1. Evolution in power semiconductor device modules

Two-level and three-level traction inverters

Two-level or three-level inverters are used in most electric traction applications. Two level and three level traction inverters are shown in Fig.2 and Fig.3 respectively. These figures show the connections using power modules. Most of the traction inverters are of Variable Voltage Variable Frequency (VVVF) type. Two-level inverter has higher switching loss at higher frequency. The voltage rating of switches used in a three-level inverter is lower than those
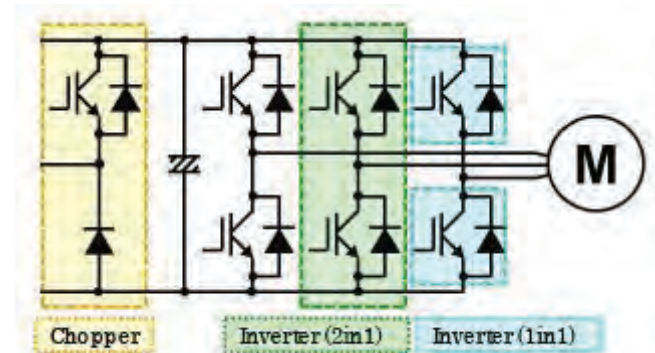
Figure 2. Two - level Traction inverter
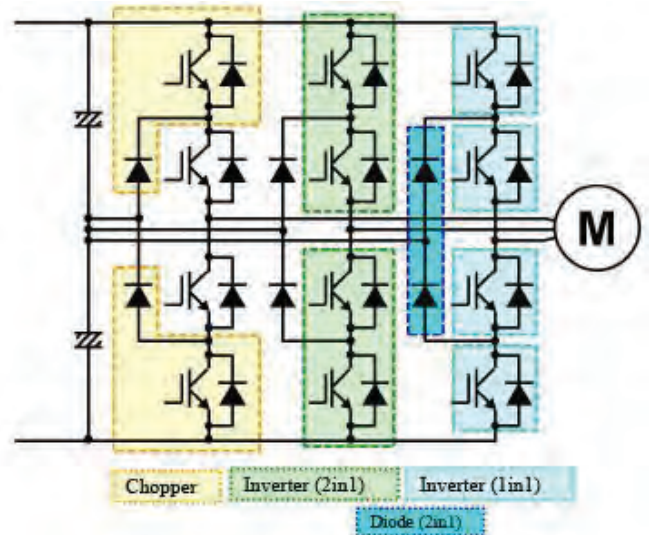
Figure 3. Three - level Traction inverter

used in a two-level inverter for the same DC bus voltage. Switching loss in a 3-level inverter goes down as the switching frequency increases. There is also a reduction in Total harmonic Distortion (THD) due to increase in the number of steps. Reduction in THD leads to less electro-magnetic interference (EMI) emission. A 3-level traction inverter [7] connected to a 3-level PWM converter is shown in Fig.4. The control technique used with such traction inverters is usually stator - flux based vector control method. The inverter uses IGBT power modules. A single inverter drives four traction motors in parallel control. A separate traction inverter is used with every traction motor in individual axle control. Reliability of the system is increased when using individual axle control.
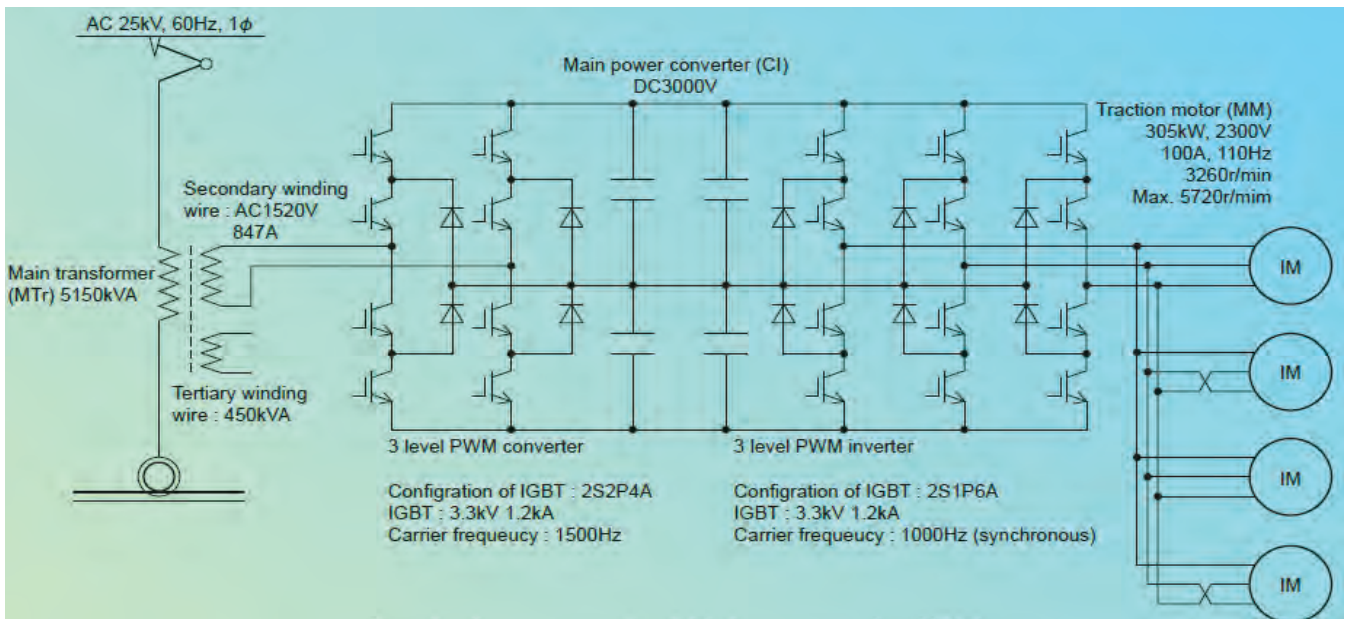
Figure 4. Traction inverter connected to PWM rectifier.

II. ALL – SiC INVERTER

A. Replacing power modules

If the IGBT power modules of converter and inverter in Fig.4 are replaced by All SiC modules shown in Fig.5, a compact, lightweight propulsion converter with higher efficiency [3] can be realized.
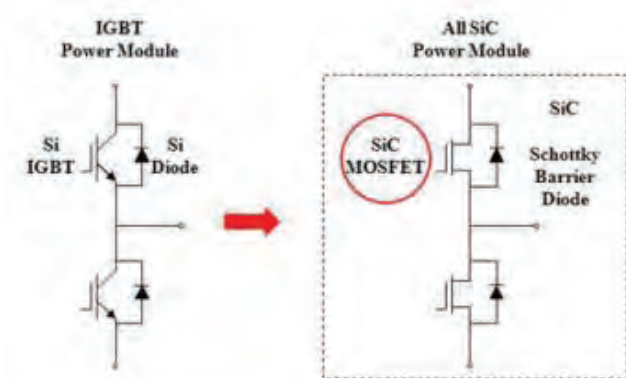
Figure 5. Replacing IGBT power module with All-SiC power module.

All – SiC power module can be switched at a higher switching frequency, which result in higher efficiency, smaller heat-sinks and increased power density. Smaller passive filters are needed when the inverter is operated at higher switching frequency. The All-SiC module is more robust than a conventional IGBT module as it can be operated at higher temperatures. Depending on the operating condition, a 3-level converter may cause a voltage imbalance at the positive and negative sides of the filter capacitor with respect to the DC neutral point. There is a risk that an excessive voltage might be applied to certain components. A technique for neutral point potential control

is needed here. When vector control is employed in a single inverter driving many motors, the phase angle of the primary flux is the common state variable. The block diagram of controller for the inverter and converter of Fig.4 is shown in Fig.6.

B. Modulation techniques and controller

Most of the traction inverters use a modulation technique that changes with speed as shown in Fig.7. Asynchronous PWM is used in low speed range, while synchronous PWM is used in medium speed range. Synchronous single pulses are applied in the high-speed range. A new and energy efficient [1] PWM control technique is shown in Fig.8. The speed range of asynchronous PWM control has been expanded. PWM control is now based on line voltage control. The carrier frequency is optimized to inhibit lower order harmonics. Low distortion synchronous PWM control is used in the upper end of medium speed range. Lower order harmonics are inhibited, and current harmonics will be reduced. Synchronous triple pulse traction system in the high -speed range also reduces lower order harmonics.

In induction machines, it is desirable to operate the machine at high flux levels allowing the machine to produce higher torques. Estimation of stator flux does not require the knowledge of magnetic circuit parameters. Hence stator flux-based control is more robust and easier to implement in the saturation region than rotor flux-based control. Superior performance, functions and efficiency can be achieved by combining All-SiC based inverter, a controller that uses Reduced Instruction Set Computer (RISC), Digital Signal Processing (DSP) and optic fiber for input and output interface. A 3.3 KV/1500 A power module with SiC MOSFET connected in parallel with a 3.3 KV SiC Schottky Barrier Diode (SBD) is currently in use. The MOSFET can block a drain current of more than five times larger than its rated current.
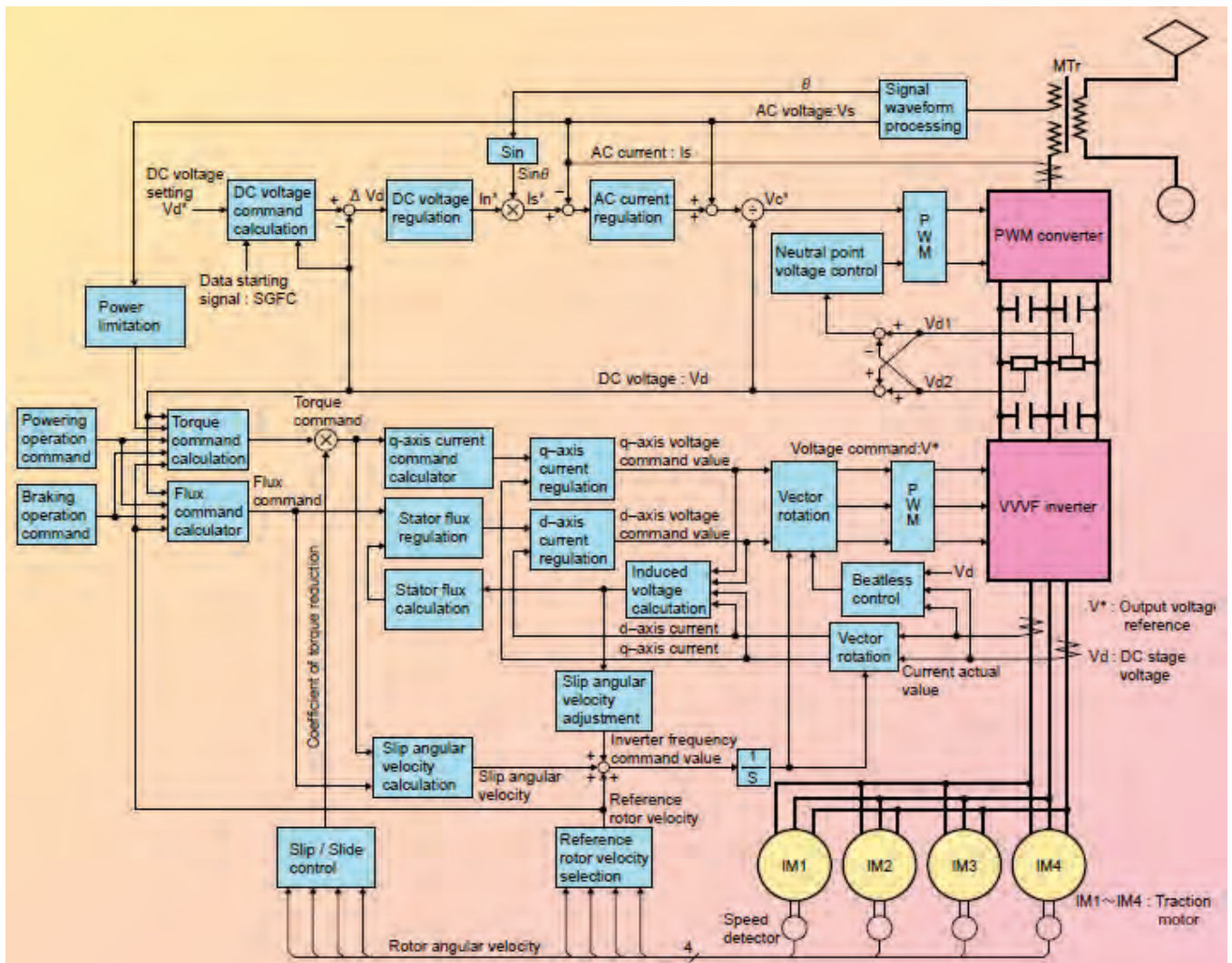
Figure 6. Control block diagram for traction inverter.
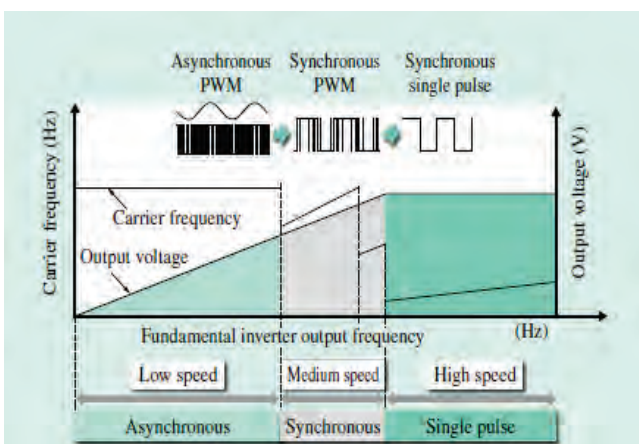
Figure 7. Conventional PWM control technique
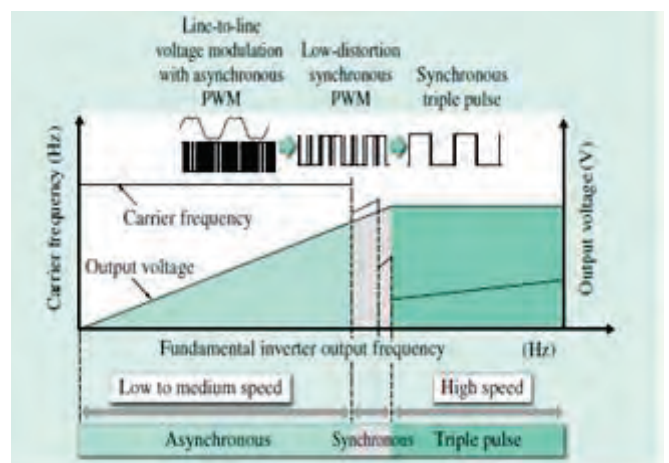
Figure 8. Efficient PWM control technique

C. Advantages

The inverter [2] becomes compact as shown in Fig. 9. This reduction in weight and volume can be attributed to simpler cooling systems, smaller coils and condensers.
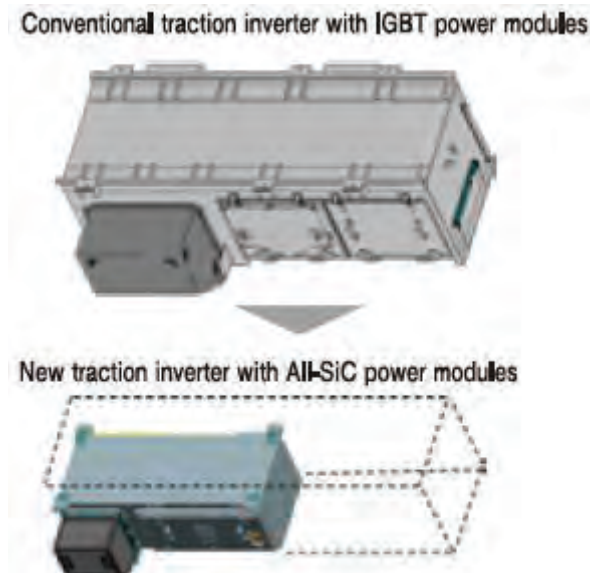
Figure 9. Reduction in the size of inverter

The All-SiC power module has an outstanding advantage as illustrated in Fig.9. The sum of switching and conduction loss remains more or less constant for the entire range of operation. This is not the case for a conventional IGBT power module where the switching loss increases rapidly with increase in switching frequency. This feature helps in recovering more energy during regeneration. As illustrated in Fig. 11 and Fig.12.
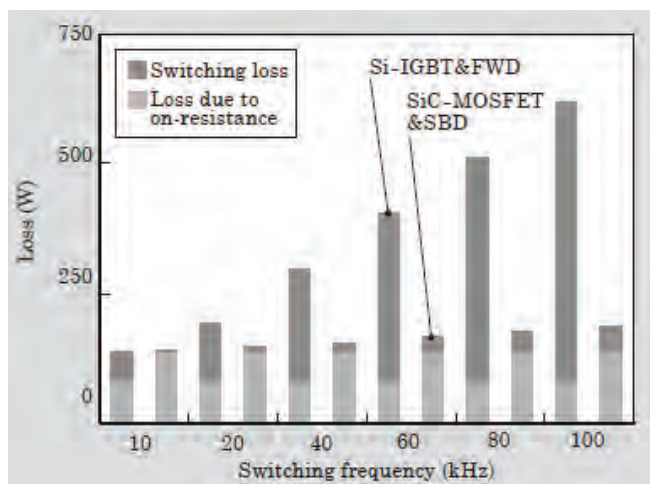
Figure 10. Losses as a function of switching frequency
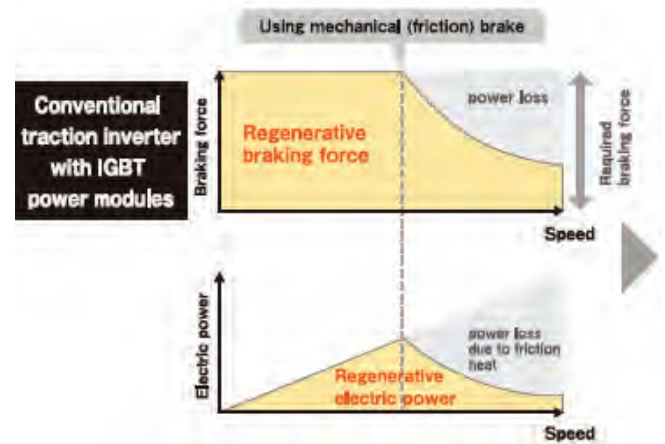
Figure 11. Regenerative braking with inverter using IGBT power modules
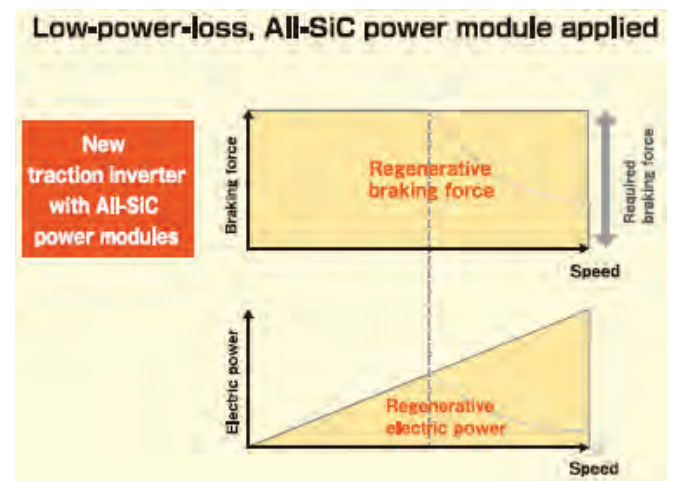
Figure 12. Regenerative braking with inverter using all SiC power modules

D. Efficiency comparision

Efficiency [5] is compared for a three-phase inverter with different power modules. An improved model [4] is considered for All – SiC power MOSFET.

Topology: Three phase inverter

Synchronous rectification (SiC version)

DC-link voltage: 400V DC

Current 480Arms (peak) 230Arms (nom)

Switching frequency: 16kHz

Vgs=+20V/-5V for SiC, Vge = ±15V for IGBT

PF: 0.8

Modulation index (MI): 1

The losses, efficiency and current vary as shown in Fig.13 Fig.14 and Fig.15 respectively. The All – SiC based inverter had 75 percent lower loss [5] than a conventional IGBT based inverter. Practically [6] the All - SiC based inverter had 40 percent lower loss. Fig.16 wider operating area of All – SiC power module comparing it with a conventional Si base power module. The All – SiC module can operate at higher switching frequency and temperature with lower losses.

Inverter losses vs %load

Figure 13. Loss in inverter as a function of load

Inverter efficiency vs %load
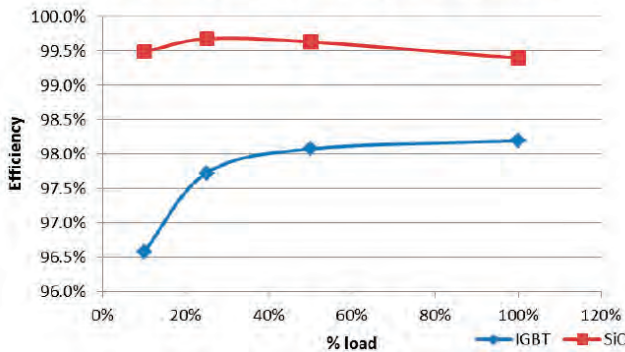
Figure 14. Efficiency of inverter as a function of load.
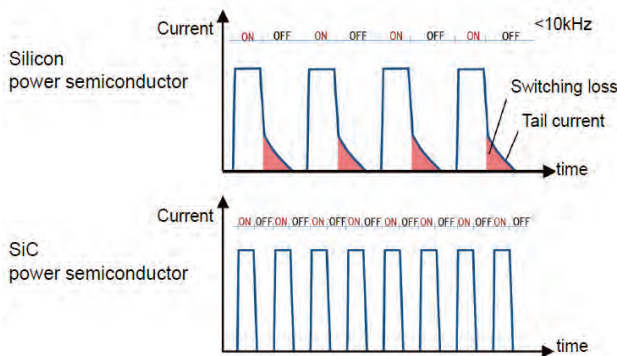
Figure 15. Current waveforms

Figure 16. Wider operating area of SiC

Mitsubishi has also started to test a silicon carbide traction converter/inverter system on Shinkansen "bullet" trains operated by the Central Japan Railway Company. These are claimed to be the first 3.3kV, 1500A traction systems to be installed on a high-speed train. Mitsubishi has been working to shrink traction systems for bullet trains.

The use of the SiC power modules reduces the size of the converter/inverter system by about 55 percent compared to existing systems – and the weight by about 35 percent. The weight of the traction motor, including the drive system, is reduced by around 15 percent. The inverters are being used to power four 305kW traction motors. Mitsubishi developed the power modules – which incorporate three-level PWM inverters with regenerative braking.

Summary of Prototype:
Main Circuit Converter: Three-level modulated single-phase PWM converter
Inverter: Three-level modulated three-phase VVVF inverter
Device used for Converter: 3,300V -1,200A SiC power semiconductor module
Inverter: 3,300V - 1,200A SiC power semiconductor module
Control system: Four 305-kW motors, parallel control
Cooling system: Natural ventilation cooling system

Cree introduced the industry's first commercially available all-silicon carbide (SiC) six-pack power module in an industry standard 45 mm package. When replacing a silicon module with equivalent ratings, Cree's six-pack module reduces power losses by 75 percent, which leads to an immediate 70 percent reduction in the size of the heat sink, or a 50 percent increase in power density. The six-pack SiC module unlocks the traditional design constraints associated with power density, efficiency and cost, thereby enabling the designer to create high performance, reliable and low-cost power conversion systems. When compared to state-of-the-art silicon modules, the SiC 1.2 kV, 50 A modules deliver performance equivalent to silicon IGBT modules rated up to 150 A depending upon efficiency requirement and switching frequency. Gate driver ICs suitable for SiC MOSFETs are available from IXYS, Texas Instruments and most recently from Avago.

III. CONCLUSIONS

Currently lowest possible losses in a traction inverter can be achieved only by using all – SiC power modules. These modules have excellent characteristics in terms of efficiency, switching frequency and operation at high temperature. These modules will gradually replace conventional modules in inverters used in traction.

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LabVIEW Based Level Control of Coupled Tank System

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Abstract: **This paper utilizes Variable Structure Control (VSC) to control the level of a two tank system. By using Sliding Mode Technique in VSC, the levels of the tanks are maintained at a desired setpoint. The system is subjected to the conventional PID controller and the results are brought out. To track the robustness of the system, an external disturbance is intentionally introduced. The ability of disturbance rejection is checked in both VSC and PID controllers. It is found that VSC offers quick settling time, low peak overshoot and low rise time, and as compared to PID control. LabVIEW(Laboratory Virtual Instrument Workbench) is the software used for the control of the whole process. This is very user friendly software. It uses Graphical programming technique. As an extension the control can be implemented by hardware using DAQ cards.**

Index Terms: **Variable Structure Control, Sliding Mode Technique, PID control, LabVIEW.**

I. INTRODUCTION

Variable Structure system contains several subsystems whose parameters can be changed or switched according to the state of the system [1]. The transfer function or the gain of the system can be changed, also the entire system can be changed in such systems. For such variable structure systems, one of the special type of control methods is Sliding Mode Control. Emelynov [2], Utkin[3] proposed and elaborated about Variable Structure systems with Sliding Mode Control (SMC) in their early research studies. This paper presents the level control of a two tank system. Phase canonical form is not employed for implementing SMC. To employ this type of control, the mathematical model of the tanks is derived. The mathematical model obtained is typically a first order system. Sliding Mode Control is applied to the first order system and later the control law is obtained [4]. The results of the controllers are compared and best controller is suggested. LabVIEW is used for simulation. This is used because it is more hardware friendly. The version of the software used is LabVIEW11. LabVIEW is a highly productive development environment that is used by engineers and scientists. This programming is used due to its graphical programming and hardware integration to rapidly design and deploy measurement and control systems [5]. Using LabVIEW the whole process is monitored and controlled. Remote systems are also controlled through internet. This additional feature increases the ease of accessibility of the level process plant

parameters even from remote places. The main idea of this paper is to present the response of the system using Variable Structure Control incorporating Sliding Mode Technique and conventional PID control. The results of both the control schemes are compared.

II. SYSTEM DESCRIPTION

This paper is a continuation of modeling of a single tank system [6]. The Fig.1. shows the schematic of a double tank system. It consists of two hold-up tanks which are identical and connected by an orifice. A variable speed pump is used to supply the input which supplies water to the first tank. The orifice present in the bottom of the first tank allows the water to flow into the second tank and in turn out to a reservoir. The objective of this control problem is to adjust the inlet flow rate q(t) so as to maintain the level in the second tank, h2(t) close to a desired set point level, H.
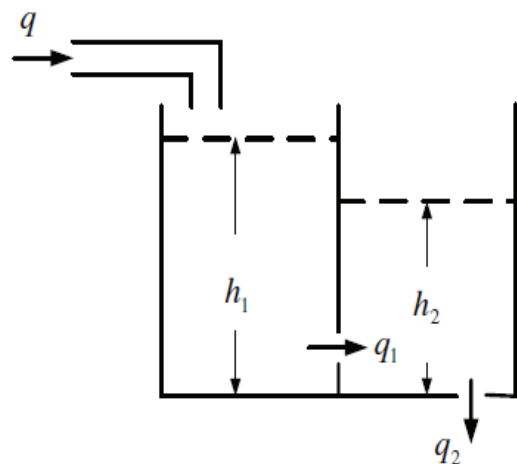
Figure 1. Schematic of the two tank system

The dynamic model of the coupled tanks is represented in (1) and (2).

$$\frac{dh_1}{dt} = \frac{1}{C}\left(-q_1 + q\right) \tag{1}$$

$$\frac{dh_2}{dt} = \frac{1}{C}\left(q_1 - q_2\right) \tag{2}$$

where

$$q_1 = c_{12}\sqrt{2g(h_1 - h_2)} \quad for \; h_1 > h_2$$
$$q_2 = c_2\sqrt{2gh_2} \quad for \; h_2 > 0$$

and

h1(t): Level of first tank;
h2(t): Level of second tank;
q1(t): Flow rate from first Tank to second Tank;
q2(t): Flow rate of second Tank ;
q(t): Inlet flow rate;
g: the gravitational constant;
C: Cross-section area of first Tank and second Tank;

c_{12}: Coupling orifice area;

c_2 : Outlet orifice area.

As for the two tank set up, the fluid flow, q, into Tank 1, cannot be negative because the pump can only pump water into the tank. Therefore, the constraint on the inflow rate is given by (3) and (4).

$$h_1 = -\frac{c_{12}}{c}\sqrt{2g|h_1 - h_2|}sgn(h_1 - h_2) + \frac{1}{c}q \tag{3}$$

$$h_2 = \frac{c_{12}}{c}\sqrt{2g|h_1 - h_2|}sgn(h_1 - h_2) - \frac{c_2}{c}\sqrt{2gh_2} \tag{4}$$

At equilibrium, for constant water level set point, the derivatives must be zero, as in (5).

$$h_1 = h_2 = 0 \tag{5}$$

Thus, at equilibrium, (6) and (7) hold true

$$\frac{c_{12}}{c}\sqrt{2g|h_1 - h_2|}sgn(h_1 - h_2) + \frac{1}{c}q = 0 \tag{6}$$

$$\frac{c_{12}}{c}\sqrt{2g|h_1 - h_2|}sgn(h_1 - h_2) - \frac{c_2}{c}\sqrt{2gh_2} = 0 \tag{7}$$

where Q is the equilibrium inflow rate.

As always flow rate is greater than zero and the height of the water is a positive variable. Hence $sgn(h_1 - h_2)$, this implies (8)

$$h_1 \geq h_2 \tag{8}$$

Let

$$z_1 = h_2 > 0, z_2 = h_1 - h_2 > 0$$

$$z_1 = \begin{bmatrix} z_1 \\ z_2 \end{bmatrix}, \qquad u = q$$

And

$$a_1 = -\frac{c_2}{C}\sqrt{2g}$$
$$a_2 = -\frac{c_{12}}{C}\sqrt{2g}$$

The output of the second tank is the final output of the two tank system. Therefore, the dynamic model can be written in (9) and (10).

$$z_1 = -a_1\sqrt{z_1} + a_2\sqrt{z_2} \tag{9}$$

$$z_2 = -a_1\sqrt{z_1} - 2a_2\sqrt{z_2} + \frac{1}{C}u \tag{10}$$

$$y = z_1$$

The objective of the control scheme is to regulate the output $y(t) = z_1(t) = h_2(t)$ to a desired value H. If $y(t) = z_1(t)$ is regulated to a desired value H, then $z_2 = h_1(t) - h_2(t)$ will be regulated to the value $\frac{a_1{}^2}{a_2{}^2}H$.

The dynamic model of this system is highly nonlinear. Therefore, a transformation is defined in such a way that the dynamic model is transformed into a form that facilitates the control design.

Let $X = \begin{bmatrix} x \\ x_2 \end{bmatrix}$, and define the transformation x = T(z) as in (11) and (12)

$$x_1 = z_1 \tag{11}$$

$$x_2 = -a_1\sqrt{z_1} + a_2\sqrt{z_2} \tag{12}$$

The inverse transformation z = T⁻¹(x) is written as (13) and (14)

$$z_1 = x_1 \tag{13}$$

$$z_2 = \left(\frac{a_1\sqrt{x_1} + x_2}{a_2}\right)^2 \tag{14}$$

The dynamic model is written as (15) and (16)

$$x_1 = x_2 \tag{15}$$

$$x_2 = \frac{a_1 a_2}{2}\left(\left(\sqrt{\frac{z_1}{z_2}} - \frac{z_2}{z_1}\right) + \frac{a_1^2}{2} - a_2^2 + \frac{a_2}{2C}\frac{1}{\sqrt{z_2}}U\right) \qquad (16)$$

Hence, the dynamic model of the system can be written in a compact form as (17) and (18)

$$x_1 = x_2 \qquad (17)$$

$$x_2 = f + \emptyset u \qquad (18)$$
$$y = x_1$$

Where

$$f = \frac{a_1 a_2}{2}\left(\left(\sqrt{\frac{z_1}{z_2}} - \frac{z_2}{z_1}\right) + \frac{a_1^2}{2} - a_2^2\right)$$

$$\emptyset = \frac{a_2}{2C}\frac{1}{\sqrt{z_2}}$$

The dynamic model is used to design control schemes for the two tank system.

III. STATIC SLIDING MODE CONTROLLER FOR A TWO TANK SYSTEM

Let α_s and Ws be positive scalars. Also, let H be the desired constant value of the output of the system.
Define the sliding surface σ_s as (19)

$$\sigma_s = x_1 + \alpha_1(x_1 - H) \qquad (19)$$

$$x_2 = -a_1\sqrt{z_1} + a_2\sqrt{z_2} + \alpha_S(x_1 - H)$$

The sign function is
$$\mathrm{sgn}(b) = \begin{cases} +1 & if\ b > 0 \\ 0 & if\ b = 0 \\ -1 & if\ b < 0 \end{cases}$$

$$u = \frac{2C\sqrt{z_2}}{a_2}\left[-\frac{a_1 a_2}{2}\left(\frac{\sqrt{z_1}}{\sqrt{z_2}} - \frac{\sqrt{z_2}}{\sqrt{z_1}}\right) - \frac{a_1^2}{2} + a_2^2 - \alpha_s\left(-a_1\sqrt{z_1} + a_2\sqrt{z_2}\right)\right]$$

asymptotically stabilizes the output of the system y = z1 = h2 to its desired value H.

The sliding equation mainly depends on (20).

$$\sigma_S = -W_s Sgn(\sigma_s) \qquad (20)$$

The trajectories are associated with the unforced discontinuous dynamics. They reach to zero within a finite time reachability given initial condition provided that the constant Ws is positive. Since σ_s is driven to zero in finite time, the output y = z1 = h2 is governed after such a finite time, by the first order dynamics

$$y + \alpha_s(y - H) = 0$$

Therefore, the output y(t) will asymptotically converge to its desired value as α_s is a positive scalar. Hence the static sliding mode controller guarantees the asymptotic convergence of the output y(t) = z1(t) = h2(t) to its desired value H.

The chattering problem affects the proposed control scheme [7]. The chattering is due to the assumption that the control can be switched from one value to another at any moment and with almost zero time delay [8]. The chattering can be reduced by using a boundary layer. Also dynamic sliding mode control can be used to reduce the chattering [9]. To test the effectiveness, a dynamic sliding mode controller is proposed in the next two sections.

IV. DYNAMIC SLIDING MODE CONTROLLER FOR A TWO TANK SYSTEM

To reduce the chattering due to the static sliding mode controller, a dynamic sliding mode controller is proposed in this section [10]. Let α_1, α_2 and Wd be positive scalars. Also, let H be the desired value of the liquid in Tank 2. Define the input-dependent sliding surface σ_d is (21)

$$u = \begin{pmatrix} \frac{2C\sqrt{z_2}}{a_2} f_1 + \alpha_1 \left(\frac{a_1 a_2}{2} \left(\frac{\sqrt{z_1}}{\sqrt{z_2}} - \frac{\sqrt{z_2}}{\sqrt{z_1}} \right) + \frac{a_1^2}{2} - a_2^2 + \frac{a_2}{2C} \frac{1}{\sqrt{z_2}} U \right) + \alpha_2 (-a_1\sqrt{z_1} \pm a_2\sqrt{z_2}) + W_d sgn(\sigma_d) \\ + \frac{1}{2z_2} \left(a_1\sqrt{z_1} - 2a_2\sqrt{z_2} + \frac{1}{C} u \right) u \end{pmatrix} \tag{21}$$

With

$$f_1 = \frac{a_1 a_2 (z_1 + z_2)}{4\sqrt{(z_1 z_2)^3}} a_1 z_1^{3/2} - 2a_2 z_1 \sqrt{(z_2)} + \frac{1}{C} z_1 u + a_1 z_2 \sqrt{(z_1)} - a_2 z_2^{3/2}$$

$$\sigma_d = y_1 + \alpha_1 x_1 + \alpha_2 (x_1 - H)$$

$$\sigma_d = \left(\frac{a_1 a_2}{2} \left(\frac{\sqrt{z_1}}{\sqrt{z_2}} - \frac{\sqrt{z_2}}{\sqrt{z_1}} \right) + \frac{a_1^2}{2} - a_2^2 + \frac{a_2}{2C} \frac{1}{\sqrt{z_2}} U \right) + \alpha_1 (-a_1\sqrt{z_1} \pm a_2\sqrt{z_2}) + \alpha_2 (z_1 - H)$$

asymptotically stabilizes the output of the system y(t) = z1(t) = h2(t) to its desired value H.

Proof: Taking the derivative of sliding surface σ_d. This indirectly indicates (22)

$$\sigma_d = -W_d sgn(\sigma_d) \tag{22}$$

The trajectories associated with the unforced discontinuous dynamics exhibit a finite time reachability to zero from any given initial condition provided that the constant W_d is positive. Since σ_d is driven to zero in finite time, the output y = z1 = h2 is governed after such a finite time, by the second-order dynamics in (23)

$$y + \alpha_1 + \alpha_2 (y - H) = 0 \tag{23}$$

Therefore, the output y(t) will asymptotically converge to its desired value H since α_1 and α_2 are positive scalars. Hence the dynamic sliding mode controller guarantees the asymptotic convergence of the output y(t) = z_1(t) = h_2(t) to its desired value H.

V. RESULTS

The areas of the orifices, c_{12} and c_2, have been experimentally determined using steady-state measurements. The values of these parameters are listed in Table 1. The cross-section area of Tank 1 and Tank 2 are found to be 208.2 cm². The gravitational constant is 981 cm/s². The desired value of the output of the system is taken to be H = 10 cm.

To obtain realistic results, the simulations are carried out using the following input constraint, $0 \text{ cm}^3 /s \le u \le 50 \text{ cm}^3/s$. Table 1 shows the constants used in the simulation.

TABLE I.
CONSTANTS FOR SIMULATION

Parameters	Values(cm²)
c_{12}	0.58
c_2	0.24
C	208.2

A. Static sliding mode controller of double tank system

The controller parameters used in the simulations are taken to be $\alpha_s = 0.1$ and $W_s = 10$ after several iterations. The following figures show the simulation results when the static sliding mode controller is used. It can be seen from Fig. 2. that the output $y(t) = z_1(t) = h_2(t)$ converges to its desired value H in about 160 s. The control input $u(t) = q(t)$ is shown in Fig. 3. chattering is evident in this graph.
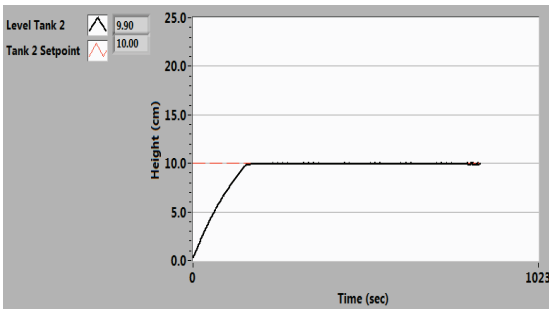
Figure 2. Liquid tank level in Tank 2 when static sliding mode controller is used.
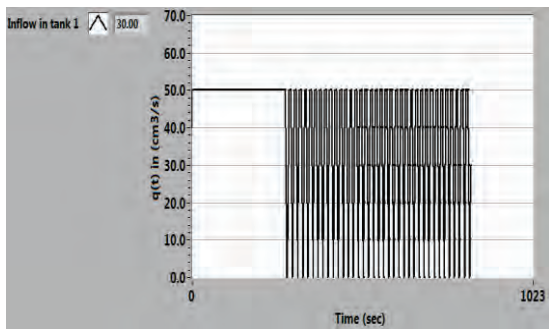
Figure 3. Inflow rate into Tank 1 when static sliding mode controller is used.

B. Dynamic sliding mode controller of a two tank system

The controller parameters used in the simulations are taken to be $\alpha_1 = 1$, $\alpha_2 = 2$, and $W_d = 5$. The following figures show the simulation results when the dynamic sliding mode controller is used. It can be seen from Fig. 4. that the output $y(t) = z_1(t) = h_2(t)$ converges to its desired value H in about 220s. The control input $u(t) = q(t)$ is shown in Fig. 5. note that chattering [12] is greatly reduced.
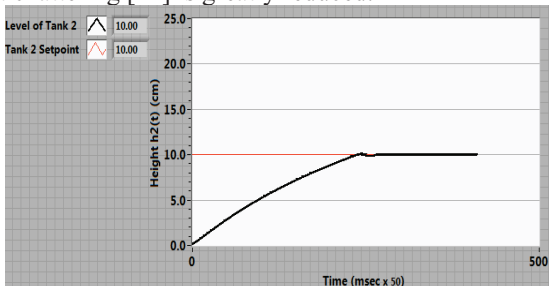
Figure 4. Level of Liquid in Tank 2on application of Dynamic sliding mode controller.
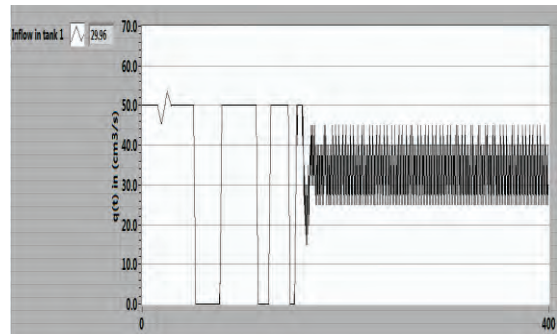
Figure 5. The input flow rate of tank 1 on application of Dynamic Sliding Mode controller.

C. PID controller of a two tank system

The controller parameters used in the simulations are taken to be Kc = 5.8, Ti = 2.4, and Td = 0.5. The tuning used is zeigles nicolos method [11] It can be seen from Fig. 6. that the output $y(t) = z_1(t) = h(t)$ converges to its desired value H (setpoint) in about 135 s. The control input $u(t) = q(t)$ is shown in Fig. 7. note that there is an overshoot.
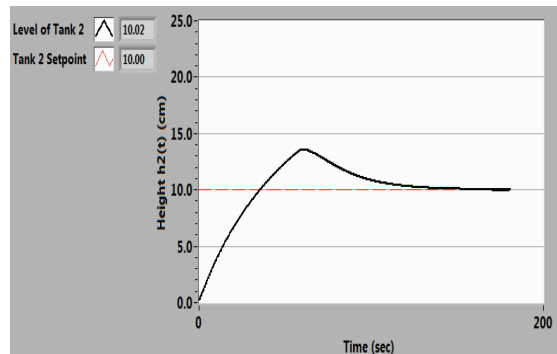
Figure 6. Liquid tank level in Tank 2 when PID controller is used.
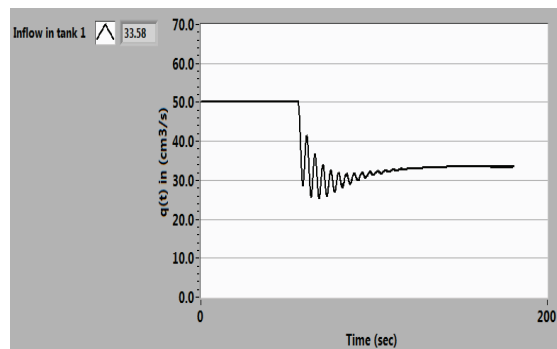
Figure 7. Inflow rate into Tank 1 when PID controller is used.

VI. Conclusions

The following are the conclusions derived from the above simulations. It is found that PID controller had an overshoot whereas both the SMC and Dynamic SMC didn't exhibit peak overshoot. The settling time were 135s, 220s and 160s for PID, Dynamic SMC and SMC respectively indicating PID controllers were faster than the other two controllers. But the chattering in the flow rate response is minimal in the Dynamic SMC [12] thereby making this controller more suitable for maintaining less wear and tear especially for the final control elements.

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Improving Life of Self-Configuring Wireless Sensor Network using Clustering Mechanism

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Abstract: **Mobile Adhoc NETwork, popularly known as MANET, is one of the networks, which is dynamic in nature, due to the reason that the nodes are added and removed as per the need. Hence, the architecture of the network is changing continuously with reference to the addition or removal of the nodes. To acquire efficient functionality from the network, the network is set to configure automatically [7]. Another associated task in this dynamic network is the inclusion of new node to the network at any instance of time. Due to this the N/w size grows drastically, as a result of which, managing the nodes in the n/w becomes tedious and the dynamic behavior of the n/w becomes more critical [8]. In proposed and implemented work, I have designed an Intelligent Auto configuration (IAC) method in Mobile Adhoc NETworks, in which efficiency and reliability has improved significantly, compared to the traditional, Dynamic Address Allocation (DAA), in Mobile Adhoc networks. In this research work, the n/w is divided into small segments called clusters and each cluster is controlled by a Cluster Head (CH), which will be defined under multiple parameters including Connectivity vector, Stability vector, and Trust vector. In this network, the overload and under load conditions are managed with the help of Wireless Sensor network, reconfigured for a particular Cluster [9]. The overload is the condition, where, the number of packets is beyond the capacity of network interface queue size and underload condition is that, the number of packets in the network is very less, so that, most of the time the network is idle. In the proposed work I have used Matlab for its implementation.**

Index Terms: MANET, auto Configuration, WSN, Cluster.

I. INTRODUCTION

The MANET, consists of independent (autonomous) computers, referred as nodes, in which each one collaborates by forwarding the packets to/between each other, so that they communicate with outside range of direct wireless transmission. In the Mobile Adhoc NETwork, it is not necessary to have a centralized administration control or fixed network infrastructure as required in traditional networks [10]. At any instance of time the information access point can be created quickly and inexpensively as needed. Due to wireless links, the communication in MANETS is slow as compared to wired links.

The nodes in this type of network handles the network activities such as topology recognition and message transfer. Thus, the mobile nodes themselves handle the routing function.

One of the important characteristics of this work is that, there is no need to configure the network, because, the network configures itself automatically. All the nodes whether, routers, host or simple node auto-configures themselves [2], which are connected through wireless links. The nodes which function as routers are free to move from one cluster to other cluster or even from one N/w to other N/w. Any node which wants to transfer message can do so only if it has a valid policy token and the required capability. As the network is connectionless oriented (i.e. wireless), in any random way, as per the requirement, new nodes may be added, or existing unrequired passive nodes may be removed from the network as a result of which network architecture changes continuously in an unpredictable level. The MANET can work in a standalone fashion or it can be connected to other N/ws (small or large), to coordinate the functioning of the entire merged network [3].
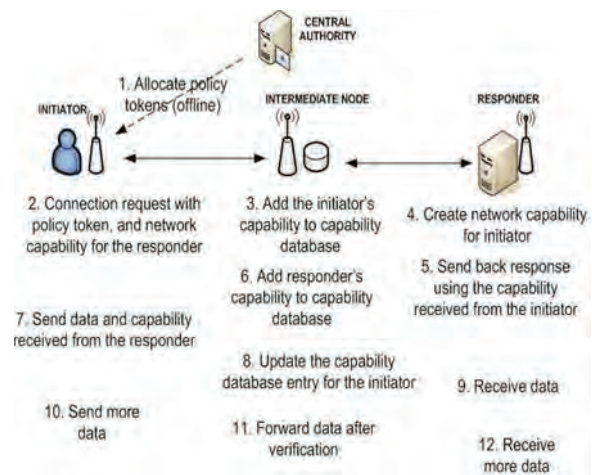
Figure 1. MANET System Architecture

Figure 1 depicts the architecture of Mobile ad-hoc N/w, which has one or more nodes acting as *Group Controller* (GC). The function of Group Controller is to allocate the required resources to the nodes during communication in the network. The allocation of resources is an important parameter and is allocated in the form of *Policy Token*. The policy tokens are signed by Group Controller and

the signature is in encrypted form and can be verified by any node in the network. if a node has some data to send to other node, then the transmitting node(initiator) requests the receiver node(responder) to provide its service. The receiver node then sends back the capability to the transmitting node. This is called as *Network Capability*.

The major attributes of MANETs are as follows:
- Connectionless oriented communication.
- The role of Hosts and Routers Performed by nodes.
- The Bandwidth Constraints and Varying Capacity.
- Limited physical security.
- Dynamic Network Topology.

The following section discusses the properties of Mobile Adhoc NETwork.

1.1 Properties of Mobile Adhoc NETwork routing protocols

In the following section the properties are discussed in detail pertaining to MANETs.

1.1.1) Distributed operation: The protocol must be distributed. It should be independent of centralized node. This distributed operation gives the nodes the capability of entering or leaving the network as and when required, due to which the network changes and is required to be partitioned or merged as per the requirement.

1.1.2) Loopless network: The N/w performance can be improved, if the routing protocol assures, the routes to be free from loops. This ensures the efficient utilization of bandwidth or CPU capability [12].

1.1.3) On Demand Operation: The network has to manage overhead for resources and other control mechanisms, so to keep the control overhead within permissible limits in the network to ensure the efficient utilization of the network resources, the protocol should be active all the time and should respond only when required.

1.1.4) Unidirectional link: Due to high frequency signal in the ad-hoc networks, it uses unidirectional links. Due to unidirectional links, in which, data flows in only one direction at a time, throughput will enhance in the network.

1.1.5) Security: Any time there may be attack on the network from unreliable sources, due to the presence of high frequency signals, called as radio frequency signals. To provide security from this type of attacks the network should use security for routing. The ways to provide security are, one is 'Authentication' and the other means is 'Encryption'.

1.1.6) Multi-directional routes: To decrease the congestion in the network, the use of multiple routes is recommended. This is necessary because, the network is dynamic, in which the nodes get added and removed as per the need. This dynamically changes the topology and size of the network.

1.2 Problems in routing with MANET

1.2.1) Dissimilar links: Many of the connection oriented networks depends upon symmetric links that are fixed i.e they are static in nature. But in Mobile Adhoc NETworks the nodes are not fixed in the network. They change their position/cluster as and when required. Hence the links have dissimilar architecture.

1.2.2) Network-overhead: In Mobile Adhoc NETwork, due to continuous changing network topology there are always some stale routes that are preserved in the routing table. These stale routes are required to be deleted, so that they do not lead to wrong routes (and new routes are required to established). This leads to Routing Overhead.

1.2.3) Interference: Due to the presence of number of channels, the interference is the major problem in the wireless links.

1.2.4) Dynamic Topology: As the nodes are inserted and removed in the N/w frequently, the topology keeps on changing continuously. So, Routing tables in the N/w must get updated frequently as and when required and the routing algorithms have to adapt to these changes.

II. EXISTING WORK

In the existing scheme called, Dynamic Address Allocation, the process of auto-configuration takes place as follows:

In wired networks each node is having an IP address, which is unique for each of the node. The IP address allocation is done by a server or a node acting as such which correctly assigns IP addresses. While, in mobile adhoc networks, there is no such centralized entity capable of carrying out this function. Therefore, a protocol is needed to perform the network configuration automatically and in a dynamic way, which will use all nodes in the network (or part thereof) as if they were servers that manage IP addresses. In my work one such most recently developed protocol called as D2HCP (Dynamic Host Configuration Protocol), is used for autoconfiguration.

In the existing scheme, the Adhoc NETwork is consisting of clusters and within each cluster, cluster-head is playing a vital role, which is responsible for managing the resources in the entire network [11]. As, the network in Mobile Adhoc NETwork is dynamic, the size of the network is continuously changing. If the mobile network grows in size, then it is partitioned into smaller networks. On the other hand, if the network shrinks then the number of such networks are merged. Under such circumstances each node is required to be assigned the HOST ID and MANET ID on the basis of their base value. There are mainly two techniques for merging; one is strong merging and the other is the weak merging technique. Table 1 shows the observations for these two merging techniques.

TABLE I.

STRONG AND WEAK MERGING TECHNIQUES

Sl.No		Rounds	Strong Merging Support	Weak Merging Support
01		50	28	11
02		100	60	31
03		150	78	45
04		200	84	52
05		250	85	62
06		300	90	70
07		350	92	72
08		400	93	80
09		450	94	83

Figure 2 plots the strong and weak merging techniques support, taking rounds on x-axis and merging support on y-axis. From the plot it is clear that strong merging technique supports more hops than weak merging technique.
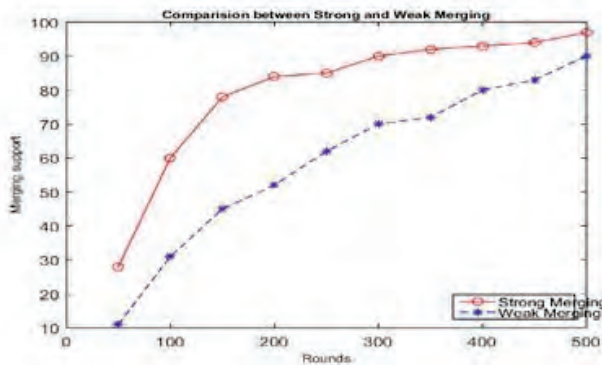
Figure 2. Comparing strong and weak merging techniques

In the traditional DAA, no hierarchy in the network is maintained, so if any of nodes become inactive during communication, then the whole network becomes useless. Further in this method no scheme is specified to include a new node in the network and no trust is defined.

Also, the Cluster Head does not monitor the overload and underload conditions.

Further auto-configuration improves performance over mobile network [13].

Finally, a multiple parameter approach is provided to configure the network.

III. PROPOSED WORK

The proposed work, Intelligent Auto Configuration (IAC) [14], is an improvement over the traditional Dynamic Address Allocation (DAA) in Mobile Adhoc networks, (and is presented with auto-configuration concept) [4]. Here the Wireless Sensor Network (WSN) is used. Based upon a number of parameters, the network configures itself, which is nothing but autoconfiguration. In traditional networks the reliability is achieved by retransmission of the lost packets. This scheme increases the overhead and also a lot of resources and time is consumed. To avoid this most of the WSNs use the scheme

of redundancy by any one of the schemes, either hop-by-hop or end-to-end scheme. Hop-by-hop method allows the intermediate nodes to perform retransmission. On the other hand, end-to-end approach retransmission is performed only at the source and destination nodes. This way the efficiency and reliability increases.

The clustering mechanism used is "Mobility-aware clustering" such as, MOBIC. In this clustering mechanism nodes disseminate their mobility information (speed and direction). In this scheme, the node with lowest mobility is selected as Cluster-head. The work is defined as follows:

3.1 Formation of Network with cluster mechanism

At the initial stage, when the *Wireless Sensor Network* is configured, the analysis of network will be under the clustering mechanism [5]. Here the network will be divided into smaller partitions called clusters and each cluster is having cluster-center and cluster objects (Nodes) as cluster members. The cluster membership of a node will depend on three main parameters:

1. Connectivity vector
2. Trust vector
3. Stability vector.

One of the nodes will be selected as Cluster Head (CH). Each cluster has an independent CH. The CH is the one which has long association with that cluster or which has least mobility.

3.2 To Handle Overload - underload conditions

When clusters are formed, then the next task is monitoring these clusters to identify the overload and under load conditions. In case of overload, the cluster is divided into small clusters where as in the case of under load condition, clusters are merged to form a large cluster. The re-clustering mechanism and network configuration will be performed under such circumstances. This equalizes the distribution of nodes over the network as well as provide stability over the network [1].

3.3 New Node Inclusion

In the next step, the addition of a new node to the network will be done based on sequential-analysis algorithm.

IV. IMPLEMENTATION

Figure 3 shows how the Mobile-Adhock NETwork is formed based on clustered mechanism.
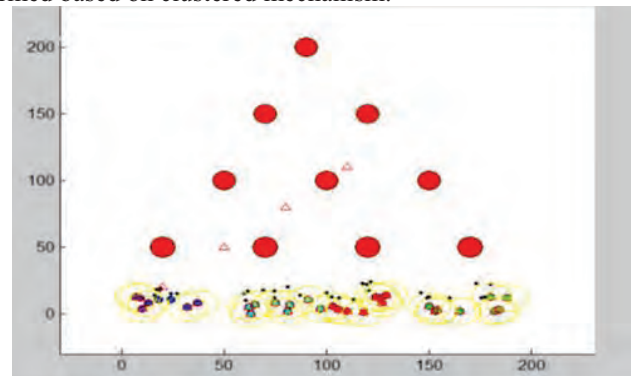
Figure 3. N/w configuration based on cluster

The hierarchical N/w which is formed under clustered mechanism is used to describe the communication among all the nodes responsible for improvement of reliability and efficiency of the network [6]. The network has a base station. The nodes which are depicted in red color forms clusters and all other nodes participate in communication in the network.

Table 2 shows Dead Nodes in a WSN in Existing Versus Proposed implemented work.

TABLE II.
DEAD NODES IN EXISTING WORK VS PROPOSED WORK

Sl.No.	Rounds	Dead Nodes	
		Existing Work	Proposed Work
01	25	20	0
02	50	32	0
03	75	37	17
04	100	37	22
05	200	38	27
06	300	38	28
07	400	38	31
08	500	38	32
09	600	38	35
10	700	38	35
11	800	38	37
12	900	38	37
13	1000	38	37

Observations of table II are plotted in figure 4.
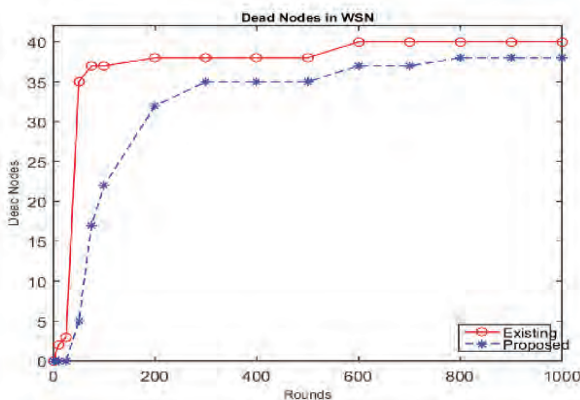
Figure 4. Nodes in WSN that are not active

Figure 4. Shows the analysis of dead nodes in both existing work (Blue curve) and proposed and implemented work (Green curve). It is clear from the figure, that the existing work require more energy and hence the life of the network is reduced. In contrast to this, the proposed implemented scheme increases the efficiency in terms of energy conservation and hence increases the life of the network.

Table 3 shows Active nodes in WSN in Existing Versus Proposed work, which is plotted in figure 5.

TABLE III..
ACTIVE NODES IN EXISTING VS PROPOSED WORK

Sl.No.	Rounds	Alive Nodes	
		Existing Work	Proposed Work
01	25	07	45
02	50	07	28
03	75	05	23
04	100	05	22
05	200	03	13
06	300	02	09
07	400	02	07
08	500	02	07
09	600	02	04
10	700	02	04
11	800	02	03
12	900	02	03
13	1000	02	03

Figure 5 Shows the number of alive nodes in Wireless Sensor Network in both proposed and existing work. It shows that network life remains up to 250 rounds in existing work whereas network life remains up to 800 rounds in the proposed implemented work.
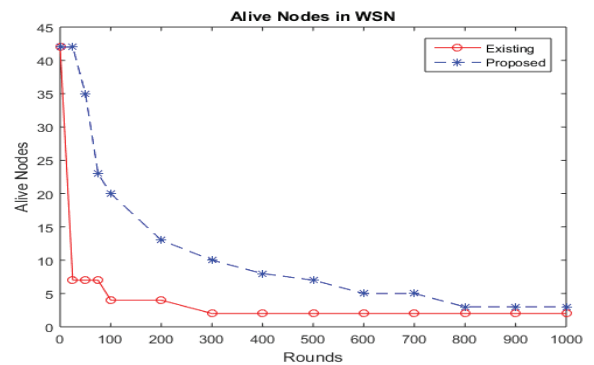
Figure 5. Active node in Wireless Sensor N/w

Table 4 shows Packets sent to Base Station in Existing Vs proposed work, which is plotted in figure 6.

TABLE IV.
PACKETS SENT TO BASE STATION

Sl.No.		Rounds	Packets Sent to Base Station	
			Existing work	Proposed work
01		25	50	200
02		50	60	400
03		75	80	550
04		100	85	600
05		200	90	900
06		300	100	1200
07		400	100	1250
08		500	100	1300
09		600	100	1400
10		700	100	1500
11		800	100	1600
12		900	100	1650
13		1000	100	1700

Figure 6 Shows the pkts transmitted to the BS (i.e. overall transmission to the Base Station over the network).
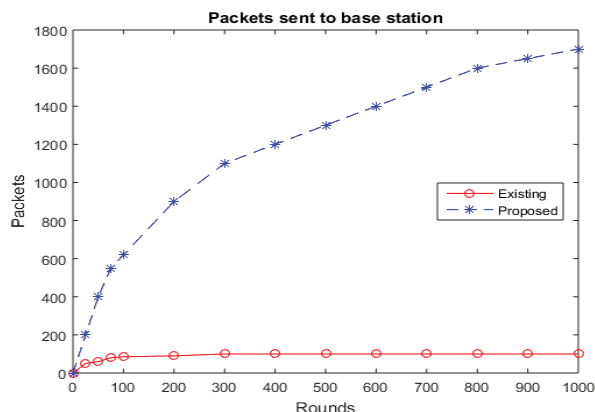
Figure 6. Pkts transmitted to the Base Station

From figure 6 it is clear that, the number of packets sent to the base station is more in implemented work, which increases the efficiency of transmission.

V. CONCLUSIONS & FUTURE WORK

The proposed implemented Intelligent Auto configuration (IAC) scheme uses multiparametric N/w which is partitioned into clusters. Each cluster in the network consists of its own cluster head and the Cluster Head selection is based on trust vector so that network reliability can be improved. The N/w also handles the overload and under load situations in the network. In this work, a network can handle the inclusion of a node in level based approach in order to make network more effective. Further, one can improve network efficiency and reliability by performing the experiments with existing auto configuration protocols which includes the size adjustment of transmitted packet.

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Genetic Algorithm based Optimized Image Registration using Fast Walsh Hadamard Transform

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Abstract: Numerous medical means are mandatory with accuracy and totality of data about a patient for a doctor for healthcare predictive analytics and so as to treat and take care of their patients' remedy. Medical image registration practices bestow more affluent diagnosis and medication information to the doctors in stipulating an all-embracing allusion resource for the beneficiaries entangled in image registration as an optimization crisis. In this research work, optimization of the Genetic Algorithm based image registration technique using Fast Walsh Hadamard Transform was implemented and their evaluation of results proved to be good.

Index Terms: Medical Image Registration, Fast Walsh Hadamard Transform, Ratio of Image Uniformity (RIU), Optimization, Genetic Algorithm.

I. INTRODUCTION

Image registration in medicine is the resolution of spatial transformation or representation that associates locations in single image specifically, the archetype picture, to their related loci in one or additional imageries called altered images from the identical or dissimilar imaging modalities [1].

The usages of medical image registration include monomodal image registration of the alike patient for observing and enumerating the sickness growth all across the time, assessment of intra-operative brain warping and intramural-operational image that steered persuasion of stereotactic devices and multimodal image registration.

Fast Walsh–Hadamard transform (FWHT) is a real progression to figure the Walsh–Hadamard transform (WHT). A straightforward effecting of the WHT of instruction $n = 2^m$ would take a computational impediment of $O(n^2)$. The FWHT demands merely n log n additions or subtractions. The FWHT is a decrease and overcome practice that is recursively splitting downhill a WHT of size n obsessed by two compact WHTs of size n/2. This procedure tag on the recursive portrayal of the 2^m X 2^m Hadamard matrix :

$$H_m = \frac{1}{\sqrt{2}}\begin{pmatrix} H_{m-1} & H_{m-1} \\ H_{m-1} & -H_{m-1} \end{pmatrix}$$

The $1/\sqrt{2}$ standardization parameters for each phase can be clustered mutually or still ignored.

This sequence ordered matrix, also known as Walsh ordered, Fast Walsh–Hadamard transform, FWHT, is acquired by calculating the FWHT as above, and then reordering the productions.

A modest fast non-recursive operation of the Walsh-Hadamard transform trails from disintegration of the Hadamard transform matrix as $H_m = A^m$, where A is m^{th} basis of H_m [2].

Optimization in image registration by means of Genetic Algorithm (GA) is to establish the conversion factors namely translation, rotation and scaling that score the least denomination of a space computation that is one of the intents of image registration [3]. The accomplishment in creation of the best or utmost good function of a status quo encompasses realizing the best factors corresponding to an intent function that is moreover decreased or increased.

Fast Walsh Hadamard transform is more reliable in medical image registration consuming less time [4].

Performance Metrics: Ratio of Image Uniformity (RIU) is castoff so as to qualitatively evaluate the execution of the algorithms and associate with prevailing algorithms. To compute the similarity of images similarity measures are manipulated. The selection of similarity measure be influenced by the modality of images to be registered. Ratio of image uniformity are exercised for monomodal image registration.

This work deliberates the purpose of Genetic Algorithm for the choice of transformation parameters (x, y, θ , s) to be applied in image registration using FWHT algorithm. Analysis was carried out with the medical images and the best outcomes for registration of monomodal images are acquired.

II. REVIEW OF LITERATURE

Genetic algorithm is portrayed by [5] for the deconvolution drawbacks of image restoration and it is demonstrated as an optimization challenge, whose price function is reduced established on system of natural selection and natural genetics.

Venkateshwara Rao Ch et al instigated and estimated a group of programmed registration processes to rectify the geometric faults of the input image with respect to the altered image, by amplifying the precision level of the registration and minimizing the Root Mean Square (RMS) error to less than a pixel. Numerous processes such as Wavelet Transformation method, Fast Fourier Transformation method, Morphological Pyramid approach and Genetic Algorithms were established and evaluated.

These processes ponder the alteration model to sub-pixel accuracy [6].

Medical images of CT, PET or MRI images were well-thought-out for investigation. But the algorithm conferred involves both the images to be of the identical scale. Chung-Hsien Huang et al anticipated a registration technique established on adaptive genetic algorithm to accomplish the registration of CT and facial surface data. The writers applied chain code scheme to lessen a big quantity of surface data and decreased the decision-making time proficiently. With the idea of the genetic algorithm in continuous space (GACS), enhancement in evolutional processes of chromosomes crossover and mutation was accomplished to hurry up the convergent process of GA. The registration technique anticipated by the writers can be castoff for non-fiducial, stereotactic brain surgeries and aid surgeons to analyze and heal brain illness precisely and easily [7].

Marcus Johansson rendered outcomes of both the genetic algorithm and simulated annealing optimization techniques as viable substitutes for execution of image registration. Assessments carried out by the writer specified zero-error registrations with four renovations [8].

Flavio Luiz Seixas et al focused on the image registration complexity by harnessing the genetic algorithm background. The instigators concentrated on the point matching setback with a technique built on nearest-neighbor [9].

In this script, the generative model for affine transformations on image points have been pondered. How the amalgamation of suitable priors of the transformation and noise into the generative model have been defined steers to the improved assessments. The usage of these approximators are exhibited on the complications of object recognition, image registration and comparison. It is perceived that the Bayesian technique outshines all additional approaches and this fabrication of the probabilistic invariant is desirable upon others [10].

Explorers propounded an innovative technique for the intermodal registration of images by means of a measure Mutual Information and they powerfully emphasize that their solutions are outstanding than the rest of the works as their outcomes such as robustness, accuracy is proved to be utmost high and mighty [11].

In this research, a newfangled automated system to register retinal images was described and tested in a medical atmosphere in view of the consistency, suitability and efficiency of diverse image transformation models and function optimization methods, succeeding an opening preprocessing phase. Three dissimilar transformation models-affine, bilinear and projective-in addition to three optimization schemes-downhill simplex method, simulated annealing and genetic algorithms-are explored and associated in terms of accuracy and efficiency [12].

This artefact conferred the traditional approaches in image registration as of the characteristics of cross-modal adaptation and geometric renovation of an image, measurement of similarity, repetition and optimization, furthermore to additional sections. In the arena of medical image investigation, image registration endures as one of the maximum explored topics. Yet, numerous complications persist to be resolute in this zone. A unique complexity is that medical images are typically grayscale images that orders advanced necessities in parameter optimization and modifications. Further hindrance is that the way in which to stimulate the accuracy and speed of registration. Likewise, the robust is one of the drawbacks that obstructs the progress of registration. Promoting research in this coverage area must concentrate on success by means of this inadequate data in handling high-accuracy registration, whereas decreasing the registration and computation time to intensify the time sensitivity of registrations [13].

The Optimized Automatic Image Registration scheme in MIPAV dominates by the key tactic for ascertaining a global optimal renovation in estimating a minimal price function, and maximal resolutions between the reference and target images at numerous dissimilar resolutions opening with the least resolution. Each step of escalating resolution operates with the formerly verified optimal transformation as an initial point and further hones its estimates. This technique frequently works fine with the images of the same modality [14].

In this research three pioneering registration approaches were conceived with the interpretations of the mutual information and optimization technique: (1) mutual information pooled with the downhill simplex method of optimization. (2) the derived mutual information fused with Quasi-Newton method. (3) mutual information blended with hybrid genetic algorithm (significant- universe brute-force search) to evade local ceiling all through the optimization. These instinctive registration classifications went through assessments by a series of images, magnitudes and voxel resolutions. Experimentations reveal that registration logic linked with mutual information and hybrid genetic algorithm can stipulate strong and precise orientations to attain a complex triggering diagram and representation for practical MRI laboratory assay.

To probe the most efficient techniques and to inspect the level of advancement attainable by augmenting them with Wavelet transform. The SIFT feature-based scheme services the Eigen appraisal for extricating thousands of significant facts created on scale invariant facts and these fact points once extended is heightened by the wavelet transform relinquishes the paramount outcomes [15].

In this research article, a mono modal image registration algorithm is completed for the alignment of T1-weighted MR images of human brain using modified Particle Swarm Optimization (PSO) technique for attainment of the best spatial coordinates of the stirring image. The investigational outcomes evidently illustrate that the anticipated algorithm assurances improved findings than the established PSO algorithm [16].

Discrete optimization propounds appealing proficiencies for non-rigid medical image registration. Reconstructed a creative non-rigid registration technique established on the preceding effort on stereo vision with huge displacement spaces. The foremost notion is to reduce the complication in working out to the persistent time complexity is to lessen the exploration space hierarchically from coarse to fine levels. The huge search space supports in keeping away from local minima in the optimization scheme. Currently this technique

is practical to a major extent in resolving demanding registration tasks pervasively and ubiquitously. This method associates very positively besides state-of-the-art registration methodologies [17].

Georeferencing images is a painstaking method thus systems for systematizing this method have been underneath research for certain period. Amongst the utmost favorable programmed registration algorithms are those built on Fast Fourier Transform (FFT). The shift concerning the two specified images can be calculated by estimating the fraction F1*conj(F2)/|F1*F2|, and then employing the inverse Fourier transform. The outcome is an impulse-like function that is almost zero ubiquitously excluding at the shift that is essential to optimally register the images. Renovating from rectangular coordinates to log-polar coordinates, shifts signifying rotation and scaling too can be too firm to accomplish the georectification process. This FFT-based algorithm has persisted magnificently realized in IDL Interactive Data Language (ID) and appended as two user roles to an image processing software package - ENvironment for Visualizing Images (ENVI) overlapping facts. ENVI dials all pre-processing and post-processing task for instance- input, output, display, filter, analysis, and file management. For assessment of this enactment, numerous dozen assessments were steered in cooperation of replicated and "physical world" imageries. The outcomes of these assessments exhibit advantages and restrictions of this algorithm. In precise, these assessments display that the precision of the subsequent registration is fairly virtuous measured up to the present physical approaches.

Wavelet Modulus Maxima process approve to grasp the images are of matching resolution. In this technique threshold factors requires to be collaboratively stipulated. Owing to its pyramidal style consents for quicker execution and sophisticated registering accuracy. It is further suitable to register images engaged commencing from the identical sensor. It operated sound for imageries acquired at dissimilar times that are distinctive to remote sensing purposes. As this utilizes the control points scheme it can correct the local faults that outdoes manual registration of images. FFT method delivers precision adequately worthy. The procedure operates for images in which the scale transformation is not as much of than 1.8 [18].

Owed to the universal transform this method cannot influence local geometric misrepresentations. The Modulus Maxima Process image registration algorithm with an intensity-based differential matching method is consistent and well-organized accomplished for computing the faults, to sub pixel precision, the movement amongst images exposed to affine transformation that embraces concurrent translation, rotation, scaling, and shearing. GAs can proficiently explore the solution space and stretches the solution in accomplishing the sub pixel precision without recognizing the control points. Over global transformation an archetypal can be instituted for translation and rotation faults. The anticipated algorithm assumes that together the images are of identical scale. Computational proficiency can be enhanced by espousing the pyramidal method. Liable to the type of discrepancies in the medical images of Computerized Tomography, PET or MRI images a few of

these methods can be approved for assembling the numerous interpretations. It is improbable that a single registration system will operate reasonably. To portray these algorithms the shared data sets from IRS PAN are castoff and there is no scale dissimilarity [19].

III. GENETIC ALGORITHM

Amongst several approaches to image registration challenge from the metaheuristics line of reasoning, genetic algorithms (GAs) [5, 6, 7, 8, 9] is very well-organized and valuable. GA's are computational representations of natural evolution in which robust persons are further liable to be the champions in a cutthroat atmosphere. It is a stochastic technique be responsible for a decent deed in gaining knowledge of factors.

A. Genetic Algorithm Based Optimization for Monomodal Image Registration Process

Algorithm: Be concerned about X and Y as the two images with 2D points. X is the archetype image and Y is the altered image acquired from X after affine transformation. The optimized image registration classification comprises of an optimizer that decreases RIU computation.

Step 1: Key in image X

Step 2: Achieve affine transformation built on the chromosome value and get the altered image.

Step 3: Accomplish optimized registration using FWHT algorithm and figure out RIU. RIU decreases the deviation between archetype and altered image.

Step 4: Iterate Steps 2 and 3 for all adherents of the residents.

Step 5: Test if the quantity of productions is 100. If as a result, end otherwise employ genetic factors to materialize the innovative residents and Iterate Step 2 to Step 5.

Figure 1. signifies fitness estimation order, where x_i', i = 1,2, …N, is the archetype fact realized by the spatial transformation characterized by affine matrix factors. The feasible resolutions are signified as a chromosome vector characterized by four genes, reproducing translation (t_x, t_y), rotation (θ) and scaling (s) impacts, for example exhibited by Figure 1.
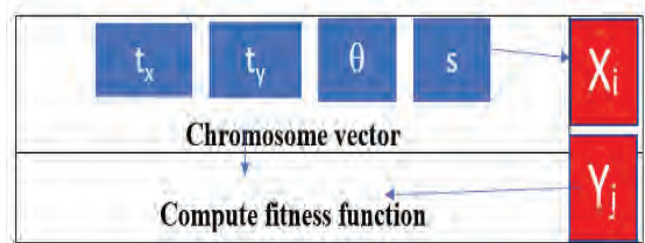
Figure 1. Fitness computing scheme - Fitness evaluation sequence

These spatial transformations are parameterized in affine matrix. The GA's aim is to discover the elite spatial transformation (chromosome) in the individual residents.

i. GA Operators

Three genetic operators (selection, crossover and mutation) are achieved on the entire inhabitants to influence the chromosomes to the optimal resolution.

Selection

Using a random selection system with roulette wheel selection method, the chromosomes (estimates) with lower RIU (higher fitness) are carefully chosen and reproduced precisely in the novel cohort deprived of every deviation. The chromosomes (estimates) with higher RIU (lower fitness) are swapped with offspring (new-fangled estimates) shaped by the parents that are chosen randomly, with crossover and mutation.

Crossover

A crossover operator is castoff for creation of descendants. The crossover process is achieved for every row or every column as specified below:

Step 1: Randomly opt for an integral figure amongst of 0 and 1 to ascertain the row or the column (If the reimbursed value is 0 at that moment the crossover process is accomplished for all row, else the crossover process is executed for every single column).

Step 2: Randomly pick out an actual value as of the range [0.0, 1.0]

Step 3: If the reverted value is equal to or less than the likelihood of crossover (0.5 in the simulations) then duplicate the row/column from the parent 1 to the descendants, otherwise duplicate the row/column from the parent 2 to the descendants.

Step 4: *Step 2* and *Step 3* are harnessed to each and every row or column.

Mutation

Only mutation approach is manipulated for fabrication of descendants in concert with the crossover. The procedure is primed as listed beneath:

Step 1: Arbitrarily choose a tangible value from the extent [0.0, 1.0].

Step 2: If the recompensed value is equal to or less than the conferred likelihood of mutation (0.02 in the simulations), then the pixel value is mutated from 0 to 1 or from 1 to 0, if not the pixel value is untouched.

Step 3: Step 1 and Step 2 are put into operation to every pixel.

The likelihood of mutation is a significant factor that extensively alters the efficiency of the algorithm. It is found to be inversely relational to the quantity of pixels of the image.

A Fast Walsh Hadamard Transform (FWHT) was anticipated in this research for medical image registration [20, 21]. This transform lessens the time usage in image registration. So, it shows to be an improved method for medical image registration than any further traditional Walsh Transform. The factors attained by means of this transform are then stabilized to acquire the exceptional number. This number signifies the local edifice of an image. Besides, this it also directs the highlights of an image for image registration. Though the investigational consequences exposed the details that the projected algorithm using Fast Walsh Hadamard Transform achieved good image registration, this current work focuses on additional enhancement in the outcomes by using Genetic Algorithm Based Image Registration.

Here while performing optimization of image registration using FWHT considering coefficients GA Operators - t_x, t_y, θ and s, after optimization it exhibited that RIU has been reduced by minimizing the fitness function.

The future work is to be pondered on surplus improvement in the outcomes with optimization of image registration using FWHT considering the same GA Operator quantities - t_x, t_y, θ and s, and to explore that after optimization it reveals that Correlation Coefficient has been increased by maximizing the fitness function.

IV. SIMULATION RESULTS

For investigation, MRI-T2 Sagittal brain image is pondered. The earliest size of these images is specified in pixels. In order to eliminate the environment of the image and the head sketch out, the archetype images and are trimmed based on the Region Of Interest (ROI), conceiving sub-images of diverse measured pixels.

TABLE I.
PERFORMANCE COMPARISON OF RIU FOR IMAGE REGISTRATION USING FWHT BASE 8 FOR MONOMODAL IMAGES

Before Registration				FWHT Base 8	
				RIU	
x	y	θ degree	s	Before Optimization	After Optimization
0	0	270	1	0.6013	0.5861

GA based optimization is performed using FWHT Base 8 algorithm. An early population size of 10 chromosomes is measured with x, y fluctuating between -25 to +25, θ varying in the interval -180 to +180 and scaling interval is fixed as 0.5 to 1.5. RIU is well-thought-out as the fitness function, subsequently it computes the degree of similarity relating two images.

Table I lists the optimized value of transformation parameters for Image Registration using FWHT Base 8 algorithm with RIU as fitness function that is decreased, and it can be noted from Table II.

TABLE II.
OPTIMIZED TRANSFORMATION PARAMETERS FOR IMAGE REGISTRATION USING FWHT BASE 8 TECHNIQUE

Before Registration			
x	y	θ degree	s
21	16	-5	1

MRI - T2 Sagittal image 400 419, 37kB Original Image

Altered Image | Registered Image
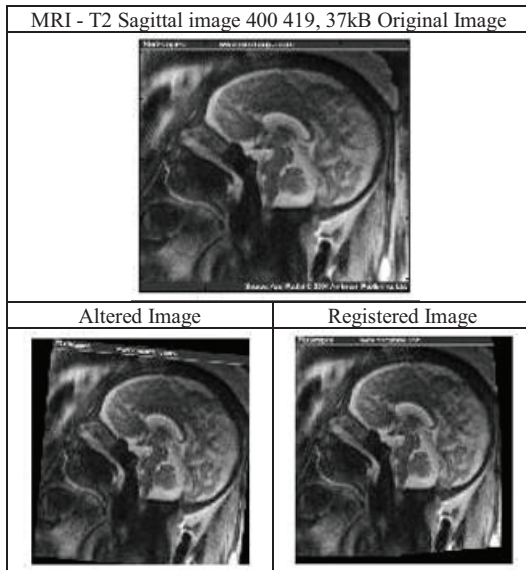
Figure 2. MRI - T2 sagittal 400 419, 37kB jpg image before GA based optimization for image registration using FWHT Base 8 technique with (x = 0, y = 0, θ = 270, s = 1)

Figure 2. depicts the image registration of MRI - T2 Sagittal image before optimization with transformation parameters as (x = 0, y = 0, θ = 270, s = 1).

Figure 3. shows the registration of the same image after optimization with transformation obtained as (x = 21, y = 16, θ = -5, s = 1). It is observed that better registration result is obtained after optimization.

MRI - T2 Sagittal image 400 419, 37kB Original Image

Altered Image | Registered Image
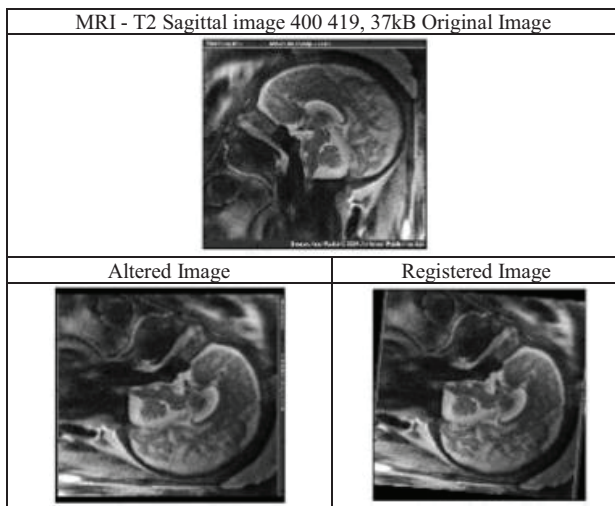
Figure 3. MRI - T2 sagittal 400 419, 37kB jpg image after GA based optimization for image registration using FWHT Base 8 technique with (x = 21, y = 16, θ = -5, s = 1)

V. SUMMARY

This simulation proves that Optimized image registration using FWHT is better one as RIU values are reduced.

Based on the observations it is noted that the usage of these transformations to the algorithm yielded MI as 3.6536

and CC as 0.7424. This revealed an augmentation of 80.05% and 36.23% respectively.

VI. CONCLUSIONS & FUTURE WORK

Fast transforms are utilized to create the algorithms to be working out truthfully and vigorously and correspondingly to recuperate the data alignment. Likewise, devotion of Genetic Algorithm (GA) for the augmented preference of translation, rotation and scaling quantities enriching the similarity measures is achieved. The elevated categorization of methods as soon as they are suitable, are habitually further disciplined in their practice of approximation resolution than the image registration and its optimization approaches. Hitherto, when few of the images are unavailable, problematic or posh to attain, or is expected to be untrustworthy, higher-order procedures that naturally form a single registration objective built on the optimization, can change to complications from being misregistered. The abilities of image registration and their optimization methodologies are that even though they are optimizationally-correlated, they are not lay open to the optimization and, they anticipate on plentiful tracks. This may not be further effectual, but it can be abundantly reliable in such state of affairs. Unique and further traits of optimization approach is that as they enhance in frequent tracks, almost limited of this can sound in the mounting channels, they can be treasured in environments everywhere there are an immeasurable resident that decrease RIU. However, this is a sensible preliminary learning, and have confidence in the aforementioned optimization of RIU measure that such developments would be additional motivation in the realism of optimization design practices in the framework of putting an end to the multi-disciplinary design optimization complications too.

The following are a small number of recommendations put forward for future work.

- The alteration systems castoff in the research can be broadened to small and large size images too.
- As per a future work, the systems can be employed for dissimilar image formats and performance metrics can be analyzed.
- Image registration methods conferred in this research study can be harnessed for additional modalities like PET, SPECT, etc.
- The systems may be assessed by utilizing other renovations that embrace shearing and reflection too.
- The task described in the research can be stretched out for fusion of brain images as well.
- The methods may be outspread for registration of other parts of bodies that take in heart, kidney, lungs etc.
- Genetic Algorithm can correspondingly be castoff to boost Mutual Information (MI) for monomodal and multimodal images.
- Optimized renovations can likewise be attained for GA Based Image Registration Techniques Using Modified Adaptive Polar Transform (MAPT) and Wang Landau Adaptive Monte Carlo (WLAMC) methods.

In the practices bestowed directly above, the metrics are estimated are centered on quantities of translational factors x, y; rotational factor, and scaling factor s selected on trial and error. The image registration algorithm is optimized to advance the registration progression by instigating Genetic Algorithm process of Image Registration using Fast Walsh Hadamard Transform (FWHT) [9] to cater GA based Optimized image registration using FWHT system. Ratio of Image Uniformity (RIU) is resolute to authorize the enhancement in registration.

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Future Trends of the Healthcare Data Predictive Analytics using Soft Computing Techniques in Data Science

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Abstract: Predictive Analytics, Soft Computing (SC) and Optimization, Data Mining and Data Science are rapidly becoming some of the most-discussed, perhaps utmost glorified topics in healthcare business. Artificial Intelligence, Machine Learning, Artificial Neural Networks, Fuzzy Logic, Expert Systems, etc., is well-studied disciplines with a long history of success in many industries. Healthcare can acquire treasured sessions from this prior achievement to startup the efficacy of predictive analytics for refining patient care, chronic disease management, hospital administration and supply chain efficiencies. The prospects that presently occurs for healthcare systems is to state what "predictive analytics" stands for to them and how can it be cast off furthermost excellently to cause further enhancements.

In all industries including healthcare, prediction plays a best worthwhile role when that data is passed on as accomplishments. The inclinations to mediate the vital data is in harnessing the power of historical and real-time data with visions from forecasting those data based on the times ahead. Importantly, to best gauge efficacy and value, both the predictor and the intervention must be integrated within the same system and workflow where the trend occurs.

A valuable report of the organized publicity and expectation of predictive analytics in healthcare through a blend of psychology, digital technology, and entrepreneurship is available for real-time implementation for the good of the public. Review and evaluation on these disciplines pave ways to open up new arenas envisaging the future trends of Predictive analytics, Data Mining and Science and Soft Computing (SC) in healthcare, stepping strongly into pervasive computing, ambient intelligence, ubiquitous computing and many more automated technical concepts and computing's ahead.

Index Terms: Predictive Analytics, Soft Computing, Optimization, Healthcare, Artificial Intelligence, Machine Learning, Artificial Neural Networks, Fuzzy Logic, Expert Systems, Data Mining, Data Science

I. INTRODUCTION

Data is a collection of standards of studies with regards to qualitative or quantitative variables. Data and information or knowledge are frequently swapping within each other; yet data becomes information once it is detected in context or in support exploration.

Data science is a concept to unify abundant hypothetical authorities or proficient fields in a button hole to an issue or challenge that aids, technical procedures, methods, algorithms and approaches to unearth information and intuitions from information in several manners, together as structured extrapolation that comprehends a mixture of statistical practices from data mining, predictive modelling, and machine learning, that evaluate recent and past realities to formulate prophecies going on for the time ahead or else strange trials and vague, related to data mining online.

Predictive analytics is the exercise of mining data beginning from prevailing information suites in the direction to govern frameworks and visualize the forthcoming endings and inclinations [1].

The passionate post is just about the three explanations - Why Comparative Analytics, Predictive Analytics and Natural Language Processing (NLP) hope for resolving Healthcare's Complications. Then retell that general catchphrases and hot topics constantly originate and go off. Identical to the up-to-date Hollywood trends that are growing and dropping, technological themes such as big data, bioinformatics, predictive analytics or genomic medicine are blended in and out create impact on retailing the summons, capital schemes, publication items and blogs for a limited time and then societies transfer on to the subsequent massive feature. Abundant of this "be on fire and reflects" can get up from the apparent be fond of concern by means of innovative technology. Globally, presently there are readily available bulky naïve data and additional materials are engendered timely on its own than may perhaps be captivated in a whole lifespan [2].

Soft Computing (SC) is an evolving arena that involves the harmonizing foundations of perceptrons, artificial intelligence, rough sets, fuzzy logic, SVM, Genetic algorithms, Bayesian network, neural computing, evolutionary computation, machine learning, expert systems, robotics, nature inspired computings and probabilistic reasoning. Owing towards their robust, deep, transfer, reinforcement, deep adversarial learnings, Q-learning, temporal difference learning and hybrid learning algorithms and reasoning capabilities, tolerance and upright acceptance of vagueness, fuzziness, ambiguity, fractional truth, guesstimate and inexactitude, soft computing practices, devise an extensive purposes across the globe turning them into applications with ambient intelligence in doing so crafting pervasive, multimedia, distributed, spatial and geographic, time series and sequence and ubiquitous functions. Thus, fixing the groundwork for a time ahead everywhere keeps people and machines stay fastened

together. They will help in the improvements of human quality of life [3].

II. DATA PREDICTIVE ANALYTICS

Data Predictive Analytics states about the structured and unstructured data. Structured data is ordered fascinated by a configured storehouse, usually a databank, subsequently that the aforementioned constituents can turn into a storage component in which all positions can be distinctly gain access to by means of a specific database intended for further robust, efficient and effective evaluation, handling of input, process, output, and assessment. A data structure is a form of storehouse that puts in order data and evidence for that resolution.

Unstructured data (information) is evidence whichever doesn't encompass an established, well advanced with data model otherwise remains unorganized in a ready-made style. Unstructured information is stereotypically text-heavy, then possibly choose to hold data such as dates, numbers, and facts in addition.

From Figure 1. Predictive Analytics involves Structured and / or Unstructured data from a configured storehouse, usually a databank performing predictions, mining, analysis, evaluation, modeling, testing, deployment and reporting.
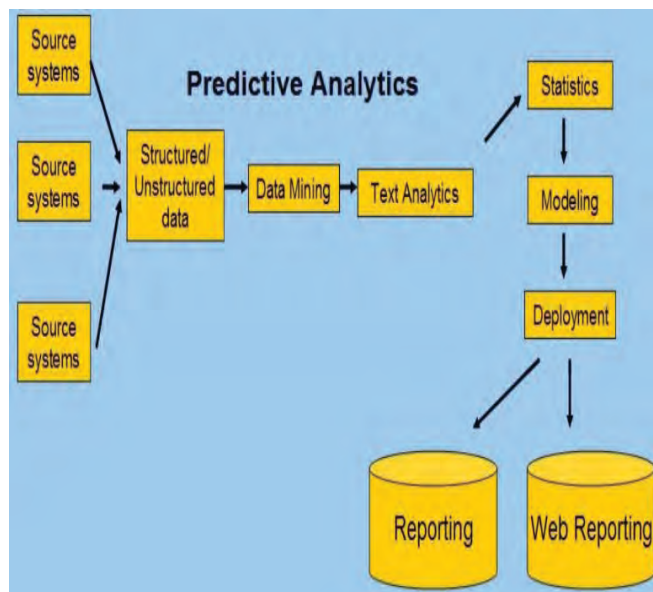
Figure 1. Predictive Analytics Detailed Process Flow

As of Figure 2. Predictive Analytics value chain indicates that based on the time and functions data can be analyzed, monitored and/or predicted established on actions that embraces what happened, why that happened, what is happening then and what is going to happen in future.

Predictive Analytics value chain aids many algorithms from Data Science, Data Mining, Statistics, Soft Computing, etc., bringing together the Management, Information Technology, Modeling Business Process, Decision Support Systems, etc., rendering **Predictive Intelligence** identifies trendy risks and opportunities time ahead in business and technology effectively interpreting big data for their benefit by assigning score remain subjective in this regard [4].
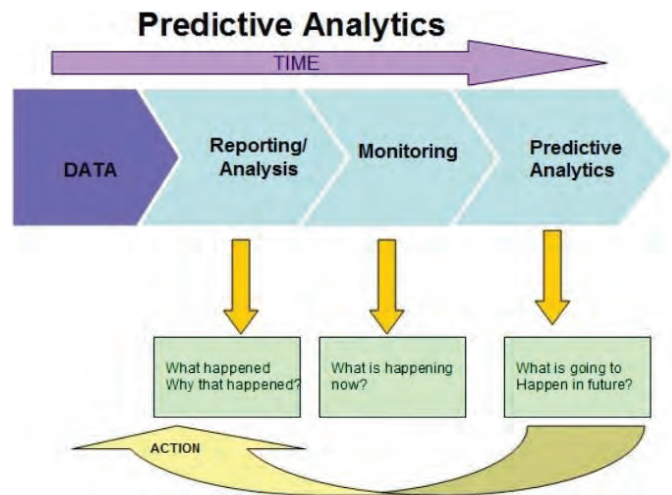
Figure 2. Predictive Analytics Value Chain

A. Advantages of Data Predictive Analytics

Basically, with its numerous forms as predictive mining and modeling, decision analysis and support, optimization, business reporting, predictive search, etc., widely, predictive analytics is pragmatic to a series of commercial approaches and a crucial team member in exploration of marketing promotions, and endorsement mechanisms delivering administrators and directors with policymaking means to impact upselling, auctions, sales and income anticipations, trade optimization, constant innovative merchandise progress, etc.

B. Disadvantages of Data Predictive Analytics

With all these values still, predictive analytics remain uncommon for one and all. Also, occasionally huge data collections remain tough to derive solutions. Few specify that predicting individual actions machines and methods decline due to study variables that are varying on or after fluctuating conditions to attitudes to associations to tempers that may change human behavior archetypes. Time to enact a share out just how fit these methods succeed. However, an archetype effective on same period, individual deeds deviates through time and hence the simulations too in essence to be streamlined just in time. The risk of economics is amalgamated with them here. Hence, only, data scientists, bolster an in-depth intelligence of predictive analytics be able to assist us in business forecasting, influencing when to and when not to realize predictive approaches into a scientific, administrative and technological know-how, schedule, handle and thriving best.

III. HEALTHCARE DATA PREDICTIVE ANALYTICS

Predictive analytics and soft computing in healthcare transpire swiftly flattering as it is the supremely pondered topic of current value, possibly extremely-glorified issues in healthcare analytics. Soft Computing is a fortunately-researched branch of learning by means of an extensive past chronicle of accomplishments in numerous trades. Healthcare can acquire appreciated experiences on or after earlier victory to startup the efficiency of predictive analytics for shooting up patient care, unceasing ailment administration, clinic management, and supply chain

proficiencies. The concern now for healthcare systems is to describe what "predictive analytics" signifies and in what manner it might be cast off utmost efficiently to cause enhancements. In healthcare, prediction is the utmost beneficial factor once that intelligence is turned over into accomplishments.

Mostly a great deal of Healthcare Data Predictive Analytics is aggrandizing the actuality of the state of affairs by means of deceptive or extraneous data that possibly will ascend on or after our apparent worship status quo through this innovative expertise. That is, the expertise is nearby, then again, the technology suffers from resources to distribute and infer real-time data hitherto on the aspect to be entirely technologically advanced.

Predictive Analytics catchphrase illness probably resolves to endure to grow and drop. Regrettably, deficient of appropriate substructure, recruitment and supplies to perform the minute a bit is prophesied with extreme conviction to materialize but drop rapidly due to the complete capability of connecting significant past, present and future inclinations and blueprints or styles in patient data. Expressed in different words that, deprived of the determination and drive for medical intrusion, any analyst – no significance how trustworthy it is will not be wholly operated.

The health catalytic agent is not alone with suitable technological context and metadata in the dwelling, then must similarly advance with new prescriptive analytics. Additionally, bond with each one and only facts prudently to medical primacies and quantifiable measures that includes price efficacy, medical etiquettes or patient consequences.

For flourishing, medical affairs forecasting and ensuing intrusion had better be mutually content and clinician piloted. Further precisely, embrace proof, endorsements and activities for each foreseen class or upshot.

Healthcare corporate, medical, and technological substantiations had better think of the identical final aspiration to make the most of the efficacy of the past, present and future inclinations for advancing patient care.

Confined via Health Catalytic agent, data modeling and algorithm evolutions are being explored using Healthcare Predictive Analytics using soft computing techniques in Python Programming language and its related automated tools. In progress tasks include classification models for a generic interpreter of clinic reentries, heart disaster, span of admission and clustering of patient conclusions to historical associates during allow-in-hospital. Furthermost significantly, core interlink to masses of de-acknowledged sickbay archives together in the inpatient and outpatient sites and elders and children populaces. This training data is vital to deal with the predictive analytics requests of customers and location customization. Consequently, as soon as the appeal arrives, whether it includes classification or clustering or feature selection, Health Catalytic agent brings forth, the tools and the data and the technology to well distribute highest executing predictive analytics.

A. Advantages of Healthcare Data Predictive Analytics

The economy of predictions. Shooting up patient care despite the fact preventing economic and repayment forfeits for sickbays.

B. Disadvantages of Healthcare Data Predictive Analytics

The societal dispute is leftovers: academic - industry productive ideas orbits to abundantly technologically advanced and employed executions in a real-time clinical aforesaid situation. Besides predictive analytics be cast off in serving cost controls and enrich patient care.
"What You See is What You Get" is both an advantage as well as a disadvantage. It is demanded as an advantage due to the reasons discussed below: Corroborate-centered drug is an authoritative means to support lessening therapy alternatives and unanticipated prices. Elite-system strategies impact more to the aspirations of systematized patient upshots and regulating expenses.

"To think in terms of a year, conceal a seed; in terms of 10 years, conceal trees; and in terms of 100 years, educate the individuals as much as possible." For the endurance victory of predictive analytics in healthcare, it's essential to carry out all of the above-mentioned practices. Still, the method can be on track on or after realizing from more corporate and technological know-how.

Auspiciously for healthcare, there remain several prevailing representations commencing from more businesses that are extremely resourceful at-risk stratification in the province of inhabitants managing. Correspondingly, the arithmetical effort of actuaries in the duty of handling populace life insurance risk and payout is as well meticulously recognized. Ahead of business knowledge, learning past will be anticipated to comfort certain possible troubles and drawbacks that can go with healthcare's approval of predictive analytics. Specified that predictive analytics are registered and obtainable of the probable stages scheduled on the Healthcare Analytics Adoption Model, about plentiful solutions and drawbacks that can arise at such a stage if not accurately arranged. Main instructions are itemized beneath:

1. Further data doesn't connect to extra acumen.
2. Awareness and worth are different.
3. Capability to infer information differs founded on the facts itself.
4. The execution itself can ascertain a trial.

For the healthcare industry, similar to further businesses, predictors resolution continuously stays extra benefits in the context of an added wide-ranging series of data, where the information can be wholly influenced to accomplishments.

The four vital instructions learnt for approving predictive analytics in healthcare are given as follows:

1. Precise Outperforms Total: Don't complicate further information through added awareness.
2. Unified Forecast: Don't complicate recognized by means of worthiness.
3. Stage of Conviction: Don't overvalue the capability to infer the information.
4. Status of the Business; Don't underrate the trial of execution.

Health Catalytic agent's new Soft Computing result prepares SC in healthcare standards, operational, and pervasive through three openings:

catalytic agent.sc—our SC representations and policy for construction of SC with wholly Health Catalytic agent.

healthcare.sc—our way of inspiring the approval of SC in healthcare done free, open-source SC software that centralizes SC by letting down blocks passing.

Healthcare analytics platform—the first pillar (basis) for SC.

Health Catalytic agent Predictive Analytics and SC Artefacts and Facilities that are to be implemented includes the following:

- catalyst.sc: Health Catalytic agent SC Result
- healthcare.sc: Health Catalytic agent Open Source SC Toolset
- Health Catalytic agent Late-Binding Data Warehouse
- Health Catalytic agent Predictive Analytics Uses
- Vital Link Connected to Arteries Infection Avoidance Progressive Use
- Employment Administration Surveyor
- Chronic Disruptive Pulmonic Disease
- Patient Stream Surveyor
- Health Catalytic agent Facilities

IV. SOFT COMPUTING TECHNIQUES

Though Soft computing was introduced earlier, it's currently practiced vigorously for solving complex real-time problems. It dispenses with rough set patterns, contrasting hard computing, is accepting fuzziness, vagueness, incomplete truth, and guesstimates. In operation, the pattern for soft computing is the human mind and is built on practices such as artificial neural networks, perceptron's, artificial intelligence, rough sets, fuzzy logic, SVM, Genetic algorithms, Bayesian network, machine learning, expert systems, robotics, nature inspired computing's and probabilistic reasoning.

Artificial neural networks: Artificial neural networks or connectionist systems are computing systems stimulated by the organic neural networks that establish instinctive brains. The neural network itself is not an algorithm, but reasonably a framework for numerous dissimilar mechanisms learning processes to operate as one and handle multifaceted data inputs.

Perceptron's: Computer archetypes or computerized machine created to signify or put on the capability of the brain to identify and differentiate.

Artificial intelligence: Intellect established by technologies, in distinction to the normal brainpower exhibited by individuals and more creatures.

Rough sets: An official rough calculation of a hard set in relationships of a pair of collections that deliver the lower and the upper estimate of the primary set.

Fuzzy logic: A method of multi-valued logic in which the truth values of variables could be any actual number amid 0 and 1 including them take up to hold the idea of incomplete truth, where the truth value may vary amongst wholly true and wholly false.

Support Vector Machine (SVM): Supervised learning models with related learning processes that investigate data applied for classification and regression analysis.

Genetic algorithms: Metaheuristic motivated by the procedure of natural selection that fits into the bigger class of evolutionary systems.

Bayesian network: Probabilistic graphical archetype that signifies a series of variables and their conditional enslavements through a directed acyclic graph (DAG).

Machine learning (ML): Technical learning systems and arithmetical patterns that computer systems practice to efficiently accomplish a precise work deprived of open commands, trusting on designs and interpretation as a substitute realized as a subdivision of artificial intelligence.

Expert systems: A part of software that utilizes catalogues of professional information to present intelligence or extend verdicts in such subjects as medical diagnosis.

Robotics: The division of knowledge that dispenses with the design, creation, operation, and use of robots.

Nature inspired computing's: Actual innovative subject that attempts to build up novel calculating methods in perceiving in what manner naturally happening incidents act to resolve complicated issues in numerous ecological circumstances. and

Probabilistic reasoning: The purpose of a probabilistic logic is to combine the capacity of probability theory to handle uncertainty with the capacity of deductive logic to exploit the structure of formal argument. The result is a richer and more expressive formalism with a broad range of possible application areas.

A. Advantages of using Soft Computing Techniques

SC is essential to attain multifaceted resolutions and select the excellent result as of numerous opportunities, via complicated systems.

SC involves speedy handing out influence and bulky memory that are just obtainable at a very small price.

Internet of Things (IoT) hypothesis initiated the need in imminent native, engineering and profitable markets for SC, demanding super-fast microcontrollers. Utilization of fuzzy logic, artificial neural networks, and expert systems in numerous normal household applications, such as washing machines, cookers, and fridges. Several industrial and commercial applications of soft computing are likewise in daily use predictable to arise in the following period. It is learnt that the soft computing theory and techniques and its applications is growing rapidly together with the use of IoT devices in future domestic, industrial and commercial markets.

B. Disadvantages of using Soft Computing Techniques

Incorrect learning algorithms and erroneous neural network architectures cause hindrances for the users. Numerous business experts are suffering from a lot of difficulties with neural network training. Besides this, bulky network is not capable to act on appropriateness to the innovative prototypes which were not operated for training.

V. DATA SCIENCE IN HEALTHCARE

Data science is a diverse domain with multi-subjects intermingling and data interpretation, system promotion, and knowledge in solving logically multifaceted issues. At the central is the **data**. Storage of raw evidence, flowing in and warehoused in the enterprise **data** warehouses. Plentiful to study through mining it.

Captivating a complete interpretation, plainness, appealing medical decision and constructing associations castoff in employing data science in healthcare [5].

Medicine detection, wearables, diagnostics, community health, lessened healthcare charges, best employment remain some of the foremost use cases wherever data science is causing a vast transformation in the healthcare industry followed by medical image analysis, genetics and genomics, manufacturing drugs, simulated support for patients and customers, predictive drug: forecast and analytical support, managing customer data and industry knowledge follow these.

- Developments in expertise
- Evolution of digital consumerism
- The necessity to contest growing prices - enhancing healthcare modernization.

Data mining embraces countless possibilities for the healthcare industry allowing health systems to methodically practice data and analytics to recognize inadequacies and excellent procedures that enhance healthcare and lessen the charges. Some specialists trust the chances to progress care and decrease expenses simultaneously may well employ to as considerable as 30% of total healthcare expenditure. This can be a win/win general. Then, owing to its difficulty and a sluggish degree of expertise, implementation, healthcare business, holdups after the others in instigating active data mining and analytic approaches.

Similar to analytics and business intelligence, the data mining too connote unusual facts to dissimilar individuals. Data mining is the study of big data sets to realize designs and practice those to estimate or forecast the probability of forthcoming proceedings.

Implementing the three systems - the analytics system, the best practice system and the adoption system is the crucial power in practical enhancement with any analytics lead in healthcare.

A. Advantages of Data Science in Healthcare

1. Seller's knowhow and special focus on healthcare.
2. SC pattern's get into widespread data bases.
3. SC pattern's affluence of operation.
4. SC pattern's understandability and get-in.
5. SC pattern's acknowledged performances with confidentiality guidelines.

B. Disadvantages of Data Science in Healthcare

1. Relative data doesn't push development.
2. Predictive Analytics fall short to contain results.
3. Variances in Healthcare Industry data confine the efficiency of Natural Language Processing (NLP).
4. A Structured method: advancing up the Diagnostic acceptance standard.

VI. EXISTING HEALTHCARE DATA PREDICTIVE ANALYTICS USING SOFT COMPUTING TECHNIQUES IN DATA SCIENCE

Data Mining and Data Science perform a vital part in healthcare. Though therapeutic data are inestimable and very wealthy in information, but numerous times the valuable information perhaps go waste as it is failing to obtain the fruitful data from it. Abstraction of real data from rich healthcare data and rendering treasured the results for forecasting the illnesses slowly alter into rudiments. Data mining practices are employed to mine the enormous therapeutic data and to study the unseen design and associations that aids in achieving active evaluations.

A primary blueprint of keen and safe healthcare systems using ML and unconventional security method predicted in the mixing of optimum storing and data security layer uphold security and privacy. Diverse procedures like concealing encryption, action supervising, granulated access control, active data encryption and conclusion point authentication have been unified. The fusion of four-layer healthcare archetype looks extra effective illness investigative big data system.

VII. REVIEW OF LITERATURE

Coronary artery disease is a general enduring sickness, similarly predictable as an ischemic heart illness that is a cardiac dysfunction caused by the scarcity of blood amount to the heart and take a life of limitless individuals every single year. In current eons, coronary artery disease levels earliest and first amid the biosphere's topmost ten reasons of demise.

This investigation instructs a programmed cataloging method for phonocardiograms by means of deep and ensemble learning methodologies through a Savitzky–Golay filter [6]. This research paper contributes a multi-centroid diastolic duration model for the Hidden Semi-Markov Model (HSMM) built for heart sound segmentation.

The centroids are calculated by hierarchical agglomerative clustering of the neighboring diastolic period rates using Ward's technique till focus of clusters is initiated at least a systolic interval apart. The numerous peak distributions produce a high-pitched slope of probability from place to place the expected centroids and advances the discriminability of analogous interpretations [7]. Deep belief networks are a type of the deep learning methods, choosing the significant characteristics to lessen the high dimensionality via stack of Restricted Boltzmann Machine and optimize to boost weights and diminish the renovated feature error. Thereby, removing the qualities that entertain extra reconstruct error and only use only less constrict error showing the experimental enhancements of results in Virtual Screening outcomes [8].

This scientific study's objectives are classifying the data mining methods and systems that are generally realized in exploring linked to numerous disease risk prediction archetypes also detecting the accuracy of these systems entails many techniques, but this scientific work is aiming at global precision that is evaluated by the over-all sums of precisely predicted outcome on top of the entire amount of estimates. A methodical review and creative writing about five databases initiate 170 articles, of which 7 items were nominated in the ending activity. This evaluation instituted that utmost prediction patterns used classification method, with an emphasis on decision tree, neural network, support vector machines, and Naïve Bayes algorithms everywhere heart-associated illness is usually researched [9]. This survey paper primarily reports on the optimization procedures of Particle Swarm Optimization (PSO), Gravitational Search Algorithm (GSA), and Ant Colony Optimization (ACO), that

remain exploited recently with Fuzzy Logic (FL) to recuperate the accomplishment of the optimization processes [10].

The 2014 DARPA notice of the plug-in detailed, "Plasticity turns to neutralize formerly had notions that the matured brain is a "completed" object that can be statically charted. Due to elasticity, scientists are cheerful that the brain can be qualified or cured to reestablish usual functionality ensuing hurt or the inception of neuropsychological sickness."

Cognitive remedy is of progression creditable, then who is successful in describing "regular workability" and for what determination? [11].

Useful paper as contents are with Introduction, Discussions, BERLIN Agreement, Plenaries, Plenary Sessions, Pre-Workshops Research, Education, Traditional Healing Systems, Orals Clinical Care, Medicine and Symposia, Posters, Various Topics, Author Index Workshops, etc., [12].

VIII. FUTURE TRENDS AND ENHANCEMENTS IN HEALTHCARE DATA PREDICTIVE ANALYTICS USING SOFT COMPUTING TECHNIQUES IN DATA SCIENCE

Data Science and Data mining turn into more and more generic together in the private and public zones. Businesses such as banking, insurance, medicine, and retailing normally use data mining to reduce charges, boost exploration, and rise auctions. So, data science and mining will be progressively valuable in the upcoming period ahead.

Data science is yet similar to software growth and its extra multifaceted venture nurture it further into its viability to decline.

An undertaking might be required externally for our comfort regions to obtain the chances and disputes that this digital gold fetches. As the volume of data continues to grow, SC algorithms get elegant and our computational skills advances, and the requirements to adapt. Confidently, by generating a robust situation for using data science in our establishment and be virtuously equipped for what the approaching spell ahead fetches.

The three entangled inclinations of growing volumes of data, better-quality SC procedures and improved computing possessions are influencing the data science field in electrifying ways.

Improvement of valuable visions on artefacts/corporate from data and its mined information. Practically all corporations today handle data-driven choices by using one method or additional methods. And if they don't, they will have to resolve it in the nearest imminent time ahead.

Data Science is on a temporary approach and it is in relationships of how the modern data technologies are cast off in resolving commercial complications for a premeditated benefit. At the close time to come, data scientists will handle their occupation more contrarily. As Big Data, Algorithmic economics, IoT, and Cloud endure in developing as a mainstream amid of universal establishments, trades drive lingering becoming mostly accustomed to the new inexpensive policies and stay ahead of the curve. The two furthermost outstanding facts of this evolution are amplified mechanization of data methods and distribution of instant logical results.

The forthcoming of SC in healthcare is enormously auspicious with a numberless of forward-thinking SC practices such as deep reinforcement learning, one-shot learning, and capsule network be in collaboration with clinicians to allow innovative data in biomedicine and healthcare that SC can be omnipresent and unseen in the future health care areas realizing novel data from entire sources. Furthermore, there requires a crossing point between clinicians with data and computer scientists with analytics to assure a data-to-information continuum and a knowledge-to-intelligence transfer.

The Future of SC: Augmented and Virtual Reality Blockchain and Cybersecurity Cloud Computing Deep Learning and New Types of Learning (Capsule Network) (Third Wave) (Deep Cognition) Internet of Everything Other Key Concepts: Virtual Assistants and Bots, Swarm Intelligence, Quantum Computing - Neuromorphic Computing - Hypergraph Databases - Brain-Computer Interface

Finally, need to disseminate a human-machine synergy via a clinician-data scientist collaboration without hubris to push future healthcare and medicine to the highest echelon.

IX. MEASURES AND METRICS FOR HEALTHCARE DATA PREDICTIVE ANALYTICS

Healthcare analytics is specifically based on **data**, and **data sets** that comprises of massive volume of medical data, numerous measurements, economic **data**, arithmetical **data**, demographics of definite residents, and insurance **data**, a limited data declared, collected from many **healthcare data** bases. A list of the maximum healthcare data sets that is made up of both free healthcare data sets and business data sets applied for arithmetical investigations are given below. *Healthdata.gov, World Health Organization, data.gov, The Human Mortality Database (HMD), Data and Tools of the National Center for Health Statistics, openFDA, The Big Cities Health Inventory Data Platform, Medicare.gov, US Census Bureau, National Cancer Institute, etc.*

1. Volume Metrics, 2. Revenue Leakage Metrics, 3. Utilization Metrics, 4. Quality Metrics, 5. Financial Metrics, 6. Incidents Metrics, 7. CMS Program Performance, 8. Cohorts Metrics, 9. Clinical Metrics are the few metrics need to be predicted*.*

1. Volume Metrics: refers to the stream of patients to our facility. This includes:

    a.   Total number of patients by section, by specialism
    b.   Time of appointment and length of visit
    c.   Tracking origin of and number of inbound referrals

2. Revenue Leakage Metrics denotes the data associated to the flow of patients over our ability with missing revenue prospects. This consist of:

    a.   Negated arrangements owed to patients not disclosing in the lead
    b.   Tracking the amount of outbound appointments as it should be unconfirmed specialties
    c.   Invalid or reorganized engagements suitable for member of staff inaccessibility.

3. Utilization Metrics speak of the patient traffic and utilization of supplies caused by every sections separately, expert knowledge, and good turn dealer. This takes in:

   a. Appointments accomplished per doctor
   b. Surgeries carried out per surgeon
   c. Appointments booked per section and special study.

4. *Quality Metrics* imparts to the effectiveness of our quality, safety, and access initiatives. It is the most extensive data-set that will be tracked on our dashboard. This comprises:
   a. Member Satisfaction
   b. Patient Satisfaction and Engagement
   c. Post-Treatment metrics
      i. Readmission rates for specific diseases (e.g. heart failure, pneumonia, etc.)
      ii. Clinical outcome rate statistics
      iii. Occurrence of hospital acquired infections
      iv. Clinical error ratios
      v. Outpatient wait time
      vi. Mortality
      vii. Safety of care
      viii. Timeliness of care
      ix. Patient experience
      x. Effectiveness of care
      xi. Efficient use of medical imaging

5. *Financial Metrics* is further magnificently modified and aimed on the fiscal performance of our healthcare facility. This embraces:
   a. Revenue made per doctor
   b. Revenue created by section
   c. Revenue caused by specialty
   d. Revenue/expenses per doctor/ section/ specialty.

6. *Incidents Metrics* comprise unpremeditated effects or lateral outcomes of hospital events, including unsolicited conditions like sepsis, postoperative respiratory failure, pulmonary embolisms, hemorrhages, and further consequences or contaminations. This metric deals with the capability of healthcare specialists to deliver wide-ranging, superior care to patients deprived of eliciting an adversative response.

7. *CMS Program Performance* Value-based programs targeting to cut down the total healthcare expenses and advance care eminence throughout deals with monetary prizes for enhancement on a variation of clinical and quality metrics irrespective of the facility aimed for or establishment.

8. *Cohorts Metrics* Inspect the activities and functioning of clusters of manipulators associated by joint qualities. A **cohort** is a cluster of manipulators who apportion a generic trait that is branded in the report by an **Analytics** facet. The **Cohort** Analysis report permits to segregate and evaluate **cohort** conduct.

9. *Clinical Metrics* are operational **metrics**, or key performance indicators or data points that make available awareness into operative occurrences with the uses as: refining methods within and establishment of associations with promoters.

Statistical Metrics are quantitative measurements. This includes:
   a. R-squared
   b. Average error
   c. Mean Square Error (MSE)
   d. Average absolute error
   e. Median absolute error

   f. Tracking Signal
      i. Mean Absolute Deviation
      ii. Mean Absolute Percentage Error
   g. Control Chart.

Evaluation Metrics that desires to be included are available in the following:
   a. Accuracy
   b. Sensitivity & Specificity
   c. True Positive, True Negative, False Positive, and False Negative
   d. Consistency
   c. Precision & recall
   e. Chances of illness
   f. Quality Ratings
   h. Positive Predictive Value, Negative Predictive Value
   i. ROC Curve - **Receiver Operating Characteristic** Curve & AUC - Area Under the Curve
   j. Lift and Gain charts
   k. Percent correction classification (PCC)
l. Confusion matrix

A **Dashboard** is a concise, clearly legible, frequently graphical exhibit of the key performance indicators (KPI) an administration team requires to proctor repeatedly. It delivers a single view of statistics commencing from corner to corner of an organization and portrays it in an easily handy means.

Benefits of the ***Dash Boards*** in Healthcare includes the following - discerning wherever setbacks are and latent extents for revolution in consenting them to render nobler resolutions, advance the quality of concern, making available additional proficient resource management, **decrease expenses** and to augment the amount of work of the medicinal staff. Statistical investigation is vital in signification-based medication.

Dash Boards for the following are to be incorporated with:
   a. Prediction Interval
   b. Confidence Interval
   c. Predictive Statistics
   d. Predictive Inference
   e. Predictive Analytics
   f. Demands for Healthcare Services –
      i. Percent Adjustment,
      ii. 12 Months Moving Average,
      iii. Trendline,
      iv. Seasonized Forecast.
   g. Healthcare Needs
   h. Prediction Score.

X. CONCLUSIONS AND FUTURE ENHANCEMENTS

At the end of this review, exploration core points were taken in performance to confer what is the one and only tangible subsequent step to be acquired in the direction of state-of-the-art diffusion of investigations ahead motivating the investigators to learn novel platforms and procedures: identify the status that seem dedicated to publicizing the discoveries of their efforts. Even though investigators are intensive on hypothetical contributions, a variety of broadcasting events are ensuing useful even if in n *profitable* manner. Still, what establishes real propagation (in terms of influence and return on savings) stay uncertain. Investigators

want superior and vibrant supervision on how worthiest to propose, source, and enable their broadcasting events.

Experienced, knowledgeable and skilled human assets are a prime qualification for any established development. All traditional healthcare systems are handling a stern disaster of manpower growth, deployment and headship. There is no appropriate guidance automated for outdated doctors. Hypothetical and other establishments are befalling track with deprived financial funding's, scheduling, organization, measuring, forecasting and governance.

It is trusted that the evidences provided will support the researcher in the time ahead to escalate the complications of reviewing remedial healthcare and the problems integral in this form of education. The future developments are formulated in terms of current ages is to be inflicted with defined and essentially aids examiners to design scientific prosecutions of remedial healthcare that would esteem mutually the perceptions of the time-honored conventional, resent and modern systems of medicine, healthcare correspondingly, those of modern clinical tribunal techniques.

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Machine Learning Approaches to Classify Diabetes Patients based on Age, Obesity level and Cholesterol level

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Abstract: **Nowadays finding the root cause of some diseases and their effect on different organs of the human body is challenging rather than treatment of the disease. Diabetes stands first in that category. Diabetes is a condition in which the body is incapable of producing insulin or it is not in a situation to make use of the produced insulin, and sometimes both. It is also called as Diabetes Mellitus. In this paper, we experimented machine learning algorithms to find the impact of age obesity level (O), and cholesterol level (C) of a person on diabetes. We have collected real-time data of 50 patients, where 34 are nondiabetic and 16 are diabetic. Each record consists of AOC of a person along with class label attribute. Experimental results unfold that, there is a significant effect of obesity and cholesterol in diabetic patients. Results are compared using rule-based classifier JRip, probability-based classifier Naïve Bayes, and decision tree based classifiers J48, Random forest. All experiments are conducted using 10 fold cross validations by considering the random blood sugar levels of patients.**

Index Terms: **Diabetes, Stress, diet, Obesity, Blood Cholesterol, classification, machine learning.**

I. INTRODUCTION

In Diabetes people, the body impairs to get the sugar from the blood into the tissues of the human body, raising the sugar levels in the bloodstream [1]. The excess blood sugar within the blood vessels can harm the blood vessels, this situation leads to different problems like cardiovascular diseases, kidney damages, nerve damage, eye damage and stroke [2]. Most of the time people are victims of diabetes either because of genes or because of lifestyle modifications. But the present day's research reveals that lifestyle changes are one of the leading causes of diabetes prevalence. Beta cells in the pancreas produce insulin to unlock the tissues of the human body to receive sugar in the blood. The received sugar is used for energy or for storage. In diabetic people either insulin is not produced by the pancreas or insulin produced is not able to unlock tissues of the human body to receive sugar in the blood, in such cases sugar levels in the blood raises, and in this situation if a person consumes more carbohydrates from which sugar is generated, then the sugar levels in the blood are at their peak. According to the American Diabetic Association, general symptoms of diabetes include loss of weight, increased thirst, hunger, frequent urination, drowsiness, blurry vision, foot problems, anxiety, and erectile dysfunction in men. According to the World Health Organization (WHO), in the last two decades, diabetes has risen from 108 million to 422 million [7]. There are mainly 3 types of diabetes.

A. Type 1 Diabetes: Beta cells in the pancreas stop production of insulin or produce a small amount of insulin. It may happen because of damaged Beta cells or because of the death of the Beta cells. Most of the times it happens because of the attack of the autoimmune system on Beta cells mistakenly. It is an altered response of the human body to lifestyle changes. In this case, there is no other alternative apart from taking insulin externally, if not patient may die. Type 1 diabetic happens normally in children or in adults.

B. Type 2 Diabetes: This is also called insulin resistance condition. In this pancreas produces insulin but tissues of the human body resist the insulin and they won't get unlocked to receive sugar in the blood. So, pancreas keeps on producing more insulin to unlock tissues, over the period of time as it over functions, Beta cells may get damaged and lead to under insulin. Generally, Type 2 diabetes happens when people age over 40 [3]. The exact cause of Type 2 diabetes is unknown, but genetics, lack of exercise, being overweight, sedentary lifestyle may be the reason.

C. Type 3 Gestational diabetes: It occurs due to insulin-blocking hormones produced during pregnancy. This type of diabetes only occurs during pregnancy. After the pregnancy period, in most cases, the patient may be back to her original health. The differences between these three types are as shown in Table 1.

TABLE 1.
DIFFERENT TYPES OF DIABETES

Feature	Type 1 diabetes	Type 2 diabetes	Gestational Diabetes
Age	Children	Adults	During pregnancy time
Prevalence	Rare	More Common	Becoming Common
Treatment	Insulin Injections	Pills, exercise, diet, life style change	Exercise and diet control medications
Cause	Autoimmunity	Insulin resistance	Hormonal Imbalance

II. MACHINE LEARNING AND CLASSIFICATION

Machine learning is the concept where a machine or computer is trained to learn a model based on training data. Later on, this model is used by the machine for prediction, decision making, or solving a task. It includes many concepts from statistics, probability, databases, etc. It is broadly divided into 2 types [3][6], one is supervised learning another is unsupervised learning, in supervised learning we study about classification algorithms, like decision tree based, function-based, probability based, rule-based, etc. In unsupervised learning, we study about the association, clustering, anomaly detection and etc. Classification is a supervised learning approach, in which we divide the population into two parts. One part is the training data set by using which a classification model is built. Another is training data set tested against the model being built. We use various performance measures to validate the performance of the classification model, such as accuracy, precision, recall, and f –measure, etc [8].

TABLE II.
DATA SET DETAILS

	Minimum	Maximum	Mean	Standard Deviation
Age	18	65	39.1	11.051
Obesity level	15.1	37	24.74	4.42
Cholesterol level	102	258	173.08	35.499
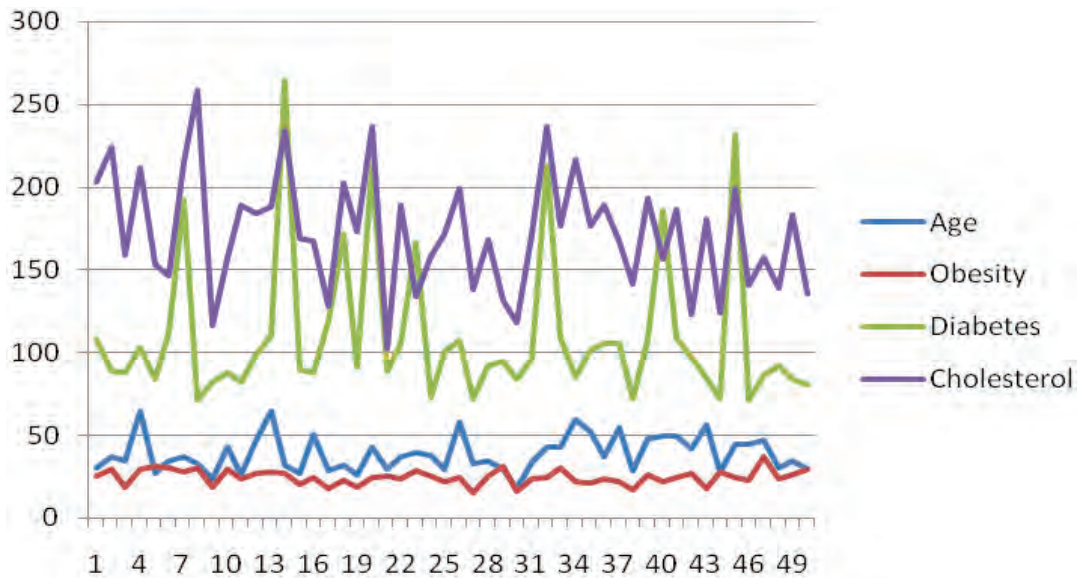
Figure 1. Distribution of Data Set

TABLE III.
SAMPLE DATA SET COPY

S.No	Age	Obesity Level	Cholesterol level	Diabetic
1	31	25.1	203	no
2	37	29.2	224	no
3	35	19	159	no
4	65	29.4	211	no
5	27	31.4	200	yes
6	35	30.5	146	no
7	37	28..3	215	yes
8	33	30.2	258	no
9	24	18.7	116	no

10	43	29.4	157	no
11	26	23.9	189	no
12	47	27.4	184	no
13	65	27.6	188	no
14	32	26.7	234	yes
15	27	20.5	169	no

In the current scenario machine learning techniques are playing a vital role in the bio-medical data processing. Exclusively classification is being used in disease diagnosis and treatment. Classification algorithms are extensively used in biomedical engineering systems to help medical professionals to diagnose the problem with more accuracy. In this paper, we have used different classification algorithms to classify data of diabetic patients. We collected real-time data from a medical diagnostic center. Data set consists of diabetes and nondiabetes people. The details of the data set are as shown in table 2 and Table 3 shows the sample data set copy. Figure 1 shows the distribution of total data set, X-axis represents the total number of records and Y-axis represents the values of selected attributes.

III. RESULTS AND DISCUSSIONS

Experimentation is done using 10 fold cross-validations. In each fold, 90% data is used for training and leftover 10% data is used for testing. For comparative analysis, we conducted experiments using JRip, Naïve Bayes, J48, and Random forest algorithms. **JRip:** It is a rule-based classifier supported by WEKA. It uses two stages to learn optimized rules. The first stage is building stage, rules are generated, second is the pruning stage, rules are pruned. **Naïve Baysed Classifier:** It is a probability-based classifier; it uses conditional probability to build a classification model. The

model is built using training records, and then the same model is tested against the test records whose class label has to be predicted. **J48 Classifier:** It is a decision tree based classifier, it builds a decision tree, where each node is a decision node, and each branch is the outcome of the decision taken at the selected node. It uses information gain and entropy to find the best split attribute. **Random Forest Algorithm:** It is also a supervised learning algorithm. It initially builds random forest of trees using a training data set and selects the best tree to classify the test samples. The performance measures of different classifiers considered for experimental analysis is shown in Table 4. Although, Naïve Baysed classifier is good at accuracy, it is only good at predicting negative class tuples, but it is not good at predicting positive class tuples. JRip is reasonably good at predicting positive class as well as negative class tuples compared to all other classifiers. Although, the accuracy of the existing algorithms is not well performed, the experiments are interesting because so far, no research is found in the literature to predict diabetes patients based on their age, obesity and cholesterol levels. However, we are proposing a novel priority based rule-based classifier as part of the future research work to classify diabetes patients with improved accuracy. The relative absolute, the root relative squared errors are more because as we considered only 50 records for experimentation.

TABLE IV.
ACCURACY AND ERROR RATES

S. No	Algorithm used	Accuracy	Mean absolute error	Relative absolute error	Root relative squared error
1	JRIP	74%	0.3682	83.4766 %	97.7523 %
2	Naïve Bayesed	76%	0.328	89.9363 %	99.4892 %
3	Random Forest	72%	0.328	80.1247 %	95.067 %
4	J48	74%	0.3536	86.3722 %	101.0526 %
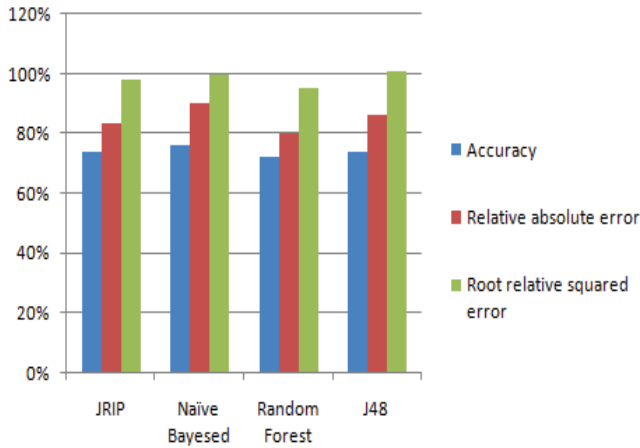
Figure 2. Details of Accuracy and Error Rates

Figure 2 represents the accuracy details of different classifiers, Figure 3 represents the performance of each classifier in predicting diabetic patients, from the figure we can understand that Naïve Bayes is good at Precision and JRip is good at TP rate while predicting yes class tupples. Figure 4 represents the performance of each classifier in predicting nondiabetic patients, J48 is good at TP rate and JRip is good at precision while predicting no class tupples.
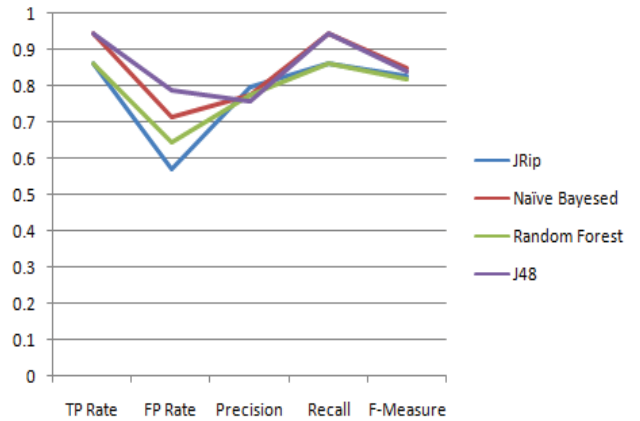
Figure 4. Performance Details of No Class

Figure 3. Performance Details of Yes Class

Here, TP rate represents True positive rate of the classifier means how good classifier is good at predicting positive class tuples, Fp rate represents False Positive rate means a number of tuples actually negative are predicted as positive. F-measure is a harmonic mean of precision and recall. Figures 3, 4 unfold that some classifiers are good at predicting positive class tuples, some are good at predicting negative tuples. Table 5 represents the confusion matrix of each classifier, Table 6 represents the Tp rate, Fp rate Precision, recall, and F – a measure of each classifier with respect to each decision class.

TABLE V.
CONFUSION MATRIX

Algorithm used		Predicted class	
	Actual class	YES	NO
JRip	YES	6	8
	NO	5	31
Naïve Bayesed	YES	4	10
	NO	2	34
Random Forest	YES	5	9
	NO	5	31
J48	YES	3	11
	NO	2	34

TABLE VI..
PERFORMANCE DETAILS OF DIFFERENT CLASSIFIERS WITH RESPECT TO YES CLASS AND NO CLASS

Algorithm used	Class	TP Rate	FP Rate	Precision	Recall	F-Measure
JRip	YES	0.429	0.139	0.545	0.429	0.480
	NO	0.861	0.571	0.795	0.861	0.827
Naïve Bayesed	YES	0.286	0.056	0.667	0.286	0.400
	NO	0.944	0.714	0.773	0.944	0.850
Random Forest	YES	0.357	0.139	0.500	0.357	0.417
	NO	0.861	0.643	0.775	0.861	0.816
J48	YES	0.214	0.056	0.600	0.214	0.316
	NO	0.944	0.786	0.756	0.944	0.840

IV. CONCLUSIONS

In this paper, we used age, obesity and cholesterol levels of a person to classify whether a person is Diabetic or not. Experiments revealed that, there is a significant level of impact of obesity and cholesterol levels in diabetic patients. Although the accuracy of Naive Bayes is more in classifying the records, but JRip is outperformed well in classifying the positive class records. The experimental analysis concludes that the patients are prone to diabetes if their cholesterol level is more than 200 and obesity is more than 30. Results also reveal that the people age over 45 are also more likely prone to diabetes. In the future, more parameters may be considered like family history, diet, smoking, drinking, and stress levels in classifying diabetic patients. A new model (priority-based rule-based classifier) may be built to improve the overall accuracy of the prediction system.

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Proposed Methodology for Personalized Medicine in Healthcare System using Data Mining Techniques with an Emphasis on Mental Illness Disease

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Abstract-Today, the Medicare system has been improved their models to achieve the best care for the patients and customized the delivery of healthcare treatment to the individuals by helping the doctors in the diagnosis of a disease. The systems are useful due to implementation of personalized medicine that is an effective way of doing treatment to a patient by considering omic data and electronic health record data while classifying the patient into subgroups based on common biological basis of diseases. This paper discusses the mental illness disease and its categorization to predict a disease based on its symptoms along with various challenges while processing data sets. There is data mining and machine learning algorithms used for feature selection and classification in order to improve the prediction performance for the specific mental illness disease are discussed to develop a new model. The proposed methodology is to develop a personalized Medicare system considering omic or Electronic Health Record (EHR) data using the best feature selection and classification mining algorithms to help the doctors to diagnose the disease at the early stage and identify the root cause for better treatment.

Index Terms: Personalized Medicine, Mental Illness, Data Mining, Classification, omic and EHR data.

I. INTRODUCTION

Personalized Medicine is an emerging approach for disease treatment and prevention that considers individual variability in genes, environment and lifestyle for each person [7]. It takes personal care about the patient and has a very strong potential to consolidate modern e-health systems called precision medicine. The author [7] has studied about psychiatric disease that has rich information exists in serial measurement of mental health symptom scores.

They basically try to plot a trajectory [1, 2] using multiple symptoms to make personalized predictions about future symptoms and some psychiatric events. This approach deals with an estimation of a population that is average trajectory for symptom scores of other people and estimates the individual deviations from average trajectory. Then, the author tries to estimate the risk of experiencing an event using the symptom trajectory. This paper [7] demonstrates a study of anti psychotic therapy for schizophrenia.

Personalized medicine for mental illness disease takes care of the patient based on personalized measures. Personalized medicine is also treating the patient health appropriately. Clinician can be benefited by using this new approach of precision medicine that is based on individual tailored treatment where patient individual profiles are taken into consideration. Individual patient details are required for tailor made treatment and the details of each step are described. Taking this into account, the author [9] discusses the technology which allows collection of different real time data like electronic medical records and wearable smart device to achieve predictions. This kind of tailor made treatment can also be implemented in psychiatric field [14].

Personalized medicine does not mean that caring to only VIPs' and giving them personalized care instead the drugs which are widely used by many healthcare and media are for more common people also. The drugs that are used by most of the patients and which are 100% effective and safe because of human genome project. Sometimes Personalized medicine can also be defined based on genetic and genomic tests where it treats the disease more effectively than traditional treatments [4]. Personalized medicine can be viewed as short term treatment due to faster recovery of the patient at whatever level the disease resides. Personalized Medicine is very powerful in modern e-health care system that consolidates the personalized drugs to suite to a person. It also takes care of side effects which are very much limited because it applies specific drugs to specific individuals.

II. LITERATURE REVIEW

There is a study about omic data set and Electronic Health Records (EHR) are used as basis for the precision medicine [3] to predict effectively the symptoms of a disease. Omics refers to a field of study in biology ending in omics like genomics, proteomics and metabolomics that are very important features towards personalized health care systems. Genomics is the study of Structure, function, evolution and mapping at editing of genomes. Progeomics is the large-scale study of proteins and Metabolomics is the study of chemical processes that involves metabolites. Omics always differs from person to person that depends upon food habit of a person. Omics data plays a huge role, for example a person who resides near river

banks has more chance of being affected than a person who stays in a cosmopolitan city though both the genomes of the persons are altogether different. When the omic data of a person is collected in form of a catalog, it is used as basis for the precision medicine. Some of the omic structures are responsible for uncovering communication among different omic structures, which form the basis for the medical attention.

Some research has been carried out for genomic interpretation and genetic prediction. To conduct the experiments on psychiatric diseases, get information online at patient health information. The way a person's symptoms change over time and with respect to other symptoms is informative about the course of disease. The author has developed a model for prediction that takes repeated symptom scores as input and makes predictions about future symptoms and a binary event that is an event that are not directly a function of symptoms like suicidal behavior, hospitalization [7, 14]. Due to wide spread use of Electronic Health Records (EHR) in many health care facilities, healthcare data are available for analysis in order to improve the quality of patient care more efficiently [5]. Also, its exploration is challenging due to its heterogeneity incompleteness and unbalanced structure. This paper [11] addresses the issue of imbalanced health care or medical data through a case study using real brain tumor diagnosis problem. Though the Morph metric analysis of histopathological images is rapidly emerging as a valuable tool for a variety of diseases, the author [11] has studied a disease called Oligodendroglioma which is a subset of brain tumors that has high rate of responsiveness to chemotherapy.

The three main goals of personalized medicine is to prevent, diagnosis and treat the patients. It is essential that early detection of problem for mental illness patient is to improve the quality. As a result, the children may not suffer from complicated problems [8]. It may be one of the biggest challenges globally by 2020 [7] to predict in advance the common mental illness problem of children.

III. MENTAL ILLNESS

Mental illness is a chronic illness with recurring persistent episode of schizophrenia, anxiety disorder and depression that can last from one day to months. Mental disorder is one type of disease where the patient may do any inactive thing which may lead to some other problem. This mental illness causes unusual and dramatic shifts in mood, energy, hallucination, lack of motivation, loss of interest, sleep disorder, hyper sexuality and the ability to think clearly. Analyzing an individual mental illness data such as behavioral information, motivational behavior, poorly sleeping information, anxiety

disorder, eating disorder, poor social adjustment etc. are the points to know how he/she will respond to a therapy.

A. Disease Taxonomy

It can be classified the mental disorder disease [7] into four different types 1. schizophrenia 2. Anxiety disorder 3. Depression 4. Alcoholism disorders. [1]Schizophrenia is classified into two types i.e. positive and negative. Positive Schizophrenia is easy to treat and the symptoms for this kind of disease are like hallucination and delusion. It refers to symptoms which make irrational form of thinking or behavior. These symptoms are also known as psychotic symptoms. Negative Schizophrenia symptoms are blunt affect, emotional withdrawal, poor rapport, apathetic social withdrawal, difficult in abstract thinking, lack of spontaneity and lack of flow of conversation, stereotyped thinking.[2]Anxiety disorder is classified into general anxiety disorder, panic disorder, phobias, OCD (Obsessive Compulsive Disorder), PTSD (Post-Traumatic (socking) Stress Disorder). The symptoms for general anxiety disorder are panic attack, physical symptoms like pain, nausea and headache, fear of leaving the house. [3]Depression is also one type of mental disorder where the patient having symptoms like sadness, unhappiness, sleep disturbance, severe lack of energy, loss of interest in hobbies, fogginess, confusion, slower peaking, feeling worthiness or guilty [7]. [4]Alcoholism disorders are classified into three types mild, moderate and severe. When the people suffering from this kind of disease, these symptoms are observed like being unable to limit the amount of alcohol they drink, using alcohol in situations where it is not safe like driving and swimming. It leads to giving up or reducing social work activities and hobbies.

B. Challenges

With respect to the collection of omic data there are some challenges [3] such as [1]Diverse data collection, [2]Data quality, [3]High dimensionality and [4]Different data types. Diverse data collection refers to as omic data differs with time and tissue types at the specified environment. Data quality refers to as Omic data sample may be contaminated at biological factors may take a toll. High dimensionality is refers to as Omic data often has many dimensions which is greater than 104. Different data types refer to as Integrating multi omic data is a challenge because of different variations in biological techniques.

Electronic Health Records are the systemized collection of patient data and population health information in digital formats that are collected during a patient admission into hospital [3]. The EHR Data can be unstructured, structured or semi structured but written clinical notes are the most efficient at human intuitive way of documentation. The Challenges with the EHR data is like diverse data frequency, Data Quality issues, High dimensionality and Different data type [3]. Diverse data frequency refers to some of the data is collected

at high frequency, where as some are taken over days. Data Quality issues refer to Missing data or entry mistakes of data. High dimensionality refers to the large number of sample size available in data set. Different data type refers to the data that is inherently heterogeneous in the EHR.

IV. Data Mining Techniques

Every day, the data that are collected from clinician and pharmacological becomes so much huge which require some statistical analysis to improve the prediction performance. In the same way, the machine learning methodology are also used in the psychiatry field to improve the prediction performance. There is a model called Gaussian mixture model [6] is an unsupervised clustering algorithm that fit the data as a number of structures which determine the dimension in which the subgroup are found. The aim is identifying subgroups with in patient rather than classify. Gaussian mixture model with the support vector machine used to segregate the patients where it is explained about the relationship between PANSS (Positive and Negative Syndrome Scale). The PANSS used to identify two statistically distinct subgroups of patients to investigate whether the two identified subgroup are related to treatment or not [7].

A. Classification Mining

Classification of medical data and symptoms of the disease which help in determining the mental disorder based on certain condition [10]. Different classification techniques may be used in order to classify healthcare data such as C4.5 (J48), Random forest (RF) and Random Tree (RT) algorithm. The proposed classification approaches C4.5 (J48) and Random forest (RF) are the efficient techniques which give better classification and disease symptom finding. To improve the accuracy and efficiency of the classification process the filter feature ranking score combined with the wrapper is proved to be good [11]. In the first approach, wrapper process is used for searching better feature for better performance of the model. In this work, the method hybridized a MI (Mutual Information) and MR (Maximum Relevance) with artificial Neural Network (ANN). The unique contribution of this approach is that it amalgamates the potential of wrapper approach to get better features [12, 13].

A classification has the ability to extract useful information from large set of data. This paper [7] discusses a review of classification techniques and analysis on the clinical dataset. However, Bipolar disorder is one type of psychiatry disease where aim is to identify three subgroup of patient according to their age at onset and based on different phenotypical features. To understand the disease and the symptoms of the disease on medical data according to its condition, an approach for predicting the risk [14] of disease by using polymorphism interaction analysis to explore SNP interactions and colon cancer risk. In order to obtain the most likely interaction that the best predict risk of disease uses two unique scoring

functions called Gini index and the percentage wrong. They also have used ten-fold cross validation to analyze the data. The author discusses mental health problem which basically comes at an early stage. There are eight different machine learning mechanism that are used for analyzing and diagnosis the medical health data [8]. The comparative result of classifier on various machine learning technique lead to the conclusion that the Multilayer Perceptron, Multiclass Classifier and LAD Tree produced more accurate results in full attribute set [8].

B. Prediction Models

The author has developed two sub models i.e. [1]sub model for symptom scores and [2]sub model for binary events [7]. The sub model for symptom scores needs specifying a form of trajectory that symptoms may take over time with reference to baseline. It has been observed that the way an individual's trajectory for one symptom deviates from mean trajectory is selected or similar to how that person's trajectory or symptom scores for other symptoms deviate from the mean [1, 2]. In some cases, it needs to use sub groups each having a different mean trajectory. This is done because one form of trajectory cannot fit the whole population. So, each sub model, populations have its own mean trajectory. [2]sub model for binary events try to compare the individual scores with other and estimate the odds of happening of an event.

There are large volumes of data that are taken from more features of a particular disease. Also, there is an importance to select the feature set for the solution of a particular disease. There is a work for novel feature selection called backdrop neural networks that propose a weight analysis based heuristics to choose only effective features of a disease. The weight analysis based method is called ANNIGMA [11, 12] where the weight is associated with feature basically used in training stage to remove the noisy data.

There is a proposed classification mining algorithm for brain tumor disease which provides a simple diagnosis rule. In order to generate the rules, the author has used decision tree along with bagging algorithm. The author has claimed the work as a globally optimized hybrid feature selection algorithm derived from artificial neural network [11]. The GANNIGMA (Globally Optimized Artificial Neural Network Input Gain Measurement Approximation) is a hybrid feature selection in the proposed approach finds the significant features which help to generate a simplified rule. The GANNIGMA Hybrid feature selection [11] consists of three independent approaches called [1]Filter approach, [2]Wrapper approach and [3]Hybrid approach. [1]filter approach is cost effective but not so accurate. [2]Wrapper approach is not cost effective but accurate. Therefore a [3]Hybrid approach is involved in this feature selection process by combining filter approach with wrapper approach. The proposed hybrid feature selection with ensemble classification technique in this paper [11] combines a maximum relevance and minimum redundancy filter heuristic with globally optimized wrapper heuristic

GANNIGMA. Hence, the results indicate that GANNIGMA + MRMR + Bagging + Decision Tree feature selection based proposed ensemble approach provides a more simplified decision rule with higher accuracies.

V. PROPOSED METHODOLOGY

There are proposed methods [3] that deal with the idea of classifying people into subgroups who share the same biological disorder to provide precision medicine using algorithms like Bayesian classification, KNN neural networks.

A. Objective

- The main objective of the proposed system is to develop a Personalized Medicare system in such a way that it treats the individual requirement of a patient according to environment and space.
- The system also allows the doctors to diagnos at the early stage and immediately starts the treatment procedure.
- This system considers the nature, genes of an individual and environmental factor for the preparation of a particular drug.
- The system presents the disease by facilitating disease prediction and treatment along with minimizing the risks of development of disease.
- Personalized treatment helps doctor to identify the root cause of the problem for better treatment and soon recovery of the patients.
- As a suggestion, the doctor can tell the patient what the treatments are necessary for the patient instead of trial various types of treatment.
- Thus, major goal of personalized medicine is to predict an individual vulnerability to develop illness, achieve accurate diagnosis and optimized the most effective and efficient treatment.

B. The Process

- The EHR or omic data set are collected from hospital and try to precise the data set to select only those features that are related to that disease.
- The proposed Medicare system collects and processes all the EHR or omic data set in order to select best features using feature selection algorithms and categorize the disease using classification mining algorithms.
- The feature selection which extracts the original set of features into new subspace to select the best feature set that gives more accuracy and eliminates the unwanted feature.

- The purpose of the classification mining is to organize the data into categories of the disease for its most effective and efficient usage.
- It is planned to classify the mental illness disease data based on the symptoms of the disease for the better diagnosis of the patient.
- The users of the proposed Medicare System may be a patient or a nurse to send the query and gets the report of the patient.
- The doctor is also a peer user to the proposed Medicare System who executes the query and receives the suggestions for the drug in order to select a specific drug for the patient.

VI. CONCLUSIONS

The focus of this research is to propose a model for today's healthcare system using data mining techniques that can guide a doctor to provide right drug to right patient. There is various literature for personalized medicine approach that are studied and explained in this paper. The personalized medicine for mental illness disease is found to be taken care of because it treats the patient health by considering the individual profiles. Though mental illness is a chronic illness lasting from one day to months, patient may do inactive things which may lead to some other problem, its challenges and symptoms are also analyzed. In this paper, a proposed process model is developed considering the omic and Electronic Health Record data of a patient for mental illness disease. In future, the results will be compared by implementing various data mining algorithms for accuracy and proving suitability of the algorithm.

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Active Electronically Steered Array (AESA) Radar Data Visualization Software

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Abstract: **AESA stands for Active Electronically Steered Array based Antenna. In this type of Radar, the antenna is viewed as a two-dimensional array of radiating elements. Number of radiating elements varies from few hundreds to few thousands. Each radiating element is illuminated with an underlying Transmit-Receive Module (TRM). The AESA system is controlled by Radar Controller Software designed with required GUI controls for accepting data from operator.**

The proposed Radar Data Visualization Software integrates into Radar Controller Software as an independent module. It uses AESA Radar data that is being handled in Radar Controller Software and presents the data to the operator in wide variety of forms including File view, Tree View, Table view, Beam view etc.,

Index Terms: **TRM (Transmit and Receive Module), SPI, Radar Data, Elevation Angle, Azimuth Angles, Views, Antenna.**

I. INTRODUCTION

The RADAR system is used for detecting an object by using electromagnetic waves; it also identifies the range, the altitude, the direction and the speed of both the moving and the stationary objects. It also does searching and tracking of aerial objects by positioning the RADAR beam at desired angles. The RADAR acronym is Radio Detection And Ranging, it was coined in 1940 by the U.S Navy. The applications of radar are aircraft, ships, motor vehicles, weather formations, terrain etc.,

Figure 1. Basic principle block diagram of Radar

Conventional Radars do have a gimbal based mechanism for steering the beam from one position to another position. Generally, "Fig. 1" shows the Radar systems do work by connecting an antenna to a radio transmitter which is very powerful in nature to transmit a short pulse of signal. Then transmitter is disconnected and the antenna is attached to a sensitive receiver which intensifies any reverberation from target objects and then sends the resulting output to a display and the transmitter elements are typically klystron tubes, which are suitable for amplifying a small range of densities.

In order to examine a portion of the sky, the radar antenna has to be physically rotated to point in different directions. New trend in RADARs is Electronically Steering the beam position, called as AESA Radars. In AESA Radars, single transmitting source is replaced with many typically few hundreds of Transmit-Receive Modules.

This paper describes AESA Radar Data Visualization Software which is a real time application developed using QT Designer. The following section **II** deals with technical background of the AESA Radar which may be necessary to understand the terminology of each electronic system used in the project. Working of AESA Radar Controller Software and communication between all the Controllers are discussed in section III**.**

II. TECHNICAL BACKGROUND

Terminology of Radar:
Radar can be classified into many ways[1]:
1. Whereabouts of Radar: Ground based, Ship borne, Airborne, Space borne.
2. Actions performed by Radar: Tracking, Surveillance, imaging, data link, exploration.
3. Radar utilization: air traffic control (terminal area), air defense (application to defense), monitoring of surface (remote sensing), space borne measurement of sea surface, ground penetrating radar (geology).
4. Frequency band
5. Radar Beam Scanning: Fixed beam, electronic scan (frequency control and mixed in azimuth/elevation), mechanical scan (rotating, oscillating), multi beam configurations.
6. Different data accessed from Radar: Range (delay time), azimuth (antenna beam pointing for both
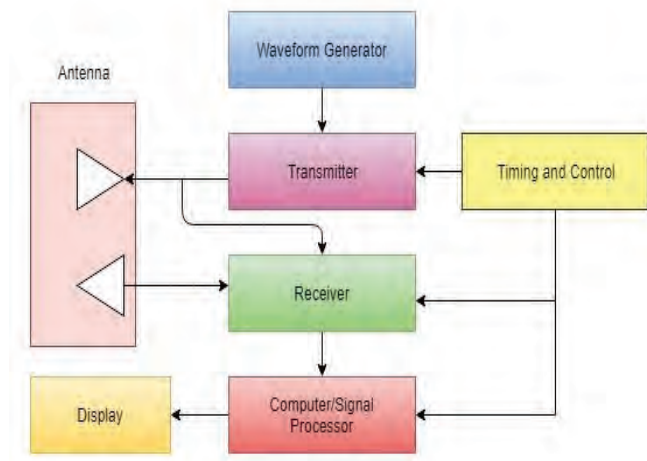
horizontal and vertical), power (amplitude), and elevation (3-D functional tracking for both horizontal and vertical), and speed (measurement of different phase due to Doppler Effect coherency).

7. Radar contour: mono-static (transmit and receive – same antenna), bi-static (separated transmitter and receiver – two antennas), multi-static (one or more transmitters/receivers).

8. Transmitter waveform: continuous, pulsed and digital.

9. Hardware machinery used for radar: antenna, array, transmitter, receiver.

Transmitter:

Transmitter can also be referred as an oscillator, which is also pulsed by the modulator to generate trains of pulses.

The transmission line helps to channelize the waveform to the antenna which is then emitted into the space. One antenna can perform the function of both the receiver and the transmitter.

Receiver:

The receiver is of the super heterodyne type. Low noise RF amplifier is the first stage, such as parametric amplifier or a low noise transistor.

The input is fed into the device at the mixer stage, in spite of a receiver with a low noise. The front end will be more sensitive and this mixer input can have a high dynamic range, less sensitivity to overload and less compulsion to electronic interference.

Antenna:

The tracking, processing and successive measurement of the estimated target are done by the radar antenna. The radar antenna is the common form of reflectors that is of a parabolic shape.

The beam is scanned in space by using a mechanical pointing mechanism of the antenna. Imaging can also be done by generating two or three dimensional image of targets. Classification, discrimination and identification, determining the characteristics, type and identity of a target are also done by the radar.

Formation of Beam:

Beam forming [3] is crux, that the constructive sum is a set of signals emitted from a set of small non-directional antennas in order to form a large directional signal. Once the signal is generated it can either be physically steered by pointing the antenna in the particular direction, or it can be electronically steered without disturbing it mechanically.

By having a clear signal at the receiver, it allows the beam steering to have a precise method for signal's maximum power output to reach its destination. All individual elements of the antenna array will radiate the waves with different amplitudes and phases. Due to this difference in amplitude and phase these waves conflict with each other both constructively (causing peaks) and destructively (causing nulls) for designing the overall radiation pattern for the full array.

III. AESA RADAR

Active Electronically Steered Array **(AESA)** radar takes an approach of using an array antenna into a further step. Instead of shifting the phase signals from a single high power transmitter here, AESA employs a grid of hundreds of small "Transmitter-Receiver (TR)" Modules that are associated together by high-speed processors.

TR Modules are arranged in a row that forms a *Linear Array (LA)* which is shown in "Fig. 2". Associated with each linear array there is a *Linear Array Controller (LAC)* unit. This LAC controls all the TRMs in the linear array this is stacked upon each other to form a complete two-dimensional array of radiating elements. A high-speed digital system called as an *Array Controller (AC)* unit is used to control the Linear Array Controller units in the array.

Radar Controller (RC) controls the operation of the AESA Radar in terms of calibration mode, operation mode etc., by commanding the Array Controller unit with appropriate data.
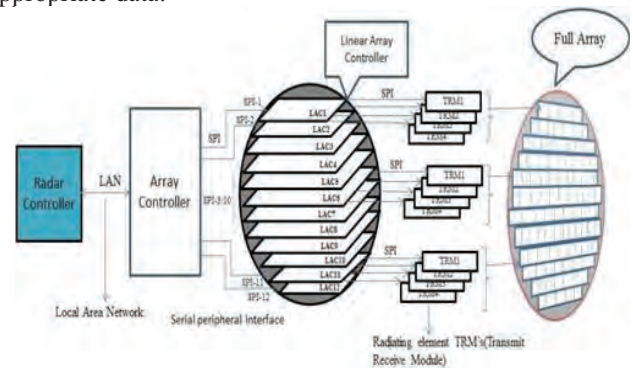
Figure 2. Block Diagram of AESA Radar

The AESA radar will radiate a multiple beams of radio waves at different frequencies simultaneously. The emission of AESA radar signals across a wider range of frequencies, which it makes them more over difficult to detect background noise. The ships and aircrafts may radiate powerful radar signals while still they remain stealthy. Most of the radar systems used in modern combat aircrafts is AESA systems.

Each TR module has its own transmitter, receiver, processing power and small spike like radiator antenna on top. This TR module has been computed to act as a transmitter; receiver and TR modules can be assigned to any role with output power or receiver sensitivity of any one of the "subsystems".

A. Controllers

1. Radar Controller :

The Radar Controller is connected to the array controller over LAN (Local Area Network) /Ethernet on this interface, the interaction happens between both of them is server-client fashion using TCP/IP protocol. The radar controller acts as a server and array controller as a client. This radar controller issues command, array controller executes that command and sends back response.

2. Array Controller:

The Array Controller interacts with the Linear Array Controller units on individual, dedicated SPI (Serial Peripheral Interface) channels. In this context, the Array controller acts as Master and Linear array Controller as slave over the SPI channels, which are capable of operating in full-duplex mode, with 50 MBPS data rate.

3. Linear Array Controller:

Each array has got a controller unit, called as Linear Array Controller (LAC). The linear array controller interacts with its TRMs on individual/dedicated SPI channels, linear array controller acts as Master and TRM acts as Slaves. The SPI channels are capable of operating in simplex mode (i.e., data transfer happens from linear array controller to TRM) with 10 mbps data rate.

4. Transmit-Receive Module (TRM):

TRMs known as Radiating Elements are arranged in Linear Array Controller. Each TRM will have a set of programmable values namely Tx Phase, Tx Attenuation, Rx Phase, Rx Attenuation to control the element and array beam. So, when compared to conventional RADAR, AESA radar has to handle huge data.

B. Communication Interface

SPI (Serial Peripheral Interface) is a synchronous protocol which is defined as clock, data and latch combination for data transmission from Array Controller to individual TRM. Devices communicating via SPI are in a master-slave relationship.

In "Fig. 3" SPI [2] is a single master communication protocol. It means that only one central device initiates all the transmissions with the regarding slaves. In "Fig. 4" it shows how the SPI master communication wants to send data to a slave and/or request information from it. This will select a slave by pulling the associated SS line low, and it activates the clock signal at a clock frequency which is being used by the master and the slave.
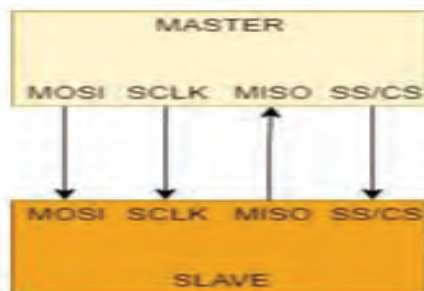
Figure 3. SPI Block diagram

A master/slave in "Fig. 5" show how the same set of slave parameters are used to communicate with the same set of master parameters. If the multiple slaves are used to connect to the master then it will have the different fixed configuration parameters.
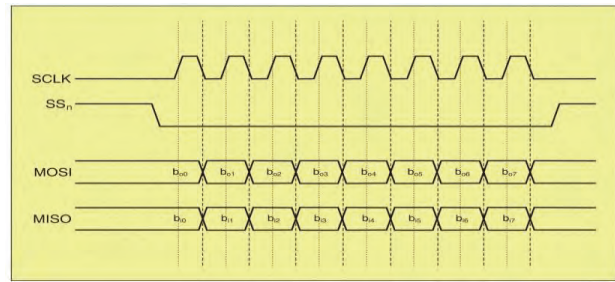
Figure 4. A simple SPI communication

Master Slaves:
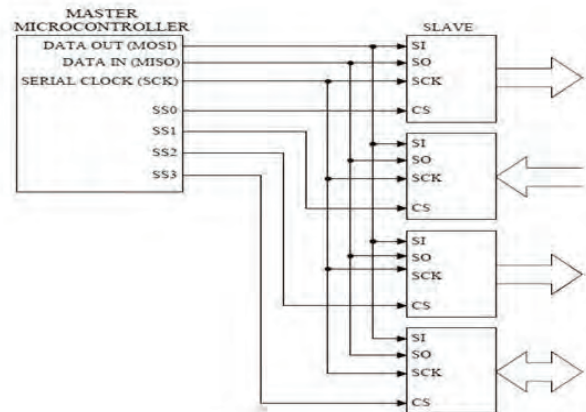
Figure 5. Block diagram of Multiple slaves

Work Flow of SPI:

SPI works in a "synchronous" data bus, it means that this data bus uses separate lines for "data" and a "clock", which keeps both in perfect synchronization.

1. Sending Data:

The clock which is a data bus and also it acts as an oscillating signal that it tells the receiver exactly when to send the sample bits on the data line, so that it will be the rising or falling edge of the clock signal. "Fig. 6" shows how the receiver detects that edge; it will immediately look at the data line to read the next bit. Along with the data the clock is sent, to specify the speed, though devices can be operated at the top speed.
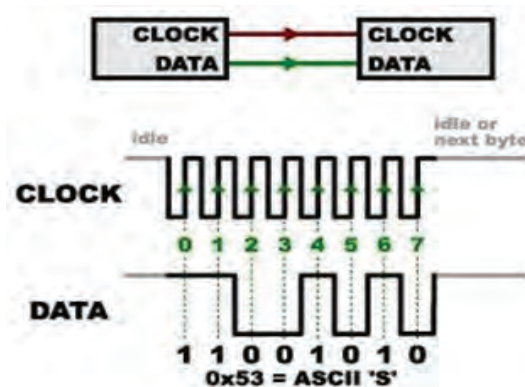
Figure 6. Sending data

2. Receiving Data:

In SPI, it generates the clock signal (called as CLK or SCK for Serial Clock). The clock side which is generated is called the "master" and another side which is generated is called the "slave". In SPI, only one master (which acts as microcontroller) and also it can have multiple slaves.

In "Fig. 7" it shows how the data is sending from the master to a slave, this data is sended on a data line called MOSI (Master Out / Slave In). The response from the slave sent back to the master, then the master will continue to generate a prearranged number of clock cycles, and the slave will put the data onto a third data line called MISO (Master In / Slave Out).
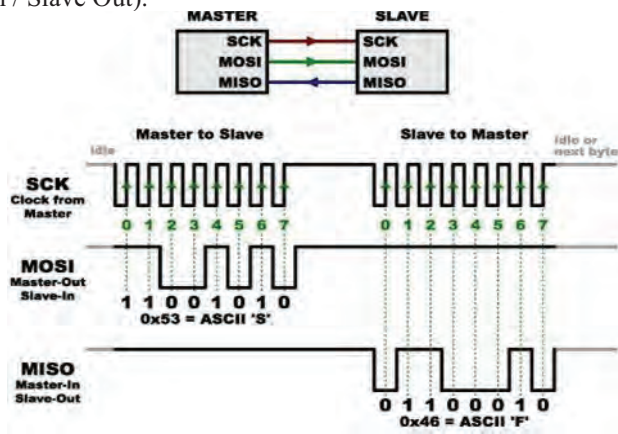
Figure 7. Receiving data

3. Slave Select Working:

The "Fig. 8" Slave Select is also called SS, it tells that it should be active to receive or send data and be present in multiple slaves to select each slave chip. The SS line is normally held high, which disconnects the slave from the SPI bus.
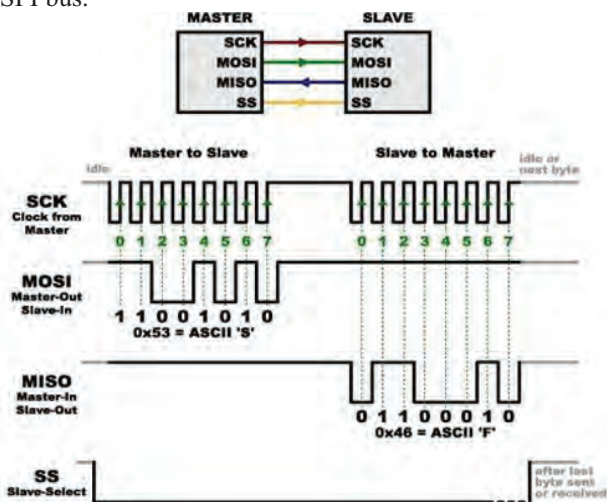
Figure 8. Working of Slave Select

SPI Capabilities:

Full-Duplex (Communicates in both directions simultaneously), multiple Mbps transmission speed of 0-50 MHz clock speed and transfers data in 4-16 bit characters.

SPI Bus Wiring:

SPI bus wiring is done like shown below:
Master-Out, Slave-In (MOSI),
Master-In, Slave-Out (MISO),
System Clock (SCLK),
Slave Select / Chip Select (SS1, SS or CS).

SPI Signal Functions:

MOSI – carries data out of master to slave
MISO – carries data out of slave to master (both MOSI and MISO are active during every transmission)
SS# (or CS) – unique line to select each slave chip
SCLK – produced by master to synchronize transfers

IV. DESIGN AND IMPLEMENTATION

A. Developing of GUI for Radar Controller

In "Fig. 9" it talks about the process flow of entire application how it is working.

1. Communication with Array Controller:

The interaction between Radar Controller and Array Controller happens in server-client fashion using TCP/IP protocol. RC acts as server and AC as client, RC issues commands, AC will executes them and sends back the response.

2. Interface Messages between Radar and Array Controllers:

Health:

Operator will initiate the health checking of LAC(s) or complete array by clicking a button on GUI. RC will issue a health command to AC. AC in-turn issue the command to selected LAC(s). LACs will respond back to AC. AC will post the response to RC. After due processing of response message, RC will display the individual TRMs health status on GUI.

Signature:

The Signature command (message) is used for knowing the hardware batch numbers, software version no. and checksum of Linear Array.

Status:

The status command (message) is to read-back the programmable values that are set to TRMs.

Programmable values:

The programmable values (Tx Ph (Transmit Phase), Rx Ph (Receive Phase) and Rx Attn (Receive Attenuation)) uses total 8-bits, 2-bits are used for identifying and remaining 6-bits are used for sending the data.

Each LA (Linear Array) uses 32db power supply for whole the TRM's inside it, means each TRM in the linear array will use 0.5db power. Attenuation is used to decrease the power of each TRM in the linear array and phase is used for moving radar antenna, in degrees like 0˚, 45˚, 67.5˚, 90˚ up to 360˚.

CW Mode:

Each TRM is tested in CW mode only, to get the absolute amplitude and phase values in VNA (Virtual Network Analyzer)

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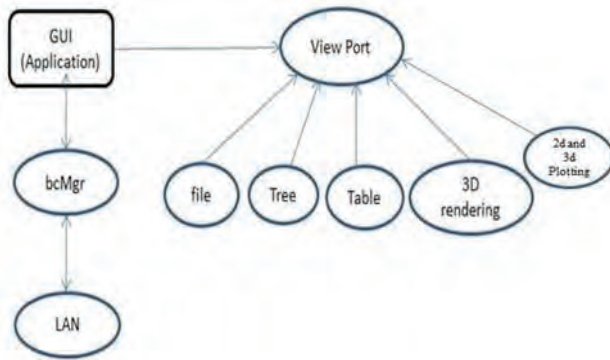
Figure 9. Process flow of entire application

3. Data representation to the user:

File view:

This File View is used to store the programmable values in the text file, so that any time modifications can be done and can import, load and share the file. The QFile System Model class provides a data model for the local file system in the file view.

The fileInfo (), isDir (), name () and path () functions provide information about the files and directories related to items in the model. Directories can be created and removed using mkdir (), rmdir ().
QFileSystemModel :: QFileSystemModel (QObject * parent = 0)
QFileSystemModel   *model   =   new QFileSystemModel;
Model -> setRootPath (QDir::currentPath ());

Table view:

The Table View is used to show the values in the 2D table as rows and columns so that any calculations required for the element can be done easily. The QTableView class is one of the Model/View Classes and is a part of Qt model/view framework.

A QTableView implements a table view that displays items from a model. This class is used to provide standard tables that were previously provided by the QTable class, but more flexibility is provided by Qt's model/view architecture.
QTableView::QTableView (QWidget *parent = nullptr)

Tree view:

The TreeView is an hierarchical structure of radar controller, linear array controller and TRM values. In this structure the values of particular radiating element can be shown clearly. The QTree View class provides a default model/view implementation of a tree view.

A QTree View implements a tree representation of items from a model. This class is used to provide standard hierarchical lists that were previously provided by the QList View class, but more flexible approach   is provided by Qt's model/view architecture.

QTreeView::QTreeView (QWidget * parent = 0)
QFileSystemModel   *model   =   new QFileSystemModel;
Model->setRootPath (QDir:: currentPath ());
QTreeView *tree = new QTreeView (splitter);
tree->setmodel (model);

Beam View:

The rendering of data surface is done through the OpenGL using 3D graphics so that the beam position can be seen clearly. A beam formed out of the values, is shown as a 3D projection to mimic the real-world scenario.

The beam steering is animated while the AESA RADAR steers its beam according to its operation. This Beam View is done through the Qt OpenGL, with the QGL library file. In profile "QT += opengl" should be added. Using QGLWidget the OpenGL functions can be used. The main functions that are used for producing a 3D graphics of beam are the following,
Void   initializeGL
Void   resizeGL ()
Void paintGL ()

Plotting:

In this work, 2D plotting is done for Rx Phase and Rx Attenuation values separately using 'plot' command for 2D projection and setting x and y ranges according to the TRM values which are drawn from the measurement data. 3D plotting is done for phase and attenuation values of Rx and projected in 3D using 'splot' command through terminal based on both phase and attenuation values from the data file.

Number of plotting styles is there in Gnuplot for plotting 2D or 3D plots. Few commands like set style data and style function change the default plotting style for subsequent 2(D) 'plot' and 3(D) 'splot'. Each plot has its own expected set of data entries in a data file. The illusion of 3D is enhanced by choosing hidden line removal or depth-sorted surface elements. The 'splot' command can also calculate and draw contour lines corresponding to contour z values. A special case of 'splot' command is to map the z coordinate onto a 2D surface by projecting the plot along with z-axis.

B. Beam Display in 3D

In "Fig. 10" the three-dimensional-(3D) Beam [4] is constructed in OpenGL in accordance with vector graphics rules. Every object is composed of a certain number of polygons. The most essential problem is arrangement of the objects in order starting from those, lying at the farthest, up to these, which are located nearest to the observer. OpenGL offers z-Buffer algorithm to perform this assignment. It uses a structure of the memory, where Z coordinates of every pixel are stored. For each animation frame, Z coordinates of all the pixels, which constitute the 3D objects display, are compared with Z coordinates saved in Z-Buffer (of the previous frame). In case a specific pixel is characterized with shorter Z coordinate, then it is drawn up its previous place.
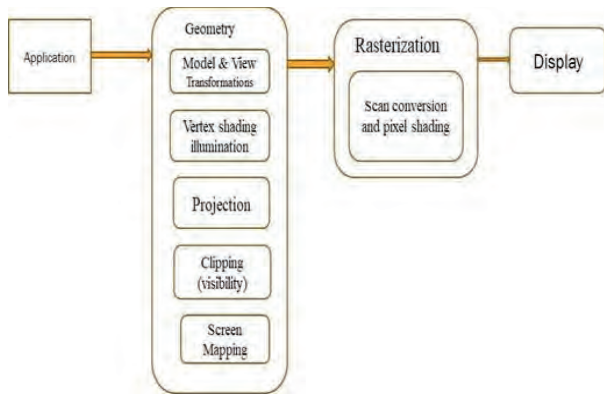
Figure 10. Process flow of beam in 3D

The next step in visualization of 3D stage is texture mapping. It consists in covering an object composed of 3D polygons, with a two-dimensional bitmap. Textures placing algorithm is based on at least two bitmaps, different in sizes. If the observer is close to the object, then the largest bitmap is projected on the beam. With its movement, the bitmaps are replaced each time with smaller ones.

C. Estimation of Elevation and Azimuth angles

Radar systems have become available for automotive, surveillance, anti-drone, medical and personal security applications. Due to this the need of inexpensive high performance radar is increasing. FWMC (Frequency Modulated Continuous Waveform) radar [6] has become popular due to its inheriting ability to utilize a large bandwidth with a low sampling rate.

The FMCW radar is one of the most popular CW radar types with ability to obtain range information. A K-band portable radar with beam forming [7] array is used to localize short range. It includes both transmitter and receiver channels. The beam forming array is a linear array element in which each element is a series-fed micro strip patch array element. The beam of the array can be continuously steered with a range of 45degrees on the H-plane through an array of radar controllers.

D. Effective beam pattern

The effective beam pattern [8,5] is derived from the radar data analysis and radar phase optimized values. The height of the melting layer is determined from range-height indicator (RHI) that scans from the radar bright band signature by considering only the single beam pattern. The pattern was measured from the isotropic radiated power and normalized by the calculated transmit power given by the RF system output power.

E. Experimental Results

Based on the QT software the below shown application is developed. The "Fig. 11" is the output design of entire radar application and it shows how each module is connected.
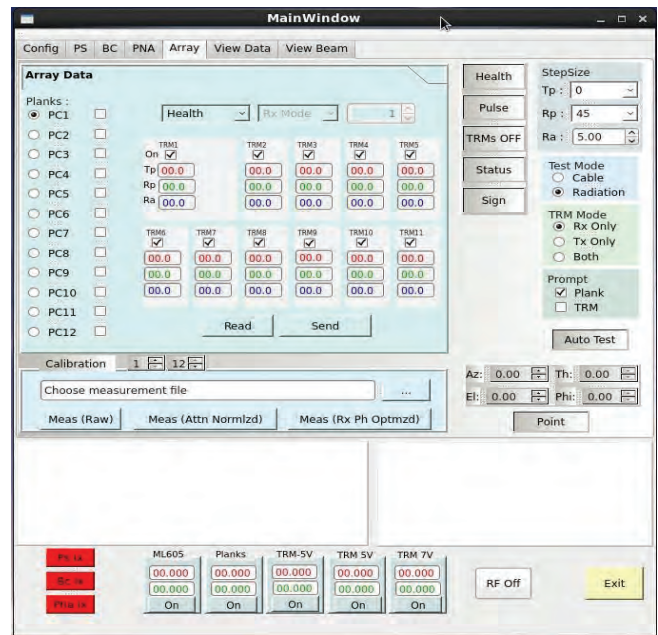
Figure 11. Design of Radar Application Software

The below shown "Fig. 12" is the output of some random values generated from the AESA radar in table view.
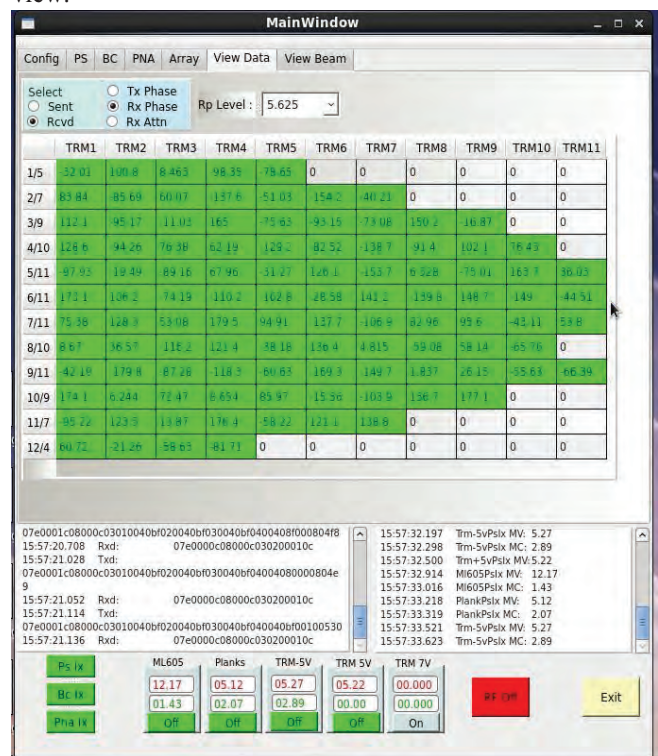
Figure 12. Data viewed in Table view

The below shown "Fig. 13" is output of beam steering at desired angles shown in projection view
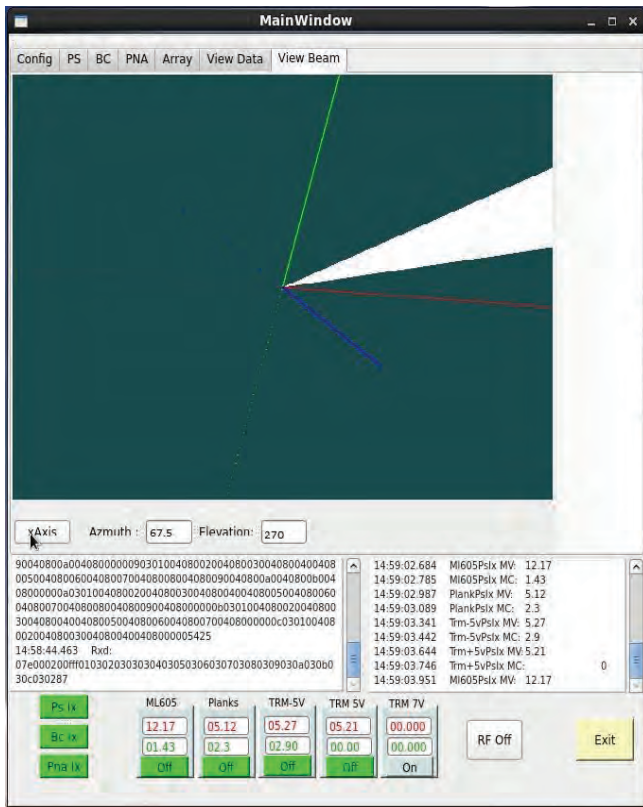
Figure 13. Beam view at certain angles

F. Experimental Results of Receiver

Based on the results, using Gnuplot software, plots are drawn. Some such plots are shown below. Through this software, 2D and 3D plots are stimulated for only receiver values of both attenuation and phase.

RX Attenuation:

The 2D plotting of Rx Attenuation values are drawn in "Fig. 14", on x-axis plane TRM no's and on y-axis plane Attenuation values with step size 5db.
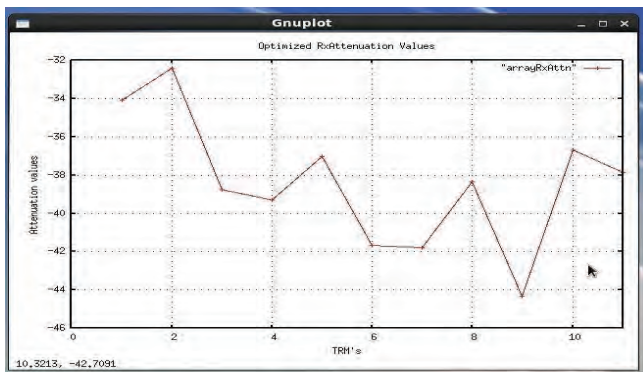
Figure 14. TRM RX Attenuation values in 2D graph

RX Phase:

The 2D plotting of Rx Phase values are shown in "Fig. 15", TRM no's on x-axis, and phase values (in degrees from 0-360) on y-axis, is shown below.
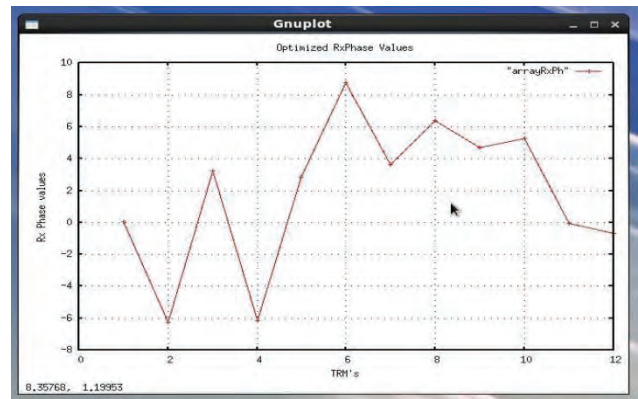
Figure 15. TRM RX Phase values in 2D graph

RX Phase and Attenuation:

The below shown "Fig.16" is the 3D plotting of both Rx phase and attenuation values.
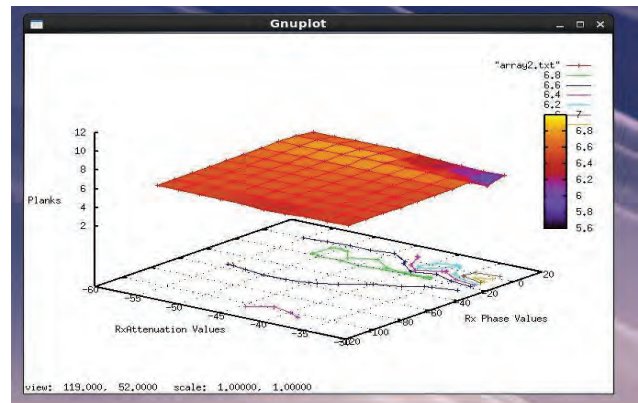
Figure 16. Both RX Phase and Attenuation values in 3D graph

V. CONCLUSIONS

In this paper, AESA Radar data visualization - each antenna element is controlled in such a way that the beam of radio waves can be electronically steered in different directions without moving the antenna. The beam steering is done according to the Azimuth and Elevation angles which are given through the GUI itself.

Measured results are shown in different views like file, table, tree, plotting and beam realizes the scanning range from −60° to 60° in 3D graphics within the frequency range of operation. Using VNA (Virtual Network Analyzer) as the signal processor, the azimuth, elevation and range information are obtained by two orthogonal frequency-scanned antennas.

The further scope of the paper is application of Amplitude Tapering, which is used for measuring the amplitude values. The values are filtered in pulse mode and calibrated in CW mode according to the power given and based on the frequency range. According to the calibrated values beam steering is done by locking the individual targets of enemy radars.

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Industrial IoT Gateway Configurator

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Abstract: Internet of Things (IoT) is a fast-growing phenomenon that attracted the attention of researchers and many business organizations. It has enhanced the demand for connecting various networks that include heterogeneous networks with different protocols. From this point of connectivity through networks, sensors have a limited capability as they cannot offer connectivity to complex and large networks such as internet. The present paper is based on the experience in the design and implementation of an industrial IoT gateway configurator for real time monitoring that enhances the performance of assets. It includes configuration of the gateway, asset and transducer to build solutions efficiently in various areas like agriculture, industry, health, transportation, etc.,

Index Terms: IoT, an Asset, the Gateway, Sensor, a Web-socket connectivity protocol

I. INTRODUCTION

Now-a-days everything connects to the Internet, which is growing to send information to servers for processing, storage and to provide full control of physical devices over the web. It is become medium for everyday communication.

The Thing- A device/ a conceptual device becomes a thing if it is at-least the following:

a) Self-described b) Reconfigurable c) Interacting with some decision systems d) Autonomous e) Safe and Secure f) Uniquely identified g) Connected h) Reliable i) Resilient.
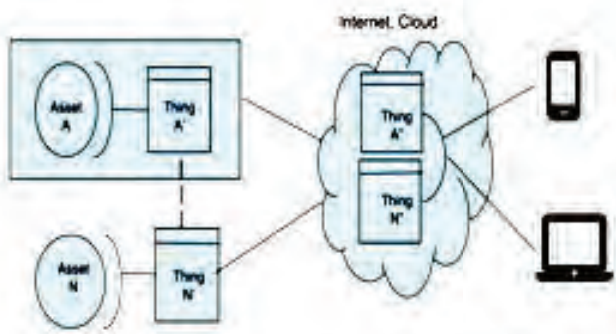
Figure 1. Internet of Things

- In Fig. 1, shown are the Assets A and N connected as A", N" in the cloud.
- This is the crux of IoT designs. Once the software objects of Assets are present in the "Compute", environment, it opens doors of "Connected" Applications.

The Internet of things (IoT) is the network of physical devices, home appliances and other items embedded with electronics, software, sensors, actuators and transducers to setup the objects, which communicates and exchanges information [1][2][3]. Each thing has unique identification which collaborates with the existing Internet infrastructure. Objects are remotely sensed across existing network frameworks, to create opportunities for direct integration of the physical world into computer-based systems and the results improved according to accuracy, efficiency and economic benefit.

A. IoT Edge Analytics Gateway
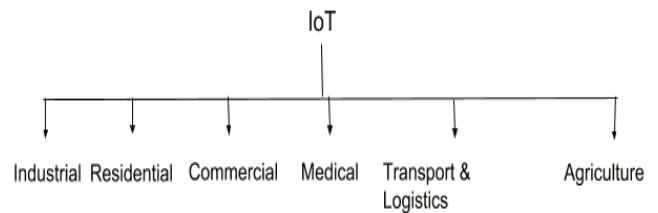
Figure 2. Internet of Things

- As shown in Fig. 2, IoT is applicable to all business where "Assets" are connected.
- IoT is a new channel to observe and control the industrial production.
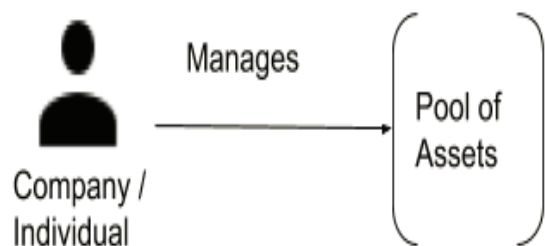
Figure 3. Asset Overview

- As shown in Fig. 3, a business manages "Assets" and creates value; it is very obvious that those "Assets" are subjects of IoT.

B. Asset Management System

Asset management includes IoT Edge Gateway and Cloud Decision Support applications.
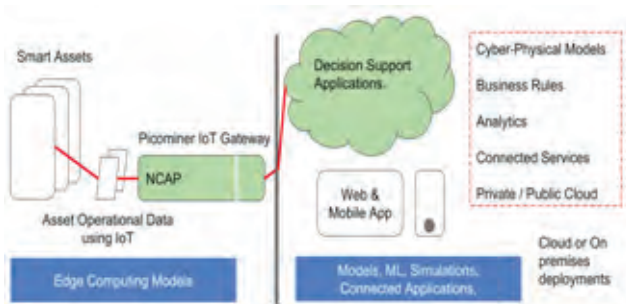
Figure 4. Asset Management System

NCAP (Network Capable Application Processor)

As depicted in Fig. 4, the NCAP Runs on the SBC (Single Board Computer) such as Raspberry Pi, Beaglebone etc., interfaces with Transducer Boards (Anybus Communicators, Texas Instruments, Arduino, Custom Boards). It handles millions of data points at the gateway and supports a variety of communication protocols.

II. DESIGN AND IMPLEMENTATION

A. Gateway Architecture
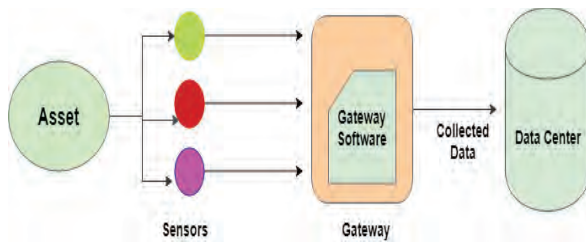
Figure 5. Gateway Architecture

The input of the application is an asset and the output are to configure the gateway by monitoring the asset. Device-to-gateway communication model is used in-order to implement and configure the IoT gateway.

As shown in the Fig. 5, the gateway architecture is the most prevalent architectural design where the assets are attached to sensors to monitor the asset resource but gateway itself is not setup the sensors, the gateway software which is installed on the device is held for collecting information from the various sensors, pre-processing that data and sending the results of the collected data to the data center with the help of web-socket connectivity protocol.

Asset

Asset is an input resource controlled by the thing. Assets like industrial floor, packaging machine whose are attached with sensors to monitor the asset data.

Sensor

Sensor is a device which is used to identify the changes in an environment in the system. Sensors like temperature, pressure, weight etc., Major role of sensors is to hit the physical phenomenon and converts it into an electric signal.

Gateway

Gateway acts as an interface between the sensors and cloud servers. The Gateways can connect to the IoT devices through web-socket connectivity protocol, store and parse the data and then send them over to cloud servers for processing and analytics. The IoT gateways not only acts as an interface for communication but also provides the security in the form of unique id for the gateways while transmitting the information.

The Gateway Software

The gateway software is responsible for collecting the data from sensors and sending them to the data center for pre-processing the data and it will decide that at any stage of processing the data in temporary, kept in-memory. The gateway software application is the heart of the gateway. It will handle the failures like when power is off while using the application, it should be bootstrapped and started automatically as power returns to the device, and it should continue to work where it was interrupted.

Device Management and Configuration

In this architecture, an IoT gateway handles up to eight different types of sensors and their data. To store the connected sensor information, IoT Gateway device is required. In addition to this, IoT Gateway manages and configures the information of all the devices.

B. Cloud Connectivity

Cloud <> Gateway (for decision events)
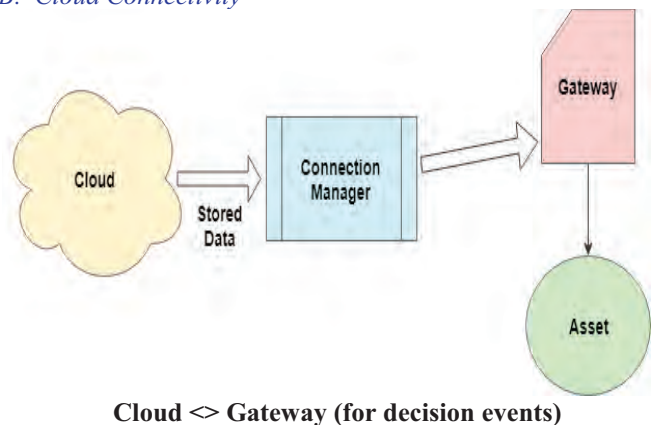
Figure 6. Cloud Connectivity Diagram

Data Communication Protocols

The IoT Gateway connects with the cloud over web-socket connectivity protocol to stream the input data. Two-way communication channel is established from asset to the cloud for exchanging of data to get the decision events.

Cloud Connectivity Manager

The connection manager is responsible for consistent connectivity from the gateway to the cloud. It handles the reconnection when power is in on/off state and maintains the heart-beat message from the cloud to gateway device through web-socket connectivity protocol. The same has been displayed in Fig. 6.

Custom Application

IoT Gateway application is designed as per business needs. The Gateway software application interacts with services, functions to manage data between sensor node and the gateway to the cloud in an efficient, secure and responsive manner.

C. Platform Model
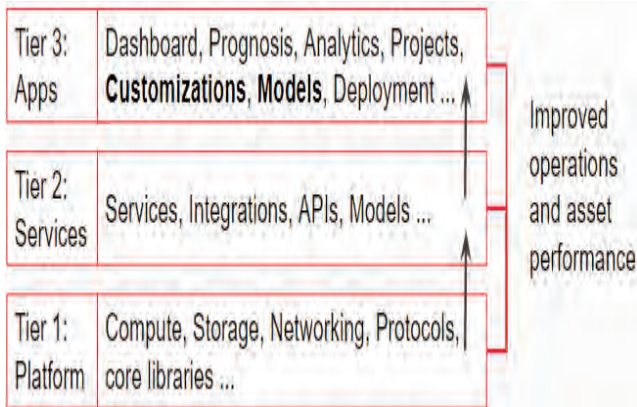
Figure 7. Tier 1, 2 are core platform offerings. Tier 3 (Apps) is a service layer.

Tier 1 – Web-Socket Connectivity Protocol [4]

From Fig. 7, web sockets allow two-way (full-duplex) communication between asset and cloud through a single connection [5][6]. The protocol is helpful to reduce unnecessary network traffic and latency. Web-Socket is used to communicate and exchange data at the same time. This protocol is used to optimize the performance, resulting in more responsive web applications. The data which is collected from the gateway is sent to the cloud using the web-socket connectivity protocol, the protocol will stream all the data, pre-process it and send back to the gateways and assets using the same connectivity protocol. RFC 6455 is the latest specification of Web Socket protocol, it is supported in all browsers like Mozilla Firefox, Internet Explorer, Google Chrome, etc.

Following is the API which creates a new Web-Socket object.

var socket = new Web-Socket(url, [protocol]);

The first argument url, specifies the URL (Uniform Resource Locator) to connect. The second argument, protocol is used to connect the server.

Tier 2 - Restful Services of API

"Reference [7]" proposed an asynchronous RESTful web service recursively. To invoke the RESTful web services from the Internet of Things, there will be various methods explained. To access the data for a resource is via HTTP URI, in-order to accept the input data is via PUT method and to access output data is via GET method [8]. To minimize latency and network communication, RESTful web services will be helpful.

APIs Code to login in to the application (client side)

This API is developed using typescript.

```
// Let's Login to the Portal (Application) using the APIs.
Const mylogin = {

'email' :emailId,

'password' : passwd

};

this.headers = new HttpHeaders({'Accept':
'application/json','Content-Type':'application/json'
, 'Access-Control-Allow-Origin': '*'});
   this.httpClient.post<any>(
`https://dashboard.picominer.com/es/login,
   mylogin,{ headers: this.headers}).subscribe(
   // callback
   (Success)(val) => {
   if (val === null || val === undefined) {
        // Something wrong. Check the API.
        return;
   }
   // Let's extract the data from the API response.
If(val['api-response']['header']['result'] === null    ||
val['api-response']['header']['result'] === undefined) {
   return; }
   // Portal API returns success (result = 0) if everything is OK.
   if (val['api-response']['header']['result'] !== 0)
   {
   constappError=val['api-response']['header']['response'];
this.stopPortalSpinner();return; }
   // Now set the Application State Variables.
this.appState.setUserData(val['api-
response']['header']['email'],val['api-
response']['header']['login'],val['auth-token'],val['api-
response']['header']['accessed_at'],`${new
Date().toLocaleTimeString()}`);
   // User has logged into the Portal.. Redirect to Dashboard pages.
   Returnthis.router.navigate(['/site-analytics']);
   }
```

Tier 3: Dashboard
Node.js

To use Angular framework, it requires Node.js version 8.x or 10.x. Node.js is an open source JavaScript engine developed by Google on top of V8 [9]. It is efficient for real-time applications because it uses an event-driven model. The features and functionalities of Angular, the Angular CLI (Command Line Interface) and Angular apps are provided by libraries which are available as npm packages, npm package manager must be required to download and install npm packages.

Based on the package.json file information, Node Package Manager (NPM) is included inside to provide the installations of the third-party modules and dependencies.

Data Visualization (client side)
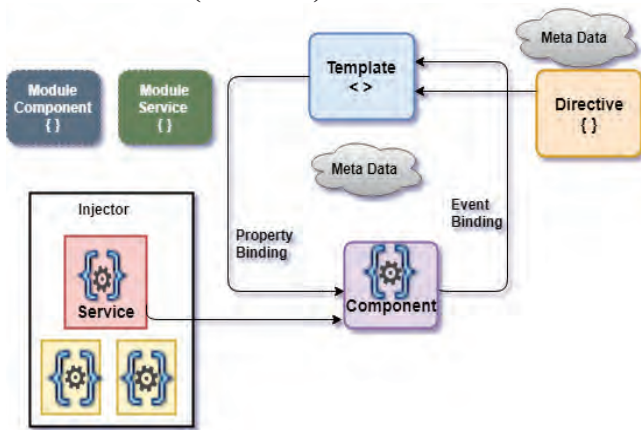
Figure 8. Angular JS Architecture [10]

To develop client side of web applications, Angular framework is very helpful [10]. To build angular applications, HTML, JavaScript language is used. Angular framework is in type script language which then compiles into java script language. This framework contains plenty of built-in libraries that some installed by default and others are optional.

As given in the Fig. 8, Angular JS architecture shows the component classes which are created to manage the templates, application logic is added in services, components and services are included in modules to inject the objects and classes. The main advantage of angular JS framework is routing i.e. navigating from one page to other page without reloading the entire page and binding the data in terms of property, event. Directives are helpful in an application in-order to perform the actions in an application.

Angular 6 Portal Application Example -Installation of Angular6

To set up the node.js in a device, for using the angular framework.

Step 1: Go to required directory then install the following commands:

npm install –g @angular/cli –save
ng new filename

The project will be created with some components and modules in type script.

For web-socket connectivity to cloud, install the following dependency:

npm install -S rxjs-websockets
npm install -S queuing-subject

The following sample code is the web socket connectivity to the cloud to stream the input data.

Code to connect the server using angular framework

Connect to the server with the help of web-socket connectivity protocol using the address **'wss://dashboard.picominer.com:7681'**.

```
public connect() {
if (this.messages)
return
// Using share() causes a single web-socket to be created
when the first observer subscribes.
```

```
// This socket is shared with subsequent observers and
closed when the observer count falls to zero.
   this.messages = websocketConnect(
'wss://dashboard.picominer.com:7681',
   this.inputStream = new QueueingSubject<string>()
).messages.share()
}
public send(message: string):void {
// If the websocket is not connected then the
QueueingSubject will ensure
   // that messages are queued and delivered when the
websocket reconnects.
   // A regular Subject can be used to discard messages sent
when the websocket
   // is disconnected.
   this.inputStream.next(message)
}
```

First, connect to the server using web-socket connectivity protocol and try to subscribe to the portal with 34 characters of length.

```
ngOnInit() {
   this.socket.connect();
   this.socketSubscription =
this.socket.messages.subscribe((message: string) => {
   console.log('received message from server: ', message);
   });
   // send message to server, if the socket is not connected it
will be sent
   this.socket.send('prathyushaprathyushaprathyushahello');
}
```

D. Design of Portal Application to Configure the Gateways

Fig. 9, shows the flow of the gateway, transducer and asset configuration to the cloud.
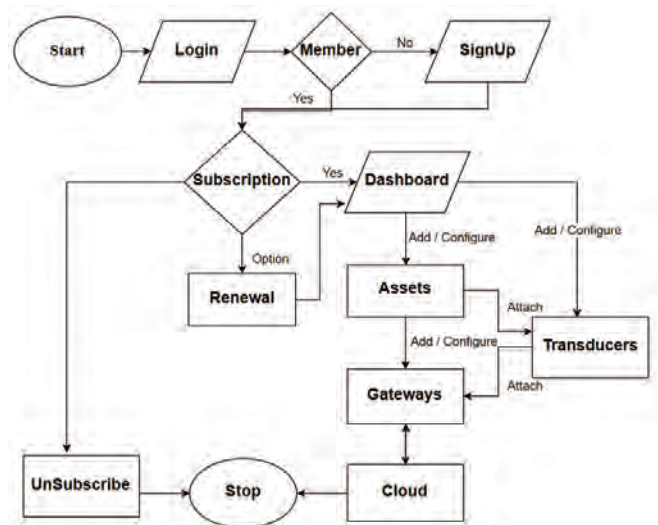
Figure 9. Flow Chart Diagram

Steps for Application:

1. First, login to the application using the **https://dashboard.picominer.com/v/2.0/#/login** with an email id and a password, otherwise register to the application.
2. After login into the application with proper authentication, dashboard will be displayed with sites, HMI, knowledge base, assets, gateways, transducers and account settings.
3. The user will select the site if required.
4. And the user will be add/configure the assets, gateways and transducers.
5. After configuration, the real time data for assets, gateways and transducers will be displayed in the form of various charts like radar, pie, line chart with state and status.
6. The application having the support for help and account settings to change password and logout from the portal.

E. Configuration

Configuring the Gateways

// Login to the Portal Application using Application using**dashboard.picominer.com/v/2.0/**

1. There are various gateways like an industrial machine gateway, a sensor node gateway and video processing gateway to add and configure the required gateway.
2. After selecting the required gateway, add the basic information like the name of the gateway, the description, local id, unique id, version id and cloud gateway information like ipv4 address, port number, domain name, like-wise physical gateway. After that, by clicking on the add button, displays a message in a dialogue box whether it is the correct gateway or not in-order to configure the gateway.
3. After adding the required gateway, update the details of the gateway if required, by clicking on configure gateway.
4. Update the gateway information if required and click on apply button then it will be displayed in the real-time gateway data with state, status of the gateway and data in the form of charts like radar, pie and line charts.

Configuring the Transducers

1. There are various transducers like temperature(LM35), pressure(PX40 series) and weight(HX711) to add and configure the required transducer.
2. Then, select the transducer and add the basic information like the name of the transducer, the description, local id, unique id, version id, latitude, longitude and location. Likewise, calibrations, engineering units, interfaces like serial SPI, serial I2C, Wi-Fi and simulations as capabilities, distributors, generators like linear congruential engine for the required transducer. After that, by clicking on the add button, it displays a message in a dialogue box whether it is the correct transducer or not in-order to configure the transducer.
3. After adding the required transducer, update the details of transducer if required, by clicking on calibrate transducer and attach the transducer to gateway and asset, by clicking on configure transducer.

4. Update the information of the transducer if required, then click on apply and close it.
5. And attach the required transducer to the gateway and asset, then click on apply button, it will be visible in real- time gateway data list in the form of various charts.

Configuring the Assets

1. The assets like an industrial floor, the packaging machine, etc., to add and configure the required asset.
2. After selecting the asset, add the basic information like the name of an asset, the description, local id, unique id, version id, latitude, longitude and location. After that by clicking on the add button, it displays a message in a dialogue box whether it is the correct asset or not in-order to configure the asset.
3. After adding the required asset, update the details of an asset if required, by clicking on the configure button.
4. Update the asset information if required and click on apply button then it will be display in the real-time asset data with state, status of asset and data in the form of charts like radar, pie and line chart.

Finally, the overall performance of the information of site analytics shows the equipment availability, equipment efficiency, production quality, overall equipment efficiency, filling volume accuracy, product spill, sustained peak output, batches completed, alerts to staff, data archival, equipment service time and equipment up time with date and time.

The configured gateways like an industrial machine gateway, sensor node gateway and the video processing gateway about the gateway details and state, status of the configured gateway will be visible in the list of real-time gateways.

The following resulted displays show the real-time data of an industrial machine gateway with eight transducers of data in the form of various charts like radar(traffic data), pie(resources), line chart(trends) and information of the device.

Fig. 10, shows the real time data for the configured industrial machine gateway in radar chart i.e. traffic data for gateway:
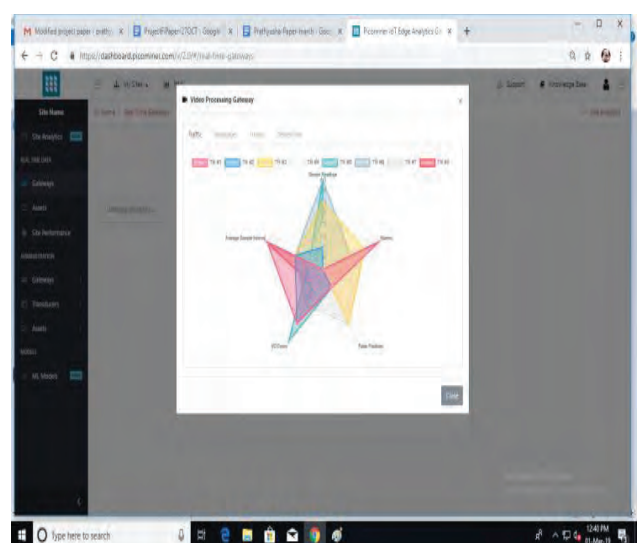
Figure 10. Traffic data of gateway in radar chart

Fig. 11, shows the real time data for the configured industrial machine gateway in pie chart i.e. resources of gateway:
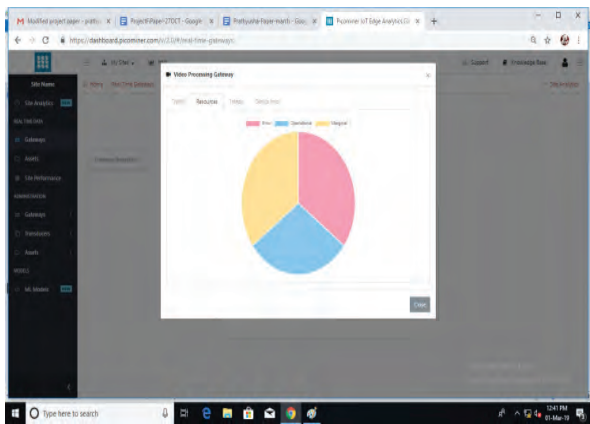
Figure 11. Resources of gateway in pie chart

Fig. 12, shows the real time data for the configured industrial machine gateway in line chart i.e. trends of gateway:
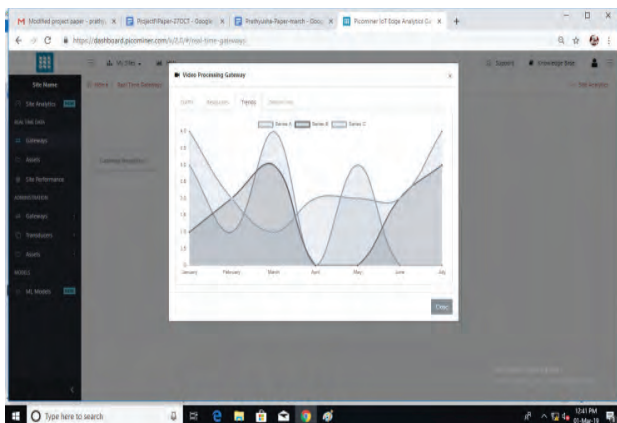
Figure 12. Trends of gateway in line chart

Fig. 13, shows the real time transducer data of event statistics in the form of pie chart and readings of the transducer which are attached to the gateway.

Figure 13. Event statistics of transducer in pie chart

Figure 14. Real time assets data

Fig. 14, show the real time assets data with state and status of industrial floor and packaging machine asset.

III. CONCLUSIONS

The IoT has been making our life simple and more convenient through new applications. This paper proposed a practical implementation of an IoT gateway dedicated to real-time monitoring and to improve an asset performance. Thus, Industrial IoT gateway configurator is a crucial business step in building solutions. The elegant solution is to build efficient turn-around time.

Future scope is to implement the millions of sensors, thousands of gateways and hundreds of data centers/ clouds. A view is given as the Fig. 15.
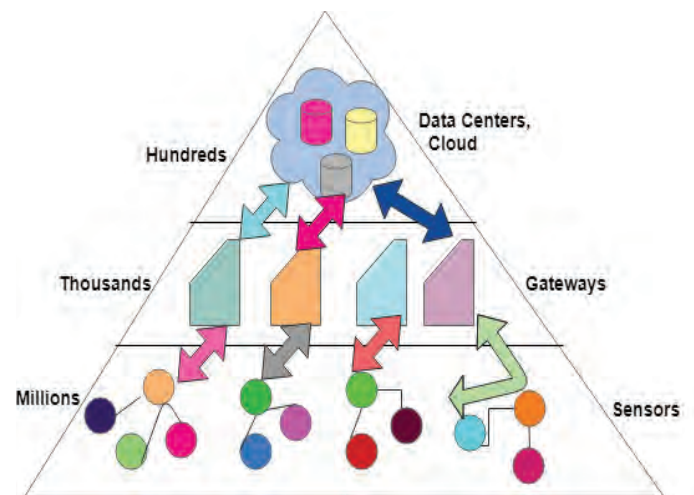
Figure 15. Future IoT Gateway Configurator

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[10] Angular Docs [online]. URL: https://angular.io/

Applying Linear Programming in Employee Scheduling Problem during Off-Season: A Case Study

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Abstract: **To improve competitive positioning, the effective utilisation of resources has become a favourable consideration for small and medium scale enterprises (SMEs). Among others, the scheduling of staff in SMEs has been regarded as a common problem. So, the present work is an attempt to solve this problem, particularly during the low production days. The study aim is achieved in steps. In the first step, the associated query is transformed into the linear programming problem, and in the second step, the application of MATLAB software is utilized to solve the problem. As a case study, the issue of scheduling for 8-hour shift is discussed. Study results are found in favour of both workers and employees. The study's assumptions may treat as its limitations.**

Index Terms: **Scheduling, Linear Programming, Optimization.**

I. INTRODUCTION

The increasing global pressure is forcing manufacturing industry to optimise their operation, training and schedules. Optimum production planning has become critically important to sustain in a highly competitive marketplace. In the field of industrial engineering, numerous researchers and practitioners have formulated many methods for scheduling, purchasing, capacity planning and other production activities. Still, in many organisations, the employee's scheduling is a challenging job. Which operator does performing what kind of job? And, when? The solution to these problems must meet certain restrictions concerning demand conditions. These are job experiences, specification, legal or contractual duties, employees' favourites, among others. The solution to these constraints (number of breaks & their placement, total duration, shift timing & length) becomes difficult and time-consuming if it is done manually [1, 2]. Effective scheduling makes decency at the workplace and creates harmony among workers. The modeling of scheduling has broad application in the service and manufacturing sector [3]. Owing to the small number of employees, in general, the scheduling in manufacturing SMEs is not a difficult task, but it becomes complex during off days [4]. The weak scheduling can be a massive barrier to teamwork that can severely affect the worker's output [5]. According to Becker et al. [6] in scheduling the tasks that need to be considered are employee's sequencing, shifting, grouping, timing and so on. Generally, constraints are categorized as (i) hard and (ii) soft constraints. The first category is also termed as mandatory constraints that must

be satisfied in order to achieve possible scheduling. The second category is also desirable but has a scope of alteration, therefore can be damaged.

Linear programming (LP) is a mathematical system employed to determine the genuine potential solution in distributing limited assets to achieve the most significant benefit [7]. In particular, LP is a means to deliver the optimal solution for a linear objective function, subjected to linear constraints. Here the term 'programming' has nothing to do with a computer program. It is all related to planning. Planning for optimum solutions and planning for optimum use of available resources and so on. In the current highly competitive marketplace SMEs are in search of increasing benefits with reducing costs and limited utilisation of available resources [8, 9]. In the present study, an effort has been made to optimise the required number of workers and to assure the worker's availability all the time. The rest of the paper is organized as the following section presents a literature review — sections 3 and 4 present case study design and study results, respectively. Finally, section 5 conclude the results and recommendations for SMEs.

II. LITERATURE REVIEW

Dantzig [10] has been considered as founding "father" of linear programming techniques. In world war II, Dantzig was involved in strategy making particularly in the area of transportation and assignment. In 1947 he developed the Simplex method of Linear programming model to solve underlying problems in transportation. The application of this technique was recognised in business organisations after the Second World War, and since then they are continuously being used in various fields. In 1949, Koopmans [11] further developed LP theory. Kuhn and Tucker [12] were the first to check its application in large scale in the scheduling of iron, steel production and paper industries. Practitioners were successful due to its application to different organistional setup.

With its application in different organisational setup practitioners were successful in minimising transport cost.

Kantorovich pointed out that LP can be used to improve economic planning [13]. He used LP on the Russian economy as a whole and established a connection between resource allocation and pricing system. Assar extended the work of Kantorovich and established the connection among a different combination of input and output factors, followed by Cooper who found its application in petroleum refineries.

Dantzig [14], provided that Nueman worked on the theory of game and the application of LP in it. Further, the Bell Laboratory Mathematician devised an entirely new method to speed up the routine handling of problems by business. The method made it possible to undertake problems that can be used to include a mixture of business and government applications. The earlier trend continued and advanced with changing the degree of knowledge, and the application of LP techniques has reached to daily life situations.

In the year 2004, Ernst et al. [1] presented a scheduling framework model for manual allocation of labour. The framework provided a way to reduce the cost associated with human allocation and production duration. The Genetic algorithm was applied to obtain solutions for the scheduling problem. The decision taken based on study results confirmed that the new optimal solution was profitable. It saved both cost and time.

Similarly, Keitany [3] suggested an alliance methodology solve the employee scheduling problem. The recommended methodology consists of management science and artificial intelligence. It can include the weight to penalise elements (e.g., location & timing) and gives more reliable results. Fikar & Hirsch [15] attempted to investigate shift order for the nurse scheduling problem (NSP). The study used LP application to optimise the balance of schedule considering all the constraints. The optimisation result assured the effectiveness of time and effort with a balanced workload.

Hiermann et al. [16] employed a two-stage methodology to solve the nurse scheduling problem. In the first stage, only sequence conditions were analysed to build quality sequences while in the second stage roster constraints were also considered. The comprehensively structured literate on scheduling is well presented in Jorne et al. [17]. In their study, authors have presented through discussion on scheduling its techniques and their features. Further, the study provided future scope and possible improvements in the field of scheduling. Chen and Wang [18] presented an integrated approach for planning in a Canadian steel production industry.

A LP model was developed to design a production and transportation planning system. In this project, researches used real data available with firm and results were calculated. Planning managers well appreciated final project's report and the proposed suggestions were taken seriously in the formulation of a detailed plan model. Overall the employees' scheduling task is crumbled into several small jobs, and then each job is handled individually or few in a group.

Two types of situations are reported in the literature. First, to allow the days off for each employee during the whole training period and the second one is to adjust to the shift of each working day during the training period. These two situations are usually described in the literature, namely, days-off and shift scheduling problems, respectively. When tackled together they are called tour scheduling problem. The tour scheduling problems are commonly observed it industries which operates 24 hours a day and 365 days a year. Further, the tour schedule has been classified into two groups cyclic and non-cyclic depending upon whether all employees have the same or different scheduling.

III. APPLICATION OF LP IN A MANUFACTURING FIRM

The ultimate aim of a firm is to maximise profits or minimise costs incurred to make a product. LP is concerned with decision making at various stages in a production facility and helps in achieving the above-said aim. According to Jorne et al., [17], a typical manufacturing firm has to make three decisions frequently:

- Technical decision: to finalised the method of production.
- Quantity decision: to decide the number of goods to be produced.
- Marketing decision: to forecast sales and growth behaviour.

Technical decisions at the production floor may involve the optimum use of available resources (man, machine and material) with best suitable combination aiming to minimise costs. LP has an essential application in aggregate planning; it also shows how multi-period planning problems can be approached quantitatively. The total plan involves developing a preliminary schedule for overall operations of a firm. In small scale manufacturing industries it is useful in preparing capacity planning for intermediate range.

IV. CASE STUDY DESIGN

A. Need to study

The present study is an attempt to optimise the worker's scheduling for manufacturing SMEs operating in the Northern part of India. The company has a packed schedule during the peak production season. However, during 'off' season it has some free slot, which it wants to utilise for employee training. Recently, the company established two automatic centres in sheet metal section. The objective was to utilise off-season time in imparting training on these newly initialled work centres.

B. Problem definition

Before packaging the product has to go through six shops:
(i) Sheet metal: to cut the raw material into required size with the help of press tools;
(ii) Forging shop: heating and hammering to required shape;
(iii) Machining section: streaming of an extra part after forging (removing scaling);
(iv) Grinding section: to impart surface finish;
(v) Assembling: joining into the final part;
(vi) Electroplating: nickel coating.

Usually, a shift lasts for eight hours, but sometimes workers have to work overtime. During the training days, top management desired that workers should work at least the first 6 hours in their respective shops and then last 2 hours should be utilised for training purpose. The shop-wise requirement of workers during training days is presented in Table 1.

C. LP problem formulation

LP often uses an algorithm. An algorithm is a limited set of following directions that drive to an expected objective

from a given initial situation and that are applied to resolve a problem. A common LP problem requires:
  (i) Objective function [criterion to optimise, i.e., profit, costs, return on investment etc.]
  (ii) Decision variable [unknown variable to be computed, i.e., input and output.]
  (iii) constrained (limited resources); and
  (iv) parameters (mathematical statements).

At the production floor generally, its objective is to find the answer to 'how to use available resources optimally. In general, LP algorithms include various iteration steps to accomplish a task. Results are then optimised based on some constraints. The constraints often present the availability of feasible options and lead towards a mathematical model.

In this study, this part was accomplished in four steps:

Step 1. It was assumed that all works are multitasked, i.e., can perform satisfactory work in any of the shops.
Step 2. Define decision variables, i.e., $V_1, V_2, V_3, V_5, V_6, V_7$ & V_8 be the number of workers in the respective shift, i.e., 1 to 8.
Step 3. Define objective function: *Minimize Z* = $V_1 + V_2 + V_3 + V_5 + V_6 + V_7 + V_8$.
Step 4. Setting constrained for objective function to be optimize: $V_1+V_2 \geq 10$; $V_2+V_3 \geq 20$; $V_3+V_4 \geq 22$; $V_4+V_5 \geq 18$; $V_5+V_6 \geq 15$; $V_6+V_7 \geq 9$; $V_7+V_8 \geq 12$; $V_8+V_1 \geq 10$; $V_1, V_2, V_3, V_4, V_5, V_6, V_7, V_8 \geq 0$.

Note: Z represents objective function (i.e., the minimum number of work jointly needed at the beginning of period 1, 2, 3, 4, 5, 6, 7& eight respectively).

The worker's requirement in different shops at a various interval of time was calculated and given in Table 1. Table 1 shows a 24:00 hours scheduling where the interval between 8:00 to 11:00 we need a total of 10 workers i.e., 2 in each SM, F, M, A and 1 each in G and E. The maximum worker strength need during 14:00 to 17:00 and minimum during 23:00 to 2:00. All workers are multi-skilled and are willing to join any shop at any period. A worker once entered the industry has to stay for a minimum of 8 hours (6 operations plus 2 hours training). The training hours needs to be scheduled at the end of the shift (last two hours).

D. Analysis and results

The MATLAB software inbuilt function was used to solve the above formulated LPP problems.
  Solver: fmincon- constrained nor linear minimisation
  Algorithm: Active set
  Derivatives: Approximated by the solver
  Max iterations: Use default 400
  Max function evaluations: Use default*100 number of variables
  Function tolerance: 1e-06.

E Results and discussion

Table II depicts the complete schedule during the training period, and Table III answers the question:

Q1. Which worker need to go where?

Q2. Who will come to a particular shop for a particular period?

For instance, as per the requirement, ten workers were needed during the period of 8 to 11, for that, worker number 1, 2, 3, 57, 4, 58, 59, 5, 6 and 7 need to be presented. Worker number 1 & 2 needed to go to sheet metal shop, 3 & 7 were allotted to forging shop, 4 and 58 were assigned machining, only one person, i.e., 59 went to ground, and 5 & 6 sent to the assembly line, and the worker number 7 remained in electroplating shop. Likewise, table III present the exact number of workers and their duties concerning each shop. Further, the aggregate results of the study showed that:

  i.   The minimum objective function value is 59;
  ii. The maximum number of worker required in shift 3;
  iii. The minimum workers required in shift 6.;
  iv. Worked number 41 and 42 were free during the period from 23:00 to 2:00 were not required in production and could be engaged in other activities (depend upon management decision).

F. Suggested scheduling of workers

With the help of colour coding suggested scheduling details of workers for training period is prepared and presented in Table 2.

V. Conclusions

Employees scheduling is, time and cost consuming task. It describes the central administration matters for any organisation, either from manufacture sectors or service sectors. The paper presents a case study of a scheduling problem in manufacturing SME. The chief objective is to find the minimum number of workers who can manage the need of the organisation. An effort has been made to define the constraint satisfaction system regarding shift and worker demands. Based on the study results it can be concluded that the optimum number of workers is 59. Shift 2 needs the maximum number of workers while shift 8 requires a minimum workforce. The critical finding is that two workers (W47 and W 48) are engaged only for 5 hours only rest of the three hours these workers can be utilized, as per the need of the company.

The case study presented in this paper gives the ability to define the number of minimum and maximum employees needed during off time. The manager would also be able to know which worker is free and for how much time so that that appropriate work can be assigned to them during offseason. The worker would get to know where they need to go and for what period. Employees are inhomogeneous concerning their performance, skills levels and status attributes. It limits the scheduling freedom (assigning job). The training period is considered as a critical time to learn new skills; hence the frequent change of job within the different department will provide a sense of responsibility towards obtaining multi-skills. It can be taken as a future work to solve these kind of problems in scheduling context.

TABLE I.
SIFT WISE WORKER DEMAND

Shift	Timing (24 hours/day)	Shopwise minimum requirements						
		Sheet metal (SM)	Forging (F)	Machining (M)	Grinding (G)	Assembling (A)	Electroplating (E)	Total
1	8:00 – 11:00	2	2	2	1	2	1	10
2	11:00-14:00	3	4	4	3	3	3	20
3	14:00-17:00	4	4	4	3	4	3	22
4	17:00-20:00	4	3	4	2	3	2	18
5	20:00-23:00	2	2	3	2	3	3	15
6	23:00-2:00	2	2	2	1	1	1	9
7	2:00-5:00	3	2	2	1	2	2	12
8	5:00-8:00	2	2	2	2	1	1	10

TABLE II.
SUGGESTED SHIFT SCHEDULE

Worker	8:00-10:00	10:00-11:00	11:00-13:00	13:00-14:00	14:00-16:00	16:00-17:00	17:00-19:00	19:00-20:00	20:00-22:00	22:00-23:00	23:00-1:00	1:00-2:00	2:00-4:00	4:00-5:00	5:00-700	7:00-8:00
W1	Sheet metal				Training											
W2	Sheet metal				Training											
W3	Forging				Training											
W4	Machining				Training											
W5	Assembly				Training											
W6	Assembly				Training											
W7	Electroplating				Training											
W8			Sheet metal				Training									
W9			Forging				Training									
W10			Forging				Training									
W11			Forging				Training									
W12			Machining				Training									
W13			Machining				Training									
W14			Machining				Training									
W15			Grinding				Training									
W16			Grinding				Training									
W17			Grinding				Training									
W18			Assembly				Training									
W19			Electroplating				Training									
W20			Electroplating				Training									
W21					Sheet metal				Training							
W22					Sheet metal				Training							
W23					Sheet metal				Training							
W24					Forging				Training							
W25					Machining				Training							
W26					Assembly				Training							
W27					Assembly				Training							
W28					Assembly				Training							
W29					Electroplating				Training							
W30							Sheet metal				Training					
W31							Forging				Training					
W32							Forging				Training					
W33							Machining				Training					
W34							Machining				Training					
W35							Machining				Training					
W36							Grinding				Training					
W37							Grinding				Training					
W38							Electroplating				Training					
W39									Sheet metal				Training			
W40									Assembly				Training			
W41									Assembly				Training			
W42									Assembly		Free slot		Training			
W43									Electroplating				Training			
W44									Electroplating		Machining		Training			
W45											Forging				Training	
W46											Machining				Training	
W47											Grinding				Training	
W48											Forging		Electroplating		Training	
W49											Sheet metal				Training	
W50	Training													Sheet metal		
W51	Training													Sheet metal		

W52	Training									Forging
W53	Training									Machining
W54	Training									Assembly
W55	Training									Assembly / Grinding
W56	Training									Electroplating
W57	Forging	Training								Forging
W58	Machining	Training								Machining
W59	Grinding	Training								Grinding

TABLE III .
WORKS ALLOTMENT TO ALL DEPARTMENT DURING TRAINING PERIOD

Shifts → / Shops ↓	8-11	11-14	14-17	17-20	20-23	23-2	2-5	5-8
SM	W1,2	W1,2,8	W8,21,22,23	W21,22,23,30	W30,39	W39,49	W49,50,51	W50,51
F	W3,57	W3,9,10,11	W9,10,11, 24	W24,31,32	W31,32	W45,48	W45,52	W52,57
M	W4,58	W4,12,13,14	W12,13,14,25	W25,33,34,35	W33,34,35	W44,46	W46,53	W53,58
G	W59	W15,16,17		W36,37		W47		W59,55
A	W5,W6	W5,6,18	W18,26,27,28	W26,27,28	W40,41,42	W40	W54,55	W54
E	W7	W7,19,20	W19,20,29	W29,39	W38,43,44	W43	W48,56	W56
Total	10	20	22	18	15	9	12	10

Where: SM= Sheet metal; F=Forging; M= Machining; G=Grinding; A=Assembly; E=Electroplating; W=Worker, and the number represent a particular worker.

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Optimization of Electrical Discharge Coating Process by Desirability Function approach

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Abstract: **Optimization is used to obtain a higher value of output with a lower value of the input. To attain high quality with low cost in the manufacture process, the optimization of method factors is required. In this work process factors of electrical discharge coating (EDC) process are optimized by using desirability function approach (DFA), a multi-objective optimization technique used in optimization multiple output responses at a time. ANOVA table and response table are also calculated to show the importance of individual parameters.**

Index Terms: **Optimization, EDM, Desirability, Taguchi**

I. Introduction

The coating is the process of applying hard and wear resistance layer material on the workpiece to improve its wear and corrosion resistance. Recently, a different composite coating of materials is used in a variety of applications like automobile, aerospace, die making industries which required coating on the used materials to increase its wear and corrosion resistance. Electro-discharge coating (EDC) is performed by the electric discharge machining process where deposition of material occurs on the surface of workpiece. A large number of processes have been used for EDC for surface reform, by using tool made up of powder metallurgy and surface modification tool by using composite electrodes. In the EDC process tool electrode made by powder metallurgy process is used by Sahu et al. (2018) [1]. Patowari et al. (2011) and Patowari et al. (2015) have used Cu-W composite tool during EDC process on C-40 steel workpiece [2,3]. Ahmad (2016) has used Ti-B$_4$C tool during EDC on Aluminum workpiece [3]. Sahu et al. (2018) have optimized the EDC process by VIKOR based Harmony search algorithm [4]. Again Sahu and Mahapatra (2018) have used the GRA based Harmony search algorithm for optimization of the EDC process [5]. In this present study, desirability function approach (DFA) has been used for multi-criteria optimization of the EDC process.

A. Optimization

Optimization is generally used to solve any engineering problem. The importance of optimization in different engineering fields are listed below; Effective utilization of input resources, Maximization of benefits and Minimization of cost in various manufacturing and construction, Optimal production planning, controlling and scheduling, peak allocation of assets or facilities among numerous activities, preparation of maintenance and equipment replacement to decrease operational cost, Inventory mechanism, selection of

manufacturing condition in metal cutting method to minimize manufacture cost, improvement of industry productivity. [6]

Maximization of output in terms of quality and quantity of the process with minimization of input in terms of material and cost is the basic target of every manufacturing industry. The EDM technique is a combination of number of factors like electro-dynamics, electro-magnetic, thermo-dynamic and hydro-dynamic activities, which unveils a complex nature of the process performance. A number of factors (namely; workpiece material, electrode, dielectric medium, pulse on & off time, voltage, current, Flushing pressure, etc.) influence its performance characteristics. Change in a single parameter will affect the practice in a complex way. The EDM companies and customers always try to attain higher productivity with a required accuracy and surface finish. Therefore, it is essential for optimization WEDM process parameters.

On the basis of requirements, optimization can be classified into two types; Design Optimization & Process Optimization. On the basis of versatility, optimization can also be divided into two types; single response optimization and multi-response optimization technique. Multi-response optimization is used to optimize more than one output parameter simultaneously. In this present study desirability function technique is applied for optimization of the process parameters.

B. Desirability function approach (DFA)

The desirability function methodology is a multiple response optimization technique, which is mostly used for the optimization problem in the industry. This method is based on the quality characteristics with most acceptable value, least acceptable or completely unacceptable values. This technique finds operating sequence which provide the "most desirable" response values (Bara et al. (2018) [7], Sahu and Mahapatra (2019) [8], Karande et al. (2013) [9], Singaravel and Selvaraj (2016) [10]).

1st Step: The individual desirability index (di) for the corresponding outputs can be calculated by using the equations (1) to (3), as per given below. According to the performance characteristics, there are 3 systems of the desirability functions

i. Nominal - the best

$$d_i = \begin{cases} \left(\dfrac{y_j - y_{min}}{T - y_{min}}\right)^s, y_{min} \leq y_j \leq T, s \geq 0 \\ \left(\dfrac{y_j - y_{min}}{T - y_{min}}\right)^s, T \leq y_j \leq y_{max}, s \geq 0 \\ 0 \end{cases} \quad (1)$$

The value of y_j is essential to attain a particular objective T. When the value of 'y_j' equals to the value of T, the desirability value becomes 1. When the value of 'y_j' surpasses a specific range from the mark, the desirability value becomes 0, that condition denotes the worst case.

ii. Larger-the better

In this case, the value of 'y_j' is likely to be larger is the better case. When the 'y_j' surpasses a specific criteria value, that can be observed as per the requirement, the desirability value becomes 1. If the 'y_j' is smaller than a specific standard value, then that is unacceptable and the desirability value becomes 0.

$$d_i = \begin{cases} 0, y_j \leq y_{min} \\ \left(\dfrac{y_j - y_{min}}{y_{max} - y_{min}}\right)^r, y_{min} \leq y_j \leq y_{max}, r \geq 0 \\ 1, y_j \geq y_{min} \end{cases} \quad (2)$$

iii. Smaller-the better

$$d_i = \begin{cases} 1, y_j \leq y_{min} \\ \left(\dfrac{y_j - y_{max}}{y_{min} - y_{max}}\right)^r, y_{min} \leq y_j \leq y_{max}, r \geq 0 \\ 0, y_j \geq y_{min} \end{cases} \quad (3)$$

In this case, the value of 'y_j' is likely to be the smaller is the better criteria. When the value of 'y_j' is smaller than a specific standard value, the desirability value becomes 1. If the value of 'y_j' surpasses a specific range value, the desirability value becomes 0. In this current experiment, "smaller is the better" and "larger is the better" characteristics are used for calculation of the individual desirability values for minimization and or maximization of response characteristics.

2nd Step: For calculation of the overall desirability (d_0), all the di values are combined and forms a particular value called overall desirability (d_0) by the by using the given equation.

$$d_0 = \sqrt[w]{\left(d_1^{w1} \times d_2^{w2} \cdots \cdots d_i^{wi}\right)} \quad (4)$$

3rd Step: For calculation of the ideal parameter and its level sequence, the higher d_0 value is taken into consideration. On the basis of the d_0 value, the parameter

outcome and the optimal level for all parameters can be predicted.

C. Analysis of variance (ANOVA)

ANOVA table is calculated to find out the best factors. ANOVA provides the comparative significant parameters. Calculation of the total sum of square values is required to find out the relative effect of the individual parameters. ANOVA is used to calculate the percentage of involvement of each input parameter for the overall results of the experiment.

ANOVA table can be calculated by the help of the given following equations.

$$SS_t = \sum_{i=1}^{m} \left(\eta_j - \bar{\eta}\right)^2 \quad (5)$$

$$SS_f = q \times \sum_{q=1}^{q} \left(\eta_j - \bar{\eta}\right)^2 \quad (6)$$

$$SS_e = SS_t - \sum_{q=1}^{q} SS_f \quad (7)$$

DOF = No. of level -1 (8)

Total DOF = Total no. of expt. – 1 (9)

$$MS_f = \frac{SS_f}{DOF} \quad (10)$$

$$\% \ Contribution = \frac{SS_f}{SS_t} \times 100 \quad (11)$$

These above equations are used for calculation of the ANOVA table.

II. RESULT AND DISCUSSION

The model used in this work is developed by Sahu and Mahapatra (2018) as a three objective function optimization process where maximization of material deposition rate (MDR) and minimization of tool wear rate (TWR) and radial under deposition (RUD) simultaneously. The input parameters which affect the output responses are (A)sintering temperature (ST), (B)compaction pressure (CP), (C)discharge current (Ip), (D)duty cycle (τ) and (E)pulse-on-time (Ton). Here, higher-is-better is used for MDR and lower-is-better is used for TWR and RUD. By following the procedure of DFA as discussed in Eqs. (1) to (4), di and do values are calculated and presented in the

table I. By taking the do value, the ANOVA is generated by using MINITAB software and presented in table II. The ANOVA is found out with R-square value of 77.4%. From the ANOVA table, it is found that sintering temperature has the highest percentage contribution of 31% towards the outputs. Similarly, compaction pressure and pulse-on-time have % contribution of 19% and 13% respectively. The diagram of percentage contribution is given in figure 1.

The response table for the means is given in table III. The optimum level of the input parameters is marked as '*' mark in this table. The corresponding '*' mark levels are the

optimum levels like Level-2 for A, Level-1 for B, Level-2 for C, Level-1 for D and level-3 for E. The means and interaction graphs for the do values are shown in figure 2 and figure 3 respectively. The optimum level corresponds to the higher value do in figure 2. Similarly, the signal-to-noise (S/N) ratio of the overall desirability is presented in table I. The ANOVA of the S/N ratio is given in table IV. Similarly, the graph of ain effect plot for S/N ratio and interaction plot for S/N ratio are shown in Figure 4 and 5 respectively.

TABLE I.
INDIVIDUAL DESIRABILITY INDEX (DI) AND OVERALL DESIRABILITY INDEX (DO) FOR EDC PROCESS

Sl. No.	Di (MDR)	Di (TWR)	Di (RUD)	do	S/N
1	0.393	0.411	0.506	0.434	-7.250
2	0.595	0.077	0.261	0.229	-12.803
3	1.000	0.173	0.661	0.485	-6.285
4	0.191	0.585	0.000	0.000	-60.000
5	0.393	0.450	0.298	0.375	-8.519
6	0.595	0.000	0.265	0.000	-60.000
7	0.000	0.607	0.004	0.000	-60.000
8	0.393	0.702	0.258	0.415	-7.639
9	0.595	0.435	0.251	0.403	-7.894
10	0.393	0.406	0.903	0.525	-5.597
11	0.393	0.660	0.902	0.617	-4.194
12	0.595	0.157	1.000	0.454	-6.859
13	0.393	0.614	0.417	0.466	-6.632
14	0.191	0.475	0.463	0.348	-9.168
15	0.393	0.253	0.769	0.425	-7.432
16	0.191	0.499	0.661	0.398	-8.002
17	0.191	1.000	0.394	0.423	-7.473
18	0.393	0.541	0.424	0.449	-6.955

TABLE II.
ANALYSIS OF VARIANCE FOR MEANS

Source	DF	SS	MS	F	P	% of Contri bution
A	1	0.172872	0.172872	2.72	0.241	31
B	2	0.107328	0.053664	0.84	0.543	19
C	2	0.029555	0.014777	0.23	0.812	5
D	2	0.009145	0.003567	0.06	0.947	2
E	2	0.070228	0.016524	0.26	0.794	13
A*B	2	0.019045	0.009523	0.15	0.870	3
B*C	4	0.027632	0.006908	0.11	0.968	5
Error	2	0.127340	0.063670			22
Total	17	0.563146				100

TABLE III.
RESPONSE TABLE FOR MEANS

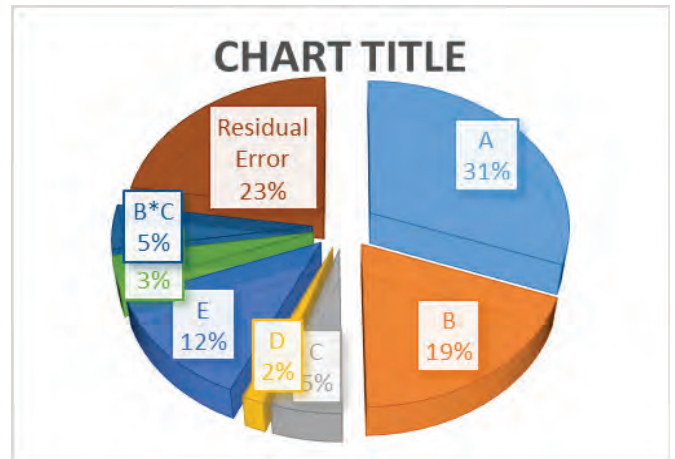| Level	A	B	C	D	E
1	0.2601	0.4573*	0.3038	0.3837*	0.3080
2	0.4561*	0.2690	0.4012*	0.3288	0.3202
3	-	0.3480	0.3693	0.3618	0.4462*
Delta	0.1960	0.1883	0.0973	0.0548	0.1382
Rank	1	2	4	5	3

*Optimum level

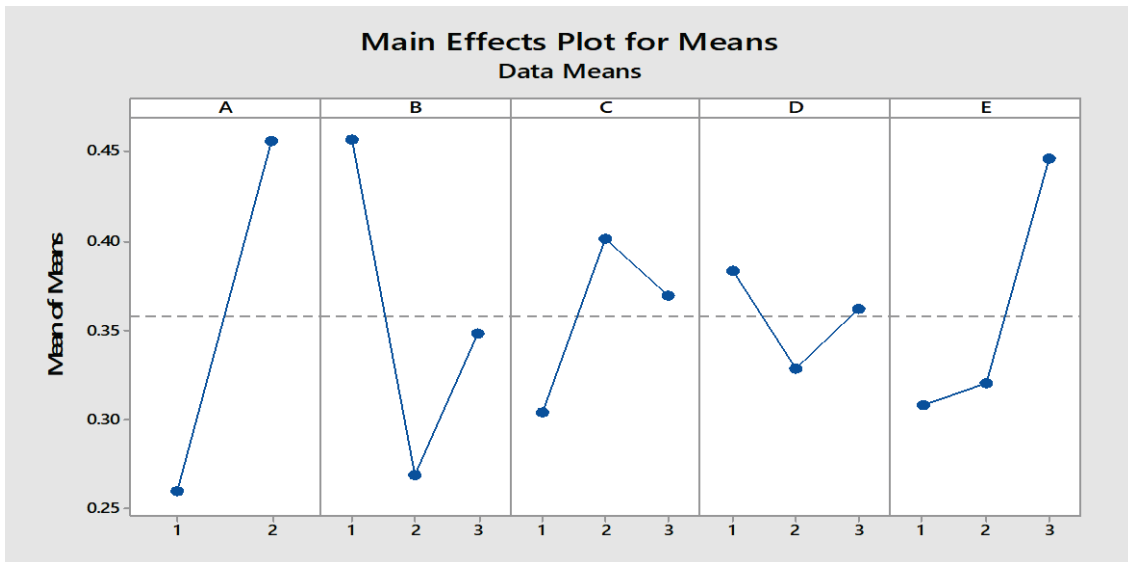Figure 1. % of contribution of Individual parameters
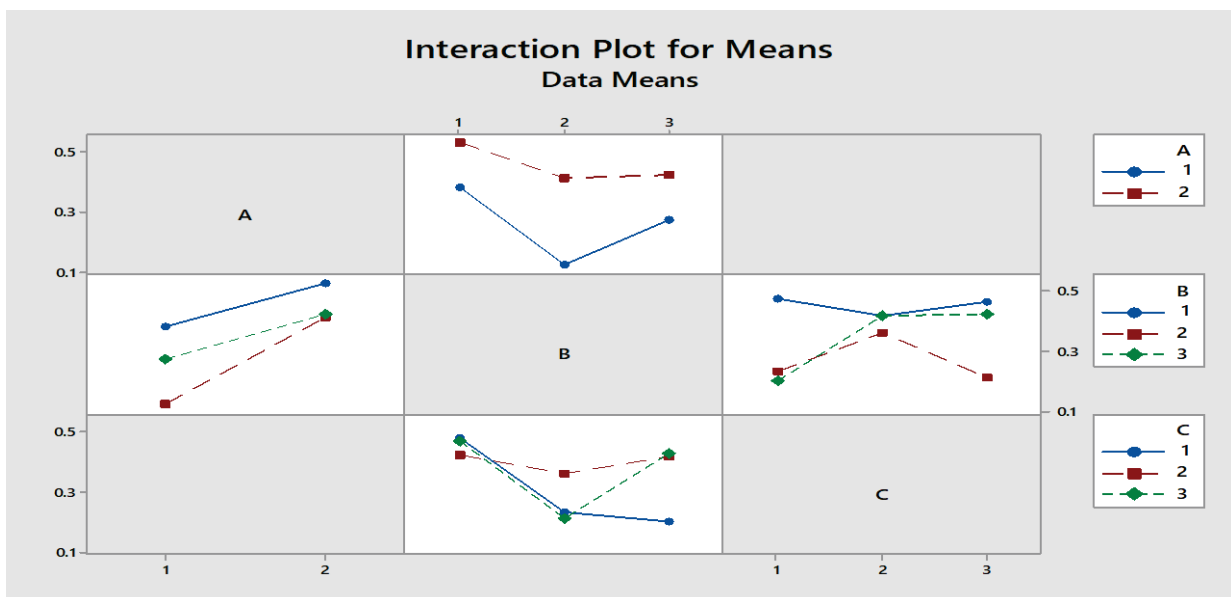

Figure 2. Main effect plot for means

Figure 3. Interaction plot for means

TABLE IV.
ANALYSIS OF VARIANCE FOR S/N RATIO

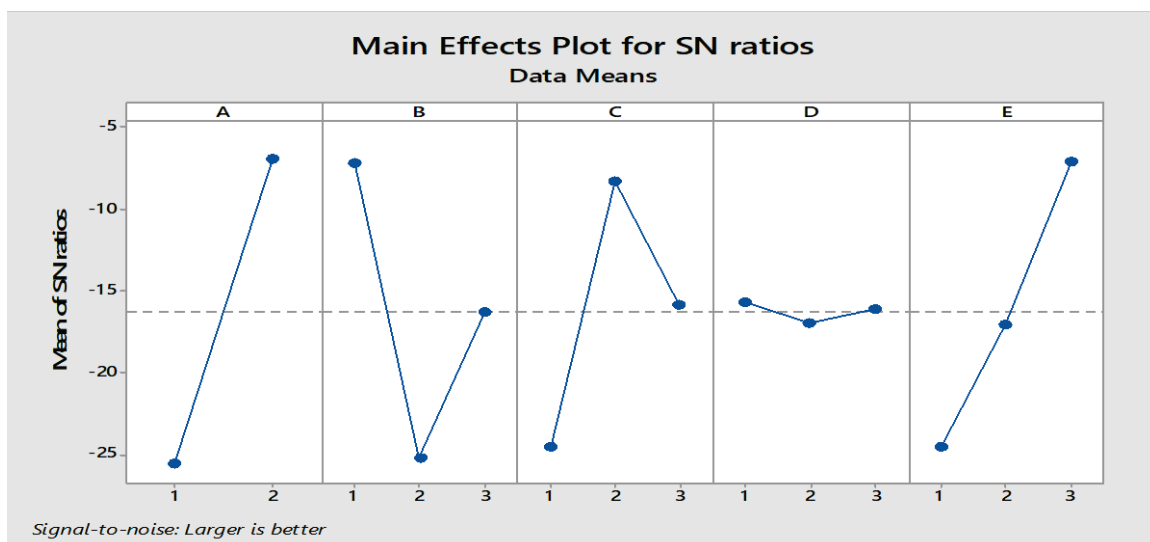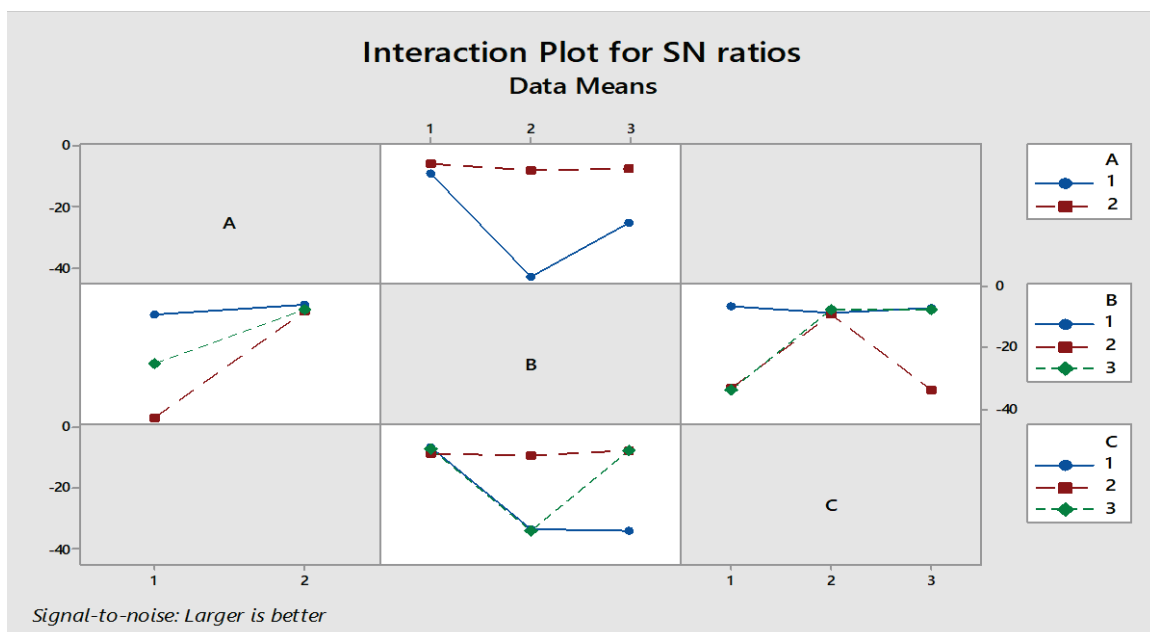| Source	DF	SS	MS	F	P	% of Contri bution
A	1	1569.45	1569.45	2.95	0.228	22.62443
B	2	985.83	492.92	0.93	0.519	14.21125
C	2	796.33	398.16	0.75	0.572	11.47951
D	2	4.91	1.90	0.00	0.996	0.07078
E	2	928.36	397.21	0.75	0.573	13.38279
A*B	2	763.71	381.86	0.72	0.582	11.00927
B*C	4	822.89	205.72	0.39	0.810	11.86238
Error	2	1065.49	532.75			15.35959
Total	17	6936.97				100

Figure 4. Main effect plot for S/N ratio

Figure 5. Interaction plot for S/N ratio

III. CONCLUSIONS

Multi-objective optimization of process parameters of the EDC process is performed using DFA and the optimum input parameters are obtained. The optimum levels are found to be Level-2 for sintering temperature, Level-1 for compaction pressure, Level-2 for discharge current, Level-1 for duty cycle and level-3 for pulse-on-time. It is found that DEA is suitable to obtain the optimum parameters during the EDC process.

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MHD Stagnation Point Flow with Heat Transfer Past a Porous Sheet along with Viscous Dissipation and Thermal Radiation

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Abstract: In this article, we study the magnetohydrodynamics stagnation point flow for the upper-convected Maxwell fluid with the viscous dissipation and thermal radiation effects using the Cattaneo-Christov heat flux model. The flow equations are reconstructed and the obtained set of partial differential equations is then converted into an arrangement of nonlinear, coupled O.D.E. by utilising some reasonable similarity transformations. After this, the set of O.D.E. is solved by applying shooting method. Graphs and tables describe the behavior of physical parameters.

Index Terms: Maxwell fluid; Viscous dissipation; Thermal radiation; Magnetohydrodynamics; Shooting method.

I. INTRODUCTION

"The point in the flow field where the fluid's velocity is zero is called stagnation point". The study of viscous, incompressible, fluid past a permeable plate or sheet has great importance in the field of fluid dynamics. During the past few decades, the work on stagnation point flow of an incompressible fluid past a permeable sheet has got significant importance because of its large number of applications in manufacturing industries. Some of the main applications are refrigeration of electrical gadgets by fan, atomic receptacles cooling for the duration of emergency power cut, solar receiver, etc. The study of two-dimensional (2D) stagnation point flow was first investigated by Hiemenz [1], whereas for getting the accurate solution, Eckert [2] extended this problem by adding the energy equation. In view of that Mahapatra and Gupta [3], Ishak et al. [4], and Hayat et al. [5] have studied the effects of heat transfer in stagnation point over a permeable plate.

"The study of magnetic properties of electrically conducting fluids is known as Magnetohydrodynamics (MHD)". The study of MHD fluid flow was first introduced by Swedish Physicist, Alfven [6]. The effect of heat transfer in Magnetohydrodynamics flow of Jeffrey fluid model over a permeable plate is invested by Hayat et al. [7]. Mustafa et al. [8] inspected the Magnetohydrodynamics flow of Maxwell fluid with heat transfer.

The study of flow behaviour and heat transfer generated by means of stretching medium, has plenty of significance in numerous industrialized developments (e.g, in the process of rubber and plastic sheets manufacturing, upgrading the solid materials like crystal, turning fibers etc). The most widely used coolant liquid among them is water. In above cases, flow behavoiur and heat transfer investigation is of major importance because final product quality be determined to bulk level on the basis of coefficient of skin friction and heat transfer surface rate. Numerous investigators talked over different traits of stretching flow problem. Some of them are Crane [9], Chaim [10], Liao and Pop [11], Khan and Sanjayanand [12], and Fang et al. [13].

In future, advancement in nano-technology is expected for making unbelievable changes in our lives. A very big number of researchers are working in this area due to its great use in the engineering and its linked areas. In the process of air cleaning, development of microelectronics, safety of nuclear reactors etc, thermophoretic magnetohydrodynamic flow of heat and mass transfer consumes prospective uses. Choi [14] was the first who introduced the idea of "nanofluids" and presented the report on the heat transfer properties of nanofluids. The thorough explosure on thermophoretic flow was examined by Derjaguin and Yalamov [15]. Heat and mass transfer of MHD thermophoretic stream above plane surface was also studied by Issac and Chamka [16]. Thermophoresis effect on aerosol particles was investigated by Tsai [17]. In fluid temperature, no doubt, viscous dissipation produces a considerable ascend. This would happen because of change in kinetic motion of fluid into thermal energy.

Viscous dissipation is unavoidable in case of flow field in high gravitational field. Viscous flow past a nonlinearly stretching sheet was deliberated by Vajravelu [18]. For external natural convention flow over a stretching medium, the impact of viscous dissipation was also studied by Mollendro and Gebhart [19], whereas the impact of viscous dissipation and Joule heating on the forced convection flow with thermal radiation was presented by Duwairi [20].

Our prime objective is, we providing a review study of Shah et al. [21] and extend the flow analysis with viscous dissipation parameters.

II. MATHEMATICAL MODELING

Consider the time independent, incompressible, two-dimensional MHD, laminar, and steady state flow of a fluid past a semi-infinite stretching surfece. The geometry of the flow model is given in Figure 1.
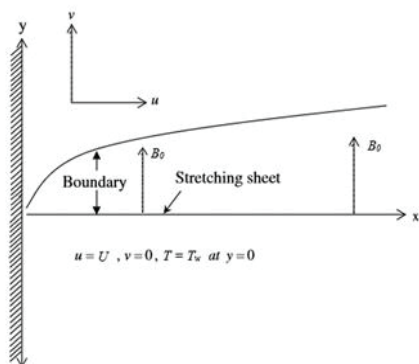

Figure 1. Geometry for the flow under consideration.

Here Cattaneo-Christov heat flux model is under consideration. Along $y-$axis, a constant magnetic field of strength B_0 is applied perpendicular to $x-$axis. Further its is supposed that the induced magnetic field is negligible. It is supposed that boundary layer approximations are appropriate to the governing equations considered by Renardy for "Maxwell fluid models". By making use of boundary layer approximations, the arrangement of representing PDEs like continuity, momentum and energy equations can be expressed as follows:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \tag{1}$$

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + \lambda_1\left(u^2\frac{\partial^2 u}{\partial x^2} + v^2\frac{\partial^2 u}{\partial y^2} + 2uv\frac{\partial^2 u}{\partial x\partial y}\right) = v\nabla^2 u - \frac{\sigma B_0^2}{\rho}(u), \tag{2}$$

$$\rho C_p\left(u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y}\right) = -\nabla.q + \sigma B_0^2 u^2 - \frac{\partial q_r}{\partial y} + \frac{v}{\rho c_f}\left(\frac{\partial u}{\partial y}\right)^2 \tag{3}$$

where u and v are the components of velocity along the x and y directions respectively. Moreover, λ_1 denotes the relaxation time, ρ denotes the fluid's density, B_0 is constant magnetic field, σ be the electric conductivity constant, kinematic viscosity is denoted by v, C_p is the specific heat, fluid temperature is T, q_r is the radiative heat flux. According to Christov , we have

$$q + \lambda_2\left(\frac{\partial q}{\partial t} + V.\nabla q + (\nabla.V)q\right) = -k\nabla T \tag{4}$$

On abolishing q from Eqs. (3) and (4), we have

$$\left(u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y}\right)$$
$$+ \lambda_2\left(\begin{array}{c}\left(u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\right)\frac{\partial T}{\partial x} + \left(u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}\right)\frac{\partial T}{\partial y} + \\ u^2\frac{\partial^2 u}{\partial x^2} + v^2\frac{\partial^2 u}{\partial y^2} + 2uv\frac{\partial^2 T}{\partial x\partial y}\end{array}\right)$$
$$= \alpha\frac{\partial^2 T}{\partial y^2} + \sigma\frac{B_0^2}{\rho C_p}u^2 - \frac{1}{\rho C_p}\frac{\partial q_r}{\partial y} + \frac{v}{\rho c_f}\left(\frac{\partial u}{\partial y}\right)^2 \tag{5}$$

where V denotes the fluid velocity, λ_2 is the relaxation time and thermal diffusivity is denoted by α. Also, the radiative heat flux q_r, by using the Rosseland approximation for radiation, can be written as

$$q_r = \frac{-4\sigma^*}{3k^*}\frac{\partial T^4}{\partial y} \tag{6}$$

where σ^* and k^* stand for the Stefan-Boltzmann constant and coefficient of mean absorption.
"Expansion of T^4 about T_∞ by making use of Taylor's series is":

$$T^4 = T_\infty^4 + \frac{4T_\infty^3}{1!}(T - T_\infty)^1 + \frac{12T_\infty^2}{2!}(T - T_\infty)^2 + \frac{24T_\infty}{3!}(T - T_\infty)^3 + \frac{24}{4!}(T - T_\infty)^4 \tag{7}$$

Disregarding the higher order terms,

$$T^4 = T_\infty^4 + 4T_\infty^3(T - T_\infty)$$
$$\Rightarrow \frac{\partial T^4}{\partial y} = 4T^3\frac{\partial T}{\partial y} \tag{8}$$

Using (8) in (6) and the differentiate w.r.t. y, we get

$$\frac{\partial q_r}{\partial y} = -\frac{16\sigma^* T_\infty^3}{3\kappa^*}\frac{\partial^2 T}{\partial y^2} \tag{9}$$

The boundary conditions for the above system of PDE are

$$\left\{\begin{array}{cccc}u = U, & v = 0, & T = T_w(x), & at\ y = 0 \\ u \to 0, & T \to T_\infty, & as\ y = \infty\end{array}\right\} \tag{10}$$

III. DIMENSIONLESS FORM OF THE MODEL

Now, we introduce similarity transformations or (dimensionless variables) Shah et al. [21] which are useful in transforming the PDEs Eqs. (1) - (3) into the ODEs along with the boundary conditions Eqs. (8).

$$\eta = \sqrt{\frac{U}{vx}}(y), \qquad \theta(\eta) = \frac{T - T_\infty}{T_w - T_\infty},$$
$$u = Uf'(\eta), \qquad v = -\frac{1}{2}\sqrt{\frac{Uv}{x}}(f - \eta f') \tag{11}$$

where the prime represents derivative w.r.t η, T_∞ and T_w are the ambient and constant fluid temperature at wall respectively and θ is the dimensionless temperature. The set of corresponding ODEs is:

$$f''' + \frac{1}{2}ff'' - \frac{\beta}{2}\left(\eta f'^2 f'' + 2ff'f'' + f^2 f'''\right) - Mf' = 0 \tag{12}$$

$$\frac{1}{Pr}\left(1 + \frac{4}{3}R\right)\theta'' + \frac{1}{2}f\theta^1 - \frac{\gamma}{2}\left(3ff'\theta' + f^2\theta''\right) + MEcf'^2 = 0 \tag{13}$$

The boundary conditions for the governing ODEs are

$$f(\eta) = 0, \ f'(\eta) = 1, \ \theta(\eta) = 1, \ at \ \eta = 0. \tag{14}$$
$$f'(\eta) \to 0, \theta(\eta) \to 1, \ at \ \eta = \infty. \tag{15}$$

In Eqs. (12) - (13), β is the Deborah number, Pr is the Prandtl number, M is the magnetic parameter, radiational parameter is R, Ec is the Eckert number and γ is the non-dimensional thermal relaxation time parameter. Some important dimensionless parameters are formulated as

$$\beta = \frac{\lambda_1}{2x}, Pr = \frac{\nu}{\alpha} = \frac{\mu C_p}{k}, M = \sigma \frac{B_0^2 x}{\rho U}, \quad R = \frac{4\sigma^* T_\infty^3}{k\kappa^*},$$
$$Ec = \frac{U^2}{C_p(T_w - T_\infty)} \text{ and } \gamma = \frac{\lambda_2 U}{2x} \tag{16}$$

IV. NUMERICAL SOLUTION

As system of Eqs. (12) - (15) with the associated boundary conditions is coupled and nonlinear, so approximate solution cannot be found directly. For this we use the numerical technique i.e., the shooting method along with Adams-Moultan method. By making use of this technique, we convert the system of higher order ODEs into the system of first order ODEs.

$$f''' = \frac{1}{2-\beta f^2}\left(\eta\beta f'^2 f'' + 2\beta 2ff'f'' - ff^{11} + 2Mf'\right) \tag{17}$$

$$\theta'' = \frac{3Pr}{6+8R-3Pr\gamma f^2}\left(3\gamma ff'\theta' - f\theta^1 - 2MEcf'^2 - Ecf''^2\right) \tag{18}$$

subject to boundary conditions

$$f'(\eta) = 1, f(\eta) = 0 \text{ at } \eta = 0, f'(\infty) \to 0, \text{as } \eta \to \infty, \tag{19}$$

$$\theta(\eta) = 1 \text{ at } \eta = 0; \ \theta(\eta) \to 0, \text{ as } \eta \to \infty \tag{20}$$

Let us use the notations

$$f = y_1, \theta = y_4$$

Further denote

$$f' = y_1' = y_2, f'' = y_2' = y_3, \theta' = y_4' = y_5, \theta'' = y_5'.$$

The system of first Order ODEs along with the boundary conditions becomes

$$y_1' = y_2, \qquad\qquad y_1(0) = 0 \tag{21}$$

$$y_2' = y_3, \qquad\qquad y_2(0) = 1 \tag{22}$$

$$y_3' = \frac{1}{2-\beta y_1^2}\left(\eta\beta y_2^2 y_3 + 2\beta y_1 y_2 y_3 - y_1 y_3 + 2My_2\right),$$
$$y_3(0) = s \tag{23}$$

$$y_4' = y_5, \qquad\qquad y_4(0) = 1 \tag{24}$$

$$y_5' = \frac{3Pr}{6+8R-3Pr\gamma y_1^2}\left(3\gamma y_1 y_2 y_5 - y_1 y_5 - 2MEcy_2^2 - Ecy_3^2\right),$$
$$y_5(0) = t \tag{25}$$

For solving above system numerically, we replace the domain $[0, \infty]$, by the bounded domain $[0, \eta_\infty]$ where η_∞ is some suitable real number. In the above system of equations we have $y_3(\eta)$ and $y_5(\eta)$ at $\eta = 0$ i.e., s and t are missing conditions and are to be chosen such that

$$y_2(\eta_\infty, s, t) \approx 0 \text{ and } y_4(\eta_\infty, s, t) \approx 0.$$

Finally, the choice of $\eta_{max} = 16$ was more than enough for end condition. The convergence criteria is choosen to be successive value agree up tp 2 significant digites.

V. RESULT AND DISCUSSION

This section aims to investigate the numerical impacts of different parameters such as Prandtl number Pr, non-dimensional thermal relaxation time parameter γ, Deborah numbers β, Eckert number Ec, magnetic parameter M and radiational parameter R displayed graphically and tablularly. The computations are worked out for different values of the effects of magnetic parameter M, Eckert number Ec, Prandtl number Pr, Deborah number β and non dimensional thermal relaxation time parameter γ and also discussed the effects of various physical parameters on velocity and temperature profiles.

The impact of various parameters like, Magnetic parameter, Radiational parameter, Eckert number, Prandtl number, radiational parameter is discussed graphically. In Table 1 and 2 numerical values for temperature gradient $-\theta'(0)$ and velocity $-f''(0)$ are calculated for different physical parameters.

For visualizing the effects of different parameters on velocity $f'(\eta)$ and temperature profile $\theta(\eta)$, graphs are plotted below. In every one of these estimations, we have considered $\gamma = 0.5, Pr = 0.72, M = 0.1, \beta = 0.5, R = 0.23$ and $Ec = 0.1$. Figure 2 determines the impact of magnetic parameter M on dimensionless velocity $f'(\eta)$. The graphical demonstration shows that for the increasing values of magnetic parameter M, there is decrease in the velocity profile. It happens for the reason that Lorentz force which decreases the horizontal flow risen by rising the magnetic parameter M. Figure 3 is the graphical representation which shows the temperature profile for the various values of magnetic parameter M. By this graph, it is observed that the effect of magnetic parameter M on velocity and temperature profile is opposite. From Figure 4, it can be seen that by increasing the value of Eckret number Ec, temperature profile also increases. The effect of radiational

parameter R on dimensionless temperature $\theta(\eta)$ is represented in Figure 5. In this graph it is observed that on increasing the value of radiational parameter R, temperature profile $\theta(\eta)$ also increases. So, the rate of heat transfer decreases with increase in radiational parameter R, and because of which temperature profile increases. In Figure 6, the influence of non-dimensional thermal relaxation time parameter γ on temperature profile $\theta(\eta)$ is shown. This graph represents that on increasing the non-dimensional thermal relaxation time parameter γ, value of temperature profile $\theta(\eta)$ decreases, because of this fact that when non dimensional thermal relaxation time parameter increases results decreases in time of deformation which causes the decrease in temperature of fluid. Figure 7 shows the influence of Deborah number β on velocity profile $f'(\eta)$. For the increasing values of Deborah number β, velocity increases near the plate while in the rest portion of the boundary layer it diminishes for expanding β. From Figure 8, it can be seen that by the increase in Deborah number β, temperature profile $\theta(\eta)$ increases. Figure 9 illustrates the difference of temperature $\theta(\eta)$ for different values of the Prandtl number Pr. It is perceived that the temperature decreases, for the increasing values of Prandtl number. Decrease in thermal boundary layer comes across when Pr is larger and decrease in the thermal diffusivity causes rise in the Prandtl number. In this way increment in Pr diminishes diffusivity and the variety in thermal characteristics increments.

TABLE I.
VALUES OF THE REDUCED NUSSELT NUMBER $-\theta'(0)$,FOR DIFFERENT VALUES OF Pr, γ, β, M, Ec and R.

Pr	γ	β	M	Ec	R	$-\theta'(0)$
0.72	0.5	0.5	0.1	0.1	0.23	0.20963440
0.3						0.10691930
0.5						0.15225160
0.7						0.20440960
	0.2					0.21996200
	0.3					0.21646850
	0.4					0.21303090
		0.2				0.22867970
		0.5				0.20963430
		0.7				0.20664860
			0.3			0.17987930
			0.5			0.15613890
			0.7			0.13709520
				0.5		0.13016200
				0.9		0.05068963
				1.1		0.01095345
					0.3	0.19704990
					0.7	0.14891000
					1.8	0.10241040

TABLE II.
COMPARISON OF $-f''(o)$ WHEN $Pr = 0.72$, $\gamma = 0:5, Ec = 0:1$ and $R = 0.1$.

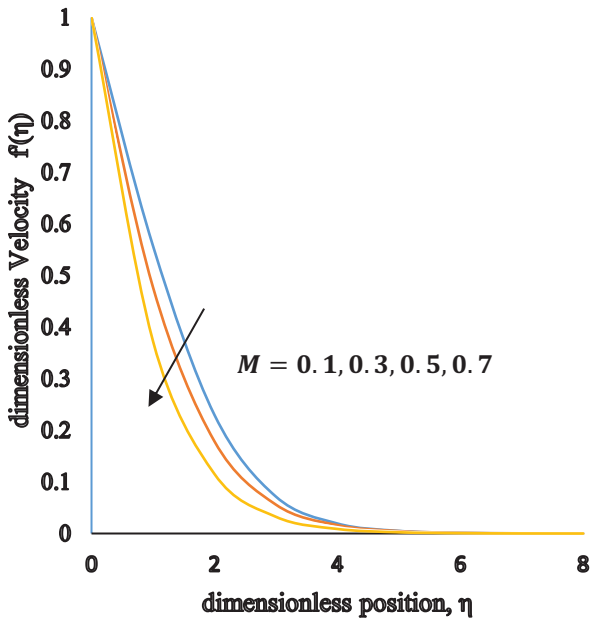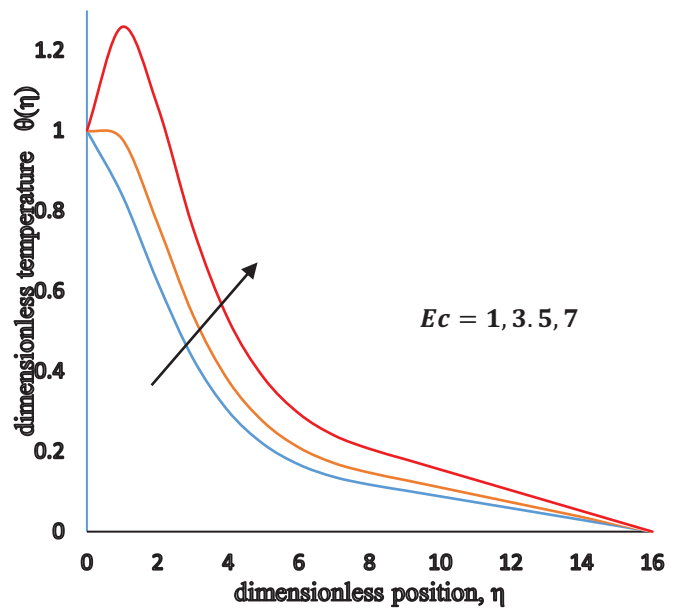| Pr	γ	β	M	Ec	R	$-f''(o)$	
						Present Value	S. Shah et al [21]
0.72	0.5	0.2	0.1	0.1	0.23	0.51593330	0.5169288
		0.5				0.48199610	0.4822495
		0.7				0.45818500	0.45824237
			0.1			0.48199610	0.4822495
			0.3			0.64494780	0.6450524
			0.5			0.78028870	0.7803249
			0.7			0.89726330	0.8972758

Figure 2. Dimensionless Velocity vs M

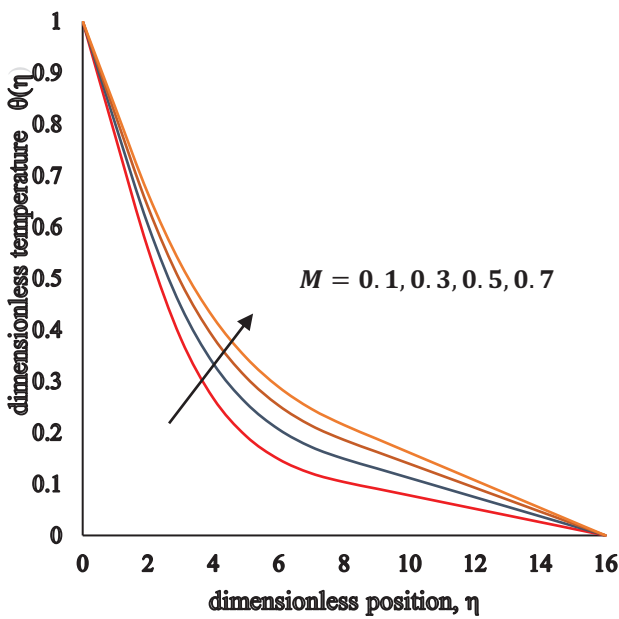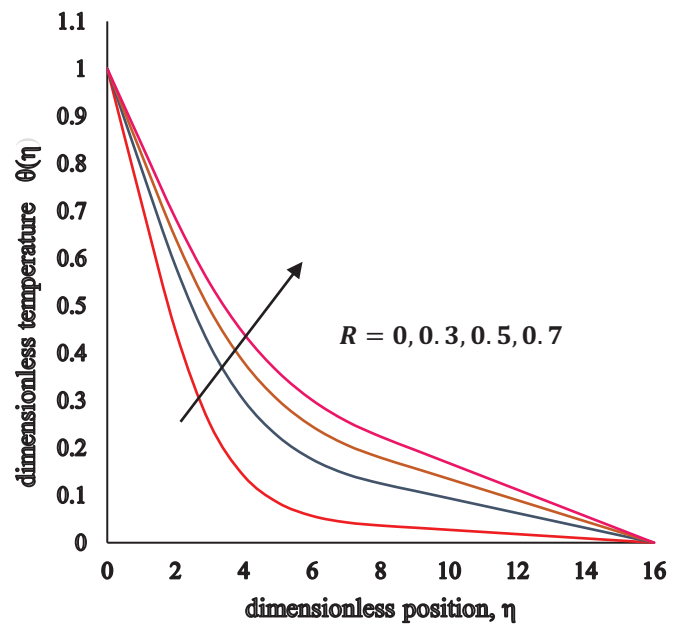Figure 4. Dimensionless Temperature vs Ec

Figure 3. Dimensionless Temperature vs M
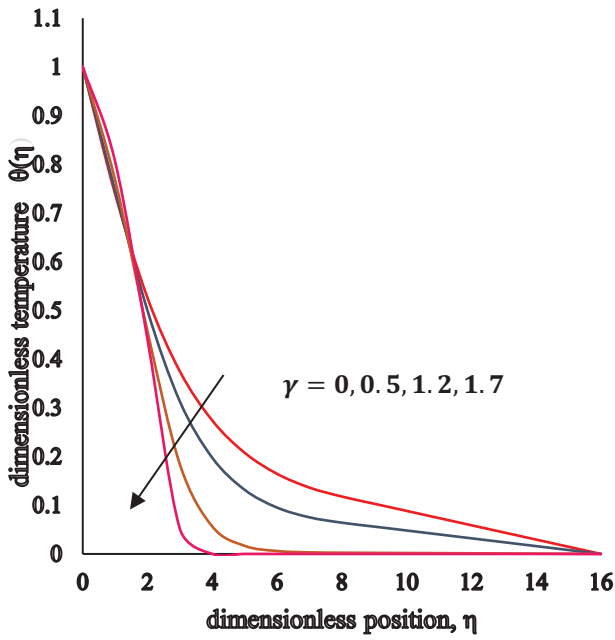

Figure 5. Dimensionless Temperature vs R

Figure 6. Dimensionless Temperature vs γ

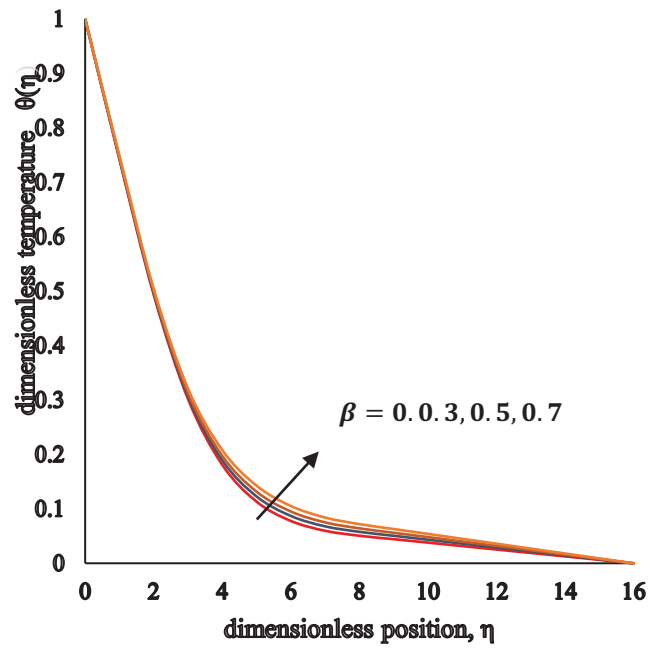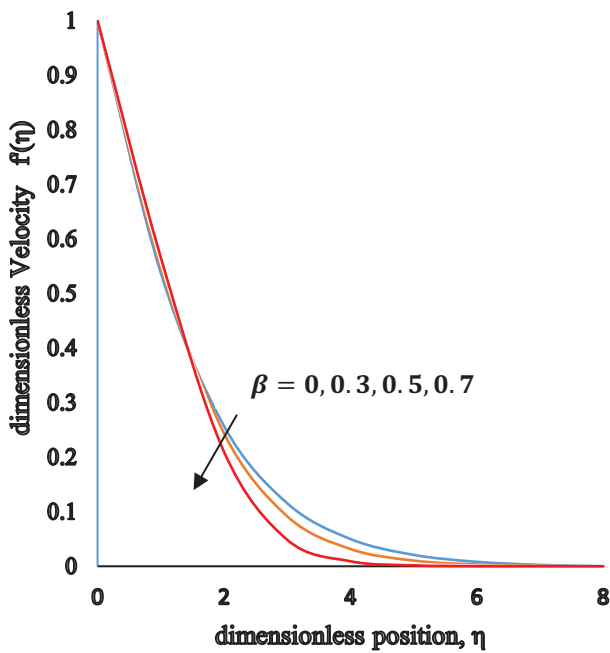Figure 8. Dimensionless Temperature vs β

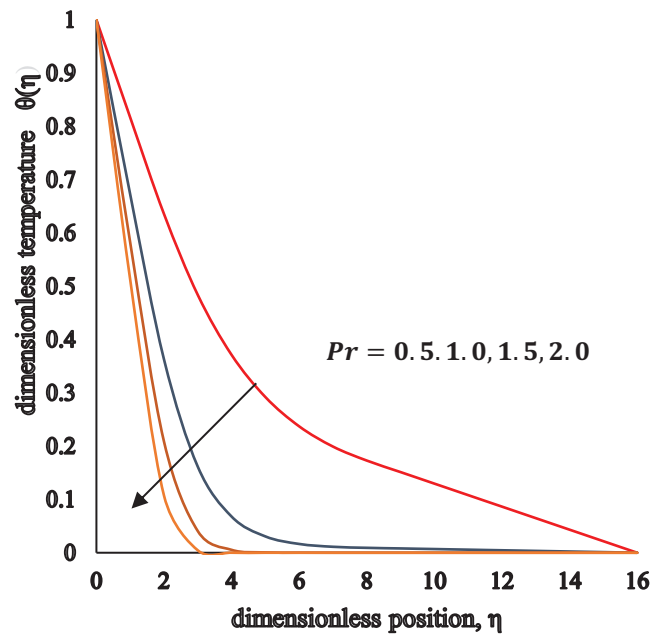Figure 7. Dimensionless Velocity vs β

Figure 9. Dimensionless Temperature vs Pr

VI. Conclusions

Conclusions which are obtained:

- Because of strong Magnetic parameter M it causes diminish in velocity and increment in temperature.

- Increase in Deborah number β temperature increases, while the velocity decreases in the horizontal direction.

- Temperature profile rises while extending the radiation parameter and a same effect of Eckert number is seen on the temperature field.

- On temperature profile Prandtl number has decreasing effects.

- Velocity filed f' decreases for increasing values of β.

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Template for the Preparation of Papers for Publication in CVR Journal of Science and Technology

First Dr.A. Author[1] and Second B. Author[2]
[1]Designation, Name of Institution/Department, City, Country
Email: first.author@hostname1.org
[2]Designation, Name of Institution/Department, City, Country
Email: second.author@hostname2.org

Abstract: **These instructions give you basic guidelines for preparing camera-ready papers for CVR College journal Publications. Your cooperation in this matter will help in producing a high quality journal.**

Index Terms: **first term, second term, third term, fourth term, fifth term, sixth term**

I. INTRODUCTION

Your goal is to simulate the usual appearance of papers in a Journal Publication of the CVR College. We are requesting that you follow these guidelines as closely as possible. It should be original work. Format must be done as per the template specified. Diagrams with good clarity with relevant reference within the text are to be given. References are to be cited within the body of the paper. Number of pages must not be less than five with minimum number of 4000 words and not exceeding eight pages. The journal is published in colour. Colours used for headings, subheadings and other captions must be strictly as per the template given in colour.

A. Full-Sized Camera-Ready (CR) Copy

Prepare your CR paper in full-size format, on A4 paper (210 x 297 mm or 8.27 x 11.69 in). No header or footer, no page number.

Type sizes and typefaces: Follow the type sizes specified in Table I. As an aid in gauging type size, 1 point is about 0.35 mm. The size of the lowercase letter "j" will give the point size. Times New Roman has to be the font for main text. Paper should be single spaced.

Margins: Top and Bottom = 24.9mm (0.98 in), Left and Right = 16 mm (0.63 in). The column width is 86mm (3.39 in). The space between the two columns is 6mm (0.24 in). Paragraph indentation is 3.7 mm (0.15 in).

Left- and right-justify your columns. Use tables and figures to adjust column length. On the last page of your paper, adjust the lengths of the columns so that they are equal. Use automatic hyphenation and check spelling. Digitize or paste down figures.

For the Title use 24-point Times New Roman font, an initial capital letter for each word. Its paragraph description should be set so that the line spacing is single with 6-point spacing before and 6-point spacing after. Use two additional line spacings of 10 points before the beginning of the double column section, as shown above.

TABLE I.
TYPE SIZES FOR CAMERA-READY PAPERS

Type size (pts.)	Appearance		
	Regular	Bold	Italic
6	Table caption, table superscripts		
8	Tables, table names, f irst letters in table captions, figure captions, footnotes, text subscripts, and superscripts		
9	References, authors' biographies	Abstract	
10	Section titles ‚Authors' affiliations, main text, equations, first letters in section titles		Subheading
11	Authors' names		
24	Paper title		

Each major section begins with a Heading in 10 point Times New Roman font centered within the column and numbered using Roman numerals (except for ACKNOWLEDGEMENT and REFERENCES), followed by a period, two spaces, and the title using an initial capital letter for each word. The remaining letters are in SMALL CAPITALS (8 point). The paragraph description of the section heading line should be set for 12 points before and 6 points after.

Subheadings should be 10 point, italic, left justified, and numbered with letters (A, B, …), followed by a period, two spaces, and the title using an initial capital letter for each word. The paragraph description of the subheading line should be set for 6 points before and 3 points after.

For main text, paragraph spacing should be single spaced, no space between paragraphs. Paragraph indentation should be 3.7mm/0.21in, but no indentation for abstract & index terms.

II. HELPFUL HINTS

A. Figures and Tables

Position figures and tables at the tops and bottoms of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Leave sufficient room between the figures/tables and the main text. Figure captions should be centered below the figures; table captions should be centered above. Avoid placing figures and tables before their first mention in the

text. Use the abbreviation "Fig. 1," even at the beginning of a sentence.

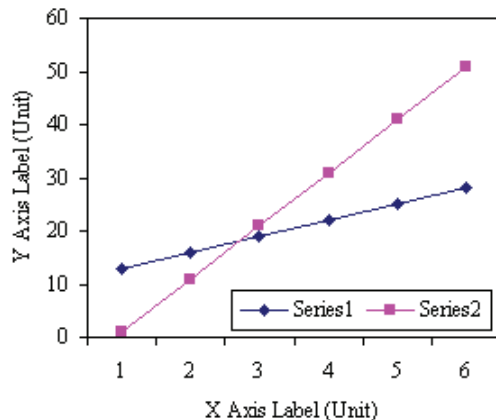To figure axis labels, use words rather than symbols. Do

Figure 2.   Note how the caption is centered in the column.

not label axes only with units. Do not label axes with a ratio of quantities and units. Figure labels should be legible, about 9-point type.

Color figures will be appearing only in online publication. All figures will be black and white graphs in print publication.

B. References

Number citations consecutively in square brackets [1]. Punctuation follows the bracket [2]. Use "Ref. [3]" or "Reference [3]" at the beginning of a sentence:

Give all authors' names; use "et al." if there are six authors or more. Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. In a paper title, capitalize the first word and all other words except for conjunctions, prepositions less than seven letters, and prepositional phrases. Good number of references must be given.

C. Footnotes

Number footnotes separately in superscripts [1, 2, …]. Place the actual footnote at the bottom of the column in which it was cited, as in this column. See first page footnote as an example.

D. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the

abstract. Do not use abbreviations in the title unless they are unavoidable.

E. Equations

Equations should be left justified in the column. The paragraph description of the line containing the equation should be set for 6 points before and 6 points after. Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). Italicize Roman symbols for quantities and variables, but not Greek symbols. Punctuate equations with commas or periods when they are part of a sentence, as in

$$a \ + \ b \ = \ c \ . \tag{1}$$

Symbols in your equation should be defined before the equation appears or immediately following. Use "(1)," not "Eq. (1)" or "equation (1)," except at the beginning of a sentence: "Equation (1) is ..."

F. Other Recommendations

Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) If your native language is not English, try to get a native English-speaking colleague to proofread your paper. Do not add page numbers.

III. CONCLUSIONS

The authors can conclude on the topic discussed and proposed, future enhancement of research work can also be briefed here.

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In the next issue (Vol 17, December 2019)

ABOUT THE COLLEGE

*CVR College of Engineering (A UGC Autonomous Institution) was established in the year 2001, and its fourteenth batch of students graduated from the College. This college is on a roll with the recent **NIRF** ranking of 132 in the Country, followed by record placements.*

*The College was the **first** college in Telangana that was promoted by NRI technology professionals resident in the US. The NRI promoters are associated with cutting-edge technologies of the computer and electronics industry. They also have strong associations with other leading NRI professionals working for world-renowned companies like IBM, Intel, Cisco, Facebook, AT&T, Google and Apple who have agreed to associate with the College with a vision and passion to make the College a state-of-the-art engineering institution.*

*The college has many accomplishments and to name a few, it obtained **NBA Tier 1 accreditation for its UG Programs,** **NAAC 'A' grade**, **UGC autonomous status**, **National Employability Award** for seventh year in a row and received a very high rating by several ranking agencies including the most recent Education World ranking of third best college in Telangana and Outlook magazine, rating CVR CE, one among the **top 100 colleges in the country**, and **AAAA grade** from careers 360. The college received the **ISTE Best Engineering College award** and, the Director Dr. K. Rama Sastri, the ISTE Lifetime Achievement Award in 2017.*

The college received Rs. 2.87 crores from Newgen IEDC of the DST. Faculty members are working on Rupees One crore worth projects with funding from the AICTE, UGC and ISRO.

*The college has been creating records year after year. With more than 100 companies visiting CVR and more than 650 placements for the 2017-18 academic year, it is the highest among the peer group of colleges. The highest offer is Rs. 24 Lakhs and close to 40 students got offers higher than Rs. 7 Lakhs. About 75 offers are higher than Rs. 5 Lakhs. With this, CVR becomes the leading college in entire Telangana in terms of the offers with higher salaries. CVR has made huge progress in a short span of time and is preferred by the students and parents during the EAMCET counseling this year and is among **the top 3 colleges** in the state.*

In keeping with the current global emphasis on green and eco-friendly energy generation, 360kW Solar PV plant has been installed in the campus to meet the power requirements of the college to a significant extent.

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