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# Solar Cell Characteristics and SPICE Model

*A Minor Project Report (18EC81)*

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**In partial fulfillment of the requirements for the degree of**

**Bachelor of Engineering in**

**Electronics and Communication Engineering**

**2021-22**

# RV College of Engineering®, Bengaluru

*(Autonomous institution affiliated to VTU, Belagavi)*

**Department of Electronics and Communication Engineering**

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## CERTIFICATE

Certified that the minor project (18EC81)work titled ***Solar Cell Characteristics and SPICE Model*** is carried out by **Pavan Kumar C Banasode** (**1RV21EC116**) and **Pratham G** (**1RV21EC128**) who are bonafide students of RV College of Engineering, Bengaluru, in partial fulfillment of the requirements for the degree of **Bachelor of Engineering** in **Electronics and Communication Engineering** of the Visvesvaraya Technological University, Belagavi during the year 2021-22. It is certified that all corrections/suggestions indicated for the Internal Assessment have been incorporated in the minor project report deposited in the departmental library. The minor project report has been approved as it satisfies the academic requirements in respect of minor project work prescribed by the institution for the said degree.

| Signature of Guide | Signature of Head of the Department | Signature of Principal |
|---|---|---|
| Mr. Ramavenkateshwaran | Dr. K S Geetha | Dr. K. N. Subramanya |

**External Viva**

| Name of Examiners | Signature with Date |
|---|---|
| 1. | |
| 2. | |

# DECLARATION

We, **Pavan Kumar C Banasode** and **Pratham G** students of sixth semester B.E., Department of Electronics and Communication Engineering, RV College of Engineering, Bengaluru, hereby declare that the minor project titled '**Solar Cell Characteristics and SPICE Model**' has been carried out by us and submitted in partial fulfilment for the award of degree of **Bachelor of Engineering** in **Electronics and Communication Engineering** during the year 2021-22.

Further we declare that the content of the dissertation has not been submitted previously by anybody for the award of any degree or diploma to any other university.

We also declare that any Intellectual Property Rights generated out of this project carried out at RVCE will be the property of RV College of Engineering, Bengaluru and we will be one of the authors of the same.

Place: Bengaluru

Date:

Name Signature

1. Pavan Kumar C Banasode(1RV21EC116)
2. Pratham G(1RV21EC128)

# ACKNOWLEDGEMENT

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Lastly, we take this opportunity to thank our family members and friends who provided all the backup support throughout the project work.

# ABSTRACT

Highlights of significant contributions: One page with 3 to 4 paragraphs

Paragraph 1: Importance and relevance of Topic, reported issues and limitations of the topic in performance or computation etc, issues involved in those limitations, need for addressing those issues and a short note on how that is addressed in this report.

Paragraph 2 Objectives of this work, short note on algebraic methods used and formulations achieved, computational procedures developed. Integrated Circuit (IC).

Paragraph 3: Description of simulation procedure including SW tools used and choice of test cases. Short note on results achieved and significant highlights of improvements if any in terms of percentage , for example the architecture presented in this report shows 22 % improve in power consumption as compared to the previously reported articles. IC

Paragraph 4:The last para needed only if emulation (after simulation) or Hardware developed to validate simulation results in para 3.

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# Chapter 1

# Introduction to Analog and Digital converters

# CHAPTER 1

# INTRODUCTION TO ANALOG AND DIGITAL CONVERTERS

## 1.1 Introduction

The title of the project can be introduced in this section. This section should neatly elaborate the context of the project, the relevance of the area chosen and the title. You can bring a brief history and arrive at the title of the project. Use appropriate number of paragraphs within this section.

You are allowed to use figures or diagrams which can help in introducing the topic acknowledging the source. For example , if you are introducing a particular topic, an appropriate figure can be used. The figure should be referenced in the text as Figure. 1.1

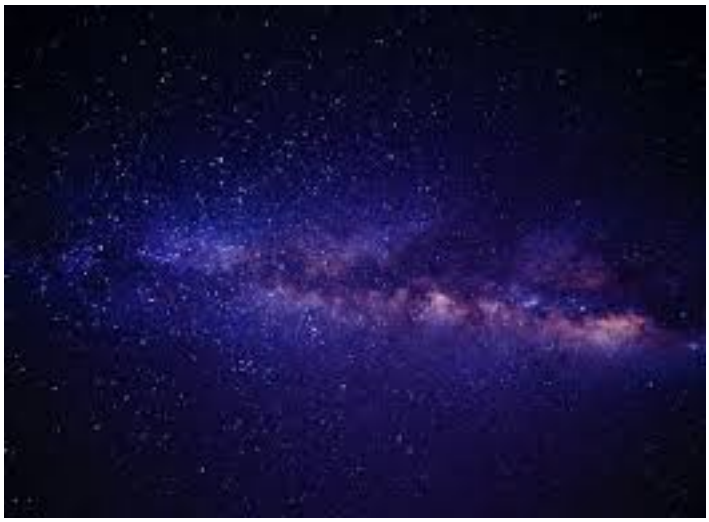

Figure 1.1: Sample picture of universe

These guidelines are provided to formally expose you to the various ethical and technical issues involved in writing up your work and the format you are required to adhere to while submitting your project report.

## 1.2 Motivation

Brief the motivation of selecting your project title. You can elaborate the challenges in the specific area, relevance and importance of the chosen topic.

## 1.3 Problem statement

Define the problem statement in this section, in one paragraph.

## 1.4 Objectives

The objectives of the project are

1. To design a pipelined ADC for audio frequency range
2. List all the objectives in the above format , starting with "To"
3. Limit the number of objectives to a maximum of three

## 1.5 Literature Review

A literature review is a text of a scholarly paper, which includes the current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic. Literature reviews are secondary sources, and do not report new or original experimental work. Most often associated with academic-oriented literature, such reviews are found in academic journals, and are not to be confused with book reviews that may also appear in the same publication. Literature reviews are a basis for research in nearly every academic field . A narrow-scope literature review may be included as part of a peer-reviewed journal article presenting new research, serving to situate the current study within the body of the relevant literature and to provide context for the reader. In such a case, the review usually precedes the methodology and results sections of the work.

### 1.5.1 Sample

The main types of literature reviews are: evaluative, exploratory, and instrumental. A fourth type, the systematic review, is often classified separately, but is essentially a literature review focused on a research question, trying to identify, appraise, select and synthesize all high-quality research evidence and arguments relevant to that question. A meta-analysis is typically a systematic review using statistical methods to effectively combine the data used on all selected studies to produce a more reliable result.

**Review types**

The main types of literature reviews are: evaluative, exploratory, and instrumental. A fourth type, the systematic review, is often classified separately, but is essentially a

literature review focused on a research question, trying to identify, appraise, select and synthesize all high-quality research evidence and arguments relevant to that question. A meta-analysis is typically a systematic review using statistical methods to effectively combine the data used on all selected studies to produce a more reliable result.

**Process and product**

Distinguish between the process of reviewing the literature and a finished work or product known as a literature review. The process of reviewing the literature is often ongoing and informs many aspects of the empirical research project. All of the latest literature should inform a research project. Scholars need to be scanning the literature long after a formal literature review product appears to be completed.

**Page limitation**

A careful literature review is usually 15 to 30 pages and could be longer. The process of reviewing the literature requires different kinds of activities and ways of thinking and link the activities of doing a literature review with Benjamin Bloom's revised taxonomy of the cognitive domain (ways of thinking: remembering, understanding, applying, analysing, evaluating, and creating).

This section should contain the review of the literature in the past.You should review a minimum of 10 papers from standard reference journals. Kindly avoid local conference papers and papers from predatory journals. Kindly consult with your guide and finalize papers to be considered for review before adding in this section.Report the major observations and findings from each paper in one paragraph in the format given below.

proposed various techniques for adders and multipliers.Add the reference papers to the bibliography section using Jabref and cite it here using the instructions given in further chapters.

**Plagiarism**

To use someone else's exact words without quotation marks and appropriate credit, or to use the unique ideas of someone else without acknowledgement, is known as plagiarism. In publishing, plagiarism is illegal; in other circumstances, it is, at the least, unethical. You may quote or paraphrase the words or ideas of another if you document your source. Although you need not enclose the paraphrased material in quotation marks, you must document the source.

Paraphrased ideas are taken from someone else whether or not the words are identical. Paraphrasing a passage without citing the source is permissible only when the information paraphrased is common knowledge in a field. (Common knowledge refers to historical, scientific, geographical, technical, and other type of information on a topic readily available in handbooks, manuals, atlases and other references).

**How to add Reference**

Use `Jabref` which will help in adding the reference in a separate file, from which one can use `\citep\{\}` command to add reference. A sample, referring to a textbook would look something like this,[1].

## 1.6 Brief Methodology of the project

Discuss about the methodology you identified to execute the objectives of your project in brief. Methodology is a system of practices, techniques, procedures, and rules used to execute a particular project. You can elaborate the methodology in a later chapter. Here you can present in the form of a flow diagram and explain the methodology in a paragraph.

## 1.7 Assumptions made / Constraints of the project

List the assumptions made for the execution of the project in this section. You can also elaborate on the major constraints of the project. This section should clearly state under what conditions your project is valid. It is mandatory to have this section in your project report.

## 1.8 Organization of the report

This report is organized as follows. Write the discussions in each chapter. A sample is as follows.

- Chapter 2 discusses the fundamentals of ADC and the performance parameters for evaluation.
- Chapter 3 discusses .
- Chapter 4 discusses .
- Chapter 5 discusses .

- Chapter 6 discusses .

.

# Chapter 2

# Theory and Fundamentals of Analog to Digital converter

# CHAPTER 2

# THEORY AND FUNDAMENTALS OF ANALOG TO DIGITAL CONVERTER

From Chapter 2 onwards, every chapter should start with an introduction paragraph. This paragraph should brief about the flow of the chapter. This introduction can be limited within 4 to 5 sentences. The chapter heading should be appropriately modified (a sample heading is shown for this chapter).But don't start the introduction paragraph in the chapters 2 to end with "This chapter deals with....". Instead you should bring in the highlights of the chapter in the introduction paragraph.

## 2.1 Contents of this chapter

This chapter should discuss about the prerequisite learnings before the execution of the project. Organise and elaborate the theory and necessary fundamentals required for the execution of the project. You can use `\subsections` and `subsubsections` in this chapter.

## 2.2 Contents of this chapter

If a specific programming language is required for the project, a section can be allotted in this chapter to discuss it.

## 2.3 Contents of this chapter

Tools used could be another possible section to discuss about the software tools used in the work.

## 2.4 Contents of this chapter

The details in this chapter can be added in consultation with the project guide. For an internship based projects, subsections can be modified accordingly.

## 2.5 Use of Acronyms and Glossaries

Acronyms are nothing but the short form of regular repeated word. Say for example, you have a repeat word "Integrated Circuits" and you want to use a short form for it as "IC". For which you have to first define the word and use it wherever you wanted to refer it.

First, let's look at the definition, which has to be entered in `Glossaries.tex` under `CoverPages` directory.

```
%\newacronym{<Ref>}{<Short-Form>}{<Expanded word>}
\newacronym{ic}{IC}{Integrated Circuits}
```

In order to use the defined acronym, use the commands `\gls{<Ref>}` as shown below

As an example, call the definition with `\gls{ic}` and the outcome of it is reflected as, Integrated Circuit (IC).

Note: For the First time, the expanded form appears along with the Short-form definition inside parenthesis. But when the `\gls{}` is repeated, only Short-form appears inside the parenthesis.

Now, let's look at the definition of symbols. Follow the syntax to define the symbol first, inside `Glossaries.tex` under `CoverPages` directory.

```
%\newglossaryentry{<Ref>}{name=<Symbol>, description={<description about the symbol>}
\newglossaryentry{rc}{name=$\tau$, description={Time constant}, type=symbolList}
```

As an example, the rate of change is defined with `\gls{rc}` and the outcome of it is reflected as, the rate of change is defined with $\tau$.

**The chapters should not end with figures, instead bring the paragraph explaining about the figure at the end followed by a summary paragraph.**

After elaborating the various sections of the chapter (From Chapter 2 onwards), a summary paragraph should be written discussing the highlights of that particular chapter. This summary paragraph should not be numbered separately. This paragraph should connect the present chapter to the next chapter.

# Chapter 3

# Design of Pipelined Analog to Digital converter

# CHAPTER 3

# DESIGN OF PIPELINED ANALOG TO DIGITAL CONVERTER

From Chapter 2 onwards, every chapter should start with an introduction paragraph. This paragraph should brief about the flow of the chapter. This introduction can be limited within 4 to 5 sentences. The chapter heading should be appropriately modified (a sample heading is shown for this chapter).But don't start the introduction paragraph in the chapters 2 to end with "This chapter deals with....". Instead you should bring in the highlights of the chapter in the introduction paragraph.

## 3.1 Contents of this Chapter

This chapter should contain the following sections and subsections in detail.

1. Specifications for the Design
2. Pre analysis work for the design or Models used
3. Design methodology in detail
4. Design Equations
5. Experimental techniques (if any)

Apart from the aforementioned sections, you can add sections as per the requirements of the project in consultation with your guide.

## 3.2 Paraphrasing

When you paraphrase a written passage, you rewrite it to state the essential ideas in your own words. Because you do not quote your source word for word when paraphrasing, it is unnecessary to enclose the paraphrased material in quotation marks. However, the paraphrased material must be properly referenced because the ideas are taken from someone else whether or not the words are identical.

Ordinarily, the majority of the notes you take during the research phase of writing your report will paraphrase the original material. Paraphrase only the essential ideas. Strive to put original ideas into your own words without distorting them."

## 3.3 Quotations

When you have borrowed words, facts, or idea of any kind from someone else's work, acknowledge your debt by giving your source credit in footnote (or in running text as cited reference). Otherwise, you will be guilty of plagiarism. Also, be sure you have represented the original material honestly and accurately. Direct word to word quotations are enclosed in quotation marks."

**The chapters should not end with figures, instead bring the paragraph explaining about the figure at the end followed by a summary paragraph.**

After elaborating the various sections of the chapter (From Chapter 2 onwards), a summary paragraph should be written discussing the highlights of that particular chapter. This summary paragraph should not be numbered separately. This paragraph should connect the present chapter to the next chapter.

# Chapter 4

# Implementation of Pipelined Analog to Digital converter

# CHAPTER 4

# IMPLEMENTATION OF PIPELINED ANALOG TO DIGITAL CONVERTER

From Chapter 2 onwards, every chapter should start with an introduction paragraph. This paragraph should brief about the flow of the chapter. This introduction can be limited within 4 to 5 sentences. The chapter heading should be appropriately modified (a sample heading is shown for this chapter).But don't start the introduction paragraph in the chapters 2 to end with "This chapter deals with....". Instead you should bring in the highlights of the chapter in the introduction paragraph.

## 4.1 Contents of this chapter

This chapter should elaborate the following in detail.

1. Implementation details for hardware based projects
2. Top level Design for software based projects

You can add sections and sub sections to elaborate your project work done.

**The chapters should not end with figures, instead bring the paragraph explaining about the figure at the end followed by a summary paragraph.**

After elaborating the various sections of the chapter (From Chapter 2 onwards), a summary paragraph should be written discussing the highlights of that particular chapter. This summary paragraph should not be numbered separately. This paragraph should connect the present chapter to the next chapter.

# Chapter 5

# Results & Discussions

# CHAPTER 5

# RESULTS & DISCUSSIONS

From Chapter 2 onwards, every chapter should start with an introduction paragraph. This paragraph should brief about the flow of the chapter. This introduction can be limited within 4 to 5 sentences. The chapter heading should be appropriately modified (a sample heading is shown for this chapter).But don't start the introduction paragraph in the chapters 2 to end with "This chapter deals with....". Instead you should bring in the highlights of the chapter in the introduction paragraph.

## 5.1 Contents of this chapter

All the results obtained for your objectives should be discussed in this chapter. This chapter should contain the following sections as per the project.

1. Simulation results
2. Experimental results
3. Performance Comparison
4. Inferences drawn from the results obtained

All the figures should be properly explained by bringing the scenarios of the design done in the project. A detailed discussion of results obtained should be done in this chapter.

## 5.2 Tables in thesis

- All Table Caption should be in Sentence Case, TNR 10 Pt. It should be of the Format:
  - Table 1.1 Results of the experiment ....(Centered)
- It should be cited as Table 1.1.
- Caption should appear above the Table.
- Table Header and the entries should be of Font TNR 10 Pt, Justified.
- For wider Table, the page orientation can be Landscape.

- For Larger Table, it can run to pages and the header should be repeated for each page of the Table.
- Table must be adjusted to fit in the page and no single row is left out for a new page.

Sample Table 5.1 is given below for your reference,

Table 5.1: Country List

| **Country Name or Area Name** | **ISO ALPHA 2 Code** | **ISO ALPHA 3 Code** | **ISO numeric Code** |
|---|---|---|---|
| **Afghanistan** | AF | AFG | 004 |
| **Aland Islands** | AX | ALA | 248 |
| **Albania** | AL | ALB | 008 |
| **Algeria** | DZ | DZA | 012 |
| **American Samoa** | AS | ASM | 016 |
| **Andorra** | AD | AND | 020 |
| **Angola** | AO | AGO | 024 |

## 5.3 Math equation in thesis

All equation should be written using equation editor or using an equivalent tool.

- Equations should be numbered as : 1.1, 1.2 ...
- Equation should be Centered, 12 Pt, TNR.
- Equation number should be right Justified
- It should be cited as Eqn. 1.1.
- If the sentence starts by citing an equation, then it should be written as Equation 1.1 For example, Equation 5.1 states the Pythagoras theorem.

For example in Eqn. 5.1, The well known Pythagorean theorem $x^2 + y^2 = z^2$ was proved to be invalid for other exponents. Meaning the next equation has no integer solutions:

$$x^n + y^n = z^n \tag{5.1}$$

The mass-energy equivalence is described by the famous equation in Eqn. 5.2

$$E = mc^2 \tag{5.2}$$

discovered in 1905 by Albert Einstein.

**The chapters should not end with figures, instead bring the paragraph explaining about the figure at the end followed by a summary paragraph.**

After elaborating the various sections of the chapter (From Chapter 2 onwards), a summary paragraph should be written discussing the highlights of that particular chapter. This summary paragraph should not be numbered separately. This paragraph should connect the present chapter to the next chapter.

# Chapter 6

# Conclusion and Future Scope

# CHAPTER 6

# CONCLUSION AND FUTURE SCOPE

## 6.1 Conclusion

This chapter should not contain an introduction paragraph like other chapters. You can directly write conclusion of the work done under this section. Typically this section can have 3 to 4 paragraphs.

First paragraph should bring in the scenario of the project and every objective should be explained here.

Second paragraph should say how the objectives are implemented and achieved.

Last paragraph should draw the conclusions from each objective with quantitative results, performance improvement etc.

## 6.2 Future Scope

Briefly discuss the constraints and limitations of the project and state the possibilities of extending the work in future.

## 6.3 Learning Outcomes of the Project

- List the learning outcomes here
- List a minimum of 5 learning outcomes

# Appendix A

# Code

# APPENDIX A

# CODE

## A.1 First Appendix

You can use `tcblisting` for creating the code snippets. The following example illustrates how one can customize the `tcblisting` to achieve the `tcl` script. Similarly, one can use it for other programming language listing, including HDL.

```
# Since our design has a clock with name clk,
## specify that name under [get_port ]
create_clock -period 40 -waveform {0 20} [get_ports clk]

# Setting a 'delay' on the clock:
set_clock_latency 0.3 clk

# Setting up constraints on your I/P and O/P pins
set_input_delay 2.0 -clock clk [all_inputs]
set_output_delay 1.65 -clock clk [all_outputs]

# Set realistic 'loads' on each output pin
set_load 0.1 [all_outputs]

# Set 'maximum' fanin and fan-out for the input and output pins
set_max_fanout 1 [all_inputs]
set_fanout_load 8 [all_outputs]
```

# BIBLIOGRAPHY

[1] B. Razavi, *Design of Analog CMOS Integrated Circuits*. McGraw-Hill Education, 2000, ISBN: 978-0072380323.