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Journal of Advances in Electronic and Electric Engineering

Aims and Scope

Advances in Electronic and Electric Engineering is a Journal that publishes original research papers in the fields of electronics and electrical engineering and the recent advances in these fields. It is open to all researchers from all kind of universities and organizations across the globe and aimed at the increasing important area of electronic and electrical engineering. The Journal policy is to publish high quality original scientific articles and reviews with permission from the Editorial Board. Papers must be written in English. They must not have been previously published and should not be under consideration for publication elsewhere. The principal aim of the journal is to bring together the latest research and development in various fields of science and technology such as electrical engineering, electrotechnics, electric machines modeling and design, control of electric drive systems, non-conventional energy conversion, sensors, electronics, communications, data transmission, energy converters, transducers modeling and design, electro-physics, nanotechnology, computer science, artificial intelligence, pattern recognition, knowledge engineering, process control theory and applications, distributed systems, computer networks and software engineering

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Contents

Use of Electronic Resources by Teacher of Degree College in Cuddalore District

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ABSTRACT

The paper presents the result of a survey on the use of electronic resources by Degree College in cuddalore district. The objectives of the survey were to know the sources and purpose of accessing e-resources. A Questionnaire was randomly circulated to three hundred Teachers in four degree colleges in cuddalore.

Keywords: Information communication technology, e-book, e-journal, search engine, OPAC

INTRODUCTION

Advanced micro electronic-based Information Communication Technology (ICT) is at the heart of recent social and economic transformations in both industrialized and developing countries. As information technology capabilities are increasing, they are being increasingly applied in all sectors of education and societies.

The widespread of ICT opens up new opportunities for information to harness these technologies and services to serve their goals. In the last few years, there have been many initiatives at the highest level of government to promote the construction of a global information infrastructure. The secret of success in all sectors of society depends on the optimum utilization of information technology. Moreover, it creates faith and confidence about the products and services of an organization among its customers. The advances in information technology and the advent of internet and e-commerce have resulted in the knowledge products forming a substantial portion of the economic growth of many countries. Countries that master the techniques of creating, managing and protecting their knowledge and information products would emerge as the superpowers in the ensuing knowledge era.

The large amount of information produced in the world poses many problems in information handling, retrieval and dissemination. To overcome these problems, professionals have to equip themselves with the latest information communication technology provides efficient services. The increased availability of CD-ROM products, electronic publishing activity, the education and training activities in the country have focused on the application of new expansion of utilization of computer and its application in many areas.

OBJECTIVES

1. To investigate the usage of e-resources and services
2. To find out the sources of accessing e-resources
3. To examine the purpose of using e-resources; and
4. To find out the automated information services

LIMITATIONS

The findings of this study are mainly applicable to degree colleges in cuddalore faculty members and not applicable to other college faculty members. Only four institutions have been selected for this study since studying of all institutions would be not possible for an individual researcher, owing to constraints of money, time, energy, and efforts.

METHODOLOGY

A questionnaire based survey method was adopted to gather the data on the use of e- resources by the degree college teacher in cuddalore. Questionnaires were distributed randomly to 100 teachers in each four colleges under survey. In all 400 questionnaires were personally distributed to the teachers. A Total of 290 filled in questionnaire were received with response rate.

ANALYSIS OF DATA

The data collected from the teachers through questionnaires was analyzed using simple percentage technique.

Table – 1 Gender wise distribution of respondent

S.No	Gender	Number of Respondents	Percentage
1	Male	110	37.94
2	Female	180	62.06%
	Total	290	100%

Table 1 shows that gender-wise distribution of respondents; in this study 62.06 % of the respondents belong to the category of female where as 37.94 % of the respondent belong to the category of male.

Table -2 Types of E-Resources Accessed

Types of resources	Response received	Percentage
Electronic journals	86	29.65
Electronic books	95	32.75
Bibliographic Databases	54	18.62
CD-ROM Databases	55	18.96

Table 2 shows that types of e-resources access. 32.75% of respondents are accessed e-books, 29.65% of respondents are access e-journal, 18.96% of respondents access CD-ROM database, 18.62% Bibliographic database.

Table3 Sources of Accessing Resources

Sources for e-resources	Response received	Percentage
OPAC	89	30.68
Search engines	130	44.82
Websites of other institutions	80	27.58

Table 3 shows that sources of accessing resources. Majority of the respondents 44.82% Access search engine, 30.68% of respondent access OPAC, 27.58% of respondents' access websites of the other institutions.

Table 4 Frequency of Using E-Resources By Teachers

Types of e-resources	Frequently	Some times	Never
Electronic journals	104 (35.86)	75(25.86)	111(38.27)
Electronic books	98(33.79)	50(17.24)	142(48.96)
Bibliographic Databases	75(25.86)	44(15.17)	171(58.96)
CD-ROM Databases	49(16.89)	38(13.10)	203(70.00)
Online database	51(17.58)	37(12.75)	202(69.65)

Table 4 shows that frequency of using e-resources by teachers. Very few teachers frequently accessed the e-resources 35.86% teachers used e0journals, 33.79% teacher used e-book and 25.86% teacher used bibliographic database, 17.58% teacher used online database; 16.89%teachers used CD-ROM database. While these e-resources has found favor by a few more teacher who could access them some times. However, a little more than half of the teachers were yet to use e-resources.

Table 5 Purpose of Using E-Resources by Faculty

Purpose	Response received	Percentage
For academic assignment	95	32.75
To keep up-to-date on subject of interest	108	37.24
For career development and growth	87	30

Table 5 shows that the purposes for which e-resources were used by the teachers. 37.24% teachers used e-resources to keep up-to-date on subject of interest; 32.75% used e-resources for doing their academic assignment; 30% teacher used for career development and growth.

Table 6 Problem in Accessing E-Resources

Problem	Agree	Disagree
Too much information is retrieve	180 (62.06)	183(63.10)
Lack of IT knowledge and skills for effectively utilizing services	107 (36.89)	110 (37.93)
Using e-resources often distracts from work	169 (58.27)	121(41.72)
Limited access to compute	89 (30.68)	201 (69.31)

Table 6 shows that problem accessing e-resources. 62.06% of teachers agreed that there was too much information is retrieved; 58.27% of teachers agreed that there was using e-resources often distracts from work. Around half of the teachers, is, 68.31% disagreed that using e- resources often distract from work.

Table 7 Use of Automated Information Services

Categories of automated service	Response received	Percentage
Circulation service	98	33.79
Reference service	50	17.24
Bibliographic service	40	13.79
Current awareness service/SDI	74	25.51
Inter library loan services	28	9.25
News paper clippings	-	-

Table 7 shows that use of automated information services. The circulation service was used the most by 33.79% teachers; 25.51% use of CAS/SDI; 17.24 % use of Reference service; 13.79% use of bibliographic service; 9.25 % use of inter library loan services.

CONCLUSION

Result of the shows that in use of electronic resources by teachers of degree colleges and they confidently use of most of these resources.32.75% respondents most prefer to use e- journal.44.82% of respondents most prefer to access search engines. 73.24% of respondents most prefer to using keep up-to-date on subject interest. 33.79% of respondents most prefer to use of circulation services. Overall, majority of the teachers found that too much of the information retrieve and access to computers being the problems to use e-resources and indicated their willingness to get trained to learn more about using the internet and e- resources.

REFERENCES

1. *Adams, J.A. and Bonk, S.C. (1995), "Electronic information technologies and resources: use by university faculty and faculty preference for related library services", College and Research Libraries, Vol. 56, pp. 119-31.*
2. *Adeogun, M. (2003), "The digital divide and university education system in Sub- Saharan Africa", African Journal of Library Archives and Information Science, Vol. 13 (1), pp. 11-20.*
3. *Ajayi, G.O. (2002), "Information age virtual technology – opportunities and challenges to Africa", paper presented at: UNESCO National Workshop on the Pilot Virtual University Laboratory Project, the Obafemi Awolowo University, Ile-Ife A, 9- 12 September.*
4. *Alasa, M. and Kalechukwu, I. (1999), "Internet and academic library services development in Nigeria", Nigerian Libraries, Vol. 33 (1), pp. 17-29.*
5. *Ali, A. (2004), "Application of information technology in the educational media libraries in Delhi", Proceedings of the XX IATLIS National Conference on Globalization of Library and Information Science Education, University of Madras, Chennai, pp. 89-96.*

An Efficient Data Embedding Technique using Image as A Digital Media

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ABSTRACT

In the present world of communication, one of the necessary requirements to prevent data theft is securing the information. Security has become a critical feature for thriving networks and in military alike. Cryptography and Steganography are well known and widely used techniques that manipulate information (message) in order to cipher or hide their existence. These techniques have many applications in computer science and other related fields: they are used to protect military messages, E-mails, credit card information, corporate data, personal files, etc. Data hiding is a technique that conceals data into a carrier signal for conveying secret messages confidentially. Steganography hides the message in digital media. The purpose of steganography is to conceal the fact that some communication is taking place. Digital images are widely transmitted over the internet; therefore, they often serve as a carrier for covert communication. Images used for carrying data are termed as cover images and images with data embedded are termed as stego images. After embedding, pixels of cover images will be modfii ed and distortion occurs. The distortion caused by data embedding is called the embedding distortion The basic idea of pixel pair matching is to use the values of pixel pair as a reference coordinate, and search a coordinate in the neighborhood set of this pixel pair according to a given message digit, the pixel pair is then replaced by the searched coordinate to conceal the digit. Exploiting modification direction (EMD) and diamond encoding (DE) are two data-hiding methods proposed recently based on PPM. In the EMD method 5-ary method is used as notational system so its payload is 1.161 bpp and DE extends the payload of EMD by embedding digits in a larger notational system. The APPM method offers lower distortion than DE by providing more compact neighborhood sets and allowing embedded digits in any notational system. Image distortion occurs when pixel values are modified because of data embedding. We use MSE to measure the image quality. MSE represents the mean square error between the cover image and stego image. A smaller MSE indicates that the stego image has better image quality.

Keywords: PPM (pixel pair matching), MSE (mean square error), cover image, stego image

I. INTRODUCTION

In the present world of communication, one of the necessary requirements to prevent data theft is securing the information [1]. Security has become a critical feature for thriving networks and in military alike. Cryptography and Steganography are well known and widely used techniques that manipulate information (message) in order to cipher or hide their existence. These techniques have many applications in computer science and other related fields: they are used to protect military messages, E-mails, credit card information, corporate data, personal files, etc.

Steganography hides the message in innocent digital file [1]. The purpose of steganography is to conceal the fact that some communication is taking place [3] [2]. With any type of hidden communication, the security of the message often lies in the secrecy of its existence and/or the secrecy of how to decode it.

The steganography hides the secret information behind a cover so that it draws no special attention [6]. The cover represents any digital file like image, text, and video, sound and …, etc. If we used the digital image, the cover-image after embedding is called stego-image [1].

Data hiding is a technique that conceals data into a carrier for conveying secret messages confidentially [1], [2]. Digital images are widely transmitted over the internet; therefore, they often serve as a carrier for covert communication. Images used for carrying data are termed as cover images and images with data embedded are termed as stego images. After embedding, pixels of cover images will be modfiied and distortion occurs. The distortion caused by data embedding is called the embedding distortion [3]. A good data-hiding method should be capable of evading visual and statistical detection [4] while providing an adjustable payload [5].

Steganography is applicable to

1. Confidential communication and secret data storing,
2. Protection of data alteration,
3. Access control system for digital content distribution,

Steganalysis is the science of detecting hidden information [1]. The main objective of Steganalysis is to break steganography and the detection of stego image is the goal of Steganalysis. Almost all Steganalysis algorithms rely on the Steganographic algorithms introducing statistical differences between cover and stego image. Steganalysis deals with three important categories [1, 4].

(a) Visual attacks: In these types of attacks with a assistance of a computer or through inspection with a naked eye it reveal the presence of hidden information, which helps to separate the image into bit planes for further more analysis.

(b) Statistical attacks: These types of attacks are more powerful and successful, because they reveal the smallest alterations in an images statistical behavior.

Statistical attacks can be further divided into (i) Passive attack and (ii) Active attack.

Passive attacks involves with identifying presence or absence of a covert message or embedding algorithm used etc.

Mean while active attacks is used to investigate embedded message length or hidden message location or secret key used in embedding.

(c) Structural attacks: The format of the data files changes as the data to be hidden is embedded; identifying this characteristic structure changes can help us to find the presence of image.

II. LITERATURE SURVEY:

In 2004, Chan et al. [6] proposed a simple and efficient optimal pixel adjustment process (OPAP) method to reduce the distortion caused by LSB replacement. In that method the pixels with even values will be increased by one. The pixels with odd values will be decreased by one. If the adjusted result offers a smaller distortion, LSB bits are either replaced by the adjusted result or otherwise kept unmofideid. In 2006, Mielikainen [7] proposed an LSB matching method based on PPM. He used two

pixels as an embedding unit. The LSB of the first pixel is used for carrying one message bit, while a binary function is employed to carry another bit. In the same year, Zhang and Wang [8] proposed an exploitingficmatoiodni direction (EMD) method. EMD improves Mielikainen's method in which only one pixel in a pixel pair is changed one gray-scale unit at most and a message digit in a 5-ary notational system can be embedded. Therefore, the payload is (½) log 5 = 1.16 bpp. LSB matching and EMD methods greatly improve the traditional LSB method in which a better stego image quality can be achieved under the same payload. However, the maximum payloads of LSB matching and EMD are only 1 and 1.161 bpp, respectively. Hence, these two methods are not suitable for applications requiring high payload .In 2008, Hong [9] presented a data-hiding method based on Sudoku solutions to achieve a maximum payload of (1/2) log9 bpp. In 2009, Chao et al. [10] proposed a diamond encoding (DE) method to enhance the payload of EMD further. DE employs an extraction function to generate diamond characteristic values (DCV), and embedding is done by modifying the pixel pairs in the cover image according to their DCV's neighborhood set and the given message digit. Wang et al. [11] in 2010 proposed a novel section-wise exploring modification direction method to enhance the image quality of EMD. Their method segments the cover image into pixel sections, and each section is partitioned into the selective and descriptive groups. The EMD embedding procedure is then performed on each group by referencing a predefined selector and descriptor table. This method combines different pixel groups of the cover image to represent more embedding directions with less pixel changes than that of the EMD method. By selecting the appropriate combination of pixel groups, the embedding efficiency and the visual quality of the stego image is enhanced.

In this project proposes a new data embedding method to reduce the embedding impact by providing a simple extraction function and a more compact neighborhood set. The proposed method embeds more messages per modification and thus increases the embedding efficiency. The image quality obtained by the proposed method not only performs better than those obtained by OPAP and DE, but also brings higher payload with less detectability.

III. RELATED WORK:

A. LSB substitution method:

1. The pixels with even values will be increased by one or kept unmodified.
Ex: If the pixel value is 36 -> 00110110
After applying LSB substitution method for data embedding Pixel value will be equal to 37–> 00110111(increased by one)

2. The pixels with odd values will be decreased by one or kept unmodified.
Ex: If the pixel value is 35–>00110101

After applying LSB substitution method for data embedding Pixel value will be equal to 34–> 00110100(decreased by one) If we take another example:
A pixel (225,100,100) with character "a", then we can obtain:
Original pixel = (11100001, 01100100, 01100100) "a" = 01100001(ASCII value 97)
New pixel = (11100011, 01100000, 01100101)
New pixel = (227, 96,101),
Here we can notice that the new pixel of (227, 96,101) is almost the same value as the old pixel of (225,100,100). So there will not be noticeable color difference in the image.

B. OPAP (Optimal Pixel Adjustment Method):

Optimal pixel adjustment process (OPAP) is proposed to enhance the image quality of the stego-image obtained by the simple LSB substitution method.

Let p_i ,p_i' andp_i'' be the corresponding pixel values of the i^{th} pixel in the cover-image *C*, the stego-image *C*′obtained by the simple LSB substitution method and the refined stego-image obtained after the OPAP. Let $\delta_i = p_i' - p_i$ be the embedding error between andp_i Accorp_i'ding to the embedding process of the simple LSB substitution method is obtained by the direct replacement of the k least significant bits of p, with k message bits, therefore,$-2^k \quad \delta_i \quad 2^k < \quad <$

The value of δ_i, can be further segmented into three intervals. Such that,

Interval 1: $-2^{k-1} < \delta_i < 2^k$,

Interval 2: $-2^{k-1} \leq \delta_i \leq 2^{k-1}$,

Interval 3: $-2^k < \delta_i < -2^{k-1}$.

Based on the three intervals, the OPAP, which modifies p_i' to form the stego-pixelp_i'' can be described as follows:

Case I

$(-2^{k-1} < \delta_i < 2^k)$:

If $p_i' \geq 2^k$, then $p_i'' = p_i' - 2^k$;

Otherwise $p_i'' = p_i'$;

Case II

$(-2^{k-1} \leq \delta_i \leq 2^{k-1})$:

If $p_i' < 256 - 2^k$ then $p_i'' = p_i' + 2^k$;

Otherwise $p_i'' = p_i' - 2^k$.

C. EMD (Exploiting Modification Direction):

In which only one pixel pair is changed one grayscale unit at most and a message digit in a 5- ary notational system can be embedded.

That is pixel values are represented in 5-ary notational system before embedding the data in that pixel.

Ex: Take an pixel with value (1101 0110 1001)

This is represented in 5-ary as (23 11 14)

For 1101 ⟶ 13 ⟶ 13+10=23(if the resulting decimal value is one digit ,we should add 5(5*1) to that value ,similarly if the if the resulting decimal value is two digit ,we should add 10(5*2) to that value and so on)

For 0110 ⟶ 6 ⟶ 6+5=11

For 1001 ⟶ 9 ▸ 9+5=14

EMD method offers the fixed payload, because in this method notational system is fixed for 5-ary.

Therefore,
Payload = $(1/2)\log_2 5 = 1.161$ bpp (bits per pixel)

D. Diamond Encoding Method (DE)

This method is purely based on pixel pair matching. This method conceals the data in a B-ary system in to two pixels.

Where,

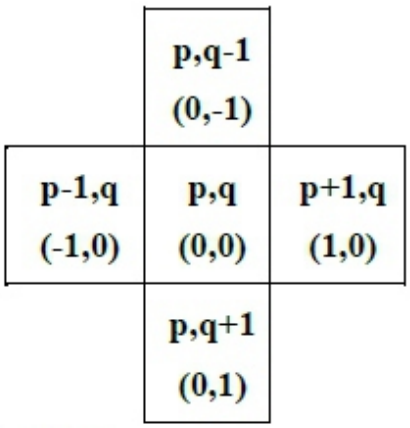
$$B = 2k^2 + 2k + 1, \quad k \geq 1 \text{.....(1)}$$

Therefore,

$$\textbf{Payload} = (1/2)\log_2(2k^2 + 2k + 1) \text{ bpp.....(2)}$$

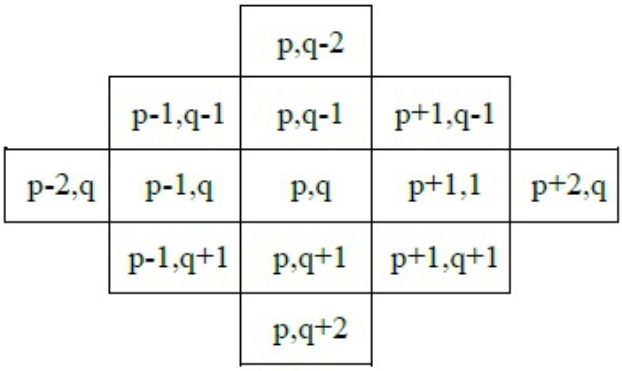
Where,

$$\text{Payload} = (1/2)\log_2(2k^2 + 2k + 1)$$
$$= (1/2)\log_2(2 + 2 + 1) = 1.161 \text{ bpp}$$



For k=2,

$$\textbf{Payload} = (1/2)\log_2(2k^2 + 2k + 1)$$
$$= (1/2)\log_2(2(4) + 2(2) + 1)$$
$$= 1.850 \text{ bpp}$$



The neighborhood set (x,y) is represented as,

$$(x,y) = \{(x,y)|\ |a-x| + |b-y| \leq\ k\}.....(3)$$

Where,

(x, y)represents the set of the coordinates(a,b)'s whose absolute distance to the coordinate (x,y) is smaller or equal to k.

A diamond function ' f' is then employed to calculate the DCV (diamond characteristic values) of (x,y),

Therefore,

$$f(x,y) = \big((2k+1)x + y\big)\ \boldsymbol{mod}\ B.....(4)$$

Where,

Payload = $(1/2)\log_2 13$=1.85 bpp

To calculate the **DCV** (diamond characteristic values) of (x,y) using equation (4),

$$f(0,0) = \big((5) * 0 + 0\big)mod\ (13) = \mathbf{0}$$

$$\boldsymbol{f(0,1)} = \big((5) * 0 + 1\big)mod\ (13) = \mathbf{1}$$

$$\boldsymbol{f(0,2)} = \big((5) * 0 + 2\big)mod\ (13) = \mathbf{2}$$

$$f(0,-1) = \big((5) * \mathbf{0} - 1\big)mod\ (13) = \mathbf{12}$$

$$f(0,-2) = \big((5) * \mathbf{0} - 2\big)mod\ (13) = \mathbf{11}$$

$$\boldsymbol{f(1,0)} = \big((5) * 1 + 0\big)mod\ (13) = \mathbf{5}$$

$$\boldsymbol{f(1,1)} = \big((5) * 1 + 1\big)mod\ (13) = \mathbf{6}$$

$$f(1,-1) = \big((5) * \mathbf{1} - 1\big)mod\ (13) = \mathbf{4}$$

$$f(-1,0) = \big((5) * (-1) + 0\big)mod\ (13) = \mathbf{8}$$

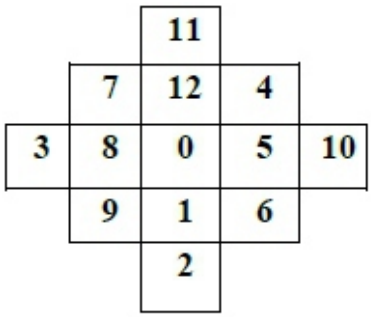
$$f(-1,1) = \big((5) * (-1) + 1\big)mod\ (13) = \mathbf{9}$$

$$f(-1,-1) = \big((5) * (-1) - 1\big)\boldsymbol{mod}\ (13) = \mathbf{7}$$

$$\boldsymbol{f(2,0)} = \big((5) * 2 + 0\big)mod\ (13) = \mathbf{10}$$

$$\boldsymbol{f(-2,0)} = \big((5) * (-2) + 0\big)mod\ (13) = \mathbf{3}$$

This can be shown in a diamond structure as,



Ex: For k=2

We know that,

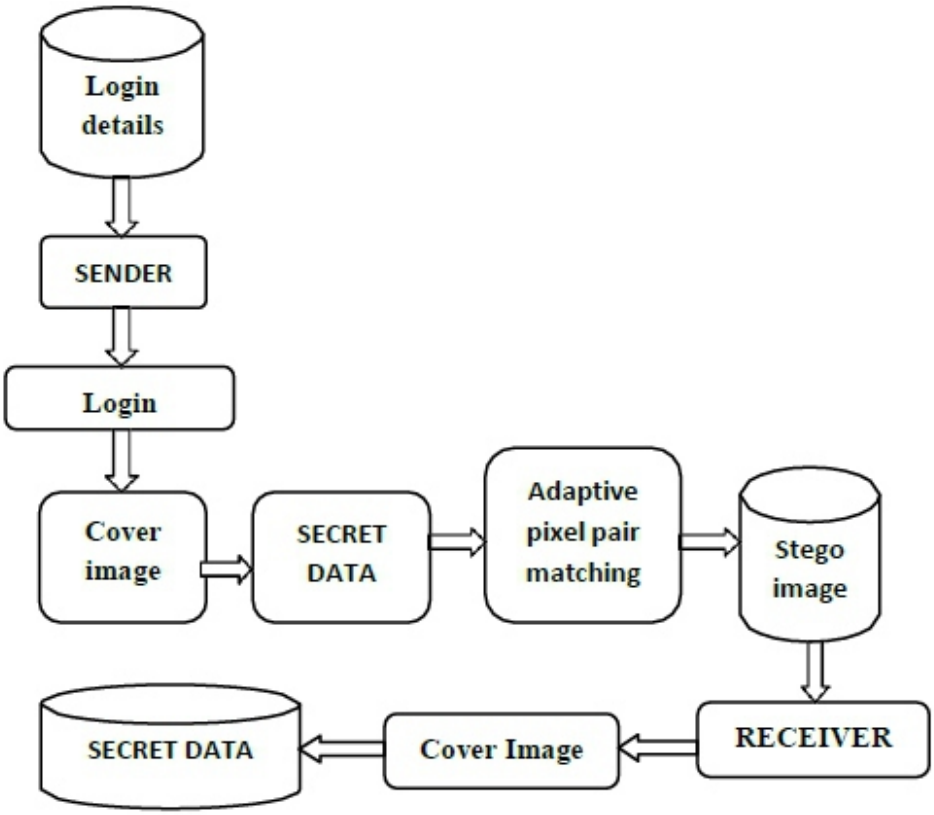
$B=2k^2+2k+1$, $k \geq 1$(from equation (1))

Therefore, B=2(4) + 2(2) + 1 = **13.**

Disadvantages of DE method:

However embedding digits in a 4-ary (i.e, 1-bit per pixel) or 16-ary(i.e, 2-bits per pixel) are not supported in DE method, because, the value of notational system is fixed in diamond encoding method and it depends completely on the K's value.

IV. SYSTEM ARCHITECTURE



A. Existing System

The least significant bit substitution method referred to as LSB in this paper, is a well-known data-hiding method. This method is easy to implement with low CPU cost, and has become one of the popular

embedding techniques. However, in LSB embedding the pixels with even values will be increased by one or kept unmodified. The pixels with odd values will be decreased by one or kept unmodified. Therefore, the imbalanced embedding distortion emerges and is vulnerable to steganalysis. Optimal pixel adjustment process (OPAP) method to reduce the distortion caused by LSB replacement. In their method if message bits are embedded into the rightmost LSBs of an 2-bit pixel, other bits are adjusted by a simple evaluation. Namely, if the adjusted result offers a smaller distortion, these bits are either replaced by the adjusted result or otherwise kept unmodified. Exploiting modification direction (EMD) and diamond encoding (DE) are two data-hiding methods proposed recently based on PPM.

Disadvantages of existing system

- Imbalanced embedding distortion emerges and is vulnerable to steganalysis.
- The existing technique can be easily cracked.

B. Proposed System

The basic idea of PPM is to use the values of pixel pair as a reference coordinate. And search a coordinate in the neighborhood set of this pixel pair according to a given message digit. The pixel pair is then replaced by the searched coordinate to conceal the digit. This paper proposes a new data embedding method to reduce the embedding impact by providing a simple extraction function and a more compact neighborhood set. The proposed method embeds more messages per modification and thus increases the embedding efficiency. The image quality obtained by the proposed method not only performs better than those obtained by OPAP and DE. But also brings higher payload with less detect ability. Moreover, the best notational system for data concealing can be determined and employed in this new method according to the given payload so that a lower image distortion can he achieved.

Advantages of Proposed System:

The proposed method offers lower distortion than DE by providing more compact neighborhood sets and allowing embedded digits in any notational system. Compared with the optimal pixel adjustment process (OPAP) method, the proposed method always has lower distortion for various payloads. Experimental results reveal that the proposed method not only provides better performance than those of OPAP and DE. But also is secure under the detection of some well known steganalysis techniques.

V. MODULES

1) Extraction Function and Neighborhood Set.
2) Embedding Procedure.
3) Extraction Procedure
4) Statistical Analysis

Modules Description

1) Extraction function and neighborhood set

In this module we perform the action of extraction function and neighborhood set. Where the system does a new data embedding method to reduce the embedding impact by providing a simple extraction function and a more compact neighborhood set. The proposed method embeds more messages per modification and thus increases the embedding efficiency. The image quality obtained by the proposed method not only performs better than those obtained by OPAP and DE. But also brings higher payload with less detectability. Moreover, the best notational system for data concealing can be determined and

employed in this new method according to the given payload is that a lower image distortion can be achieved.

2) Embedding Procedure

Input: Cover image of size, secret bit strewn, and key.

Output: Stego image. and.

1. Find the minimum satisfying, and convert into a list of digits with a •ary notational system.
2. Solve the discrete optimization problem to find and.
3. In the region defined by record the coordinate such that..
4. Construct a no repeat random embedding sequence using a key.
5. To embed a message digit. two pixels in the cover image are selected according to the embedding sequence. and calculate the modulus distance between and then replace with.
6. Repeat Step 5 until all the message digits are embedded.

3) Extraction Procedure

To extract the embedded message digits. pixel pairs are scanned in the same order as in the embedding procedure. The embedded message digits are the values of extraction function of the scanned pixel pairs

Input: Stego image., . and.

Output: Secret bit stream.

1. Construct the embedding sequence using the key.
2. Select two pixels according to the embedding sequence.
3. Calculate, the result is the embedded digit.
4. Repeat Steps 2 and 3 until all the message digits are extracted.
5. Finally, the message hits can be obtained by converting the extracted message digits into a binary hit strewn.

4) Statistical Analysis of the Histogram Differences

In this module, we perform the goal of system analysis by using histogram technique. The goal of steganography is to evade statistical detection. It is apparent that MSE is not a good measure of security against the detection of steganalysis.

$$MSE_{\Phi(x,y)} = \frac{1}{2B}\sum_{i=0}^{B-1}((x_i - x)^2 + (y_i - y)^2) \ldots . (5)$$

Histograms are used to plot density of data, and often for density estimation: estimating the probability density function of the underlying variable. The total area of a histogram used for probability density is always normalized to 1. If the lengths of the intervals on the x-axis are all I. then a histogram is identical to a relative frequency plot.

MSE comparison of the proposed method with LSB and OPAP

Payload (bpp)	LSB	OPAP	APPM	MSE improvement over OPAP
1	0.500	0.500	.375	0.125
2	2.500	1.500	1.344	0.156
3	10.50	5.500	5.203	0.297
4	42.50	21.50	20.51	0.982

VI. CONCLUSION

- Simple and efficient
- APPM allows users to select digits in any notation system embedding
- Offer small MSE compared with OPAP and DE

VII. FUTURE WORK

It is expected that our adaptive idea can be extended to other steganographic methods such as audio/video steganography in the spatial or frequency domains

VII. REFERENCES

[1] Ingemar J. Cox, J.Fridrich, "Digital Watermarking and Steganography" second edition, Morgan Kaufmann Publishers, Press, 2008.

[2] N. Provos and P. Honeyman, "Hide and seek: An introduction to steganography," IEEE Security Privacy, vol. 3, no. 3, pp. 32–44, May/Jun. 2003.

[3] A. Cheddad, J. Condell, K. Curran, and P. McK evitt, "Digital image steganography: Survey and analysis of current methods," Signal Process., vol. 90, pp. 727–752, 2010.

[4] Saurabh Singh,Gaurav Agarwal"Use of image to secure text message with the help of L SB replacement,"International journal of applied engineering research, dindigul volum e 1, no1, 2010

[5] S. Lyu and H. Farid, "Steganalysis using higher-order image statistics,"IEEE Trans. Inf. Forensics Security, vol.1, no. 1, pp. 111–119, Mar.2011.

[6] C. K. Chan and L. M. Cheng, "Hiding data in images by simple LSB substitution," Pattern Recognit., vol. 37, no. 3, pp. 469–474, 2004.

[7] J. Mielikainen, "LSB matching revisited," IEEE Signal Process. Lett. vol. 13, no. 5, pp. 285–287, May 2006.

[8] X. Zhang and S. Wang, "Efficient steganographic embedding by exploiting modification direction," IEEE Commun. Lett., vol. 10, no. 11, pp. 781–783, Nov. 2006.

[9] W. Hong, T. S. Chen, and C. W. Shiu, "A minimal Euclidean distance searching technique for Sudoku steganography," in Proc. Int. Symp. Information Science and Engineering, 2008, vol. 1, pp. 515–518.

[10] R.M.Chao, H.C.Wu,C.C.Lee, and Y.P.Chu, "A novel image data hiding scheme with diamond encoding," EURASIP J. Inf. Security, vol.2009, 2009, DOI: 10.1155/2009/658047, Article ID 658047.

[11] J. Wang, Y. Sun, H. Xu, K. Chen, H. J.Kim, and S.H.Joo, "An improved section-wise exploiting modification direction method," Signal Process. vol. 90, no. 11, pp. 2954– 2964, 2010.

Merits and Demerits of Optical Fiber Communication

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ABSTRACT

A fiber optic communication system consists of three components: an optical transmitter, a fiber optic cable, and an optical receiver. The optical transmitter converts electrical signal to optical signal; the fiber cable carries the optical signal from the transmitter to the receiver; and the optical receiver reconverts the optical signal to electrical signal. Most optical fibers are made of silica or sand, raw material abundant compared with copper. With just a few pounds of glass, approximately 43km of optical fiber can be produced. Optical fibers can be used as a medium for telecommunication and networking because it is flexible and can be bundled as cables. It is especially advantageous for long-distance communications, because light propagates through the fiber with little attenuation compared to electrical cables. The fiber optics is superior to metallic conductors as a T/N line for signals because of its high bandwidth, low attenuation, interference, low cots and light in weight. Due to these advantages the fiber optic is used in field of telecommunication. In this paper, I present the advantages and disadvantages of optical fiber communication.

Keywords: ATTENUATION, FIBER OPTIC CABLE, T/N LINE, INTERFERENCE, OPTICAL TRANSMITTER , OPTICAL RECEIVER.

I. INTRODUCTION

The use of light for transmitting information from one place to another place is a very old technique. In 800 BC., the Greeks used fire and smoke signals for sending information like victory in a war, alerting against enemy, call for help, etc. Mostly only one type of signal was conveyed. During the second century B.C. optical signals were encoded using signaling lamps so that any message could be sent. There was no development in optical communication till the end of the 18th century. The speed of the optical communication link was limited due to the requirement of line of sight transmission paths, the human eye as the receiver and unreliable nature of transmission paths affected by atmospheric effects such as fog and rain. In 1791, Chappe from France developed the semaphore for telecommunication on land. But that was also with limited information transfer. In 1835, Samuel Morse invented the telegraph and the era of electrical communications started throughout the world. The use of wire cables for the transmission of Morse coded signals was implemented in 1844. In 1872, Alexander Graham Bell proposed the photo phone with a diaphragm giving speech transmission over a distance of 200 m. But within four years, Graham Bell had changed the photo phone into telephone using electrical current for transmission of speech signals. In 1878, the first telephone exchange was installed at New Haven. Meanwhile, Hertz discovered radio waves in 1887. Marconi demonstrated radio communication without using wires in 1895. Using modulation techniques, the signals were transmitted over a long distance using radio waves and microwaves as the carrier. During the middle of the twentieth century, it was realized that an increase of several orders of magnitude of bit rate distance product would be possible if optical waves were used as the carrier.

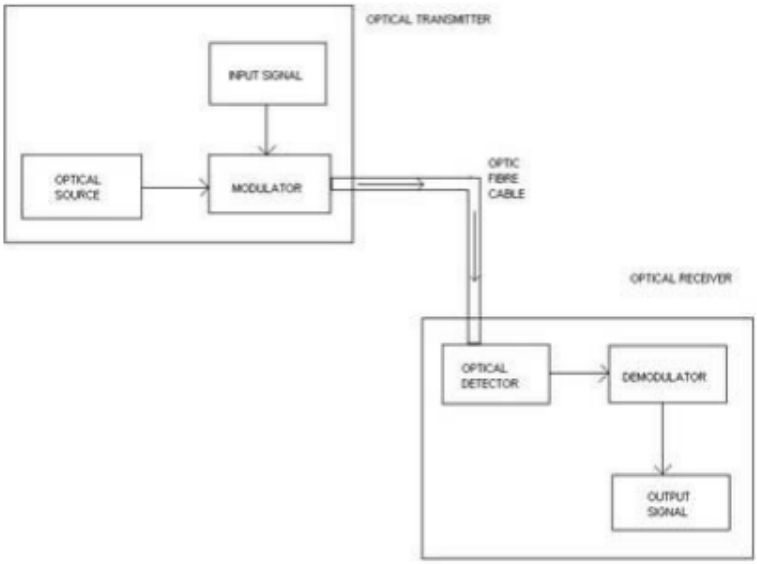

Fig: Block Diagram of Optical Fiber Communication

A new era in optical communication started after the invention of laser in 1960 by Maiman. The light waves from the laser, a coherent source of light waves having high intensity, high monochromaticity and high directionality with less divergence, are used as carrier waves capable of carrying large amount of information compared with radio waves and microwaves.

II. ADVANTAGES OF OPTICAL FIBER COMMUNICATION:

1. Extremely high bandwidth – No other cable-based data transmission medium offers the bandwidth that fiber does.

2. Easy to accommodate increasing bandwidth – Using many of the recent generations of fiber optic cabling, new equipment can be added to the inert fiber cable that can provide vastly expanded capacity over the originally laid fiber. DWDM, or Dense Wavelength Division Multiplexing, lends fiber optic cabling the ability to turn various wavelengths of light traveling down the fiber on and off at will. These two characteristics of fiber cable enable dynamic network bandwidth provisioning to provide for data traffic spikes and lulls.

3. Resistance to electromagnetic interference – Fiber has a very low rate of bit error (10 EXP- 13), as a result of fiber being so resistant to electromagnetic interference. Fiber-optic transmission is virtually noise free.

4. Early detection of cable damage and secure transmissions – Fiber provides an extremely secure transmission medium, as there is no way to detect the data being transmitted by “listening in” to the electromagnetic energy “leaking” through the cable, as is possible with traditional, electron-based transmissions. By constantly monitoring an optical network and by carefully measuring the time it takes light to reflect down the fiber, splices in the cable can be easily detected.

5. When high freq signal are propagated through convention coaxial cable ,it loss half of its power only after a few hundred meters where as the optical fiber loss the sauce amount of power in 15km or more .Thus repeater will be required at very long distance.

6. The T/N rate is possible on optical fiber is 10GB/sec while in coaxial cable is 1GB/sec.
7. Because of very small size and light in weight and large Flexibility, it produces a number of advantages over cupper wires at the installation time.
8. As the fiber optic has no electrical conductivity, there fore Grounding and protection are not necessary.
9. Insensitivity to electromagnetic interference, such as when a telephone wire loses some of its signal to another.
10. Fiber do not lose any light, therefore the transmission is also secure and cannot be disturbed.
11. Lack of electrical signals in the fiber, so it cannot shock or other hazards. This makes fibers suitable for work in explosive atmospheres.
12. Easy to install and Compatibility with digital technology.
13. Lightness and small size of the cable, capable of carrying a large number of signals.

III. DISADVANTAGES OF FIBER OPTICS:

1. Installation costs, while dropping, are still high – Despite the fact that fiber installation costs are dropping by as much as 60% a year, installing fiber optic cabling is still relatively costly. As installation costs decrease, fiber is expanding beyond its original realm and major application in the carrier backbone and is moving into the local loop, and through technologies such as FTTx (Fiber to the Home, Premises, etc,) and PONs (Passive Optical networks), enabling subscriber and end user broadband access.

2. Special test equipment is often required – The test equipment typically and traditionally used for conventional electron-based networking is of no use in a fiber optic network. Equipment such as an OTDR (Optical Time Domain Reflect meter) is required, and expensive, specialized optical test equipment such as optical probes are needed at most fiber endpoints and connection nexuses in order to properly provide testing of optical fiber.

3. Susceptibility to physical damage – Fiber is a small and compact cable, and it is highly susceptible to becoming cut or damaged during installation or construction activities. Because railroads often provide rights-of-way for fiber optic installation, railroad car derailments pose a significant cable damage threat, and these events can disrupt service to large groups of people, as fiber optic cables can provide tremendous data transmission capabilities. Because of this, when fiber optic cabling is chosen as the transmission medium, it is necessary to address restoration, backup and survivability.

4. Wildlife damage to fiber optic cables – Many birds, for example, find the Kevlar reinforcing material of fiber cable jackets particularly appealing as nesting material, so they peck at the fiber cable jackets to utilize bits of that material. Beavers and other rodents use exposed fiber cable to sharpen their teeth and insects such as ants desire the plastic shielding in their diet, so they can often be found nibbling at the fiber optic cabling. Sharks have also been known to damage fiber optic cabling by chomping on it when laid underwater, especially at the repeating points. There is a plant called the Christmas tree plant that treats fiber optic cable as a tree root and wraps itself around the cable so tightly that the light impulses traveling down the fiber are choked off.

5. Price - Even though the raw material for making optical fibers, sand, is abundant and cheap, optical fibers are still more expensive per metre than copper. Although, one fiber can carry many more signals

than a single copper cable and the large transmission distances mean that fewer expensive repeaters are required.

6. Fragility - Optical fibers are more fragile than electrical wires.

7. Affected by chemicals - The glass can be affected by various chemicals including hydrogen gas (a problem in underwater cables.)

8. Opaqueness - Despite extensive military use it is known that most fiber become opaque when exposed to radiation.

9. Requires special skills - Optical fiber cannot be joined together as a easily as copper cable and requires additional training of personnel and expensive precision splicing and measurement equipment.

10. The joining of fiber optics cables need greater care because if the Joining is not correct; a lot of attenuation will produce in high Wave length.
11. As the fiber optics have no electrical conductivity, therefore additional Copper cable is not used with optical fiber to provide power supply to the repeaters.
12. The installation cost is very high as compare to the other types of T/N lines.

IV. CONCLUSION:

There are a number of essential points about fiber optics that have been mentioned throughout this paper. Optical communication offer several advantages such as higher bandwidth, higher interconnection densities, and lower crosstalk, crosstalk which is independent of data rate, inherent parallelism and immunity from electromagnetic interference. These advantages mean that optical communication have the potential to exhibit higher data rate communication. The shortest interconnections however, will remain electrical ones, due in part to the inverse relationship between electrical interconnection length and power consumption, and to a length independent minimum latency time inherent to optical interconnections caused by the time delays required for electrical to optical to electrical conversions As conclusion, fiber optic technology is a revolutionary technological departure from the traditional copper wires twisted-pair cable or coaxial cable. As we more forward in the Information Technology age, the responsibility of moving extreme amounts of data must fall on the shoulders of this new technology. There is no doubt as to the vast opportunities that fiber optic technology can give and it should be continuously researched and expanded to cater for future demands.

ACKNOWLEDGMENT

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REFERENCE:

[1] Keiser Gerd 'optical fiber communication', Mc Graw-hill publications (ISBN 0-07- 100785-7).
[2] M Nakazawa, Soliton transmission in telecommunication networks, IEEE Communication magazine, March 24 (1994)
[3] M ARUMUGAM 'Optical fiber communication —An overview' journal of Nov. & Dec. 2001 Vol. 57, Nos 5 & 6 physics pp. 849–869.
[4] How stuff works. 27. Nov 20012 http://www.howstuffworks.com/fiber-optic1.html
[5] Katiyar Sapna 'Optical fiber communication' Katson Publication New delhi.
[6] SiewHung Tee'Optical Fiber the Backbone of Telecommunication' report for Mat E 115, Fall 2002.
[7] Das Satyjeet ' Text book on Opto electronics' Katson Publication New delhi.

Performance Analysis of Buck & Boost Converter

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A B S T R A C T

This paper presents performance analysis of buck & boost converter. Buck converter step up DC input voltage while boost converter step down DC input voltage. Both converters are analysed in closed loop mode. Firstly a PI controller is used to analyze the performance of buck & boost converters. Later we have used a fuzzy controller to analyse these converters. Circuit model has been developed using MATLAB. Different voltage waveform is being compared for different reference voltage. We also analyze that using FLC (fuzzy logic controller) gives better response than PI controller in feedback path.

Keywords: Buck & boost converter, PI controller, fuzzy controller.

I. INTRODUCTION

A buck converter is a step-down DC to DC converter. It is a switched-mode power supply that uses two switches (a transistor and a diode), an inductor and a capacitor. A boost converter is also a step-up DC-to-DC power converter with an output voltage greater than its input voltage and its design is similar to the buck converter A Buck - Boost converter is a combination of both buck an boost converter whose output voltage is either less or greater than the input voltage.

The output voltage is of the opposite polarity as the input. This is a switched-mode power supply with a similar circuit topology to the boost converter and the buck converter. The output voltage is adjustable based on the duty cycle of the switching device.

The work in paper [1] gives the modeling and simulation technique to analyze and design for an overall efficiency optimization. The paper [2] describes a comparison of the characteristics of buck converter and applying PSM (pulse space modulation) by obtaining experimental results from a (1.2 kW)setup and their computer simulation.

The step by step process of designing, construction and testing a bidirectional buck-boost converter for an ultra capacitor based auxiliary energy system of electric vehicles is introduced in paper[3], converter is used as a controlled energy transfer equipment between main and auxiliary energy system that transfers energy in both directions.

II. THEORY OF OPERATION

A. BUCK CONVERTER

The operation of the buck converter is fairly simple, with an inductor and two switches (usually a transistor and a diode) that control the inductor. It alternates between connecting the inductor to source voltage to store energy in the inductor and discharging the inductor into the load.

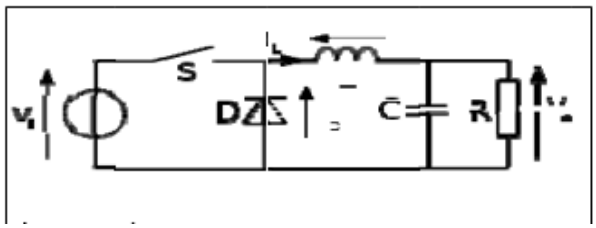

Fig1: Buck Converter

B. BOOST CONVERTER

The key principle that drives the boost converter is the tendency of an inductor to resist changeswin current. In a boost converter, the output voltage is always higher than the input voltage. When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores the energy. Polarity of the left side of the inductor is positive. When the switch is opened, current will be reduced as the impedance is higher.

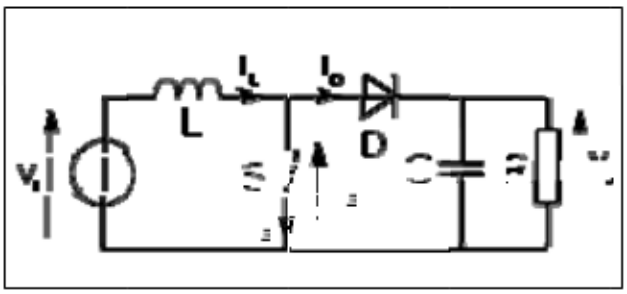

Fig2: Boost Converter

III. BOOST CONVERTER WITH PI CONTROLLER

Now to achieve proper objective of converter, it is need to measure and maintain output voltage at required voltage level. So for that purpose it is needed to use feedback loop into the system.

Conventionally, PI, PD and PID controller are most popular controllers and widely used in most Power Electronic closed loop appliances. The PI control is the most popular control system; it is versatile and can be tuned adjusting three constants. PI is a well proved and successfully applied in many control systems.

$$V_i * ton + (V - V_o) * t_{off} = 0 \qquad (1)$$

Where

Vi = The input voltage, V.

Vo =The average output voltage, V.

ton = The switching ON time of the MOSFET, sec toff = The switching OFF time of the MOSFET, sec

Dividing both sides by TS and re-arranging items

$$\frac{\quad}{\quad} = \frac{\quad}{\quad} = \frac{\quad}{\quad} \qquad \text{.....(2)}$$

Where,

T_s: The switching period, s.

D : The duty cycle

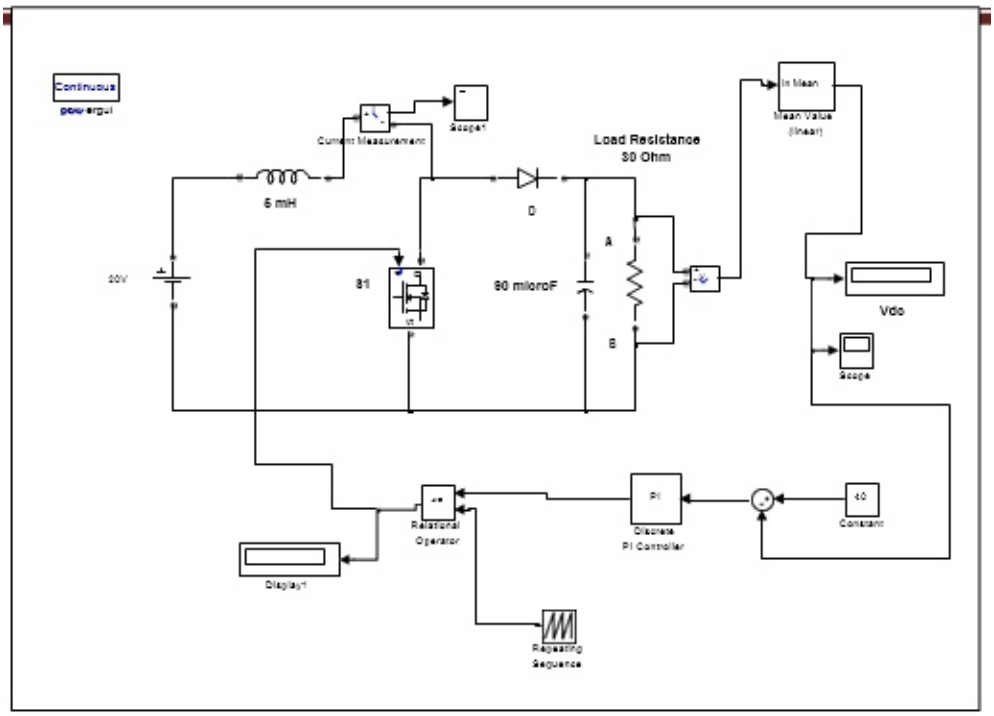

Fig3: Close loop Simulink Model for Boost Converter Using PI Controller

Table I: The parameters and values for the boost dc-dc converter.

Parameters	Values
Voltage Input V_{in}(V)	10
Voltage Output V_{out}(V)	45
Inductor(mH)	5
Resistance(?)	30
Capacitor(μF)	90

IV. BUCK CONVERTER WITH PI CONTROLLER

The buck converter from previous context is extended with a PI control. We will create a model where the mosfet is controlled from the block diagram where the PI controller is modeled.

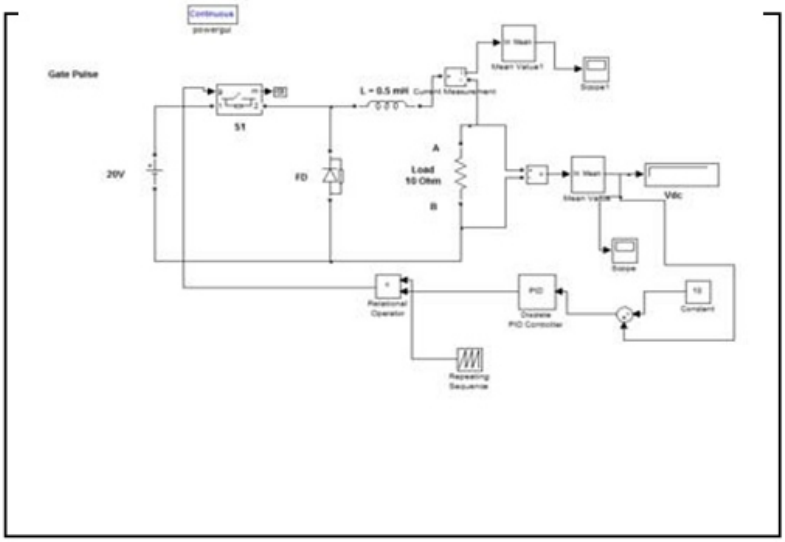

Fig4: Close loop Simulink Model for Boost Converter Using PI Controller

V. BOOST CONVERTER WITH FUZZY CONTROLLER

A simple fuzzy logic control is built up by a group of rules based on the human knowledge of system behaviour. Matlab/Simulink simulation model is built to study the dynamic behaviour of dc-to-dc converter and performance of proposed controllers.

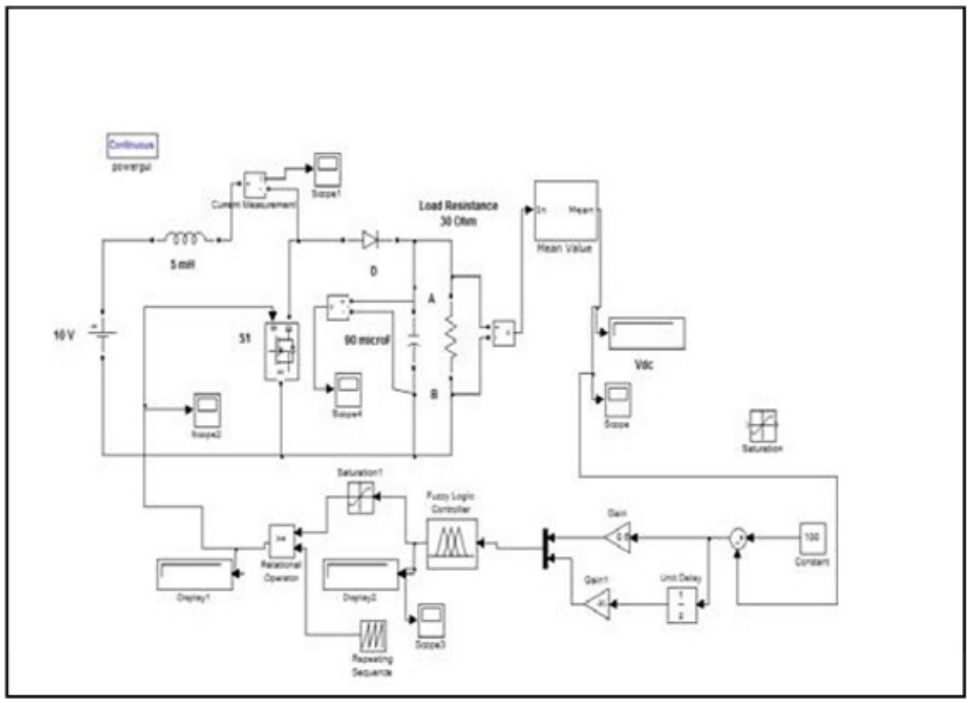

Fig5: Close loop Simulink Model for Boost Converter Using Fuzzy Controller

VI. BUCK CONVERTER WITH FUZZY CONTROLLER

Traditionally, PI, PD and PID controller are most popular controllers and widely used in most power electronic closed loop appliances however recently there are many researchers reported successfully adopted Fuzzy Logic Controller (FLC) to become one of intelligent controllers to their appliances. With respect to their successful methodology implementation, control closed loop boost converter and opened loop boost converter will compare the efficiency of the converters.

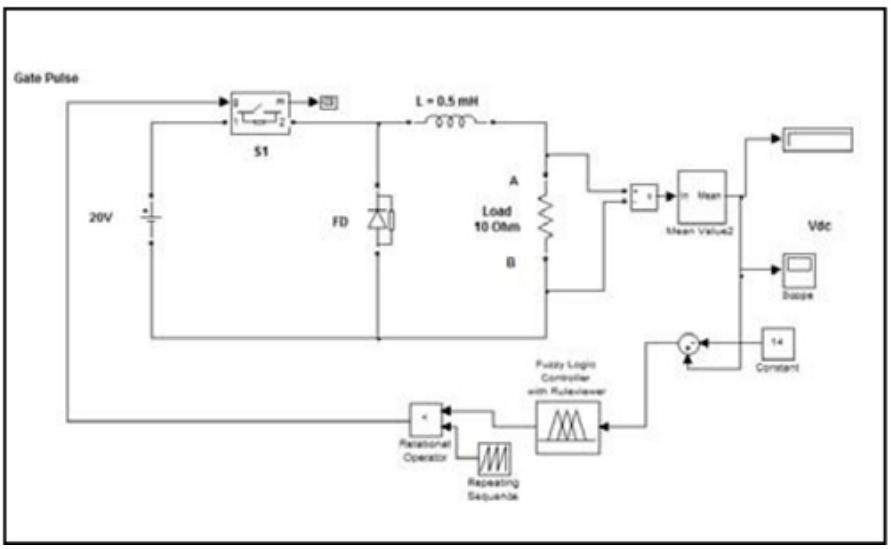

Fig6: Close loop Simulink Model for Buck Converter Using Fuzzy Controller

VII. RESULTS OF SIMULINK MODEL

A. Boost Converter using PI

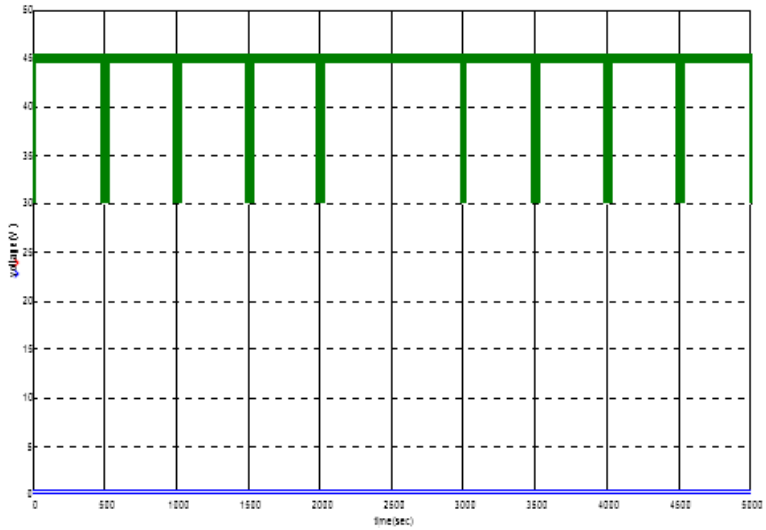

Fig7: Output voltage across load using PI converter

B. Boost converter using fuzzy controller

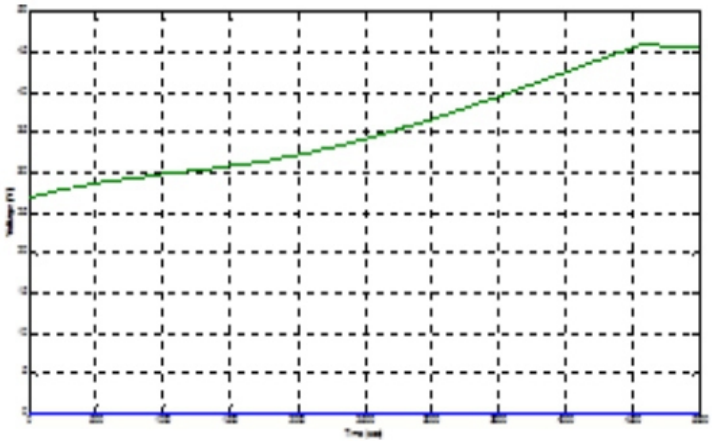

Fig8: Output voltage across load using fuzzy controller

C. Buck converter using PI controller

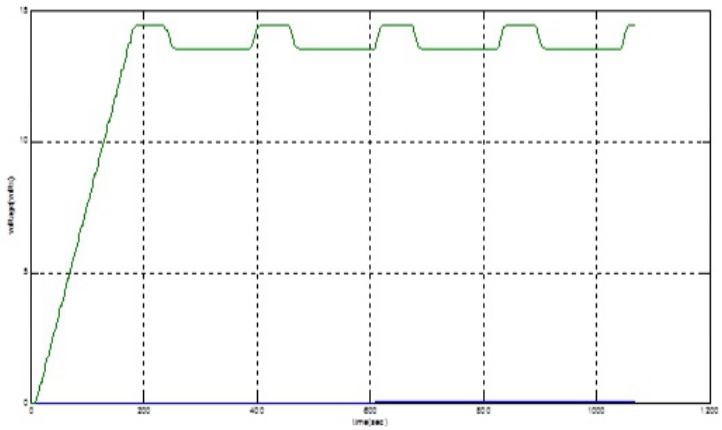

Fig 9 : Output voltage across load using PI controller

D. Buck converter using fuzzy controller

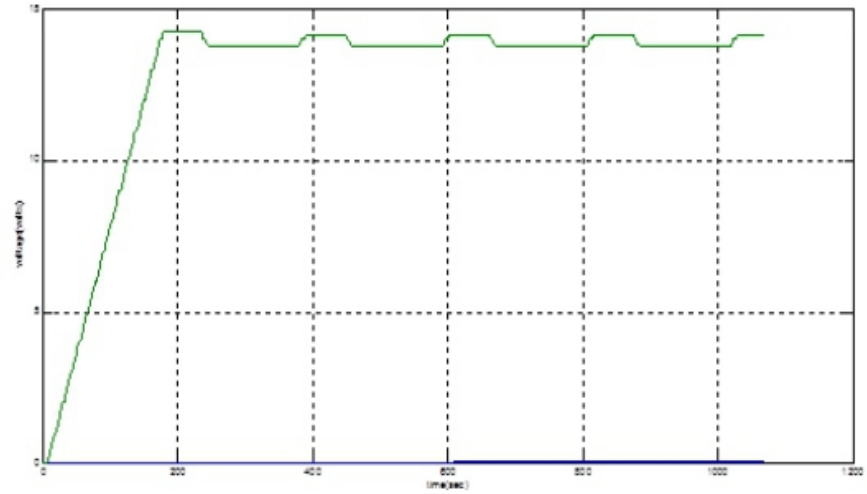

Fig10: Output voltage across load using fuzzy controller

VII. COMPARISON OF RESULTS

TABLE 2: BOOST CONVERTER

Parameters	PI controller	FUZZY controller
Input Voltage (V)	10	10
Output Voltage (V)	40.48	39.99
% Error	1.2	0.025
Settling Time (sec)	6000	5000

TABLE 3: BUCK CONVERTER

Parameters	PI controller	FUZZY controller
Input Voltage (V)	20	20
Output Voltage (V)	14.45	14.19
% Error	3.2	1.357
Settling Time (sec)	183	160

VIII. CONCLUSION

Design of a fuzzy logic controller on control buck converter and boost converter by using MATLAB has been successfully achieved. A simple algorithm based on the prediction of fuzzy logic controller, possibly using the fuzzy rules parameter, is showing to be more convenient than the circuit without fuzzy. Using a closed loop circuit with fuzzy logic controller, it is confirmed that the dc-dc converter gives a value of output voltage exactly as circuit requirement. Hence, the closed loop circuit of dc-dc converter controlled that by fuzzy logic controller confirmed the methodology and requirement of the proposed approach. These studies could solve many types of problems regardless on stability because as we know that fuzzy logic controller is an intelligent controller to their appliances.

IX. REFRENCES

[1] Sven E. Fagerstrom, Nagy N. Bengiamin," buck/boost converter modeling and simulation for performance optimization", Department of Electrical and Computer Engineering 5241 N. Maple Avenue, Fresno, CA 93740, U.S.A.

[2] Atsushi NAKAJIMA, Shin-ichi MOTEGI and Akeshi MAEDA,"Comparison of the Characteristics between Buck and Buck-Boost High-Power-Factor Converters with Pulse- Space-Modulation",Power Electronics Lab., Dept. of Electronic and Computer Eng., Tokyo Denki University.

[3] Fathi Shaban Jaber, " Development Of A Dc-Dc Buck Boost Converter Using Fuzzy Logic Control " A thesis submitted in fulfilment of the requirement for the award of the Degree of Master of Electrical Engineering.
[4] Jingquan Chen, Dragan MaksimoviC and Robert Erickson, "Buck-Boost PWM Converters Having Two Independently Controlled Switches", Colorado Power Electronics Center Department of Electrical and Computer Engineering.
[5] Dong-Kurl Kwak, Seung-Ho Lee, and Do-Young Jung, "A New Buck-Boost DC/DC Converter of High Efficiency by Soft Switching Technique" Professional Graduate School of Disaster Prevention, Kangwon National University, 245-711, Korea.
[6] S. Rahman, F. C. Lee, "Computer Simulations of Optimum Boost and Buck-Boost Converters", Viginia Polytechnic Institute and State University.
[7] Biying Zhou,Peng Zhang, "Analysis of Modeling and Simulation of Buck-boost Converter Considering Dynamic Phasor Method", Department of Computer Science and Technology, Weinan Teachers University.
[8] R. Bharom, M. K. Hamzah, "Computer Simulation of Single-phase Matrix Converter Operating as Buck or Boost rectifier", Universiti Teknologi MARA.
[9] Sevki Demirbas, "Internet Based Toolkit For Simulation of DC/DC Converters", IEEE.
[10] Ma Hongbo, Feng Quanyuan, "Hybrid Modeling and Control for Buck-Boost Switching Converters", IEEE School of Information & Technology, SWJTU, Chengdu, Sichun, China.

Comparsion Between Nominal and Fuzzy Logic Control in Speed Control of D. C. Machine

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A B S T R A C T

The project presents an insight into the speed control of D.C motor using a fuzzy logic controller to meet the desired speed. Fuzzy logic is one of the most successful applications of fuzzy set in which the variables are linguistic rather than numeric. A fuzzy logic controller (FLC) is based on a set of control rules (fuzzy rules) among linguistic variables. The personal computer provides the necessary flexibility in setting any speed profile with the use of fuzzy packages. The proposed fuzzy controller results in a better response compared to the normal response of D.C motor. The step response parameters can be closely controlled with the help of simple operations within the controller. The simulation of nominal and FLC control model is carried out and the simulation results present the flexibility of the motor speed control.

We have to design the separately excited dc motor system and to run the motor at rated speed and also control the armature current.

Keywords—fuzzy logic controller (FLC), Fuzzification, De- fuzzification

I. INTRODUCTION

In recent years, Fuzzy logic met a growing interest in many motor control applications due to its non-linearities handling features and with a very wide range of operation. The fuzzy controller (FLC) operates in a knowledge-based way, and its knowledge relies on a set of linguistic if-then rules, like a human operator.

The wonderful world of fuzzy logic is a powerful new paradigm, helping us to analyze unknown and complicated systems. The importance of fuzzy logic various methods have been reported, that includes linear regression, exponential smoothing, stochastic process, ARMA models, etc.

Fuzzy logic controller also makes good performance in terms of stability, precision, reliability and rapidity achievable.

The advantages provided by a FLC are listed below:

- It is simple to design.
- It provides a hint of human intelligence to the controller.
- It is cost effective.

Disadvantages of the fuzzy logic controllers are the lack of systematic, effective and useful design methods.

The present work consists of the development and simulation of a controller for a closed loop speed control where the manipulated variable is the firing angle.

Speed of the DC motor is controlled by controlling the armature voltage. Armature voltage is controlled using different single phase AC/DC converter. Half converter, semi converter, full converter and dual converter are some of the thyristor based circuits which are used for speed control of DC motor. This paper studies Fuzzy Logic speed control technique of DC motor and makes a comparative study with Nominal Model (without controller).

II. MODELS USED

1. NOMINAL MODEL

The simulation model of the complete nominal system means system is an open loop system; no control strategy is applied on the motor. The system SIMULINK model is shown in figure5.

In this model armature voltage control strategy is followed, the voltage across the armature is varied by varying the firing angle. The following are the parameters of nominal model.D.C. motor
D.C. motor input voltage = 150

Armature resistance and inductance [Ra (ohms) La (H)]: [0.5 0.01] Field resistance and inductance [Rf (ohms) Lf (H)]: [84.91 13.39] Field-armature mutual inductance Laf (H): 0.7096
Total inertia J (kg.m^2): 0.05

Viscous friction coefficient Bm (N.m.s): 0.02 Coulomb friction torque Tf (N.m): 1

Converter specifications:
Supplied voltage = 230 V, 3 – phase A.C. Frequency = 50 Hz

Synchronised 6 pulse generator
Frequency of synchronisation voltages (Hz): 50 Pulse width (degrees): 10

Thyristor Convertor
Number of bridge arms: 3 Snubber resistance
Rs (Ohms):50 Snubber capacitance
Cs (F):1e-7 Ron (Ohms):1e-3
Lon (H):0
Forward voltage Vf (V): 0.8

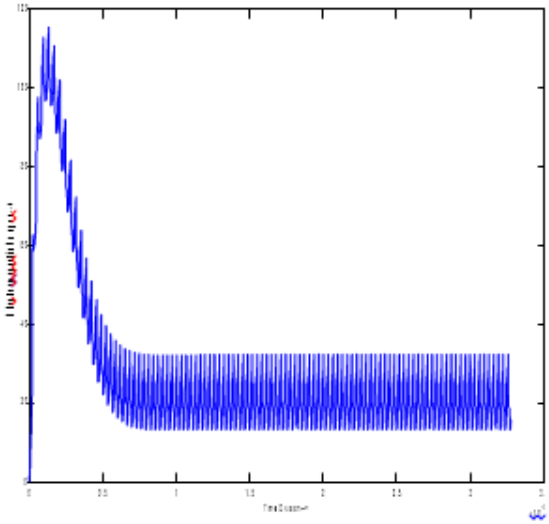


Fig 1: Electromagnetic Torque with nominal model

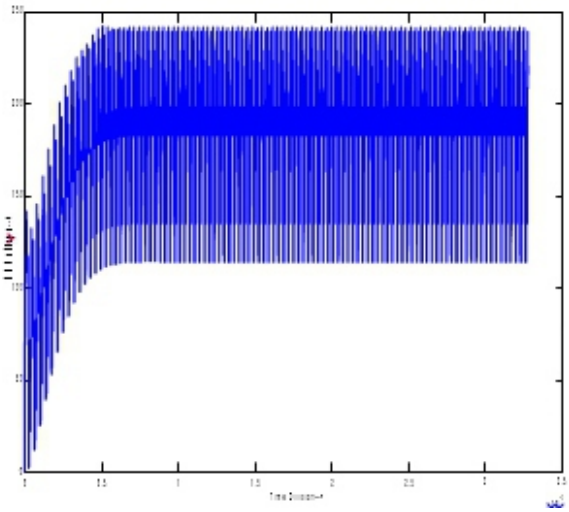


Fig 2: Response of DC voltage with nominal model

2. FUZZY LOGIC MODEL

In the last few years, fuzzy logic has met a growing interest in many motor control applications due to its non-linearities handling features and independence of the plant modeling. The fuzzy controller (FLC) operates in a knowledge-based way, and its knowledge relies on a set of linguistic if-then rules, like a human operator.

This paper makes use of simplified fuzzy inference in which the consequence of the fuzzy rule is expressed in crisp number. We can add new membership functions as per our 1convenience in fuzzy approach. To make a more accurate fuzzy expert system, regions are divided into intervals.

The interval for error (input 1) has been divided into seven triangular membership functions which are as follows:

- Large Negative(LN)
- Negative(N)
- Negative Zero(NZ)
- Zero(Z)
- Positive Zero(PZ)
- Positive(P)
- Large Positive(LP))

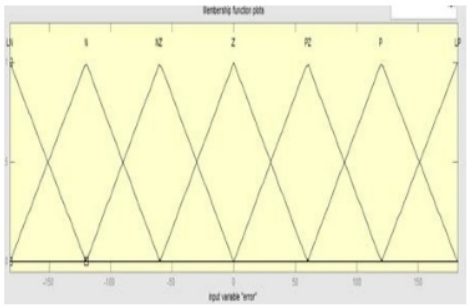


Fig 3: Triangular membership functions of error

The interval for firing angle (input 2) has been divided into seven triangular membership functions which are as follows:

- Large Negative(LN)
- Negative(N)
- Negative Zero(NZ)
- Zero(Z)
- Positive Zero(PZ)
- Positive(P)
- Large Positive(LP)

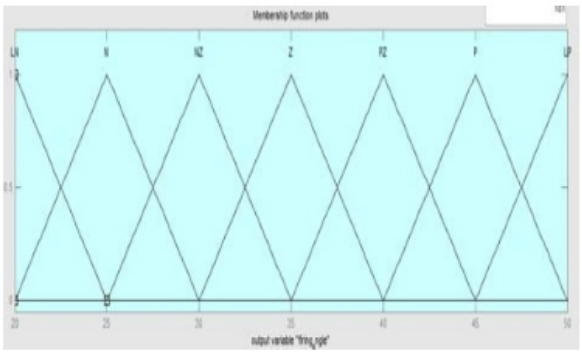


Fig 4: Triangular membership functions of firing angle

In the fuzzy logic approach, the calculations are based on the entire profile of the membership functions rather than based on the point values. This approach is much closer to people decision making process in real life.

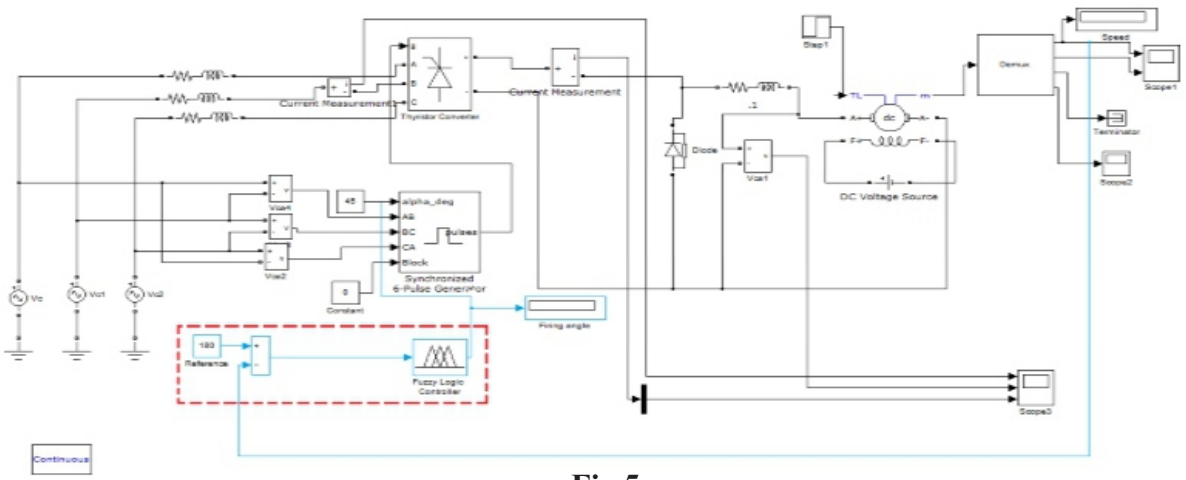


Fig 5:

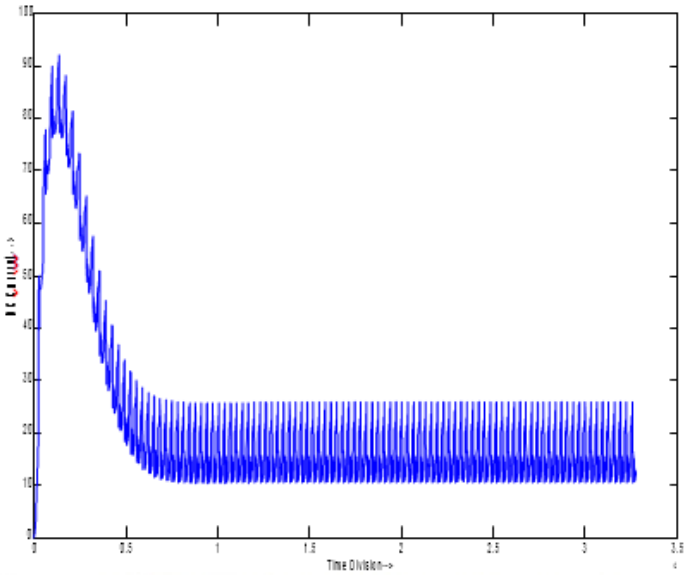
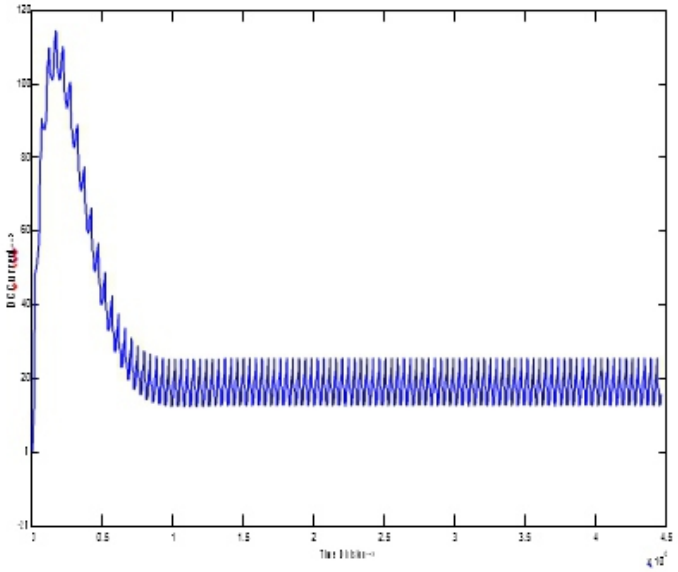


Fig 6(a): Armature current with nominal model **Fig 6(b): Motor speed with nominal model**



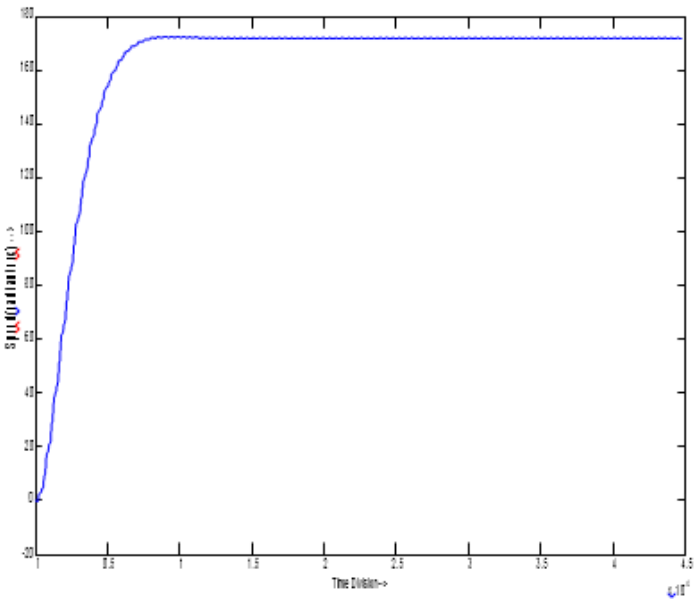


Fig7(a): Armature current with fuzzy model **Fig7(b):Motor speed with fuzzy model**

III. DEFUZZIFICATION

Defuzzification means the fuzzy to crisp conversions. The fuzzy results generated cannot be used as such to the applications, hence it is necessary to convert the fuzzy quantities into crisp quantities for further processing. This can be achieved by using defuzzification process [2, 6].

Defuzzification can also be called as "rounding off" method. Defuzzification reduces the collection of membership function values in to a single sealer quantity.

There are seven methods used for defuzzifying the fuzzy output functions.

They are:

(1) Max-membership principle,
(2) Centroid method,
(3) Weighted average method,
(4) Mean–max membership,
(5) Centre of sums,
(6) Centre of largest area, and
(7) First of maxima or last of maxima

In this paper we have used the 'CENTROID Method' for defuzzification. This is the most widely used method. This can be called as centre of gravity or centre of area method.
It can be defined by the algebraic expression:

$z^* = \{ \int \mu_c(z).z\,dz \} / \{ \int \mu_c(z)\,dz \}$

$\int$ is used for algebraic integration.

IV. RESULT

After running the two models viz. Nominal model and Fuzzy logic model successfully on Simulink the following results were obtained:

PARAMETERS	NOMINAL	FUZZY
Firing Angle	45^{o}	Output of Fuzzy Controller
Motor Speed	137 radian/sec	175 radian/sec
Settling Time	0.9 sec	0.25 sec

V. CONCLUSION

Two separate models were developed for determining the response of DC motor. The result of nominal model shows oscillation in response of motor armature current and speed response of motor with less speed of motor.

On the contrary the precision of the fuzzy logic model was found to be adequate enough to discriminate between the two models used. It is concluded that the oscillations in current response is die out and speed response becomes smoother as compared to nominal model. Also, the settling time is reduced to 0.25 sec.

VI. REFERENCES

[1] Bolognani, s; Zigliotto, "DC motor speed control a fuzzy approach".

[2] R.Arulmozhiyal1, and Dr. K.Baskaran, "Speed Control of Induction Motor using Fuzzy PI and Optimized using GA", International Journal of Recent Trends in Engineering, Vol 2, No. 5, November 2009.

[3] J. Martínez García, J.A. Domínguez "Comparison between Fuzzy logic and PI controls in a Speed scalar control of an induction machine".

[4] Ramón C. Oros, Guillermo O. Forte, Luis Canali, "Scalar Speed Control of a dq Induction Motor Model Using Fuzzy Logic Controller".

[5] Approach Varuneet Varun, G. Bhargavi, Suneet Nayak, "Speed Control of Induction Motor using Fuzzy Logic".

[6] Martina Malkova, "D.C. motor speed control".

[7] Rohit Gupta, Ruchika Lamba, Subhransu Padhee, "Thyristor Based Speed Control Techniques of DC Motor: A Comparative Analysis", International Journal of Scientific and Research Publications Vol.2, Iss. 6, June 2012, ISSN 2250-3153.

[8] Abhishek Nayak and Bharat Mahendru, "Application of Fuzzy Logic In Short Term Load Forecasting (Roorkee Region)" International Journal of Research Engineering and Applied Sciences (ISSN: 2249-3905) vol.- 2 issue 4 April 2012

[9] www.mathworks.com, The Mathworks company, Inc.

Comparative Study of the Topologies of Multilevel Inverter

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A B S T R A C T

The multilevel inverter topologies have proved recently as very important alternative in the area of high power and medium voltage energy control .This paper presents the comparison of different topologies of multilevel inverter that are diode clamped multilevel inverter, flying capacitor multilevel inverter and cascaded multilevel inverter. The paper also presents the comparison of the topologies in terms of total harmonic distortion. The main function of multilevel inverter is to obtain a desired ac voltage from several levels of dc voltages. As we increase the number of voltage levels, the harmonic content decreases significantly. These multilevel inverters are used to increase inverter operating voltage, to minimize THD with low switching frequency, to reduce EMI due to lower voltage steps. The advantages of this multilevel approach includes good power quality, good electromagnetic compatibility, low switching losses and high capability. This project proposes to study various multilevel topologies, to compare the topologies and the levels. The main objective of this study is to reduce total harmonic distortion, comparison of THD and fundamental component for different modulating techniques.

Keywords: Multilevel Inverter, DCMLI, FCMLI, CHBMLI, THD.

I. INTRODUCTION

Various industrial applications require higher power apparatus. Some medium voltage motor drives and utility applications require medium voltage and megawatt power level. For a medium voltage grid, it is very difficult to connect only one power semiconductor switch directly to it. As a result, a multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations. A multilevel converter not only achieves high power ratings, but also enables an efficient use of renewable energy sources. Renewable energy sources such as photovoltaic, wind, and fuel cells can be easily connected to a multilevel converter system for a high power application.

The concept of multilevel inverters has been introduced since 1975. The functioning of multilevel inverter began with three level converter. Several advancements have been made tiil date that includes development of various topologies that are very efficiently used these days in the industrial field. The basic concept of a multilevel inverter to achieve higher power is to use a series of power semiconductor switches with several low voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform that is ac in nature. Capacitors, batteries, and other renewable energy voltage sources can be used as the multiple dc voltage sources. The commutation of the power switches aggregate these multiple dc sources in order to achieve high voltage at the output; however, the rated voltage of the power semiconductor switches depends only upon the rating of the dc voltage sources to which they are connected.

II. MULTILEVEL PRINCIPLE

The multi-level inverter [1-3] includes an array of power semiconductors and capacitor voltage sources, the output of which generate voltages with stepped waveforms. The commutation of the switches permits the addition of the voltages, which reach high voltage at the output, while the power semiconductors must withstand only reduced voltages. This paragraph has the aim to introduce to the general principle of multilevel behavior. The general idea of multilevel converters is to synthesize a sinusoidal voltage from several voltage-levels, typically obtained from capacitor voltage sources. As the number of levels increases, the synthesized output waveform adds more steps, producing a staircase wave which approaches the sinusoidal wave with minimum harmonic distortion.

III. Multilevel Inverter Topologies

A. Diode Clamped Multilevel Inverter:

The most commonly used multilevel topology is the diode clamped inverter in which the diode is used as the clamping device to clamp the dc bus voltage so as to achieve steps in the output voltage. The voltage across each capacitor for an N level diode clamped inverter [4-5] at steady state is Vdc/(n-1). Although each active switching device is only required to block Vdc/ n-1, the clamping devices have different ratings. The diode clamped inverter provides multiple voltage levels through connection of the phases to a series of capacitors. Fig. 1 shows a three phase three level diode clamped multilevel inverter.

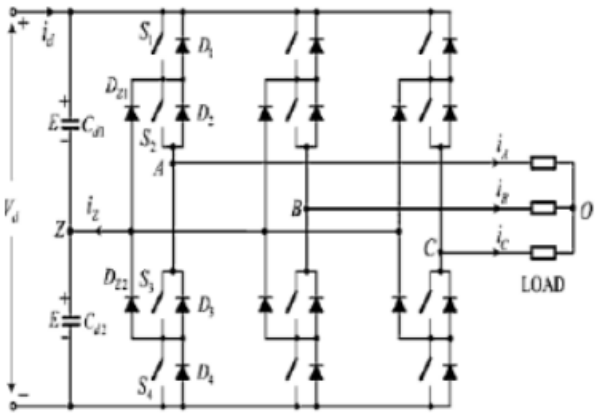

Fig.1 Three phase three level diode clamped multilevel inverter

An m level inverter leg requires 2(m-1) switching devices and (m-1)(m-2) clamping diodes. For a three level inverter, m=3, so it needs 4 switching devices and 2 clamping diodes per leg as shown in fig. (1).

(1) For an output voltage of Va = Vdc, all the upper half switches of a- phase leg are turned ON i.e S1 and S2 are ON.
(2) For output voltage of Va = Vdc/2, only S2 and S3 are ON.
(3) For output voltage of Va = 0, the lower half switches of a- phase leg are turned ON i.e. S3 and S4 are ON.

Table 1 shows the voltage levels and their corresponding switch states. State condition 1 means the switch is ON and state condition 0 means the switch is OFF. It should be noticed that there are two complementary switch pairs. These pairs for one leg of the inverter are (S1, S3) and (S2, S4).

Table 1 Switch states for various voltages of a phase leg.

Voltage level V_a=	S_{A1}	S_{A2}	S_{A3}	S_{A4}
V_{dc}	1	1	0	0
$V_{dc}/2$	0	1	1	0
zero	0	0	1	1

Thus, if one of the complementary switch pairs is turned ON, the other of the same pair must be OFF. Two switches are always turned ON at the same time. Output voltage waveform of a three level diode clamped inverter is as shown in fig. 2.

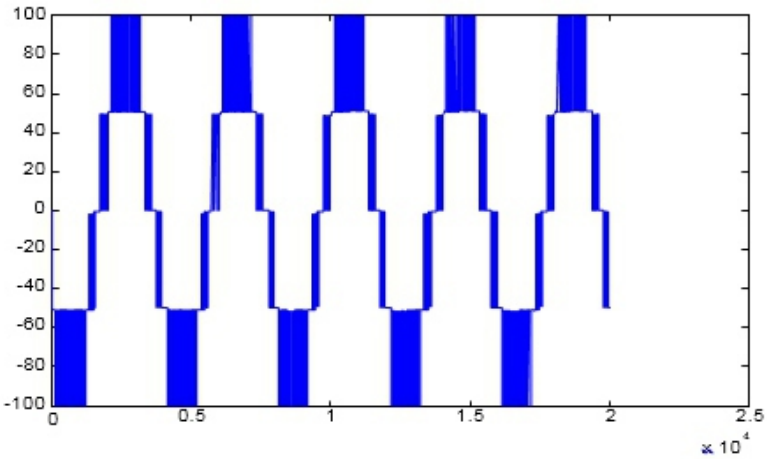

Fig. 2 Output voltage of three level Diode Clamped Multilevel Inverter.

B. Flying Capacitor Multilevel Inverter:

The flying capacitor muitilevel inverter [6] is relatively new compared to diode clamped and cascaded h bridge multilevel inverter. Figure 2.2(a) shows one phase of a three phase three level flying capacitor multilevel inverter. In this topology each capacitor is charged to a different voltage level and by changing the transistor switching states, the capacitors and dc source are connected in different ways and produce various line to ground output voltages. For the analysis presented herein the line - to-ground voltage and capacitor currents are of interest. From the topology KVL and KCL equations, these quantities can be expressed as:

$V_{ag}=(T_{a3})V_{dc}+(T_{a2}-T_{a3})V_{c2a}+(T_{a1}-T_{a2})V_{c1a}$

$i_{c1a} = (T_{a2} - T_{a1})\, i_{as}$

$i_{c2a} = (T_{a3} - T_{a2})\, i_{as}$

Based on these fundamental equations, the line - to – ground voltage and capacitor currents, can be determined for all combinations of transistor signals as shown in table 2.

The three phase implementation involves three branches of the structure shown in fig 3 connected in parallel on the dc side and connected to a wye configured load on the ac side.

Table 2 Three level FCMI output voltages

T_{a1}	T_{a2}	T_{a3}	v_{ag}	i_{c1a}	i_{c2a}
0	0	0	0	0	0
0	0	1	$v_{dc}-v_{c2a}$	0	i_{as}
0	1	0	$v_{c2a}-v_{c1a}$	i_{as}	$-i_{as}$
0	1	1	$v_{dc}-v_{c1a}$	i_{as}	0
1	0	0	v_{c1a}	$-i_{as}$	0
1	0	1	$v_{dc}-v_{c2a}+v_{c1a}$	$-i_{as}$	i_{as}
1	1	0	v_{c2a}	0	$-i_{as}$
1	1	1	v_{dc}	0	0

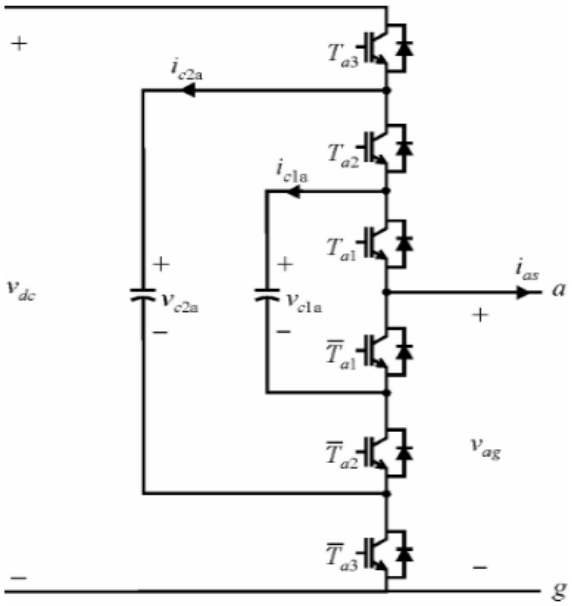

Fig. 3 The three level FCMI inverter topology (a- phase)

The output of a three phase three level flying capacitor multilevel inverter is as shown in fig. 4

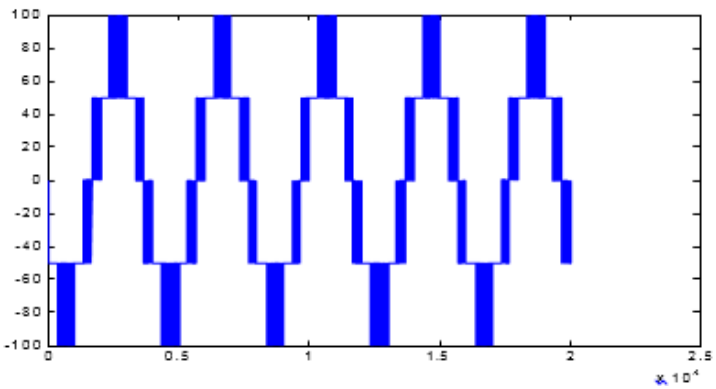

Fig. 4 Output voltage waveform of three level flying capacitor multilevel inverter

C. Cascaded H Bridge Multilevel Inverter

In cascaded H bridge [7-9] topology the H- bridges are cascaded in every phase. With the increase in H-bridges in a phase, the output voltage waveform tends to be more sinusoidal. Fig. 5 shows its 3- level topology. It consists of 2 identical H-bridges in each phase. In n level topology , (n-1)/2 identical H-bridges are used in each phase. There must be a separate DC source for the DC bus of every individual H-bridge. Hence this topology is useful for collecting energy from renewable energy resources eg. solar panels and fuel cell.

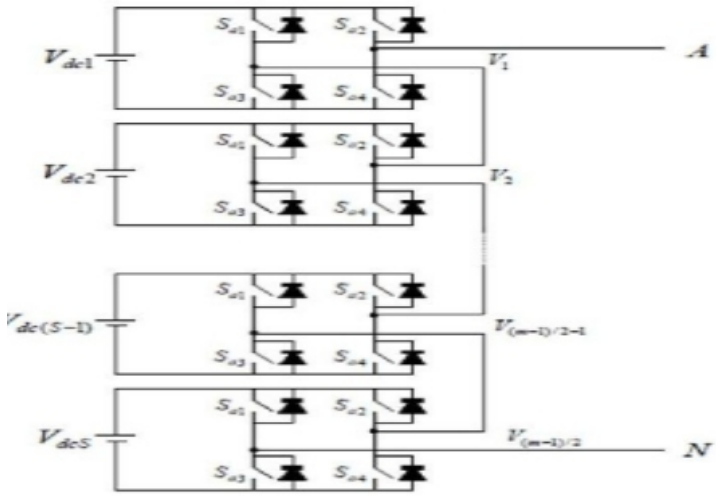

Fig. 5 Three level cascaded H bridge Multilevel Inverter

A cascaded multilevel inverter is made up from series connected single full bridge inverter each with their own isolated DC bus. This multilevel inverter can generate almost sinusoidal waveform voltage from several separate dc sources, which may be obtained from solar cells, fuel cells, batteries ultra capacitors etc. This type of converter does not need any transformers, or clamping diodes or flying capacitors. Each level can generate five different voltage outputs +2Vdc, +Vdc, 0, -Vdc, -2Vdc. by connecting the DC sources to the AC output side by different combinations of the four switches. The output voltage waveform of an M- level inverter is the sum of all individual inverter outputs.

IV. COMPARISION OF TOPOLOGIES IN TERMS OF THD

The THD [10-12] for diode clamped multilevel inverter is as shown in fig. 6. The optimal value of modulation index of 0.8 and switching frequency of 750 hz has been selected to get much better performance. The THD is decreased significantly to 17.53%. Also it is observed that 7th harmonic is reduced significantly.

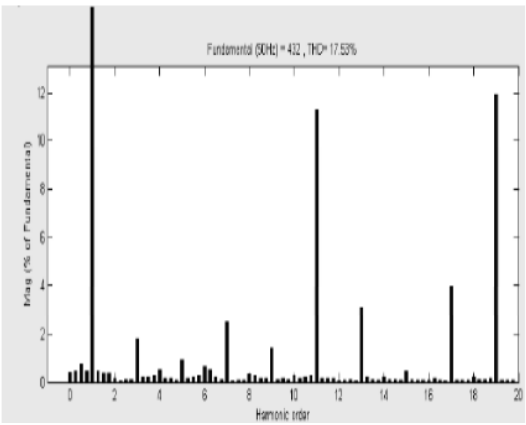

Fig. 6 Harmonic Spectrum of DCMLI

Fig. 7 shows the harmonic spectrum for the output phase voltage of a three level flying capacitor mli. It is shown that 26.35% of harmonics present in the line- line voltage i.e. the THD will decrease significantly to 26.35%. Switching frequency of 500 Hz and flying capacitors of 3344μF has been selected for this topology.

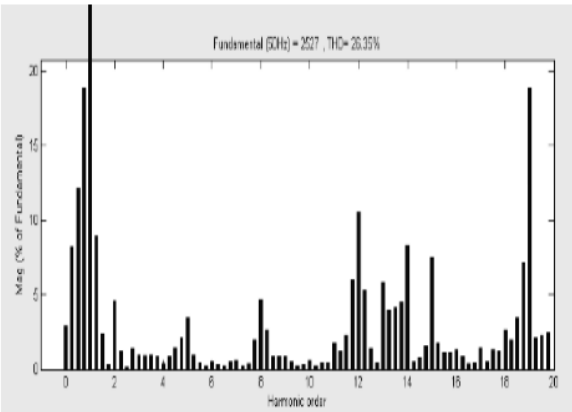

Fig. 7 Harmonic spectrum of FCMLI

Simulation of cascaded H bridge inverter yields harmonic spectrum as shown in fig. 8. The THD is significantly reduced to 12.01%. Also the most of the lower order harmonics are suppressed.

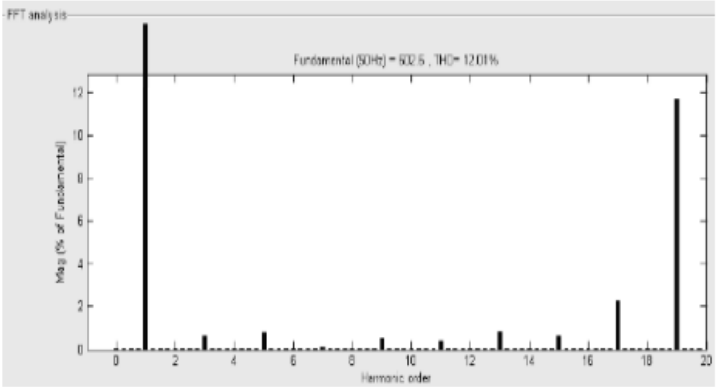

Fig. 8 Harmonic Spectrum of CHB Inverter

V. COMPARISIONS

Table 3 : Comparision of THD

Power circuit topology	V line- line THD (%)
3 level FCMLI	26.35
3 level DCMLI	17.53
3 level CHBMLI	12.01

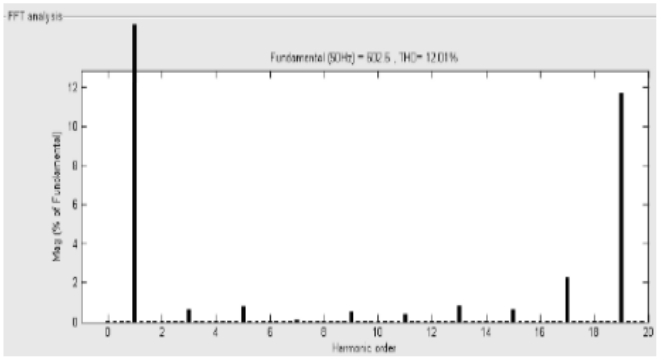

Fig 9 Comparision of THD for all the investigated topologies.

VI. RESULT

The topologies have been compared in terms of structure , cost and efficiency. The voltage waveforms of the three level inverters show that the voltage across the motor contains not only the “fundamental” sinusoidal component but also pulses of voltage i.e. the harmonics are high. In case of DCMLI, main drawbacks are the requirement of clamping diodes, lack of modularity and unequal semiconductor loss distribution. The additional expense of FC, particularly at low carrier frequency and a high number of cells are main disadvantage of FC topology. For CHB, main disadvantage is the separate DC sources usually provided by a bulky and non- standard transformer. CHB is particularly necessary for very high power applications.

VII. CONCLUSION

This paper proposes the three multilevel topologies (3L DCMLI, 3L FCMLI and 3L CHBMLI) and they cover different needs for different types of applications. The harmonic spectrum of the three topologies are studied and it is shown by FFT analysis that the output voltage includes THD along with the fundamental voltage. It is seen that 3 L CHB has minimum THD content and 3L FCMLI has maximum THD content. It was shown that the output voltage levels are increased in the multilevel inverter to approach near sine wave and to get the higher voltage and reduced THD.

VIII. REFERENCES

[1] J.S. Lai and F.Z. Peng,”Multilevel Converters- A new breed of power converters”, IEEE Trans. Ind.Applicat., vol. 32, pp. 509-517, May/June 1996

[2] L.Tolbert, F.Z.Peng, T.Habetler, “Multilevel converter for large electrical drives”, IEEE Trans.Ind.Applicat., vol. 35, pp. 36-44, Jan/Feb. 1999

[3] R.Teodorescn, F.Beaabjerg, J.K.Pederson, E.Cergelei, S.Sulistijo, B.Woo, and P.Enjeti, “Multilevel converters- a survey”, in Proc. European Power Electronics Conf (EPE ‘99), Lansane, Switzerland, 1999

[4] V.Naga Haskar Reddy, Ch.Sai.Babu and K.Suresh- “Advanced Modulating Techniques for diode clamped multilevel inverter”, ISSN 1819-6608, vol.6 no.1 Jan. 2011

[5] Sule Ozdemir, Engin Ozdemir, Leon M.Tolbert and Surin Khomfoi, “Elimination of Harmonics in a five level diode clamped multilevel inverter using fundamental mod.”, PEDS 2007

[6] Y.Liang, C.O. Nurankpa, “ A powerline conditioner based on flying capacitor multilevel voltage source inverter with phase shift SPWM”, IEEE transactions on industry applications, vol. 36, no. 4, pages 965-971, July 2000

[7] M.Kavitha, A.Arunkumar, N.Gokulnath, S.Arun, “New cascaded H bridge Multilevel Inverter topology with reduced no. of switches and sources”, ISSN: 2278-1676, vol- 2 issue- 6 (sep-oct 2012), pp 26-36

[8] P.Palanivel and Subhransu Sekhar Dash, “Analysis of THD and output voltage performance for cascaded multilevel inverter using carrier PWm Techniques”, IET Power Electronics. Vol. 4 issue 8, Sep 2011, pp 951-958

[9] P.Palanivel and Subhransu Sekhar Dash, “Comparative study of constant switching frequency and variable switching frequency multicarrier PWM for 3 phase multilevel inverter”, International Journal of recent trends in Engg, Vol 2, no. 7, Nov. 2001, pp 49-52.

[10] M.Ghasem Hosseini Aghdam, S.hamid Fathi, Gevorg B.Gharehpetian, (2008) ”Harmonic optimization techniques in multilevel vsi with unequal DC sources”, Journal of Power Electronics, Vol. 8, no. 2

[11] Zhong Du, Burak Ozpineci and Leon M.Tolbert, (2007) ”Modulation Extension Control of hybrid Cascaded H- Bridge multilevel conv. with 7 level fundamental frequency switching scheme”, IEEE 2007

[12] T.Prathiba, P.Remga, “A comparative study of total harmonic distortion in multilevel inverter topologies”, Journal of information Engg and applications ISSN 2224- 5782 (print) ISSN 2225- 0506 (online) vol. 2 no. 3, 2012

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Keywords

Keywords are terms or phrases showing adequately the article content for indexing and search purposes. They should be allocated heaving in mind widely accepted international sources (index, dictionary or thesaurus), such as the Web of Science keyword list for science in general. The higher their usage frequency is the better. Up to 10 keywords immediately follow the abstract and the summary, in respective languages.

Acknowledgements

The name and the number of the project or programmed within which the article was realized is given in a separate note at the bottom of the first page together with the name of the institution which financially supported the project or programmed.

Tables and Illustrations

All the captions should be in the original language as well as in English, together with the texts in illustrations if possible. Tables are typed in the same style as the text and are denoted by numerals at the top. Photographs and drawings, placed appropriately in the text, should be clear, precise and suitable for reproduction. Drawings should be created in Word or Corel.

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Footnotes

Footnotes are given at the bottom of the page with the text they refer to. They can contain less relevant details, additional explanations or used sources (e.g. scientific material, manuals). They cannot replace the cited literature.
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