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

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1 Completed Deliverables Status

To summarize the status of our final project, 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 and assembled μMudd respin	Not started
Reworking Lab 6	Rewrite EasyPIO.h with SAM4S support	In progress
	Integrate MCP3002, photodiode, and BlueSMiRF	In progress
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

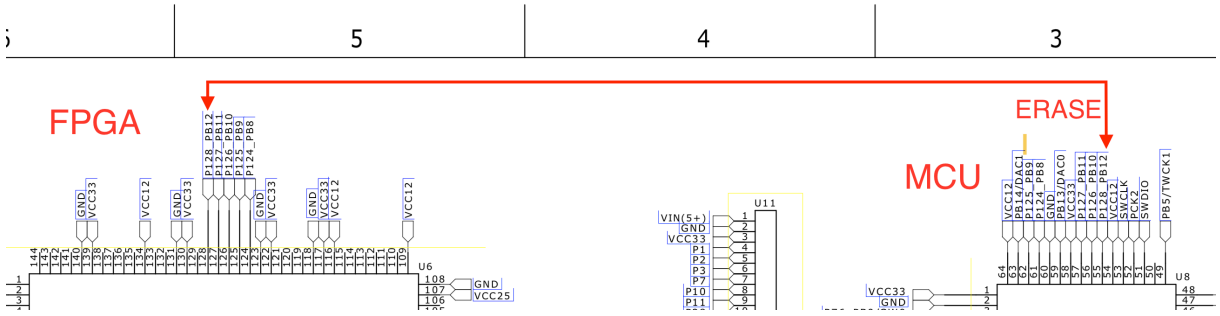
2.1 Schematic Errors

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 as well as resetting the processor. The ERASE pin can also serve as general-purpose I/O after configuration. [1]

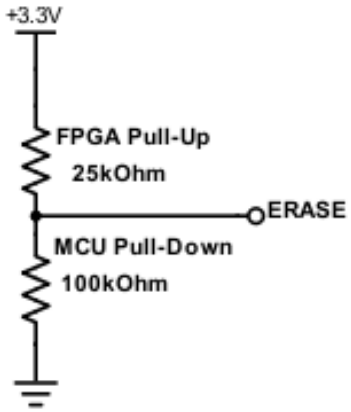
[1] SAM4S Series Datasheet p37

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 resistor 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

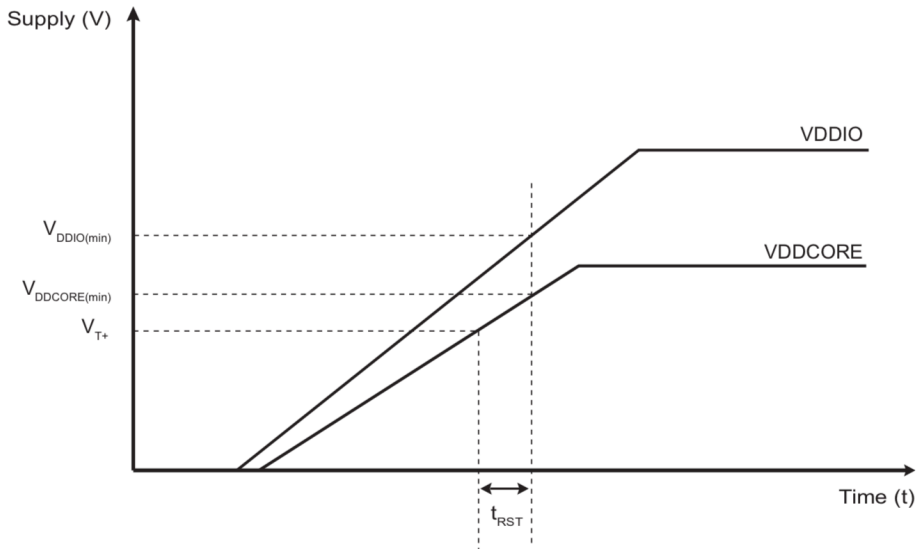


Figure 1: Timing requirements for the 1.2V (VDDCORE) and 3.3V (VDDIO) supplies, taken from the SAM4S Series Datasheet p27

2.1.3 JTAG connector pinout

The MCU JTAG connector was incorrectly wired on the current μMudd.

2.2 Schematic and Layout Changes

We are currently implementing a set of changes to solve the problems noted above and to improve the PCB. 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
3. Correcting JTAG wiring erros
4. Replacing 0.1" pitch JTAG connectors with 0.05" pitch SWD connectors. This adds compatibility with J-Link EDU Mini programmers
5. Adding a separate 40MHz clock to the FPGA. The clock is currently supplied by a MCU I/O pin

3 Deliverable Status: Reworking Lab 6 and EasyPIO.h

this is the only existing bug. This project will involve identifying and correcting bugs in the μMudd Mark V, and reworking Lab 6 to fit the new board.

4 Project Deliverables

The following tasks will be completed in this project:

1. Identifying blocking bugs in the μMudd which completely prevent MCU programming and operation
2. Determining and implementing a solution to the above bugs. This solution may take several forms, as described below
3. Reworking Lab 6 with instructor guidance to fit the new μMudd MCU

4.1 Revised μMudd

We cannot yet explicitly state deliverables for the functional μMudd PCB as they depend on unknown bugs in the design. Below are several potential deliverables, at least one of which will be provided at the end of the project:

1. A modified version of the physical, pre-existing, μMudd Mark V PCB that provides full MCU functionality
2. Modified PCB design files that provide full MCU functionality
3. A completed respin of the μMudd with full MCU functionality
4. A new JTAG cable that provides full MCU functionality

4.2 Reworked Lab 6 Requirements

To maintain the IoT theme of the current lab 6, our reworked lab will include:

1. Wireless connectivity (Bluetooth, WiFi, etc)
2. Serial communication (I^2C, SPI, UART, etc) between the MCU and another device
3. C programming for the MCU
4. A practical use-case for the completed lab

While lab specifics will be determined after meeting with the instructor, we suggest the following:

4.3 Reworked Lab 6 Proposal

The reworked lab 6 will provide a wireless light sensor. Students will interface the μMudd Mark V MCU with a photodiode and BlueSMiRF to relay temperature data over a bluetooth connection hosting a transparent serial link. This serial link will connect the MCU to a character or graphics LCD display through another BlueSMiRF. This introduces students to two new pieces of hardware: the BlueSMiRF and the serial display. A point of extra credit is available for adding more sensors, such as a thermistor, or for adding a novel feature to the project. The following block diagram illustrates the completed lab:

5 Project Budget

The project budget is also ill-defined at this stage, as it depends on unknown bugs in the current design. I estimate the project will require a reference board for the SAM4S MCU, a respin of the current board, and an unknown set of new equipment and components, which may include a JTAG adapter and/or a replacement MCU. Also included are new components for the proposed lab 6. A preliminary budget is described below, with costs estimated from previous board development purchase orders or online vendors.

Item Name	Item Description	Vendor	Item Cost
SAM3-P256	SAM3S Development Board	Olimex	$31.09
ARM-USB-TINY-H	USB-JTAG Adapter	Olimex	$47.86
PCB Fabrication		Advanced Circuits	$264.00
ATSAM4S4BA-AU	SAM4S MCU	Digikey	$3.93
2x BlueSMiRF Silver	Bluetooth Transceiver	Sparkfun	$55.90
16x2 SerLCD	Serial Character LCD	Sparkfun	$19.95
Total Budget			$422.19