# *STM32 Microcontroller Programming and Applications*

**Course Description** This course provides a comprehensive introduction to STM32 microcontrollers, focusing on hardware architecture, software development, and practical applications. Participants will learn to use STM32CubeMX, HAL libraries, and ARM Cortex features to design, program, and debug embedded systems effectively. The course includes hands-on projects to solidify concepts and develop proficiency in real-world embedded system programming.

**Audience Profile**

- Engineers and developers seeking to specialize in microcontroller-based systems.
- Students and hobbyists interested in embedded systems programming.
- Professionals transitioning from other microcontroller platforms to STM32.

**Prerequisites**

- Basic understanding of programming in C.
- Familiarity with electronics and microcontroller fundamentals.
- Knowledge of software development tools and processes.

**Course Objectives**

- Understand the architecture and features of STM32 microcontrollers.
- Configure STM32 toolchains and software development environments.
- Develop embedded applications using STM32CubeMX and HAL libraries.
- Master peripheral programming, including GPIO, ADC, UART, and PWM.
- Implement interrupt-driven and DMA-based applications.
- Explore real-world projects demonstrating STM32 capabilities.

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- Adding Functionality to the Program
- Compiling and Executing the Modified Program
- Simple Modification for the main.c Function
- Complex Modification for the main.c File

5. **General-Purpose Input Output (GPIO) and the STM Hardware Abstraction Layer (HAL)**
    - Memory-Mapped Peripherals
    - Core Memory Addresses
    - Peripheral Memory Addresses
    - HAL_GPIO Module
    - GPIO Pin Hardware
    - LED Test Demonstration
    - Enabling Multiple Outputs
    - Push-Button Test Demonstration
    - Clock Speed Demonstration
    - Setting the Pin Clock Speeds

6. **Interrupts**
    - NVIC Specifications
    - Interrupt Process
    - External Interrupts
    - Interrupt Demonstration

7. **Timers**
    - STM Timer Peripherals
    - STM Timer Configuration
    - Update Event Calculation
    - Polled or Non-interrupt Blink LED Timer Demonstration
    - Test Run

    - Interrupt-Driven Blink LED Timer Demonstration
    - Test Run
    - Multi-rate Interrupt-Driven Blink LED Timer Demonstration
    - Test Run
    - Modification to the Multi-rate Program
    - Test Run

8. **Bit Serial Communications**
    - UARTs and USARTs
    - USART Configuration
    - Windows Terminal Program
    - Enabling USART2
    - USART Transmit Demonstration Program
    - Test Run
    - USART Receive Demonstration Program
    - Test Run

9. **Analog-to-Digital Conversion**
    - ADC Functions
    - ADC Module with HAL
    - ADC Conversion Modes
    - Channels, Groups, and Ranks
    - ADC Demonstration
    - ADC Demonstration Software

10. **Pulse Width Modulation (PWM)**
    - General-Purpose Timer PWM Signal Generation
    - Timer Hardware Architecture
    - PWM Signals with HAL

- Enabling the PWM Function
- PWM Demonstration Software
- Adding Functional Test Code
- Test Results

11. **Direct Memory Access (DMA) and the Digital-to-Analog Converter (DAC)**
    - DMA
    - Basic Data Transfer Concepts
    - DMA Controller Details
    - Using HAL with DMA
    - Demonstration One
    - DAC Peripheral
    - DAC Principles
    - HAL Software for the DAC