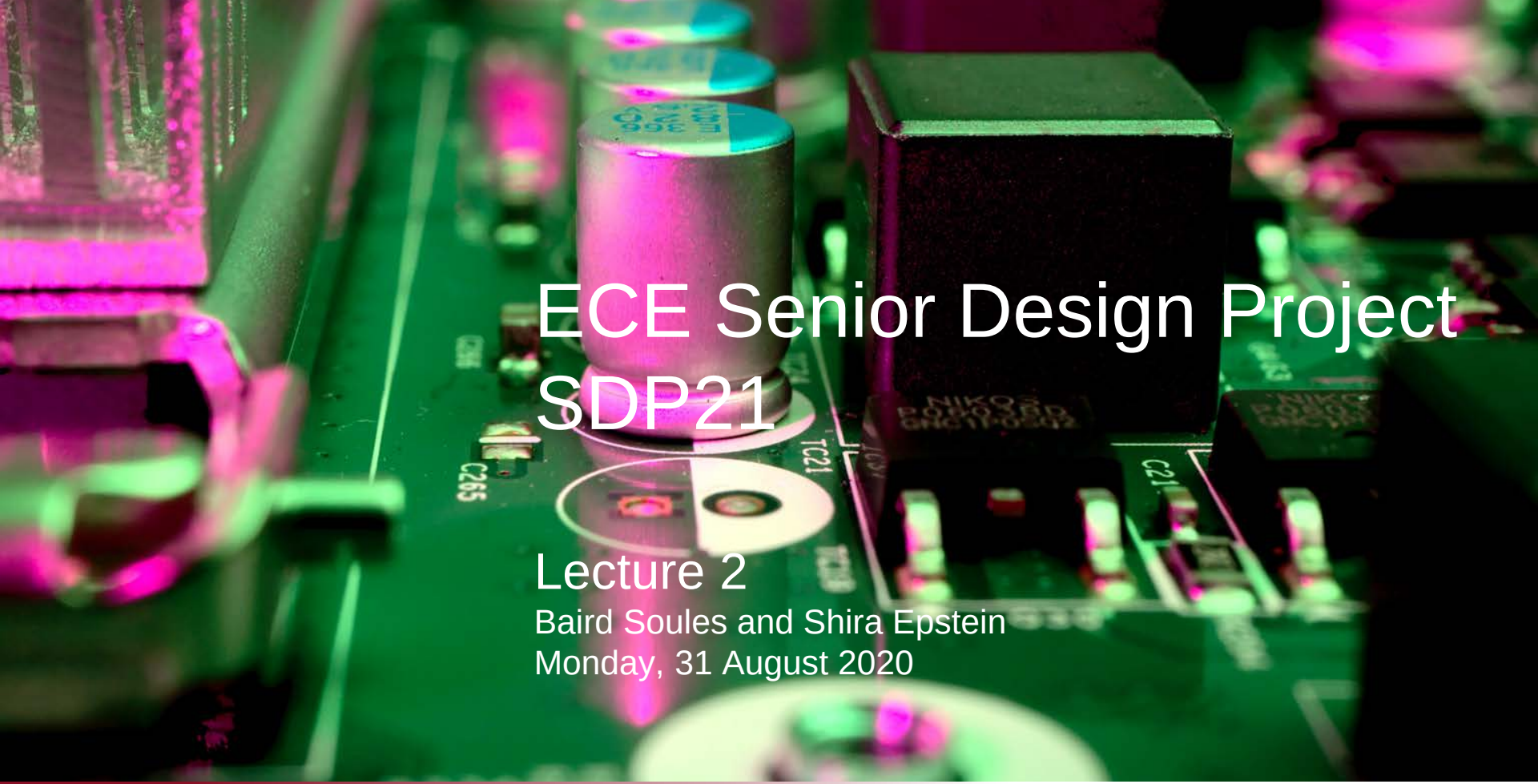


ECE Senior Design Project SDP21

Lecture 2

Baird Soules and Shira Epstein

Monday, 31 August 2020

Outline of Lecture 2, 31 August 2020

- Administrative Matters
- Course Communication Infrastructure
- A Detailed Design Process Example (VoxCaliper1)
- Custom Hardware Design Requirement
- Design Resources

Important Reminders

11 days until advisor choice due

20 days until PDR Week

77 days until MDR Week

236 days until SDP21 demo days
(Friday, April 24 and Saturday, April 25, 2021)

Check-in #2 is tentatively scheduled for
7 PM - 9 PM EDT

August/September 2020						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
23	24 Lecture 1	25	26	27	28	29
30	31 Lecture 2	1	2	3	4	5
6	7 Lecture 3	8	9	10	11 Advisors due	12
13	14 Check-in #2 Evaluators due	15 Check-in #2	16 Check-in #2	17 Check-in #2	18	19
20	21 PDR	22 PDR	23 PDR	24 PDR	25 PDR	26
27	28 Lecture 4	29	30			

October 2020						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
	28 Lecture 4	29	30	1	2	3
4	5 Lecture 5	6	7	8	9	10
11	12	13	14	15	16	17
18	19 Check-in #3	20 Check-in #3	21 Check-in #3	22 Check-in #3	23	24
25	26	27	28	29	30	31

November 2020						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2 Lecture 6	3	4	5	6	7
8	9 Check-in #4	10 Check-in #4	11 Check-in #4	12 Check-in #4	13	14
15	16 MDR	17 MDR	18 MDR	19 MDR	20 MDR	21
22	23	24	25	26	27 Reading Day	28 Reading Day
29	30 Exams begin					

SDP21 Slack Profiles

Aaron Hanley
CompE(Group 4)

Achuthan Panikath CE

Andrew Hartnett CompE

Angela Wong CompE

Ben Plamondon EE

Brendan Truong CompE

Picking up your face shield

Students should show up to **Marcus 8** between **9AM and 3:45PM, Monday through Friday**

Keith Shimeld's office is in 8A; students will locate Keith to obtain a face shield and use the computer stationed in the back to enter their info into the face shield checkout spreadsheet.

Students receive one face shield for the semester and must wear it in all laboratory settings along with their face mask.

Signage with instructions is on the door of 8C and on the computer to right of the door.

Logistics… updates coming soon…

How to order parts

Picking up team tool kits

Reservation system for benches and tables
M5 + SDP Lab (Marcus 10 & 12)
will go live on Monday, Sep 14

Logistics: Remote Students

- teams work to distribute tasks within the team
- you may work on a part of the project
  that involves needing parts and equipment
- think about the logistics, what you would
  need, and then email Shira to come up with a plan

Course Communication Infrastructure

Website (public):

http://www.ecs.umass.edu/sdp/sdp21/

Course Communication Infrastructure

Moodle (private)

Links to the lecture slides (.pdf files) and

videos (.mp4 files).

Course Communication Infrastructure

Official course slack: sdp21.slack.com

Each team will set up their

own slack workspace for team

communications.

Course Communication Infrastructure

Github

Each team will set up their

own github repository for team

code and documents.

We’ll offer a Github workshop soon.

Course Communication Infrastructure

Google Drive

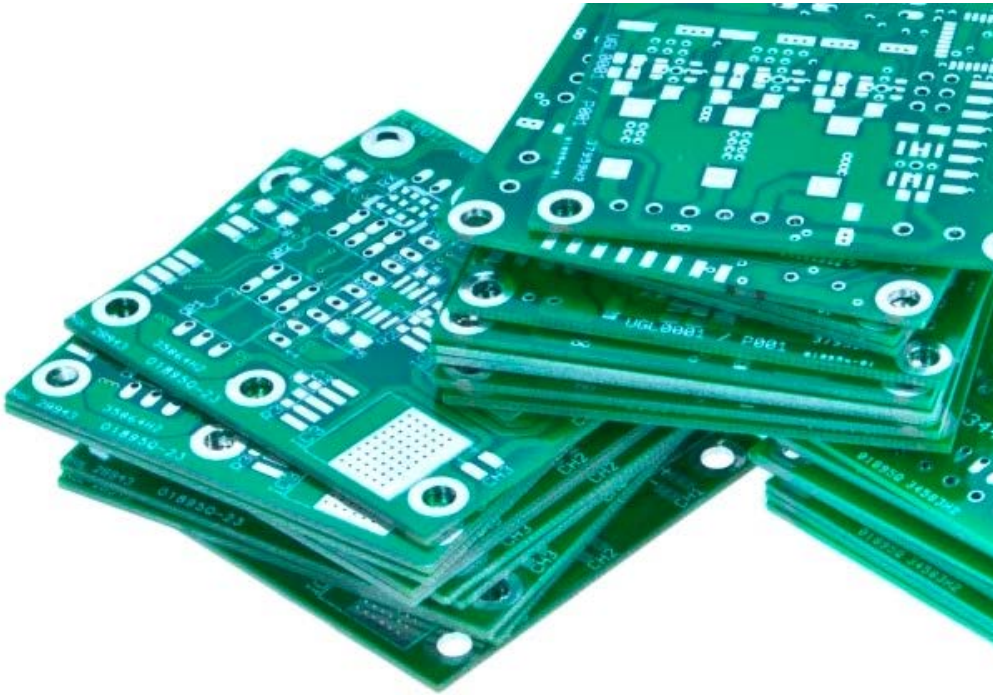
It is recommended that each team

have a shared Google Drive folder

for team documents (presentations, etc.)

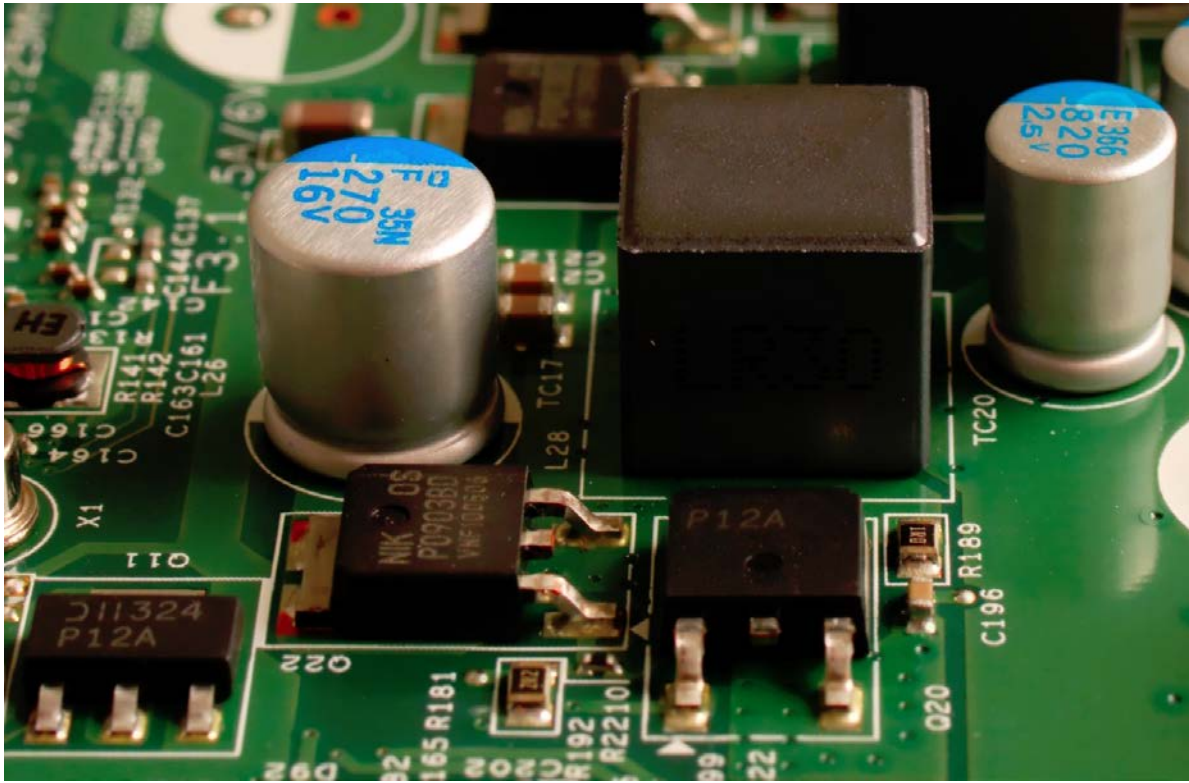
Hardware Requirement:
A PCBA of Significant Complexity

PCB = Printed Circuit Board



Hardware Requirement

PCBA = Printed Circuit
Board Assembly



Hardware Requirement

- Significant custom analog and/or digital electronic circuit:
  - solderless breadboard at MDR
  - solderless breadboard or PCBA at CDR
  - PCBA at FPR and demo days
- Identify the individual who is taking primary responsibility for the PCBA (involve EEs and CSEs)
- Solderless breadboards are not allowed at FPR and demo days.

Hardware Requirement

- Prototype rapidly for MDR.
- Use solderless breadboards, development boards & breakout boards for MDR.
- Development & breakout boards not allowed at FPR and demo days.
  - including Arduino, mbed and no-operating-system 8-bit and 32-bit dev boards.
  - instead, migrate your MDR design onto your custom PCB and migrate your Arduino code to ANSI C code.

Processor Selection

- Raspberry Pi and the Beagleboards are allowed throughout the course unless it is determined that your justification for using a power-hungry and complex single-board Linux-based computer is found lacking. In those cases you'll be required to migrate your design down to an 8-bit or 32-bit microcontroller on your own PCB.
- Recommend:
  - Altium Design for PCB layout
  - Surface-mount technology (SMT) as opposed to through-hole technology

Our example (less complex than a real SDP project--therefore this example uses a 2 person team)

A friend who works at a school for the blind and visually impaired mentioned that the school is introducing students to 3D design and 3D printing. The school has many different accessibility tools but finds it difficult to find/source “talking” digital calipers (they exist, but are expensive).

Some machinists at the makerspace also mentioned that as their vision is progressively getting worse with age, they would benefit from talking digital calipers, micrometers, and other measurement equipment

I start to think--I bet I could design these to be cheap(er) to manufacture even at small scale.

Googling

Google few things!

We tried, “talking caliper”

Here’s what we found

1. Further confirmation that this is an interesting idea
2. Other solutions to a similar problem
3. Feasibility confirmation
4. Similar projects and background materials that will help guide our project

Confirmation of importance of idea:
This Digi-Voice Tool is $695!!!

https://abledata.acl.gov/product/talking-digital-tools-dial-gauges-micrometers-calipers

http://assistivetech.net/search/productDisplay.php?product_id=39190

Digital tools that are to be used with their Digi-Voice Tool Module (see separate entry [MSRP $695]). Precision instruments for machinists, mechanical/ industrial process control engineers, etc. to measure accurately to . 0001 inch. All instruments require separate cables. Choice of 2705 Dial Gauge .4-.8 inches for $285; 2736 Dial Gauge .8-1.2 inches for $299; 2735 Dial Gauge Stand for $95; 2710, 0-1 inch Micrometer for $195; 2711, 1-2 inch Micrometer for $245; 2712, 2-3 inch Micrometer for $295; 2713, 3-4 inch Micrometer for $320; 2701, 6 inch Vernier Caliper for $ 175, and 2702, 8 inch Vernier Caliper for $220. Some of the above items are purchased specifically for an order and cannot be returned so consult with manufacturer prior to order.

Price Check

as of:

04/23/2003

Additional Pricing Notes:

Contact manufacturer

Tactile calipers, doesn’t meet system specs (what if you can’t read braille)

Link: tinyurl.com/sdp21aac

Bluetooth caliper, relies on phone as part of the system
https://www.ebay.com/itm/332572483269

SAVE UP TO 6% WHEN YOU BUY MORE

iGaging Digital Caliper Absolute Origin Smart Bluetooth IP54 4"/100mm

Be the first to write a review.

Condition: New

Bulk savings: Buy 1 $39.95/ea | Buy 2 $39.15/ea | Buy 3 $38.35/ea

Quantity: 1 4 or more for $37.55/ea

6 available
87 sold / See feedback

Price: US $39.95/ea

Buy It Now

Add to cart

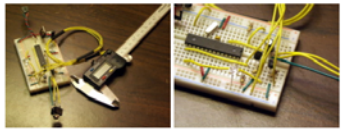
♡ Add to Watchlist

100% buyer satisfaction | 87 sold | More than 93% sold

Shipping: FREE Standard Shipping | See details

This project similar to what I envision making. Just because it is already done doesn't mean I can't decide to work on this project. Their design seems to need an update and isn't available for sale other than as a kit/tutorial for makers. http://www.nerdkits.com/videos/talking_calipers/ Their write-up could be useful background reading.

The second version of the circuit, which Mike demonstrates in the video, has a power supply connector and handles a caliper with the "slow" communication protocol:



Digital Caliper Interface

There are at least two common types of digital caliper interfaces, and we built one version of this circuit for each. (It would certainly be possible to build one that would detect and handle either.) In our Digital Calipers DRO video, the calipers transmitted 2 sets of 24 bits in quick succession, with a bit period of only about 12µs ("fast"). However, in the code published here, we were working with calipers of the other type, which transmit 6 sets of 4 bits, with a bit period of roughly 400µs ("slow"). The "slow" protocol also transmits information about whether the calipers are set to inch or millimeter mode, while in the "fast" protocol, only the absolute measurement is transmitted.

Sound Storage and Playback

The only difference between how we stored and played sound for our Halloween Huffman-Coded Audio project and this one is that here, we stored the second difference of the sound signal instead of the first difference, as for speech data this yielded better compression.

Power Supply

One version of this circuit used the BJT-based power supply that we demonstrated in the Digital Calipers DRO video. The other used a simple resistor plus LED as a nearly-constant voltage source, since the voltage drop across the LED is quite similar to the voltage needed by the calipers.

Schematic

Could I actually make this?

I think so, because I have reflected and reached these conclusions:

- I know that many calipers have a standard data port on them, and I've read enough articles to know that people have "hacked" that port!
- I've made a list of what other design components would be involved and they all seem feasible too!
  - Audio storage and playback--seems reasonable! In 2020 I'd be hard pressed to find a product that doesn't involve that
  - Battery and battery management--same logic
  - As a point of reference, there exist portable battery powered voice recorders (and other similar consumer product categories) for under $25 so my general feeling is that this is feasible from a cost and weight/size

An example where I say no to “Could I actually make this?”

Exoskeletons are really cool and have lots of applications. But keep in mind:

It’s a primarily **mechanical engineering** project

Involving testing a dangerous system on **human subjects** (if it can move your body, it can break your body)!

Articles online speculate the price might drop to as low as $40,000, one day...that’s too **expensive**! I doubt I could make a $500 model

Where to start? Try the problem statement and system specs (“Project Plan”)

UMass SDP20 PDR – Evaluation Sheet

Team Members: Evaluators:

Team Number/Name

Presentation (10%)	❑ (4.0) A professional presentation that demonstrates knowledge and practice. ❑ (3.5) The presentation should have been practiced more. ❑ (3.0) The presentation was confusing at a few points. ❑ (2.5) The presentation was confusing at more than a few points. ❑ (2.0)The presentation was poorly organized or presented.
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Problem statement

Project: Voxcaliper1

Document: Problem Statement

Team Members: Baird Soules and Shira Epstein

The arrival of low cost digital calipers has been welcomed by makers everywhere. They are easy to use--but only if one is able to see the display clearly. The sight-impaired and those that would like to have the option of a non-visual method of receiving a measurement need a talking caliper. Enter Voxcaliper1. Voxcaliper1 is a low-cost add-on to the popular low-cost digital caliper such as the VINCA DCLA-0605. The user simply takes a measurement and presses a button, and the Voxcaliper1 immediately speaks the new measurement in English or Spanish (or any language for which localization files have been provided).

Revised on 25 Aug 2020

System Spec

Project: Voxcaliper1

Document: System Specification

Team Members: Baird Soules and Shira Epstein

Voxcaliper1 is a low-cost add-on to the popular low-cost digital caliper such as the VINCA DCLA-0605. The user simply takes a measurement and presses a button, and the Voxcaliper1 immediately speaks the new measurement.

Voxcaliper1 will meet or exceed the following system specifications:

- Power-up in under two seconds
- Power-down in under two seconds
- Rechargeable battery
- Battery life of two hours on a full-charge
- Speech on speaker clearly audible and intelligible in moderately busy environment (busy workshop without power tool running)
- Speech in English or Spanish (or any language for which localization files have been provided).
- Weight (added to caliper): 100 grams (3.5 oz), *no more than 200 grams
- Volume (added to caliper): 96 cubic cm. (4 x 4 x 6 cm) (5.9 cubic in. (1.58 x 1.58 x 2.36 in))

What's next?

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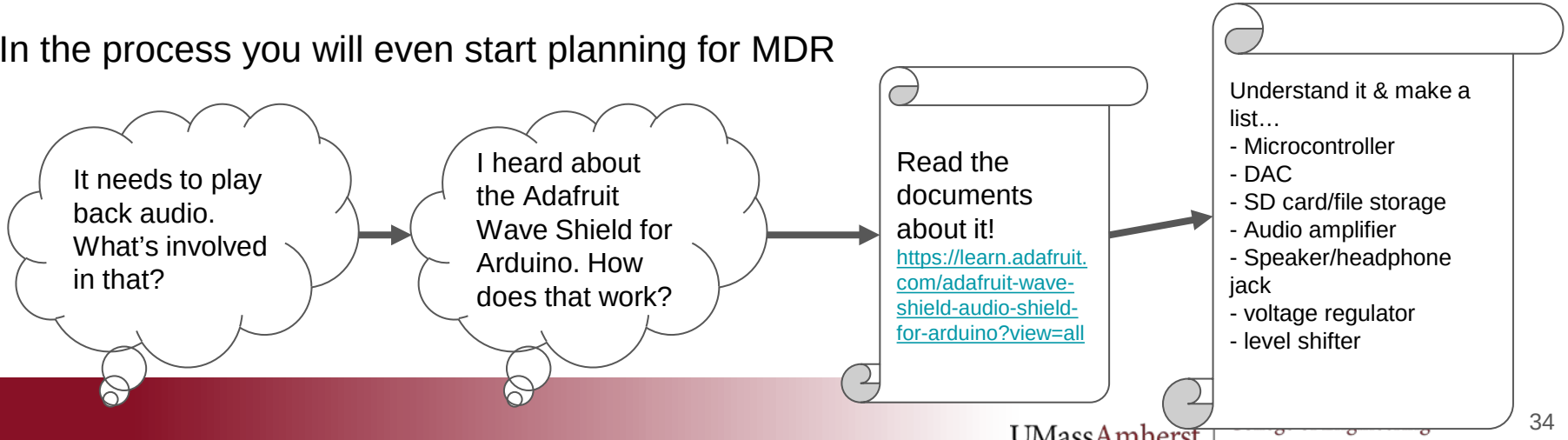
What's next? Block diagram? Not so fast

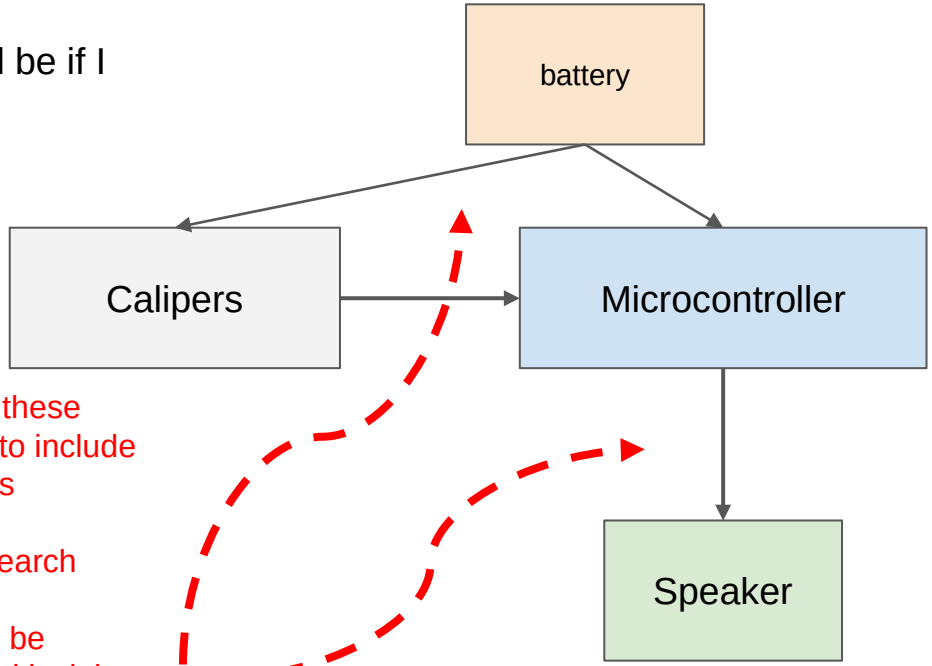
A block diagram doesn't magically follow from the system specifications. You will need to spend some time doing preliminary research and discussion to develop it.

What are the main parts we think will be needed in Voxcaliper1? How do we come up with that list?

In the process you will even start planning for MDR



What my block diagram would be if I hadn't done my research



I am not familiar with these systems so I neglect to include important submodules

I should do some research

Level of detail should be consistent with how critical that part is to the design work that will go into my project

Since I'm designing this part, I need to flesh it out

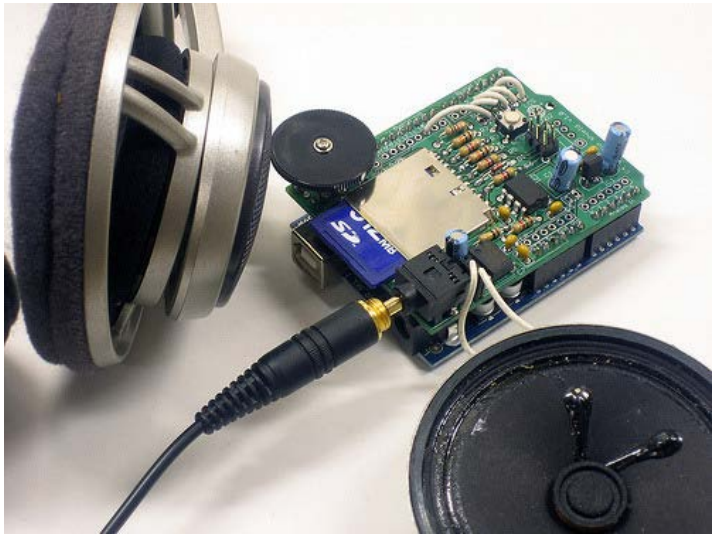
Suggestion: go “virtual shopping”

- Get a sense for the kinds of things that you might end up needing even though you aren’t ready with a design/bill of materials yet.
    - What kinds of sensors are for sale?
    - What kind of microcontrollers, single board computers are for sale?
    - What kind of actuators, motors, and mechanical assemblies are for sale?
    - What breakout boards/development boards exist?

Doing some research to fill in the gaps in my knowledge

Adafruit's Wave Shield Kit is an Arduino Shield meant to provide hobbyists with an easy solution to adding audio to their Arduino projects. As with all of Adafruit's designs, the full documentation including a detailed write-up and schematic are available, making it an excellent place to learn.

https://learn.adafruit.com/adafruit-wave-shield-audio-shield-for-arduino



My proto-block diagram, a kind of visual list of parts with edges showing signal and power connections

Momentary Switch

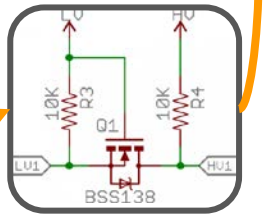
Microcontroller

DAC

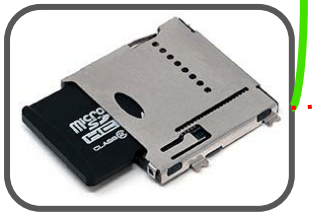
Speaker

Amplifier

Headphone jack



Level shifter



SD Card/Reader

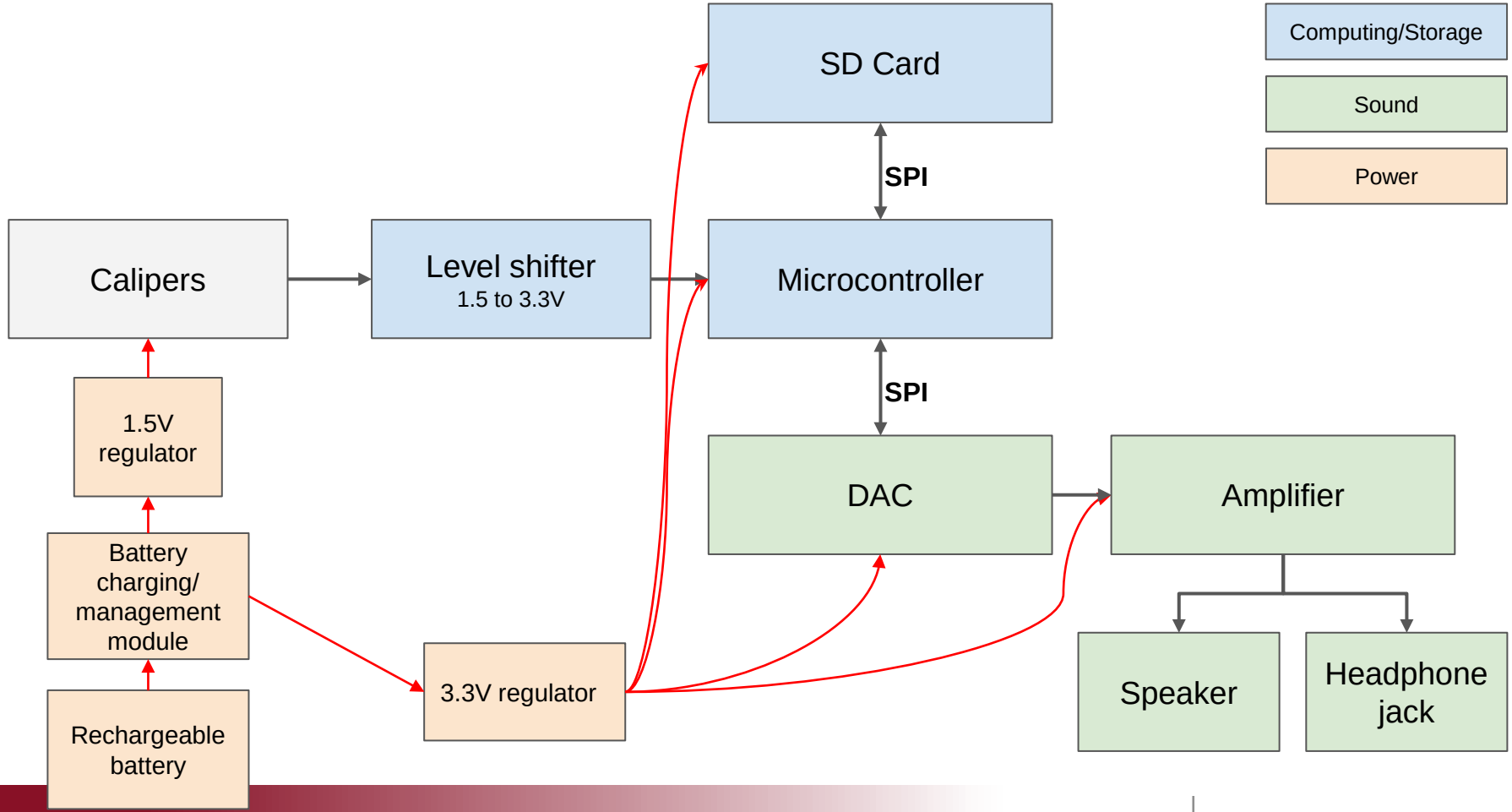
3.3V regulator

Digital Calipers

1.5V regulator

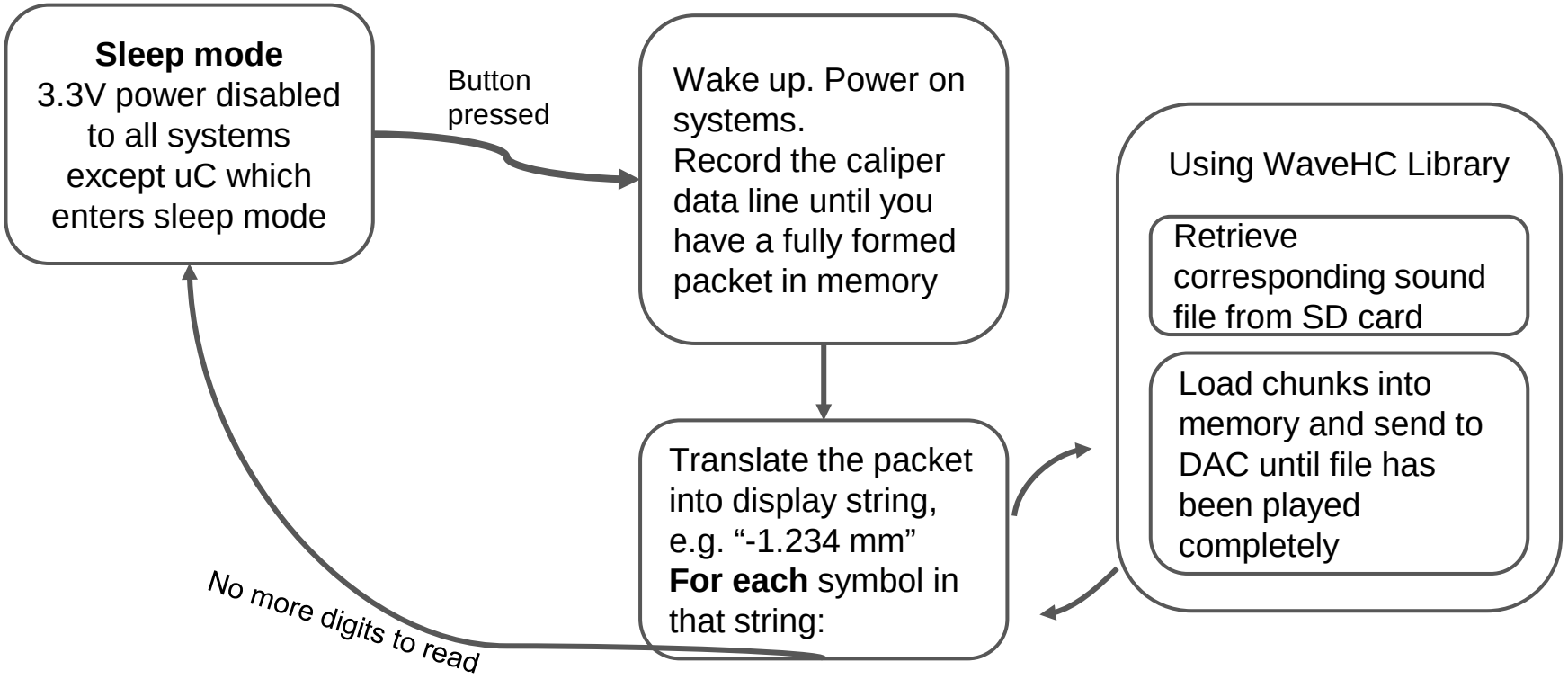
Charging/monitoring module, USB

Rechargeable Battery

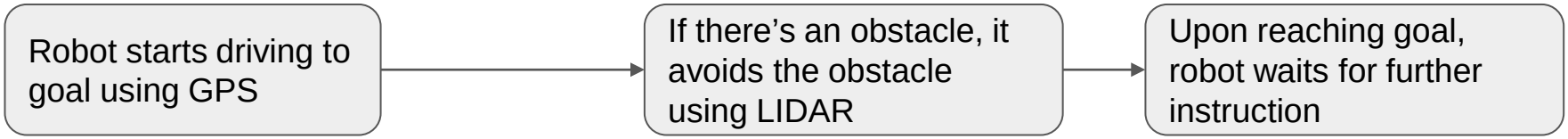

Computing/Storage
Sound
Power
SD Card
SPI
Calipers
Level shifter
1.5 to 3.3V
Microcontroller
SPI
1.5V
regulator
DAC
Amplifier
Battery
charging/
management
module
3.3V regulator
Speaker
Headphone
jack
Rechargeable
battery

...but wait! What does the software do?

Software diagram



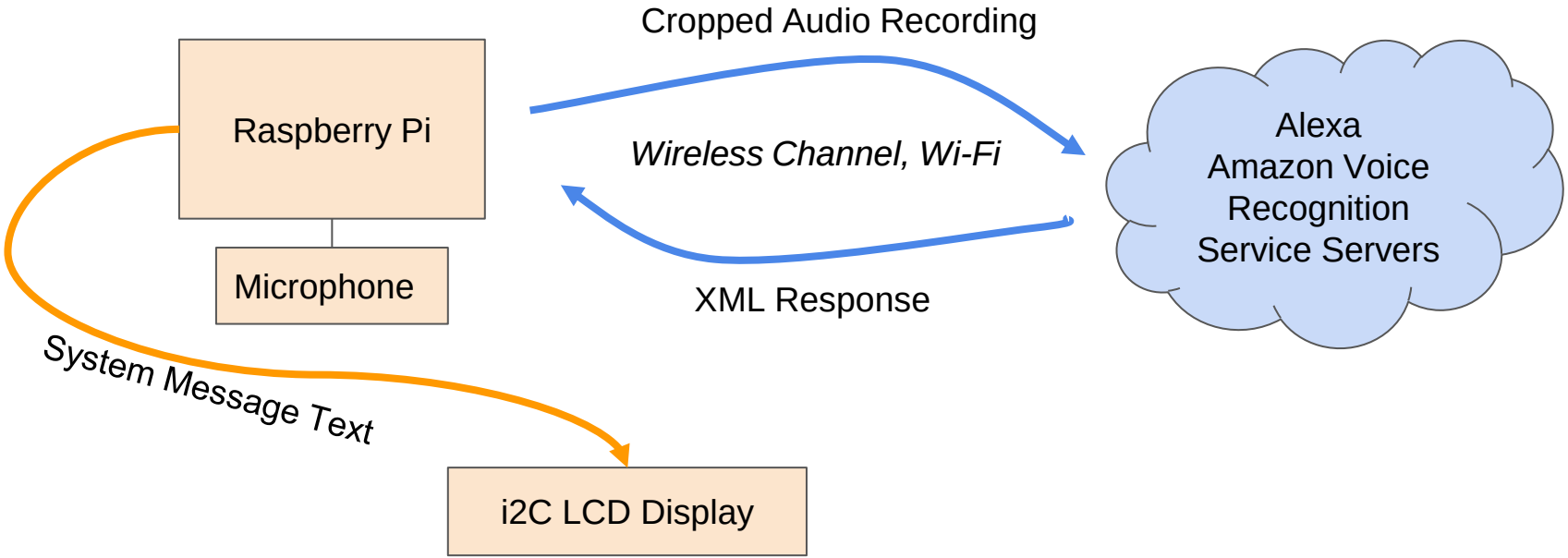
Early stages of thinking about the problem -- not PDR ready!!!



Along what path???
Straight line directly to the goal?
Are there roads?
How does it know about those?
What kind of path planning does it do?
What kind of steering does it have????

How does it know where the obstacle is??? How does it plan a path around the obstacle? What if the obstacle is moving?

Depending on the software scope, think about the most appropriate information you need to convey. For example,what about information flow?



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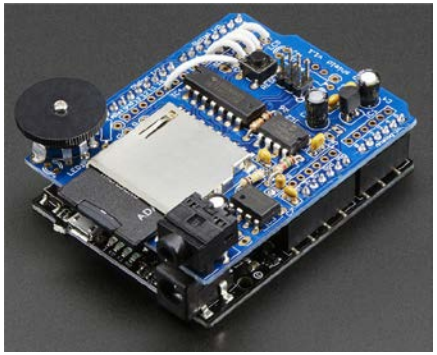
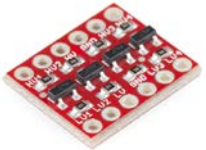
Fast forward -- show the functioning subsystems for MDR

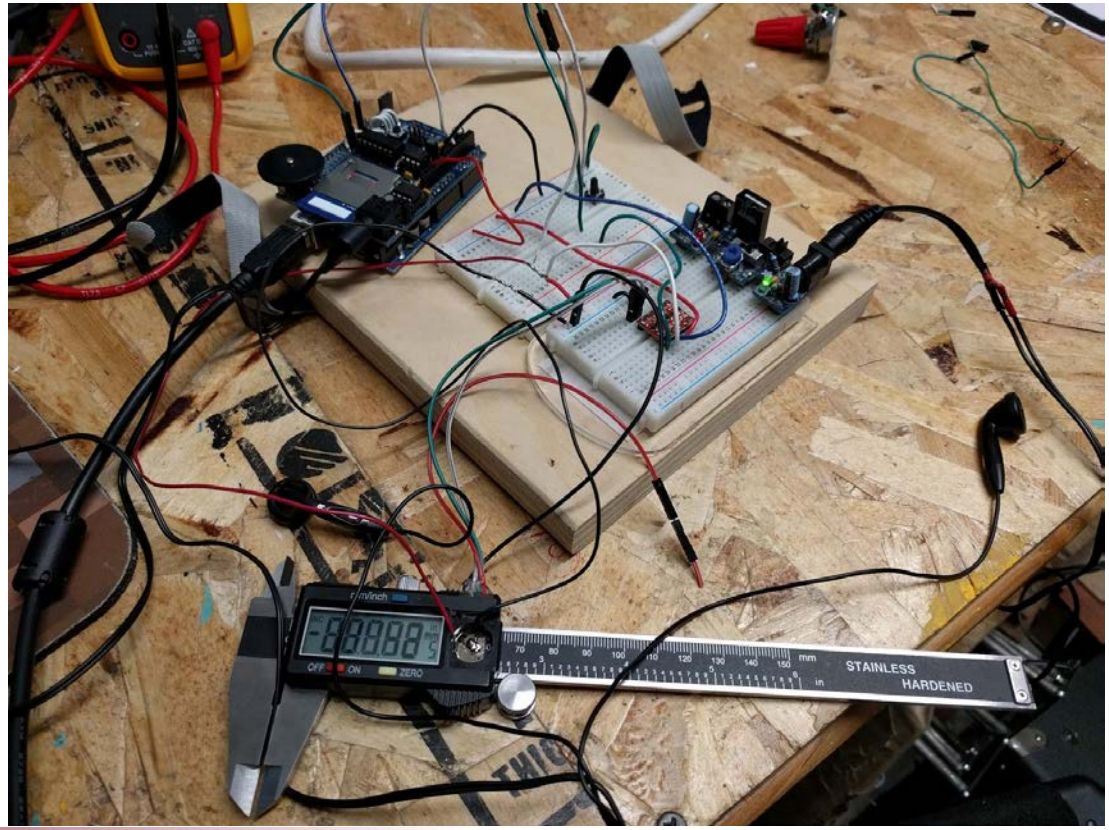


https://www.adafruit.com/product/94



https://www.sparkfun.com/products/12009

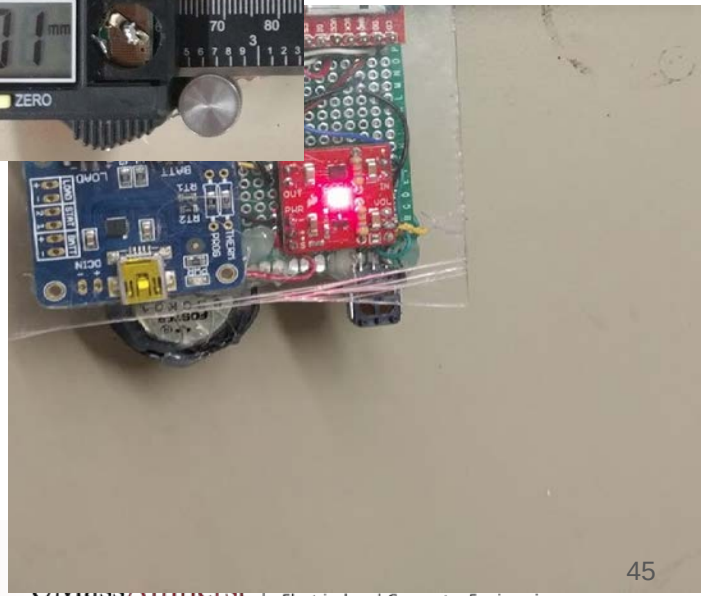
https://learn.adafruit.com/adjustable-breadboard-power-supply-kit/overview



Preview CDR -- integration of subsystems

http://buildingfriends.blogspot.com/2017/03/talking-calipers-2.html

- Teensy 3.1
  https://www.pjrc.com/teensy/teensy31.html
- Sparkfun Mono Audio Board
  https://www.sparkfun.com/products/11044
- Adafruit LiIon/LiPoly charger board
  https://www.adafruit.com/product/259
- Sparkfun MicroSD card breakout board
  https://www.sparkfun.com/products/544
- LiIon 1000mAh battery
- LM4860 Audio power amplifier
  http://www.ti.com/lit/ds/symlink/lm4860.pdf



Project Idea Checklist

1. **Modularity**: Can this proposed project be divided into four significant areas of primary responsibility? (one per team member?) (Block Diagram)
2. **Difficulty**: Is the project feasible? Is it too challenging? Is it too easy?
3. **Hardware**: Is there a significant custom hardware design element?

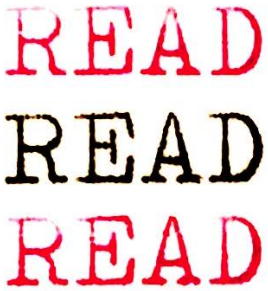
Note: Originality/Impact

Note: Career Goals: Will this project move me towards my dream job? Will I be excited to discuss my project role in a job interview?

Rapid Prototyping

Development Boards, Single-board Computers (Beagle, Arduino, etc)
Breakout boards…

Sparkfun
Adafruit
Pololu


READ
READ
READ

Search for the O’Reilly Safari Learning Platform at the UMass library site and then search for these three ebooks. All three are by Charles Platt.

Link to the playlist of O'Reilly Safari ebooks recommended for SDP21:

tinyurl.com/sdp21aad

Please feel free to suggest additions to the playlist on the #safariplaylist slack channel.

Documents, publications for ideas, etc.:

- Data Sheets
- Application Notes
- Reference Designs (see ti.com)
- White Papers
- Case Studies (example: see case study at particle.io)
- Magazine articles (see Circuit Cellar, etc)
- New York Times
- Blogs
- Podcasts (see embedded.fm and the Amp Hour)
- eBooks (Safari and others)
- IEEE journals (see IEEE Xplore at UMass library)

Reach out to people for feedback, ideas, etc.:

- SDP21 Slack
- M5 Discord Join the M5 Discord https://discord.gg/tbvGBJ
- ECE Faculty
- ECE Alums (via Prof. Hollot's UMass Amherst ECE LinkedIn group and via ECE faculty)
- Application Engineers (at chip companies and vendors like Digikey)


WALL·E