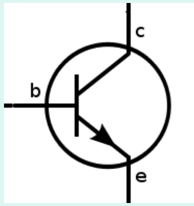
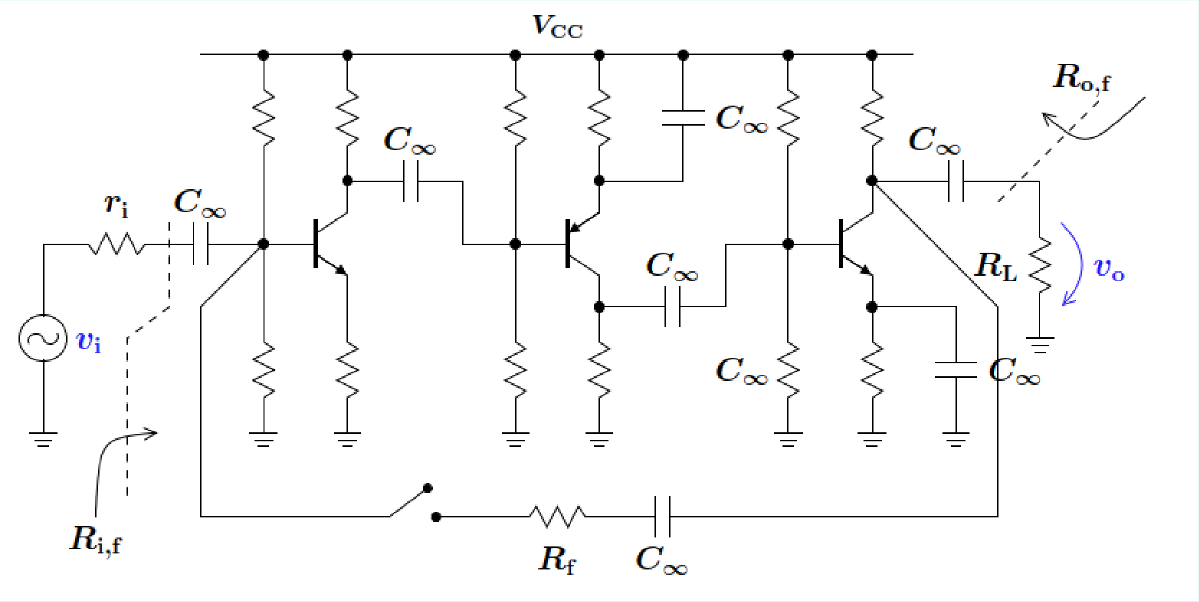
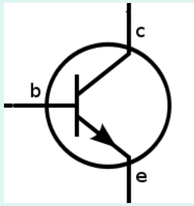


ELEC 301 - Electronic Circuits

Instructor: Edmond Cretu
Email: edmondc@ece.ubc.ca



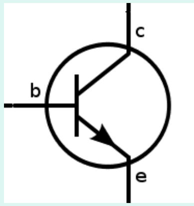


ELEC301 – Electronic Circuits

- Sep 4th , 2025

- Course description and motivation

Instructor: Edmond Cretu



Administrative issues

- **Instructor:**

Dr. Edmond Cretu

Email address:

edmondc@ece.ubc.ca

Course website: Canvas

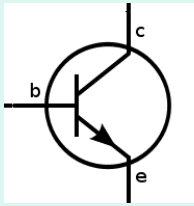
Prerequisites: Either

(a) one of ELEC 201, ELEC 203 and ELEC 202; or

(b) ELEC 204

- Lect/Tut/Lab = 4/0/0
- Mon: 3:30 - 4:30pm, MCLD2018
- Tue, Thu – 3:30 - 5pm, DMP110
- Lectures provided for download from website
- Complementary references:
- Sedra+Smith - Microelectronic Circuits
- Sansen[2006]Analog design essentials, Springer

- Articles related to specific topics



Grading system

- Final Examination: 45%
- iClicker: 5%
- Midterm: 20%
- 2-3 mini-projects: 30%

iClicker Cloud

https://lthub.ubc.ca/guides/iclicker-cloud-student-guide/#set-up-an-iclicker-account-0

iClicker Cloud Student Guide

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Access	✔	You can set up an iCl iClicker.
Bandwidth	✔	Low demand on inte
Privacy	✔	Verified by UBC's Pri

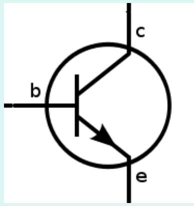
What do I need to use iClicker Cloud?

☑ A supported web browser

iClicker runs in your web browser and supports using Chrome, Firefox, or Safari. iClicker works on desktop or laptop computers, as well as mobile devices. You may find it easiest to use iClicker on a mobile device, especially if you are using your computer for other course activities.

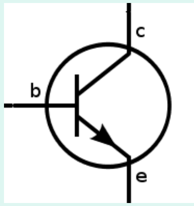
☑ A UBC iClicker student account

You will need to create an iClicker account that is associated with UBC, as outlined below.



Spice simulators

- Several available software simulators:
  - LTSpice - free, relatively intuitive and easy to use, for multiple operating systems, https://www.analog.com/en/resources/design-tools-and-calculators/ltspice-simulator.html
  - Micro-Cap - former commercial software now free, https://gotroot.ca/spectrum/www.spectrum-soft.com/download/download.html

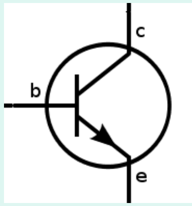


Course content sketch

Acknowledgements: Thanks to **Prof. N. Jaeger** (UBC) and **Prof. M. Sima** (U Victoria) for allowing sharing of some of their materials

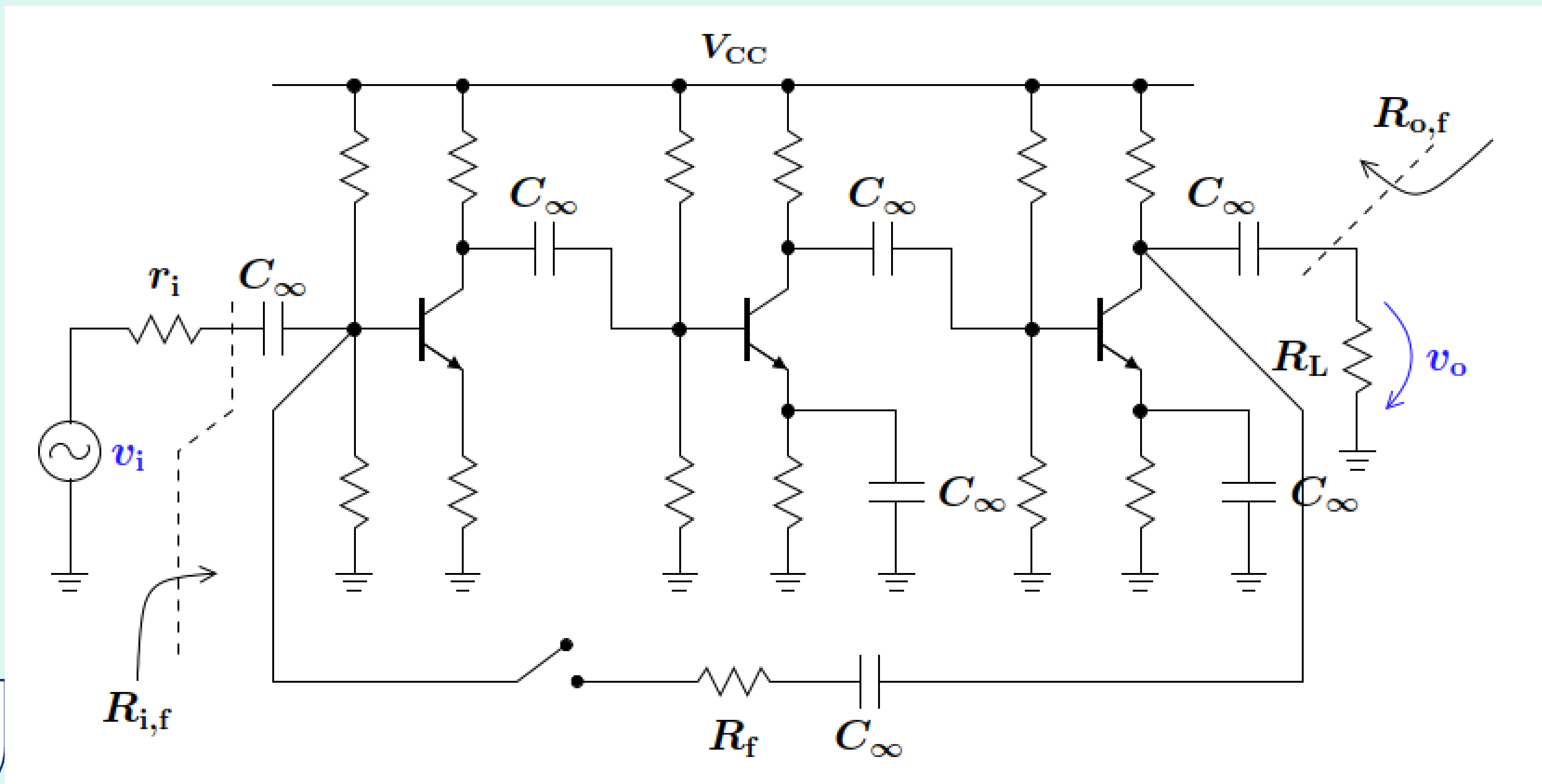
Course content at a glance:

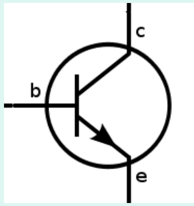
- Frequency Responses of Amplifiers
- Open-Circuit/Short-Circuit Time Constants
- Transistor bias (DC operating point)
- Small Signal Models for Transistors
- Differential Amplifiers
- Basic Op Amp Design
- Non-Ideal Characteristics of Op Amps
- Feedback Amplifiers
- Stability of Amplifiers
- Active Filters and Oscillators



Long-term goals

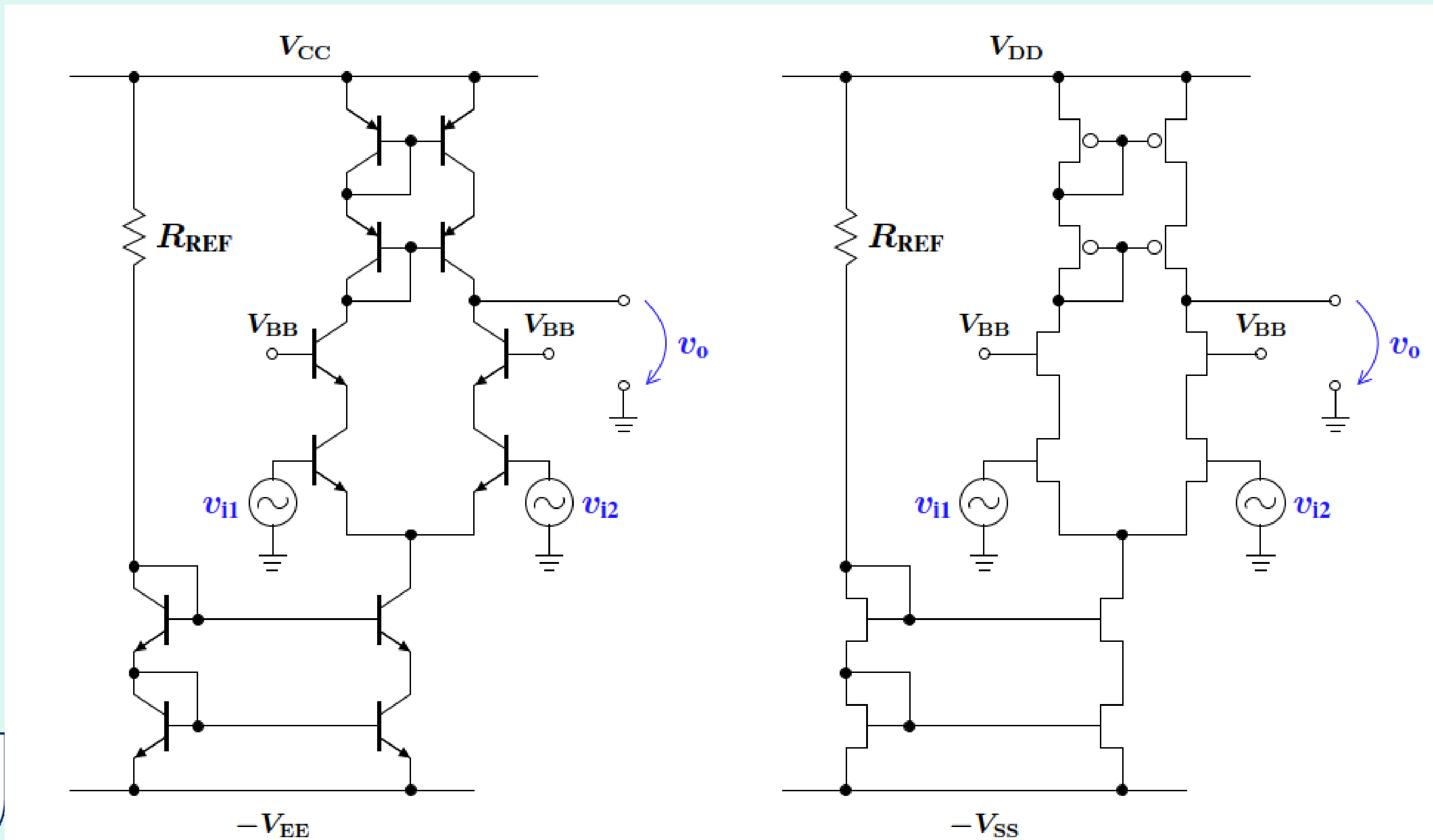
- Analyze/design analog circuits of the following complexity:





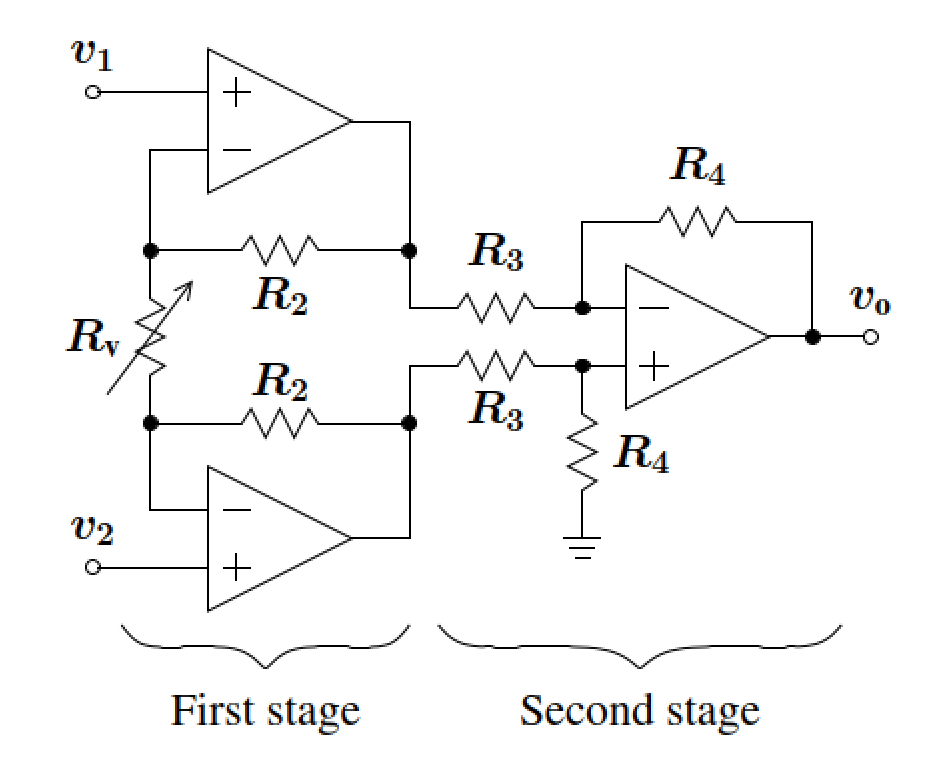
Long-term goals (2)

- Cascode differential amplifiers with active biasing and load



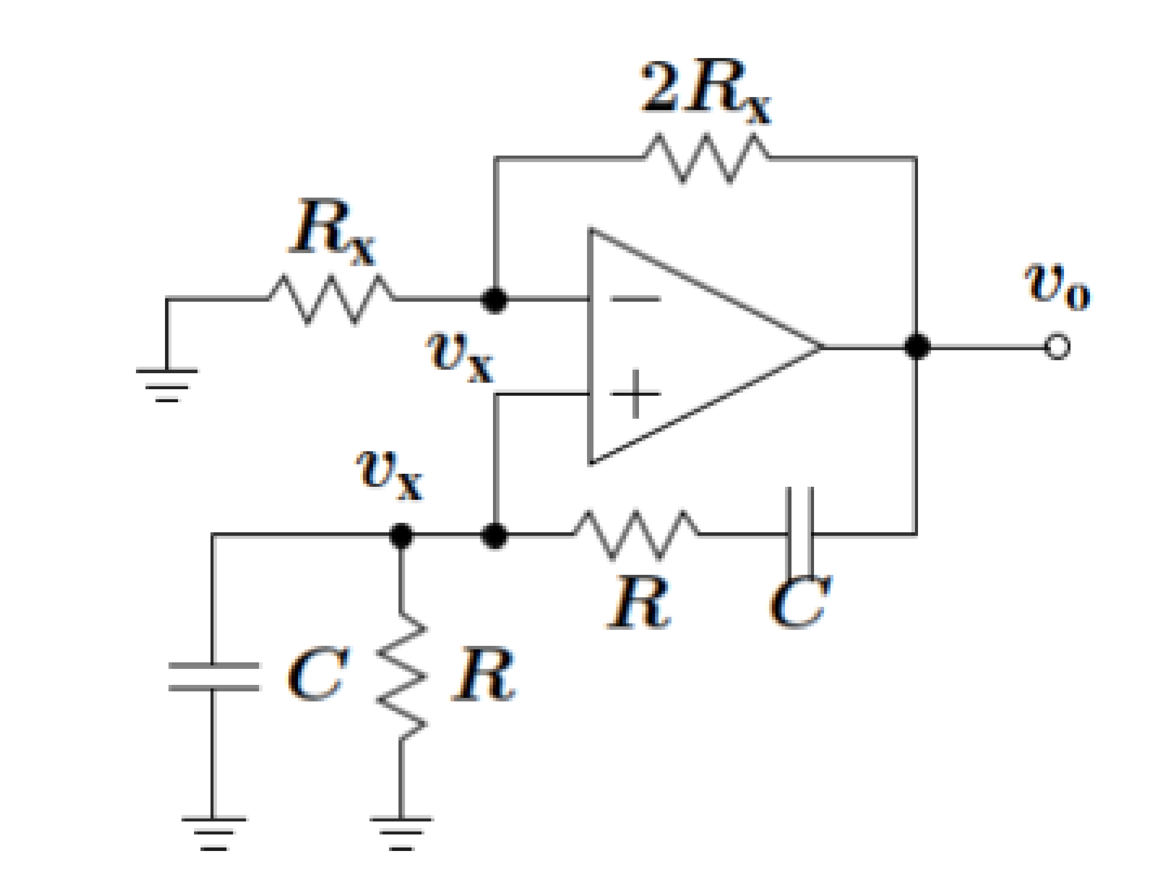
Long-term goals (3)

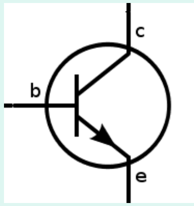
- Instrumentation amplifier with increased CMRR:



Long-term goals (4)

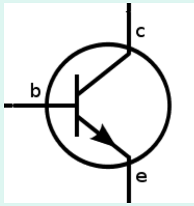
- Wien bridge oscillator:





General outcomes/expectations

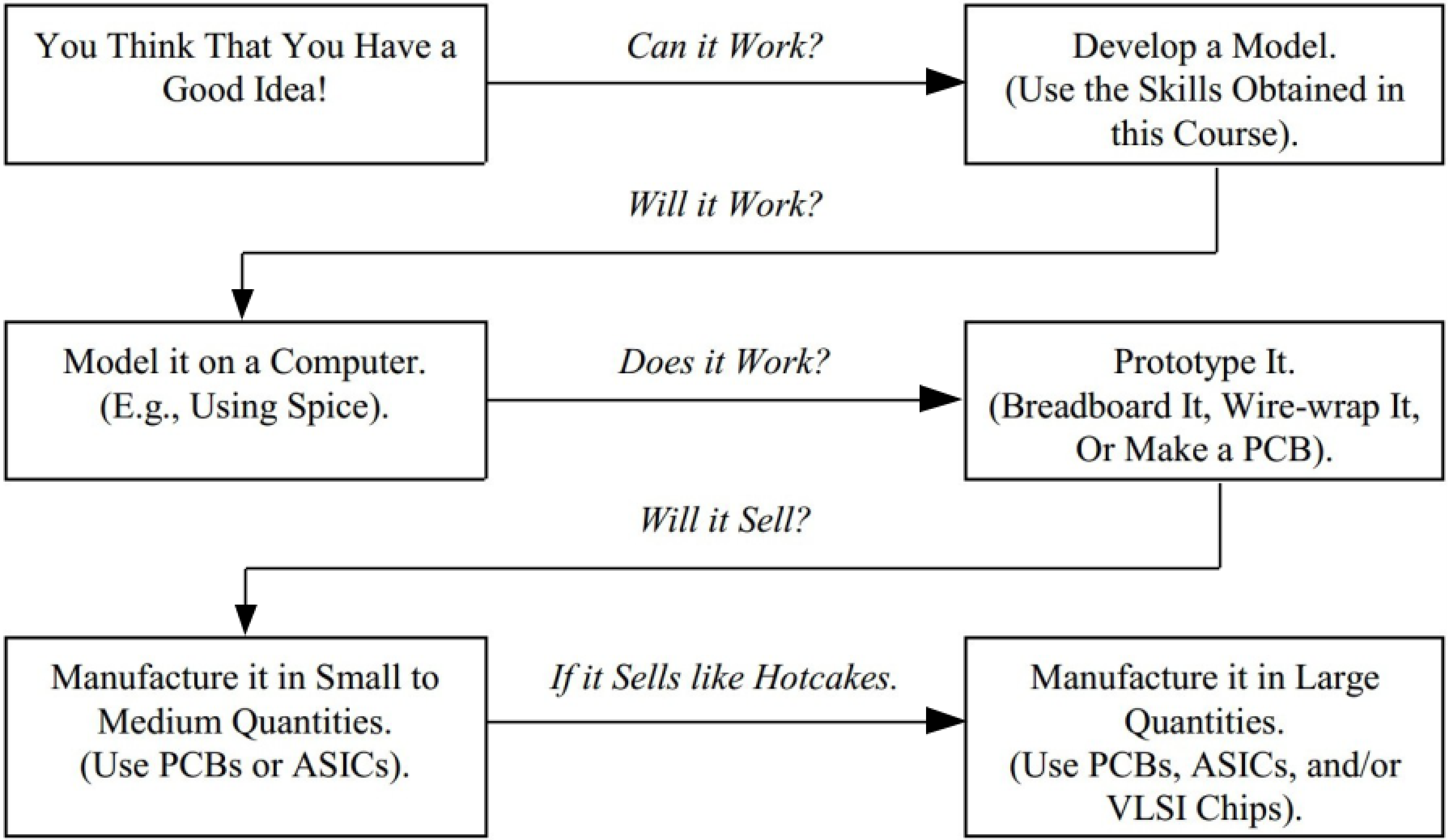
- Recognize and be Able to Analyse the Various Stages of an Operational Amplifier (opamp)
- Be Aware of Some of the Limitations and Non-Ideal Characteristics of an opamp
- Calculate the Common Mode Rejection Ratio of a Differential Amplifier or an opamp
- Calculate the Small Signal Gain and Frequency Response of a Simple Open Loop opamp
- Recognize the Four Basic Feedback Topologies
- Be Aware of the Uses of Feedback in Electronic Circuits
- Calculate the "Amount of Feedback" Applied to an Amplifier

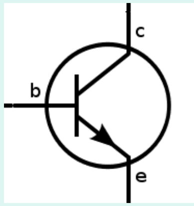


General outcomes/expectations (2)

- Apply Feedback to Various Types of Amplifier to Achieve Calculated Improvements
- Use Bode Plots to Determine the Phase and Gain Margins of an Amplifier
- Use Feedback to Shift the Poles of an Amplifier and Achieve Stability
- Find the Transfer Function for a Butterworth or Chebyshev Filter
- Design Low Pass, Band Pass, High Pass, and Notch Active Filters

Where ELEC 301 fits in





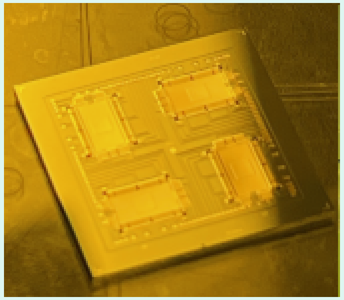
Know the instructor - Edmond Cretu

MASc in Microelectronics, PhD in Nanotechnology/MEMS - TU Delft, The Netherlands

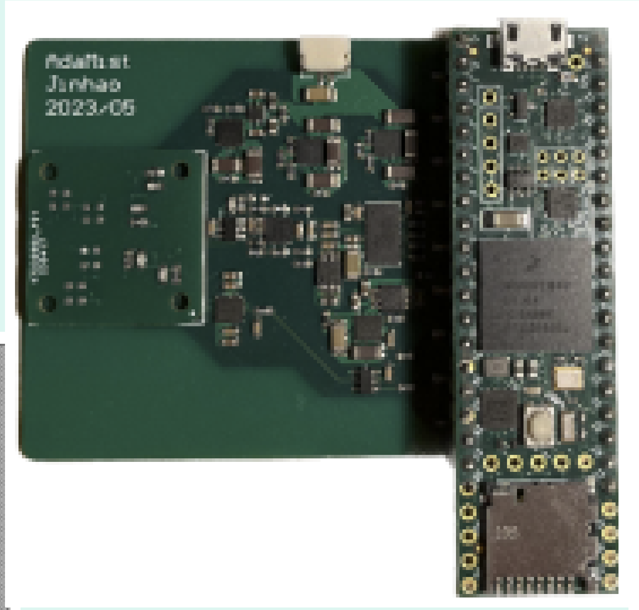
Research areas:

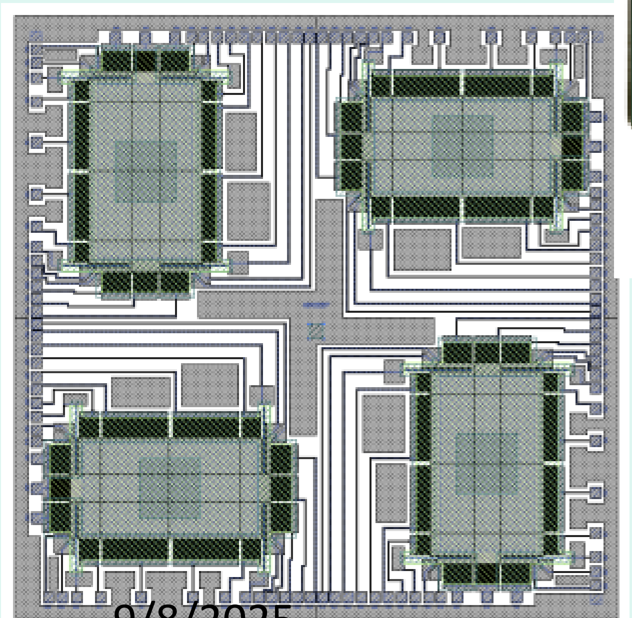
- (Alternative) microfabrication technologies: silicon and polymer-based transducers
- MEMS/Nanotechnology transducers: inertial MEMS sensors (microaccelerometers, microgyroscopes), resonant microdevices, ultrasonic transducers
- Microsystem level: MEMS + electronics interface + signal processing and control
- IoT/network systems + system level integration

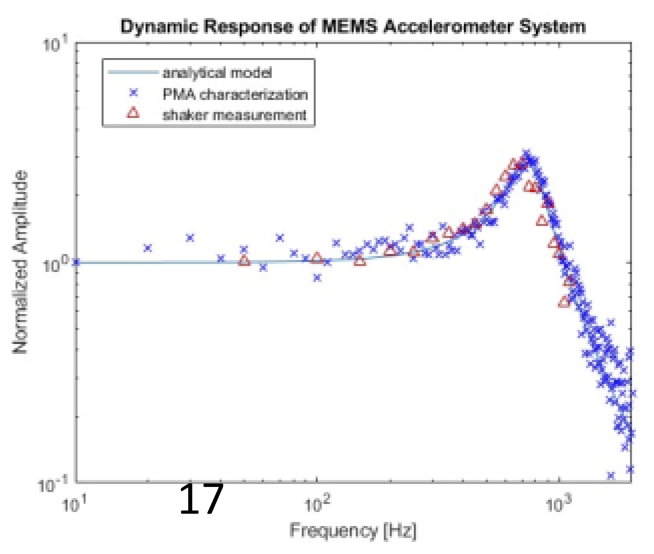
Project example 1



High-sensitivity MEMS accelerometer (MEMS = Micro-electro-mechanical system)





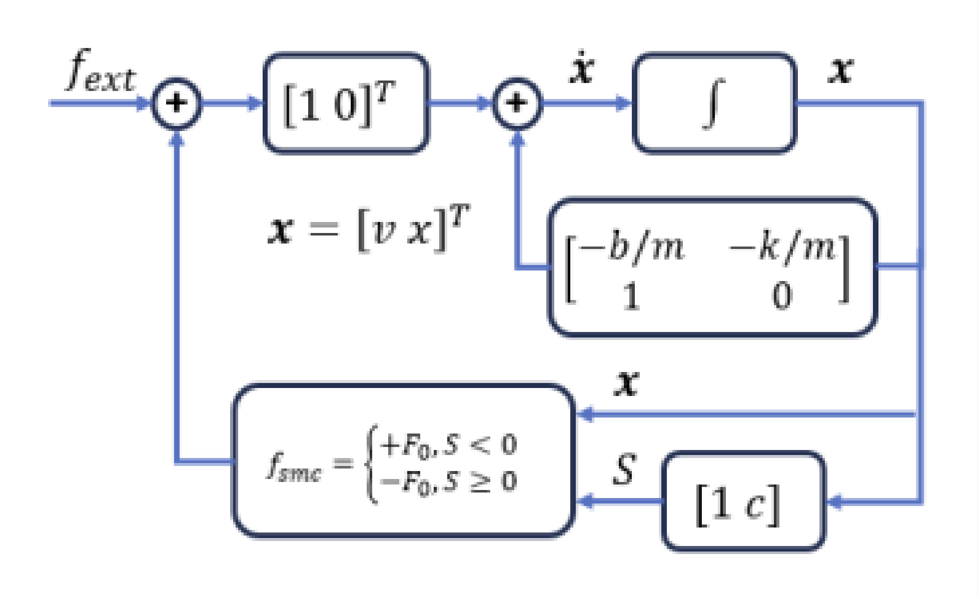


High sensitivity accelerometer (2)

Challenge: how to obtain high-sensitivity when the inertial mass is in the ng..ug range ?

Sliding mode control of MEMS devices - feedback control can maintain stability even when operating beyond the stability border

Learn to transform a limitation (loss of stability) into an advantage

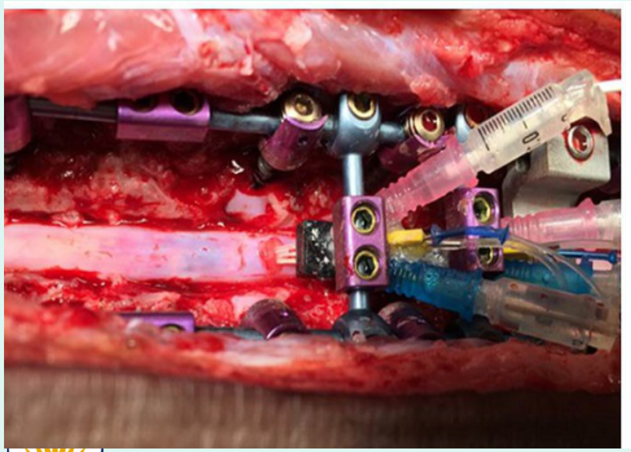


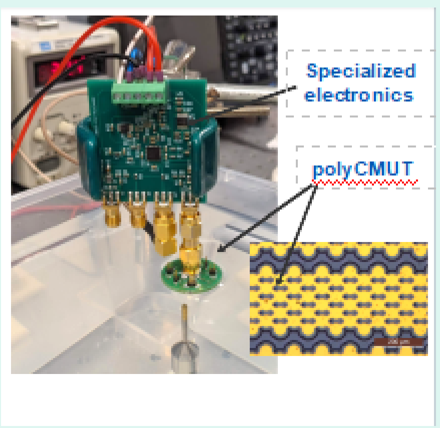
Project example 2: Mend the Gap

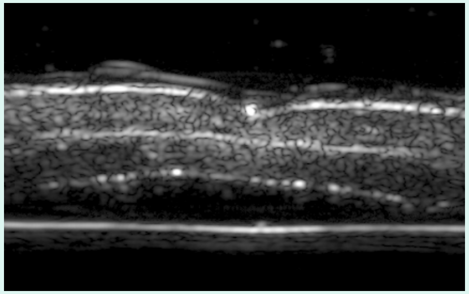
https://mendthegap.ubc.ca

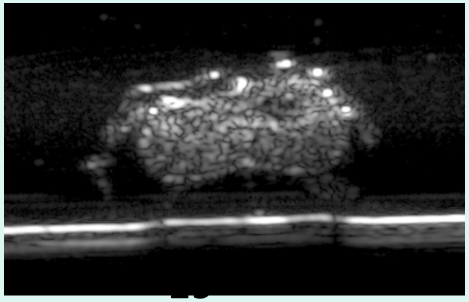
Goal: guided regeneration of the spinal cord after injury

Role: ultrasound imaging of the spinal cord, hydrogel and drug injection - monitor the evolution of the regenerative treatment of neurons





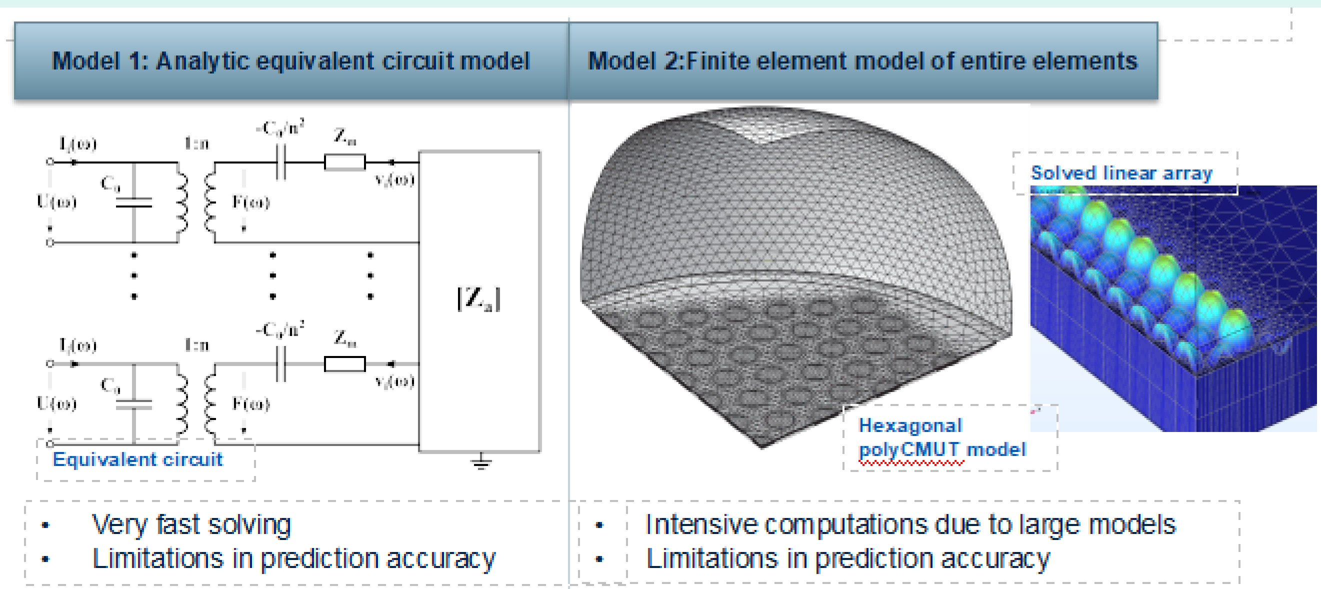


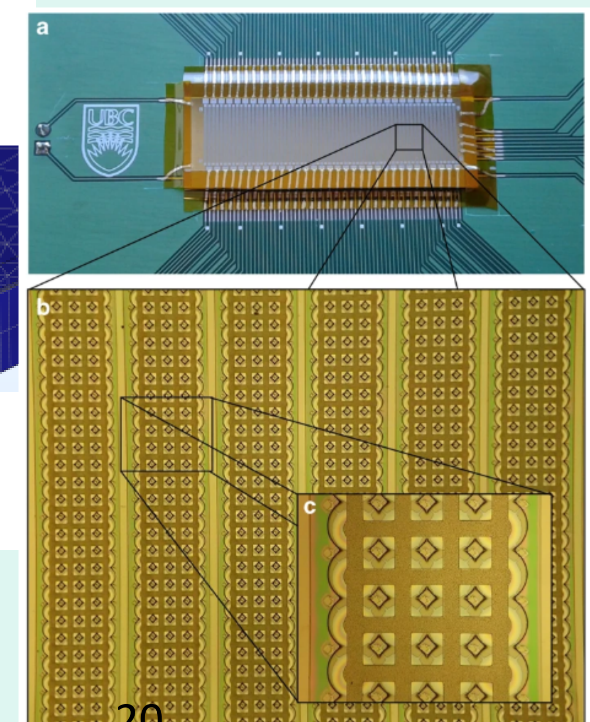


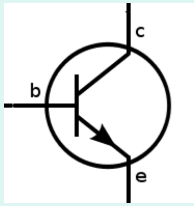
Mend the Gap (2)

PolyCMUT - ultrasound transducer arrays

Challenges: modeling complex multiple energy domain interactions (electrical + mechanical + acoustic)





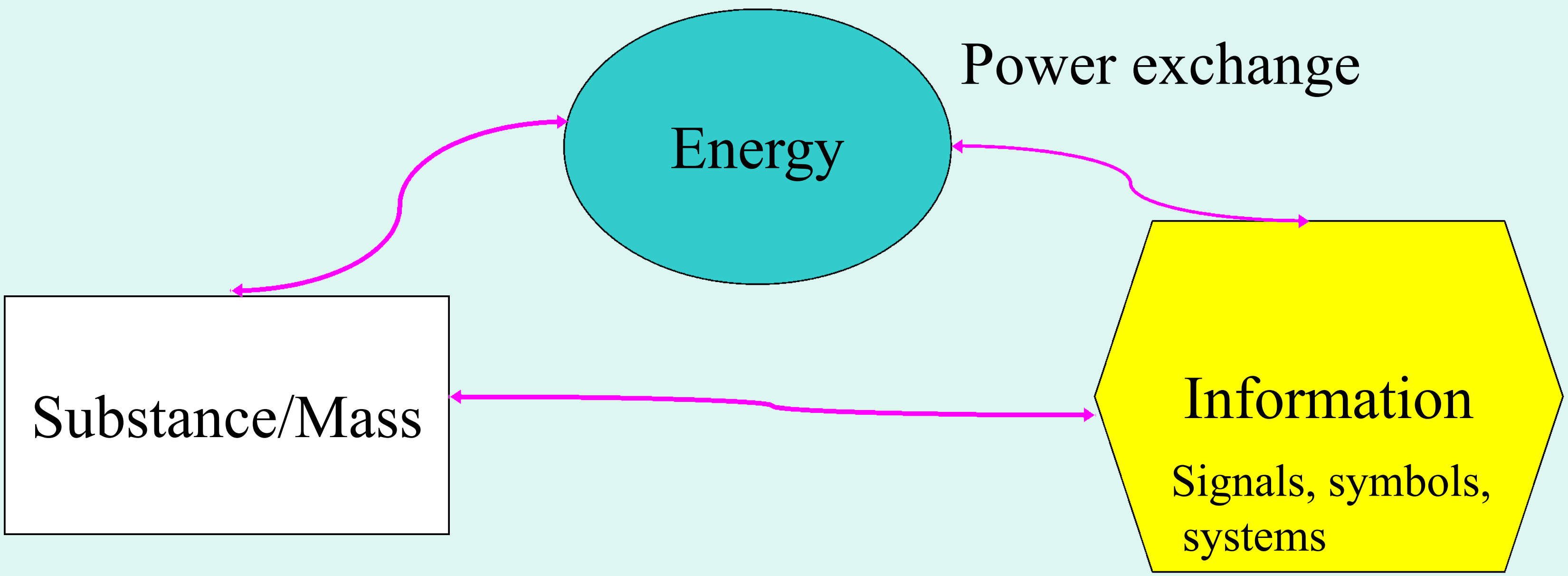


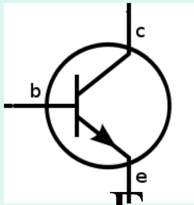
Other projects

- **Tx-Med** (Timely & Extended Monitoring in Emergencies and Disasters): VGH-UBC-Rogers collaboration to monitor patients in the emergency dept. - body sensor network + data analysis to assess patients acuity level
- **Fireline** - wildfire monitoring: using drones with sensors + fast fireline modeling framework to get a fast assessment of the wildfire dynamics and risk estimation

Unified perspective

- Engineering is all about being able to deal with a triptych in a unified manner
- General issues - their combination impose the constraints in the design space:
  - Generation/transformation aspect: processing, generation, conversion (of information/energy/substance)
  - Transmission (of information/energy/substance)
  - Storing (of information/energy/substance)

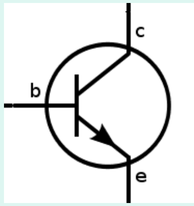




General trends in (electronic) systems

- Functionality/size increase:
  - Downscaling – trend given by microelectronics (low-power in mobile communication, minimally invasiveness)
  - Functional integration
    - Add intelligence as product differentiator
    - Emergence of low-cost sensor clusters and arrays
    - Technological advances in fabrication and packaging
- The pervasiveness of information technology:
  - Digital signal processing power ↑↑ (downscaling influence)
  - Programmability and real-time reconfigurability
  - Analog functions gradually replaced with digital equivalents (keep the analog to a minimum and correct in digital domain)

"There are only 10 types of people in the world —
those who understand binary, and those who don't."



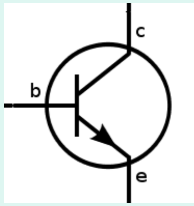
Information flow vs. energy flow

Information flow characteristics:

- Causal (input→ output)
- Signals as information carriers
- Specific modeling approaches: block diagrams, signal flow graphs, state space models (ELEC 341)
- Directionality of signal propagation makes it easier to design/analyze/synthesize very complex systems
- Specific behavioral modeling languages: VHDL, Verilog, Modelica
- Typical digital systems + software

Energy/power flow features:

- Acausal (constraint equations, e.g. constitutive equations of devices)
- Physical variables: voltage, current, charge, power
- Physical conservation laws: energy conservation, charge conservation - Kirchhoff laws
- Behavioral modeling languages: Spice, Verilog-A, Verilog-AMS, VHDL-AMS
- Typical continuous-time signal processing



Larger perspective - digital vs analog

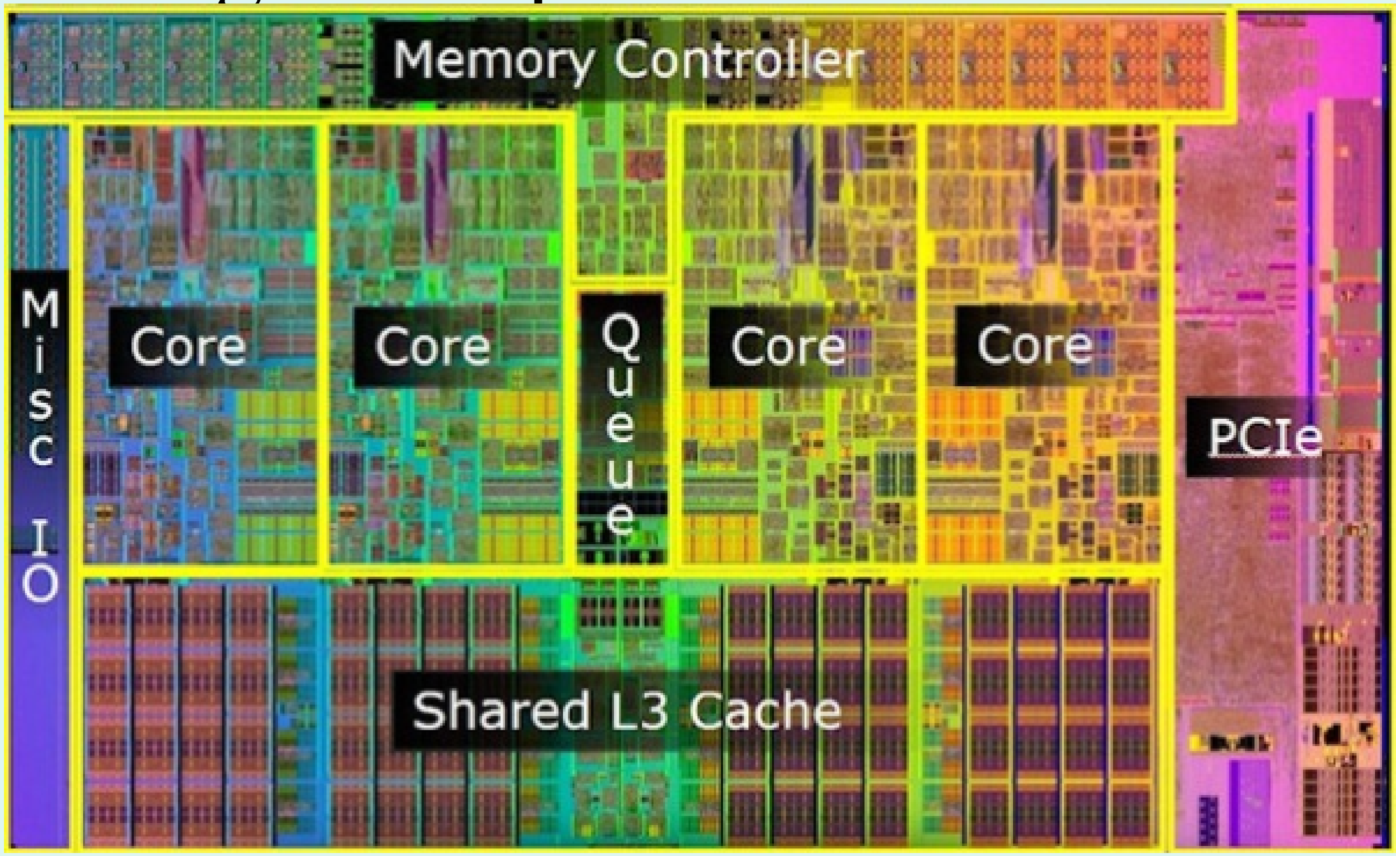
Digital hardware:

- Information flow and processing - bits, input→ output directionality
- Programmability - microprocessors, FPGA
- (Automatic) synthesis of large systems from behavioral description
- Bits, gates, memory blocks
- Typically clocked (DT) systems
- Limited noise immunity

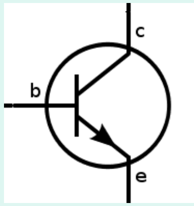
Analog hardware:

- Energy flow perspective: power-conjugate variables (voltage and currents), energy ports for input-output
- Natural way to interface to the analog universe around (sensors, actuators)
- Difficult to achieve automatic synthesis based on specifications/behavioral description
- Interconnected basic components: R,L,C, D, BJT, J-FET, MOSFET, etc.

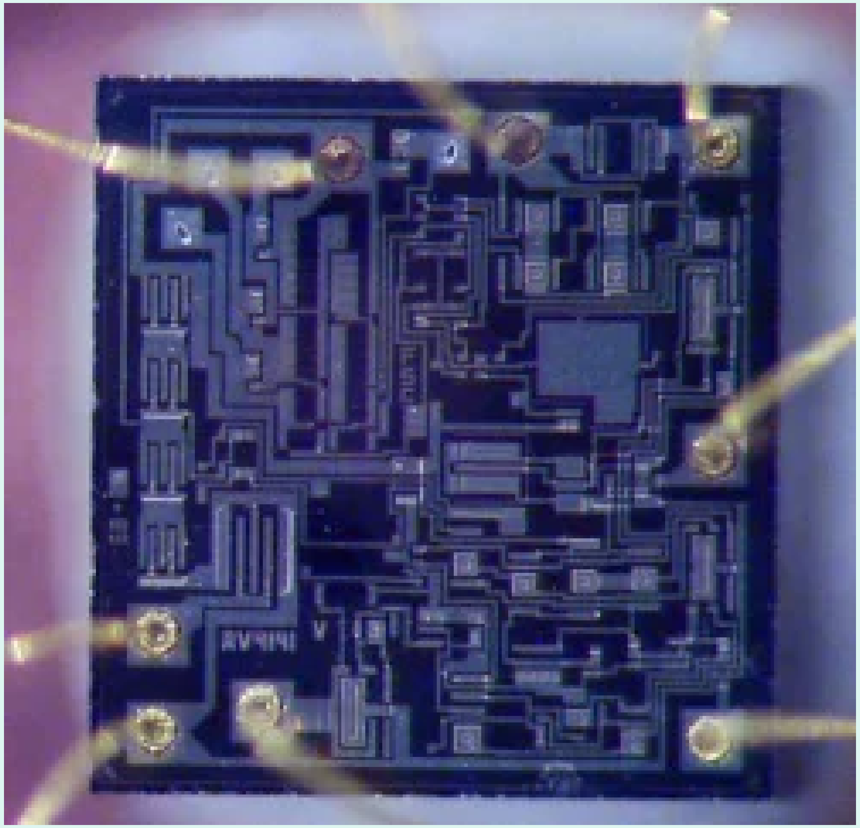
Digital chip

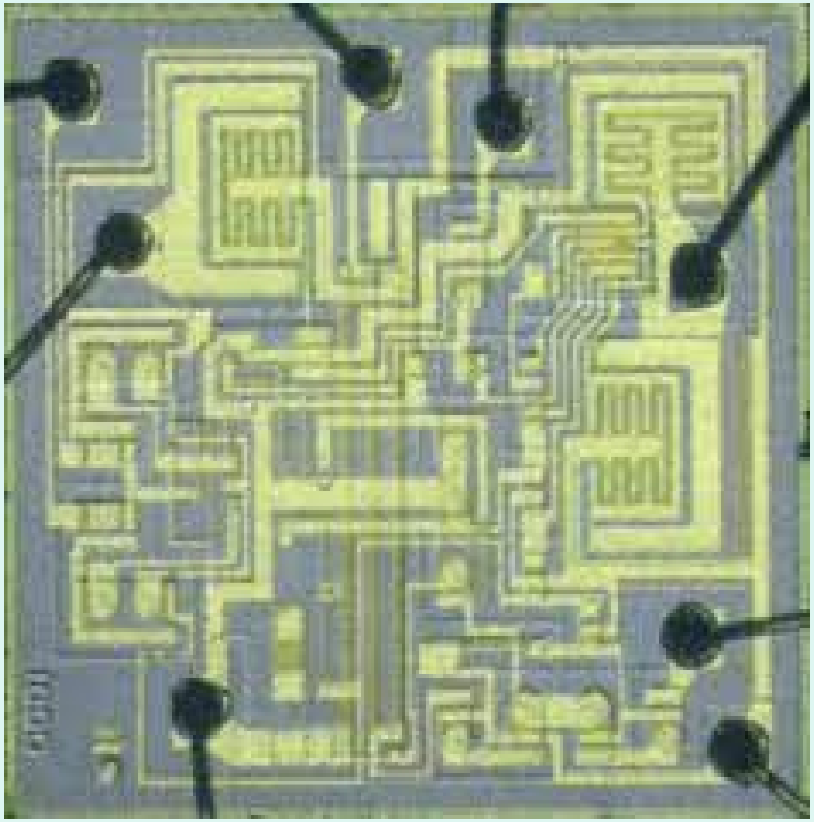


Annotated floor plan - quad core i5
Source: https://arstechnica.com/gadgets/2009/09/intel-launches-all-new-pc-architecture-with-core-i5i7-cpus



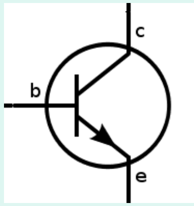
Analog chips





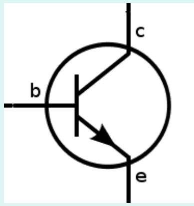
Source: https://gideonlabs.com/categories/failure-analysis-of-op-amp

555 Timer IC



Is analog electronics still relevant?

- Analog circuits serve as physical-to-digital interface
- Lower power consumption for certain operations (filtering) - use in IoT systems
- Better performance for high-speed processing (RF circuits, telecom) - avoid latencies
- Higher resolution in advanced instrumentation - no quantization errors
- Analog computing revival: Custom analog AI chips - analog processors are good for parallel processing of complex computation - efficient neural networks operations
- Information flow can be simulated by analog circuits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