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 conversion and transfer. As a result, all electronic systems must 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 devices (e.g., pacemakers, nanotechnology probes, and so on) and commercial products (e.g., laptops, cellular phones, microsensors, and more) to military hardware (e.g., unmanned aerial vehicles, light-weight electronic equipment, etc.) and space exploration (e.g., remote meters, robots, and so forth). It is impossible to imagine engineering real-life solutions without the help and support of analog microelectronics.

Gabriel Alfonso Rincón-Mora
Georgia Institute of Technology
www.Rincon-Mora.com
Analog Integrated Circuit Design: Why?

Outline

What is the difference between analog and digital signals?

Why analog?

What is the difference between analog and digital IC design?

What is the design process really like?

Why do I have a passion for analog IC design?

What is the difference between analog and digital signals?

Definitions

Analog Signal: Continuous over time and space.
→ "Analogous" to the physical signal it represents.

Digital Signal: Sampled at discrete points in time and discrete values (amplitude).
→ Signal is quantized, so it is an approximation.

Infinite versus 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.*

E.g.: Seismic, audio, video, biological, and so on.

But: Digital signals are easier to process and more robust.

I.e.: More room for error → Higher noise immunity.

So: Interface and process analog signals, and when possible, convert into and process digital stream.

---

**What is the difference between analog and digital IC design?**

**Analog Design Process**

1. Specification
2. System Design
3. Circuit Design
4. Component Design
5. Circuit Simulations
7. System Simulations
9. Circuit Layout Design
10. Top-Level Layout/Interconnect
11. Verification
12. Fabrication
13. Device Debug
14. Circuit Debug
15. System Debug

---

**Digital Design Process**

1. Specification
2. System Design
3. Ckt. = Autogenerated
4. Verification
5. Fabrication
6. System Debug

* Designer's major tasks

Digital circuit and layout design can be automated with computer-aided design (CAD) tools.
Analog Integrated Circuit Design: Why?

What is the difference between analog and digital IC design?

Trend: On-chip integration → Mixed-signal design

Digital circuits inject switching noise via substrate, supplies, circuits, and traces.

Trend: 50%–90% of chip is digital and 10%–50% is analog.

Die is mostly digital. Engineers optimize technologies for digital circuits.

Design-Time Syndrome:

In a 10% analog–90% digital die, 10% analog requires 90% of total design time.


High-performance analog design cannot be automated. No standard cell libraries.

E.g.: Operational Amplifier → Optimizing all possible parameters is impossible,

And not all parameters are equally important. Continually redesigned.

Analog design is difficult, challenging, and always new,
so good analog IC designers are always in high demand.

What is the design process really like?

Brainstorm Ideas

Design Block-Level System

Verify Design (with Simulations)

Design Component-Level Circuit

Design Physical Translation (Layout)
Why do I have a passion for analog IC design?

It is challenging:

Analog circuits are sensitive
to noise, supplies, loads, temperature, process, and others factors.

It is a creative process:

There is no unique logical method to design a circuit.
It is like painting a portrait and writing a poem,
except we use semiconductors to create our art.

It must be insightful and intuitive:

Cannot design complex analog systems 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 have a passion for analog IC design?

It is state-of-the-art work:

Use and master latest technologies.

It is a difficult, yet simple process:

Basic requirements are pencil, paper, and a skilled engineer.

Best designs: Often conceived and drawn on a small piece of paper.

Computer: As good as the user → "Garbage in, garbage out."

∴ Good to verify, tweak, and document, but not to design.

Ultimately, the circuit and the end product are rewarding, but not as much as the design process, the sense of accomplishment, and the eventual impact.