This course covers both Cortex-M4 and Cortex-M4F (with FPU) ARM core

Objectives

- This course is split into 3 important parts:
  - Cortex-M4 architecture
  - Cortex-M4 software implementation and debug
  - Cortex-M4 hardware implementation.
- Although the Cortex-M4 seems to be a simple 32-bit core, it supports sophisticated mechanisms, such as exception pre-emption, internal bus matrix and debug units.
- Through a tutorial, the Cortex-M4 low level programming is explained, particularly the ARM linker parameterizing and some tricky assembly instructions.
- The course also indicates how to use new DSP and FPU instructions to boost DSP algorithm implementation.
- Note that attendees can replay these labs after the training.
- The course also details the hardware implementation and provides some guidelines to design a SoC based on Cortex-M4, taking benefit of concurrent AHB transactions.
- An overview of the Coresight specification is provided prior to describing the debug related units.

A more detailed course description is available on request at formation@ac6-formation.com

Prerequisites

- A basic understanding of microprocessors and microcontrollers.

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.

Modalités d'évaluation

- Les prérequis indiqués ci-dessus sont évalués avant la formation par l'encadrement technique du stagiaire dans son entreprise, ou par le stagiaire lui-même dans le cas exceptionnel d'un stagiaire individuel.
- Les progrès des stagiaires sont évalués par des quizz proposés en fin des sections pour vérifier que les stagiaires ont assimilé les points présentés
- En fin de formation, une attestation et un certificat attestant que le stagiaire a suivi le cours avec succès.
  - En cas de problème dû à un manque de prérequis de la part du stagiaire, constaté lors de la formation, une formation différente ou complémentaire lui est proposée, en général pour conforter ses prérequis, en accord avec son responsable en entreprise le cas échéant.

Plan

FIRST DAY - ARCHITECTURE

INTRODUCTION TO ARM CORTEX-M4

- ARM Cortex-M4 processor macrocell
- Programmer s model
- Instruction pipeline
- Fixed memory map
- Privilege, modes and stacks
- Memory Protection Unit
- Interrupt handling
- Nested Vectored Interrupt Controller [NVIC]
- Power management
- Debug

ARM CORTEX-M4 CORE

- Special purpose registers
- Datapath and pipeline
- Write buffer
- Bit-banding
- System timer
- State, privilege and stacks
- System control block

ARCHITECTURE OF A SOC BASED ON CORTEX-M4

- Internal bus matrix
- External bus matrix to support DMA masters
- Connecting peripherals
- Sharing resources between Cortex-M4 and other CPUs
- Connection to Power Manager Controller

SECOND DAY - PROGRAMMING

EMBEDDED SOFTWARE DEVELOPMENT WITH CORTEX-M4

- Application startup
- Placing code, data, stack and heap in the memory map, scatterloading
- Reset and initialisation
- Placing a minimal vector table
- Further memory map considerations, 8-byte stack alignment in handlers

THUMB-2 INSTRUCTION SET

- General points on syntax
- Data processing instructions
- Branch and control flow instructions
- Memory access instructions
- Exception generating instructions
- If&then conditional blocks
- Stack in operation
- Exclusive load and store instructions, implementing atomic sequences

- Memory barriers and synchronization

CORTEX-M4 DSP INSTRUCTION SET

- Multiply instructions
- Packing / unpacking instructions
- V6 ARM SIMD packed add / sub instructions
- SIMD combined add/sub instructions, implementing canonical complex operations
- Multiply and multiply accumulate instructions
- SIMD sum absolute difference instructions
- SIMD select instruction
- Saturation instructions

FLOATING POINT UNIT

- Introduction to IEEE754
- Floating point arithmetic
- Cortex-M4F single precision FPU
- Register bank
- Enabling the FPU
- FPU performance, fused MAC
- Improving the performance by selection flush-to-zero mode and default NaN mode
- Extension of AAPCS to include FP registers

C/C++ COMPILER HINTS AND TIPS FOR Cortex-M4

- Mixing C/C++ and assembly
- Coding with ARM compiler
- Measuring stack usage
- Unaligned accesses
- Local and global data issues, alignment of structures
- Further optimisations, linker feedback

THIRD DAY - EXCEPTIONS, DEBUG

INTERRUPTS

- Basic interrupt operation, micro-coded interrupt mechanism
- Interrupt entry / exit, timing diagrams
- Interrupt stack
- Tail chaining
- Interrupt response, pre-emption
- Interrupt prioritization
- Interrupt handlers

EXCEPTIONS

- Exception behavior, exception return
- Non-maskable exceptions
- Privilege, modes and stacks
- Fault escalation
- Priority boosting
- Vector table

MEMORY PROTECTION UNIT

- Memory types
- Access order
- Memory barriers, self-modifying code

- Memory protection overview, ARM v7 PMSA
- Cortex-M4 MPU and bus faults
- Fault status and address registers
- Region overview, memory type and access control, sub-regions
- Region overlapping

INVASIVE DEBUG

- Coresight debug infrastructure
- Halt mode
- Vector catching
- Debug event sources
- Flash patch and breakpoint features
- Data watchpoint and trace
- ARM debug interface specification
- Coresight components
- AHB-Access Port
- Possible DP implementations: Serial Wire JTAG Debug Port [SWJ-DP] or SW-DP

NON-INVASIVE DEBUG

- Basic ETM operation
- Instruction trace principles
- Instrumentation trace macrocell
- ITM stimulus port registers
- DWT trace packets
- Hardware event types
- Instruction tracing
- Synchronization packets
- Interface between on-chip trace data from ETM and Instrumentation Trace Macrocell [ITM]
- TPIU components
- Serial Wire connection

FOURTH DAY HARDWARE IMPLEMENTATION

AMBA3.0 INTERCONNECT SPECIFICATION

- Purpose of this specification
- Example of SoC based on AMBA specification
- Differences between AMBA2.0 and AMBA3.0

AHB - ADVANCED HIGH PERFORMANCE BUS

- Centralized address decoding
- Address gating logic
- Arbitration, bus parking
- Indivisible transactions
- Single-data transactions
- Address pipelining
- Sequential transfers
- AHB-lite specification
- Parameterizing the AHB core provided by ARM

APB - ADVANCED PERIPHERAL BUS

- Second-level address decoding
- Read timing diagram
- Write timing diagram
- Operation of the AHB-to-APB bridge

- APB3.0 new features

AHB CORTEX-M4 HARDWARE IMPLEMENTATION

- Clocking and reset, power management
- Using an external Wake-up Interrupt Controller (WIC)
- Bus interfaces: Icode memory interface, Dcode memory interface, System interface and External Private Peripheral Bus interface
- AMBA-3 compliance
- Unifying the code buses
- Unaligned access management
- Debug interface
- Connection to the TPIU
- AHB Trace Macrocell (HTM)

Renseignements pratiques

Renseignements : 4 jours