Topic 1

Microprocessor Architecture

Department of Electronics

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Internal architecture of a microprocessor

Internal architecture

- ALU
- Register C
- Register A
- Register B
- Instruction decoder
- Instruction register
- Program Counter
- Address latch
- Address bus
- Data bus
- Clock
- Reset
- Read
- Write

Digital Electronic Systems
Electronics Department
OPERATIONS THAT A CPU CAN PERFORM:

- LOAD REGISTERS
- READ OR WRITE MEMORY LOCATIONS
- PERFORM ARITHMETIC OR LOGIC OPERATIONS
- ROTATIONS AND SHIFTS
Internal architecture of a microprocessor

- Internal architecture

**OPERATING SECTION**

- registers
  - store temporary data
- ALU
  - logic and arithmetics operations, shifts and rotations
- with or without accumulator
**Internal architecture of a microprocessor**

**Internal architecture**

**CONTROL SECTION**

- LOAD INSTRUCTIONS
- DECODE
- GENERATES MICROORDERS
  - ENABLE THE TRANSFER BETWEEN THESE REGISTERS AND CONFIGURE THE ALU OPERATIONS
Internal architecture of a microprocessor

Internal architecture

OTHERS REGISTERS

- AUXILIARY REGISTERS
- STATUS REGISTER
  - FLAGS: ZERO, SIGN CARRY, OVERFLOW
- PROGRAM COUNTER REGISTER
- STACK POINTER REGISTER
Internal architecture of a microprocessor

- **Instruction register**
  - It loads the operation code from the memory.
  - The decoder generates microorders depending on its content.

- **Program counter**
  - It contains the address of the instruction to be executed.
  - After execution of an instruction PC is modified to point to the next one.
**Internal architecture of a microprocessor**

- **Status register**
  - It contains flags that provide information on the outcome of an operation: sign, zero, carry, overflow.
  - It allows decisions conditional on the outcome of the previous operation.

- **Stack pointer**
  - It stores a memory address where data can be stored automatically or manually.
Internal architecture of a microprocessor

Internal bus

- It’s a communication bus between the various components of the microprocessor.
- The number of bus lines is determined by the number of bits processed in parallel in the ALU and it’s one of the parameters to classify microprocessors.
- This bus is related to the external data bus through the data bus buffer.
**Instructions. General concepts**

**What is a program?**
- It’s a sequential set of instructions that describe, define or characterize the execution of a task in a microprocessor.

**What is an instruction?**
- It’s the CPU elementary command.
- It’s a set of digital input signals to the decoder.
- The instruction decoder (sequential circuit) state evolves and it changes its outputs sequentially based on these signals.
- The output signals of the instruction decoder are the microorders.
Instructions. General concepts

◆ Coding Instructions

❖ The instructions are stored in memory

❖ Binary format, set '1' and '0', machine code

◆ Possible generation of binary codes

❖ Directly from a conversion table function / code

❖ Using an assembly starting from an assembly language
  ♦ Assembly language: set of mnemonics associated with the instructions

❖ Using a compiler, starting from a high level language
  ♦ Generates machine code from a program in high level language (eg C)
Example of Instruction

- Add 2 to the contents of register 'A'
  - (Historical solution) Using a conversion table it shows that this operation corresponds to the code 0x23, followed by the value 0x02.
  - (Tedious solution) Using an assembler program, it would be written to a file: "add 2, A", the result would be the same after you run the assembler (0x23, 0x02).
  - (Current solution) Using a high-level language: "A += 2", and after compiling, the result would be the same again (0x23, 0x02).
Instructions. General concepts

**Instruction format**

- Opcode + [Source operand] + [Destination operand]

**Access to the operands**

- Effective address: location of the operand
- Addressing Modes: Different ways to express the effective address
  - Provide power to the device
  - Simplify programming
**Instructions. General concepts**

**Steps in the execution of an instruction**

- Instruction fetch
  - PC → ADDRESS BUS; READING OPCODE
- Calculation of the effective address
- Search operands
- Executing operation
- Store the result
- Increased PC, new cycle
Type of instructions

- **Transfer instructions**
  - To Copy information from registers, registers and memory, or between memory.

- **Arithmetic instructions**
  - They perform simple arithmetic operations: addition, subtraction, etc..

- **Logical Instructions**
  - They perform logic operations on the operands: AND, OR, XOR, etc..
Types of instructions

- **Bit manipulation instructions**
  - They modify a single bit of the operand

- **Shift Instructions**
  - They shift the contents of a register in both directions

- **Program Control Instructions**
  - They change the flow of program execution
Addressing modes

- Mechanism for specifying the location of an operand.
- A microprocessor has several addressing modes.

Objectives of addressing modes:
- Facilitate the management of the data structures.
- Allow relocation code.
- Reduce the memory space occupied by the instructions.
**Addressing modes**

◆ Possible addressing modes:
  - Implicit
  - Register direct
  - Immediate
  - Memory direct
  - Indirect
  - Indirect with offset
  - Indirect with Index
  - Indirect with pre-indexed
  - Indirect with post-indexed