



## OS3 - FreeRTOS Programming

*Programming applications using the FreeRTOS operating system*

### Objectives

- Understanding the FreeRTOS architecture.
- Discovering the various FreeRTOS services and APIs.
- Learning how to develop FreeRTOS applications.
- Learning how to debug FreeRTOS applications.
- Becoming familiar with FreeRTOS APIs.
- Managing the Task priorities and clarifying the scheduling algorithm.
- Explaining the inter-task communication.
- Developing interrupt service routines.

Practical labs are conducted on STM32 boards under System Workbench for STM32.

(Keil or IAR can also be used for on site courses).

ACSYS is able to adapt the course to the Cortex-M based microcontroller chosen by the customer.

See our website for the various families we are covering: ST STM32, NXP LPC and Kinetis, TI Stellaris.

### Course environment

- Example code, labs and solutions are provided to the attendees.
- An ARM-based target board (Cortex/M) with a JTAG probe.
- For open courses labs are done on STM32 boards using Sytem Workbench for STM32.
- For on site courses, the customer may select Keil or IAR IDEs.

### Prerequisites

- Familiarity with embedded C concepts and programming
- Basic knowledge of embedded processors

### Environnement du cours

- Cours théorique
  - Support de cours au format PDF (en anglais) et une version imprimée lors des sessions en présentiel
  - Cours dispensé via le système de visioconférence Teams (si à distance)
  - Le formateur répond aux questions des stagiaires en direct pendant la formation et fournit une assistance technique et pédagogique
- Au début de chaque demi-journée une période est réservée à une interaction avec les stagiaires pour s'assurer que le cours répond à leurs attentes et l'adapter si nécessaire

### Audience visée

- Tout ingénieur ou technicien en systèmes embarqués possédant les prérequis ci-dessus.

# Plan du cours

## First day

### The FreeRTOS source code

- Introduction to FreeRTOS
  - The FreeRTOS architecture and features
  - The FreeRTOS license
- Getting FreeRTOS source code
  - Files and directories structure
  - The demo applications
- Data types and coding style
  - Naming conventions
- FreeRTOS on the Cortex/M processors

### Task Management

- The Task life-cycle
  - Creating tasks
  - Deleting tasks
  - The Endless-loop pattern
- Task Priorities
  - Assigning task priorities
  - Changing task priorities
- The idle task
  - Idle task hooks

### Scheduling

- Deterministic preemptive scheduling
  - Scheduling strategies
  - Cyclic scheduling (RMA)
  - Deadline scheduling
- Cooperative scheduling
  - Hybrid scheduling

### Queue Management

- Purpose of queue management
- Basic use
  - Creation
  - Sending on a queue
  - Receiving from a queue
- Data management
  - Sending compound types
  - Transferring large data

## Second day

### Resource Management

- Mutual exclusion
  - Mutexes and binary semaphores

- Deadlocks
- Priority inversion
- Priority inheritance
- Critical sections
  - Critical sections
  - Suspending (locking) the scheduler
  - Gatekeeper tasks

## Memory Management

- FreeRTOS-provided memory allocation schemes
  - Allocate-only scheme
  - Best-fit without coalescing
  - Thread-safe default malloc
- Checking remaining free memory
- Adding an application-specific memory allocator

## Interrupt Management

- FreeRTOS interrupt processing
  - Writing ISRs in C
  - Interrupt safe functions
  - Interrupt nesting
- Deferred interrupt processing
  - Using semaphores within an ISR
  - Counting semaphores
  - Using queues within an ISR
  - Tasks with interrupt synchronization

## Software Timers

- The timer daemon task
- Timer configuration
- One-Shot and Auto-reload timers
- The Software Timer API

## Trouble Shooting

- Checking for stack problems
- Common pitfalls

## FreeRTOS-MPU

- The Cortex/M MPU
  - User and privileged modes
  - Access permissions
- Defining MPU regions
  - Overlapping regions
  - Predefined regions
  - Programmer-defined regions
- Needed linker configuration
- Practical usage tips