# THE INTRODUCTION AND USAGE OF

# LaTeX THESIS TEMPLATE FOR

# TEXAS A&M UNIVERSITY

A Thesis

by

FAN GAOFENG

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in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE

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|---|---|
| Chair of Committee, | Edgar Sánchez-Sinencio |
| Co-Chair of Committe, | José Silva-Martinez |
| Committee Members, | Samuel Palermo |
| | Aydin IlKer Karsilayan |
| | Sebastian Hoyos |
| | Kamran Entesari |
| Head of Department, | Miroslav M. Begovic |

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# ABSTRACT

This is the first numbered page, lower case Roman numeral (ii). Page numbers are outside the prescribed margins, at the bottom of the page and centered; everything else is inside the margins.No bold on this page (Exception: heading ABSTRACT is bold if major headings are bold. *This LATEX template applies to this exception*).

Text begins two double spaces below the major heading. Recommended length of text is no more than 350 words. Vertical spacing is double spaced or space-and-a-half. (*This LATEX template applies double space for this ABSTRACT.*) The same margin settings and text alignment are followed else where in this thesis. There should be no numbered references or formal citations in ABSTRACT.

The content of this ABSTRACT provides a complete, succinct snapshot of the research, addressing the purpose, methods, results, and conclusions of the research. As a result, it should stand alone without any formal citations or references to chapters/sections of the work. To accomodate with a variety of online database, images or complex equations should also be avoided.

The next three pages, which are Dedication, Acknowledgements and Nomenclature, are optional.

To my mother, To my father, To my grandfather, To my grandmother. I make it long to

see the effect of two lines in this dedication page.

# ACKNOWLEDGMENTS

This chapter is also optional, limited to four pages. It must follow the Dedication Page (or Abstract, if no Dedication). If listing preliminary pages in Table of Contents, include Acknowledgments. Heading (ACKNOWLEDGMENTS) is bold if major headings are bold. It should be in same type size and style as text. So does vertical spacing, paragraph style, and margins.

I would like to thank Texas A&M University Office of Graduate and Professional Study to give me this chance to organize the Thesis LaTeX template. Special Thanks to JaeCee Crawford, Amy Motquin and Christine Brown for carefully reviewing this material.

# NOMENCLATURE

OPAGS             Office and Graduate and Professional Study at Texas A&M University

B/CS             Bryan and College Station

TAMU             Texas A&M University

XXXXXXXX             This is an optional page. Random word to test how long the sentence can be? This is just for test purpose. The current setting aims to align left/right margin same as all other pages.

# TABLE OF CONTENTS

# LIST OF FIGURES

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# 1 INTRODUCTION AND

# LITERATURE REVIEW

## 1.1 Author's Message

Howdy! This is my honor to organize the LaTeX Thesis Template for Texas *A&M* University[1] as a graduate student at ECE under the guidance of OGAPS@TAMU. I have been applied LaTeX to write my bachelor and master thesis in Chinese and English previously. My approach is to deal with all the questions/settings with high level package or global settings. I don't intend to touch the low level of LaTeX, which I think is sophisticated and un-necessary for the thesis writing, though some minor necessary local modifications are un-avoidable currently. That is also the purpose of briefing this section. I am glad if you have any questions about the thesis template and please send me an e-mail as soon as possible. My e-mail address is gaofeng@exchange.tamu.edu.

### 1.1.1 Brief Usage Of The Template

If you have no idea bout what LaTeX is and plan to use it for your thesis writing. Read the lshort on-line to have a brief idea of how LaTeX document is organized. It works like any other programming language, aim at providing a PDF document output as what you see now. While Office Word is usually called WYSIWYG[2], LaTeX follows the principle of WYSIWYM[3]. Its purpose is to allow you to concentrate on text typing while LaTeX will

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[1] This is a test to see how the footnote is display in long long text below the main content. The font size is 10pt if you doesn't modify the default setting. As you can see, it is single space.

[2] What you see is what you get

[3] What you see is what you mean.

deal with the format for you while actually people like me will constantly compile the files and see what is going not correctly in the PDF output. The use of LaTeX requires the user has basic understanding of programming.

**Software To Install**

MikTeX or **ProTeXt** is the free software recommended for Windows PC users to compile your LaTeX document. To compile for this document, XeLaTeX compiling engine is used. Another software called **JabRef** is also recommended for bibliography/reference management, its usage is similar with EndNote under Office Word.

**Procedure To Compile LaTeX document**

Both CMD[4] and GUI[5] methods are introduced. It's not needed to use both. You can choose either way to compile the code.

**CMD** This approach is general and applicable to Windows/Linux/Mac system with minor difference. An example under Windows Operating System is described here.

1. Open the CMD interface in Windows as Figure 1.1 shows.

2. Apply Change Directory command to the folder path where the .tex files are saved. For example use ``cd /homes/grads/gaofeng/Desktop/LaTex'' for Linux/Mac or apply the command in Figure 1.2 for Windows.

3. (Optional) Type in ``'dir' to see the files listed under current foler

4. Compile the .tex file with the command **xelatex TAMUthesis_Template.tex** as shown

---

[4]command line
[5]Graphic User Interface

in Figure 1.3.

5. if reference files ended with .bib are referred in the .tex files, apply the following command **bibtex TAMUthesis_Template** to compile the document to update reference information.

6. Re-compile the files with the command **xelatex TAMUthesis_Template** to take into the effect of bibtex. If there is no output, try the command again.

7. If the compilation stops due to error, type **q** and **Enter** to exit for re-compilation is recommended.
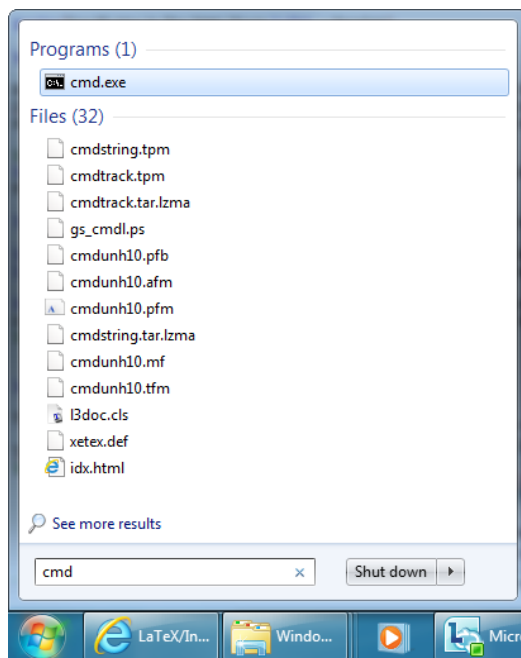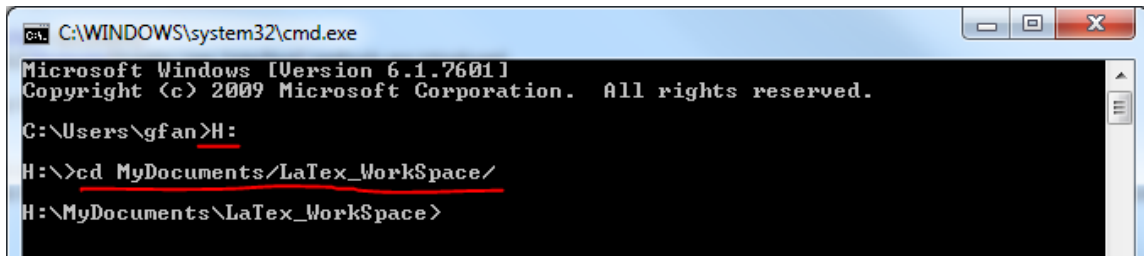


Figure 1.1: Open CMD (Command Line Interface) Under Windows
[Open the data/chapterI.tex file to search for the implementation of this figure, as you can see that, to precisely contorl the position of the figure is not as straightforward as that in Office Word.]
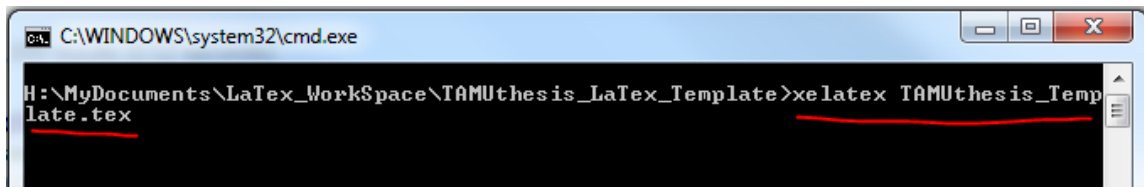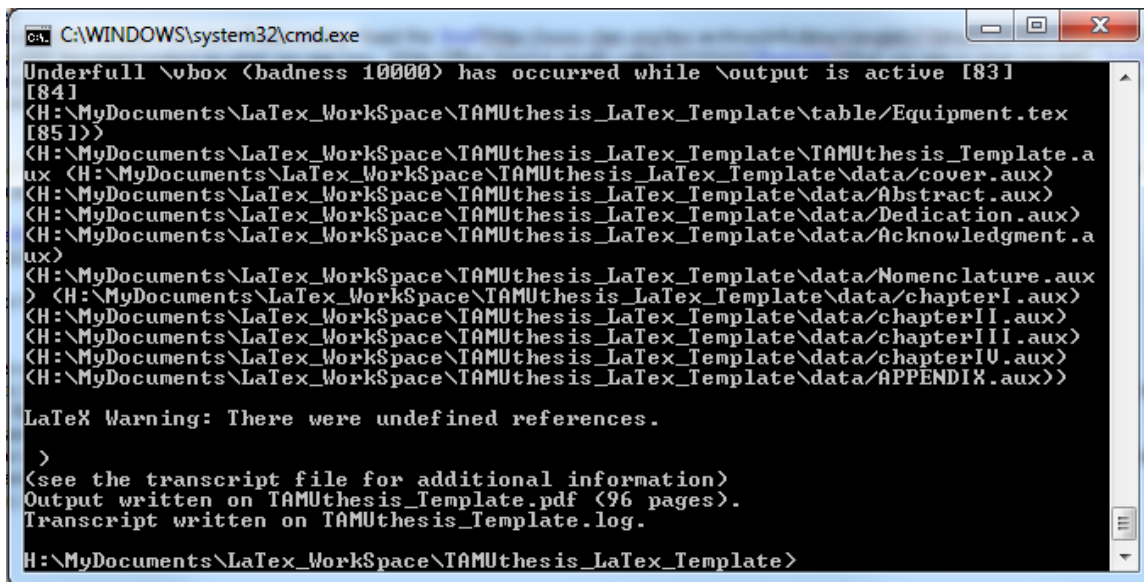
Figure 1.2: Change Directory Command Under Windows
[Before applying cd command in Windows, change to another disk segment by typing ``H:" or ``D:" instead of ``cd some_path"]



Figure 1.3: Compile .tex File



Figure 1.3 Continued.
[Example usage for Figure continued. Please Don't display text for Continued Figures. This is just an example.]

**GUI** Open the .tex file using MikTeX and choose the option as shown in Figure 1.4 to execute.
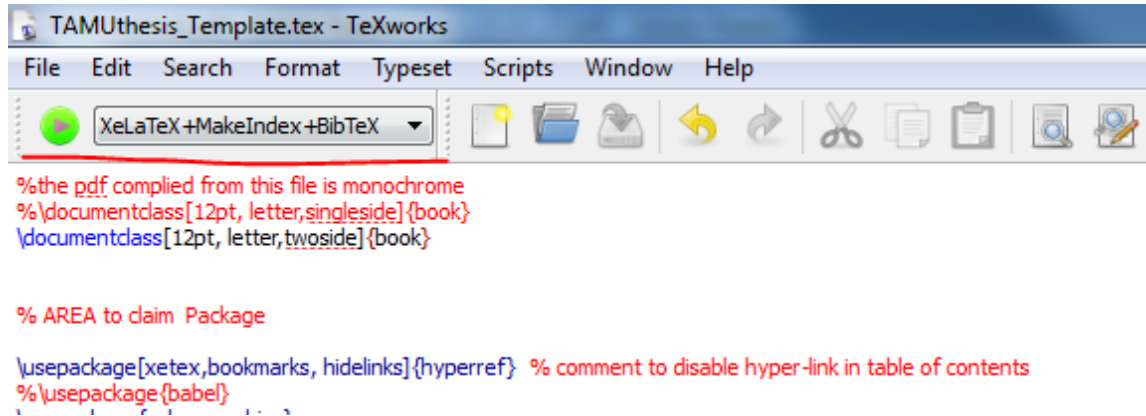


Figure 1.4: Compile .tex file Under Windows System

### 1.1.2 How To Fill In This Document

The document structure is organized in the main .tex file, TAMUthesis_Template.tex, which has the same name as the output PDF file. Content in each chapter is under the folder of data. You can open the .tex files under the data folder to modify. Four chapters are added initially. To add in more chapters into the LATEX document, please open the TAMUthesis_Template.tex files and goto line No. 280 as shown in Figure 1.5 .

For the rest of the document, you can just delete the content in the data folder and fill your documents and then compile under TAMUthesis_Template.tex.

### 1.1.3 Reference Usage And Example

This subsection test the usage of Reference. Paper[1] is referred in this way. Actually, the option is available for you to change the default way how reference appears. The default

```
273  \newpage
274  \pagenumbering{arabic}
275
276  \begin{spacing}{2}
277        \include{data/chapterI}
278        \include{data/chapterII}
279        \include{data/chapterIII}
280        \include{data/chapterIV}
281  %      \include{data/myNewChapterName.tex}
282
```

Figure 1.5: Add More Chapters Into TAMUthesis_Template.tex
[For example, a new chapter named ``myNewChapterName.tex'' is created under the
folder of **data**. To put this new file for the compilation by adding the line
`\include{data/myNewChapterName.tex}` as shown in 281 (uncomment the % in
front.).]

and most commonly used option [2] is displayed here. Please download a free software
called JabRef to manage your references. When you need any references, do search it
on-line and download the bib format to import into the JabRef.

Unrelated citations are referred here for test of Reference Section only[3]. If you
find the Reference[4] has more items than you need [5]. It's possible that the old bbl file[6]
is not updated yet.The simple solution[7] is to delete the bll file and re-compile the whole
PDF [8]. Of sometimes, if you really makes a mistake, read the .log files to see what is the
error information there.

### 1.1.4  Equation Usage

It looks like there are some fundamental problems for LATEX to accurately control
the vertical spacing above/below equations. While I have tried my best to fine tune the

spaces above/below equations. You should pay special attentions when use two **equation** environments consecutively. As this might results in ugly large vertical spacing between equations and texts. As I have stated somewhere else in this document, I would suggest you to use **align** environment for a list of equations. And you can also refer and label them one by one as the example code shown in Equ. (3.7).

### 1.1.5 Cover Page

The default cover page has three line title which might not fit your case. The requirement for the cover page is not so strict. You can adjust the vertical space and find out the most balanced top/bottom margin for cover page. Hence, some fine tuning might be necessary from user perspective. Please refer to the **data** folder and open the file named cover.tex for modification.

## 1.2 Specification In This TAMU Thesis LaTeX Template

### 1.2.1 Chapter Method Requirement

Below are the general requirements for thesis chapter from OGAPS. The bold/Italic font is applied to the setting that is currently implemented in this document when there is a choice[6].

1. Standard margins on this document is 1.4" left, 1.15" right, 1.25" top and bottom. The page number (Arabic) 1 is outside the margin, at the bottom of the page and

---

[6]The default non-indentation setting is removed after reviewing with OGAPS. All the new paragraph will automatically indent. When writing the document in LaTeX, just 'Enter' twice to leave a blank line for indentation. I see questions on-line about how to enable single space in footnote, the settings used in this LaTeX document doesn't affect the single space setting in footnote, which is my lucky. So there is no local settings needed for footnote to keep in single space.

centered. Number every page of the thesis in sequence through the Appendix, which is the last page.

2. *Chapter method* are mostly applied in organizing the document. Before the chapter method is stabilized/approved by OGAPS, no section method is going to be tested and verified.

3. the major heading consists of the chapter designation (CHAPTER I) and the title. Both are centered, in all capital letters. While chapter designation being in capital is automatically controlled by the LaTeX , the title needs author to type in capital or use LaTeXcommand \textsc{} to brace the them. The effect of these two commands are a little bit difference but can all satisfy the thesis requirement.

4. if the *chapter title* is longer than one line, use spacing of text between the lines of the title (**double space** or space-and-a-half). Use same front size as other major headings (**and bold if other major headings are bold**). Be consistent with spacing between chapter title and text for all chapters (one or two double spaces)

### 1.2.2 Subheadings Requirements

This is the second-order subheadings in this LaTeX  document.

TAMU graduate theses and dissertations do not have a specific "style" for subheadings.Some rules for ALL levels of subheadings are:

- Vertical spacing above and below each subheading needs to be consistent for *each* level.

- Vertical spacing within a subheading with more than one line needs to be the same

as spacing of the text.

- Include the chapter/major section number if numbering or lettering the subheadings, ex. I.1, II.1. or 1.1, 2.1 (first level subheadings) and I.1.1, II.1.1 or 1.1.1, 2.1.1 (second level subheadings)

- Style and format need to match for *each level* (numbering is enough to differentiate the levels -- if numbered they can look the same or each level can look different).

- Type size and style need to follow text.

- Capitalization needs to be consistent for *each level* of subheading.

First-order subheadings, which are section in this LaTeX document, must be included in the Table of Contents, which is implemented in this TAMUthesis.

Second-order subheadings, which are subsections in this LaTeX document, need to differ from first level unless they are numbered. If numbered, all levels of subheadings may match for style (but they do not have to). Second levels do not need to be included in the Table of Contents.

### 1.2.3 Third-Order Subheadings

Third-order subheadings, if numbered, may match the other levels of subheadings. If unnumbered, they need to have a different style. Third levels do not need to be included in the Table of Contents.

### 1.3 Test Section

Test Content is displayed below.

## 1.4 Thesis Organization

Example code below for LaTeX **description** environment.

**The 1st chapter**  introduces the background.

**The 2nd chapter**  briefly describes how to do it.

**The 3rd chapter**  details the design of the hardware. Test and verification of this hardware is located in Appendix A.

**The 4th Chapter**  issues the discussions and gives the summary.

**The Appendix**  contains some less-intersting, but still significant test benches, test setup details and test result information. It is provided in Appendix B. Appendix B.3 details the usage.

# 2   PAGES WITH A FIGURE, A TABLE AND A EQUATION

## 2.1   Figure Placement and Size

Figures need to be within the set text margins and be large enough to read (1.5mm or about 7 pt type). You need spacing above and below the figure or table that is more than the spacing of the text. At least a triple (or three single) spaces is needed. Figures do not need to have the same size or style of type in them.

## 2.2   Figure Titles

The style of the figure titles needs to be **consistent** for all the figures. This includes bold or not, italics, abbreviations, (Fig.1 vs Figure 1, for instance), vertical spacing, flush or centered on the page. This does not include type size and style, which can vary from figure to figure. See Figure 2.1 and caption for information on figure numbering and spacing.

## 2.3   Continued Figures

It's not recommended to use continued figures in this LATEX document since figure/table numbering increases automatically. But if you would like to use it, refer to Figure 2.2 for how Continued Figure works.

Figure 2.2 Continued. provides high level blocks of the system.
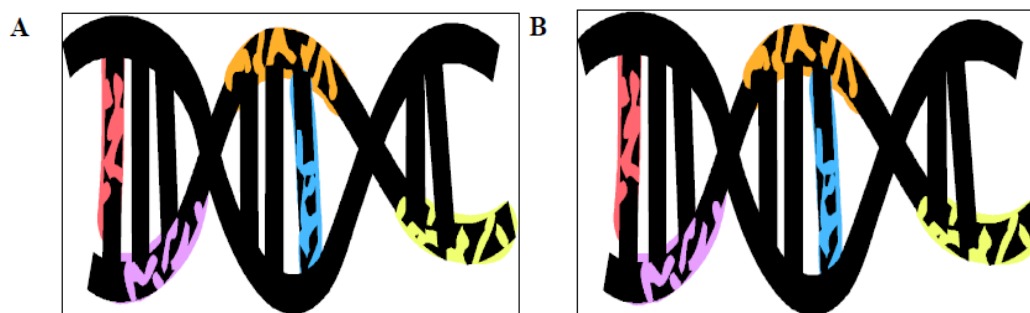
Figure 2.1: The entire title up to the first period must be included in the List. Lists of Figures and Tables must agree word for word with figure and table titles in the text. The figures can be numbered consecutively throughout the thesis (1, 2, 3, 4, etc) or **numbered by chapter (1-1, 1-2, 2-1, etc.)**. (A) Each figure should be referred to by that number within the text, within $1\frac{1}{2}$ pages of the figure.(B) The figures can be put on a separate page from the text, but if they are incorporated into the text, they must be offset by at least a triple space above and below.(C) Figures must fit within the normal page margins. Figure captions are not considered regular text, and so may be a different font size and may be single spaced. Each figure must have a unique caption, and captions, up to the first period, must be included in the List of Figures. Though larger size font for picture are allowed, it needs to be consistency throughout the whole thesis.



Figure 2.1 Continued.

## 2.4   Table Placement, Size and Table Title

As with figures, tables placed in text need to be separated from the test by at least a triple space. Table titles can be numbered by chapter or numbered consecutively throughout the thesis. Their titles need to be consistent, as figure titles. If you have a continued table, repeat the column headings. Please see Table 2.1 as a reference. Free software is
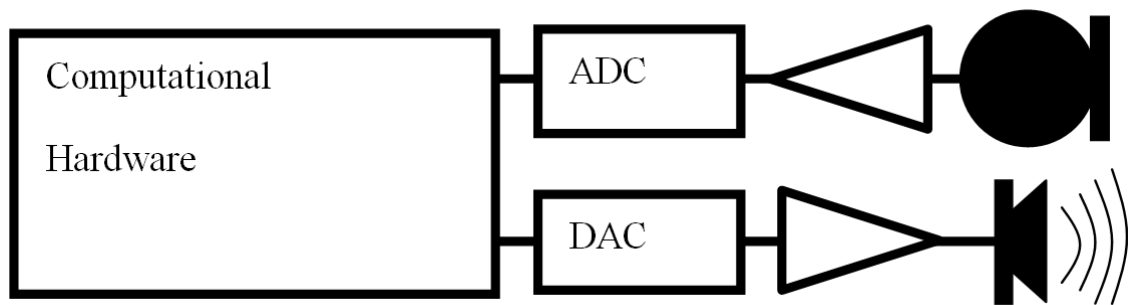
Figure 2.2 : Please Check This Figure's Implementation Code To See How To Meet University Requirement Of Single Space Long Figure/Table Titles.
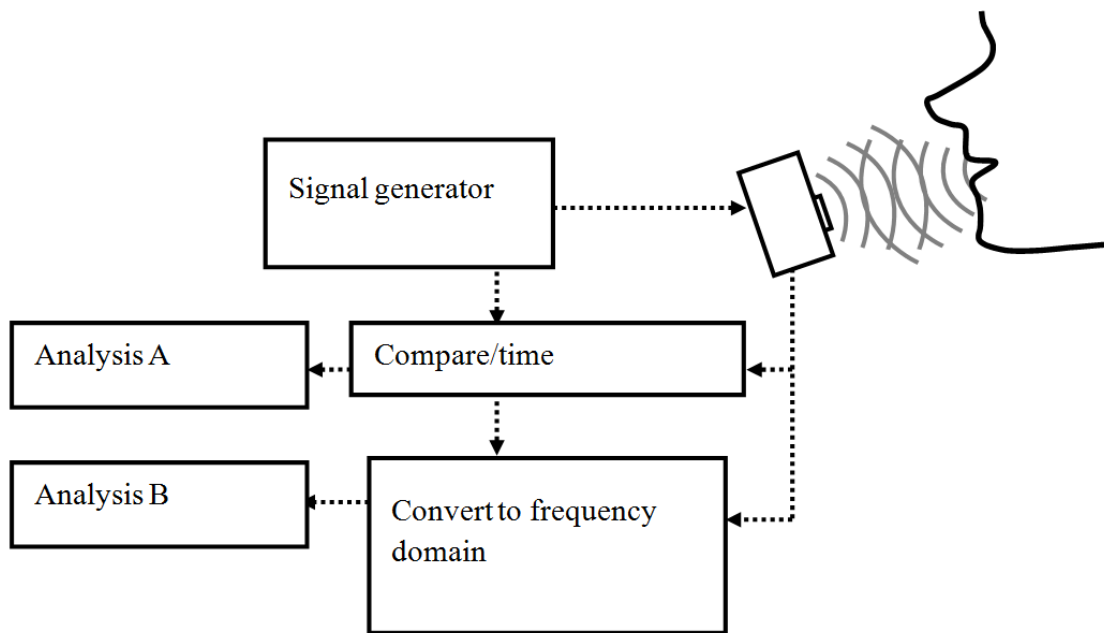


Figure 2.2 Continued.



Figure 2.3 : Figure Name Should Have Consistent Behavior Along This Document.

available on-line to convert excel table into LaTeX table format, please refer to

`http://www.ctan.org/pkg/excel2latex`.

Table 2.1: Results From Experimental And Control Runs

| Species | Experiment 1 | Experiment 2 | Control 1 | Control 2 |
|---|---|---|---|---|
| Cow | + | – | – | + |
| Brown Horse | – | + | – | – |
| Gray Cow | | | | |
| White House | – | + | + | – |
| Tan Cow | + | – | – | + |

Table 2.1 Continued.

| Species | Experiment 1 | Experiment 2 | Control 1 | Control 2 |
|---|---|---|---|---|
| White Cow | + | – | – | + |
| Spotted Pig | + | + | + | – |
| White Pig | + | – | – | – |
| Brown Pig | | + | + | – |
| Gray Pig | + | – | – | + |
| Black Pig | + | – | – | + |

For more table format, please refer to Table 3.4 for more information.

## 2.5 Equations

The following format is recommended to be used to display. The equation can be referred as Equ. (2.3). Please pay special attention when using **equation** environment for it will cause extra large vertical space in the LaTeX documents. Use other environment like **align** to write multi-line equations. When equation environment is applied, please don't leave a blank line before it.

When refer to any equations, command \eqref{} [Equ. (2.3)] instead of \ref{} [Equ. 2.3] is preferred.

$$x' = x \cdot cos(a) - y \cdot sin(a) \tag{2.1}$$

$$y' = y \cdot cos(a) + x \cdot sin(a) \tag{2.2}$$

$$e^{ja} = cos(a) + j \times sin(a) \tag{2.3}$$

The test here is to show the vertical spacing after the equations.

## 2.6 Equation Vertical Spacing

Please read the two Equ. (2.4) and (2.5) below to have a brief idea about equation vertical spacing. The usage of equation environment **array** is tested as well. In the code implemented, no extra line is provide between the text and equation in Equ. (2.4). This provides tight vertical spacing as shown, however, adding the extra line command will cause un-balanced vertical spacing before/after the equation. The reason seems fundamental and unchangeable under LATEX. A temporary local fix is provided in the code below for Equ. (2.5)

$$WAD(S_n) = \begin{cases} +1 & if & E(S_n) > \varepsilon_2 \\ -1 & if & E(S_n) < \varepsilon_1 \\ sign(zcr(S_n)) - \varepsilon_{zcr} & if & \varepsilon_1 \leq E(S_n) \geq \varepsilon_2 \end{cases} \tag{2.4}$$

This line is to separate the two equations below and above. The equation below has a temporary local solution to adjust the vertical spacing before the equation. Please notice the difference of the code implemented. The easiest way is to do as Equ. (2.4) do.

$$WAD(S_n) = \begin{cases} +1 & if & E(S_n) > \varepsilon_2 \\ -1 & if & E(S_n) < \varepsilon_1 \\ sign(zcr(S_n)) - \varepsilon_{zcr} & if & \varepsilon_1 \leq E(S_n) \geq \varepsilon_2 \end{cases} \tag{2.5}$$

Test text for vertical spacing test only.

## 2.7 Other Information In This Document

All requirements in this document comes from OGAPS Thesis manual, which you can download from OGAPS Current Students Thesis/Dissertation Service web page. After this section, most content in this document repeats what the manual thesis say. You might notice there are plenty of non-meaningful text appearing in this document. They are for the purpose of testing the structure of toc/lof/lot, Appendix and Word `Page` etc. You can just ignore them and use the blank template provided. However, code examples in this document might be useful if you are not sure about the implementation of certain features in your thesis and you can refer to this document then.

## 2.8 Another Test Section

The section title is to test the toc only, no other purpose.
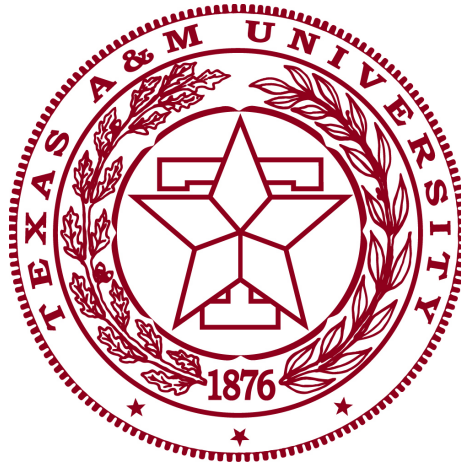


Figure 2.4 : You Can Choose Your Style for Figure Title, But Please Keep Consistent Throughout The Document.

## 2.9    Another Test Section 3

The section title is to test the toc only, no other purpose.

## 2.10    Another Test Section 4

The section title is to test the toc only, no other purpose.



Figure 2.5 : TAMU Logo
[Picture for test lof only, no other purpose]

## 2.11    Another Test Section 5 & 6

Just a test section.



Figure 2.6 : In This Document, Figure Title Keeps First Character Capital.

# 3 VERY VERY VERY VERY VERY LONG TITLE I TEST THE DISPLAY IN THE HEADER

Refer to Appendix A.

## 3.1 Section Test Example 1
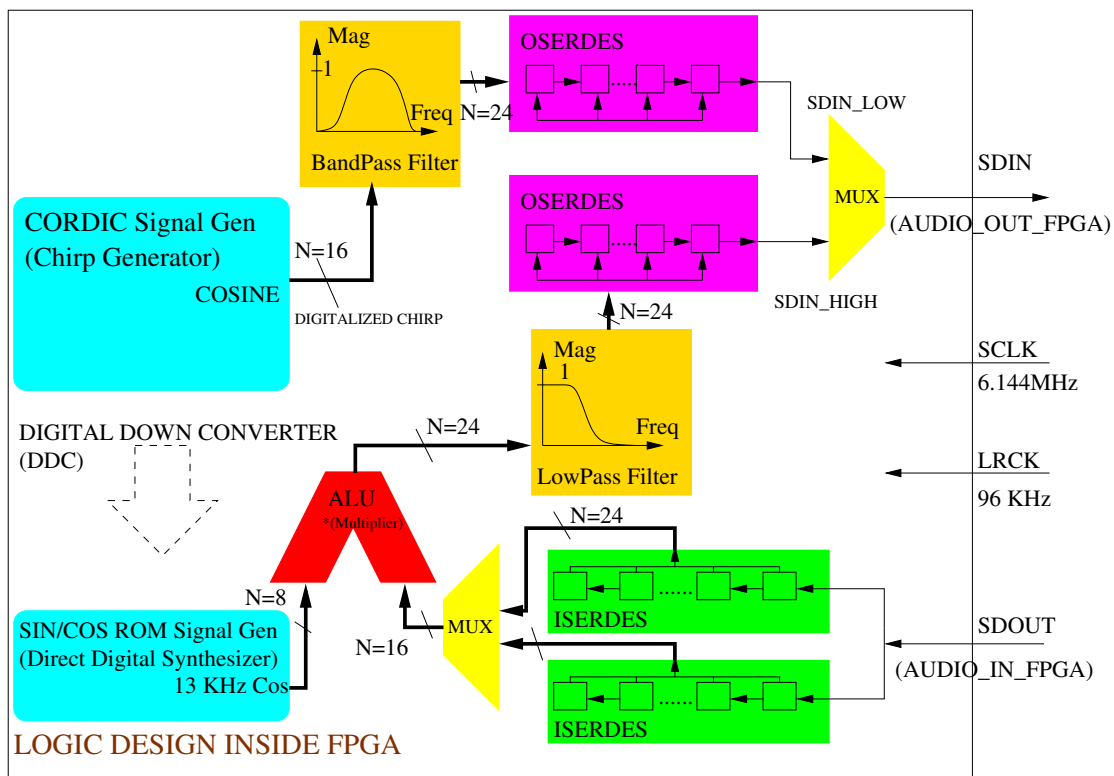


Figure 3.1 : Chapter 3 Figure Illustration Example

Fig 3.1 is referred here.

## 3.2 Test Section In This Chapter

Section Title is to test toc display only, no actual meaning.

### 3.2.1 Test Subsection In This Chapter

Picture/Table are only for illustration purpose, testing lof/lot, no exact meaning.
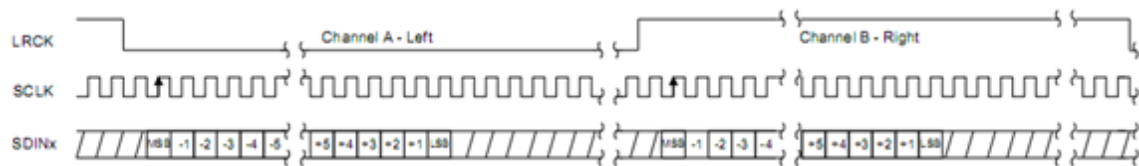


Figure 3.2 : $I^2S$ Random Pictures Showing Here For Test Purpose

### 3.2.2 Subsection Test Example 1
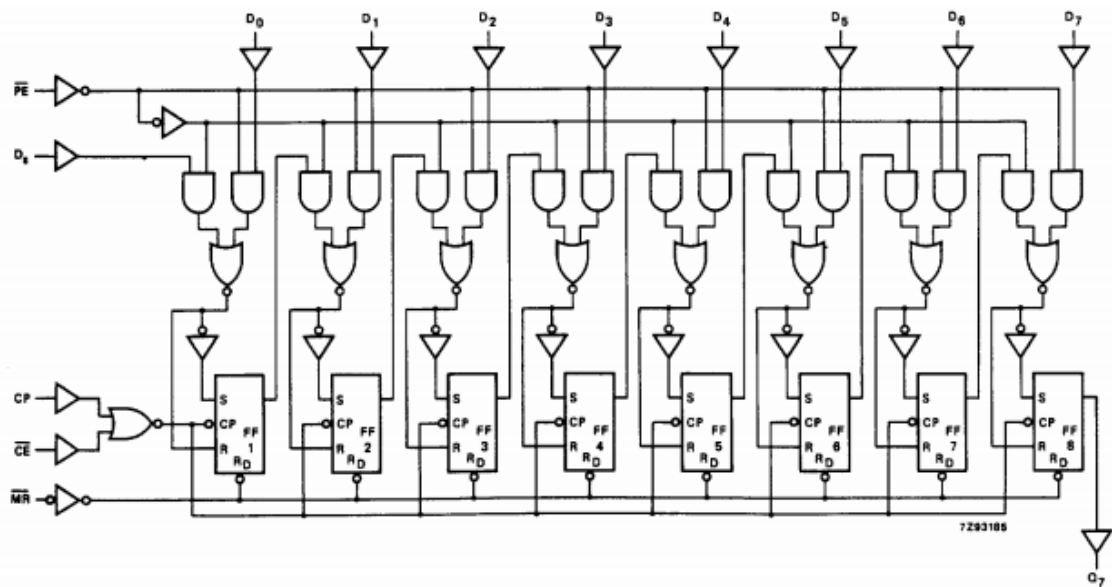


Figure 3.3 :  This Is Another Example Of Long Figure/Table Title That Will Display As Single Spacing In The List Of Figures.

## 3.3 Section Test Example 2

Fig 3.1 are two practical implementations for the DDS framework.

### 3.3.1 Subsection Test Example 2

A chirp is a signal whose frequency increases (`up-chirp', Fig 3.4 or decreases `down-chirp') with time.

In a linear chirp, the instantaneous frequency $f(t)$ varies linearly with time, as shown in Equation (3.1);

$$f(t) = f_0 + k \cdot t \tag{3.1}$$

$f_0$ is the starting frequency for sweeping in chirp. Its corresponding time domain function for a cosine linear chirp is;

$$x(t) = cos(2\pi \int_0^t f(t')dt') = cos(2\pi f_0 t + k\pi t^2) \tag{3.2}$$

The implementation of 3.2 could be simplified.

### 3.3.2 Subsection Test Example 3

**Subsubsection Test Example 1**

Example of multiple line **verbatim** environment.

```
    123

x   456

==========

    738   (this is 123 x 6)

   615    (this is 123 x 5, shifted one position to the left)

+492      (this is 123 x 4, shifted two positions to the left)

=========

  56088
```

### Subsubsection Test Example 2

Example Equation is below in Equ. (3.5):
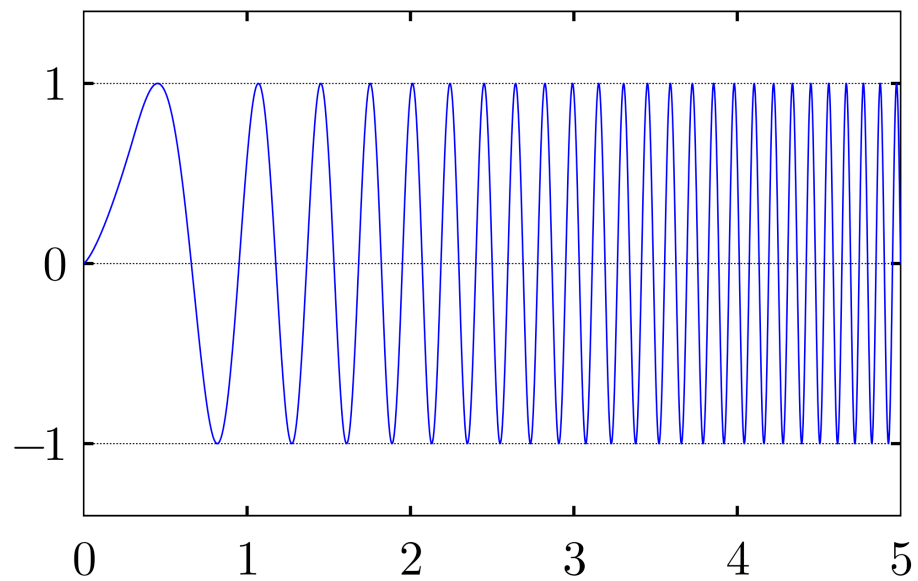


Figure 3.4 : Test Example Picture
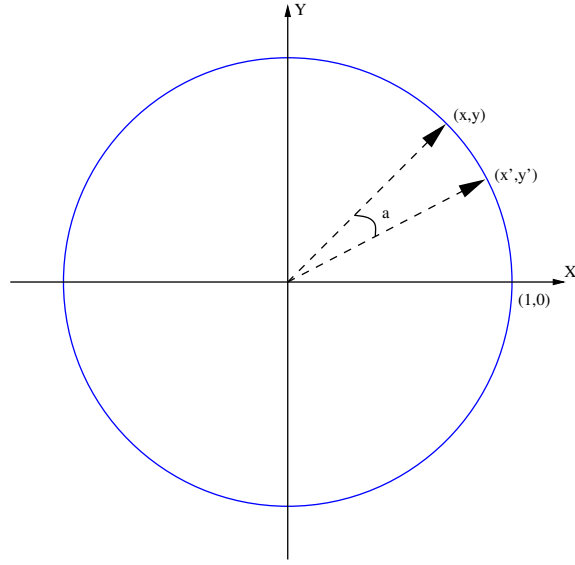
Figure 3.5 : Put All The Pictures Here To Fill The First Page To Test Purpose
[Rotate from (x, y) to $(x',y')$ via angle of 'a']

$$V' \quad = \quad e^{ja} \times V \tag{3.3}$$

$$= \quad [cos(a) + j \times sin(a)] \times (x + j \times y) \tag{3.4}$$

$$= \quad x \cdot cos(a) - y \cdot sin(a) + j \cdot [x \cdot sin(a) + y \cdot cos(a)] \tag{3.5}$$

With the help of complex numbers and Euler's identity, the relationship between $V$

and $V'$ could be deduced:

$$V = \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x \cdot cos(a) - y \cdot sin(a) \\ y \cdot cos(a) + x \cdot sin(a) \end{bmatrix} \tag{3.6}$$

Equ. (3.6) could be re-arrange as (3.7) and (3.8).

$$x' = cos(a) \cdot [x - y \cdot tan(a)] \tag{3.7}$$

$$y' = cos(a) \cdot [y + x \cdot tan(a)] \tag{3.8}$$

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Table 3.1: Value Of $tan(2^{-i})$, i=0, 1, 2, 3...

| i | $2^{-i}$ | $Degree(Arctan(2^{-i}))$ |
|---|----------|--------------------------|
| 0 | 1 | 45 |
| 1 | 0.5 | 26.56505 |
| 2 | 0.25 | 14.03624 |
| 3 | 0.125 | 7.125016 |
| 4 | 0.0625 | 3.576334 |
| 5 | 0.03125 | 1.789911 |
| 6 | 0.015625 | 0.895174 |
| 7 | 0.007813 | 0.447614 |
| 8 | 0.003906 | 0.223811 |
| 9 | 0.001953 | 0.111906 |
| 10 | 0.000977 | 0.055953 |
| 11 | 0.000488 | 0.027976 |
| 12 | 0.000244 | 0.013988 |
| 13 | 0.000122 | 0.006994 |
| 14 | 0.000061 | 0.003497 |
| 15 | 0.000031 | 0.001749 |
| 16 | 0.000015 | 0.000874 |

$$x_{i+1} = cos(a_i) \cdot [x_i - y_i \cdot 2^{-i} \cdot d_i] \tag{3.9}$$

$$y_{i+1} = cos(a_i) \cdot [y_i + x_i \cdot 2^{-i} \cdot d_i] \tag{3.10}$$

$$cos(\alpha) = \frac{1}{\sqrt[2]{1 + tan^2(\alpha)}} \tag{3.11}$$

$$K_i = cos(arctan(2^{-i})) = \frac{1}{\sqrt[2]{1 + tan(arctan(2^{-i}))}} = \frac{1}{\sqrt[2]{1 + 2^{-2 \cdot i}}} \tag{3.12}$$

The product of $K_i$ represents the so-called $K$ factor (Equ. 3.13)

$$K = \prod K_i = \prod_{i=0}^{n-1} \frac{1}{\sqrt{1 + 2^{-2 \cdot i}}} \tag{3.13}$$

Table 3.2 indicates the change of $K$ factor as the iteration increases. It can be noticed that $K$ will reach the limit of 0.607252935. Hence, The $K$ factor could be calculated in

advance and applied elsewhere in the system. A good solution to implement the $K$ factor is to initialize the iterative rotation with a vector of length $\frac{1}{|K|}$ and this will compensate the gain inherent in the CORDIC algorithm.

Table 3.2: Trend of K Factor As Iteration Increase

| i | Degree $\phi_i$ | $cos(\phi_i)$ | Product of $cos(\phi_i)$ $K = \prod K_i = \prod cos(\phi_i)$ |
|---|---|---|---|
| 0 | 45.00000000 | 0.70710700 | 0.70710678 |
| 1 | 26.56505118 | 0.89442700 | 0.63245553 |
| 2 | 14.03624347 | 0.97014300 | 0.61357199 |
| 3 | 7.12501635 | 0.99227800 | 0.60883391 |
| 4 | 3.57633438 | 0.99805300 | 0.60764826 |
| 5 | 1.78991061 | 0.99951200 | 0.60735177 |
| 6 | 0.89517371 | 0.99987800 | 0.60727764 |
| 7 | 0.44761417 | 0.99996900 | 0.60725911 |
| 8 | 0.22381050 | 0.99999200 | 0.60725448 |
| 9 | 0.11190568 | 0.99999800 | 0.60725332 |
| 10 | 0.05595289 | 1.00000000 | 0.60725303 |
| 11 | 0.02797645 | 1.00000000 | 0.60725296 |
| 12 | 0.01398823 | 1.00000000 | 0.60725294 |
| 13 | 0.00699411 | 1.00000000 | 0.60725294 |
| 14 | 0.00349706 | 1.00000000 | 0.60725294 |
| 15 | 0.00174853 | 1.00000000 | 0.60725294 |
| 16 | 0.00087426 | 1.00000000 | 0.60725294 |

Removing the $K$ factor, Eqn. (3.9) and (3.10) turn into the classical CORDIC Equations (3.14) and (3.15).

$$x_{i+1} = [x_i - y_i \cdot 2^{-i} \cdot d_i] \tag{3.14}$$

$$y_{i+1} = [y_i + x_i \cdot 2^{-i} \cdot d_i] \tag{3.15}$$

Considering the aim of the CORDIC algorithm is to rotate a vector $V(x,y)$ to unit vector $(1,0)$, the direction of each rotation can be decided by $y_{i+1}$ or the angle accumulator,

which is defined as $Z_{i+1}$. Since $y_{i+1}$ would finally be 0, via Equ. (3.15), the direction of rotation could be defined as:

$$d_i = \begin{cases} +1 & if \quad y_i < 0 \\ -1 & if \quad y_i \geq 0 \end{cases} \tag{3.16}$$

To be consistent of the definition above, defining the original angle $Z_0$, the angle accumulator can be defined as:

$$Z_{i+1} = Z_i + d_i \cdot arctan(2^{-i}) \tag{3.17}$$

Another approach to decide the direction of ratation is by judging the current Accumulated Angle $Z_0$. With the definition in Equ. (3.17), Eqn. (3.16) could be re-defined as:

$$d_i = \begin{cases} +1 & if \quad y_i < 0 \quad or \quad Z_i < 0 \\ -1 & if \quad y_i >= 0 \quad or \quad Z_i \geq 0 \end{cases} \tag{3.18}$$

Now, both $y_i$ and $Z_i$ are consistent with the rotation direction $d_i$. The sum of an infinite number of iterative rotation angles would be equal to $-Z_0$ [Equ. (3.19)].

$$Z_0 = -\sum_{i=0}^{+\infty} d_i \cdot arctan(2^{-i}) \tag{3.19}$$

With Equation (3.14), (3.15),(3.17) and Equation (3.18), the CORDIC algorithm in rotation mode is completely described. Because $arctan(2^0) = 45°$ is add/subtract in the 1st iteration, the CORDIC approach is originally applicable for angles within $-\pi/2$ and $\pi/2$. But trigonometric (sin/cos) is symmetric from quadrant to quadrant. That makes it easy to extend the range to within 0 and $2\pi$.

Table 3.3 continues the iterative process.

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Table 3.3: The completed procedure of CORDIC iteration

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Vector Indicator | $X_i$ | $Y_i$ | $d_i$ | $Z_i + d_i \cdot arctan(2^{-i})$ | $\sum_0^i d_i \cdot arctan(2^{-i})$ | $i$ | $2^{-i}$ | $arctan(2^{-i})$ |
| X0,Y0 | 0.920505 | 0.390731 | -1 | 23 | -45 | 0 | 1 | 45 |
| X1,Y1 | 1.311235982 | -0.52977372 | 1 | -22 | -18.43494882 | 1 | 0.5 | 26.56505 |
| X2,Y2 | 1.576122844 | 0.125844266 | -1 | 4.565051177 | -32.47119229 | 2 | 0.25 | 14.03624 |
| X3,Y3 | 1.607583911 | -0.26818645 | 1 | -9.471192291 | -25.34617594 | 3 | 0.125 | 7.12502 |
| X4,Y4 | 1.641107217 | -0.06723846 | 1 | -2.346175942 | -21.76984157 | 4 | 0.0625 | 3.57633 |
| X5,Y5 | 1.64530962 | 0.035330745 | -1 | 1.230158433 | -23.55975218 | 5 | 0.03125 | 1.78991 |
| X6,Y6 | 1.646413706 | -0.01608518 | 1 | -0.559752175 | -22.66457846 | 6 | 0.015625 | 0.89517 |
| X7,Y7 | 1.646665037 | 0.009640033 | -1 | 0.335421535 | -23.11219264 | 7 | 0.0078125 | 0.44761 |
| X8,Y8 | 1.64674035 | -0.00322454 | 1 | -0.112192636 | -22.88838214 | 8 | 0.00390625 | 0.22381 |
| X9,Y9 | 1.646752945 | 0.003208042 | -1 | 0.111617865 | -23.00028781 | 9 | 0.001953125 | 0.11191 |
| X10,Y10 | 1.646759211 | -8.27E-06 | 1 | -0.000287813 | -22.94433492 | 10 | 0.000976563 | 0.05595 |
| X11,Y11 | 1.646759219 | 0.001599891 | -1 | 0.055665079 | -22.97231137 | 11 | 0.000488281 | 0.02798 |
| X12,Y12 | 1.64676 | 0.00079581 | -1 | 0.027688627 | -22.9862996 | 12 | 0.000244141 | 0.01399 |
| X13,Y13 | 1.646760195 | 0.000393768 | -1 | 0.0137004 | -22.99329371 | 13 | 0.00012207 | 0.00699 |
| X14,Y14 | 1.646760243 | 0.000192748 | -1 | 0.006706286 | -22.99679077 | 14 | 6.10E-05 | 0.0035 |
| X15,Y15 | 1.646760255 | 9.22E-05 | -1 | 0.003209229 | -22.9985393 | 15 | 3.05E-05 | 0.00175 |
| X16,Y16 | 1.646760257 | 4.20E-05 | -1 | 0.001460701 | -22.99941356 | 16 | 1.53E-05 | 0.00087 |

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**Paragraph Test Example 1** The structure is directly described by schematics in Figure 3.6

. The branch of $X(i)$ representing the Equation 3.14, the branch of $Y(i)$ that corresponds

to the Equation 3.15. Equation 3.17 is mapped to the 3rd branch with $Z(i)$. Table 3.3 can

be referred to for a better understanding of the whole process.
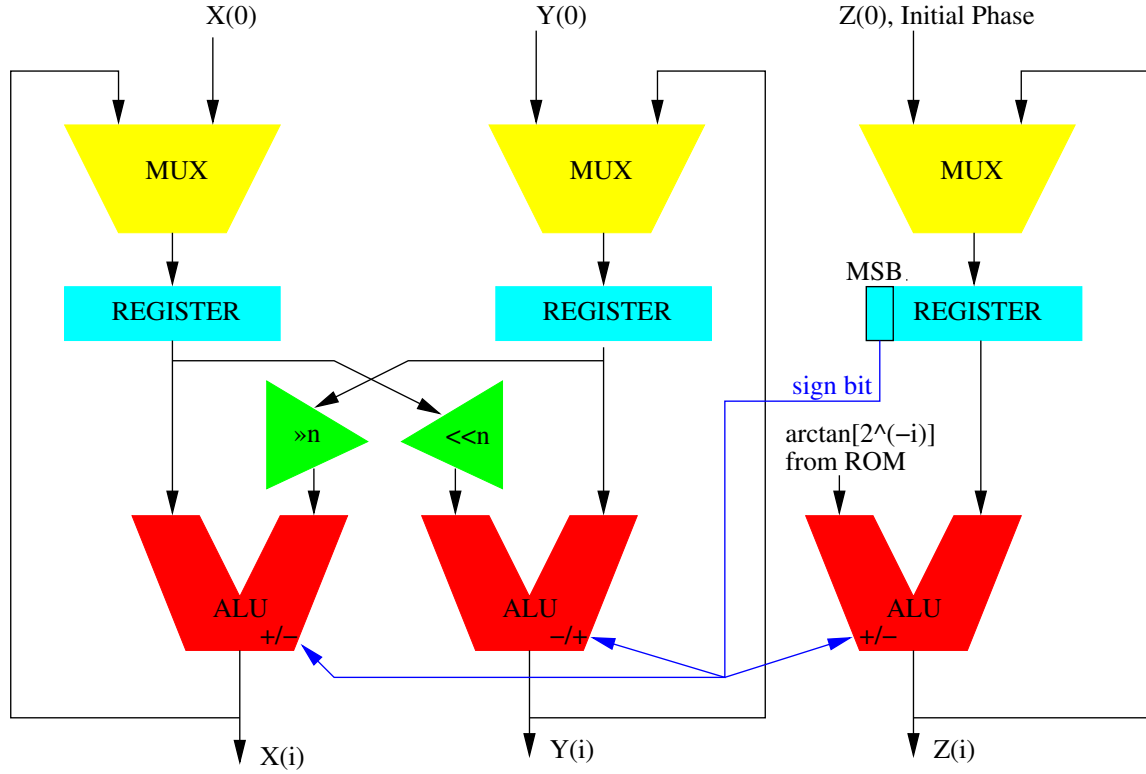


Figure 3.6 : Example Of Bit Parallel Iterative CORDIC
[Picture is from `http://goo.gl/AwCnb`, re-draw for this thesis template]

The ROM address to obtain $arctan[2^{-i}]$ in the Z branch above.

**Paragraph Test Example 2** Test paragraph without meaningful text. As shown in Figure

3.7 . Several simplifications become possible here.
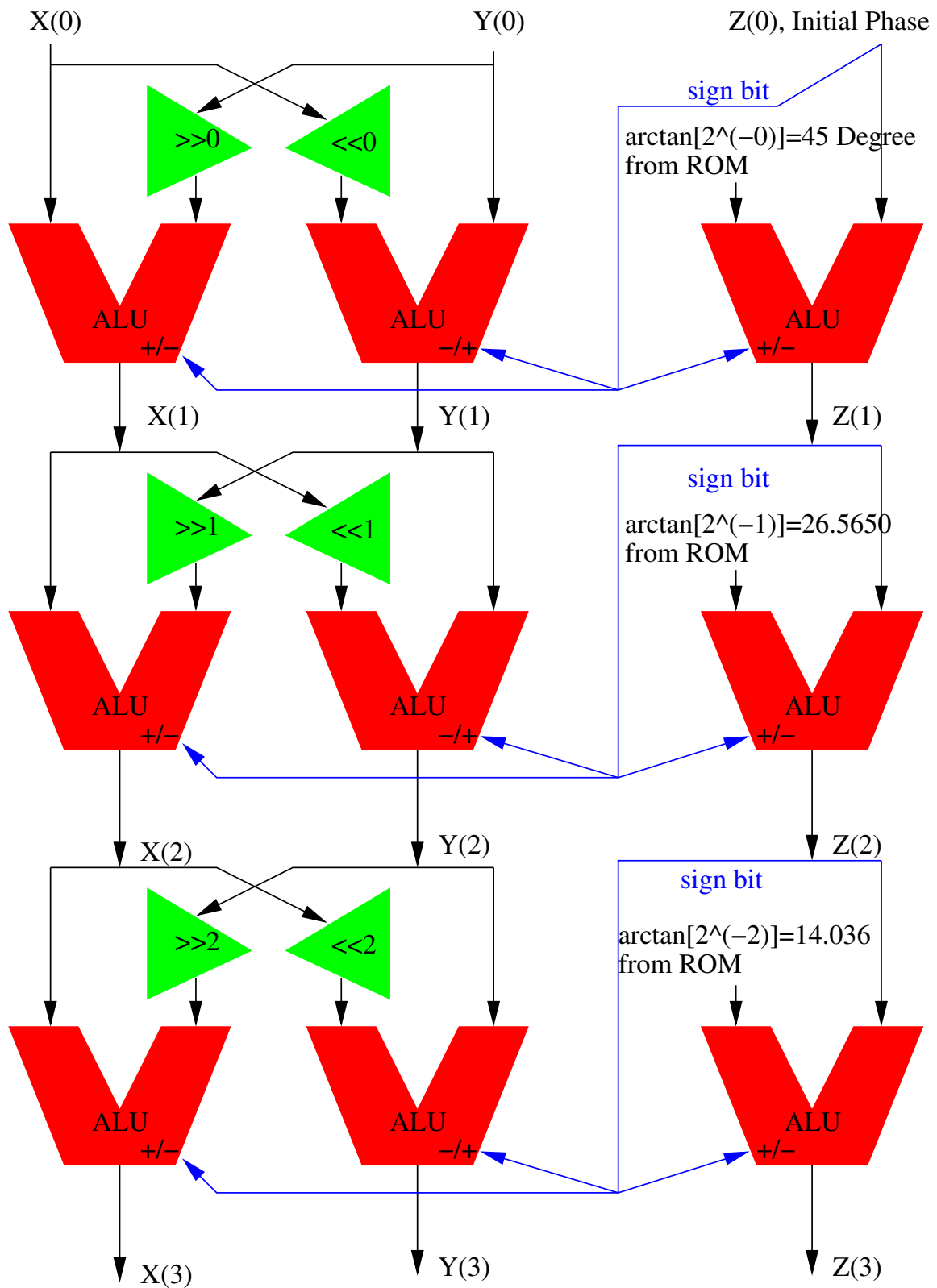
Figure 3.7 : Bit Parallel Unrolled CORDIC

[Picture comes from `http://goo.gl/AwCnb`, re-draw for this thesis template]

### 3.3.3 Subsection Test Example I Forget

### 3.3.4 Section Summary

**Phase To (X, Y)**

I would recommend to put some text between section title and equation.

$$d_i = \begin{cases} +1 & if \quad y_i < \phi \\ -1 & if \quad y_i \geq \phi \end{cases} \qquad (3.20)$$
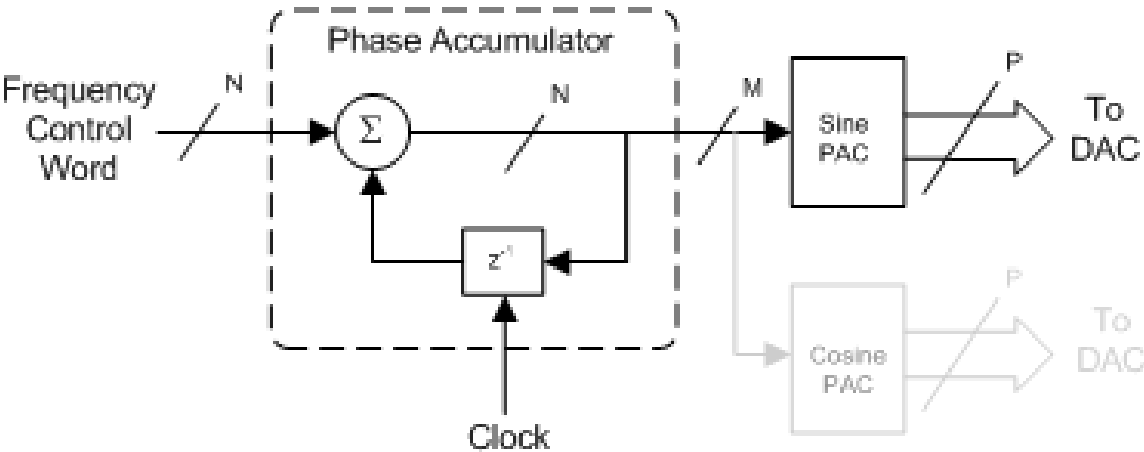


Figure 3.8 : Example Picture
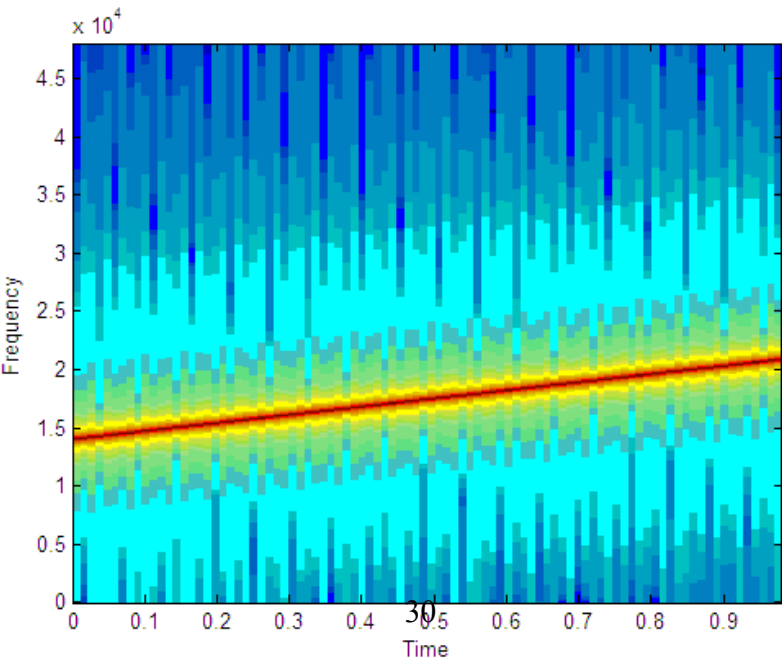


Figure 3.9 : Matlab Output Example

Test Text between equations. After the specific iteration round is reached, like i = 16, the value in register of X and Y, after multiplication by K factor, are equal to $cos(\phi)$ and $sin(\phi)$. Table 3.5 shows the steps in detail for calculating $(cos(\phi), sin(\phi))$ from phase $\phi$. In that case, The degree or phase targeted is a **known** value, which is 23 degree before calculation. The column of 4 is decided by the Equ. (3.21).

$$d_i = \begin{cases} +1 & if \quad y_i < 23 \\ -1 & if \quad y_i \geq 23 \end{cases}$$ (3.21)

**(X, Y) To Phase**

Table 3.4 can be referred for this procedure. The only difference from Table 3.5 to this is the calculation of $d_i$ is decided by the positive/negative of $y_i$ which shows in Equation 3.16.

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Table 3.4: (X,Y) To Phase CORDIC calculation

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Vector Indicator | $X_i$ | $Y_i$ | $d_i$ | $Z_i + d_i \cdot arctan(2^{-i})$ | $\sum_0^i d_i \cdot arctan(2^{-i})$ | i | $2^{-i}$ | $arctan(2^{-i})$ |
| X0,Y0 | 0.920505 | 0.390731 | -1 | 23.000 | -45 | 0 | 1 | 45.00000 |
| X1,Y1 | 1.311235982 | -0.52977372 | 1 | -22 | -18.43494882 | 1 | 0.5 | 26.56505 |
| X2,Y2 | 1.576122844 | 0.125844266 | -1 | 4.565051177 | -32.47119229 | 2 | 0.25 | 14.03624 |
| X3,Y3 | 1.607583911 | -0.26818645 | 1 | -9.471192291 | -25.34617594 | 3 | 0.125 | 7.12502 |
| X4,Y4 | 1.641107217 | -0.06723846 | 1 | -2.346175942 | -21.76984157 | 4 | 0.0625 | 3.57633 |
| X5,Y5 | 1.64530962 | 0.035330745 | -1 | 1.230158433 | -23.55975218 | 5 | 0.03125 | 1.78991 |
| X6,Y6 | 1.646413706 | -0.01608518 | 1 | -0.559752175 | -22.66457846 | 6 | 0.015625 | 0.89517 |
| X7,Y7 | 1.646665037 | 0.009640033 | -1 | 0.335421535 | -23.11219264 | 7 | 0.0078125 | 0.44761 |
| X8,Y8 | 1.64674035 | -0.00322454 | 1 | -0.112192636 | -22.88838214 | 8 | 0.00390625 | 0.22381 |
| X9,Y9 | 1.646752945 | 0.003208042 | -1 | 0.111617865 | -23.00028781 | 9 | 0.001953125 | 0.11191 |
| X10,Y10 | 1.646759211 | -8.2721E-06 | 1 | -0.000287813 | -22.94433492 | 10 | 0.000976563 | 0.05595 |
| X11,Y11 | 1.646759219 | 0.001599891 | -1 | 0.055665079 | -22.97231137 | 11 | 0.000488281 | 0.02798 |
| X12,Y12 | 1.64676 | 0.00079581 | -1 | 0.027688627 | -22.9862996 | 12 | 0.000244141 | 0.01399 |
| X13,Y13 | 1.646760195 | 0.000393768 | -1 | 0.0137004 | -22.99329371 | 13 | 0.00012207 | 0.00699 |
| X14,Y14 | 1.646760243 | 0.000192748 | -1 | 0.006706286 | -22.99679077 | 14 | 6.10352E-05 | 0.00350 |
| X15,Y15 | 1.646760255 | 9.22377E-05 | -1 | 0.003209229 | -22.9985393 | 15 | 3.05176E-05 | 0.00175 |
| X16,Y16 | 1.646760257 | 4.19826E-05 | -1 | 0.001460701 | -22.99941356 | 16 | 1.52588E-05 | 0.00087 |

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Table 3.5: Phase to (X,Y) CORDIC calculation

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Vector Indicator | $X_i$ | $Y_i$ | $d_i$ | $Z_i + d_i \cdot arctan(2^{-i})$ | $\sum_0^i d_i \cdot arctan(2^{-i})$ | $i$ | $2^{-i}$ | $arctan(2^{-i})$ |
| X0,Y0 | 1 | 0 | 1 | 0 | 45 | 0 | 1 | 45 |
| X1,Y1 | 1 | 1 | -1 | 45 | 18.4349488 | 1 | 0.5 | 26.56505 |
| X2,Y2 | 1.5 | 0.5 | 1 | 18.43495 | 32.4711923 | 2 | 0.25 | 14.03624 |
| X3,Y3 | 1.375 | 0.875 | -1 | 32.47119 | 25.3461759 | 3 | 0.125 | 7.125016 |
| X4,Y4 | 1.484375 | 0.703125 | -1 | 25.34618 | 21.7698416 | 4 | 0.0625 | 3.576334 |
| X5,Y5 | 1.52832 | 0.610352 | 1 | 21.76984 | 23.5597522 | 5 | 0.03125 | 1.789911 |
| X6,Y6 | 1.509247 | 0.658112 | -1 | 23.55975 | 22.6645785 | 6 | 0.015625 | 0.895174 |
| X7,Y7 | 1.51953 | 0.63453 | 1 | 22.66458 | 23.1121926 | 7 | 0.0078125 | 0.447614 |
| X8,Y8 | 1.514573 | 0.646401 | -1 | 23.11219 | 22.8883821 | 8 | 0.0039063 | 0.223811 |
| X9,Y9 | 1.517098 | 0.640485 | 1 | 22.88838 | 23.0002878 | 9 | 0.0019531 | 0.111906 |
| X10,Y10 | 1.515847 | 0.643448 | -1 | 23.00029 | 22.9443349 | 10 | 0.0009766 | 0.055953 |
| X11,Y11 | 1.516475 | 0.641967 | 1 | 22.94433 | 22.9723114 | 11 | 0.0004883 | 0.027976 |
| X12,Y12 | 1.516162 | 0.642708 | 1 | 22.97231 | 22.9862996 | 12 | 0.0002441 | 0.013988 |
| X13,Y13 | 1.516005 | 0.643078 | 1 | 22.9863 | 22.9932937 | 13 | 0.0001221 | 0.006994 |
| X14,Y14 | 1.515926 | 0.643263 | 1 | 22.99329 | 22.9967908 | 14 | 6.104E-05 | 0.003497 |
| X15,Y15 | 1.515887 | 0.643356 | 1 | 22.99679 | 22.9985393 | 15 | 3.052E-05 | 0.001749 |
| X16,Y16 | 1.515867 | 0.643402 | 1 | 22.99854 | 22.9994136 | 16 | 1.526E-05 | 0.000874 |

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Table 3.6: Phase Control Word

| | | Phase Control Word(Binary) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency | Phase Control Word | Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| 48000 | 16384 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1000 | 341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 8000 | 2731 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| 14000 | 4779 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21000 | 7168 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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A simple paragraph of Verilog code is below in verbatim.

```
Always@(posedge LRCK)

      Begin

       Counter = Counter + 1

       If (Counter == 40)

       Begin

        Counter = 0

       Phase_control_word = Phase_Control_word + 1

        If (phase_control_word >= 7168)

        Begin

        Phase_control_word =4778

     end

      end

     end
```

## 3.4   Section Test Example 3

Test section for toc display only.

### 3.4.1   Subsection Test 1

Test subsection for toc display only.

### 3.4.2   Subsection Test 2

Test subsection for toc display only.

### 3.4.3 Subsection Test 3

Test subsection for toc display only.

### 3.4.4 Subsection Test 4

Test subsection for toc display only.

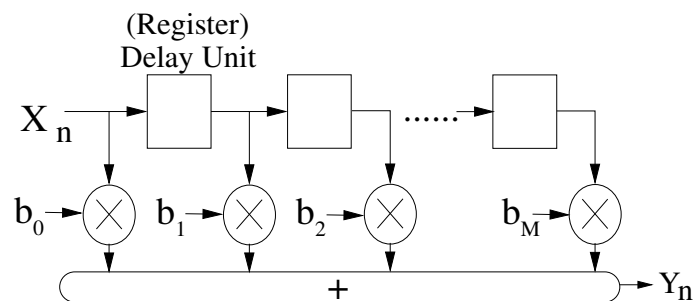## 3.5 Section Test Example 4

Test subsection for toc display only.



Figure 3.10 : Example of FIR Filter
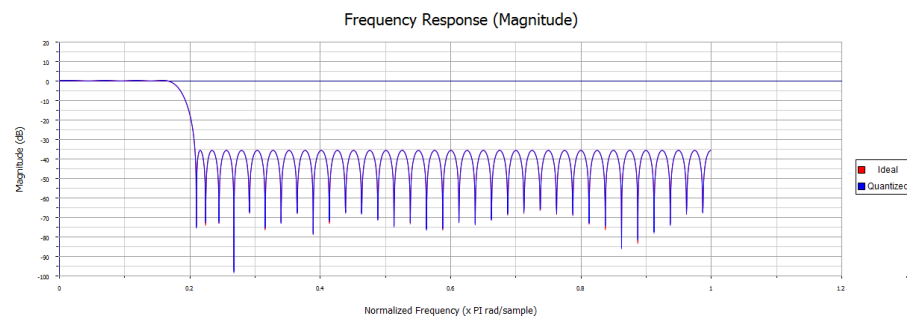[Test Picture for lof display purpose only.]



Figure 3.11 : Low Pass FIR Filter Spectrum Characterization
h=firpm(80, [0 8 10 48]/48, [1 1 0 0]); [Test Picture for lof display purpose only.]
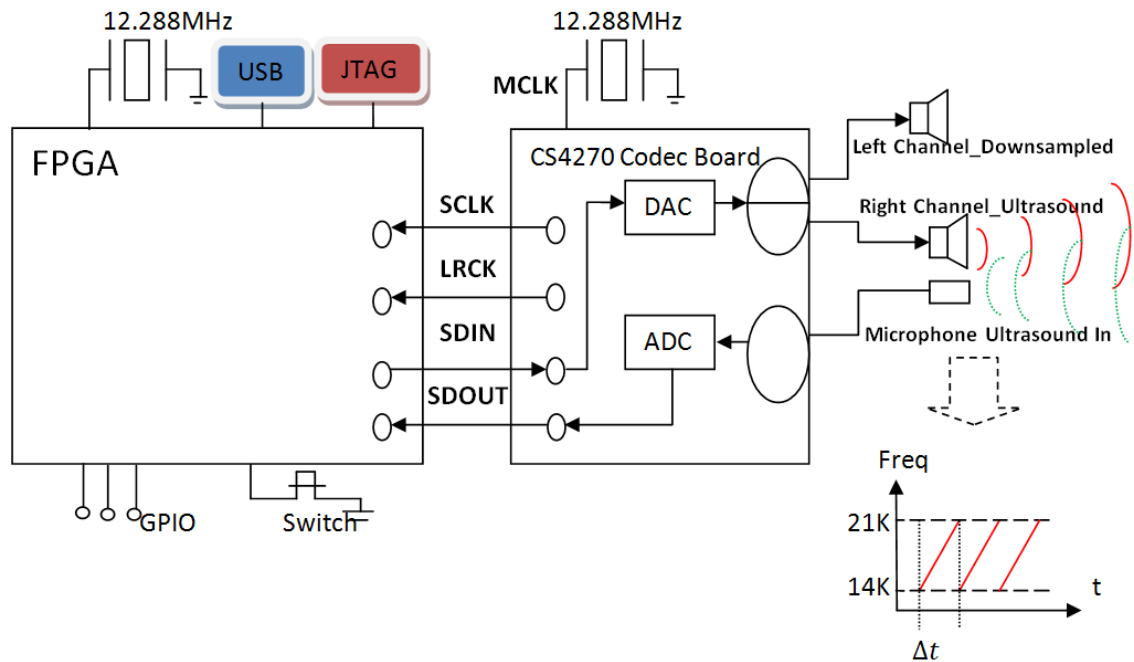
# 4    SUMMARY AND CONCLUSIONS



Figure 4.1 : Example of Hardware System Overview
[Test Picture for lof display test purpose only.]

Figure 4.1  gives the simplified top level hardware blocks.

## 4.1    Section Test Unknown Part

Section here is to test toc display purpose only.

## 4.2    Section Test Unknown Part 1

Section here is to test toc display purpose only.

## 4.3 Section Test Unknown Part 2

Section here is to test toc display purpose only.
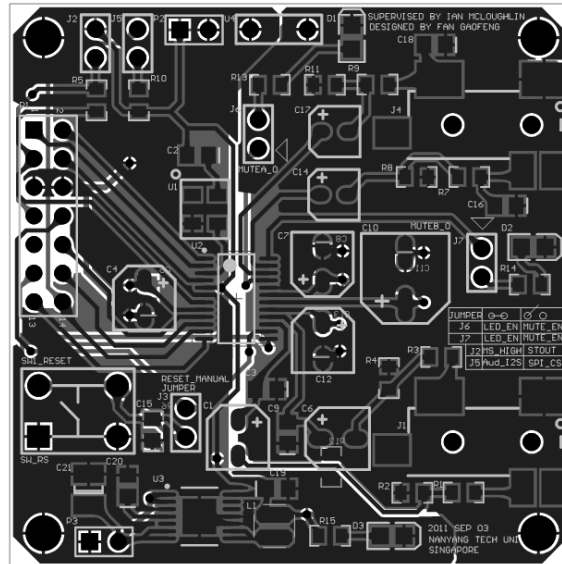
## 4.4 Section Test Unknown Part 3



Figure 4.2 : Layout
[Test Picture for lof display test purpose only.]

## 4.5 Section Test Unknown Part 5

Section here is to test toc display purpose only.

## 4.6 Section Test Unknown Part 6

Section here is to test toc display purpose only.

## 4.7 Section Test Unknown Part 7

Section here is to test toc display purpose only.

# REFERENCES

[1] I. M. Ahmadi F, ``Method and apparatus for mouth state determination using acoustic information,'' 16,Feb,2012.

[2] P. Vary and R. Martin, *Digital Speech Transmission:Enhancement, Coding and Error Concealment*. John Wiley & Sons Ltd, West Sussex, 2006.March.

[3] R. Andraka, ``A survey of cordic algorithms for fpga based computers,'' in *Proceedings of the 1998 ACM/SIGDA sixth international symposium on Field programmable gate arrays*, FPGA '98, (New York, NY, USA), pp. 191--200, ACM, 1998.

[4] M. Azzarello, B. Amy De La Breteque, R. Garrel, and A. Giovanni, ``Determination of oesophageal speech intelligibility using an articulation assessment,'' *Revue de laryngologie otologie rhinologie*, vol. 126, no. 5, pp. 327--334, 2005.

[5] F. Beritelli, S. Casale, G. Ruggeri, and S. Serrano, ``Performance evaluation and comparison of g.729/amr/fuzzy voice activity detectors,'' 2002.

[6] J. H. Boyd, M. Varvares, and S. Fitzmaurice, ``Vocal rehabilitation after laryngectomy.,'' *Archives of Otolaryngology*, vol. 2, no. 3, pp. 39--44, 1985.

[7] J. F. Carew and J. P. Shah, ``Advances in multimodality therapy for laryngeal cancer,'' *CA: A Cancer Journal for Clinicians*, vol. 48, no. 4, pp. 211--228, 1998.

[8] V. Callanan, P. Gurr, D. Baldwin, M. White-Thompson, J. Beckinsale, and J. Bennett, ``Provox valve use for post-laryngectomy voice rehabilitation.,'' *The Journal of laryngology and otology*, vol. 109, no. 11, pp. 1068--1071, 1995.

# A   MISCELLANEOUS

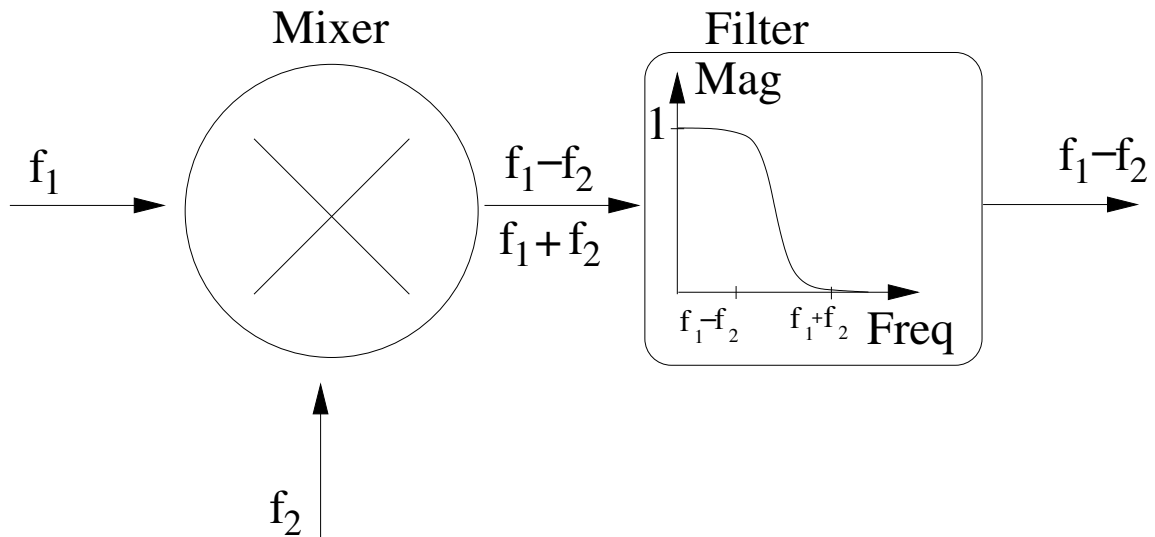## A.1   Figures/Tables in Appendix



Figure A.1: Test Picture for lof (List of Figures) Display Test Purpose Only
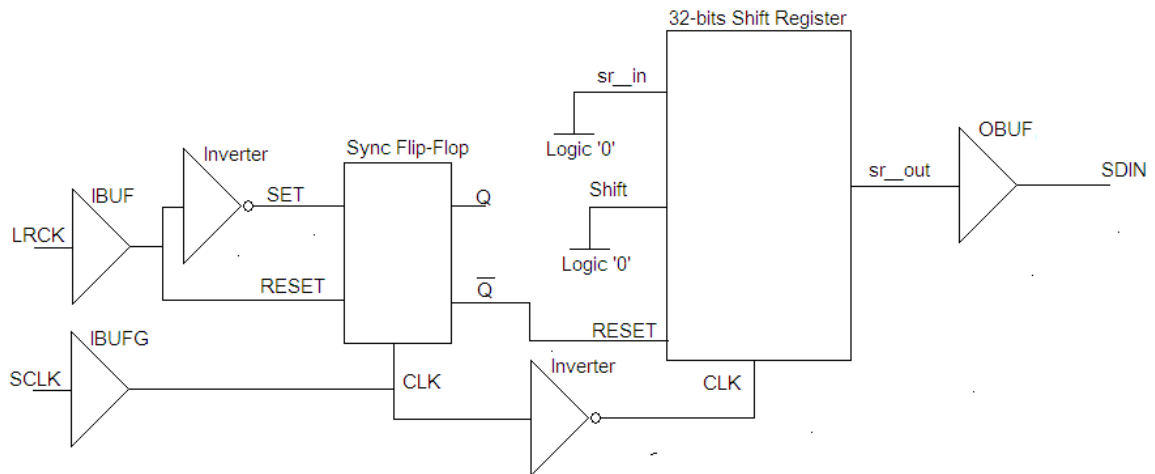[The file used is in PDF format.]



Figure A.2: CS4270 Test Bench 1 FPGA Design Diagram
[Picture is for test display purpose only. No meaning.]

### A.1.1 TEST1
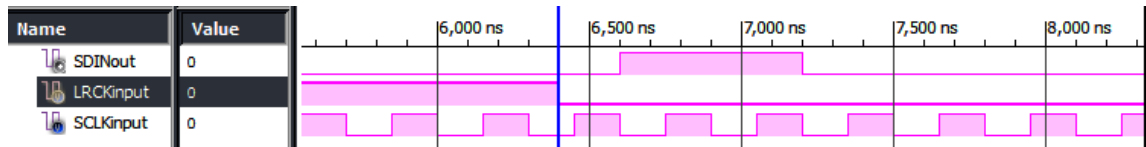
Test subsection for toc display purpose only.



Figure A.3: Behavioral simulation for **TEST1**
[Picture is for test display purpose only. No meaning.]

### A.1.2 TEST2

```
begin

if (shift == 1'b1)

begin

sr[(N-1):1] <= sr[(N-2):0];

sr[0] <= sr_in;

end

else

begin

sr[(N-1):1] <= sr[(N-2):0];

sr[0] <= sr[(N-1)];

end

end
```

## A.2  Random Pictures and Test

Section here is to test toc display purpose only.

## A.3  Misc Test

Section here is to test toc display purpose only.

# B   SOURCE CODE

There is certain trick to display the third page word `Page` in the toc. The code from package afterpage below needs to specifically used at certain places. Please read the source code in this Appendix.tex file to locate the position of the code below.

```
\TAMUTocAddWordPage
```

## B.1   Misc Test 2

Section here is to test toc display purpose only.

## B.2   Misc Test 3

Section here is to test toc display purpose only.

## B.3   Resource Usage

Design Summary (This page shows how to use landscape format in Appendix.)

--------------

Design Summary:

Number of errors:      0

Number of warnings:     0

Logic Utilization:

  Number of Slice Flip Flops:        3,899 out of  33,280    11%

  Number of 4 input LUTs:            3,717 out of  33,280    11%

Logic Distribution:

  Number of occupied Slices:         2,198 out of  16,640    13%

    Number of Slices containing only related logic:   2,198 out of   2,198 100%

    Number of Slices containing unrelated logic:         0 out of   2,198    0%

      *See NOTES below for an explanation of the effects of unrelated logic.

  Total Number of 4 input LUTs:      3,890 out of  33,280    11%

Table B.1: Summary of Equipment Used

| NAME | NO. | COMMENT |
| --- | --- | --- |
| Tektronix TDS7704B Scope | 1 | 7GHz, 20GSa/s time-equivallent sampling oscilloscope |
| Tektronix P7240 Probe | 2 | 4GHz Single Ended Active Probe(High Impedance) |
| Agilent 81130A Function Generator | 1 | 2 CHs Signal Generator |
| Xilinx Spartan-3A DSP 1800A Demo Board | 1 | http://goo.gl/Svvpy |

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