

**ALANYA ALAADDIN KEYKUBAT UNIVERSITY**

**FPGA BASED OPTICAL PULSE MODULATOR**

**EEE 402 GRADUATION PROJECT**

**IN**

**ELECTRICAL & ELECTRONICS ENGINEERING**

**BY**

**Name SURNAME**

**JUNE 2022**

**ABSTRACT**

**FPGA Based Optical Pulse Modulator**

**SURNAME, Name**

**Graduation Project in Electrical and Electronics Engineering**

**Supervisor: Assist. Prof. Dr. Name SURNAME**

**June 2022, XX pages**

Abstract

**Keywords:** FPGA, Optical, Modulator

UYGUNL

**ÖZET**

**FPGA Based Optical Pulse Modulator**

**SURNAME, Name**

**Mezuniyet Projesi, Elektrik ve Elektronik Mühendisliği Bölümü**

**Proje yöneticisi: Dr. Öğr. Üyesi Name SURNAME**

**Haziran 2022, XX sayfa**

Özet

**Anahtar kelimeler:** FPGA, Optik, Modülatör

VE ONAY

**ACKNOWLEDGEMENTS**

First and foremost, I would like to thank my supervisor, Assist. Prof. Dr. Name SURNAME, who guided me during term.

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Finally, I would like to thank my father and my mother that have supported me throughout the year.

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SYMBOLS

**Symbol Defination**

: Dielectric coefficient of prisma

: Dielectric coefficient of medium

θ : Phase angle

*ns* : Refractive index of medium

: Plasma frequency

: Free electron density

: Plasma wavelength

: Collision wavelength

: Oscillation wavelength

*c* : Speed of light at free space

ABBREVIATIONS

SPR : Surface Plasmon Resonance

ELISA : Enzyme-Linked ImmunoSorbent Assay

PCR : Polymerase Chain Reaction

RIU : Refractive Index Unit

FOM : Figure of Merit

NA : Numerical Aparture

μm : Micrometer

nm : Nanometer

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1. **INTRODUCTION**

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Figure 1.1. Schematic.

**2. FPGA BASED OPTICAL MODULATOR**

**2.1. How FPGA Works**

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Figure 2.1. Schematic.

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Figure 2.2: Xxxx Xxx.

**2.2.2. Xxxx Xxxxxx**

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Figure 2.3. Xxxxxx Xxx Xxxxxxxxx Xx

**2.3. Xxxxx (Xxxx)**

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**3. HARDWARE**

**3.1. Monitor**

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There are 2 main units of this system;

* Xxxxx
* Xxxxxx

**3.2. Xxxxx Xxxxx**

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**3.3. Xxxxxxx Xxxxxxxxx Xxxxxxxxx Xxxx**

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**3.4. XXX Xxxxxxx**

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**3.5. Xxxxxxxx**

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**3.7. Xxxxxxxxxxxxxxxxxxx**

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**4. SOFTWARE**

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Below is given MATLAB codes;

>> s=tf('s');H1=(10\*exp(-0.2\*s))/s^3+4.5\*(s^2)+5.5\*s+15

H1 =

a =

x1 x2 x3 x4 x5 x6 x7 x8

x1 0 0 0 0 0 0 0 0

x2 1 0 0 0 0 0 0 0

x3 0 1 0 0 0 0 0 0

x4 0 0 0 1 0 0 0 0

x5 0 0 0 0 1 0 0 0

x6 0 0 0 0 0 1 0 0

x7 0 0 0 0 0 0 1 0

x8 0 0 0 0 0 0 0 1

b =

u1

x1 4

x2 0

x3 0

x4 0

x5 0

x6 -2

x7 0

x8 -2

c =

x1 x2 x3 x4 x5 x6 x7 x8

y1 0 0 2.5 2.25 0 0 2.75 0

d =

u1

y1 15

e =

x1 x2 x3 x4 x5 x6 x7 x8

x1 1 0 0 0 0 0 0 0

x2 0 1 0 0 0 0 0 0

x3 0 0 1 0 0 0 0 0

x4 0 0 0 0 1 0 0 0

x5 0 0 0 0 0 1 0 0

x6 0 0 0 0 0 0 0 0

x7 0 0 0 0 0 0 0 1

x8 0 0 0 0 0 0 0 0

(values computed with all internal delays set to zero)

**5. CONCLUSION**

The idea behind xxxxxxxxxxx xxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxx x xxxxxx. Xxxxxxxxxxxxxxxxx xxxxx x xxxxxxxxx xxxxxxxxxxxxxxxxxx. Xxxxxxxxxxxxxxxxxxx. Xxxxxxxxxxxx xxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxx x xxxxxx. Xxxxxxxxxxxxxxxxx xxxxx x xxxxxxxxx xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxx. Xxxxxxxxxxxx xxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxx x xxxxxx.

By achieving this project, this system essentially helps people who xxxx xxxx xxxxxxxxxxx xx xxxxxxxx.

Xxxxxxxxxxxx xxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxx x xxxxxx. Xxxxxxxxxxxxxxxxx xxxxx x xxxxxxxxx xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxx. Xxxxxxxxxxxx xxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxx x xxxxxx.**REFERENCES**

**1.** Stilgoe, A. B., Nieminen, T. A., Knöner, G., Heckenberg, N. R., & Rubinsztein-Dunlop, H. (2008). The effect of Mie resonances on trapping in optical tweezers. *Optics express*, *16*(19), 15039-15051.

**2.** Ji, W., Li, L., Song, W., Wang, X., Zhao, B., & Ozaki, Y. (2019). Enhanced Raman scattering by ZnO superstructures: synergistic effect of charge transfer and Mie resonances. *Angewandte Chemie*, *131*(41), 14594-14598.

**3.** Lai, H. M., Lam, C. C., Leung, P. T., & Young, K. (1991). Effect of perturbations on the widths of narrow morphology-dependent resonances in Mie scattering. *JOSA B*, *8*(9), 1962-1973.

**4.** https://refractiveindex.info/?shelf=other&book=air&page=Ciddor

**APPENDICES**

**A) COST ANALYSIS**

|  |  |  |  |
| --- | --- | --- | --- |
| Count | Item | Cost | |
| TL | € |
| 1 |  | 8 | 100,75 |
| 1 |  | 15 | 150,50 |
| 1 |  | 0,25 | 10 |
| 2 |  | 7 | 125 |
| 2 |  | 1,5 | 25,42 |
| 2 |  | 1 | 16,17 |
| 10 |  | 0,75 | 12,47 |
| Total: | | X,X TL | X,X € |

**B) CODES**

>> s=tf('s');H1=(10\*exp(-0.2\*s))/s^3+4.5\*(s^2)+5.5\*s+15

>> s=tf('s');H1=(10\*exp(-0.2\*s))/s^3+4.5\*(s^2)+5.5\*s+15

>> s=tf('s');H1=(10\*exp(-0.2\*s))/s^3+4.5\*(s^2)+5.5\*s+15

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>> s=tf('s');H1=(10\*exp(-0.2\*s))/s^3+4.5\*(s^2)+5.5\*s+15

>> s=tf('s');H1=(10\*exp(-0.2\*s))/s^3+4.5\*(s^2)+5.5\*s+15

**C) TIME PLAN**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Week 1** | **Week 2** | **Week 3** | **Week 4** | **Week 5** | **Week 6** |
| **Research** |  |  |  |  |  |  |
| **Planning** |  |  |  |  |  |  |
| **Xxxxxxx** |  |  |  |  |  |  |
| **Xxxxxxxx** |  |  |  |  |  |  |
| **Xxxxxxx** |  |  |  |  |  |  |
| **Presentation** |  |  |  |  |  |  |