The Heart of Innovation: Choosing a Career in Analog IC Design

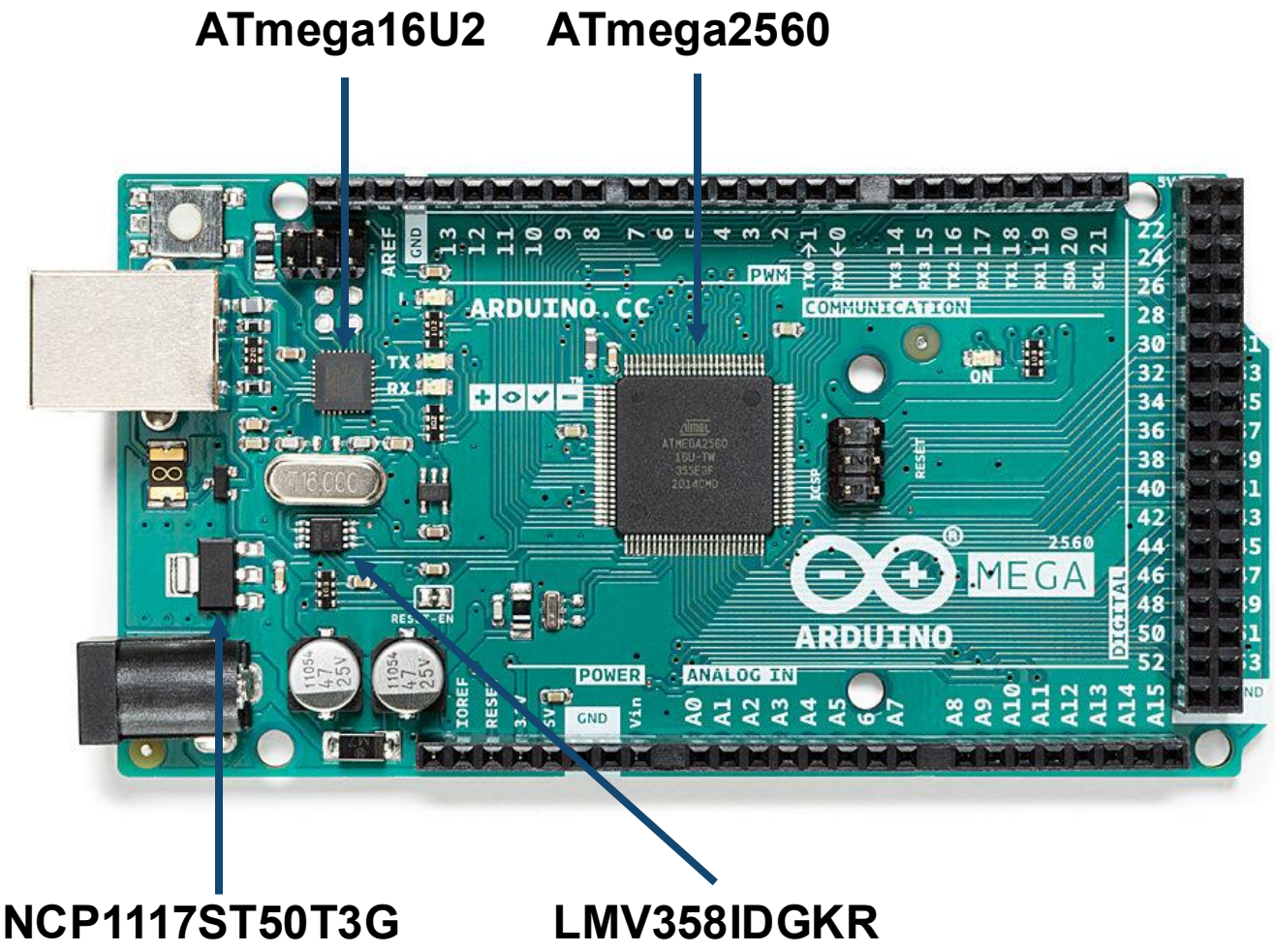
04 May 2025

Nilan Udayanga,
Senior IC Design Engineer,
Cirtec Medical Corporation, USA.
gknudayanga@gmail.com

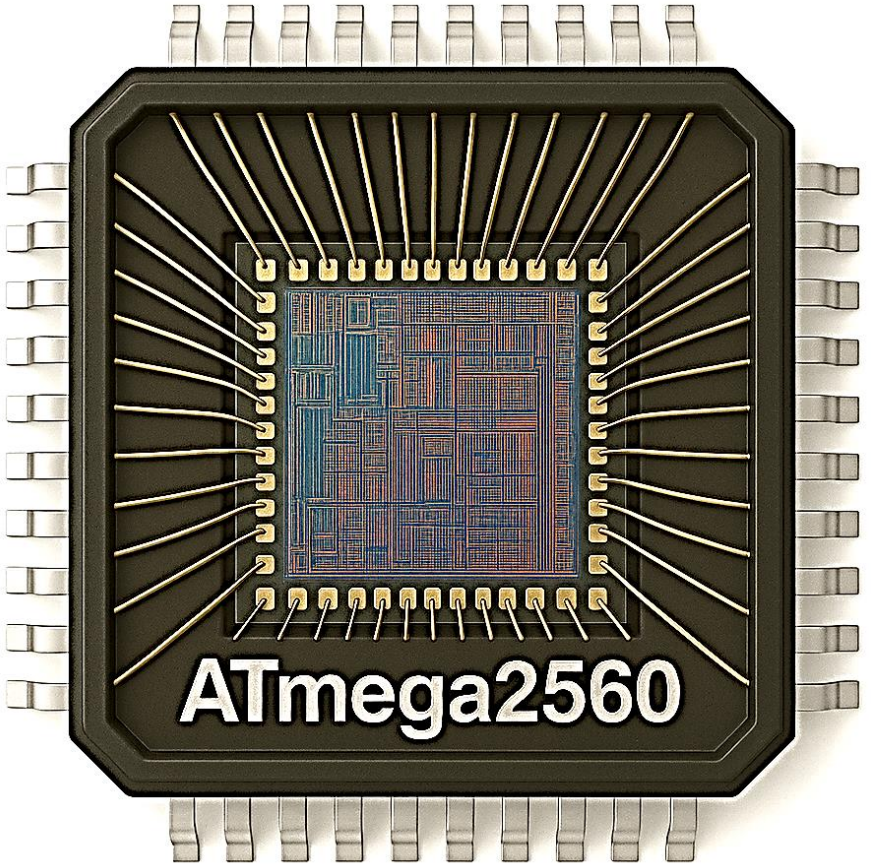
Roadmap: Why Choose Analog IC Design?

- What is an IC, and what is IC design?
- Digital vs Analog IC designs.
- Real-world systems with ICs.
- My journey into IC designs.
- Future directions in analog IC Designs.

What is an IC?

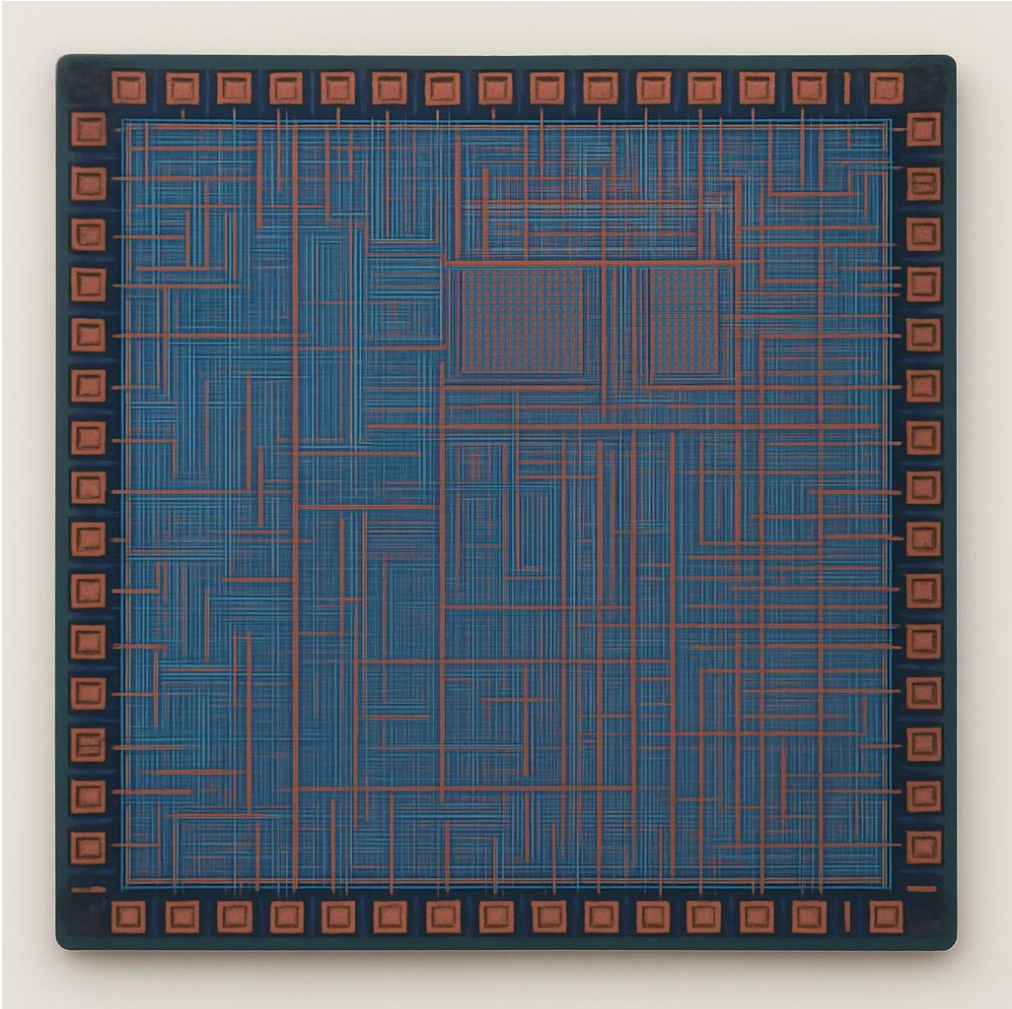

ATmega16U2
ATmega2560
NCP1117ST50T3G
LMV358IDGKR
ARDUINO.CC
ARDUINO
.MEGA
2560
POWER
ANALOG IN
COMMUNICATION
DIGITAL
PWM

What is an IC?



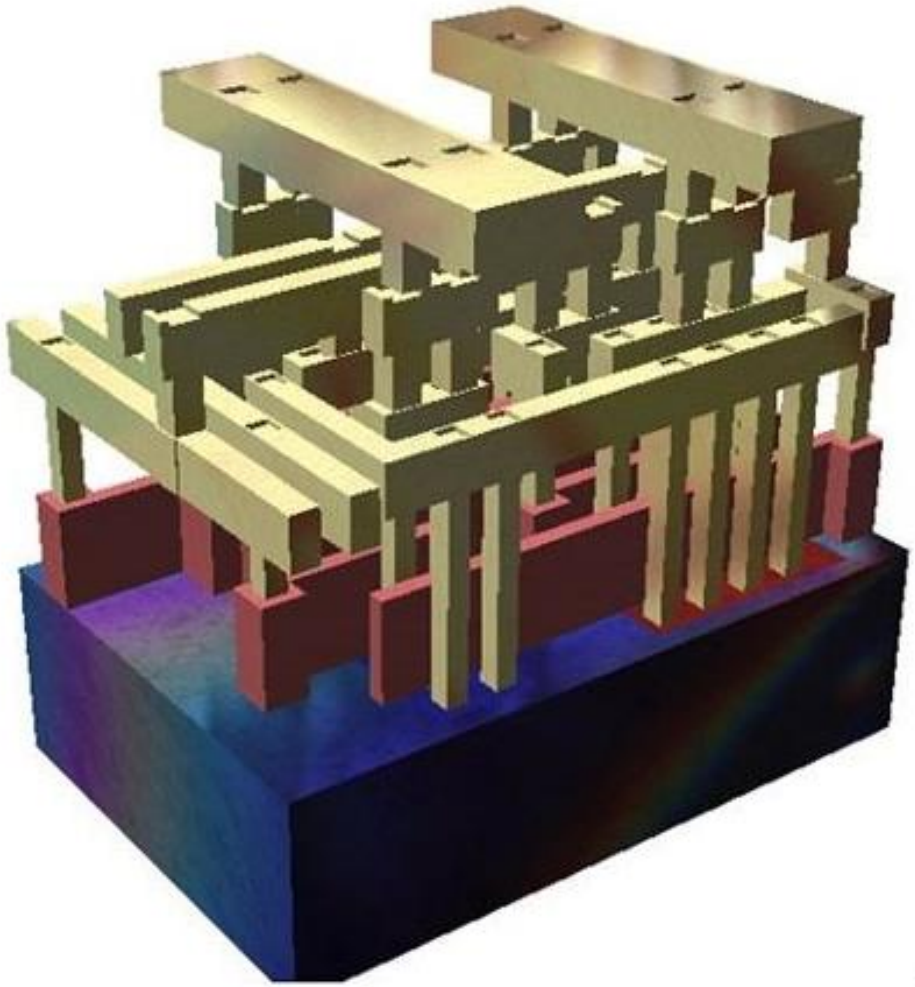
Package

What is an IC?



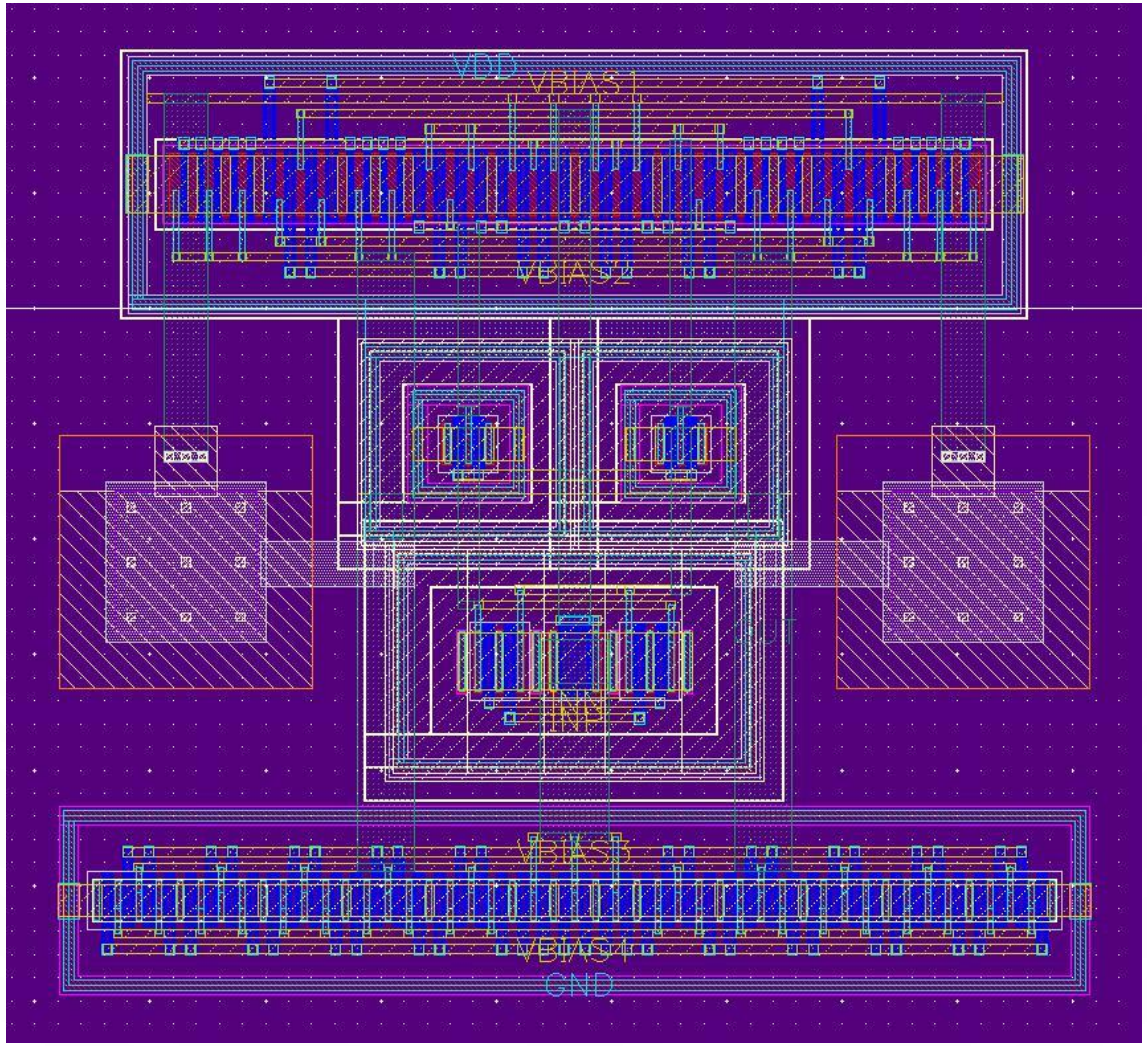
Die

What is an IC?



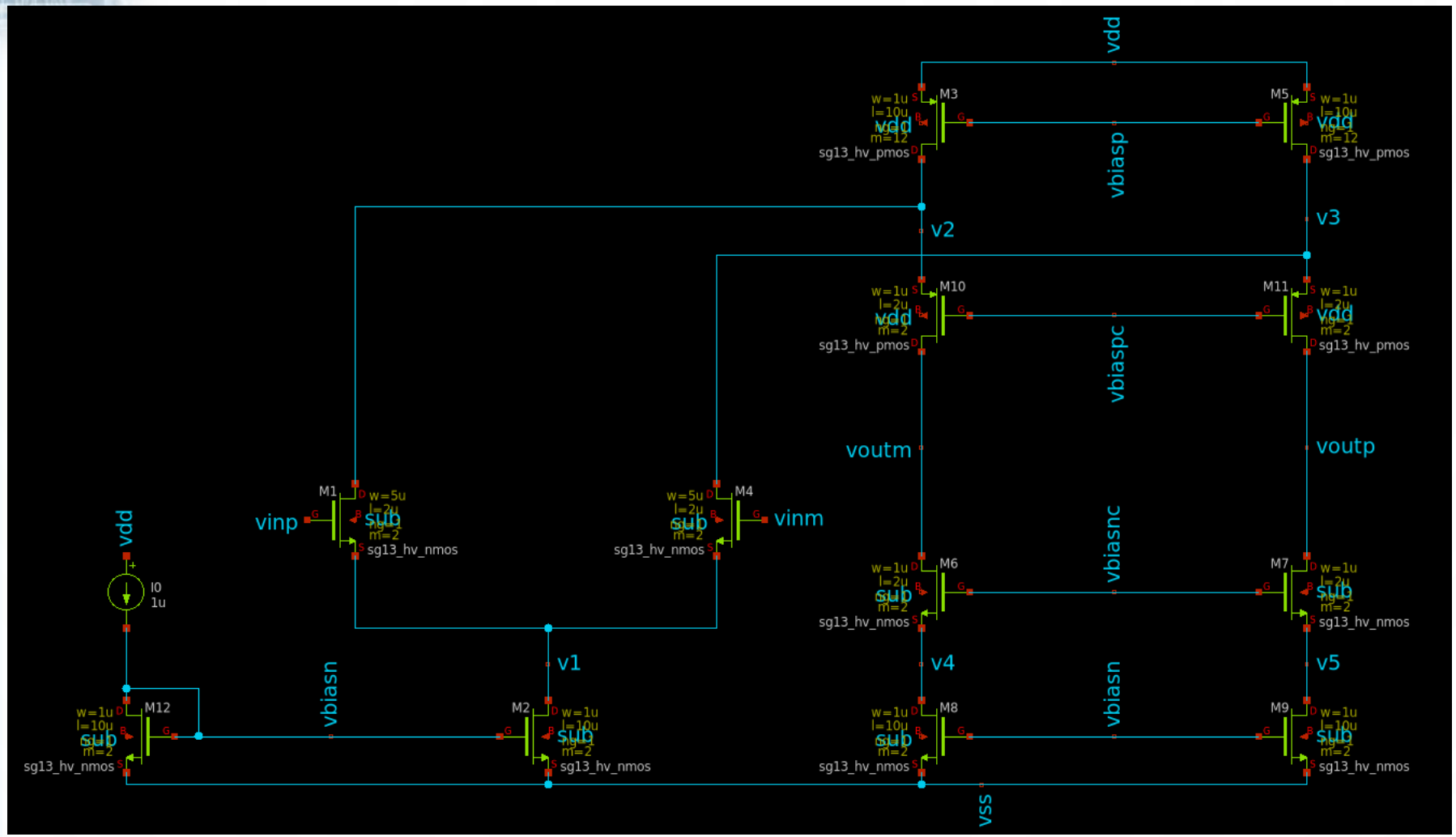
Inside an IC

What is an IC?



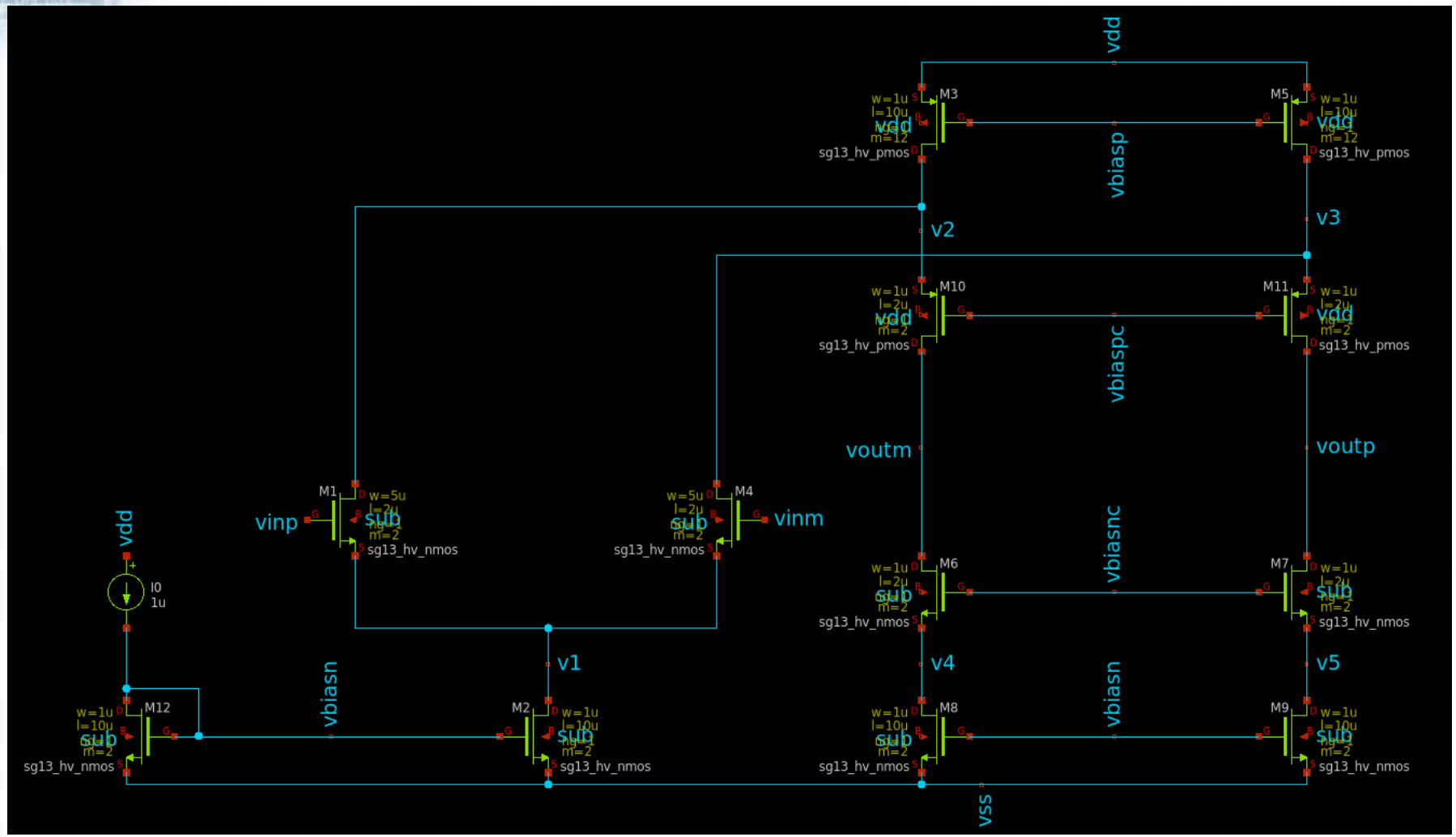
Layout

What is an IC?



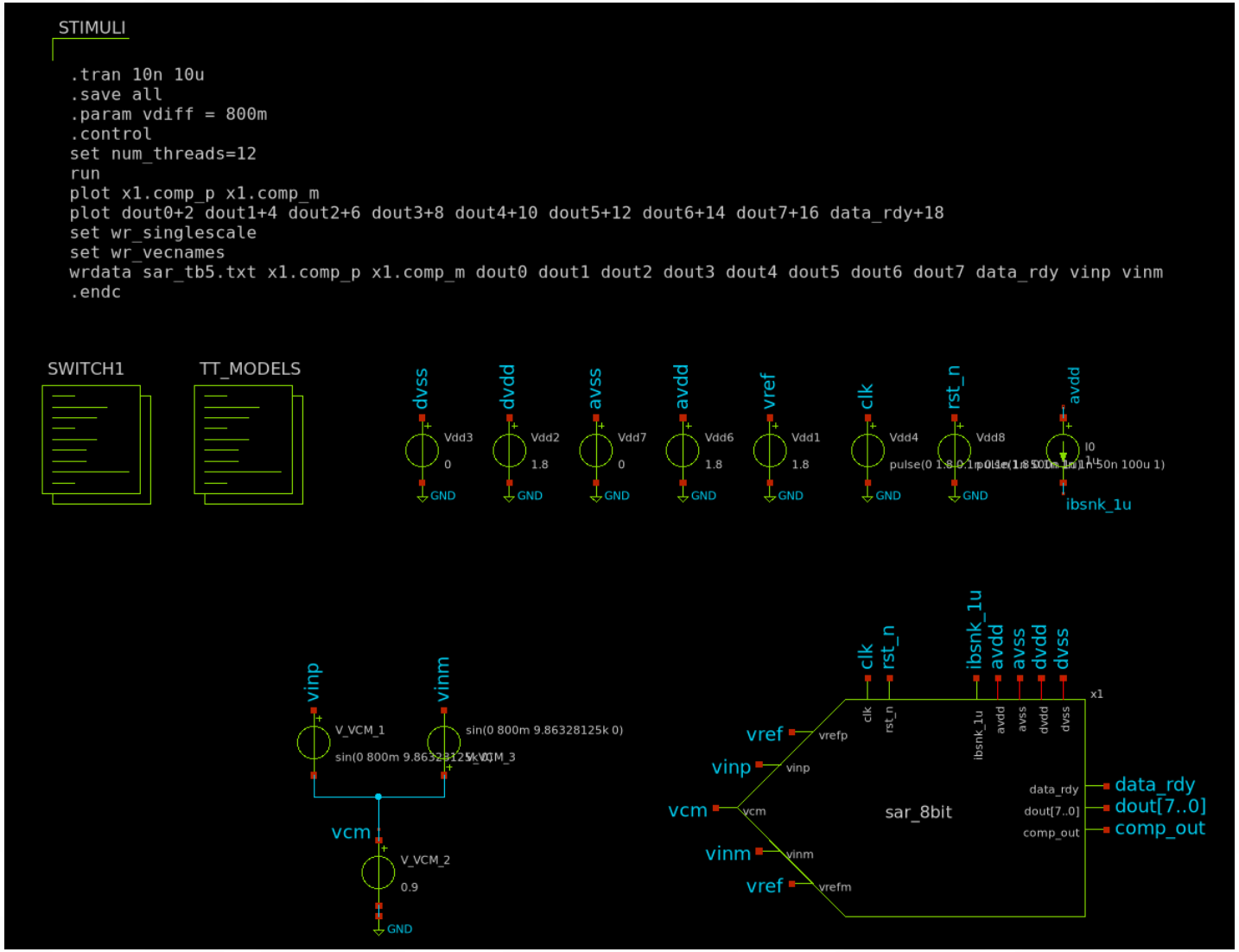
Schematic

What is Analog IC Design?



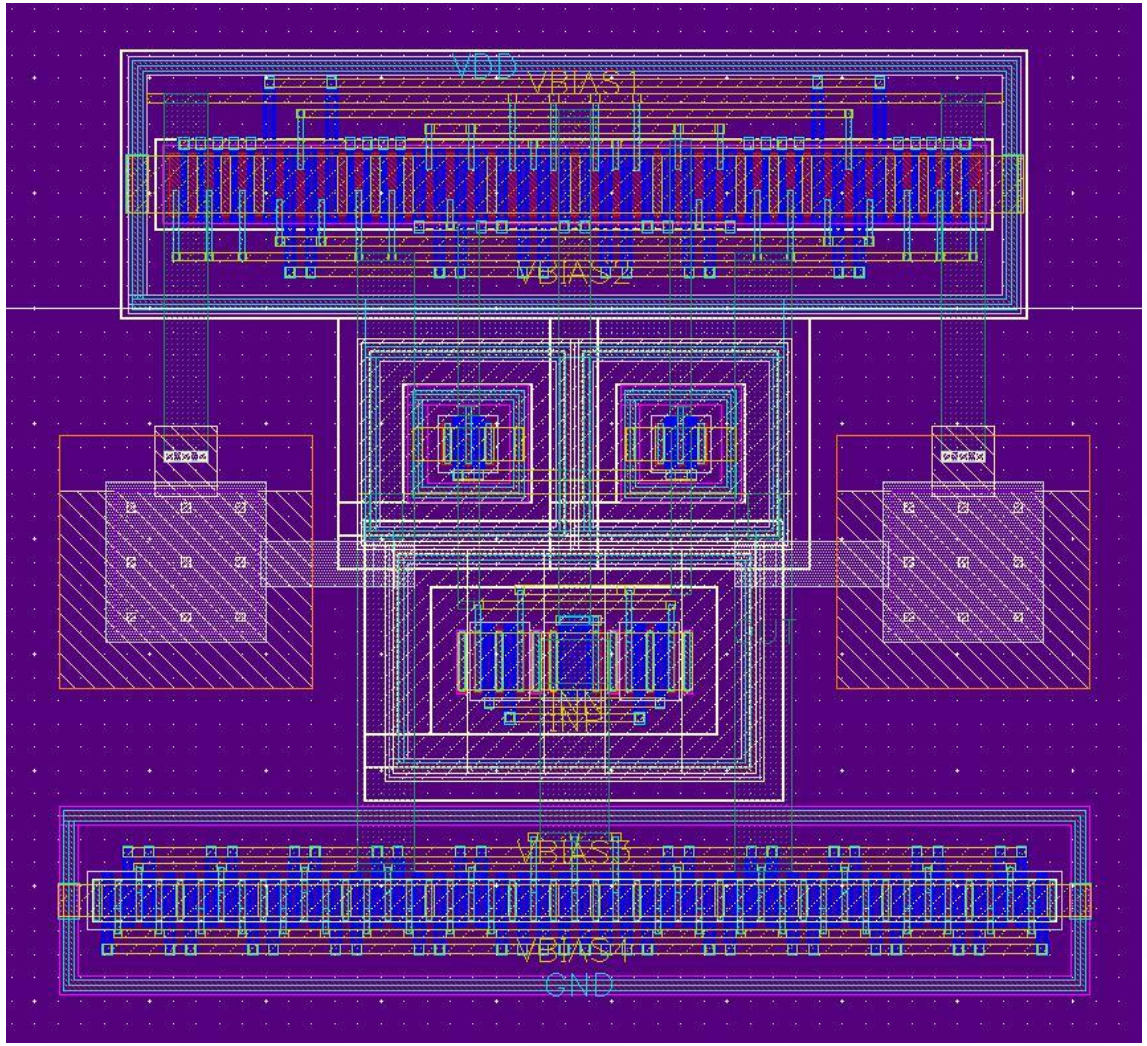
Schematic

What is Analog IC Design?



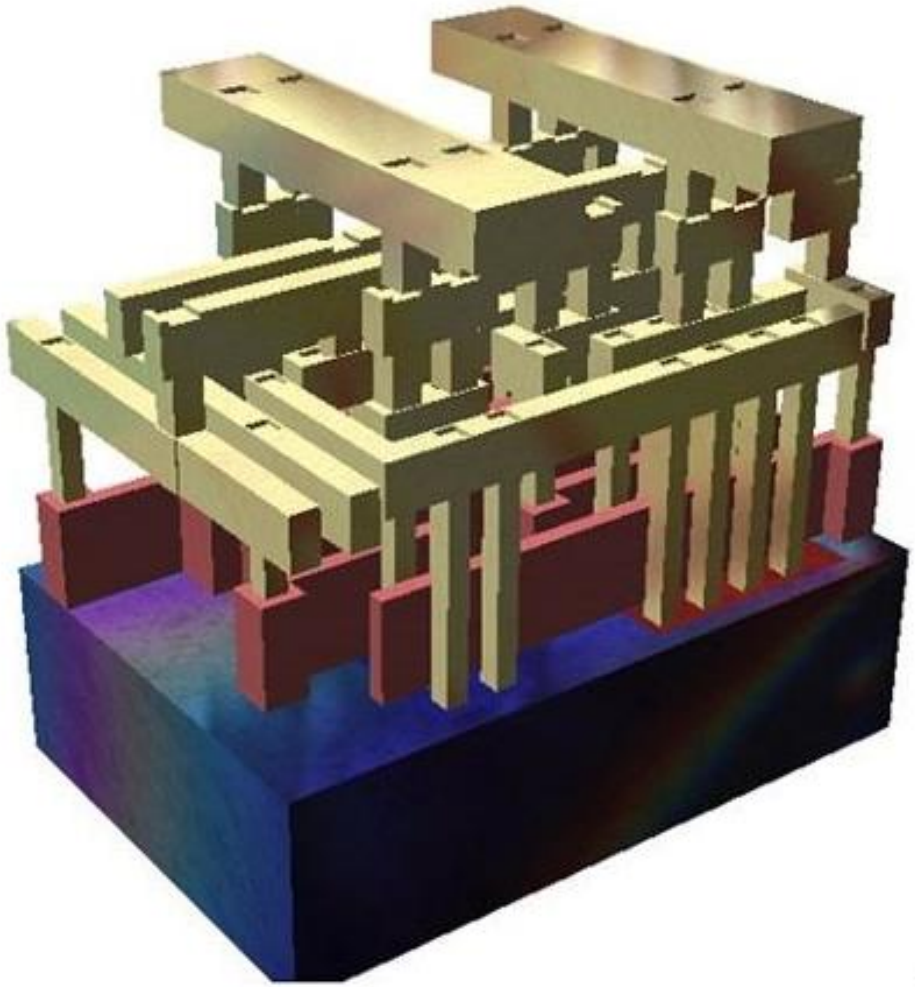
Test bench

What is Analog IC Design?



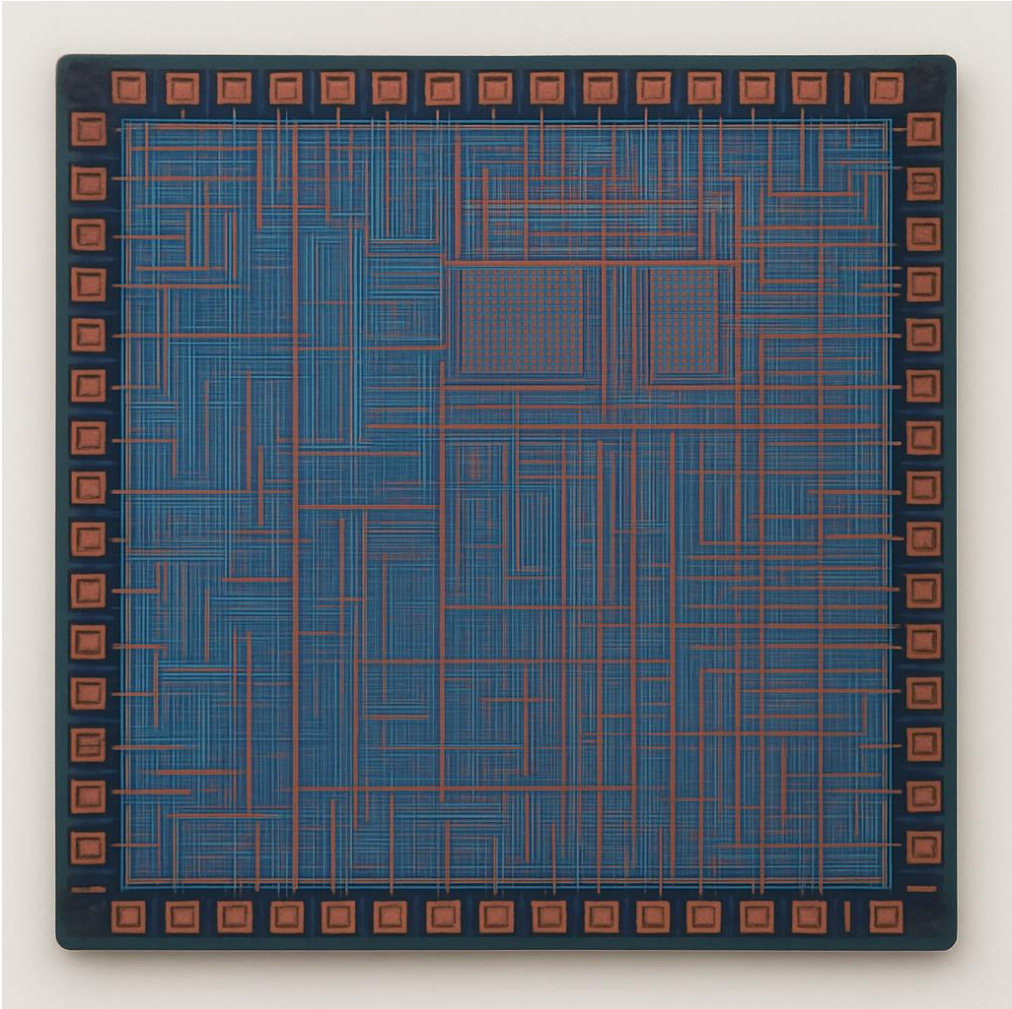
Layout

What is Analog IC Design?



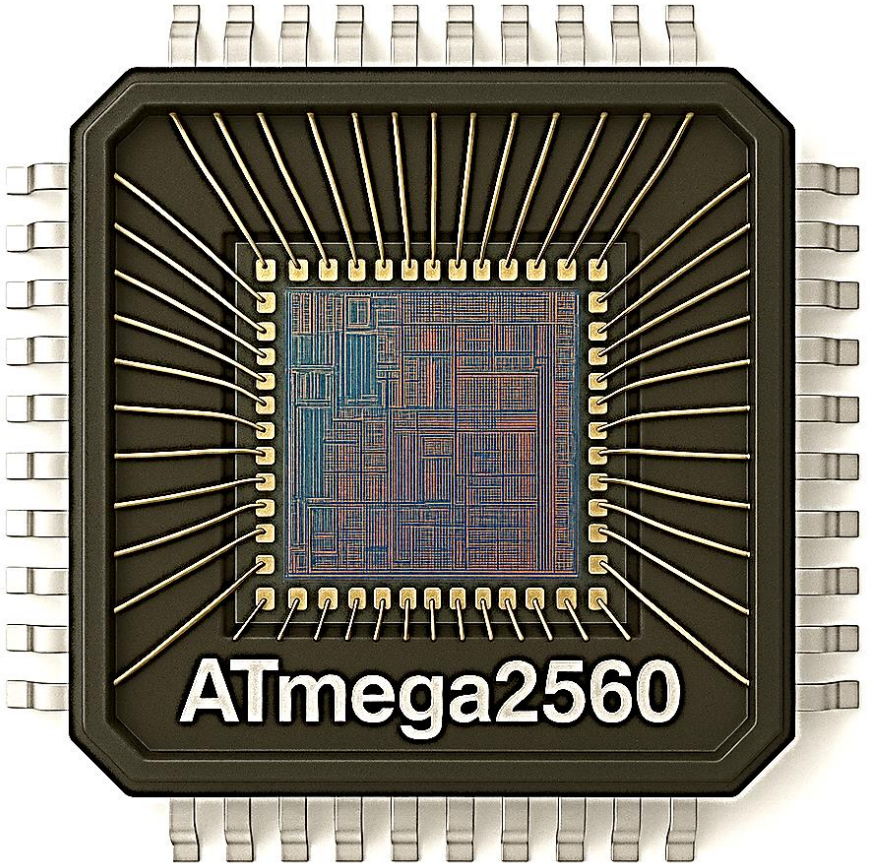
Inside of an IC

What is Analog IC Design?



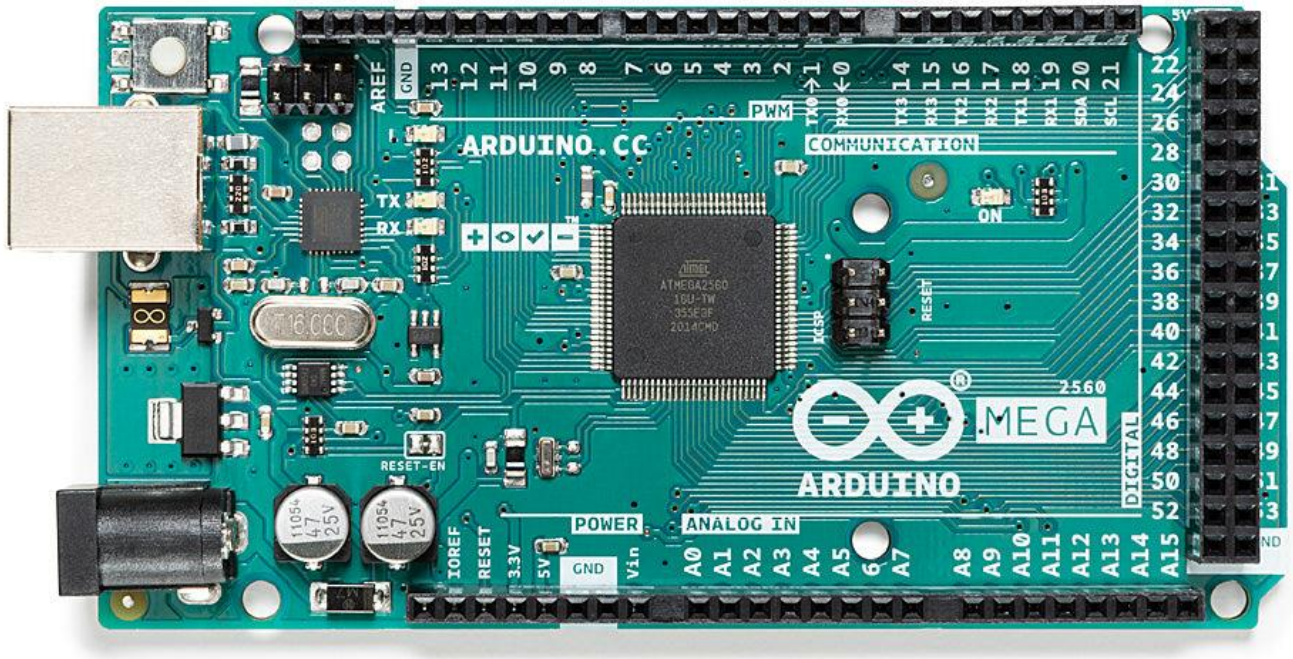
Die

What is Analog IC Design?



Package

What is Analog IC Design?



System

Analog Vs Digital IC Design

Analog

- Handles continuous-time signals such as sound, light, and RF.
- Focuses on transistor physics (I-V characteristics, operating regions, noise, parasitic, etc.)

Digital

- Processes discrete signals represented by two logic levels (0 and 1).
- Focuses on logic gate design (AND, OR, NAND, etc.), Boolean operations, timing, and synchronization using clocked circuits (latches, flip-flops, etc.).

Analog Vs Digital IC Design

Analog

- **Example applications:**
  - Amplifiers
  - Power management circuits
  - RF circuits
  - Data converters (ADCs and DACs)

Digital

- **Example applications:**
  - Microprocessors (CPUs)
  - Graphical processors (GPUs)
  - Memory chips (RAM, flash)
  - Digital signal processors (DSPs)

Analog Vs Digital IC Design

Analog

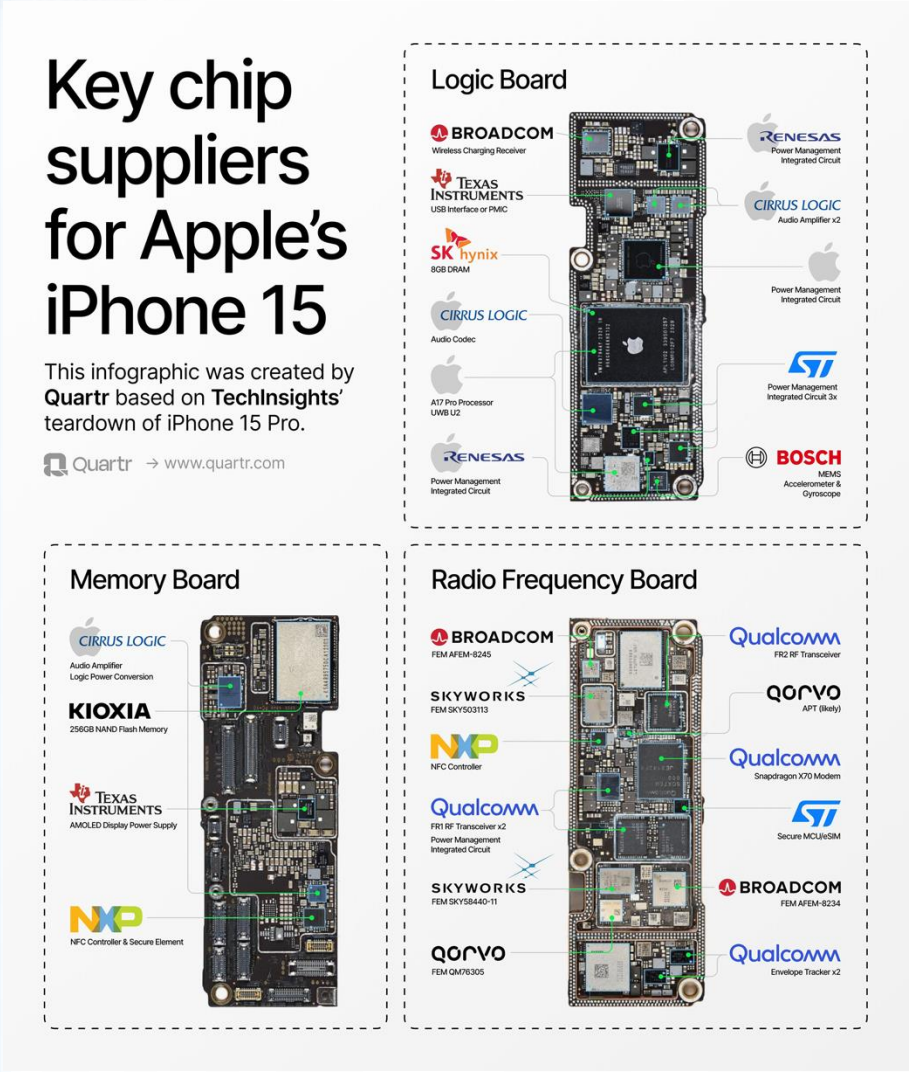
- **Design challenges:**
  - Handling noise
  - Precision and accuracy
  - Matching and layout sensitivity
- **Key skills:**
  - Deep understanding of transistor physics
  - Circuit intuition
  - Noise analysis
  - Layout parasitic

Digital

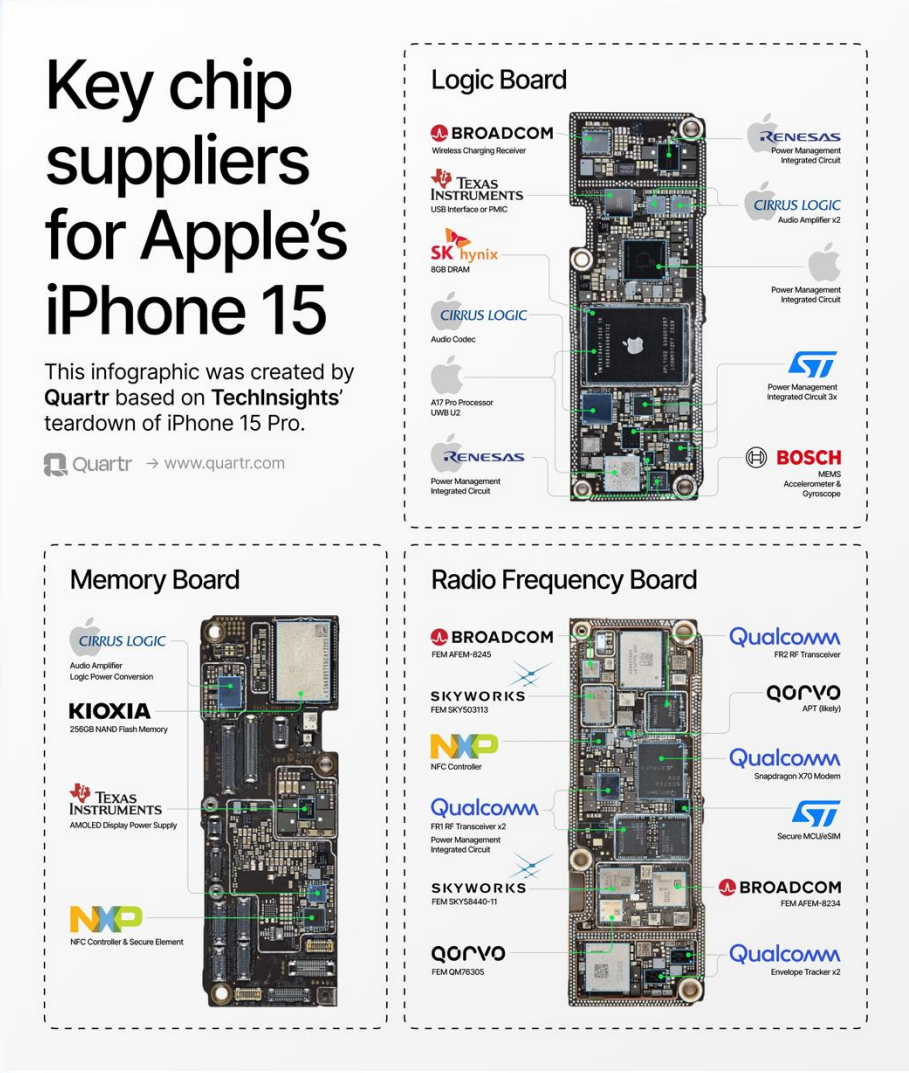
- **Design challenges:**
  - Timing (clock synchronization)
  - Power consumption (dynamic/static)
  - Area optimization (how small you can make it)
- **Key skills:**
  - Hardware description languages
  - Logic design
  - State machines
  - Timing analysis

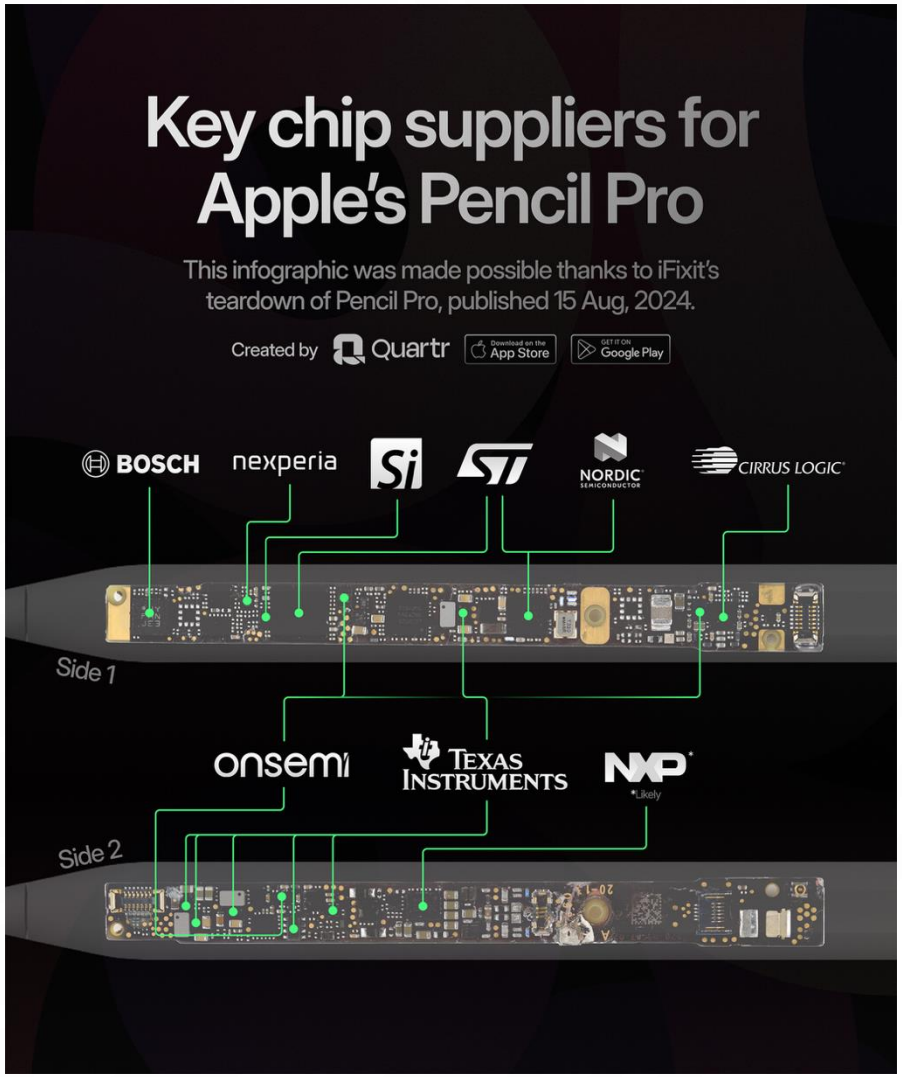
In most systems, digital and analog integrated circuits coexist to perform their respective functions.

Analog Vs Digital IC Design



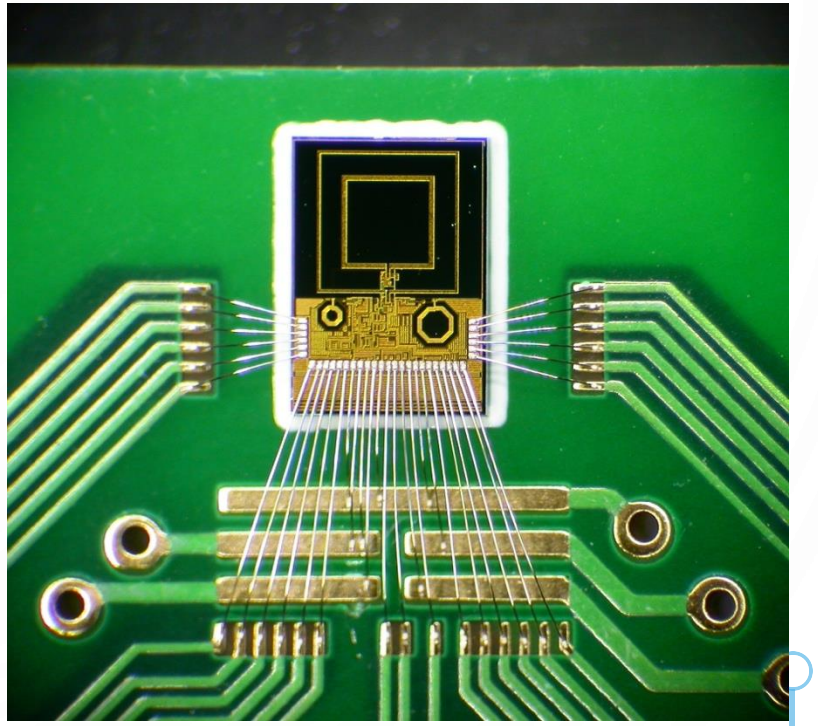
Analog Vs Digital IC Design





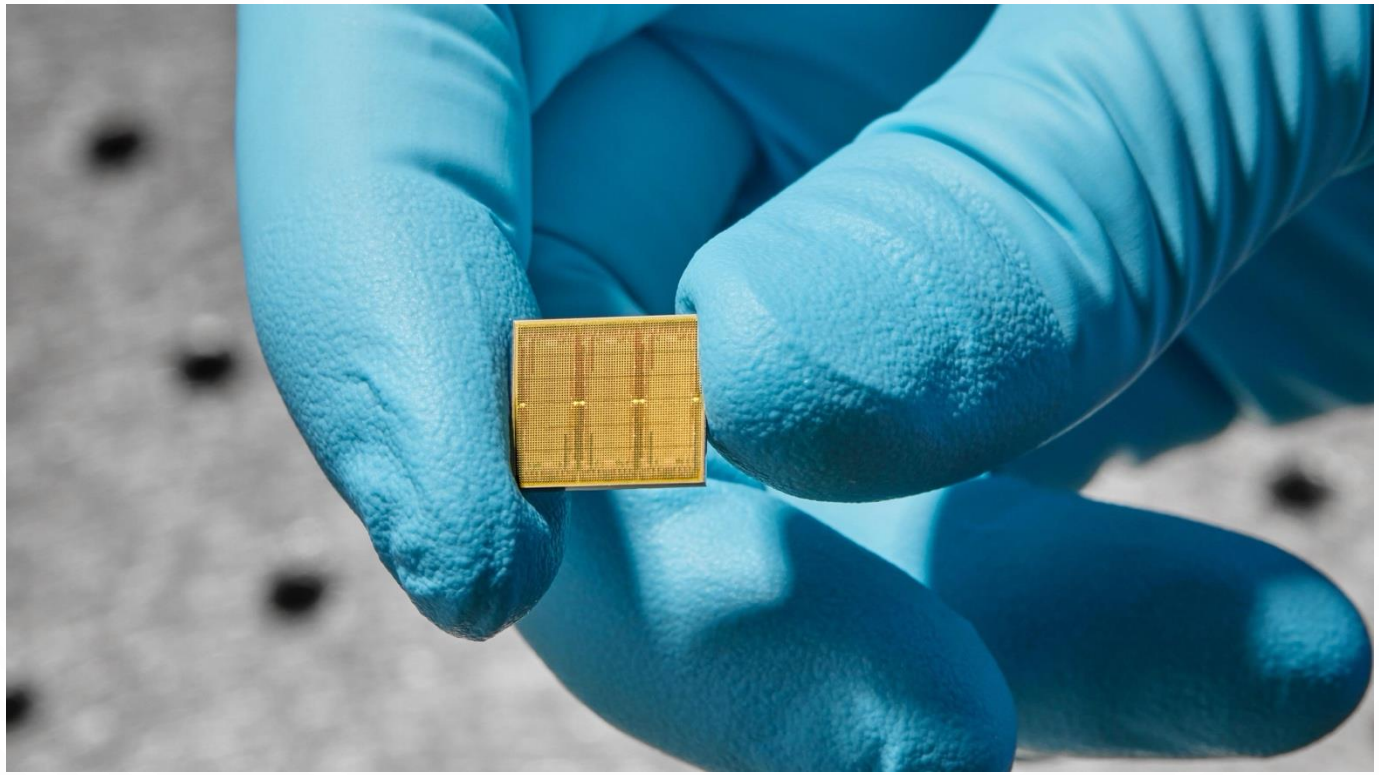
My Journey into Analog IC Design

- **2007:** Started undergraduate studies at the University of Moratuwa.
- **2008:** Selected electronics and telecommunication engineering field – first major step.
- **2011:** Graduated from the University of Moratuwa.
- **2013-2015:** Master's from the University of Akron.
- **2015:** Ph.D. from Florida International University.
  - This is where I truly began my deep dive into IC design.
  - Experienced the excitement of my first IC designs and tape-out!
  - Achieved my first publication in JSSC.
- **2019-2021:** Postdoctoral researcher at the University of Southern California, focusing on ICs for implantable medical devices. The dual-band TRX design led to a patent.
- **2021-Present:** Contributing to real-world impact as an IC Design Engineer at Cirtec Medical, developing ICs for implantable medical applications.



Key Takeaway: I started my focused journey into IC design during my Ph.D. You are still not too late to discover and pursue your passion in this exciting field!

Future Directions in Analog IC Designs



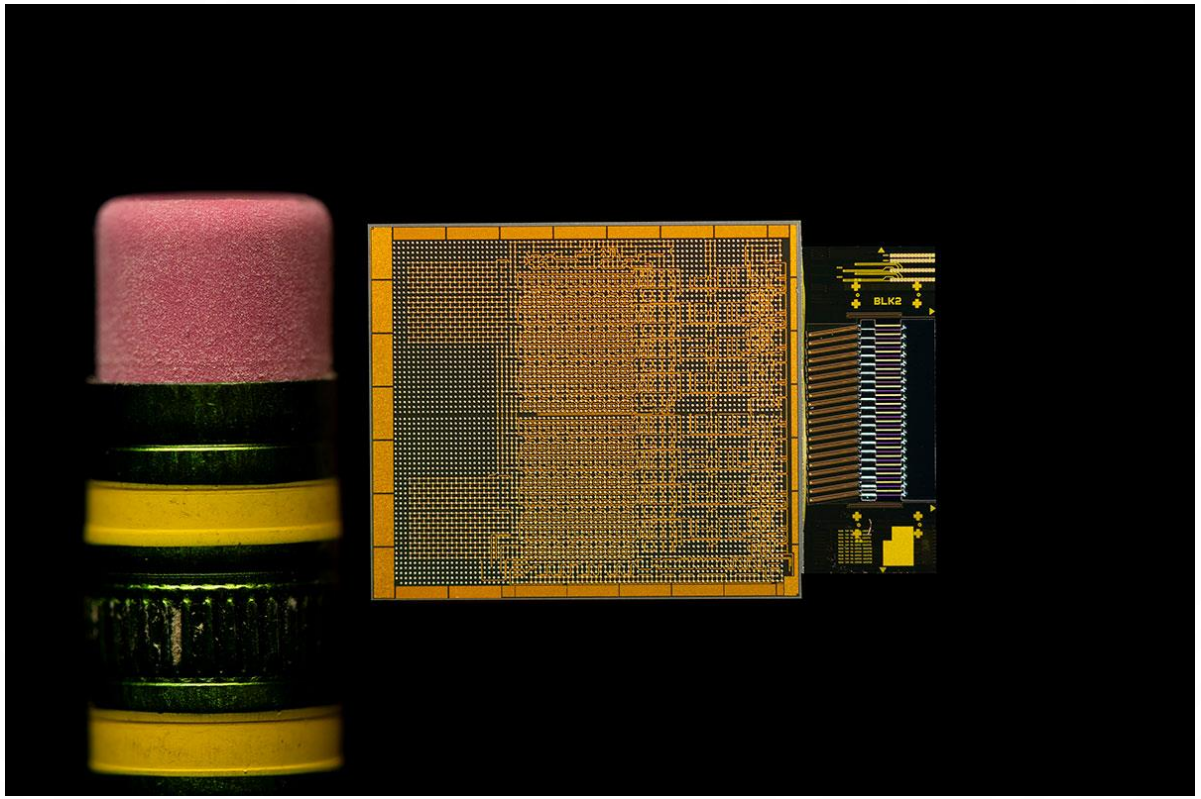
IBM Research's latest analog AI chip prototype. http://research.ibm.com/blog/analog-ai-chip-low-power

Neuromorphic AI accelerators (Brain-inspired Analog Computing)
Analog circuits that mimic biological neurons and synapses, enabling ultra-low-power processing for AI and sensory applications.

Major Companies: Intel, IBM

Good Reference: Neuromorphic Computing, Frank Mizrahi, ESM 2024, York (pdf)

Future Directions in Analog IC Designs



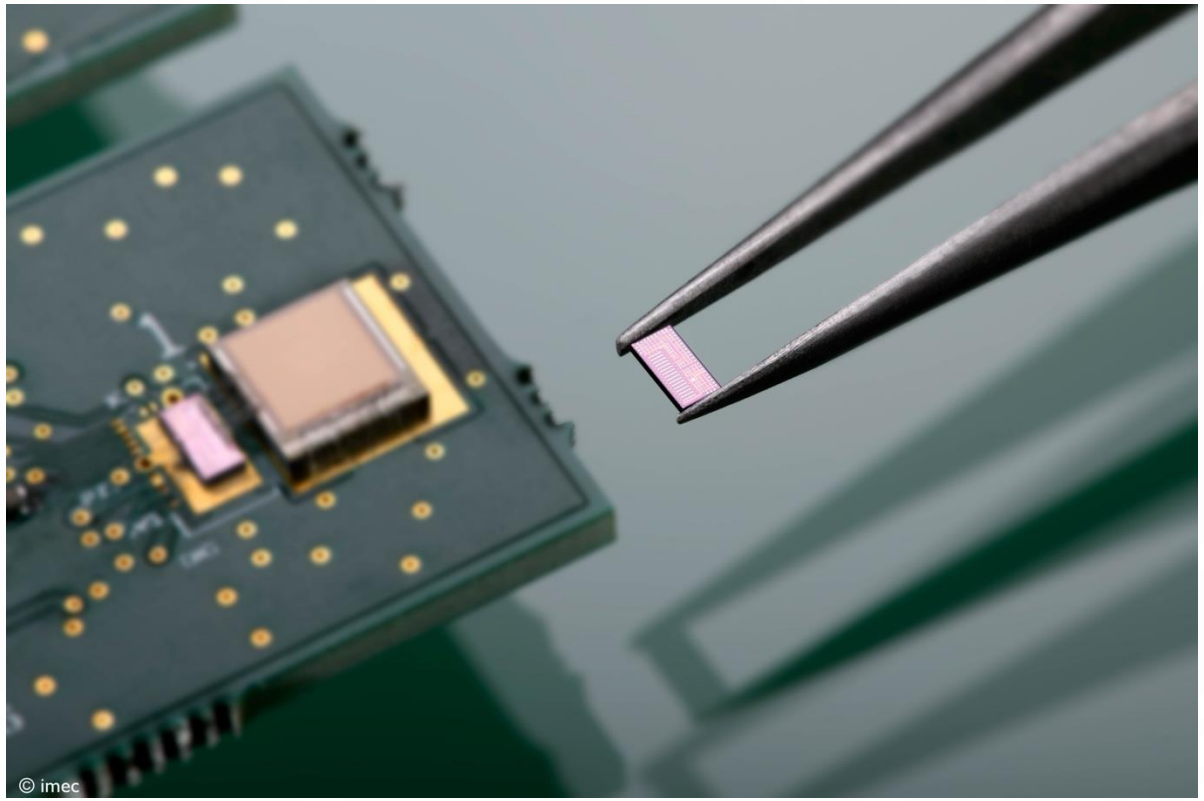
The optical compute interconnect chiplet of Intel's Integrated Photonics Solutions Group, shown next to a pencil eraser
https://newsroom.intel.com/artificial-intelligence/intel-unveils-first-integrated-optical-io-chiplet

Silicon Photonic ICs
Integration of light-based and electronic components to achieve ultra-fast data transmission, optical sensing, and on-chip photonic computing.

Major companies: Intel, IBM, D-Wave, PsiQuantum

Good Reference: Silicon Photonics: From Basics to ASICs, Sudip Shekhar, ISSCC 2021 tutorial (video)

Future Directions in Analog IC Designs



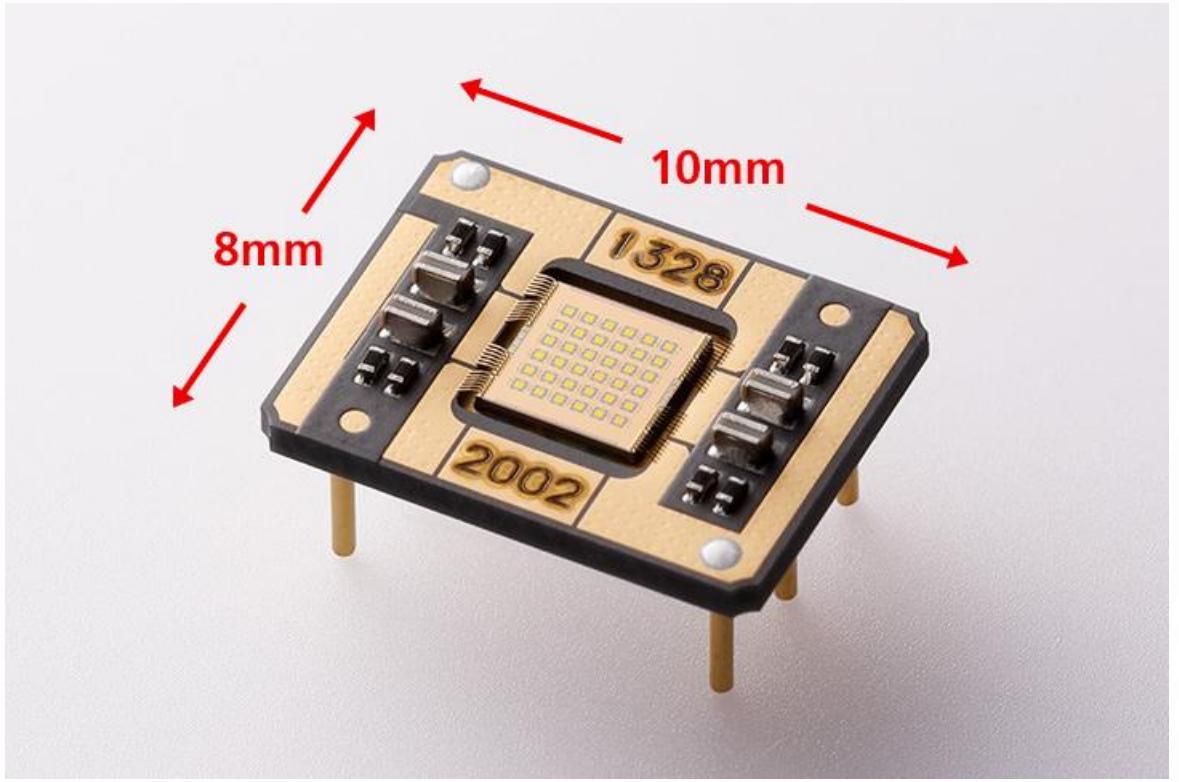
IMEC's ultrasound-based proof of concept wireless powering chip, fabricated in 65 nm. https://www.imec-int.com/en/press/imec-introduces-compact-wireless-powering-technology-featuring-record-low-energy-consumption

Implantable and Wearable Medical ICs
Specialized analog circuits for brain-computer interfaces and biomedical implants, focusing on ultra-low-power and biocompatibility.

Major Companies: Medtronic, Abbott, Neuralink, IMEC

Good Reference: Circuit Insights, Biomedical Circuits, Carolina Mora Lopez, IEEE Solid-State Circuits Society (Video)

Future Directions in Analog IC Designs



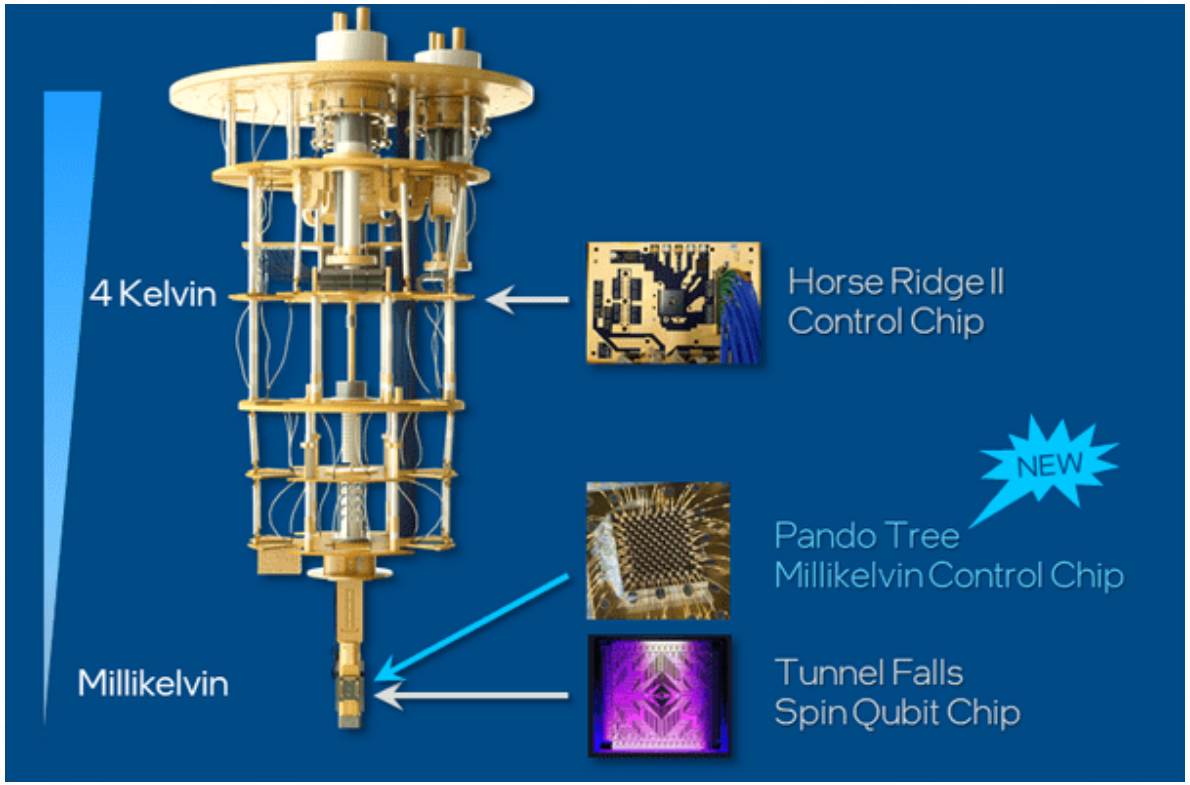
The semiconductor terahertz source developed by Canon, https://global.canon/en/technology/terahertz-device-2023.html

RF / mm-Wave / Tera Hertz IC Designs
High-frequency analog designs enabling next-generation wireless communications, imaging systems, and radar technologies.

Major Companies: Qualcomm, Broadcom, Skyworks Solutions

Good Reference: SSCS Webinar: THz and mm-wave circuit design in CMOS, Prof. Patrick Reynaert (Video)

Future Directions in Analog IC Designs



Intel has introduced a millikelvin quantum research control chip, dubbed Pando Tree.
https://thequantuminsider.com/2024/06/21/intel-debuts-new-chip-focused-on-addressing-quantum-computings-wiring-bottleneck/

Cryo-CMOS Designs for photonic/superconductor/Quantum Computing
Development of CMOS circuits operating at cryogenic temperatures to control and interface with quantum processors.

Major companies: Intel, Google, IBM, D-Wave, PsiQuantum

Good Reference: Cryogenic CMOS interfaces for large-scale quantum computers: from system & device models to circuits, Fabio Sebastiano, IEEE Solid-State Circuits Society (video)

The Path to Becoming an IC Designer

- **Take advantage of open-source tools.** A decade ago, IC design wasn't accessible in places like Sri Lanka. Today, **open-source tools and PDKs** open the door. Walk through it.
- **Numerous IC design contests are out there.** Especially organized by IEEE Circuits and Systems (CAS) and Solid-State Circuits Societies. I encourage you to take advantage of these opportunities and actively participate.
- **Do at least one real IC project** during your degree. **Publish your results.** This can be your ticket to a top-tier IC research group.
- **Once you're in, your path is set.**

In 10 years from now,

- ***One of you could design a chip for the next-gen iPhone.***
- ***One of you could design the cryo-CMOS control chip for future quantum computers.***

Thank you