**Benha University**
**Shoubra Faculty of Engineering**
**Communication and Computer Engineering Department**
**2024/2025 Academic Year**

كلية الهندســـة بشبرا
FACULTY OF ENGINEERING- SHOUBRA

# Report on What key skills did you develop during your Embedded Systems studies?

Presented by

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# 1.Introduction:

As the fields of **electrical engineering, telecommunications, and computer systems** rapidly expand, infrastructure and network systems are becoming significantly more complex. This complexity is a direct result of the increasing integration of **automation and digitalization** across a wide range of applications, from smart grids and advanced communication systems to cloud computing and the Internet of Things. In this context, **fault analysis** (including fault detection, diagnosis, and prediction) has become critically important. Consequently, this area has attracted growing research attention, with investigations into fault analysis typically being conducted using real-time, online, or automated techniques for fault detection or alarming.

# 1.Embedded Systems Fundamentals

### 1.1 Introduction

An **Embedded System** is a dedicated computer system designed to perform one or a few specific tasks, often within a larger mechanical or electrical system. These systems are characterized by real-time performance constraints, low power consumption, compact size, and cost-effectiveness.


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**How an Embedded System Works**
**An embedded system is a small computer dedicated to performing one or more specific functions within a larger system. Unlike a personal computer, an embedded system is designed to perform a specific task with precision and efficiency.**

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**Core Components:**

- **Central Processing Unit (CPU): The brain of the system, it executes commands and programs.**
- **Memory: Used to store the program (non-volatile memory - ROM) and temporary data during execution (volatile memory - RAM).**
- **Input/Output Ports (I/O Ports): Allow the system to interact with the outside world, such as receiving data from sensors or controlling motors.**
- **Peripherals: Such as Timers, Counters, and Analog-to-Digital Converters (ADCs).**

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**Concept of Operation Using C Language:**

1. **Code Writing:**
    - **Code is written in the C programming language using a program like MikroC.**
    - **The code contains the control logic that defines how the system interacts with its inputs and outputs. For example, you can write code that reads the temperature from a sensor and then turns on a fan if the temperature is above a certain limit.**
2. **Compilation:**
    - **The MikroC program compiles the C code into machine language (Assembly Code), which the CPU can understand and execute directly.**
    - **The machine language is saved in a .hex file.**
3. **Simulation:**
    - **The Proteus software is used to simulate the embedded system's electronic circuit.**
    - **The .hex file created in the previous step is loaded into the microcontroller within the Proteus environment.**

- **Proteus then simulates the entire system's operation, allowing you to test the code and the circuit without the need to build a real one.**

4. **Programming:**
   - **After verifying that the code works correctly in the simulation, the actual microcontroller is programmed by copying the .hex file to it.**
   - **The microcontroller then becomes capable of performing its function independently.**

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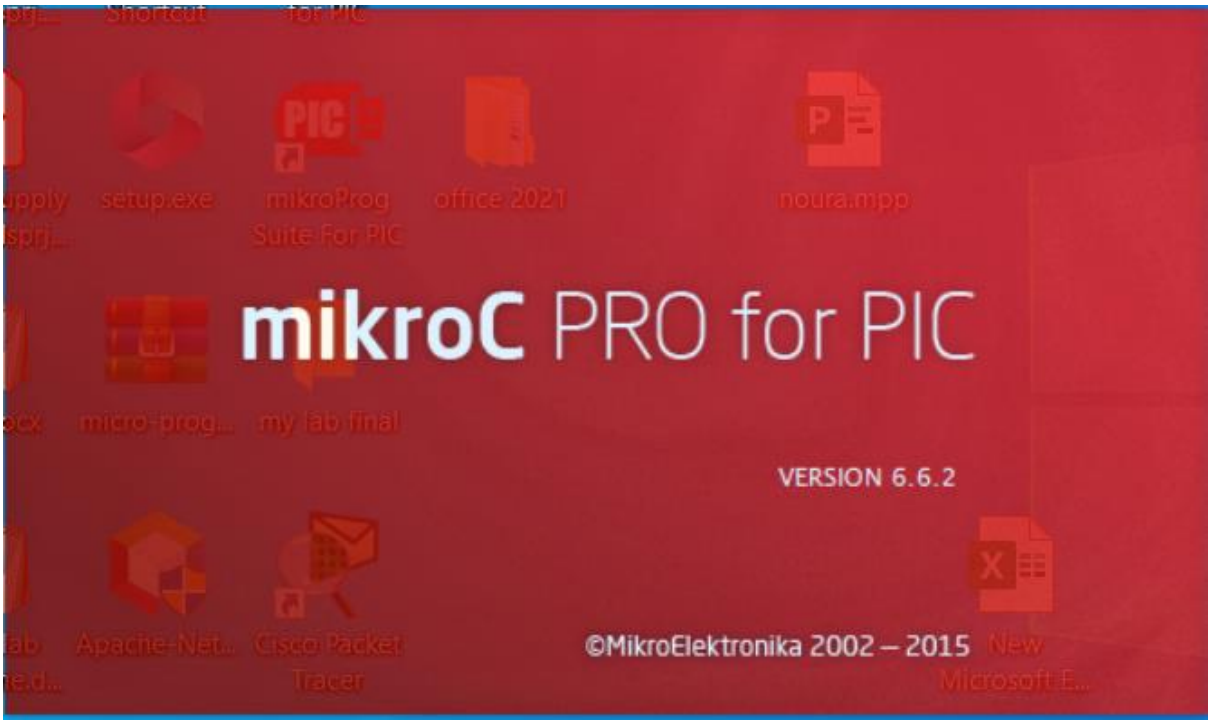


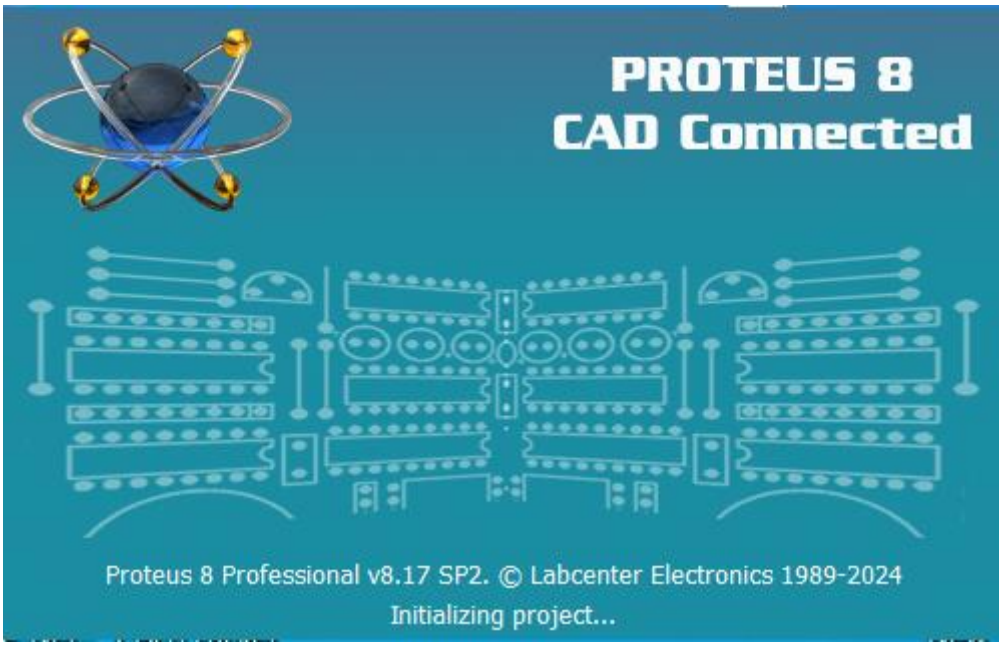


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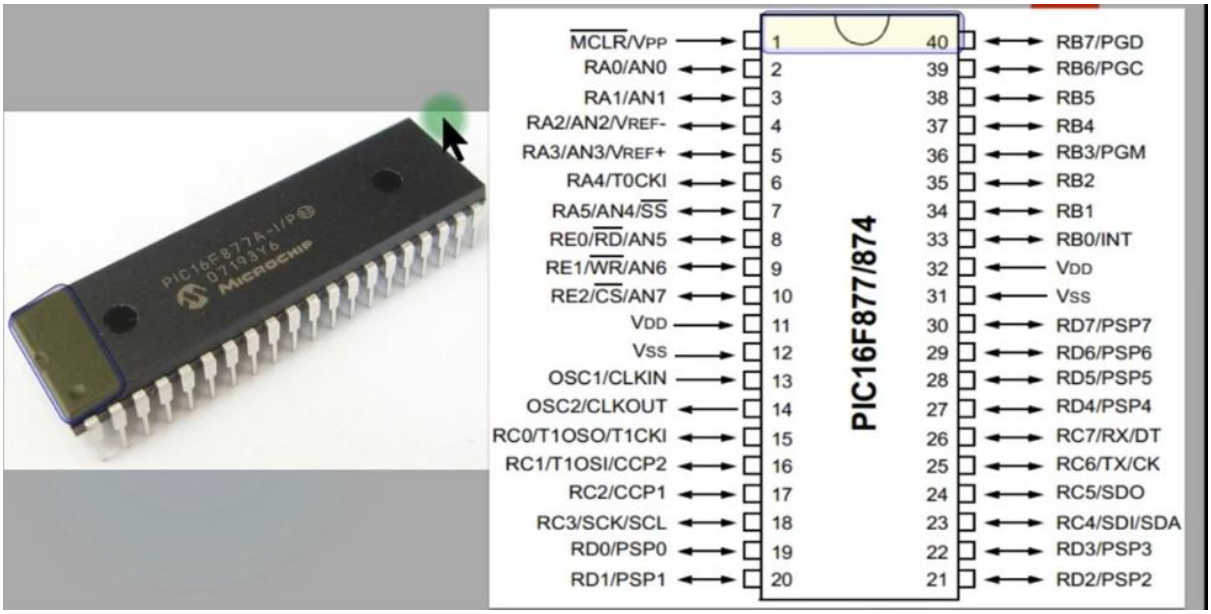
## 2. Microchip PIC Microcontrollers

### 2.1 Overview of PIC Microcontrollers

**Peripheral Interface Controllers (PIC)** from Microchip are widely used microcontrollers in embedded applications. They are known for:

- Simplicity
- Efficiency
- Wide range of models: PIC10, PIC12, PIC16, PIC18

The **PIC16F877A** is a popular educational and practical microcontroller due to its balance between features and simplicity.

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### 2.2 Core Features of PIC Microcontrollers

| Unit | Description |
|---|---|
| **CPU** | Executes instructions and controls data flow (the "brain"). |
| **I/O Ports** | Configurable pins for input (e.g. sensors) or output (e.g. LEDs). |
| **Memory** | 3 types: |
| – Flash: Stores program code (non-volatile) | |
| – RAM: Temporary data (volatile) | |
| – EEPROM: Permanent data (non-volatile) | |

**3. Oscillator (Clock Generator)**

**3.1 Function**

The oscillator provides timing signals that synchronize all internal operations of the microcontroller. Its frequency determines instruction execution speed.

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**3.2 Common Oscillator Types**

| Type | Frequency Range | Capacitor Range | Notes |
|---|---|---|---|
| **LP** | 32 kHz | ~33 pF | Low-power applications |
| **XT** | 1–4 MHz | ~15 pF | Stable crystal |
| **HS** | 8–20 MHz | 15–33 pF | High-speed operations |
| **RC** | Varies | None | Low-cost, less precise |
| **Internal** | Built-in | — | Requires no external parts |

**Note:** Crystals often need capacitors to reduce noise and ensure stability.

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**4. Basic Connections & I/O Ports**

To operate a PIC microcontroller:

1. **Power**: Connect Vcc (5V) and GND.
2. **Oscillator Circuit**: Crystal + capacitors connected to OSC1, OSC2.
3. **Reset (MCLR)**: Connect to Vcc with a pull-up resistor.
4. **I/O Ports**: Pins configured as input/output using TRIS registers.

**Example: Blinking LED on RB0**

```
TRISB = 0x00;       // Set PORTB as output
while(1) {
  PORTB.b0 = 1;     // LED ON
  Delay_ms(1000);
  PORTB.b0 = 0;     // LED OFF
  Delay_ms(1000);
}
```

**5. First Program with MicroC & Proteus**

**5.1 Tools**

- **MicroC PRO for PIC**: Writing and compiling the code.

- **Proteus ISIS**: Simulating circuits using .hex file from MicroC.

**5.2 Steps**

1. Write LED blinking code.
2. Compile to generate .hex file.
3. In Proteus, add PIC, crystal, LED, resistor.
4. Load .hex into PIC.
5. Run simulation – the LED blinks.

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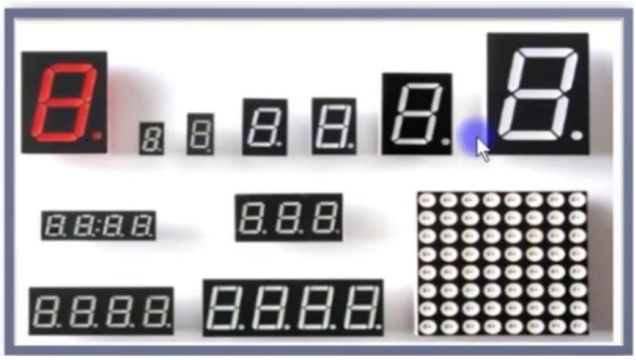
# 6. 7-Segment Displays

## 6.1 Overview

A **7-Segment Display** shows decimal numbers using seven LEDs labeled (a–g), and sometimes a decimal point (DP).



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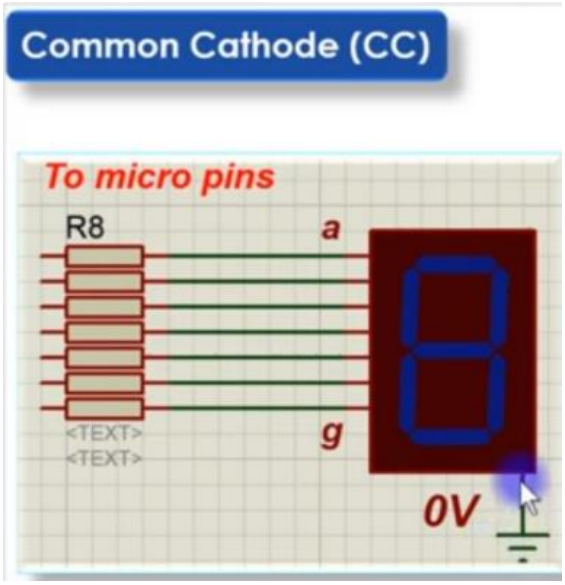
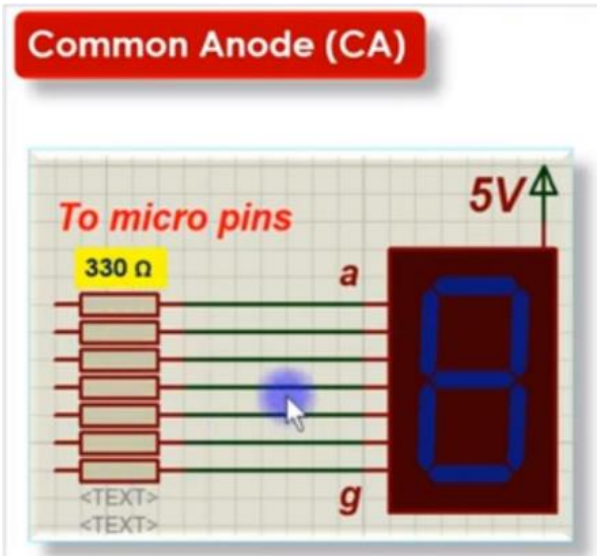
## 6.2 Types

| Type | Common Terminal | Lighting Logic |
|---|---|---|
| **Common Anode (CA)** | All anodes tied to `Vcc` | Segments lit by driving cathodes `LOW` |
| **Common Cathode (CC)** | All cathodes tied to `GND` | Segments lit by driving anodes `HIGH` |

Each segment is connected to a microcontroller I/O pin through a resistor.




## Example: Displaying '0' on Common Cathode

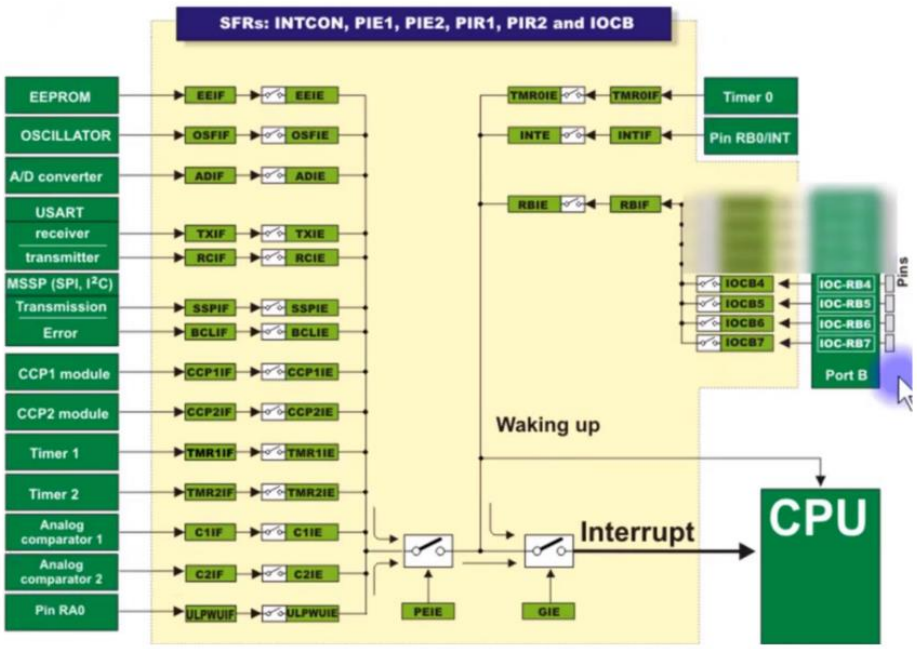
To light up `a, b, c, d, e, f`:

```
PORTD = 0b00111111;  // Binary pattern for digit 0
```

### 7. Interrupts

#### 7.1 What Are Interrupts?

**Interrupts** allow the microcontroller to react to internal/external events **asynchronously**, pausing current execution to handle urgent tasks.



### 7.2 How They Work

1. Event triggers an interrupt.
2. Controller saves current state.
3. Jumps to **Interrupt Service Routine (ISR)**.
4. Executes task (e.g., button press).
5. Returns to main code.

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### 7.3 Types of Interrupts in the PIC16F877A Microcontroller

The PIC16F877A has 15 types of interrupts, broadly categorized into two types:

- **External Interrupts**: Triggered by signals from outside the microcontroller. Examples include:
    - **MCLR Pin**
    - **RB0/INT Pin**
    - **Change on PORTB pins (RB4-RB7)**
- **Internal Interrupts**: Triggered by events inside the microcontroller. Examples include:
    - Timers (Timer0, Timer1, Timer2)
    - Serial Communication (UART)
    - EEPROM

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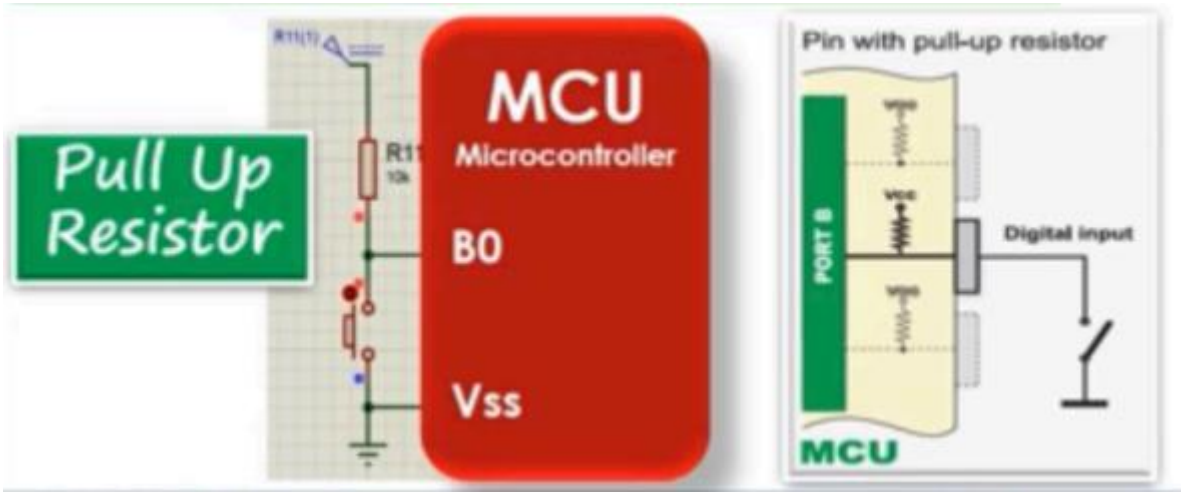
### 7.4 The RB0/INT External Interrupt

The RB0 interrupt is a crucial external interrupt. To control it, specific registers are used:

- **INTCON Register**: Contains the main control bits:
    - **GIE (Global Interrupt Enable)**: Enables/disables all interrupts. Must be set to 1 to enable any interrupt.
    - **INTE (RB0/INT External Interrupt Enable)**: Enables/disables the RB0 interrupt specifically. Must be 1 to enable it.
    - **INTF (RB0/INT External Interrupt Flag)**: This flag is automatically set to 1 when the interrupt occurs. It must be cleared manually (set to 0) by the user within the ISR.
- **OPTION_REG Register**: Controls the behavior of the RB0 interrupt:
    - **INTEDG (Interrupt Edge Select)**: Determines the signal edge that triggers the interrupt.
        - 1 = Interrupt on the rising edge.

- 0 = Interrupt on the falling edge.

- **RBPU (PORTB Pull-up Enable)**: Controls the internal pull-up resistors on PORTB pins.
  - 1 = Disables the pull-ups.
  - 0 = Enables the pull-ups.

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**7.5 Conditions for Interrupt Execution**

For an interrupt to be executed successfully, three main conditions must be met:

1. **Cause Exists**: The event that causes the interrupt must occur, which automatically sets the flag bit (IF bit) to 1.
2. **Specific Interrupt Enabled**: The specific interrupt bit (IE bit), such as INTE_bit for the RB0 interrupt, must be set to 1.
3. **Global Interrupts Enabled**: The global interrupt enable bit (GIE_bit) must be set to 1.

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**7.6 Programming Example: Configuring an RB0 Interrupt**

To configure the RB0 interrupt using MicroC, you can use the following commands:

**In the main program (void main())**:

```
TrisB.B0 = 1;     // Configure RB0 as an input
GIE_bit = 1;      // Enable global interrupts
INTE_bit = 1;     // Enable the RB0 interrupt
```

```
INTEDG_bit = 0;   // Select falling edge trigger
// To enable internal pull-up resistors on PORTB
// NOT_RBPU_bit = 0;
```

**In the Interrupt Service Routine (void interrupt())**:

```
void interrupt() {
   if (INTF_bit == 1) { // Check if the interrupt is from RB0
      INTF_bit = 0;    // Clear the interrupt flag
      //... Place your interrupt code here
   }
}
```

**Note**: It is crucial to always clear the interrupt flag bit (INTF_bit) within the ISR to prevent the interrupt from re-triggering immediately.

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