Advanced Embedded Systems Programming with C and STM32 Microcontrollers

Course Description

This course covers the fundamentals of programming embedded systems using the C language and STM32 microcontrollers. It includes topics such as basic programming concepts in C, advanced programming concepts in C, STM32 microcontroller hardware, GPIO programming, timers and PWM, DMA and ADC in STM32, display and input units interfacing, and project development using STM32 microcontroller. The course also provides practical exposure to real-time embedded systems programming using the STM32 platform.

Audience

This course is designed for students and professionals who want to learn embedded systems programming with C and STM32 microcontrollers. It is suitable for anyone with basic programming knowledge in C and an interest in developing applications for embedded systems.

Pre-requisite Knowledge/Skills

Participants should have a basic understanding of programming concepts in C and digital electronics. Familiarity with microcontrollers is a plus.

Course Objectives

- Understand the basics of programming embedded systems using C
- Understand the features and uses of STM32 microcontrollers
- Interface various peripherals inside STM32 microcontrollers
- Develop reusable firmware in C language
- Understand the concepts of memory protection and security in STM32
- Develop applications using GPIO, timers, and PWM in STM32
- Develop applications using DMA and ADC in STM32
- Interface various display and input units with STM32 microcontroller
- Develop a complete project using STM32 microcontroller.

Course Outline

The course comprises 40-hours of theory and labs. It's divided into 10 different modules.

Module 1: Introduction to C and Embedded Systems

- Why C in Embedded Systems

- Fundamentals of C
- ANSI Standard
- Introduction to Embedded Systems and STM32 ARM Cortex Family
- ST Microcontrollers and the STM32 platform
- Key Features and Uses of STM32

Module 2: Basic Programming Concepts in C

- Conditional statements
- Loops
- Functions
- Arrays
- Strings
- Storage Classes
- Structures & Unions
- Enumerated Data Types
- Bit Operations
- Pointers
- Dynamic Memory Allocation
- File Handling Concepts
- Raw Data Handling
- Low-Level Programming
- Command Line Arguments
- Compiler in Practical

Module 3: Advanced Programming Concepts in C

- Data Structures
- Sorting and Searching Techniques
- Concepts and Real-Time Exposure
- Development Tools and Environment
- Make Utility and Multi-File Programming
- Industry Coding Standards
- Object/Executable File Format
- Debugging Large Programs

Module 4: STM32 Microcontroller Hardware

- Understanding the Internals of STM32 Microcontroller Hardware
- Memory Protection Unit & Security in STM32

- Interface Various Peripherals Inside of STM32 Microcontrollers
- Setting Up Integrated Development Environment
- Use of Software and Tool Chains Compiler, Debugger and ICSP
- Getting Started with STM32 Family

Module 5: STM32 GPIO Programming

- Use of HAL Library
- Digital Output & Delay Programming
- Digital Input Sense and Programming
- Debugging Using ST-Link
- STM32 Interrupts & Priorities
- Get Familiar with Interrupts & NVIC
- External Interrupts & Concept of Interrupt Latency

Module 6: STM32 Timers and PWM

- STM32 Timers Configuration & Programming
- Timer Implementation in STM
- Configuring Counter Mode in Timers
- Using and Programming Watchdog Timers
- PWM Generation Techniques in STM

Module 7: DMA and ADC in STM32

- Use of DMA in STM32
- STM32 ADC Interfacing
- Sensor Interfacing: Analog and Digital Sensors ADC with PWM
- Use of DAC in STM32
- Analog Waveform Generation using DAC
- Serial Communication

Module 8: Display and Input Units Interfacing

- Interface Various Display Units 7-Segments, Alphanumeric LCD etc.
- Interface Various Input Units like Buttons, Rotary Encoders, Keypad etc.

Module 9: Reconfigurable Reusable Firmware in C Language

- Concepts of Reconfigurable Reusable Firmware in C Language

Module 10: Project Development

- Project Development using STM32 Microcontroller