

# Choosing an MCU and Custom Board Bring-up

Lecture 16

Microprocessor-based Systems (E155)

Prof. Josh Brake



# Outline

- Choosing an MCU
  - Design steps
- Custom board bring-up
  - Example: 2019 MicroPs Board
- Mid-semester feedback survey

# Choosing an MCU

- Block diagram
  - Layout each device that will be connected to the board
- Selecting hardware
- Schematic capture
- PCB layout
  - Component placement
  - Layers
  - Routing
  - Verification
  - Gerber generation

# Choosing an MCU

- Cost
- Performance
- Packages available (number of pins/GPIO)
- On-board peripherals
- Power consumption

# Performance

- Architecture
  - Number of bits
  - Instruction set
- Hardware accelerators/co-processors (e.g., floating point unit, DSP)
- Max clock speed/number of instructions per second/benchmarks
- RAM
- Flash storage

# Packages

## VARIOUS PACKAGES OPTIONS TO FIT ANY APPLICATION CHALLENGE



### WLCSP

WLCSP25 (~2x2 mm)  
WLCSP36 (~2x3 mm)  
WLCSP49 (~3x3 mm)



### QFN

QFN28 (4x4 mm)  
QFN32 (5x5 mm)  
QFN48 (7x7 mm)



### BGA

BGA64 (5x5 mm)  
BGA100 (7x7 mm)



### TSSOP

TSSOP14 (4.4x4.1 mm)  
TSSOP20 (4.4x6.6 mm)



### LQFP

LQFP32 (7x7 mm)  
LQFP48 (7x7 mm)  
LQFP64 (10x10 mm)  
LQFP100 (14x14 mm)

WLCSP = wafer level chip scale package

QFN = quad-flat no-leads

BGA = ball-grid array

TSSOP = thin-shrink small-outline package

LQFP = low-profile quad-flat package

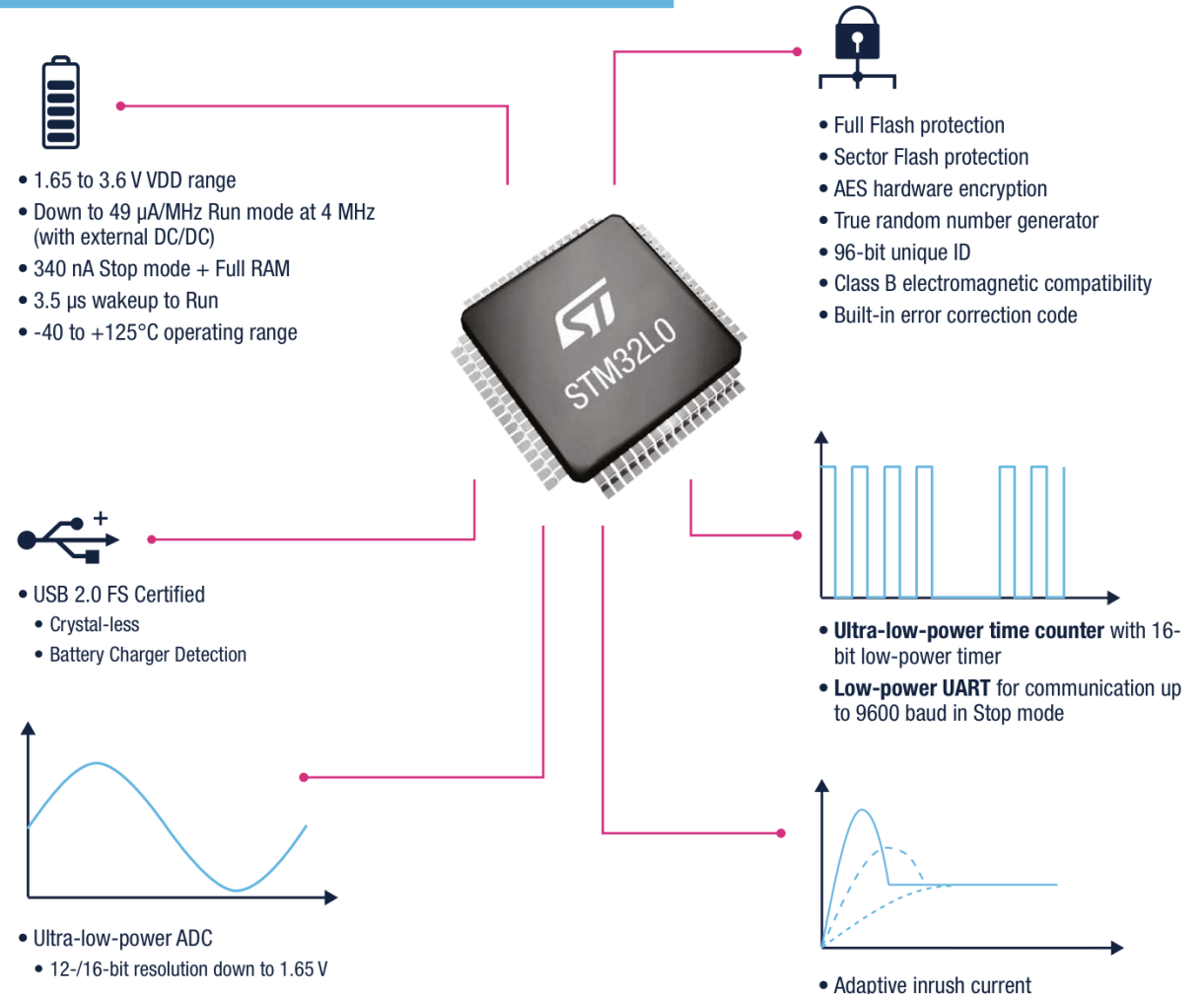
# On-board peripherals

- Serial interfaces
- ADCs/DACs
- Timers
- PWM generators

# Power Consumption

- Current draw per MHz
- What sleep modes are available

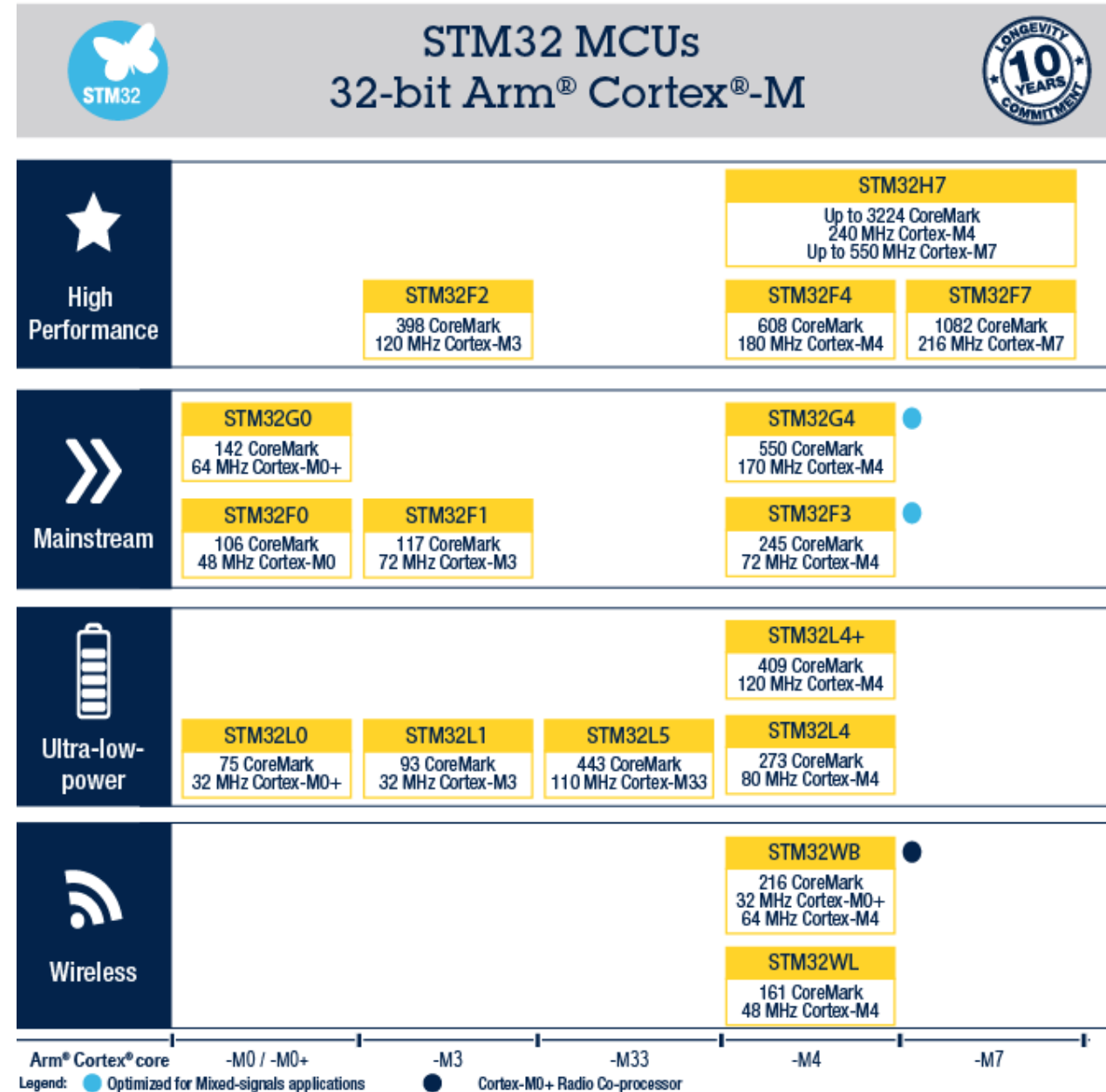
## STM32 Ultra-low-power



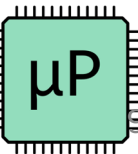


# STM32 MCUs

- Several different options to choose from
  - M0, M3, M4

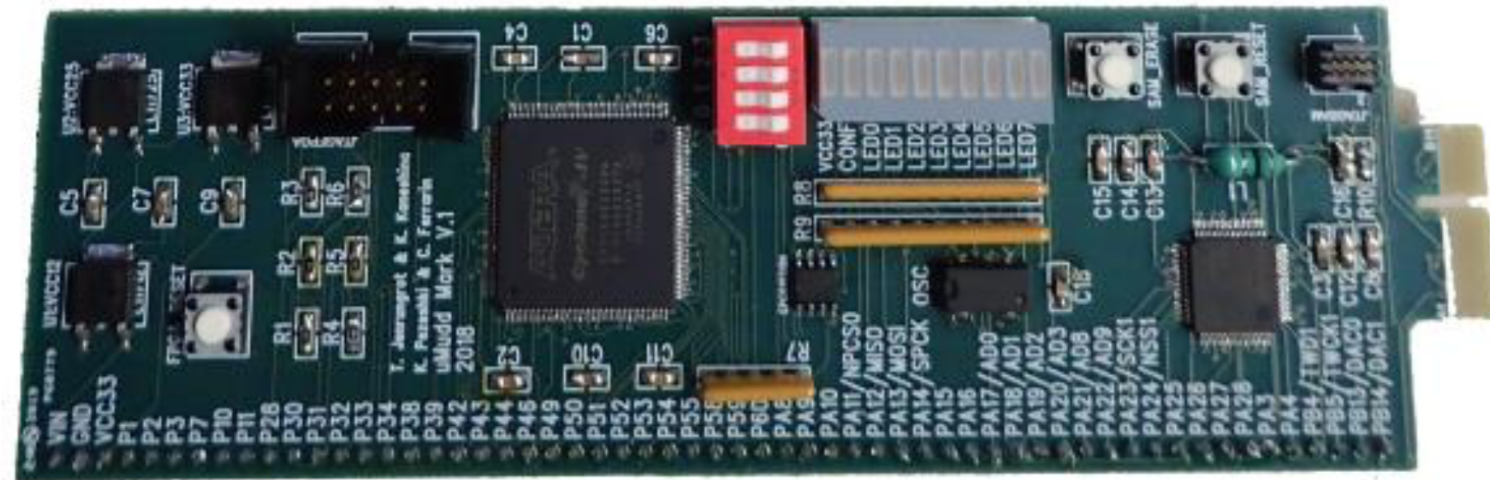
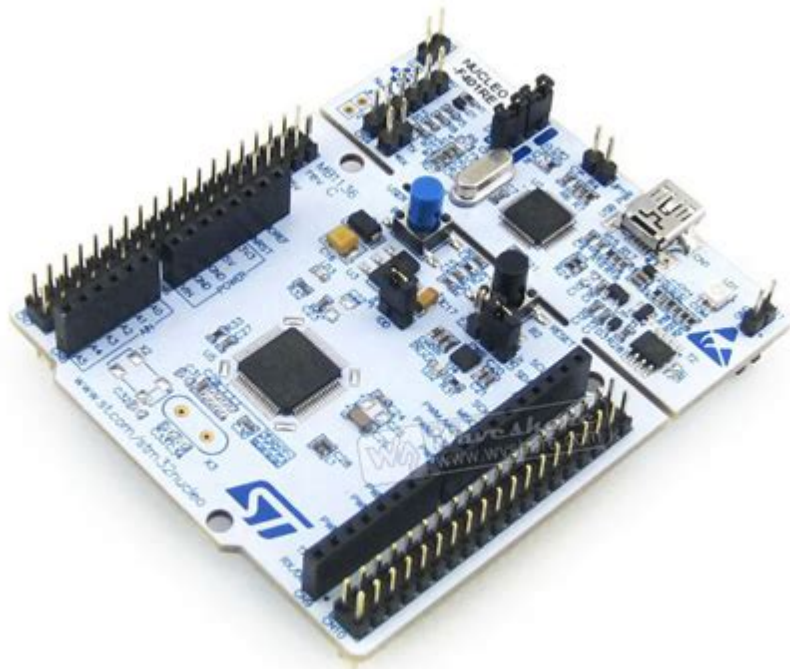


# Custom Board Bring-up



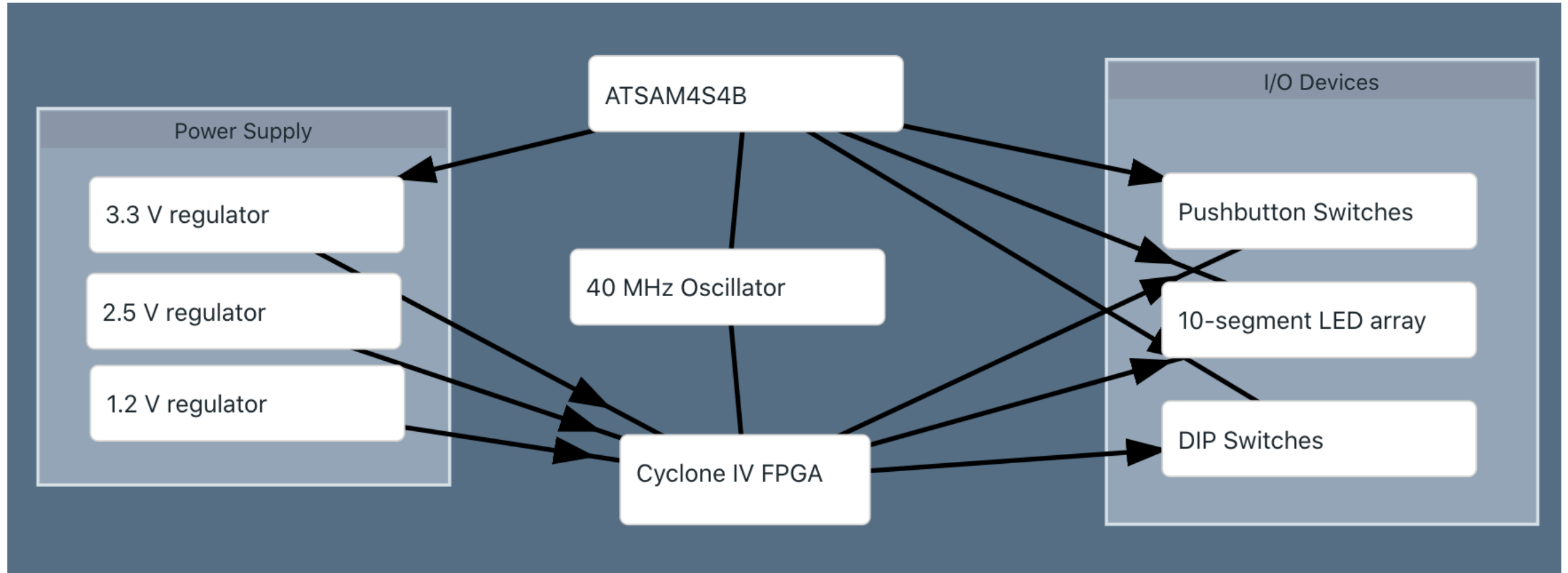
# How would you go about building a custom development board around an MCU?

- Where would you start?
- What components would you need?



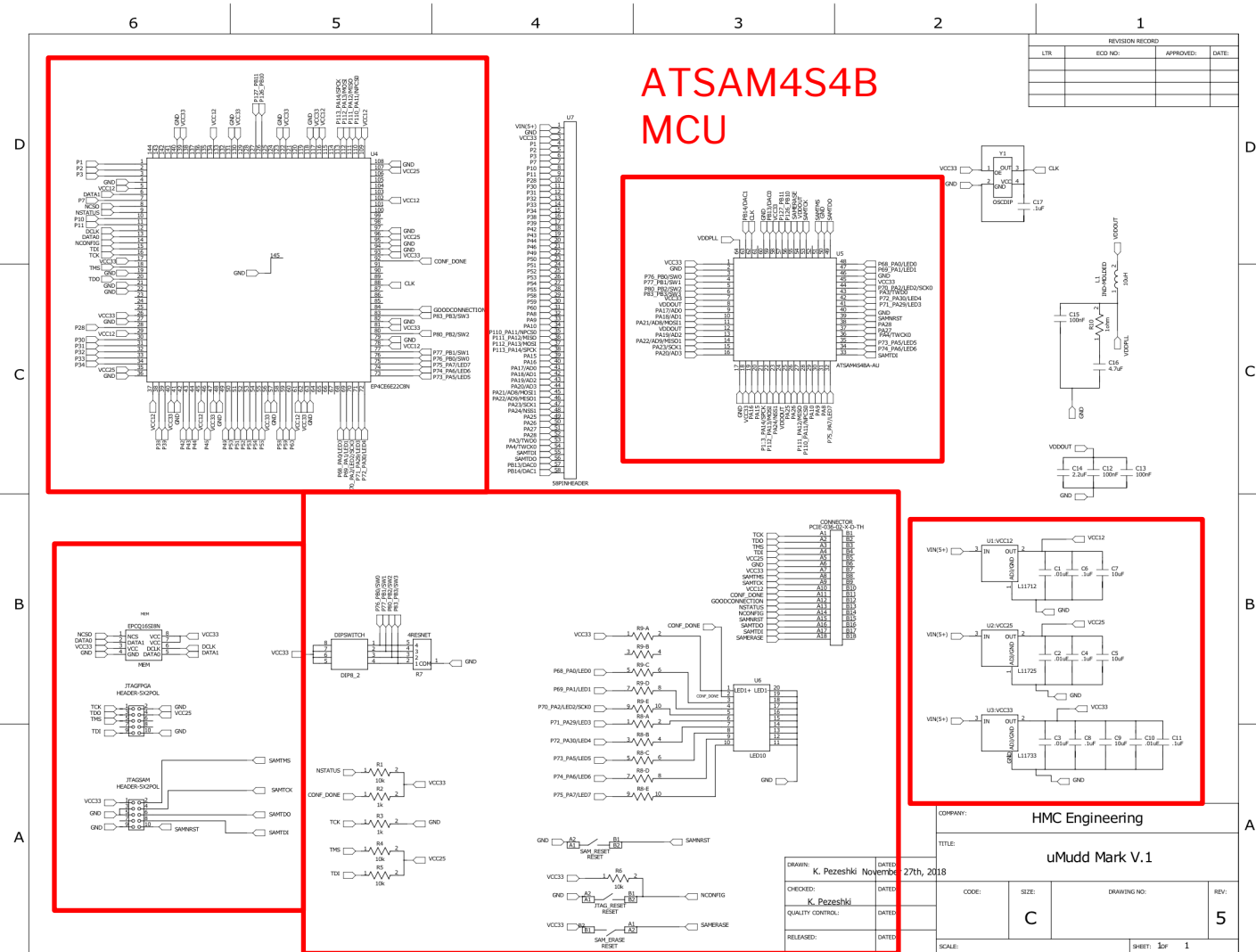
HMC2019: Cyclone IV + ATSAM4S4BA

# Custom Board Bring-up



# Schematic

Cyclone IV FPGA



Voltage Regulators

Programming Connectors

Buttons, LEDs, General I/O

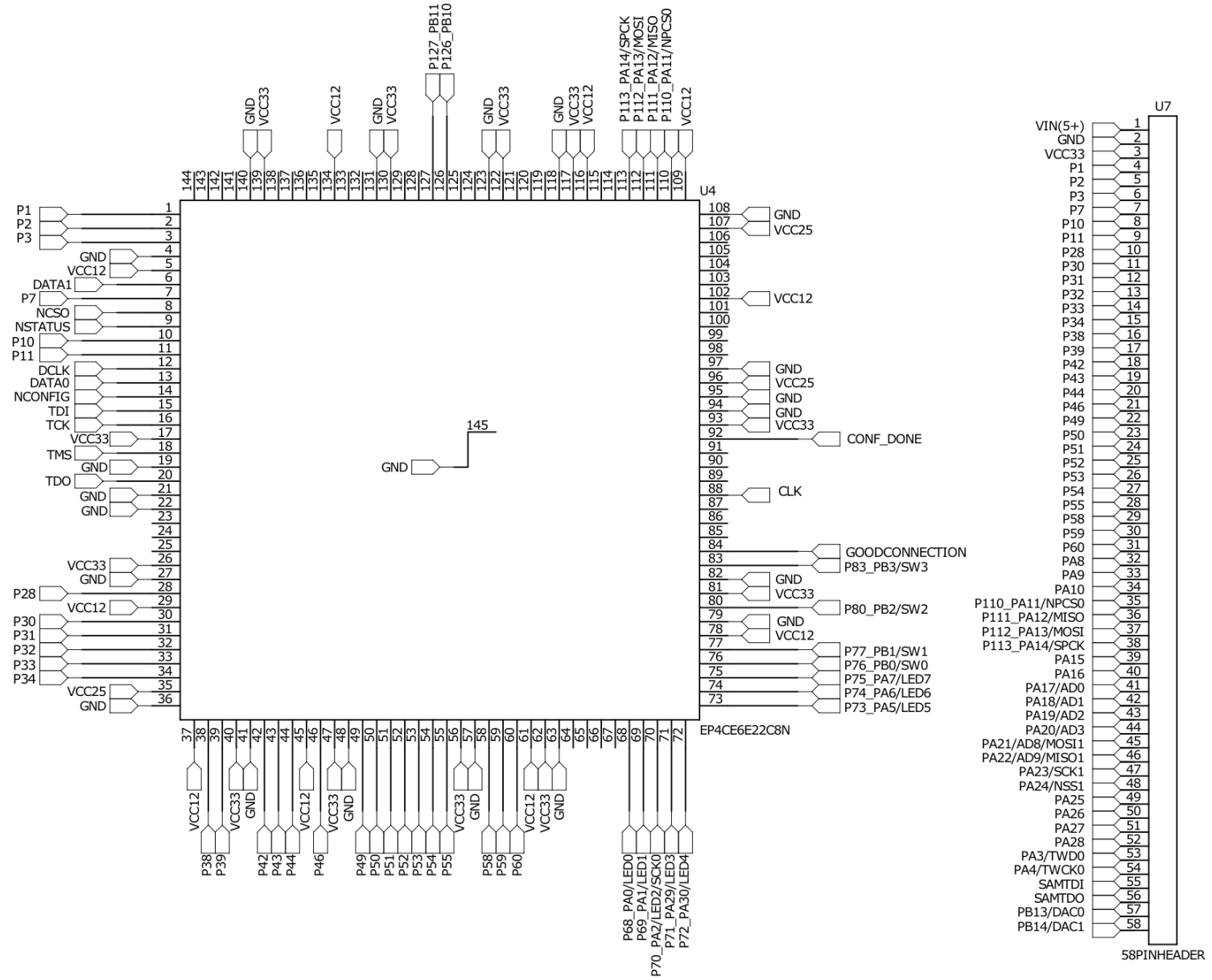
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TITLE:		uMudd Mark V.1	
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CHECKED:	K. Pezeshki	DATE:	
QUALITY CONTROL:		DATE:	
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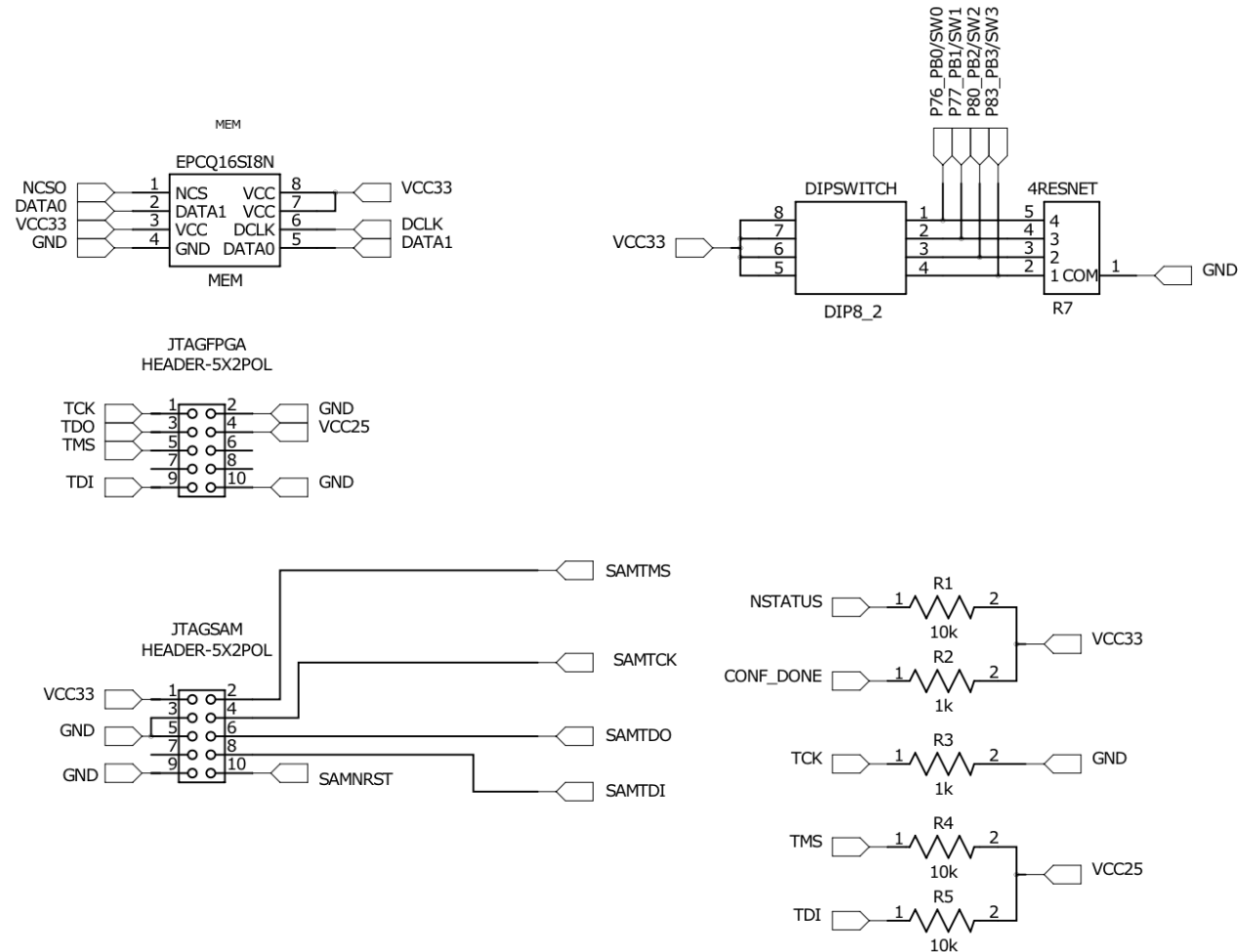
# Bill of Materials

Part Description	Part Identifier	Manufacturer	Manufacturer P/N	Supplier	Supplier P/N	Quantity	Unit Price	Total Price
<b>PCB</b>		Advanced Circuits				1	\$ 15.03	\$ 15.03
<b>Cyclone IV FPGA</b>	U6	Altera	EP4CE6E22C8N	Digikey	544-2746-ND	1	\$ 11.95	\$ 11.95
FPGA flash	U5	Altera	EPCQ16AS18N	Digikey	544-3440-ND	1	\$ 7.35	\$ 7.35
<b>Atmel SAM4S4B</b>	U8	Microchip technology	ATSAM4S4BA-AU	Digikey	ATSAM4S4BA-AU-ND	1	\$ 3.93	\$ 3.93
Quad DIP switch	U9	Grayhill	76SB04	Digikey	GH7170-ND	1	\$ 0.92	\$ 0.92
1.2 V low-dropout regulator	U1	ST	LD117DT12TRI	Digikey	497-1231-1-ND	1	\$ 1.16	\$ 1.16
2.5 V low-dropout regulator	U2	ST	LD117DT25CTR	Digikey	497-1233-1-ND	1	\$ 1.16	\$ 1.16
3.3 V low-dropout regulator	U3	ST	LD117DT33CTR	Digikey	497-1235-1-ND	1	\$ 1.16	\$ 1.16
SPST pushbutton switch	PB1, PB2, PB3	Panasonic	EVQ-PAE04M	Digikey	P8008S-ND	3	\$ 0.29	\$ 0.87
10-segment LED array	U10	Lumex	SSA-LXB10IW-GF/LP	Digikey	67-1010-ND	1	\$ 2.85	\$ 2.85
330 Ω 5 resistor network	R8, R9	Bournes	4610X-2-331LF	Digikey	4610X-2-331LF-ND	2	\$ 0.29	\$ 0.57
FPGA download connector	JTAGFPGA	Tyco	5103309-1	Digikey	A33160-ND	1	\$ 0.76	\$ 0.76
36-pin header	U11	3M	929400-01-36-RK	Digikey	929400E-01-36-ND	2	\$ 1.32	\$ 2.65
2.2 KΩ 4 resistor network	R7	Bournes Inc.	4605X-101-222LF	Digikey	4605X-101-222LF-ND	1	\$ 0.51	\$ 0.51
1 KΩ resistor	R2, R3	Panasonic Electronic Components	ERJ-6GEYJ102V	Digikey	P1.0KACT-ND	2	\$ 0.10	\$ 0.20
10 KΩ resistor	R1, R4, R5, R6	Panasonic Electronic Components	ERJ-6GEYJ103V	Digikey	P10KACT-ND	4	\$ 0.10	\$ 0.40
1 Ω resistor	R10	Bournes Inc.	CRS0805-FW-1R00ELF	Digikey	CRS0805-FW-1R00ELFCT-ND	1	\$ 0.39	\$ 0.39
0.1 μF capacitor	C4, C6, C8, C11, C12, C13, C15, C17	Samsung Electro-Mechanics America, Inc	CL21F104ZBCNNNC	Digikey	1276-1007-1-ND	8	\$ 0.10	\$ 0.80
0.01 μF capacitor	C1, C2, C3, C10	Murata Electronics North America	GRM216R71H103KA01D	Digikey	490-1664-1-ND	4	\$ 0.10	\$ 0.40
10 μF capacitor	C5, C7, C9	Samsung Electro-Mechanics America, Inc	CL21A106KPFNNNG	Digikey	1276-6456-1-ND	3	\$ 0.14	\$ 0.42
2.2 μF capacitor	C14	AVX Corporation	0805ZG225ZAT4A	Digikey	478-12511-1-ND	1	\$ 0.41	\$ 0.41
4.7 μF capacitor	C16	Murata Electronics North America	GRT21BC8YA475KE13L	Digikey	490-12361-1-ND	1	\$ 0.45	\$ 0.45
10 μH inductor	L1	Bournes Inc.	77F100K-TR-RC	Digikey	77F100K-TR-RCTR-ND	1	\$ 0.10	\$ 0.10
SAM download connector	JTAGSAM	Samtec	FTSH-105-01-F-D-K	Digikey	SAM8909-ND	1	\$ 2.74	\$ 2.74
40 MHz oscillator	Y1	TXC Corporation	9B-40.000MAAJ-B	Digikey	887-2030-ND	1	\$ 0.39	\$ 0.39
<b>Total</b>								\$ 57.56

# FPGA

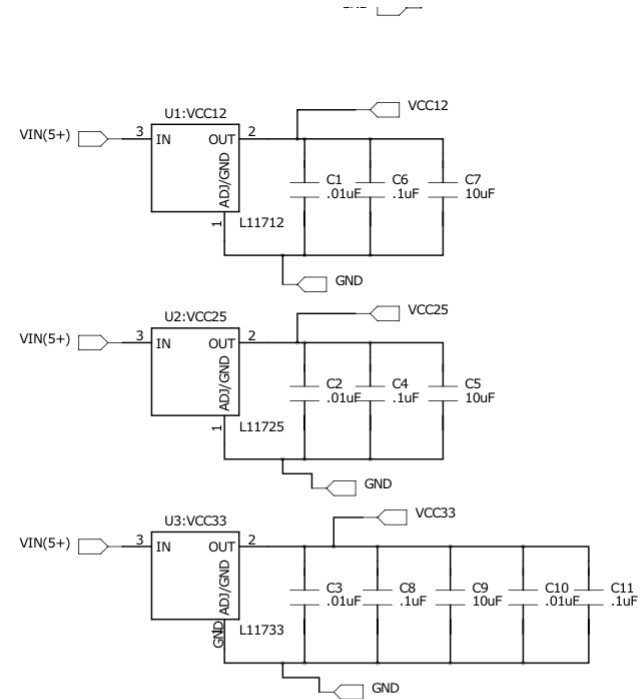
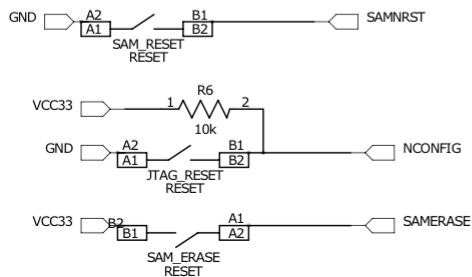
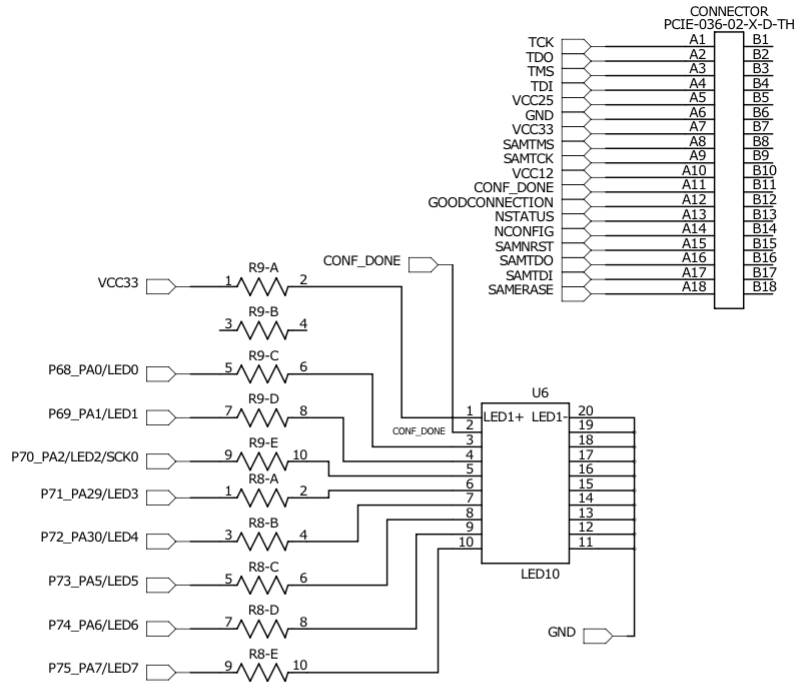


# Memory, Programming Headers



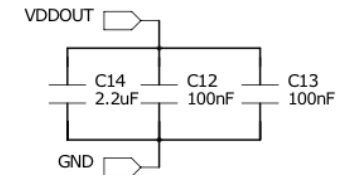
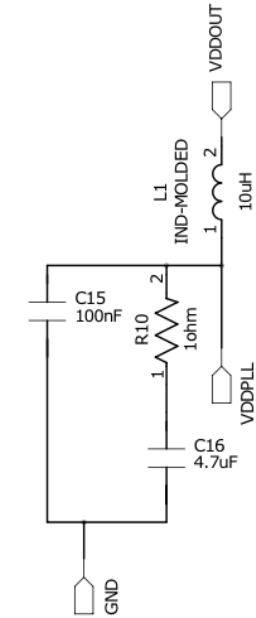
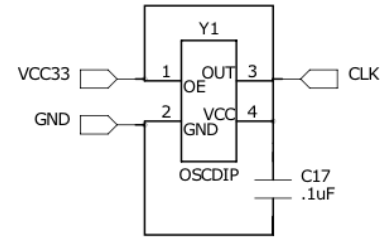
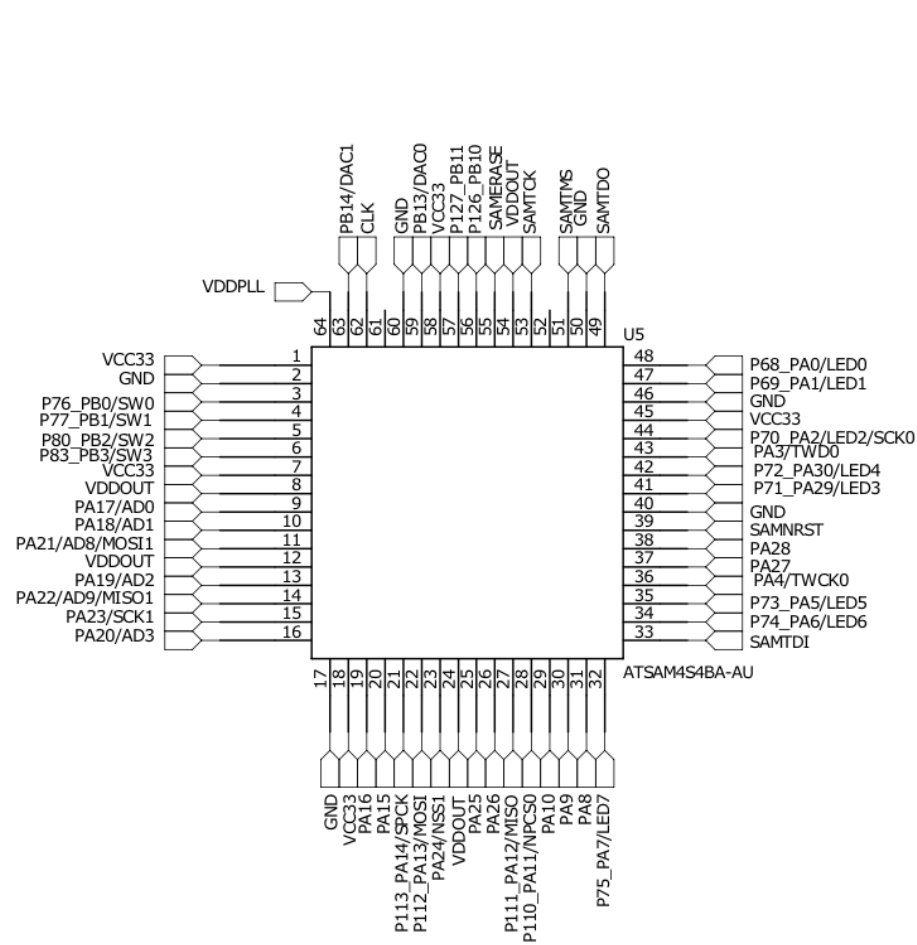


# Buttons, LEDs, Voltage Regulators, I/O



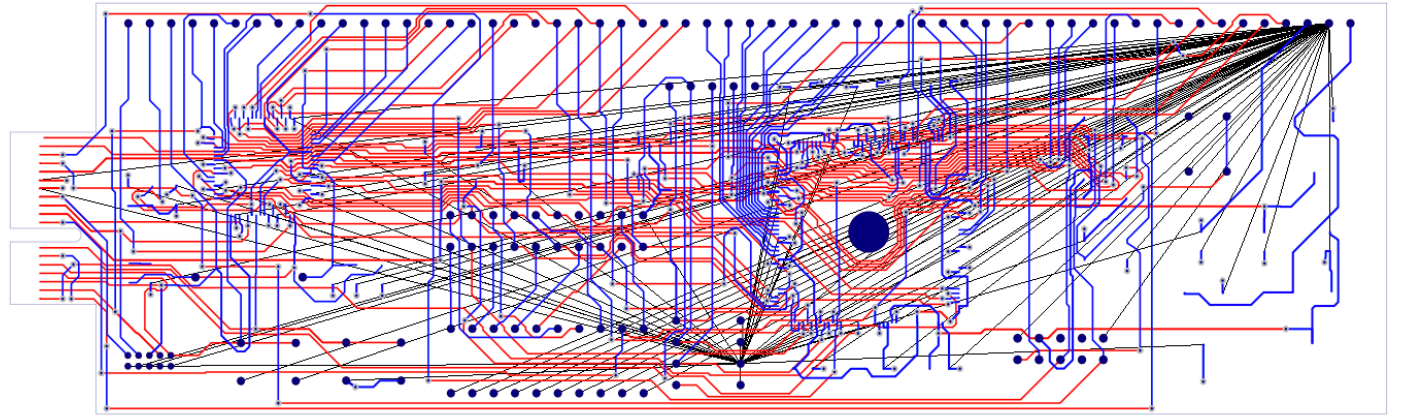
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RELEASED:		DATED:					

# MCU, Oscillator, Decoupling Caps

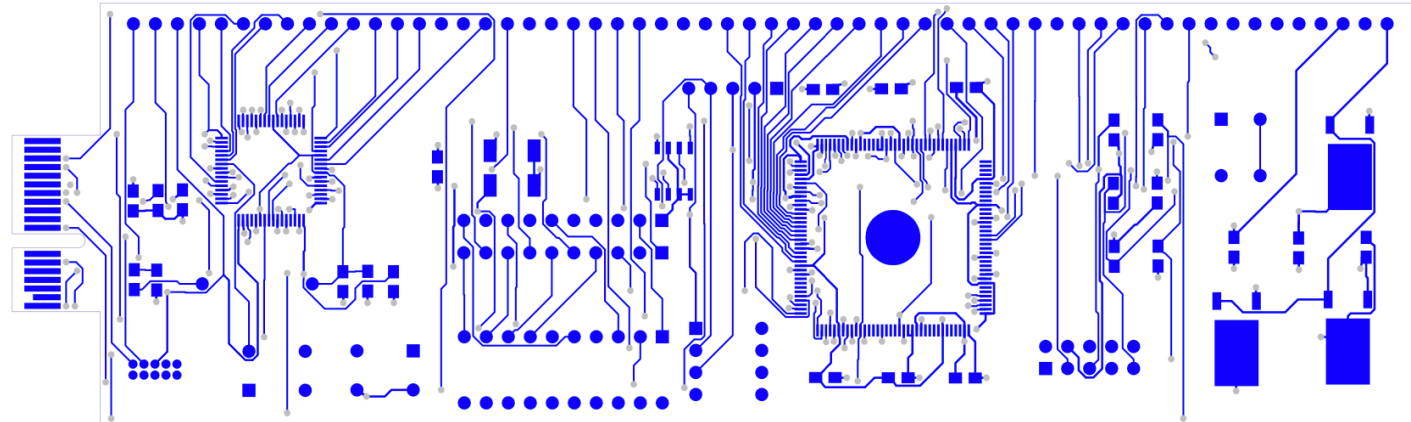


# PCB Design

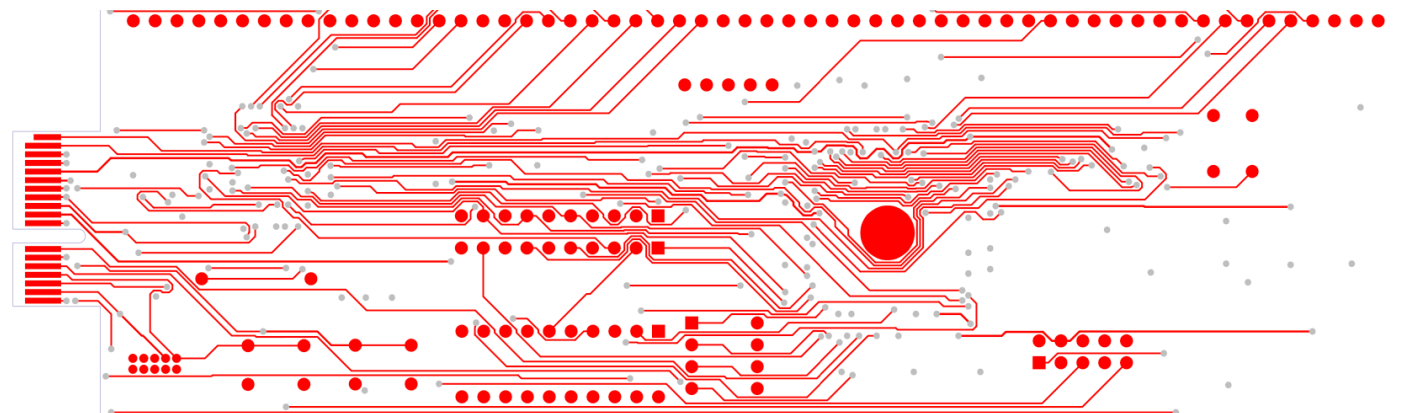
Raw Traces



Top



Bottom



# Final Project Timeline

Due Date	Deliverable
10/19	Project Proposal Due (via Sakai)
10/28-10/29	Proposal Debriefs (During checkoffs as team)
11/11-11/12	Project Status Report & Demo Due (During checkoffs as team)
11/9, 11/11	Project Presentations (In class)
11/30	During Final Exam Time Slot (2-5 pm)
11/30	Final Report Due (via Sakai)

# Final Project Proposal

I expect a typical project will use new functionality of the STM32 microcontroller and will perform a function that is useful or interesting. You can find examples of past final projects on the class web page from previous iterations of the course. Examples include games, electromechanical systems, prototypes for a startup company, or elements of a Clinic project (with your advisor's permission).

## Project Proposal

A 2-page proposal describing what you plan to build. It must be specific enough that I can tell when you demonstrate your project that it meets the specs of the proposal. Do not list stretch goals or wobble words; simply state what you are committing to delivering. You may need to do some preliminary technical work to gain confidence you can deliver what you are promising. Include a budget for any supplies. Describe the main subsystems of the design and the features of the STM32 MCU that you plan to use. Explain the new piece(s) of hardware and show that the STM32 is performing nontrivial functions. Include a block diagram showing the components and the interfaces between them. Only one team member needs to upload the proposal to Sakai for their team.

# Up Next

- Monday: PCB Design
- Wednesday: Motors and Speakers
- Lab 7: The Internet of Things
  - No checkoffs this week
  - Final project proposal due date unchanged (Monday via Sakai)

# Mid-semester Feedback Survey

<https://forms.gle/SbyfAXoYZmgVbeSp6>