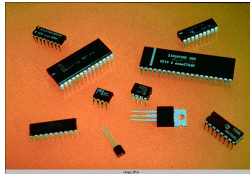


Analog Integrated Circuit Design: Why?

Abstract: What is analog? Everything we see, hear, and perceive in life is analog, from voice, music, and seismic activity to visual perception, voice recognition, and energy delivery. Consequently, all electronic systems must necessarily interface with the world via analog electronics. Conforming these functions to today's and tomorrow's relentless demand for small, chip-integrated, mobile, battery-operated devices challenges analog engineers and researchers to design and create smart, robot-like solutions with state-of-the-art accuracy, speed, and extended battery life, which demands and requires training. Examples of the types of applications the field enjoys range from biologically inspired (e.g., pace-makers, nanotechnology probes, and so on) and commercial products (e.g., laptops, cellular phones, microsensors, and more) to military (e.g., unmanned aerial vehicles, light-weight electronic equipment, etc.) and space exploration applications (e.g., remote metering, robots, and so forth). It is therefore impossible to fathom engineering real-life solutions without the help and support of high-performance analog electronics.

Analog Integrated Circuit Design: Why?



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Analog Integrated Circuit Design: Why?

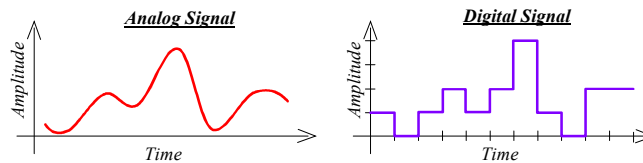
OUTLINE

- What is the difference between analog and digital circuits?
- Why analog?
- How is analog IC design different from digital?
- What is the design process really like?
- Why do I like analog IC design?

What is the difference between analog and digital circuits?

Definitions:

- **Analog Signal: Continuous over time and space.**
 - *"Analogous" to the physical signal it represents.*
- **Digital Signal: Sampled at discrete points in time and at discrete values (amplitude).**
 - *Signal is quantized (approximated).*

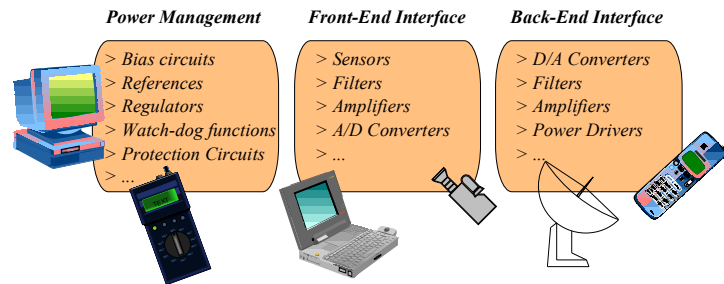


- Infinite vs. finite number of states → *Analog = digital + every point in between.*

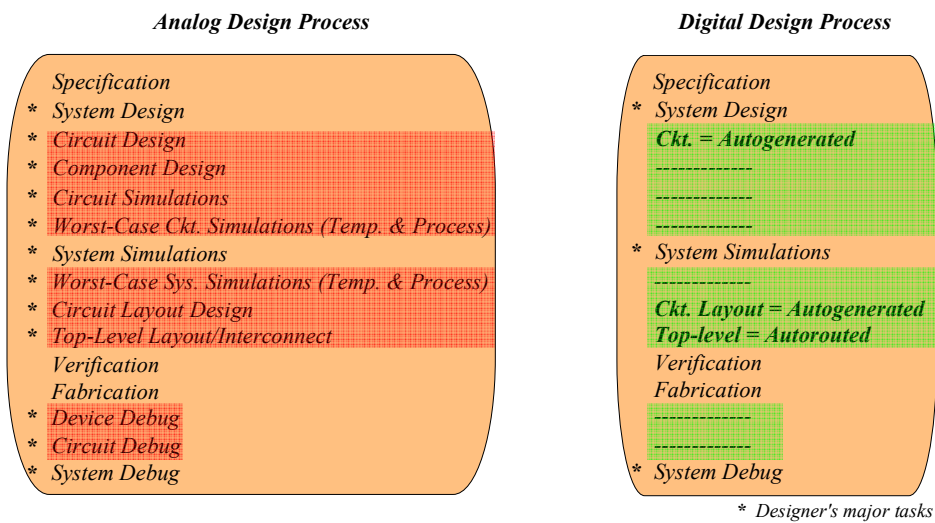
Analog Integrated Circuit Design: Why?

Why analog?

- ❑ **Fact:** Physical signals are continuous in time and amplitude → *Analog...*
 - Seismic, Audio, Video, Biological, and so on.
- ❑ **But:** Digital signals are easier to process and more robust.
 - More room for error → *Higher noise immunity*
- ❑ **So:** Process as much as possible digitally.
- ❑ **And Even Then:** *Analog processing will nonetheless be required:*



How is analog IC design different from digital?



Digital circuit and layout design can be automated (with CAD tools).

Analog Integrated Circuit Design: Why?

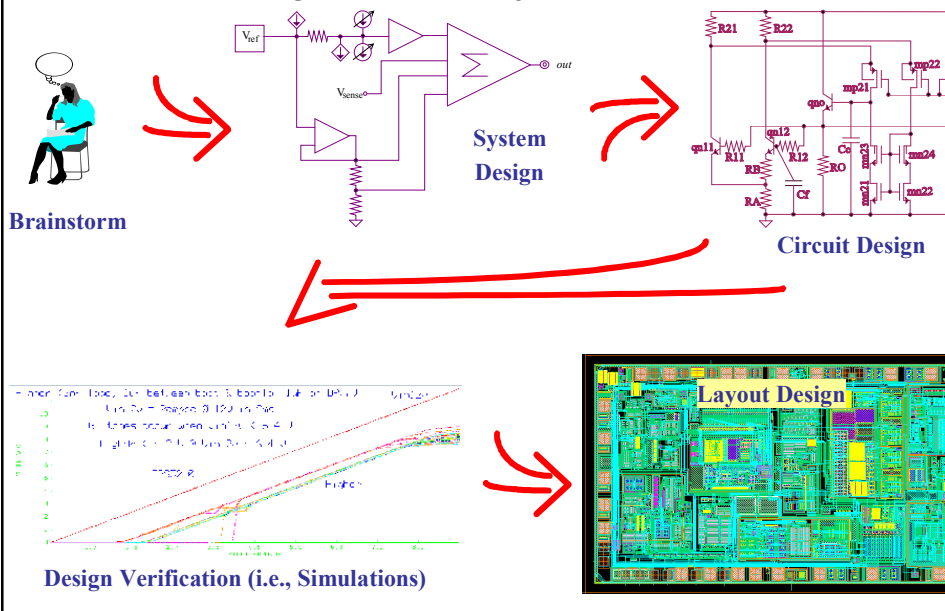
How is analog IC design different from digital?

- ❑ Trend: System on a chip (SoC) → Mixed-signal design
 - **Injected digital switching noise** (through substrate, supplies, circuits, and traces)
- ❑ Trend: 50 to 90% Digital and 10 to 50% Analog
 - Die is mostly digital → Process **technologies are optimized for digital circuits.**
- ❑ Design-Time Syndrome:
 - In 10%-90% analog-digital die, **10% analog demands 90% of total design time.**
- ❑ Pass/Success Ratio: **Digital Designs ~ 1** **Analog Designs ~ 2 – 3**
- ❑ **Analog design cannot be automated** (i.e., no standard cell libraries)
 - E.g.: **Operational Amplifier** → **Many designs exist...**
(because every application and process has specific requirements/constraints.)



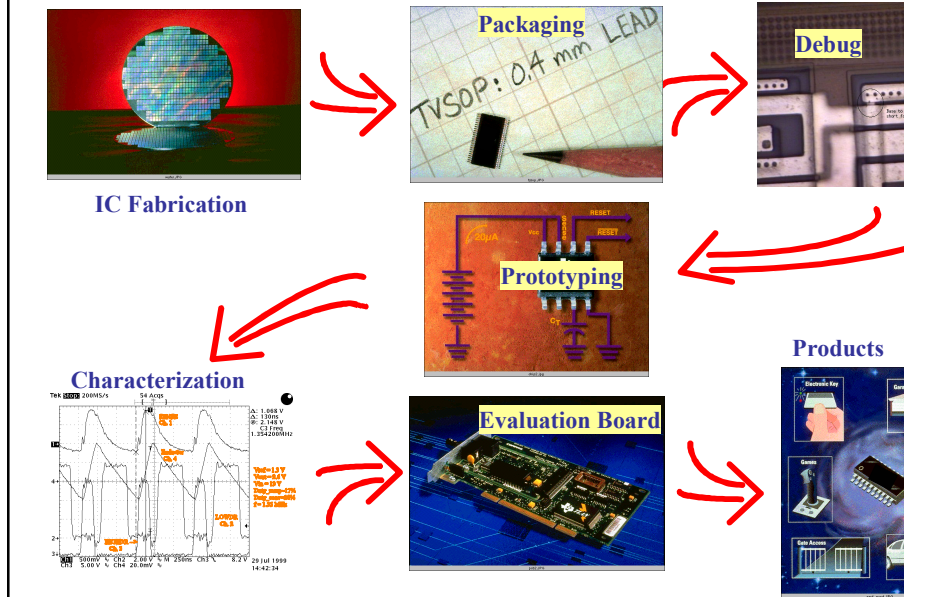
Analog design is difficult, challenging, and always new.
I.e., Analog designers are always in high demand.

What is the design process really like?



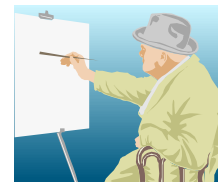
Analog Integrated Circuit Design: Why?

What is the design process really like?



Why do I like analog IC design?

1. It is **challenging**.
 - **Analog circuits are sensitive.**
(To noise, supplies, loads, temperature, process, etc.)
2. It is a **creative** process.
 - There is **no clear logical way to design a circuit.**
(Like painting a picture or writing a poem, except we use semiconductors to create our art.)
3. It **must be intuitive**.
 - **Cannot design from equations or truth tables.**
 - **Must understand** how to condition and process real-life continuous-time signals **under extreme conditions** (e.g., temperatures, voltages, noise, etc.)



Analog Integrated Circuit Design: Why?

Why do I like analog IC design?

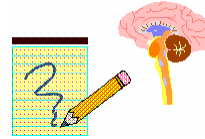
4. It is **state-of-the-art work**.

- Use and master latest and finest technologies.



5. It is a **difficult, yet simple process**.

- Requirements: *Pencil, napkin, and a DESIGNER.*



- Best designs: Often conceived on a scrap piece of paper (or a dream).
- Computer: **Garbage in, garbage out** (only good to verify, tweak, and document).

It is not the circuit or end-product that is exciting;
it is the process of designing it (and the sense of accomplishment).