Final SPAR Presentation 2005

Hardware and Firmware

by

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Introduction

- Hardware
  - Overview
  - USB
  - FPGA
  - LABRADOR 3
- Firmware
  - Overview
  - Top-level modules
  - How we made it
- Boards
SPAR - Overview

• **SPAR** – *Salt Propagated Askaryan Receiver*
• USB 2.0 High speed interface
• 3 Low-Frequency Input Channels
• 2 High-Frequency input Channels
• 2.5 GSa/s – 20 MSa/s
• External trigger and force trigger via USB
• Self trigger from Low-Freq. input channels
• 2 Analog Output channels
• USB-Powered. No external power supply is needed
LABRADOR 3

- Large Analog Bandwidth Recorder and Digitizer with Ordered Readout version 3
- 8 + 1 RF Channels
- 260 sampling Switched Capacitor Array (SCA) cells / Channel
- Each SCA storage cell contains a 12-bit Wilkinson ADC
- Can digitize all 9 x 260 samples (2,340) in parallel
USB Interface

- Cypress EZ-USB FX2 High Speed Device
- We use:
  - 16-bit wide data bus
  - Asynchronous data transfer
  - FPGA main clock from USB, 48Mhz
- Transfer speed can be improved using synchronous mode
Analog output

- Two TxDAC AD9762 DACs
- 12-bit, 125 MSPS
- Max output Frequency 62.5 Mhz
- Output voltage range 0V to 5 V
- Possible to create waveforms, calibration voltage etc.
Trigger

- Two Low-Freq inputs have self-trigger
  - Both channels are divided with two filters
  - After each filter is a comparator for trigger
- 3rd Low-Freq Input can be used for external trigger
- Trigger Edge can be chosen from sw
- Threshold Level is set by a 12bit DAC
FIFO

Hardware

Analog Inputs

LAB3

TRIGGER

Spartan 3

FPGA

USB CHIP

PC

FIFO

FIFO

EZ-USB FX2
Trigger

From PC

DAC

Threshold level

CMP.1

To FPGA

Analog Signal from Low Freq. Input
Low Frequency Inputs

CH1
- CH1G1
- CH1G2
- EXT TRIG

CH2
- CH2G1
- CH2G2

CH3
- CH3G1
- CH3G2

To LAB3 / Comparators
To LAB3
To FPGA
High Frequency Inputs

CH4 → CH4G1

CH5 → CH5G1

To LAB3
Firmware - Overview

• Supports all LAB3 RF-Input Channels
• Communicates with USB chip
• Trigger Source and Edge can be set
• Controls two Serial DACs which are used to adjust Sampling Frequency and Trigger Threshold Level
• Possible to select Readout Channels
• Does not support analog outputs yet
• PWM-drivers for LEDs :)
How We Made it?

• All Low-Level modules are written in VHDL
• VHDL-modules are connected together in Top-Level Schematic
• Firmware is based on State Machines
• Benefits:
  – Easy way to understand big firmware
  – Very complicated modules can be made easily
  – VHDL Language is a standard -> Code can be used in Different environments
Commands

- All commands are 4 bytes wide (32 bit)
- 4 bits reserved for target code
- Rest 28 bits used for Command/Data

Software

Target DATA

Targets

Trigger

DACs

Misc

Channel select

send via USB
We have work with

- **STD**
  - USB, LABRADOR 1
- **PARROT 1 and 2**
  - LABRADOR 1 & 3, DACs
- **STUD**
  - LABRADOR 3, Trigger, DACs
- **SPAR**
  - Hardware is not finished yet
Hawaii

Extremely expensive for Finnish student
Unique place to explore
Always summer
Lots of BIG things
Hawaiian Music not #1
Hawaii vs. Finland

Kuopio from Puijo tower

Honolulu from Diamond Head
Hawaii vs. Finland

Sun shine

~ 12 hours

Winter

Kuopio
~ 5 hours

Lapland
~ 0 hours

Summer

Kuopio
~ 18 hours

Lapland
~ 24 hours
Hawaii vs. Finland

**Swedish fake saunas**
- Temperature: 80F-122F
- Size: 1.0 Liter
- Cost: ~4.0 $ for 3.78 Liter

**Milk**
- Temperature: 160F-210F
- Size: 1.0 Liter
- Cost: ~2.7 $ for 3.78 Liter

**SAUNA**
Hawaii vs. Finland

Cats

Gasoline

~ $2.65 per Gallon

~ $6.30 per Gallon

~ 1.36€ per Liter
ALOHA & MAHALO

Our project was very instructive and interesting
It was very nice to work with all of you

Kiitos ja Hyvät Jatkot
Thanks and Good Luck