



## FQ1 - LS1021A QorIQ implementation

*This course covers the LayerScape LS1021A SoC*

### OBJECTIVES

- The course clarifies the architecture of the LS1021A, particularly the tuning of the interconnect.
- Cache coherency protocol is introduced in increasing depth.
- Only an overview of the ARM Cortex-A7 is provided, since this CPU is entirely covered by a separate course.
- The boot sequence and the clocking are explained.
- The course focuses on the hardware implementation of the LS1021A.
- A long introduction to DDR4 SDRAM operation is done before studying the DDR3L/DDR4 SDRAM controller.
- An in-depth description of the PCI-Express port is done.
- The course highlights both hardware and software implementation of gigabit / fast / Ethernet controllers .
- Communication interfaces are explained including QuiccEngine.
  
- This course is only delivered on site and therefore its contents can be adapted to specific customer needs from the outlines described hereafter.

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

### PREREQUISITES AND RELATED COURSES

- Experience of a 32-bit processor or DSP is mandatory.
- Knowledge of PCI Express bus is recommended.
  
- This course provides only an overview of the Cortex-A7.
- Our course reference cours [RA4 - Cortex-A7 implementation](#) details the operation of this complex ARM CPU.
- Our course reference cours [RC1 - NEON-v7 programming](#) explains how to vectorize and implement algorithms to be executed by NEON SIMD engine.
  
- The following courses could be of interest:
  - USB Full Speed High Speed and USB On-The-Go, reference cours [IP2 - USB 2.0](#)
  - USB Super Speed, reference cours [IP3 - USB 3.0](#)
  - Ethernet and switching, reference cours [N1 - Ethernet and switching](#)
  - IEEE1588, reference cours [N2 - IEEE1588 - Precise Time Protocol](#)
  - CAN bus, reference cours [IA1 - CAN bus](#)
  - Memory cards, reference cours [IS2 - eMMC 5.0](#)
  - SATA, reference cours [IS3 - Serial ATA III](#)
  - PCI Express, reference cours [IC4 - PCI Express 3.0](#)

### 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

## INTRODUCTION TO LS1021A

### BLOCK DIAGRAM

- SoC architecture
- Fixed memory map
- Local vs external address spaces, inbound and outbound address decoding

### INTERCONNECT

- CCI-400, Cache Coherent switch fabric
- AMBA 4 snoop request transport
- Snoop connectivity and control
- Ensuring data coherency of I/O streams through ACE-Lite ports
- System MMU
- Programming the TrustZone firewall
- OCRAM controller
- QoS tuning

## THE CORTEX-A7 CPUs

### OVERVIEW OF CORTEX-A7

- Cortex-A7 architecture
- 64-Byte cacheline size, integrated L2 cache
- VFPv4 and SIMDv2
- Instruction pipeline

### TRUSTZONE

- TrustZone conceptual view
- Secure to non secure permitted transitions
- L1 and L2 secure state indicators, memory partitioning
- System security, Central Security Unit
- Secure Non Volatile Storage

### EXCEPTION MECHANISM

- V7-A exception mechanism
- GICv2

### LARGE PHYSICAL ADDRESS EXTENSIONS SPECIFICATION (LPAE)

- Need to introduce support for a second stage of translation as part of the Virtualization Extensions
- New 3-level system
- Hypervisor-level address translation
- Level-1 table descriptor format
- Level-2 table descriptor format
- Attribute and Permission fields in the translation tables
- Complete set of cache allocation hints
- Handling of the ASID in the LPAE

## LEVEL ONE SUBSYSTEM

- Cache organization, 2-way instruction cache, 4-way data cache
- Pseudo random replacement algorithm
- Speculative accesses
- Hit Under Miss, Miss under Miss
- Detailing cache maintenance operations

## LEVEL TWO SUBSYSTEM

- L2 Cache
- Read allocate mode
- ACE master interface
- By means of sequences involving a multi-core Cortex-A7 and external masters, understanding how snoop requests can be used to maintain coherency of data between caches and memory

# INFRASTRUCTURE

## RESET, CLOCKING AND INITIALIZATION

- Clock subsystem block diagram
- Reference clock for SerDes protocols
- Voltage configuration selection
- Power-on reset sequence, detailing Reset Configuration Words
- Power-on reset configuration
- Pre-Boot Loader, required format of data structure consumed by PBL
- Boot from parallel flash: NOR and NAND
- Boot from serial flash: eSDHC and QuadSPI
- Watchdog timer

## SECURE BOOT AND TRUST ARCHITECTURE

- Objectives of trust architecture
- Internal boot ROM, secure boot sequence
- Security fuse processor
- Code signing
- External tamper detection
- Run time integrity checker
- Key revocation

## RUN CONTROL AND POWER MANAGEMENT

- Software-controlled power management states
- Core power management, doze and nap states
- Device power management, sleep and deep-sleep states
- Wake-up sources

## SERDES MODULE

- Interfaces from 1.25 to 6 Gbps
- External Signals Description
- SerDes Lane Assignments and Multiplexing
- SerDes clocking

## DDR3L/DDR4 SDRAM MEMORY CONTROLLER

- DDR3L and DDR4 Jedec specification
- DDR4 new features: Pseudo Open Drain termination, bank groups
- Calibration mechanism
- Command truth table
- Hardware interface
- Bank activation, read, write and precharge timing diagrams, page mode
- ECC error correction
- Freescale DDR 3/4 controller
- Initial configuration following Power-on-Reset

## INTEGRATED FLASH CONTROLLER

- Functional muxing of pins between NAND, NOR, and GPCM
- Normal GPCM FSM
- Flexible timing control
- NOR flash FSM
- Generic ASIC FSM
- NAND flash FSM
- ONFI-2.2 asynchronous interface
- ECC generation/checking
- SLC and MLC Flash devices support with configurable page sizes
- Internal SRAM of 9 KByte

## PCI EXPRESS INTERFACE

- 4-lane PCI Express interface
- Modes of operation, Root Complex / Endpoint
- Transaction ordering rules
- Programming inbound and outbound ATMUs
- MSI management
- Configuration, initialization

## QUAD SPI

- External signal description
- Interface to one single or two external serial flash devices
- Programmable sequence engine
- AHB buffers, Look Up Table
- Memory mapped read access to connected flash devices
- Flash programming

## INTEGRATED CONTROLLERS

- eDMA
- qDMA

## SATA3 CONTROLLER

- SATA basics
- Electrical specification
- AHCI command layerStandard ATA master-only emulation
- Command list structure
- Interrupt coalescing
- FIS-based switching

## SECURITY ENGINE

- Introduction to DES, 3DES and AES algorithms

- Job descriptor parsing
- Sharing descriptors
- Data movement, FIFOs
- Scatter / gather DMA
- Selecting the authentication / cryptographic algorithm
- Export and Import of cryptographic Blobs
- Public Key Hardware Accelerator (PKHA)
- SNOW 3G Accelerator
- Data Encryption Standard Accelerator (DES)
- Cyclic Redundancy Check Accelerator (CRCA)
- Message Digest Hardware Accelerator (MDHA)
- Elliptic Curve Cryptographic Functions

## INPUTS/OUTPUTS

### COMMUNICATION INTERFACES

- Ethernet Controllers
  - 802.3 specification fundamentals
  - Address recognition, pattern matching
  - Physical interfaces
  - Layer 2 acceleration accept or reject on address or pattern match
  - Management of VLAN tags and priority, VLAN insertion and deletion
  - Quality of service, managing several transmit and receive queues
  - TCP/IP offload engine, filter programming
  - IEEE1588 compliant time-stamping
  - Interrupt coalescing
- UARTs
- I2C
- SPI
- FlexCAN controllers

### ENHANCED SECURE DEVICE HOST CONTROLLER

- Introduction to MMC and SD card
- Storing and executing commands targeting the external card
- Multi-block transfers
- Read transfer sequence
- Write transfer sequence

### USB CONTROLLERS

- USB 2.0 controller
- USB 3.0 controller

### MULTIMEDIA INTERFACES

- Display interface unit
- SSI interfaces
- Asynchronous Sample Rate Converter
- SPDIF receiver / transmitter

### FLEXTIMER MODULE

- 16-bit timer modes, up-counter, down-counter,
- Input capture
- Output compare

- PWM

## QUICC ENGINE

### OVERVIEW OF QUICC ENGINE

- Communication between Host ARM CPU and QE RISC CPU, utilization of Command Register
- Mapping of integrated resources

### INTEGRATED INTERRUPT CONTROLLER

- Priority management, understanding the priority table
- Managing the priority within priority groups and between priority groups
- 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
- NMSI vs TDM
- Enabling connections to TSA or NMSI
- CMX registers

### BUFFER MANAGEMENT

- Utilization of Buffer Descriptors
- Chaining descriptors into rings
- Interrupt management

### UNIFIED COMMUNICATION CONTROLLERS

- Handling UCC interrupts
- Initialization sequence
- Defining Tx- and Rx-FIFO thresholds

### UCC HDLC CONTROLLER

- HDLC frame description
- Flow control
- Host commands

### UCC TRANSPARENT CONTROLLER

- Transparent data encapsulation, frame sync and frame CRC
- Flow control
- Host commands

### SERIAL INTERFACE

- Connecting TDM lines
- Parameterizing the timings related to Rx/Tx clock, sync and data signals

### MULTI-CHANNEL CONTROLLER ON UCC - UMCC

- Clarifying the various tables that must be implemented in MURAM
- Connecting time-slots to logical channels through Rx/Tx routing tables
- Implementing Rx/Tx channel buffers
- Interrupt management, benefits of interrupt queues
- Modes of operation, transparent, HDLC