Thesis Title

A Thesis Submitted for the Partial Fulfillment of the Requirements for the degree of Master of Technology

in

Dept. Name (Specialization: Specialization)

by

John / Jane Doe
Enrollment no.: 20XXYYYXXX

Under the guidance of

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CERTIFICATE

This is to certify that we have examined the thesis entitled "**Thesis Title** ", submitted by **John / Jane Doe** (Roll Number: *20XXYYYXXX*), a postgraduate student of **Department of Dept. Name** in partial fulfillment for the award of degree of **Masters in Technology** with specialization of **Specialization**. We hereby accord our approval of it as a study carried out and presented in a manner required for its acceptance in partial fulfillment for the post graduate degree for which it has been submitted. The thesis has fulfilled all the requirements as per the regulations of the institute and has reached the standard needed for submission.

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CERTIFICATE OF APPROVAL

The forgoing thesis report is hereby approved as a creditable study of "**Thesis Title** "carried out and presented satisfactorily to warrant its acceptance as a pre-requisite for the Degree of Master of Technology of University. It is understood that by this approval the undersigned do not necessarily approve any statement made, opinion expressed and conclusion drawn there in but approve the progress report only for the purpose for which it is submitted.

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Place: Shibpur
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First of all, I would like to express my sincere and deep gratitude to my supervisor, **Supervisor Name**, Faculty, Department of Dept. Name, for his kind and constant support during my post-graduation study. It has been an absolute privilege to work with Supervisor Name for my master thesis dissertation. His valuable advice, critical criticism and active supervision encouraged me to sharpen my research methodology and was instrumental in shaping my professional outlook.

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ABSTRACT

In recent microprocessors or ASIC chips, the operating frequency is set by the target market.This leads to very tight timing and power constraints for the proposed circuit design. The industrial shift for adopting lower technology nodes also presents a new challenging frontier as transistors get less efficient as they undergo scaling. Analog designers are expected to optimize these conventional designs and yet meet the reduced power constraints and performance metrics imposed by various applications.

Keywords: Level shifter, energy efficient design, ultra low voltage, ULPLS, 22 nm technology.

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Chapter 1

Introduction

The environmental impact of global warming has accelerated the interest to adopt non-conventional power generation [1]. There are several promising sustainable energy alternatives, among which the adoption of Thermoelectric (TE) materials to scavenge the by-product heat generation is widely accepted [1]. It is crucial for applications associated with energy harvesting to posses a high figure of merit ZT (≥ 1) [1].

The ZT can be related to other thermoelectric parameters by ZT $=(\frac{\sigma_e \times S_B^2 \times T}{\kappa_{ph}+\kappa_e})$, where σ, S_B, $\kappa_{ph}+\kappa_e$, and T are the electrical conductivity, Seebeck coefficient, total thermal conductivity, and temperature value respectively [1].

Experimental and theoretical identification of two dimensional (2D) [1] or three dimensional (3D) efficient TE materials is laborious and time inefficient [1]. It is also a colossal task to compile databases of thermoelectric parameters for various synthesized TE materials and their variations with doping (n-type or p-type) [1]. Computational methods using density functional theory (DFT) are also time consuming and demand high computational complexity for exploring TE materials [1].

Efficient TE materials require a large ZT which in turn requires to maximize the Seebeck coefficient absolute value, minimize the thermal conductivity and possess a high electrical conductivity. Optimizing these parameters is a complicated task as they are inherently dependent and conflicting in nature [1]. Thus, optimizing ZT requires a thorough understanding of these various transport properties and their interrelated material characteristics.

The Seebeck coefficient depends on this energy-dependent conductivity around a fermi window centered about the fermi energy level, which is given by the Mott expression (Eq. 1.1) [1].

$$S_B = \frac{\pi^2}{3}(\frac{{K_B}^2 \times T}{q})[\frac{d[ln(\sigma(E))]}{dE}]_{E=E_F} = (\frac{8\pi^2 {K_B}^2 T}{3qh^2})m_d^*(\frac{\pi}{3n})^{2/3} \tag{1.1}$$

where n is the carrier concentration and effective mass m_d^* of the carrier when present in the conduction band or valence band. This effective mass (m_d^*) is obtained from the function of the density of states (DOS) and is thus also known as m_{DOS}^* [1]. The underlying assumption for the final closed form expression is the presence of a parabolic band and an energy-independent scattering approximation [1]. The electrical conductivity (σ_e) can be approximated by the Drude model in terms of its carrier concentration (n) and mobility (μ) as shown in Eqn. 1.3. Thus, the influence of carrier concentration impacts both the parameters contradictorily as shown in Fig. 1.1.

Figure 1.1: Figure 1.1

$$\sigma_e = nq\mu = \frac{nq^2\tau}{m} \tag{1.2}$$

$$\kappa = \kappa_{ph} + \kappa_e = (\frac{\pi^2}{3})(\frac{nK_B^2T\tau}{m}) + L_n \times \sigma_e T \tag{1.3}$$

$$L_n \approx (\frac{\pi^2}{3})(\frac{K_B}{q})^2 \tag{1.4}$$

1.1 Section 1.1

1.1.1 Sub-Section 1.1.1

content.

1.1.2 Sub-Section 1.1.1

content.

Table 1.1: Table Caption

Material	Crystal	Space Group	Bandgap(ev)	Direct / Indirect	$\kappa(Wm^{-1}k^{-1})$	$\sigma_e(\times 10^{-3}Scm^-1)$	ZT(10^{-4})
xxx	xxx	xxxxxx	YYYXXXXX ZZZ exp. YYYexp. XXXexp,	Direct	ZZ exp,	YY exp,	XX exp,

Chapter 2

Methodology

Table 2.1: Table Caption

Database	Crystal information	Mechanical parameters	Thermodynamic parameters	Electronic parameters
Database 1	Y	Y	Y	Y
Database 2	Y	Y	Y	Y
Database 3	Y	Y	Y	Y
Database 4	Y	Y	Y	Y
Database 5	Y	N	Y	Y

Chapter 3

Chapter 3

- Item1
- Item2
- Item3
- Item4
- Item5
- Item6

Chapter 4

Chapter 4

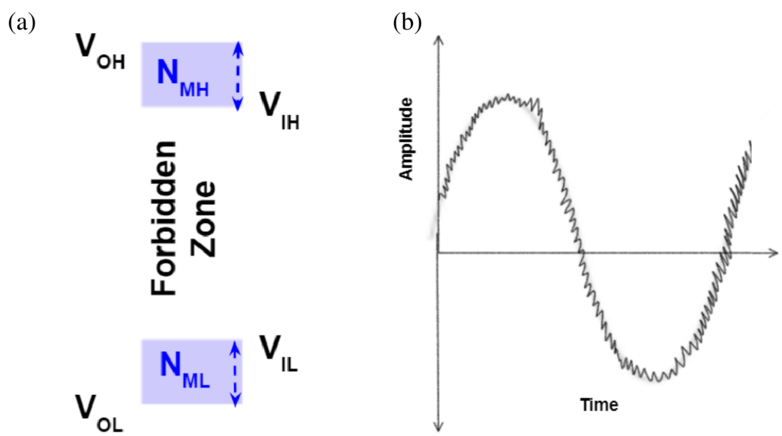

Figure 4.1: My caption.

Chapter 5

Chapter 5

5.1 Summary

- Item1
- Item2
- Item3
- Item4
- Item5
- Item6

5.2 Future Work

5.2.1 Work Breakdown Structure (WBS)

- Item1
- Item2
- Item3

- Item4
- Item5
- Item6

Chapter 6

Chapter 6

References

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[3] LTspice simulator, Analog devices, available at `https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html`

[4] Wang, A. P. Chandrakasan and S. V. Kosonocky, “Optimal supply and threshold scaling for subthreshold CMOS circuits, ”Proceedings IEEE Computer Society Annual Symposium on VLSI. New Paradigms for VLSI Systems Design. ISVLSI 2002, 2002, pp. 7-11, doi: 10.1109/ISVLSI.2002.1016866.

APPENDIX-A: Guide

A quick guide to LaTeX

What is LaTeX?

LaTeX(usually pronounced "LAY teck," sometimes "LAH teck," and never "LAY tex") is a mathematics typesetting program that is the standard for most professional mathematics writing. It is based on the typesetting program TeX created by Donald Knuth of Stanford University (his first version appeared in 1978). Leslie Lamport was responsible for creating LaTeX a more user friendly version of TeX. A team of LaTeX programmers created the current version, LaTeX 2ε.

Math vs. text vs. functions

In properly typeset mathematics variables appear in italics (e.g., $f(x) = x^2 + 2x - 3$). The exception to this rule is predefined functions (e.g., $\sin(x)$). Thus it is important to **always** treat text, variables, and functions correctly. See the difference between x and x, -1 and -1, and $sin(x)$ and $\sin(x)$. There are two ways to present a mathematical expression—*inline* or as an *equation*.

Inline mathematical expressions

Inline expressions occur in the middle of a sentence. To produce an inline expression, place the math expression between dollar signs (`$`). For example, typing `$90^{\circ}$ is the same as $\frac{\pi}{2}$ radians` yields 90° is the same as $\frac{\pi}{2}$ radians.

Equations

Equations are mathematical expressions that are given their own line and are centered on the page. These are usually used for important equations that deserve to be showcased on their own line or for large equations that cannot fit inline. To produce an inline expression, place the mathematical expression between the symbols `\[` and `\]`. Typing `\[x=\frac{-b\pm\sqrt{b^2-4ac}}{2a}\]` yields

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}.$$

Displaystyle

To get full-sized inline mathematical expressions use `\displaystyle`. Use this sparingly. Typing `I want this $\displaystyle \sum_{n=1}^{\infty} \frac{1}{n}$, not this $\sum_{n=1}^{\infty} \frac{1}{n}$.` yields

I want this $\displaystyle \sum_{n=1}^{\infty} \frac{1}{n}$, not this $\sum_{n=1}^{\infty} \frac{1}{n}$.

Images

You can put images (pdf, png, jpg, or gif) in your document. They need to be in the same location as your .tex file when you compile the document. Omit `[width=.5in]` if you want the image to be full-sized.

```
\begin{figure}[ht]
\includegraphics[width=.5in]{imagename.jpg}
\caption{The (optional) caption goes here.}
\end{figure}
```

Text decorations

Your text can be *italics* (`\textit{italics}`), **boldface** (`\textbf{boldface}`), or underlined (`\underline{underlined}`).
Your math can contain boldface, $\mathbf{R}$ (`\mathbf{R}`), or blackboard bold, $\mathbb{R}$ (`\mathbb{R}`). You may want to used these to express the sets of real numbers ($\mathbb{R}$ or $\mathbf{R}$), integers ($\mathbb{Z}$ or $\mathbf{Z}$), rational numbers ($\mathbb{Q}$ or $\mathbf{Q}$), and natural numbers ($\mathbb{N}$ or $\mathbf{N}$).
To have text appear in a math expression use `\text`. `(0,1]=\{x\in\mathbb{R}:x>0\text{ and }x\le 1\}` yields $(0,1] = \{x \in \mathbb{R} : x > 0 \text{ and } x \le 1\}$. (Without the `\text` command it treats "and" as three variables: $(0,1] = \{x \in \mathbb{R} : x > 0 and x \le 1\}$.)

Spaces and new lines

LaTeX ignores extra spaces and new lines. For example,

```
This   sentence will        look
fine after      it is     compiled.
```

This sentence will look fine after it is compiled.
Leave one full empty line between two paragraphs. Place `\\` at the end of a line to create a new line (but not create a new paragraph).

```
This
compiles

like\\
this.
```

This compiles
like
this.
Use `\noindent` to prevent a paragraph from indenting.

Comments

Use `%` to create a comment. Nothing on the line after the `%` will be typeset. `$f(x)=\sin(x)$ %this is the sine function` yields $f(x) = \sin(x)$

Delimiters

description	*command*	*output*
parentheses	`(x)`	(x)
brackets	`[x]`	[x]
curly braces	`\{x\}`	{x}

To make your delimiters large enough to fit the content, use them together with `\right` and `\left`. For example, `\left\{\sin\left(\frac{1}{n}\right)\right\}_{n}^{\infty}` produces $\left\{\sin\left(\frac{1}{n}\right)\right\}_{n}^{\infty}$.
Curly braces are non-printing characters that are used to gather text that has more than one character. Observe the differences between the four expressions `x^2`, `x^{2}`, `x^2t`, `x^{2t}` when typeset: x^2, x^{2}, x^2t, x^{2t}.

Lists

You can produce ordered and unordered lists.

description	*command*	*output*

unordered list	`\begin{itemize}`
	`\item`
	`Thing 1`
	`\item`
	`Thing 2`
	`\end{itemize}`
		• Thing 1
		• Thing 2

ordered list	`\begin{enumerate}`
	`\item`
	`Thing 1`
	`\item`
	`Thing 2`
	`\end{enumerate}`
		1. Thing 1
		2. Thing 2

Symbols (in *math* mode)

The basics

description	*command*	*output*
addition	`+`	$+$
subtraction	`-`	$-$
plus or minus	`\pm`	$\pm$
multiplication (times)	`\times`	$\times$
multiplication (dot)	`\cdot`	$\cdot$
division symbol	`\div`	$\div$
division (slash)	`/`	$/$
circle plus	`\oplus`	$\oplus$
circle times	`\otimes`	$\otimes$
equal	`=`	$=$
not equal	`\ne`	$\ne$
less than	`<`	$<$
greater than	`>`	$>$
less than or equal to	`\le`	$\le$
greater than or equal to	`\ge`	$\ge$
approximately equal to	`\approx`	$\approx$
infinity	`\infty`	∞
dots	`1,2,3,\ldots`	$1,2,3,\ldots$
dots	`1+2+3+\cdots`	$1+2+3+\cdots$
fraction	`\frac{a}{b}`	$\frac{a}{b}$
square root	`\sqrt{x}`	$\sqrt{x}$
nth root	`\sqrt[n]{x}`	$\sqrt[n]{x}$
exponentiation	`a^b`	a^b
subscript	`a_b`	a_b
absolute value	`|x|`	$\lvert x\rvert$
natural log	`\ln(x)`	$\ln(x)$
logarithms	`\log_{a}b`	$\log_{a}b$
exponential function	`e^x=\exp(x)`	$e^x=\exp(x)$
degree	`\deg(f)`	$\deg(f)$

APPENDIX-A: Guide

Functions

description	*command*	*output*
maps to	`\to`	$\to$
composition	`\circ`	$\circ$

piecewise function	`|x|=`
	`\begin{cases}`
	`x & x\ge 0\\`
	`-x & x<0`
	`\end{cases}`
		$\lvert x\rvert = \begin{cases} x & x \ge 0 \\ -x & x < 0 \end{cases}$

Greek and Hebrew letters

command	*output*	*command*	*output*
`\alpha`	α	`\tau`	τ
`\beta`	β	`\theta`	θ
`\chi`	χ	`\upsilon`	υ
`\delta`	δ	`\xi`	ξ
`\epsilon`	ϵ	`\zeta`	ζ
`\varepsilon`	ε	`\Delta`	Δ
`\eta`	η	`\Gamma`	Γ
`\gamma`	γ	`\Lambda`	Λ
`\iota`	ι	`\Omega`	Ω
`\kappa`	κ	`\Phi`	Φ
`\lambda`	λ	`\Pi`	Π
`\mu`	μ	`\Psi`	Ψ
`\nu`	ν	`\Sigma`	Σ
`\omega`	ω	`\Theta`	Θ
`\phi`	ϕ	`\Upsilon`	Υ
`\varphi`	φ	`\Xi`	Ξ
`\pi`	π	`\aleph`	$\aleph$
`\psi`	ψ	`\beth`	$\beth$
`\rho`	ρ	`\daleth`	$\daleth$
`\sigma`	σ	`\gimel`	$\gimel$

Set theory

description	*command*	*output*
set brackets	`\{1,2,3\}`	$\{1,2,3\}$
element of	`\in`	$\in$
not an element of	`\not\in`	$\not\in$
subset of	`\subset`	$\subset$
subset of	`\subseteq`	$\subseteq$
not a subset of	`\not\subset`	$\not\subset$
contains	`\supset`	$\supset$
contains	`\supseteq`	$\supseteq$
union	`\cup`	$\cup$
intersection	`\cap`	$\cap$
big union	`\bigcup_{n=1}^{10}A_n`	$\bigcup_{n=1}^{10}A_n$
big intersection	`\bigcap_{n=1}^{10}A_n`	$\bigcap_{n=1}^{10}A_n$
empty set	`\emptyset`	$\emptyset$
power set	`\mathcal{P}`	$\mathcal{P}$
minimum	`\min`	$\min$
maximum	`\max`	$\max$
supremum	`\sup`	$\sup$
infimum	`\inf`	$\inf$
limit superior	`\limsup`	$\limsup$
limit inferior	`\liminf`	$\liminf$
closure	`\overline{A}`	$\overline{A}$

Calculus

description	*command*	*output*
derivative	`\frac{df}{dx}`	$\frac{df}{dx}$
derivative	`\f'`	f'
partial derivative	`\frac{\partial f}` `{\partial x}`	$\frac{\partial f}{\partial x}$
integral	`\int`	$\int$
double integral	`\iint`	$\iint$
triple integral	`\iiint`	$\iiint$
limits	`\lim_{x\to \infty}`	$\lim_{x\to\infty}$
summation	`\sum_{n=1}^{\infty}a_n`	$\sum_{n=1}^{\infty}a_n$
product	`\prod_{n=1}^{\infty}a_n`	$\prod_{n=1}^{\infty}a_n$

Logic

description	*command*	*output*
not	`\sim`	$\sim$
and	`\land`	$\land$
or	`\lor`	$\lor$
if...then	`\to`	$\to$
if and only if	`\leftrightarrow`	$\leftrightarrow$
logical equivalence	`\equiv`	$\equiv$
therefore	`\therefore`	$\therefore$
there exists	`\exists`	$\exists$
for all	`\forall`	$\forall$
implies	`\Rightarrow`	$\Rightarrow$
equivalent	`\Leftrightarrow`	$\Leftrightarrow$

Linear algebra

description	*command*	*output*
vector	`\vec{v}`	$\vec{v}$
vector	`\mathbf{v}`	$\mathbf{v}$
norm	`||\vec{v}||`	$\lvert\lvert\vec{v}\rvert\rvert$

matrix	`\left[`
	`\begin{array}{ccc}`
	`1 & 2 & 3 \\`
	`4 & 5 & 6\\`
	`7 & 8 & 0`
	`\end{array}`
	`\right]`
		$\left[\begin{array}{ccc} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 0 \end{array}\right]$

determinant	`\left|`
	`\begin{array}{ccc}`
	`1 & 2 & 3 \\`
	`4 & 5 & 6 \\`
	`7 & 8 & 0`
	`\end{array}`
	`\right|`
		$\left\lvert\begin{array}{ccc} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 0 \end{array}\right\rvert$

determinant	`\det(A)`	$\det(A)$
trace	`\operatorname{tr}(A)`	$\operatorname{tr}(A)$
dimension	`\dim(V)`	$\dim(V)$

Number theory

description	*command*	*output*
divides	`|`	$\mid$
does not divide	`\not |`	$\nmid$
div	`\operatorname{div}`	div
mod	`\mod`	mod
greatest common divisor	`\gcd`	$\gcd$
ceiling	`\lceil x \rceil`	$\lceil x \rceil$
floor	`\lfloor x \rfloor`	$\lfloor x \rfloor$

Geometry and trigonometry

description	*command*	*output*
angle	`\angle ABC`	$\angle ABC$
degree	`90^{\circ}`	90°
triangle	`\triangle ABC`	$\triangle ABC$
segment	`\overline{AB}`	$\overline{AB}$
sine	`\sin`	$\sin$
cosine	`\cos`	$\cos$
tangent	`\tan`	$\tan$
cotangent	`\cot`	$\cot$
secant	`\sec`	$\sec$
cosecant	`\csc`	$\csc$
inverse sine	`\arcsin`	$\arcsin$
inverse cosine	`\arccos`	$\arccos$
inverse tangent	`\arctan`	$\arctan$

Symbols (in *text* mode)

The followign symbols do **not** have to be surrounded by dollar signs.

description	*command*	*output*
dollar sign	`\$`	$
percent	`\%`	%
ampersand	`\&`	&
pound	`\#`	#
backslash	`\textbackslash`	\
left quote marks	``` `` ```	“
right quote marks	`''`	”
single left quote	`` ` ``	‘
single right quote	`'`	’
hyphen	`X-ray`	X-ray
en-dash	`pp. 5--15`	pp. 5–15
em-dash	`Yes---or no?`	Yes—or no?

Resources

Great symbol look-up site: Detexify
LaTeX Mathematical Symbols
The Comprehensive LaTeX Symbol List
The Not So Short Introduction to LaTeX 2ε
TUG: The TeX Users Group
CTAN: The Comprehensive TeX Archive Network

LaTeX for the Mac: MacTeX
LaTeX for the PC: TeXnicCenter and MiKTeX
LaTeX online: WriteLaTeX.

Dave Richeson, Dickinson College, http://divisbyzero.com/

A width=!,height=!,scale=0.8,pages=-,pagecommand=APPENDIX - A