Design

- ▶ The act of design is creating something within a set of constraints.
- ▶ Constraints, which are specifications, guide a design to meet its goals.
- ▶ Design is iterative, roughly systematic, full of twists, turns and dead-ends.
- ▶ Design is social and collaborative. Its best done with a variety of voices.
- ▶ *"As iron sharpens iron, So one man sharpens [and influences] another [through discussion]." Proverbs 27:17*

Design

- ▶ Circuit analysis and design are derived from fundamental principals in physics. These you can ignore at your own peril.
- ▶ The better you know the fundamentals, the better designer you will be.
- ▶ However, usually physics is too exacting for most designs, so we use models derived from the physics of devices.
- ▶ Models are incomplete. They do us the greatest good when they contain only the essential details for the design at hand.
- ▶ Many models are actually only macro models. For example, no OPAMP supplier would ever give you the detailed circuit of their products.
- ▶ No matter how you analyze a circuit, the results are only as good as the models.

Design

- ▶ Documenting your design:
  - ▶ Documentation happens in the process of designing. It's not an afterthought or busywork.
  - ▶ Documentation catches mistakes in the cheapest way; up front.
  - ▶ The designer's intent should be really, really clear.
  - ▶ Its good to see what others have done. If you borrow, do so with attribution.

Design

- The "Zen of Python" for electronic design:
    - Beautiful is better than ugly; simple than complex.
    - Use abstraction only when it helps.
    - Readability, clarity, "understand-ability" is paramount.
    - If the implementation is hard to explain, it's probably a bad idea.
    - If the implementation is easy to explain, it might be a good idea.

Design

- Documentation golden rules:
    - **Clear** - understandable by a knowledgeable person
    - **Concise** - no extra "fluff'
    - **Complete** - everything necessary to replicate the work is there
    - **Correct** - no mistakes
    - **Neat** - orderly, structured, legible
- Use "engineer speak":
    - NO: "fried", "toast", "stuff", "saw something", "acts weird", "dead", "won't work"
    - If something seems "funny", document the amount of "funny".
    - *"The sloppy use of words leads to incorrect assumptions. Wrong assumptions lead to wrong conclusions. Wrong conclusions leads to errors in judgment and decision making ...then airplanes fall out of the skies." Andreas Weisshaar circa 2015*

Design

- ▶ Good design really does matter. It carries consequences.
  - ▶ 1980's: Therac 25, cancer treatment via radiation, half dozen dead
    https://hackaday.com/2015/10/26/
    killed-by-a-machine-the-therac-25/
  - ▶ 1991: Patriot Missile, SCUD interception missed, 28 died
    https://barrgroup.com/software-expert-witness/articles/
    case-study-lethal-software-defect
  - ▶ 2018,2019: Boeing 737 Max, 346 dead
    https:
    //link.springer.com/article/10.1007/s11948-020-00252-y
  - ▶ Toyota Unintended Acceleration: 89 killed, 57 injured over 10 years.
    Settlement was reached for $1.5B. "In a nutshell, the team led by
    Barr Group concluded they'd found what NASA's engineers sought: a
    systematic software malfunction in the Main CPU that opens the
    throttle without operator action and continues to properly control fuel
    injection and ignition that is not reliably detected by any fail-safe."
    https://embeddedgurus.com/barr-code/2013/10/
    an-update-on-toyota-and-unintended-acceleration/
- ▶ How do you ethically handle design?