



## FCQ10 - T1040 QorIQ implementation

*This course covers NXP QorIQs T1020, T1022, T1040, T1042*

### Objectives

- This course has the following objectives:
  - Describing the hardware implementation, particularly the boot sequence and the DDR3 controller
  - Understanding the features of the internal interconnect and related units and mechanisms such as PAMU, CPC and stashing
  - Explaining the standard bus interface controllers, PCIe, USB, SATA and MMC-SD
  - Describing the units which are interconnected to other modules, such as clocking, interrupt controller and DMA controller, because the boot program generally has to modify the setting of these units
  - Clarifying the operation of the Datapath Acceleration Architecture that assists the processor core in taking in charge buffer allocation, queue management, frame management and particularly incoming frame classification, pattern searching, and encryption
  - Describing the various debug units and their utilization to fix errors in a multicore / multimaster SoC.

A more detailed course description is available on request at [training@ac6-training.com](mailto:training@ac6-training.com)

This document is necessary to tailor the course to specific customer needs and to define the exact schedule.

### Pre-requisites and related courses

- Experience of a 32-bit processor or DSP is mandatory.
- Note that the e5500 Power core is covered in a separate course reference [FCC2 - e5500 implementation](#) course.
- The following courses could also be useful:
  - PCIe [IC4 - PCI Express 3.0](#) course
  - Ethernet [N1 - Ethernet and switching](#) course
  - USB 2.0 [IP2 - USB 2.0](#) course
  - SATA [IS3 - Serial ATA III](#) course
  - DDR4 [SDR1 - DDR4 / LPDDR4](#) course

### Course Environment

- Theoretical course
  - PDF course material (in English) supplemented by a printed version for face-to-face courses.
  - Online courses are dispensed using the Teams video-conferencing system.
  - The trainer answers trainees' questions during the training and provide technical and pedagogical assistance.
- At the start of each session the trainer will interact with the trainees to ensure the course fits their expectations and correct if needed

### Target Audience

- Any embedded systems engineer or technician with the above prerequisites.

# Course Outline

## T104X, T102X ARCHITECTURE

### OVERVIEW

- CoreNet coherency fabric
- Coherency subdomains
- Memory map, local access windows
- Highlighting data paths inside the T104X, T102X
- Application examples

### SOC PLATFORM

### POWER, RESET AND CLOCKING

- Reset causes
- Reset configuration words source
- Pre-boot loader
- PCIe configuration
- Clocking, system clock domains
- SerDes high speed lanes configuration
- Advanced power management

### SECURE BOOT

- Internal boot ROM, secure boot sequence
- Security fuse processor
- Code signing
- External tamper detection
- Run time integrity checker
- Secure debug controller

### CORENET PLATFORM CACHE

- Cache operation, write-through or write-back operation
- Operation as memory-mapped SRAM
- Partitioning between coherency domains
- Stashing, address-based or CoreNet signalled
- Soft error detection and correction

### PERIPHERAL ACCESS MANAGEMENT UNIT (PAMU)

- Controlling master access permissions through Logical I/O Device Number
- Address translation
- Data structures, Peripheral Access Authorization and Control Entry
- Operation mode translation
- Steps in processing of DSA operations by PAMU
- PAMU gate closed state

### IO BRIDGE

- Bridging agent
- Transaction ordering

- Resolution of coherency effects
- Authorization, access control and address mapping of I/O-initiated transactions flowing into the CoreNet coherency domain

## **MULTIPROCESSOR PERIPHERAL INTERRUPT CONTROLLER**

- Open PIC architecture compatibility
- Interrupt nesting
- Message interrupts
- e5500-to-e5500 interrupt capability

## **LOW SPEED PERIPHERALS**

- Description of the NS16452/16552 compliant Uarts
- I2C protocol fundamentals: addressing, multimaster operation
- Transfer timing diagrams, SCL and SDA pins
- eSPI controller

## **ENHANCED SDHC**

- Interface to SD and MMC cards
- Transfer protocol, single block, multiple block read and write
- Internal and external DMA capabilities
- SD protocol unit

## **USB CONTROLLERS**

- Host or device support
- High-speed operation
- EHCI support, scheduling the various transactions into frames
- Endpoint configuration
- Device operation

# **HARDWARE IMPLEMENTATION**

## **THE DDR3 / 4 MEMORY CONTROLLER**

- On-Die termination and calibration
- DDR3 fly-by architecture, write leveling
- Reset sequence, dynamic ODT, ZQ calibration
- Bank activation, read, write and precharge timing diagrams, page mode
- Initial configuration following Power-on-Reset
- Address decode unit
- Timing parameters programming
  - Initialization routine
  - Testing the memory using patterns

## **INTEGRATED FLASH CONTROLLER**

- Functional muxing of pins between NAND, NOR, and GPCM
- Normal GPCM FSM
- Flexible timing control
- NOR flash FSM
- Configurable even/odd parity on address/data bus supported
- NAND flash FSM
- ONFI-2.0 asynchronous interface
- ECC generation/checking

- SLC and MLC Flash devices support with configurable page sizes

## **INTEGRATED DMA CONTROLLERS**

- Scatter / gathering
- Selectable hardware enforced coherency
- Ability to start DMA from external 3-pin interface

## **PCI EXPRESS INTERFACE**

- Modes of operation, Root Complex / Endpoint
- Transaction ordering rules
- Programming inbound and outbound ATMUs
- Benefits of MSIs
- Low power management
- Configuration, initialization

## **SATA CONTROLLER**

- Support for SATA II extensions
- Native command queuing, command descriptor
- Standard ATA master-only emulation
- Interrupt coalescing

## **DISPLAY INTERFACE UNIT**

- Modes of operation
- Area descriptor
- Pixel structure
- Alpha-blending
- Chroma keying
- Gamma correction
- Internal DMA channels

# **DATAPATH PROCESSING SUBSYSTEM**

## **DPAA OVERVIEW**

- Data formats
- Frame formats
- Packet walk through
- DPAA Configuration and initialization

## **QUEUE MANAGER**

- Objectives if this accelerator
- Structure of frame queues
- Active and suspended frame queues
- Frame queue descriptor, frame queue descriptor cache
- Frame queue state machine
- Work queues and channels
- Enqueue and dequeue portals
- Utilization of rings
- Dequeue dispatcher operation
- Message ring
- Congestion avoidance, Weighted Random Early Discard
- Order definition point implementation

## **BUFFER MANAGER**

- Objectives of this accelerator
- Central resource pool management function
- Per-pool stockpile
- CoreNET software portals
- Direct connect portals
- Buffer Pool State Change Notifications

## **FRAME MANAGER**

- Objectives of this accelerator
- FMAN submodules
- Rx BMI features
- Tx BMI features
- Offline parsing, host command features
- Frame processing manager
- FMan controller
- Parser
- Key generator
- Policer

## **DATA PATH THREE-SPEED ETHERNET CONTROLLERS**

- Frame format with and without VLAN option
- Connection to packet FIFO interface
- Physical interfaces
- 256-entry hash table for unicast and multicast
- Accessing PHY registers
- RMON statistic counters, carry registers
- Client IEEE1588 timers

## **10-GIGABIT MAC**

- XAUI interface to PHY
- Multicast address filtering
- Dynamic inter packet gap (IPG) calculation
- MAC address insertion
- Support for VLAN
- IEEE 1588 timestamping

## **SECURITY ENGINE**

- Introduction to DES, 3DES and AES algorithms
- Job management using QMan interface
- Input / output rings
- Cryptographic operations
- Data movement, FIFOs
- Scatter / gather DMA
- Selecting the authentication / cryptographic algorithm
- Run Time Integrity Checking
- Example, implementing IPsec

# GLOBAL FUNCTIONS, DEVELOPMENT AND DEBUG

## PERFORMANCE MONITOR AND DEBUG FEATURES

- Introduction to NEXUS specification
- NEXUS Aurora link
- Event processing unit
- Watchpoint facility
- Trace buffer
- Event Combining for the Creation of Advanced Triggers
- Cross-Functional Debug Components
- DDR SDRAM interface debug, measuring per-master bandwidth

## 8-PORT ETHERNET SWITCH

### OVERVIEW

- Integration in the T1040/T1020
- Block diagram

### MAC LAYER

- Auto-negotiation
- Flow control, priority based flow control (IEEE 802.1Qbb)
- Energy Efficient Ethernet
- Port trunking (link aggregation)

### INGRESS PROCESSING

- Frame Classification (QoS, VLAN), translation / remarking
- Basic classification + advanced classification through IS1 TCAM
- Security Enforcement, MAC/IP binding through IS2 TCAM
- Dynamic Load Balancing policies, compliancy with Metro Ethernet Forum
- L2 forwarding
- Global storm policers for all the ingress traffic

### SHARED QUEUE SYSTEM

- Cut-through operation
- Buffer management
- Frame Reference management
- Watermark programming and consumption monitoring
- Shapers and schedulers for egress traffic
- Deficit Weighted Round Robin algorithm

### EGRESS PROCESSING

- Rewriter, VLAN translation, push/ pop tags DSCP remapping, through ES0 TCAM
- ES0 key
- Green/Yellow departures
- Statistics

### LAYER2 FRAME FORWARDING

- IEEE802.1P and IEEE802.1Q implementation
- Frame aging

- Learning through Source MAC address
- Multicast management, IGMP/MLD snooping
- Adding entries by software in the forwarding table
- Support of STP, RSTP, MSTP

## QUICC ENGINE

### OVERVIEW OF QUICC ENGINE

- Integrated RISC CPU
- Communication between Host CPU and QE RISC CPU

### INTEGRATED INTERRUPT CONTROLLER

- Priority management
- Steering the interrupt source to either Low priority or High priority input of the platform PIC

### SYSTEM INTERFACE AND CONNECTION TO EXTERNAL COMMUNICATION PORTS

- Serial DMA
- QUICC engine external requests
- NMSI vs TDM
- Enabling connections to TSA or NMSI

### BUFFER MANAGEMENT

- Utilization of Buffer Descriptors
- Chaining descriptors into rings
- Parameter RAM independent of protocol

### UNIFIED COMMUNICATION CONTROLLERS

- UCC as slow communications controllers, UART mode
- UCC for fast protocols, virtual FIFOs

### UCC HDLC CONTROLLER

- Flow control
- Setting global parameters
- Describing the parameter RAM

### UCC TRANSPARENT CONTROLLER

- Transparent data encapsulation, frame sync and frame CRC
- Describing the parameter RAM

### SERIAL INTERFACE

- Connecting TDM lines
- Parameterizing the timings related to Rx/Tx clock, sync and data signals
- Connecting the TDM line to UCC using Rx/Tx routing tables

### MULTI-CHANNEL CONTROLLER ON UCC - UMCC

- Comparison with MCC and QMC
- Connecting time-slots to logical channels through Rx/Tx routing tables
- Implementing Rx/Tx channel buffers
- Interrupt management

- Channel-specific HDLC parameters
- Per channel exception management
- UMCC host commands