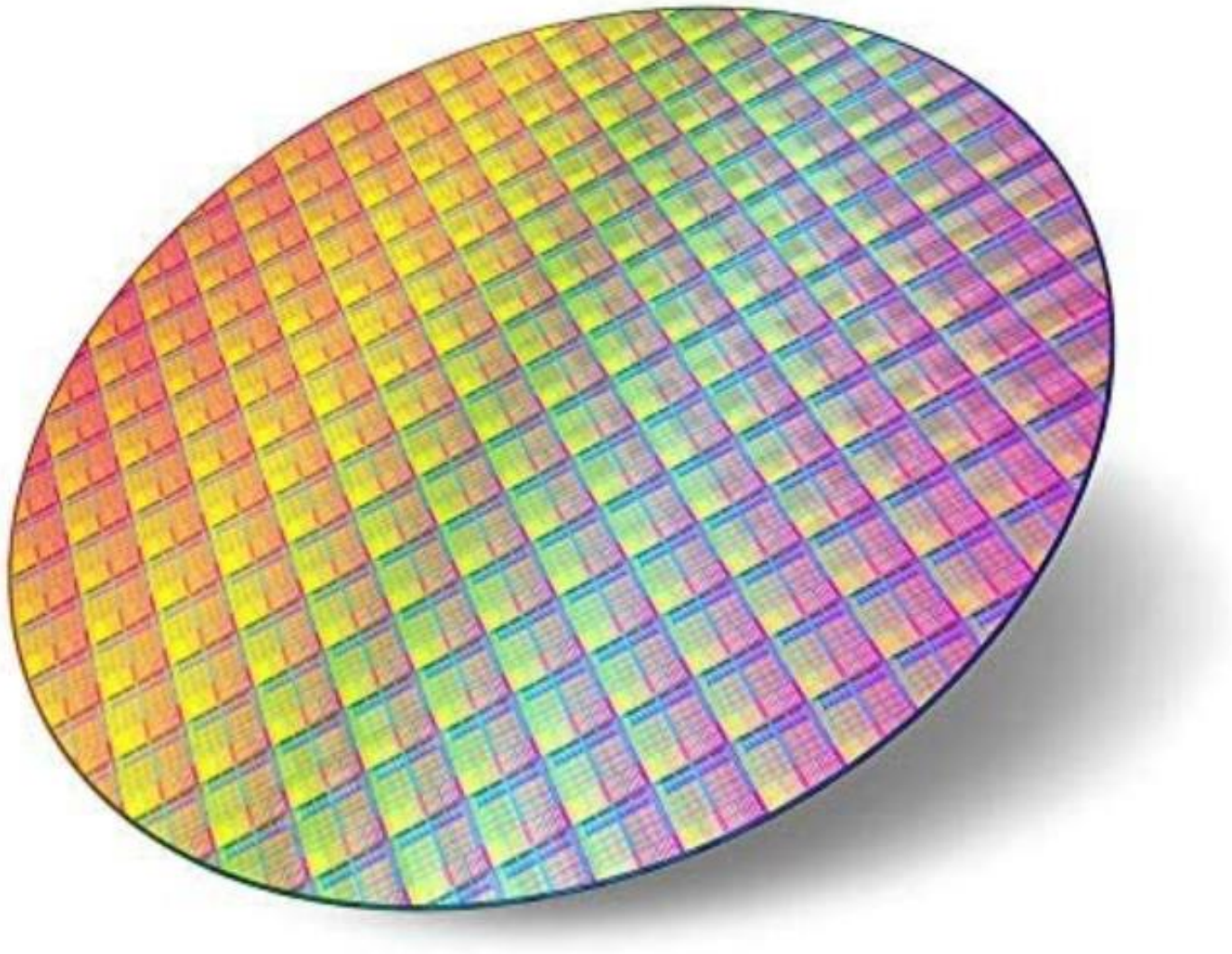
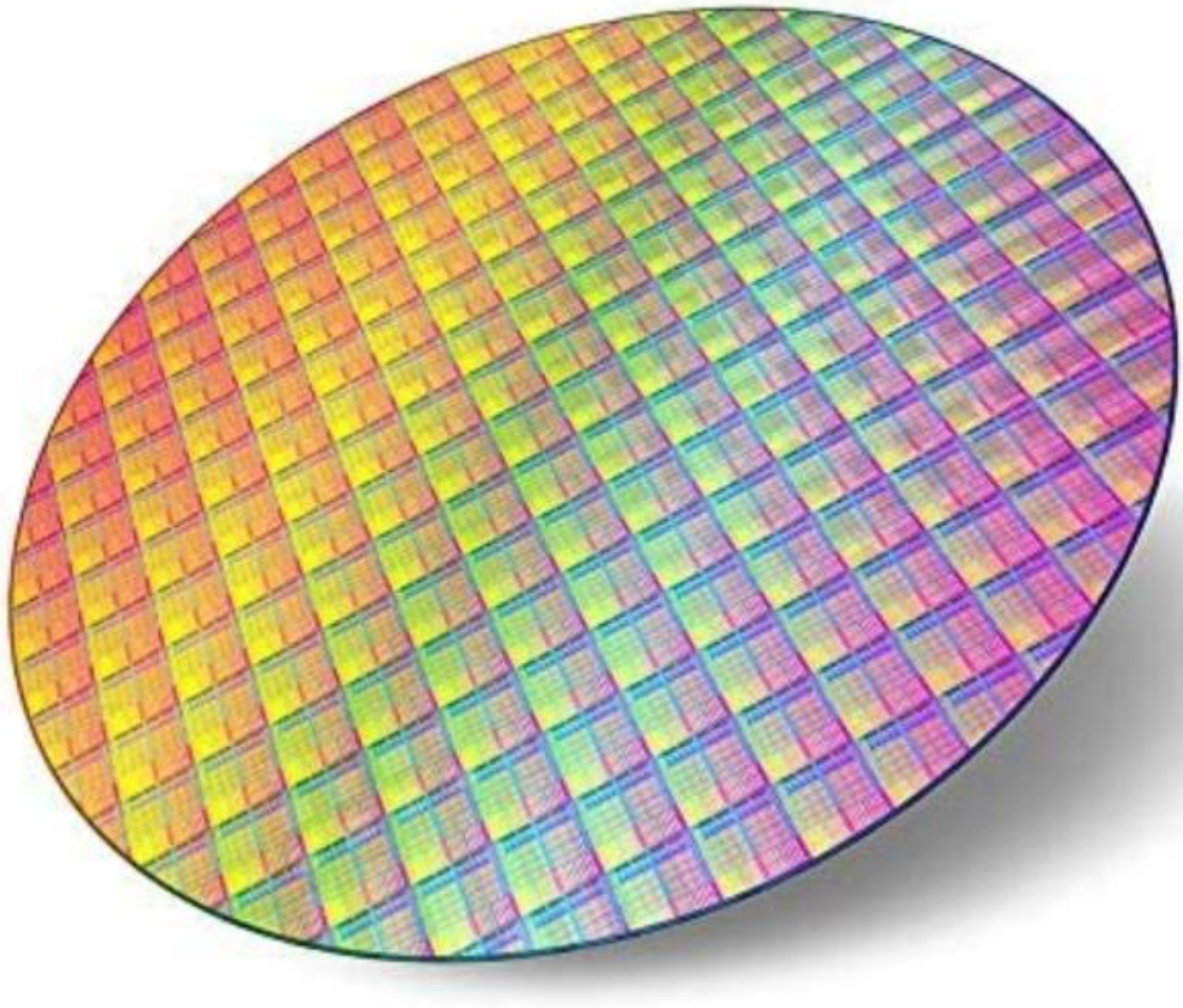
Chip Day,

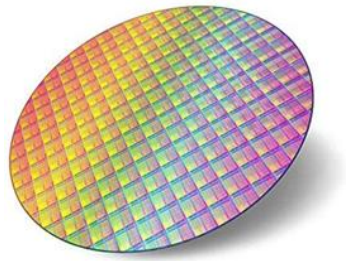
DTU,
April 2022



Analog IC design



Who are we?



Calvin Maxsen de Oliveira
Analog IC Designer at Oticon

oticon

Jakob Graversgaard Thomsen
Analog IC Designer at Oticon

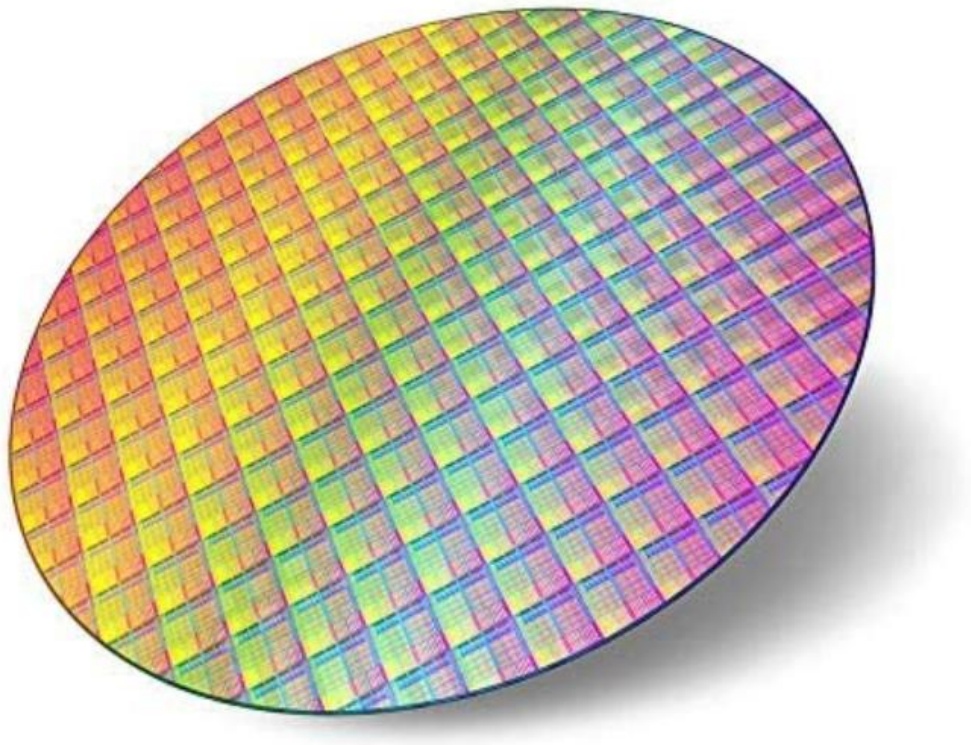
oticon

Pere Llimós Muntal
CEO at Skycore Semiconductors

Skycore® Semiconductors

Agenda – **Analog IC design**

- Background: What is Analog IC Design?
- Analog IC design in Audio Systems
- Analog IC design in Power Conversion



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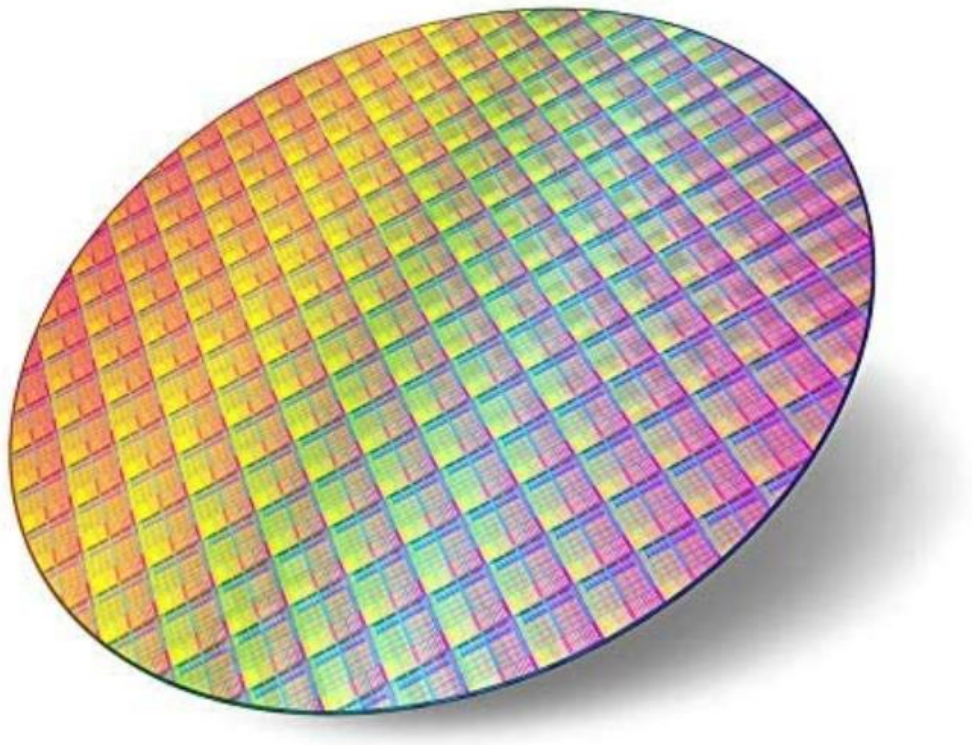
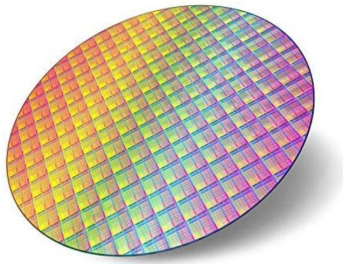
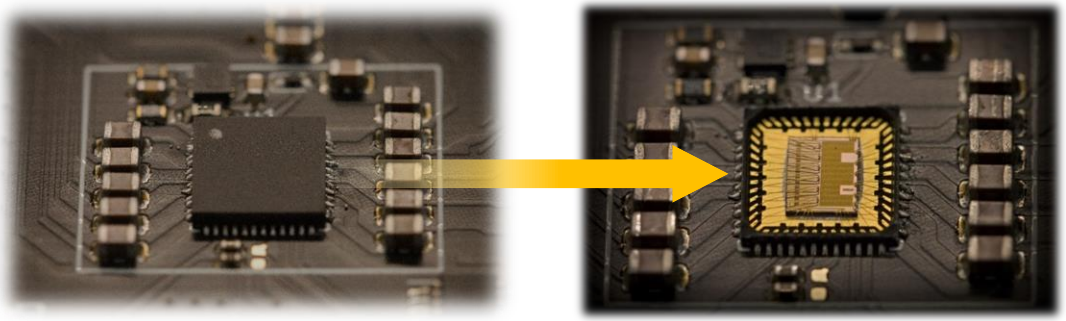
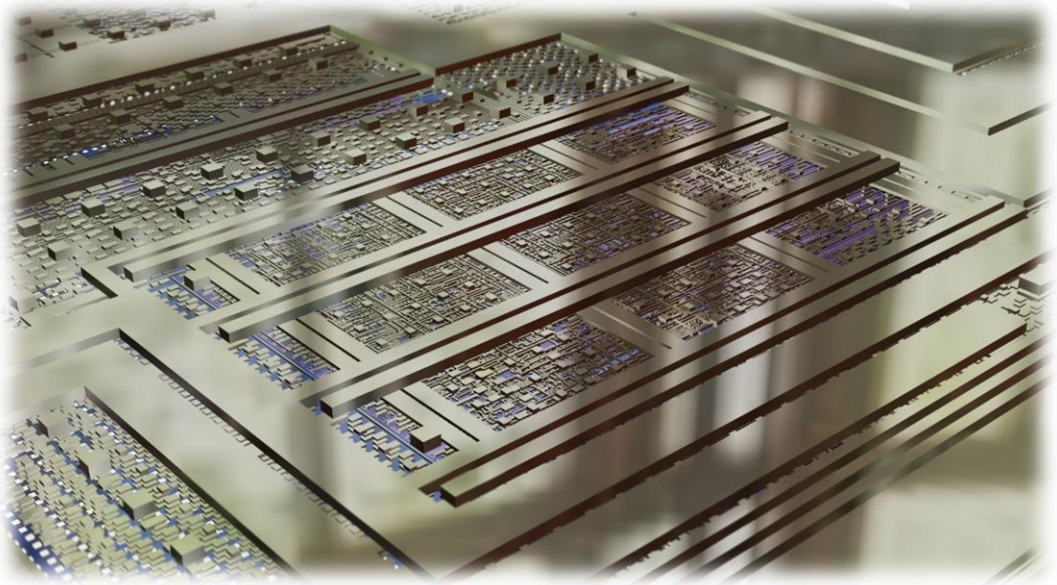


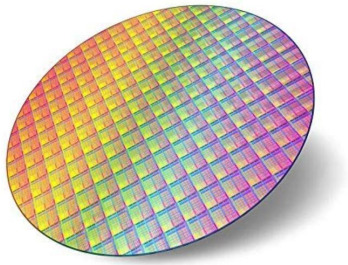
Inside a microchip – Silicon die

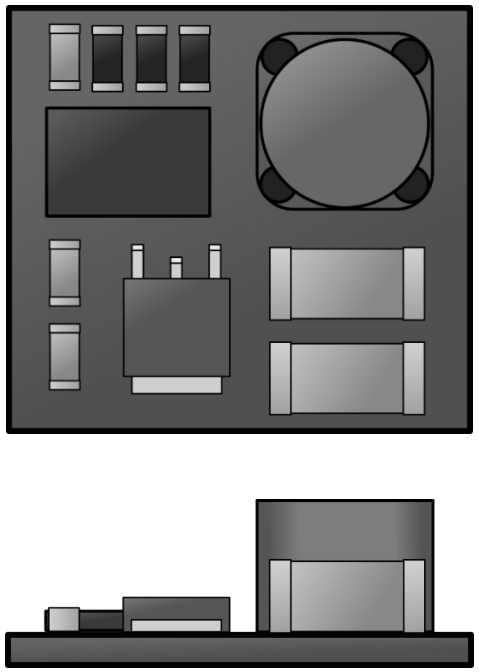


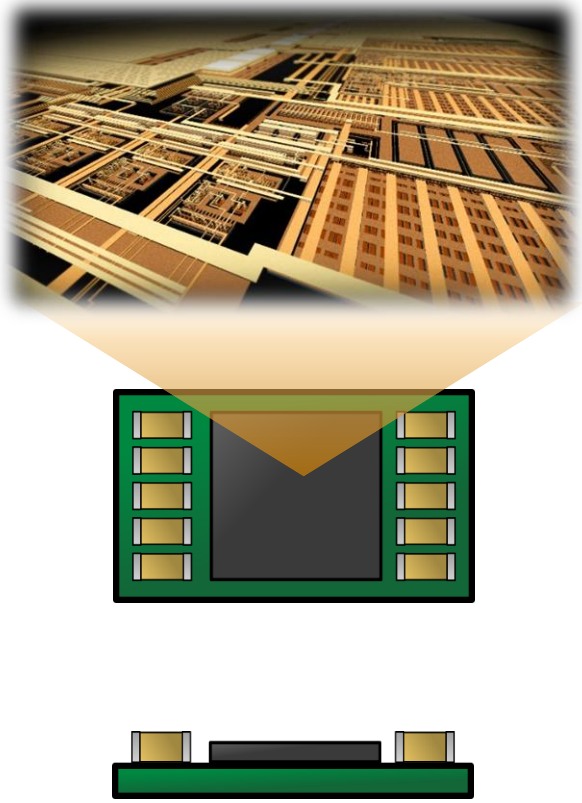




Implementation of Electronic Circuits





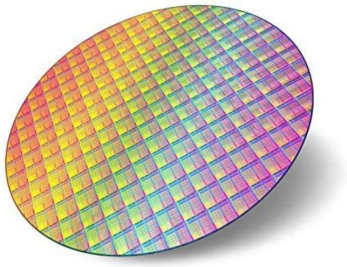


Different design flow and tools, e.g., Cadence Virtuoso.

Discrete component implementation
(Electronics Engineer)

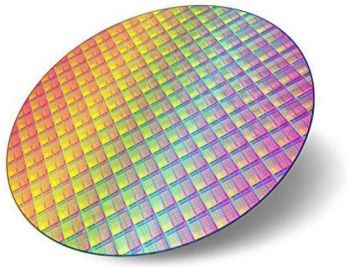
Integrated circuits implementation
(Integrated Circuit Designer)

Advantages of IC design



- Custom designed integrated circuits
- Custom functionalities and features
- Enables tradeoff optimization:
  - Performance vs power consumption
  - Size vs power consumption
- IC design makes certain systems possible
  e.g. Microprocessors, hearing aids, extreme-power density power converters, etc.
- Chip art!

Wide range of applications



- Analog IC design covers a wide range of applications:
  - **Audio Systems**, e.g. Hearing aids, headphones, …
  - **Power Conversion**, e.g. Power converters, gate drivers, …
  - **High-speed communications,** e.g. Data centers, 5G transceivers, ...
  - **Sensors,** e.g. image sensors, temperature sensors, …
  - … and many more!

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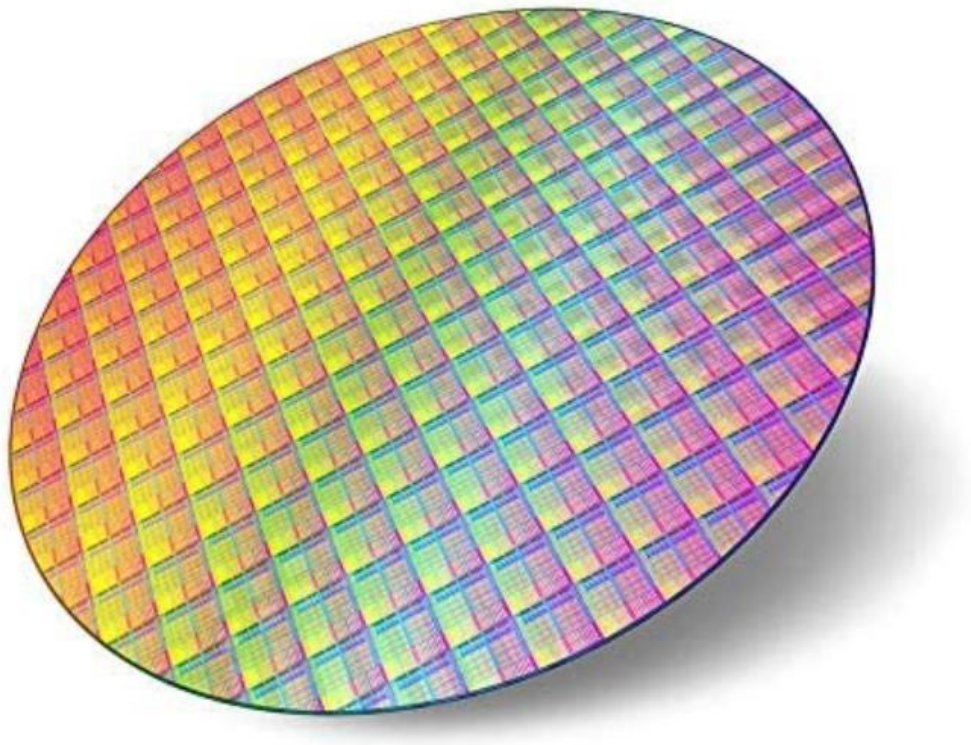
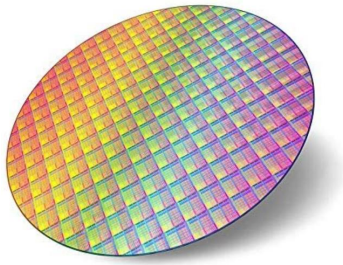
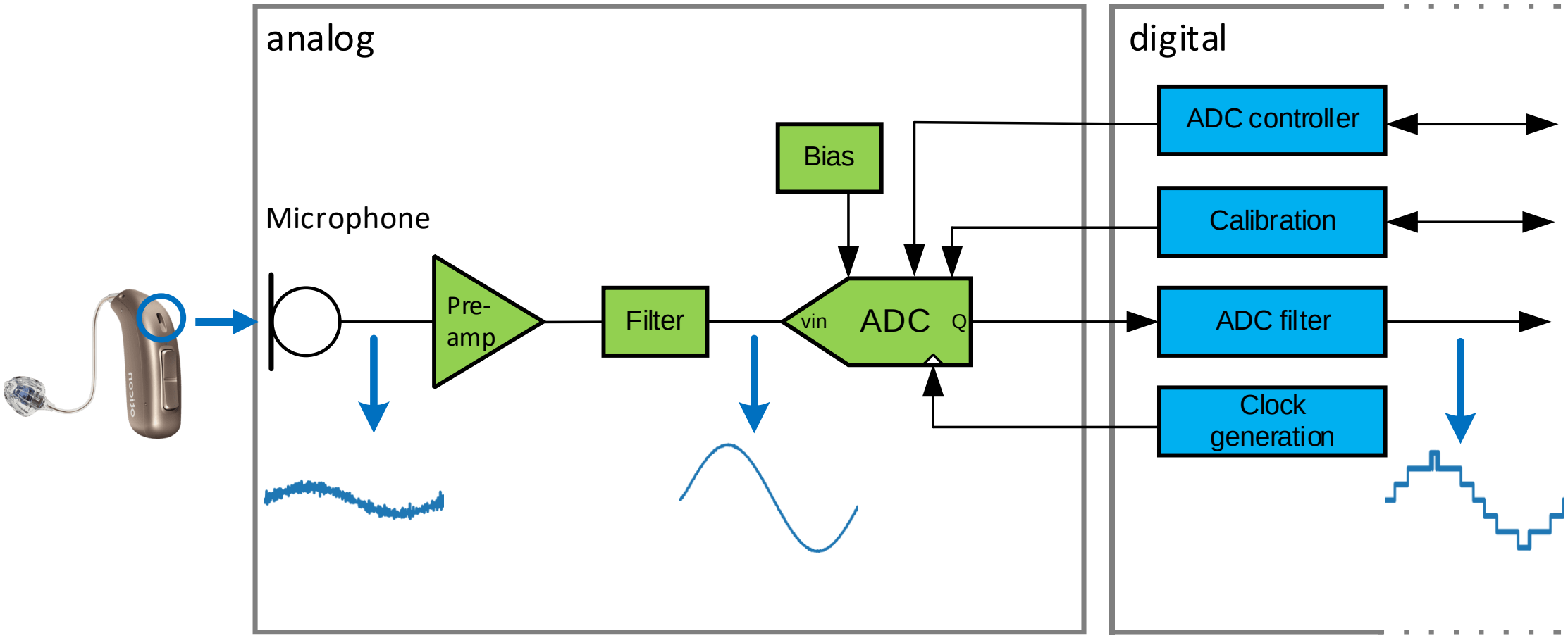


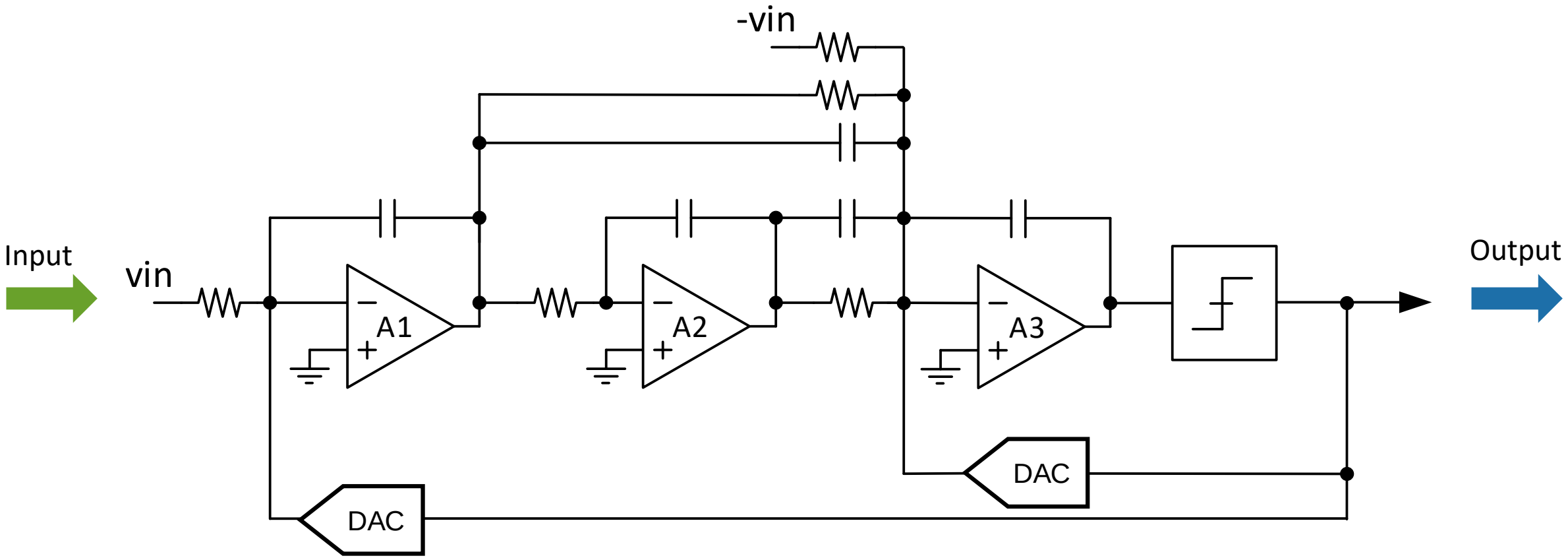
Audio input – block diagram



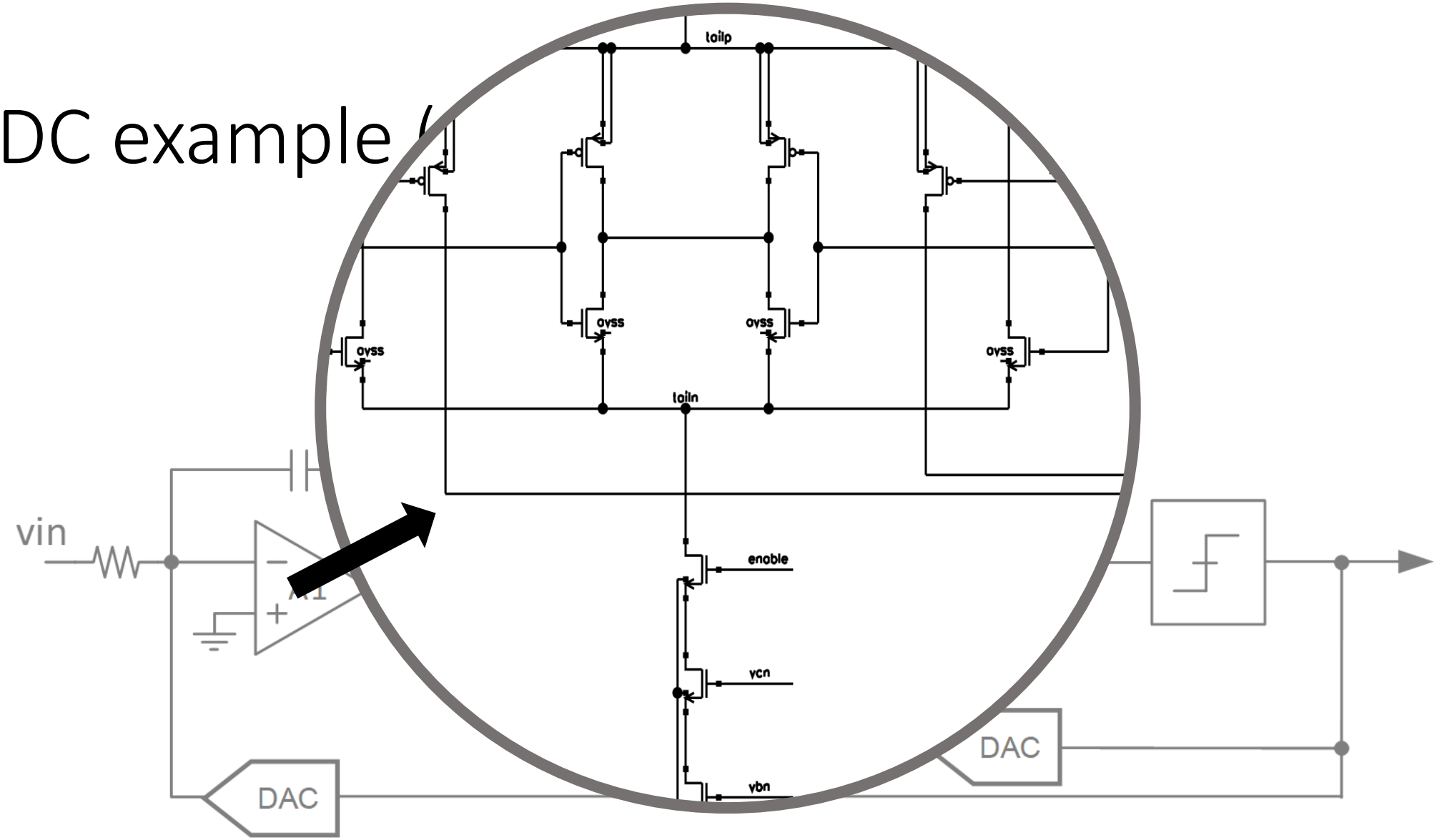


4-bit 10-bit

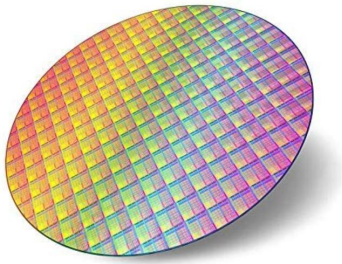
ADC example (sigma-delta)

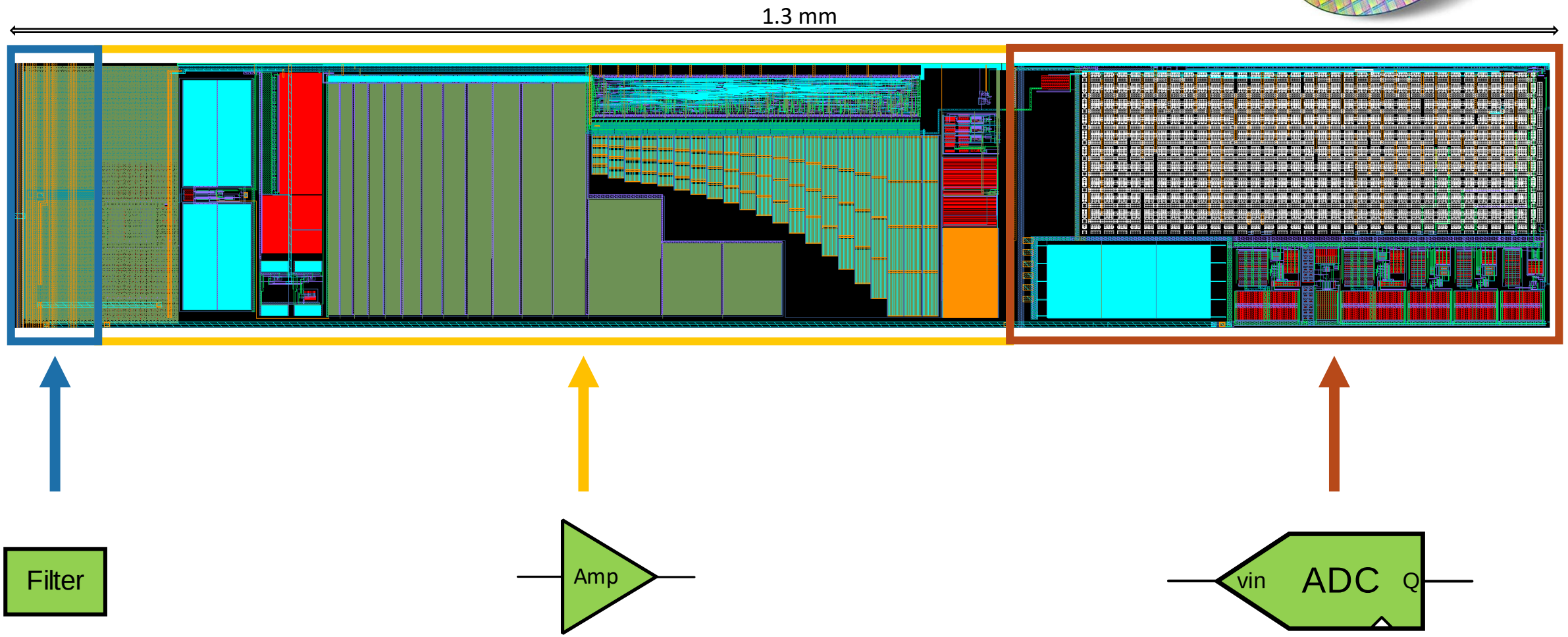


ADC example (

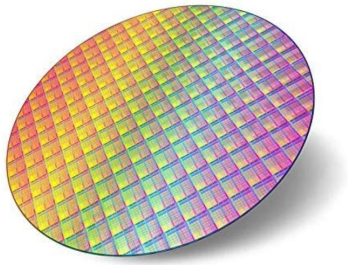


Audio input – layout view

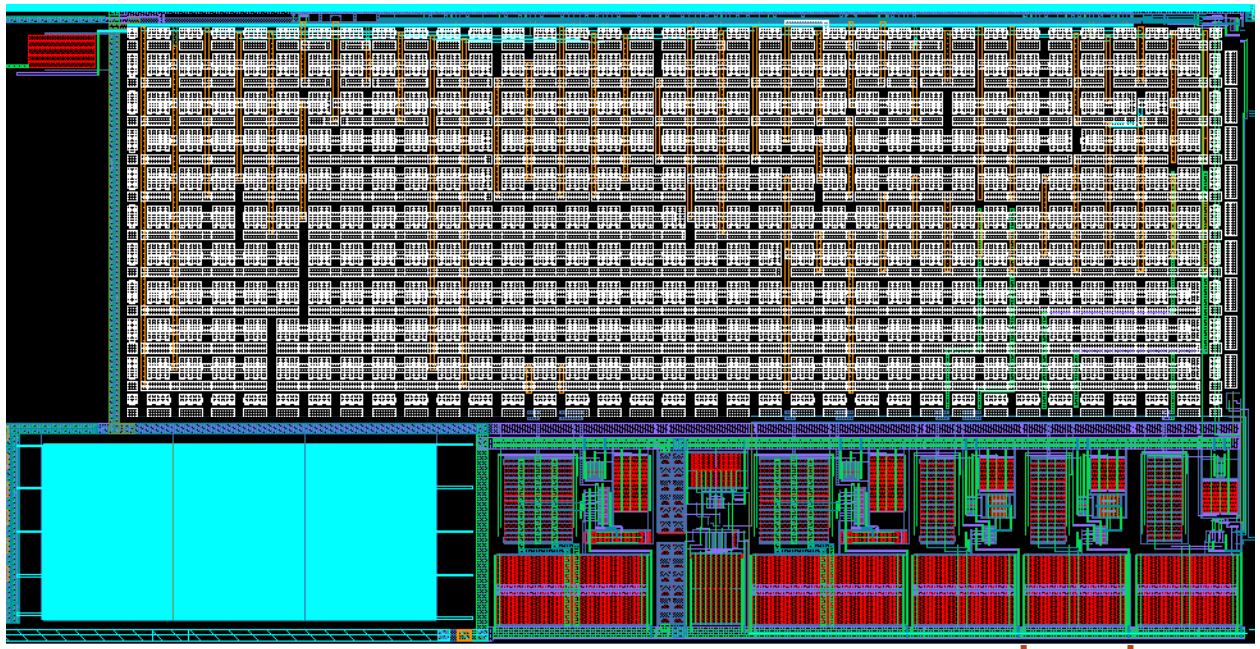


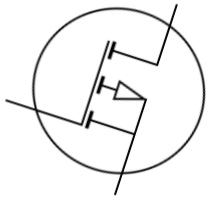


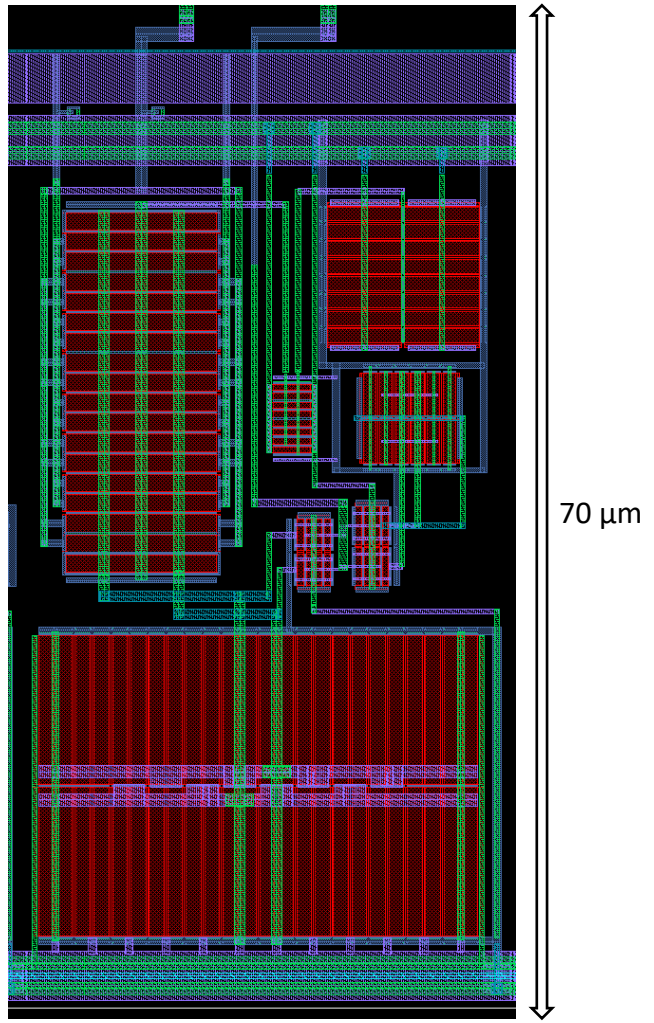
Audio input – layout view

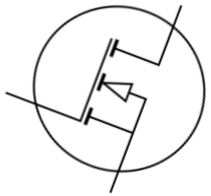


Zoom in of the ADC









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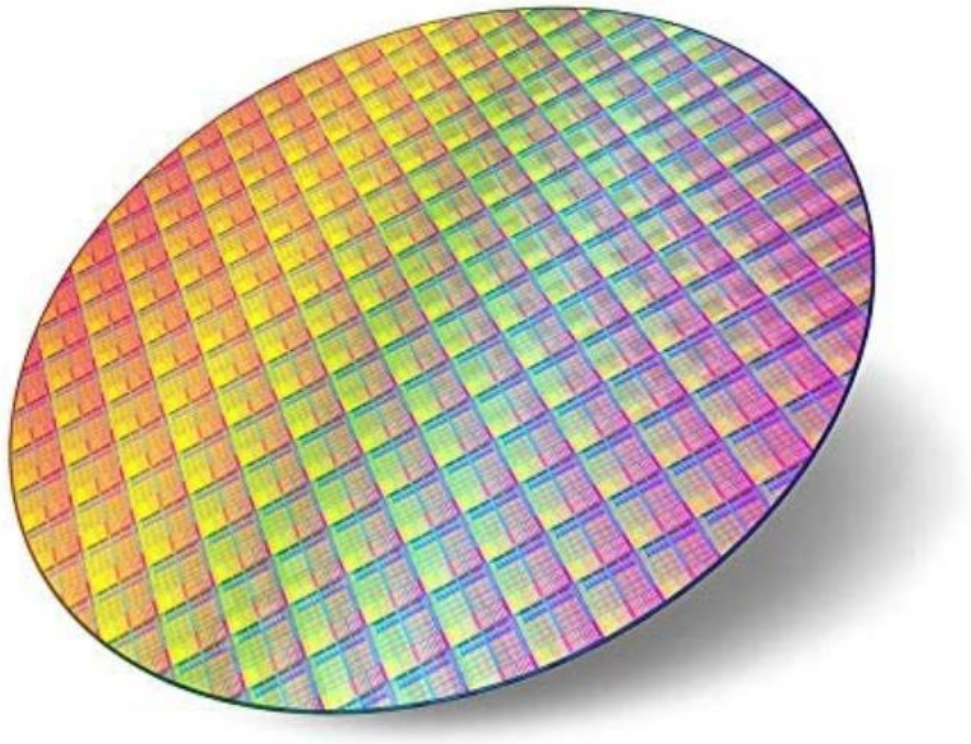
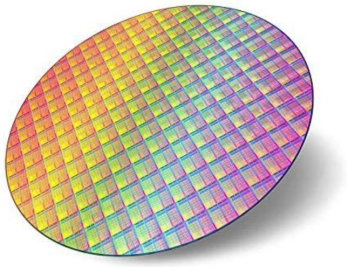
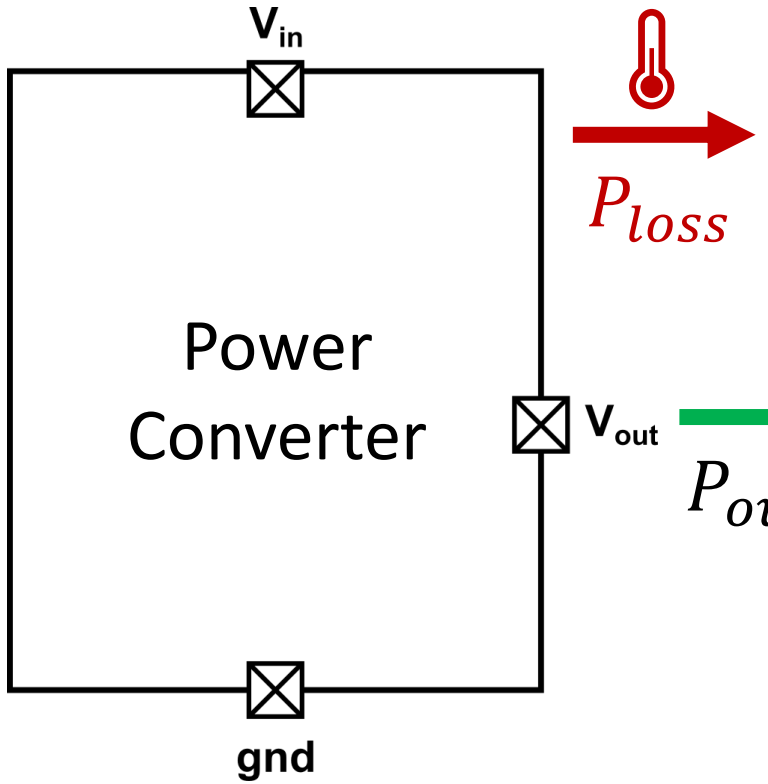


Power conversion basics



$$P_{in} = V_{in} \cdot I_{in}$$



P_{loss}

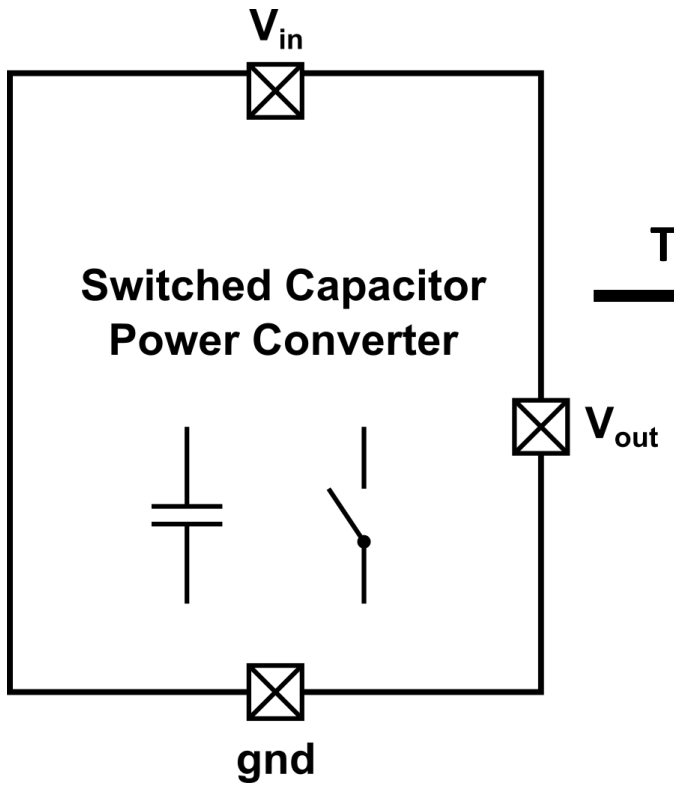
$$P_{out} = V_{out} \cdot I_{out}$$

$$\eta = \frac{P_{out}}{P_{in}} = \frac{P_{in} - P_{loss}}{P_{in}}$$

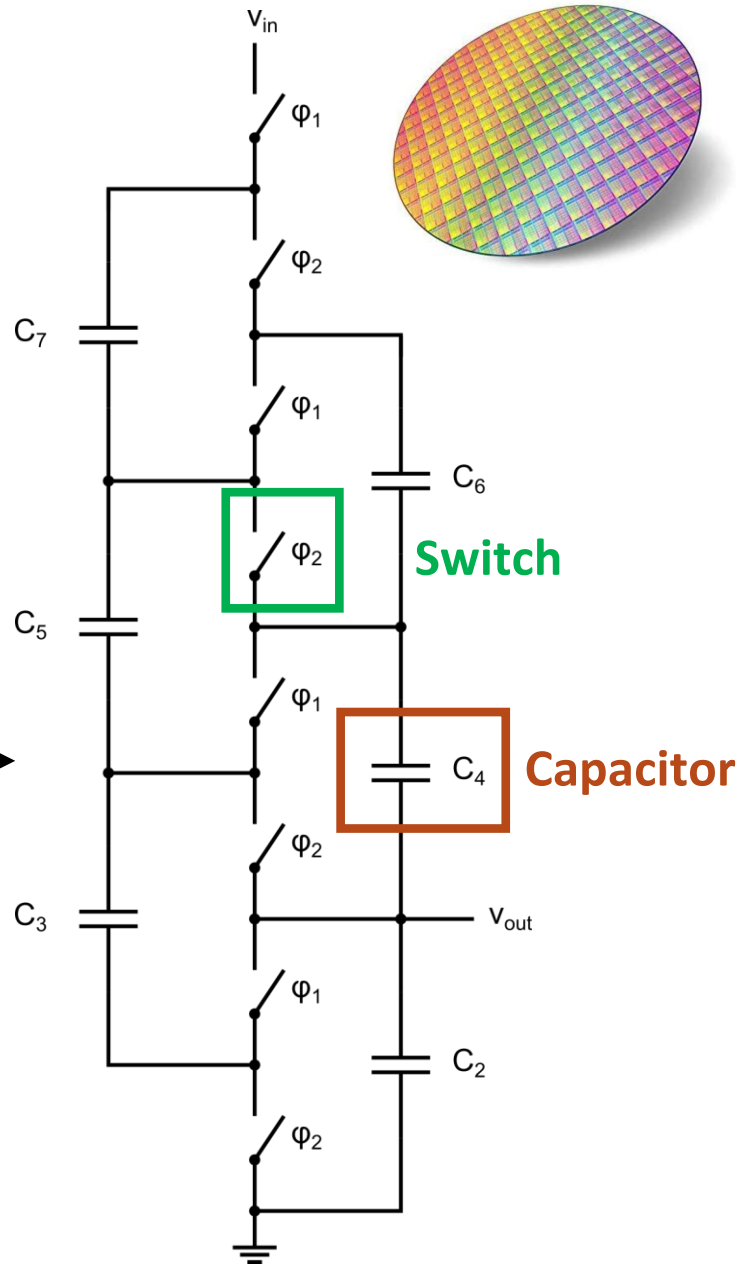
Power conversion IC example

Switched-Capacitor Power Converter (SCPC)

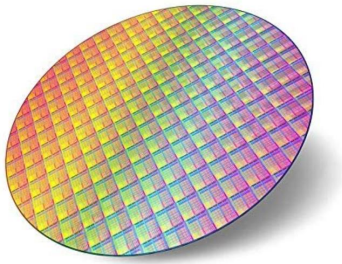
- V_{in} = 48 V
- V_{out} = 12 V
- I_{out} = 1.6 A



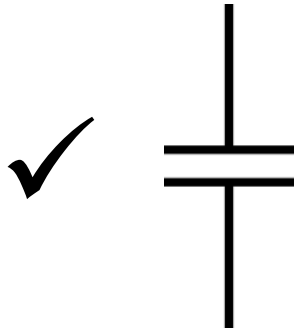
Topology

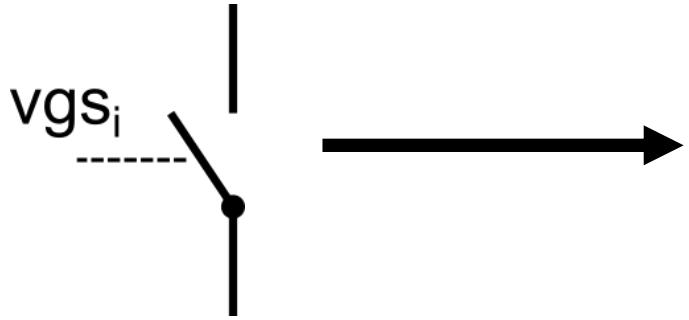


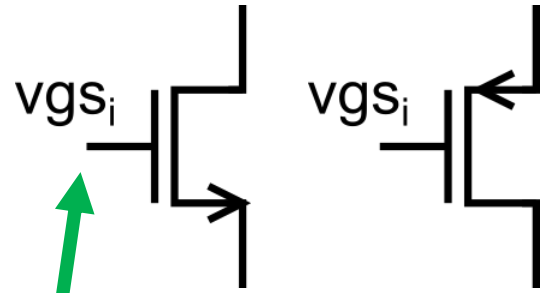
Switched-Capacitor Basic Components



- Capacitors
- Switches
- Switch implementation







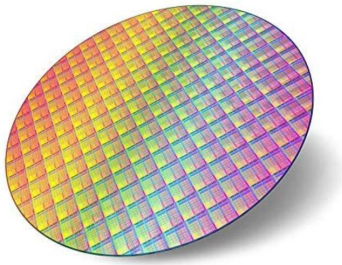
- Discrete capacitors
- On-chip capacitors

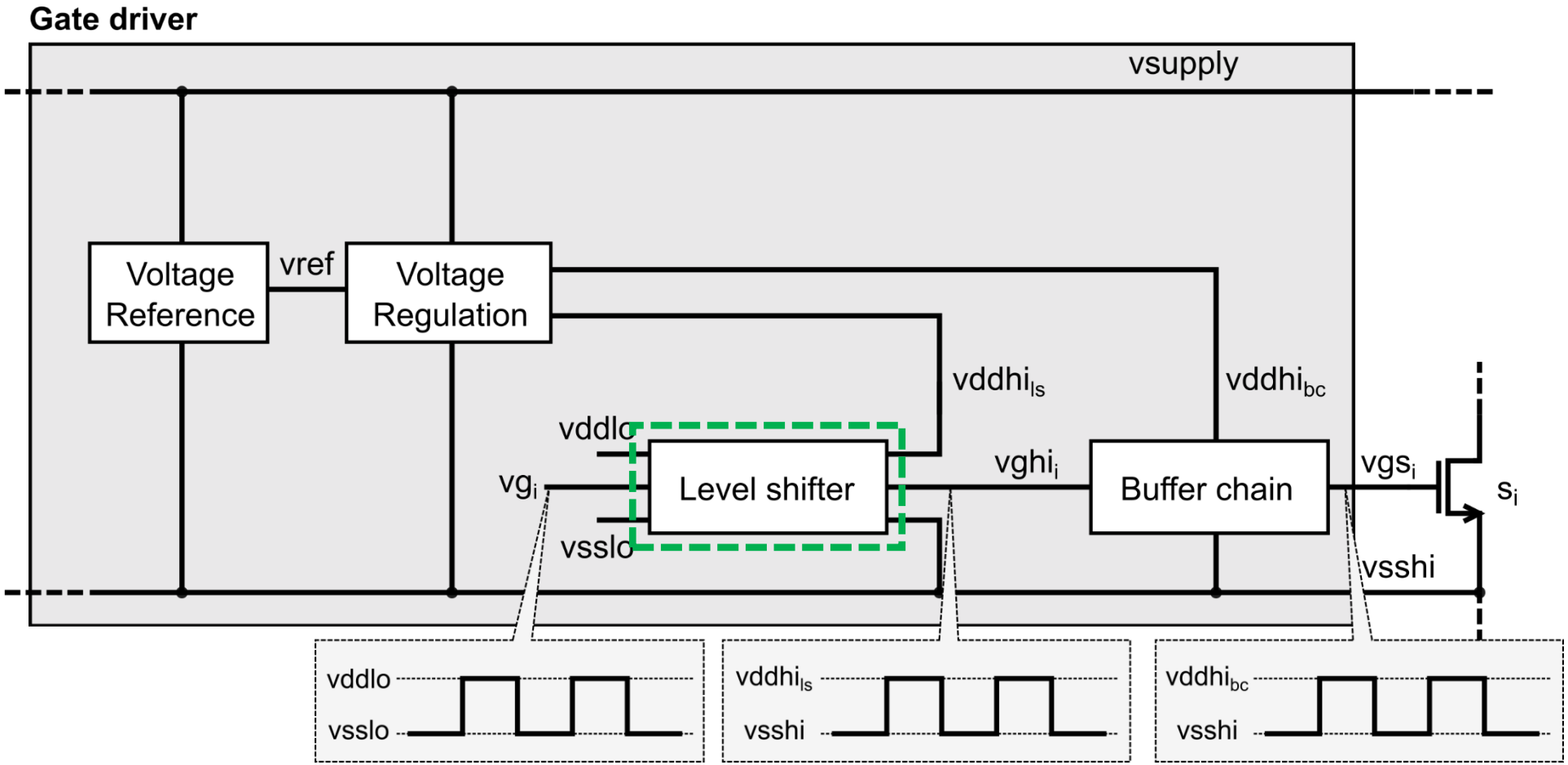
- Discrete switches
- Integrated switches

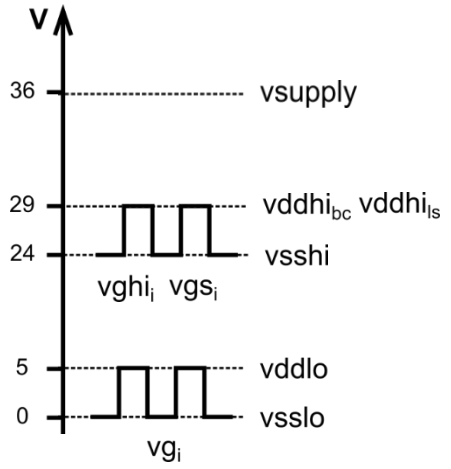
- Integrated NMOS
- Integrated PMOS
- …

How do we drive them?

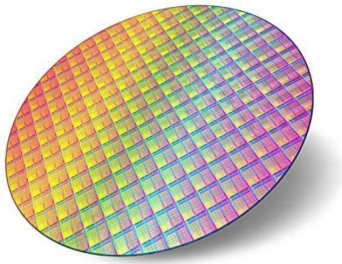
Gate driver and sub-circuits

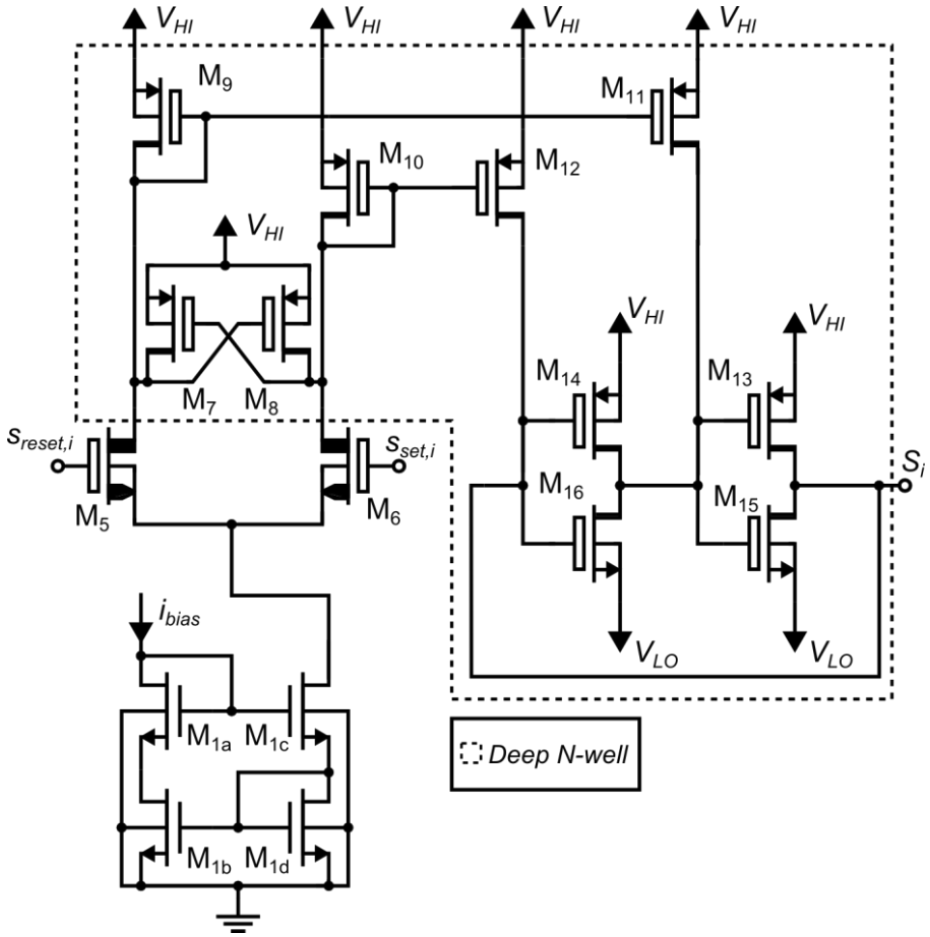




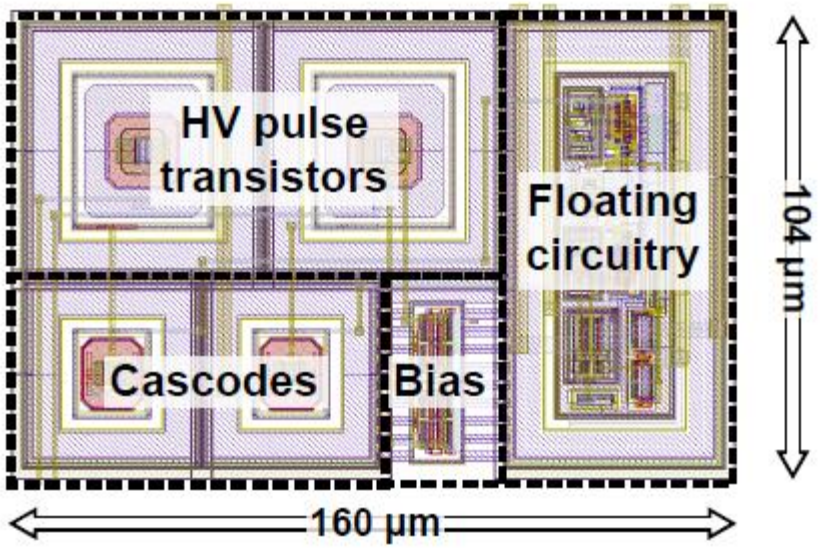


Subcircuit example: Level shifter

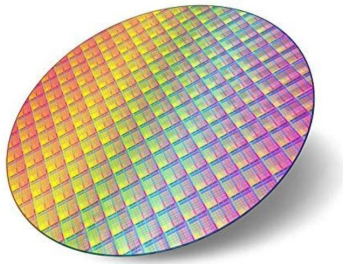




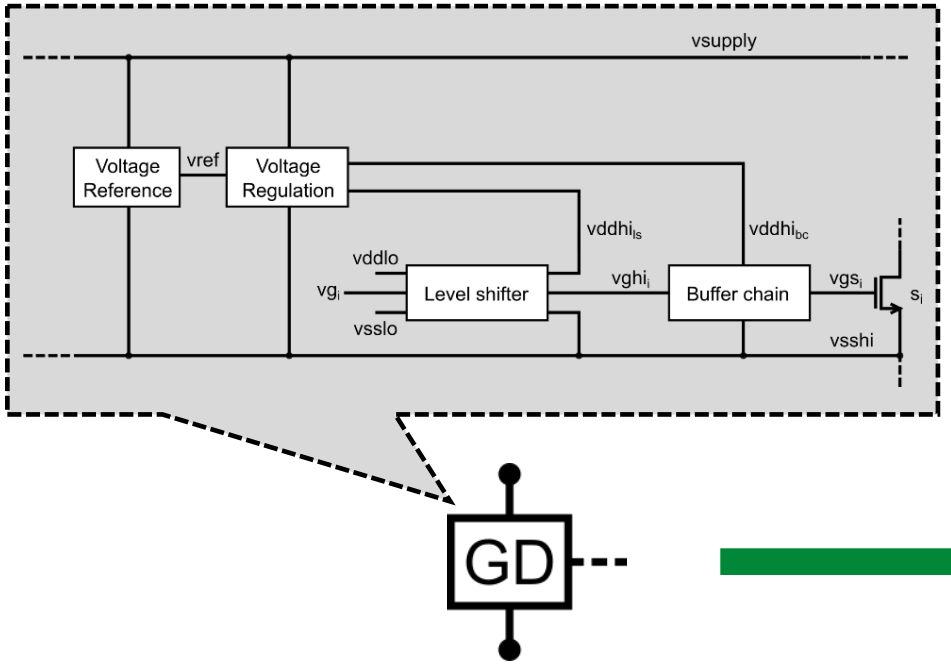
- Pulse-triggered level shifter
- Transistor-level implementation schematic
- Different transistor types for different voltage levels
- Layout:

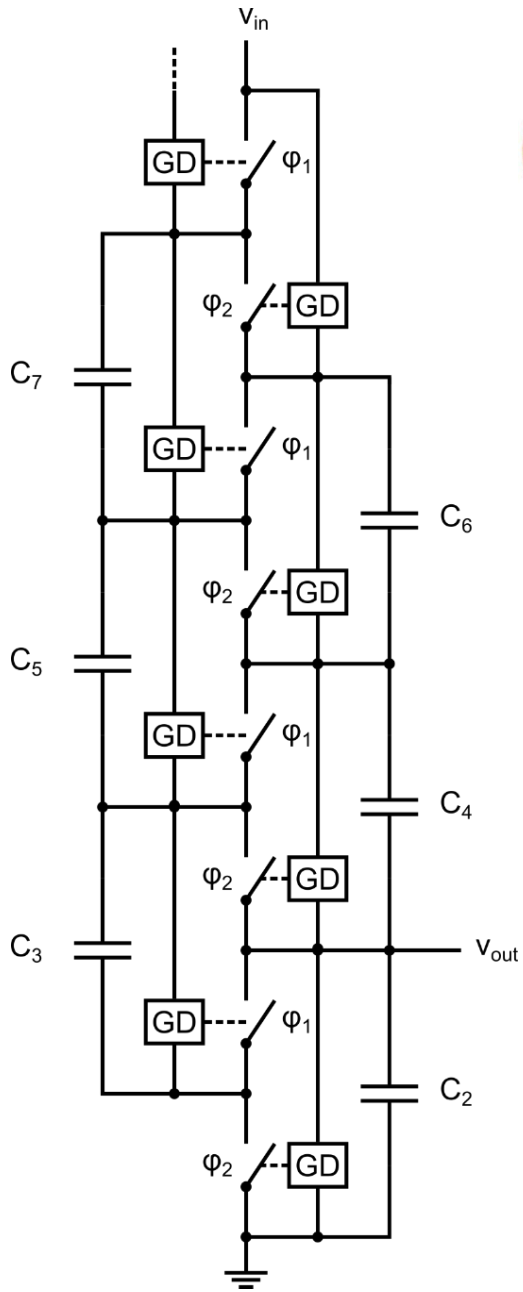


Gate driver within the IC

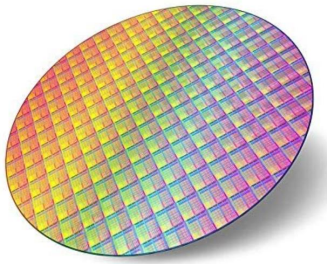


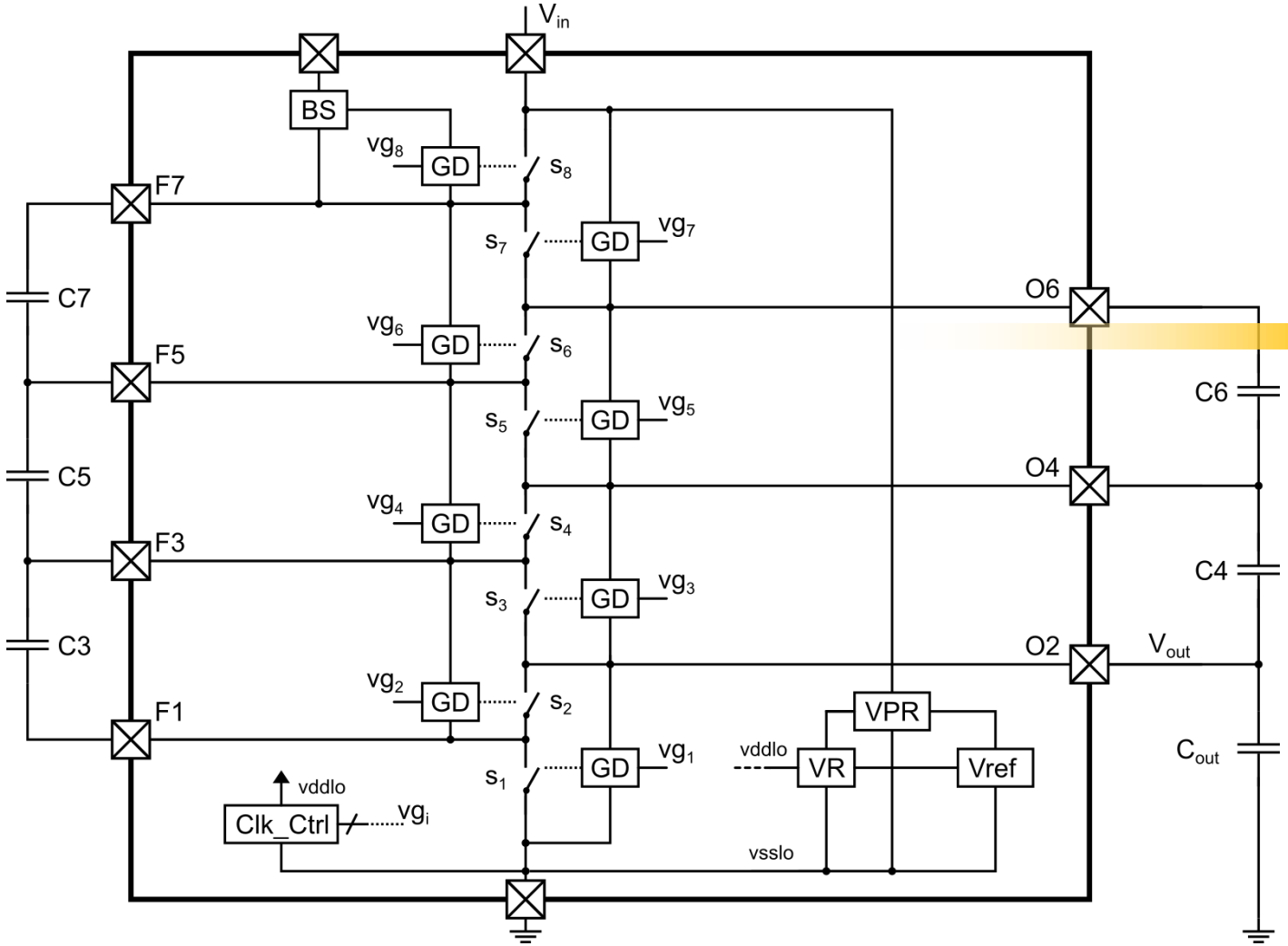
Gate driver

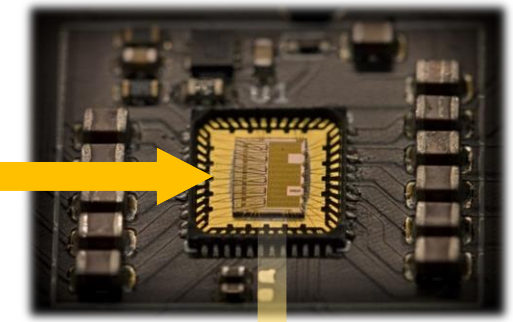


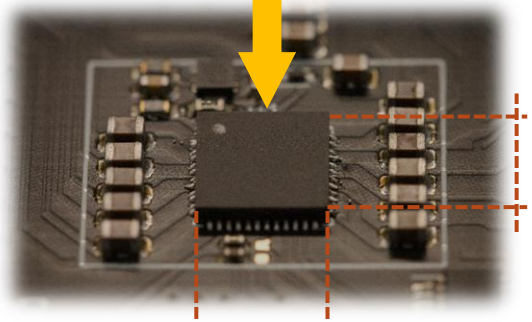


Overview of the IC (simplified)









Thank You