# VE215 Introduction to Circuits

Instructor: Rui Yang

JOINT INSTITUTE
交大密西根学院

# About the instructor

- 2011.08 – 2016.05. Ph.D., Electrical Engineering, Case Western Reserve University


- 2016.07 – 2018.07. Postdoc Fellow, Electrical Engineering, Stanford University


- 2018.08 – 2022. Assistant Professor, UM-SJTU JI, Shanghai Jiao Tong University, Shanghai, China
- 2022 – Now. Associate Professor, UM-SJTU JI, Shanghai Jiao Tong University, Shanghai, China
  - Instructor of VE215
  - Instructor of ECE4230J
  - Instructor of VE510/ECE6209J
  - Former Instructor of VE320

# Course schedule

- Lectures: Tuesday 4:00 – 5:40 pm (Beijing time)
  Thursday 4:00 – 5:40 pm (Beijing time)
- Location: DZY-2-206 (at least weeks 1-6)
- My office hours: Tuesday 1-3pm. Or ping me on Feishu or Piazza anytime if you have questions.
- Recitation: TBD
- TA:

– Mingnan Yao（姚明楠）, Email: yao_mn@sjtu.edu.cn
– Jingyu Liu（刘璟昱）, Email: liujingyu@sjtu.edu.cn

# My contact

- Office location:
  Rm. 434, UM-SJTU JI Building (You can discuss with me online through Feishu, email or Piazza)

- Office tel:
  3420-8540 ext. 4341

- Email:
  rui.yang@sjtu.edu.cn

# Feishu group


仅限企业内部成员加入

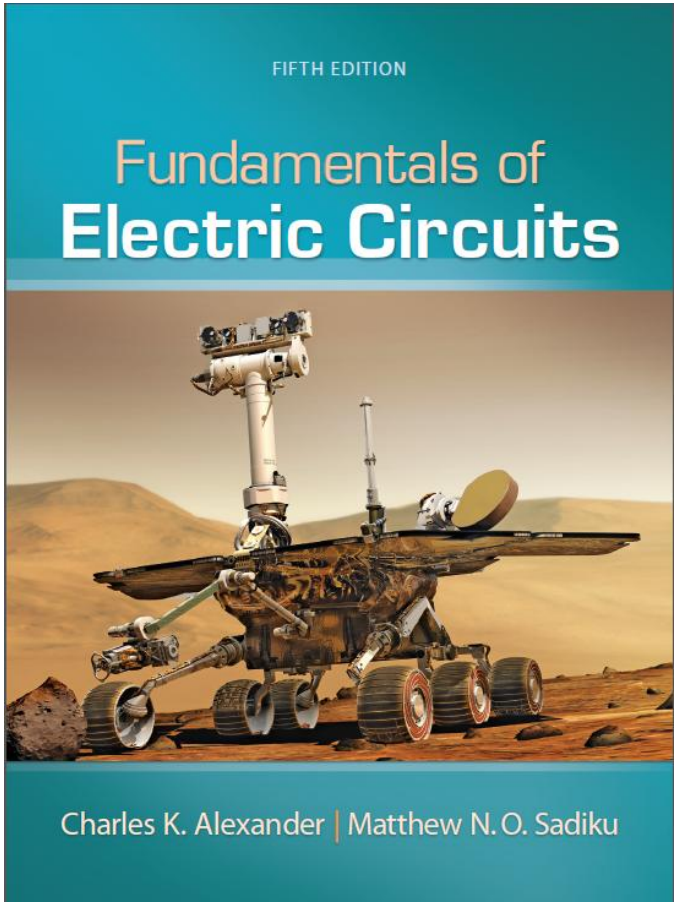
该二维码 1 年内 (2026/4/29前)有效

# Course expectation and requirement

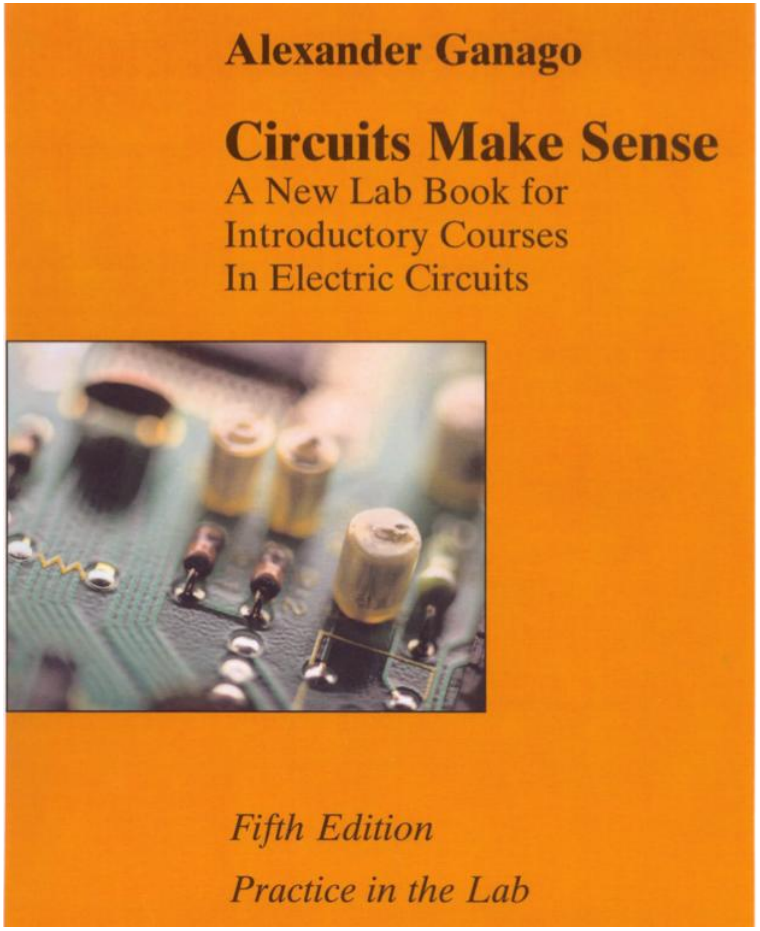
- Pre-requisites: VV156 or VV186, VG101
- Co-requisites: VP240 or VP260
- Basic college math and physics
  - Scalar & Vector
  - Differentiation & Integration
  - Electric Charge
  - Current & Voltage

# Textbook

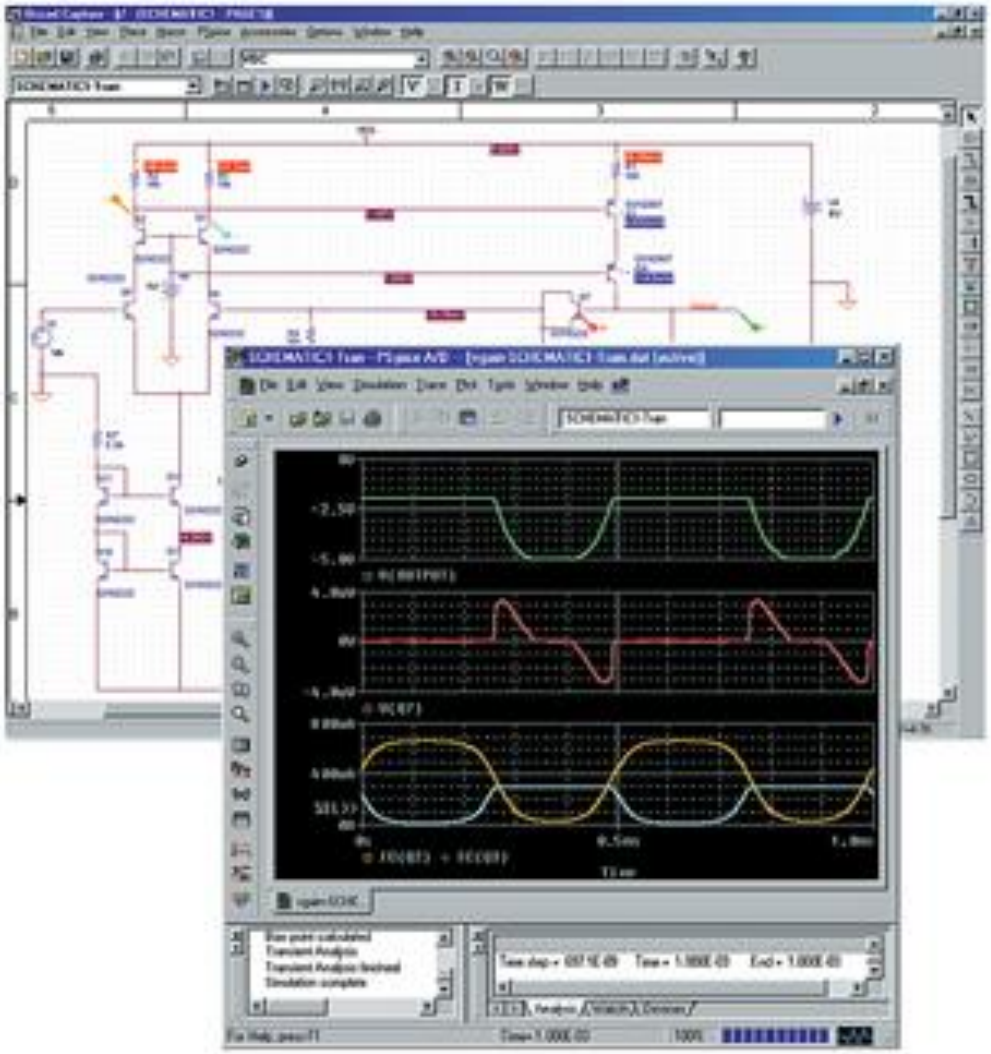
Main Textbook




Laboratory book



# Computer Aided Design - CAD



- PSPICE CAD tool to simulate most analog and digital circuits.
- Demo version available online for free. https://www.orcad.com/pspice-free-trial
- Download link of PSPICE will also be posted on Canvas for convenience.
- Some tutorial posted on Canvas.
- Also check online tutorials, such as https://www.bilibili.com/video/BV1Wb41177J1

# Lab

- 9 labs in total, ~3 hours each
- Time: will be announced
- Change in the policy of report:

Previous: pre-lab and post-lab,

Now: 1 single report is enough. But make sure you read the materials carefully before the lab.

- Try to finish the lab report during the lab sessions. If you cannot finish it within the lab session, notify the TAs and send to them asap.
- Lab: You are recommended to get familiar with PSPICE before the lab sessions.

# Grading policy

- Ve215 has about 8 problem sets (homework assignments), random in-class quizzes (also for checking attendance), 9 labs, and 2 exams:
- In-class Quizzes: 10%
- Problem Sets: 10%
- Labs: 15%
- Exam 1 (Midterm Exam): 30%
- Exam 2 (Final Exam): 35%

# The JI Honor Code

- Personal integrity as students and professionals.
- Respect other people and their work.
- Respect yourself and your own efforts.
- Applicable to all your academic activities here, including homework, quizzes, lab reports, projects and exams.
- Violations will be reported to the Honor Council.
  - Copy other student's homework, quizzes, lab reports, exams.
  - Illegal copy of online resource and academic literatures.
  - Helping others on the abovementioned activities.
  - Fake ID for exams.

# Class rules

- Please do not come in late and do not get up to leave until the class is dismissed.
- You are responsible for all material covered in class, whether or not it is in the book.

# Homework rules

- Homework will be assigned online at Canvas as scheduled. They are usually due one week later or specified otherwise. One day automatic grace period. Second day late penalty - 25%, later no credit.

- Students should complete the homework independently. Copy of others' homework is not allowed and is a violation to the Honor Code.

- Students on campus should hand in the homework in person. Students outside of China can take a photo of the homework or type them electronically, and then upload on Canvas.

- Solutions will be posted on Canvas about two days after the due date.

# Quiz

- We will have random quizzes.
- Open book, open discussion.
- We will not focus on whether your final answer is correct but we will mainly check your solution process, *i.e.*, You need to write your thinking steps related to the question. Do not simply write the answer, or simply copy the textbook equations without your thoughts.
- Also for checking attendance.
- No make-up quizzes are allowed.
- Handing in the quiz deserves half of the total points automatically (blank page doesn't count).

# Exam rules

- There will be one midterm exam and one final exam.
- Each lasts 100 minutes, will be conducted offline.
- Students should complete the exam independently. No talk and collaboration are allowed.
- Closed book, cheat sheet may be allowed.
- No electronic devices except basic calculators will be allowed to use.

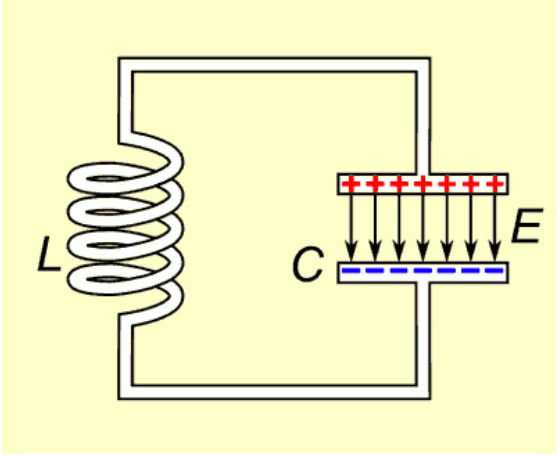
# Tentative schedule: (subject to change)

| Week | Date | Lecture Topics | Homework: main content; may vary slightly | Labs |
|---|---|---|---|---|
| 1 | May 13 | Introduction to Ve215, Ch1. Basic concepts | | |
| | May 15 | Ch2. Basic laws | | |
| 2 | May 20 | Ch3. Methods of analysis | | |
| | May 22 | Ch3. Methods of analysis | HW1: Chaps. 1-3 | |
| 3 | May 27 | Ch4. Circuit theorems | | Lab1 |
| | May 29 | Ch5. Operational amplifiers | HW2: Chap. 4 | |
| 4 | Jun 3 | Ch5. Operational amplifiers | | Lab2 |
| | Jun 5 | Ch6. Capacitors and inductors | HW3: Chaps. 5,6 | |
| 5 | Jun 10 | Ch7. First-order circuits | | Lab3 |
| | Jun 12 | Ch8. Second-order circuits | | |
| 6 | Jun 17 | Ch8. Second-order circuits | HW4: Chaps. 7,8 | Lab4 |
| | Jun 19 | Ch9. Sinusoids and phasors | | |
| 7 | Jun 24 | No lecture, Midterm Exam | | |
| | Jun 26 | Ch9. Sinusoids and phasors | | |
| 8 | Jul 1 | Ch10. Sinusoidal steady-state analysis | HW5: Chaps. 9,10 | Lab5 |
| | Jul 3 | Ch11. AC power analysis | | |
| 9 | Jul 8 | Ch11. AC power analysis | | Lab6 |
| | Jul 10 | Ch12. Three-phase circuits | | |
| 10 | Jul 15 | Ch12. Three-phase circuits | HW6: Chaps. 11,12 | Lab7 |
| | Jul 17 | Ch13. Magnetically coupled circuits | | |
| 11 | Jul 22 | Ch13. Magnetically coupled circuits | | Lab8 |
| | Jul 24 | Ch13. Magnetically coupled circuits | HW7: Chap. 13 | |
| 12 | Jul 29 | Ch14. Frequency response | | Lab9 |
| | Jul 31 | Ch14. Frequency response | HW8: Chap. 14 | |
| 13 | Aug 4-8 | No lecture, Final Exam | | |

# What are circuits?

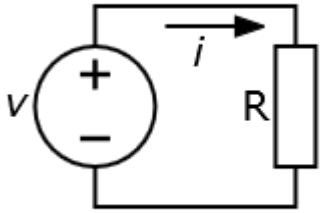
# Circuit – Electrical Engineering

- In **electrical engineering**
  - Circuit analysis
  - Analog circuit or Digital circuit
  - Integrated circuit
    - Mixed-signal integrated circuit
  - Asynchronous circuit or Synchronous circuit
  - Printed circuit board (PCB)
  - Series and parallel circuits
  - Telecommunication circuit
  - Circuit diagram
  - Balanced circuit
  - LC circuit



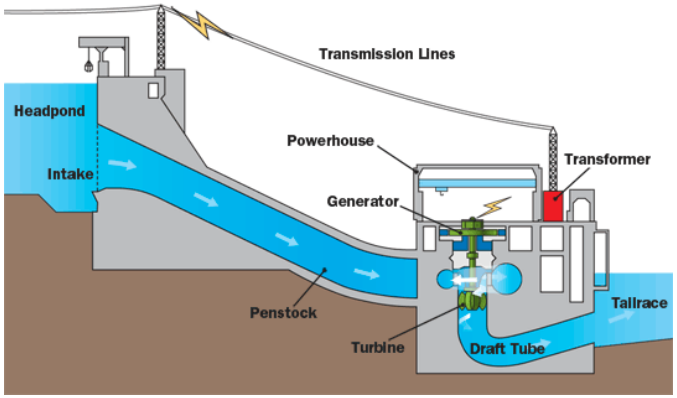
# Electrical circuit

- An **electrical circuit is a path in which electrons from a voltage or** current source flow.
- Electric current flows in a closed path called an electric circuit.
- A simple electrical circuit. This circuit has a power source, a complete path for electrons to flow, and a resistor as the load.



# Electrical circuits and electronic circuits

- **Electrical circuits**
  - Usually use alternating current sources
  - Load: refrigerators, televisions, or microwave ovens; the output of a hydroelectric power generating station.




- **Electronic circuits**
  - Usually use low voltage direct current sources
  - Load: the flash in a digital camera; the microprocessors.

# More on electronic circuit

- Definition:

  An electronic circuit is composed of individual electronic components, such as resistors, transistors, capacitors, inductors and diodes, connected by conductive wires or traces through which electric current can flow.

- Function:

  The combination of components and wires allows various simple and complex operations to be performed:

  - signals can be amplified
  - computations can be performed
  - data can be moved from one place to another.

# More on electronic circuit

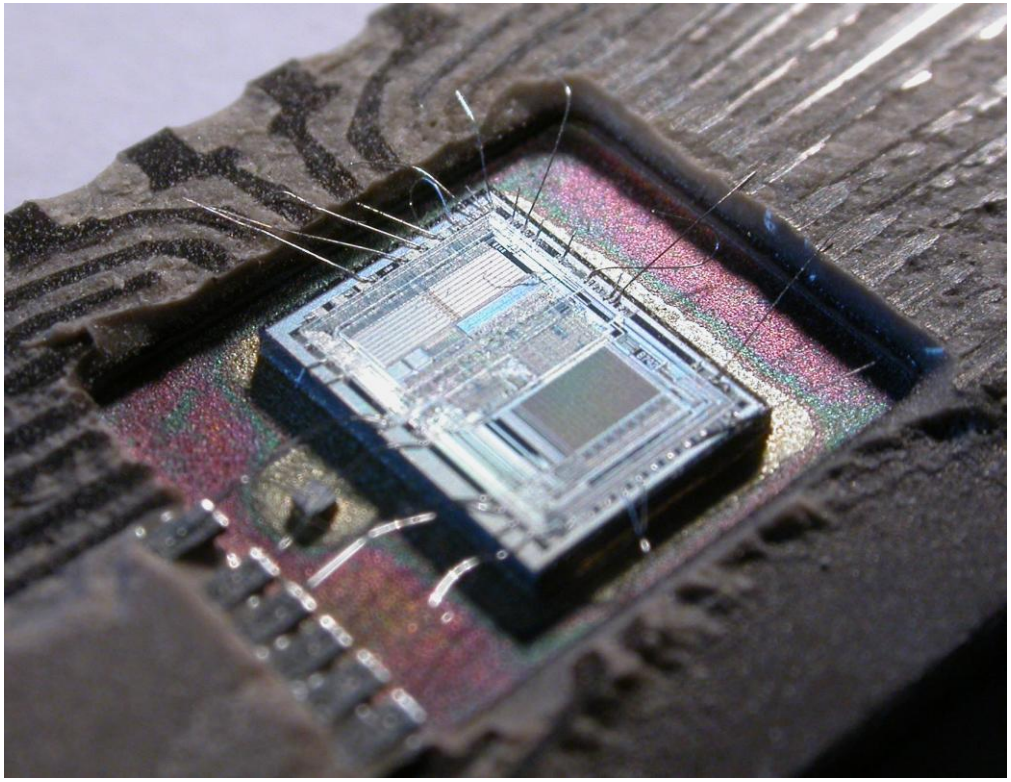
- Print circuit board (PCB):

  Circuits can be constructed of discrete components connected by individual pieces of wire, but today it is much more common to create interconnections by photolithographic techniques on a laminated substrate (a printed circuit board or PCB) and solder the components to these interconnections to create a finished circuit.

# More on electronic circuit

- Integrated circuit (IC)

  In an integrated circuit or IC, the components and interconnections are formed on the same substrate, typically a semiconductor such as silicon or (less commonly) gallium arsenide.



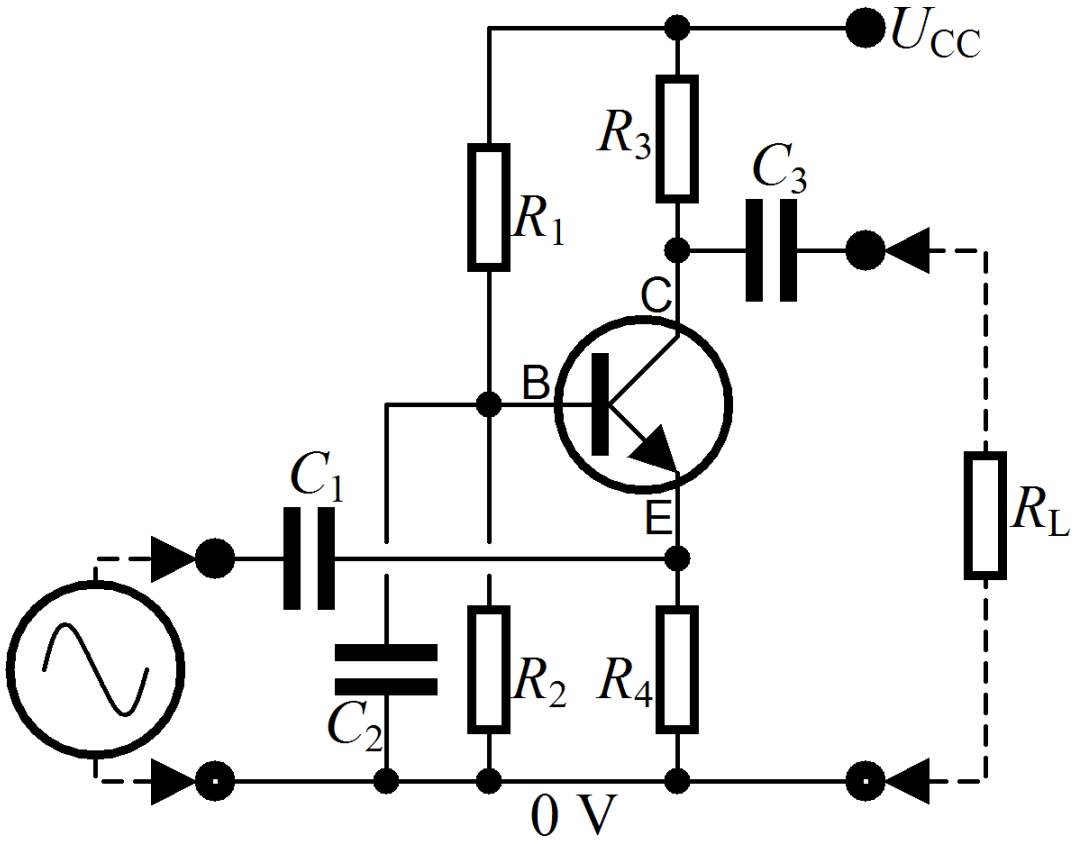
The die from an Intel 8742, an 8-bit microcontroller that includes a CPU, 128 bytes of RAM, 2048 bytes of EPROM, and I/O in the same chip.

# Categories of electronic circuit

- Analog circuits
- Digital circuits
- Mixed-signal circuits (a combination of analog circuits and digital circuits).

# Analog circuits

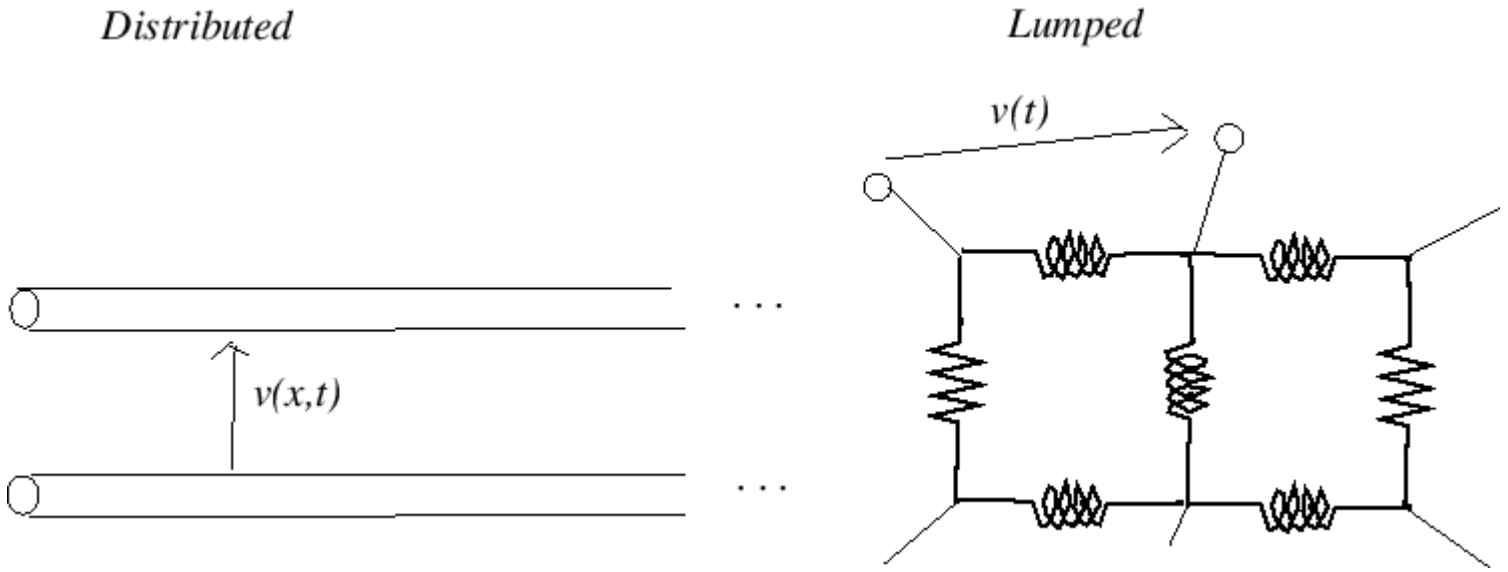
- Analog electronic circuits are those in which current or voltage may vary continuously with time to correspond to the information being represented.




A circuit diagram representing an analog circuit, in this case a simple amplifier

# Lumped and distributed

- A lumped system is one in which the dependent variables of interest are a function of time alone.
- A distributed system is one in which all dependent variables are functions of time and one or more spatial variables.



# Analog circuits

- Analog circuit analysis employs Kirchhoff's circuit laws: all the currents at a node (a place where wires meet), and the voltage around a closed loop of wires is 0.
- Applicability/Validity

  $L_c$: circuit's characteristic length; $\lambda$: circuit's operating wavelength

  – The lumped element model ($L_c << \lambda$):
    - Ignores the finite time it takes signals to propagate around a circuit.
    - The attributes of the circuit elements are **concentrated into idealized electrical components** (resistors, capacitors, and inductors, etc.) joined by a network of **perfectly conducting wires**.

  – Distributed circuit model ($L_c \sim \lambda$):
    - When the circuit size is comparable to a wavelength of the relevant signal frequency
    - Such considerations typically become important for circuit boards at frequencies above a GHz.

# Digital circuits

- In digital electronic circuits, electric signals take on discrete values, to represent logical and numeric values.

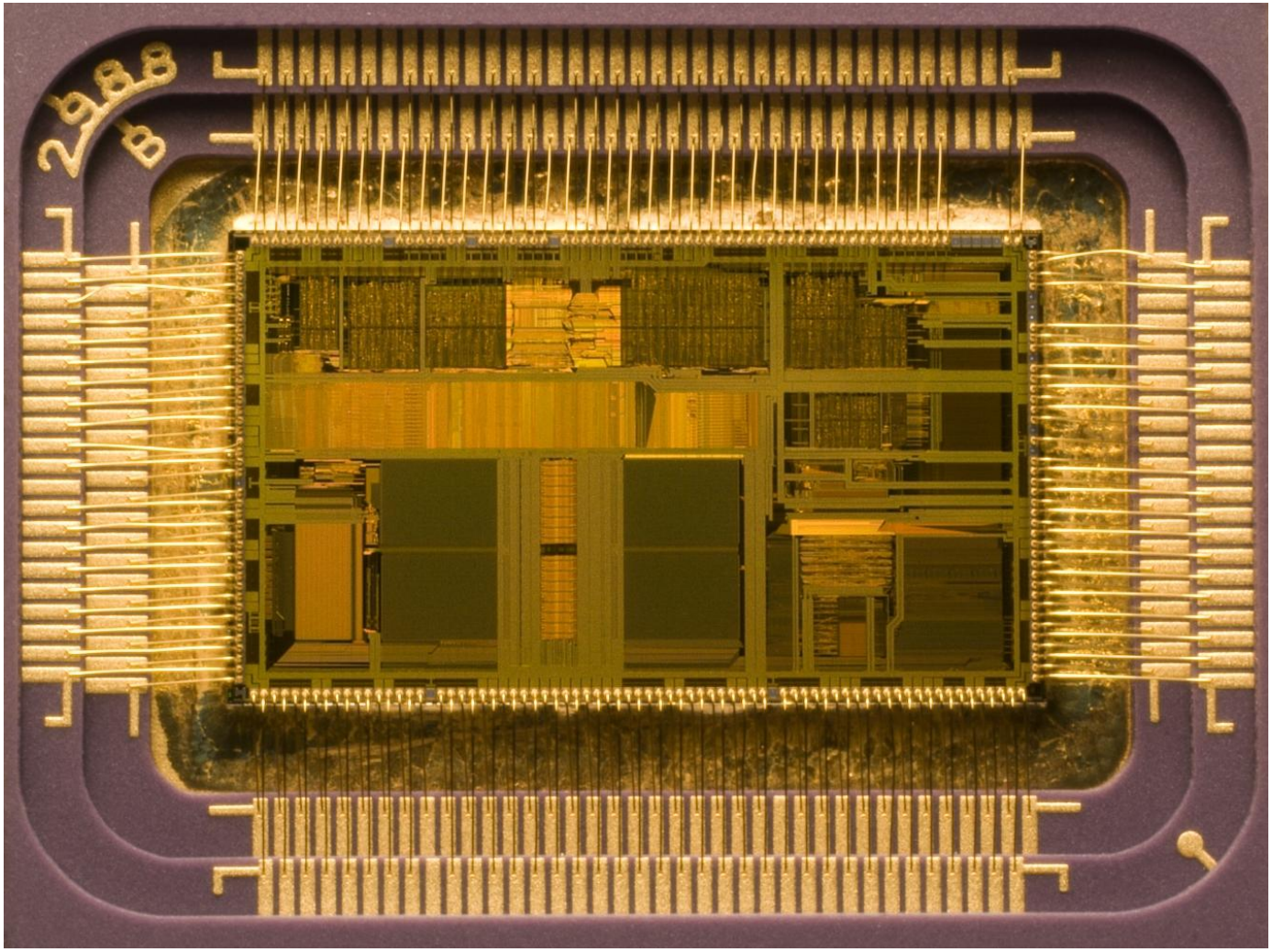
- In the vast majority of cases, binary encoding is used: one voltage (typically the more positive value) represents a binary '1' and another voltage (usually a value near the ground potential, 0 V) represents a binary '0'.

- Digital circuits make extensive use of transistors, interconnected to create logic gates that provide the functions of Boolean logic: AND, NAND, OR, NOR, XOR and all possible combinations thereof.

# Digital circuits

- Advantages over analog circuits:
  - Each logic gate regenerates the binary signal, so the designer need not account for distortion, gain control, offset voltages, and other concerns faced in an analog design.
  - Extremely complex digital circuits (billions of logic elements integrated on a single silicon chip) can be fabricated at low cost.
- Digital circuitry
  - General purpose computing chips, such as microprocessors
  - Custom-designed logic circuits, known as application-specific integrated circuit (ASICs).
  - Field-programmable gate arrays (FPGAs), chips with logic circuitry whose configuration can be modified after fabrication
- Applications
  - Ubiquitous in modern electronic devices

# Digital circuits-microprocessor




Intel 80486DX2 microprocessor

# Digital circuits-FPGA


FPGA from Altera


FPGA from Xilinx

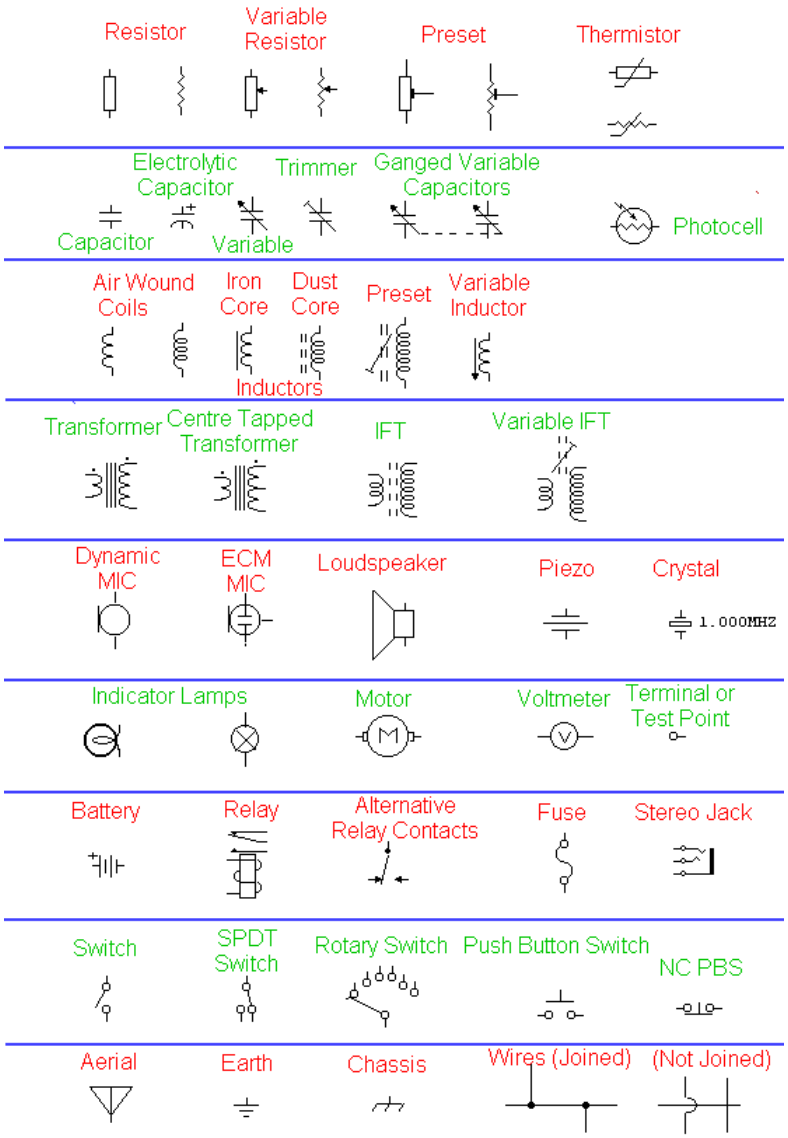
# Mixed-signal circuits

- Definition: Mixed-signal or hybrid circuits contain elements of both analog and digital circuits.

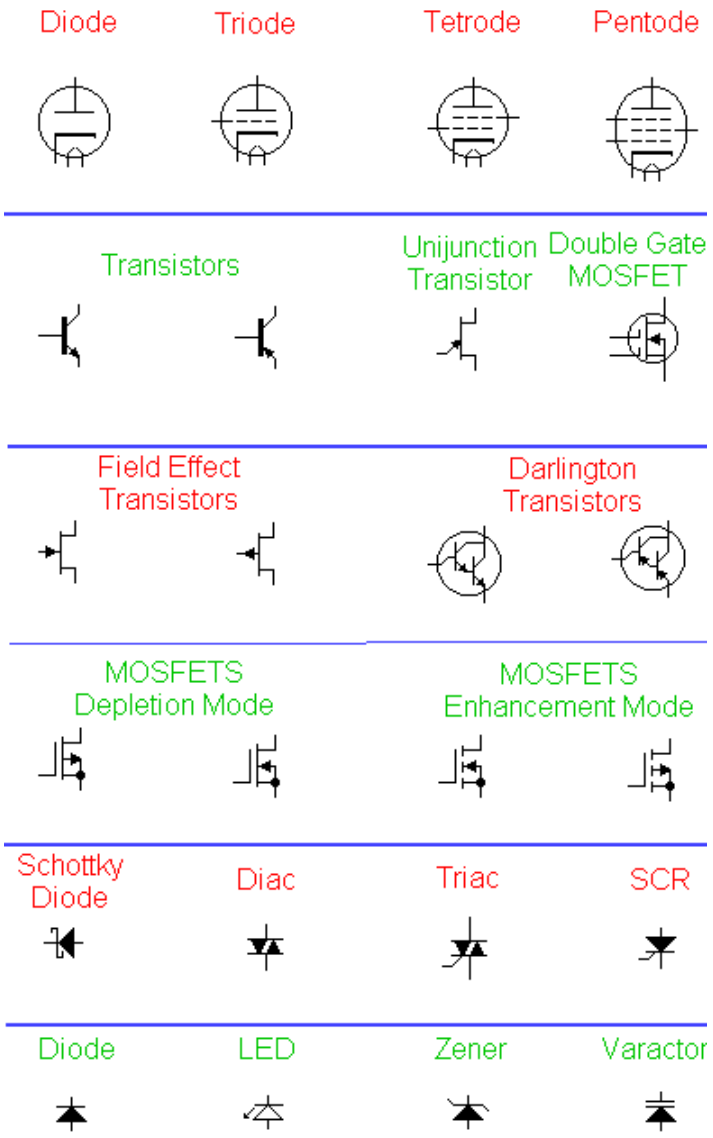
- Examples: Comparators, timers, phase-locked loops, analog-to-digital converters, and digital-to-analog converters (E.g., A laser marking machine).

- Most modern radio and communications circuitry uses mixed signal circuits. For example, a receiver.
  - Analog: amplification, frequency conversion
  - Digital: signal processing

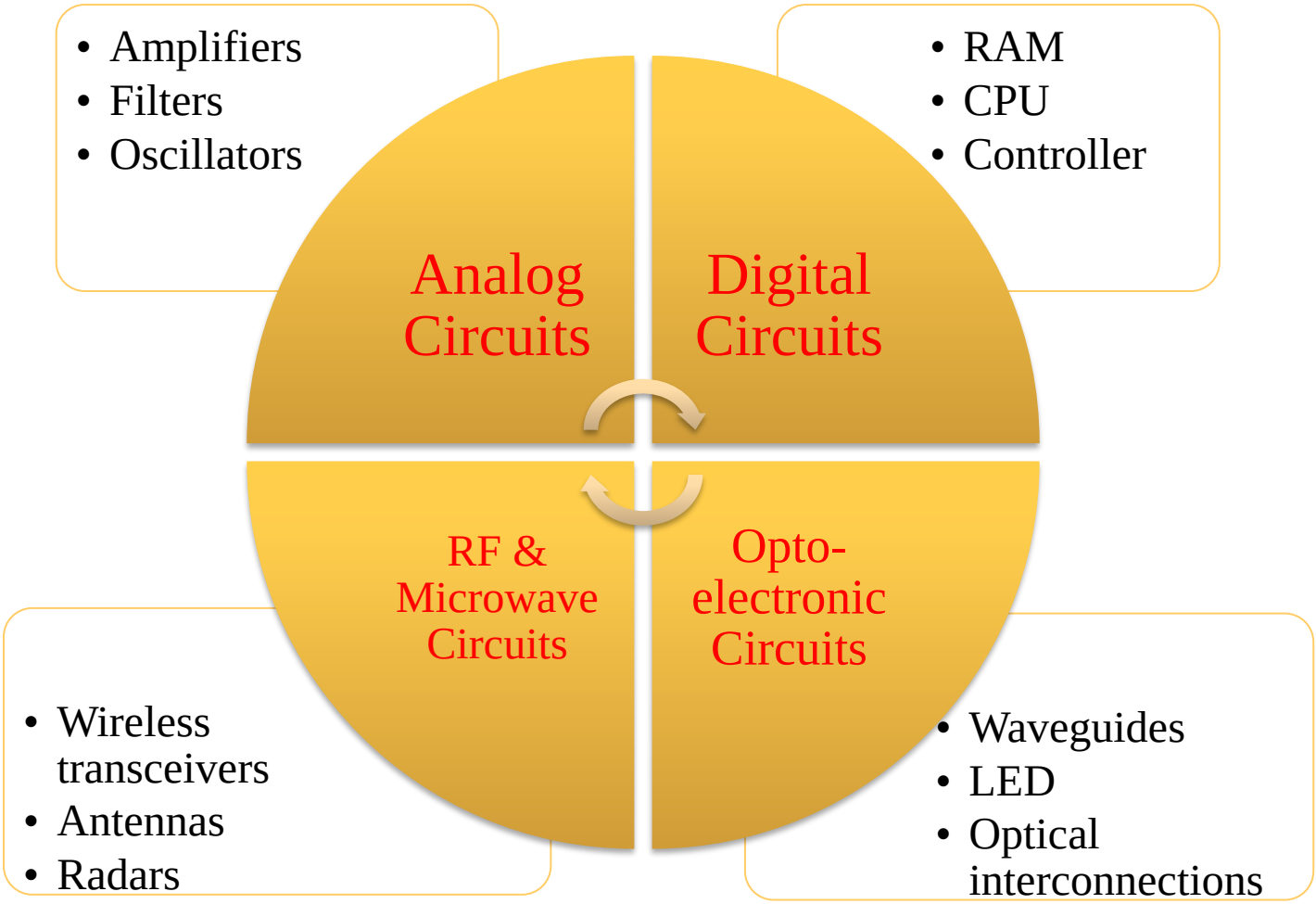
# Circuit symbols-passive components



# Circuit symbols-active components



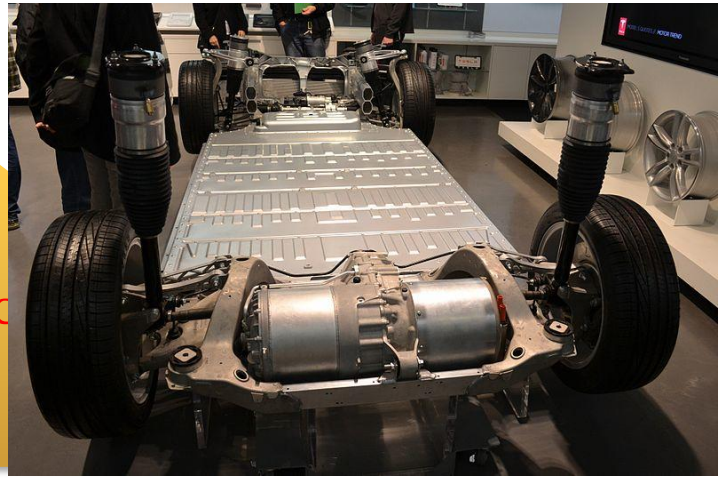
# Circuit types



# Circuit types

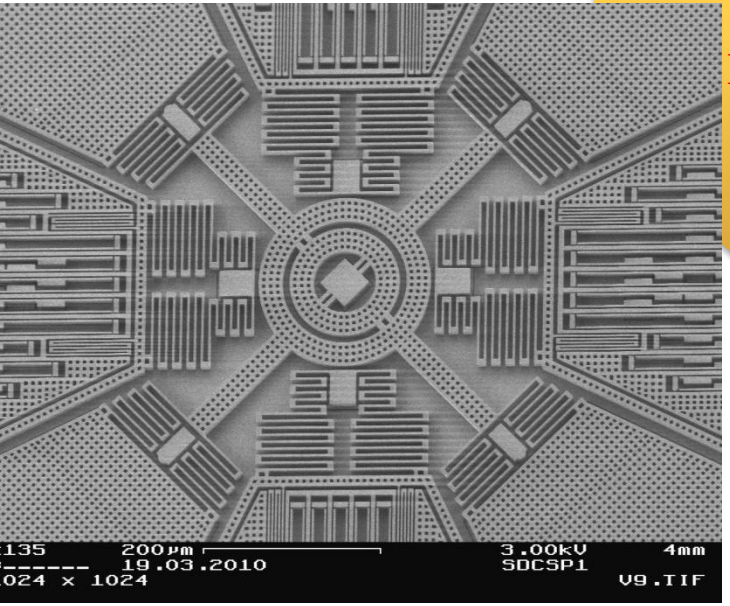

Electrical Circuits

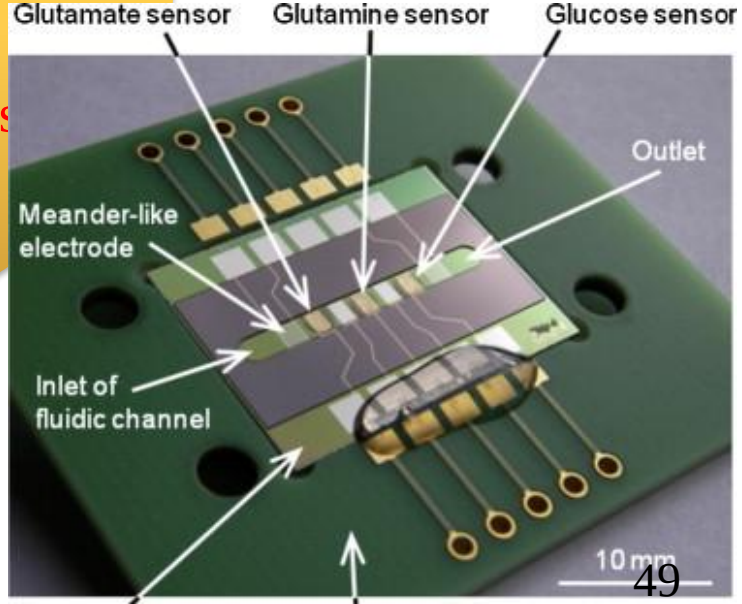
Magnetic Circuits



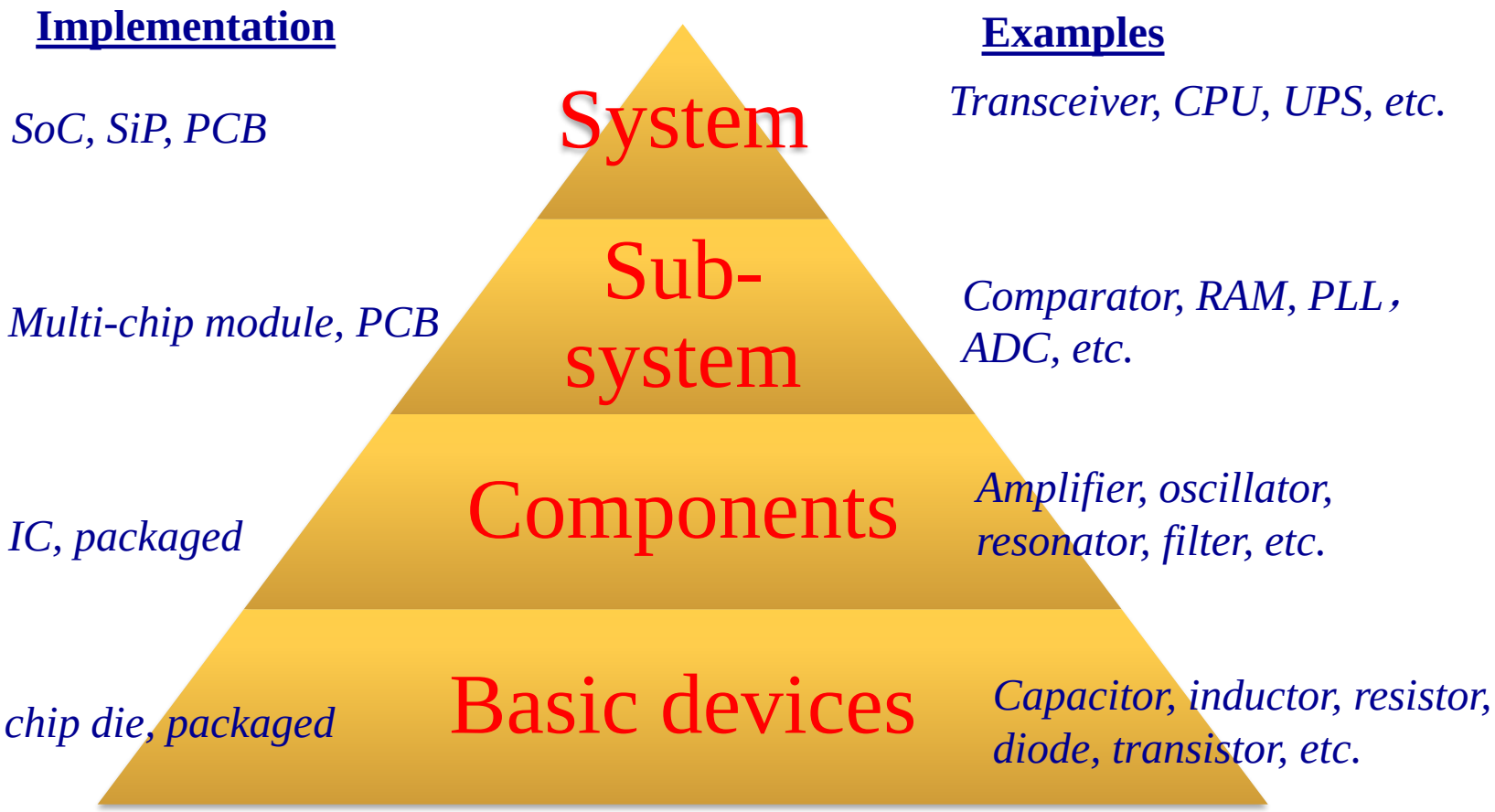
Mechanical Circuits

Bio Circuits



# Circuit hierarchy



# Circuit related curriculum in JI

| Freshmen | Sophomore | Junior | Senior |
| --- | --- | --- | --- |
| • Math<br>• Physics<br>• Programming | • VE215 Introduction to Circuits<br>• VE216 Signal and System<br>• VE230 Electromagnetics<br>• VE270 Introduction to Logic Design | • VE311 Analog circuits<br>• VE320 Semiconductor<br>• VE330 Electromagentics II<br>• VE312 Digital Integrated Circuits<br>• VE334 Optics | • VE413 Analog IC<br>• VE411 RF Microwave Circuits<br>• VE427 VLSI I<br>• VE434 Photonics |