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Parametric Analysis of Tunable Multi Layer Multi Dielectric-High Impedance Surface Reflector

By Praveen Kumar Kancherla & Dr. Habibulla Khan
JNT University, India

Abstract- A novel Tunable Multi Layer Multi Dielectric High Impedance Surface (TMMD-HIS) Reflector is proposed and designed in Ansoft HFSS software. The structure of TMMD-HIS consists of square metal patch arrays arranged in three dimensional, connecting vias, dielectric substrates arranged in ascending order. It exhibits two important properties first one barrier to EM waves in certain band of frequencies. Second it reflects the waves with a co-efficient of +1. Some important parameters of TMMD-HIS reflectors architecture and its effect on reflection phase characteristics, operating frequency and band width is investigated and results are presented.

Keywords: reflection phase, width of patch, gap between patches, height of substrate, operating frequency, band width.

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Praveen Kumar Kancherla [α] & Dr. Habibulla Khan [σ]

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Keywords: reflection phase, width of patch, gap between patches, height of substrate, operating frequency, band width.

I. Introduction

In present communication systems the engineered electromagnetic structures occupying important role because of its interesting characteristics the tunable Multi Layer Multi Dielectric High Impedance Surface Reflector proposal is an engineered EM structure exhibits high surface impedances for both transverse electric (TE) and transverse magnetic (TM) polarisations and can suppress surface wave propagation at certain frequency ranges. Furthermore, the surface wave band gap property of Multi Layer Multi Dielectric High Impedance Surface helps to increase the antenna band width, minimize backward radiation, and reduce mutual coupling. In phase reflection between incident and ground reflected waves, this resembles the property like PMC (Perfect Magnetic Conductor). Hence, they can play an important role in developments of new applications in wireless radio communications, antenna engineering and beam steering.

II. Unit Cel Meodeling

The structure of Multi Layer Multi Dielectric High Impedance Surface consists of an optically planar ground plane, dielectric substrates arranged in ascending order, square metal patches (protrusions) arranged in three dimensionally and metal vias joining the metal protrusions to ground. The arrangement is shown in figure 1.

Author α: Research Scholar, Department of Electronics and Communication Engineering, JNT University, Hyderabad, AP, India. e-mail: kpraveenkumar24817@gmail.com
Author σ: Professor, HOD Dept of ECE, KL University, Vaddeswaram, Guntur, AP, India.

The unit cell has following dimensions; thickness of lower substrate t =62mil with a relative permittivity of εr =2.2 and loss tangent 0.0009, diameter of via d =0.65mm, width of patch w = 41mm, gap g = 2.5mm, hidden layer patch width Hw = 46mm height of TMMD-HIS h = 3mm and an air is considered as another dielectric exist between top and bottom layers. This structure resonates at 1.89GHz.

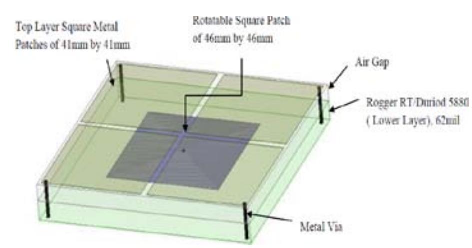

Fig. 1 : Description of structural parts unit cell.

III. Reflection Phase Measurement

A proposed unit cell is designed and executed in Ansoft HFSS software. By placing in a box to which a periodic boundaries are applied and extended to infinity. Finite Element Method is adopted to analyze the proposed unit cell.

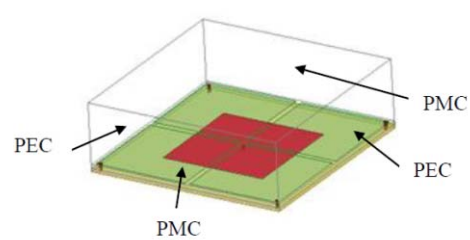

Fig. 2 : Reflection Phase Measurement Setup.

The diagrams in figure 2 is showing perfect electric boundary at opposite walls of unit cell box, and perfect magnetic boundary at opposite walls of remaining unit cell box. The figure 3 is showing the reflection phase of normally incident plane wave on TMMD-HIS structure versus frequency. At low frequencies this structure reflects with a $+180^0$ phase shift as the frequency increases the phase slops downward and crosses through zero degree point and reaches to -180^0 the frequency at this phase is high. The point of intersection of the phase curve with zero degree

Global Journal of Researches in Engineering (F) Volume XIV Issue IV Version I Year 2014

line, frequency at this point is considered as operating frequency. The region between +87.92 degree to –176.08 degree shown in Figure3 with highlighted region reflects the plane waves in phase with transmitted wave. This region functions like Perfect Magnetic Conductor (PMC). This range corresponds to surface wave band gap. The region before and after to highlighted region functions like ordinary reflector.

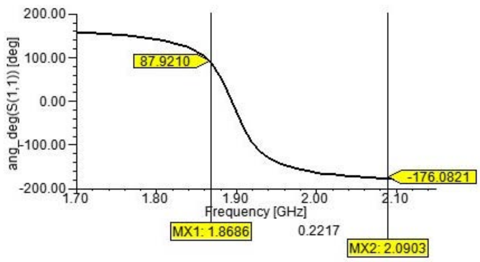

Fig. 3 : Reflection Phase

IV. Parametric Study of TMMD- his Reflector

It has investigated and observed that the input match frequency band of TMMD-HIS reflector has a range starts from +87.92 degree to –176.08 degree shown in Figure3. The reflection phase is mainly depends on following parameters. Top layer patch width (W), gap width (g), height of structure (h), thickness of lower substrate (t), hidden layer patch width (Wh). This analysis may give design guidelines to engineered electromagnetic structures. A finite element method is used to analyse, by taking complete electrodynamics of TMMD-HIS reflector in account. The input match frequency band in this section refers to surface wave band gap.

a) Patch Width Effect (W)

Patch width plays an important role in determining the frequency band. To study the effect of patch width, all other parameters are kept in its specified size as explained in unit cell design. The patch width is varied from 32mm to 54mm Figure 4 is showing the reflection phases of normally incident plane waves by the TMMD-HIS reflector at different width values of patch. Table I showing the operating frequency and band width at different values of patch widths. In two dimensional EBG structures consists of an array of patches backed by some dielectric substrate and are connected to ground reflector with via. This two dimensional structure is effected by some parameters like width of patch, gap width, height, substrate permittivity. Results given in many papers [--]. For the first time TMMD-HIS is a three dimensional structure, this novel structure is allowing to change its surface impedance by physically varying the capacitive reactance in the structure. when patch width increases the operating frequency is falling down and band width is increases, from table I it is clearly showing that, when patch width value is at 32mm the operating frequency is 2.0467GHz and band width is 172.9MHz as the patch width progresses and reaches to 54mm the operating frequency falls down to 1.6976GHz and band width increases to 214.4MHz. The figure 5 and 6 are clearly showing the effect of patch width and corresponding variation of operating frequency and band gap.

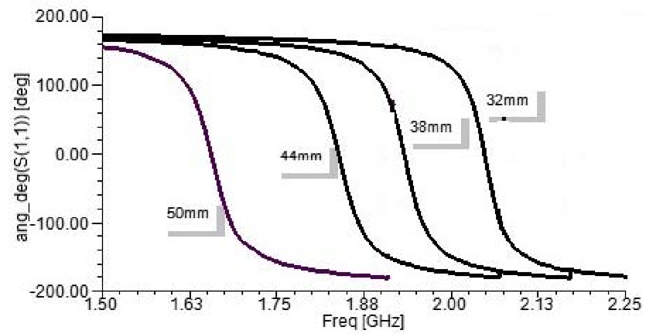

Fig. 4 : Reflection Phase of patch widths at 32mm, 38mm, 44mm, 50mm

Table I : Patch Width Effect

Width (mm)	Operating Frequency (GHz)	Upper Frequency (GHz)	Lower Frequency (GHz)	Band Width (MHz)
32	2.0467	2.1981	2.0252	172.9
34	2.0252	2.18	2.0022	177.8
36	1.9577	2.1109	1.9347	176.2
38	1.933	2.0878	1.9083	179.5
40	1.9067	2.0648	1.8820	182.8
42	1.8820	2.0467	1.854	192.6
44	1.8375	2.0022	1.8112	191.0
46	1.7618	1.9182	1.7355	182.8
48	1.7289	1.8985	1.7025	195.9
50	1.6548	1.8326	1.6284	204.2
52	1.6679	1.8458	1.6383	207.5
54	1.6976	1.8771	1.6630	214.1

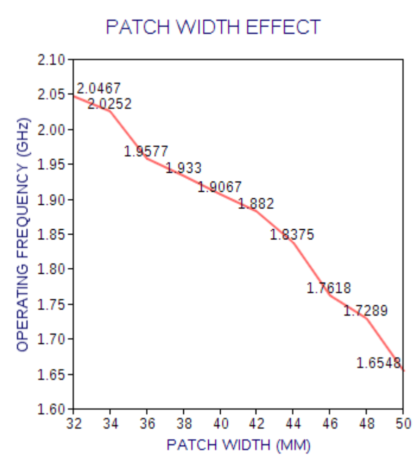

Fig. 5 : Patch width effect on operating frequency

Global Journal of Researches in Engineering (F) Volume XIV Issue IV Version I Year 2014

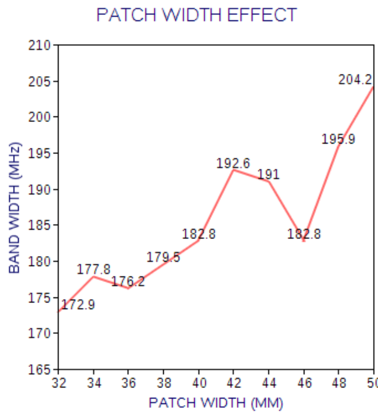

Fig. 6 : Patch width effect on Band width

b) Gap Width Effect (g)

The gap width is the distance between adjacent patches, where the small amount of capacitance is developed due to fringing fields between the patches. In the proposed work it controls the coupling between patches of TMMD-HIS. To understand the effect of the gap width on the structure the gap width is varied from 1.5mm to 3.5mm. During this investigation all other parameters are kept in its specified size as explained in unit cell design. The operating frequency and band width are the parameters to visualize the effect. Figure 6 is showing the reflection phase characteristics of the proposed structure when gap width is varied for normal incident plane waves. Represents variation of operating frequency due to gap width. Table II showing how the operating frequency and band width for different gap width values. As you observe the progress in gap width there is demolish in both the operating frequency and band width. When gap width is at 1.5mm the operating frequency is 1.9042mm and band width is 219.8MHz respectively as the band width reaches to 3.5mm both operating frequency and band width falls down to 1.8919GHz and 174.5MHz respectively. This is clearly visualized in figure 7 and 8.

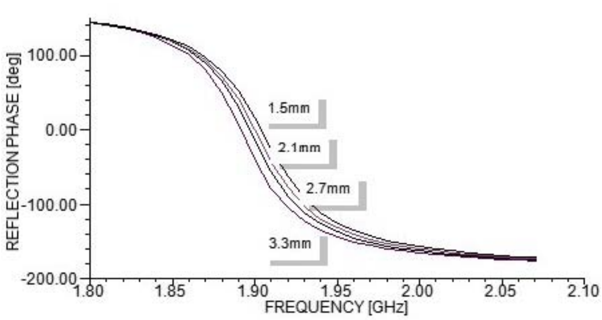

Fig. 6 : Reflection Phase of gap width at 1.5mm, 2.1mm,2.7mm,3.3mm

Table 2 : Gap Width Effect

Gap (mm)	Operating Frequency (GHz)	Upper Frequency (GHz)	Lower Frequency (GHz)	Band Width (MHz)
1.5	1.9042	2.0952	1.8754	219.8
1.7	1.9042	2.0804	1.8754	205.0
1.9	1.9009	2.0730	1.8729	200.1
2.1	1.9001	2.0689	1.8729	195.9
2.3	1.9001	2.0656	1.8729	192.6
2.5	1.8952	2.0574	1.8688	188.5
2.7	1.8968	2.0574	1.8713	186.1
2.9	1.8952	2.0524	1.8696	182.8
3.1	1.8927	2.0475	1.8680	179.5
3.3	1.8919	2.0450	1.8664	178.6
3.5	1.8919	2.0417	1.8664	175.4

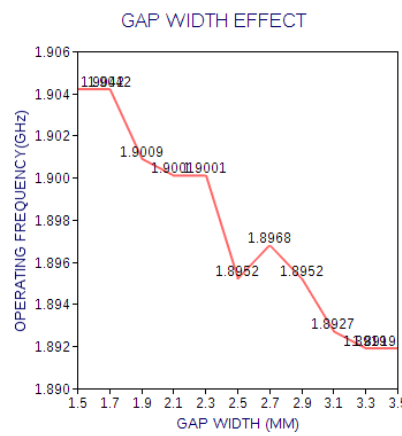

Fig. 8 : Gap width effect on operating frequency

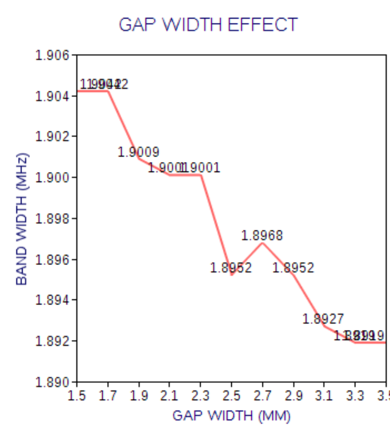

Fig. 9 : Gap width effect on band width

c) Height of Structure (H)

In Tunable Multi Layer Multi Dielectric High Impedance Surface total height of structure is considered from lower substrate bottom face contains optically planar conducting surface to higher substrate bottom face containing array of square patches of fixed structure. The total height of a structure here is the sand which of Rogger/RT Duriod 5880 and air substrates. In this case of investigation all other parameters are kept in its specified size as explained in unit cell design. Since we are considering thickness of Rogger/RT Duriod is at fixed value of 62mil and varying the height will indirectly vary the air gap causes the reactive capacitance developed in this air gap going to be change. In two dimensional structures as you vary the height of structure the operating frequency is giving to vary inversely with respect its height and band width has linear relation. In TMMD-HIS is giving liner results in both operating frequency and band gap. Table 3 is showing the simulated results, clearly showing that as the positive progress in the height of structure The operating frequency, band width are increasing. When height is at 2mm the operating frequency is 1.6805GHz and band width is 167.3MHz, when height is reaches to 3mm the operating and band width reaches to 1.8952GHz and 189MHz. This is clearly visualized in figure 11. figure 12.

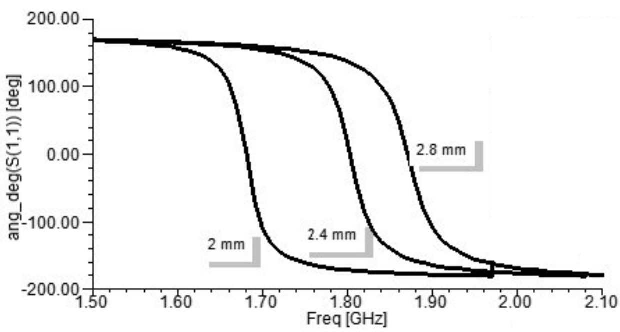

Fig. 10 : reflection at different h values

Table 3 : Effect of structure height

Height (mm)	Operating Frequency (GHz)	Upper Frequency (GHz)	Lower Frequency (GHz)	Band Width (MHz)
2	1.6805	1.8333	1.6660	167.3
2.2	1.7523	1.9031	1.7345	168.6
2.4	1.8030	1.9610	1.7825	178.5
2.6	1.8431	2.0052	1.8207	184.4
2.8	1.8701	2.0322	1.8458	186.4
3	1.8952	2.0578	1.8688	189.0

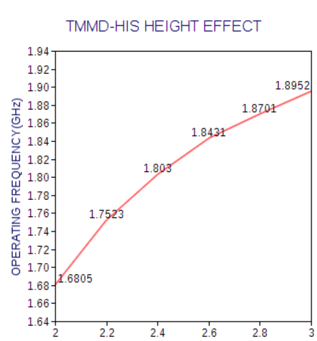

Fig. 11 : height effect on operating frequency

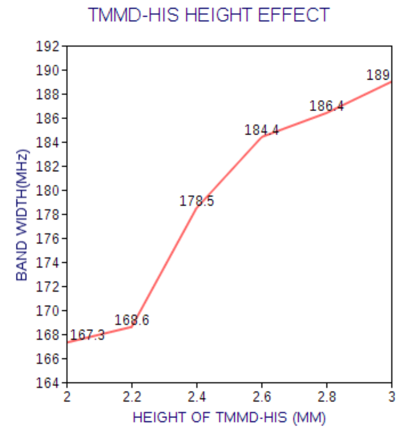

Fig. 12 : height effect on band width

d) Thickness of Lower Substrate (t)

Lower substrate thickness is another parameter effect when there is changes in its structure. the structural variation may present in mode, here we considered only thickness is varied from 55mil to 65mil by considering remaining all other parameters are kept in its specified size as explained in unit cell design. The variation in lower substrate thickness alters the air gap height since total structure height is considered constant. The simulated results obtained are presented in table 4. When thickness is at 55mil operating frequency is at 1.9268GHz band width is at 179.1. Thickness is next raised to 65mil the operating is moved down to 1.8794GHz and band width raised to 195.6MHz. This is visually presented in figure 14 and 15. figure 13 is showing the reflection phase characteristics of plane when normally incident the surface when thickness is at 55mil, 59mil, 62mil, 66mil.

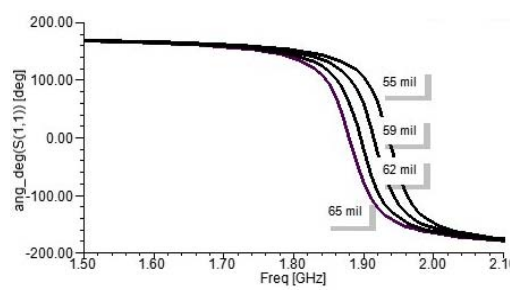

Fig. 13 : Reflection phase characteristics at different thickness values of lower substrate

Table 4 : Thickness of Lower Substrate effect

Thickness (mil)	Operating Frequency (GHz)	Upper Frequency (GHz)	Lower Frequency (GHz)	Band Width (MHz)
57	1.9268	2.0828	1.9011	179.1
59	1.9136	2.0717	1.8873	184.4
61	1.9011	2.0618	1.8741	187.7
63	1.8925	2.0578	1.8655	192.3
65	1.8794	2.0486	1.8530	195.6

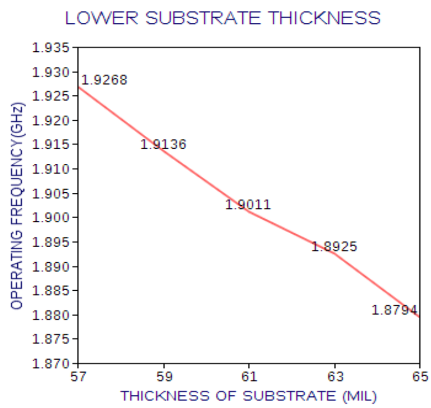

Fig. 14 : effect of substrate thickness on operating frequency

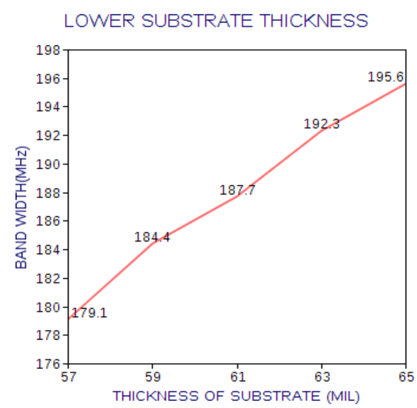

Fig. 15 : effect of substrate thickness of band width

e) Hidden layer Patch Width (revolving Patch)(Wh)

This patch has a very important nature of work i.e revolving around its center axis either in clock or anti clock wise direction with respect to immovable layer of patches lying above to it. When it starts revolving alters the parallel plate capacitance reactance exist. Present analysis to understand its effect only patch width is varied from 40mm to 50mm during this time all other parameters are kept in its specified size as explained in unit cell design. Varying this it's structure means altering the overlapping area between parallel plates result change in capacitive reactance. Table 5 is showing the simulated results explaining that as the patch width increases the operating frequency and band are going demolish. When patch width is at 40mm the operating frequency and band width are at 2.0653GHz and 242.6MHz, when patch width increased to 49mm the operating frequency and band width are reached to 1.8238GHz and 171.2MHz. Figure 17, 18 are visualizing the above statement. Figure 16 is showing the reflection phase characteristics at 40mm, 43mm, 46mm and 49mm values of rotatable patch width.

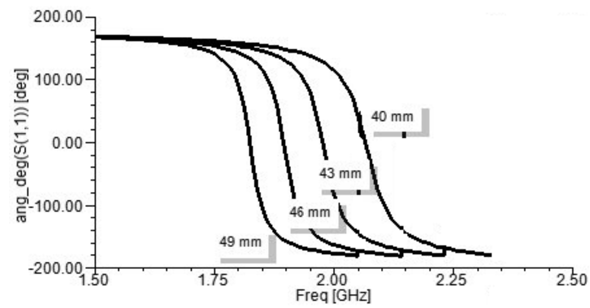

Fig. 16 : Reflection phase characteristics of rotatable patch width

Table 5 : revolving patch width effect

Wh (mm)	Operating Frequency (GHz)	Upper Frequency (GHz)	Lower Frequency (GHz)	Band Width (MHz)
40	2.0653	2.2684	2.0258	242.6
41	2.0335	2.2289	199.73	231.6
42	2.0027	2.1905	1.9676	222.8
43	1.9764	2.1564	1.9435	213.0
44	1.9468	2.1202	1.9160	204.2
45	1.9204	2.0884	1.8919	196.5
46	1.8952	2.0576	1.8677	188.9
47	1.8710	2.0280	1.8447	183.3
48	1.8469	1.995	1.8227	176.7
49	1.8238	1.9720	1.8008	171.2

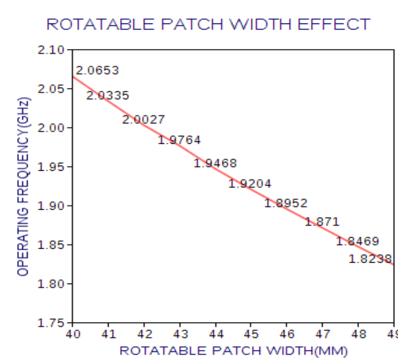

Fig. 17 : effect of rotatable patch width on operating frequency

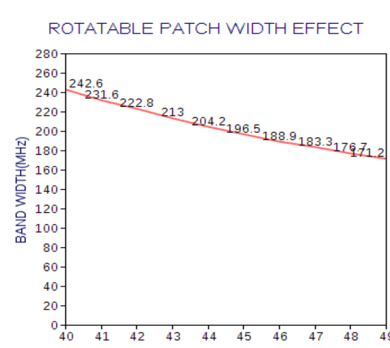

Fig. 18 : effect of rotatable patch width on band width

f) Via Radius

The radius of via is varied from 0.4mm 0.8mm remaining all other parameters are considered are kept in its specified size as explained in unit cell design. It was found that the radius has small effect on the frequency band due to thin via used. Figure 19 is showing the reflection phase at 0.3mm, 0.5mm, 0.7mm, 0.9mm values of via radius. Figure 20,21 are visualizing effect of via radius on operating frequency and band width. The increase in via radius increases the operating frequency and reducing the band width.

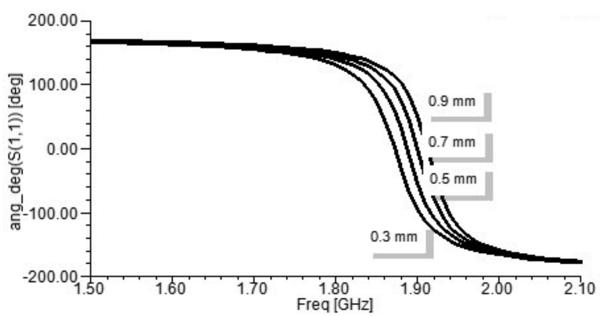

Fig. 19 : Reflection phase curve for different via radius values Table effect of Via Radius

Radius (mm)	Operating Frequency (GHz)	Upper Frequency (GHz)	Lower Frequency (GHz)	Band Width (MHz)
0.3	1.8715	2.0605	1.8425	218.0
0.5	1.8873	2.0572	1.8603	196.9
0.7	1.9	2.0318	1.8741	187.7
0.9	1.9123	2.0671	1.8866	180.5

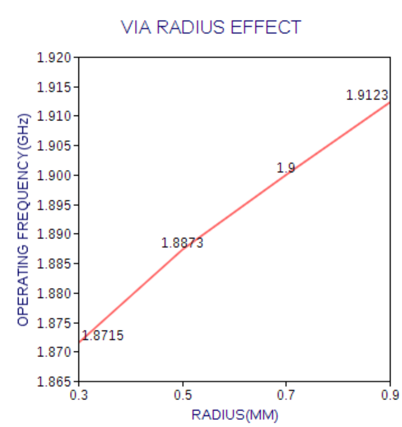

Fig. 20 : effect of via radius on operating frequency

V. Conclusion

A novel Tunable Multi Layer Multi Dielectric High Impedance Surface is proposed. Some of its important parameters and its effect on reflection, operating frequency and band width is studied and presented.

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Novel Design of BCD to Excess-3 Code Converter in Quantum Dots Cellular Automata (QCA)

By Anisur Rahman, Md. Ahsan Habib, Ali Newaz Bahar & Ziaur Rahman
Mawlana Bhashani Science and Technology University, Bangladesh

Abstract- Quantum-dot cellular automata (QCA) represent a new technology at the nanotechnology level. Conventional digital technologies use ranges of voltage or current to represent binary values. In contrast, QCA uses the positions of electrons in quantum dots to represent binary Values '0' and '1'. Quantum technology has gradually applied in various fields. A quantum-dot cellular automaton is projected as a promising nanotechnology for future ICs. A QCA is an array of structures known as quantum-dots. The advantages of using QCA technology are smaller circuit size, higher clock frequency, and lower power consumption. Two electrons occupy each cell. Each electron is free to tunnel between dots within one cell, but cannot leave the cell. The two electrons within each cell repel each other to diagonally opposite corners of the cell. This leaves only two stable states for each cell. These two states are used to represent logic values. The occupation of upper-left and lower-right dots represent logic '0'. In this case, the QCA cell is said to be polarized to -1. Similarly, the occupation of upper-right and lower left dots represent logic '1'. In this case, the QCA cell is said to be polarized to +1. In this paper, a BCD to excess-3 code converter circuit is proposed based on QCA logic gates: the 3-input MV OR gate, 3-input MV AND gate, MV NOT gate. This 3-input AND & 3-input OR gates, 3-input complex gates, multi-input complex gates. The proposed circuit is a remising future in constructing of nano-scale low power consumption information processing system and can stimulate higher digital applications in QCA.

Keywords: quantum cellular automata (QCA); QCA logic gates; BCD-to-excess-3 code converter in QCA; 3-input QCA and gate, BCD by QCA.

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NOVELDESIGNOFBCDTOEXCESS3CODECONVERTERINQUANTUMDOTSCELLULARAUTOMATAQCA

Strictly as per the compliance and regulations of :

Novel Design of BCD to Excess-3 Code Converter in Quantum Dots Cellular Automata (QCA)

Anisur Rahman [α], Md. Ahsan Habib [σ], Ali Newaz Bahar [ρ] & Ziaur Rahman [ω]

Abstract- Quantum-dot cellular automata (QCA) represent a new technology at the nanotechnology level. Conventional digital technologies use ranges of voltage or current to represent binary values. In contrast, QCA uses the positions of electrons in quantum dots to represent binary Values ‘0’ and ‘1’. Quantum technology has gradually applied in various fields. A quantum-dot cellular automaton is projected as a promising nanotechnology for future ICs. A QCA is an array of structures known as quantum-dots. The advantages of using QCA technology are smaller circuit size, higher clock frequency, and lower power consumption. Two electrons occupy each cell. Each electron is free to tunnel between dots within one cell, but cannot leave the cell. The two electrons within each cell repel each other to diagonally opposite corners of the cell. This leaves only two stable states for each cell. These two states are used to represent logic values. The occupation of upper-left and lower-right dots represent logic ‘0’. In this case, the QCA cell is said to be polarized to -1. Similarly, the occupation of upper-right and lower left dots represent logic ‘1’. In this case, the QCA cell is said to be polarized to +1. In this paper, a BCD to excess-3 code converter circuit is proposed based on QCA logic gates: the 3-input MV OR gate, 3-input MV AND gate, MV NOT gate. This 3-input AND & 3-input OR gates, 3-input complex gates, multi-input complex gates. The proposed circuit is a remising future in constructing of nano-scale low power consumption information processing system and can stimulate higher digital applications in QCA.

Keywords: quantum cellular automata (QCA); QCA logic gates; BCD-to-excess-3 code converter in QCA; 3-input QCA and gate, BCD by QCA.

I. Introduction

Quantum technology has gradually applied in various fields [1, 2]. Quantum-dot cellular automata are projected as a promising nanotechnology for future ICs [3, 4]. A QCA is an array of structures known as quantum-dots. Computing with QCA is achieved by the tunneling of individual electrons among the quantum-dots inside individual electrons among the quantum-dots inside a cell and the classical columbic interaction among them.

A quantum cell can be viewed as a set of four charge containers or dots positioned at the corners of a square, as shown in Fig.1. It contains two extra mobile electrons. The electrons can quantum mechanically tunnel between dots but cannot come out from the cell and are forced to settle at the corner positions due to coulomb interaction. Thus, there exist two equivalent energetically minimal arrangements for the electrons in a QCA cell (Figure 1), a QCA cell and its binary Logic are shown, the energetically position of the diagonal electrons identifies the binary logic 0 or 1. This phenomenon is useful in nanotechnology which affects high resolution fast electronic circuits.

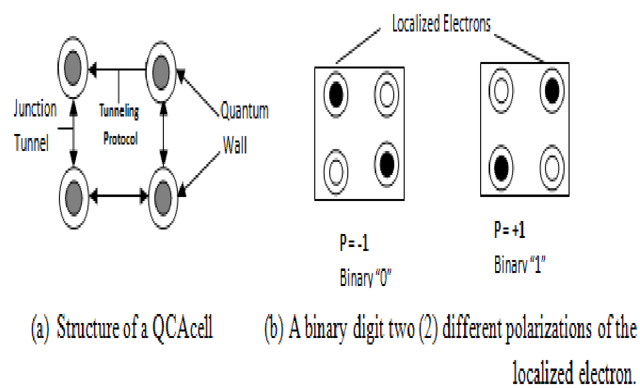

Figure 1 : A QCA cell and its binary logic

The QCA cells themselves comprise the interconnecting wires as described in [4]. An example of a QCA wire is shown in Figure 2. In this example, a value of 1 is transmitted along the wire. Only a slight polarization in a cell is required to fully polarize its neighbor. The direction for the flow of information through a gate or a wire is controlled by a four stage clocking system described in [4] which raises and lowers barriers between the cells.

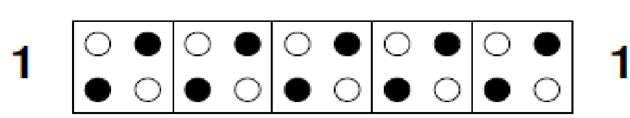

Figure 2 : QCA Wire

Described in [3] were other logic gates formed by restricting the polarity of one input to the 3-input majority gate to be a constant value. Figure 3 illustrates a 2-input AND gate and a 2-input OR gate formed in this manner. By replacing input c with a cell having a fixed

Author α σ ρ ω: Department of Information and Communication Technology, Mawlana Bhashani Science and Technology University, Tangail, Bangladesh. e-mail: bahar_mitdu@yahoo.com

polarity of 0, the 3-input majority gate functions as an AND gate. In the example AND gate on the left side of Figure 3., out = ab. Similarly, replacing input c with a cell having a fixed polarity of 1 creates a 2-input OR gate. In the example OR gate on the right side of Figure 3, out = a+b.

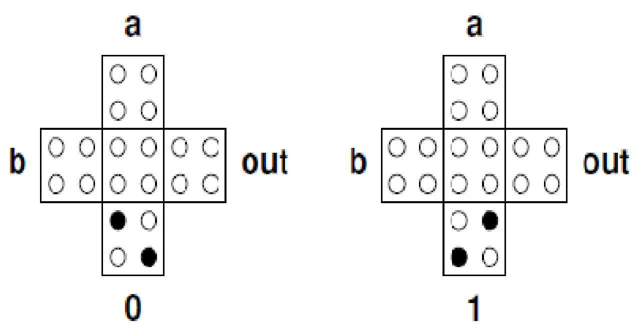

Figure 3 : 2-input AND & 2-input OR gates

The QCA cells can form the primitive logic gates shown in Figure 4 (inverter gate).

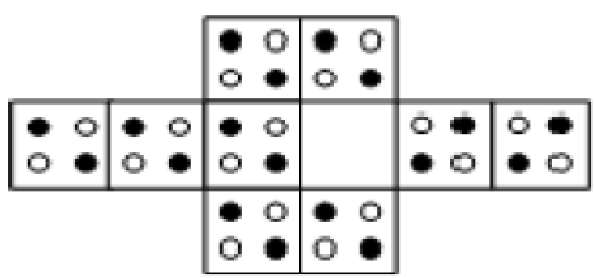

Figure 4 : inverter gate

II. Proposed Circuit and Presentation

a) BCD-to-EXCESS-3 code converter

A conversion circuit must be inserted between the two systems if each uses different codes for the same information. Thus, a code converter is a circuit that makes the two systems compatible even though each uses a different binary code. To convert from binary code A to binary code B, the input lines must supply the bit combination of elements as specified by code A and the output lines must generated the corresponding bit combination of code B. A combinational circuit performs this transformation by means of logic gate. The design procedure of code converters will be illustrated by means of a specific example of conversion from the BCD to the excess-3 code. The bit combinations for the BCD and excess-3 code [5] listed in Table 1. Since each code uses four bits to represent a decimal digit, there must be four input variables and four output variables. Let us designate the four input binary variables by the symbols A,B,C and D and the four output variables by the W,X,Y and Z .The truth table relating the input and output variables is shown in Table 2. The bit combinations for the inputs and their corresponding outputs are obtain directly from Table 1. We note that four binary variables may have 16bit combinations, only 10 of which are listed in the truth table. The six bit combinations not listed for the input variables are don't-care combinations. Since they will never occur, we are liberty to assign to the output variables either a 1 or a 0, whichever gives a similar circuit. The manipulation of BCD-to-excess code converter, shown below, illustrates the flexibility obtain with multiple-output systems when implemented with three or more levels of gates.

Z= D'

Y= CD+(C+D)'

Z= B'(C+D) + B(C+D)'

W= A + B(C+D)

Table 1 : Truth table for decimal input to binary output

Decimal digit	BCD	Excess-3
0	0000	0011
1	0001	0100
2	0010	0101
3	0011	0110
4	0100	0111
5	0101	1000
6	0110	1001
7	0111	1010
8	1000	1011
9	1001	1100

Table 2 : Truth table for BCD input to Excess-3 output

Input BCD				Output Excess-3- code			
A	B	C	D	W	X	Y	Z
0	0	0	0	0	0	1	1
0	0	0	1	0	1	0	0
0	0	1	0	0	1	0	1
0	0	1	1	0	1	1	0
0	1	0	0	0	1	1	1
0	1	0	1	1	0	0	0
0	1	1	0	1	0	0	1
0	1	1	1	1	0	1	0
1	0	0	0	1	0	1	1
1	0	0	1	1	1	0	0

b) BCD-to-EXCESS-3 code converter gate in QCA

The block diagram of QCA is the BCD-to-excess-3 code converter gate shown in Fig.5. The BCD-to-excess-3 code converter gate has four inputs and four outputs asshown in figure 5. Uses eight majority voter (MV) gate and two NOT gate to design BCD-to-excess-3 code converter in QCA as shown in Figure 5.The fundamental logic gate for QCA is the BCD-to-excess-3 code converter gate shown in Figure 6 that is composed of two hundred (200) cells with total area of 0.06 μm2. Four of these, representing the inputs to the cell, are labeled A, B, C and D. using the terminology of [3]. The center cell is the "device cell" that performs the calculation for three input majority voter gates in QCA. The remaining cell, labeled out, provides the output. The circuit shown in Figure 6, performs the Boolean function Z= D', Y= CD+(C+D)', X= B' (C+D) + B(C+D)', W= A + B(C+D);

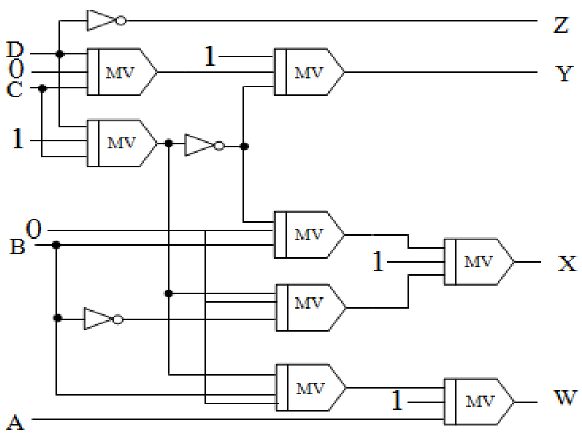

Figure 5 : QCA Block Diagram of BCD-to-excess-3 code converter

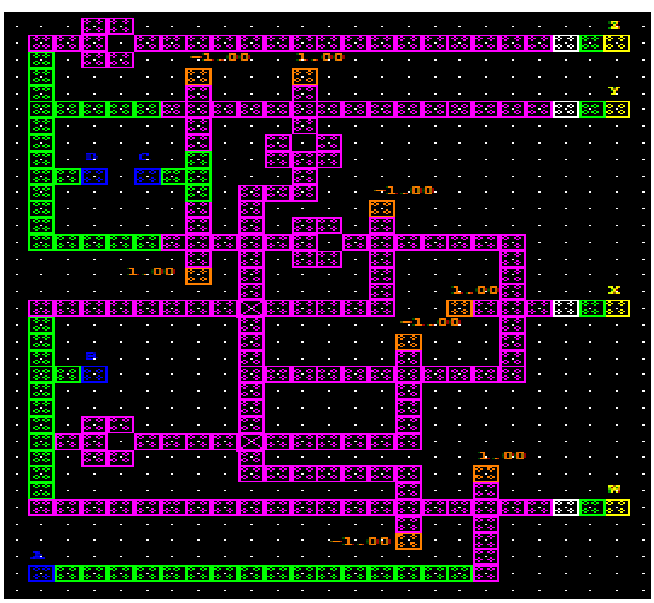

Figure 6 : BCD-to-excess-3 code converter gate simulation using QCA Designer

III. Methods

First of all, the logic behind any proposed circuit is deduced and then the circuit diagram is drawn at gate level. The gate level circuit is converted to QCA layout using majority gates, inverters, etc. as described in the above sections and then these designs are simulated in QCA Designer which is the product of an ongoing research effort by the Walus Group at the University of British Columbia to create a design and simulation tool for QCA. The designer tool allows the designer to layout a QCA design and simulates it quickly. QCA Designer has provided a new platform for developers; results from simulations, using this tool, have been published by many international groups [6-11]. Results obtained by this tool are then compared to theoretical values to verify the correctness of the circuit.

IV. Simulation Result and Discussion

The circuit was functionally simulated using the QCA Designer. Figure 7 shows the simulation results of a BCD-to-excess-3 code converter gate. In the Figure, from the input signals of A, B, C and D to the output signals of Z=D', Y=CD+(C+D)', X= B'(C+D)+ B(C+D)', W= A+B(C+D) in this module goes through four clock zones; it means its delay is a full clock cycle. Therefore at the output of Z, Y, X and W are available one clock cycles after A, B , C and has been applied. On the other hand, we can consider the value of the curve shown in Figure 7.

A=0, B=0, C=0,D=0

Z= D'

=(0)'

=1

Y= CD+(C+D)'

=Maj[Maj(C,D,0),1,Maj(C,D,1)']

= Maj[Maj(0,0,0),1,Maj(0,0,1)']

=Maj[0,1,(0)']

=Maj[0,1,1]

=1

X= B' (C+D) + B(C+D)'

=Maj[Maj{B' ,0,Maj(C,1,D),}1, Maj{B,0,Maj(C,1,D)'}]

= Maj[Maj{(0)' ,0,Maj(0,1,0),}1,Maj{0,0,Maj(0,1,0)'}]

=Maj[Maj{1,0,0},1,Maj{0,0,(0)'}]

=Maj[0,1,0]

=0

W= A + B(C+D)

=Maj[A,1,Maj{B,0,Maj(C,1,D)}]

=Maj[0,1,Maj{0,0,Maj(0,1,0)}]

=Maj[0,1,Maj{0,0,0}]

=Maj[0,1,0]

=0

A= 0, B=0, C=0,D=1

Z= D'

= (1)'

= 0

Y= CD+(C+D)'

Y= CD+(C+D)'
=Maj[Maj(C,D,0),1,Maj(C,D,1)']
=Maj[Maj(0,1,0),1,Maj(0,1,1)']
=Maj[0,1,(1)']
=Maj[0,1,0]
=0

X= B' (C+D) + B(C+D)'
=Maj[Maj{B' ,0,Maj(C,1,D),}1, Maj{B,0,Maj(C,1,D)'}]
= Maj[Maj{(0)' ,0,Maj(0,1,1),}1,Maj{0,0,Maj(0,1,1)'}]
=Maj[Maj{1,0,1},1,Maj{0,0,(1)'}]
=Maj[1,1,0]
=1

W= A + B(C+D)
=Maj[A,1,Maj{B,0,Maj(C,1,D)}]
=Maj[0,1,Maj{0,0,Maj(0,1,1)}]
=Maj[0,1,Maj{0,0,1}]
=Maj[0,1,0]
=0

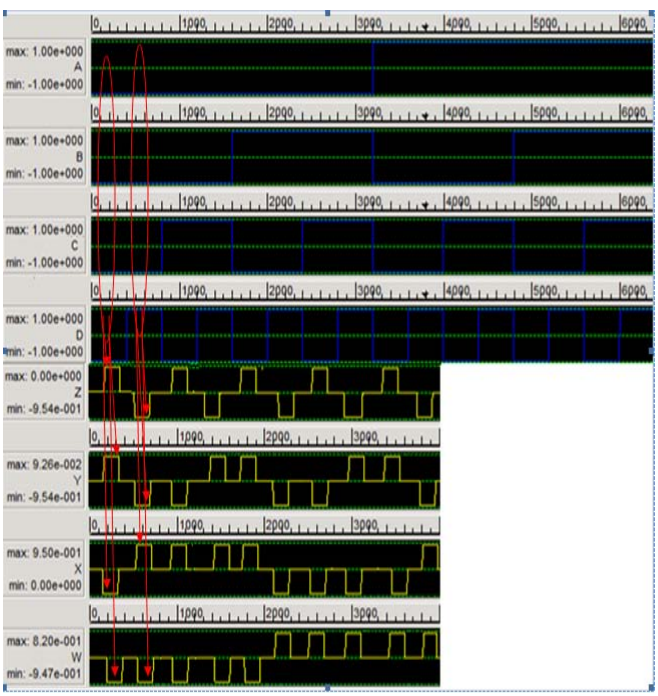

Figure 7 : Simulated waveforms for BCD-to-excess-3 code converter gate circuit

We can find the Output value of W, X, Y, Z is two level such as low and high when the various input digits of A,B,C,D . We look into the every output values of W, X, Y, Z are translating the input data successfully. Based on the mentioned reversible logic gate BCD-to-excess-3 code converter gate numeral logical circuit design method, we also construct BCD-to-excess-3 code converter gate by QCA. The sizes of layouts are measured on the basis of size of QCA cells. The All designs are carefully clocked and were functionally verified using QCADesigner; a layout and simulation tool for QCA. Finally, in Table 3, designs are compared according to number of cells, area, and delay.

Table 3 : Result analysis of proposed BCD-to-excess-3 code converter gate in QCA

Parameter	Value
Number of cells	200
Covered area (μm^2)	0.06
Clock used	4
Time delay (clock cycle)	1

V. Conclusion

This paper present a BCD-to-excess-3 code converter gate based on QCA does logic gates .This QCA circuit design provide a new functional paradigm for information encoding. In addition, QCA binary logic functions and the associated new nano-technology will provide high-speed computing, high-density applications. It is believed that QCA will become a more practical ways to create a faster and denser circuit

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Performance Analysis of BLDC Motor Drive using New Simulation Model with Fuzzy and ANFIS Speed Controllers

By C. Subba Rami Reddy & M. Surya Kalavathi
KSRM College of Engineering, India

Abstract- This paper presents the mathematical model of the brushless DC (BLDC) motor drive fed by the hysteresis current controlled inverter, which is designed using the new switching function concept. The developed simulation model is applied with the fuzzy logic controller (FLC) and adaptive neuro fuzzy inference system (ANFIS) controller as speed controllers to enhance the performance of the BLDC motor drive system. The complementary strengths of FLC and neural networks are combined together to obtain the ANFIS controller. The ANFIS controller is trained by the data of closed loop BLDC motor drive system simulated with PI controller. The ANFIS controller avoids the selection of fuzzy control rules and tuning of membership functions in the manual manner as done in FLC. A comparative study of different performance specifications is proposed between FLC and ANFIS speed controller as applied to the BLDC motor drive system. The simulation results show that the ANFIS controller is more effective as compared to FLC during most of the operating conditions considered.

Keywords: *BLDC motor, switching function, FLC, ANFIS controller, performance specifications.*

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Abstract- This paper presents the mathematical model of the brushless DC (BLDC) motor drive fed by the hysteresis current controlled inverter, which is designed using the new switching function concept. The developed simulation model is applied with the fuzzy logic controller (FLC) and adaptive neuro fuzzy inference system (ANFIS) controller as speed controllers to enhance the performance of the BLDC motor drive system. The complementary strengths of FLC and neural networks are combined together to obtain the ANFIS controller. The ANFIS controller is trained by the data of closed loop BLDC motor drive system simulated with PI controller. The ANFIS controller avoids the selection of fuzzy control rules and tuning of membership functions in the manual manner as done in FLC. A comparative study of different performance specifications is proposed between FLC and ANFIS speed controller as applied to the BLDC motor drive system. The simulation results show that the ANFIS controller is more effective as compared to FLC during most of the operating conditions considered.

Keywords: BLDC motor, switching function, FLC, ANFIS controller, performance specifications.

I. Introduction

Now a days, the brushless dc (BLDC) motors are very widely used in many applications because of high efficiency, high power density, silent operation, long operating life, low maintenance and good dynamic performance [1-5]. Lot of research work is progressing towards the BLDC motor drive due to the increased demand of such systems in the market [6-9]. However, the use of BLDC motors is restricted due to the complexity involvement in the speed control for applications with the variable speed and varying loads [10-13]. The classical controllers with fixed gains may not work properly due to the changes in plant dynamics with ageing process, parameter variations and external disturbances [14-16].

Fuzzy control is one of the most interesting techniques that can be well applied for the control of imprecise, nonlinear and ill-defined systems [17-21]. The selection of membership functions and the development of fuzzy control rules is a difficult task without the information from the skilled operator. More over the fuzzy control rules could not be defined properly if the skilled operator is unable to give the exact instructions about the process operation. The artificial neural networks have the learning capability which gains the knowledge of a process automatically from the sample input and output relationship of the process [22-23]. This paper introduces the implementation fuzzy logic controller (FLC) and adaptive neuro fuzzy inference system (ANFIS) controller for the speed control of BLDC motor drive system to improve the performance at different operating conditions. This paper is organized in the following manner. Section II illustrates the description of BLDC motor drive that consists of speed controller, current controller, BLDC motor and inverter. Section III presents the simulation results of the drive with FLC as speed controller. Section IV explains the application of ANFIS speed controller to the BLDC motor drive system along with the simulation results. Section V gives the comparative performance of BLDC motor drive for different operating conditions between FLC and ANFIS controller. Finally the main concluding remarks are given in section VI.

Author α: Associate professor, Electrical and Electronics Engineering, KSRM College of Engineering, Kadapa, Andhra Pradesh, India. e-mail: csubbaramireddy2020@gmail.com

Author σ: Professor, Electrical and Electronics Engineering, JNTUH, Hyderabad, Andhra Pradesh, India. e-mail: munagala12@yahoo.co.in

II. Description of BLDC Motor Drive System

The block diagram of BLDC motor drive system with the combination of FLC and the neural network as speed controller is shown in figure 1. The drive system consists of BLDC motor, rotor position sensor, combined FLC and neural network known as ANFIS controller and three phase voltage source inverter.

There are two basic control loops in the description of the drive system known as speed control loop and current control loop [24-25]. The speed control loop is the outer control loop which consists of BLDC motor, rotor position sensor, speed controller, reference current generator, hysteresis controller and three phase voltage source inverter. The current control loop is the inner control loop which consists of reference current generator, hysteresis current controller and three phase voltage source inverter. The back electro motive force (EMF) wave forms of BLDC motor are in trapezoidal shape. These trapezoidal waveforms for all the three phases are built based on the rotor position (θ).

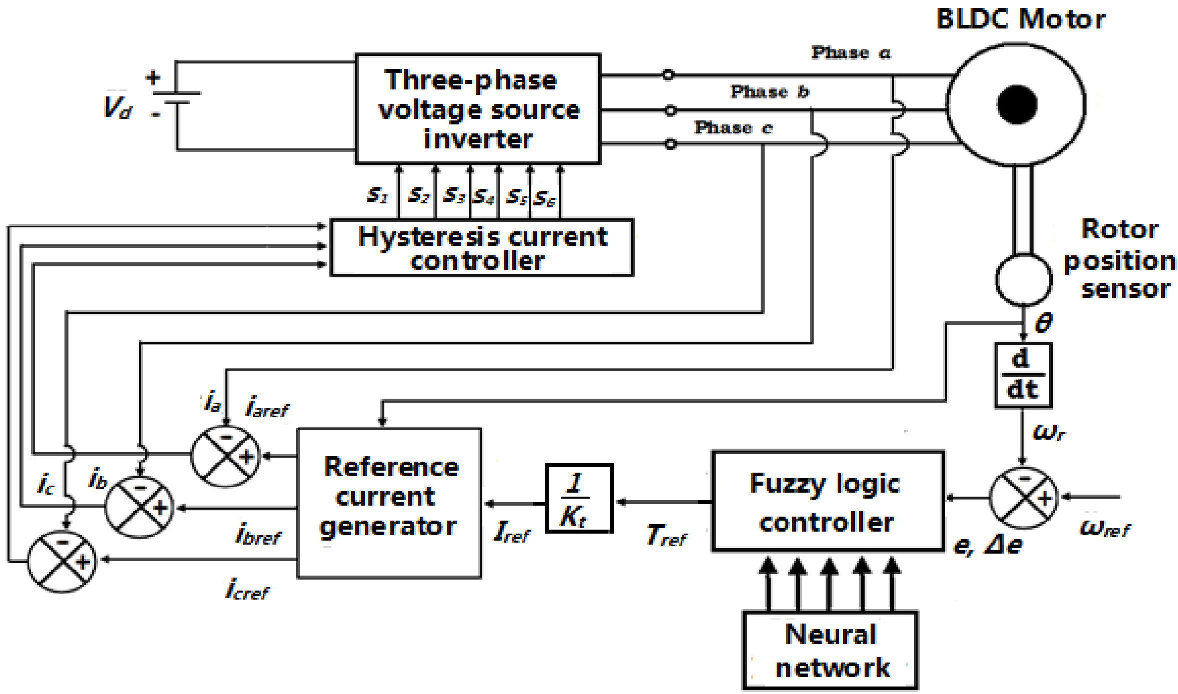

Fig. 1 : Block diagram of BLDC motor drive with the combined FLC and neural network based speed controller

The rotating speed (ω_r) of BLDC motor is determined by means of knowing the position of the rotor from the back EMF wave forms. The actual speed of the motor is compared with the reference speed (ω_{ref}) and then the error signal (e) is given to the speed controller. The two types of speed controllers considered are FLC and ANFIS controller. The speed controller processes the error signal of speed to generate the signal equivalent to the reference torque (T_{ref}).

The reference torque divided by the torque constant (K_t) gives the reference current (I_{ref}). The reference current generator generates the reference currents i_{aref}, i_{bref} and i_{cref} for phases a, b and c based on the rotor position. The reference phase currents are compared with the actual phase currents to generate the current error in the respective phases. The hysteresis current controller generates the firing pulses for the semiconductor switches of the three phase inverter based on the values of current error and the rotor position.

The three phase inverter fed by the constant DC supply produces the variable voltage and frequency based on the turn-on and turn-off of semiconductor switches. Therefore the inner loop synchronizes the currents while the outer loop synchronizes the speed. The overall simulation model of the drive system shown in figure 2 is developed using MATLAB and Simulink environment by considering the basic process equations of each component of the drive system. The attention is made to focus the implementation of FLC and ANFIS controller as speed controllers rather than the details of modeling of BLDC motor drive system.

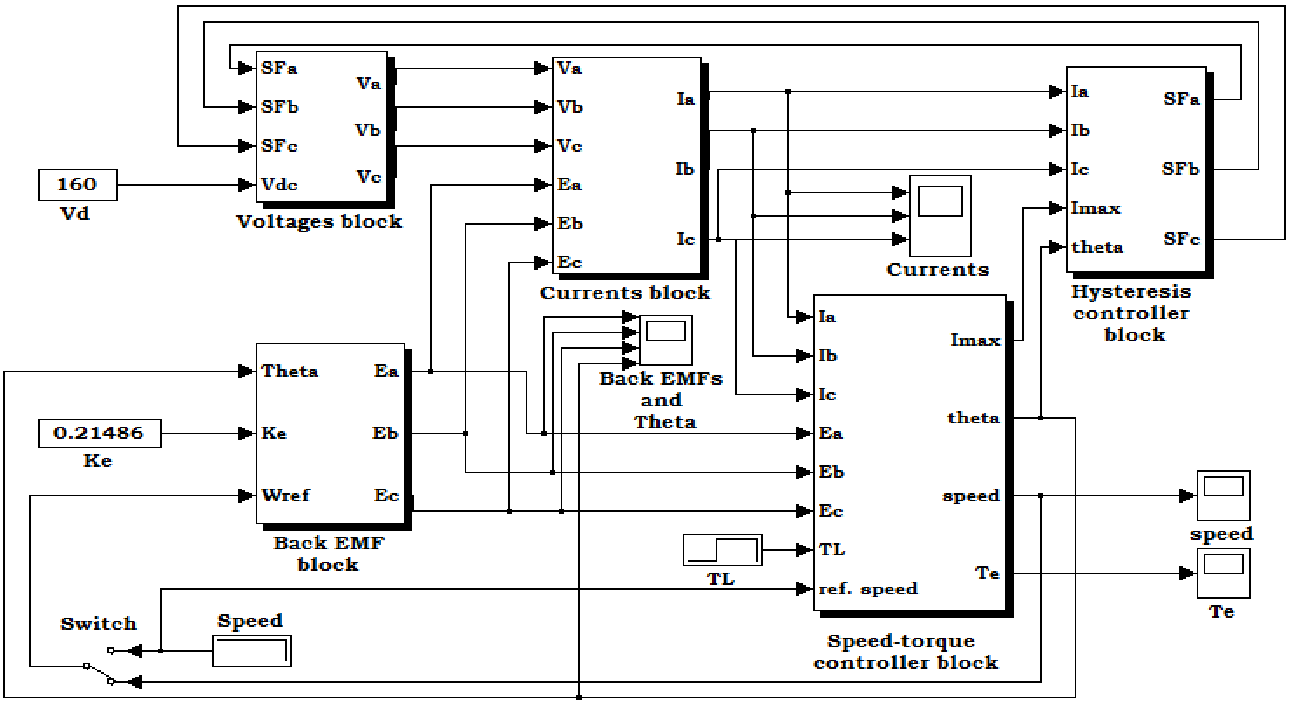

Figure 2 : Simulation model of drive system using MATLAB and Simulink

III. Implementation of BLDC Motor Drive with FLC

The inputs of FLC are signals of error (e) and change in error (Δe) in the speed of BLDC motor from the reference value. The seven membership functions are chosen for the representation of inputs and the output of FLC. They are large negative (LN), medium negative (MN), small negative (SN), zero (ZE), small positive (SP), medium positive (MP) and large positive (LP). The triangular membership functions are chosen for the membership functions of MN, SN, ZE, SP and MP while the trapezoidal membership functions are chosen for the membership functions of LN and LP. The ranges of input and output membership functions of FLC over the universe of discourse are shown in figures 3 and 4. The output control signal (u_f) of FLC is as per the fuzzy control rules stored in the rule base shown in table 1.

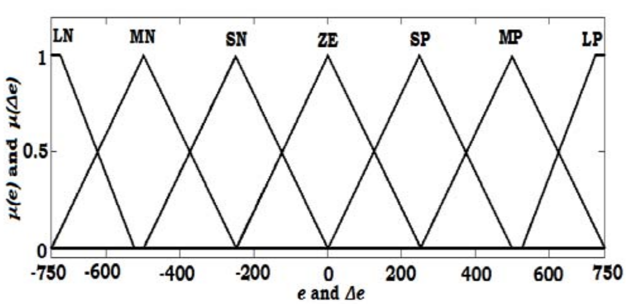

Figure 3 : Membership functions for the inputs of error and change in error

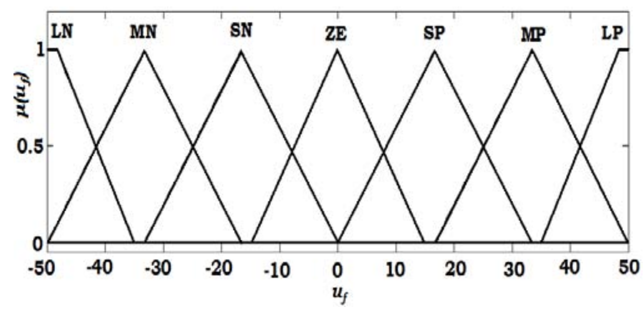

Figure 4 : Membership functions for the output of FLC

Table 1 : Fuzzy rules for the control signal (u_f) .

e/Δe	LN	MN	SN	ZE	SP	MP	LP
LN	LN	LN	LN	MN	SN	SN	ZE
MN	LN	MN	MN	MN	SN	ZE	SP
SN	LN	MN	SN	SN	ZE	SP	MP
ZE	LN	MN	SN	ZE	SP	MP	LP
SP	MN	SN	ZE	SP	SP	MP	LP
MP	SN	ZE	SP	MP	MP	MP	LP
LP	ZE	SP	SP	MP	LP	LP	LP

a) Simulation Results of Drive with FLC

The simulation results of BLDC drive with FLC are shown in figures 5 to 10 for various operating conditions at a set speed of 3500 rpm. The parameters of the BLDC motor considered are 4 poles, 1 HP, star connected, 3500 rpm, 160 V DC supply, 5 A, resistance of 0.75Ω per phase, self inductance minus mutual inductance of 0.00305 H per phase, torque constant of 0.21476 N-m/A, moment of inertia of 0.82614 e-4 Kg-m2 and back EMF constant of 0.10743 V-s per radian. The

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sudden load of 0.662 N-m is applied at 0.05 second and withdrawn at 0.12 second. The motor speed is changed at 0.15 second to a value equal to the set speed but in the opposite direction.

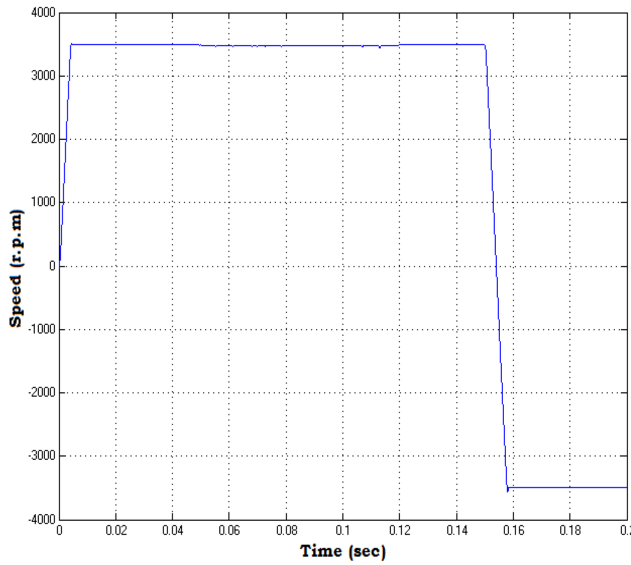

Figure 5 : Speed response of drive with FLC

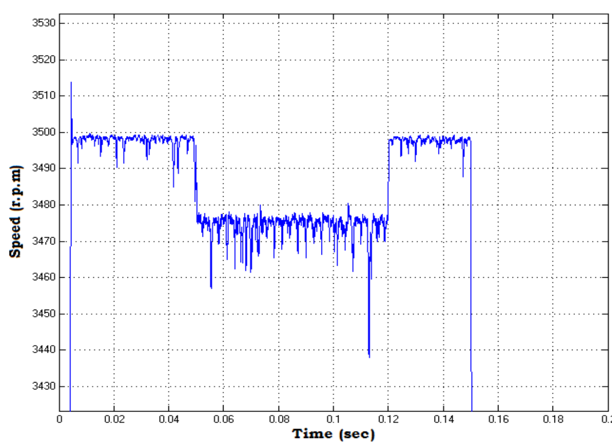

Figure 6 : Magnified view of speed response with FLC

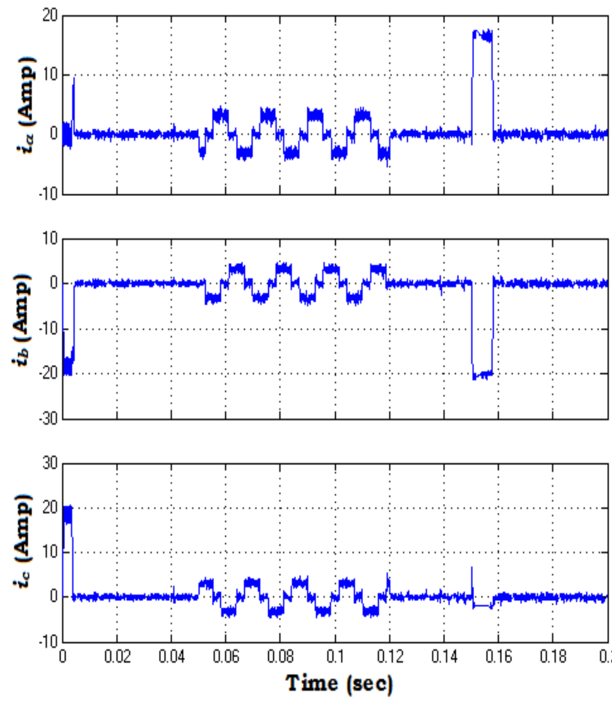

Figure 7 : Phase current waveforms with FLC

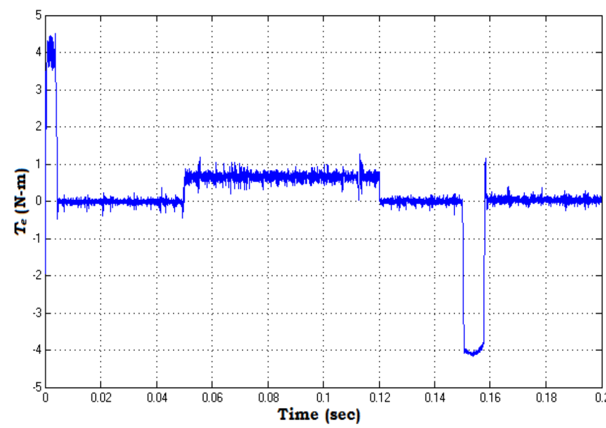

Figure 8 : Torque response of drive with FLC

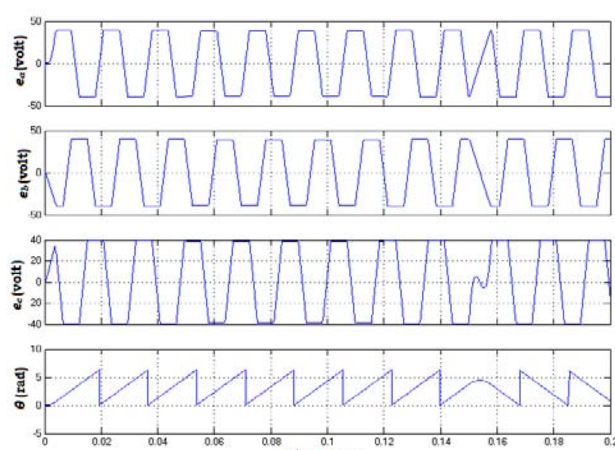

Figure 9 : Back EMFs and rotor position with FLC

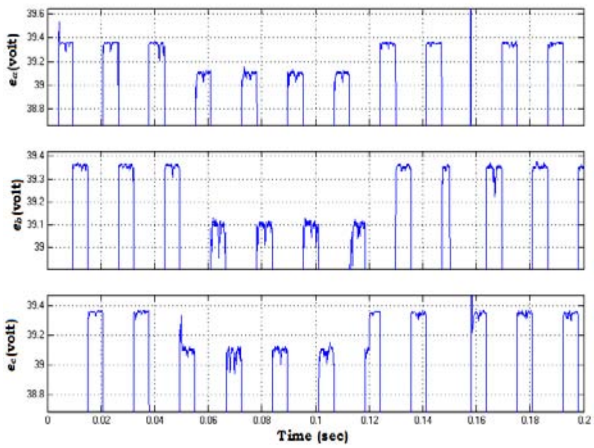

Figure 10 : Magnified view of back EMFs with FLC

IV. Implementation of BLDC Motor Drive with ANFIS Controller

The properties of both fuzzy control and artificial neural networks are combined to produce the ANFIS controller. The FLC is provided with the learning capability by the structure of neural network that helps the FLC to select the best possible ranges for the input and output membership functions that match the sample input and output data. The response of BLDC motor drive with the proportional-integral (PI) controller is used as sample input and output data to train FLC. The basic structure of ANFIS network obtained through the MATLAB is shown in figure 11. The trained membership functions with the best possible ranges for error (e) and change in error (Δe) are shown in figure 12.

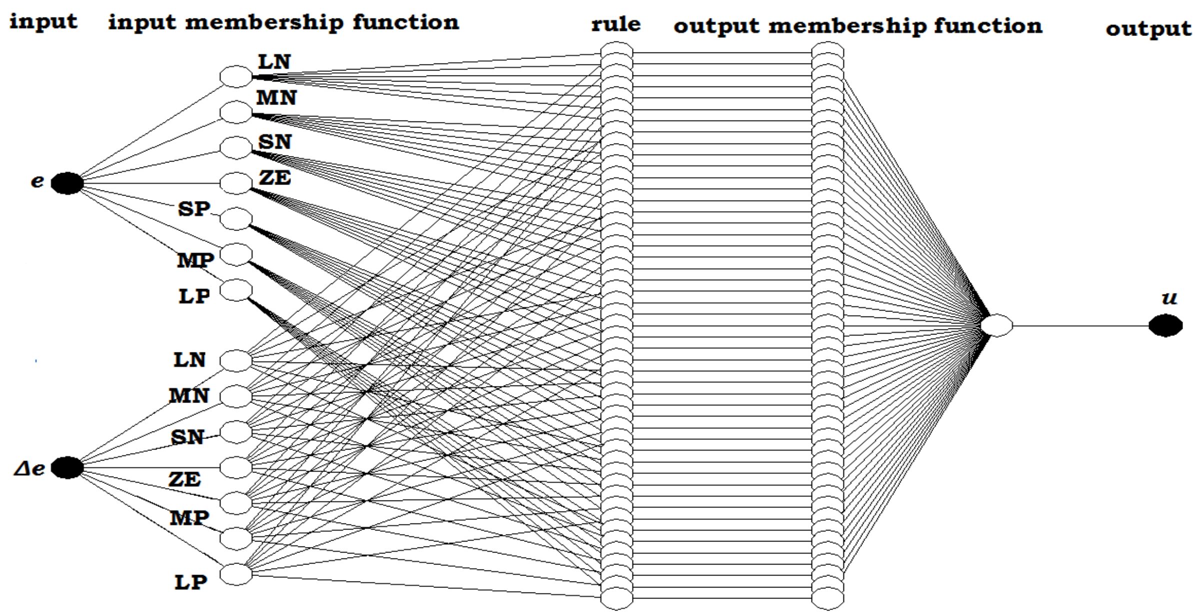

Figure 11 : The network of ANFIS controller

The chosen fuzzy inference system for FLC is Takagi-Sugeno-Kang type of fuzzy inference system. The selected membership functions are the generalized bell shaped one. The parameters of membership functions are tuned by both the back propagation and least squares method through the neural networks structure. The structure of neural network is helping in tuning and selection process of membership functions and fuzzy control rules respectively thereby eliminating the use of human expert. The updating of parameters through the learning process is facilitated by the gradient vector.

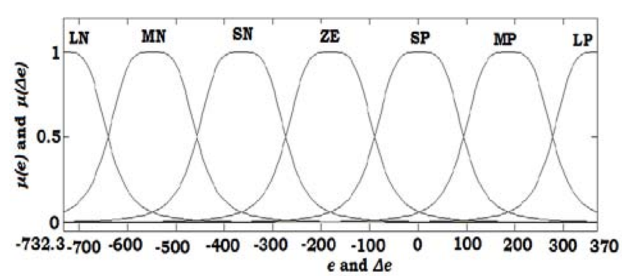

Figure 12 : Membership functions for error and change in error

a) Simulation Results of Drive with ANFIS Controller

The simulation results of BLDC drive with ANFIS controller are shown in figures 13 to 18 for different operating conditions as done with FLC at a set speed of 3500 rpm.

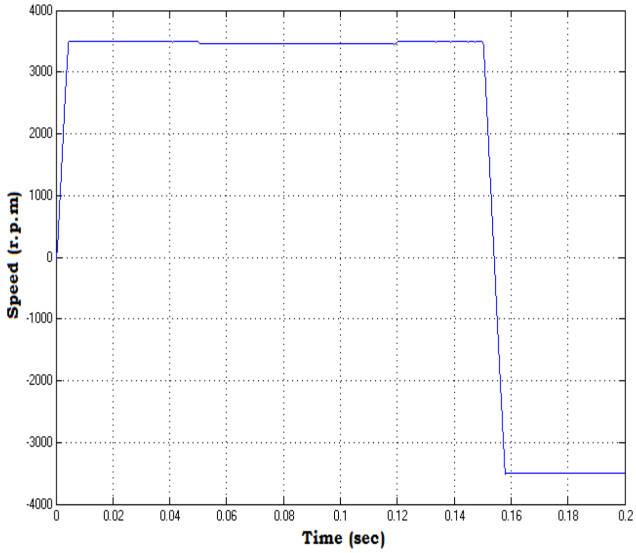

Fig. 13 : Speed response of drive with ANFIS controller

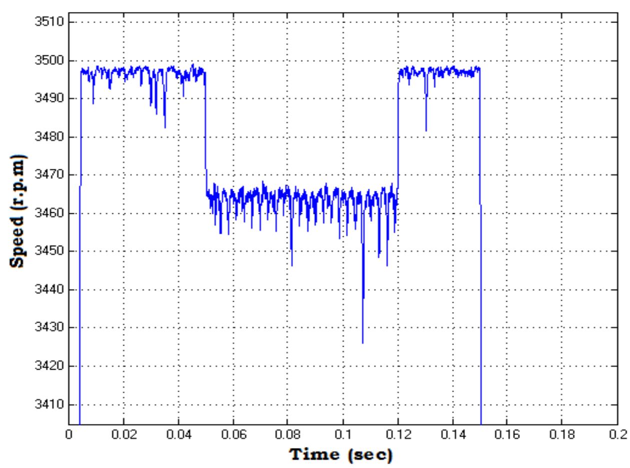

Fig. 14 : Magnified view of speed response with ANFIS controller

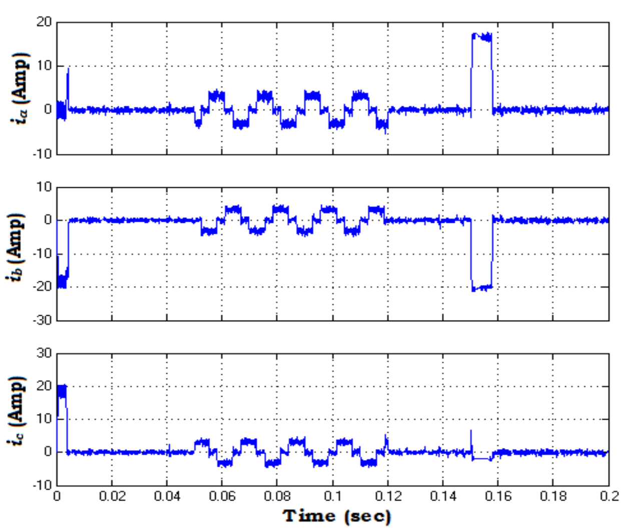

Fig. 15 : Phase current waveforms with ANFIS controller

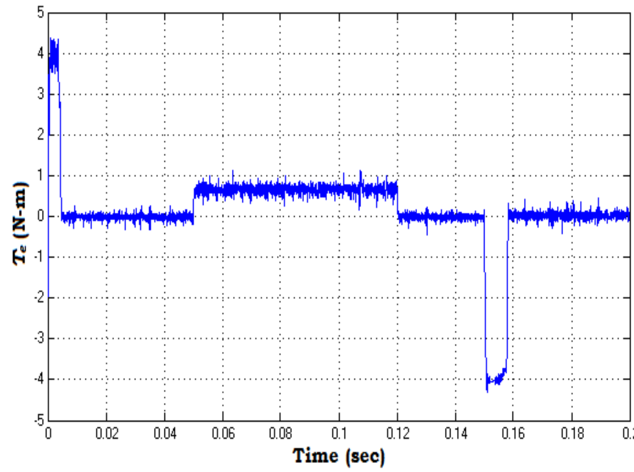

Fig. 16 : Torque response of drive with ANFIS controller

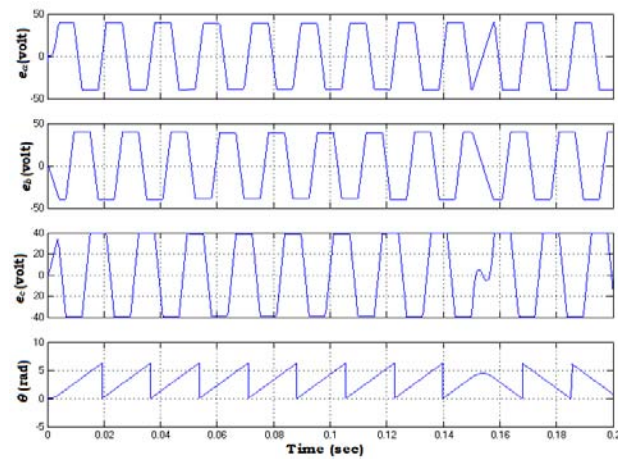

Fig. 17 : Back EMFs and rotor position with ANFIS controller

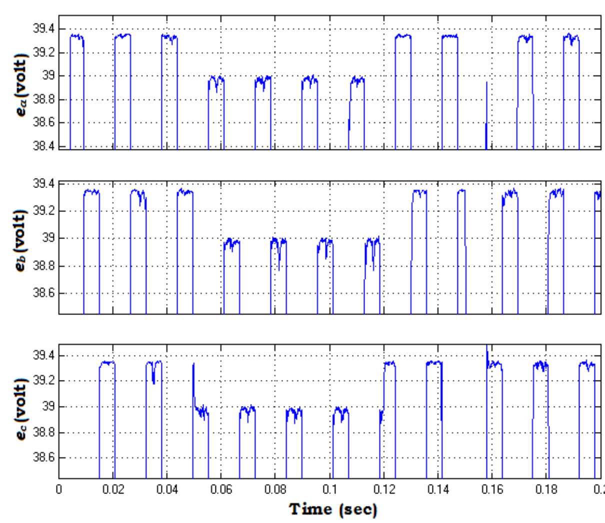

Fig. 18 : Magnified view of back EMFs with ANFIS controller

V. Comparison of Performance Indices between FLC and ANFIS Controller

A comparison of FLC and ANFIS controller is carried out in terms of different performance indices at various set speeds for different operating conditions. The table 2 shows the comparison for the performance specifications of settling time, steady state error, peak overshoot and time taken to reach the set speed in the reverse direction between FLC and ANFIS controller. The table 2 shows the comparison for the error constants of integral of absolute error (IAE), integral of squared error (ISE), integral of time weighted absolute error (ITAE) and integral of time weighted squared error (ITSE) between FLC and ANFIS controller.

Table 2 : Comparison of performance specifications

Reference speed in rpm	Type of Controller	settling time in sec	Steady state error in rpm	Dip in speed at a load of 0.662 N-m in rpm	Peak Overshoot in rpm	Settling time during speed reversal in sec
3500	FLC	0.0048	9	35	13.8	0.0092
	ANFIS	0.00461	11	40	1	0.0095
3100	FLC	0.0049	3	30	49.33	0.0085
	ANFIS	0.0046	3	40	55.1	0.0082
2600	FLC	0.00455	2	30	88.65	0.0069
	ANFIS	0.0042	0.9	40	22.39	0.0067
2100	FLC	0.0044	0.6	30	127.4	0.0062
	ANFIS	0.0044	0.4	40	72.3	0.006
1600	FLC	0.004	0.4	30	149	0.0049
	ANFIS	0.00353	0.4	37	74.44	0.0049
1100	FLC	0.003	0.4	24	116.7	0.004
	ANFIS	0.0028	0.4	35	38.18	0.0038

Table 3 : Comparison of error constants

Reference speed in rpm	Type of Controller	IAE	ISE	ITAE	ITSE
3500	FLC	0.8379	219.3	0.001193	0.2356
	ANFIS	0.8425	220	0.001209	0.2379
3100	FLC	0.6617	155.1	0.0008305	0.1489
	ANFIS	0.6703	157.3	0.0008512	0.1528
2600	FLC	0.4795	96.1	0.0005099	0.07939
	ANFIS	0.4808	95.93	0.0005148	0.0796
2100	FLC	0.3398	56.69	0.0003074	0.04047
	ANFIS	0.333	54.72	0.0002998	0.03832
1600	FLC	0.1991	26.27	0.0001324	0.01498
	ANFIS	0.2011	26.01	0.0001371	0.01487
1100	FLC	0.1016	9.634	$4.645X10^{-5}$	0.00425
	ANFIS	0.1072	9.932	$5.416X10^{-5}$	0.00439

a) *Starting Performance*

The time taken by the BLDC motor to settle at the set speed from standstill is observed for FLC and ANFIS controller at different set speeds of 3500, 3100, 2600, 2100, 1600 and 1100 rpm. It is found that the drive is taking less time with ANFIS controller for all the speeds. ANFIS controller is giving less overshoot at all speeds except at 3100 rpm as compared to FLC. The steady state error is almost equal in both the cases.

b) *Speed Reversal and Load Perturbation*

The drive rotating at set speed is suddenly reversed to rotate in the opposite direction. The ANFIS controller is attaining the set speed in the reverse direction quickly at most of the speeds. When the drive is running under steady state condition, a rated load of 0.662 N-m is applied at time of 0.05 second and withdrawn at 0.12 second. The dip in the speed is slightly high with ANFIS controller as compared to FLC.

VI. Conclusion

The simulation model of BLDC motor drive is developed to study the transient and steady state performance with FLC and ANFIS controller. The use of expert in selection of fuzzy control rules and tuning the membership functions is eliminated. The ANFIS controller is giving better performance during the different operating conditions at all speeds as compared to FLC except during the load perturbation where the performance is slightly decreased.

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AC Characteristics of a Dual Gate Large Area Graphene MOSFET

By Md. Tawabur Rahman, Ashish Kumar Roy, Md. Shamim Sarker &Md. Tajul Islam

Khulna University of Engineering & Technology, Bangladesh

Abstract- This paper presents a detailed study of RF characteristics together with the high frequency performance of dual gate large area graphene MOSFET. A quasi analytical modeling approach is presented here. To know the RF characteristics of a graphene MOSFET, the transconductance is simulated using small signal equivalent model. Finally the intrinsic top and back gate gain of graphene MOSFET are also shown which are very important figure of merit for RF applications.

Keywords: graphene MOSFET, GFET, large area graphene, top and back gate gain, transconductance.

GJRE-F Classification : FOR Code: 290903

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AC Characteristics of a Dual Gate Large Area Graphene MOSFET

Md. Tawabur Rahman [α], Ashish Kumar Roy [σ], Md. Shamim Sarker [ρ] & Md. Tajul Islam [Ѡ]

Abstract- This paper presents a detailed study of RF characteristics together with the high frequency performance of dual gate large area graphene MOSFET. A quasi analytical modeling approach is presented here. To know the RF characteristics of a graphene MOSFET, the transconductance is simulated using small signal equivalent model. Finally the intrinsic top and back gate gain of graphene MOSFET are also shown which are very important figure of merit for RF applications.

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I. Introduction

Graphene is a flat monolayer of sp[2] carbon atoms tightly packed into a two-dimensional (2D) honeycomb lattice including a linear energy dispersion relation [1]. Graphene offers many of the advantages such as high carrier mobilities up to 10×2^5 cm^2 V^{-1} s^{-1} in substrate supported devices and high saturation velocity [2] [6]. The novel electronic properties of graphene lead to intense research into possible applications of this material in nano scale devices such as dual gate graphene MOSFETs.

There have been studies on designing and fabrication of dual gate graphene MOSFETs. However, the progress in designing and fabricating of G-MOSFETs is at initial stage. In order to fabricate high performance G-MOSFETs, understanding of detailed device modeling and performance evaluations is urgently required. The recent works have been concentrated mostly on the DC characteristics of large area graphene MOSFETs using different approaches. However, there have no significant works on AC characteristics although graphene is predicted to highly attracted material for nano-scale devices.

II. Device Model

A dual gated graphene MOSFET is considered for our work shown in *Fig.1.* Graphene grown on metal and transferred to a *SiO_2* covered Si wafer is used as the channel of the MOSFET. The length and width of the graphene channel are 5 μm and 1 m respectively. Here, *HfO^2 (k=9)* is used as top-gate oxide and *SiO_2 (k=3.9)* is used as back-gate oxide [5], [7].

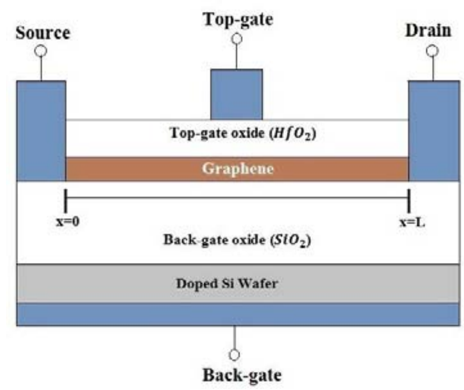


Figure 1 : Cross section of the modeled graphene MOSFET [8]

a) *Channel Charge Calculation*

The goal of this work is to model the high-frequency characteristics of these devices. This will be done by calculating the elements of the small-signal equivalent circuit. Before we can deal with these elements we need to know how to calculate the channel charge, since this is essential in order to determine the gate-source and gate-drain capacitances. In general the channel charge Q_{ch} can he calculated by subtracting the amount of electrons from the amount of holes and multiplying the result by the elementary charge. This can be written as [09].

$$Q_{ch} = qW\int_0^L (p(x) - n(x))dx \qquad (01)$$

To obtain Q_{ch}, a simple numerical integration is performed using a trapezoidal approximation. The x dependence of the local hole and electron sheet densities can be translated into a dependence on the local voltage V(x). By using this equation [09].

$$\frac{dx}{dV(x)} = \frac{qW_{\rho_{real}}(V(x))\mu}{I_d} + \frac{\mu}{v_{sat}(V(x))} \qquad (02)$$

The overall net charge can be expressed using Eqn.01 and the necessary equation of Q_{ch}

Author α: Electrical and Electronic Engineering from Khulna University of Engineering & Technology, Bangladesh department of EEE in the Khulna University of Engineering & Technology as a Lecturer.
e-mail: tawabur_eee06@yahoo.com
Author σ: Electrical and Electronic Engineering from Khulna University of Engineering & Technology, Bangladesh.
e-mail: ashroyeee@gmail.com
Author ρ: Electrical and Electronic Engineering from Khulna University of Engineering & Technology, Bangladesh department of EEE in the Khulna University of Engineering & Technology as a Lecturer.
e-mail: sarkershamimbd@gmail.com

$$Q_{ch}=qW\int_{0}^{V_{ds-\text{int}}}[p(V(x))-n(V(x))]\frac{dx}{dV(x)}dV(x) \quad (03)$$

$$Q_{ch}=\int_{0}^{V_{ds-\text{int}}}[\rho(V(x))-nV(x)]\left(\frac{qW_{\rho_{real}}(V(x))\mu}{I_d}+\frac{\mu}{v_{sat}(V(x))}\right)dV(x) \quad (04)$$

It is important to distinguish between p, n and in ρ_{real} the formula above. If we neglect the minority charge carriers, p(V(x))-n(V(x)) is equal to ρ_{real} can be expressed as:

$$p(V(x))-n(V(x))\cong-(V_{gs-top}-V(x)-V_{gs-top,0})\frac{\frac{1}{2}C_{ox-top}C_q}{C_{ox-top}+C_{ox-top}+\frac{1}{2}C_q}$$

$$-(V_{gs-top}-V(x)-V_{gs-top,0})\frac{\frac{1}{2}C_{ox-back}C_q}{C_{ox-top}+C_{ox-top}+\frac{1}{2}C_q} \quad (05)$$

The integral to determine Qch is solved numerically. We have used the MATLAB simulation. Note that to calculate channel charge as well as small signal parameters the internal voltages have to be used [09].

a) Small-Signal Equivalent Circuit

The high-frequency behavior of the transistor can be modeled with a small-signal equivalent circuit [10] as shown in Figure2. The intrinsic transistor is described by the transconductance g_m, the drain conductance gds, the gate-source capacitance C_{gs}, and the gate-drain capacitance C_{gd}. Thereby the whole behavior of the device is described by these four elements: g_m, g_{ds} C_{gs} and C_{gd}. The reason why this is possible is the following. The high-frequency AC signal is thought to be superimposed onto a DC signal, which defines the DC operating point. If the amplitude of the AC signal is small, the nonlinear transistor characteristics can be linearized around the DC operating point. Thus all elements of Fig. 2 are explained in the following as mentioned [09].

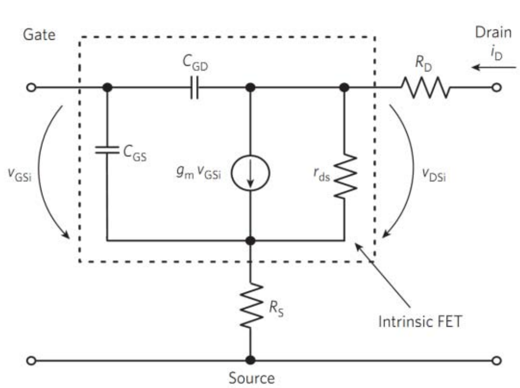


Figure 2 : The small-signal equivalent circuit of a graphene MOSFET

The intrinsic transconductance, gm, is related to the internal small-signal gate source and drain– source voltages, VGSi and VDSi, whereas the terminal transconductance, gmt, is related to the applied gate–source and drain–source voltages, VGS and VDS [10].

III. Transconductance Calculation

The transconductance calculation is very important to know the radio-frequency characteristics of a graphene MOSFET. The transconductance is defined as the variation in the drain current caused by a small variation in the drain current caused by a small variation in the gate voltage. They are two types: intrinsic transconductance and drain-conductance.

a) Intrinsic Transconductance

The intrinsic transconductance is defined as the change of the drain current Id caused by small variations of the internal gate-source voltage Vgs-top-int at a fixed drain source voltage Vds-int-const, denoted by gm [09], [10].

$$g_{m-top}=\left.\frac{dI_d}{dV_{gs-top-\text{int}}}\right|_{V_{ds-\text{int}}=const} \quad (06)$$

$$g_{m-back}=\left.\frac{dI_d}{dV_{gs-back-\text{int}}}\right|_{V_{ds-\text{int}}=const} \quad (07)$$

The transconductance due to top-gate voltage ($g_{m\text{-}top}$) and the transconductance due to back-gate voltage ($g_{m\text{-}back}$) can be evaluated using Eqn. 06 and Eqn.07 clearly. It describes how the output signal (drain current) reacts on changes of the input signal (gate- source-voltage).

b) Drain Conductance of GFET, g_{ds}

The drain-source conductance g_{ds} describes the resistance of the graphene channel, since it is the inverse of r_d. It is expressed by the variation of the drain current I_d caused by a change of the internal drain-source voltage Vds-int at a fixed $V_{gs\text{-}top\text{-}int.}$

$$g_{ds-top}=\left.\frac{dI_d}{dV_{ds-\text{int}}}\right|_{V_{gs-top-\text{int}}=const} \quad (08)$$

$$g_{ds-back}=\left.\frac{dI_d}{dV_{ds-\text{int}}}\right|_{V_{gs-back-\text{int}}=const} \quad (09)$$

The drain conductance due to fixed value of top-gate voltage (gds-top) and the drain conductance due to fixed value of back-gate voltage (gds-back) can be evaluated using Eqn.08 and Eqn.09.

IV. Intrinsic Capacitance Calculation

The intrinsic capacitance is very necessary to calculate the cut-off frequency and other radiofrequency behaviour of a graphene MOSFET. The mobile channel charge depends on the top-gate voltage $V_{gs\text{-}top\text{-}int}$, the back-gate voltage $V_{gs\text{-}back\text{-}int}$ and drain-source voltage $V_{ds\text{-}int}$. This dependence is modeled by the gate-source capacitance C_{gs} & the gate-drain capacitance C_{gd} [09].

a) Gate-Source Capacitance, C_{gs}

The gate-source capacitance C_{gs} is defined as the variation in the channel charge Q_{ch} caused by a small variation in the top-gate voltage $V_{gs\text{-}top\text{-}int}$ with a fixed value of drain-source voltage $V_{ds\text{-}int}$.

$$C_{gs-top} = -\frac{dQ_{ch}}{dV_{gs-top-\text{int}}}\bigg|_{V_{ds-\text{int}}=const} \quad (10)$$

$$C_{gs-back} = -\frac{dQ_{ch}}{dV_{gs-back-\text{int}}}\bigg|_{V_{ds-\text{int}}=const} \quad (11)$$

The gate-source capacitance due to top-gate voltage ($C_{gs\text{-}top}$) and the gate-source capacitance due to back-gate voltage ($C_{gs\text{-}back}$) can be evaluated using Eqn.10 and Eqn.11 clearly.

b) Gate-Drain Capacitance, C_{gd}

The gate-drain conductance C_{gd} is defined as the variation in the channel charge Q_{ch} caused by a small variation in the drain-source voltage $V_{ds\text{-}int}$ with a fixed value of top-gate voltage $V_{gs\text{-}top\text{-}int}$.

$$C_{gd-top} = -\frac{dQ_{ch}}{dV_{ds-\text{int}}}\bigg|_{V_{gs-top-\text{int}}=const} \quad (12)$$

$$C_{gd-back} = -\frac{dQ_{ch}}{dV_{ds-\text{int}}}\bigg|_{V_{gs-back-\text{int}}=const} \quad (13)$$

The gate-drain capacitance due to the fixed value of top-gate voltage ($C_{gd\text{-}top}$) and the gate-drain capacitance due to the fixed value of back-gate voltage ($C_{gd\text{-}back}$) can be evaluated using Eqn.12 and Eqn.13 also.

V. Intrinsic Gain Calculation

Finally, we show an example of projection of the intrinsic gain as a figure of merit commonly used in RF/analog applications. In small signal amplifiers, for instance, the transistor is operated in the ON-state and small RF signals that are to be amplified are superimposed onto the DC gate-source voltage [41]. Instead, what is needed to push the limits of many analog/RF figures of merit, for instance the cut-off frequency or the intrinsic gain, is an operation region where high trans conductance together with a small output conductance is accomplished. Next, we will give an example on how to use our current-voltage DC model to project an important figure-of-merit (FOM) used in RF/analog applications, namely the intrinsic gain (G).

a) Intrinsic Top-Gate Gain, G_{top}

The intrinsic top-gate gain G_{top} which is defined as the ratio of the transconductance g_{m-top} to the drain-conductance g_{ds-top} expressed as:

Intrinsic top-gate gain,

$$G_{top} = \frac{g_{m-top}}{g_{ds-top}} \quad (14)$$

The top-gate gain (G_{top}) is very important in RF/analog applications as well as cut-off frequency.

b) Intrinsic Back-Gate Gain, Gback

The intrinsic back-gate gain G_{top}, which is defined as the ratio of the trans conductance (g_{m-top}) to the drain-conductance (g_{ds-top}) expressed as:

Intrinsic back-gate gain,

$$G_{back} = \frac{g_{m-back}}{g_{ds-back}} \quad (15)$$

VI. Results and Discussion

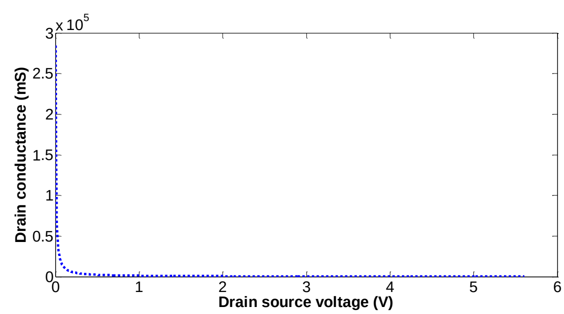


Figure 3 : Drain transconductance as a function of Drain Source voltage of a graphene MOSFET

Fig. 3. shows the variation of drain transconductance as afunction of drain-source voltage of graphene MOSFET

Figure 4(a) shows the intrinsic peak top-gate gain (G_{top}) for different for top-gate voltages. The intrinsic peak top-gate gain (G_{top}) is increasing with the increase of top-gate voltages at $V_{gs\text{-}back} = +40$V. At a top-gate voltage, (Gtop) = 1.5V, the intrinsic peak top-gate gain is found. approximately 73 which is very important figure of merit for high speed devices. Also the peak

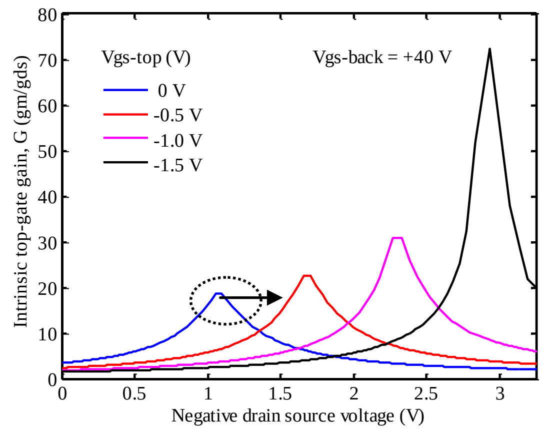
Global Journal of Researches in Engineering (F) Volume XIV Issue IV Version I Year 2014

point of the top-gate gain (G_{top}) shifts towards right with increasing $V_{gs\text{-}top}$.

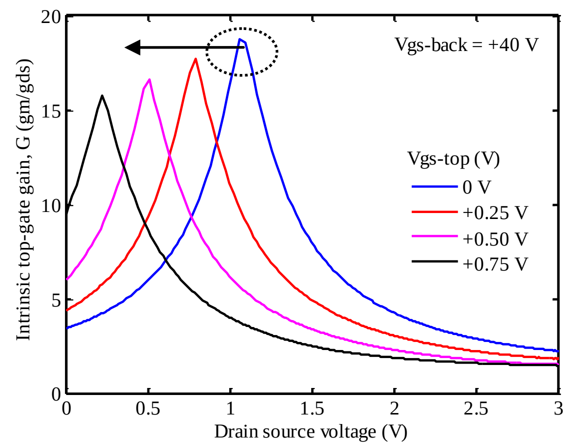
Figure 4(b) shows the intrinsic peak top-gate gain (G_{top}) for different positive gate bias condition. We have found G_{top} ≈15.79, 16.60, 17.69 and 18.77 as a function of V_{ds} for top-gate voltages +0.75V, +0.50V, +0.25V and 0.0V respectively with $V_{gs\text{-}back}$=+40V. There has no significant change of top-gate gain (G_{top}) shown in Fig.4 (b) except the shifting of the peak point towards left.

The effect of both positive and negative gate bias on intrinsic peak top-gate gain (G_{top}) is shown in Fig. 4(c) which shows the significant increase in intrinsic peak G_{top} in case of negative gate bias in comparison with positive gate bias.

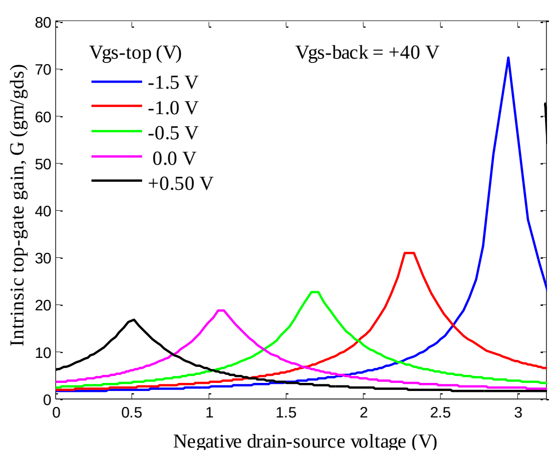
Fig. 4(d) shows the variation of intrinsic peak back-gate gain (G_{back}) with drain-source voltage for different positive back-gate voltages. At a back-gate voltage, $V_{gs\text{-}back}$ = +40V, the highest peak G_{back} ≈73 is obtained and shifts towards left with increasing $V_{gs\text{-}back}$ positively.



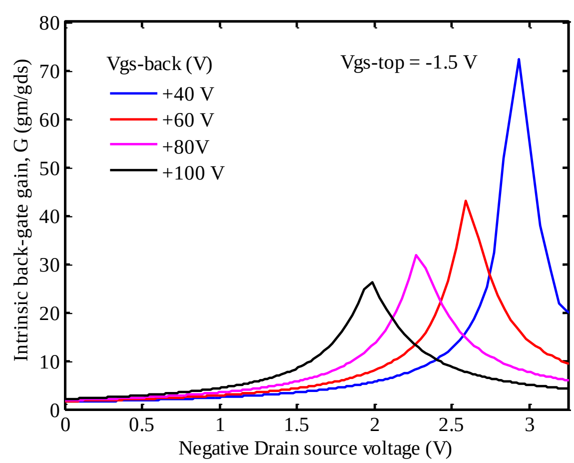
(a)



(b)



(c)



(d)

Figure 4 : (a) Intrinsic top-gate gain ($G_{top= gm/gds}$) as a function of drain source voltage V_{ds} at $V_{gs\text{-}top}$ = 0V, -0.50V, -1.0V and -1.5V with $V_{gs\text{-}back}$= +40V. (b) Intrinsic top-gate gain ($G_{top= gm/gds}$) as a function of drain source voltage V_{ds} at $V_{gs\text{-}top}$ = 0.0V, +0.25V, +0.50V and +0.75V with $V_{gs\text{-}back}$= +40V. (c) Intrinsic top-gate gain ($G_{top= gm/gds}$) as a function of drain source voltage V_{ds} at $V_{gs\text{-}top}$ = -1.50V, -1.0V, -0.5V, 0.0V and +0.50V with $V_{gs\text{-}bac}$k= +40V. (d) Intrinsic back-gate gain ($G_{back= gm/gds}$) as a function of drain source voltage V_{ds} at $V_{gs\text{-}bac}$k = 40V, +60V, +80Vand+100V with $V_{gs\text{-}top}$=-1.5V.

VII. Conclusion

In this paper, the AC characteristics of a dual gated Graphene MOSFET are studied using analytical approach. The drain transconductance of the device is computed. We have simulated the top and back gate gain as a function of drain to source voltage. The resulting high intrinsic top ate ain 73 which is promising.

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Control of Collimator for Conformal Radiation Therapy based on FPGA Implementation

By Khan Zarrarahmed Zaferullah, Dr. B. K. Mishra, Rajesh Bansode, Mandar Vidwans, Kelvin Dsouza, Rignesh Deladia & Sanoj Singh
Mumbai University, India

Abstract- In this paper of Collimator control system we discuss the beam shaping device namely secondary collimator which creates field intensity. Due to different arrangement of jaws different field size can be created. The hardware design for control of collimator for treatment of cancerous tissue leads towards the conformal treatment and thereby sparing good tissue which leads toward the increase in quality of treatment. Cadence FPGA System planner is used to generate the schematic for the hardware of collimator. VHDL code is written in XILINX ISE 13.9 and it is implemented on SPARTAN 6LX9TQG 144. VHDL code is tested on design PCB.

Keywords: stepper motor, collimator, field programmable gate array (FPGA), linear accelerator (LINAC), dynamic, radiotherapy, multi-leaf collimator (MLC).

GJRE-F Classification : FOR Code: 111208, 090699

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Khan Zarrarahmed Zaferullah [α], Dr. B. K. Mishra [σ], Rajesh Bansode [ρ], Mandar Vidwans [Ѡ], Kelvin Dsouza [¥], Rignesh Deladia [§] & Sanoj Singh [χ]

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I. Introduction

Cancer is one of the leading diseases in the world. Cancer is a term used for diseases in which abnormal cells divide without control and are able to invade other tissue. Cancer cells can spread to other parts of the body through the blood and lymph systems.

Cancer cells can spread to other parts of the body through the blood and lymph systems. There are more than 100 types of cancer, including breast cancer, skin cancer, lung cancer, colon cancer, prostate cancer. Cancer symptoms vary widely based on types of cancer. Cancer treated using Chemotherapy (drugs), Radiation therapy (radiotherapy and brachytherapy), Surgery. The choice of treatment depends on a number of factors including the size of the tumor and position of the tumor [1].

Radiation therapy involves the use of machine known as linear accelerator which focuses the high radiation beams on the area which require treatment. The major components of the high energy LINAC are: the operator console, modulator cabinet, drive stand and gantry. The operator console is used to input all operator commands and consists of a high resolution color monitor and a dedicated keyboard. The monitor displays the treatment parameters that have been entered via the dedicated keyboard. Some of the important parameters shown are the selected photon energy, dose, dose rate, time, gantry angle, field size, and other patient information. The modulator cabinet contains the high voltage power supply (HVPS), the pulse forming network (PFN), a voltage regulator, and thyratron tubes. The drive stand contains the radio-frequency (RF) driver, klystron, and the PFN pulse transformer. The gantry contains the Linear accelerator structure, electron gun, energy switch, vacuum system, automatic frequency control (AFC) system, bending magnet electron transport system, primary collimator, secondary collimator, beam shaping system and Multi-Leaf Collimator (MLC) [2].

II. Collimator

Collimators are mainly used to align the beam to a specific area. It has its application in the treatment of cancer therapy. The accelerated beams from the LINAC hits a target and produces X-rays. These rays are undefined and scatter in all direction. To get this ray's fall in the region of operation, they are confined by collimating the beam [3, 4]. There are three types of collimator used in medical linear accelerator i.e. primary collimator, secondary collimator and Multi-Leaf Collimator (MLC). The primary collimator is used to align the beam in fixed conical beam. The secondary collimator is positioned after either a scattering foil (for electron therapy) or a flattening filter (for photon therapy). MLC is used after the secondary collimator to further confining of the beam for precise treatment of heart and kidney.

This paper deals with the control of secondary collimator for conformal radiation therapy. Secondary collimator consists of four jaws i.e. X1 and X2 to collimate the beam in X-direction and Y1 and Y2 which collimates the beam in Y-direction, this operation controlled to get conformal radiation treatment. The secondary collimator consists of two movement they are Symmetric and Asymmetric movement. In symmetric movement both the jaws of X and Y direction are moved simultaneously by equal distance giving symmetric field along the beam axis. In asymmetric movement each jaws i.e. X1 and X2 or Y1 and Y2 can be moved in a plane independently to generate asymmetric field along

Author α σ ρ: Thakur College of Engineering and Technology, Mumbai University. e-mails : zarrartech@gmail.com, drbk.mishra@thakureducation.org, rajesh.bansode@thakureducation.org
Author Ѡ ¥ § χ: Scientist at Society of Applied Microwave Electronics Engineering and Research, Govt. of India, Mumbai. e-mails: kelvindsouza@gmail.com, rkdeladia@gmail.com, sanojsingh4@gmail.com

the beam axis. After accurately positioning the jaws to get confined field beam is fired.

Secondary collimator can also be used in dynamic mode. In dynamic mode the jaws is moved in beam ON state to generate a spatial dose distribution. In earlier physical wedges are used for this purpose for the variation in the intensity. The dynamic mode has many advantages over conventional physical wedge since physical wedges are graduated piece of brass that has a thick and thin end. The thick end causes the less attenuation than thin end; this causes a shift in the isodose curve within the treated volume.

III. Hardware Description

Fig.1 below show the block diagram of collimator for controlling the jaw X1.Similarly we can control the other jaws X2, Y1 and Y2.

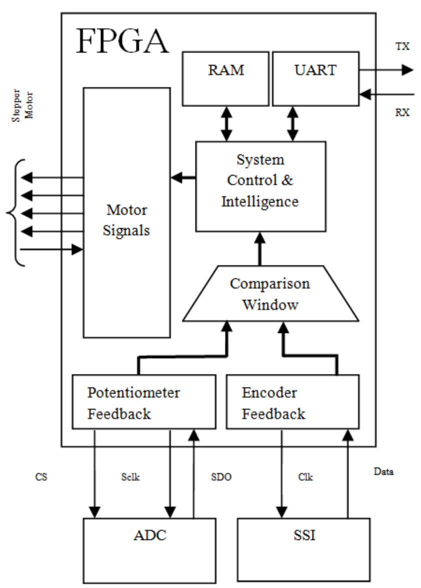

Figure 1 : Block diagram for collimator jaw X1

a) FPGA

SPARTAN 6 is used for designing the hardware control of the collimator. The FPGA has many advantages over the other controller. The advantages are processing of information faster, controller architecture can be optimized for space and speed and it involve parallel processing also [5]. SPARTAN 6 is selected since it has the feature such as 45nm low power processing technology, low cost design, 1050 MHz Clock Management Tile (CMT), memory can be increased up to 4.8 Mb and it consists of 180 efficient DSP 48A1 slices. The above features add beauty for selecting SPARTAN 6[6].

b) Stepper motor and its Driver

Here Stepper motor is a brushless open loop electromechanical device which can rotate in the small resolution of angle. It is highly effective in motion control application for high precision and high performance of torque control. Instead, it is low cost, simple and offers better torque performance over wider speed ranges. Stepper motor are used in wide range of precise motion and measurement applications such as nuclear power plant, aeronautics, robotic, automotive, medical, manufacturing industry etc. An ideal example is the pick and place machines used in Surface Mount Technology (SMT) line [7]. Stepper motor uses different types of drives for commercial and industrial use. There are three different types of drives which can be design to control the stepper motor. The types of drives are unipolare drive, L/R drive and bipolar drive. Now-a-days due to advancement in the technology the stepper motor industries provide the drive with motor itself for position and speed control. For controlling the jaws the stepper motor and the driver is selected by PARKER AUTOMATION [8]. The signals given to the driver by FPGA are step, direction, remote and gear. Fault signal is received by FPGA from driver.

c) Double Feedback System

There is double feedback used in the control of collimator. The double feedback system involves feedback from both encoder and to compare the value to get precise position. These two encoders are optical encoder which is attached to the motor using the chain mechanism and linear encoder which is attached to the jaw perpendicularly. Optical encoder output is given to FPGA via SSI while output from linear encoder is given to FPGA via ADC. These two outputs are than compare inside the FPGA using comparing window to give the feedback about the current location of jaws. The signals given for the optical encoder are clk, data and fault. The signals given from FPGA to ADC are chip select (CS), Sclk and the digital data is read from ADC by FPGA.

IV. Results and Discussion

The top view and the bottom view of designed PCB for controlling collimator pair of jaws is shown in Fig.2 and Fig.3. The schematic for the design PCB is made in the Cadence FPGA System planner. The hardware is tested using chipscope in XILINX ISE 13.9.

Fig.4 shows the simulation result of the VHDL code of stepper motor signal i.e. clk out, direction, optical encoder, linear encoder and UART design for communication. The VHDL code was written and simulated in XILINX ISE 13.9. The simulation results shows as the rx command send from the Treatment Delivery Controller (TDC) the operation starts. Since time required sending each bit is 8.6μs hence the total time to send 8 bit data total time required is 68.8μs.

Figure 2 : Top view of the designed PCB for control of collimator

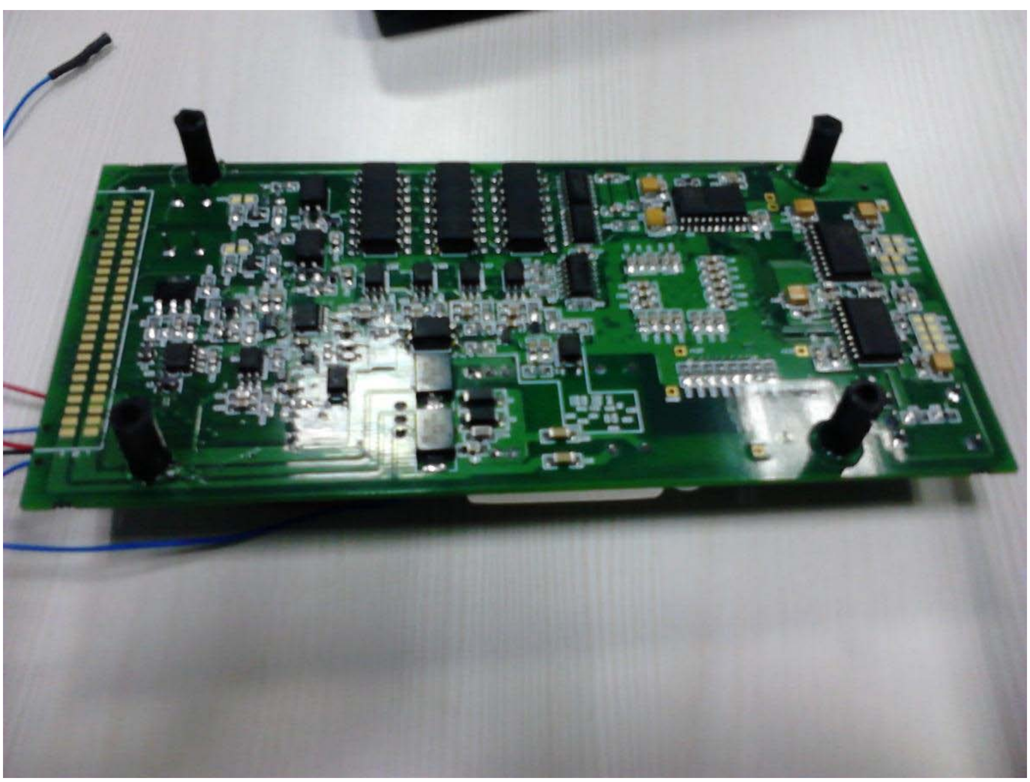

Figure 3 : Bottom view of the designed PCB for control of collimator

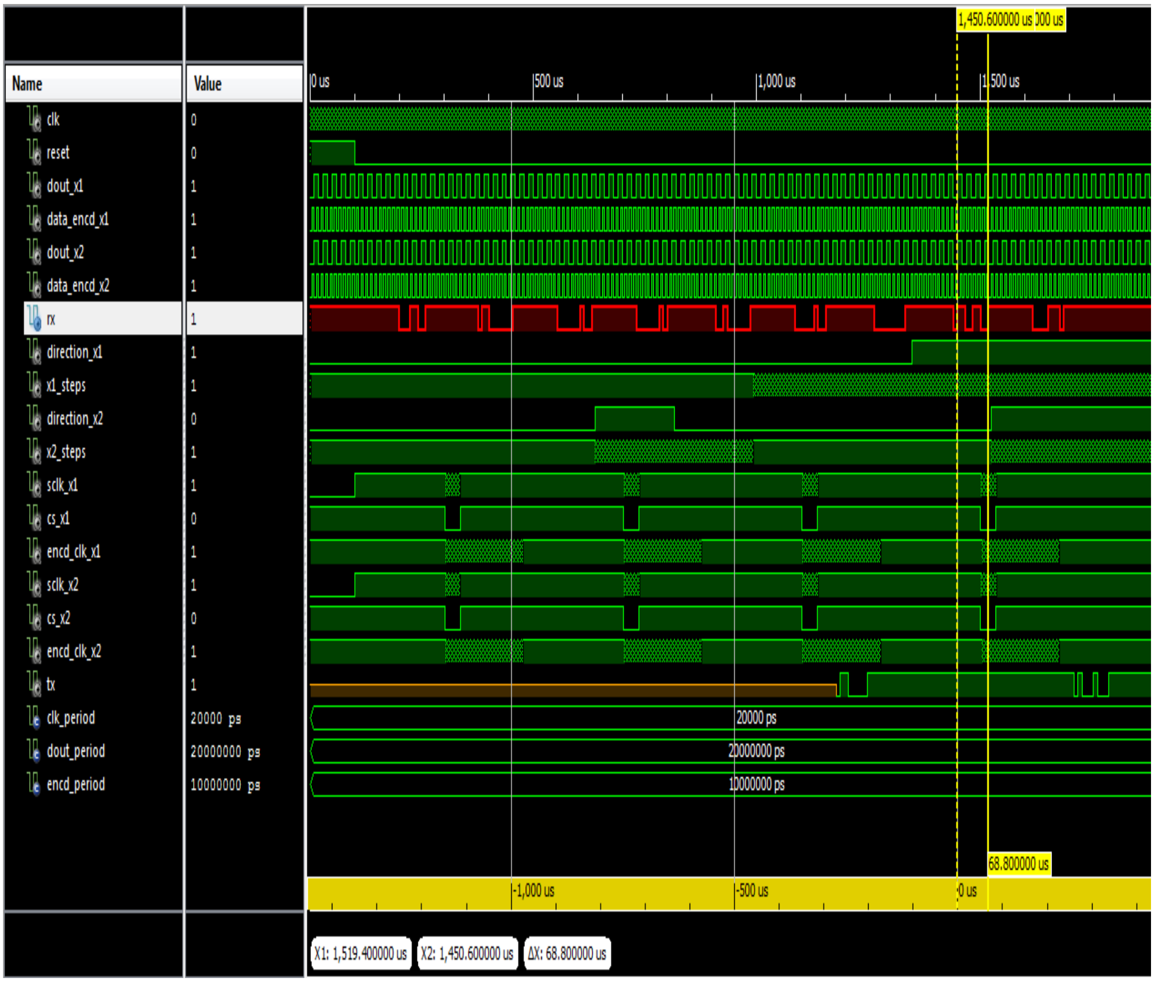

Figure 4 : Results for collimator control that states about the steps and direction control of stepper motor and also about the feedback from encoders

V. Conclusion

This study investigated the feasibility of using the collimator to vary according to given field size. Calculation and simulation were conducted that successfully generate the movement of stepper motor and feedback from optical encoder is checked. This algorithm implemented on FPGA allows a substantial decrease of the equivalent processing time develop by classical other controller. For making design faster Dual port RAM can also be implemented.

Due to the system architecture, one FPGA can drive other stepper motors of the jaws simultaneously without increasing the processing time. And hence we can control more than one motor for controlling of collimator other jaws. Also the feedback system design using optical and linear encoders provides successful results for the movement of jaws and stepper motors

VI. Acknowledgements

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Effect of Band Gap Difference and Doping Concentration on the Performance of an InxGa1-XN based Multi Quantum Well Solar Cell

By Nezam Uddin, Atiqul Islam, Md. Nasmus Sakib Khan Shabbir, Aparajita Adhikary Poonam & Md. Samiul Zahid

Bangladesh University of Business & Technology (BUBT), Bangladesh

Abstract- Increasing the efficiency of solar cell is the prime concern in the field of photovoltaic technology as solar cell has become the promising source of renewable energy in recent years. This paper presents InxGa1-xN based multi quantum well solar cell for higher efficiency. In this paper the performance of the solar cell i.e., open circuit voltage, short circuit current and efficiency are justified with the variation of band gap difference and donor and acceptor doping concentration. The maximum efficiency is found when the baseline cell is designed at 1.424eV and the maximum efficiency is 30.17% and 31.94% for a band gap difference of 0.3eV and donor doping concentration of 5*1018 cm-3 respectively.

Keywords: *PV Technology, MQW, baseline cell, donor concentration , acceptor concentration.*

GJRE-F Classification : *FOR Code: 090605*

Effect of Band Gap Difference and Doping Concentration on the Performance of an $In_xGa_{1-x}N$ based Multi Quantum Well Solar Cell

Nezam Uddin [α], Atiqul Islam [σ], Md. Nasmus Sakib Khan Shabbir [ρ], Aparajita Adhikary Poonam [Ѡ] & Md. Samiul Zahid [¥]

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Keywords: PV Technology, MQW, baseline cell, donor concentration , acceptor concentration.

I. Introduction

Solar energy represents a clean, renewable energy. As solar light is at our disposal, it represents a primary source of abundant clean energy. The internal quantum efficiency close to 100% in bulk hetero junction Solar Cells (SCs) makes SCs promising candidates among renewable energy sources [1]. But the cost per KWH is high due to low efficiency of the conventional solar cell. In conventional solar cell (Si p-n solar cell) maximum 18%-20% energy conversion can be possible [2]. To be competitive with the conventional energy source the efficiency of solar cell must be improved. There are many approaches to increase the efficiency, such as MJ solar cells, multiple spectrum solar cells; multiple absorption path solar cells, multiple energy level solar cells, multiple temperature solar cells, p-i-n and Multi quantum well solar cell. Among these approaches MJ solar cell is being studied widely all over the world during last few decades. But this approach has some limitations. Practically, there is a very little range of materials that could be used to make these cells. The primary requirements for the materials used for MJ solar cells are band gap matching with the solar spectrum, highmotilities and lifetimes of charge carriers, thermal and lattice matching etc. The currently used conventional materials for MJ solar cells are not suitable according to the requirements. Formation of series resistance is another problem when several cells are placed in tandem. The fabrication of MJ solar cell requires highly sophisticated technology which results in higher fabrication cost. But in case of p-i-n and quantum well solar cell there are no such problems. So, the fabrication cost may be lower in these approaches.

A multiple-energy gap structure, similar to tandem solar cells, can also be achieved using the Quantum-Well Solar Cell (QWSC) structure was proposed by Keith Barnham's group in 1991 [2][3].The Multi-Quantum Well solar cell tries to overcome the single band gap limitations by combining more than one band gap, into an intrinsic region between the p and n regions, one or normally more quantum wells are added [4]. Carriers can be absorbed at energies below the band gap of most of the cell, giving more current that of a wide band gap cell alone. Well depth of the quantum well should be carefully considered to get a reasonable open circuit voltage. The AlGaAs MQW solar cell developed by Joanna Prazmowska &, Ryszard Korburowicz was able to provide maximum efficiency of 27.4% on air mass AM1.5 [2]. Although the efficiency is greater than convention one, it can be increased more by other approaches. R. Dahal B. Pantha, worked on $In_xGa_{1-x}N$ MQW solar cell's wave length dependence and found that a maximum efficiency can be obtained at 420nm wavelength [5]. J. Li. K. Aryal developed a model of $In_xGa_{1-x}N$ MQW solar cell for x=0.3 and discussed about the effect of the concentrator [6]. Omkar Jani in his research developed p-i-n solar cell and showed that a maximum efficiency is found to be 27% [7], which can also be increased by other approaches.

In this research we intend to develop a model for $In_xGa_{1-x}N$ MQW solar cell where x=.4. Different parameters such as quantum well width, depth, doping concentration, intrinsic layer length, no. of well will be varied to get the optimized model, so that an efficiency

Author α: Lecturer, Department of Electrical & Electronic Engineering, National Institute of Textile Engineering and Research.
Author ¥: Lecturer, Department of Electrical & Electronic Engineering, Northern University Bangladesh.
e-mail: samiulzahid@hotmail.com
Author σ ρ Ѡ: Lecturer, Department of Electrical & Electronic Engineering, Bangladesh University of Business & Technology (BUBT). e-mails: atiqulislam.atiq@gmail.com, eng.sakib@gmail.com, 0703043@gmail.com

more than the existing can be found. In this model we intend to use air mass AM 1.5[8]. In order to design the solar cell Sim windows software is to use. Collecting the data from the software MATLAB coding is to use to analysis the performance of the designed MQW solar cell and consequently determine the optimized condition.

II. Modeling of $In_xGA_{1-x}N$ MQW Solar Cell

MQW's are made by inserting quantum wells, which are very thin layers of lower band gap material, within the intrinsic region of a p-i-n solar cell. In this proposed model InGaN is used as high band gap material (barrier) and GaN as low band gap material (channel).

The band gap energy Eg of solar cell material is the minimum for which an electron in the valance band can be excited into conduction band in order to produce electricity. Here approximate calculations were performed in order to identify the band gap energy, Eg, of $In_xGa_{1-x}N$ alloys that are used for MQW solar cell.

$$E_{g_{InGaN}}(x) = (1-x)\,E_{g_{GaN}} + x\,E_{g_{InN}} - bx(1-x) \qquad (2)$$

Where energy gap $E_{g_{GaN}}$ and $E_{g_{InN}}$ are equal to 3.4eV and 0.7eV, respectively and bowing parameter b=2.5eV ($In_xGa_{1-x}N$). The compositional dependence of the band gap energy in $In_xGa_{1-x}N$ material is shown Fig. 1

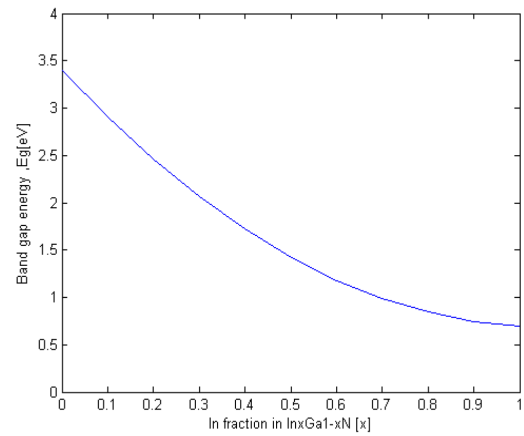


Figure 1 : Calculated band gap energy of semiconductor as a function of Indium fraction x

For this model some simplifying assumptions e.g. Depletion Approximation, Radiative Limit, Quasi-Equilibrium, Infinite Mobility Limit, Symmetry have been considered [2].

The band gap difference (ΔE) at which quantum well recombination becomes important can be found by calculating the point at which $r_G\,\beta = 1$ for ΔE, which yields:-

$$\Delta E = \frac{kT}{q}\ln\left(\frac{1-\beta(1-f_W)}{\beta f_W\,\gamma_B\,\gamma_{DOS}^2}\right) \qquad (2)$$

The J-V equations for the multy quantum well solar cells are

$$J_{MQW}(V) = J_0(1+r_R\beta)\left[\exp\left(\frac{qV}{kT}\right)-1\right] + (J_1 r_{NR} + J_s)\times\left[\exp\left(\frac{qV}{2kT}\right)-1\right] - qW\phi \qquad (3)$$

III. Proposed Model

The schematic arrangement of a InGaN/GaN MQW consists of a InGaN/GaN MQW with p-GaN and n-GaN on both side respectively [5]

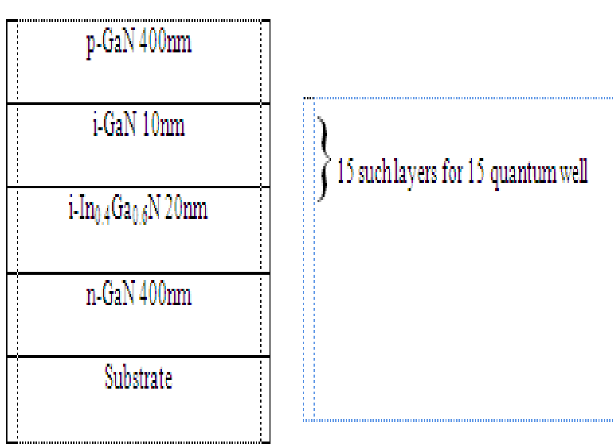


Figure 2 : Proposed model of MQWsolar cell

IV. Result and Discussion

a) Effect Band gap difference

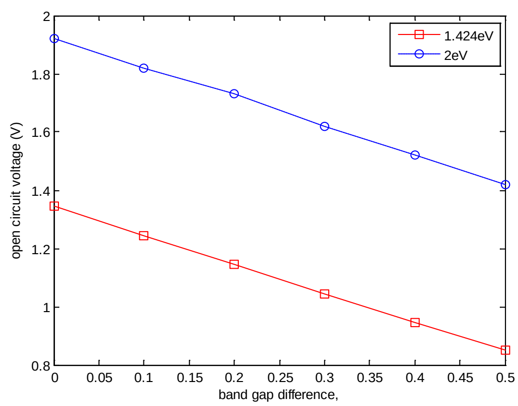
At baseline cell band gap of 1.424eV and 2eV parameters like J_{sc} , Voc and η% have been calculated at various, ΔE.

Table 1 : Variation of Voc, J_{sc} scand η% of MQW solar cell with band gap difference when baseline cell band-gap is 1.424eV

Band gap difference ΔE(eV)	Open circuit voltage V_{oc} (V)	Short circuit current density J_{sc} (mA/cm²)	Efficiency η(%)
0.0	1.345	22.56	26.76
0.1	1.245	25.79	28.32
0.2	1.145	29.46	29.75
0.3	1.045	32.73	30.17
0.4	0.9449	35.63	29.69
0.5	0.85	38.57	28.74

Table 2 : Variation of Voc, J_{sc} and η% of MQW solar cell with band gap difference when baseline cell band-gap is 2.0eV

Band gap difference ΔE(eV)	Open circuit voltage V_{oc} (V)	Short circuit current density J_{sc} (mA/cm²)	Efficiency η(%)
0.0	1.92	12.05	20.4
0.1	1.82	13.4	21.5
0.2	1.73	14.94	22.8
0.3	1.62	16.39	23.42
0.4	1.52	18.16	24.35
0.5	1.42	20.46	25.6



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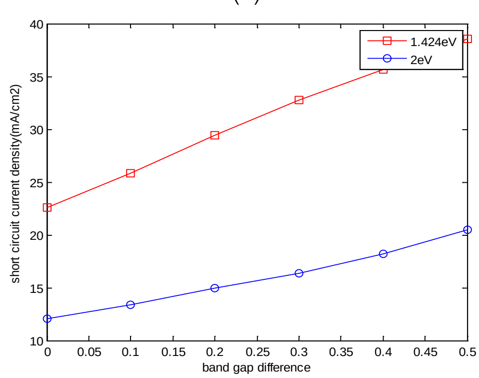

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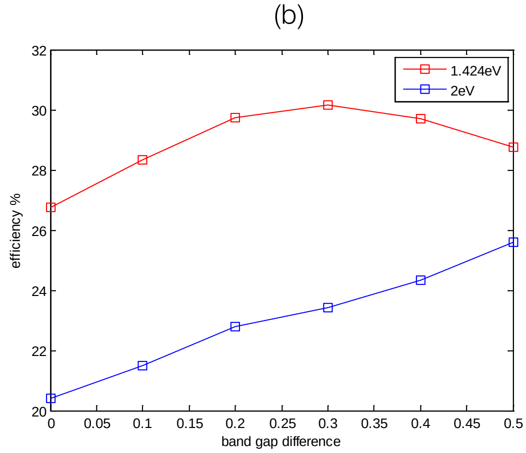


(c)

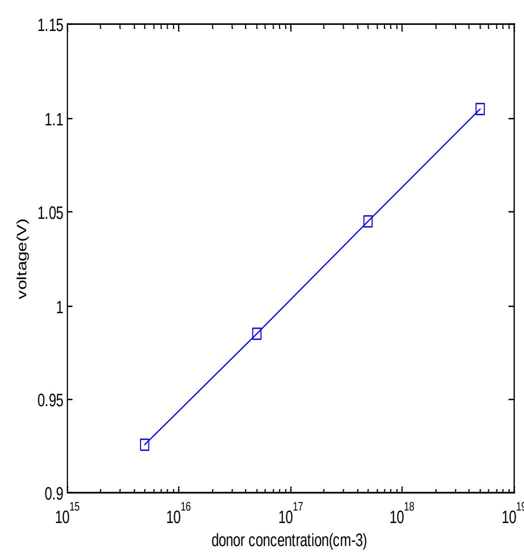
Figure 3 : Variation of (a) Voc (b) J_{sc} and (c) η% with ΔE

The fig.3 (a) implies that at every baseline band gap as the ΔE increases, the V_{oc} decreases. For example, in case of baseline cell of 1.424eV band gap as the ΔE increases from 0.1eV to 0.2eV the V_{oc} decreases from 1.82V to 1.73V. When there is an increase of ΔE, it puts an impact on the r_R which is exponentially depends on the ΔE and is the parameter giving rise to the reduced open circuit voltage in the quantum well cell. As the ΔE increases the recombination of carriers at the well increases which results in the reduced open circuit voltage. Fig 3(c) shows the variation of efficiency at various ΔE for baseline cell band gap of 1.424eV and 2eV. The maximum efficiency is found when the baseline cell is designed at 1.424eV with ΔE =0.3eV and the maximum efficiency is 30.17%.

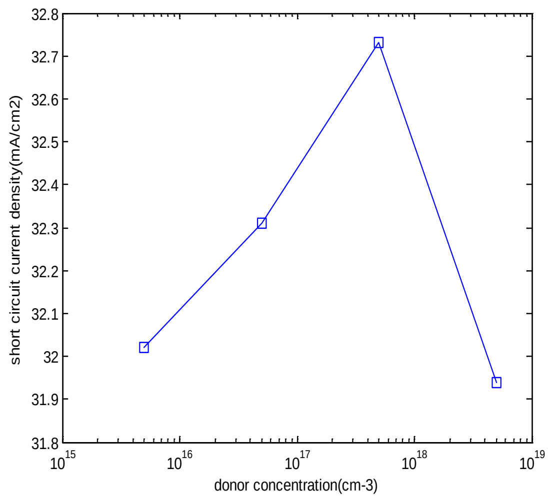
b) Effect of doping concentration

Table 3 : Variation of Voc, J_{sc} and η% of MQW solar cell With donor doping concentration(Nd) when acceptor concentration(Na) is kept $5*10^{17}$ (cm^{-3}) and well depth is 0.3 eV (Baseline band-gap is 1.424 eV)

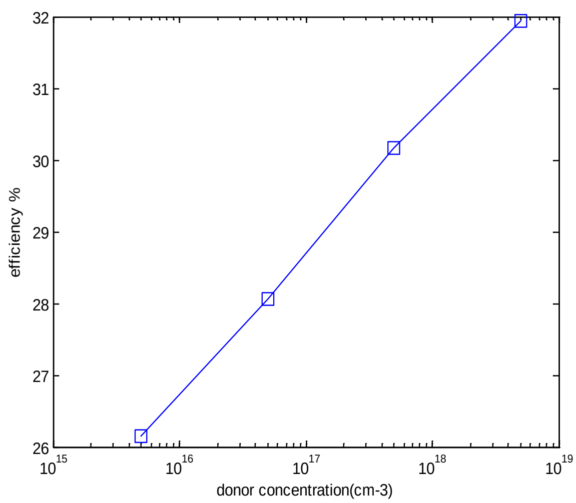
Donor doping concentration Nd(cm^{-3})	Open circuit voltage V_{oc} (V)	Short circuit current density J_{sc} (mA/cm²)	Efficiency η(%)
$5*10^{15}$	0.926	32.02	26.15
$5*10^{16}$	0.985	32.31	28.07
$5*10^{17}$	1.045	32.73	30.17
$5*10^{18}$	1.105	31.94	31.94



(a)



(b)



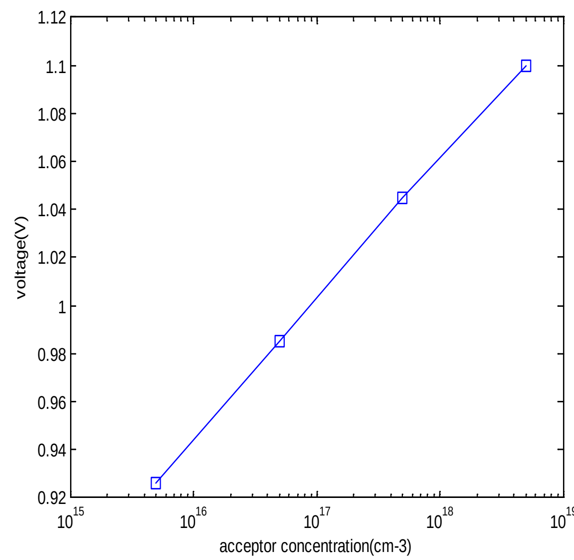
(c)

Figure 4 : Variation of (a) Voc (b) J_{sc} and (c) η% with Nd when Na=5*10^{17} cm^{-3}

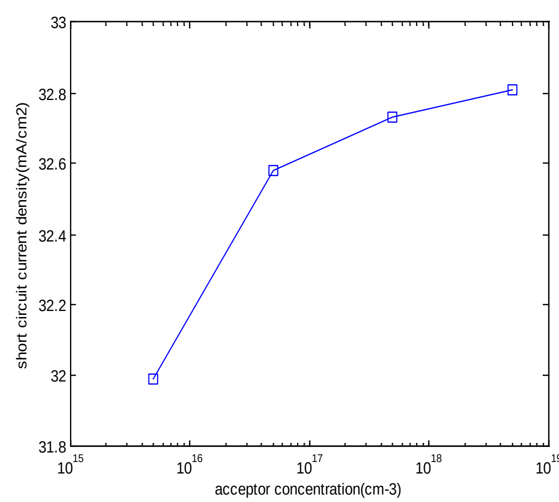
The doping density plays an important role on efficiency. It is well known that radioactive lifetime decreases with increasing doping level. Consequently, radioactive recombination becomes dominant compared to non radioactive recombination. The variation of efficiency with donor doping concentrations is shown in Fig.4(c) where the efficiency is found to increase with increasing carrier concentration. If the doping concentration is increased the, open circuit voltage Voc also increases (fig. 4(a)). It is well established that if the doping concentration is increased the reverse saturation current is decreased. As a result efficiency is increased due to increase of Voc as shown in fig 4(c).

Table 4 : Variation of Voc, J_{sc} and η% of MQW solar cell With acceptor doping concentration(Na) when donor concentration (Nd) is kept 5*10^{17} (cm^{-3}) and well depth is 0.3 eV (Baseline band-gap is 1.424 eV)

Acceptor doping concentration Na (cm^{-3})	Open circuit voltage V_{oc} (V)	Short circuit current density J_{sc} (mA/cm^2)	Efficiency η(%)
5*10^{15}	0.926	31.99	26.13
5*10^{16}	0.985	32.58	28.3
5*10^{17}	1.045	32.73	30.3
5*10^{18}	1.1	32.81	31.8



(a)



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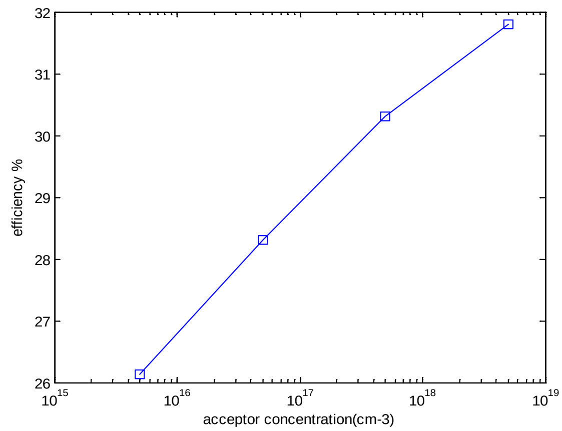

(c)

Figure 5 : Variation of (a) Voc (b) J_{sc} and (c) η% with Na when Nd=5*10^{17} cm^{-3}

The acceptor concentration is varied keeping Nd=5*10^{17} cm^{-3} constant. The variation of efficiency is shown in figure 5(c), where the efficiency increases with the increase of acceptor concentration .This is because, the open circuit voltage also increases shown in fig.5 (a).

V. Conclusion

In the proposed model InGaN is used because, InGaN has low effective mass of electron. As a result it has greater mobility, high peak and saturation velocities, high absorption coefficients and radiation tolerance [11].

InGaN also has an apparent insensitivity to high dislocation densities as the polarization and piezoelectric properties [9][10] of the material introduce electric fields and surface diploes that may counter the effect of dislocations. With the incorporation of MQW structure in the i-region, the conversion efficiency exceed the efficiency limit of a conventional homojunction single-gap solar cell. The overall result is that, InGaN solar cell attains greater short circuit current density consequently the efficiency of InGaN MQW solar cell is higher than the AlGaAs MQW solar cell.

VI. Future Work

In future the optimization of the geometry and composition of all layers of the structure should be more improver in order to achieve the enhancement of the quantum well solar cell structure performance. The lattice mismatch could be minimized by selecting materials of appropriate band gap.

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Voice-based Door Access Control System using The Mel Frequency Cepstrum Coefficients and Gaussian Mixture Model

By Kayode F. Akingbade, Okoko Mkpouto Umanna & Isiaka A. Alimi
Federal University of Technology, Nigeria

Abstract- Access to an area or environment can be controlled by conventional and electronic keys, identity cards, personal identification numbers (PINs) pads and smartcards. Due to certain limitations of existing door access schemes deployed for security in buildings, this paper presents speaker recognition for building security as a better means of admission into important places. This is proposed due mainly to the fact that speech cannot be stolen, copied, forgotten, lost or guessed with accuracy. This paper, therefore presents design of an affordable voice activated door control system for building security. The proposed system uses the Mel Frequency Cepstrum and the Gaussian Mixture Model for feature extraction and template pattern matching respectively. The analysis of the result which is based on the false acceptance and rejection rates indicate a system accuracy of more than 80%.

Keywords: PINs, access control, voice, security, Smartcard.

GJRE-F Classification : FOR Code: 090602

Voice-based Door Access Control System using The Mel Frequency Cepstrum Coefficients and Gaussian Mixture Model

Kayode F. Akingbade [α], Okoko Mkpouto Umanna [σ] & Isiaka A. Alimi [ρ]

Abstract- Access to an area or environment can be controlled by conventional and electronic keys, identity cards, personal identification numbers (PINs) pads and smartcards. Due to certain limitations of existing door access schemes deployed for security in buildings, this paper presents speaker recognition for building security as a better means of admission into important places. This is proposed due mainly to the fact that speech cannot be stolen, copied, forgotten, lost or guessed with accuracy. This paper, therefore presents design of an affordable voice activated door control system for building security. The proposed system uses the Mel Frequency Cepstrum and the Gaussian Mixture Model for feature extraction and template pattern matching respectively. The analysis of the result which is based on the false acceptance and rejection rates indicate a system accuracy of more than 80%.

Keywords: PINs, access control, voice, security, Smartcard.

I. Introduction

The implementation of access control prevents unauthorized individuals to access secure areas, buildings, documents and services. The control system consists of two main stages namely, the identification and verification stages. People that want to access a secure facilities introduce themselves to the system in the identification stage and the verification stage check the validity of the identities of the introduced users. If the identity of the user is valid, then the user may access secure area with the assigned permissions. The access control system is used for numerous applications such as for logging on ATM machines, e-banking accounts or for physical security of a room or building as a whole [1].

Access control for buildings is an essential device for protecting important places in the building that have valuable or highly sensitive materials. Server and strong room of banks are important areas where extremely effective control system is required. There ways of security implementation in a building and door access control is an integral part of them. The door access control is a means of securing building by giving limited access to specific people and by keeping records of such accesses [2]. Smartcard according to [2, 3] is the most common authentication method for the door access controls. It has been observed that a card-based access system can only control the access of authorized cards that are pieces of plastic, but not the ownership of the card. It can be used illegitimately by an unauthorized person when in possession of it. Furthermore, systems using PINs require individual to enter specific numbers to gain entry but the shortcoming is that those who really enters the codes cannot be determined system.

The limitations of conventional security systems call for better ones. There are varieties of biometric methods that could be employed in access control system for verification of authorized person into important or sensitive places. An automatic verification of identity in terms of behavioral and/or physiological characteristics of a person is carried out in the biometric methods [2, 3]. The biometric device identifies people by certain unique features such as the fingerprint, voice, face and eye (iris). Additionally, the device can eliminate the need for card-based access system. In the light of this, biometric devices can reduce the need for reissue of lost or damaged cards as the fingerprint, voice, face and eye are rarely stolen or lost.

The advantages of voice as a biometrics method are expatiated in [2] among which are simplicity for the user, speed of authentication and level of false-rejection rate. To resolve problems of the PINs pads and smartcards-based door access control, this paper presents voice-based door access control system using the Mel Frequency Cepstrum and Gaussian mixture model for building security.

The paper is organized as follows. Section 2 describes the proposed system. Section 3 focuses on system design and implementation. Results and performance evaluation are discussed in section 4. Conclusions are drawn in section 5.

In the following sections, we will quickly go through feature extraction and Gaussian Mixture Model. Next, we look at the operation and implementation of the voice based door control system and finally, we present performance evaluation and results.

Author α: Department of Electrical and Electronics Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Akure, Nigeria. e-mail: kfakingbade@futa.edu.ng

Author σ: Department of Electrical and Electronics Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Akure, Nigeria. e-mail: compeasywalus2@yahoo.com

II. Proposed System

Research in speaker recognition and speech recognition is presently mature. Speaker recognition is essentially used in access control systems to give access to individuals whose identities are validated from their previously stored voice records or models. This involves both speaker identification and speaker verification [4]. It is, however, different from speech recognition which relies on the shared characteristic of what is said and what is stored in order to make a decision. Both are employed in speaker identification and verification systems [5]. This paper uses a text independent speaker identification and verification process where the phrase or word to be said is not known to the system.

The design is implemented in two parts namely the software and the hardware parts. For the software, we use the Mel Frequency Cepstral Coefficients (MFCCs) for feature extraction and the Gaussian Mixture Model (GMM) for template matching. We use MFCCs because they are very robust and are the dominant features used for speech recognition [6]. Also, GMMs are usually preferred because they offer high classification accuracy while still being robust to corruptions in the speech signal. Also, they are very successful when it comes to noise handling. This has led to the extensive use of GMM based speaker recognition systems. The hardware part uses such components as d.c. motors, the L293B H-Bridge integrated circuit, a parallel port and the door structure.

a) *Feature Extraction*

The intention here is to have a model of the speech waveform that is sufficiently an accurate representation to the speech. It has been observed that the speech signal is a slowly time varying signal (quasi-stationary). This means that when observed over a sufficiently short period of time (between 5 and 100 ms), its characteristics are fairly stationary but change over long periods (0.2s or more) in order to reflect the different sounds being spoken. Therefore, to characterize the speech signal, the Mel Frequency Cepstral Coefficients (MFCCs) which is a tool for short time spectral analysis is employed. We refer to [6] for a complete description of the procedures for obtaining the MFCCs features. In this work, the programming platform used for voice processing and software development is MATLAB.

b) *Gaussian Mixture Model*

In [7-10], a Gaussian Mixture Model is described as a weighted sum of M component Gaussian densities given by the equation,

$$p(x|\lambda) = \sum_{i=1}^{M} \omega_i g(x|\mu_i, \Sigma_i) \qquad (1)$$

Where x is a D-dimensional continuous-valued data vector (measurement or features)$\omega_i, i = 31, \dots, M,$ are the mixture weights, and $g(x|\mu_i, \Sigma_i), i = 1, \dots, M,$ are the component Gaussian densities with mean vectors μ_i and covariance matrices Σ_i. Each component density is D-variate Gaussian function of the form,

$$g(x|\mu_i, \Sigma_i) = \frac{exp\left\{-\frac{1}{2}(x-\mu_i)' \, \Sigma_i^{-1}(x-\mu_i)\right\}}{(2\pi)^{D/2}|\Sigma_i|^{1/2}} \qquad (2)$$

The mixture weights satisfy the constraint that $\sum_{i=1}^{M} \omega_i = 1$. The parameters of the complete Gaussian model are collectively represented by the notation,

$$\lambda = \{\omega_i, \mu_i, \Sigma_i\} \qquad i = 1, \dots, M. \qquad (3)$$

In training the GMM, these parameters are estimated such that they best match the distribution of the training vectors [Fuzzy mixture Model for Speaker Recognition].

III. System Design and Implementation

The process begins with the recording and training of voice samples otherwise called enrolment, which could be done either in real time or using a pre-recorded sample. A database for each of these samples exists such that any newly recorded speech would be saved there and not be lost either before or after the recognition process. For optimal results as in this case, it is very important that the recorded speech be obtained through the same means and if possible, processes every time. This is because the intrinsic properties of different microphones vary and could greatly affect the quality of the signal and the recognition system in general.

It is in this process that the analogue speech signal is converted to a digital signal by sampling. The analogue signal is conditioned with anti-aliasing filtering (and additional filtering if required to compensate for any channel impairments). The anti-aliasing filter limits the bandwidth of the signal to approximately the Nyquist rate (half the sampling rate) before sampling. This digitized speech is then further analyzed to extract the features that would be used for the recognition algorithm. Figure 1 shows the series of processes that the voice samples would undergo for a typical case where a verified I.D is enrolled and its model is subsequently compared with the features of a claimed I.D.

The hardware of this project is designed and built using a simple door prototype made with wood (plywood) having two DC motors. The DC motors are lightweight and consume less power, which implies that the batteries would last much longer. These motors provide the needed rotational displacement for the door to open and they are controlled by an H-Bridge IC (L293B). This IC is in turn driven directly by the parallel port of the system connected via a parallel port cable and controlled through MATLAB.

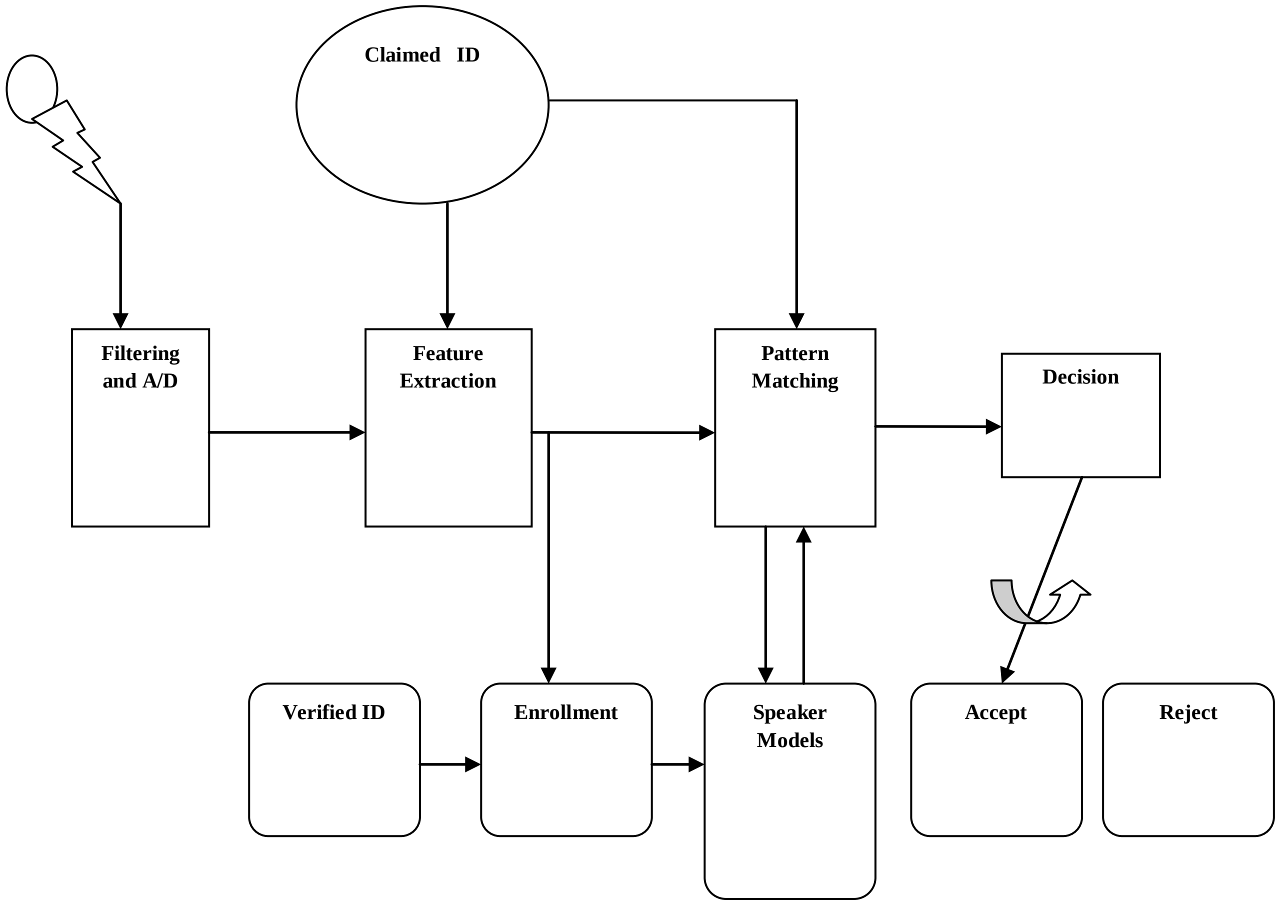

Figure 1 : Operations on a typical analogue signal

IV. Results and Performance Evaluation

A total of seven (7) voice samples from ten (10) different speakers that are recorded through the same process and at a sampling rate of 88.2KHzis used for the performance evaluation. Since this system is not a text-dependent system, the voice samples are varied from names to numbers depending on the choice of the speaker. Furthermore, in assessing the system performance with respect to accuracy and reliability, we use the false accept rate and the false reject rate. Therefore, out of ten (10) verification trials each for every individual set,

$$\sum \frac{total\ false\ acceptance\ precentage}{total\ number\ of\ trials} \equiv \sum \frac{total\ number\ of\ false\ acceptance}{total\ number\ of\ trials} \quad (4)$$

$$FAR = 13.27\%$$

This invariantly means that the genuine acceptance probability of the system is;

$$100 - 13.27 = \mathbf{86.73}\%$$

The figures obtained for the FAR and Genuine Accept Rate (GAR) of this system clearly indicates that the system based on this test, has an efficiency of more than 80% so far. Similarly,

$$\sum \frac{total\ false\ rejection\ percentage}{total\ number\ of\ trials} \equiv \sum \frac{total\ number\ of\ false\ rejects}{total\ number\ of\ trials} \quad (5)$$

$$FRR = 18.5\%$$

The lower the False reject rate, the higher the efficiency of any biometric system. Additionally, this test also proves the efficacy of the given system. The performance of the Automated Speaker Recognition is summarized in table 1.

Table 1 : General Performance Automated Speaker Recognition

	FAR (%)	FRR (%)
Speaker 1	20	10
Speaker 2	0	20
Speaker 3	30	0
Speaker4	10	20
Speaker 5	50	40
Speaker 6	20	30
Speaker 7	10	10

V. Conclusions

This paper has described the design of a voice activated door control system. We have used the MFCCs for feature extraction while the GMM is used for pattern matching. We have also shown that the door control system could easily be assembled using cheap and easily available materials. Analysis of the results using standard performance metrics such as FAR and FRR produced accuracy (genuine acceptance probability) of more than 80%, which is high when compared with existing access control schemes.

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Prospects of Wind Energy at Sitakunda and a Proposal for Hybrid Power System for Remote Areas

By Md. Ahsan Habib, Md. Mijanur Rahman & Md. Motaher Hossain
Pabna University of Science and Technology, Bangladesh

Abstract- Wind is most probable future fuel for production of electricity. Due to the fact that power production using nonrenewable fuel is become costly and they are diminishing day by day. Weibull distribution which is a good statistical tools for analyzing characteristics of wind and power probability of wind. So by using Nordex N80 wind turbine we get power which is supplied to the remote sites of local areas. We got few hundred kilowatt power. Here, We proposed a new hybrid power system. Where wind power, solar power and Hydrogen power are connected. Wind power supplied to electric load but when more power is generated, it supplied to electrolyzer. Electrolyzer produced Hydrogen from water. A battery is used for power smoothing of electrolyzer. Hydrozen then stored in a Hydrogen storage tank. A fuel cell is used to produced power. This then connected to ac and supplied to local electric load. A solar power system is also connected in this system. The solar power goes to electrolyzer or with the output of fuel cell when needed. In this way we generated power easily for local areas.

Keywords: hybrid power system, sitakunda, renewable energy, wind energy, weibull distribution.

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PROSPECTSOFWINDENERGYATSITAKUNDAANDAPROPOSALFORHYBRIDPOWERSYSTEMFORREMOTEAREAS

Strictly as per the compliance and regulations of :

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Index Terms: hybrid power system, sitakunda, renewable energy, wind energy, weibull distribution.

I. Introduction

Wind is the flow of gases on a large scale. On the surface of the Earth, wind consists of the bulk movement of air. In outer space, solar wind is the movement of gases or charged particles from the sun through space, while planetary wind is the outgassing of light chemical elements from a planet's atmosphere into space. There are different places of Bangladesh where there are strong wind is available. But we select only one site for this work.

II. Site Selection

Sitakunda is one of most important the places of Bangladesh where there is a possibility of production of wind energy. The geographical position of sitakunda is 22°35.68' North Latitude 91°42.52'East Longitude. [1] Twenty years monthly wind speed of sitakunda is given below.

Table 7.1 : Monthly variation of wind speed at Sitakunda from 1988 to 2007

EAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1988	5.88	6.58	6.16	8.13	10.65	7.29	7.99	6.87	6.02	9.11	5.18	5.6
1989	5.46	7.43	8.27	8.41	6.44	5.6	4.34	4.48	3.92	3.78	2.94	2.8
1990	5.04	3.64	6.3	7.57	6.44	7.43	7.29	6.16	5.32	9.11	8.69	3.78
1991	5.32	7.15	6.73	6.44	9.39	6.87	6.58	5.46	5.04	5.18	3.22	3.5
1992	6.16	7.29	7.43	8.27	5.88	4.62	5.6	3.78	4.9	4.76	3.36	3.78
1993	5.74	8.13	5.6	5.32	6.44	6.02	5.32	4.62	3.92	3.22	3.08	4.2
1994	4.62	4.48	5.74	4.62	4.34	5.46	4.06	4.62	4.2	3.22	2.94	2.8
1995	3.08	4.06	4.62	5.04	6.44	4.34	3.92	3.92	4.62	3.08	4.06	2.24
1996	3.36	3.78	5.6	6.16	7.85	4.76	5.04	3.5	3.22	9.81	2.8	3.92
1997	4.62	5.6	7.01	5.88	7.29	7.15	4.76	5.32	4.2	2.8	2.8	3.5
1998	3.08	4.2	5.46	5.46	6.44	5.04	4.76	4.48	4.06	4.2	2.24	2.66
1999	3.22	2.94	6.73	6.02	5.6	6.73	5.18	4.62	4.62	3.64	2.8	3.64
2000	3.64	3.64	6.02	5.6	5.32	4.48	6.16	4.48	4.06	3.64	2.52	2.94
2001	2.66	3.08	2.38	5.88	3.92	5.74	4.06	5.74	5.18	3.36	1.96	2.52
2002	2.8	3.36	3.78	5.04	5.74	3.92	4.06	4.34	3.22	3.5	7.43	2.24
2003	2.94	3.36	2.8	4.9	4.76	5.04	6.44	4.06	2.8	2.66	1.54	1.82
2004	1.82	3.08	6.16	7.85	4.48	5.74	6.44	8.55	7.15	8.42	2.66	3.08

Author α σ ρ: Department of Electrical and Electronic engineering, Pabna University of Science and Technology, Pabna, Bangladesh. e-mails: ahsan.pstu@gmail.com, mijansinha51@gmail.com, motahertex@yahoo.com

2005	3.92	8.41	9.81	7.57	7.85	8.13	6.44	6.16	4.48	5.04	2.24	2.52
2006	3.5	6.73	6.73	6.44	6.44	7.15	6.16	6.02	5.32	2.8	2.24	2.1
2007	4.06	3.78	5.32	7.01	5.46	5.88	6.44	5.18	5.32	7.29	4.62	1.96

III. Weibull Distribution

Weibull distribution function which has recently been proposed by some researchers. This is due to its greater flexibility and simplicity, as well as good agreement with experimental data. In other words, this analytical distribution for fitting wind speed data is generally accepted for energy assessment analyses and wind load studies. [2]

Weibull distribution function is written for wind speed [3][4]

$$Q(v) = \left(\frac{k}{c}\right)\left(\frac{v}{c}\right)^{k-1} exp\left[-\left(\frac{v}{c}\right)^{k}\right] \quad (1)$$

Where Q(v) is the probability of observing wind speed v, k the dimensionless Weibull shape parameter (or factor), and c reference value in the units of wind speed (so-called: Weibull scale parameter).

The k values range from 1.55 to 3.10 for most wind conditions.

The generalized cumulative distribution function is [4][5]

$$Q(v) = 1 - \exp\left[-\left(\frac{v}{c}\right)^{k}\right] \quad (2)$$

Determination of the parameters of the Weibull distribution requires a good fit of Equation (2) to the recorded discrete cumulative frequency distribution. Taking the natural logarithm of both Sides of Equation (2) twice, gives

$$\ln\{-\ln[1 - Q(v)]\} = kln(v) - kln(c)$$

So, a plot of ln $\{-\ln[1 - Q(v)]\}$ versus lnv presents a straight line. The k is the gradient of the line and the intercept with the y-axis is -k lnc.

The relation between k and c for wind speed v_m is [2]

$$v_m = c\Gamma(1 + \frac{1}{k})$$

Where gamma function is Γ( )

Weibull distribution is a good statistical tool for analyzing wind speed. It shows the power probability and weibull distribution of a site. Two important parameters Weibull's shape factor k and Weibull's scale factor c have been obtained from the data.

The power probability, weibull distribution, shape factor and scale factor helps to determine the charactterristics of wind wave and potential of wind power.

We know, the cumulative distribution function is given as

$$Q(v) = 1 - \exp\left[-\left(\frac{v}{c}\right)^{k}\right]$$

Rearranging and taking ln two times we gets

$$\ln\{-\ln[1 - Q(v)]\} = k\ln(v) - k\ln(c)$$

So, a plot of ln {-ln[1-Q(v)]} versus lnv presents a straight line. The gradient of the line is k and the intercept with the y-axis is -klnc.

So the graph is shown below:

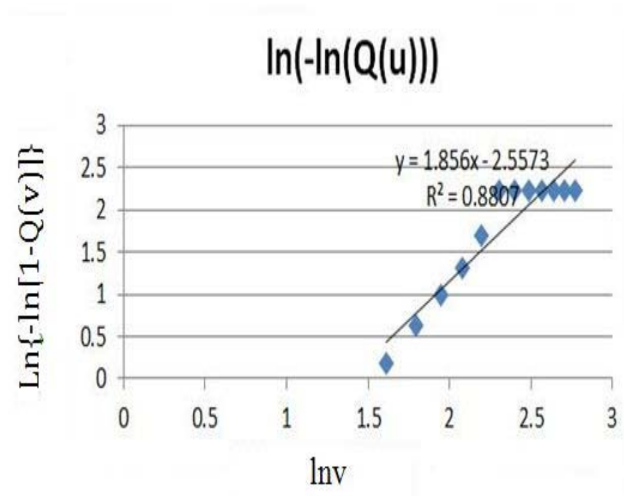


Figure 7.1 : Curve of ln $\{-\ln[1 - Q(v)]\}$ versus lnv

We get the value of scale factor c=3.97 and the value of shape factor k=1.86 which is the appropriate value for most wind conditions.

Now, we draw a curve of probability and weibull distribution versus wind speed.

The curve is shown below.

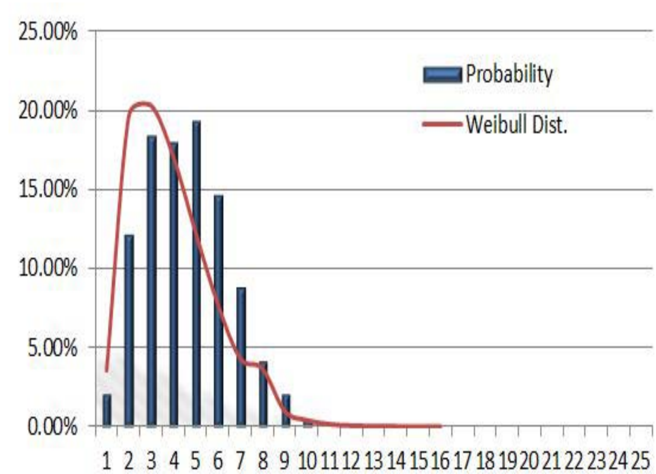


Figure 7.2 : Histogram for monthly mean speed with probability and weibull distribution of wind speed

Histogram represents 20 years of monthly mean wind data at sitakunda plotted together with the weibull probability distribution. This figure illustrates that the weibull distribution is a good representation of the wind resources of a site. The imperfectness of the weibull distribution compared with the histogram may be a significant source of error.

IV. Power Calculation

Here, we calculate theoretically available power for twenty years from 1988 to 2007 for yearly speed.

For 1988, speed, v=7.12, Cp=.410

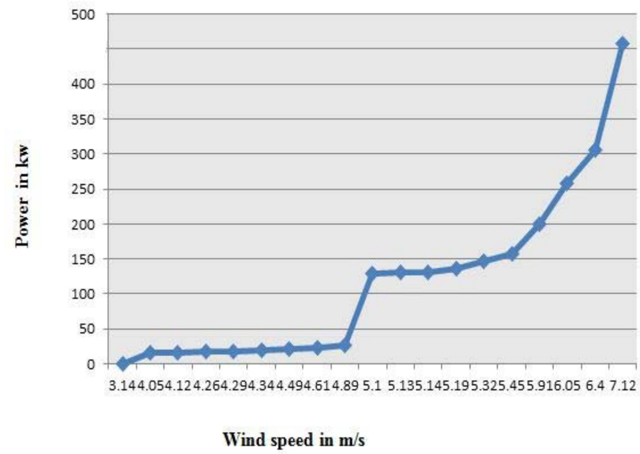
$$\text{Pavail} = \frac{1}{2}\rho A\ Cp\ v^3$$

$$= \frac{1}{2} \times 1.23 \times 5026 \times .410 \times 7.12^3$$

$$= 457.426 \text{ Kw}$$

The SI unit for magnetic field strength H is A/m. However, if you wish to use units of T, either refer to magnetic flux density B or magnetic field strength symbolized as $\mu 0$H. Use the center dot to separate compound units, e.g., "A·m^2."

YEAR	SPEED,V in m/s	Cp	POWER, Pav in Kw
1988	7.12	.410	457.426
1989	5.32	0.314	146.137
1990	6.4	.377	305.477
1991	5.91	.314	200.350
1992	4.49	.076	21.264
1993	5.13	.314	131.352
1994	4.26	.076	18.161
1995	4.12	.076	16.428
1996	4.89	0.76	27.469
1997	5.1	.314	128.747
1998	4.34	.076	19.203
1999	4.61	.076	23.015
2000	4.29	.076	18.547
2001	4.05	.076	15.605
2002	4.12	.076	16.428
2003	3.4	00	00
2004	5.45	.314	157.114
2005	6.05	.377	258.050
2006	5.14	.314	131.800
2007	5.19	.314	135.684



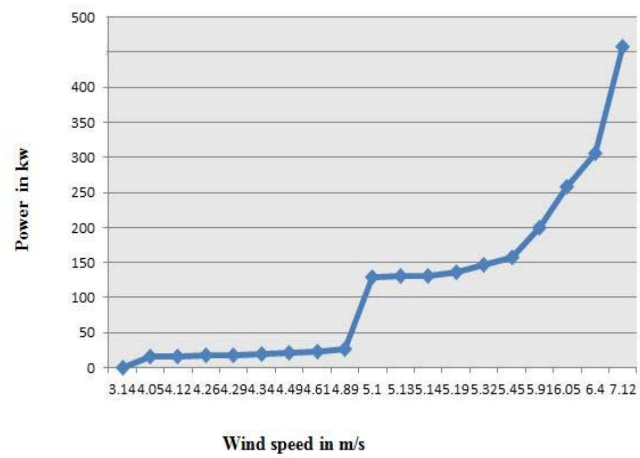


Figure 7.3 : Power for corresponding wind speed that obtained in sitakunda

Table shows the power which is produced over twenty years at sitakunda. Wind speed varies from 3 m/s to 7 m/s and power varies 16 kw to 457 kw. This power is obtained from one turbine. So if we place a few numbers of wind or make a wind farm we get certain MW power from them. This power is supplied to the remote areas. This helps the people of the remote areas is on the under of electricity.

If we want to cover a larger area which is greater than the area covered by the wind farm, we need more power .So for this reason, we here design a new combined power system. This power system consists of wind, hydrogen and solar. The combination of this will produce large power. The combination is make in such a way that if one parts of this system is falls there is a continuity of supply.

V. Proposed System

The combined power system shown in below:

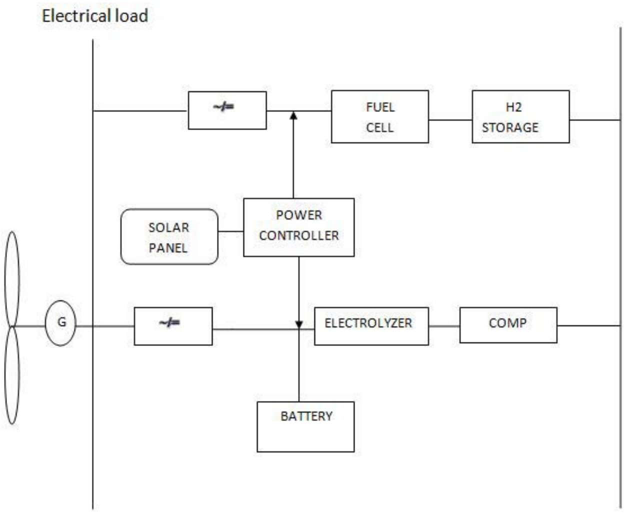


Figure 7.4 : Proposed power system consisting of wind, hydrogen and solar

When wind blows, turbine rotates and power is generated. This power is supplied to electric load. But when speed of wind is high, more power is generated. If this power is larger than the load which is connected, excess power is goes to eletrolyzer. An electrolyzer is an electrochemical apparatus which is used to perform electrolysis. Here, electrolyzer is used to splitting water into hydrogen and oxygen. The hydrogen is stored in hydrogen storage tank. The battery is used to smooth the turbulent wind power to protect the electrolyzer from wear due to rapid and large wind power variations. This hydrogen then passed to fuel cell where it used as fuel. Now, we get dc power from fuel cell which is converted to ac. This ac power is supplied to the electric load. A solar panel is connected whose electricity is goes to electrolyzer or to the point where fuel cell out is obtained. The hydrogen which is obtained from electrolyzer is also used for mobile applications when more power is not needed i.e from fuel cell.

VI. Conclusion

In future, wind energy will be the most cost effective source of electrical power. Most probably it reached this state. The major technology developments enabling wind power commercialization have already been made. This paper analyze the characteristics of wind and power probability of wind at sitakunda. This site is able to produce huge power. This papers also introduce a new power production model. If it is possible to implement with proper knowledge, equipment and sincere to proper maintenance of the ground equipments (especially from flood water), it takes a great role to improve power crisis of Bangladesh.

There is huge power crisis in Bangladesh. Only 50% people get electricity. So there many remote areas in Bangladesh specially hilly area where this power production system is very suitable. Here, we proposed this system theoretically. There are many equipments associated this model such as electrolyzer, battery, hydrogen storage tank, controlling device and fuel cell. The final power output depend on the performance of all this device. So sizing of fuel cell, battery and electrolyzer is very important. In future we size all of this equipment so that optimum output is obtained.

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Integrated Solar – Wind Hybrid Power Generating System for Residential Application

By Medugu, D. W. & Michael, E.
Adamawa State University, Nigeria

Abstract- A hybrid power system consisting of PV-arrays and wind turbines with energy storing devices (battery bank) and power electronic device was designed and constructed in this paper. The system is aimed at the production and utilization of the electrical energy coming from more than one source, provided that at least one of them is renewable. The efficiency of the designed power electronic device is about 95% and 73% for capacitive and resistive loads respectively. The integration of the hybrid is to electrify a residential house and its surrounding in order to reduce the need for fossil fuel leading to an increase in the sustainability of the power supply. This approachis techno-economically viable for rural electrification.

Keywords: hybrid power system, wind turbines, electronic device, resident house, rural electrification.

GJRE-F Classification : FOR Code: 850505, 850509, 090699

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I. Introduction

The more noticeable benefits of usable electric power include: improved health care, improved education, better transportation systems, improved communication systems, a higher standard of living, and economic stability. Unfortunately, almost 33% of the world's populations live without usable electrical power (Osama & Egon, 2007). Most of the non-electrified regions are found in developing countries (Phuangpornpitak & Kumar, 2007). Nigeria is one of the developing countries that most of its population lives without usable electricity. Many of the rural areas of Nigeria have not benefited from these uses of electricity in the same proportion as the more populated urban areas of the country (Akinboro, et al 2012). These rural areas can be electrified either by extending the grids of the existing power systems or by constructing isolated new power systems, which are alternative energy sources. Electrifying these remote areas by extending grid system is difficult and costly. Some of the rural areas that were electrified Like Mubi, Adamawa State, experience unreliable power supply characterized by low voltage and incessant power cuts often without warning or even apologies to consumers (Medugu & Markus, 2011). The fluctuating power supply causes problem to electronics appliances used at homes. House occupants are forced to use fossil fuel generators. These fossil fuel generators do not only create noise but contribute to global warming.

As the current international trend in rural electrification is to utilize renewable energy resources; solar, wind, biomass, and micro hydro power systems can be seen as alternatives. Among these, combined wind and solar systems are becoming more popular for stand–alone power generation applications, due to advances in renewable energy technologies and subsequent rise in prices of petroleum products. Research and development efforts in solar, wind, and other renewable energy technologies are required to continue improving their performance, establishing techniques for accurately predicting their output and reliably integrating them with other conventional generating sources (Oji et al, 2012).

(Prasad & Natarajan, 2006), presented a new method for optimization of a wind–PV integrated hybrid system. (Nelson et al, 2006) performed an economic evaluation of a hybrid wind/photovoltaic/fuel cell generation system for a typical home in the Pacific Northwest. (Grinspan et al, 2006) presented the development of a Savonius rotor configuration which is simple in design, fabrication and maintenance, and is suitable for small-scale rural application. (Mojola, 1985), examined the performance characteristics of the Savonius windmill rotor under field conditions.

In order to reduce the need for fossil fuel leading to an increase in the sustainability of the power supply, wind and solar energy systems in stand-alone or hybrid forms are thought to be ideal solution for residential electrification due to abundant solar radiation and significant wind distribution availability in Mubi. Thus, in this research, hybrid renewable power generation system integrating solar and wind resources is to be designed and modeled, to electrify a residential house and its surrounding.

A hybrid Photovoltaic-wind power generation system is proposed to supply electricity to a residence. The Hybrid Renewable Power Generation System (HRPGS) is a system aimed at the production and utilization of the electrical energy coming from more than one source, provided that at least one of them is renewable (Gupta, 2008). Residential generating systems harnessing wind and solar energies are seen as a potential answer to individual energy concern. The integration of renewable energies such as solar and wind are the best solution for feeding the mini-grids and isolated loads in remote areas.

Author: Department of Pure and Applied Physics, Adamawa State University, Mubi, Nigeria. e-mail: dalemedugu@yahoo.com

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II. Hybrid Power Generating System

A hybrid power generating system is a system in which two or more supplies from different renewable energy sources are integrated to supply electricity. The hybrid used here is based on Photovoltaic (PV) modules and wind turbine.

a) Wind Turbine

Energy available in wind is basically the kinetic energy of large masses of air moving over the Earth's surface. Blades of the wind turbine receive this kinetic energy, which is then transformed to useful mechanical energy, depending on end use (Mathew, 2006)

Air of mass m (kg) moving with speed *v* (m/s) has a kinetic energy given by (Patel, 2006; Mathew, 2006):

$$KE = \frac{1}{2}mv^2 \quad (1)$$

The power P in moving air is the flow rate of KE per second. Thus the theoretical power in the moving air is giving by (Patel, 2006):

$$P = \frac{1}{2}\rho A v^3 \quad (2)$$

Where ρ is the density of the air stream, A the area of the wind captured.

The most accurate estimate for wind power density in W/m^2 is that given by eqn (3) (Getachew, 2009)

$$\frac{P}{A} = \frac{1}{2}.\frac{1}{n}.\sum_{j=1}^{n}\left(\rho_j.v_j^3\right) \quad (3)$$

Where n is the number of wind speed readings and ρ_j and v_j are the jth readings of the air density (kg/m^3) and wind speed (m/s) respectively.

The swept area, *A* depends on the dimensions of the rotor. For a horizontal axis turbine of rotor diameter d, the swept area can be given by (Patel, 2006):

$$A = \frac{\pi d^2}{4} \quad (4)$$

For a vertical axis turbine of maximum rotor width *w* and rotor height *h*, the swept area can be approximated by (Patel, 2006):

$$A = \frac{2}{3}wh \quad (5)$$

The air density ρ depends on pressure and temperature. It can be expressed as (Patel, 2006):

$$\rho = \frac{P}{RT} \quad (6)$$

Where *p* is air pressure (Pa) and *R* is the specific gas constant (287 Jkg^{-1}K^{-1}) and *T* is air temperature in K. If we know the elevation Z' (m) and temperature T at a site, then the air density can be calculated by (Mathew, 2006).

$$\rho = \frac{353.049}{T} e^{\left(-0.034\frac{Z''}{T}\right)} \quad (7)$$

If pressure and temperature data are not available, the following correlation may be used for estimating the density (Getachew, 2009)

$$\rho = 1.225 - (1.194 * 10^{-4}) * Z' \quad (8)$$

a) PV Cells

The complex physics of the PV cell can be represented by the equivalent electrical circuit shown in Fig. 1.

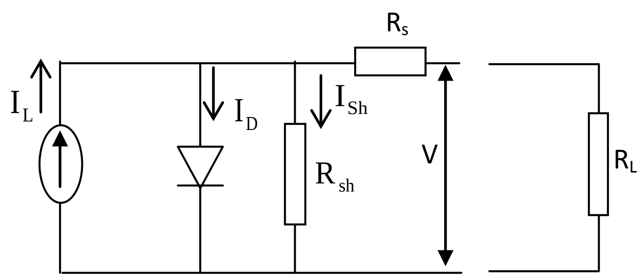

Figure 1 : A PV cell equivalent electrical circuits after (Duffie & Beckman, 2006)

The current I at the output terminals is equal to the light-generated current I_L less the diode current I_D and the shunt-leakage current I_{sh}. The series resistance R_s represents the internal resistance to the current flow, and depends on the p-n junction depth, impurities, and contact resistance. The shunt resistance R_{sh} is inversely related to the leakage current to the ground. In an ideal PV cell $R_s = 0$ and $R_{sh} = \infty$. The PV conversion efficiency is sensitive to small variations in Rs, but insensitive to variations in R_{sh}. A small increase in R_s can decrease the PV output significantly.

The open-circuit voltage V_{oc} of the cell is obtained when the load current is zero and is given by the following

$$V_{oc} = (I_L - I_D)R_{Sh} \quad (9)$$

The diode current is given by the classical diode current expression

$$I_D = I_0\left[exp\left(\frac{qV_{oc}}{AKT}\right) - 1\right] \quad (10)$$

Where *Io* is the saturation current of the diode (A), *q* is electron charge (1.6×10^{-19} C), Ais curve-fitting constant, K is Boltzmann constant (1.38×10^{-23} J/K), T is temperature on absolute scale K.

Thus, the load current is given by the expression

$$I = I_L - I_D - I_{Sh} \quad (11)$$

$$I = I_L - I_0\left[exp\left(\frac{qV_{oc}}{AKT}\right) - 1\right] - \frac{V_{oc}}{R_{Sh}} \quad (12)$$

The last term is the leakage current to the ground. In practical cells, it is negligible compared to I_L and I_o and is generally ignored.

The maximum photo voltage is produced under the open-circuit voltage. Again by ignoring the ground leakage current, eqn 11 gives the open-circuit voltage as follows

$$V_0 = \frac{AKT}{q} ln\left[\frac{I_L}{I_0} + 1\right] \quad (13)$$

III. System Description and Design Implementation

The solar – wind with power generation system is designed as shown in Fig. 2. The generating system has a DC bus which combines the DC output of the PV module, the DC output of the wind turbine, and a battery. The AC bus combines the output of the inverter and the load. This parallel configuration requires no switching of the AC load supply while maintaining flexibility of energy source.

When solar radiation falls on the solar panel, DC electricity flows. This electricity flows through the charge controller which regulates the DC energy for efficient charging. Similarly, when wind blows over the blades of the turbine, it turns the DC generator. The electricity generated is used for battery charging. The powers from the solar panel and the wind turbine add up when the two sources are at reasonable potentials. When the wind speed is below the cut-in point, and in a sunny day, solar energy takes over the charging. If on the other hand the wind speed is reasonably high and no solar radiation, especially at night, the wind turbine takes over charging the battery. Power inverter is then connected to transform the direct current energy of the battery into alternating current energy.

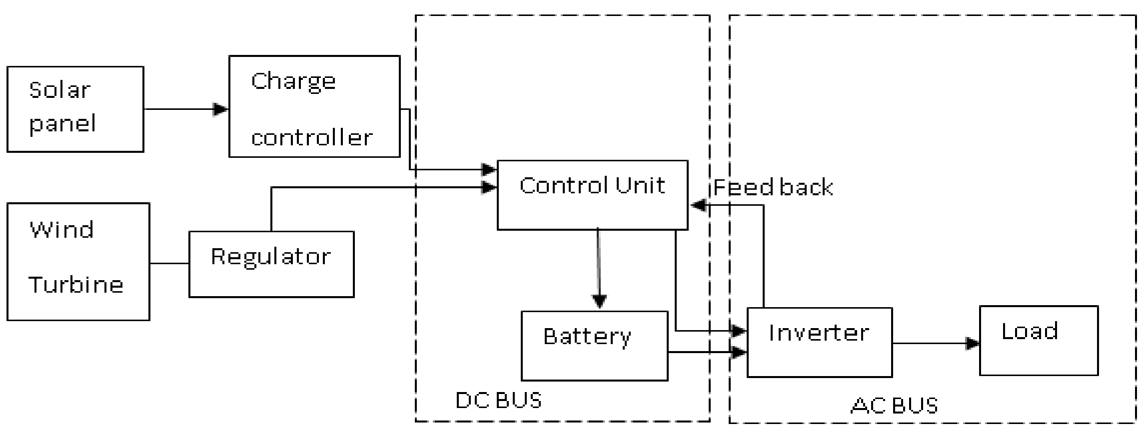

Figure 2 : Block diagram of PV- Wind Hybrid Power Generating System

a) *The control unit plays two roles*

- It controls the operation of the inverter. That is if it senses solar energy, it automatically switches off the inverter and allows only charging of battery. This also means that the control unit switches OFF the inverter during the day and switches ON at night.
- It controls the modulation of the inverter through the feedback loop by adjusting the modulation current. This process helps to maintain a constant 220V across the load when the voltage of a fully charged battery drops from 14V to 10V

IV. Inverter Charge Controller and Control Unit Design

The inverter is designed around the TL494 Pulse Width Modulation control Integrated Circuit which has an in-built oscillator among other features as shown in Fig.3. The picture is shown in Fig. 4.

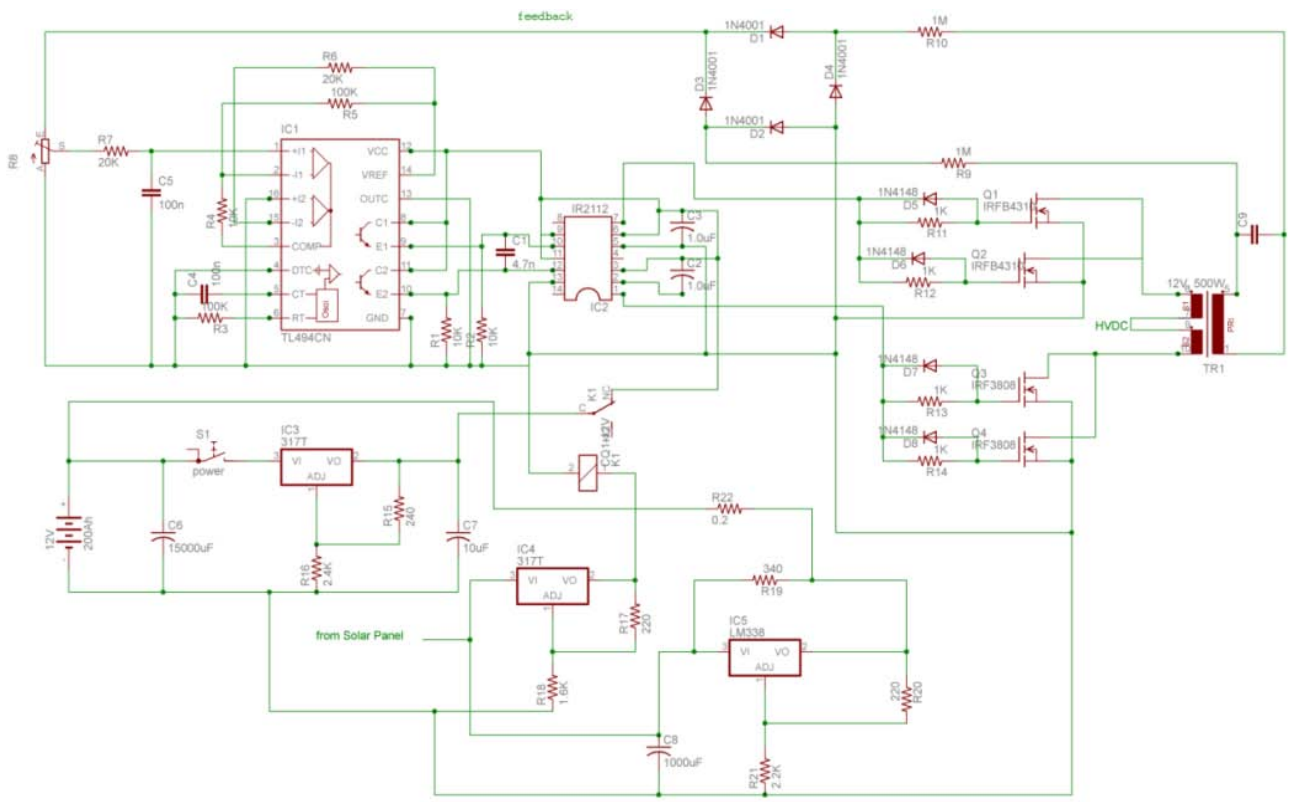

Figure 3 : Complete Circuit diagram of the Inverter Module/ Charge Controller and the Control unit.

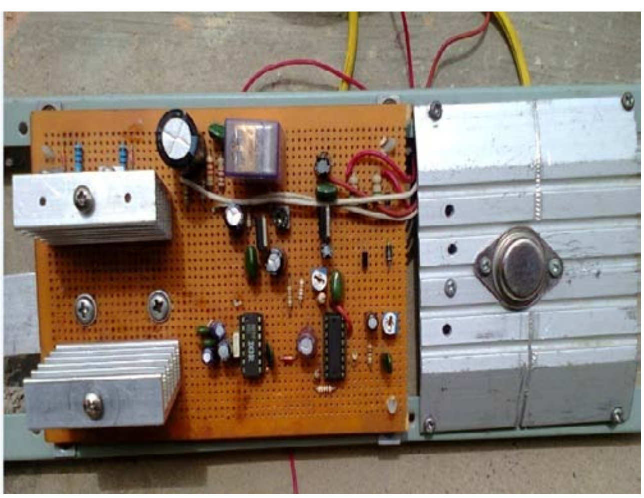

Figure 4 : Constructed Inverter and Charge controller

Connecting an external capacitor C_4 and resistor R_3 to pins 5 and 6 control the oscillation frequency of the TL494.

Choosing C_4 to be 100nF and using eqn 14, R_3 is obtained as 100$k\Omega$(Alberkrack, 2002).

$$f = \frac{1}{2R_3C_4} \tag{14}$$

The 220VAC from the inverter output is rectified and dropped to a lower value by R_9 and R_{10} allowing a current of 0.2mA and a voltage of 2.5V at pin 1. R_9 and R_{10} can be obtained using voltage divider as nearest preferred value of 1.0 $m\Omega$.

The error amplifier of the TL494 compares a sample of the internal 5V reference voltage to the voltage at pin 1 through R_4 and R_5. The two resistors also set the gain for the amplifier to 11 and using R_4 to be 10KΩ, R_5 can be calculated using eqn 15 obtaining the value of 100 $k\Omega$.

$$R_5 = (gain - 1)R_4 \tag{15}$$

R_8 and R_7 set the potential at pin 1 variable to 2.5V the error between pins 1 and 2 controls the pulse width modulation.

C_5 filters the ripple from the rectifier and R_6 serves as feedback to the second internal error amplifier of the TL494.

The output is referenced to ground through R_1 and R_2 which gives a voltage drop of 4.7V at 0.5mA.

The battery charger/controller was designed using LM338 a 5A variable voltage regulator. The output voltage is set to 14V. The power supply to the on-board components was designed using LM317 variable voltage regulator. The power unit regulates the output to 10V over battery voltage variation of 11V to 14V. Complete innovation of the inverter with the accessories discussed is displayed in Fig. 5.

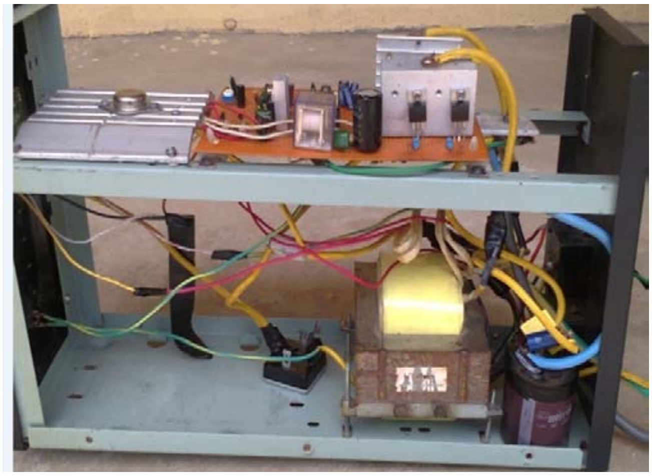

Figure 5 : The 500W Power Inverter after Casing

V. Description of the Main Parts of the Wind Turbine

A wind turbine consists of the following four main parts: the base, tower, nacelle, and blades, as shown in Fig. 6. The blades capture the wind's energy and spin a generator in the nacelle with the aid of an improvised gear box housed two gear system of ratio 1:6. The shaft with fewer gears was attached to the wind turbine rotor while the shaft with more gears was attached to the generator. The tail was cut to the shape shown in Fig.6 for turning the turbine to the direction of the wind.

The tower contains the electrical circuits, supports the nacelle, and provides access to the nacelle for maintenance while the base is made of concrete and steel and supports the whole structure.

Figure 6 : Shows the picture if the Integrated Electricity generating system in operation

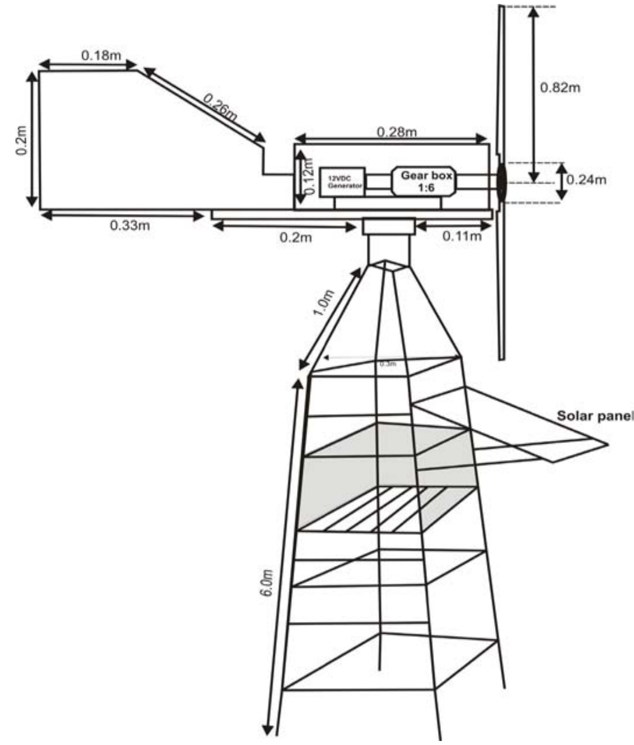

Figure 7 : structural frame of the wind turbine and solar panel

Figure 8 : The Hybrid-Power Generator Working after Sunset

VI. Results and Discussion

a) Results

Once the mechanical and electrical aspects of the system were completed the entire device was tested. The current and voltage values from the Wind Turbine, Solar Panels, Battery group and load are measured. The efficiency of the designed electricity generating machine (inverter) is about 95% and 73% for capacitive and resistive loads respectively. The efficiencies were determined from the ratio of full-load DC voltage to the no-load DC voltage. The control unit of the inverter was also tested and was in conformity with the design which was auto-switching (OFF for sun rises and ON for sunset).

The battery's state of charge was 8.7V. The charger was connected at 8:12am and the corresponding voltage across the battery was measured at an interval of thirty minutes.Fig,8 shows the graph of the voltage across battery against the corresponding time of the day indicating the three charging stages of the charge controller.

The system is able to power a 3 bedroom resident containing 16 energy saving bulbs, 1 TV set, 4 fans and 2 computer system for 12 hours without draining the battery.

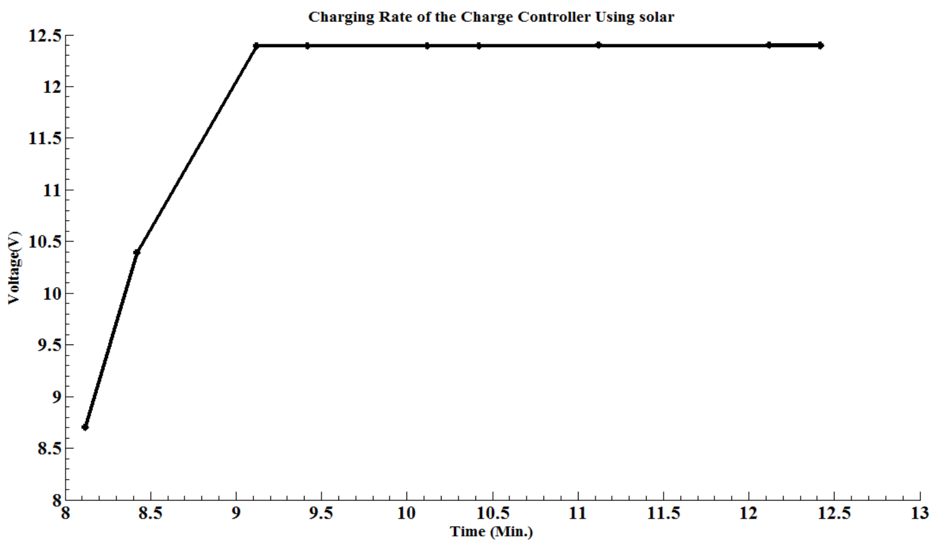

Figure 8 : Graph of voltage across the battery against time.

VII. Discussion

It was observed that wind and solar are complementary since sunny days are usually calm and strong winds are often accompanied by cloud and may occur at night. The inverter under capacitive loads draws less energy from the battery than resistive loads. This is practically indicated by a lower drain from the battery voltage.

The graph of Fig. 8 shows how the battery rapidly charged from 8.7V to 10.39V within 30minutes indicating boost stage, and from 10.39V to 12.39V for two hours thirty minutes indicating the floating stage. While the last stage showed how the charging fluctuates indicating trickle mode. The charging of the battery by the wind turbine greatly depends on the rotational speed of the blade which in turn depends on the wind speed. The readings were obtained at low wind speed. The charger was able to add 0.77V to the battery's state of charge within two hours thirty minutes.

The control unit switches ON the inverter once the solar plate could not detect any solar radiation and switches OFF once it detects it.

VIII. Conclusion

A hybrid power generating system consisting of a PV array and wind turbine with energy storage device and power electronic converter was designed and constructed to take advantage of the seasonal wind and sunshine. The design is achieved as an efficient and cost competitive system configuration so that hybrid power source can improve the life of people especially in rural areas where electricity is not stable or is absent. The efficiency of the designed electricity generating machine (inverter) is about 95% and 73% for capacitive and resistive loads respectively. The wind turbine performance showed a promising output, but there was a challenge with the generator at lower wind speed as can be seen from table 4.4 where only 0.77V was added to the battery's state of charge. This platform has been laid to harvest the wind energy and the abundant solar radiation availability in Mubi. The integrated solar-wind hybrid power generating system is environmentally friendly and maintenance free.

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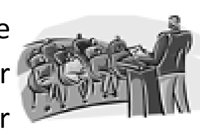

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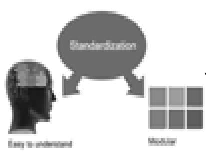

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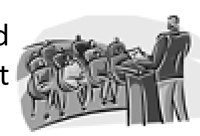

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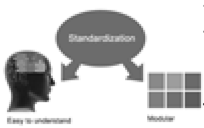

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21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

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26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

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33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

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Key points to remember:

- Submit all work in its final form.
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- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

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Mistakes to evade

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- Separating a table/chart or figure - impound each figure/table to a single page
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· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

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· Shun use of extra pictures - include only those figures essential to presenting results

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- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

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- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

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- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

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- Explain materials individually only if the study is so complex that it saves liberty this way.
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- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

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- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

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What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

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The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
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What to stay away from

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- Never confuse figures with tables - there is a difference.

Approach

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- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

Index

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