E155 Final Project Status Report: μMudd Mark V Debugging and Lab 6 Revision

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1 Completed Deliverables Status

Below is a summary of project deliverables and deliverable status:

Deliverable Category	Deliverable Name	Deliverable Status
Identifying blocking μMudd Bugs	Identifying MCU programming failure	Complete
Revising μMudd to allow MCU functionality	Hardware modification of pre-existing PCBs	Complete
	New JTAG cable	Complete
	Modified schematic and layout	In progress
	Completed μMudd respin	Not started
Reworking Lab 6	Rewrite EasyPIO.h with SAM4S support	Complete
	Integrate MCP3002, photodiode, and BlueSMiRF	Complete
	Formally write up lab for student readability	Not started
Testing other labs	Lab 4	Not started
	Lab 5	Not started
	Lab 7	Not started

2 Deliverable Status: Revised μMudd

A major component of this final project is identifying errors in the PCB design that lead to a non-programmable MCU. We have identified two errors which when solved allowed MCU programming

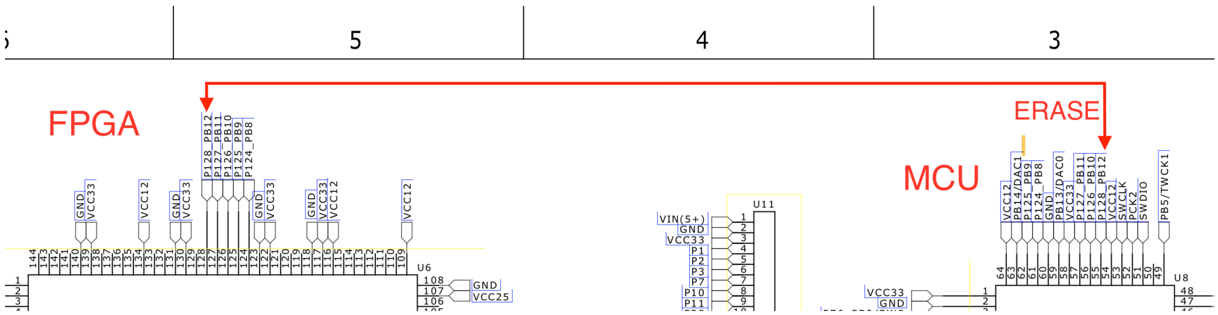
2.1 Schematic Errors

2.1.1 MCU ERASE Pin

The largest problem with the current μMudd design lies in the MCU ERASE pin, which reinitializes the onboard flash and resets the processor. The ERASE pin can also serve as general-purpose I/O after configuration. [1]

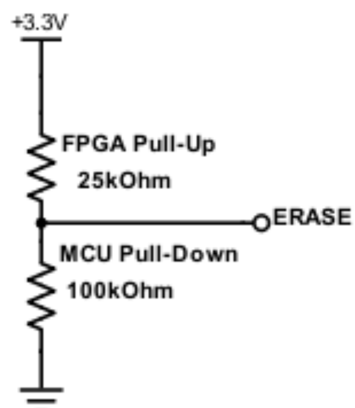
[1] SAM4S Series Datasheet p37

On boot, ERASE must be held low to prevent flash erase and reinitialization of the processor. On the current μMudd, ERASE was tied to a general I/O pin on the Cyclone IV FPGA. The connection can be seen in the following schematic:



The marked connection ties ERASE on the MCU to pin 128 on the FPGA

The ERASE pin contains a 100kΩ pull-down resistor[2].An unconfigured Cyclone IV I/O pin contains a 25kΩ pull-up resistor [3]. This creates a voltage divider circuit as shown below:



This provides a predicted voltage of 2.64V on the MCU ERASE pin, close to the 2.86V we observed. This is a high logic level which prevented FPGA programming.

2.1.2 MCU Power Supply

The MCU requires a 3.3V and 1.2V power supply. It can be powered via one 3.3V supply, and use an internal regulator to generate 1.2V, or it can be powered with an external 3.3V and a 1.2V supply. The dual-regulator design of the current board can introduce startup issues if timing is not correct.

We believe that these potential timing errors can cause system instability, as we observed an unresponsive MCU after startup that could only be solved with a full erase and reset.

[2]SAM4S Series Datasheet p37
[3]Cyclone IV Device Handbook p6-3

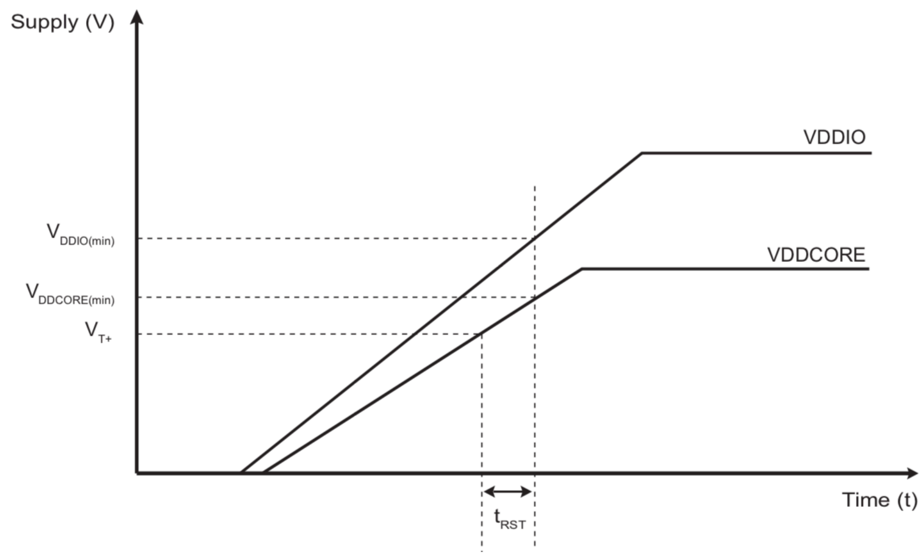


Figure 1: Timing requirements for the 1.2V (VDDCORE) and 3.3V (VDDIO) supplies, taken from the SAM4S Series Datasheet p27

2.1.3 JTAG connector pinout

The MCU JTAG connector was incorrectly wired on the current μMudd. This led to wiring errors in the I^2C connection

2.2 Schematic and Layout Changes

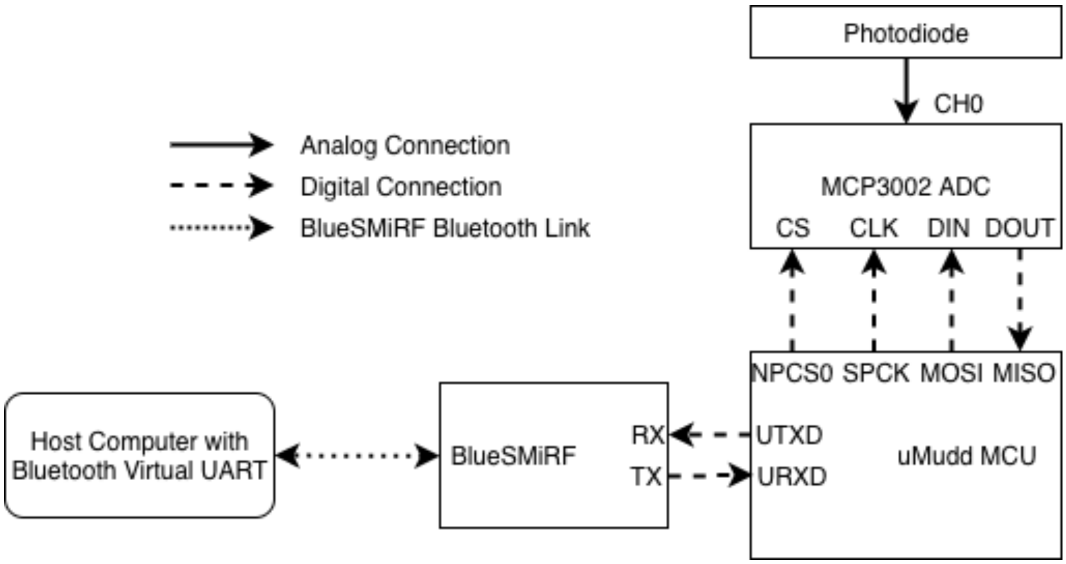
We have implemented a set of changes to the schematic to solve the problems noted above and to improve the PCB, but have not yet propagated these changes to the layout. These include:

1. Moving ERASE control to the MCU RESET pushbutton. RESET will be accessible through JTAG
2. Powering the 1.2V MCU VDDCORE with the onboard regulator, and adding necessary passives
3. Correcting JTAG and I^2C wiring errors
4. Replacing 0.1” pitch JTAG connectors with 0.05” pitch SWD connectors. This adds compatibility with J-Link EDU Mini programmers
5. Adding 0.1” jumpers on critical MCU pin connections to assist debugging

3 Deliverable Status: Reworking Lab 6 and EasyPIO.h

3.1 Reworking Lab 6

The proposed Lab 6 architecture is shown in detail below:



To maintain a low lab cost we exchanged one BlueSMiRF and the serial display for a computer with an integrated Bluetooth module. We added a MCP3002 ADC to retain the datasheet interpretation component of the lab.

We have successfully demonstrated Bluetooth communication between two computers, using a Bus Pirate as a USB to UART converter. We have also successfully demonstrated voltage measurement with the MCP3002 through a SAM3S/SAM4S SPI peripheral.

In reworking Lab 6, we still need to write an updated version of the lab manual and polish it so that it easily readable by a future student. We also seek to implement any recommendations we receive in our presentation for ways to improve this lab, as the replacement of the web server with a Bluetooth link may render the lab simpler than we'd like.

3.2 Targeting easyPIO.h for the SAM4S

We have created an I/O header file, easySamIO.h, which provides Arduino-style access to the GPIO, timer, UART, and SPI peripherals on the SAM4S. In the style of easyPIO.h, we provide only the configuration and functionality necessary to complete labs. We aim to provide adequate inline documentation for students to add functionality as necessary. This documentation includes functional descriptions of memory access, references to the datasheet, and brief descriptions of other peripheral features.

In total, we have completed implementation of the PIO, timer, SPI, and UART peripherals, but still need to provide access to additional ports of the PIO peripheral, additional channels of the timer peripheral, and additional clock routing for the FPGA on the μMudd.

We believe a thorough and well-documented EasySamIO.h will be more useful for lab 4,5, and 7 bringup than testing labs 4,5, and 7 as discussed in the lab manual.

4 Appendix 1: Updated Schematic

5 Appendix 2: C Code

5.1 EasySamIO.h

5.2 lab6.c