SDP22
Lecture 2
8 September 2021
Preliminary Design

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PDR Coming Soon

PDR

27 Sep – 1 Oct

~~27 days~~

20 days

Team To-Do List

1. Sign-up for lab bench (Keith Shimeld, Marcus 08A)

2. Set day/time for weekly team meetings (team only)

3. Set day/time for faculty advisor meetings (team + adviser)

4. Faculty Advisors: <mark>due Wed, 8 Sep</mark>

5. Project proposal: <mark>due Fri, 10 Sep</mark>

   – use slack team channel to communicate with course coordinators

6. Evaluator nominations (7 names): <mark>due Fri, 10 Sep</mark>

7. Fill out progress in Google Form
   – Link: https://forms.gle/coEdivPmemJrFSeV6

8. Sign-up for Check-in 2, 6.30-8.30pm, Mon-Thu, 13-16 Sep'21, Zoom

The (Preliminary) Design Process

The Skunk Works name was taken from the moonshine factory in the comic strip Li'l Abner. The designation "skunk works" or "skunkworks" is widely used in business, engineering, and technical fields to describe a group within an organization given a <mark>high degree of autonomy and unhampered by bureaucracy, with the task of working on advanced or secret projects</mark>.

Artwork & Prints - Lockheed Martin Skunk Works Round Metal Sign

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1981　　IBM Personal Computer

1984　　Apple Macintosh

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The Preliminary Design Process

1. Research Neighboring Solutions
2. Problem Statement & Description of System
   - design agnostic
   - top level description
3. System Specifications
   - Quantitative
   - Verifiable (testing plan)
4. Preliminary Design (a <mark>proposed</mark> design solution)
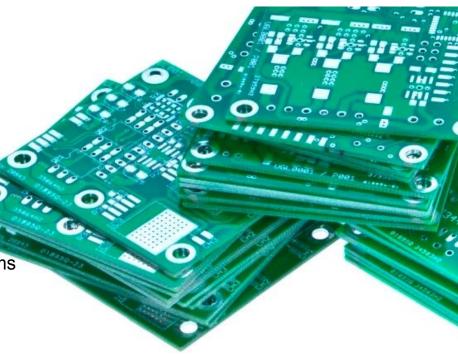   - Focus on rapid prototyping
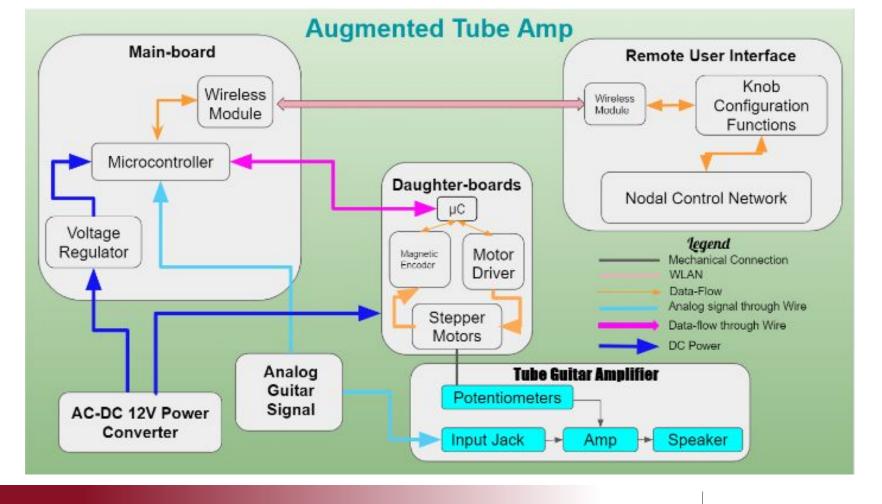   - Breakout boards, software libraries
   - Diagrams, mock-ups (paper and tape)
   - Brainstorming
   - Researching - Reading
   - Block diagrams & schematic circuit diagrams

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?
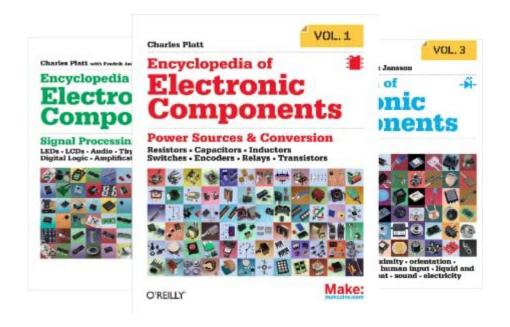
Rapid Prototyping

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

Sparkfun
Adafruit
Pololu

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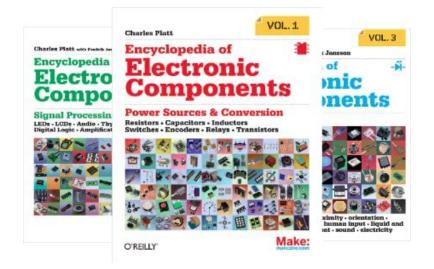
READ

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 SDP:

tinyurl.com/sdp21aad

Please feel free to suggest additions to the playlist on the #safariplaylist slack channel.
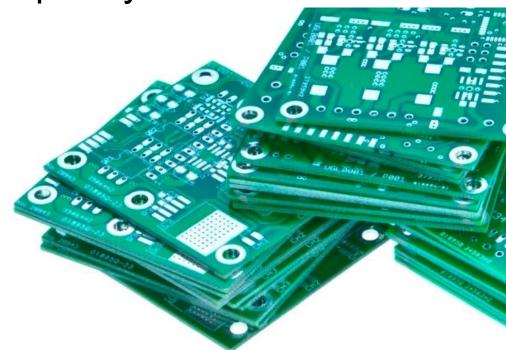
Documents, publications for ideas, etc.:

- Data Sheets
- Application Notes   (written by Applications Engineers)
- 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.:

- SDP22 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)

Hardware Requirement:
A PCBA of Significant Complexity

PCB = Printed Circuit Board

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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.

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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 or KiCAD for PCB layout
  - Surface-mount technology (SMT) as opposed to through-hole technology

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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.

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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

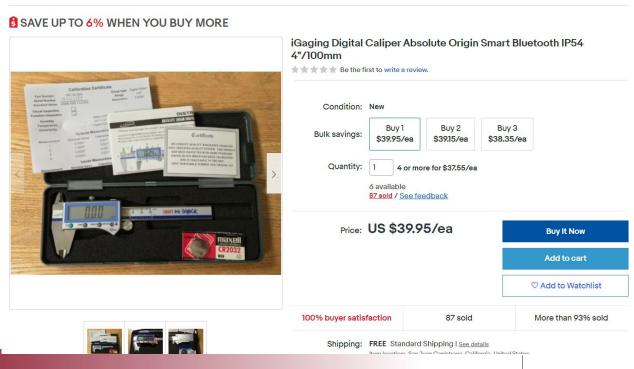# Tactile calipers, doesn't meet system specs (what if you can't read braille)

Link:

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
Item location: San Juan Capistrano, California, United States

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

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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 <u>portable</u> battery powered voice recorders (and other similar consumer product categories) for <u>under $25</u> so my general feeling is that this is feasible from a cost and weight/size

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.
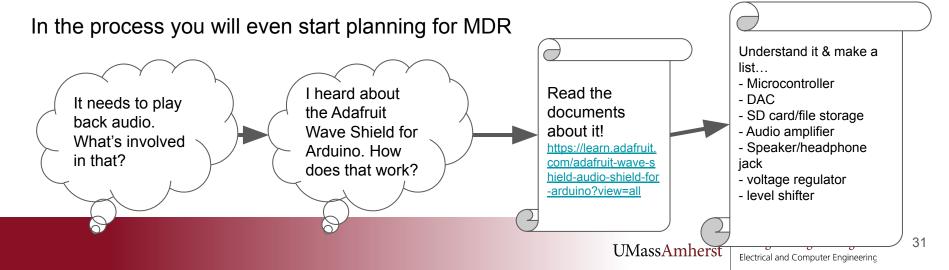
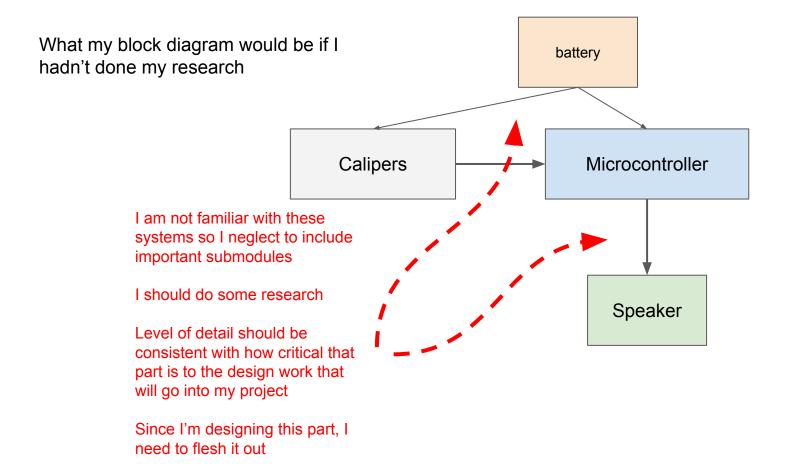Voxcaliper1 will meet or exceed the following system specifications:

- 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? 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?
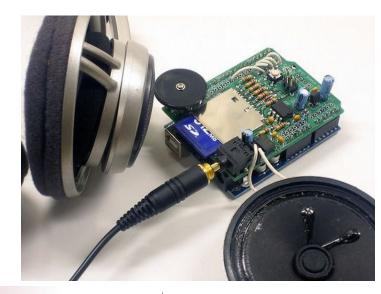
In the process you will even start planning for MDR

It needs to play back audio. What's involved in that?

→

I heard about the Adafruit Wave Shield for Arduino. How does that work?

→

Read the documents about it! https://learn.adafruit.com/adafruit-wave-shield-audio-shield-for-arduino?view=all

→

Understand it & make a list…
- Microcontroller
- DAC
- SD card/file storage
- Audio amplifier
- Speaker/headphone jack
- voltage regulator
- level shifter

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

battery

Calipers

Microcontroller

Speaker

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?
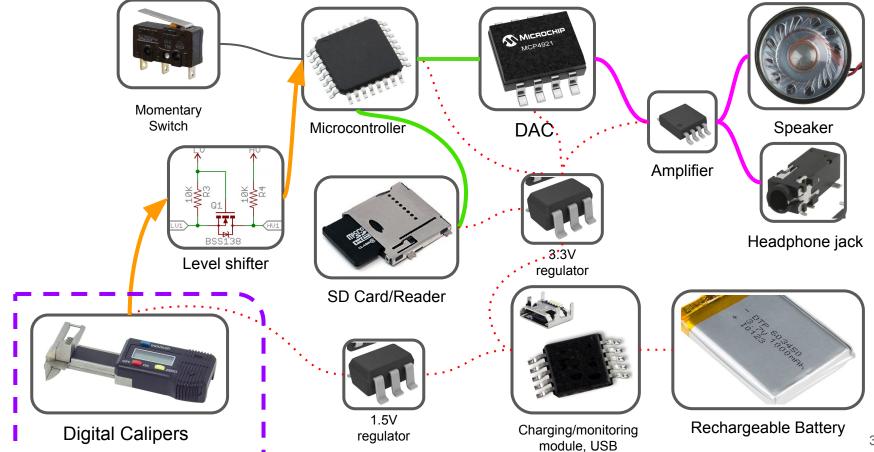 - What breakout boards/development boards exist?

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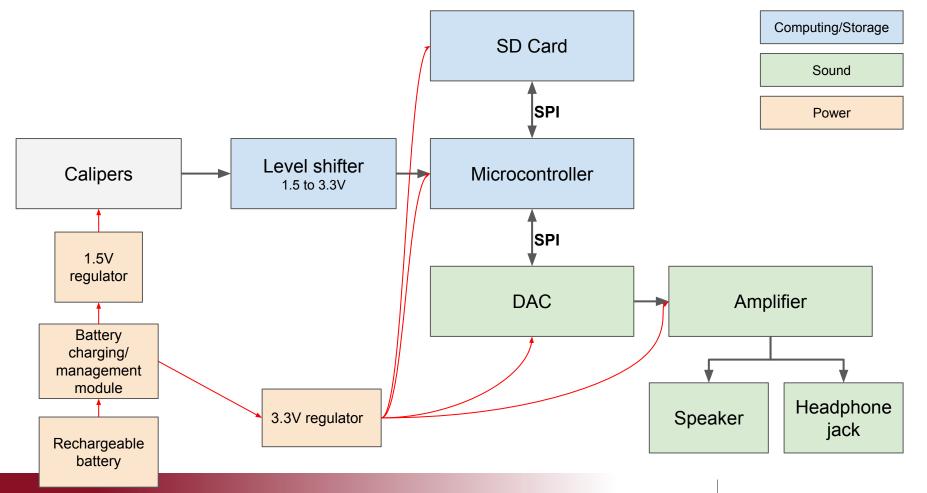
Adafruit's Wave Shield Kit is an Arduino Shield meant to provide hobbyists with an easy solution to adding audio to their Arduino projects. As with all of Adafruit's designs, the full documentation including a detailed write-up and schematic are available, making it an excellent place to learn.

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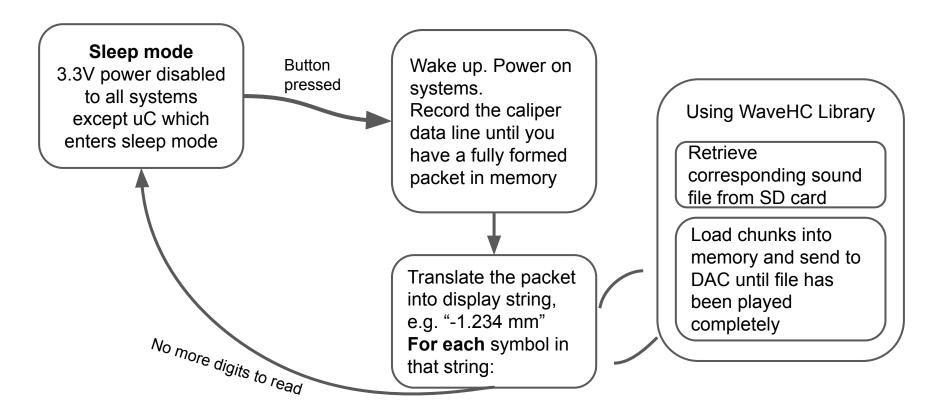adafruit-wave-shield-audio-shield-for-arduino

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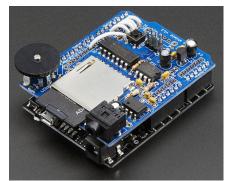

Momentary Switch

Microcontroller

DAC

Speaker

Amplifier

Level shifter

SD Card/Reader

3.3V regulator

Headphone jack

Digital Calipers

1.5V regulator

Charging/monitoring module, USB

Rechargeable Battery

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

Sleep mode
3.3V power disabled to all systems except uC which enters sleep mode

Button pressed

Wake up. Power on systems.
Record the caliper data line until you have a fully formed packet in memory

Using WaveHC Library

Retrieve corresponding sound file from SD card

Load chunks into memory and send to DAC until file has been played completely

Translate the packet into display string, e.g. "-1.234 mm"
For each symbol in that string:

No more digits to read

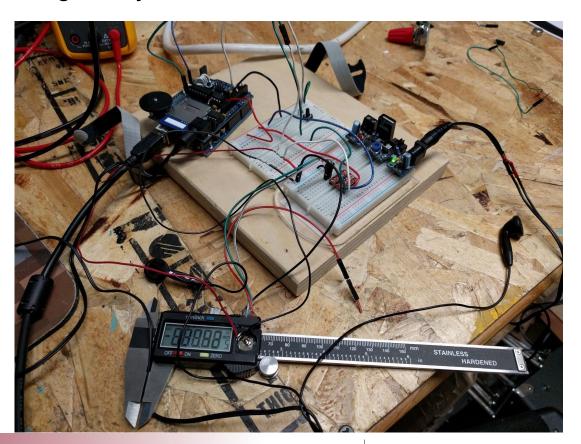# Fast forward -- show the functioning subsystems for MDR

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

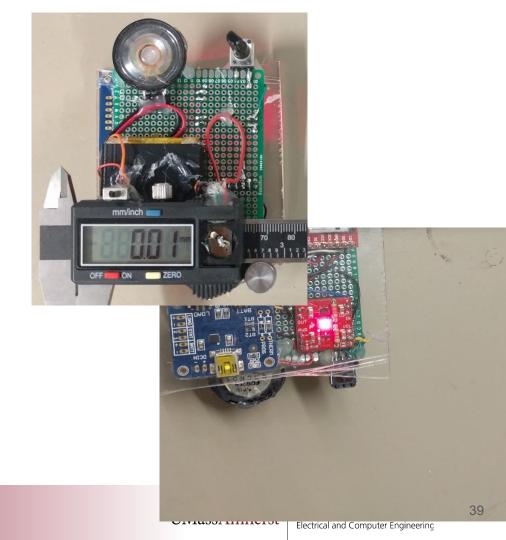https://www.sparkfun.com/products/12009

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

Next Course Meeting

- Lecture 3 (Preliminary Goals, Specifications & Testing Plan)
  - 4pm, Mon, 13 Sep
  - Elab II, Rm 119

      PDR
      10% Presentation
      10% Survey of Similar Existing Solutions
      ==20% Preliminary Goals, Specifications & Testing Plan==
      40% Preliminary Design
      10% MDR Deliverables
      5% Project Expenditures
      5% Project Management

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