FPGA firmware framework for MTCA.4 AMC modules

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INTRODUCTION

In MTCA.4 architecture all boards communicate with the central processing unit (CPU) over PCI Express (PCIe), send data to each other using Multi-Gigabit Transceivers (MGT), use the same backplane resources and have the same Zone3 IO or FPGA mezzanine card (FMC) connectors. All those interfaces are connected and implemented in Field Programmable Gate Array (FPGA) chips.

The MTCA.4 firmware framework introduces an additional abstraction layer that separates the hardware dependent logic from user application logic. The framework specifies universal interfaces on this layer. This allows the same firmware and software components to be reused, irrespective of the type of the used hardware.

INTERFACES

Between board and application universal interfaces can be defined. Definitions of universal interfaces are common for all boards. The include:

- **IBUS** – internal memory access bus, used to access registers and memory areas in FPGA from CPU, always connected to communication interface
- **DAQ** – data acquisition bus, allows to write stream of data to external memory. This data is accessed using Direct Memory Access (DMA) over communication interface
- **LLL** – low latency links bus, middle layer of point to point communication between boards using MGT
- **FMC** – FPGA Mezzanine Card I/O
- **RTM** – Rear Transition Modules I/O
- **AMCIO** – backplane differential signals for clocks and triggers
- **CLK** – clock resources

FRAMEWORK STRUCTURE

Firmware groups are filed in folders based on code structure and functionality.

- **boards**
  - FMC25
  - SIS300L
  - SIS8900
  - SIS8901
  - I2C
  - SPI
  - PCIe
- **modules**
  - RTM
  - AD18
  - MD22
  - MGT
  - AMC
- **applications**
  - LLC
  - cpl
  - driver
  - proc
  - lib
  - scripts
- **libraries**
  - clk
  - diag
  - dll
  - I2C
  - PCIe
  - aston
  - migras
- **projects**
  - main.tcl
  - module1.tcl
  - module2.tcl

- **MTCA.4 firmware framework folder structure**

USE CASES

Presented MTCA.4 firmware framework is used for control systems at FLASH and European XFEL accelerators at DESY in Hamburg. Mainly used for Low Level Radio Frequency (LLRF) control systems and optical synchronization.

- **Application**
  - LLRF controller field detection part
  - Single cavity LLRF controller
  - Toroid detection application
- **RTM**
  - DWC10
  - DWC9VM
- **AMC**
  - SIS300L
  - SIS8901

CONCLUSION

Proper structure and interfaces were defined as well as automation scripts were written. The MTCA.4 firmware developed using this framework was successfully deployed for XFEL and FLASH accelerators. The framework by its modularity brings significant improvement in terms the development time.