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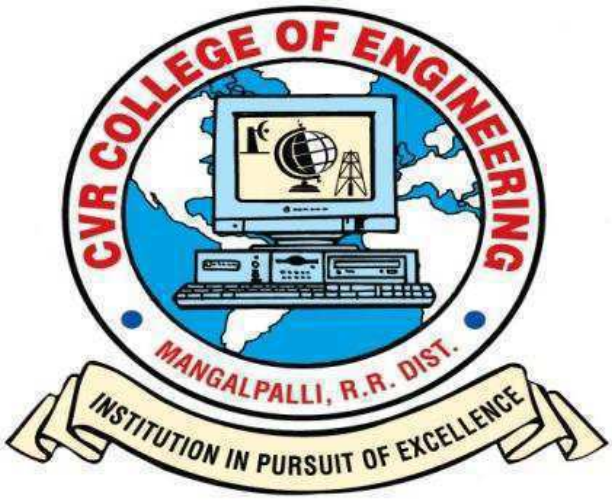

CVR COLLEGE OF ENGINEERING
(An Autonomous College affiliated to JNTU Hyderabad)
Mangalpalli (V), Ibrahimpatan (M),
R.R.District, A.P. – 501510
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EDITORIAL

We are happy to bring out Volume 5 of CVR Journal of Science and Technology. The present volume contains 17 papers selected from the various disciplines as per the breakup given below.

CSE - 4, ECE – 5, EEE – 1, EIE – 1, H&S – 2, IT-2, Management -1and Medical – 1

We are happy to note that, apart from the authors from among the staff members of our college, there are a few from external academic institutions and from industry. We wish to thank all the authors for their interest in contributing to our journal. I am confident that with continuing support from the Management of the college and growing research culture in the college, our journal will continue to play a significant role in enhancing the knowledge dissemination process through high quality papers.

I wish to thank all the members of the Editorial Board for their timely support. My special thanks are to Sri Venkateswara Rao (Associate Professor, CSE) and Deepak (Programmer, CSE), who worked hard in preparing the papers in camera ready form for final printing.

K.V.Chalapati Rao
Editor

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Pattern Language and Traditional Programming Practices for Exporting Functionality

Dr. Hari Ramakrishna, Professor,
Department of Computer Science and Engineering, C.B.I.T Gandepet , Hyderabad- 500075
Email: dr.hariramakrishna@rediffmail.com

***Abstract*— A set of programming practices and a model pattern approach to document and communicate expert programming tips are presented. Pattern approach is adapted to the task of exporting functionality. Traditional development frameworks which are presented in integrated development environment are adopted to suit the implementation of the presented models. Extreme Programming (XP) approach for change management is adopted. The model starts its journey from known simple techniques to complex models. Such models are useful for training programmers. The presented models depend on concepts such as static function , polymorphism, virtual functions, static and dynamic libraries, Object files, managing project work spaces, code COM models, ATL and Active X controls , Simple Object access protocol SOAP. This paper presents a new approach to train the programmers.**

***Index Terms*— Pattern, Pattern-frames, Frameworks, Pattern language, Extreme programming (XP), Refactoring, Object oriented primitives, Component technology, Function classes, Middleware frameworks**

I. INTRODUCTION

Software industry is looking for rapid application development mechanisms with client orientation and short time span delivery, increasing quality and withstanding rapid changes in technology and requirements.

In this connection, exporting third party tools plays a major role. Using third party tools decreases testing time. Development of frameworks for increasing degree of reuse has become an important focus. Customization of such frameworks as per client requirements increases importance of frameworks. Frameworks are different from libraries; client code is embedded in frameworks whereas client code includes and calls libraries.

Frameworks can be classified into three classes namely 'system frameworks', 'middleware integration frameworks' and 'business oriented frameworks'. System frameworks provide basic reusable environment required for the development, middleware integration frameworks provide Integrated Development Environment (IDS); for example, Microsoft MFC, Document view architecture, COM Framework, ATL, .NET frameworks come under such types. The third class of frameworks focuses on building and exporting business functionality focused on one or more domains. Such frameworks help in increasing quality and decreasing development cost and time.

Exporting data and functionality, and integrating and assembling modules for building applications are important tasks in such models. Several programming practices and styles, useful for such purpose, are presented as a series of techniques, in the increasing order of complexity starting from basic known concepts. Extreme Programming (XP) and refactoring also suggest such practices.

Extreme Programming (XP) is a software development methodology which is intended to improve software quality and responsiveness to changing customer requirements. It is an agile software process, it advocates frequent "releases" in short development cycles. The approach is intended to improve productivity and introduce checkpoints at which new customer requirements can be adopted. Such approaches enable programmers to withstand and adopt multidimensional rapid growth and changes in the software development technologies.

The presented models which are experimented in several applications are adopting such processes. They focus on presenting various techniques in practice for exporting functionality for the purpose of building function libraries and frameworks, starting from traditional basic concepts of refining code and adopting object oriented concepts. At the end, a new concept referred as 'function classes, is presented. The paper concludes with techniques for porting such models into upcoming technologies in a simple and safe way. Pattern approach of documentation and communication of professional practices is advised for such purposes.

II. PATTERN APPROACH FOR DOCUMENTATION OF PROFESSIONAL PRACTICES

Pattern approach for documenting and training expert skills was introduced by Christopher Alexander and was applied in architectural domain [4]. He has proposed a pattern language consisting of a series of patterns for improving quality of architectural designs. The same was suggested by Grady Brooch to Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides who are well-known by Group of four (GOF). They found a set of solutions for problems in design issues which are known as design patterns, which are classified as creational, structural and behavioral patterns [6]. Microsoft COM Technology uses several design patterns for building COM frameworks. Programming in Component Technology needs understanding of these design patterns.

GOV known as Group of Five presented Architectural patterns. Frameworks are defined as semi completed reusable applications, using patterns for building

applications in an efficient way. Frameworks are domain specific unlike design patterns.

A series of patterns which address a common problem are named as pattern language. Pattern language is useful for documenting expert skills for communicating and training professionals. Coplien presented C++ programming styles as a set of patterns. The pattern language mechanism is in use for presenting Java-based programming models. Coplien says that a good pattern solves a problem, is a proven concept, describes relationships, contains a significant human component such as comfort, quality of life etc.

Several pragramming practices have been in use before evolution of the pattern concepts. As they are very common and well known they will be generally referred to as primitive patterns. For example, Object Oriented Programming addresses several programming issues and presents several concepts and environment implementation of these concepts. Programming practices and concepts such as Polymorphism, function overload, static functions and data, exception handling, inheritance, interface, abstraction, encapsulation, friend functions, inline functions and several object oriented features are reffered to as primitive pattern.

The main reason to call existing programming features like object oriented features as primitive patterns is to use them as participating in forming a pattern language. Each primitive practice has a purpose and design to solve a set of problems. Giving pattern light to programming style makes programmer understand the specified purpose of usage of these concepts.

III. A JOURNEY TO OBJECT ORIENTATION

This section presents the need of object orientation in the light of managing functionality in the Extreme Programming way of development in small cycles, refactoring for client requirements and change management (from simple C to C++). A simple first step programming in C for handling requirements of a list of elements represented as a matrix is considered as base requirement as presented in Table 1.

The purpose of the example C program is to read, store, sort and print a list of elements of user choice. Finding the limitations and reconsidering the requirements is referred to as refactoring (in XP), and the process helps in evolving and introducing new concepts. By repeating such process leads to the evolution of new programming methodologies and models.

TABLE I.
C PROGRAM FOR MANAGING MATRIX OPERATIONS

```
void main()
{
<<   1. code for   Declare data  variables >>
            int List[10];
            int  Count, totalNoOfElements, temploc;
< <  2. Code for Initialize variables  >>
<<   3.  Code for Read the list of  Elements  >>
<<   4.  Code for Print the Input  List >>
<<   5. Code for Perform Sorting operation >>
<<   6. Code for Printing  Sorted List >>
<<   7. Code segment for Exiting  Application >>
}
```

For example, generalizing concepts of given C program in the light of reuse, the new concept, namely template, evolved. Templates are created in several languages to store and sort any element types to reuse the procedures. Further generalization of concepts leads to evolution of design pattern 'Template'.

Template is a design pattern (behavioral pattern). As per GOF, *Template is intended to define the skeleton of an algorithm in an operation, deferring some steps to subclasses*. The Template method lets subclasses define certain steps of an algorithm without changing the algorithms structure.

TABLE II.
A PROGRAM IN C FOR MANAGING A SIMPLE LIST OPERATIONS

```
typedef struct
{
        int List[101];
        int m_itotalnos;
} DataList;
<< Define function to perform operation on data  >>
void ReadDataList(DataList* Data)
void DisplayDataList(DataList data)
void SortDataList(DataList* Data)
void AddToDataList(DataList* Data,int Ele)
void Exit()
<<  Write main  program which is a client for these above reusable code
segments >>
void main( )
{
   DataList MyData; // Declare List
   ReadDataList(&MyData); //  Read List
   printf("The input list is shown below \n "); // Print List
   DisplayDataList(MyData); // Sort DataList
  SortDataList(&MyData); // Print Sorted List
   DisplayDataList(MyData); // Print List
   Exit();// Exit program
}
```

As a next step to the selected example, the following modifications improve the quality of the program. The new program structure with new changes is presented in the Table 2.

i) Introducing functions, code segment are reused

ii) Defining a proper data type enables data binding problems to be handled.

Refactoring the changed program creates scope for new client requirements.

i) Requirements related to packing data and procedures defined on it forming a single entity
ii) Techniques for exporting the functionality
iii) Addressing Encapsulated issues
iv) Requirements related to configuration of functionality
v) Exporting functionality across the process, in a distributed environment and over the internet.

These questions raise the need to use object oriented features. A simple sample class in C++ is presented in table: 3.

TABLE III
A CLASS IN C++ FOR MANAGING FOR SIMPLE LIST OPERATIONS

```
class DataList
{
private:
        int m_ List[101];
        int m_iTotalNos;
public:
        DataList(void); // Constructor
        void ReadDataList();
        void DisplayDataList();
        void SortDataList();
        void AddDataList();
        void AddToDataList(int Ele);
       ~DataList(void); // distracter
}
```

Typical practices and techniques related to exporting functionality are addressed in the following sections.

Iv. EXPORTING FUNCTIONALITY THROUGH LIBRARIES

The project work space concepts and creating a directory structure are essential for exporting functionality. Microsoft Integrated development environments (IDE) provide several frameworks for managing project work spaces suiting several requirements. The management of directory structure provides good program code management practices; it is also helpful for sharing files across different project workspaces. Sample generic directories used frequently are BIN, DEGUD, RELEASE, SRC, INCLUDE, OBJ, LIB and DEF. Creating proper directory structure is an essential feature of complex projects where several places of project development share files across projects. Sometimes the directories are shared across Internet using FTP protocols. Visual sources like code management tools also suggest proper directory structure for code management where several programmers work in parallel and share common files for development and bug fixing.

The *static data* and *static function* are known as class members. But the token word static represents limited scope, which means a static function defined in a source file exists and extends its visibility to that file scope only. This behavior of static functions can be used for exporting functions across files within a project workspace encapsulating the internal implementation and dependent functions. Object files carry the implementation code and headed files carry interface function definitions which are exported to the client. This procedure of exporting functions through object files is presented in Table 4:

TABLE IV.
EXPORTING FUNCTIONS THROUGH OBJECT FILES

SERVER PROCEDURE:

i) Define internal functions which have no relevance to client and which are required to perform client task through interface functions as static functions.
ii) Define interface functions which are exported to the client as non-static functions
iii) Define prototype of these in a header file and keep the header in a INCLUDE directory.
iv) Compile the source file which generates an OBJ extension object file; this can be directed to OBJ directory with suitable settings at project workspace.

CLIENT PROCEDURE:

Include the header file in client code and attach the object to project workspace.
Use the interface functions defined in header file at client code irrespective of hidden dependent functions.

The next model presents exporting through static and dynamic libraries using special project files. IDE of Microsoft provides projects workspace for static and dynamic libraries separately. The static libraries attach functions to executables at the time of linking. This will increase the size of executables in proportion to included functionality.

In dynamic libraries, the functionality is attached through a dll extension file at run time. In dynamic link libraries the executable file needs to carry all the dependent dlls. The lib file generated at the time of building the server application carries the dll path and other required information.

The dynamic library concept makes the executable files lightweight. Large scale applications can be loaded with limited RAM as the executable size is very low. In huge applications, the total functionality supported and implemented in an application is larger than the functionality required at a particular time of execution for performing task of that time. The operating system automatically unloads the unused dlls and loads required dlls dynamically for optimizing the internal memory.

This model of exporting functionality has another advantage; it allows loading required (purchased or permitted) functionality alone to be distributed to clients. In case the required dll file is not available during run time, due to some problem (or unauthorized usage), the operating system will raise an exception and give a message to the user, thus preventing runtime error problems.

Implementations of these models need a '*definition file'* with def extension. A sample def file is presented in the Table 5. The functions defined in def file alone will be exported to the client project. The project space will

automatically encapsulate the internal details. Defining internal functions as static functions is not required in this model.

TABLE V.
A MODEL SAMPLE DEFINITION FILE FOR BUILDING A DYNAMIC LINKED LIBRARY SCRIPT FOR THE SRC/Srever.def FILE

```
LIBRARY         DLLSERVER
;CODE           PRELOAD MOVEABLE DISCARDABLE
;DATA           PRELOAD MOVEABLE SINGLE
HEAPSIZE        1024
EXPORTS

   InterfaceFunction01          @1
   InterfaceFunction02          @2
```

In case of function overload (same name is used for more than one function with different arguments), the name of the functions along with arguments (generated by the compiler) which are available in the library and object file will need to be used in definition file.

V. FUNCTION CLASSES

This section presents framework model for exporting functionality. This is referred to as '*function classes'*. The function class is a class which has only functions or methods defined without data like interfaces. Interface classes are abstract but function classes are not abstract classes; they include implementation. In general, a class has data (to compute the state of object) and methods (to implement behavior) that work on data to change object state. The function class is coined only to export functions with client-oriented features using object primitives.

In applications like CAD, GIS we find lot of function libraries at different levels. For managing and exporting functions in a professional way function classes provide solutions. Several object oriented features (primitive patterns) can be applied on these classes to make these libraries user friendly and allow client to configure the inherent procedures as per requirements in an authorized way. For example if client want to define his own model which is used in building the interface function client can do such operations using object oriented features for managing multiple behavior.

Table 7 will present sample code segment required to export a function class. In the given sample macros are defined to manage a uniform header file for class definition which will present the definition as per the requirements of client and server. A brief description of function class is presented in Table: 6

TABLE VI
THE FUNCTION CLASS PATTER-FRAME

Name: Function-class pattern-frame

Intent: The intent of this framework is to manage scalable function libraries.

Motivation and Applicability: Several scalable function-groups are required in the domain of graphic, CAD and GIS. Such requirements are managed using such pattern-frame models.

Structure: The Architecture of function–class frameworks is presented in Figure 1.

Participants: Abstract Function class: This class defines the function – groups.

Function class: This class implements the function groups

Abstract Primitive: This class is used for defining the configurable function-groups.

Primitive Library: This class is used for implementation of configurable function-groups

Collaboration and consequences: The Function class implements the abstract function class which is an interface. This implementation depends on Abstract Primitive which is another interface. The primitive library which is supposed to implement the abstract primitives is used for configuring the function-groups. The client can add his own primitive library for configuring the function group as per the requirements. Sample Code segment for implementation is presented in table 8.

TABLE VII
A MODEL CLASS DEFINITION FOR EXPORTING A CLASS

```
#ifdef BEEPSERVER
class __declspec( dllexport ) CBeep
#else
class __declspec( dllimport ) CBeep
#endif
{
public:
void Interface Function01(void);
void Interface Function01(void);
};
```

TABLE VIII
SAMPLE CODE SEGMENT FOR FUNCTION CLASS

```
class AbstractPrimitive
{
public:
 virtual   Line (<<list of argument >>) = 0;
 virtual  EllipticalArc (<<list of argument >>) = 0;
}
class AbstractGraphicFunctions
{
public:
virual   Rectangle(<<list of argument >>)) = 0 ;
virual   Square(<<list of argument >>)) = 0;
virual   Polygon(<<list of argument >>)) = 0;
virual   Circle(<<list of argument >>)) = 0;
virual   Ellipse(<<list of argument >>)) = 0;
};Class GraphicFunction : public AbstractGraphicFunctions,
AbstractPrimitives
{
   << Implements Abstract functions and depends on AbstractPrimitives
>>
};class PrimitiveLibary: public AbstractPrimitives,GraphicFunctions
{<<  Implementation of AbstractPrimitives >>
}
```

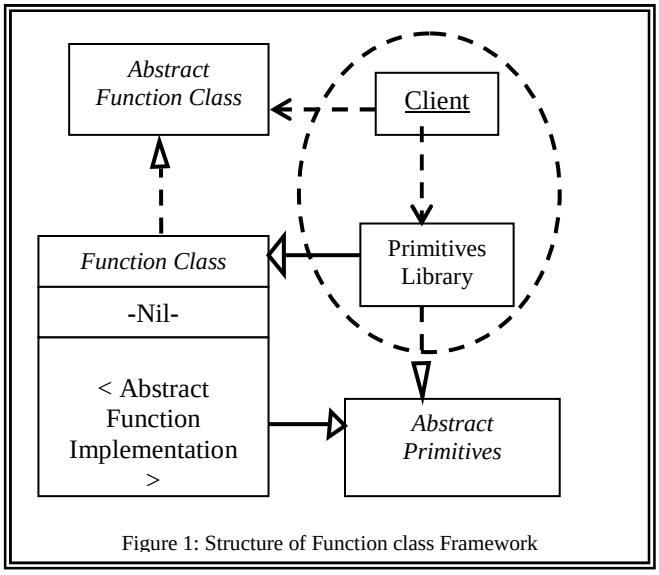

Figure 1: Structure of Function class Framework

The above classes do not have any data members. They have only functions. The Architecture of this function class framework is named as function class pattern-frame. This is different from the set of function libraries. Important features of function class framework as compared with a function library are listed below.

i) The Function class frameworks allow user to configure to the user requirements. As an example, the user of the above class wants to use the above class, but he wants to use another DDA algorithm instead of the simple DDA algorithm both for line and elliptical arc. For achieving this, client will inherit from the abstract-primitive class and will implement the virtual functions.

ii) The client can extend the function class by adding some more graphic primitive procedures. In this case, the client defines another abstract function class. The abstract-function class of the existing framework will become abstract primitive for the new extended framework. This procedure can be used in an iterative way.

iii) Exporting a class is more efficient than exporting a set of functions.

iv) These function classes are not objects and they do not have state. They exhibit behavior. They can be treated as a package of functions.

v) It is possible to implement these function classes even in other languages like Java. Any language that implements Object oriented patterns such as inheritance and polymorphism, and supports Dynamic linked libraries, is suitable for implementing function classes.

vi) The Dynamic Linked Libraries make the function classes loosely coupled with the Applications. This will enable changing the implementation of function classes without affecting the client application or modules, thereby making function-classes scalable.

V. MIDDLE WARE FRAMEWORKS FOR CREATING COMPONENTS

The middle ware frameworks provided in IDE allow exporting functionality in modern and other complex technical environment in a simple way through a set of wizards. The COM DLL enables a procedure to export functionality over COM interfaces which are more efficient in management but core COM object implementation is complex. Several frameworks like Active Template Library for creating ATL objects are available in IDE for exporting over COM interfaces. Several pattern-frames are designed to handle COM model simple to use [3]. The SOAP simple object access protocol is also providing frameworks for exporting functionality as web services. All these frameworks work like wrappers over existing traditional models of exporting. Figure 2 presents a middleware integration framework for exporting object oriented frameworks using IDE and middleware interaction frameworks for components. The same can be adopted for other IDE models.

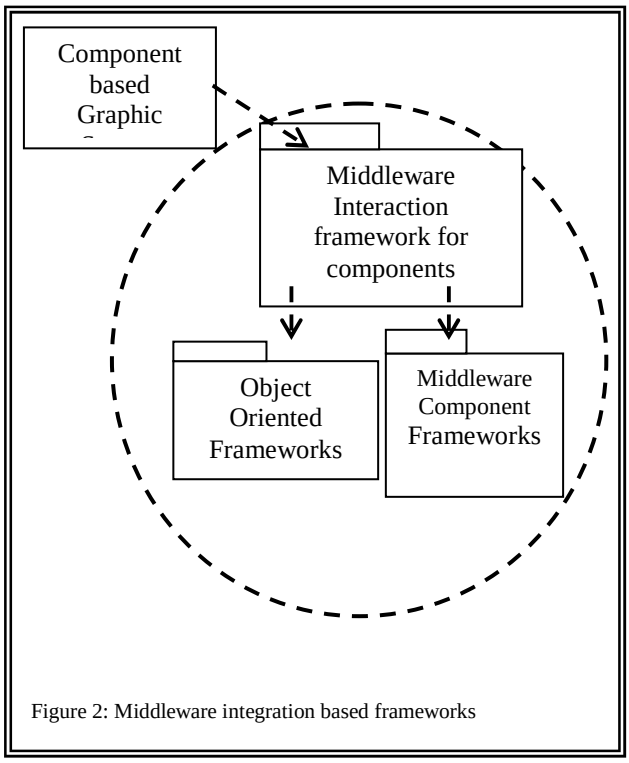

Figure 2: Middleware integration based frameworks

CONCLUSIONS

Various programming practices for exporting functionality are presented starting from simple unstructured first level programming is C. The method of refactoring for changing to new model as specified in extreme programming XP is adopted along with a pattern way of presentation. The former presented models referred to as programming tips are styles and latter are known as pattern-frames. The later models use object oriented pattern primitives to solve the problems. Presented pattern frame exports functionality in a user friendly way, enabling client applications to configure the functionality as per requirement. These models can be further exported to new technologies using frameworks available in IDE. Some of the pattern frames are not discusses in detail as they are beyond the scope of this paper. The solutions are aimed at training programmers for efficient programming related to a particular problem. Such sequence of models for domain specific problems forming a pattern language is suggested.

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AUTHOR'S PROFILE

Dr. Hari Ramakrishna was awarded B.E in Computer Science and Engineering in 1989 by Osmania University, Hyderabad, A.P., INDIA, M.S., in Computer Science by BITS PILANI, INDIA and Ph.D. in Computer Science and Engineering by the Faculty of Engineering Osmania University in "Pattern languages for graphic /CAD frameworks". He has worked in Software Industry for several years developing Graphic, CAD /GIS products using Microsoft environment. He has about 16 years of teaching experience. Presently he is working as a Professor for last 8 years in the Department of Computer Science and Engineering at Chaitanya Bharathi Institute of Technology, Hyderabad INDIA. He is involved in the design and development of several graphic frameworks for various Engineering applications

Heart Disease Prediction System Using CRISP-ADM and Decision Trees

V.Krishnaiah[1] ,Dr.G.Narsimha[2], Dr.N.Subhash Chandra[3]
[1] Assistant Professor, Dept. of CSE, CVR College of Engineering, Ibrahimpatnam(M),R.R.Dist., AP, India.
Email: varkala.krish@gmail.com
[2] Associate Professor,Dept. of CSE, JNTUH College of Engineering, Kondagattu, Karinagar(D), AP, India.
Email: narsimha06@gmail.com
[3]Professor of CSE & Principal, Holy Mary inst. of Tech. & Sc., Keesara (M), R.R.Dist., AP, India.
Email: subhashchandra_n@yahoo.co.in

***Abstract*—This paper aim is to average the use of techniques of decision trees, in combination with the management model CRISP-ADM, to help in the prediction of heart diseases. It is widely based on decision trees, an important concept in the field of artificial intelligence. This paper focuse on discussing how these trees are able to assist in the result making process of identifying heart diseases by the analysis of information provided from the hospitals. This information is captured with the help of techniques and the CRISP-DM management model of data mining in large prepared databases logged from hospital day to day transactions.**

***Index Terms*—Heart disease, Data mining, prediction, Decision tree. CRISP-ADM, etc.**

I. INTRODUCTION

Accurate and error-free of diagnosis and treatment given to patients has been main issue decorated in medical service present days. These systems produce enormous amounts of data which take the form of numbers, text, charts and images. This data may consist a lot of hidden information which can be use in behind the clinical decision making. The main inspiration for this article is: "How we can turn the data into useful information to support decision making by healthcare practitioners?"

A good prediction system for heart disease can be proved as a better tool for improving the efficiency of a hospital and clinicians. It is very important for clinician as well as patients to know the future holds of heart disease patients for planning the better treatment. The taking of use of data mining approaches in present healthcare system is increasing quickly, because the success of these approaches to classification and prediction systems has enhanced, mainly in relation to helping medical practitioners in their decision making. This article can play an important role in civilizing patient outcomes, cost reduction of medicine, and further advance clinical studies.

II. METHODOLOGY

*Purpose***:** Heart disease prediction using decision trees uses the one of the prominent models of classification which is decision trees to predict the status of possibility of patient having disease or not using the training dataset.

Scope: Clinical diagnosis is regarded as an main yet difficult task that needs to be executed accurately and well. The mechanization of this system would be very useful. Efficient and accurate implementation of mechanical system wants a relative study of different techniques available. This paper intention is to analyze the different predictive/ descriptive data mining techniques proposed in present years for the diagnosis of heart disease.

Classification:

Classification is a data mining function that assigns items in a group to target categories or classes. The objective of classification is to accurately predict the target class for each case in the data.

The Decision tree growing algorithm is mentioned beneath.

Tree Growing (S, A, y):

Here:
S - Training Set
A - Input attributes Set
y - Target attribute
Create a new tree T with a single root node.

IF one of the Stop Criteria is fulfilled THEN
Mark the root node in T as a leaf with the mainly general value of y in S as a tag.
ELSE

Find a discrete function f (A) of the input attributes values such that splitting S according to f (A)'s outcome (v1... vn) gains the best splitting metric.

IF best splitting metric >threshold THEN
Label t by f (A)

FOR each outcome v_i of f (A): Set Sub tree *I* = Tree Growing ($\sigma f(A) = v_i S$, A, y).
Connect the root node of *T* to Sub tree *I* with an edge that is labeled as v_i

END FOR
ELSE

Mark the root node in T as a leaf with the most general value of y in S as a tag.

END IF
END IF

RETURN

Top-Down Algorithmic structure for Decision Trees Induction:

The possibility vector has a part of 1 (the variable *x* gets only one value), then the variable is defined as clean. On the other hand, if all components are equal, the level of infection reaches maximum. Given a training set *S*, the possibility vector of the target attribute *y* is defined as:

The good–of–split due to discrete attribute *ai* is defined as reduction in dirtiness of the target attribute after partitioning *S* according to the values vi,j a *dom* (*ai*):

$$\Delta\Phi(a_i,S)=\phi(P_y(S))-\sum_{j=1}^{|dom(a_i)|}\frac{|\sigma_{a_i=v_{i,j}}S|}{|S|}\cdot\phi(P_y(\sigma_{a_i=v_{i,j}}S))$$

Information Gain: Information gain is an impurity-based criterion that uses the entropy measure (origin from information theory) as the impurity measure

$$InformationGain(a_i,S)=$$
$$Entropy(y,S)-\sum_{v_{i,j}\in dom(a_i)}\frac{|\sigma_{a_i=v_{i,j}}S|}{|S|}\cdot Entropy(y,\sigma_{a_i=v_{i,j}}S)$$

Where:

$$Entropy(y,S)=\sum_{c_j\in dom(y)}-\frac{|\sigma_{y=c_j}S|}{|S|}\cdot\log_2\frac{|\sigma_{y=c_j}S|}{|S|}$$

The CRISP-ADM Methodology:

The CRISP-ADM methodology is describe in conditions of a hierarchical method representation, comprise four levels of abstraction (from general to specific): phases, generic tasks, specialized tasks, and procedure instances.

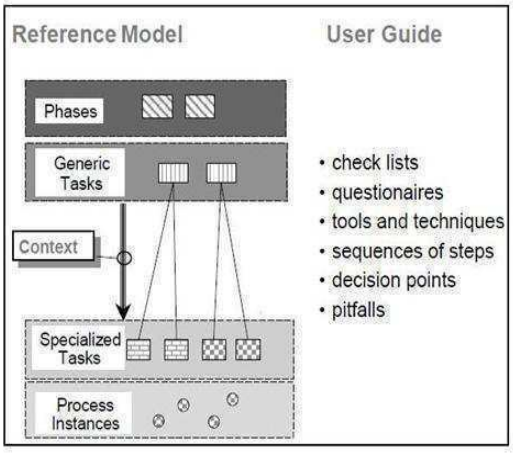

Figure 1. Four level breakdown of the crisp-dm methodology

The CRISP-ADM methodology distinguish between the Reference Model and the User Guide. while the Reference Model presents a fast outline of phases, tasks, and their outputs, and describes what to do in a data mining project, the User Guide gives more thorough instructions and hints for each phase and each task within a phase and depicts how to do a data mining project.

TABLE I.
DATASET ATTRIBUTE EXPLANATION
ATTRIBUTE INFORMATION 15 ARE USED.

1. Id: patient identification number

2. Age: age in years (that will be changed to nominal attribute with values ranging young, idle, old, very old.)

3. Sex: sex (1 = male; 0 = female)

4. Cp: chest pain type
   -- Value 1: typical angina
   -- Value 2: atypical angina
   -- Value 3: non-angina pain
   -- Value 4: asymptomatic

5. Trestbps: resting blood pressure (in mm Hg on entrance to the hospital)

6. Chol: serum cholesterol in mg/dl

7. Smoking: (1 = yes; 0 = no (is or is not a smoker)

8. Fbs: (fasting blood sugar > 120 mg/dl)
   (1 = true; 0 = false)

9. Restecg: resting electrocardiographic results
   --Value 0: normal
   --Value 1: having ST-T wave abnormality (T wave inversions and/ ST elevation or depression of > 0.05 mV)
   --Value 2: showing probable or definite left ventricular hypertrophy by Estes' criteria

10. Thalach: greatest heart rate achieved

11. Exang: exercise induced angina
    (1 = yes; 0 =no)

12. Slope: the slope of the max out exercise ST segment
    -- Value 1: up sloping
    -- Value 2: flat
    -- Value 3: down sloping

13. Thal :(3 = normal; 6 = fixed defect;
    7 = reversible defect)

14. Overweight :(yes =1, no=0)

15. Alcohol intake: (Never, Past, Current)

The goal of our project is to establish a standardized process which can be reliably performed by marketing people with only little data mining skills and little time to experiment with different approaches.

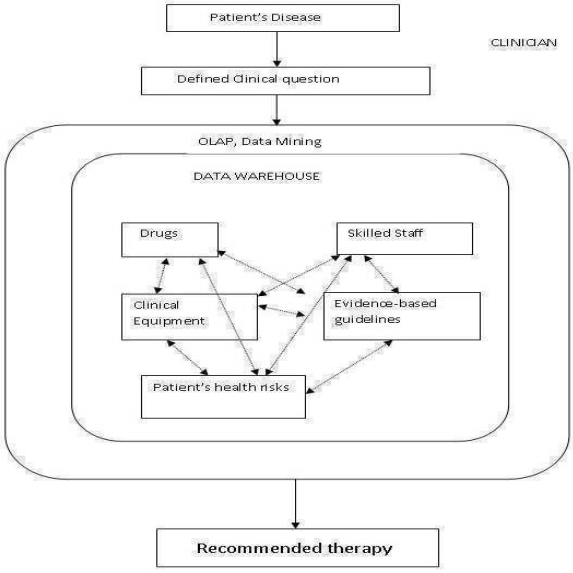

Figure 2: clinical task

III..DESIGN

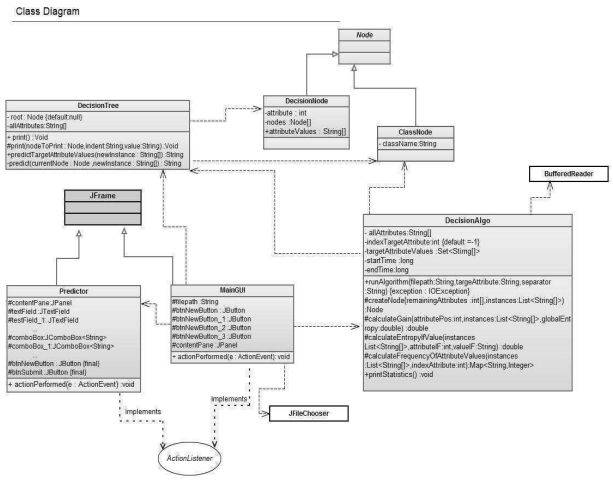

Figure 3: class diagram

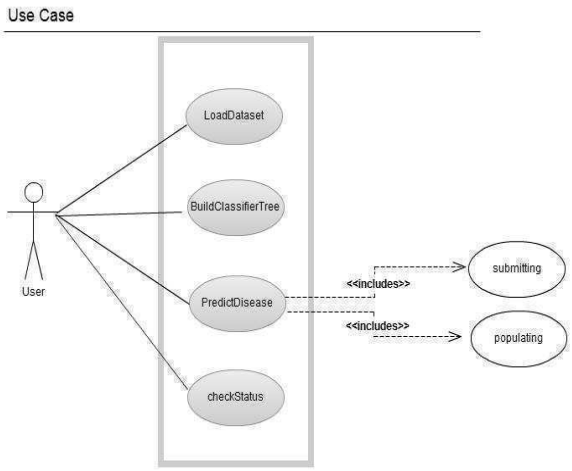

Figure 4: use case diagram

The above use case diagram has user as actor. The user first selects the document set on which the classification must be performed by clicking the "Load Dataset" button. The user can then go for a classification model build based on the loaded dataset. Once the dataset is built new patient details (symptoms) can be entered through the predictor frame. Once the predictor is appropriately populated he can then know the status of the heart disease.

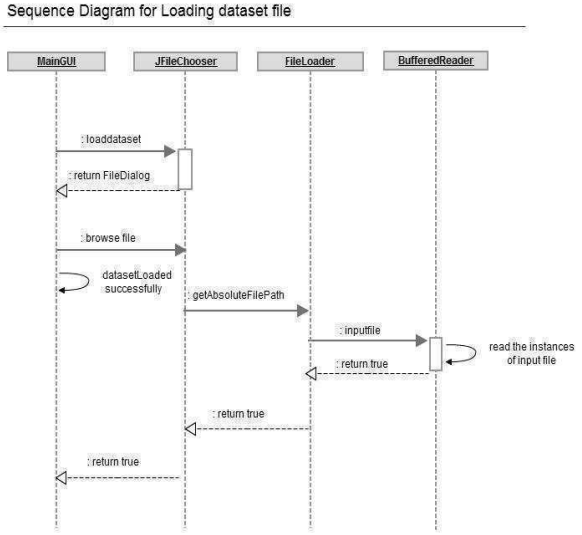

Figure 5:Sequence Diagram for loading dataset file

The above sequence diagram how the different objects come into existence while loading the dataset from local or remote system. Once the instance of Main GUI is running the user clicks the load dataset button and get a J File Chooser which is used to browse for the file we are interested in. Once we are done with choosing the file File Loader object will load the file into the memory. Using the Buffered Reader object we read the instances of dataset.

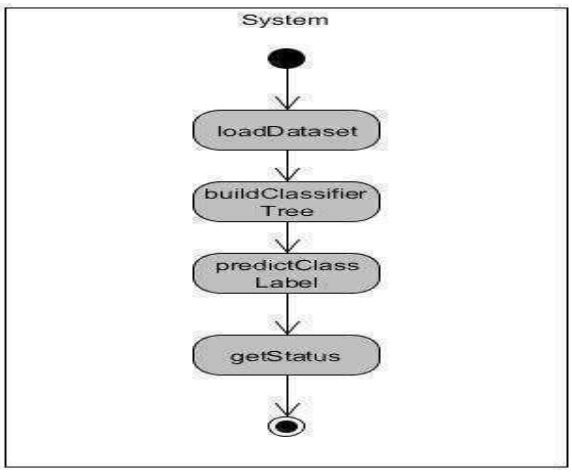

Figure 6:Activity Diagram to get the disease status of patient

The above activity diagram has user as actor. The user first selects the document set on which the classification must be performed by clicking the "Load Dataset" button. The user can then go for a classification model build based on the loaded dataset. Once the dataset is built new patient details (symptoms) can be entered through the predictor frame. Once the predictor is appropriately populated he can then know the status of the heart disease.

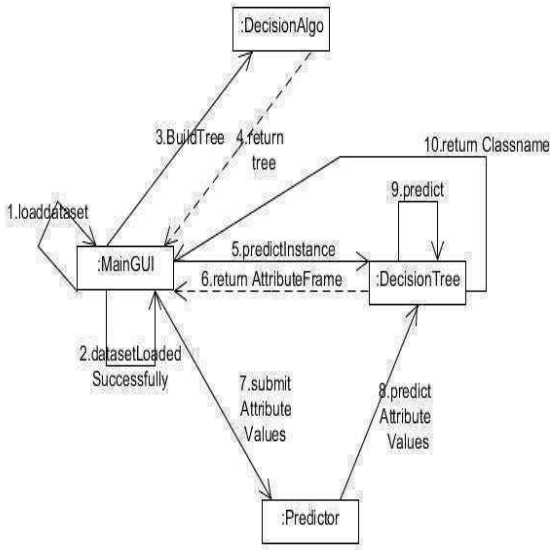

Figure 7: Collaborating Diagram for Predicting the class label of an instance.

The over collaboration diagram shows the different objects come into existence user is trying to predict the class label of a particular instance given by user has already entered the details of a new patient

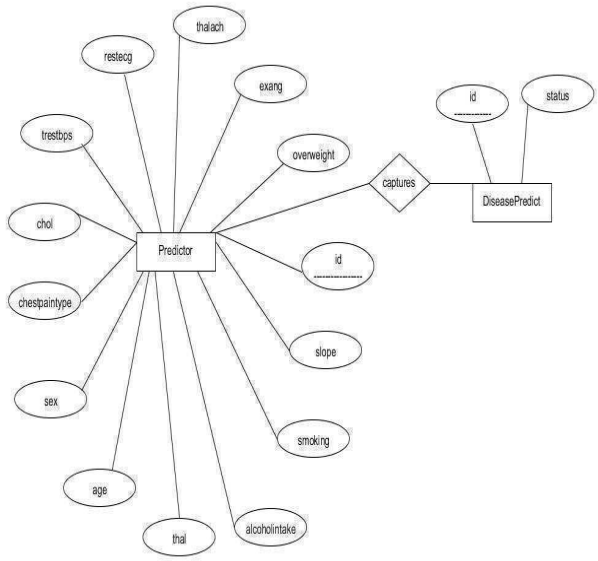

Figure 8: ER diagram

IV.IMPLIMENTATION

Test_Case_id: 01

Test_Case _name: Check whether the application main window is executed and displayed properly or not.
Assumptions: Everything is ok with the IDE and java runtime system is installed apriori.
Procedure: We need to run the main program which is name after "Main GUI. Java".

Expected Result: The Frame is displayed properly.
Actual Result: The Frame is displayed as intended.
Status: PASS.

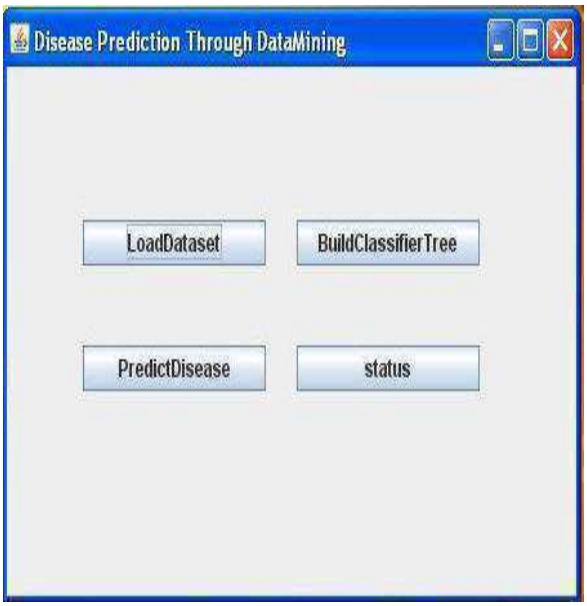

Figure9: Test case 1

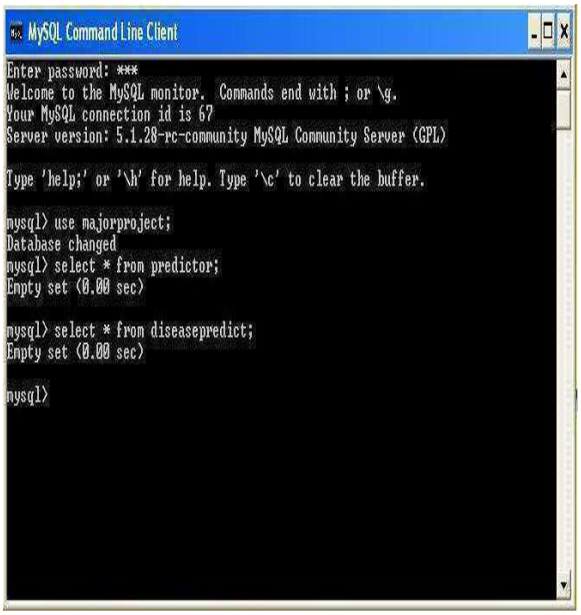

Figure 10: Test case 2

Test_Case_id: 02

Test_Case _name: Check the status of database tables when no records are available.
Assumptions: The database software we are using MySql is properly configured and the database and tables are accordingly created with no default values initially.

Procedure: We need to click open"MySql" command prompt and check the status of tables with the query "select * from predictor".

Expected Result: At the start of the execution the query should show "Empty Set".
Actual Result: The query resulted in "Empty Set".
Status: PASS.

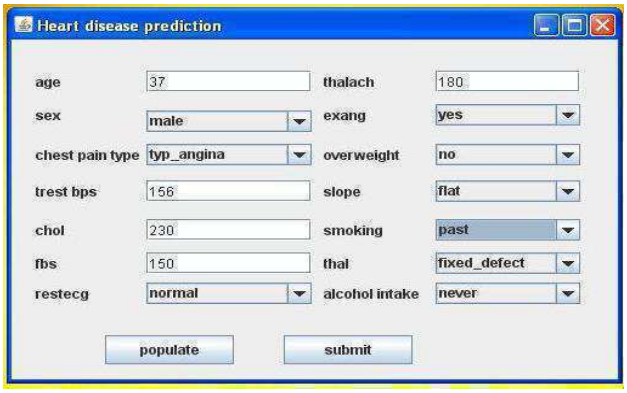

Figure 11: Test case 3

Test_Case_id: 03

Test_Case _name: Check whether the "Predict Disease" button is working properly or not.
Assumptions: Everything is ok with the IDE and java runtime system is installed apriori. And the main class of "Main GUI java" is successfully run and displays the frame. A dataset on heart disease is loaded successfully. And a Classifier is built.
Procedure: We need to click on the "Predict Disease" button.

Expected Result: The Predictor frame can open up where we can give different attributes of heart attack symptoms. And a Dialog box should open up to show the unique id of the patient.

Actual Result: The Predictor Frame opened up successfully where we can give different attributes of heart attack symptoms. And a Dialog box open to show the unique id of the patient.
Status: PASS.

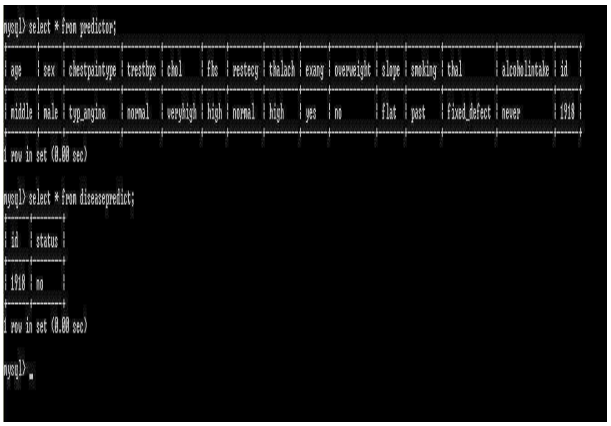

Figure 12: Test case 4

Test_Case_id: 04

Test_Case _name: Check the status of database tables "diseases predict "when the patient status is predicted.
Assumptions: The database software we are using MySql is properly configured and the database and tables are accordingly created with no default values initially. And by successfully enter the values using the predictor frame which is opened by clicking the "Predict Disease" button. And user wants to find the status by selecting the status button.

Procedure: We need to click open"MySql" command prompt and check the status of tables with the query "*select * from disease predict".

Expected Result: The query should show tuples list according to patients.

Actual Result: The query resulted in some tuples.
Status: PASS

V.CONCLUSION

At the present days, the decisions taken by experts and practitioners from many different branches of action must be rapid, accurate and with the possible lowest level problems caused by these decisions. Not with position this fact, due to the difficulty of factors and methods, specialists are level to making incorrect conclusions in their work. Based on the implementation of our proposed decision tree, and the test results on a sample actual database, we conclude that the decision trees with a criteria for data mining help in decision making, particularly in the managing of large data.

ACKNOWLEDGMENT

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Improving the Software Quality using AOP

B Vasundhara
Associate Professor, Computer Science Department, AMS School of Informatics, Andhra Pradesh, India,
vasu_venki@yahoo.com

Abstract **- The goal of software engineering is to solve a given application problem by implementing a software application system. Programming languages are important in software engineering. Ever since the advent of high-level programming languages, improvements have been motivated because of the need to build better software more rapidly. Concerns exist at every level of the system development process. The goal of modularization is to build application software that is maintainable and reusable. To implement such concerns we need to use a programming language that supports modularization. All the software engineering methodologies are expected to recognize the concerns of a system like the aspect-oriented software development (AOSD). AOSD additionally also classifies each of the concerns identified. Concerns in a system are of two types, core concerns and cross-cutting concerns. Core concerns make up the primary structure of the system. Cross-cutting concerns are those concerns that spread throughout the system. A major objective in software engineering is to increase code reuse in new systems as reuse saves development time. We can use the aspect-oriented programming (AOP) technique to improve software quality characteristics including, correctness, reliability, reusability, usability, efficiency, extendibility, timeliness, easy to use, etc.**

Index Terms **- AOSD, AOP, Software Quality, AspectJ, Crosscutting Concerns, Join Point, a Pointcut**

I. EVOLUTION OF SOFTWARE ENGINEERING CONCEPTS – MODULARIZATION AND REUSE

The increasing intricacy, configuration and adaptability of real-time systems have become a strong motivation for applying new software engineering principles, like aspect-oriented development. AOSD improves the existing programming techniques by allowing the identification and description of concerns that crosscut many modules of the system. Applying AOSD in real-time application systems reduces the complexity of the system design and development. AOSD provides a way for a structured and efficient way to handle the crosscutting concerns in the system. We use AOP, a method for improving separation of concerns in software [1]. AOP is built on preceding technologies, like procedural and object-oriented programming which have already made substantial improvements in software modularity. The idea behind developing AOP is that, though the modularity mechanisms of object-oriented languages are extremely useful, they are essentially unable to modularize all concerns of interest in complex systems. To achieve this, AOP deals with crosscutting aspects of a system's behavior as isolated as possible.

Software modularity is a software design technique that builds the modules by breaking down the possible program functions [2]. Each module devised handles one of the many functions. Each module represents each of the separation of concerns, and thus improves the system maintenance by enforcing valid boundaries between the concerns. Aspects help in achieving increased modularity of the system and separation of concerns. Separating the functionalities as modules helps to control the system complexity. Software systems are conceptually complex by very nature, and increasing their complexity in the implementation means increasing the expense and the probability of failures. The code needed to integrate a complex implementation is expensive. The cost would be even higher if new features are to be added as and when required. Mostly adding new feature implies deep changes in several parts of the application implementation. So, we have to single out the modules that will implement the core business functions and that justify the design and implementation of software.

II. DRAWBACKS IN OBJECT-ORIENTED PROGRAMMING

An application may have some functionalities crossing it transversally, called as crosscutting concerns**.** A crosscutting concern is an independent entity that crosses other functionalities of software. Common crosscutting concerns include security of the system, logging across different functions when encountered, the transactions management, tracing, performance, synchronization, exception handling, etc. Such crosscutting concerns, if implemented only with object-oriented programming (OOP), results in a bad matching between the core concerns and the modules that implement the cross cutting concerns. So, when using OOP we are forced to deal with the execution of the crosscutting functionalities in separate modules, and further there may be a need to add other related modules or modify the existing ones. Therefore, it becomes necessary to modify the code in which these modules are used. This is undesired, but a necessary matching that the OO implementation unavoidably brings with it.

The crosscutting concerns in OOP gives rise to the problem of scattering code, due to the transversality of the crosscutting concerns that are implemented in classes. In such situations, AOP provides support to OOP for uncoupling modules that implement crosscutting concerns. AOP's purpose is the separation

of concerns. In OOP, the fundamental unit is the class**,** while it is an aspect in AOP [1]**.** The aspect contains the implementation of a crosscutting concern. Code scattering appears when the application functionality is scattered due to its implementation in separate modules. Code tangling takes place when a module has to manage quite a lot of concerns at the same time, like logging into an application system. With an OO system, code tangling and code scattering can occur, thus causing the system to have duplicate code and result in functionalities not being clear.

AOP is a programming concept that is based on the identification and separation of both the core and crosscutting concerns of software. AOP is an extension of OO paradigm, in the sense that it provides new constructs for the modularization of crosscutting concerns. The main objective here is to define an implementation methodology using AOP to achieve better software with better quality [2]. With AOP, the crosscutting functionalities are extracted from the OOP implementations and applied as advices where they are actually executed. In OOP, we develop the code for every module where a functional component is encountered. While in AOP, an aspect code is developed and injected into the right locations of the base program using an aspect weaver. The main aim of an AOP language, like AspectJ, is to make sure that the aspect code and non-aspect code run together in a coordinated way using the process called aspect weaving.

III. ISSUES IN REAL-TIME APPLICATION SYSTEMS

The correctness of a real-time application system, depends both on the correct result produced by the computation and the time when the result is produced. Hence, enforcing timeliness is essential to the overall correctness the system. The increasing complexity in the design, adaptability and performance of a real-time system prompts us to use new software engineering programming methodologies, like AOP. Using AOP, the modules or concerns identified are incorporated into the program through interfaces.

Software reliability depends on system requirements, good design and implementation. A system fails if its behaviour is not consistent with its specification. The applications that need systems to maintain a predictable and correct functionality even in the presence of faults include online banking, mobile commerce, etc. For a system to be dependable, it must be available, reliable, safe, and secure. Software may undergo several upgrades during the system life cycle. These upgrades enhance the software reliability by re-designing or re-implementing the required modules. Further, new unexpected problems may arise. The two main concerns that have to be considered when designing the real-time application systems are the timeliness and criticality of the system. Additionally, we need to also consider that the systems are bounded by limited resources. To achieve the criticality and timeliness concerns with minimal resources, the real-time application systems use different techniques which involve a number of modules of the system. This makes it mandatory to use approaches like AOP.

IV. USING AOP FOR REAL-TIME APPLICATION SYSTEMS

The functional perspective of real-time application systems can be developed using conventional OOP, but the real-time perspectives like scheduling policies and synchronization mechanisms are better implemented using AOP. The purpose of AOP is to provide systematic means to modularize crosscutting concerns. AOP is an approach in this direction, which attempts to achieve the resuse of code and design in a much better way than OOP. Aspect-orientation is used in realtime application systems for distribution, timeliness and dependability domains [1].

We have a number of benefits in using AO techniques when compared to OO techniques. The primary benefit of this transition is the increased modularity. As concerns have been separated, the system's modules that were implemented to solve a given concern are not tangled with calls to modules that deal with unrelated, cross-cutting concerns. Also, these cross-cutting concerns are not scattered and are packaged into a single module. This, in turn, has several benefits throughout the software life-cycle, such as increased maintenance and reusability. An additional benefit of aspects is that of a reduction in the size of code. As aspects collect commonly repeated code into advice with a pointcut to where that code is relevant, the code-base will be smaller, when aspects are used, than when they are not used.

The key problems a system designer would face during the aspect-oriented design process include the identification and classification of concerns, testing the concern designs, reusing them, designing the concern modules, and refining the AO design. A standard aspect-oriented design process is an extensible, customizable and independent process which is easy to adopt. The existing literature describes less about the aspect oriented design processes in use; we can evaluate and validate the aspect oriented design process by applying it to case studies. Examples of the cross-cutting concerns include logging, exception handling, security.

The code to employ features like authentication, authorization, logging, exceptions, etc., is frequently scattered across the whole application. This will reduce the consistency, sustainability and quality of software. These characteristics are called crosscutting concerns. It is difficult to modularize the crosscutting concerns as they affect multiple functions and modules in the system. The AOP allows the localization and modularization of crosscutting concerns, thereby providing another level of abstraction called aspects.

While we are aware that crosscutting concerns can occur in various software systems, not much is known on how AOP and in particular AspectJ have been used.

Several studies encompass the capabilities of AOP to improve the modularity, customization, and the evolution of software, but less is known about how AOP is used. Modularization of the crosscutting concerns of a software system will persist to be the source of initiative for progress in software engineering.

For a system concern like security, first we need to check for the users who attempt to access unauthorised data, and secondly prevent users from declassifying the data. If we use the OOP approach to implement the security concern, it will result in code scattering and code tangling, and its implementation will be weak. This weak implementation of security concern can be because of the intrinsic design of the system or a program error. The AOP approach using AspectJ language presents a strong implementation of security concern [1]. This reduces the load on the programmers to correctly recognize the positions in the base code where authorization is necessary. This can be achieved using AspectJ which is difficult to achieve using OOP language like Java. Even if the OOP concept provides a normal way to implement security concern, it does not really prevent any security flaws caused by bad program coding or poor system design.

AspectJ offers improved separation-of-concerns (SoC) in the system design phase, better encapsulation and also makes the implementation much cleaner than Java [5].

V. OVERVIEW OF AOP AND COMPARISON WITH OOP

A concern in software engineering means, a goal, functionality, or a requirement. The modularity mechanisms of OOP languages are useful, but they are essentially unable to modularize all the concerns in complex systems that involve more functionality. AOP attempts to achieve the reuse of code and design in a much improved way than OOP [3]. Therefore, AOP is more appropriate to implement the crosscutting concerns with better modularity. A software developer can use AOP language like AspectJ to isolate the code for implementing concerns like logging, security, etc., which otherwise are present at different locations in the base code. AOP achieves a more direct correspondence between design-level and implementation-level constructs, which leads to improved code quality which results in the reduction of the cost of designing, developing, and maintaining complex software systems.

AOP enhances the abstract degree and module character of software, which can improve the expansibility, reuse, easy understanding and maintenance of software and enhance other factors influencing the quality of software. The required methods codes are described within the aspect where the code executes instead of a class. Whenever the aspect code needs changes, there is only one place where we need to alter it. But, in OOP the software developer will have to trace all the classes employing the function code that needs changes. The aspect code is weaved or inserted wherever needed in the system at compile time or at run time. AOP modularizes the crosscutting concerns by encapsulating the replicated, scattered and tangled code into aspects.

The assimilation of base code and aspect code is called aspect weaving. The source code weaver merges the original source code with the aspect code. The aspects are interpreted and combined with the main program code and submitted to the compiler. After this, the compiler will generate the intermediate or machine language output.

VI. ASPECTJ AS AN AOP LANGUAGE

AspectJ is the most popular among the existing AOP languages [2]. AspectJ is an easy and convenient AOP language and is an extension to Java programming language with some new programming elements. It supports modularity and reuse of the aspects identified. Mostly crosscutting concerns implementation in AspectJ is dynamic [5]. To design a crosscutting behaviour, we have to identify the join points where we want to add or modify the behaviour. To apply such a design, we initially write an aspect for the module identified. Next, within the aspect we write the pointcuts to capture the required join points. Finally, we build an advice for each pointcut. Within the advice body we write the action that is to take place when the corresponding join points are reached. For instance, in the implementation of the logging concern affects every significant module in the system, the authorization concern affects every module with access control requirements, and the storage-management concern affects every stateful business object. We start by creating the aspect that encapsulates the logging concern. Next, we write the pointcut within the aspect that captures all join points where the operations are performed. Lastly, within the aspect we write an advice for the pointcut concerned, where we print the logging statement. Since the logging code lies inside the logging module and logging aspect; clients will no longer hold the code for logging. We find that the logging requirements are mapped directly into a single aspect. With such modularization, changes to the logging requirements will affect only the logging aspect. So, using AspectJ the core modules will no longer hold calls to the logging services.

There are crosscutting concerns that are not well captured by the traditional programming methodologies [5]. This motivates us to use AspectJ. Let’s consider for example, the performance of a security policy in an application. We know that security concern cuts across an application. The security policy should be consistently applied to any improvements as the application advances, and also the security policy being applied may itself progress. Identifying such crosscutting concerns in a closely controlled way is complicated in a long-established programming language like Java. The advantage of implementing the crosscutting concerns in AspectJ over Java is that, the

organization, evolution and implementation of the crosscutting concerns is easier and more stable.

VII. APPLICATION OF AOP TO REAL-TIME APPLICATION SYSTEMS

We are aware that the precision of a real-time application depends on the consistent result it produces and the instant when the results are produced. Therefore, enforcing timeliness is essential for the overall correctness of a real-time application system [4]. The aspects created represent the crosscutting concerns in the system. The aspects improve the system maintenance by enforcing logical boundaries between the concerns. Aspects are incorporated in the software through interfaces [4]. AOP approach is applied to case studies like Online Banking System and Shopping Catalogue. In particular, the concentration is on exception handling, logging, authentication, authorization, etc., as they contribute to the efficiency and reliability of these application systems. These Web-based systems need to use advanced technology to give the option of evading the time consuming and paper based features of conventional business. This results in managing the transactions more quickly and efficiently. Consumers' insight of security, accuracy, user-friendliness, and performance speed has become the essential factors for the success of such applications.

An online banking system is the technology which helps in avoiding prolonged and paper based characteristics of conventional banking, and thereby manages the business more efficiently. This application system allows us to connect to a bank through the Internet to view our accounts, credit, debit and transfer money, etc. Transaction security, accuracy, user friendliness and performance efficiency are the critical factors for the success of online banking. Quality attributes such as reliability, response time, security and availability are stringent system requirements for online banking. The Online Shopping Catalogue application provides Web access to various items. A user can browse a range of categories of items, select and add items to the catalogue and finally check out, do the payment and get the items. The requirements of this application can be considered as cross-cutting concerns.

VIII. RESULTS

AOP especially AspectJ can have a considerable affect on the program code size of an application by removing the code scattering and tangling [2]. AspectJ can be expected to reduce the program code volume by better code reuse and by reducing the code replication. There is a considerable decrease in the code redundancy. The 35-40% drop found in the code size is by separating the major functions of the system as aspects. There is lesser number of methods and also the program control flow is simplified [4]. While evaluating the AspectJ model for exception handling implementation, it is found that there is a decline in the number of lines of the concerned program. There is a considerable reduction of about 3% in the AOP version when compared to the 9% in the total code size in the OOP version. When crosscutting concerns are homogeneous, aspects considerably reduces the redundant code fragments.

It is found that there is an improvement in system modularity after the concerns are written as aspects [5]. This results in an increased consistency of functions in the system and a significant decrease in coupling between the crosscutting concerns. In the implementation of case studies we observed that the AO approach supports code mobility, usability and usefulness [3]. It is found that the AspectJ solution supports improved modularity because it reduces the overall coupling between the concerns. We know that for a software to be good, it should be flexible to take in necessary modifications through less effort. If the crosscutting concerns identified during software development are well modularized and implemented using AspectJ, we can accomplish the desirable software qualities like code stability, volatility, maintenance, etc.

The design stability is assessed in AspectJ implementations considered. The design stability is found mainly when the modifications were made in a particular crosscutting concern. These modifications are more simple to apply and less intrusive. The effect of overall AspectJ maintenance time mostly decreases. The study shows that AOP especially AspectJ, provides more support in the software evolution and maintenance than other solutions. Application development time using AspectJ is found to be less than other language implementation.

With new language constructs, AspectJ proposes modern ways to implement traditional programming mechanisms. For example, the case study implementation applies aspects to modularize the exception handling concern. It is found that AspectJ offers improved support for implementing exception handling. It is observed that when exception handling concern is non-uniform and complex, then use of AOP does not give the desired returns. The AOP implementation of exception handling concern reduces the code to define the exception interface and improves the separation between the base and aspect code. Effective join point representations have to be developed for more robust handling of the exception handling concern [4].

The advantages and restrictions of AOP, in particular AspectJ depend on the criterion like the software performance, application code size, system modularity, software evolution and language mechanism. After evaluation of the application of AspectJ in our case studies the behaviour of the above criteria is [5]:

- Performance: The results show that AspectJ generates positive outcomes with respect to the execution performance of the application systems because of better response time and minimum use of memory.
- Code size: AspectJ shows considerable decrease in the volume of application code, because of the

separation of crosscutting concerns. According to the results, there is a noteworthy decrease in the overall application code volume by 40%.

- Modularity: Modularity is very prominent, especially in Separation of Concerns (SoC).
- Evolution: AspectJ has the capability to adapt to the incessant modifications in the user needs and functioning conditions. The outcome is positive in evolution context.

CONCLUSIONS

AOP has an optimistic impact on the software development process and improves the application software quality. The more the crosscutting concerns are isolated, the more effortless it is to carry out changes locally. Its effect on cognition and language mechanism is less likely to be positive. AspectJ can improve a system's performance where ever the crosscutting concern context is alike.

We observe improvements in the facets of AspectJ language evolution which includes volatility, extensibility, code stability, maintenance. AspectJ has the potential to develop evolving real-time application systems software whose maintenance is easy. AOP is a capable approach and a solution to the problems we face in conventional programming approaches. However, the solution presented by AOP necessarily may not come out well in terms of lower compilation time and less memory usage [4].

The basic concept and programming idea of AspectJ elaborates the software development approach based on AOP [3]. AOP has many works that need to be completed in future applications. The support languages need to be further enriched and their accuracies ensured, and more tools should be studied to support AOP and fulfil the demands in various stages from software design to maintenance. In view of the increasing software scale and complexity of software structure, the software development based on AOP technology would certainly play a more important function. AOP has remarkable prospective for constructing software for future applications. AspectJ compiler (ajc) needs to do more work than a pure Java compiler, so it is likely to take a little more time to compile an application. The small performance overhead caused is because of the need to analyze the classes, to see if any advice code needs to be woven into them.

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ABOUT AUTHOR

Ms Vasundhara is working as Associate Professor at AMS School of Informatics. Her areas of interest are Software Engineering, AOP, and Operating Systems. She has done her M Tech (CSE).

Digital Watermarking – A Multidisciplinary Approach

L. Venkateswarlu[1], Associate Professor and Dr. N V Rao[2], Professor,
[1]CVR College of Engineering, Department of CSE, Ibrahimpatan, R.R. District, A.P., India
Email: venkatlendale@gmail.com,
[2]CVR College of Engineering, Department of CSE, Ibrahimpatan, R.R. District, A.P., India
Email:nvr@ieee.org

Abstract: **For the last six decades, Digital Watermarking, as an art of hiding information in a cover or host image has drawn much attention of researchers from academic institutions and industry. Especially after 1990, a good number of the publications in various Journals and seminars proves the fact that the issue is considered in various disciplines with common goals and applications such as authentication and copyright protection in the era of internet. Many issues such as embedding in transformation domain, attack models, capacity issues, and applications have been addressed mainly because of its multidisciplinary nature. This paper briefly brings out the issue of watermarking in the perspective of different disciplines like Communications, Information Theory, Signal Processing, Human Visual system, Coding Theory, Cryptography, Mathematics and Statistics.**

Index Terms**: Watermarking, Communication theory, Information theory, capacity of watermark**

I. INTRODUCTION

Almost for the last six decades, research and experimental work on digital watermarking has been going on, as evidenced by a good number of publications in international journals and conference proceedings. Majority of the conferences held every year on multimedia, signal processing, communications and other allied themes have been organizing regularly a special track on this watermarking under multimedia security. Academic institutions and research organizations tried to evolve a theory for watermarking with theoretical models and limits. It is observed that a few thousands of papers have been published on various issues on watermarking. Steganography or Information hiding has emerged as a potential research area having ample applications, very relevant in the present era of internet through which digital transmission has been made very easy. These potential applications such as copyright protection for digital media, watermarking, fingerprinting, steganography, and data embedding, authentication of ownership, buyer-seller information etc. are one-way tools for Digital rights management in the internet era. Information hiding, or steganography, has a broad range of applications from copyright protection and transaction tracking, to broadcast monitoring, data integrity, authentication and fingerprinting. Thus, watermarking has become a major and significant research activity in multimedia processing, leading to the standardization of JPEG-2000, MPEG-4, and digital video disks etc.[1].

II. DEVELOPMENT OF WATERMARKING

The development of Watermarking in theory and Practice can be noticed by the following factors.

Even though the concept of electronic watermark was initiated in 1940's, the actual momentum gained in 1990's. Since then the number of papers published on the subject are exponentially growing. By this time a few thousands of papers are made available in journals and conferences. Professional Societies under IEEE have been publishing papers and special issues in their magazines and Transactions such as Communications Magazine, IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, Signal processing Magazine, Multimedia, Security and Privacy, Computer, Proceeding of IEEE, Transactions on Image Processing. Transactions on Instrumentation and measurement, Information Theory etc. Some of these publications regularly carry featured articles on Watermarking. In addition, some issues of the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS and of the PROCEEDINGS OF THE IEEE, IEEE Signal Processing were devoted to copyright and privacy protection or Digital Rights Management (DRM). The other publishers/ magazines include ACM, IEICE, Electronic Imaging, EURASIP, and ELSEVIER. International Workshops on Information Hiding have been held regularly since 1996, with special sessions on digital watermarking or Information Hiding for DRM.

2.1 First 50 years of electronic watermarking(1954 – 2004) [4]:

The very first work on watermarking can be traced to the patent by Emil Hembrooke, "Identification of sound and like signals", US Patent 3,004,104 Filed in 1954, issued in 1961. Since then for the first fifty years, a very good and promising trend has been observed especially in the International scene. During the next ten years there had been a momentum significantly in Indian universities in terms of published papers**.** Cox et. al [4] observed an exponential growth since 1995 at an average of 200 published papers per year in many reputed Journals and Magazines mentioned earlier. Organizational support is also visible as Universities and companies like IBM, HP continued a continuous research towards product standardization of watermarking.

2.2 Generic Information –Hiding Problem:

In general steganography or Information Hiding problem can be stated as a process in which a message is to be embedded in a host data set, and the resulting data may face data processing operations known as attacks. These attacks always try for the removal of information hidden. Watermarking is regarded as a subset of Steganography, where the information to be hidden in the cover is related to the cover. Hidden information is called Watermark. A text, image or an audio clip , logo can be taken as a watermark. The essential features of any watermark are stated below.

Fidelity: The degree of degradation in perception or loss of visual quality due to the insertion of watermark.

Robustness: The level of immunity against all forms of attacks to remove the traces of watermark (intentional and non-intentional manipulations).

Payload: This is otherwise known as capacity of watermark, an indication of how much can be added as the watermark to the cover under constraints.

Security: Watermark should be secure enough, depending on the application.

III. Watermarking as truly interdisciplinary:

By carefully observing the research and experiments carried out in the field of digital watermarking, one can obviously notice that it is truly interdisciplinary.

The disciplines that emerge in the study of watermarking are:

Information Theory and Communications Theory Image and signal processing, compression, Transforms with cryptography, Game Theory, Coding Theory, Detection and Estimation Theory,
Cryptography and Protocol Design, Visual perception theory, Mathematics and Statistics.

Perhaps a key reason for the rapid work and enthusiasm in this field is the fact that digital watermarking is inherently a multi-disciplinary topic that builds on developments in diverse subjects but for a common objective.

3.1 Watermarking and communications:

Even a general examination of any watermarking scheme reveals the idea that there is a significant similarity between the watermarking and communications. Just let us see how a communication system works. Specified information is introduced into a communication channel, which is also known as communication medium. The transmitted information is received at the destination by the receiver. But the main goal of communications is to receive the transmitted information with high reliability, without much distortion. Similarly watermark is additional information embedded in a multimedia like an image (communication Channel) and transmitted. It is to be extracted at the receiver end without any quality degradation. Both need robustness and reliability. The case of attacks on watermarked media is viewed as communications in a hostile environment such as transmission errors and noise. Thus in simple terms, this common model considers watermarking as a form of communications, in which the original medium is a communication channel and watermark is a modulated signal that contains the message. This analogy has been shown in Fig:1.

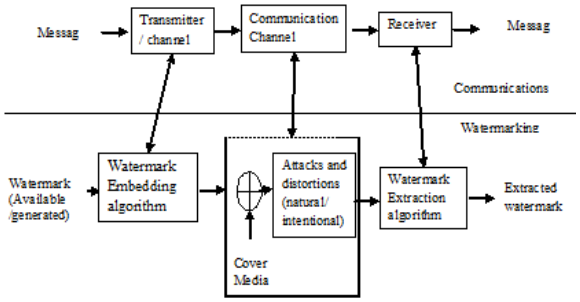

Fig 1: Analogy between communications and water marking

A few models have been developed in the study of theoretic analysis of watermarking. Signal Processing and communication concepts were used initially. In the Digital Rights Management, watermarking of digital media is considered as a potential application for copyright Protection. So Fidelity of the cover is a factor for the evaluation of any algorithm for embedding. So Fidelity, robustness and capacity are the serious requirements of any watermark.

Spread Spectrum methods:

The initial models of watermark considered spread spectrum techniques for watermarking algorithms. Watermark spreads over the image for robustness. In communications, Spread spectrum systems are considered as they transmit very little power within any single frequency. They have excellent interference and anti-jamming properties. These properties are quite suitable for WM applications. Many research papers are published on Spread spectrum Image watermarking.

In spread spectrum methods, the message is scattered across the image making it difficult for image manipulations like cropping, rotation and other basic image manipulation techniques to remove or manipulate the hidden watermark. This is also somewhat resistant to statistical analysis of steganographic images because it gives it the impression of noise in an image. Here mention is to be made about Patchwork from IBM which is a tool to scatter hidden information based on statistical distribution of intensity values in the given image.

It is not out of context to remember the inventors of Spread Spectrum communications. Hedy Lamarr, then the international beauty icon, along with co-inventor George Anthiel, developed a "Secret Communications System" to help combat the Nazis in World War II. By manipulating radio frequencies at irregular intervals between transmission and reception, the invention formed an unbreakable code to prevent classified messages from being intercepted by enemy personnel. On August 11, 1942, U.S. Patent 2,292,387 was granted to them.

Communications with side information:

In [3], Cox *et al.* introduce the paradigm of watermarking as a coded communication system with side information at the embedder. Based on this paradigm, and by considering a statistical model for attacks, some detection rules are proposed for detecting the presence of watermarks in images. Capacity or load of a watermark is the amount of information a cover can hold within the constraints mentioned above. So in order to improve capacity, watermarking is modeled as a form of communication with side information. In this, the cover is considered as side information and is available to transmitter or receiver or to both. It is to be noted that, in this model, cover is not considered as a noise.

In these applications of watermarking information is hidden within a host data set and is to be reliably communicated to a receiver. The cover or host data set is corrupted in a covert way, and is not easily detectable by a casual analysis. There may be attacks to destroy this stegno information. For this end, additional distortion to the data set is introduced. Side information usually in the form of cryptographic keys / information about the cover signal may be available to the information hider or to the decoder or to both.

The Parallel Between Communication and Information Hiding Systems [1,6]:

Communication Perspective	*Information Hiding*
Encoder-Decoder	Embedder-Detector or extraction of Watermark
Side information	Host or Cover image
Channel noise	Attacks to removal or manipulations
Power constraints	Perceptual distortion Limits
Signal to noise ratio (SNR)	Embedding distortion To attack distortion (WNR)

A communication analogy for watermarking has helped to answer the fundamental questions**:** a) Where should most of the watermark energy be placed so that it is robust to perceptual coding; b) How much information can reliably be hidden. Watermarking is greatly benefited from the richness of the communication paradigm[1]. This has given an ample opportunity for communication engineers to view deeply into the theory and applications of digital watermarking

3.2 Information Theory: [1,6]

Information theory has been a valuable tool in studying watermarking problems. Publications include a definition of watermarking capacity or computation of payload for watermarking hosts, watermarking security, etc.. Many mathematical models and tools form the basis of Information theoretic studies of watermarks are carried out on the basis of mathematical models. From Communications point of view, watermarking has been considered as a way of communication, in which the cover image is viewed as a communications channel to send messages. So traditional Information theory is used to formulate and solve watermarking capacity issues. Here capacity of watermark is to estimate how much can be embedded. Shannon's Formula is the basis of these Information Theoretic studies on Capacity of watermarks. Information hiding can be seen as an application of "dirty paper" coding, in multi-user communications [2]. Thus, the role of information theory in Watermarking is so fundamental that it becomes the basis in characterizing the fundamental limits of watermarking systems and in guiding the development of optimal

watermark embedding algorithms and optimal attacks [1]. As already stated, Watermarking can be viewed as a communication problem with side information. This side information may be in the form of the host signal and/or a cryptographic key and is available at the encoder and the decoder. This problem is mathematically defined by distortion constraints, by statistical models for the host signal, and by the information available in the game among the information hider, the attacker, and the decoder. In particular, information theory explains why the performance of watermark decoders that do not have access to the host signal may surprisingly be as good as the performance of decoders that know the host signal [1].

Watermarking security analysis based on information theory :[5]

From an information theory point of view, Watermarking security is quantified via the equivocation and mutual information between Secret and public parameters as per the design of watermarking. Information theory tools are used to estimate the measure of information leakage for a variety of scenarios and also the tradeoff between different requirements of watermarking: robustness, imperceptibility and security. This analysis in the watermarking in transformation domain has been carried out to improve the visual quality of watermarked image and robustness of watermark. [5]

3.3 Human Perception:

Another approach similar to information theory is based on human perception . Perceptual models take into consideration the human audio-visual system. In some watermarking techniques both information theoretic and perceptuality criteria has been proposed, in which perceptually significant features are selected for watermark insertion. The just noticeable difference criterion is usually used for this purpose. The algorithms in transformation domain are tried in this context.

3.4 Capacity of watermark and Game Theory:[1,9]

Hiding capacity is evaluated for upper-bound of the rates of reliable transmission. It also objectively quantifies the fundamental tradeoff among three quantities: information-hiding rates that can be practically achievable, levels of distortion that can be tolerated for the information hider and the attacker. The hiding capacity or the pay load of watermark is modeled as the result of a game between the information hider and the attacker. The optimal attack strategy is the solution of a particular rate-distortion problem, and the optimal hiding strategy is the solution to a channel-coding problem. The hiding capacity is derived by extending the Gel'fand–Pinsker theory of communication with side information at the encoder. Many extensions to this study are made such as the presence of distortion constraints, side information at the decoder, and unknown communication channel **[1].**

O'Sullivan *et al* [9] first formulated the watermarking scenario as a game played between an information hider and an attacker. The mutual information between the input and output of the attack channel was taken as the cost function of the game. The attacker tries to minimize this cost while the hider tries to maximize it. The upper bound on this mutual information is the data hiding capacity. The main result of the work is the insight that the best attack approach is equivalent to the most efficient data compression possible subject to a distortion constraint, and the optimal information hiding strategy corresponds to optimal channel coding in which the attacker determines the channel characteristics [9].

In these techniques the entire watermarking process is considered to be a game and optimal joint data hiding and attack strategies are derived. The watermark and attacker are both assumed to be at "peak" performance. Expressions for the possible data hiding rate are derived and analyzed to gain perspective as to the potential of the technology.

Modeling of attacks or distortions:

Watermarking researchers have modeled all possible distortions between the stages of embedding and detection, and drawn metrics for quality measures. These attacks include not only noise (Natural) but also intentional attacks such as modifications, geometric transforms and compression.

Mutual Information Theory (MI):

It is a basic concept taken from information theory. It is a measure of the statistical dependence or correlation between two given random variables. It is a measure of common information between them. So It is appropriately used to see the correlation between cover images: original and watermarked. And also watermark: original and extracted.

In Watermarking research, watermark detection using Mutual Information detector has been used effectively, and it has been proved to be efficient as it incorporates higher order statistics of non-Gaussian image distribution. In addition Geometric invariants such as translation, rotation and scaling are improved. [8]

Watermark extraction becomes even impossible at times when attacks or distortions are powerful.

This residual information is named as the scar and it is used to confirm the existence of an attacked watermark. However, it is possible only when the mutual information between the embedded message and

the attacked copies is above a certain threshold. Scar is made use of by measuring the correlation between the attacked watermark and the original one. The watermarking scar can be measured using mutual information between the embedded watermark and the marked/attacked copies.[7]

3.5 Statistics in Watermarking:

Natural images have statistics and any modifications to original or natural brings an observable change in their statistics. This factor is made use of in detecting a watermark in a cover image [10]. Experimental Investigation has been made to study if stego images containing embedded information are statistically natural and it is found that the hidden images disturb the fundamental statistical features of original image. This study is used to detect watermarks in images. It is shown that, within multi-scale, multi-orientation image decompositions such as wavelets, first- and higher-order magnitude and phase statistics are relatively consistent across a broad range of images, but are disturbed by the presence of embedded hidden messages. Thus higher order statistics is used to detect hidden steganographic messages in digital images [11].

Assessing the quality of images is a key step in the determination of fidelity of watermarking, and is an essential requirement for acceptance . Objective assessment is done through statistical measures like MSE (Mean square Error), RMSE (Root Mean square Error), SNR, PSNR, Structural Index etc.

3.6 Signal Processing and Mathematical Transformations in watermarking algorithms:

There was initial work in the use of basic digital signal processing (DSP) strategies for data hiding. In fact many papers have been published in IEEE transactions of Image Processing on image watermarking, a publication of Signal Processing Society of IEEE. An image can be viewed as a signal and watermark is considered as a message signal transmitted through a cover signal.

In Signal Processing, many transformations are used for analysis. Fourier, Trigonometric and Wavelet are very prominent among them. For robustness of watermarking, frequency or transformation domain has been suggested. Many transformations have been experimented for embedding watermark. In the literature, more than 20 transforms are used for watermark fusion: DCT, DST,DFT, SVD, Arnold, DWT (Bi- orthogonal, packet decomposition, stationary wavelet, second generation wavelet, dual tree wavelets, curvelets, ridgelets, chirplets, noiselets, shearlets), Hadamard transformation, KL transformations, Walsh 2D transformation, Z transformation, Genetic transformation, Binomial transformation, Slant transformation, Affain Transforms, Back projection and tensor transformation, Bandlet transformation, Radon transformation, Counterlet transformation). In addition, dual transformation domains are used for better robustness. They are DWT + DCT, DWT+SVD, DWT+DCT+SVD.

Among them DWT and its variants like bi orthogonal wavelets are more promising. Signal processing concepts can be aptly used in the theory of Watermarking. It is to be noted that Signal Processing society of IEEE publishes *Transactions of Image Processing*, which is considered as the leading research journal on Image Processing. This publication also has a regular feature on Multimedia security that contains research articles on watermarking.

3.7 Image Processing Techniques:

Much research work in watermarking was done in the media of digital images. Majority of papers published are pertaining to Image watermarking. The human Perception is limited by not differentiating the embedded image in an image. This was better used in watermarking algorithms development and experimentation. Embedding watermark in a cover image can be considered as fusion of images. Image Compression is an attack that can diminish the quality and hence the criterion of watermarking is that it is resistant to compression.

The above current scenario clearly explains the role of Signal Processing, Image Processing, Mathematical Transformations in the study of Watermarking.

SCOPE FOR FURTHER RESEARCH

Any research should lead to a useful tool for the society. Digital watermarking as viewed from multi disciplinary perspective provides ample opportunities for wider research and applications based on sound theoretic principles of communications and information theory. Hence the following are expected from the future research.

1. Watermarking research should converge towards a standard tool for authentication.
2. A hardware realization is required for automatic finger printing for multimedia security and authentication.

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Leaky Least Mean Mixed Norm Algorithm

Mohammed Abdul Nasar
CVR College of Engineering /ECE, Hyderabad, India
Email: nasar.mohammed@gmail.com

***Abstract*— In this paper, the leakage-based variant of the Least Mean Mixed Norm (LMMN) algorithm, the leaky Least Mean Mixed Norm (LLMMN) algorithm, is derived. The proposed algorithm will help mitigate the weight drift problem expe-rienced in the conventional Least Mean Square (LMS) and Least Mean Fourth (LMF) algorithms. The aim of this paper is to derive the LLMMN adaptive algorithm and perform the transient analysis using the energy conservation relation framework. Finally, simulation results are carried out to support the theoretical findings, and show improved performance obtained through the use of LLMMN over the conventional LMMN algorithm in a weight drift environment.**

***Index Terms*—Adaptive filters, weight drift, leaky least mean mixed norm.**

I. INTRODUCTION

In our everyday life the Adaptive filters are used in a variety of areas such as plant modelling or system identification, noise cancelation and adaptive equalization, to name a few. The theory about adaptive filters, advantages and applications are widely described in the literature [1].

The LMF algorithm outperforms the LMS in non-Gaussian noise environments. Another example of adaptive filter algorithms is the leaky Least Mean Square (leaky LMS) algorithm [4]. This leaky LMS algorithm was first introduced to overcome the weight drift problem in LMS adaptive filters. The LMF algorithm also suffers from the weight drift problem under the same conditions as LMS algorithm,. The LMMN algorithm [5] is found to provide a better performance in both Gaussian and Non-Gaussian environments than either LMS or the LMF and hence the LMMN algorithm will behave identically in such a scenario. Therefore, in this paper, a new variant of the LMMN is introduced which overcomes the weight drift instability from occurring using the leakage technique.

In this paper, the leaky LMMN algorithm is derived and its transient analysis is carried out using energy conservation concept [1] and the conditions for the mean and mean square stability of the algorithm are also derived.

II. THE LEAKY LEAST MEAN MIXED NORM ALGORITHM UPDATE RECURSION

The output of an FIR channel of length *M* in the presence of an additive noise can be written as follows [1]:

$$y_k = u_k w_0 + n_k \tag{1}$$

where u_k is a zero mean stationary input process with variance σ_u^2, $\{n_k\}$ is a stationary noise process with zero mean and variance σ_n^2, and w_o is weight vector for M taps impulse response for unknown input.

In the case of the LMMN algorithm, the cost function to be minimized is given by [5]

$$J_{LMMN}(w) = \delta E[e_n^2] + (1-\delta) E[e_n^4] \tag{2}$$

with α being the mixing parameter and e_n is the error between the output of the unknown system and the adaptive filter and is defined as

$$e_n = y_n - u_n w_n \tag{3}$$

The LMMN cost function is modified and leakage parameter α is introduced to obtain the proposed method same way as was done for the leaky LMS [1]. Therefore, the cost function that we wish to minimize is given as

$$J(w) = \alpha \| w \|^2 + \{\delta E[e_n^2] + (1-\delta) E[e_n^4]\} \tag{4}$$

The corresponding update equation of the leaky LMMN is then

$$w_{n+1} = w_n + \mu e_n \{\delta + (1-\delta) e_n^2\} u_n \tag{5}$$

The LMMN update equation is obtained for $\alpha = 0$ in (5) and μ is the step size.

III. PERFORMANCE ANALYSIS OF THE LEAKY LMMN ALGORITHM

In this section, the proposed leaky LMMN algorithm is analyzed in both the mean and the mean-square sense using the frame work of fundamental energy relation. Consequently, all the assumptions applicable for long filters are employed. In addition, the following assumptions are used:

A1 The noise sequence $\{v_n\}$ is i.i.d. with zero odd order moments and variance $\sigma_v^2 = E[v_n]^2$

A2 The sequence v_n is independent of u_j, w_k for all *j, k.*

A3 The regressor u_j are i.i.d Gaussian random vectors with covariance matrix $R_u = E[u_n^T u_n] > 0.$

A4 The random variables $d_n, u_n and v_n$ have zero means.

The mean and mean square stability conditions are derived and learning curves are constructed to calculate MSD and EMSE.

A. Mean Behaviour

Defining the weight error vector w_n as follows:

$$w_n = c - \bar{w}_n \tag{6}$$

Results in following update equation

$$\bar{w}_{n+1} = (1-\mu\alpha)\bar{w}_n + \mu\alpha c - \mu u_n^T e_n[\delta + (1-\delta)\| e_n \|^2] \tag{7}$$

taking the expectations on both sides and using the assumptions, we get

$$E[\bar{w}_{n+1}] = (1-\mu\alpha)E[\bar{w}_n] + \mu\alpha c - \mu E[u_n^T e_n[\delta + (1-\delta)\| e_n \|^2]] \tag{8}$$

To solve $E[u_n^T e_n[\delta + (1-\delta)\| e_n \|^2]]$, we will make use of above assumptions to solve the equation:

$$E[u_n^T e_n[\delta + (1-\delta)\| e_n \|^2]] = \delta E[u_n^T e_n] + (1-\delta)E[u_n^T e_n^3]$$
$$= \{\delta + 3(1-\delta)(\sigma_v^2 + \zeta)\}RE[\bar{w}_n] \tag{9}$$

Using (9) in (8), we get

$$E[\bar{w}_{n+1}] = [I - \mu[\alpha I + (\delta + 3(1-\delta)(\sigma_v^2 + \zeta)R)]]E[\bar{w}_n] + \mu\alpha c \tag{10}$$

Where ζ is defined as

$$\zeta = E[e_a^2(n)] \tag{11}$$

The range of step-size values for which w_n remains bounded is given as

$$0 < \mu < \frac{2}{\alpha + [\delta + 3(1-\delta)(\sigma_v^2 + \upsilon)\lambda_{\max}(R)]} \tag{12}$$

Where $\lambda_{\max}(R)$ is the largest eigen value of R.

B. Behavior of Mean Square Error

In this section the performance of the leaky LMMN algorithm in the mean-square sense is analyzed. The assumption used is that the adaptive filter is long enough to justify the following:

A5 The norm of the input regressor $(\| u_n^2 \|)$ can be assumed to be uncorrelated with e_n^6

1) Error and Performance Measures:

We are interested in studying the time-evolution and the steady-state values of $E[\| w_n \|^2]$ and $E[e_a{}^2(n)]$ which give the EMSE and the MSD, respectively.

For some symmetric positive definite weighting matrix A, the weighted *a priori* estimation error is defined as

$$e_a{}^2(n) = u_n A w_n \tag{13}$$

the standard *a priori* estimation error is obtained when A = I from the above equation as,

$$e_a(n) = e_a^{\Sigma}(n) = u_n w_n \tag{14}$$

It is easy to see that the estimation error, e_n, and the *a priori* estimation error, $e_a(n)$, are related via

$$e_n = e_a(n) + v_n \tag{15}$$

Thus, using **A3** and (14), the EMSE can be set up as follows:

$$\zeta_n = E[e_a^2(n)] = E[\| w_n \|_R^2] \tag{16}$$

2) Time evolution of the weighted variance $E[\| w_n \|_A^2]$:

In this section, the time evolution of the weighted variance $E[\| w_n \|_A^2]$ is derived for the leaky LMMN algorithm using the framework of fundamental weighted-energy conservation relation. Thus, by using (8) and (14), one can arrive at:

$$E[\| \tilde{w}_{n+1} \|_{\Sigma}^2] = (1-\mu\alpha)^2 E[\| \tilde{w}_n \|_{\Sigma}^2] + \| \mu\alpha c \|_{\Sigma}^2$$
$$+\mu^2 tr(R)H_U - 2\mu(1-\mu\alpha)E[e_a(n)e_a^{\Sigma}(n)]H_G \tag{17}$$
$$+2\mu\alpha c^T \Sigma J E[\tilde{w}_n]$$

Where

$$J = [I - \mu\{\alpha I + [\delta + 3(1-\delta)(\sigma_v^2 + \zeta)]R\}] \tag{18}$$

The transient behavior of the weighted variance $E[\| w \|_{\Sigma}^2]$ is shown above for any constant weight matrix Σ. Proper choice of the weight matrix Σ gives various performance measures. Now depending upon the correlation of the input the analysis is further divided into two parts.

3) Transient Analysis

When the input data is correlated, i.e., R is a non-diagonal matrix, different weighting matrices will appear on both sides of the equation. Therefore, we again resort to the technique given in [1]. At the end, we get

$$\underbrace{\begin{bmatrix} A_{n+1} \\ E[\mathrm{w}_{n+1}] \end{bmatrix}}_{w_{n+1}} = \underbrace{\begin{pmatrix} F_1 & F_2 \\ 0 & J \end{pmatrix}}_{F_n} \underbrace{\begin{bmatrix} A_n \\ E[\mathrm{w}_n] \end{bmatrix}}_{w_n}.$$

Where $F_1, F_2, A_n and L_n$ given as

$$A_n = \begin{bmatrix} E[\| w_n \|^2] \\ E[\| w_n \|_R^2] \\ E[\| w_n \|_{R^2}^2] \\ . \\ . \\ . \\ E[\| w_n \|_{R^{M-2}}^2] \\ E[\| w_n \|_{R^{M-1}}^2] \end{bmatrix} \quad (19)$$

$$L_n = \mu H_U \begin{bmatrix} tr(\mathrm{R}) \\ \mathrm{tr}(\mathrm{R}^2) \\ \mathrm{tr}(\mathrm{R}^3) \\ . \\ . \\ . \\ \mathrm{tr}(\mathrm{R}^M) \end{bmatrix} + \mu\alpha^2 \begin{bmatrix} \| \mathrm{c} \|^2 \\ \| \mathrm{c} \|_R^2 \\ \| \mathrm{c} \|_{R^2}^2 \\ . \\ . \\ . \\ \| \mathrm{c} \|_{R^{M-1}}^2 \end{bmatrix} \quad (20)$$

$$F_2 = 2\mu\alpha c^T J \begin{bmatrix} I \\ R \\ R^2 \\ . \\ . \\ . \\ R^{M-1} \end{bmatrix} \quad (21)$$

$$F_1 = \begin{bmatrix} k_1 & -k_2 & 0 & 0 & \cdots & 0 \\ 0 & k_1 & -k_2 & 0 & \cdots & 0 \\ 0 & 0 & \ddots & \ddots & \ddots & \vdots \\ \vdots & \vdots & \ddots & \ddots & \ddots & 0 \\ 0 & 0 & \cdots & 0 & k_1 & -k_2 \\ k_2 p_0 & k_2 p_1 & \cdots & \cdots & k_2 p_{M-2} & k_1 + k_2 p_{M-1} \end{bmatrix}$$

Where

$$k_1 = (1-\mu\alpha)^2 \quad (22)$$

$$k_2 = 2\mu(1-\mu\alpha)\mathrm{H}_G$$

$H_U = \mu M \delta^2 \sigma_v^2 + \mu M (1-\delta)^2 \xi_v^6 + 2\mu\delta(1-\delta)\xi_v^4$ the first and second entries of the state vector w_{n+1} show the development of $E[\| w_n \|^2]$ and $E[e_a^2(n)]$. The learning curve of the filter then becomes

$$E[\mathrm{e}^2(\mathrm{n})] = \mathrm{E}[\mathrm{e}_a^2(\mathrm{n})] + \sigma_v^2 \quad (23)$$

B. Mean Square Stability

One of the conditions for the mean square stability of the leaky LMMN algorithm to be convergent, is obtained from the block structure of F_k as shown in (20-21). To obtain the mean square stability of the leaky LMMN the same approach of mean convergence on the step size is used as shown in (12).

$$0 < \mu < \frac{1}{\lambda_{\max}(\mathrm{G}_1^{-1}\mathrm{G}_2)} \quad (24)$$

Where $\lambda_{\max}(\mathrm{G}_1^{-1}\mathrm{G}_2)$ is the largest eigenvalue of $\mathrm{G}_1^{-1}\mathrm{G}_2$ with

$$G_1 = 2(\alpha \mathrm{I} + \mathrm{H}_G^* \mathrm{B}) \quad (25)$$

$$\mathrm{G}_2 = \alpha(\alpha \mathrm{I} + 2\,\mathrm{H}_G^* \mathrm{B})$$

Where in from above equations

$$\mathrm{B} = \begin{bmatrix} 0 & 1 & 0 & 0 & \cdots & 0 \\ 0 & 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & \ddots & \ddots & \ddots & \cdots \\ \vdots & \vdots & \ddots & \ddots & \ddots & 0 \\ 0 & 0 & \cdots & 0 & 0 & 1 \\ -p_0 & -p_1 & \cdots & \cdots & -p_{M-2} & -p_{M-1} \end{bmatrix} \quad (26)$$

and

$$H_G^* = \delta + 3(1-\delta)\{\sigma_v^2 + \vartheta\}$$

For the proposed method to converge in both the mean and mean square sense (12) and (24) are combined the condition obtained is

$$\mu_{\max} = \left\{ \frac{2}{\alpha + H_G^* \lambda_{\max}(\mathrm{R})}, \alpha > \frac{H_G^* \lambda_{\max}(\mathrm{R})}{4} \right\} \quad (27)$$
$$\left\{ \frac{1}{\lambda_{\max}^{G_1^{-1}G_2}}, otherwise \right\}$$

IV. Experimental Results

The simulations are based on a system identification setup where the regression vector u_n is a Gaussian vector with filter of length 5.

The weight drift process is carried out in the same way as was done in [7]. With a filter vector of $[0.7071 - 0.7071]^T$ and regressor vector $\pm[0.5, -0.5]$ and choosing it to be equal probable making input matrix as singular, the proposed algorithm is compared with the LMMN in a weight drifting environment. The output and the quantization noise are grouped together and modeled as a Gaussian vector with mean of $[0.49, -0.49]^T$ and a variance of 10^3.The adaptive filter coefficients and the regressors are set to 10 quantization bits with a step size of 0:0156 and the product of the step size and the leakage factor was set at 0:002. By taking the infinite norms of the updated weight vectors the experiment is run over 10^4 samples..

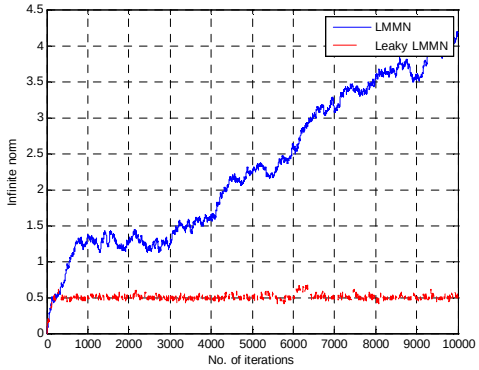

Figure 1. Comparison of LMMN and Leaky LMMN in a weight drift environment.

The above Fig(1) shows that the parameter drift causes the adaptive filter weights to blow up while in the case of the leaky LMMN they remain bounded.

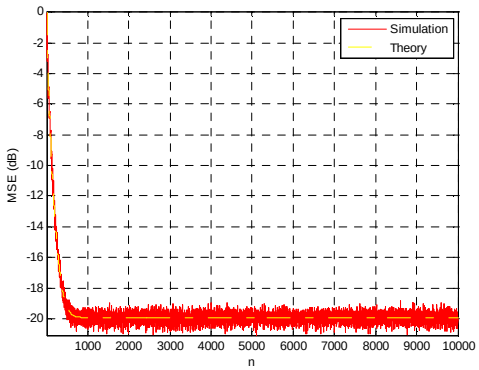

Figure 2. MSE learning curve of the LLMMN in Gaussian noise environment for white data

The white Gaussian data was used with the step size 0.01 and leakage factor is 0.001 to compare the theoretical findings with the simulation result, while the number of trials set at 500 and number of samples were 10^4. The randomly generated normalized system weight vector with the number of taps set at 5 is taken and the Gaussian with variance 0.1 was chosen. The Fig. 2 shows a good match between the theoretical and simulation results.

CONCLUSIONS

In this paper, a new adaptive algorithm, the leaky LMMN algorithm, is presented. The expressions were derived for the transient analysis of the algorithm and also derived the conditions for the mean and mean square stability. Monte Carlo simulations were performed which match well with the theoretical values. Finally, the advantage of the leaky LMMN over the conventional LMMN in a weight drift environment is also shown.

ACKNOWLEDGMENT

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High Performance Operational Amplifier for Pipelined Analog to Digital Converters

A.Anitha,
CVR College of Engineering/ECE, Hyderabad, India
Email: anitha90@yahoo.com

***Abstract*—As electronics and telecommunication worlds are moving fast towards digitalization and there is an ever increasing demand on speed and accuracy of the processed data, the need for high speed and high resolution ADCs has grown dramatically over recent years. Pipelined ADC is the architecture of choice in high speed and medium resolution applications. Op-Amps are basic building blocks of a wide range of analog and mixed signal systems. In this paper a Op-Amp is designed using 90nm CMOS technology, the small voltage difference can be around tens of millivolts is amplified by this Op-Amp. As new generations of CMOS technology tend to have shorter transistor channel length and scaled down supply voltage, the design of Op-Amps stays a challenge for designers.**

The main focus in this work is the Op-Amp design to meet the requirements needed for the 12-bit pipelined ADC. The Op-Amp provides enough closed-loop bandwidth to accommodate a high speed ADC (around 300MSPS) with very low gain error to match the accuracy of the 12-bit resolution ADC. The amplifier is placed in a pipelined ADC with 2.5 bit-per-stage (bps) architecture to check for its functionality. The Effective Number of Bits (ENOB) stays higher than 11 bit and the SNR is verified to be higher than 72 dB for sampling frequencies up to 320 MHz.

***Index Terms*—ADC, Op-amp, CMOS, Low supply, bandwidth. Pipelined, Gain Boosting, CMFB, Flash, MDAC.**

I. INTRODUCTION

Analog to digital converters are the most important building blocks in lots of applications. For these applications the digitalization and speed and accuracy of the processed data and high resolution is required.The ADC applications fall into four market categories 1) data acquisition, 2) precision industrial measurement, 3) voice band and audio and 4) high speed. For high speed and medium resolution applications the Pipelined ADC architecture is the best choice. Examples of these applications are instrumentation, communications and consumer electronics.

The choice between different architectures can be made based on the speed, resolution, area and power consumption requirements in the target application. Knowing the specification, one can choose between different architectures to achieve the needed performance. Among available ADC architectures, flash, folding, sub-ranging and pipelined ADCs are fast enough to be considered as a high speed ADC. Pipelined ADC is built from several low resolution converters in a pipeline. The number of stages and the number of bits resolved by each stage along with redundancy bit(s) should be determined wisely considering power, speed and resolution of the ADC and accuracy requirements on sub converters. Most of the time, in high speed ADCs lower resolution per stage is chosen to have lower inter-stage gain and settling time which results in higher conversion rate. Low resolution per stage also relaxes the requirement on accuracy of voltage references in Sub ADC and comparators. Drawbacks of having lower bits resolved in stages are higher number of stages that are needed and more noise and gain and offset errors from latter stages brought back to the input due to lower inter-stage gain and will lower the total ADC's accuracy.

Usually in high resolution ADCs, more bits are resolved in each stage. Higher resolution per stage gives the benefit of having higher inter-stage gain which will reduce the later stages' noise contribution to the overall noise of the ADC. However, this increases the power dissipation of the ADC and also the area required for the ADC. The noise and other errors of subsequent stages are reduced by former stages' squared gain. Adding more bits to be resolved in early stages, especially stage1, will relaxes the requirements on following stages' accuracy and noise requirements and will allow scaling to be applied to them. This technique helps with area and power limitations. Stages can also have redundancy bit that can be shared between neighbouring stages by overlapping. This technique leaves room for error correction (does not produces 111) and adds ½ LSB offset to prevent saturation of coming stages due to comparison errors occurred in present stage. This offset helps to keep the residue signal within the 0-Vref range of the ADC. Another advantage of this technique is the reduced inter-stage gain for higher number of resolved bits. For example in a 2.5 b stage with 3 raw bits and 2 resolved bits (one redundant bit) from total bits of the ADC, stage gain will be instead of . Reduced gain will relax the requirements on the OpAmp employed in the MDAC. Redundant bit can be added to any sub ADC with different resolution.

II. PIPELINED ADC'S ARCHITECTURE

A 12-bit pipelined ADC incorporating 2.5 b stages is shown in Figure 1. The ADC incorporates 6 stages; each one (except for stage 6) consists of a sample and hold, DAC, subtraction and amplification circuitry (all of which known as multiplying DAC or MDAC) and a low resolution but high speed flash ADC. Stage 6 is a 3-bit flash ADC. In Figure 2 one stage of pipelined ADC is represented.

Inside each stage input voltage is converted to 3 raw bits by the high speed flash ADC and then reconstructed back to analogue by the DAC. The reconstructed signal is subtracted from original sampled signal and the difference is multiplied by the amplification factor, producing the residue signal. The residue signal is applied to the next stage to be processed and the current stage starts sampling the incoming signal and processing on the sampled and held data. The pipelining operation produces latency to the digital data production but after that there will be one conversion per clock cycle. As a result of this concurrency conversion rate of the ADC is independent of the number of stages.

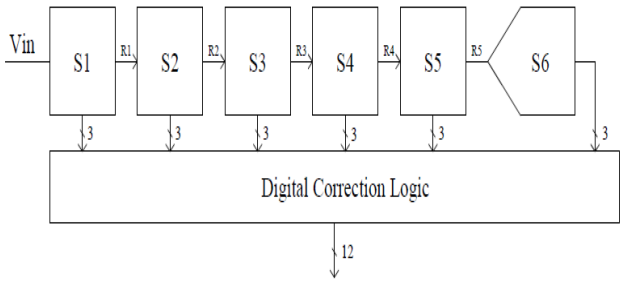

Figure 1: 12-bit Pipelined ADC

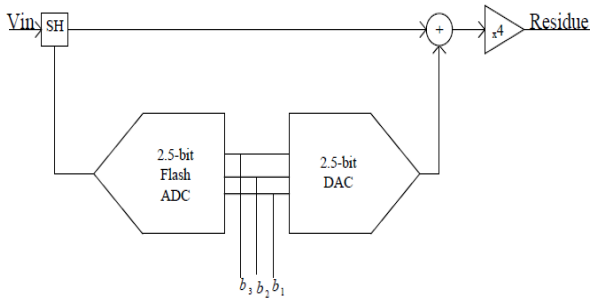

Figure 2. one stage of pipelined ADC

A. *Flash Sub-ADC*

The pipelined ADC has fully differential architecture. Fully differential architecture allows more dynamic range and reduces even harmonics' effect on nonlinearity. One out of six segment of the sub-ADC is presented in Figure 3.10].

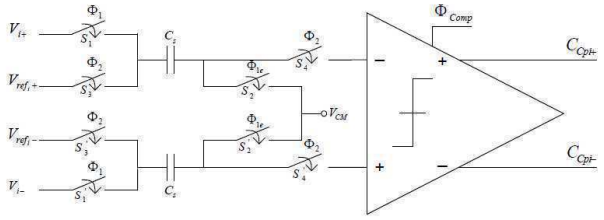

Figure 3. One Segment of Comparing Circuitry in Sub-ADC

Comparators clock is delayed version of clock2. In comparator's circuit pre-amplification is used to amplify small differences between input and reference voltage to increase the accuracy of the comparator. The pre-amp circuit needs time to settle and the delay allows the output to reach its final value to be used in comparison.

B. *Thermometer Decoder*

The thermometer decoder can be implemented using lots of techniques, for example by using pass-transistors, multiplexing, etc. In this design thermometer codes are used as address bits of an OR-based ROM. Figure 2-7 shows a 3-to-2 bit thermometer to binary decoder (Figure 1-2-b), using the ROM implementation. The address decoder circuit is OR-based designed as well. All address and data lines in the address decoder and ROM are connected to through PMOS devices which are always on. Whenever a line in the ROM should be chosen, all transistors in that line should be turned on which means the address line should be kept high. For an address line to be high, all transistors that are connected to it should be off. For example, if $C_2C_1C_0$ is 000 ($V_{in} \leq V_{ref1}$) then Add1 is V_{dd} and the transistors in the first line turn on, bringing data lines to 00 which is the binary output expected $V_{in} \leq V_{ref1.}$

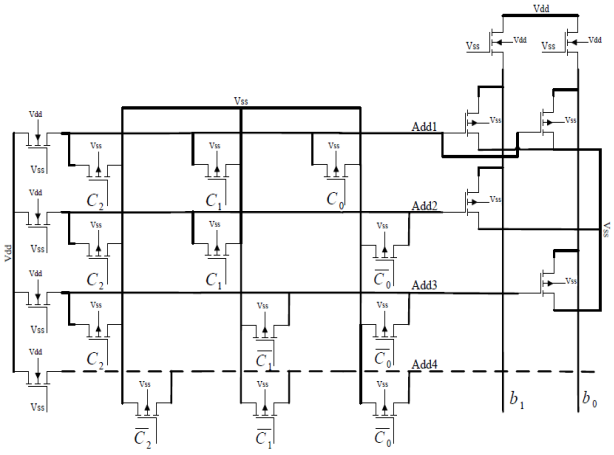

Figure 4. Thermometer to Binary Decoder Implemented by OR-Based ROM

In picture above, the last address line (dashed line) is not needed to be implemented, as it does not drive any transistor in the ROM. It has been kept in the picture for the sake of more accuracy. The actual design is fully differential 6-to-3 bit decoder (2.5bit/s implementation).

C. Comparator

Comparators are made of two basic building blocks, a preamplifier and a latch. The comparator is used to resolve small input signal and produce a digital 0 or 1 output. Therefore, the amplifier does not have a linearity requirement. It should amplify the small input signal enough to make the latch change its state if necessary. The basic concept of a comparator is shown in Figure 5.

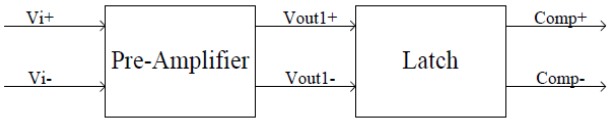

Figure 5. Basic Concept of a Comparator

The comparator operates in two phase, reset and evaluation (latching). In reset phase, the latch is pre-charged to V_{dd} to reduce the power dissipation in this phase. In evaluation phase, the amplified input signal causes the latch to change its state in either direction and by the aid of positive feedback the output signal will clip to one of the supply sources, producing the digital outputs.

D. MDAC

An MDAC performs sampling, digital to analogue conversion, subtraction and amplification. The circuit shown in Figure 2-12 is responsible for sampling, subtraction and amplification in an MDAC: Amplifier's clock is a delayed version of comparator's clock. This delay is needed for thermometer decoder and DAC to complete the conversions from thermometer codes to binary codes and from digital codes to analogue signal.

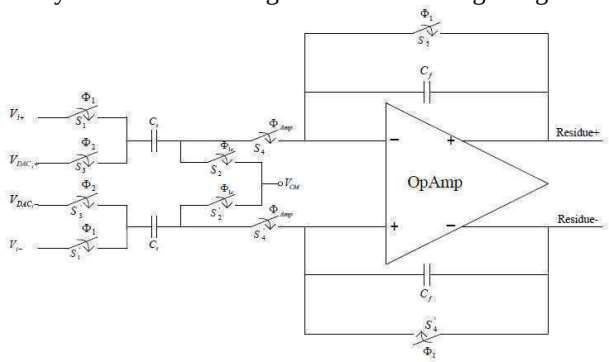

Figure 6. Sampling and Multiplication Part of The MDAC Circuit

E. Bootstrapping

High linearity requirement of the 12-bit ADC necessitates linear operation of the switches in the sub-ADC and MDAC structure. For a switch to work with high linearity, it should work with constant overdrive voltage. To serve this purpose some of the switches are bootstrapped, especially front end switches whose overdrive voltage suffers from the changes of input voltage. The bootstrap circuit, designed in [10] and adapted for low-voltage 65nm CMOS technology, is depicted in Figure7.

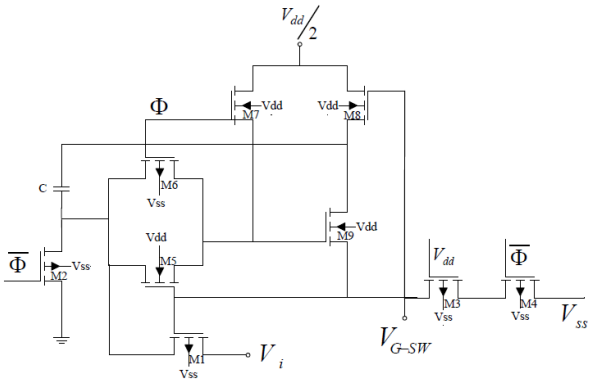

Figure7. Bootstrap Circuit

Bootstrapping also helps with switches conducting constant high voltages. It can provide a high enough overdrive voltage for those switches.

F. Clocking Scheme

Clock phases needed within the stage are depicted in Figure 8.Clock1 is used to sample the input data by the sampling network in flash sub-ADC and MDAC simultaneously. Pulse width of this clock is almost ¼ of the sampling period. Clock1e is similar to clock1 in regards to period and 25% pulse width, but it turns off before clock1 to cancel charge injection problem from sampling switches. Allocating less time to sampling allows the circuit to spend more time on amplifying which gives amplifier more time to settle, increasing maximum sampling frequency.

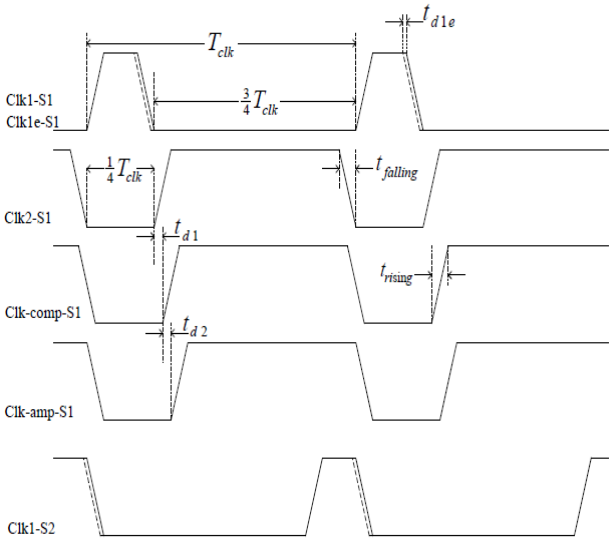

Figure 8. Stage Clock Phases

Clock2 is used for introducing reference voltages to the sampling network to be compared to sampled data (in

sub-ADC) or subtracted from it (in MDAC). The pulse width of clock2 is almost ¾ of sampling period. As explained before, in sub-ADC and MDAC sections, the comparators' clock and amplifier's are delayed version of clock2. All clocks' pulse width is lowered by rising and falling time to obtain non-overlapping clocks.

Sampling in each stage (except for stage1) starts at the last 25% of the amplification clock of preceding stage. This way, as the OpAmp amplifies the residue signal and resides within the accepted error (½ LSB) of its final value, the sampling capacitance of succeeding stage is charged with the residue signal to reach the final value simultaneously. Using this scheme, conventional sampling period can be reduced by 25%.

G. Digital Correction and Time Alignment

The bits from each stage are not resolved at the same time. As a result the output bits from 6 different stages that correspond to the same input sample are ready at different point in 28 time and should be time aligned and then digitally corrected. In order to align the bits related to the same sample shift registers are used.

III. DESIGNE OF OPAMP

In this work, a two-stage gain boosted amplifier is designed to achieve high DC-gain and output swing. The price to be paid is high power consumption which is not avoidable when a high performance amplifier is needed. An OpAmp to be employed in a 12-bit pipelined ADC is designed and its performance metrics are shown.

A. OpAmp Requirements

For an OpAmp-based design of a high resolution and high speed pipelined ADC, there are high requirements for the OpAmp design to be satisfied. These two definition "high resolution" and "high speed" for an ADC adds a great deal of challenge on the OpAmp design to achieve the required performance regarding DC-gain, Bandwidth, noise, stability, speed and swing. All of which should be achieved under critical conditions of decreased supply voltages and intrinsic gain of today's CMOS technology. The down sized transistors of new coming technologies also have higher leakage and lower output resistance. They are faster switches as a result of the reduced parasitic capacitances (due to reduced transistor dimensions). Because of the higher number of transistors in smaller area, heat production is another problem of scaling in new technologies which will cause slower operation and reduced reliability and lifetime of the transistors. These transistors are also more prone to process variation. All of these characteristics of new scaled down technologies add more error to the OpAmp's transfer function, making it harder to satisfy the stringent requirements on the OpAmp.

OpAmps are the basic building block of an ADC which determine the speed and accuracy of the ADC. They introduce gain error and nonlinearity which should be minimized in design process or compensated for by digital correction circuitry. They are also the most power hungry part of the ADC and dissipate almost 60-80% of the total power. There are a few techniques to reduce OpAmps power consumption [18], like using class AB amplifiers which only consumes dynamic current, OpAmp sharing and OpAmp current reuse.

As discussed earlier, the OpAmp is used in the 2.5 b MDAC structure of the pipelined ADC. The OpAmp is placed in a negative feedback with amplification factor of 4. Now it is time to see what the requirement specification for this OpAmp is. Here we discuss DC-gain, Gain-Bandwidth (GBW), Slew-Rate (SR) and Noise. In the Table 1, the needed requirements on the OpAmp to be used in the pipelined ADC are summarized.

TABLE I.
SUMMARY OF OP AMP's REQUIREMENTS

Performance Metrics	Required Values
f_u	2.12 GHz
Slew Rate	5.27Kv/µs
Dc-gain	67 dB
SNR	71dB

B. Proposed OpAmp Architecture

The proposed OpAmp is a two-stage, fully differential, Cascode current mirror topology modified for low-voltage operation. It is an extended version of OpAmp used [19]. In Figure 9.the architecture of the amplifier is shown: The OpAmp is a two-stage amplifier to achieve high gain and voltage swing. It is also uses gain boosted cascode devices. Input devices are chosen to be PMOSFETs because of their lower flicker noise and more flexibility about the input CM level. Second stage incorporates NMOS devices for their higher intrinsic gain. Second stage is a simple CS stage to allow more output swing. 2pF load capacitor is considered to simulate next stage's input capacitance. The compensation scheme used here is Miller Compensation.

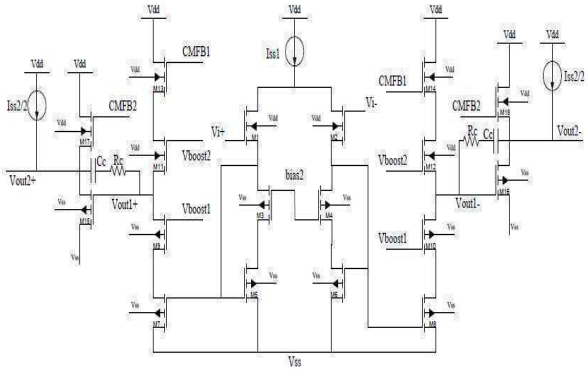

Figure 9. OpAmp Architecture

C. Common-Mode Feedback (CMFB)

Both stages CM levels are regulated by common-mode feedbacks. Figure 10 represents CMFB circuit:

Differential outputs of each stage are sensed by a differential pair and compared to a voltage reference. In case of any differentiation, the CMFB brings back the output CM mode level to its equilibrium.

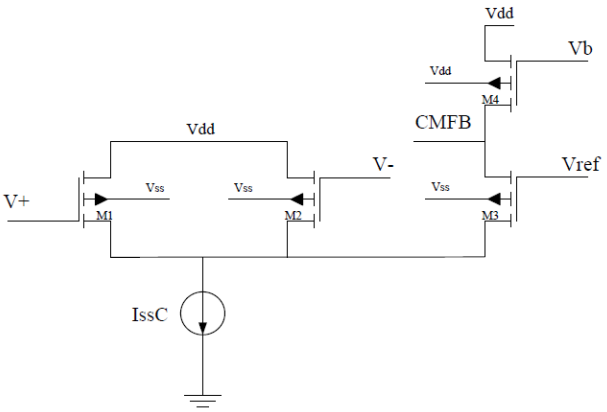

Figure 10. CMFB Circuit

D. Boosting Amplifiers

Boosting amplifiers are folded-cascode OpAmps. The folded-cascode OpAmps have high voltage swing and moderate gains. They also allow more input CM mode range. The 4 stacked transistors of first stage and the boosting amplifiers placed in the main amplifiers circuit are shown in Figure 11.

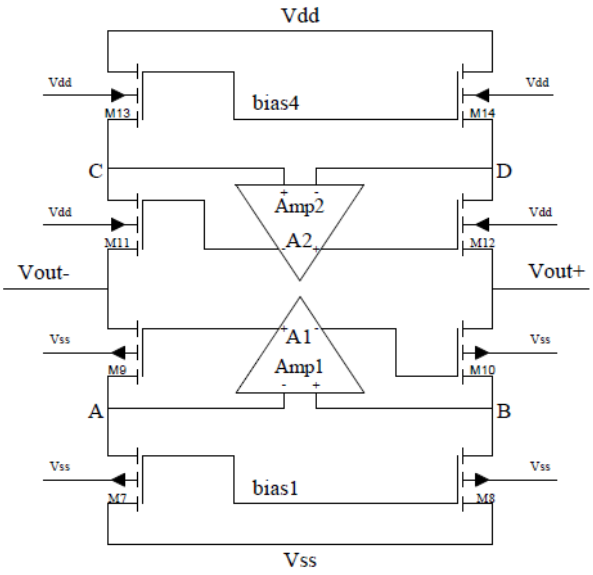

Figure11: Boosting Amplifiers Placed in The First Stage's Output Branch

Amp1 senses voltages of points A and B, regulates the cascode devices' (M9-M10) gate-source voltages and amplifies the total gain by A1. Amp1 has PMOS input devices to deal with low voltage CM levels in A and B. Amp2 incorporates NMOS input devices due to same reasoning. The architecture of boosting amplifier number two is shown in figure12.

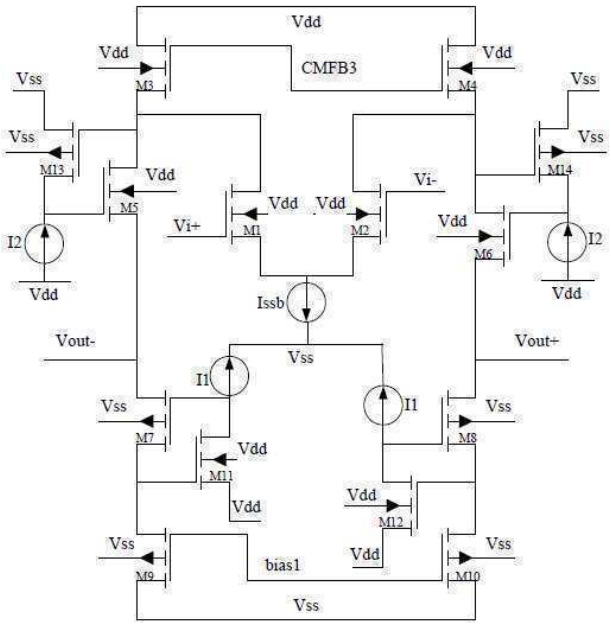

Figure 12: Boosting Amplifier

Boosting amplifiers are gain boosted as well. The technique is called Nested-boosting [14]. Sometimes the second boosting amplifier is simple, like this case, but it also can be scaled version of main boosting amplifier if more gain is needed. One should be cautious when putting boosting amplifiers into the circuit as they introduce internal loops that can be unstable.

To check for stability around internal loops, probes (to break the loop during simulation) and stability simulation can be used. In Figure 13, Figure 14, Figure 15 and Figure 16 gain and phase plots of both boosting amplifiers are shown and Table 2 and Table 3 contains simulated parameters for boosting amplifiers.

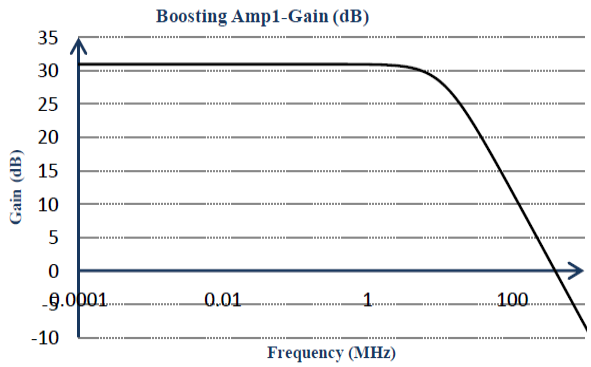

Figure 13: Boosting Amp1 Gain Plot

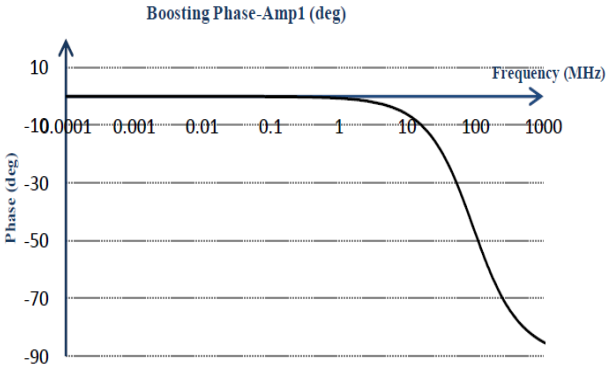

Figure 14: Boosting Amp1 Phase Plot

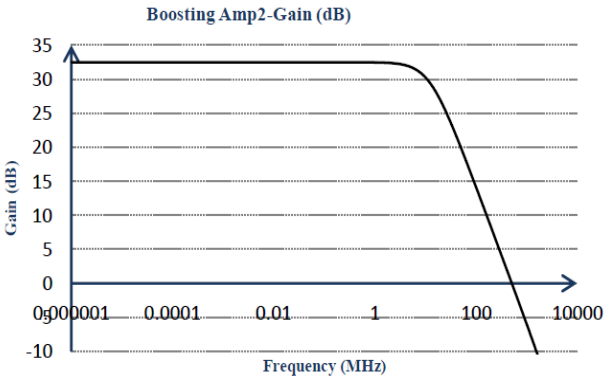

Figure 15: Boosting Amp2 Gain Plot

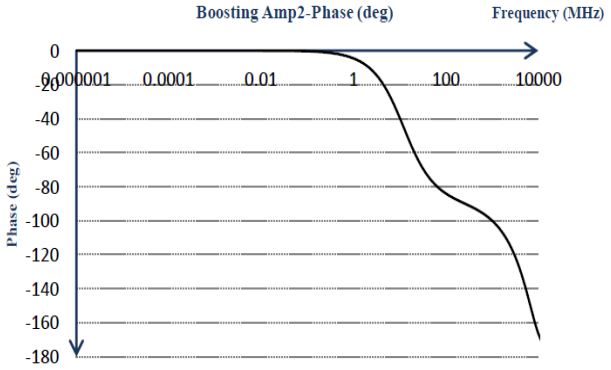

Figure 16: Boosting Amp1 Phase Plot

TABLE II
BOOSTING AMPLIFIERr NO.1 RESULTS.

Performance Metrics	Simulated Value
f_u	393.4 MHz
BW_{3dB}	11.45 MHz
$DC-gain$	30.98 dB
PM	89.93 deg
$i_{V_{dd}}$	11.44 mA

TABLE III
BOOSTING AMPLIFIER NO.2 RESULTS.

Performance Metrics	Simulated Value
f_u	512.9 MHz
BW_{3dB}	12 MHz
$DC-gain$	32.48 dB
PM	94.25 deg
$i_{V_{dd}}$	15.5 mA

IV. RESULTS

The OpAmp is placed in the test bench illustrated in Figure 17 to be simulated and its parameters are calculated. Sampling capacitor is 4 times of feedback capacitor to provide gain of 4 for the MDAC (C_s/C_f=1). The noise voltage at the output of amplifier falls below 0.2LSB by Choosing C_s larger than 100fF for 10-bit ADC and 2pF for 12-bit ADC. C_l is chosen 2pF to simulate the load effect of next stage.

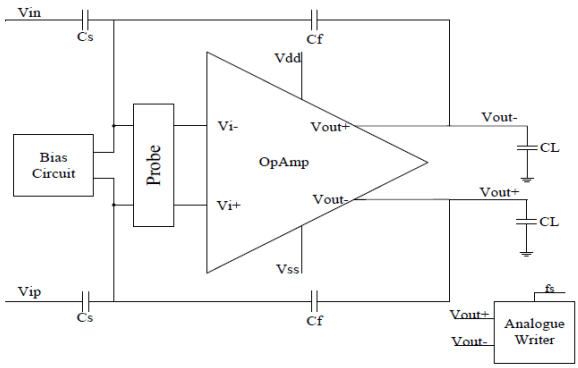

Figure 17. OpAmp Test Bench

The probe module shown in the figure17 is placed in the feedback to break the loop when using the stability simulator (stb Analysis in Analog Design Environment) in Cadence. The stability simulator calculates loop-gain and loop-phase and is used to determine stability of the circuit around the loop.

The analog writer module is responsible for sampling the output data and dumping the sampled data into a text file. The text file can be read by Matlab and used for OpAmp's performance determination.

The OpAmp reaches 72dB DC-gain and the gain stays constant when the output swing increases up to the point that the output voltage clips. In Figure 18 and Figure 19 the open-loop gain and phase of the designed OpAmp is shown. Other performance metrics of the amplifier are simulated and summarized in Table 4:

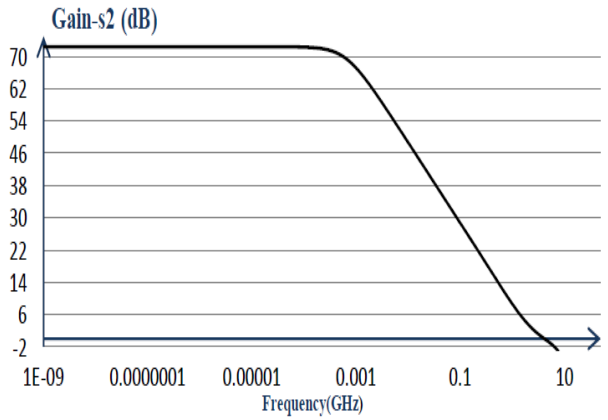

Figure 18. Open-Loop Gain Plot of 2-stage, Gain Boosted OpAmp

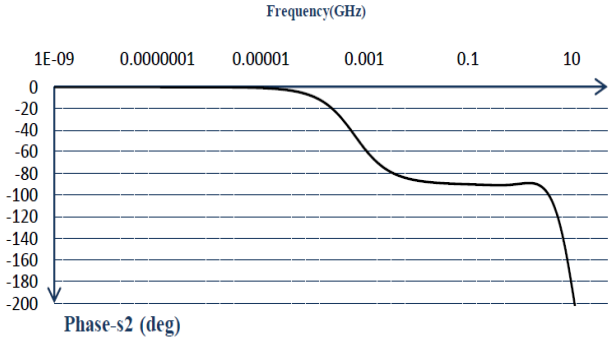

Figure 19: Open-Loop Phase Plot of 2-stage, Gain Boosted OpAmp

TABLE 4-4
OPAMP SIMULATED PERFORMANCE METRICS

Performance Metrics	*Simulated Value*
f_u	*4.077 GHz*
BW_{3dB}	*640.4 KHz*
DC – gain	*72.35 dB*
PM	*76.01 deg*
$i_{V_{dd}}$	*123.3 mA*
SNR(for fs up to 320 MHz)	*>100dB*
Slew Rate	*22.5kv/µs*

Settling behaviour of the OpAmp, for being used in 12-bit or 10-bit pipelined ADC and placed in the 2.5 bps MDAC (amplification factor of 4) is verified. The simulation is done applying low frequency (1MHz) pulse waves with different amplitudes to the input and recording the settling time of the amplifier, when the OpAmp settles to half of the corresponding LSB.

Table 5: Settling Time of The OpAmp for Being Placed in 12-bit ADC LSB for 10-bit ADC with maximum 1.4v input voltage (differential peak to peak voltage) is 1.37mv and settling between the 683.6µv (half LSB) error from final value is evaluated. Table 6: Settling Time of The OpAmp for Being Placed in 10-bit ADC.

TABLE V
SETTLING TIME OF THE OPAMP FOR 12-BIT ADC

$V_{in-pp-Diff}(mv)$	$V_{out-pp-Diff}(mv)$	$T_{settling}(ns)$	$f_{s-max}(MHz)$
200	800	2.243	356.66
240	960	2.92	273.97
280	1120	3.27	244.65
320	1280	3.56	224.71
360	1440	3.86	207.25

TABLE VI
SETTLING TIME OF THE OPAMP FOR 10-BIT ADC

$V_{in-pp-Diff}(mv)$	$V_{out-pp-Diff}(mv)$	$T_{settling}(ns)$	$f_{s-max}(MHz)$
200	800	2	400
240	960	2.25	355.55
280	1120	2.57	311.28
320	1280	2.79	286.74
360	1440	2.84	281.7

CONCLUSIONS

In this work, an OpAmp with very high gain-bandwidth, high linearity and Signal-to-Noise ratio has been designed. The performance of the OpAmp is verified using Cadence simulation and Matlab and they satisfy the requirements on the amplifier of a 2.5bps MDAC in a 12-bit pipelined ADC. The amplifier is placed in a pipelined ADC which is also designed in transistor level. The main focus in this work was the OpAmp design to meet the high requirements needed for 2.5 bps MDAC and provide an inter-stage gain of 4 in the ADC. The OpAmp should provide a high closed-loop bandwidth to accommodate a high speed ADC with very low gain error to match the high resolution definition.

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FPGA Implementation of MC-CDMA for High Security Applications

R.Ganesh[1] and Ch.Sandeep Reddy[2]
[1]CVR College of Engineering/ECE Department, Hyderabad, India
Email: rachaganesh@gmail.com
[2] CVR College of Engineering/ECE Departments, Hyderabad, India
Email: sandeepredy.ch@gmail.com

***Abstract*—The demand of wireless communications is increased in high speed, high security applications like missile communication, satellite communication etc. The communication with these features can be achieved by using different carrier modulation techniques like single carrier, multi carrier modulation etc. The multi carrier modulation with orthogonality of carriers provides high speed communication. This process is called Orthogonal Frequency Division Multiplexing (OFDM). The high speed and band width utilization can be achieved by using OFDM. The high security communication can be achieved by using coders and spreaders with different random generator sequences with the help of Spread Spectrum techniques. This can be done by using a method called Code Division Multiple Access (CDMA). The Multi Carrier CDMA is defined by adding the features of OFDM and CDMA and this is used for high speed and high secured communication system. The MC-CDMA uses convolution coder, viterbi decoder and spreader, de spreader etc to provide security.**

The MC-CDMA technique consists of a back to back connected transmitter and receiver with 8-point FFT/IFFT and QPSK modulation. This technique is designed by using Verilog HDL with Xilinx ISE Design suite 12.4 version tool. The design is implemented in Xilinx virtex-5 XUPV5LX110T FPGA board.

***Index Terms*—OFDM, CDMA, Orthogonality, Convolution Encoder, Viterbi Decoder.**

I. INTRODUCTION

The present communication systems components require high speed and high security in different application areas like missiles, satellites, mobile etc. The high speed or high security communication systems alone may creates some problems related to bandwidth inefficiency, spectrum utilization etc [1].To achieve better non functional performance parameters the high speed features of OFDM and security features of CDMA are combined to get a new technique called as Multi Carrier CDMA (MC-CDMA).

The MC-CDMA is one of the spectrum utilization techniques that are used for multiple access schemes. This technique gives best spectrum utilization, flexibility in terms of speed and security.

This paper explains the FPGA implementation of MC-CDMA for high security applications. This paper is organized such that the section 2 describes the introduction of basic wireless communication models for high speed, high security applications by using multi carrier techniques like OFDM, CDMA, and MC-CDMA, section 3 describes the results of MC-CDMA system by using Xilinx ISE tools, and section 4 describes the FPGA implementation of MC-CDMA by using Xilinx virtex5 FPGA. The conclusion is presented in section 5 followed by references.

II. OVERVIEW OF MC-CDMA

In wireless communication the data can be sent through the channel in two ways i.e. either single-carrier or multi-carrier. In single-carrier technique the available data stream is transferred sequentially, in this technique each modulated carrier occupies the entire bandwidth of the channel. But, in the multi-carrier technique the total bandwidth is divided into different sub frequencies so that each frequency can be used for one data input. This division of frequency gives better bandwidth spectrum utilization.

The single data input system uses one carrier signal with the total bandwidth allotted to this channel only. In multiple data input system the bandwidth is divided into N number of carrier signals for N inputs. The bandwidth utilization for single input and multiple input systems is shown in Figure1.

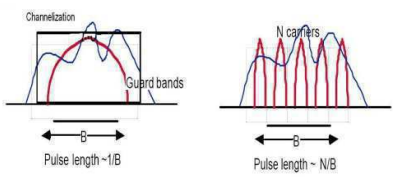

Figure.1: Difference between single-carrier and multi-carrier

Based on the application the multi-carrier technique is divided in to different types like CDMA (Code Division Multiple Access), OFDM (Orthogonal Frequency Division Multiplexing) and MC-CDMA (Multi-Carrier Code Division Multiple Access) etc. The CDMA can be implemented by using the spreading techniques, so it is used for high security applications. In OFDM the available spectrum is divided into N number of orthogonal sub carriers and this technique is used for high speed applications. The MC-CDMA technique is designed by adding the high speed features of OFDM and security features of CDMA [7]. The MC-CDMA uses frequency domain to spread the data, in this technique each sub carrier is having different spreading code. Another spreading technique called as MC-DS-CDMA spreads data in time domain, in this technique all sub carriers uses common spreading code. This concept of multiple spreading codes and single spreading codes for multi carrier design is shown in Figure2 (Fig2.a and Fig. 2.b).

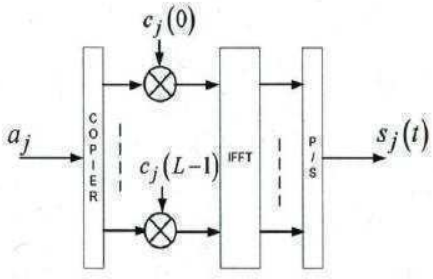

Figure. 2(a) MC-CDMA

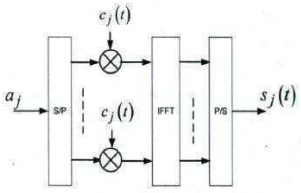

Figure. 2(b) MC-DS-CDMA

Figure 2: Classification of MC-CDMA

Advantages of MC-CDMA:

1. Higher data rates with better bandwidth utilization.
2. Best suitable for wireless systems with delay spread, Doppler spread.
3. Fading is reduced by using frequency diversity.
4. Limited energy loss due to the scattering of energy in all sub carriers.

Problems in MC-CDMA:

1. Peak-to-Mean Envelope Power Ratio (PMEPR) is high due to non linearity in amplification.
2. For high speed vehicles designs complex analysis is required because of carrier frequency offset sensitivity.
3. Sensitive to phase noise.
4. The frequency reusing factor is less compared to other techniques.

Block diagram of MC-CDMA:

The MC-CDMA communication system at base band level can be designed by using a transmitter and a receiver section . This design of transmitter and receiver consists of both security features using multi carriers with the help of encoders, decoders and speed features using OFDM with QPSK modulation/demodulation techniques. The transmitter section consists of convolution encoder, QPSK framer, IFFT etc. The receiver section consists of FFT, QPSK deframer, viterbi encoder etc. The block diagram of the MC-CDMA is shown in Figure3.

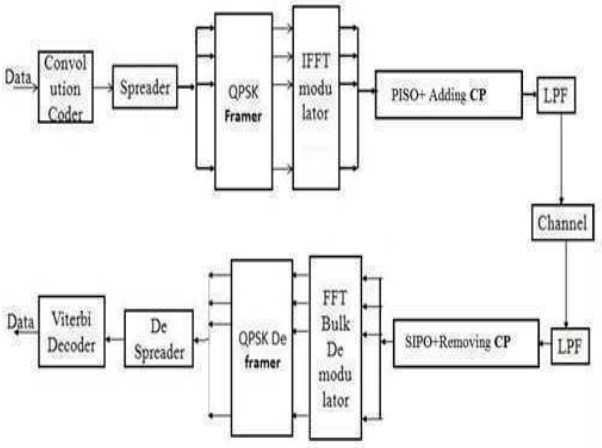

Figure 3: Block diagram of MC-CDMA

The individual blocks of MC-CDMA are explained below with respect to functionality.

Convolution Encoder:

The convolution encoder is used for security purpose, it will convert single bit input to two bit or multi bit output [12]. Convolution encoder is represented by (n, k, m) notation, where n is the number of output bits, k is the number of input bits and m is the constrained length. The rate of convolution encoder is defined as the ratio of number of input bits to number of output bits. It can be implemented by using FSM (Finite State Machine). The Figure 4 below illustrates a simple convolutional coder with k=1, n=2, g1 (n) = (1 0 1), g2 (n) = (1 1 1) and R=1/2. Where R is the code rate.

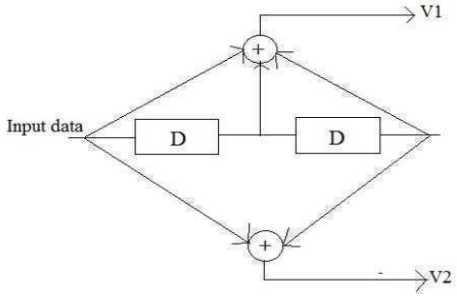

Figure 4: Convolution encoder

The state table for convolution encoder is shown in Table1indicating input, present state, next state and output values.

TABLE I
STATE TABLE OF CONVOLUTION ENCODER

Input (u)	Present state (S1,S0)	Next state (S1,S0)	Output (V1,V2)
0	00	00	00
1	00	10	11
0	01	00	11
1	01	10	00
0	10	01	10
1	10	11	01
0	11	01	01
1	11	11	10

The state diagram and the trellis diagram of ½ convolution encoder in Figure 4 are shown below Figure 5.a and 5.b.

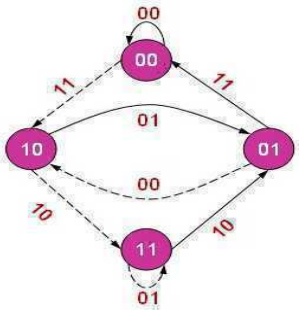

Figure. 5(a) state diagram

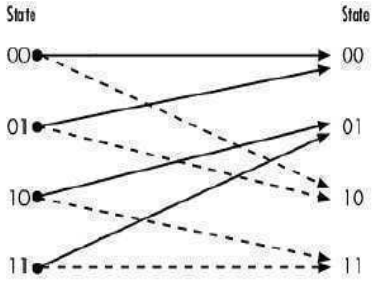

Figure. 5(b) Trellis diagram

Spreader:

The Spreader is also used for security purpose. This can be implemented by using Linear Feedback Shift Register (LFSR). The m-stage LFSR block diagram is shown in Figure 6.

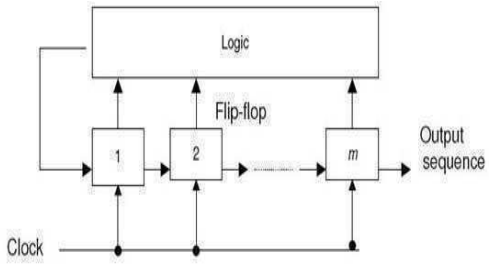

Figure 6: m-stage LFSR block diagram

The LFSR can be designed by using flip flops and some combinational logic circuit. The values in the flip flops are shifted by a single timing clock. The logic in the above diagram can be implemented by using the EXOR gates. The output of EXOR gate is feedback to the input of the LFSR.

QPSK Framer:

The Quadrature Phase Shift Keying (QPSK) is used to modulate the input data signal with the carrier by using four combinations of real and imaginary I and

Q channels [8]. The selection of I and Q channels can be done by using the one of four possible carrier phase shifts (0, Π/2, Π, and 3Π/2). This mapping of I and Q channels to the input two bits in the form of constellation diagram is shown in Figure 7.

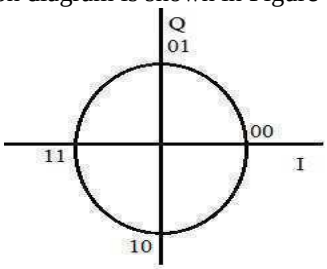

Figure7: QPSK Constellation diagram

IFFT (Inverse FFT) Modulator:

The IFFT is used in the transmitter section of MC-CDMA to minimize the complexity of the design. The IFFT is an algorithm that is useful for speeding up the computation and converts frequency domain to time domain [5].

The DFT of a sequence {x(n)} of length N by a complex valued sequence {X(K)}

$$X(K)=\sum_{n=0}^{N-1} x(n)e^{-\frac{j2\pi nk}{N}} \quad , \ 0\le k \le N-1.$$

Let W_N be the complex-valued phase factor, which is an N th root of unity expressed by

$$W_N = e^{-j2\pi/N}$$

Hence X(K) becomes

$$X(K)= \sum_{n=0}^{N-1} x(n)\, W_N^{nk} \quad , \ 0\le k \le N-1.$$

Similarly Inverse Discrete Fourier Transform (IDFT) become

$$x(n) = 1/N \sum_{k=0}^{N-1} X(K) W_N^{-nk} \quad , \ 0\le n \le N-1.$$

The butterfly diagram of 8-point IFFT is shown in Figure 8.

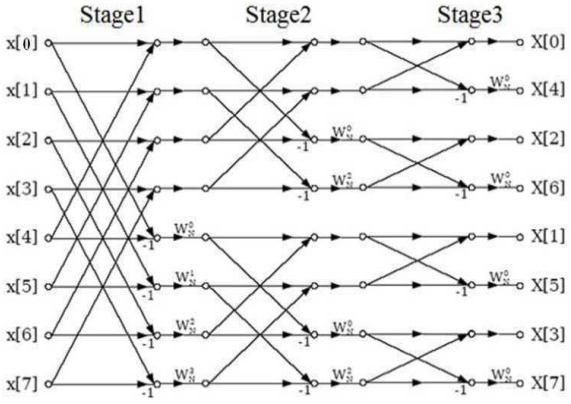

Figure 8: Butterfly diagram of 8-point IFFT

PISO (Parallel In Serial Out):

The parallel in serial out block accepts parallel data and produces serial data as output. The Inter Symbol Interference (ISI) problem of OFDM can be minimized by adding a guard time is inserted with duration longer than the multipath channel maximum delay. This ISI effect can be removed by extending this guard time cyclically in OFDM symbol. The cyclically extension of an OFDM symbol is shown in Figure 9.

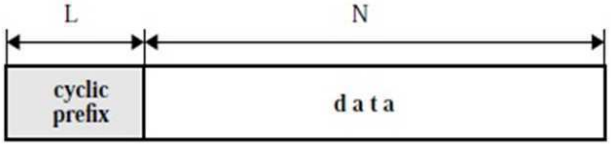

Figure 9: PISO with addition of CP

SIPO (Serial In Parallel Out):

The serial data can be converted into parallel data by using this block. Before applying the outputs of SIPO to FFT (Fast Fourier Transform) demodulator cyclic prefix can be removed.

FFT (Fast Fourier Transform) demodulator:

To reduce the complexity of MC-CDMA, Fast Fourier Transform (FFT) technique is used in receiver [6]. The FFT is used to convert from time domain to frequency domain.

The FFT is an algorithm that is useful for speeding up the computation. The 8-point FFT butterfly diagram is shown in Figure 10.

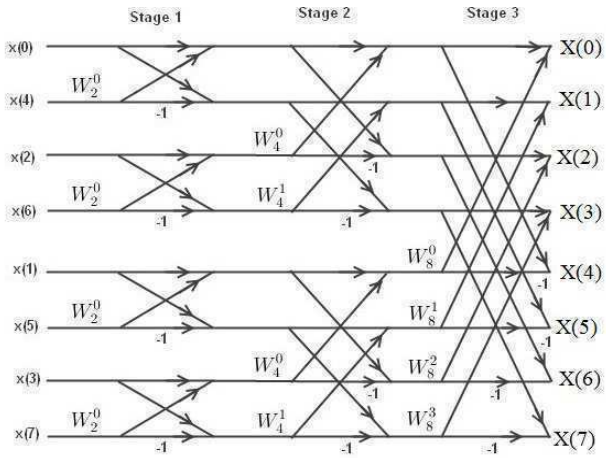

Figure 10: The 8-point Butterfly diagram of FFT

QPSK Deframer:

The parallel data bits are taken two bits together and converted from I, Q to the data bit pattern. The

parallel data is converted into serial data. This operation is exactly reverse to QPSK framer.

Despreader:

The serial data is again Exclusive-ORed with the PN pattern and resulting in original data bit pattern.

Viterbi Decoder:

The viterbi decoder is used to decode the output of the convolution encoder [11]. Block diagram of the viterbi decoder is shown in Figure11.

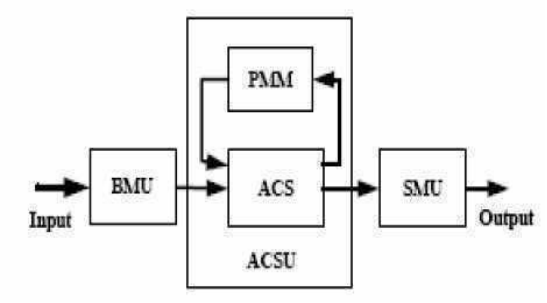

Figure 11: Block diagram of the viterbi decoder

The Viterbi decoder is designed by using Branch Metric Unit (BMU), Add Compare Select Unit (ACSU), and State Metric Unit (SMU) [13-15]. The branch metric computation block is used to count the number of differing bits in the received code symbol and expected code symbol. This is called as hamming distance. The ACSU makes a sum of branch metric and previously accumulated path metric, compare the path metric and select the smallest path metric and decision bits that are supplied to SMU. The SMU finds out the survivor path and decoding bits, SMU produces the decoded bits.

III. RESULTS OF MC-CDMA

The design of MC-CDMA is implemented on Xilinx ISE (Integrated Software Environment) tools; the design is simulated by using Isim simulator and synthesized by using XST (Xilinx Synthesis Tool).The design is prototyped on to XUPV5LX110T FGPA board using IMPACT configuration tool.

The simulation results of MC-CDMA transmitter and receiver are shown below figures 12 and 13.

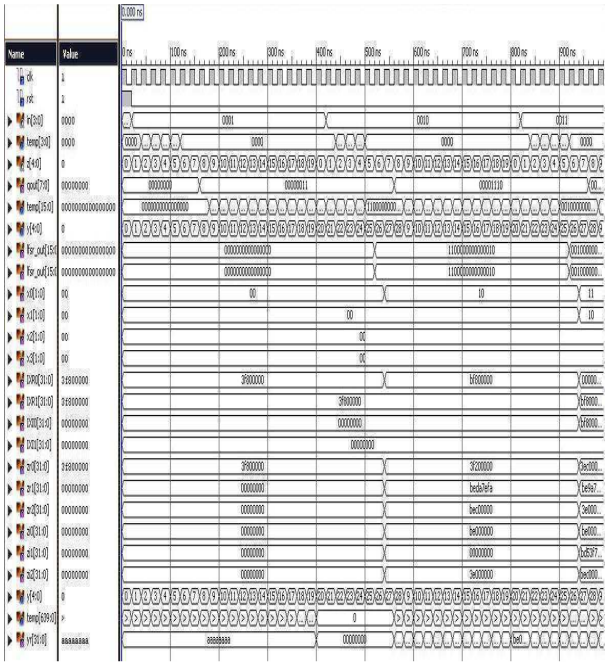

Figure 12: Simulation results of MC-CDMA transmitter

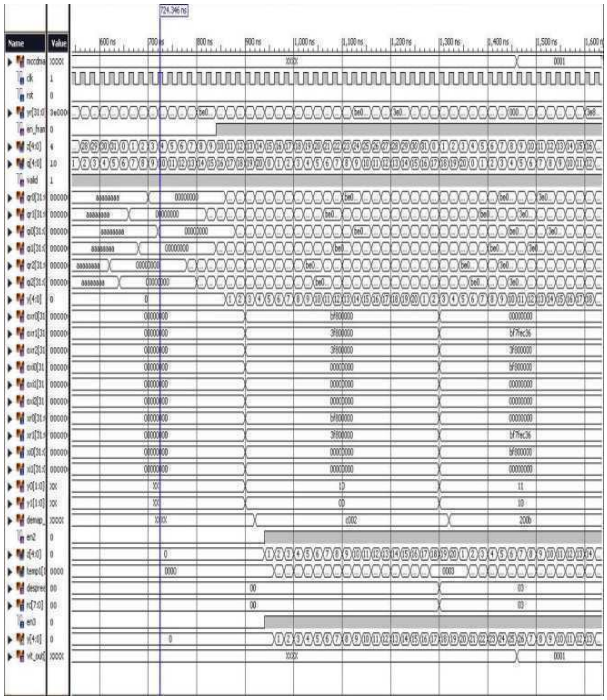

Figure 13: Simulation results of MC-CDMA receiver

V. FPGA IMPLEMENTATION OF MC-CDMA

The design of MC-CDMA system is verified on Xilinx Virtex-5 FPGA by using Xilinx iMPACT tool. The output of MC-CDMA on virtex-5 FPGA is shown in Figure 14.

Figure 14: Output of MC-CDMA on Virtex-5 FPGA

V. CONCLUSION

The design of MC-CDMA system is implemented with 8-point IFFT/FFT, QPSK modulation, spreader, de spreader, convolution encoder and viterbi decoder is designed by using Xilinx ISE Design suite 12.4 version with Verilog HDL.

The design is simulated for functionality by using Xilinx ISE simulator tool. The synthesized MC-CDMA design has 1382 LUT slices, 2005 slice registers and 3 buffers. Timing analysis results show that the critical path is 2.329 ns, i.e. the maximum clock frequency is 429.369 MHz

The synthesized MC-CDMA design is implemented on XILINX Virtex-5 FPGA.

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Lifting Wavelet Transform for Super Resolution Image Reconstruction using MATLAB

B. Janardhana Rao[1] and O. Venkata Krishna [2]
[1] CVR College of Engineering/ECE, Hyderabad, India
Email: janardhan.bitra@gmail.com
[2] CVR College of Engineering/EIE, Hyderabad, India
Email: venkatakrishna.odugu@gmail.com

Abstract: **The aim of this paper is to develop a high resolution image from a sequence of low resolution compressed images. An image with improved resolution is desired in almost all of the applications to enhance qualitative features and is reported to be achieved by Super Resolution Image Reconstruction (SRIR). Some low resolution images of same scene which are usually rotated, translated and blurred are taken to form a super resolution image.**

The image registration operation orients translated, scaled and rotated images in similar way to that of source image. Lifting Wavelet Transform (LWT) with Daubechies4 coefficients is applied to color components of each image due to its less memory allocation compared to other techniques. Further Set Portioning in Hierarchical Trees (SPIHT) algorithm is applied for image compression as it possess lossless compression, fast encoding/decoding, adaptive nature. The three low resolution images are fused by spatial image fusion method. The noise component is removed by dual tree Discrete Wavelet Transform (DWT) and blur is removed by blind de-convolution or iterative blind de-convolution. Finally, the samples are interpolated to twice the number of original samples to obtain a super resolution image. The structural similarity for each intermediate image compared to source image is estimated via objective analysis and high structural similarity is observed for image constructed by the proposed method.

***Index Terms*—Wavelets, Lifting Scheme, Super Resolution, Daubechies, Image Registration, SPIHT**

I. INTRODUCTION

Super resolution is nothing but improving the resolution of an image. High resolution images are widely used in most of the image processing applications such as remote surveillance video enhancement, industrial inspection, medical imaging, robot vision and remote sensing. Super Resolution is the technique of producing a higher spatial resolution image from one or more under sampled low resolution images, low resolution refers to the less pixel density in an image which gives very few details. The purpose behind the reconstruction of a single high resolution image from several low resolution images is that the images are degraded and mis-registered such as blur and noise, these images are sub pixel shifted due to sub-sampling which results in an aliased low resolution image. From these sub pixel shifted images, a variety of information can be collected from each low resolution image. A simple version of SRIR Model is shown in figure 1 [1]

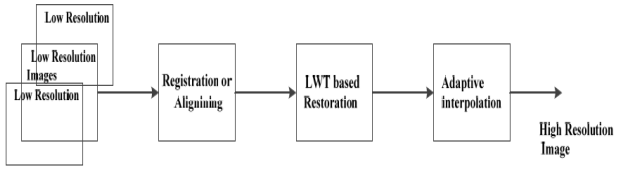

Figure 1: Super Resolution Image Reconstruction Model.

Super Resolution is an emerging technology in signal processing to get a High Resolution (HR) image. The main aim of Super Resolution (SR) is to enhance the spatial resolution of multiple lower resolution images. The super resolution technique is an efficient lossy and low cost technology. In this paper we are using Wavelet Transform (WT) technique to get an HR image from Low Resolution (LR) images by involving image registration, blurring, decimation, re-registration, de-blurring, de-noising and interpolation operation.

The major challenges for super resolution are image registration, computation efficiency, robustness aspects, and speed issue (fast algorithm implementation).

II. IMAGE REGISTRATION

Image registration is a process of overlaying two or more images of the same scene taken at different times, from different viewpoints and by different sensors. Source image is taken as the reference and compared with the input images. The main goal is to make the input image appear as the source image by applying spatial transformations which help in mapping the locations in one image to the new locations in the other. Image registration mainly depends on the properties of the capturing device such as sampling rate, resolution of the sensor, the imperfection of the lens that adds blur and the noise of the device used for image acquisition. An accurate registration of two low resolution images becomes more difficult because If the resolution of an image goes down, the two dimensional structure of an image also goes down. Here the registration technique used is based on Fast Fourier Transform proposed by Fourier Mellin, DeCastro and Morandi. Transformation used is rotation, translation and shift estimation and the process of the Image Registration is shown in Figure 2 [2].

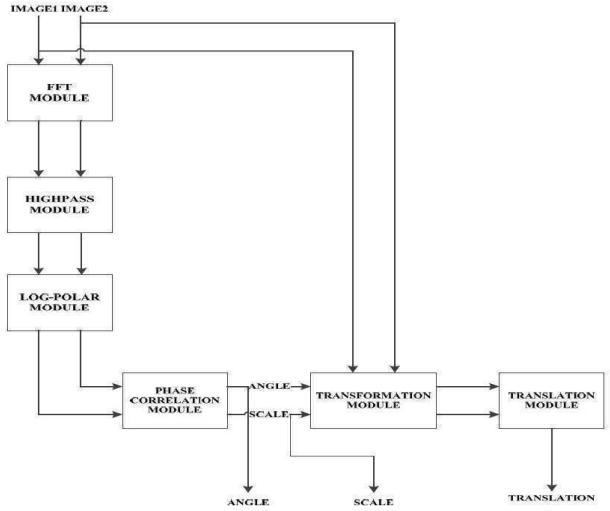

Figure 2: Image Registration Algorithm.

III. LIFTING WAVELET TRANSFORM

Wavelet is a function of finite length and is oscillatory. The dilations and translations of a source wavelet are used to operate the spatial or frequency analysis of the input data in wavelet transform. Wavelets are widely used in major applications, since the image quality can be improved by the addition of detailed information. This makes wavelets more attractive for progressive transmission of images. Wavelets build the complex filters to generate the data which can improve the quality of the specified region of the image. Wavelet techniques found applications in noise reduction, signal variance estimation, frequency analysis and also for data compression. One of the features of wavelet techniques is the perfect reconstruction. This means extraction of original data set from the result of inverse wavelet transform. The wavelet transforms can be used in image processing due to their capability of reducing the size (storage) of the image without affecting the image resolution which can save computation time [3].

Lifting is a transform that makes use of means and differences. The mean values have a control over the entire structure of the signal and termed as *update* and in differences, if the difference between two samples is almost same or very small, then it can be concluded that the first sample is the *prediction* of the second one. The wavelet lifting scheme is a method that separates the wavelet transform into a set of steps.

The forward wavelet transform is considered in forward lifting wavelet transform, the data under process is divided into an odd and an even element.

The simple form of a forward lifting wavelet transform is shown in figure 3 [5]. The process is initiated with a finite sequence S_j of length 2^j. It is transformed into two sequences, each of length $2^{j-1}$and denoted S_{j-1} and d_{j-1}, respectively.

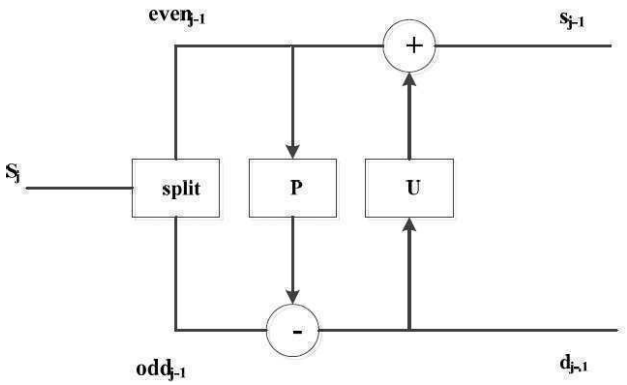

Figure 3: Three step lifting scheme.

Note that the minus represents 'the signal from the left minus the signal from the top'

The following are the three steps of lifting scheme

Split The split step sort the entries into the even and the odd entries. The functionality of the algorithm is made clear in this split operation. In effective implementation the entries are not moved or separated.

Predict A correlation between the sample and its nearest neighbors is predicted when the signal containing some structure. Given at the sample number 2n, we predict that the value at sample 2n+1 is the same. When the value at 2n+1 is replaced with the correction to the prediction, which is the difference.

$$dj-1[n] = sj[2n+1] - sj[2n]$$

In general, the idea is to have a prediction procedure *P* and then compute

$$dj-1 = oddj-1 - p(evenj-1)$$

Thus in the **d** signal each entry is one odd sample minus some prediction based on a number of even samples.

Update For a given even entry, a prediction is made that the next odd entry has the small value and the difference is stored. Then an update of the even entry is done to show our knowledge of the signal.

$$sj-1[n] = sj[2n] + dj-1[n]/2$$

In general, a suitable updating procedure is chosen and then used in computing

$$sj-1 = evenj-1 + U(dj-1)$$

The Predict step finds the wavelet functions in the wavelet transform. This is a High pass filter. The Update step finds the scaling function resulting to a smoother version of the data. This is a Low pass filter.

A combination of number of lifting steps yields the DWT. The computed differences D_{j-1} are left behind and the average sequence s_{j-1} of the previous lifting step is used as input for the preceding lifting step. The two step discrete wavelet transform is shown in the figure 4 [5]

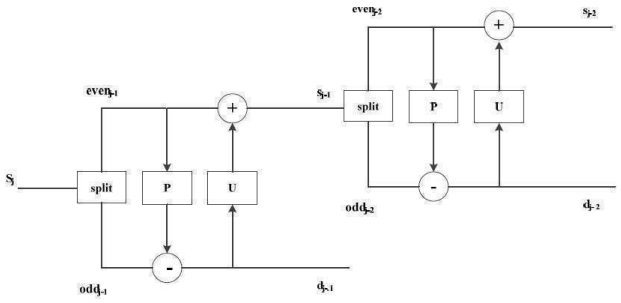

Figure 4: Two-steps Discrete Wavelet Transform.

The Inverse Lifting Scheme is a mirror of Forward Lifting Scheme and is checked by reversing the arrows and changing the signs. The direct form is

$$oddj-1 = oddj-1 - P(evenj-1)$$

$$sj-1 = evenj-1 + U(dj-1)$$

is inverted by the steps

$$evenj-1 = sj-1 - U(dj-1)$$

$$oddj-1 = dj-1 + P(evenj-1)$$

These steps are illustrated in Figure 5 [5]

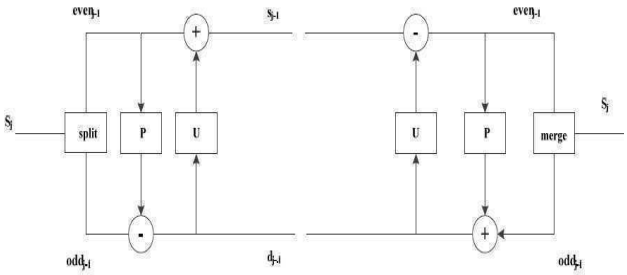

Figure 5: Direct and Inverse lifting step.

A. Lifting scheme version of the Daubechies 4 Wavelet transforms

The two steps of Lifting Scheme wavelet transform are update and predict. Here a new step is included named normalization, shown in figure 6 [1].

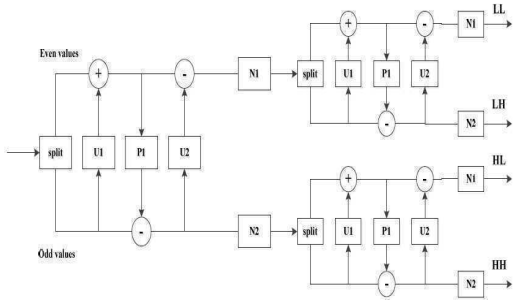

Figure 6: Two stages Daubechies Db4 forward lifting wavelet transform.

The input data in the split step is separated into even and odd elements. The even elements are kept in S_0 to S_{half-1}, the first half of an N element array section. The odd elements in S_{half} to S_{n-1}, the second half of an N element array section. The equations below the expression S_{half+n} refers to odd element, S_n refers to the even in the forward transform. The term LL refers to low frequency components and LH, HL, HH represents the high frequency components in the horizontal, vertical and diagonal directions respectively.

The forward step equations are

Update1 (U1):

For n=0 to half-1

$$S[n] = S[n] + \sqrt{3}\,S[half + n]$$

Predict (P1):

$$S[half] = S[half] - \frac{\sqrt{3}}{4}S[0] - \frac{\sqrt{3}-2}{4}S[half + 1]$$

For n=1 to half-1

$$S[half + n] = S[half + n] - \frac{\sqrt{3}}{4}S[n] - \frac{\sqrt{3}-2}{4}S[n+1]$$

Update2 (U2):

For n=0 to half-2

$$S[n] = S[n] - S[half + n + 1]$$

$$S[half - 1] = S[half - 1] - S[half]$$

Normalize (N)

For n=0 to half-1

$$S[n] = \frac{\sqrt{3}-1}{4}S[n]$$

$$S[n + half] = \frac{\sqrt{3}+1}{4}S[n + half]$$

The addition and subtraction operations interchanged in the inverse transform, as the inverse transform is a mirror of the forward transform [6].

IV. SET PARTITIONING IN HIERARCHICAL TREES

The image compression algorithms like Embedded Zero tree Wavelet (EZW), Set Partitioning in Hierarchical Trees (SPIHT). Image compression is of two types, Lossless and lossy compression. In Lossless compression, after performing decompression exactly the original image is obtained, in practice images with natural scenes error free compression is not possible. Coming to the lossy compression, there are methods in lossy compression such as EZW algorithm, SPIHT algorithm, WDR algorithm and ASWDR algorithm etc. These recent image compression algorithms have fewer errors per compression rate and the perceptual quality is also high. Compression of an image involves five stages as shown in the figure 7 and here is lossy compression only because of quantize step is not invertable, Quantizing is a quality reduction of the wavelet transform floating point values of 32-bit or 64-bit.

The important point here in wavelet based compression is the connection between Quantize, Encode step and the block diagram is shown in figure 7 [7].

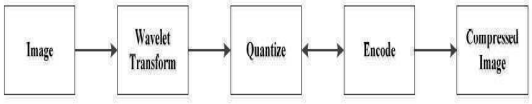

Figure 7: Block Diagram of a transform based coder.

The SPIHT algorithm achieved the higher PSNR values for a given compression ratios and high perceptual quality also the greater computational complexity is obtained by this algorithm. The drawback of SPIHT is that, it is difficult to perform on certain selected points or selected region of a compressed image where increase in resolution is required [7]. SPIHT is a powerful wavelet based image compression algorithm. It is a benchmark state of art algorithm for image compression.

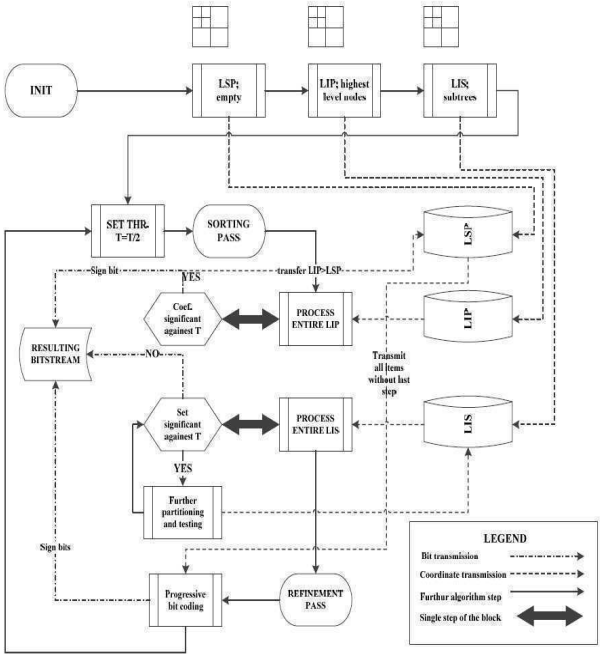

Figure 8: SPIHT algorithm scheme.

The operation of SPIHT goes on from testing the ordered wavelet coefficients for significance in a decreasing bit plane order, and just quantizing the significant coefficients. This algorithm achieves high coding efficiency because of group testing of the wavelet tree coefficients. This algorithm maintains the insignificant coefficients group in bigger subsets with the use of sequenced partitioning of trees. SPIHT algorithm does the grouping of wavelet coefficients and trees into sets depending on their significance information. Sorting and Refinement are the two stages used in SPIHT encoding algorithm. The significant wavelet transform coefficients are coded first and later the bits are transmitted as a result a more enhanced copy of the original image is obtained.

Following the initialization step, for each level of threshold, sorting pass and refinement pass are the next two stages. In the first stage i.e., sorting pass, SPIHT tries to group the coefficients accordingly depending on their magnitude. Quantization of the coefficients is improved in the refinement pass, where actual progressive coding transmission is done [4]. Relative to the threshold, sorting and refining is performed.

The threshold is set and without any interruption it is made smaller while operating throughout the algorithm. A form of bit-stream is obtained as output result. In the decomposition, SPIHT allows three lists of coordinates of coefficients. In the order, they are the List of Insignificant Pixels (LIP), the List of Significant Pixels (LSP), and the List of Insignificant Sets (LIS). At a certain threshold, a coefficient is considered significant if its magnitude is greater than or equal to threshold. The LIP, LIS, and LSP concept can be defined based on the idea of significance. SPIHT algorithm in detail is shown and explained in the figure 8 [8].

V. IMAGE FUSION

The process of getting important information from two or more images and combining it into a single image is called Image Fusion. The resultant image contains more information compared to each of the input images. Remote sensing applications give access to large amount of space borne sensors which provides a motivation for various image fusion algorithms. High spatial and spectral resolutions are needed in a single image in today's situation. Image fusion is the solution for it, as this technique allows the integration of several information sources and hence the output fused image contains attractive spatial and spectral resolution characteristics. In case of multispectral data, while merging the spectral information can be distorted by the standard image fusion techniques. High Pass Filtering is the basic method for image fusion. The other techniques available are IHS transform based image fusion, PCA based image fusion, and Wavelet transforms image fusion, Pair-wise spatial frequency matching. These techniques are based on DWT, Uniform rational filter bank, and laplacian pyramid.

DWT is very useful tool for fusion. For images to perform image fusion, they must be registered before fusion. The major applications of image fusion are classification of image, Aerial and Satellite imaging, Medical Imaging, Robot Vision, Concealed weapon detection, Multi focus-image fusion, Digital Camera Application, Battle field Monitoring etc.

Wavelet transform fusion is defined by considering the wavelet transforms φ of the two or more registered images $g_1(x,y)$, $g_2(x,y)$, $g_3(x,y)$ together with the fusion rule. Inverse wavelet transform φ^{-1} is computed, and the fused image is reconstructed.

$$g(x,y) = \varphi - 1(\sigma(\varphi(g1(x,y)),\varphi(g2(x,y)),\varphi(g3(x,y)))$$

Directional information is obtained from wavelet transform, i.e. low-low (LL), high-low (HL), low-high (LH), and high-high (HH) bands, which contains unique information and the process is shown in figure 9 [9].

FFT based technique has been used to register the three low resolution images as proposed in introduction. Each low resolution image is down sampled using two level bi-orthogonal filter based discrete wavelet transform and

later these are fused. Here approximate and detail coefficients are fused.

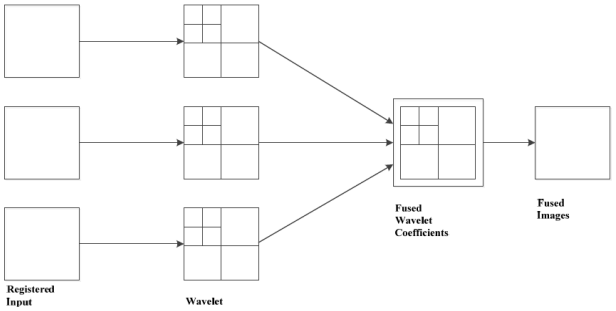

Figure 9: DWT based fused image.

The fusion of decomposed images is done by using fusion rule i.e. Maximum Frequency Fusion: "fusion by averaging for each band of decomposition and for each channel the wavelets coefficients of the three images are averaged". That is
approximate and detail coefficients are fused separately

$$M_j{}^c I = (M_j{}^c I_1 + M_j{}^c I_2 + M_j{}^c I_3) / 3$$

$$N_j{}^o I = (N_j{}^o I_1 + N_j{}^o I_2 + N_j{}^o I_3) / 3$$

The fused image is obtained by using Inverse wavelet transform. The resulting image is a de-noised image, the blur present in the image is removed using Iterative Blind Deconvolution. The high resolution image is obtained from wavelet based interpolation.

VI. DECONVOLUTION METHODS

The blur present in the image is removed using Deconvolution methods.

A .Blind Deconvolution

The standard de-convolution problem in the frequency domain is given as

G (Kx, Ky) = F (Kx, Ky) H (Kx,Ky) + N (Kx, Ky)

Here we need to estimate the input spectrum F (Kx, Ky). The noise spectrum N (Kx, Ky) is unknown. Also if the systems Optical Transfer Function (OTF) H (Kx,Ky) is also an unknown then de-convolution problem occurs. By looking at the equation this blind de convolution problem seems impossible as measured output system G (Kx, Ky) is equal to product of two unknown quantities plus a random noise process.

The solution for this problem can be found by iterative procedures carried out in frequency domain. The basic constraints of the solutions are that they have *finite support*, i.e. the sought input distribution is known to be confined to certain spatial region and is zero outside this region. The Blind de-convolution method not only estimates or restores the original input distortion but also the PSF responsible for the degradation.

B. Iterative Blind Deconvolution

Iterative Blind De-convolution technique is a kind of de-blurring filter used to remove blur in the image. The Blind de-convolution of two convolved functions is shown by a simple iterative method. Mathematically, the convolution c(x) of two functions, f(x) and g(x) is given by integral equation

$$c(x) = \int_{-\inf}^{+\inf} f(x1)g(x - x1)dx1$$

The Fourier transform representation of the above equation is

C (u) = F (u) G (u)

The basic de-convolution method consists of the following steps. First, a non negative valued initial estimation $fo(x)$ is input into the iterative scheme. This function is Fourier transformed to yield $F\,\hat{}\,(u)$, which is then inverted to form an inverse filter and multiplied by $C(u)$ to form a first estimate of the second functions spectrum Go (u). This estimated Fourier spectrum is inverse transformed to give $g_o(x)$. The image-domain constraint of non-negativity is now imposed by putting to zero all points of the function go(x) that have a negative value. A positive constrained estimate $g_o\hat{}(x)$ is consequently formed that is Fourier transformed to give the spectrum Go$\hat{}(u)$. This is inverted to form another inverse filter and multiplied by C(u) to give the next spectrum estimate $F_1(u)$. A single iterative loop is completed by inverse Fourier transform $F_1(u)$ to give $f_1(u)$ and by constraining this function to be nonnegative, yielding the next function estimate $f_1\hat{}(x)$. The iterative loop is repeated until two positive functions with the required convolution.

Blind de-convolution is a technique that allows the reconstruction of image from a single or more blurred image in the presence of a poorly determined or unknown PSF. Blind de-convolution can be performed iteratively where each iteration improves the estimation of the PSF and the scene IBD starts with an initial estimate of the restored image, an initial estimate of the PSF restoring the image is by making an initial estimate of what the PSF and image are. One of the constraints that we apply to the image is that of finite support. Finite support basically says that the image does not exist beyond a certain boundary. The first set of Fourier constraints involve estimating the PSF using the FFT of the degraded image and FFT of the estimated PSF

$$Hk(u,v) = \frac{G(u,v)conj(F1(u,v))}{|F1(u,v)| \wedge 2 + alpha|F(u,v)| \wedge 2}$$

By applying IFFT to $Hk(u,v)$, we obtain the PSF. The true image is restored by deconvolution of the PSF with the degraded image. Hence the second set of constraints Involve

$$Fk(u,v) = \frac{G(u,v)conj(H1(u,v))}{|H1(u,v)| \wedge 2 + alpha|H(u,v)| \wedge 2}$$

The blur constraints that are applied are from the assumptions that we know or have some knowledge of the size of the PSF [10].

C. Image Quality Measurement

The image quality is measured from the parameters Mean Square Error (MSE), Structural Similarity Index Metric (SSIM) and Mean SSIM (MSSIM)

(i)Mean Square Error (MSE)

The two metrics are used to measure the performance index of image compression are Objective Fidelity criteria and Subjective Fidelity criteria. MSE is a measure belongs to Objective Fidelity criteria. The energy lost in the lossy compression of the original image *f* is estimated using this. If we consider two images affected by same type of degradation, the image with low MSE is closer to the original image. The Mean Square Error between the original image *f(m,n)* and the reconstructed image *g(m,n)*, which contains M x N pixels is

$$MSE = \frac{1}{M * N}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}(f(m,n)) - g(m,n))2$$

$$PSNR = 10 * \log 10\left[\frac{(2b-1)2}{MSE}\right]$$

For an 8-bit image, b = 8 which gives the PSNR value as

$$PSNR = 10 * \log 10\left[\frac{2552}{MSE}\right]$$

(ii)Structural Similarity Index Metric (SSIM)

SSIM, Structural Similarity Index Metric is an objective video quality assessment metric used in predicting the video quality. The structural similarity among two frames is calculated by using SSIM. An alternative in evaluation of perceptual quality is SSIM.
It takes the quality degradations in the frames as perceived changes in the variation of structural information among two frames

$$\text{SSIM (x, y)} = \frac{(2\mu_x\mu_y + C_1')\quad(2\sigma_{xy} + C_2')}{(\mu_x^2 + \mu_y^2 + C_1')\quad(\sigma_x^2 + \sigma_y^2 + C_2')}$$

where μ_x, μ_y are the average of x and y respectively, σ_x, σ_y are the variance of x and y respectively, σ_{xy} is the covariance of x and y. c_1, c_2 are the constants used in order to evaluate any instabilities in the structural similarity comparison.
The Mean SSIM index to evaluate the overall image quality

$$MSSIM(X,Y) = \frac{1}{M}\sum_{j=1}^{M} SSIM(xj, yj)$$

where M is number of local windows in the image [11].

V. IMPLEMENTATION

The growing requirement for high resolution images resulted in the need for super resolution image reconstruction. Our goal in creating a super resolution image is to consider different types of same scene image of low resolution as inputs and combine them to generate a high resolution image through a series of steps. The implementation consists of taking either a source image for developing low resolution images like blurred, noisy and rotated versions of it as shown in Figure 10. The noisy image is generated by mixing the signal with a statistical random noise in particular an Additive White Gaussian noise. Such a noise component has a zero mean and constant power spectral density. The value at each time is uncorrelated to the value at any other time instant in Gaussian noise components. The blurred version is generated by convolution of the image with a window of chosen value. The convolution by a windowed function decreases the amplitude at some points and increases the amplitude at other points thereby generated a blurred image. Finally the rotated version is generated by inbuilt Matlab function viz.imrotate( ). By providing the arguments label of the image, angle through which it should be rotated, size of the returned image along with method of interpolation. Bicubic interpolation is chosen that provides pixel outside the image range to rectify for pixels lost due to rotation. The ´crop` option returns the image of same size as that of source image.
The next step in the process is image registration which influence only on rotated, translated, scaled and shear images and passes all other images without any action. By comparing with reference images the rotated image input(s) are oriented back to its original form. It is the process of overlaying two or more images of the same scene taken at different times, from different viewpoints and or by different sensors. To a base image taken as reference the other images are compared. Spatial transformation helps in orienting the input images in the same direction as base or reference image. Using the translational, rotational, scaled and sheared estimations of translational, rotational, scaled and sheared images constructs the base image from spatial transformations. The output of this step is an image oriented as input image along with noisy and blurred versions that are passed through.

For color images, R G and B components are separated from each image and Lifting Wavelet Transform (LWT), is applied to each component using Daubechies 4

coefficients. Daubechies wavelets are a family of orthogonal wavelets defining a discrete wavelet transform and characterized by a maximal number of vanishing moments for some given support. With each wavelet type of this class, there is a scaling function (called the *father wavelet*) which generates an orthogonal multi resolution analysis. A wavelet transform for an image implies that it is sampled both in frequency and time to form wavelets.

A two level decomposition is applied such that after decomposing an image using first level decomposition it retains maximum information in LL band. The 'LL' band is decomposed for second time so that available information is concentrated in a very small band ´LLLL´. Each output image is compressed by a powerful wavelet based image compression method known as SPIHT. The output from the two level transformations is encoded and then decoded by SPIHT method. The output differs from the input in a way that is compressed without any loss of data, with high quality and without any error.

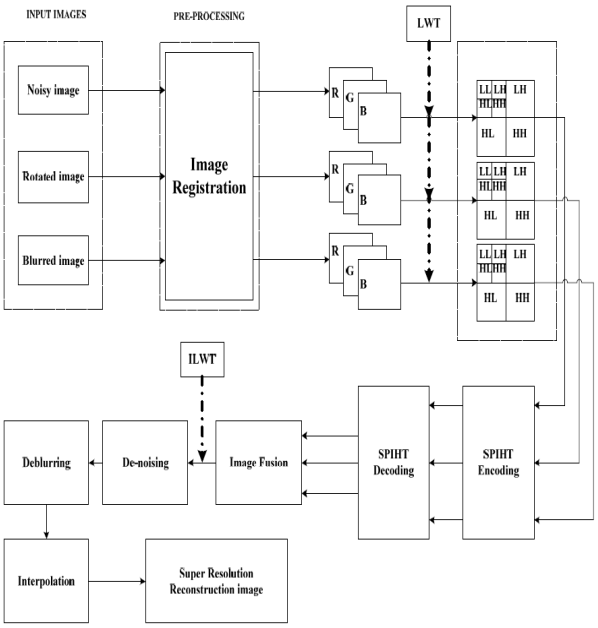

Figure 10: Block diagram for Super resolution image reconstructed

The three outputs are fused together to form a single image by a process of image fusion. The fusing technique used here is averaging, a sub class of spatial domain fusion along with transform domain.

The noise component of the image is removed by using a Dual tree Discrete Wavelet Transform abbreviated as Dual Tree DWT. The transform estimates the original image adaptively from the noise image by taking mean square error as optimisation criteria. The blurred part of the image is removed by using iterative blind deconvolution or blind deconvolution. Blind deconvolution is a process where in a target image is obtained from a single or set of blurred images by deducing its point spread function (PSF).

The final step in construction of a super resolution reconstruction image is interpolation of samples. Interpolation appends as many samples as needed between two input samples to generate band limited signal by applying a low pass filter. It is just the opposite of sampling process. The data points in the image increases by appending more samples between two input samples. The interpolation method used here is bicubic interpolation since images resampled with bicubic interpolation are smoother than bilinear interpolation. So by integrating three low resolution versions of same scene image over an algorithmic procedure, the resolution of the image is enhanced to obtain a super resolution reconstructed image.

VI. RESULTS

Image Quality Measurement values for proposed method are listed in table 1.

TABLE I
SSIM VALUE FOR PROPOSED CASE FOR LENA IMAGE & HD IMAGE

Image Quality Metric	Input Images			Super Resolution Reconstruction Image			
	noise	blurred	rotated	after Image Fusion	after denoising	after BD	after IBD
SSIM for Lena Image	0.578	0.686	0.229	0.8044	0.8138	0.7534	0.7744
SSIM for HD Image	0.5387	0.7565	0.2868	0.8171	0.83	0.7658	0.8245

From the below represents The low resolution source image from which versions of it were developed is shown in figures 10, Fig (a), Fig (b) represents the noisy image derived from source image by adding an additive white Gaussian noise with variance 0.05. Fig (c) is the rotated version of source image by an angle of 10 degrees. It was noted that rotation was checked for different angles and results coalesce. Fig (d) is the blurred version of source image developed by convolution with an impulse response of [1 2 2 2 2 2 2 2 2 2 1]. The images were Pre-processed using image registration with arguments such that it applies to only rotational, translational and scaled images. By overlaying with reference images provided, the orientation of rotated image aligns similar to that of reference image. Fig (e) represents the super resolution reconstructed image after average fusing the three images obtained after applying LWT, two level decomposition, SPIHT encodes and SPIHT decodes in order. Fig (f) represents the image where noise is suppressed, obtained by applying dual tree DWT and interpolation. Fig (g) and Fig (f) represents the super resolution reconstructed images after reducing blur by blind deconvolution and iterative blind deconvolution respectively and are interpolated to twice the samples.

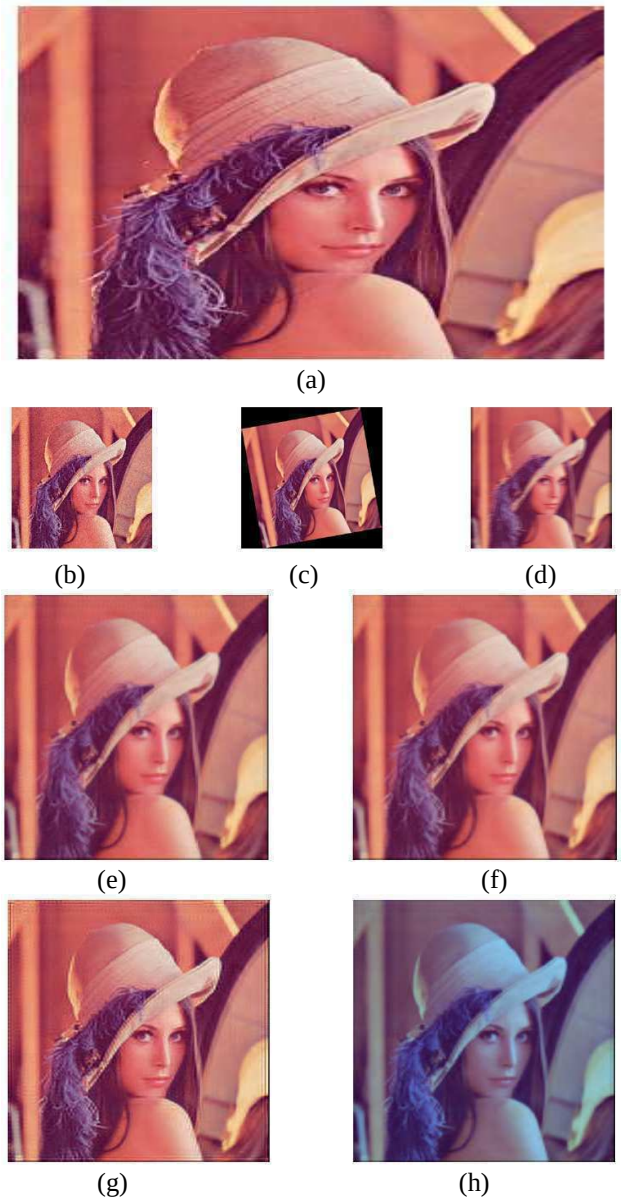

Figure 11: (a) Source image(512x512), (b) Noisy image(256x256), (c) Rotated image(256x256), (d) Blurred image(256x256), (e) SRR image after Image fusion(512x512), (f) SRR image after Denoising(512x512), (g) SRR image after Blind deconvolution(512x512),(h) SRR image after Iterative blind deconvolution(512x512).

CONCLUSIONS

It can be concluded that output is a high resolution version of input image with higher perceptual quality judging from the value of structural similarity (SSIM) with reference to input image shown in Table 1. We obtained the results for different varieties of input images i.e. noisy, blurred, translated and rotated images. Image fusion is applied and improved SSIM values are noted. However some blur and noise component is observed in the image. Denoising is performed by Dual tree DWT based algorithm and enhance SSIM values are noted. Blur component is suppressed by Blind Deconvolution (BD) and Iterative Blind Deconvolution (IBD). Also it can be concluded that debluring using IBD yields better SSIM values compared to BD so the former one is more advantageous than later but this comes at a higher computational cost. The results from proposed models concludes that a high resolution image can be achieved by combining two or more low resolution images of same scene. The key to the success of the algorithm is having an accurate observation model. This includes the image registration parameters and the system PSF.

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Design of Higher Order Modulation Schemes for Orthogonal Frequency Division Multiplexing (OFDM) Systems

P. Naga Malleswari
CVR College of Engineering /ECE, Hyderabad, India
Email: pinjalamalleswari@gmail.com.

***Abstract*—In this paper we design and simulate OFDM (Orthogonal Frequency Division Multiplexing) to study the performance of the OFDM system at higher order modulation schemes. It is very important to evaluate performance of the communication system, to test the efficiency and quality of the service it can provide. We use Matlab program to design the functionality of OFDM, then BER(Bit Error Rate) is obtained to different SNR(Signal to Noise Ratio) values, for M-array PSK and M-array QAM modulations techniques. BER is widely used as performance measurement tool, it tells number of bits destroyed while the data is travelling from source to the destination, AWGN(Additive White Gaussian Noise) is used as transmission channel.**

***Index Terms*—OFDM, Bit error rate, QAM, noise, AWGN.**

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) uses multiple sub-carriers for data transmission. In this transmission scheme all the sub-carriers are orthogonal to each other. OFDM is the combination of multi carrier modulation and multiplexing i.e. it is the process of mapping digital data on multiple carrier frequencies sharing bandwidth with other independent channels. In this modulation technique data symbols modulate the orthogonally separated sub-carriers. This technique is similar to FDM technique except that the N non-overlapping Sub-carrier signals are made orthogonal. Unlike other conventional frequency multiplexing techniques, it overcomes the problem of bandwidth wastage by using overlapping but orthogonal sub-carriers.

In this paper the higher order digital modulation techniques that are used for Orthogonal Frequency Division Multiplexing (OFDM) designed. In OFDM we set frequency constant to maintain orthogonality of the sub-carriers and alter amplitude or phase or both at same time. We also discuss communication channels and fading channels, which are used to calculate Bit Error Rate (BER) and the system performance of OFDM transmission technology. In the modulation process to convey the message properly the base band signal is imposed on to high frequency carrier signal and is transmitted without disturbing the original data for long distances. Further we are going to discuss about different modulation techniques and their effect on carrier signal. Frequency of the carrier signal is always higher than the frequency of base band signal. In digital modulation the modulating signal is digital bit stream. Digital modulation is classified into different types based on the variation in the characteristics of carrier signal, Three characteristics of the signal that can be varied over time are amplitude, phase and frequency. After modulation any one of the three parameters is changed and the other two remains constant. The three fundamental techniques of digital modulation are, Amplitude shift keying (ASK), Frequency shift keying (FSK) and Phase shift keying (PSK).

II. OFDM Signal generation

The block diagram of orthogonal Frequency Division Multiplexing is shown in figure 1.

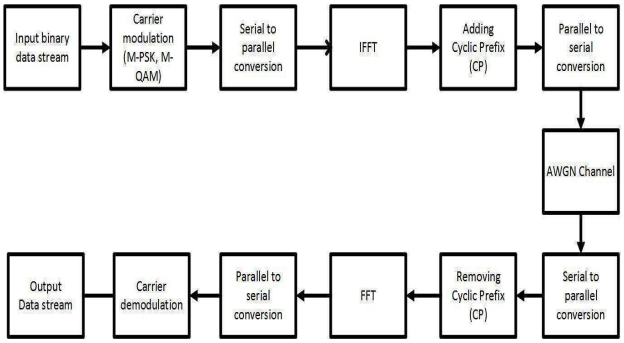

Figure 1: block diagram of OFDM.

A. Transmitter

Here we discuss the steps involved in transmitting the OFDM signal. Initially the information to be conveyed is given as input to the system as binary data. Unlike other modulation techniques using a single carrier for modulation, OFDM system uses a number of sub-carriers one for each symbol of input bit stream. To accomplish this input serial stream of data is converted to parallel streams. Consider a serial bit stream of 3 bits and it is converted in to parallel , Now, each stream is mapped with a complex symbol stream using PSK/QAM. The reason behind choosing particularly these techniques is, they are high level modulation techniques. Mapping using BPSK, QPSK or QAM helps to increase the data rate of OFDM. In this paper the BER vs. SNR of all the three modulations techniques observed. Simple

illustration of the mechanism going on in this block is given below,

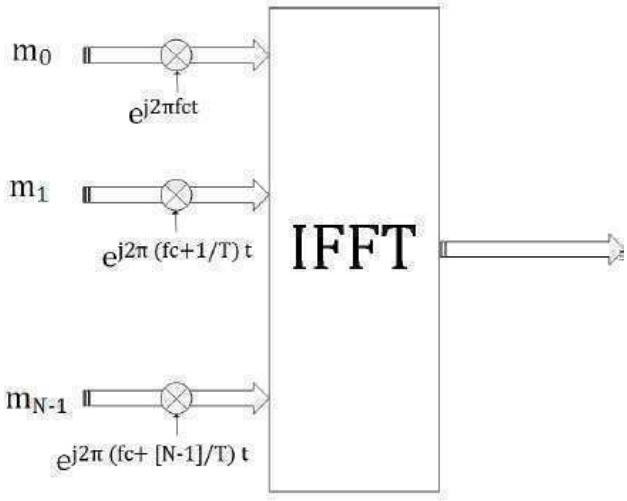

Figure 2: Figure showing conceptual modulation block

In the figure 2. $m_0, m_1, \ldots m_{N-1}$ represents N parallel bit streams obtained after serial to parallel conversion and each branch corresponds to a sub-carrier. Each sub-carrier modulates a symbol m_k. To maintain orthogonality, frequency spacing of 1/T Hz is maintained between the successive sub-carriers. This is because sinusoidal signals differing in the frequency 1/T will be orthogonal over the period T.

$$\int_{t_n}^{t_n+T} e^{j2\pi f_c t}\left[e^{-j2\pi(f_c+\frac{1}{T})t}\right] dt = 0$$

Individual sub-carriers are arranged, such that the frequency separation between two successive sub-carriers is $\Delta f = 1/T$. Complex symbol streams obtained from modulation block are set as input to the Inverse Fast Fourier Transform (IFFT) block is shown in figure 3. where the domain changes takes place. Usually data obtained after mapping parallel data streams onto sub-carriers is in frequency domain. IFFT converts the data in frequency domain function to time domain function. Obtained time domain functions are given as input to parallel to serial converter and the signal are multiplexed. The final output from IFFT is multiplexed time domain signal.

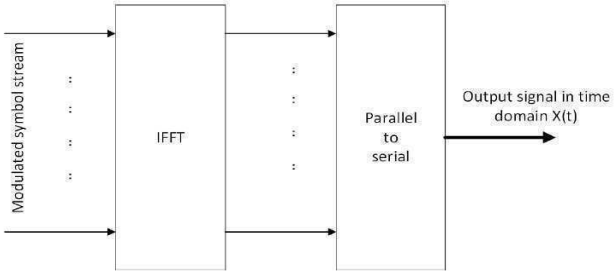

Figure 3: IFFT block diagram

If N modulated symbol streams are set as input to IFFT with a symbol duration T, then the output OFDM symbol duration is NT. The output signal X(t) in time domain acts as base band signal for OFDM system. Addition of cyclic prefix To this OFDM signal cyclic prefix is appended to avoid power loss due to echoes. It is generated by prefixing a symbol with its last samples. Important point to be considered in order to serve effectively is its length. Length of the cyclic prefix should be at least equal to the delay of its multipath channel. Apart from this it retains sinusoids properties.

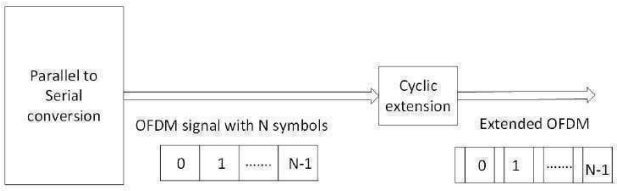

Figure 4: shows the multiplexed OFDM signal with N symbols.

This is given as input to cyclic prefix extension where cyclic prefix is appended to each symbol. It also shows the difference between OFDM and its extended version. In normal signal which is obtained after multiplexing, all the N symbols are together one after the other but in case of extended OFDM signal there are samples appended to each symbol shown in figure 5. Thereby the two successive symbols do not interfere with each other. Now the question may arise, which samples are added as prefix and to which extent? What is the use of appending? These questions are answered in the further sections of this chapter. Clear view of extended version of OFDM symbol answers half of our questions.

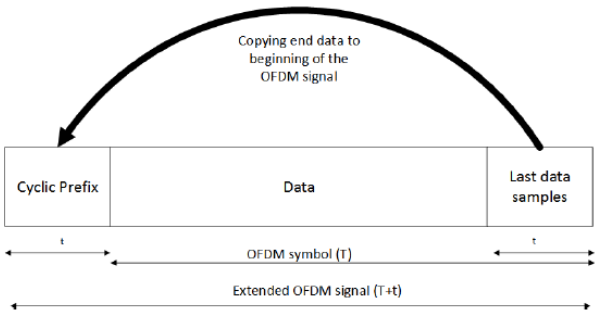

Figure 5: OFDM symbol with cyclic prefix.

The Figure 5 shows the OFDM signal with and without cyclic prefix. It is clearly shown that last samples of the symbol are added as prefix. In the figure last samples and the prefix are in same color and length (4), which indicates that both the samples are same. The length of prefix depends on the delay of multi path channel. It should be longer than the excess delay of longest significant echo. Length of cyclic prefix (4) is also called as guard interval. This extended version of OFDM signal is transmitted through a channel to the receiver.

B. Effects of Inter Symbol Interference (ISI) and Inter Carrier Interference (ICI) on OFDM

The two interferences ISI, ICI are usually originated by transmission channel. When these interferences are not introduced, orthogonality between the sub-carriers can be maintained and the individual sub-channels can be completely separated at the receiver. Practically it is easily achieved. This is because OFDM is not strictly band limited, due to this linear distortions such as multipath makes each sub channel to spread its energy to adjacent channels. This leads to Inter Carrier Interference. Simple solution to prevent this is to increase symbol duration.ISI can be avoided by taking care of guard interval while gluing it to the OFDM symbol, which should be longer than the excess delay of multipath channel.

C. Communication channels

In this paper The Additive White Gaussian Noise (AWGN) channel used. This is because we analyze different modulation techniques and AWGN is considered as universal channel for analyzing different modulation schemes. In this, the channel doesn't introduce any distorts expect the addition of white Gaussian noise to the signal passing through it. There by the channels amplitude response is at and its phase frequency response is linear for all frequencies. So Modulated signals pass through it without any amplitude loss or phase distortion. Apart from this fading doesn't exist. There by the received signal is the summation of original signal and white Gaussian noise.

D. RECEIVER

First and foremost step at the receiver is removal of appended cyclic prefix, which is equivalent to removal of guard interval.

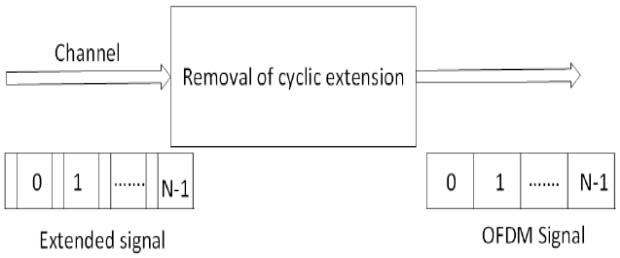

Figure 6: Removal of cyclic extension

After removal of extension the signal is converted back to normal OFDM signal, followed by serial to parallel conversion. While the effect of channel transforms into periodic convolution of discrete time channel with IFFT of data symbols. Performing FFT on received samples converts the periodic convolution to multiplication.

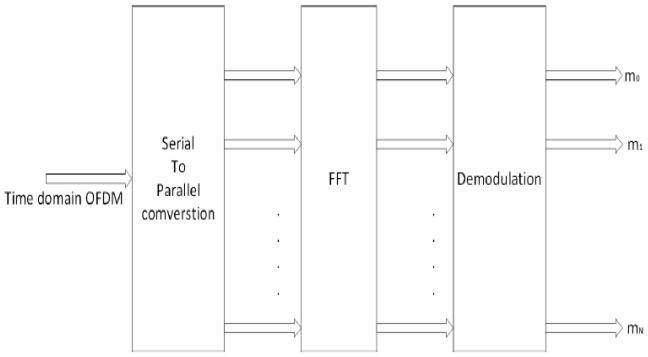

Figure 7:FFT Block diagram

Figure 7. clearly shows the input and output of FFT. FFT gets parallel steams of data in time domain as input, it converts time OFDM signal to frequency domain. Output from FFT is set as input to PSK or QAM demodulator. Demodulator separates bit streams from the carrier and gives parallel bit steams $m_0, m_1 \ldots m_{N-1}$ as output. These bit steams are multiplexed using parallel to serial converter as shown in figure 8. and the final outcome the message signal to be conveyed. Output from serial to parallel converter is S[n], which is given as input to OFDM system.

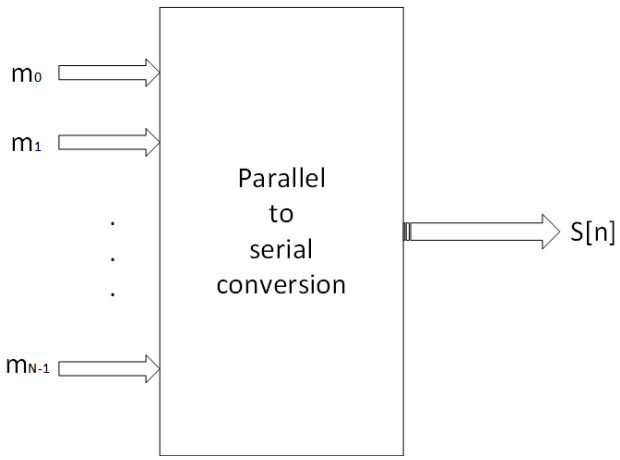

Figure 8: Parallel to serial conversion

III. IMPLEMENTATION AND RESULTS

In this chapter we investigate performance of OFDM, for different PSK modulations in AWGN channels. MATLAB program is used to obtain results and calculated SER (Symbol error rate) for various SNR (Signal to Noise Ration). We should note here that BER (Bit Error Rate) can be obtained by,

$$symbolrate = \frac{Bitrate}{Numberofbitstransmittedforsymbol}$$

A. PSK modulation scheme

In M-array PSK modulation system, I-component and Q-component are interdependent, with constant envelop which makes the data points to form in circular constellation [7]. The important goals in designing a digital communication system is to have very low error probability and conservation of bandwidth. In this section we use QPSK,16-PSK and 32-PSK modulations, with AWGN channel. The performance of the system is examined with different SNR values. The results obtained is then plotted and analysed.

B. QPSK modulation

QPSK uses only half the channel bandwidth used by binary PSK, has same error probability as of binary PSK system with same bit rate and same E_b/No [7]. In this Matlab program OFDM system is provided with 64000 binary data, M modulation level is set to 4, FFT length is set as 64, cyclic prefix is set to 10. The Table 1.shows the QPSK Simulation parameters in the OFDM.

TABLE I.
QPSK SIMULATION PARAMETERS.

QPSK	
M	4
Input binary data	64000
No. of symbols	32000
FFT length	64
Cyclic Prefix	10
No. of frames	500
Frame size	64

The constellation points of QPSK is shows in figure 9. For QPSK (Quadrature Phase shift Keying) we know it has four constellation points with two I values and two Q values.

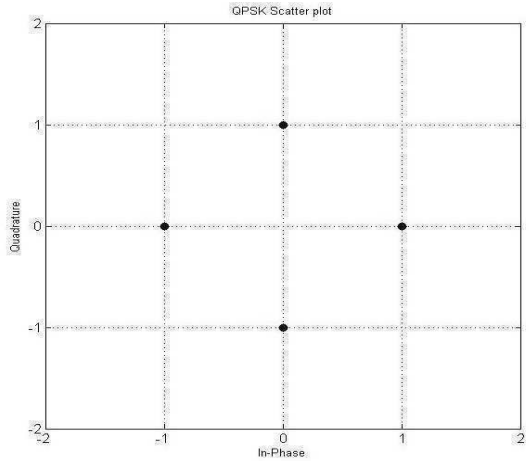

Figure 9: Constellation of QPSK

Plots in figure 10. shows the impulsive response and frequency response of the channel and Figure 11. show first 100 input and 100 output samples. The plot in figure 12, is used to visualize the error data, the red line shown in the graph is the error bit.

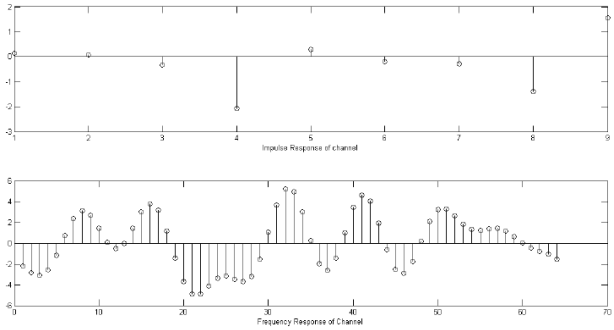

Figure 10: Impulsive and Frequency response of channel

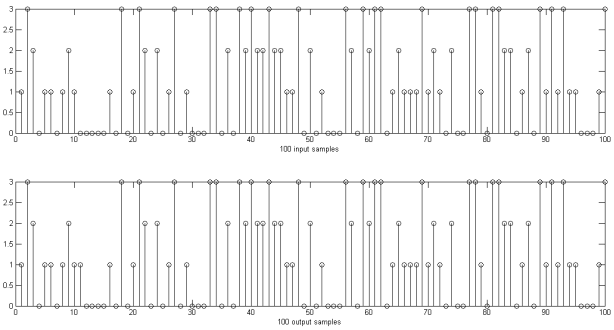

Figure 11: Input and Output samples.

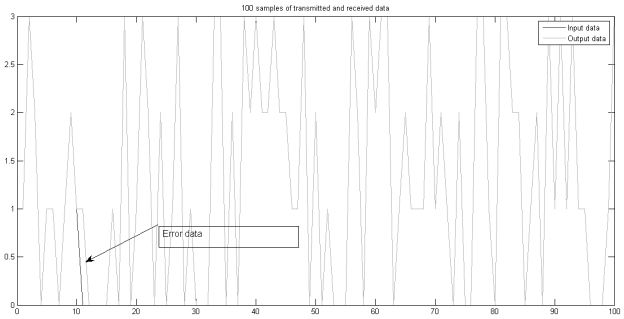

Figure 12: Plot of Input and Output signal to visualize errors.

Figure 13 shows number of errors to respective Signal to noise ratio. In figure 14 is plot of Symbol error rate Vs Signal to noise ratio for QPSK-OFDM system. Apart from this it provides same data rate as BPSK for half the bandwidth needed by BPSK. But the main problem in using QPSK is the complexity of transmitters and receivers.

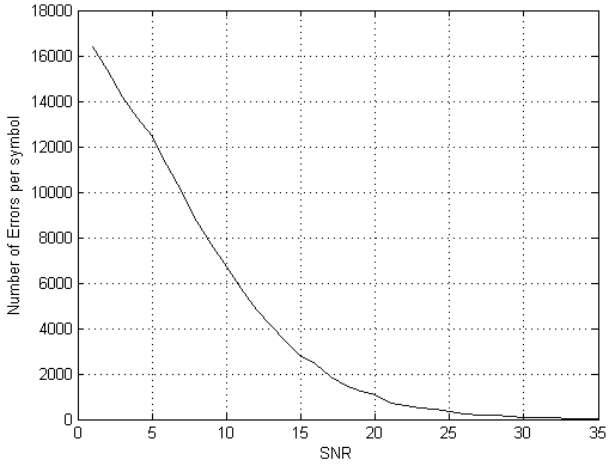

Figure 13: Number of error Vs Signal to noise ratio for QPSK-OFDM.

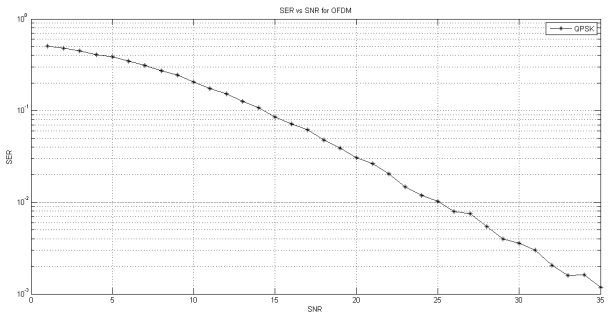

Figure 14: Symbol error rate Vs Signal to noise ratio for QPSK-OFDM.

C. 16PSK modulation

In 16PSK system we can have 4 bits/symbol. Modulation level M is set to 16, total number of bits to be transmitted is 64000, FFT length is set as 64 and cyclic prefix is 10.

TABLE II
16PSK SIMULATION PARAMETERS

QPSK	
M	16
Input binary data	64000
No. of symbols	16000
FFT length	64
Cyclic Prefix	10
No. of frames	250
Frame size	64

Figure 15. shows 16 points in a circle with phase _22:5o and the demodulator has only _11:25o phase to detect the symbol.

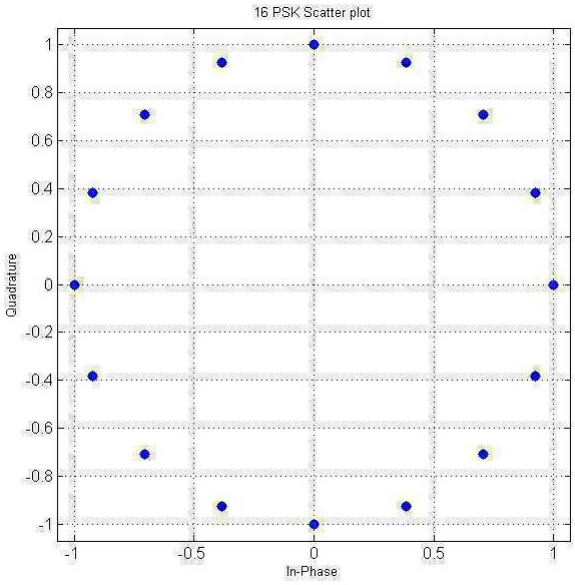

Figure 15: Constellation of 16PSK

Figure 16. show the graphs of first 100 input and output data, the red lines shows where errors has occurred.

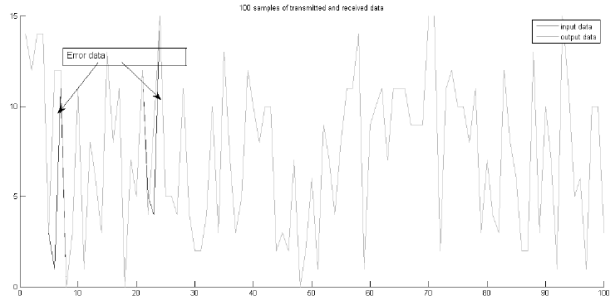

Figure 16: Plot of Input and Output signal to visualize errors.

Figure 17. shows number of errors to respective Signal to noise ratio.

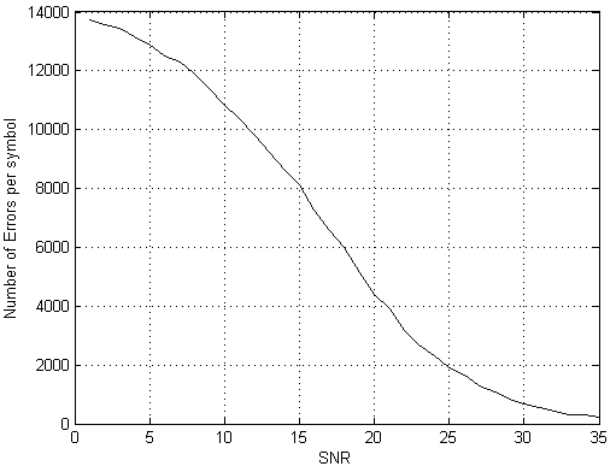

Figure 17: Number of error Vs Signal to noise ratio for 16psk-ofdm

Plot in figure 18. shows SER of the system with different SNR values.

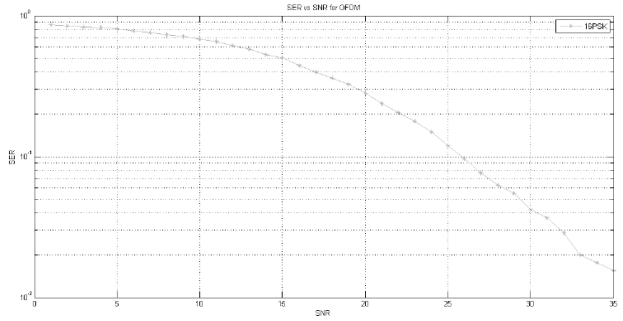

Figure 18: Symbol error rate Vs Signal to noise ratio for 16psk-ofdm

D.32PSK modulation

In 32-PSK we have 5 bits/symbol, Modulation level is set as 32, total number of bits to transmit is 64000 and FFT length is 64 and cyclic prefix is set as 10. The constellation diagram shown in figure 19 has 32 points separated with phase of _11:25o and the demodulator has _5:625o phase to detect the symbols.

TABLE III.
THE 32PSK SIMULATION PARAMETERS

QPSK	
M	32
Input binary data	64000
No. of symbols	12800
FFT length	64
Cyclic Prefix	10
No. of frames	200
Frame size	64

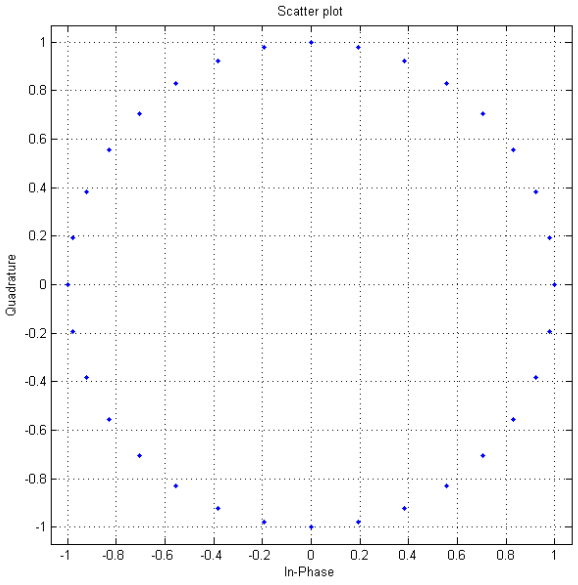

Figure 19: Constellation of 32PSK.

Figure 20. shows the first 100 input and output samples. The figure 21. shows the plot of input and output signal to visualize the error symbols. Figure 22 shows number of errors to respective Signal to noise ratio. Figure 23 show symbol error rate to corresponding Signal to noise ratios.

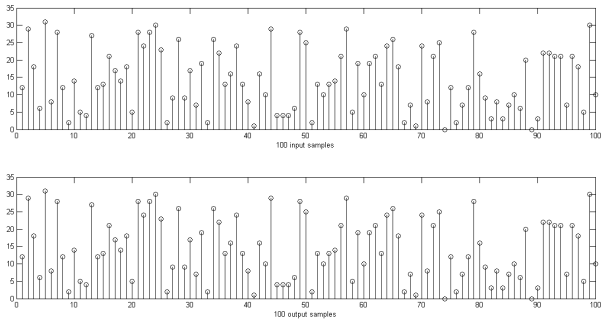

Figure 20: Input and Output samples

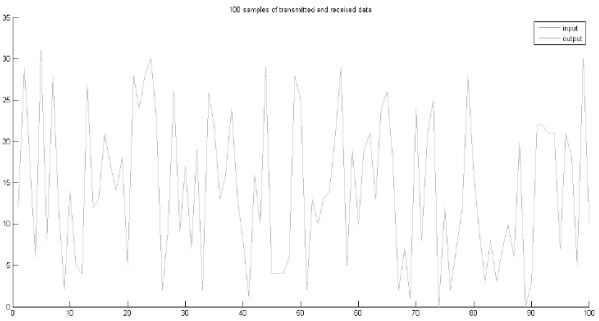

Figure 21: Plot of Input and Output signal to visualize errors.

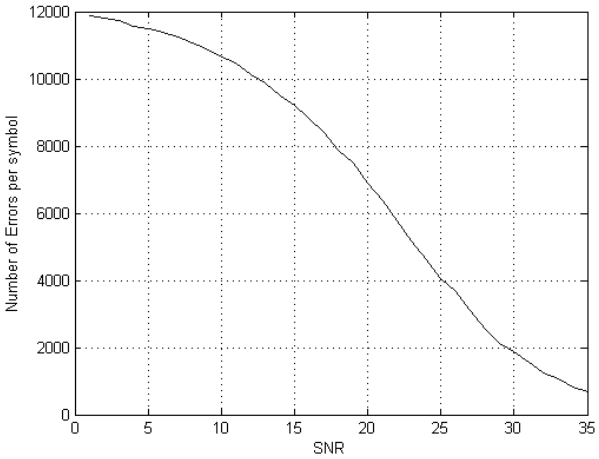

Figure 22: Number of error Vs Signal to noise ratio for 32psk-ofdm

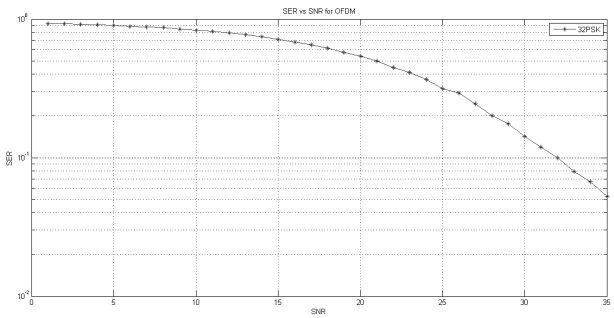

Figure 23: Symbol error rate Vs Signal to noise ratio for 32psk-ofdm.

From figure 24. we can see that when we use high modulation level we have greater symbol error rate. 32PSK has greater symbol error rate but has higher data speed while using less channel bandwidth. We can reduce symbol error rate by increasing signal to noise ration. We can choose best modulation schemes to obtain optimum performance of the system based on needs, to obtain greater data rate we can choose higher modulation schemes and to have very less loss of data we can use lower modulation schemes.

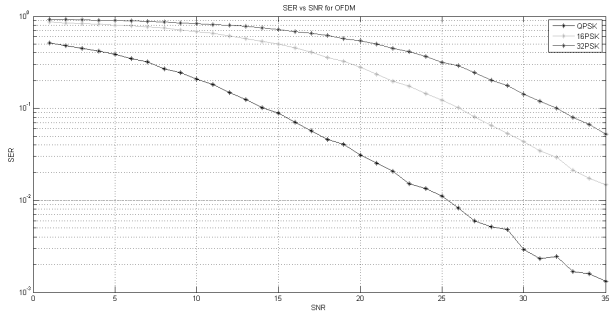

Figure 24: SER Vs SNR for PSK-OFDM

CONCLUSIONS

In this thesis we designed and investigated the performance of OFDM system at higher M-PSK(Phase Shift Keying) and M-QAM(Quadrature Amplitude Modulation). To compare different modulation techniques efficiencies it is important to calculate BER (Bit Error Rate) at different SNR(Signal to Noise Ratio). We observed from the results that we had more errors at receiver side when higher modulations are used because the symbols are located closely located in constellation diagram, we can reduce errors by increasing the SNR (Signal to Noise Ratio).From obtained results we can see that higher order M-QAM modulation gives better performance in AWGN than higher order M-PSK modulation.

In this paper we design and simulate OFDM (Orthogonal Frequency Division Multiplexing) to study the performance of the OFDM system at higher order modulation schemes. It is very important to evaluate performance of the communication system, to test the efficiency and quality of the service it can provide. We use Matlab program to design the functionality of OFDM, then BER(Bit Error Rate) is obtained to different SNR(Signal to Noise Ratio) values, for M-array PSK and M-array QAM modulations techniques. BER is widely used as performance measurement tool, it tells number of bits destroyed while the data is travelling from source to the destination, AWGN (Additive White Gaussian Noise) is used as transmission channel.

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A Review on Power Quality in Grid Connected Renewable Energy System

K.S.V. Phani Kumar[1], S. Venkateshwarlu[2], G.Divya[3],
[1]Assistant Professor, Department of Electrical Engineering, Sreenidhi Institute of Science & Technology, Hyderabad, India
kpksvenkata@sreenidhi.edu.in
[2] Prof & Head of EEE Department, CVR College of Engineering, Ibrahimpatnam, Hyderabad, India
svip123@gmail.com
[3]M.Tech, Department of Electrical Engineering, Sreenidhi Institute of Science & Technology, Hyderabad, India
divya.gopagani@gmail.com

***Abstract*— This paper presents a review on power quality problems associated with the integration of renewable energy systems in to grid and it shows how power electronic devices and Flexible AC Transmission Systems play a role to mitigate the power quality problems. Photo Voltaic (PV) and Wind energy systems integration issues and associated power quality problems are discussed. Classification of various Power Quality Issues used by different researchers has been done and put for reference. Application of various techniques as applied to mitigate the different Power Quality problems is also presented for consideration.**

***Index Terms* — Power Quality, grid connected PV, grid connected wind, Distributed Generation, FACTS Devices, Renewable Energy.**

Abbreviations:

GCSPV	: Grid Connected Solar Photo Voltaic
GCWT	: Grid Connected Wind Turbine
PQ	: Power Quality
PE	: Power Electronics
CPD	: Custom Power Devices
AII	: Anti-Islanding Issues
FACTS	: Flexible AC Transmission Systems
1Ø	: Single Phase
UPQC	: Unified Power Quality Conditioner
STATCOM	: Static Compensator
D-STATCOM	: Distributed Static Compensator

I. INTRODUCTION TO THE PQ ISSUES

It is necessary to meet the energy demand by utilizing the renewable energy sources like Wind, Solar, Hydro, Biomass, Cogeneration etc., to have sustainable growth and social progress .In sustainable energy system, energy conservation and the use of renewable sources is important. The need to integrate the power sources from renewable sources like wind and solar into power system is to make it possible to minimize the environmental impact of conventional plant reported in [1]. The integration of wind and solar energy into existing power system presents technical challenges such as voltage regulation, flicker, harmonic distortion, stability etc., these power quality issues are to be confined to IEC and IEEE standards. A review of many papers reveals that these power quality issues can occur at the generation, transmission and distribution. The issue of power quality is of great importance to the Solar (PV) and Wind turbine, as sources. A major issue related to interconnection of distributed resources into the power grid is the quality of power provided to customers connected to the grid.

In order to investigate the power quality problems and it's mitigation techniques a review of many papers published during the last ten years has been presented. Issue has been discussed in [28-32],[11],[12],[13] presents about the voltage regulation problems. Papers [33],[34],[14] presents about the voltage sags and swells and it' s mitigation methods are reported. In [13] flicker issues and it's related mitigation techniques are discussed. Researches [7],[35-38] discussed about the harmonics and it's mitigation techniques. In[39-44],[25],[15],[16] authors discussed about the real and reactive power problems and its compensation techniques. In [40], [45], [29-32], [46], [17], [20], [21] authors presents about the different power quality issues and it's mitigation techniques in general.

This paper is organized as follows: In section II Integration issues of Renewable energy systems such as GCSV Systems and particularly GCWT Systems are discussed. Section III discusses the Power Electronic solutions for Power Quality improvement with applications, presented by different authors with their respective models. In section IV Application of FACTS devices are presented and finally section V concludes the review with a summary.

II. INTEGRATION OF RENEWABLE ENERGY SYSTEMS

Here most promising and prominent technologies of GCSPV and GCWT are only considered for discussion.

A. Solar Photovoltaic Systems:

When the PV cell receives photon energy (=hμ) as a function of time, power electronic converters are to be employed to meet the load specifications [1],[2], focusing on PQ issues and Anti-Islanding Issues (AII) regarding PV systems connected to low and medium voltage levels of the network. The overall performance of SPV system including PV module, inverter, filter controlling mechanism etc., is to be optimized [3] such that the voltage variations and complex power of the line are controlled, limited to the guidelines. Based on the type of grid, the systems are designed for single-phase or three-phase. Also, when multiple PV arrays are connected, the harmonics developed are observed to have higher bandwidths of frequencies from sub-harmonic to multiple order harmonics.

Custom Power Devices (CPD) plays a vital role in many of the GCSPV connection topologies. These CPDs, connected to non-linear loads, introduce harmonics to the grid. Therefore, this needs to be considered in the controller design for the CPDs [4],[5] to make the output stabilized at the Point of Common Couplings (CPP). The applications of these are briefly discussed in [6]. Experimental outcome of a single-phase laboratory setup (2 kVA inverter) is illustrated in [7] to explain phase-synchronized grid voltage with the help of kalman filters. Recently Multifunctional PV Inverters for micro grid applications are coming up to introduce the reliability as an additional objective [8].

B. Wind Energy System:

The causes for reduced PQ in GCWT, violating the regulatory frameworks were extensively discussed in [9] considering the voltage deviation and frequency variations defined by IEC 61400-12,-13, and -21. Fluctuations, flickering and harmonics were found by simulations and experiments to explain the pressing need for CPDs in improving the PQ [6]. Each GCWT influences the overall outcome and hence a centralized approach was not found fruitful, but decentralized mitigation of PQ problems has to be done whatever connection topology is used [10].

III. CPDs FOR PQ IMPROVEMENT

PQ events may be seen from the utility perspective (Including generation, transmission and distribution) and the load perspective. Popularly known solution for these problems is to install line conditioning systems excited by flywheels, super capacitors, and other energy storage devices which smoothens the power system disturbances. Mainly power electronic devices and FACTS devices are used.

Due to innovations in the field of PE, the cost per installed kW of GCSPV and GCWT systems are coming down encouraging the bulk usage. The capacity-weighted average installed price between 2004-2008 was $6.2/W, while in 2009-10 was $3.9/W and in 2011 was $3.4/W. [9] The inverters became more efficient and reached efficiencies more than 98%, since 60% of the energy being consumed is converted, while commercial solar modules reached efficiencies of almost 33.5%. In this paper the recent trends of power electronic topologies used in such systems are presented. Typical hybrid architecture of a grid-connected renewable energy sources is shown in fig.1.

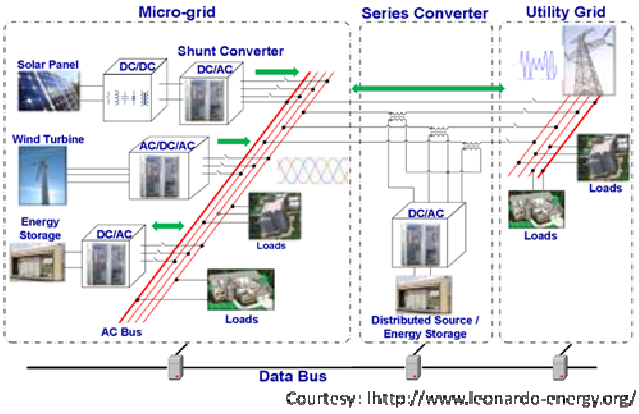

Figure 1: Architecture of Grid connected renewable energy sources

In [11-19] steady and dynamic state study is presented as a STATCOM based control scheme for grid integrated micro generators. [20], [21] authors discussed about UPQC based control scheme to mitigate the PQ problems. These methods proved through simulation and experimental results that the injected voltage gets minimized and a circulating power under all operating conditions of grid connected systems.

A. Power Electronics for GCSPV Applications:

Papers [22-25] highlight the power electronic solutions for GCSPV applications. PV module is connected to the inverter which is directly fed to the grid, so without using batteries it will supply the energy during day-time, reducing the cost of the system and maintenance. Feedback systems are mostly required to continuously monitor the grid voltage and frequency. Broad literature is available for PWM modulation techniques to fire up with switching frequencies of 2 to 20 KHz [26]. Extensive VSI based inverter designs are presented in [25], summarizing interconnection standards of PV systems. The inverter technology here is broadly classified as a) centralized

b) String technology and

c) Multi-string technology.

The topologies can be further classified based on

a) Number of power processing stages

b) Location of power decoupling capacitors

c) Types of grid interface.

References to ac-module-inverters are given in {[25]–[35]} of [25]. All these three topologies can be found in [25] where a cascaded multilevel inverter to integrate Segmented Energy Storages (SES) for a 1Ø GCSPV system to mitigate the overvoltage at PCC, while compensating reactive power flows. A new Online Overvoltage Prevention (OOP) control

strategy maintains PV terminal voltages within specified range while maximizing the PV energy [24].

B. Power Electronics for Wind Turbine (WT) Applications:

Papers [28 -48], highlight the CPDs for GCWT applications. Several issues like voltage fluctuations, sags/swells, and harmonics with real and reactive power compensations are addressed through CPDs. They are briefly addressed in this paper.

a. Voltage Regulation:

The droop characteristics are used, particularly for DFIGs to control the voltage magnitude and frequency [31]. This can be extended to GCWT systems by doing a voltage sensitivity analysis to achieve voltage regulation at PCC. The high DC bus ripple is a result of the voltage-drive mode to provide the best AC power quality [28] and concludes that the bidirectional power flow and the bottom-up decentralized control methods make DG systems are well controlled and organized. To overcome this problem in [29] author focuses on the grid-interfacing architecture, with fuzzy logic controllers to improve voltage quality. For wind generators, there are three frames of references that one can work on. In [30] a control method based on stationary-frame is used for an islanded micro grid. Here, the complex power droop control systems use a virtual impedance loop, to compensate the unbalances.

b. Voltage Sags/Swells:

The operation of Sensitive loads connected to the grid is influenced by the voltage dips. To overcome this disadvantage author presented power electronic converter, in [33] using a series compensator, which requires considerably less active power and is able to restore the voltage at the load side. Distributed Generation is one way to overcome them, particularly under transient states. [49] The CPDs like VSCs connected to the DGs also get influenced by the voltage dips. A Fault Current Limiter (FCL) can be placed to suppress these affects within 3-30 cycles. Grid-interfacing power quality compensator for three-phase four-wire micro-grid applications was developed using the sequence components to inject voltages as a complementary measure Under the Net-metering scenario a Power Quality Control Center (PQCC) would regulate voltage due to the reversal of power flows from the DG and the increase in short circuit current [34].

d. Harmonics:

Harmonic resonances occur due to GCWT systems. The theory behind this introduced and the consequences presented with necessary case studies in [50]. A wide spectrum of current and voltage harmonics is caused by the presence of power converters. An autoregressive-moving-average (ARMA) method determines the harmonic spectrum affectively. In [35] Bandwidth-harmonic power droop has been proposed to share the harmonic power among multiple converters. In [36] author introduces a new Adaptive Notch Filtering (ANF) approach which can address issues like, extracting harmonics, voltage regulation, complex power control, suppressing frequency variations and noise contents using the sequential components of voltages as reference. Some methods for harmonic damping are (i) a shunt harmonic impedance method adaptable for islanded micro-grids application [38], (ii) The voltage-based droop control strategy to have controllable harmonic current and PQ (iii) heuristic optimization techniques such as differential evolution algorithm (DEA) are used to obtain the switching states of CPDs, as a nonlinear optimization problem.

e. Real and Reactive Power:

The seasonal patterns and the diurnal variations of wind are to be addressed for GCWT systems to achieve high-quality power from inverters meeting the specifications of grid codes. A droop control method is proposed based on the reactive power produced by the negative-sequence current and the positive-sequence line voltage [40]. A variant of the droop control strategy is used in [41], which combines P/V droop control with voltage droops to control the active power. A Lyapunov-function-based current tracking controller is proposed to control both active and reactive power flow for GCSPV and GCWT micro-systems through a single-phase parallel-connected inverter. The THD levels were found satisfactory even for nonlinear loads. The real and reactive power drawn from the 1Ø grids can be controlled by optimizing the transformer tap settings [44].

IV. APPLICATION OF FACTS DEVICES

The need for network management under dynamic state and to provide a cost effective solution for mitigating the PQ problems can be addressed using FACTS devices [51], introduced by N.G. Hingorani.. The STATCOM based control schemes are a proven technology to look after the PQ problems for grid- connected systems at PCC [19], [17]. Voltage fluctuation suppression and dynamic simulations were studied [11], to verify the performance of STATCOMs and its control strategies. Static Synchronous Compensators are later devised to overcome voltage sags/swells and unbalances in distributed generators connected to micro-grids [14]. A novel multilevel, hexagram converter method for GCWT systems was developed performing reactive power compensation by One-Cycle Control (OCC) [15]. In [12] authors present a novel night-time application of a PV solar farm powering a STATCOM for voltage control, improving power transmission capacity during nights.

For low and medium power applications, DSTATCOM are employed to compensate for poor load power factors [18]. A DSTATCOM can also be used for Reactive Power Compensation in 1Ø Operation of Micro grid [16]. The placement and current ratings of these devices are optimization problems and various techniques are available for solving it [13].

Recent reports [20],[21], [52] shows the application of UPQC to DG integrated network to compensate almost all existing multipurpose PQ problems in the transmission and distribution of power.

CONCLUSION

A review of PQ problems associated with the GCSPV and GCWT systems are presented, quantifying various features of research papers published in those areas. The causes, affects, mitigation technologies featuring their topologies, highlighting the advantages of the grid integrated solar and particularly wind power systems are examined. The cost effective solutions of CPDs and FACTS devices are highlighted to give an insight to the scope of research in low and medium level voltage networks and for 1Ø and 3Ø micro-grids technologies. Most of the references listed here have laboratory results.

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High-efficiency Low-power Flash ADC for High-speed Transceivers

O. Venkata Krishna [1] and B. Janardhana Rao [2]
[1] CVR College of Engineering /EIE, Hyderabad, India
Email: venkatakrishna.odugu@gmail.com
[2] CVR College of Engineering /ECE, Hyderabad, India
Email: janardhan.bitra@gmail.com

***Abstract*-Modern communication systems require higher data rates which have increased the demand for the high speed transceivers. For a system to work efficiently, all blocks of that system should be fast.. This fact has led researchers to develop high speed analog to digital converters (ADCs) with low power consumption. Among all the ADCs, Flash ADC is the best choice for faster data conversion because of its parallel structure. This paper work describes the design of such a high speed and low power Flash ADC for the analog front end (AFE) of a transceiver. A high speed highly linear track and hold (T&H) circuit is needed in front of ADC which gives a stable signal at the input of ADC for accurate conversion. Averaging technique is employed in the preamplifier array of ADC to reduce the static offsets of preamplifiers. The averaging technique can be made more efficient by using the smaller number of amplifiers. This can be done by using the interpolation technique which reduces the number of amplifiers at the input of ADC.**

The Flash ADC is designed and implemented in 180 nm CMOS technology for the sampling rate of 1.6 G Samples/sec. The bootstrap T&H consumes power of 27.95 mW from a 1 V supply and achieves the signal to noise and distortion ratio (SNDR) of 37.38 dB for an input signal frequency of 195.3 MHz The ADC with ideal T&H and comparator consumes power of 78.2 mW and achieves 4.8 effective number of bits (ENOB).

***Index Terms*—ADC, low power, track& hold, comparator, high speed, transceivers.**

I. INTRODUCTION

For communication systems the need arises for higher data rate and high speed transceivers. To increase the data rates and handle wire losses, high speed analog to digital converters with multiple bits of resolution are needed at the receiver end. The development in analog and digital domain has grown dramatically over the years. As a result, the speed and efficiency of the digital circuits has increased to a great extent and also these circuits consume less power. In contrast to this, input output data rate of analog circuits is not as fast, because the outside world does not shrink along with the CMOS technology. Due to this technology difference we can see that the analog interfaces are the limiting factor in the whole system in terms of speed and power. The high speed Transceivers requires high bandwidth and high resolution ADCs. For high speed purposes, flash ADC is the best choice for fast data conversion. This paper work presents the design of such a high speed and low power flash ADC for the analog front end of the transceiver and concentrated on the design of track and hold circuit and preamplifier design.

The over view of the communication system shown in figure.1. This system mainly consists of a high speed transceivers and a channel through which data is transmitted and received. In high speed transceivers, the 8-level pulse amplitude modulation (PAM-8) modulation schemes are used for multi-gigabit transmission to reduce transmission time and for fast bit rate.

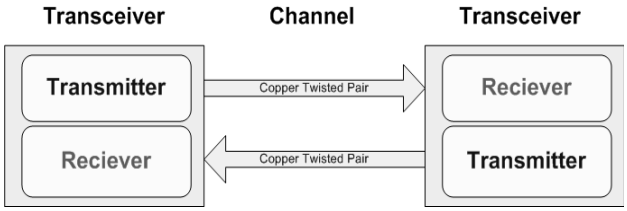

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Figure 1: Block Diagram of Transceiver.

The transmitter sends the signal by using the pulse amplitude modulation (PAM) with the data rate of several Gb/s. In the Pulse Amplitude Modulation scheme, the information is encoded in the series of amplitude signal pulses. A PAM-8 is used in the above system which transmits three bits of information in each symbol time. This reduces the effective symbol rate of binary signaling by three and the required data rate can be transmitted with reduced channel bandwidth.

The channel is used in the above system is a Copper twisted pair cable, which is capable of reducing the noise interference and crosstalk between the differential pair of wires. These cables provide bandwidth up to 600 MHz and speeds of several giga hertz.

Next, the receiver consists of two main blocks, one is analog front end (AFE) and second is digital signal processor (DSP).The AFE receives the signal which is sent by the transmitter. The received signal is converted into an equivalent digital signal by ADC before sending to the digital signal processor (DSP) for processing. The AFE contains variable gain amplifier (VGA) and analog to digital converter (ADC) and other blocks. The block diagram of the AFE is shown in figure 2.

A. Variable Gain Amplifier

In the AFE, the VGA amplifies or attenuates the input signal to produce signal amplitude which should match the full scale input range of the ADC. The variable gain amplifier (VGA) is used in many communication systems to improve the dynamic range (DR) of the overall system. There are two types of VGAs, a Digital variable gain amplifier (DVGA) and an Analog variable gain amplifier (VGA). 1. Digital variable gain amplifier (DVGA) uses binary weighted arrays of resistors and capacitors to control the gain. Application of DVGA is in cable TV system. 2.Analog variable gain amplifier (VGA) uses variable resistance to control the gain. They are used in ultra sound scanners and radars.

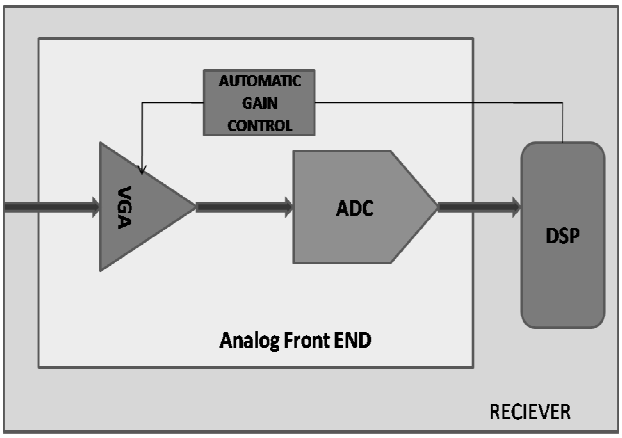

Figure 2: Block Diagram of Analog Front End.

B. Analog to Digital Converter

Analog to digital converter is used to convert an analog signal into a equivalent digital data. In the AFE, ADC takes the analog signal from VGA and converts it into digital form before sending it to the Digital Signal Processor for further processing. Mainly the Analog to digital conversion involves three steps: Sampling, Quantization and Coding. In the sampling process, the samples of the input signal are taken at discrete instants of time. Then the frequency corresponding to these samples is called the sampling rate of ADC. For accurate representation of signal, the sampling process should follow the Nyquist theorem i.e the sampling frequency should be at least twice the highest signal frequency .In quantization, the sampled signal is approximated to certain standard quantization levels depending on their amplitudes. In encoding process the quantized signal is converted into binary code.

C. Digital Signal Processor

The Digital Signal Processor (DSP) captures the digitized information from AFE through ADC and then manipulates it mathematically at a very high speed. In communication systems it is used for the Equalization, Non-linearity compensation, Decoding and Forward error correction. The other applications of DSP include audio and video compression, image processing, automatic gain control algorithms.

In this paper, the design of track and hold circuit and preamplifier for high speed and low power flash ADC for the analog front end of the transceiver system is placed.

II. FLASH ADC

Flash ADCs are suitable for applications where very high analog to digital conversion speed is required. But these Flash ADCs are limited to the resolution of six to eight bits because the number of comparators used in these ADCs double if the resolution is increased by one bit. Due to the large number of comparators, they ADC consume more power and are very costly for higher resolutions. The major applications of flash ADCs are in satellite communication, radar processing, data communications and real time oscilloscopes. In this thesis work, flash ADC is used for data communication applications.

The flash ADC can achieve better sampling rates as the only analog building block in flash ADC is comparator [21].The function of flash ADC is very simple, it compares the analog input signal with a number of reference voltages and produces the output. The parallel architecture of flash ADC allows conversion process in one clock cycle. So at the same conversion rate, flash ADC has low latency where latency is the number of clock cycles required by an ADC to convert the given input to an output. Thus, the flash ADC is extremely fast and gives the data conversion rates in several GHz. The only problem with the flash ADC is the power consumption which increase with the increase in number of bits, that's why this ADC limiting the number of bits to six to eight only. The block diagram of conventional flash ADC is shown in figure 3.

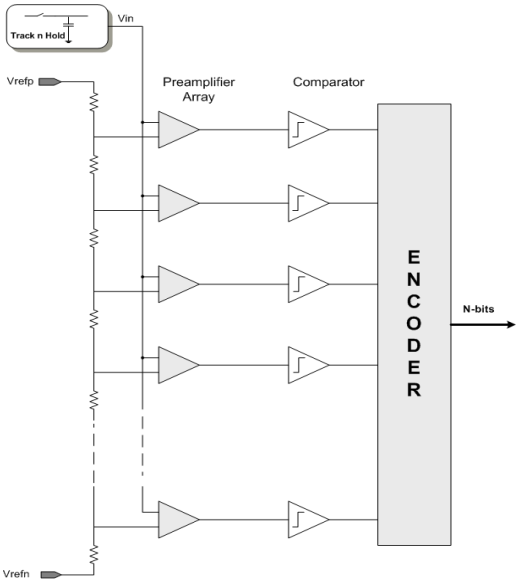

Figure 3: The block diagram of flash ADC

The signal coming from the track and hold is compared with a number of reference voltages which are generated by a reference circuit. If the input voltage is

higher than the reference voltage, the comparator gives '1' at its output, and if the input voltage is lower as compared to the reference voltage, the comparator gives '0'. The code produced by comparator array is called thermometric code which is then converted to binary output by an encoder [10].

A. Track And Hold

The first circuit in the flash ADC is the T&H circuit is as shown in figure 4, It consists of a sampling switch and a hold capacitor. During the first half of the clock cycle, the circuit tracks the signal which is called the tracking mode and during the second half of clock cycle it holds this value in the hold capacitor for subsequent processing, and this is called the hold mode. The switch and the hold capacitor make a RC network, the time constant of which determines the BW that can be achieved through this network [16, 17].

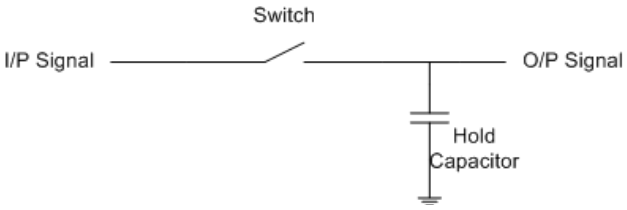

Figure 4: A basic track & hold circuit

Track and hold circuits are important building blocks of ADCs where they are used to improve the dynamic behavior and reduce the errors due to aperture jitter and clock skew [29]. This is because the T&H circuit is very small as compared to the whole ADC. The clock skew and jitter problems have effect only on the front end T&H circuit and the ADC have stable signals at their input. The overall performance of ADC depends highly on the performance of T&H circuit [6, 14].

The T&H circuits are classified into two types one is open loop and second is closed loop. In an open loop architecture, there is no feedback loop. The T&H circuit mainly consist of a sampling switch and a hold capacitor with input and output buffer. The purpose of buffers is to isolate the T&H circuit from the rest of circuit. The open loop T&H architectures are used where high BW and low power consumption is required. The accuracy of this open loop architecture is not so good due of the lack of feedback. At high speeds, the circuit produces instability.

In the closed loop architecture, a feedback loop is inserted between the output and the input. This feedback improves the accuracy of T&H circuit but reduces the speed. So this architecture is not suitable for the speeds in the range of GHz. Figure 5 shows the open loop and closed loop configuration of track and hold circuit.

B. Pre-amplifier

The function of pre-amplifiers in flash ADCs is to amplify the voltage difference between the input signal and the reference voltage. They are used at the input of comparators to suppress large dynamic offsets and reduce the meta-stability errors [2]. High gain of pre-amplifiers is needed to reduce bit error rate (BER) by reducing the offsets of comparators. The BW of Pas should also be high to improve the settling time and avoid distortions at high input signal frequencies. It is difficult to achieve high gain with high bandwidth in one stage so multiple stages of pre-amplifiers can be used to increase the gain [5, 8]. In addition to comparator large dynamic offsets, Pas also have their own static offsets. To reduce offsets of PAs, large transistor sizes can be used. These large transistor sizes increase the input capacitance of PAs which in turn increase the load for TnH circuit. Another efficient way of reducing the PA offset is to use averaging technique [13].

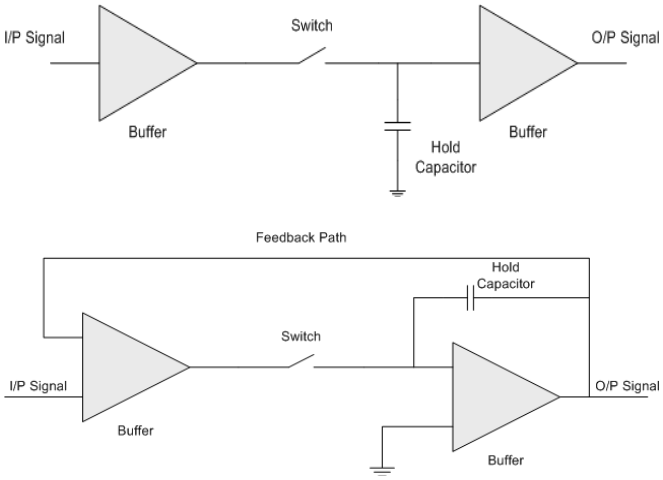

Figure 5: Open loop and Close Loop Track and Hold Circuits.

The averaging technique is used to reduce the offsets of PAs. In this technique, the outputs of PAs are interconnected through averaging resistor net work. By doing this, the errors contributed by individual PAs are averaged, and offsets are reduced. The reduction in offset depends on the ratio of averaging resistor and output impedance of PA. However, this technique causes problems at the edges of resistive network where the linearity is reduced because of boundary issues [9, 12, 13].

Averaging technique to reduce offset errors can be improved further if it is used with a reduced number of PAs [1]. To reduce the number of PAs at the first stage, interpolation is employed. In interpolation, intermediate voltage points are generated by replacing each resistor in the resistive network, with two resistors of half size. Multiple taps of interpolation are also possible [2, 13].Multiple stages of PAs can be used with averaging and interpolation to reduce the number of PAs significantly. For example, for six-bit flash ADC, if three stages of PAs are used with an interpolation factor of two, then the number of amplifiers needed at the first stage will be nine instead of 63. Another advantage of using interpolation is that the requirements for the track and hold circuit can be relieved as its output load is reduced because of the reduced number of PAs. Also, the size of PAs can be made bigger to reduce offsets further.

C. Comparators

The comparators are the basic building blocks of flash converters and are used to convert the analog signal into digital form. A comparator in flash ADC acts as a one-bit quantizer. A N-bit flash ADC requires 2^N -1 comparators and for every additional bit, the number of required comparators becomes double which increase both power and area. Due to this fact flash ADCs are not suitable for high resolution. The outputs produced by comparators are not practical to be processed in the DSP, so an encoder is needed to produce binary output for further processing.

D. Encoder

The function of the encoder is to convert the thermometer code produced by comparator array into a N-bit binary code. Encoder can be implemented in different ways such as XOR encoder, ROM and fat tree encoder. The proposed encoder is a CMOS priority encoder. In this implementation, we have used pass transistor logic and dynamic circuitry not only to achieve high performance but also to minimize silicon real estate. we describe the circuitry of a CMOS priority encoder with no lookahead. Then extremely fast priority circuitry is added to this circuit, with a very small impact on the overall number of transistors, to produce an encoder that uses a priority lookahead scheme. The four bit priority encoder is shown in figure6.

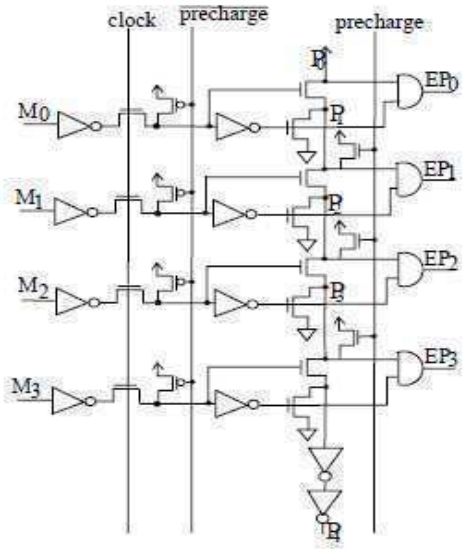

Figure 6: 4-bit priority encoder.

III. IMPLEMENTATION

In this section the blocks of the Flash ADC , mainly track and hold and preamplifiers are designed in the CMOS technology in the transistor level using 180nm technology.

A. Implementation Bootstrap Track and Hold

The open loop T&H provides high speed, but linearity of this architecture is not so good because there is no feed-back path. To overcome the linearity problems, a bootstrapped T&H circuit is employed in this paper which makes use of bootstrapped switch. Figure 7 shows the block diagram of such a bootstrap T&H circuit. One of the sources of non-linearity is a variation in on resistance Ron of sampling switch which is caused due to the non-constant gate to source voltage (Vgs) during the track mode. The Ron of sampling switch is given by ,

$$Ron = \frac{1}{\mu Cox(W/L)(Vgs - Vth)}$$

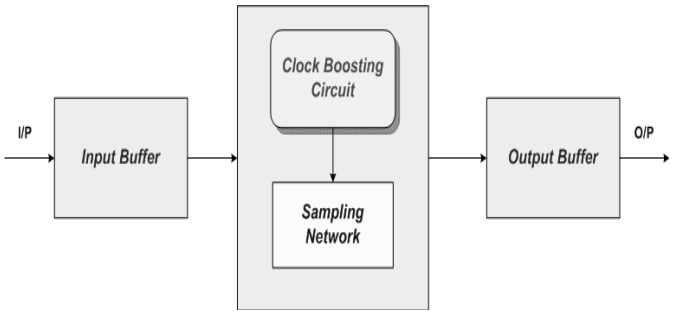

Figure 7: Block Diagram of Bootstrap Track & Hold Circuit.

The resistance of switch changes with the change in source voltage, which degrades the linearity of circuit. To avoid this, a bootstrap switch is used which keeps the Ron independent of source voltage by making the gate-source voltage of switch constant. Also, it is desired to have a small Ron for better linearity, this can be achieved by increasing the W /L ratio. The bandwidth is also reduced with small Ron. A bootstrapped switch is shown in figure 8.

The pseudo-differential architecture was chosen to design the T&H circuit. because it reduces the common mode (CM) hold pedestal and even order harmonics. In this way, it is possible to use hold capacitors of smaller sizes

There by increasing the speed of T&H circuit [18]. A pseudo differential architecture uses two separate but identical circuits which represent positive and negative part of the differential input signal [7].

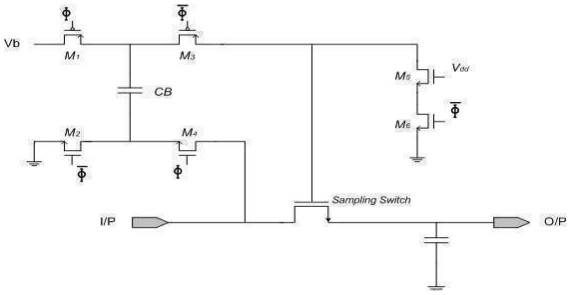

Figure 8: Bootstrap Switch.

The bootstrap T&H circuit used in this thesis is comprised of NMOS source follower (SF), a sampling network (SN) containing bootstrapped switch and a dummy switch, and finally a PMOS source follower. The description of individual blocks is given below.

B. NMOS Source Follower Buffer

Source followers (SF) are used in high speed T&H circuits as voltage buffers. A NMOS SF with resistor at source was used as an input buffer. The reason for using resistor at the source instead of current source was to get higher bandwidth. The gain of NMOS SF was limited because of using a smaller value of the source resistor to get high bandwidth. The non-linearity due to body effect was eliminated by connecting bulk of the transistor to its source. NMOS with triple well process was used to eliminate the body effect where it is possible to connect the source to bulk.

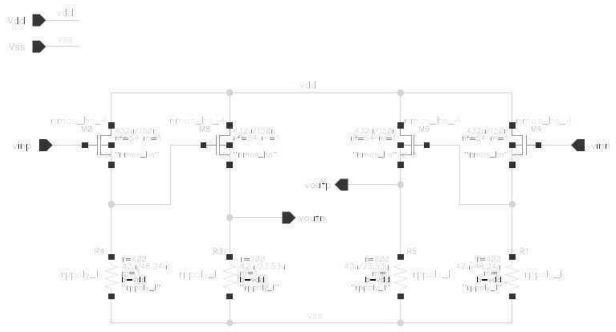

Figure 9: Transistor level implementation of NMOS Source Follower.

In this work, NMOS SF was used to drive the input capacitance of SN and isolate the TnH circuit from variable gain amplifier. A cascade of NMOS SF was used to shift the DC level of the input signal from 1.4 V to 450 mV. The level shift of signal could also be done in a single stage either by decreasing the size of transistors or by reducing the value of source resistor. In both cases, the gain of buffer reduced significantly. The level shifting was done to get the common mode voltage of 1.3 V at the output of track and hold circuit. The transistor level implementation of NMOS SF are given in figure 9.

C. Sampling Network

A NMOS transistor was used as a switch for its better speed as compared to the PMOS switch. A major drawback of the NMOS sampling switch is that it has strongly signal-dependent on-resistance [18]. A clock boosting circuit was employed for getting constant Vgs to reduce the variations in Ron. A dummy switch was added to reduce the non-linear effects due to charge injection and clock feed-through. The source and drain of dummy switch were shorted, and the gate of this switch was provided with the same clock boosting circuit as that of the sampling switch but in complemented form. The size of dummy transistor was chosen to be half the size of sampling switch, which is perfect for clock feed-through cancellation. The half size of dummy switch does not exactly match the charge from the sampling switch because of different operating regions of sampling switch while the Vds of dummy switch is constant as the drain and source terminals are shorted. It was therefore assumed that half of the channel charge from sampling switch is injected on both sides. The charge injected by the switch was absorbed by dummy switch thus preventing the error in the value of voltage on the hold capacitor. When the dummy switch turns off it also injects its charge on both sides. This is the reason why source and drain of dummy switch were shorted because in this way all the charge was injected to a low impedance, voltage driven source. Thus, the charge injection of dummy switch had no effect on the value of voltage on hold capacitor [11]. The transistor level implementation of bootstrap circuit are shown in figure 10.

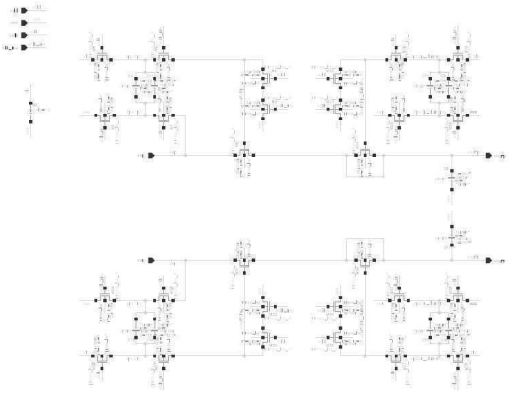

Figure 10: Transistor Level Implementation of Sampling Network.

The maximum input frequency of ADC is limited by the 3 dB frequency of sampling switch in TnH circuit. The 3 dB frequency of bootstrap switch and hold capacitor during the track mode is given by [18]:

$$f3dB = \frac{1}{2\pi\tau}$$

where

T is time constant and given by ד = Ron(CH + CP),

Ron is the on-resistance of sampling switch.CH and CP are the hold capacitance and parasitic capacitance respectively.

D. Output Buffer

The PMOS SF was used to drive the input capacitance of the amplifier array which act as a load for T&H circuit. To reduce the body effect, bulk of PMOS transistor was connected to the source so that the source bulk voltage remains constant. Due to reduced body effect, the linearity of PMOS source follower improved. The BW required for this buffer for its output to settle within half of the sampling period for 'n' bit accuracy, can be calculated by the equation given below :

$$BW > \frac{(n+1).ln(2).2.f_s}{2\pi},$$

The figure 11. shows Transistor Level Implementation of PMOS Source Follower.The PMOS SF was simulated for the load capacitance of 250 fF and achieved the required bandwidth over all the corners. The gain of PMOS SF was less than unity because of which the output signal swing is smaller than the input signal swing as shown in the transient waveform.

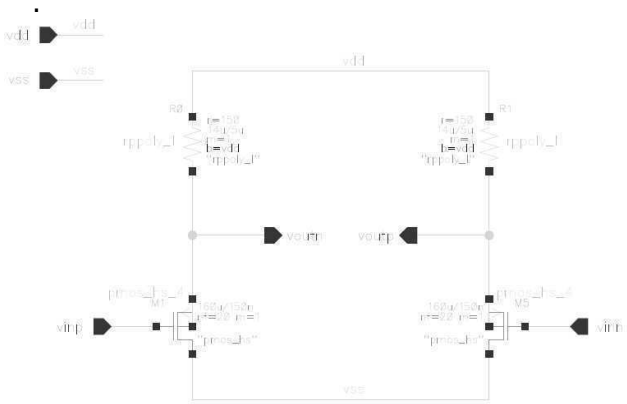

Figure 11: Transistor Level Implementation of PMOS Source Follower.

E .Design of Pre-amplifier

The PA consists of a simple differential pair which was used to amplify the output of differential difference amplifier. The amplification was need to have signal at the output of PA array be much larger than the input-referred comparator offset [13]. Three stages of PA were used for getting large amplification. The transistor level implementation of in figure 12.

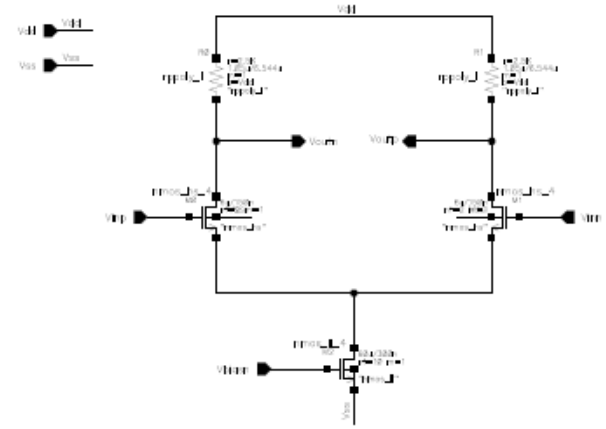

Figure 12: Transistor Level Implementation of Pre-Amplifier.

B. RESULTS

The NMOS source follower and track and hold circuit and PMOS source follower and pre-amplifier circuit blocks are simulated in 180nm CMOS technology using cadence tools and the transient responses are shown in figures 13,14,&15 respectively.

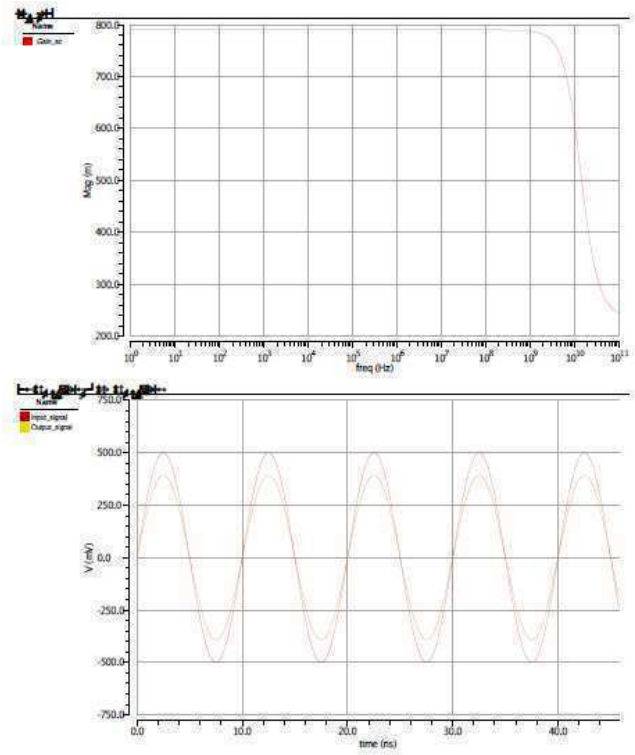

Figure 13: AC And Transient Response of NMOS Source Follower.

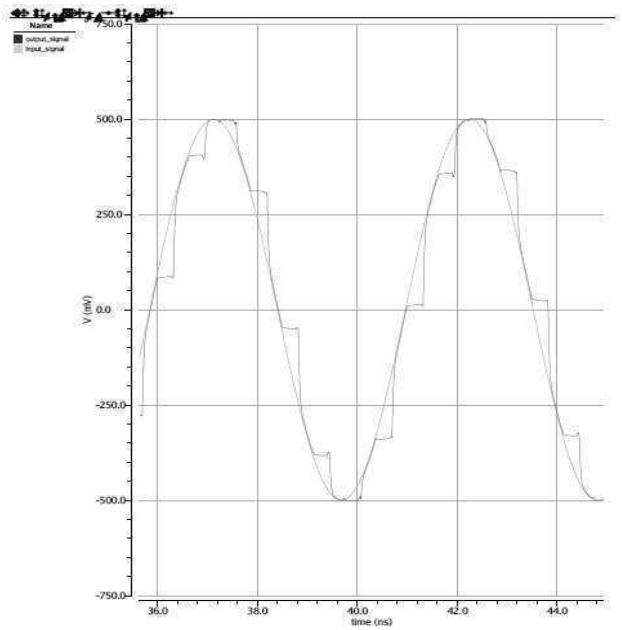

Figure 14: Transient Response of Track And Hold Operation.

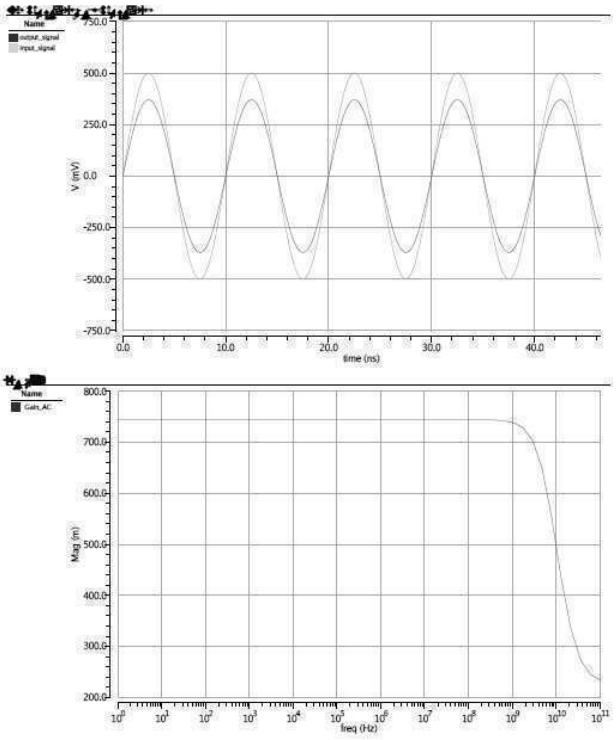

Figure 15: Transient And AC Response of PMOS Source Follower.

The simulation results show that the BW of 4.5 GHz was achieved for all the corners and SNDR of 37.38 dB was achieved. The SNDR could be improved further either by increasing the size of sampling switch or by increasing the hold capacitor value, but this also results in decrease of BW. The power consumed from bootstrap circuit was 27.95 mW, which is mainly because of large currents owing through NMOS SF. Table 1. shows the summary of results obtained from bootstrap TnH circuit with ideal clock. The results are shown for both corner and monte-carlo (MC) analysis. The Table 2. Shows the important parameters of track and hold circuit results.

TABLE 5.1
SIMULATION RESULTS FOR BOOTSTRAP TnH WITH IDEAL CLOCK.

Parameter	Minimum	Nominal	Maximum	StdDev.
BW Input Buffer (Hz)	4.55 G	7.3 G	10.73 G	7.8 M
BW Output Buffer (Hz)	6.83 G	8.87 G	12.23 G	12.86 M
BW SampleNetwork (Hz)	10.49 G	16.51 G	23.34 G	136.5 M
BW Track n Hold (Hz)	4.702 G	7.19 G	10.58 G	16.37 M
Tr.Gain InpBuf (Linear)	732.5 m	823.3 m	860.9 m	1.703 m
Tr.Gain OutBuf (Linear)	634 m	734.3 m	792.6 m	7.03 m
AC Gain InpBuf (Linear)	696 m	789.3 m	831.4 m	158 u
AC Gain OutBuf (Linear)	625.2 m	747.2 m	795 m	496.7 u
SNDR Sample Network (dB)	37.95 dB	60.12 dB	63.22 dB	226.7 m
SNDR PMOS SF (dB)	37.38 dB	55.53 dB	55.53 dB	206.6 m
Output Common Mode (V)	945 m	1.299	1.51	970.8 u
Power (W)	18.5 m	27.95 m	36.89 m	29.63 u

TABLE II
PARAMETERS OF TRACK AND HOLD CIRCUIT

Parameter	Bootstrap TnH
Bandwidth(Hz)	4.702 G
SNDR(dB)	37.38 dB
Power Consumption (W)	27.95m
Output Common Mode	1.3

The figure 16 and Table 3 shows the results of PA over corners and mismatches. Simulation results for PA shows that the gain greater than two was achieved over all the corners. The BW was simulated 1 dB low for the PA stage and minimum value obtained was 1.417 GHz with 25 fF load which is higher than the requirement. The offset for PA stage was high because of the small size of transistors. The transistor sizes for PA were kept smaller to avoid large load for preceding difference amplifier stage.

TABLE III
SIMULATION RESULTS FOR PRE-AMPLIFIER.

Parameter	Minimum	Nominal	Maximum	StdDev.
Bandwidth (Hz)	1.417 G	1.703 G	2.053 G	10.87 M
AC Gain (linear)	2.282	3.177	4.117	80.14 m
Tr. Gain (linear)	1.4	1.694	1.994	67.63 m
Input Offset (V)	0	0	0	9.894 m
Output Offset (V)	0	0	0	31.38 m
Output CM (V)	1.208	1.479	1.62	16.7 m
Power (W)	1.301 m	1.617 m	2.285 m	43.81 u

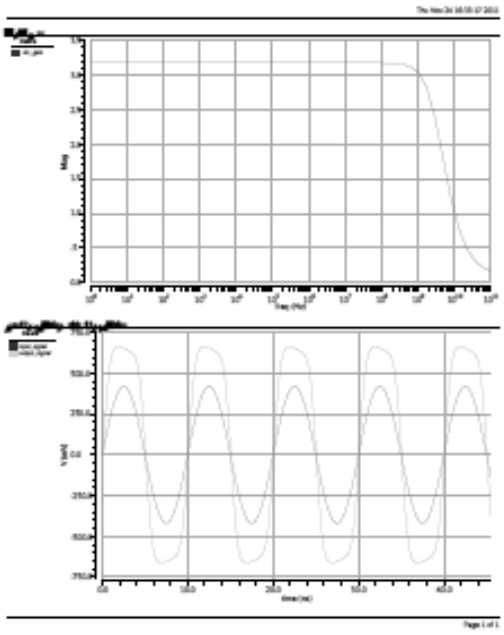

Figure 16: Transient And AC response of Pre-Amplifier.

Figure 17 shows the layout design of bootstrap Sampling Network. Antennas from digital library were included for layout to avoid the error which was occurring due to the

small gate area of transistor. This happened because some transistors were connected directly to power and their gate area was very small as compared to the area covered by power rails. Again RC extraction was used to check for parasitic capacitances and resistance. The table 4 shows the comparison between schematic and layout of sampling network.

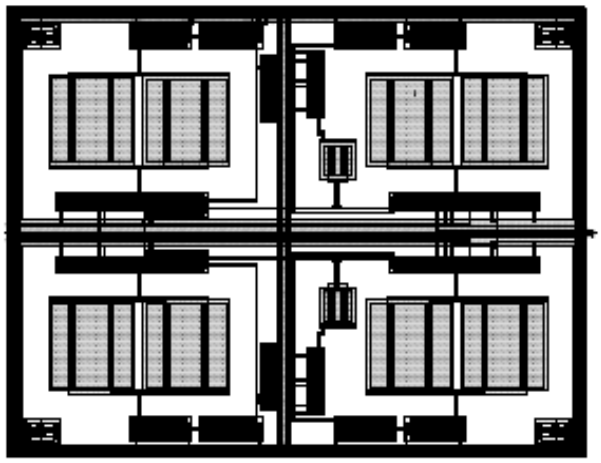

Figure 17: Layout of bootstrap sampling network.

TABLE IV
COMPARISON OF SCHEMATIC AND LAYOUT RESULTS FOR SAMPLING NETWORK.

Parameter	Schematic	Layout
Bandwidth (Hz)	17.47 G	10.71 G
SNDR (dB)	71.58 dB	57.45 dB
Power Consumption (W)	0	379.3 f
Output Common Mode (V)	428.3 m	399.1 m

CONCLUSIONS

A high speed flash ADC is presented for the AFE of receiver circuit. The flash architecture is chosen for its simplicity and fast data conversion rate. Track and hold circuit is implemented for improving the dynamic behaviour of the ADC. The bootstrapped architecture for T&H circuit a implemented in transistor level 180nm CMOS technology. The clock boosting circuit is used for bootstrap T&H circuit to reduce the non-linear effect caused by the Ron of switch and dummy switch is used to reduce clock feed-through and charge injection problem. Linearity of almost six bits is achieved from this circuit.

Preamplifiers are employed in front of comparators to reduce their large dynamic offsets. PAs also have offsets but smaller as compared to the large offsets of comparators. Averaging technique is presented to reduce the PA offset. To solve problems at the edges of amplifier array, a proper termination technique is also discussed. The effect of averaging is limited by the use of interpolation which is used to reduce the number of PAs in first stage in order to reduce load for the TnH circuit.

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Biomedical Waste Management in Indian Context

K.T. Padmapriya
CVR College of Engineering, Department of H&S, Ibrahimpatan, R.R.District, A.P., India
Email: ktpadmapriya@gmail.com

***Abstract*—This article is a detailed discussion of the biomedical waste characteristics, its effects, management and handling. Biomedical waste generated in hospitals, veterinary centers, biomedical research centers or laboratories are infectious, radioactive and chemically hazardous spreads contagious diseases, generates unhygienic conditions and end up with health hazards when the disposal or treatment is not proper. It is extremely important for each and every individual to be cognizant of all adverse effects induced by biomedical waste generation and their mishandling. This study gives an insight of all the ill effects generated by improper biomedical waste management, as human's proximity to the biomedical waste effects is very high in the present day scenario due to huge population growth and unawareness. This study also analyzes biomedical waste management and handling rules, 1998 notified under Environmental Protection Act, 1986 which is in existence to mitigate adverse effects of biomedical waste.**

***Index Terms*—Biomedical waste, biomedical waste management, proximity to biomedical waste effects, mitigation, biomedical waste management and handling.**

I. INTRODUCTION

Environmental science is a branch of science which deals with study of interaction of living species with its both living and non living components. All living species along with human beings interact with environment in a complex manner with balanced components. But all these components are strongly influenced by humans by their interference. World population is tremendously growing day by day and huge stress is imposed on all natural resources such as air, water, soil and biodiversity etc. Human is interfering, exploiting, and polluting all of them resulting dangerous consequences. Pollution can be generally referred under Air pollution, water pollution, soil pollution, marine pollution, noise pollution, radioactive pollution, thermal pollution. But, present day due to huge population growth, life styles, public unawareness, and improper technical management new problems are rising on global screen in the form of solid waste, hazardous waste and biomedical waste. There is a grave danger for the environment, human and animal health from these wastes especially in the developing countries which have relatively large populations. The reasons for this can be crowded habitat, illiteracy, low sanitation, least environmental awareness. There is an urgent necessity to the entire human community to get aware of the consequences generated by the negligence and mismanagement of dangerous and infectious waste. The civic responsibilities include (1)maintaining safe, clean and hygienic environment, (2)discussing the environmental issues, (3)establishing good rapport with local authorities related to the local environment, and (4)bringing in the notice of the government authorities in case of considerable disturbances. Various rules are notified under Environmental protection act, 1986, such as hazardous waste management and handling rules, 1999 and biomedical waste management and handling rules-1998 to handle the hazardous and biomedical waste. The purpose of this article is to educate the current generation on the negative health impacts generated by biomedical waste and also discuss the current biomedical disposal practices in India as there is clear evidence that human is very prone to various infections which may turn to health hazards when come intact with biomedical waste.

II.BIOMEDICAL WASTE

According to biomedical waste management and handling rules,1998 notified under Environmental Protection Act,1986 "Biomedical waste is defined as any solid or liquid waste that is generated in the diagnosis, treatment of immunization of human beings or animals in research pertaining Thereto, or in the production or testing of biological material." These wastes when come in contact will become infectious or may spread contagious diseases. Biomedical wastes include a wide variety of items that may carry disease-causing germs including those that cause hepatitis and the virus that causes AIDS. It also includes items such as: live vaccines; laboratory samples; cultures; sharp needles; lancets that have been used to puncture, cut, or scrape the body; and human or animal body fluids or Other wastes generated in healthcare settings include radioactive wastes, mercury containing instruments, PVC plastics etc.,. The status of poor waste

management currently practiced in the city poses a huge risk towards the health of the general people, patients, and professionals, directly and indirectly through environmental degradation. Communicable diseases like gastro-enteritis, hepatitis-A and B, respiratory infections and skin diseases are associated with hospital waste either directly as a result of waste sharp injuries or through other transmission channels.Table1,represents types of infectious, pathogens agents and transmission path due to Biomedical waste generations.

The Government of India in a recent Gazette notification has classified biomedical waste under Schedule I, into ten categories mentioned in Table2,include,(1) Human anatomical waste.),(2) Animal waste, (3) Microbiology and biotechnology waste,(4) Waste sharps, (5) Discarded medicines and cyto-toxic drugs,(6) Soiled waste,(7) Solid waste ,(8) Liquid waste generated from any of the infected areas,(9) Incineration ash and(10) Chemical waste etc. World Health Organization states (WHO) that 85% of hospital wastes are actually non-hazardous, whereas 10% are infectious and 5% are non-infectious but they are included in hazardous wastes like methyl chloride and formaldehyde. About 15% to 35% of Hospital waste is regulated as infectious waste. This range is dependent on the total amount of waste generated [1]. Among the 35 million healthcare workers worldwide, the estimations show that each year about 3 million receive hard exposures to blood borne pathogens[2], 2 million of those to HBV[2], 0.9 million to HCV and 1,70,000 to HIV[2].The hosts of micro organisms responsible for infection are enterococci, non-haemolytic streptococci, anaerobic cocci, clostridium tetani, klebsiella,cocci, non-haemolytic streptococci, anaerobic cocci, clostridium tetani, klebsiella, HIV and HBV [3].

TABLE I

TYPES OF INFECTIOUS, PATHOGENS AGENTS AND TRANSMISSION PATH DUE TO BIOMEDICAL WASTE GENERATIONS [4]

Sl.No.	INFECTION TYPE	PATHOGEN AGENTS	TRANSMISSION PATH
1	. Gastrointestinal Infections	Enterobacteria:salmonella, Shigella Spp, vibrio cholera Helminths.	Faeces or/and vomiting liquid
2	Respiratory Infection	Herpes virus Mycabocterium tuberculosis, Measles virus Sreptococcus preumonae	Respiratory secretions, saliva
3	Eye Infections	Herpes virus	Eye secretions
4	Genital Infections	Neisseria gonorrhoeae Herpes virus	Genital secretions
5	Skin Infections	Streptococcus spp	Purulent secretions
6	Anthrax Bacillus	anthracis	Secretions of skin lesions
7	Meningitis Neisseria	Neisseria meningitides	L.C.R.
8	AIDS HIV	HIV	Blood, Semen, Vaginal Secretions
9	Hemorrhagic fevers	Iunin viruses, Lassa, Ebola Marburg	Biological fluids and secretions
10	Septicemia	Staphylococcus ssp	Blood
11	Viral Hepatitis type A	VHA	Faeces
12	Viral Hepatitis type B and C	VHB, VHC	Blood, biological fluids.

III.VARIOUS POTENTIAL SOURCES OF INFECTIONS

Hospitals, biomedical centers, Veterinary hospitals, laboratories and also improper disposal act as Potential sources of infection if biomedical waste is not handled or managed properly.

A. Viral Infection Transmission At Biomedical Centers:

Viral infections such as HIV shown in Fig.1 Hepatitis B, and Hepatitis A which cause AIDS, Infectious Hepatitis are spread by pathogen contaminated needles, body Fluids, Blood, soiled linen. Fig.2 represents Enterovirus causing Dysentery and Fig.3 represents Arbovirus which causes Dengue, Japanese encephalitis, tick-borne fevers and Fig.3 shows Arbovirus which causes Dengue, Japanese encephalitis, tick-borne fevers which can be spread through body fluids, Human excreta, soiled Linen.

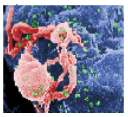

Figure 1. HIV Virus

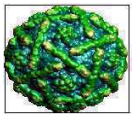

Figure 2. Enterovirus

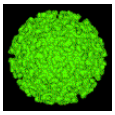

Figure 3. Arbovirus

B. Bacterial Infection Transmission At Biomedical Centers:

Shigellosis causing Shigella spp., Typhoid causing Salmonella typhi and Vibrio cholera which cause Cholera represented in Fig.4, Fig.5 and Fig.6, are transmitted by body fluid in landfills and hospital wards. Staphylococcus spp. shown in Fig.7 which cause wound infections, septicemia, rheumatic fever skin and soft tissue infections, endocarditis (inflammation of the inner layer of the heart) causing Bartonella henselae bacilli shown in Fig.8, Tetanus generating bacteria Clostridium Tetani are common bacterial transmissions by biomedical waste like Sharps such as needles, surgical blades in hospital waste.

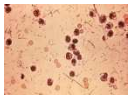

Figure 4. Shigella Spp A

Figure 5. Salmonella Typhi

Figure 6. Vibrio Cholera

Figure 7. Staphyloccocus Spp.

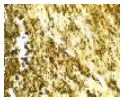

Figure 8. Bartonella Bacilli

C. Parasite Infection Transmission At Biomedical Centers:

Fig.9, Fig.10 and Fig.11 represents Giardia lamblia, Wucheraria bancrofti and Plasmodium parasites which cause - Giardia lamblia, Cutaneous leishmaniasis, Kala Azar and Malaria respectively, are transmitted by Human excreta, blood and body fluids in poorly managed sewage system of hospitals.

Figure 9. Giardia Lamblia

Figure 10. Wucheraria Bancrofti

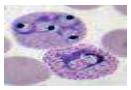

Figure 11. Plasmodium

D. Sources Of Infections At Veterinary Hospitals:

Veterinary practices without following infection control measures will end up causing zoonotic infections to the practitioners and staff members while diagnosis and treatment. A survey done veterinarians identified as practicing clinical medicine in King County proved One hundred five of 371 (28%) respondents indicated that they had been infected with a zoonotic disease in practice, with 22 respondents indicating that they had had > 1 zoonotic disease. A total of 133 cases of zoonotic disease, of which 70 (53%) were not medically confirmed, were listed by these 105 veterinarians [5].

E. Disease Transmission Due To Contamination In Laboratories :

Past history shows disease transmission is very common to the technicians, laboratorians or microbiologists working in laboratories by various reasons which can be proved by the following examples. A needle stick injury while passaging amastigotes (NIH strain 173) in mice infected a graduate student with L. tropica. [6].

While Inoculating a hamster with an infected macerate containing ~2,000 amastigotes/µl a laboratorian became infected with L. (V.)braziliensis (L1794 MHOM/VE/84[VE3]) by puncturing her thumb accidentally with a needle that “pierced its plastic hood” [7]. Four days after handling infected blood a

medical biology department student had skin excoriations and became ill. At the time of initial diagnosis his parasitemia was 5% and several days later, he developed oliguria and cerebral malaria, with altered mental status and hallucinations [8]. A solution of trypomastigotes (Tulahuen strain) was spilled by a microbiologist onto slightly abraded skin on his left hand developed Chagas' disease [9]. Ascitic fluid from infected mice was accidentally spilled onto small scratches on the left hand of a laboratorian and developed fever and left axillary lymphadenopathy 10 days later [10].

SARS coronavirus has also been propagated in reference and research laboratories, and distributed to other laboratories for research purposes after SARS outbreak in China. Research using live and inactivated SARS coronavirus – and other pathogens capable of causing serious illness -- is being conducted in many laboratories. "China's latest SARS outbreak has been contained, but biosafety concerns remain"(WHO) this statement clearly shows the risk of bio safety.

F. Effects Of Improper Disposal Of Biomedical Waste:

Biomedical waste disposal if not proper can generate high infectious, unhygienic conditions and pollutes environment. In the dumping site Bijauli as well as satellite areas of the Jhansi city the open dumping of the dangerous biomedical wastes, where found to be contaminated with disease carrying pathogens spreads infection . The disposal of incineration ash as well as fly ash having toxic because of heavy metals, dioxins and furan in it affecting ground water regime. Burning of biomedical waste at open dumping site, creating toxic elements and compounds and contaminating the environment with lethal chemical dioxin where materials containing chlorine burned [11].

Ministry of Environment & Forest, Govt. of India issued a notification on 20th July, 1998 for Biomedical Waste(Management & Handling) Rules 1998 in exercise of powers conferred by Section 6, 8 & 25 of the Environment (Protection) Act, 1986 that was published in The Gazette of India Extraordinary, Part-II, Section 3-Sub-Section (ii) New Delhi, July 27, 1998 . These rules may be called the Bio-Medical Waste (Management and Handling) Rules, 1998 by following these rules can reduce the ill effects of biomedical waste on human beings and environment.

IV.OBJECTIVES OF BIOMEDICAL MANAGEMENT

1) To prevent transmission of disease from patient to patient, from patient to health worker and vice versa
2) To prevent injury to the health care worker and workers and workers in support services, while handling biomedical waste.
3) To prevent general exposure to the harmful effects of the cytotoxic, genotoxic and chemical biomedical waste.

"Biomedical waste" according to biomedical waste rules includes categories mentioned in Schedule I; The Government of India in a recent Gazette notification has classified biomedical waste under Schedule I, into ten categories. According occupier of an institution generating biomedical waste shall be treated and disposed of in accordance with Schedule I, and in compliance with the standards prescribed in Schedule V shown in Table2.

TABLE II

TYPES OF BIOMEDICAL WASTE ,TREATMENT AND DISPOSAL UNDER SCHEDULE I AND IV OF BIOMEDICAL WASTE MANAGEMENT AND HANDLING RULES, 1998.

CATEGORIES (SCHEDULE I)	TYPES OF BIOMEDICAL WASTE	TREATMENT AND DISPOSAL(SCHEDULE V)
Category:1	Human anatomical waste (tissues, organs, body parts etc.).	Incineration/deep burial
Category:2	Animal waste (as above, generated during research/experimentation, from veterinary hospitals etc.).	Incineration/deep burial
Category:3	Microbiology and biotechnology waste, such as, laboratory cultures, micro- Organisms, human and animal cell cultures, toxins etc.	Localautoclaving/microwaving/incineration
Category:4	Waste sharps, such as, hypodermic needles, syringes, scalpels, broken glass etc.	Disinfection (chemical treatment/autoclaving /microwaving and mutilation/shredding
Category:5	Discarded medicines and cyto-toxic drugs.	Incineration/destruction and drugs disposal in secured landfills

Category:6	Soiled waste, such as dressing, bandages, plaster casts, material contaminated with blood etc.	Incineration/autoclaving/microwaving
Category:7	Solid waste (disposable items like tubes, catheters etc. excluding sharps).	Disinfection by chemical treatment/autoclaving/ microwaving and Mutilation/shredding
Category:8	Liquid waste generated from any of the infected areas.	Disinfection by chemical treatment and discharge into drains
Category:9	Incineration ash.	Disposal at municipal landfills.
Category:10	Chemical waste.	Chemical treatment and discharge into drains for liquids and secured landfill for solids

While treating the biomedical waste certain things should be taken for consideration such as, Chemical treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent and ensures disinfection. Mutilation /shredding must be such so as to prevent unauthorized reuse. There will be no chemical pretreatment before incineration. Chlorinated plastics shall not be incinerated**.** Deep burial shall be an option available only in towns with population less than five lakhs and in rural areas.

Segregation Of Biomedical Waste:

Biomedical waste shall not be mixed with other wastes. Biomedical waste shall be segregated into specific colored containers/bags at the point of generation in accordance with Schedule II prior to its storage, transportation, treatment and disposal is represented in Table 3, category wise treatment and disposal of biomedical waste is shown in Table 2 as per schedule I and II.

TABLE 3

SEGREGATION OF BIOMEDICAL WASTE IN ACCORDANCE WITH SCHEDULE II

CONTAINER COLOR CONDING	TYPE OF CONTAINER AND WASTE CATEGORY
Yellow	Plastic bag Cat. 1, Cat. 2, and Cat. 3, Cat. 6.
Red	Disinfected container/plastic bag Cat. 3, Cat. 6, Cat.7.
Blue/White translucent	Plastic bag/puncture proof Cat. 4, Cat. 7. Container
Black	Plastic bag Cat. 5 and Cat. 9 and Cat. 10. (solid waste)

Labeling The Containers:

Containers shall be labeled according to Schedule III with biohazard symbol shown in Fig.12, or Cytotoxic Hazard symbol shown in Fig.13, accordingly

Figure 12. Biohazard Symbol

Figure 13. Cytotoxic Hazard Symbol

If a container is transported from the premises where biomedical waste is generated to any waste treatment facility outside the premises, the container shall, apart from the label prescribed in Schedule III, also carry information prescribed in Schedule IV. If the waste treating site is outside the premises untreated biomedical waste shall be transported only in such vehicle as may be authorized for the purpose by the competent authority as specified by the government according to Motor Vehicles Act, 1988. Label on waste transporting shall be non-washable and prominently visible. It should have all the details like time of generation, waste category, waste class and description along with full address of sender and receiver.

Biomedical waste shall be treated and disposed of in accordance with Schedule I, and in compliance with the standards prescribed in Schedule V which gave clear guidance for standards of incineration operating and emission, autoclaving, microwaving, deep burial,

Liquid waste. No untreated bio-medical waste shall be kept stored beyond a period of 48 hours.

Prescribed authority of Government of every State and Union Territory will be granting authorization and implementing the rules. Operator of a bio-medical waste facility or occupier of an institution generating, collecting, receiving, storing, transporting, treating, disposing and/or handling bio-medical waste in any other manner, except such occupier of clinics, dispensaries, pathological laboratories, blood banks providing treatment/service to less than 1000 (one thousand) patients per month, shall make an application in Form I to the prescribed authority for grant of authorization shall be accompanied by a fee as may be prescribed by the Government of the State. Every occupier/operator shall submit an annual report to the prescribed authority in Form II by 31 January every year. They should maintain the records related to biomedical waste handling and report during inspection. Accidents should be reported in form III. By following these handling rules a clear solution is possible to minimize the burden on human health.

V.OBSERVATION AND REVIEW OF CURRENT PRACTICES OF DISPOSING BIOMEDICAL WASTE

The biomedical waste which is generated at all biomedical waste generation centers since recent past in India used to dump or incinerate without proper segregation and recycling is done by rag pickers or freelance workers scour these waste manually and separate recyclable material to pass on to relevant industries which acquire waste from them. Many of them contact diseases from syringes and needles and other biomedical waste and become carriers of great health risk to the general populace. Not only have that because of unawareness the people are still coming in risked zone.

All the reviews and observations clearly elevates the problems generated by biomedical waste at all the stages from its generation to improper disposal and human's proximity to ill effects of biomedical waste shows the immense necessity of Biomedical waste Management. Handling, segregation, mutilation, disinfection, storage, transportation and final disposal are vital steps for safe and scientific management of biomedical waste in any establishment [12]. In India at the present day biomedical waste management is given much priority in urbanized sectors can be shown by the following observations.

In KLE Society's J. N. Hospital and Medical Research Center, Belgaum, India [13], the process of segregation, collection, transport, storage and final disposal of infectious waste will be done in compliance with the Standard Procedures and the final disposal was by incineration in accordance to EPA Rules 1998**.** Sir Ganga Ram Hospital of New Delhi follows mutilation and disinfection of biomedical waste sharps and syringes while handling and disposes the sharps into sharp pit. Microwaving and shredding of syringes is opted in Ram Manohar lohia hospital, New Delhi, and plastic recycling in Ramaiah Medical College, Bangalore. Sundaram Medical Foundation, Chennai performs smelting of disinfected and mutilated metal sharps in an iron foundry. Tata Memorial Hospital, Mumbai prefers hyroclaving and shredding sharps Autoclave Effluent treatment plant has centralized facility for biomedical waste with Incinerators, WHO keenly studied Centralized Facilitly Medi, facility of Encapsulation of sharps in bunkers. at GJ Multiclave India Pvt. Ltd and Medicare Incin. Pvt-Hyderabad and expressed satisfactory management of sharps but still quotes sustainable final disposal is required [14].

VI. SOME PROPER METHODS OF HANDLING BIOMEDICAL WASTE

- The medical practitioners and veterinary practitioners need to follow bio safety measures using disinfectants, washing hands after diagnosis; prohibiting eating and drinking in testing areas can reduce their exposure to ill effects. They are suggested to give guidelines of safety to their supporting staff and made them aware of biomedical effects can improve hygienic attitude at the medical centers.
- Nasocomial infections to patients can be avoided with efficient infection control and Waste management.
- Safety measures should be taken by micro biologists and laboratory technicians while handling needles, medical sharps and biomedical liquid waste to avoid infections.
- Occupiers of any biomedical waste generation centers are to implant cost effective relevant technologies and also can opt for common biomedical waste treatment plants to manage the waste generated. Segregation should be done according to biomedical handling rules; safety is maintained by using masks and gloves. Medical and Para medical staff while handling or segregating biomedical waste suggested pertaining at most care.
- All the medical waste generating centers strictly need to follow biomedical waste management rules which are well monitored. In case of any negligence shown towards handling rules should get punished.
- Dumping Biomedical waste by following the handling rules which generates least scope of air, ground water or biological soil pollution.

- Raising awareness, Information dissemination to be done through organizing seminars, workshops, practical demonstrations, group discussions and lectures etc to all the concerned persons. Above all from common man to professionals and rag pickers to municipality staffs are to be educated with biomedical waste characteristics and ill affects so that from basic level to high technology handling and treatment according to law can revert the hazardous health and environmental conditions in the way of safe living.
- Common and combined biomedical treatment plants can be worked out for 30 to 40 bed hospitals with cost efficient biomedical waste treatment.

SUMMARY AND CONCLUSION

With the reviews done and observation Human's proximity to the ill effects of biomedical waste clearly indicated at all levels from diagnosis, treatment, research laboratories and improper dumping if measures are not taken accordingly. The risk exists even from stored pathogens in research laboratories. Biomedical waste management and handling rules, 1998 notified under Environmental Protection Act, 1986 gave clear guidelines to handle the biomedical waste at all levels following which we can mitigate the effects of biomedical waste.

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Investigation of Ultrasonic Parameters for Ultrasound Exposure of 36 kHz on E.coli Culture

M Srinivasa Reddy[1] and D Linga Reddy[2]
[1]Dept. of Physics, Anurag Group of Institutions, Venkatapur, Hyd – 08415 (A.P.), India.
Email : srmainampati@gmail.com
[2]Dept. of Physics, UCS, Osmania University, Hyderabad – 5000007 (A.P.), India.
(presently at - CVR College of Engineering, Mangal palli (V), Ibrahimpatnam (M),
R R Dist., 501 510, A.P., India.)
Email : profdlrphy@gmail.com

***Abstract*: The extensive research work has been carried out on kill rate of E.coli with increased time of ultrasound exposure that depending upon the power, frequency and intensity. In contrast, the knowledge of ultrasonic parameters induced by ultrasound is rather limited, especially when it comes to the measurement of ultrasonic parameters with kill rate of E.coli. The present paper therefore, aimed to measure the ultrasonic velocity, attenuation coefficient and acoustical impedance with disruption of E.coli as a function of ultrasound exposure time at 36 kHz frequency. The ultrasonic velocity and attenuation coefficient were carried out by using novel Pulse Echo Overlap (PEO) technique. Spread Plate Techniques were used as a measure of microbial activity. It was observed that ultrasonic velocity and attenuation coefficient of E.coli were increased with initial exposure of ultrasound. This may be due to result of increased convection in E.coli culture by onset of stable cavitation. The onset of transient cavitations disrupts cells in suspensions with increased ultrasound exposure. Therefore, it was reported that ultrasonic velocity and attenuation coefficient decreases almost linearly with disruption of E.coli. The results of ultrasonic velocity and attenuation coefficient of E.coi were found in the right order of magnitude and confirmed with A Zips and U Fast.**

***Key Words*: E.coli, Ultrasound, Pulse Echo Overlap (PEO) technique, Ultrasonic velocity.**

I. INTRODUCTION

Ultrasound is defined as acoustic energy or sound waves with frequencies above 20 kHz. Ultrasound is able to defuse bacteria, make them more vulnerable to biocides and disintegrate bacterial clusters or flocks. It is depending upon the power and frequency applied through a number of physical, mechanical and chemical effects that are arising from acoustic cavitations. The effects of a range of ultrasonic frequencies (20 kHz – 10 MHz), acoustic power and exposure time on bacterial kill have been reported [1-3]. The results showed a significant increase in kill rate for E.coli species with increasing duration of exposure and intensity of ultrasound in the low-kilohertz range (20 – 38 kHz). The results obtained at higher frequencies (above 850 kHz) indicated significant bacterial declumping. In assessing the bacterial kill with time under different sonication regimes three different types of behavior were characterized.

The high power ultrasound (lower frequencies) in low volumes of bacterial suspension results in a continuous reduction in bacterial cell numbers i.e. the kill rate predominates. The high power ultrasound (lower frequencies) in larger volumes results in effective declumping of the bacteria giving an initial rise in cell numbers, but this initial rise then falls as the declumping finishes and the kill rate becomes more important. Low intensity ultrasound (higher frequencies) gives an initial rise in cell numbers as a result of declumping. The kill rate is low, and so there is no significant decrease in bacterial cell numbers.

Ultrasound increases convection in liquid by at least two mechanisms. The first is acoustic streaming flow in which momentum from directed propagating sound waves is transferred to the liquid, causing the liquid to flow in the direction of the sound propagation. Acoustic streaming increases with insonation intensity, and there are reports of acoustic streaming flow at velocities as high as 14 cm/sec [4]. Thus any amount of ultrasound in a liquid produces additional convective transport from acoustic streaming.

The second and more notable mechanism of enhancing convection is known as microstreaming, and is produced by cavitating gas bubbles in the liquid [5-7]. The cycles of low and high acoustic pressure cause the gas bubbles to expand and shrink, which in turn creates shear flow around the oscillating bubbles causes rise in cell numbers as a result of declumping. Stable cavitation results when the acoustic intensity is sufficiently low that the bubbles do not collapse completely during their contraction cycle. The onset of stable cavitation greatly increases convective transport.

The transient cavitations occur if the acoustic pressure amplitude is sufficiently high and above a threshold level. Under this condition the encapsulated microbubbles (EMB's) will first grow in volume and then implode violently. This cavitation can affect a biological system by virtue of the localized temperature rise and mechanical stress [8-9]. Moreover, the dissociation of water molecules into H and OH free radicals, as a consequence of the very high temperature and pressures produced by cavitation, may induce adverse chemical changes such as DNA or protein denaturation [10]. However, the ultimate reason for the lethality of ultrasound on micro-organisms is still unknown.

In the present paper, the ultrasonic parameters like ultrasonic velocity, attenuation coefficient and acoustical impedance were measured with increased ultrasound exposure time at 36 kHz. The colony forming units (cfu) per ml and % of survivals were measured and used to correlate acoustical parameters.

II. MATERIALS AND METHODS

A. Bacteria and Growth Conditions

E.coli strain HB 101 (kindly supplied by Hi-media, Hyd.) was used throughout the study. Stock cultures were stored on nutrient agar slants in the dark at 0-4 ^{0}C. The cultures were either grown in nutrient Broth as 100 ml volumes in 250 ml Erlenmeyer flasks at 37^{0}C, 200 rpm or as solid cultures on Nutrient Agar plates (37 ^{0}C)

B. Ultrasonic Studies

Bacterial cultures were harvested by centrifugation (13000g, 20 min) and the resulting pellet re-suspended in sterile to a concentration of '10^8' cfu/ml. This corresponded to an optical density absorbance value of 0.72 at a wavelength of E_{600}. The re-suspended cells were placed in the 11 number of sonication vessels of 10 ml each (15 ml glass bottles, internal diameter 21mm, flat base, 2.5 mm wall thickness) to a depth of 25 mm and exposed to ultrasound for time period of 0 min (control), 1 min, 2 min, ….10 min respectively using ultrasonic-generator SG-25-500 Series with an operating frequency of 36 kHz and an output power of 500 W (kindly supplied by Roop Telsonic Ultrasonix Ltd., Bombay). A 12 mm diameter (Sonotrode) titanium probe set at 5 mm below the surface of the culture was used throughout. After sonication, samples (0.1 ml) were removed to solutions of sterile saline (9.9 ml) and serially diluted. The viable counts were made in triplicate on the surfaces of pre-dried Nutrient Agar plates. All plates were subsequently incubated at 37 ^{0}C for 24 h. The viable cells were counted by using spread plate technique. The results were expressed as percentage reductions in viability relative to appropriate unexposed controls.

C. Measuring the Ultrasonic Velocity

The ultrasonic velocities were measured with the help of microprocessor based Pulse Echo Overlap (PEO) system at same frequency (kindly supplied by Roop Telsonic Ultrasonix Ltd., Bombay). The internal circuit of pulse echo overlap system is designed with fully solid state version, which allows immediate measurement of the ultrasonic velocity as given in the following equation [11]

$$v = \frac{2l}{t}$$

Where '*l*' is the column length of the culture and 't' is the time interval to travel column length.

The error in measurement of ultrasonic velocity is ± 1 m/sec.

D. Attenuation Coefficient

The transducer is immersed into the sonication vessel then ultrasonic waves are allowed to pass through the bacteria culture under study. They are reflected from the opposite face and received by the same transducer, which now acts as a receiver. The Pulse Echo Wave train pattern is observed on the screen. Gate pulse was made to coincide with the bottom of the secondary echo pulse and amplitude is adjusted to 80% of its maximum value. The attenuation coefficients of the bacteria cultures are carried out by measuring the amplitudes of transmitted pulses of selected two successive echoes on CRO screen. The ultrasonic attenuation coefficient is calculated by using the following formula.

$$\alpha = \frac{1}{2l}\ln\left(\frac{A_n}{A_{n+1}}\right) \quad \text{nep/cm}$$

Where '2*l*' is distance travelled and 'A_n / A_{n+1}' is the ratio between two successive echoes of 'A_n' and 'A_{n+1}'. The uncertainty in the calculation of ultrasonic attenuation coefficient is ± 0.001 nep /cm.

E. Calculation of Density

The density of bacteria cultures are carried out for 100 samples under study by using bicapillary pyknometer of 10 ml volume. The transfer of bacteria cultures is made by using micro pipette in the laminar flow chamber to avoid contamination with air and body.

The density of bacteria cultures is measured by using the following procedure

Mass of the empty bicapillary pyknometer = w_1 gm
Mass of the bacteria culture + pyknometer = w_2 gm
Mass of the culture (m) = $w_2 - w_1$ gm
Volume of the culture = V cm^3
Density of the bacteria culture (ρ) =

$$\frac{Mass\ \ of\ \ the\ culture\ (m)}{Volume\ \ of\ the\ \ culture\ (V)} \quad gm/cm^3$$

F. Calculation of Adiabatic Compressibility

The Adiabatic compressibility can be calculated as

$$\beta_s = 1/\rho v^2 \quad cm^2/dynes$$

Where 'ρ' is the density and 'ν' is the ultrasonic velocity

G. Calculation of Intermolecular Free Length

The equation to calculate Intermolecular free length is

$$L_f = K\beta_s^{\frac{1}{2}} \quad A.U.$$

Where K = Jacobson's temperature constant

= 631 x 10^{-6} at 303 K
= 642 x 10^{-6} at 313 K
= 651 x 10^{-6} at 323 K

H. Acoustical Impedance

Acoustical impedance is calculated by using the following formula

$Z = \rho v$

Where 'ρ' is the density and 'ν' is the ultrasonic velocity.

III. Result And Discussion

The results ultrasonic velocity, % survivors, attenuation coefficient and acoustic impedance for exposure of ultrasound (500 W) with an operating frequency of 36 kHz on E.coli taken in 11 different sonication vessels for the time period of 0 min (control), 1 min, 2 min, ….10 min are tabulated in Table 1. Figure (1) shows the initial increase of ultrasonic velocity and then exponential decrease with increase of ultrasound exposure time. Figure (2) shows that attenuation coefficient and acoustic impedance also increases with ultrasound exposure time and then exponentially decreases with further increase of exposure time. Figure (3) shows that adiabatic compressibility and intermolecular free length decreases with sonication time upto one minute after that they increase linearly with sonication time.

The initial rise in ultrasonic velocity and attenuation coefficient of E.coli with ultrasound exposure time for all growth periods of E.coli may be due to convective transport by two mechanisms namely acoustic streaming and micro streaming. The onset of stable cavitation for the small period (around one minute) of ultrasound exposure will enhance the convective transportation. The high convective transport initiates the declumping process. The declumping decreases inter cellular distance and intern the compressibility of E.coli culture and hence the ultrasonic velocity increases. The declumping also increases attenuation coefficient because in addition to the absorption the attenuation due to scattering is increased. Further increase of ultrasound exposure time on E.coli causes onset of transient cavitation which is responsible for disruption of cells in suspension. The exponential decrease of E.coli cells in suspension intern decreases compressibility of E.coli suspension. Therefore, it was observed that the ultrasonic velocity and attenuation coefficient linearly decrease with increased ultrasound sound exposure. It was observed that the acoustic impedance within the suspension increases in the period of declumping may be increased stiffness of E.coli suspension.

TABLE I
Ultrasonic Velocity (v), Attenuation Coefficient (α), Colony Forming Units, (%) Survivors and Acoustical Impedance (z) of E.coli as a function of sonication time at 27^0C.

Sonicat iontime (t) min	Ultrasonic Velocity (v) × 10^2 cm/sec	Attenuatio n Coefficien t (α) nep/cm	Colony Forming Units (CFU/ml)	(%) Surviv ors	Acoustical Impedance (z) × 10^5 gm/cm^2-sec
0	1592	0.5271	1566	100	1.806
1	1610	0.5302	1560	99.6	1.828
2	1568	0.4523	1118	71.3	1.781
3	1553	0.3923	756	48.2	1.764
4	1531	0.3201	343	21.9	1.739
5	1510	0.3002	95	0.06	1.715
6	1501	0.2890	57	0.036	1.705
7	1493	0.2602	21	0.013	1.696
8	1486	0.2505	12	0.007	1.688
9	1481	0.2409	05	0.003	1.682
10	1480	0.2408	04	0.002	1.681

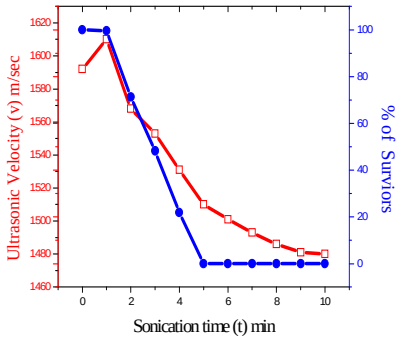

Figure 1. Sonication time Vs Ultrasonic velocity and % of Survivors

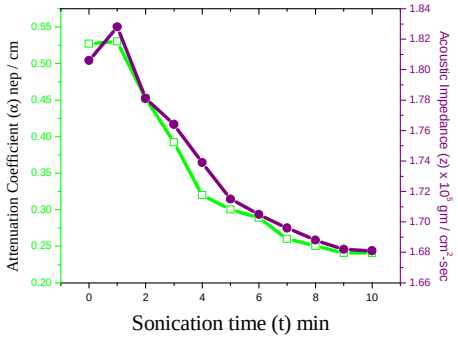

Figure 2. Sonication time Vs Attenuation Coefficient and Acoustic Impedance

TABLE II
Density (ρ), Inter molecular free length (L_f) and Adiabatic compressibility (β_s) of E.coli as a function of Sonication time at 27^0C.

Sonication time (t) min	Density (ρ) gm/cm^3	Adiabatic Compressibility (β_s)X 10^{-11} dyn/cm^2	Inter Molecular Free length (L_f)X 10^{-9} cm
0	1.134	3.479	1.176
1	1.135	3.399	1.163
2	1.135	3.583	1.194
3	1.135	3.653	1.206
4	1.135	3.758	1.223
5	1.135	3.864	1.24
6	1.135	3.910	1.247
7	1.135	3.953	1.254
8	1.135	3.989	1.26
9	1.135	4.016	1.264
10	1.135	4.022	1.265

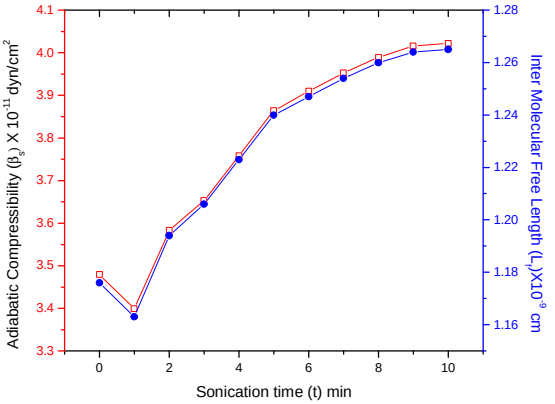

Figure 3. Sonication time Vs Adiabatic compressibility and Intermolecular free length

CONCLUSIONS

The considerable variation of ultrasonic parameters with cell destruction was noted in this present research and may be applicable to other bacteria cultures. The possibility is that the variation of ultrasonic parameters could be used to assess the cell viability and non-linear growth of bacteria cultures. Moreover, it is hypothesized that the detailed study of this research work could be used non-destructively to find the presence of bacteria in packaged food etc.

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Determining the Most Significant Factors in Classifying a Web Site – Users Perspective

B. B. Jayasingh[1] and Nayani Sateesh[2]
[1] Professor, IT Dept., CVR College of Engineering, Ibrahimpatan, RR Dist-501510.
Email: bbjayasingh9@rediffmail.com
[2] Asst. Professor, IT Dept., CVR College of Engineering, Ibrahimpatan, RR Dist-501510.
Email: nayanisateesh@gmail.com

***Abstract*- Due to the wide range of connectivity, communication over Internet becomes a single click. In this way, websites play a vital role to reach and attain the users. Hence, we must design the website considering the features the users look and the features that are most significant to them. In this work, we try to understand the user behavior and the features that are most important to them in order to classify a website as an effective website. The user behavior depends on the usage and accessing the websites in a given time. We propose to apply a statistical approach called Factor Analysis to identify the most significant features the user considered for classification. We plan to conduct a survey on various types of users by selecting the respondents using purposive random sampling. In this Survey, We conduct a pilot survey to understand the features the users generally look at.**

***Index Terms*- Purposive Random Sampling, Factor Analysis. Principal Component Analysis (PCA), Sampling methods, Website features.**

I. INTRODUCTION

The world is becoming a global village due to the connectivity provided by the Internet. In this global village environment, people are connecting over the Internet to connect, share and exchange the information or services across the world. Internet will provide the interface to connect each and everyone via a web site. Hence web site is playing a vital role to reach and attain the users. Such users may be general purpose users or business oriented.

We are trying to identify the features that the users will look when they are using the website and the features that are most significant to them in classifying the web site as an effective website using Factor Analysis [1, 7].

Understanding the user requirements is more critical in successful development of an application. Reaching the customers and attain the customers is crucial in the business community when the Internet is becoming the way of communication mode. In this way of communication websites plays a vital role to attain the customers and retain them for longer times and increase the customer base. In this work, we are training to understand the user behavior and hence to understand what features are more important to them when they are using or accessing the websites and what feature make them to classify a website an effective website[7].

We are following statistical approach, in which we are conducting a survey on various types of users by selecting the respondents using purposive random sampling. In this Survey, We are conducting a pilot survey first to understand what features users generally will look at. Based on the users' feedback, we are trying to identify the most significant features they considered for classification using Factor Analysis. Factor analysis will help us to identify the most significant factors for classification.

II. BACKGROUND

As part of this work, we are trying to identify what are the features the users will look when they are using the website and what features are most significant to them in classifying the web site as an effective website using Factor Analysis [1,7].

A. Web Site Features

Consistency in Design: A website should be designed in such a way that all pages and forms should be designed uniformly in appearance and functionality which improves the user experience. When navigating

to other pages, users should feel comfort with reference to appearance of the pages and page elements.

User-friendly: The website should be designed in such a way that a normal user will be able to navigate and find the information likes to view. Navigation should be simple and properly designed the linkages between the pages.

Perfect Content: Content is the prime factor upon which the users are engaged on to a web site for a longer time. Information or the content published on the web site should be complete, correct, concise, accurate and updated. It should be free from grammatical errors. Background colors and highlighted portions should be paid more attention. Content should be properly formatted. Too much complicated formatting and highlighting should be avoided.

Fast Loading: Try to avoid the inclusion of heavy elements like Graphics, animations, videos etc. even though they add more creativity to site but may cause the delay in loading when requested by the users. Create the site with the simple design since users may not have patience to wait for longer time.

Search Engine Friendly: Web site should be designed in such a way that the elements in web site should help in good raking of the website on different search engines. It helps to reach the more users on the web through the search engines.

Compatible on Different Browser: Web site should be tested on different versions of the web browsers and platforms in order to verify whether the web site is working properly or not since some of elements on web page may not work properly as intended.

Functionality: Poorly constructed website may frustrate the users. Avoid the page errors. Navigation should be properly designed. Links should properly make among the web pages. Need to check the functionality of all the pages and elements to improve the quality of the site.

B. Sampling Methods

Sampling methods are categorized into either probability sampling or non-probability sampling [4, 8]. Every sample point of the population has non-zero probability of being selected in probability sampling where as in non-probability sampling, sample point has the random probability of being selected. Probability sampling methods include random sampling, stratified sampling systematic sampling. Non- probability sampling includes quota sampling, convenience sampling, snowball sampling and purposive or judgment sampling.

Random sampling: Each observation has the known and equal probability of being selected. This sampling method helps to avoid the biased nature of the data.

Systematic sampling: From the population every n^{th} element is selected as the sample point and constitutes the sample. Advantage in this sampling is simplicity.

Stratified sampling : Stratum is the subset of the population which shares the common features. Based on the feature stratums are identified. Random sampling is used to select the subjects from each stratum. This sampling method used frequently when stratums have low incidence relative to other.

Convenience sampling : is used in exploratory research In this method sample is selected based on convenience. This method is used in explorative research studies in getting an inexpensive approximation of the truth.

Quota sampling :it is equivalent to stratified sample where the stratum is filled by random sampling. Stratums and their proportions are identified as they represent the total population.

Snowball sampling : It is used when the sample under study has the rare characteristic. It may be extremely difficult to locate respondents in these situations. It relies on referrals from initial subjects to generate additional subjects.

Judgment sampling / Purposive Sampling: sample is selected based on judgment. This sample is considered to be true representation of the entire population.

III. PURPOSIVE RANDOM SAMPLING

The process of identifying a population of interest and developing a systematic way of selecting cases that is not based on advanced knowledge of how the outcomes would appear. It unable to identify and differentiate the need of the various related groups. It generates the sample where the included groups are selected based on specific characteristics considered to be important. With such a sample, group differences can be compared and contrasted and a range of experiences can be summarized.

We conducted a pilot survey to understand the significance factures in users' perspective in classifying the websites [5]. Based on the features mentioned by the respondents we conducted the original survey using purposive random sampling with sample size 57. The following table shows the template of the metadata that is being collected for the analysis.

TABLE I
VARIABLE LIST USED IN ANALYSIS

Variable Name	Data Type	Description
Rand_ID	Numeric	User ID
Gender	String	Sex of the Respondent
Age	Numeric	Age of the Respondent
email	String	Respondent Contact Email Id
Time_Spent	Numeric	No. of Minutes Spent on Internet A Day
Most_Visit_Web	String	Most Frequently Used Web Site
Var_Feature1_Rank	Numeric	Rank for Influence Factor (Consistency in Design)
Var_Feature2_Rank	Numeric	Rank for Influence Factor (User-friendly)
Var_Feature3_Rank	Numeric	Rank for Influence Factor (Perfect Content)
Variable Name	Data Type	Description
Var_Feature4_Rank	Numeric	Rank for Influence Factor (Fast Loading)
Var_Feature5_Rank	Numeric	Rank for Influence Factor (Search Engine Friendly)
Var_Feature6_Rank	Numeric	Rank for Influence Factor (Compatible on Different Browser)
Var_Feature7_Rank	Numeric	Rank for Influence Factor (Functionality)

Data is collected from a sample (internet users) using purposive random sampling based on their opinion on the features which influence them in classifying the web sites as effective web sites [5]. Data given in the table is percentages. N represents Total Number of respondents i.e 57. Out of 57 respondents, there are 31 Female and 26 male respondents.

TABLE II
USER DATA

Features/Factors	Gender (N=57)		TotaL (N=57)
	Female (N=31)	Male (N=26)	
Consistency in Design	3	8	5
User-friendly	13	27	19
Perfect Content	26	8	18
Fast Loading	29	19	25
Search Engine Friendly	10	15	12
Compatible on Different Browser	13	12	12
Functionality	6	12	9

The following graph shows the influence of the feature with reference to gender comparison. The numbers shown in the graph are in percentages.

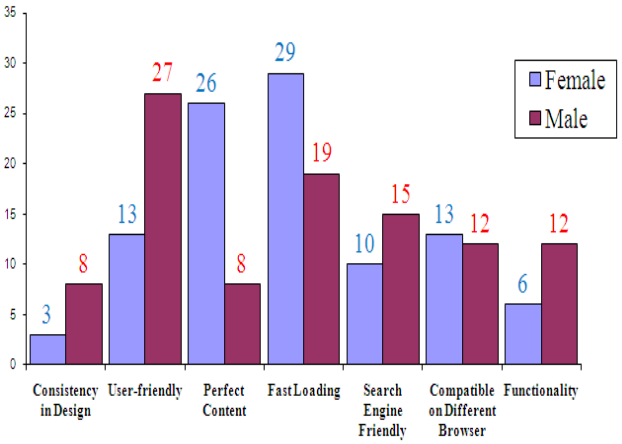

Figure 1: Feature Vs Gender Influence

The following graph shows how features are influencing irrespective of the gender. We observed that fast loading, perfect content and user friendly features are influencing the classification of web sites as effective (The numbers shown in the graph are in percentages.)

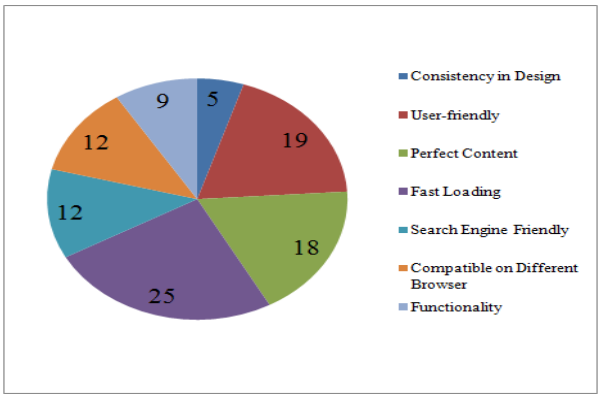

Figure 2. Feature Selection

The following test data shows that there is a significance difference in usage of internet between the Male and Female users.

Here we have used mean and standard deviation in order to calculate the mean difference between the male and female users to test whether there is any significance difference between the usages of the internet. Standard error mean is estimated by the sample estimate of population standard deviation.

TABLE III
DESCRIPTIVE STATISTICS ON INTERNET USAGE.

Group Statistics					
	Gender	N	Mean	Std. Deviation (S)	Std. Error Mean
No. of Minutes Spent on Internet A Day	Female (Y_1)	31	55.71	34.597	6.214
	Male (Y_2)	26	75.19	44.102	8.649

t-test is used to test whether there is a significance difference between two sample means. Here is the t-test to calculate the equality of means i.e between the internet usage of female vs male respondent . We used the t-statistic formula as follows.

$$T = \frac{\bar{Y}_1 - \bar{Y}_2}{\sqrt{s_1^2/N_1 + s_2^2/N_2}}$$

Where $y_1$and y_2 represents response of female and male respondent's respectively. S_1 and S_2 represent the standard deviation of the female and male respondent's response respectively. N1, N2 represents total number of female and male respondents respectively.

TABLE IV
TEST OF SIGNIFICANCE FOR USAGE OF INTERNET.

Levene's Test for Equality of Variances			
		F	Sig
No. of Minutes Spent on Internet A Day	Equal variances assumed	3.738	0.058

TABLE V
t-TEST FOR SIGNIFICANCE OF EQUALITY OF MEANS

t-test for Equality of Means						
					95% Confidence Interval of the Difference	
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
-1.869	55	.067	-19.483	10.426	-40.376	1.411

Here we are not considering the F statistic, significance of Levine's Test. t-represents for t-statistics for calculating the mean difference. At 55 df (degrees of freedom) with 95% confidence level we came to know that there is a significance difference in the usage of the internet between the Male & Female respondents. We found that the significance value (0.067) is greater than critical value (0.05) which rejects the null hypothesis that means there is a significant difference between the mean usages of the internet.

IV. FACTOR ANALYSIS

Factor analysis is a statistical procedure used to identify a small number of factors that can be used to represent relationships among sets of interrelated variables. Factor analysis is used in many areas, and is of particular value in psychology, sociology, market research and education[3]. For example, COMPUTER USE BY TEACHERS is a broad construct that can have a number of FACTORS [1] (use for testing, use for research, use for presentation development, etc.).

Multiple linear regression model:

$$x_1 = \lambda_{11}f_1 + \cdots + \lambda_{1k}f_k + u_1$$
$$x_2 = \lambda_{21}f_1 + \cdots + \lambda_{2k}f_k + u_2$$
$$\vdots$$
$$x_p = \lambda_{p1}f_1 + \cdots + \lambda_{pk}f_k + u_p$$

where
$x = (x_1 \ldots x_p)'$ are the observed variables (random)
$f = (f_1 \ldots f_2)'$ are the common factors (random)
$u = (u_1 \ldots u_2)'$ are called specific factors (random)
λ_{ij} are called factor loadings (constants)

BASIC ASSUMPTION: underlying dimensions – or factors – can be used to explain complex events or trends.

Objective: It is to identify otherwise not-directly-observable factors on the basis of a set of observable variables.

FOUR STEPS:

1. Compute a correlation matrix for all variables.
2. Determine the number of factors necessary to represent the data and the method of
Calculating them (factor extraction)
3. Transform the factors to make them interpretable (rotation)
4. Compute scores for each factor.

Factor analysis usually proceeds in two stages [1]. In the first, one set of loadings is calculated which yields theoretical variances and covariances that fit the observed ones as closely as possible according to a certain criterion. These loadings, however, may not agree with the prior expectations, or may not lend themselves to a reasonable interpretation. Thus, in the second stage, the first loadings are "rotated" in an effort to arrive at another set of loadings that fit equally well the observed variances and covariances, but are more consistent with prior expectations or more easily interpreted.

A method widely used for determining a first set of loadings is the principal component method [2]. This method seeks values of the loadings that bring the estimate of the total communality as close as possible to the total of the observed variances.

V. RESULTS

The following tables show the Eigenvalues and the factor loading which are calculated in factor analysis based on Principal Component Analysis (PCA) [6].

TABLE VI
TOTAL VARIANCE EXPLAINED

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings	
	Total	% of Variance	Cumulative %	Total	% of Variance
1	1.71	24.427	24.427	1.71	24.427
2	1.425	20.352	44.779	1.43	20.352
3	1.201	17.159	61.938	1.2	17.159
4	1.001	14.294	76.231	1	14.294
5	0.925	13.219	89.45		
6	0.738	10.55	100		
7	-1.00 E-13	-1.02 E-13	100		

TABLE VII
TOTAL VARIANCE EXPLAINED

Component	Extraction Sums of Squared Loadings	Rotation Sums of Squared Loadings		
	Cumulative %	Total	% of Variance	Cumulative %
1	24.427	1.46	20.861	20.861
2	44.779	1.316	18.805	39.667
3	61.938	1.286	18.377	58.044
4	76.231	1.273	18.188	76.231

The following tables show the significance factor loading with respect to each component. We need to consider the maximum factor loading for the corresponding component which in turn influences the classification.

TABLE VIII
FACTOR LOADING OF THE COMPONENTS.

Component Matrix				
	Component			
Factors	1	2	3	4
Compatible on Different Browser	-0.73	-0.31	0.339	
Fast Loading	0.58	0.253	-0.53	-0.3
User-friendly	-0.26	0.662	0.305	-0.19
Consistency in Design	0.332	0.558	0.298	0.369
Search Engine Friendly	-0.55		-0.72	
Perfect Content	0.42	-0.47		0.653
Functionality	0.426	-0.54	0.312	-0.56

From the above table we can infer that the features user-friendly, perfect content, fast loading and compatibility of browsers are more significant features in classifying the websites as effective web sites.

VI. CONCLUSION

We conducted a pilot survey to understand the features which are important to the web users in usage of the web. Based on the data from the pilot survey, we conducted the final survey to collect the data using the purposive random sampling. We found the list of most significant factors which are influencing in classifying the web sites. We applied factor analysis on these factors in order to understand the most significant factors from among the list of significant factors. So we conclude that the features : user-friendly, perfect content, fast loading and compatibility of browsers are more significant features in classifying the websites as effective web sites.

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Moving Towards Agile Testing Strategies

Dr. Kiran Kumar Jogu[1] and Dr. K. Narendar Reddy[2]
[1]IBM India Software Lab, Hyderabad, India
kirankumarj9@gmail.com
[2]CVR College of Engineering, Dept. of IT, Hyderabad, India
knreddy@cvr.ac.in

Abstract **- Testing is a vital activity for delivering a high quality software product to the customers. Often testing accounts for more project effort and time than any other software development activities. Traditional software development process models are being used for long time in software development. Recently, the software development in the industry is moving towards agile due to the advantages provided by the agile development process. One of the main advantages of agile software development process is delivering the high quality software to the customers in shorter intervals. Another important advantage is, the agile process models embrace the changes in requirements at any stage of software development. Due to these advantages, software industry is showing interest in software development using agile process models. One of the agile process models which is being used in the software industry is, the "scrum". Since testing plays a major role in the success of the product, it is given a lot of importance in software development. Testing strategies for conventional process models are well established, but these strategies are not directly applicable to agile testing without modifications and changes. One of the important current research areas is the agile software testing strategies. The main objective for any agile testing strategy is to reduce the testing time and at the same time ensuring the software quality. In this paper, a strategy for agile testing in the scrum software development environment is proposed and presented. The sprint activities which form the context for the proposed testing strategy are also proposed. The tools which are helpful for automation which is part of the strategy are presented. The advantages of the proposed strategy are highlighted. Case study which used the proposed strategy is presented, it indicated that the number of bugs reported by customer reduced significantly in scrum agile development using the proposed testing strategy**.

Index Terms **– Agile software development, traditional development, scrum, software industry, testing strategy, automation.**

I. INTRODUCTION

Traditional software development process models are being used for long time in software development. Present business demands the software products to be delivered in shorter intervals and software development environment having capability to embrace change at any stage of development. Traditional process models have difficulty in responding to change which often contributes success or failure of a software product [1]. Software requirements are dynamic which are driven by industry market forces. Agile approach to software development is suitable to such situations [2], [3]. Hence, more software companies are making a transition to agile software process models from traditional (plan-driven) software development process models (like Rational Unified Process (RUP), Waterfall, or V-model). Some of the key factors for success in an agile testing approach are: adopting an agile mindset, automating regression tests, collaborating and obtaining feedback from customer [4]. Some issues may arise when transition is made from traditional development to agile development. Common issues for agile models after migration from traditional models were identified in [5]. They are related to testing, test coverage, coordination overhead, and software release. In this paper we focused on testing related issues. Agile methods employ short iterative cycles, with prioritizing the requirements which actively involve users. Agile process models are iterative, incremental, self organizing and emergent [6]. One of the agile process models which is being used in the software industry is "scrum". Scrum agile process model is defined in [7], [8]. In agile software development, testing is a vital activity for delivering a high quality software product to the customers. Often testing accounts for more project effort and time than any other software development activities. Since testing plays a major role in the success of the product, it is given a lot of importance in software development. Testing strategies for conventional process models are well established, but these strategies are not directly applicable to agile testing without modifications and changes. One of the important current research areas is the agile software testing strategies. The main objective for any agile testing strategy is to reduce the testing time and at the same time ensuring the software quality. In this paper, a strategy for agile testing in the scrum software development environment is proposed and presented. The tools which are helpful for automation which is part of the strategy are presented. The advantages of the proposed strategy are discussed and highlighted.

The remainder of this article is structured as follows. Related work is briefly described in Section II. In Section III, the scrum agile process model is described. In Section

IV, the scrum agile testing strategy is given. Subsequently, conclusions are presented and future directions are proposed.

II. Related Work

Software industry is transitioning to agile methodologies from traditional approaches. One of the popular agile process models which is being used in software companies is "scrum". Scrum main characteristic is, continuous deployment of working product increment after each iteration (sprint). As per the survey on agile methods given in [9], 54% of the software companies who are using agile methods are using Scrum. In the survey conducted by [10] on agile projects in different countries found that six critical factors contribute to agile project success. These factors are: agile software engineering techniques, customer involvement, project management process, team environment, team capability, and delivery strategy. One of the attributes related to the critical factor "agile software engineering techniques" is testing strategies. To address the above mentioned critical factor and its associated attribute, currently research is being carried out on agile testing strategies [11], [12]. In this direction, authors of this paper proposed a testing strategy for scrum agile software development environment.

III. Agile Software Development Using Scrum

To provide consumers with continuous deployment of new features rapidly with the capability of embracing change at any stage of development, scrum is ideally suited for this purpose [7], [8], [13]. The scrum agile model is an iterative, incremental process of planning, development, testing, and deployment. In scrum at the end of each iteration (sprint) a working increment is released and deployed. In XP (eXtreme Programming) at the end of an iteration, the working product may not be available. Hence, scrum leads to continuous deployment when compared to XP. Due to scrum's main characteristic of continuous deployment software industry is transitioning to scrum agile software development. The scrum model is depicted in the following diagram (Fig. 1) adopted from [7]. The model shown in Fig.1 is depicting the artifacts of their underlying activities. The main framework activities of the agile process model are: Creation of product backlog, Planning, (Creation of sprint backlog and expanding the sprint backlog), and Sprint (consists of development activities). The scrum activities are performed by the scrum team which consists of product owner, development team, and scrum master.

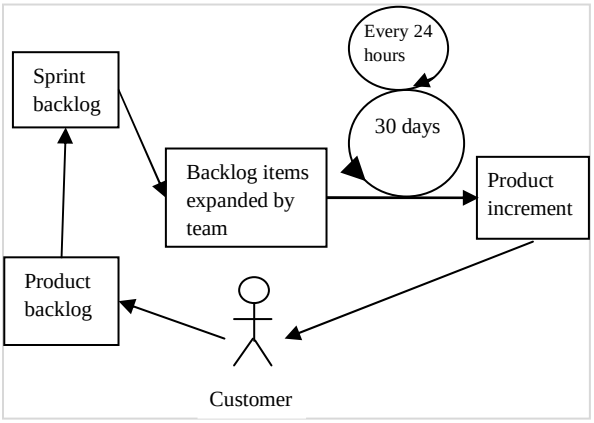

Figure 1. Scrum agile process model

Product owner is responsible for creating and maintaining the requirements in product backlog. He/she creates stories for the requirements in the product backlog. Development team is responsible for developing the product by implementing the features in sprint backlog. The development team is cross functional. Cross functional means, team is responsible for design, development, testing, and deployment. The responsibility of the scrum master is to ensure that the scrum process is followed properly by the team. The scrum activities lead to the following artifacts: product backlog, sprint backlog & task list to achieve sprint backlog, and working software product increment respectively. These artifacts are briefly discussed below.

Product backlog: The required product features or requirements by customer are identified added to product backlog. Features are prioritized as desired by the customer. The main source of agility in scrum model is the prioritized requirements list, which is flexible product backlog [8], [14]. Changes are inevitable. As the needs of the customers change the product backlog is continuously reprioritized. Hence, the software development is flexible. New features are selected from the backlog continuously & integrated and released as a working product increment at the end of the sprint. This means that one can deliver with increasing functionality more frequently, which provides flexibility and the opportunity for adaptive planning [8].

Sprint backlog: During first part of planning product owner and development team together decides which features (user stories) will be part of the next sprint. The high priority features from product backlog are given preference. These features in this backlog are addressed during the sprint. Typical time-box for a sprint is 30 days. The changes (addition of new features) to the features in the ongoing sprint will not be accepted. But, changes (new features) can be added to the product backlog while the sprint is in progress.

Expanded sprint backlog: During second part of planning development team analyses the user stories (features) in the sprint backlog and divides each user

story in its tasks. These tasks are handled by different development team members during sprint.

Working software product increment: During sprint development activities are carried out iteratively. Scrum meetings are held daily, typically of 15 minutes duration. Team discusses about the progress and what to be done in next 24 hours. At the end of sprint (30 days), working software product increment is delivered (deployed). Delivered product is evaluated by the customer to ensure that the features in the sprint backlog are implemented.

Testing is important, because it is carried out to ensure the software product quality. And moreover, success or failure of the product depends on testing. Hence, the authors of this paper focused on testing. The proposed testing strategy for scrum model is given in the following section.

IV. Proposed Agile Testing Strategy for Scrum

A. Proposed Strategy

Scrum is a framework for developing software products [15]. Various processes and techniques can be proposed and employed within the framework. Scrum framework specifies the following activities: planning, (Creation of sprint backlog and expanding the sprint backlog), Sprint (consists of activities which can deliver a working software product increment implementing sprint backlog features in a given time-box(typically 30 days)). To propose the strategy for testing, first the sprint activities need to be proposed. One of the possible set of sprint activities can be eXtreme programming (XP) type development activities. The XP development activities could be: design, test driven development & refactoring, integration & regression testing, and validation testing before release. XP activities may not produce a working product increment after completing iteration(s) (in a given time-box). This may be because of the fact that this model is not based on predefined time-box based product release, hence the authors of this paper proposed sprint activities which can deliver the working software product in predefined time-box. The proposed sprint activities are shown in Fig. 2. The activities are: design, development (coding), and testing. They are performed iteratively to produce a working product increment in a given time-box (sprint). The proposed testing strategy is based on these proposed sprint activities. The proposed testing strategy for scrum process model is given in Fig. 3. The sprint activities are carried out iteratively to implement the features (user stories) in sprint backlog. The team for sprint contains scrum master and development team. Development team is cross-functional. They will be able to perform design, coding, and testing (unit testing and integration testing). Some of the development team members (testers) can be specifically meant for regression and functional testing. The responsibilities of the testers are: to plan and update test cases for sprint stories, automate test scripts if possible, execute the tests and report defects, and run regression tests and functional tests at the end of the sprint. Testers are also responsible for testing non-functional tests such as load testing and performance testing.

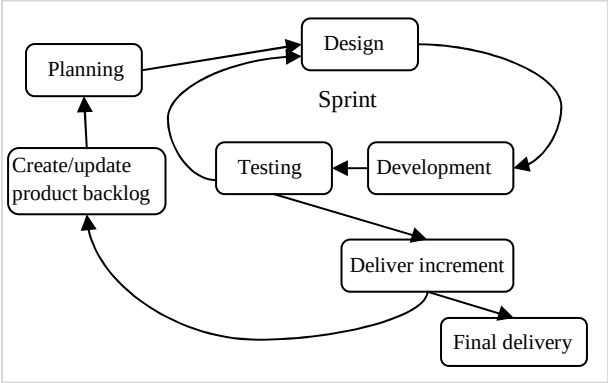

Figure 2. Proposed sprint activities for scrum

The testers in scrum agile software development participate in scrum ceremonies which includes sprint review, planning, daily, and retrospective meetings. The proposed testing strategy for scrum model is depicted in Fig. 3. Testing strategy contains: unit testing, continuous integration, and regression testing which are carried out during the sprint. Whereas, functional & non-functional testing and user acceptance testing is carried out at the end of the sprint. The testing tasks during a sprint are incremental and iterative. Unit testing is done by the developer for finding the logical errors in a module. The bugs found in unit testing are debugged before integrating with other modules. Continuous integration is performed daily. Continuous integration enables to complete the increment in the scheduled sprint time. Regression testing is done after every integration test to ensure that newly integrated module has not introduced any new bugs. Functional test cases are created based on sprint backlog stories and executed at the end of the sprint.

Unit testing, integration testing, regression testing, and functional testing are automated. These testing tasks are conducted repeatedly and frequently, hence, automation will help to reduce the testing time. Since these tests are conducted iteratively on small number of features they increase the likely hood of finding bugs early in the project in intermediate releases (sprints) and in turn reduces the likely hood of magnifying & propagating the bugs to the final project. Because of this fact the quality of software product is better in agile software development. During deployment the product increment is tested by the user which is known as user acceptance testing (UAT) to ensure that all the user stories specified in the sprint backlog are actually implemented. This testing is done manually. In addition to testing functional

requirements, it is essential to test non-functional requirements. Some of the typical non-functional requirements are: load testing, security testing, and performance testing. Tools are used for testing non-functional requirements. These non-functional tests are executed at the end of the sprint. Some of the tools which aid in automation for different agile testing tasks are given in Table I. All the members of the development team should be able to use testing automation tools.

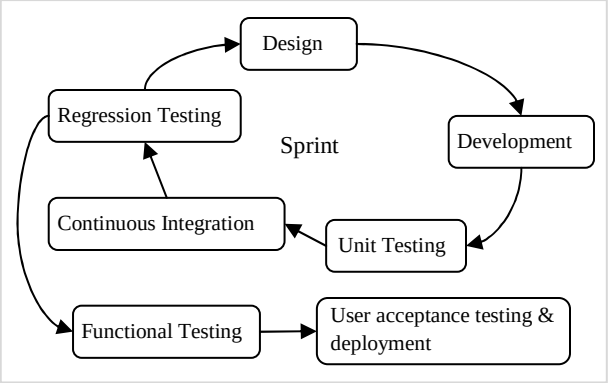

Figure 3. Proposed testing strategy for scrum

B. Automation

Software testing automation is key for the agile testing. Irrespective of agile methodology, testing automation becomes the core of agile testing [12]. The purpose of software testing automation is to automate software testing activities. Manual testing is time consuming. Manual testing is not suitable for scrum agile testing where continuous deployment is required in shorter intervals. Moreover, since testing tasks are conducted iteratively during a sprint, through testing automation testing time can be reduced considerably. Tools are available to automate all the testing activities. With automation testing efficiency can be improved and testing time can be reduced which enables to deploy the working product increments in shorter intervals. Some of the typical tools which are helpful for testing activities are given in Table I.

C. Advantages of Proposed Strategy

The proposed testing strategy in the context of proposed sprint activities offers following advantages.

- Strategy is simple.
- Refactoring overhead is not there.
- Simple design, which provides only implementation guidance.
- Development (coding) is based on design, hence less chances of errors.
- Automation is used in testing tasks, hence reduces testing time.
- Since review on testing is done daily, any mistakes can be rectified immediately.
- User feedback after every delivery helps to improve the testing activities.
- Reduces development time, improves productivity and product quality.

TABLE I.
TYPICAL AUTOMATION TOOLS FOR SCRUM AGILE SOFTWARE TESTING

Testing activity	Tools		
Unit Testing	JUnit	xUnit	MockRunner
Continuous Integration	Hudson	Fit, FitNesse	Green Pepper
Regression Testing	STAF	IBM Rational Functional Tester	VersionOne, FitNesse
Functional Testing	Selenium, Avignon	WinRunner, Cucumber	FitClipse
Non-Functional Testing	JMeter	Benerator	CLIF
Testing management	Testlink	IBM Rational Quality software	HP Quality Center

D. Case Study

Software development using scrum delivered a better quality product. This is due to the fact that only few features are added to every new increment and testing is done on few features only, which increased the chances of finding the bugs. In addition, after every iteration release, customer gave the feedback on bugs on those features, hence they could not be propagated to next iteration, otherwise, they would have got amplified and increased the number of bugs in the next iteration.

The proposed approach is applied on the real-time ETL tools which are being used by the customers. The Fig. 4 shows the ETL process.

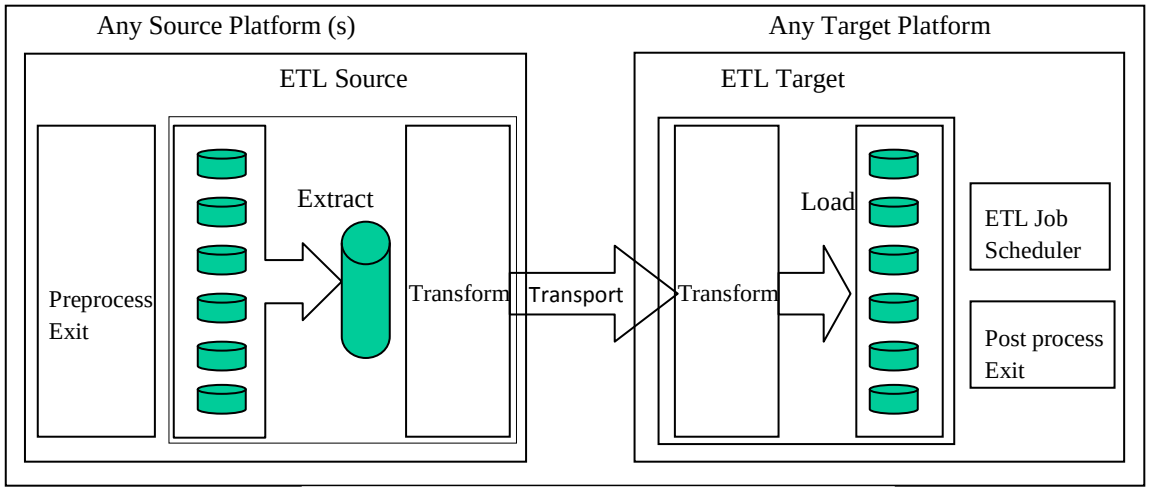

Figure 4. The ETL process

The ETL stands for "extract, transform and load", is the set of functions combined into one tool or solution that enables companies to "extract" data from numerous databases, applications and systems, "transform" it to appropriate format, and "load" it into another databases, a data mart or a data warehouse for analysis, or send it along to another operational system to support a business process.

The Fig.5 describes the number of bugs reported from the field in one year after the full product is released to the customer. Two ETL tools, DB2 ETL tool and Sybase ETL tool are developed using the scrum agile process using the proposed testing strategy. These two tools developed in the agile are compared with a similar ETL tool Teradata ETL tool which was developed in traditional development model and released to the customer. This study indicates that the number of defects received from the field for the products developed in the scrum agile process are reduced by around 50%, as compared to the products developed in the traditional model.

This reduction in the number of bugs reported from the field for the products developed in the agile process is due to two factors: first, there is a continuous feedback from the customer after every iteration in the agile development process. Second, in every iteration the testing of the features in the current iteration and regression testing of the features already delivered in the previous iterations will be done, which makes sure that the new features do not inject any regression issues. This indicates that the proposed scrum agile testing strategy reduces the number of bugs reported from field. Hence, the proposed agile testing strategy improves the quality of the products developed in the agile process.

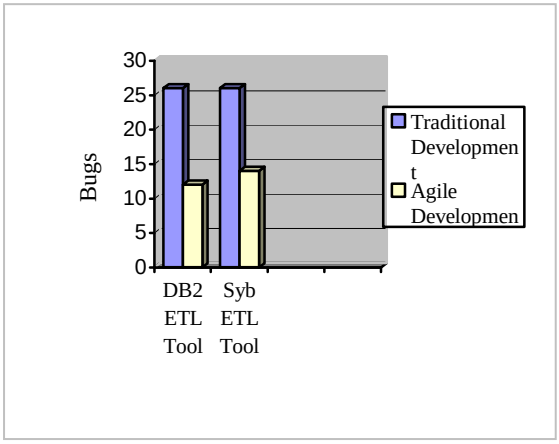

Figure 5. Traditional Vs Agile development

CONCLUSIONS

The software development in the industry is moving towards agile due to the advantages provided by the agile development process. Two main advantages of agile software development process are: delivering the high quality software to the customers in shorter intervals and having the capability of embracing the changes in requirements at any stage of software development. In majority of the situations scrum model is preferred because it delivers working software product increment in a predefined time-box (typically 30 days). Delivering a working product increment in shorter intervals (30 days) gives business advantage to the customers. Testing in agile process model plays a vital role. Testing strategies

for traditional process models are well established, but these strategies are not directly applicable to agile testing without modifications and changes. A strategy for agile testing in the scrum software development environment is proposed and presented. The context (sprint activities) in which the proposed testing strategy to be applied is also proposed. Typical tools which are helpful for automation are given. The advantages of the proposed strategy are highlighted. Case study which used the proposed strategy is presented, it indicated that the number of bugs reported by customer reduced by 50% in scrum agile development when compared to traditional development. This indicates the improvement in product quality in scrum agile development using the proposed testing strategy.

FUTURE DIRECTIONS

More number of case studies from different domains and applications need to be studied to get further insight into the research areas of agile software testing strategies.

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Life Style Diseases

Dr. M. N Ramakrishna, M.D., A.F.I.H., PG.Dip. (Diab)
Medical officer, CVR College of Engineering
Email: drrkmn@rediffmail.com

***Abstract*: Changes in social, cultural and economic status of people are resulting in people leaving the 'traditional life style' and adopting "modern westernized life style", thereby throwing them into new environment. As a result, they are suffering from some diseases called 'life style diseases', which can easily be prevented or postponed by adopting good life style. Examples of life style diseases are heart attacks (CAD), diabetes, obesity, certain cancers, liver disease, psychological problems etc. The article elaborates on the causes, the diseases and preventive steps.**

***Index Terms:* Life Style Diseases, Hypertension, Diabetes, Atherosclerosis, Coronary artery disease, Asthma, Alcoholism, Abortion, Osteo-arthritis**

I INTRODUCTION

Life style diseases are a result of inappropriate relationship of people with their environments, which can potentially be prevented.

Globally 14.2 million people in the age groups of 30-69 years are subjected to premature death every year from these diseases.

The major causes of life style diseases include:

1. Drug abuse
2. Tobacco usage – smoking, chewing etc.
3. Alcohol abuse
4. Sedentary life & lack of exercise
5. Dietary habits – like overeating, junk foods (which contain high fats) like pizza/burger, refined flours etc..
6. Stress
7. Sleeplessness
8. Adding pollution to the environment through excessive unnecessary usage of automobiles etc.

Some of the major diseases that can be included in these life style diseases are:

- Alzheimer's disease (loss of memory)
- Atherosclerosis (thickening of blood vessel walls)
- Hypertension (HTN)/ high blood pressure
- Type 2 diabetes (sugar disease)
- Coronary artery disease (heart attack)
- Cerebro-vascular accident/stroke(paralysis)
- Obesity
- Asthma
- Chronic pulmonary obstructive disease(COPD)
- Some cancers
- Chronic liver disease (cirrhosis of liver), chronic kidney disease(kidney failure)
- Depression
- Osteoporosis (weakening of bones due to loss of calcium)
- Road accidents, violence & crime, family disorganization etc.

An estimate made by Harvard school of public health tells that the "Economic burden in India due to non-communicable diseases (which are a part of life style diseases) will be close to $ 6.2 trillion for the period 2012 to 2030, which is equivalent to nearly 9 times the total health expenditure during the previous 19 years ($710 billions)".

The most important diseases -- Hypertension and Diabetes affect a person during productive years and can cause reduced productivity, and early retirement in addition to huge expenditure on health.

Information Technology (IT) sector plays predominant role in Indian "Economy" in terms of contribution to GDP and employment opportunity. Around 60% of young IT people are prone to life style diseases due to hectic work schedules, untimely and unhealthy eating habits, severe stress in the job, lack of exercise & sedentary life style. Food items like pizza, noodles, burgers, fried foods, aerated drinks and alcohol (used to overcome stress) would contribute further.

As per some surveys conducted in corporate sector, it is revealed that

- 80% of corporate employees sleep less than 6 hours.
- 36% are obese
- 21% have depression
- 12% have high blood pressure at young age.
- 8% have diabetes at an early age.

II CAUSES OF LIFE STYLE DISEASES

A).Drug Abuse:

People take drugs because they want a change in their lives.

Some reasons for young people getting addicted are:

- To fit in
- To escape/relax
- To relieve boredom
- To seem grownup

- To rebel
- To experiment

They think drugs are a solution, but eventually the drugs become the problem. The consequences of drugs are always worse than the problems.

The drugs cause a false sense of euphoria, elation, hallucinations and lack of concentration, blurred memory and finally depression, leading to taking more quantity of same drug or shifting to different high potency drugs. They never come out of the vicious circle and ruin their career and lives.

Some of the drugs used for are:

- Marijuana(ganja)
- Alcohol
- Ecstacy
- LSD
- Amphetamine
- Heroin
- Morphine/pethidine
- Opium
- Some of the pain killers, tranquilizers, anti-depressants, mood elevators etc., prescribed by doctors for various ailments, are also liable for addiction. Examples of such drugs are diazepam and alprazolam. They are sometimes used in high doses for committing suicide.

Drug abuse can cause dangerous diseases like HIV/AIDS, Hepatitis B, Hepatitis C infections (especially in intra-venous drug addicts), severe Psychosis, Depression, Suicidal tendencies, rejection in the society, loss of productive life, poor performance in studies and in work, family ruptures and also some chronic diseases like high BP, Heart ailments etc.

B).Tobacco Usage:

There is a saying that "some people commit suicide by 'drowning' but many by smoking**".**

Usage of Tobacco by any means i.e. smoking cigarettes, beedi, chutta (cigar), chewing as powder, using in pans (jarada), snuff etc., is dangerous to health. The hazards of tobacco are innumerable. Some of them are:

a) Respiratory ailments like :

- Br. Asthma
- Chronic obstructive pulmonary disease (COPD)
- Chronic Bronchitis
- Reduced lung capacity (Vital capacity)
- Cancer Cheek
- Cancer Pharynx
- Cancer Larynx
- Cancer Hard Palate (Chutta Cancer)
- Cancer Lung etc…

b) Gastro Intestinal Ailments include:

- Acute Gastritis
- Gastric and Duodenal ulcers
- Cancer oesophagus
- Cancer Stomach
- Cancer Pancreas

c) Cardio Vascular Ailments include:

- Heart Attack (CAD)
- Paralysis
- Periphenal-neurepathy
- Burger's Disease
- Heart Failure etc

d) Genito -Urinary Ailments include

- Cancer urinary bladder
- Impotence & loss of libido
- Cancer Cervix in females.

e) Other body system ailments are

- Reduced vision/blindness
- Abortions/Low birth weight babies
- Early aging
- Wrinkled skin
- Decreased Stamina in sports.
- Decreased Productivity and loss of income due to health problems related to tobacco etc.

C). Alcohol Abuse:

Alcohol abuse is worldwide social and medical problem. Due to social, cultural and economic changes, people are getting addicted to alcohol at an early age. Some people view it as a symbol of prestige and social status.

Alcohol abuse can lead to the following ailments:

1. Acute/chronic gastritis
2. Gastric and duodenal ulcers
3. Rise in blood pressure which may precipitate heart attacks / cerebro-vascular accident (paralysis)
4. Chronic liver disease (Cirrhosis of liver) and liver cancer.
5. Acute pancreatitis
6. Cardio-myopathy
7. Peripheral neuropathy
8. Toxic psychosis
9. Cancer mouth, Pharynx, Larynx, Oesophagus etc
10. Automobile accidents (People using heavy machinery may meet accident under the influence of alcohol)
11. Injuries and death due to violence and crime
12. Suicidal tendency
13. Loss of productivity to organization and personal loss of income

D).Sedentary life style and lack of exercise

Now a days in this competitive world, from the child hood, children are forced to concentrate more & more on studies and they are neither encouraged in schools nor at home on games, sports, or some sort of physical exercise. Practically no physical exercise during the growing age and even after getting employment, because of hectic work schedule or odd timing of their jobs, and various easy methods of automobile transportation etc. lead to severe sedentary life, which in turn makes them overweight/obese.

Sedentary life style can lead to certain diseases like type II diabetes, high BP, Heart ailments, High fats in blood (hyper- cholesteremia),obesity etc.

Exercise improves blood circulation and regulates body weight and high fat in blood, prevents/postpones/controls high blood pressure, heart ailments, type II diabetes and increases good cholesterol in blood (high density lipid) which protects the heart, keeps the body in fit condition, and keeps away stress. As a consequence of this, concentration on studies / work is improved.

E). Dietary Habits:

With or without knowledge change in dietary habits like

1 Overeating(eating more than their requirement)
2 Under eating
3 Eating high calorie junk foods like pizza/burger etc
4 High intake of non-vegetarian food which contains high saturated fat (Meat, Chicken, Beef, Pork etc).

can cause:

- High blood pressure (Hypertension)
- Obesity
- Type II diabetes
- Protein calorie malnutrition
- Hyper cholesteremia (High fat in blood)
- Heart ailments
- Colon cancer (due to lack of dietary fiber)
- Stomach cancer(due to regular diet with smoked fish)
- Breast cancer (due to high fat diet)

F). Obesity:

27% of urban population and 11% of rural population are obese. As per national family health survey (2005-06), 55 million people in India are obese. Obesity can lead to

- High blood pressure
- Type II diabetes
- Coronary heart disease (Heart attack)
- High fat in blood (hyper cholestremia)
- Gall bladder disease
- Breast cancer
- Varicose veins
- Abdominal hernia
- Psychological stress
- Lowered fertility
- Reduced life expectancy
- Early signs of osteo-arthritis in spine, hip, knee and ankle joint.

G).Stress:

Tensions due to family problems, financial problems, overwork burden, untimely working hours, sleeplessness etc can predispose stress in a person, and can lead to

- Drug abuse
- Alcoholism
- Smoking/tobacco usage
- Depression
- Precipitate/diabetes, high BP, heart problem etc.
- Ruptures in family relations etc.

What is the solution to get rid of these life style Diseases

Adoption of good life style is the solution. Some tips for better life style are :

1. Say no to drug abuse
2. Say no to alcohol
3. Say no to tobacco usage (smoking, chewing tobacco etc.)
4. Make regular exercise a part of life style
5. Check always your weight
6. Do not eat junk foods and adopt healthy dietary food habits, in the following way.
   - Eat plenty of green leafy vegetables & fruits
   - Avoid fried foods and use vegetable oils in limited quantity (20 ml/head/day)
   - Restrict eating chicken, mutton, beef, pork etc. as much as possible(because they contain bad fat)
   - Fish can be liberally taken since it contains good fat.
   - Add garlic to one food item as it reduces cholesterol and sugar, and prevents high BP and heart attacks
7. Cultivate the habit of regular meditation and yoga (age old practice of Pathanjali yoga), as they reduce stress.
8. Spare time for at least 6 hrs sound sleep.
9. Corporate employers should see that working conditions of their employees should be properly monitored and potential of our youth should not be over exploited for getting more profit.
10. Fast food culture should be effectively controlled

11. Automobile use should be restricted to bare minimum as a requirement for preventing pollution
12. Junior, Degree and Engineering colleges and Corporate IT companies should arrange for counseling sessions and awareness programmes at regular intervals on life style diseases
13. Corporate IT sector should arrange for medical check-ups at regular intervals, since early diagnosis can prevent and reduce life style diseases and their complications.

CONCLUSION

By taking minimum precautions and being conscious of the evils of inappropriate life style, it is possible to prevent many common health problems. It is necessary that the youth in particular be educated on the dangers of getting attracted to irregular and unhealthy habits in their lives.

Multi Unit Selective Inventory Control- A Three Dimensional Approach (MUSIC -3D)

V.R. Girija[1] and Prof. M.S. Bhat[2]
[1] Asst. Professor, Deccan School of Management, Dept. of Hospital Management, Hyderabad, India
Email: girijat4@yahoo.com
[2] Head & Professor, Department of E.I.E, CVR College of Engineering, Ibrahimpatnam, Hyderabad, India
Email: bhatms@rediffmail.com

***Abstract*-Materials contribute to a major cost factor in any enterprise. In health care institutions about 40 percent of the budgetary allocation is on procurement and management of stores. It includes all activities of stores from the stage of forecasting, utilization to final disposal. Stores management to be effective and efficient should aim to optimize the available resources.**

Modern day health care institutions are multifaceted and multidimensional dynamic organizations. In the integrated and complex role of a hospital, the stores have a pivotal function. The stores management in a hospital covers from simple house-keeping materials to vital life-saving drugs.

In the present study MUSIC -3D (Multi Unit Selective Inventory Control- A Three Dimensional Approach) analysis of pharmacy drugs is performed at two multispecialty hospitals in Hyderabad. The study is based on the secondary data collected from the records of the pharmacy stores from both the hospitals, as well as informal interviews with pharmacists, doctors and nurses. MUSIC-3D analysis for pharmacy drugs is conducted on the basis of ABC, VED and SDE analysis.

***Index terms*-ABC analysis, Drugs, Inventory control, MUSIC - 3D analysis, pharmacy, SDE analysis, VED analysis.**

I. INTRODUCTION

The goal of effective inventory management is to satisfy customers' expectations of product availability with the amount of each item that will optimize hospital net costs. Inventory management is a crucial process that any business must undertake with the paramount care. A common mistake made in this process occurs when a company assesses its entire inventory at the same level. In fact, items have different worth to a company, even though they may all be required on day to day basis and shortage of these crucial items could be damaging. ABC analysis helps in classifying these inventory items based on their worth to the hospital. A further improvement on the technique utilized in the study has been Multiunit Selective Inventory Control – A Three Dimensional Approach (MUSIC-3D) criteria of annual usage value, availability and criticality.

Hospital pharmacy should ensure adequate stock of all the required drugs to maintain uninterrupted supply. It is necessary to have an effective and efficient management of pharmacy store by keeping a close supervision on important drugs, prevention of pilferage, and priority setting in purchase and distribution of drugs. Of all inventory control systems available, MUSIC-3D is more advanced way of storing drugs.

II. LITERATURE REVIEW

"Ref. [1]" suggested that MUSIC-3D is a powerful approach in the direction of cost reduction and application of scientific management principles in hospital. .MUSIC-3D is useful to purchase executive, to take decisions on a scientific and practical basis.

"Ref. [2]" discusses integrated picture of MUSIC-3D. As per this model, the items in the stores may be grouped in three-dimensions on the basis of consumption value, availability and criticality. In this method, two levels for each of the three dimensions- high consumption / low consumption value, long lead-time / short lead-time and critical / non-critical categories are advocated.

"Ref. [3]" feels that prioritizing items for management attention has been advocated in operations management for a long time, normally using ABC analysis (inventory control). This focuses attention on the "A" category items to maximize managerial effectiveness. Empirical evidence shows that this is a reasonable rule for allocating scarce resource and management time but presents difficulties when the manager has to take more than one important dimension of a situation into account. "Ref. [3]" presents joint criteria matrix within the ABC framework and gives an industrial application. The joint criteria matrix has practical utility, provided, ranking on some scale of measurement is realistic. The appropriate number of

categories must be defined by the user. Combining criteria will probably require different analytical approaches, e.g. goal programming or heuristic approaches. Utilization of the matrix by managers can provide an explicit method for taking a range of criteria into account in the development of inventory policies. "Ref. [4]" develops an inventory strategy based on ABC analyst.

"Ref. [5]" analyzes that successful operation of a manufacturing firm depends to a large extent on an adequate inventory balance of raw materials and components. Excess inventory means a high amount of tied-up capital and a low inventory can produce interruption in the production flow. Appropriate inventory levels become even more crucial when part of the material is imported. Long lead times add to the uncertainty of demand between replenishments; in addition, import restriction by foreign countries where affiliates of multinational companies are located must also be taken into consideration. "Ref. [5]" describes financial difficulty for one of the Brazilian affiliates of a USA-based company which is highly devalued by inflation because of mandatory bank deposits. An ABC analysis provided a good insight into the situation and enabled a considerable improvement in the company's performance.

"Ref. [6]" conducted ABC and VED (vital, essential, desirable) analysis of the pharmacy store of Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh, India to identify the categories of items needing stringent management control. The annual consumption and expenditure incurred on each item of pharmacy for the year 2007-08 was analyzed and inventory control techniques, i.e. ABC, VED and ABC-VED matrix analysis, were applied. The drug formulary of the pharmacy consisted of 421 items. The total annual drug expenditure (ADE) on items issued in 2007-08 was Rs. 40,012,612. ABC analysis revealed 13.78%, 21.85% and 64.37% items as A, B and C category items, respectively, accounting for 69.97%, 19.95% and 10.08% of ADE of the pharmacy. VED analysis showed 12.11%, 59.38% and 28.51% items as V, E, and D category items, respectively, accounting for 17.14%, 72.38% and 10.48% of ADE of the pharmacy. On ABC-VED matrix analysis, 22.09%, 54.63% and 23.28% items were found to be category I, II and III items, respectively, accounting for 74.21%, 22.23% and 3.56% of ADE of the pharmacy.

"Ref. [7]" employed a matrix based on coupling of cost ABC (always, better and control) analysis and criticality (vital, essential and desirable) analysis for drug inventory containing 129 items of drug store in the Department of Community Medicine of a Medical College in Delhi. The annual drug expenditure incurred on 129 drug items for the year 2010-2011 was found to be Rs. 4, 35,847.85. On ABC analysis, 18.6, 24.0 and 57.4% drugs were found to be A,B and C category items, respectively, amounting to 69.1, 20.8 and 10.1% of annual drug expenditure. About 13.2 (17), 38.8 (50) and 48.0% (62) items were found to be vital, essential and desirable category items, respectively, amounting to 18.7, 49.5 and 31.8% of annual drug expenditure. Based on ABC-vital, essential and desirable matrix analysis there were 37 (28.68%) items in category I, 53 (41.09%) items in category II and 39 (30.23%) items in category III, amounting to 73.0, 22.2 and 4.8% of annual drug expenditure, respectively.

"Ref. [8]" formulates a matrix of nine groups based on cost and criticality, by combining ABC and VED analysis. "Ref. [9]" observed that ABC analysis, if practiced, would allow effective control over two third of the total expenditure by controlling only one fourth of the items.

III OBJECTIVES OF THE STUDY

1. To classify pharmacy drugs into ABC, VED & SDE categories.
2. To apply MUSIC-3D process of Inventory management to pharmacy drugs.

IV. METHODOLOGY

In the present study, MUSIC -3D analysis of pharmacy drugs is performed at two multispecialty hospitals in Hyderabad. ABC Analysis is carried out by analysing the secondary data collected from the records of pharmacy department and stores (for surgical items).The records were observed for a period of 6 months i.e. from Jan 2013 to June 2013. To classify the items under VED, expert opinion of doctors & nurses from the respective departments is considered .The opinions of pharmacists are also given due consideration. Informal Interview was conducted with the doctors, nurses and pharmacists to get their expert opinion regarding the criticality of the drugs. SDE analysis is done based on secondary data available in the records regarding the procurement of drugs, surgical items and their availability. Also an informal interview is conducted with the In-charges' and other staff of stores & pharmacy to collect the data regarding the availability of surgical items and drugs. MUSIC-3D analysis for pharmacy drugs and surgical items is conducted on the basis of ABC, VED and SDE analysis.

The classification of pharmacy drugs and surgical items under MUSIC-3D analysis is based on 3

dimensions:

1. Consumption value (High or Low)
2. Criticality (Critical or Non-Critical) and
3. Lead time (Long or Short)

The consumption values are in turn obtained through ABC analysis, Criticality though VED analysis and Lead time through SDE analysis.

V. DATA ANALYSIS AND RESULTS

As the classification of pharmacy drugs under MUSIC-3D analysis is based on 3 dimensions, to perform MUSIC-3 D, ABC VED & SDE analysis are performed first.

ABC analysis of drugs of pharmacy department at Hospital 1 is shown in "Table 1". Here the drugs have been classified on the basis of consumption of items.

TABLE I
ABC ANALYSIS OF DRUGS OF PHARMACY
DEPARTMENT AT HOSPITAL 1

Category	Items	% Items	% Consumption(Value)
'A' items	55	19.50	70.07791
'B' items	86	30.49	20.05315
'C' items	141	50	9.868941
Total no of items	282	100	100

As per "Table 1" the following are the interpretations of ABC analysis of pharmacy drugs at Hospital 1:

- 'A' Items: 55 items accounting for19.5035 % of total items & 70.07791% of total consumption in terms of value.
- 'B' Items: 86 items accounting for 30.4964 **%** of total items & 20.05315% of total consumption.
- 'C' Items: 141 items accounting for 50 % of total items & 9.868% of total consumption.

ABC analysis of pharmacy drugs at Hospital 1 is also shown graphically in "Figure 1"

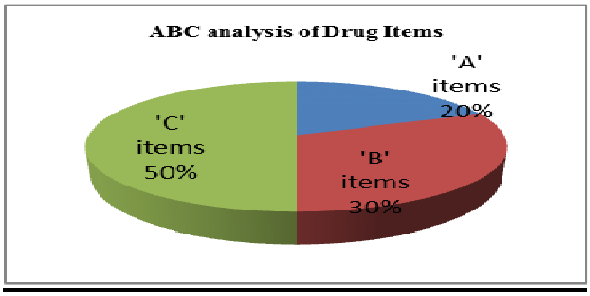

Figure 1 ABC analysis of drugs of pharmacy department at Hospital 1

ABC analysis of drugs of pharmacy department at Hospital 2 is shown in "Table 2".

TABLE II
ABC ANALYSIS OF DRUGS OF PHARMACY
DEPARTMENT AT HOSPITAL 2

Category	Items	% Items	% Consumption(Value)
'A' items	123	33.79	70.19
'B' items	102	28.03	19.85
'C' items	139	38.18	9.96
Total no of items	364	100	100

As per "Table 2" the following are the interpretations of ABC analysis of pharmacy drugs at Hospital 2:

- 'A' Items: 123 items accounting for 33.79 % of total items & 70.19% of total consumption in value.
- 'B' Items: 102 items accounting for 28.03% of total items & 19.85**%** of total consumption.
- 'C' Items: 139 items accounting for 38.18% of total items & 9.96% of total consumption.

ABC analysis of pharmacy drugs at Hospital 2 is also shown graphically through "Figure 2".

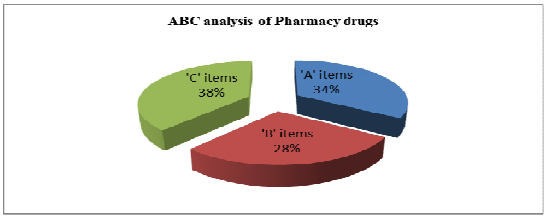

Figure 2 ABC analysis of drugs of pharmacy department at Hospital 2

VED analysis of drugs of pharmacy department at Hospital 1 is shown in "Table 3". Here the drugs have been classified on the basis of criticality of items.

TABLE III
VED ANALYSIS OF DRUGS OF PHARMACY
DEPARTMENT AT HOSPITAL 1

Category	Items	% Items	classification
Vital	27	9.57447	Vital
Essential	165	58.5106	Essential
Desirable	90	31.9149	Desirable
Total no of items	282	100	Total no of items

As per "Table 3" the following are the interpretations of VED analysis of pharmacy drugs at Hospital 1:

- 'V' Items: There are 27 items which are vital for patient care in this category.
- 'E' items: There are 165 essential items for patient care.
- 'D' Items: There are 90 desirable items.

VED analysis of pharmacy drugs at Hospital 1 is also shown graphically in "Figure 3".

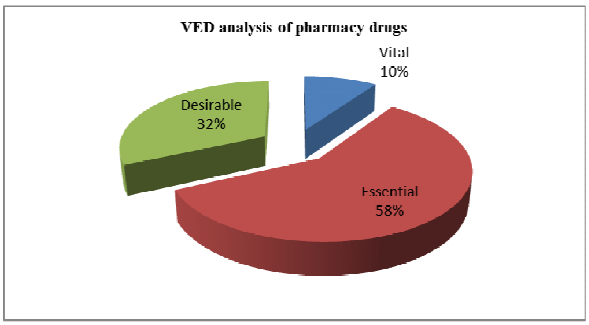

Figure 3 VED analysis of drugs of pharmacy department at Hospital 1

VED analysis of drugs of pharmacy department at Hospital 2 is shown in "Table 4".

TABLE IV
VED ANALYSIS OF DRUGS OF PHARMACY
DEPARTMENT AT HOSPITAL 2

Category	Items	% Items	classification
Vital	65	17.8	Vital
Essential	236	64.8	Essential
Desirable	63	17.4	Desirable
Total no of items	364	100	Total no of items

As per "Table 4" the following are the interpretations of VED analysis of pharmacy drugs at Hospital 2:

- 'V' Items: There are 65 items which are vital for patient care in this category.
- 'E' items: There are 236 essential items for patient care.
- 'D' Items: There are 63 desirable items.

VED analysis of pharmacy drugs at Hospital 2 is also shown graphically in "Figure 4".

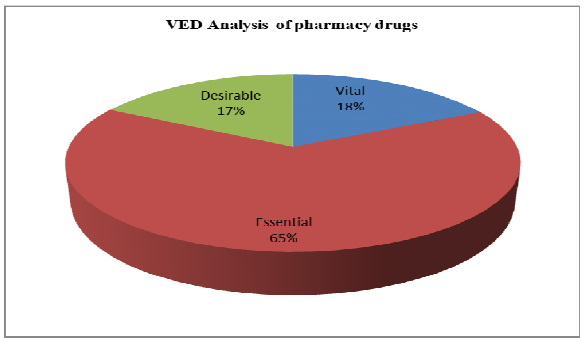

Figure 4 VED analysis of drugs of pharmacy department at Hospital 2

SDE analysis of drugs of pharmacy department at Hospital 1 is shown in "Table 5". Here the drugs have been classified on the basis of procurement, difficulty and market availability of items.

TABLE V
SDE ANALYSIS OF DRUGS OF PHARMACY
DEPARTMENT AT HOSPITAL 1

Category	Items	% Items	classification
Scarce to obtain	6	2.12766	Scarce to obtain
Difficult to obtain	33	11.7021	Difficult to obtain
Easy to obtain	243	86.1702	Easy to obtain
Total no of items	282	100	Total no of items

As per "Table 5" the following are the interpretations of SDE analysis of pharmacy drugs at Hospital 1:

- 'S' Items: These are scarce items especially imported items and are those which are on short supply. There are 6 items.
- 'D' Items: These are available with difficulty in indigenous market and cannot be procured easily. There are 33 items.
- 'E' Items: These refer to items which are easily available. There are 243 items.

SDE analysis of pharmacy drugs at Hospital 1 is also shown graphically through "Figure 5".

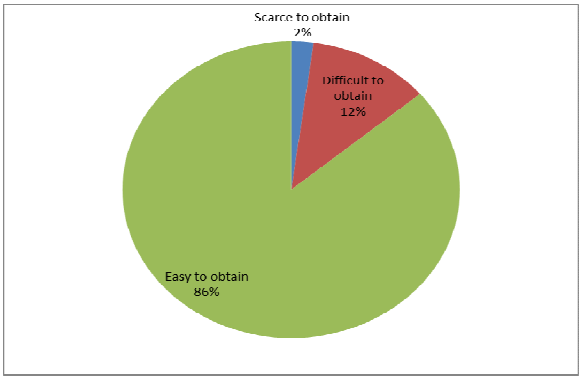

Figure 5 SDE analysis of drugs of pharmacy department at Hospital 1

SDE analysis of drugs of pharmacy department at Hospital 2 is shown in "Table 6".

TABLE VI
SDE ANALYSIS OF DRUGS OF PHARMACY
DEPARTMENT AT HOSPITAL 2

Category	Items	% Items	classification
Scarce to obtain	10	2.7	Scarce to obtain
Difficult to obtain	72	19.8	Difficult to obtain
Easy to obtain	282	77.5	Easy to obtain
Total no of items	364	100	Total no of items

As per "Table 6" the following are the interpretations of SDE analysis of pharmacy drugs at Hospital 2**:**

- 'S' Items**:** These are 10 scarce items -especially imported items- and are those which are on short supply.
- 'D' Items: These are difficult items which are available in indigenous market but cannot be procured easily. It includes 72items.
- 'E' Items: These refer to items which are easily available locally & include 282 items.

SDE analysis of pharmacy drugs at Hospital 2 is also shown graphically in "Figure 6".

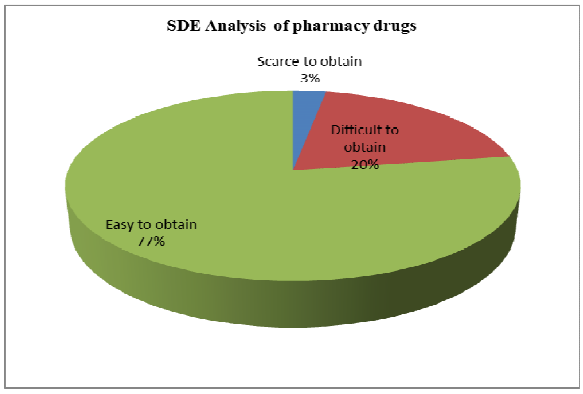

Figure 6 SDE analysis of drugs of pharmacy department at Hospital 2

MUSIC-3D analysis of drugs of pharmacy department at Hospital 1 is shown in "Table 7". MUSIC -3D analysis of pharmacy drugs is based on ABC (High or Low consumption), VED (critical or non-critical) and SDE (long lead time or short lead time) analysis.

TABLE VII
MUSIC-3D ANALYSIS OF DRUGS OF PHARMACY
DEPARTMENT AT
HOSPITAL 1

	High consumption value items		Low consumption value items	
	Long lead time	Short lead time	Long lead time	Short lead time
Critical	HLC (-)	HSC (0.7%)	LLC (7.09%)	LSC (5.3%)
Non-critical	HLN (1.06%)	HSN (18.08%)	LLN (4.25%)	LSN (63.4%)

Percentage distribution of pharmacy drugs under MUSIC–3D analysis for hospital 1 is shown in "Table 8".

TABLE VIII
PERCENTAGE DISTRIBUTION OF PHARMACY DRUGS
UNDER MUSIC – 3D ANALYSIS AT HOSPITAL 1

CATEGORY	ITEMS	%
HLC	0	0
HSC	2	0.7
HLN	3	1.06
HSN	51	18.08
LLC	20	7.09
LSC	15	5.3
LLN	12	4.25
LSN	179	63.4
Total no of items	282	100

MUSIC-3D analysis of drugs of pharmacy department at Hospital 1 is also shown graphically in "Figure 7".

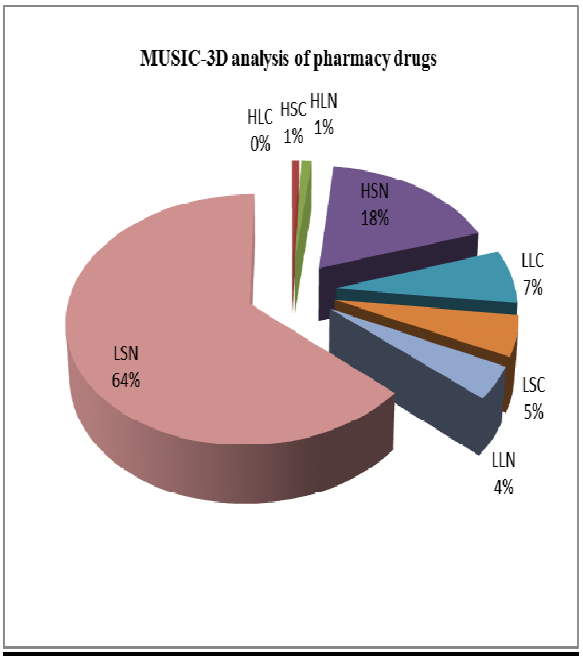

Figure 7: MUSIC-3D analysis of drugs of pharmacy department at Hospital 1

MUSIC-3D analysis of drugs of pharmacy department at Hospital 2 is shown in"Table 9".

TABLE IX

MUSIC-3D ANALYSIS OF DRUGS OF PHARMACY DEPARTMENT AT HOSPITAL 2

	High consumption value items		Low consumption value items	
	Long lead time	Short lead time	Long lead time	Short lead time
Critical	HLC(5.76 %)	HSC (3.29 %)	LLC (4.39 %)	LSC (4.94 %)
Non-critical	HLN (2.47 %)	HSN (22.25 %)	LLN (9.89 %)	LSN (46.97 %)

Percentage distribution of pharmacy drugs under MUSIC – 3D analysis for hospital 2 is shown in "Table 10".

MUSIC-3D analysis of drugs of pharmacy department at Hospital 2 is also shown graphically in "Figure 8".

TABLE X

PERCENTAGE DISTRIBUTION OF PHARMACY DRUGS UNDER MUSIC – 3D ANALYSIS AT HOSPITAL 2

CATEGORY	ITEMS	%
HLC	21	5.76
HSC	12	3.29
HLN	9	2.47
HSN	81	22.25
LLC	16	4.39
LSC	18	4.94
LLN	36	9.89
LSN	171	46.97
Total no of items	282	100

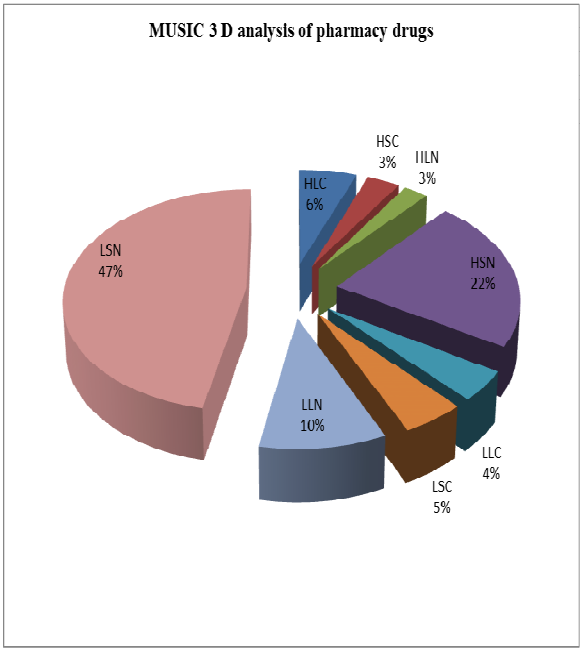

Figure 8 MUSIC-3D analysis of drugs of pharmacy department at Hospital 2

V. CONCLUSION

The conventional ABC analysis is not an effective selective control mechanism, as there are other influencing mechanisms, like criticality and availability, which influence a great deal on controlling the materials. Thus, the three-dimensional approach MUSIC -3D is helpful to classify all materials into eight categories and to control the materials effectively on all aspects and achieve cost reduction, in order to facilitate the materials department as a profit center. The initial efforts required to implement MUSIC-3D may be quite high but once implemented only a marginal effort is needed to maintain and improve it. The benefits are immense. The importance of inventory control is now recognized by the hospital administrators. Its basic objectives are to reduce investment in inventories and simultaneously avoid stock-out situation. An effective inventory control balances the two objectives to optimum advantage. Computerization, automation and use of technique like MUSIC-3D will aid in achieving these objectives.

It is imperative that all measures for the prevention of stock out situations should be implemented. Availability of pharmaceutical products is essential for patient satisfaction. It is also an essential requisite for provision of life saving, effective and efficient healthcare. Frequency of stock outs is an indicator to assess the effectiveness of the stores department and the materials management. The MUSIC -3D technique needs to be adopted as a routine practice for optimal use of resources and elimination of out-of-stock situations in the hospital pharmacy. MUSIC 3-D aids in efficient management of the pharmacy stores, as it contributes to not only improvement in patient care but also judicious use of resources as well.

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