Department of Computer Engineering
Faculty of Engineering, University of Peradeniya

CO221 : Digital Design | Project
Overall Project Specification

In this project, your task is to build a simple computer system. Computer systems you see today are too complicated and hence this is an extremely simple version which probably existed at the beginning of the computer era. But yet the core concepts still have similarities.

A typical computer system takes in a set of commands written for performing a specific task (an algorithm) and executes them one by one. These commands are formally called **"Instructions"**. Our simple computer system will have only 4 instructions to perform some basic arithmetic/logic operations on two 4-bit operands included directly in the instruction itself.

The key components in your design will be the arithmetic and logic unit (ALU), instruction loading unit, and the display output unit. The instructions will be loaded using switches/push-buttons and the output will be displayed on Seven Segment Displays (SSDs). More details about the system architecture and the structure of the instructions supported by the system are given later in the specification.

You will work in groups of 3 which are the same as your laboratory groups.

The project consists of 3 phases. The outcomes of the 3 phases are given below.

Phase 01:

A computer simulation of the system using Proteus or similar software.

Phase 02:

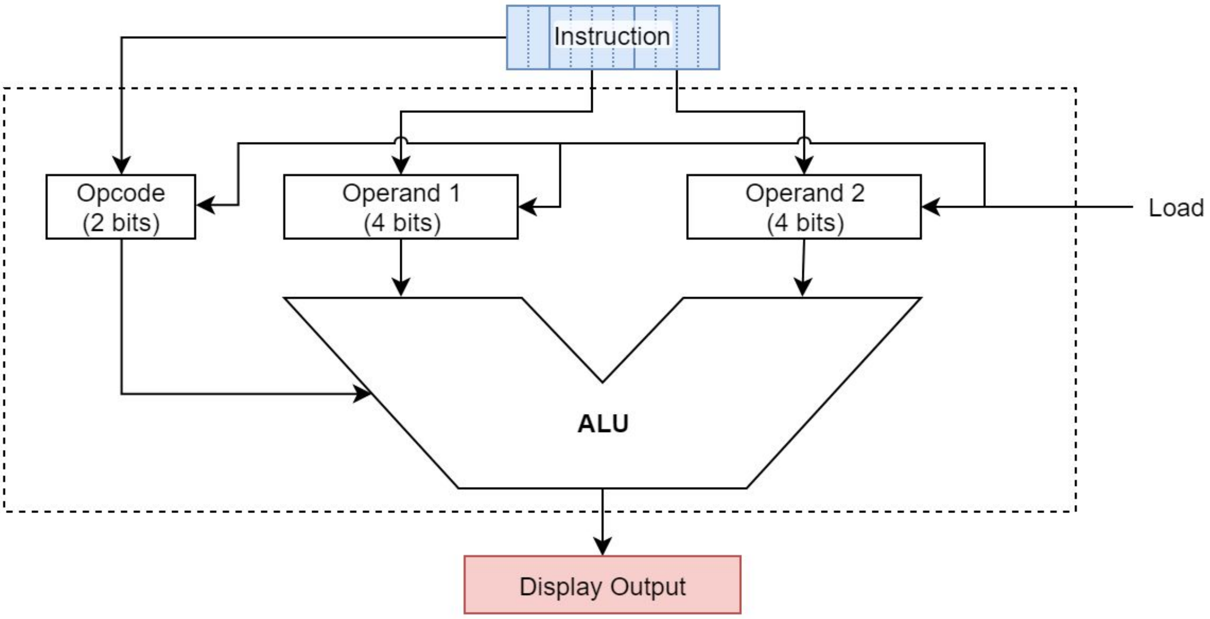
Physical implementation of the system on a Printed Circuit Board (PCB).

Phase 03:

Verilog (which will be discussed later in the course) implementation of the system.

System Architecture

Our computer system should be capable of taking in instructions given by the user and executing them on the ALU. A block diagram representing the overall architecture of the system is given in the figure below. Here, note that this is a block diagram and hence a single line or an arrow can represent multiple wires as well.

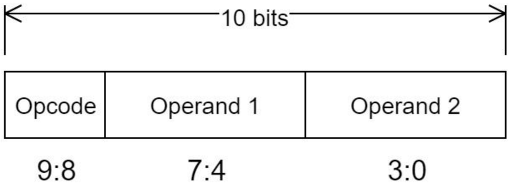


First the user sets an instruction (details about the structure of this instruction is given in the next section) using switches and gives the *Load* signal using a push button to load it to the system. A typical computer system has functionalities such as register read/write, execution through ALU, memory read/write, branching, etc. However, our simplified computer system needs to be designed only to perform a few basic arithmetic/logic operations using an ALU. Therefore, the output of the system is the result of the ALU. This output (i.e. result of the ALU) needs to be displayed on SSDs in **decimal**.

Instructions of the System

We already have discussed briefly about instructions on a typical computer system. In hardware, these instructions are represented by '1's and '0's which corresponds to the presence and absence of a specific voltage (in our project, it'll mostly be 5V) respectively. Our computer system would be capable of executing one instruction at a time given manually using switches. The size of an instruction is 10 bits and it is fixed. This type of fixed-sized instructions can be found in RISC (Reduced Instruction Set Computer) type microprocessors.

An instruction in our system tells what the operation to be performed by the ALU and the two operands are. The operation to be performed is represented by the *Operation Code* or commonly known as *Opcode*. Our ALU will perform only 4 operations. Therefore, a 2-bit Opcode would be able to differentiate one operation from another. The operands are 4-bits in size. The structure of an instruction in our system is given in the figure below.



The operations performed by our system will be addition, subtraction, multiplication and bitwise XOR. The table below shows the Opcode corresponding to each of these operations.

Operation	**Opcode**
Addition	00
Subtraction	01
Multiplication	10
Bitwise XOR	11