The Abdus Salam International Centre for Theoretical Physics

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Reconfigurable Virtual Instrumentation (RVI) based on FPGA

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Reconfigurable Virtual Instrumentation based on FPGA and open source intellectual property

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Reconfigurable Virtual Instrumentation based on FPGA and open source intellectual property

- A research initiative in the area of novel architectures for the implementation of open source RVI systems using FPGA is being carried out at MLAB.
- The goal is to provide low-cost reusable hardware/ software platforms for the implementation of multiple electronic and scientific instrumentation systems

Reconfigurable Virtual Instrumentation based on FPGA and open source intellectual property

Hardware & Software modularity

- Block-based design methodology
- Hierarchical structure

Common standardized global architecture

- Block interfaces definition
- Clear mechanism of blocks interaction

Open Source & Open Cores

- Sharing the design effort and results by a large community of user and contributors with different expertise and background (EE, Physicist, Comp. Sci. , DSP experts, etc)

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RVI SYSTEM ARCHITECTURE

- **Reconfigurable Instrument**
  a versatile hardware device that can be reconfigured into different electronic instruments using a software tool
- **Virtual Instrumentation**
  a hardware and software combination that allows the emulation of an instrument through a custom virtual console and a graphical user interface

- **Hardware system**
  RI connected to PC through a physical connection
- **Software system**
  Software related to the PC

  Code corresponding to the FPGA of the RI

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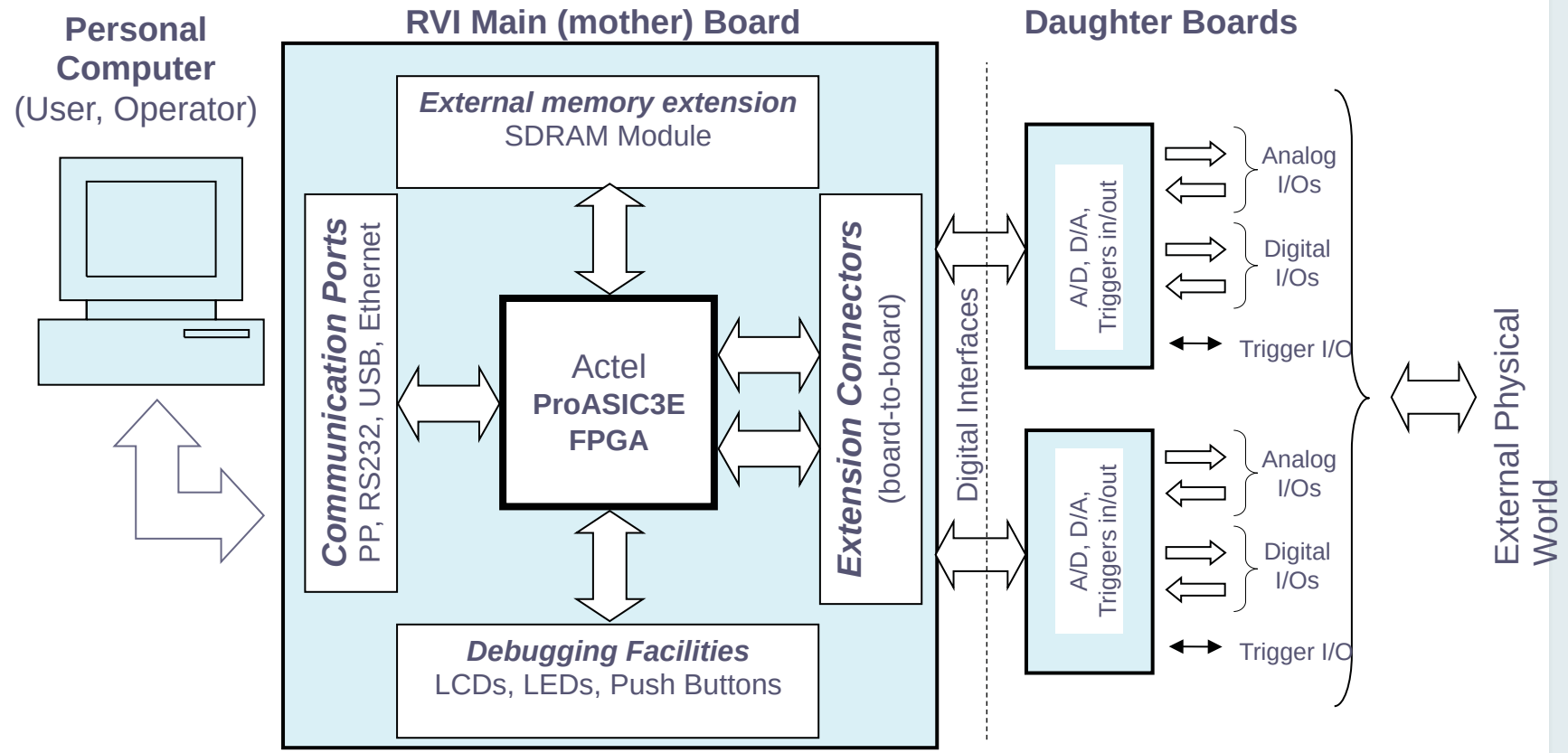
A suitable hardware platform
- the magic box -

- Flexibility and Adaptability
  - to wide variety of requirements
- Upgradeability
  - must be able to take advantage of new electronics devices and facilities
  - mitigate the obsolescence of the hardware

A complete software chain
- from FPGA cores to GUI -

- Portability and Adaptability
  - Linux, Windows, others OS
  - FPGA vendors and families
  - PP, USB, Serial, etc.
  - expansion of the potential users/developers base
- Upgradeability
  - Migration to new version

Reconfigurable Virtual Instrumentation based on FPGA and open source intellectual property - **RVI Hardware System**



Reconfigurable Virtual Instrumentation based on FPGA and open source intellectual property - RVI Hardware System

RVI mother board

- FPGA device (ACTEL AP3E family)
- a block of communication ports
- an extension memory
- debugging facilities and miscellaneous components
- two high quality board-to-board connectors with 54 pins directly connected to the FPGA gp-I/O

Low Performance Daughter Board

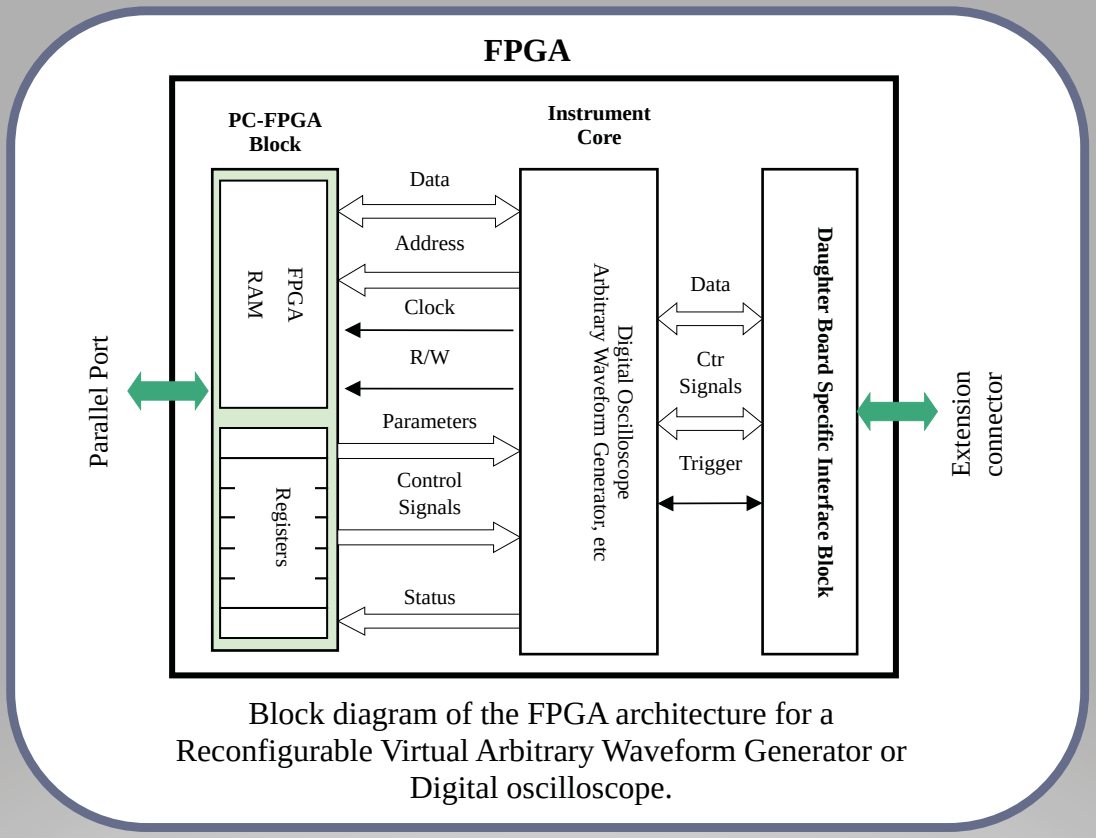
- dual channel 10-bits 20 MSPS ADC (AD9201, Analog Devices),
- dual channel 14-bit 1 MSPS DAC (LTC1654, Linear)

High Performance Daughter Board

- single channel 14-bits 125 MSPS ADC (LTC2255, Linear)
- single channel 16-bit 50 MSPS DAC (LTC1668, Linear)

Architecture for Single Instruments

Implementation Examples



Block diagram of the FPGA architecture for a Reconfigurable Virtual Arbitrary Waveform Generator or Digital oscilloscope.

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Integrating a reconfigurable instrument core in an RVI system

•The core must comply with:

- the standardized interfaces of the PC-FPGA communication block and the external hardware specific interface block

- a common mechanism of interaction

•If the three main blocks: PC-FPGA communication block, instrument core, and the external hardware interface respect both previous conditions, then each block can be updated or upgraded independently and can be reused in different contexts.

A possible FPGA Global Architecture for RVI

1) PC <-> FPGA communication

2) External Hardware

3) Instruments cores

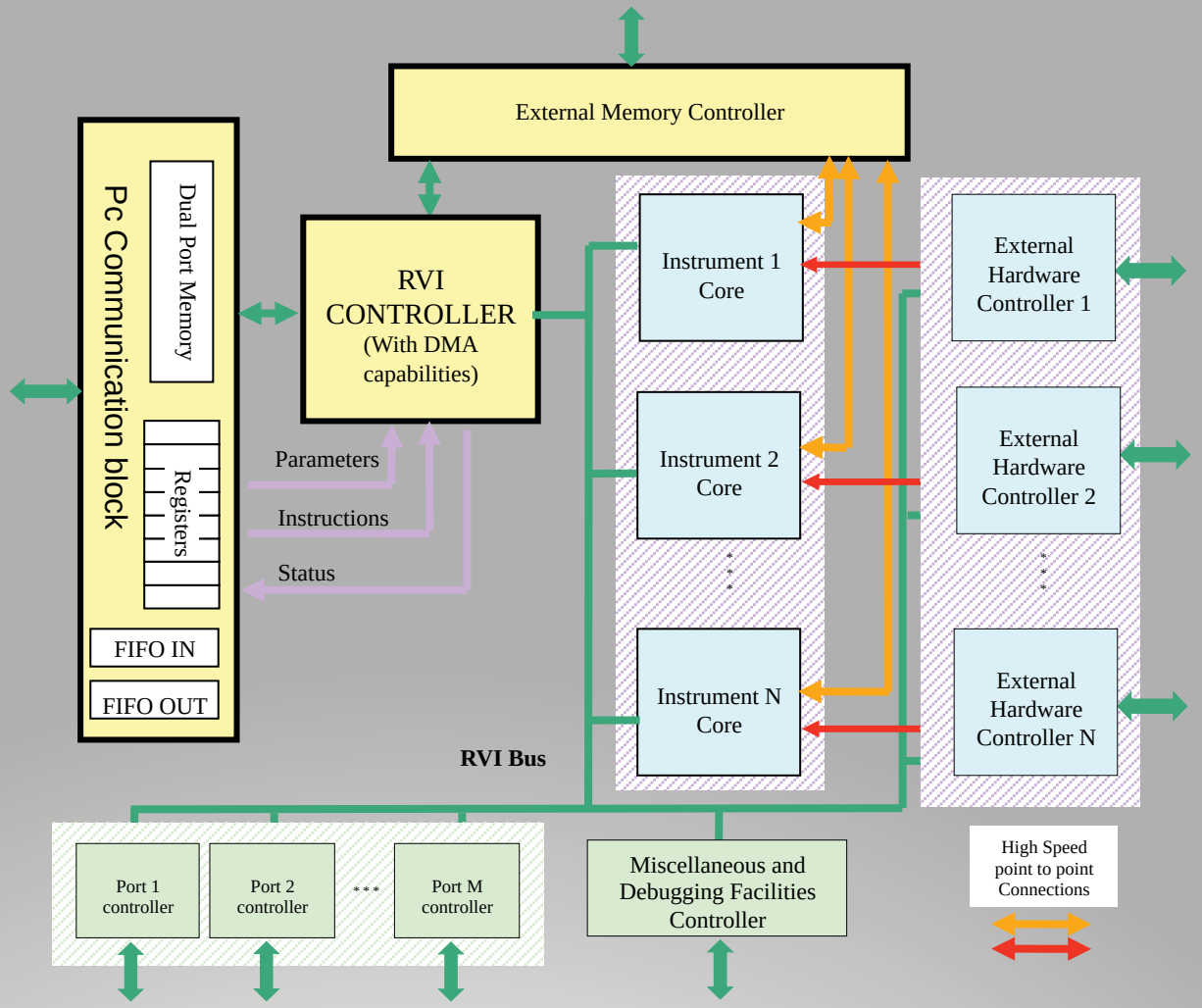
4) External memory

5) Standard Ports

6) Debugging Facilities

7) Global bus and interconnections

8) RVI Control



Reconfigurable Virtual Instrumentation based on FPGA and open source intellectual property

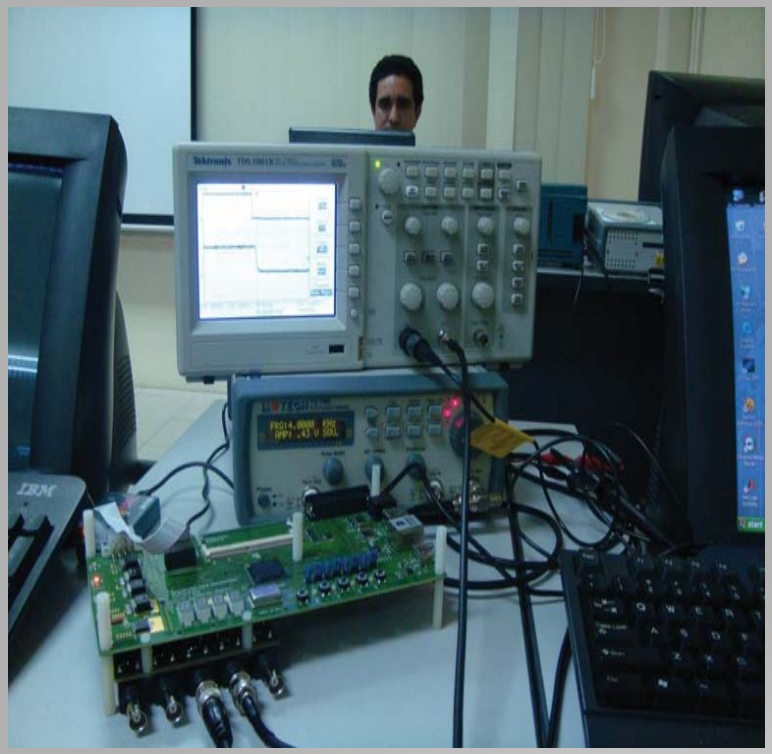
- FORGE (gforge.ictp.it)

  Project-1: RVI based on FPGA

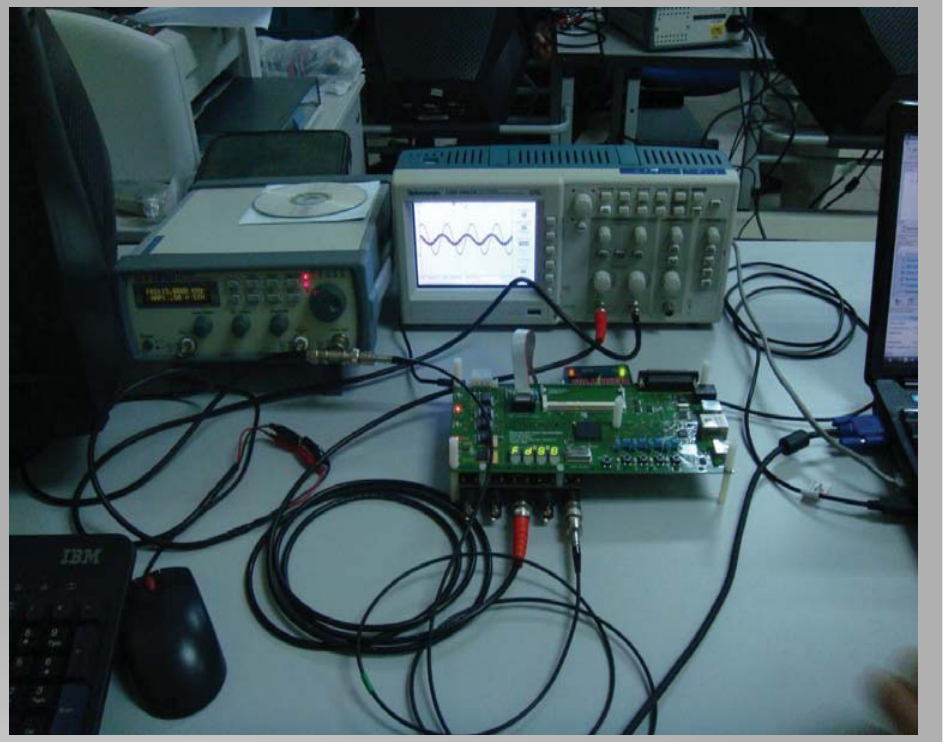
  Project-2*:* FPGA Open Hardware Platform for Science Open-Survey ICTP Open Hardware Initiative - New FPGA platform to implement reconfigurable instruments for research and higher education, with emphasis on maximizing performance at the lowest possible cost.

Implementation Examples

A low pass filter



A high pass filter (differentiator)

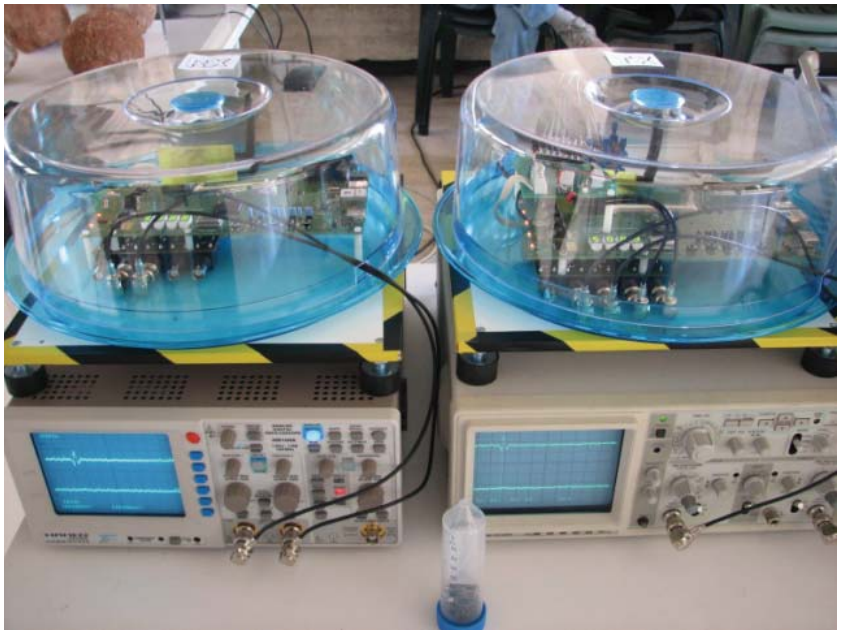


DSP with FPGA

Neuroscience Application

Neurotelemetry

RVI platform for prototyping in advanced instrumentation development for experimental neuroscience research



Conclusions

- **FPGA technologies are opening up new opportunities including in the field of scientific instrumentation**

  Excellent hardware cost/performance ratio

  High effort required to develop all the software/ hardware chain of new systems

  Wide freely available collection/library of standardized functional blocks (at PC and FPGA levels)

Conclusions

- **RVI Platform**

  Many areas of applications from basic research to Industry

  Emulation of:
  - standard general purpose instruments
  - sophisticated instrumentation for custom specific applications

  Low cost solution for universities and research institutions in developing countries

Conclusions

- The RI could be seen as a parallel coprocessor of the PC

Accelerate execution of time consuming or time critical tasks

- online digital signal processing
- real time hardware control

Reconfigurable Computing

Conclusions

- **Open Source & Open Core Approach**

  Is Affordable and Sustainable

  Stimulates Scientific Research and Production of Intellectual Properties

  Encourages South-South and Industry-Academy cooperation

  Creates new business opportunities based on free software and double licensing schemes

Thank You