Open-source FPGA Framework for the MicroTCA Ecosystem by DESY



12th MicroTCA Workshop

Cagil Gumus Hamburg, 07.12.23







What is the goal?

Goals:

• Reduce the time and complexity of developing FPGA firmware

Increase collaboration

• Reduce reinventing the wheels \rightarrow Save tax payer's money







Visit our repository today!

FPGA firmware	FPGA Firmware Documentation (public)		
Group ID: 45 🛱 Leave group	FPGA Firmware Documentation	FPGA Firmware Documentation / Start Page	
The MSK FPGA firmware framework with projects and their components. Go to MSK Firmware documentation site for more details. Subgroups and projects Shared projects Archived projects > 3* A Applications and Scripts D High level software applications and scripts used to operate firmware	Start Page > Git Repository > VHOL code Firmware Framework (fwk) Yocto (FwkLinux) > Firmware Documentation Tools	FPGA firmware documentation site Welcome to the DESY FPGA firmware PUBLIC documentation site. It is part of the internal documentation which has been put into public and is available outsite the DESY. For internal documentation accessible withing DESY network place visit: fwdocu.msktools.desy.de/ The firmware documentation follows the documentation-as-code approach. Documentation sources are kept in the git repositories and next the static site is generated with the Antora tool. Navigation	
> % L Libraries		Fach project documentation and its version can be selected using left bottom menu. For easier navigation	
> Se M Modules A RTL modules (IPs) sources		Main documentation This documentation page and project. You can navigate using current Navigation sidebar.	
> Se P Projects D Master projects		Firmware Framework (fwk) The documentation of the FPGA firmware framework. The main tool to develop the firmware. It gives all the information about the projects structure and build process.	
> Se Software D Software that runs on FPGA. Bare metal or OS applications.		Yocto (FwkLinux) All the topics related to Yocto and embedded Linux distro - FwkLinux	
> Se T Tools (Firmware Projects List of all the firmware super projects documentation pages. Firmware Modules	
> Se Y Yocto D		List of all the firmware modules/IPs documentation pages. Firmware Libraries	
Documentation The main firmware documentation module. Default on Antora generated site.		List of all the desy libraries documentation pages. <i>Firmware Tools</i>	
Firmware Framework The main firmware framework project		List of all the tools used within the FPGA	

gitlab.desy.de/fpgafw

fpgafw.pages.desy.de/docs-pub

Our open-source arsenal

Open Source support for Scientific Community

BSPs / Libraries / Tools / Example Designs ...

Available Today



SIS8300KU Example Design



DRTM-DWC8VM1 as a Module





Coming soon!



DAMC-Z7IO





DESY. | 12th MicroTCA Workshop|Çağıl Gümüş, 07.12.2023

Success Stories

- Next-generation diagnostics for ASDEX Upgrade
 - Talk by Miguel A.
 - Intregration of FWK and usage of Z7IO BSP

- AWAKE run 2c photoinjector LLRF
 - Talk by Ben Woolley, Kristiaan Pelckmans
 - Uses SIS8300KU Example Design + ChimeraTK as a basis
 - Zero to Hero in 1 year



Micro TCA WS 2023: Status of the AWAKE run 2c photoinjector LLRF at CERN

 The core of FWK/demo includes efficient memmap management. -Kristiaan Pelckmans

Success Stories

- SOLEIL II Upgrade
 - by Jade PHAM, Romain BRONÈS
 - Uses FWK + DAMC-FMC2ZUP BSP together with ChimeraTK





 This year 5 developers outside of our team pushed commits (bug fixes, new features) into our repository.



What is FWK

The Swiss Army Knife of FPGA development

- Collection of tools mostly written on tcl language
 - Creation of FPGA projects on FPGA vendor tools
 - Implementation of those FPGAs Projects (bit-stream creation)
 - Handle versioning per each IP
 - Combine multiple IPs and create address mapping for each register
 - Create documentation of the IPs
 - Package an IP

۰

. . . .

- Create an IP using Higher-Level-Synthesis (eg. Xilinx HLS)
- Embedded Linux Creation with Yocto



What is FWK

Supported FPGA Vendor Tools and Simulation Environments











Model Sim.

TODO:

What is FWK

The biggest picture





Typical Projects with FWK

The Power of Abstraction

- Most of the projects build with FWK has only 2 IPs on the top: BSP(Board Support Package) and APP(Application).
- BSP holds the FPGA logic that is not application related:
 - PCle
 - MPSoC
 - DDR
 - I2C
 - SPI
- · Application part has logic that is not board related
 - Controllers
 - DSP Algorithms
 - Data Analysis etc.
- Payload makes sure BSP and Application fits together by defining universal interfaces



Other tools

DesyRDL

Take SystemRDL to a whole new level

Once you have the register model, you can even create Synthesizable HDL code!

Hence **DesyRDL** is born:

Create all the necessary register access logic automatically using templates (**Jinja2**)

Register interface can be anything (AXI4 / IBUS / Wishbone / Avalon)

Significantly reduces the IP development stage duration.

Templating engine brings extensible interface:





Yocto Integration on FWK

The Power of Abstraction

- Xilinx MPSoC \rightarrow ARM comes first, FPGA second.
- For basic projects \rightarrow Baremetal Application is enough
- For complicated projects \rightarrow Embedded Linux is (almost) a must.
- FWK takes .xsa file, along with Yocto Layers and produces a embedded Linux image
- We have package feeds setup on Jenkins to speed up the compilation time.
- Supported Boards: DAMC-FMC2ZUP, DAMC-MOTCTRL, ZCU102, ZCU111

Application Processing Unit	Memory DDR4/3/3L, LPDDR4/3 32/64 bit w/ECC 256KB OCM with ECC	Graphics Processing Unit ARM Mali™-400 MP2		High-Speed Connectivity
Artivity Coftex TM -AS3 Coftex TM -A		Geometry Processor	Pixel Processor 1 2	DisplayPort v1.2a USB 3.0
		Memory Management Unit		SATA 3.1 PCle® 1.0 / 2.0
		64KB L2 Cache		PS-GTR
Real-Time Processing Unit ARM Cortex ^{TW} -R5 T28KB 32KB I-Cache 32KB D-Cache TCM wECC 32KB D-Cache 32KB D-Cache GIC	Platform Management Unit System Management Power Management Functional Safety	Configuration and Security Unit Config AES Decryption, Authentication, Secure Boot Voltage/Temp Monitor TrustZone	System Functions Multichannel DMA Timers, WDT, Resets, Clocking & Debug	General Connectin GigE USB 2.0 CAN UART SPI Quad SPI NOR NAND SD/eMMC
Programmable Logic Storage & Signal Processing	System Monitor	High-Speed Connectivity Interfaken GTH GTY 100G EMAC		
Block RAM Ger	eral-Purpose I/O			
UltraRAM High	Performance HP I/O			
DSP Hi	gh-Density HD I/O	PCle Gen4		



Thank you!