ECE445: The Design Document

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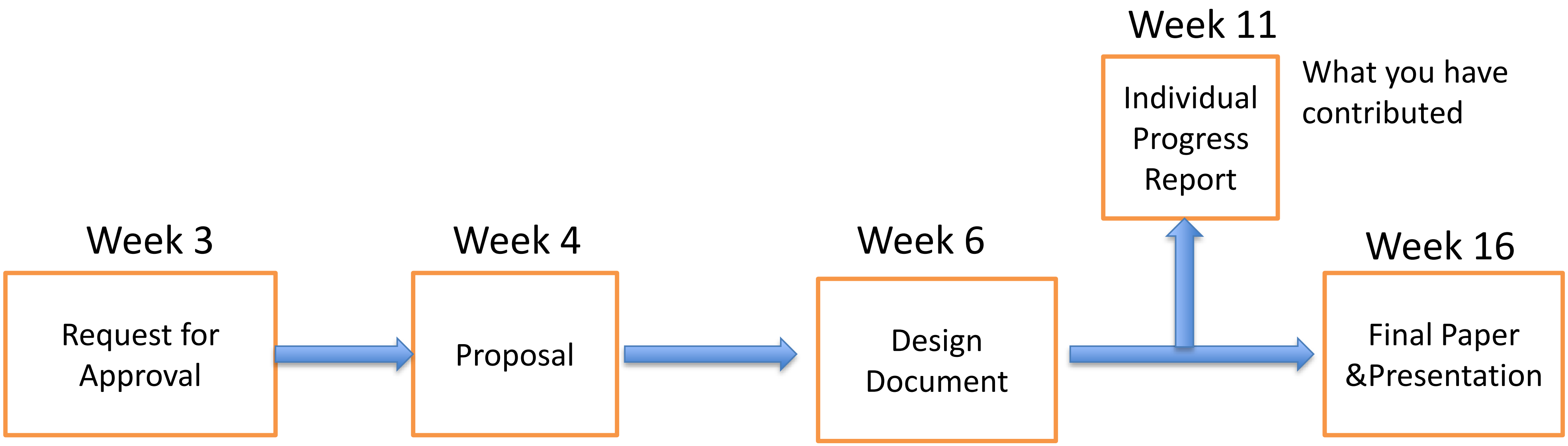
Documentation Roadmap



A reasonable and novel idea

To “sell” your project to “investors”:
- Product Feature
- Design overview
- Schedule

To discuss your project with fellow engineers:
- Product feature
- Detailed design
- Schedule with more specific engineering goals

To discuss the outcome

Check Calendar for Due Dates

What is the Design Document (DD)?

- A highly detailed deliverable presenting your completed design
  - Adhere to guidelines/rubric on the course webpage
- Submitted online by the deadline on the course calendar
- The DD constitutes the entirety of your presentation material for the Design Review—you need not bring any other materials to your Review.

What the Design Document is NOT

- The DD is not a PowerPoint
- It is not accompanied by physical hardware
- It does not contain datasheets of your parts

Structure/Sections of the Document

- Introduction
- Design
  - Block Diagram(s)
  - Physical Design Drawings (if applicable)
  - Block Design
    - Description, justification, interface definition
    - Requirements and Verification
    - Schematics, software flow charts, calculations, and simulation
  - Tolerance Analysis
- Cost analysis (parts and labor)
- Schedule
- Ethics and Safety
- Citations and References

Block Diagrams

- High level overview of components
- Clearly show hierarchy of blocks
- Clearly show signal and power flow
- Not a flowchart

Block Diagrams

Examples and Considerations

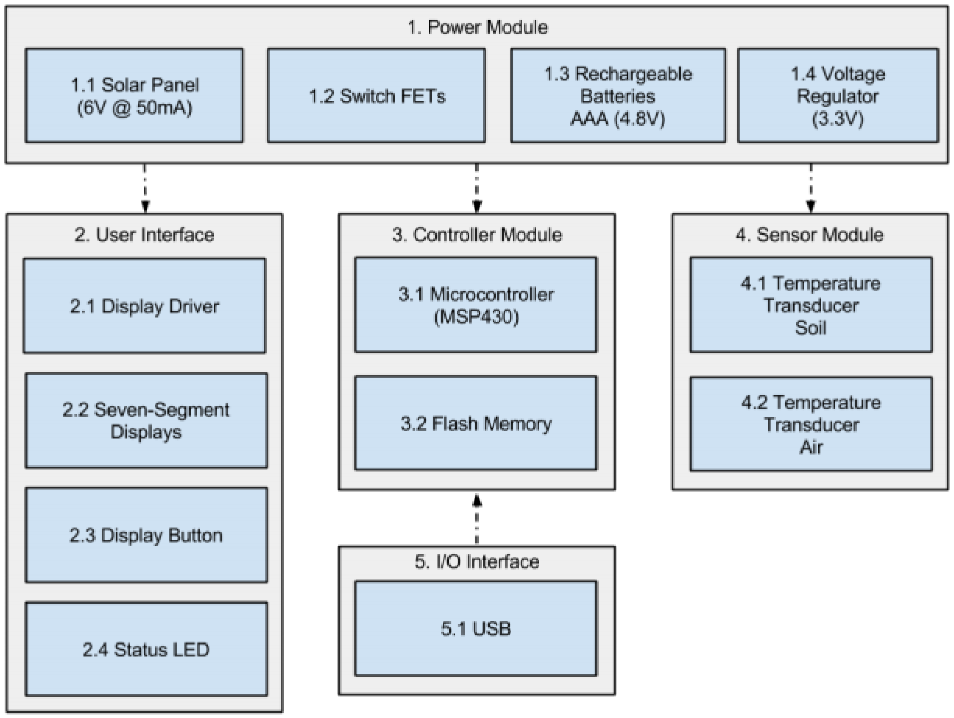


Figure 1: Top Level Power Layout

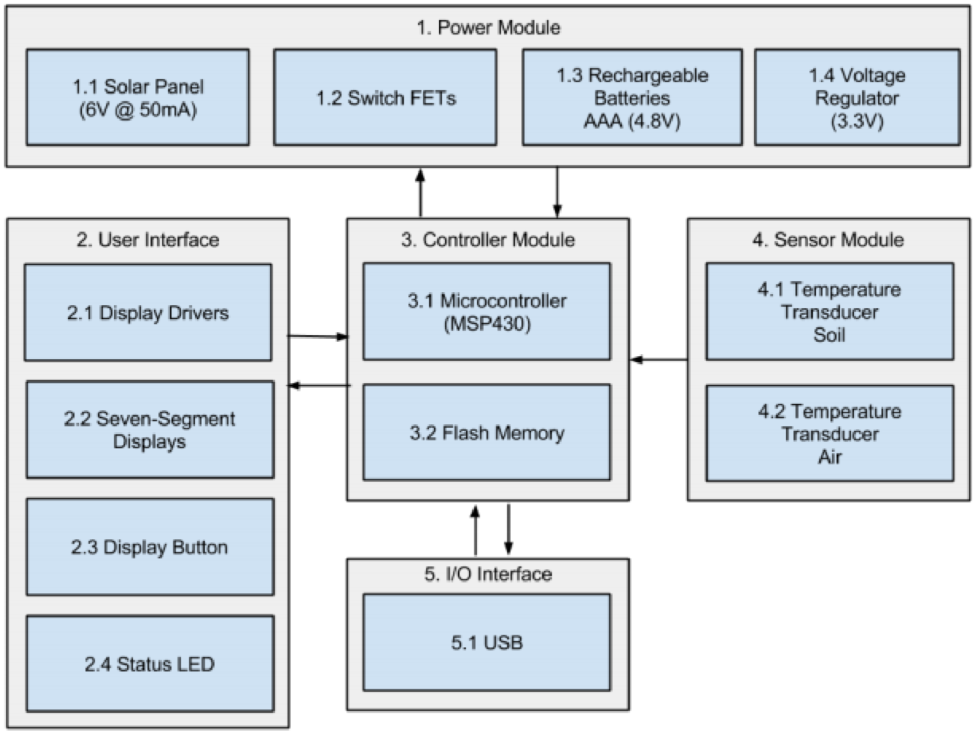
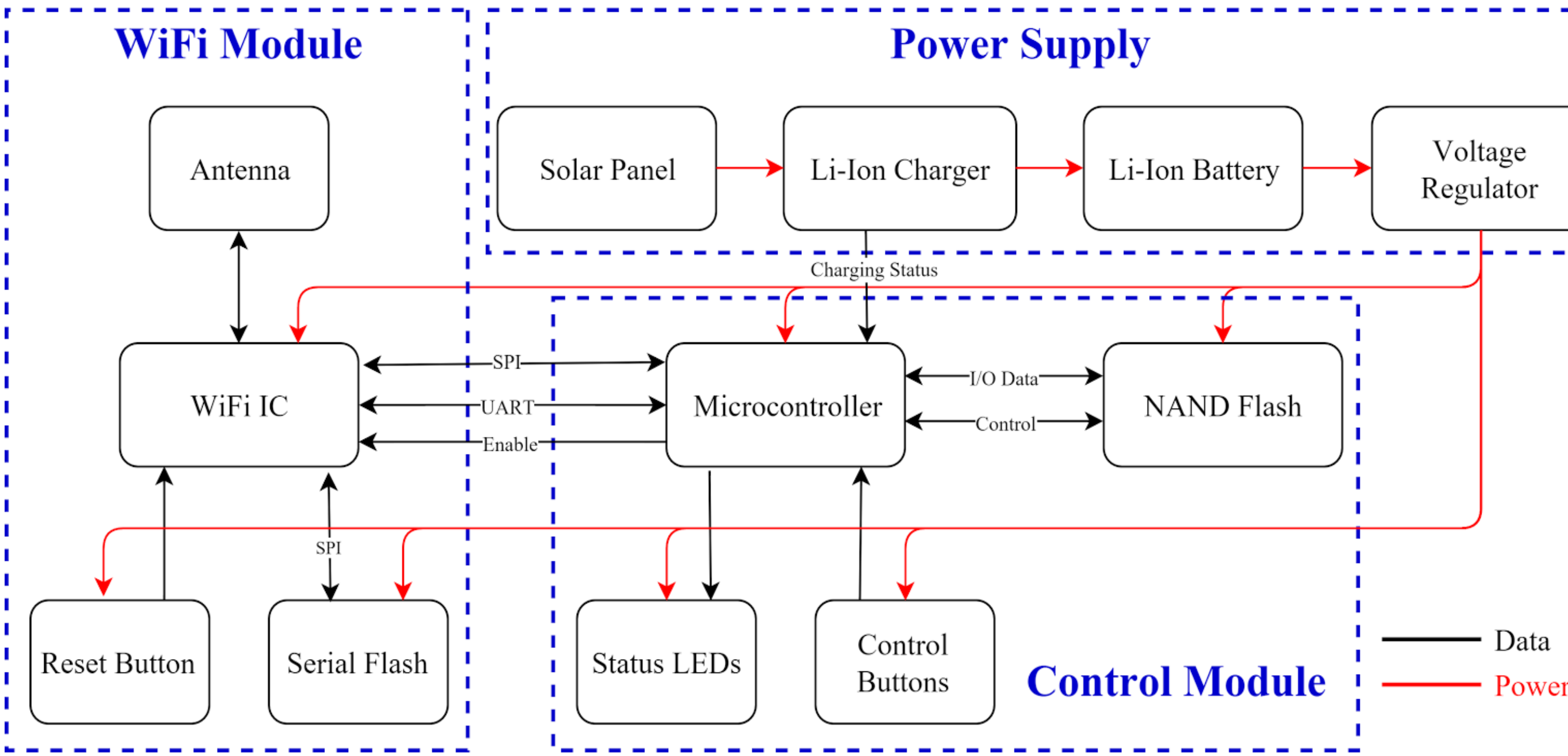


Figure 2: Top level Signal Layout.

Growing Degree Day Monitor, Spring 2014

Block Diagrams

Examples and Considerations



Wireless IntraNetwork, Spring 2016

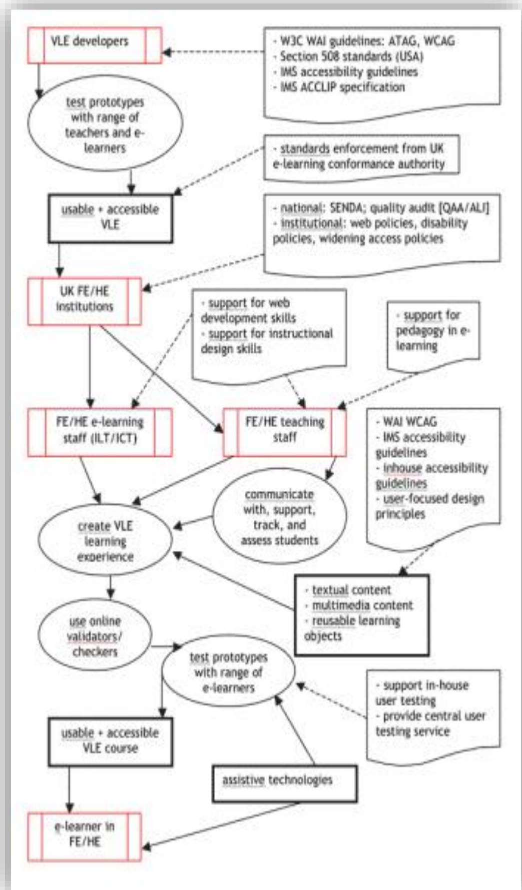
Block Descriptions

- Expands on Proposal with greater design detail
  - Justify your design decisions and how they help meet the high-level requirements
  - Define all interfaces with other blocks
  - Reference your schematics

Flowcharts

- Clearly labeled
- All decision paths shown
- No unnecessary information

Bad



Good

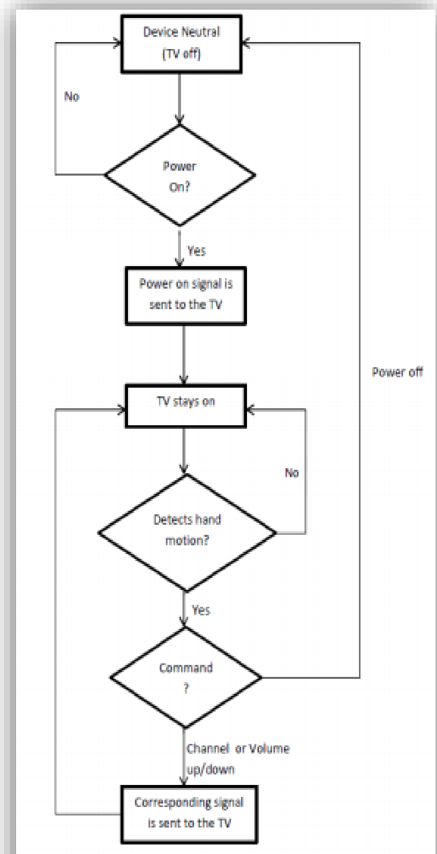


Figure 4: Flow Chart for the Software

Calculations and Simulations

- Calculations for component values
- Simulations of circuit designs
- Experimental results for circuits that are hard to simulate

Calculations and Simulations

Common simulation & calculation:

- Analog filter
- Power supply
- MCU processing ability calculation
- ADC resolution calculation

Common experimental result:

- Ultrasonic sensor reading
- Laser-Diode Circuit (used as example later in this lecture)

Calculations and Simulations cont.

$$D_{pk\,Vin} = \frac{V_o - V_{in\,(pk)min}}{V_o} = \frac{216V - 155V}{216V} * 100 = 28.24\%$$

$$V = L\frac{di}{dt} \Rightarrow L = \frac{V_{in\,(pk)min} * D_{pk\,Vin}}{f_{switch} * \Delta I_L} = \frac{155V * 0.2824}{100000Hz * 0.0857A} = 5.1mH$$

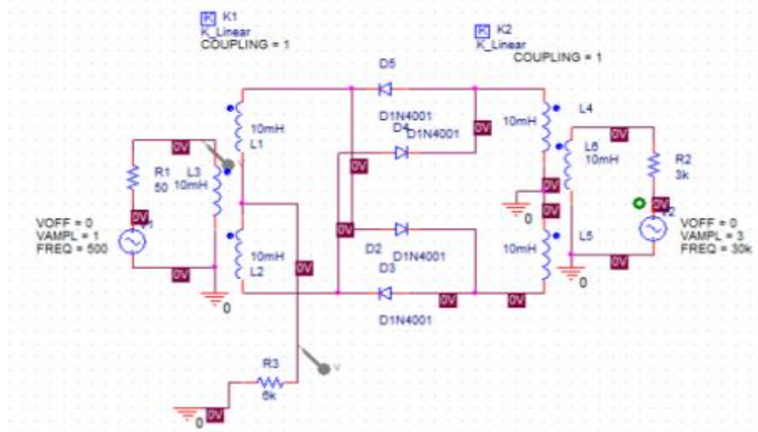
The high frequency input capacitor is used to reduce unwanted harmonics on the line side. It can be calculated assuming a desired 6% ripple is allowable. A film type capacitor will be used because of its low ESL and ESR.

$$C_{in} = \Delta I_L\% \frac{I_{in\,(RMS)max}}{(2\pi)(f_{switch})(r)(V_{in\,(RMS)min})} = 0.2\frac{0.3367A}{(2\pi)(100000Hz)(0.06)(110V)} = 16nF$$

The output capacitor is used to maintain the output voltage while the boost diode is not conducting. An electrolytic will be used because of its excellent storage capabilities. This capacitor will be chosen assuming a 20ms hold up time and allowable minimum voltage sag of 190V. A manufacturing tolerance of 20% is accounted for.

$$C_{out\,min} = \frac{2 * P_{omax} * \Delta t}{V_o^2 - V_{o\,min}^2} = \frac{2 * 30W * .020}{216^2 - 190^2} = 114\mu F$$

$$C_{out} = \frac{C_{out\,min}}{1 - \Delta C_{tolerance}} = \frac{114\mu F}{1 - 0.20} = 143\mu F$$



Schematic 2 -- Layout of Double Balanced Mixer

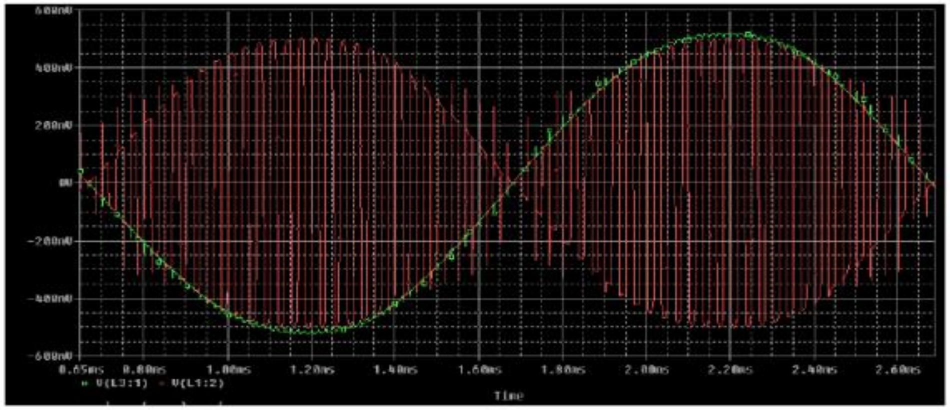


Figure 4 -- Simulation of Mixer Circuitry

Requirements and Verification

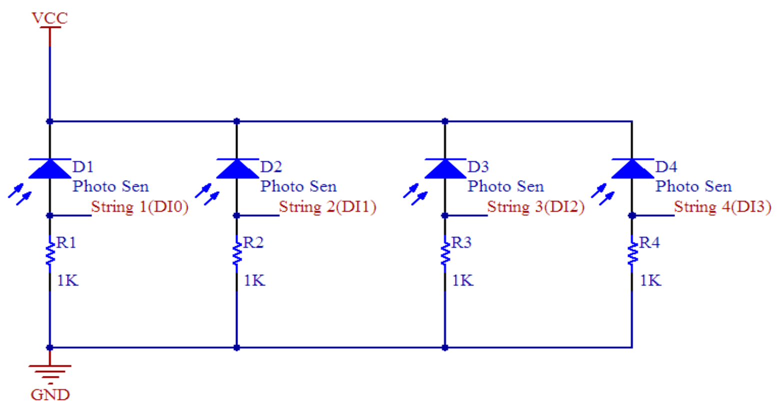
Logic:

1. I need to implement this functional block
2. In order to make the whole project work, what are the required functions and specs for this block. (Requirements)
3. Select components and design circuits based on your requirements.
4. Verify correct operation with procedures that prove this block performs the functions and meets the specs. (Verification)

Requirements and Verification

Example: Laser- Diode Circuit for Laser Guitar

1. Laser-diode pair should generate digital High/Low voltage to microcontroller
2. Read microcontroller I/O requirements for voltage levels
3. Select parts and design circuits
4. Verify the laser-diode pairs can produce desired voltage levels



Requirements and Verification

- Requirements
  - – Quantitative operational requirements
  - – Break down into sub-requirements if necessary

Laser-photodiode circuit	1.The circuit will trigger a low voltage when the laser is turned off. the output low should be between 0V-0.1V. 2 The circuit will trigger a high voltage when the laser is turned on. Make sure the output high is between the 4.5V-5.5V.(Distinguishable with the output low voltage)	1. Connect the circuit as shown in figure 5. Record voltage with laser off 2. Turn on the laser. Record forward output voltage and current. If the output voltage is out of the desired range, adjust the value of pull down resistor.

Requirements and Verification cont.

- Verification
  - Method to confirm each requirement
  - Checklist of acceptable results, quantitative
  - Debugging plan
  - "Make sure it works" is not a verification (it works because it works...)
  - **Not a verification of data sheets**

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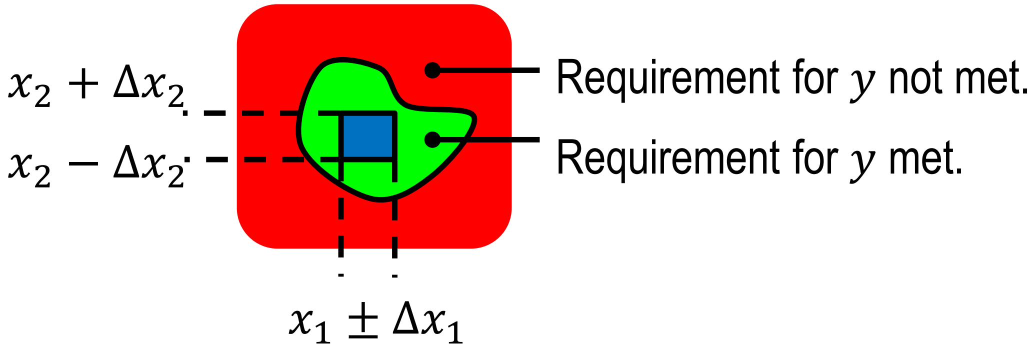
Tolerance Analysis

- An important part of any design
- Together with your TA you will identify one requirement for tolerance analysis

1. *Given a requirement y with desired tolerance*
2. *Provide a model f relating circuit components x_i to y*
3. *Calculate the required tolerance of components x_i, such that y meets its required tolerance*

$$y \pm \Delta y = f(x_1 \pm \Delta x_1, x_2 \pm \Delta x_2)$$

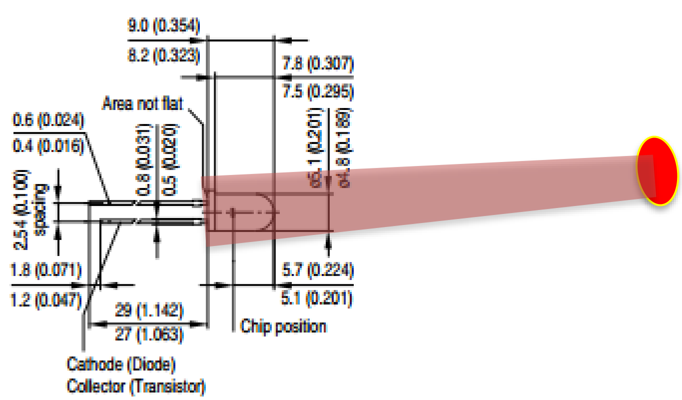


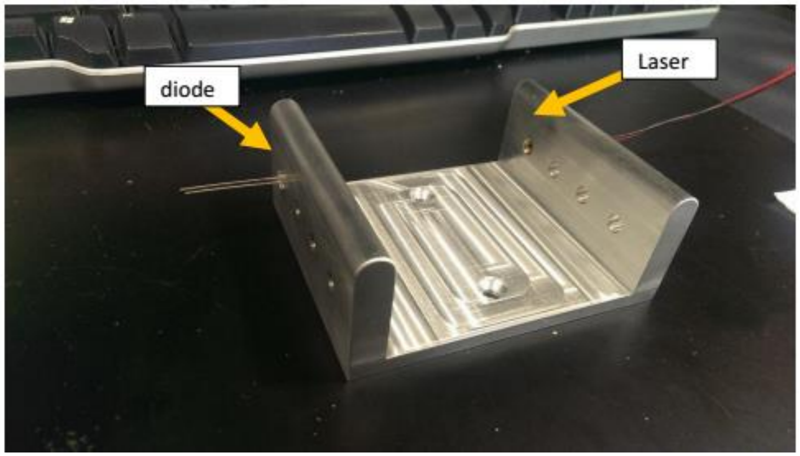
Tolerance Analysis

- Laser-Diode Circuit Example:
  - **Required tolerance:** Laser should shine on active area of the diode such that the laser-diode circuit outputs a logical high between 4.5 and 5.5V and a logical low between 0 and .1V.
  - **Tolerance analysis:**
    a) Mechanical misalignment of mounting holes
    b) Laser beam divergence angle. Gaussian distribution of photonic energy
    c) Formula for design:

Laser Beam Divergence Radius + tan(error for alignment angle) + Energy Gaussian Distribution Radius Standard Deviation $\leq$ *Radius of the diode package*

    d) Find the allowed error for alignment angle. Check produced voltages at such angles. Decide machining method





Cost Analysis

- Bill of Materials (BOM)
  - Specific part numbers & component values
  - Price and quantity

Part #	Mft	Desc	Price	Qty	Total
9C12063A3900FKHFT	Yageo	390 Ohm – ¼ W	$0.42	1	$0.42
PIC16F877	MOT	8-bit PIC	$5.46	2	$10.92
ECS-3951C-200-TR	ECS	20 MHz Oscillator	$2.78	1	$2.78
1206CG200J9B200	Yageo	20 pf CAP	$0.32	2	$0.64
C0603C104J4RACTU	Kemet	0.1 uf CAP	$0.32	5	$1.60
9C08052A1002JLHFT	Yageo	10 K RES	$0.32	4	$1.28
C0805C105K4RACTU	Kemet	1.0 uf CAP	$0.32	3	$0.96
ECJ-4YB1C106K	PAN	10 uf CAP	$0.32	2	$0.64
AD725	AD	VGA to NTSC coder	$2.34	2	$4.68
AD7083	AD	Video OP-Amp (3)	$1.72	1	$1.72
Total					$25.64

- Labor costs
- Grand Total

Schedule

- Week-by-Week
- Break down tasks
- Assign responsibility
- Stick to it

Week	Tasks	Member
2/6	• Research parts for user interface	Bob
	• Research power supply and transceiver • Complete proposal	Annie
2/13	• Sign-up for Design Review • Finalize and order parts • Preliminary simulation	Bob
	• Setup microcontroller and Putty • Complete design review	Annie
2/20	• Interface with magnetic reader	Bob
	• Interface with transceiver and RTC	Annie
2/27	• Interface with LCD monitor	Bob
	• Interface with thermal printer	Annie
3/5	• Built and test user interface	Bob
	• Program and test data logger	Annie
	ETC.	

Ethics

- Discuss ethical concerns as they apply to your project
  - Reference the IEEE code of ethics
    http://www.ieee.org/about/corporate/governance/p7-8.html
  - Address all possible use cases of your project
  - If no ethical concerns exist, justify yourself

Safety

- Discuss safety concerns
  - Electrical safety
  - Mechanical safety
  - Lab safety
  - Consider safety of both yourselves and end users
  - Include required safety documents, as applicable
  - If few safety concerns exist, justify yourself
- If you have hazardous or volatile elements of your project, you must create a “Lab Safety Manual”

Citations and References

- Use IEEE standards for in-text citations and references
  http://www.ieee.org/documents/ieeecitationref.pdf
- Should include things like…
  - Textbooks or datasheets where you got design equations
  - Informative articles or tutorials used (example codes…)
  - IEEE/ACM code of ethics
- **You must tell us if you are carrying over projects from other places (classes, startups, student teams…)**

Questions?

- The website is your primary resource
- Post on the message board
- Contact your TA

Administrative

- Note the Design Document (DD) due date is *before* Design Review week (see course calendar)
- Grading rubric on the website
- Follow the DD description and rubric closely
  - Additionally, you may find the example DD, R&V, and Tolerance Analysis webpages useful