# 8 bit Computer using 6502 microprocessor

**EC291 : Exploratory Project**

Even Semester 2023

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## Abstract

**The aim of this exploratory project was to design an 8-bit computer using the 6502 microprocessor. Due to the unavailability of the microprocessor, a simulation of the computer was created using Proteus Software. The project involved learning the basics of computer architecture and machine level language, and designing a simulation of the computer. A PCB design for the computer was also created. This report provides a detailed account of the project, the techniques used, the preliminary results, and the inferences and conclusions drawn from the project.**


## Introduction

When we first start learning computer programming, the first line of code that we often encounter is "print("hello world")". It may seem like a simple command, but it raises the question of how the computer processes this input and displays the result. In this exploratory project, we delve into the underlying foundations of any computer, starting with the basics. To accomplish this, we chose to study the 6502 microprocessor, which was developed in 1975.

You may wonder why we chose to study such an old technology when more advanced microprocessors are available, such as the 8000 series. The reason is simple. Our aim in this project was to understand the fundamentals of computer architecture, and the 6502 microprocessor provided us with a simple yet effective platform.

The 6502 microprocessor was used in several famous home computers of the 1980s, including the Apple II and the Commodore 64. By studying the 6502 microprocessor, we learned about the basic principles of computer architecture, digital circuit design, and machine-level language.

In this exploratory project, we sought to learn about memory management, input/output devices, and other support circuits necessary for computer functioning. By building a

simulation of the 8-bit computer using the 6502 microprocessor, we could experiment with different programming techniques and test the computer's functionality.
This project is a solid foundation for further exploring and studying advanced computer technologies.

## Literature Survey

In this exploratory project, we conducted a literature survey to understand better the concepts related to computer architecture and microprocessor design. Our primary source of literature was the textbook "Digital Computer Electronics" by Malvino and Brown. The book provided a comprehensive introduction to the fundamental concepts of digital electronics, including Boolean algebra, logic gates, and combinational and sequential circuits.
The textbook also included detailed information on the architecture of the SAP (Simple As Possible) computer, a basic computer design used to introduce students to the concepts of microprocessors and programming.
Additionally, we referred to the datasheets of various components, including the W65C02 microprocessor, basic RAM 62256, and ROM 27C128. These data sheets provided information on the electrical and functional characteristics of the components and their pin configurations and timing diagrams.
We also consulted various online resources to understand better the topics covered in the literature. This included online forums and discussion boards, providing valuable insights and practical advice on microprocessor design and programming.
Our literature survey revealed that designing and implementing a computer system is a complex task that requires a deep understanding of the underlying principles of digital electronics and microprocessor architecture. It also highlighted the importance of thorough research and experimentation when working on such projects.
In conclusion, the literature survey was critical in guiding our research and providing us with a foundation of knowledge for our project. It provided us with valuable insights and practical advice related to microprocessor design and programming, which helped us to design and simulate an 8-bit computer using the 6502 microprocessor.

# Methodology

## Clock Module:

The first step in building a computer is to synchronise all its components with a clock. A clock can be generated by a crystal oscillator, but these oscillators have a very high frequency. To make a slow clock that can be manually controlled, we built our clock module using N555 timer, which contains monostable, bistable, and astable modes. The clock frequency was set at 5-100 Hz, which allowed us to manually control the clock speed through a potentiometer. Also, we may switch to monostable mode, in which we manually give a clock pulse.

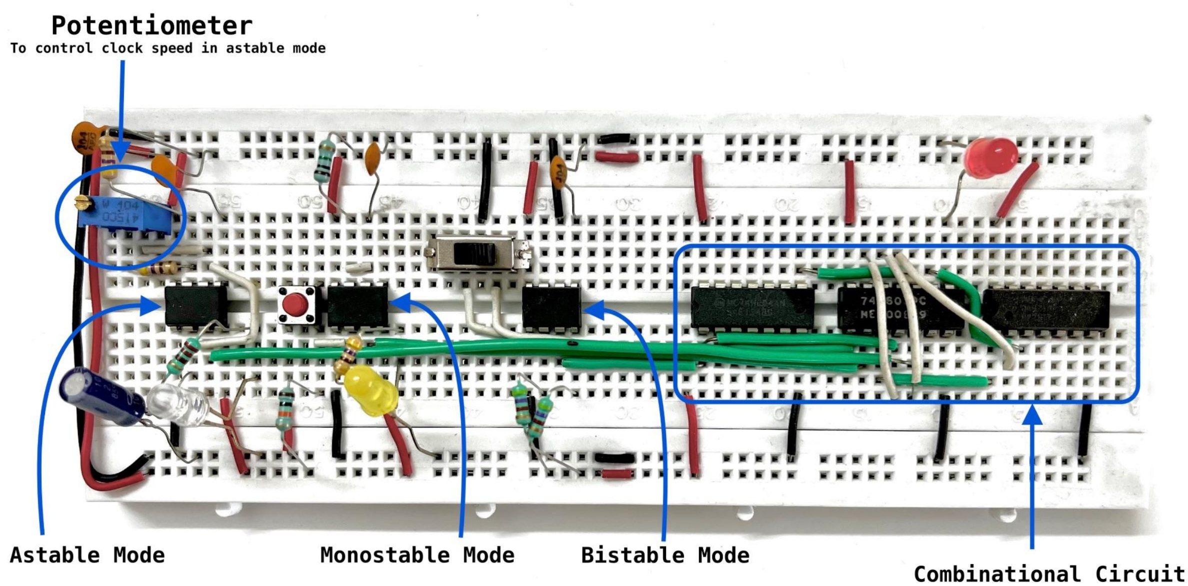


*Fig 1. Clock Module*

## Microprocessor:

Due to the non-availability of 6502 microprocessors in India, we were restricted to simulating it. We used Proteus software for our simulation, which allowed us to create a virtual environment for the microprocessor.

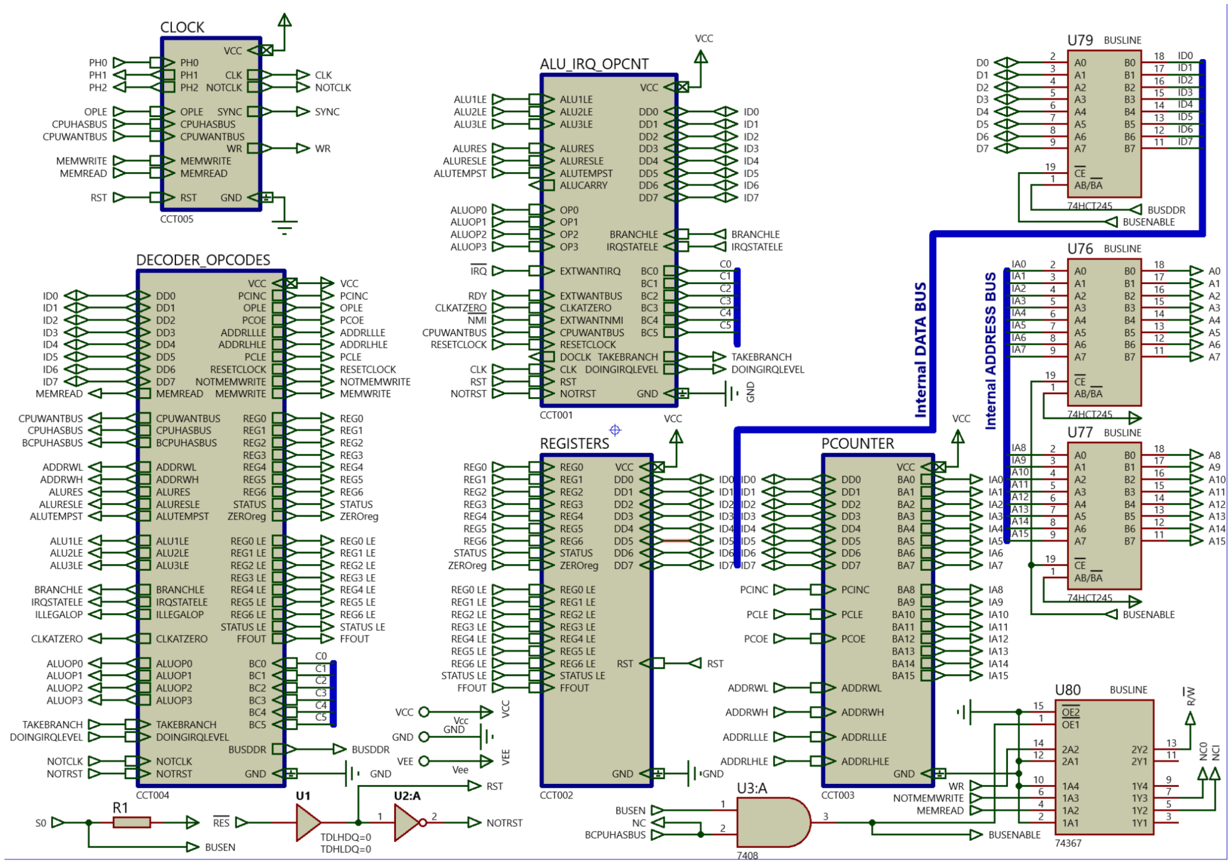


*Fig 2. Internal Schematic of the 6502 Microprocessor*

The data sheet of the microprocessor gives the instruction set for the microprocessor. We first hardcoded a NOP (No Operation) opCode into it. This process didn't do much rather than sweep over the addresses of ROM. The NOP instruction allowed us to check if the microprocessor was functioning correctly. These instruction sets and opCodes are available in Datasheet of the microprocessor.

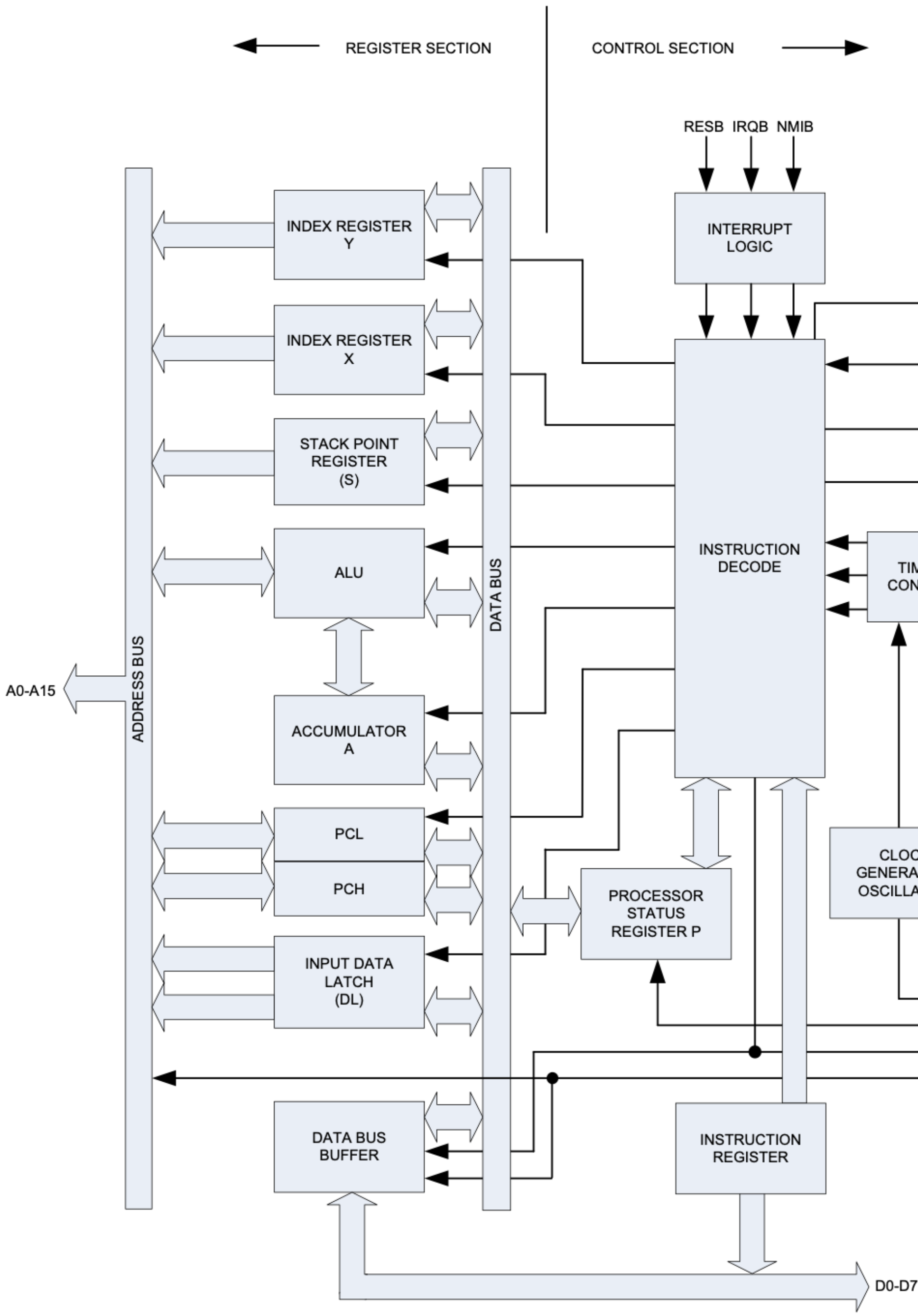


*Fig 3. 6502 internal architecture simplified block diagram*

## Proteus Design:

To store some variables in memory, we needed a RAM (62256) that could be accessed to store and read local variables. We connected the RAM to the microprocessor through the address and data bus. The RAM was initially empty and the content stored in it could be modified by the microprocessor. The content stored in ROM is required to be in a binary form (machine level). Therefore, we used a python script to generate a .bin file with the required code and then dumped it into ROM. We then loaded the ROM content into the Proteus simulation environment. The ROM was connected to the microprocessor through the address bus. The microprocessor could then read the instructions from the ROM and execute them.

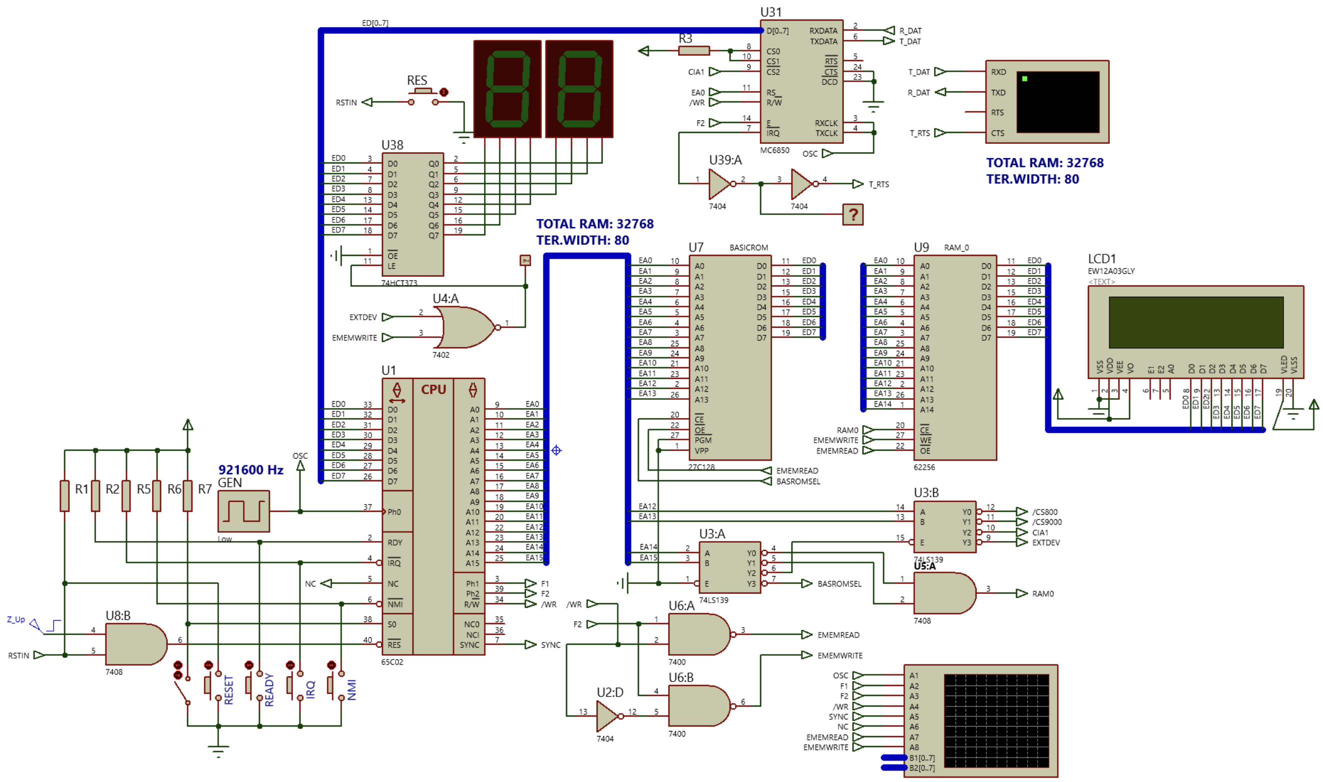

*Fig 4. Schematic of the 8-bit computer using 6502 microprocessor*

## PCB Design:

We designed a PCB for the computer using Proteus. The PCB design was based on the simulation, and it included all the components used in the simulation.

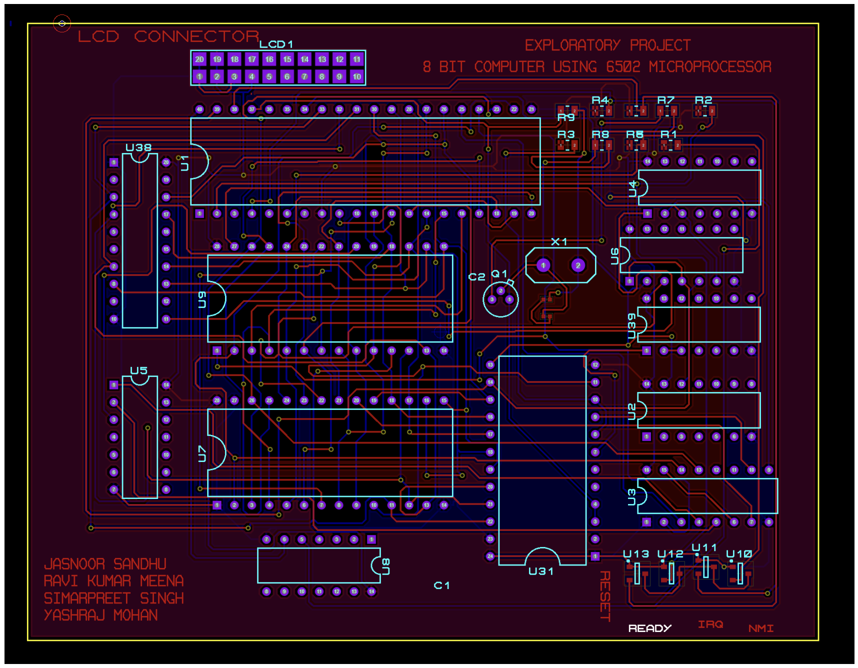


*Fig 5. PCB Layout for computer*

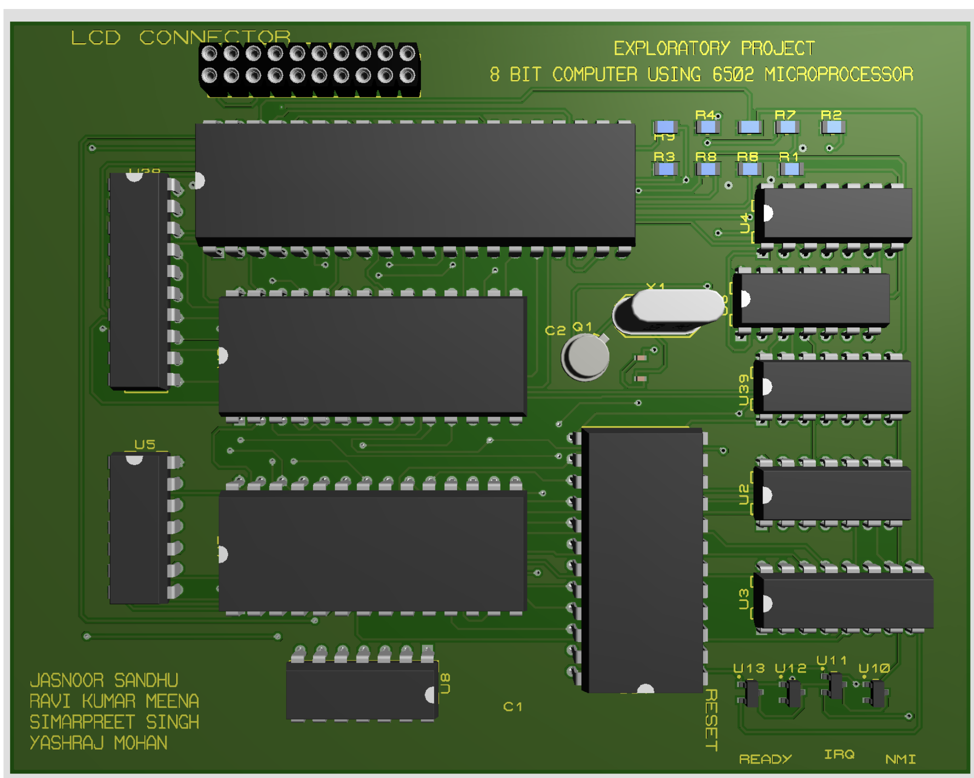


*Fig 6. 3D Visualisation of PCB*

# Results and insights

The simulation of the 8-bit computer is successfully designed using Proteus Software. The simulation included the 6502 microprocessor, memory, input/output devices, and other support circuits. The simulation allowed experimentation with different programming techniques and testing of the computer's functionality.The Clock module was also built using N555 timers in Monostable, Astable and Bistable Modes.

The design of the PCB for the computer is also completed. The PCB included the 6502 microprocessor, memory, input/output devices, and other support circuits. The PCB design was based on the simulation and intended to be used to build the computer on hardware.

The project gave the team a good understanding of computer architecture and programming. The group gained knowledge on working with the 6502 microprocessor, the basics of the machine-level language, and the design of digital circuits. The project also allowed the team to experiment with different programming techniques and test the computer's functionality.

The project results revealed that the performance of an 8-bit computer system is highly dependent on the clock speed of the CPU and the amount of memory available. Assembly language programming was shown to be a powerful way to write efficient code for 8-bit computer systems, but it can be difficult and time-consuming to learn and debug.

Learning about 8-bit computer systems can provide valuable insights into the history and evolution of computing technology and help students develop practical computer science and engineering skills.

The limitations of 8-bit computer systems, such as their limited memory capacity and processing speed, have led to the development of more advanced computing architectures to handle more complex tasks.

While 8-bit computer systems are considered outdated compared to modern computing architectures, they are still relevant and helpful for specific applications where low cost, low power consumption, and simplicity are important factors.

## Conclusion

In conclusion, the project successfully achieved its objective of designing an 8-bit computer using the 6502 microprocessor. The computer simulation provided us with a platform to experiment with different programming techniques and test the computer's functionality. The computer's PCB design was completed, which could be used to build the computer on hardware.
Through this project, we gained knowledge on working with the 6502 microprocessor, the basics of the machine-level language, and the design of digital circuits. The project also helped us develop our skills in designing digital circuits and programming.

## References and Bibliography


1. Zaks, Rodnay. Programming the 6502. Sybex, 1981.
2. Harris, David, and Sarah Harris. Digital Design and Computer Architecture. Elsevier, 2012.
3. Malvino, Brown. Digital Computer Electronics. 1993.
4. 6502 Youtube playlist by Ben Eater.