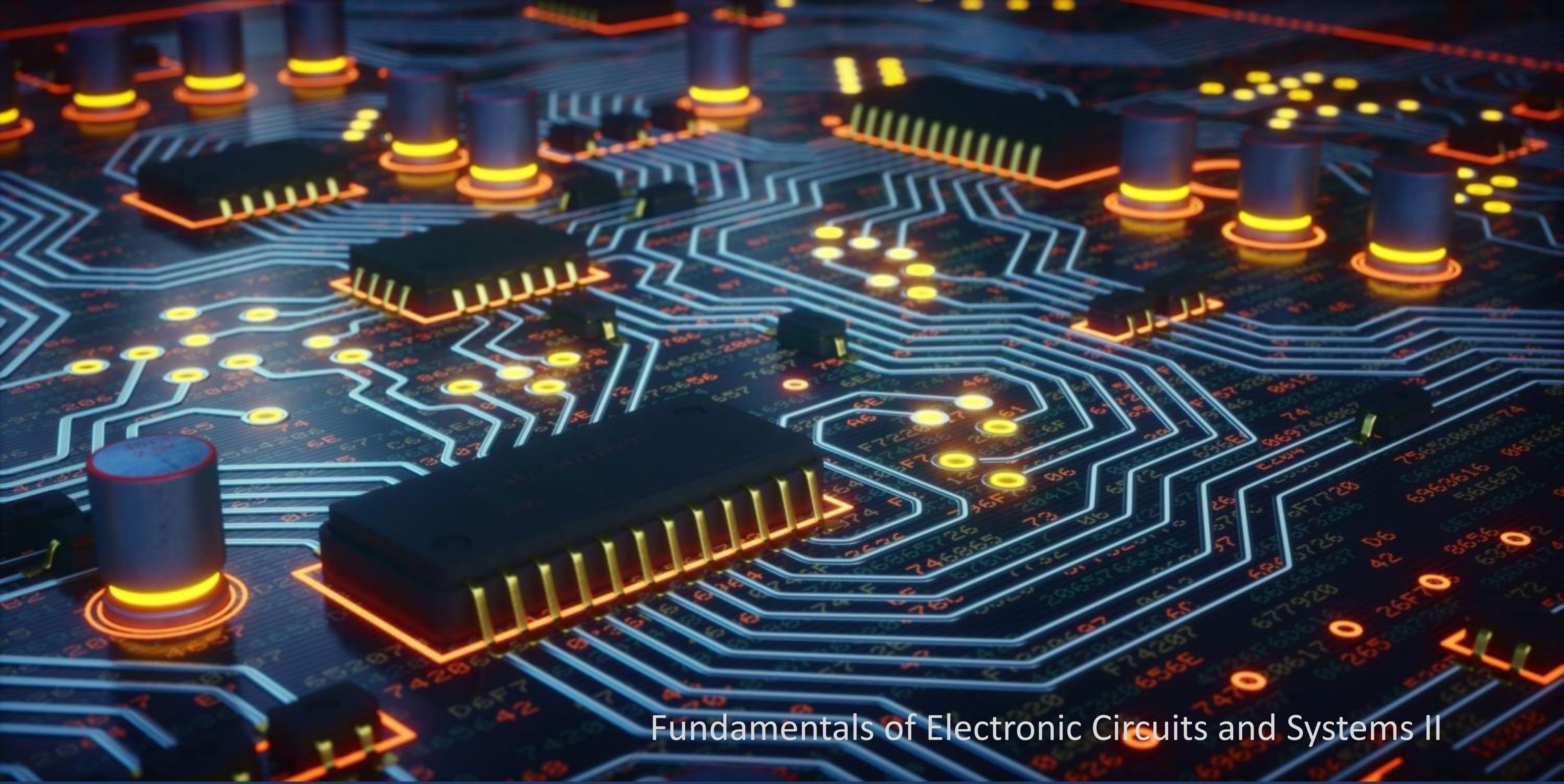


Fundamentals of Electronic Circuits and Systems II

Wrap Up

Milin Zhang
Dept of EE, Tsinghua University

Physics → **Foundations of Electronic Circuits & Systems**

L1：LMD

- The rate of change of magnetic flux linked with any portion of the circuit must be zero for all time.

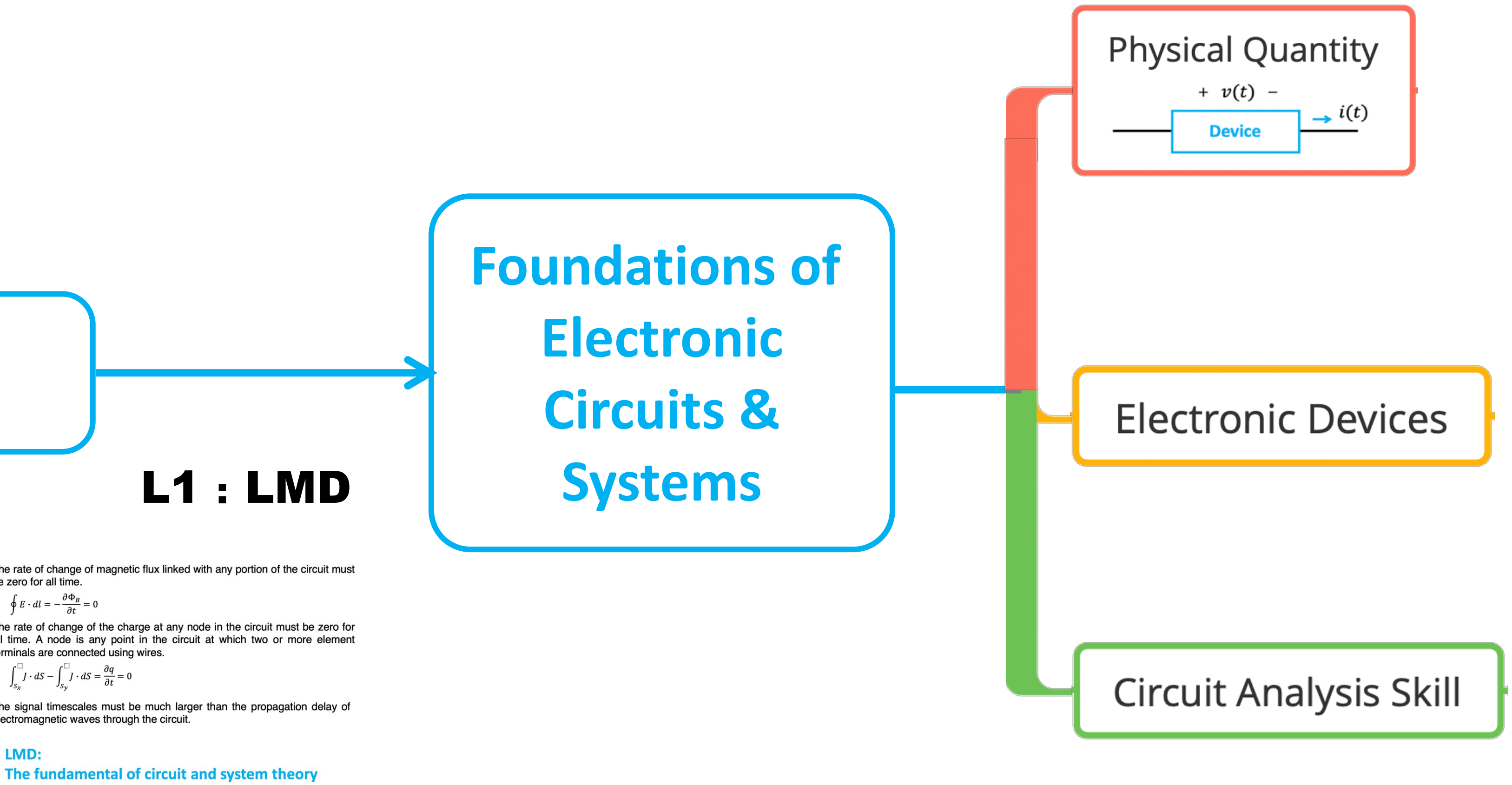
$$\oint E \cdot dl = -\frac{\partial \Phi_B}{\partial t} = 0$$

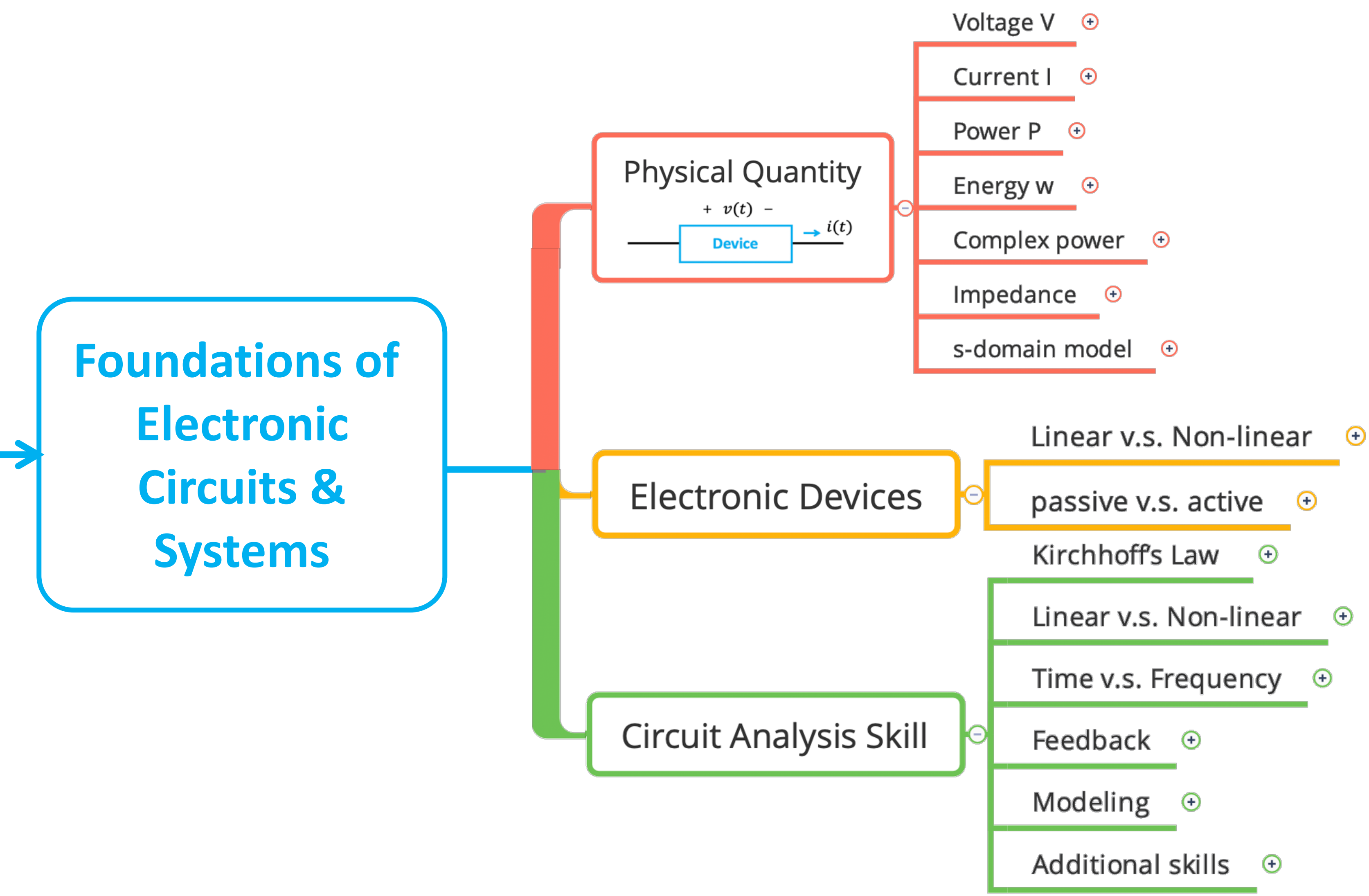
- The rate of change of the charge at any node in the circuit must be zero for all time. A node is any point in the circuit at which two or more element terminals are connected using wires.

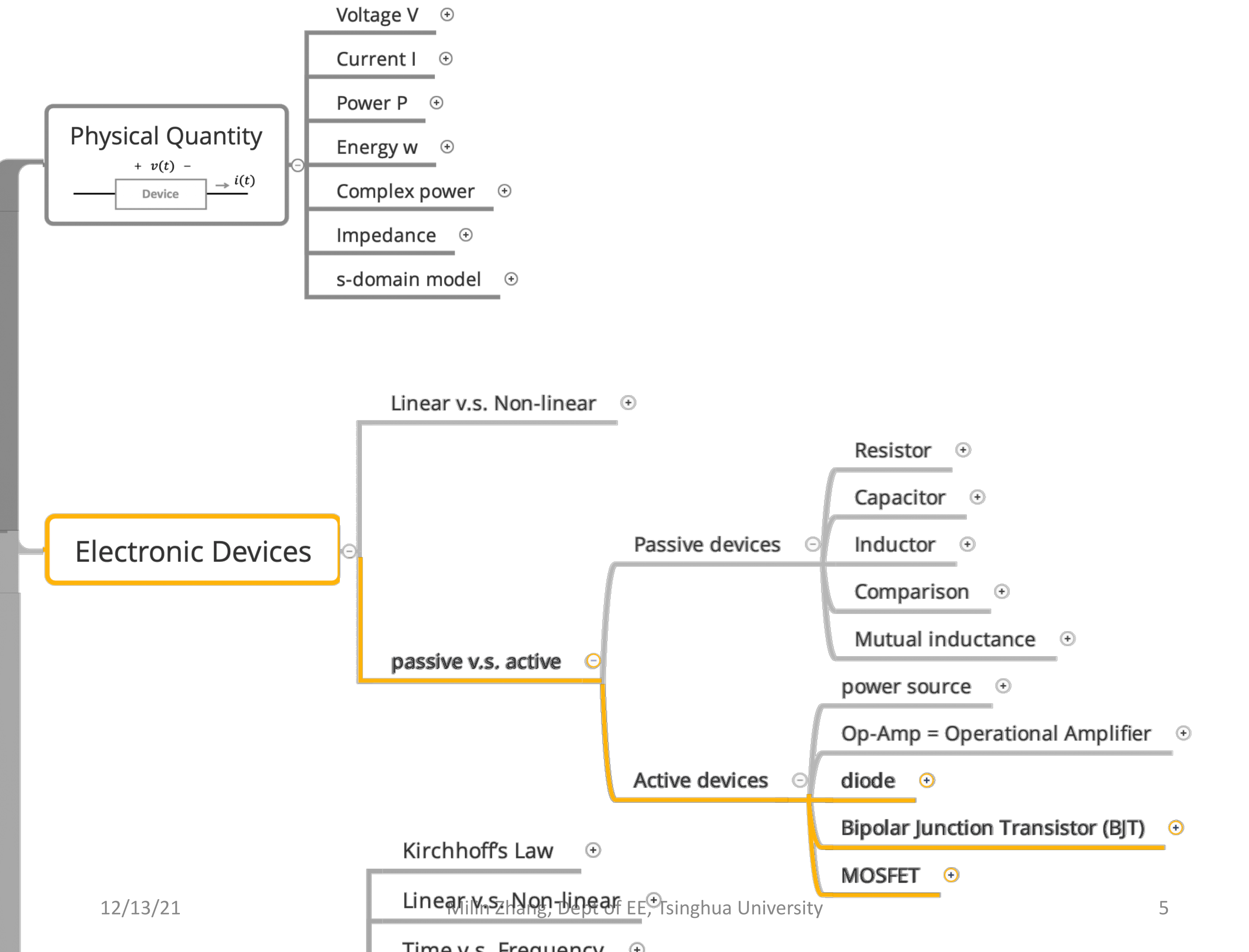
$$\int_{S_x} J \cdot dS - \int_{S_y} J \cdot dS = \frac{\partial q}{\partial t} = 0$$

- The signal timescales must be much larger than the propagation delay of electromagnetic waves through the circuit.

LMD:
The fundamental of circuit and system theory


L1 : LMD
LMD:
The fundamental of circuit and system theory
Foundations of Electronic Circuits & Systems
Physical Quantity
+ v(t) −
Device
i(t)
Electronic Devices
Circuit Analysis Skill


Foundations of Electronic Circuits & Systems
Physical Quantity
+ v(t) −
Device
i(t)
Voltage V
Current I
Power P
Energy w
Complex power
Impedance
s-domain model
Electronic Devices
Linear v.s. Non-linear
passive v.s. active
Circuit Analysis Skill
Kirchhoff's Law
Linear v.s. Non-linear
Time v.s. Frequency
Feedback
Modeling
Additional skills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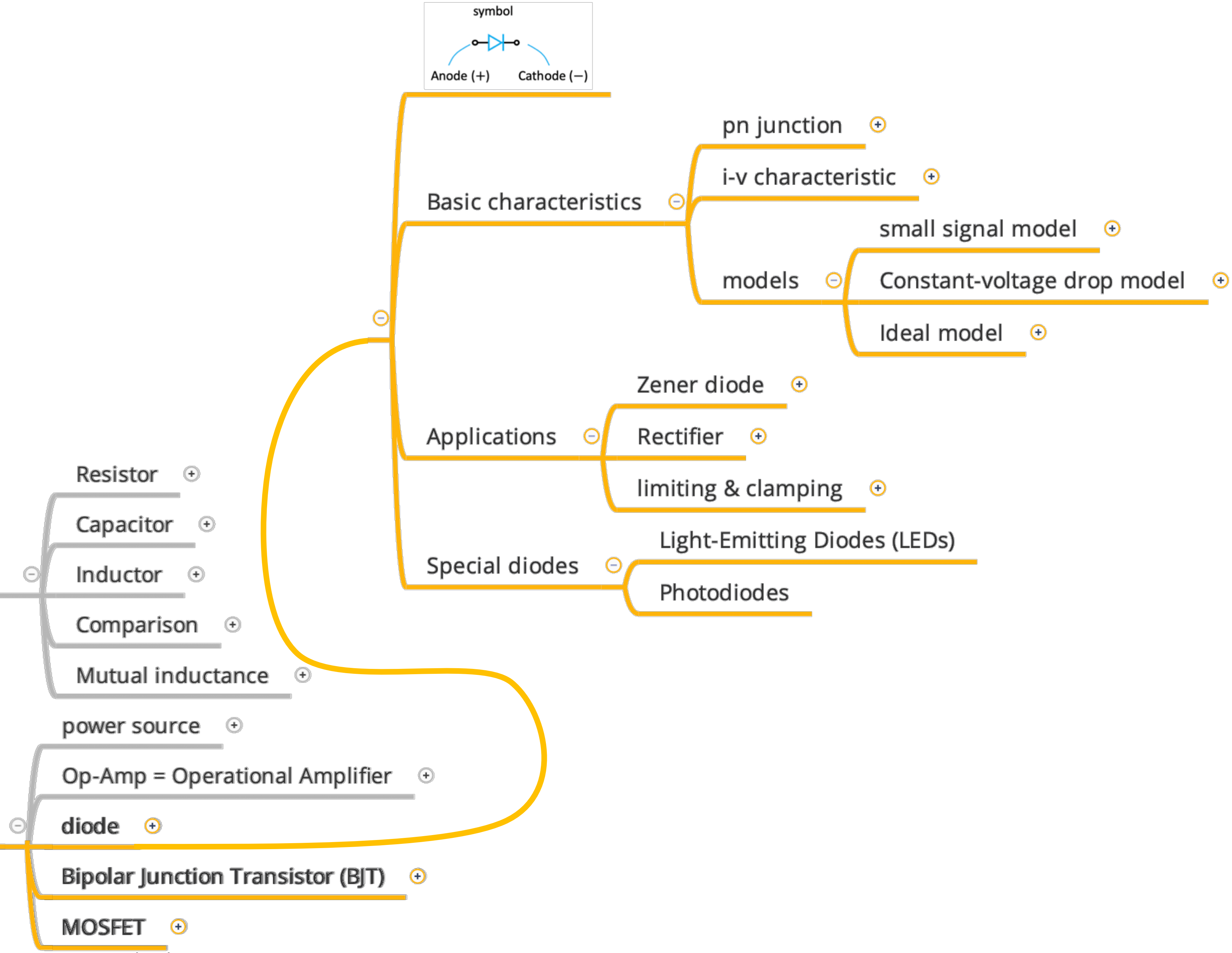
Electronic Devices
Linear v.s. Non-linear
passive v.s. active
Passive devices
Resistor
Capacitor
Inductor
Comparison
Mutual inductance
Active devices
power source
Op-Amp = Operational Amplifier
diode
Bipolar Junction Transistor (BJT)
MOSFET
Kirchhoff's Law
Linear v.s. Non-linear
Time v.s. Frequency



symbol
Anode (+)
Cathode (−)
Basic characteristics
pn junction
i-v characteristic
models
small signal model
Constant-voltage drop model
Ideal model
Applications
Zener diode
Rectifier
limiting & clamping
Special diodes
Light-Emitting Diodes (LEDs)
Photodiodes
Resistor
Capacitor
Inductor
Comparison
Mutual inductance
power source
Op-Amp = Operational Amplifier
diode
Bipolar Junction Transistor (BJT)
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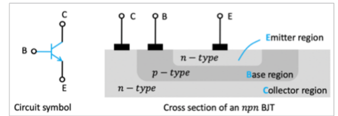
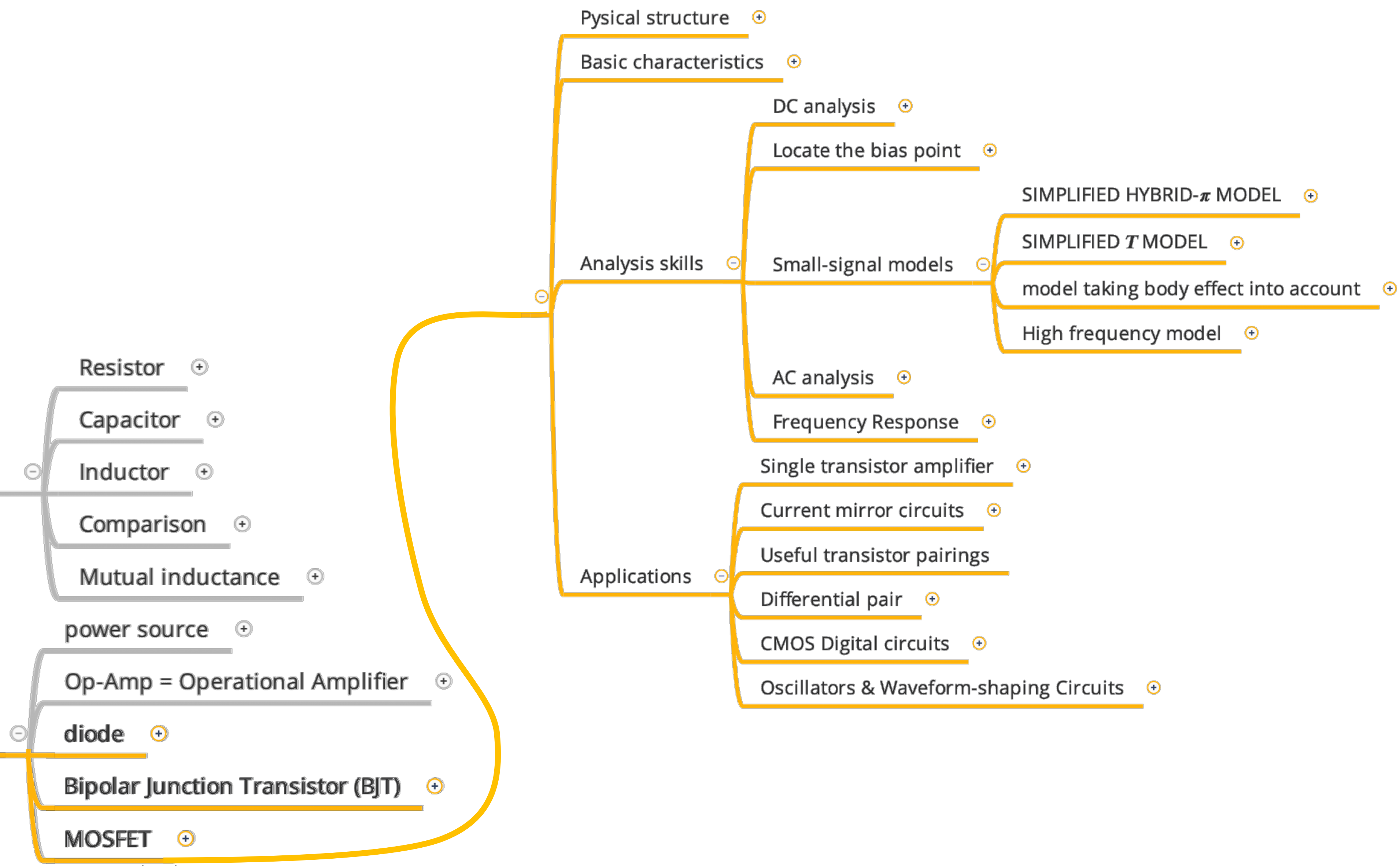


- Basic characteristics
- Analysis skills
  - DC analysis
    - quantitative analysis
      * No analytical solution
    - Graphical analysis tech
      * Easy to operate
      * not a quantitative result
    - $|V_{BE}| \approx V_{th} = 0.7V$ in active mode
  - Locate the bias point
  - small-signal models
    - SIMPLIFIED HYBRID-π MODEL
    - SIMPLIFIED T MODEL
    - THE HIGH FREQUENCY MODEL
  - Characterizing Amplifier
  - AC analysis
    - Step 1: turn off DC sources
    - Step 2: Calculate small-signal model parameters, β and r_π
    - Step 3: replace the transistor with the small-signal model
    - Step 4: Analyze the resulting circuit
- Applications
  - Single transistor amplifier
    - Common-Emitter (CE) Amplifier
    - Common-Base (CB) Amplifier
    - Common-Collector (CC) Amplifier
  - Current mirror circuits

- Resistor
- Capacitor
- Inductor
- Comparison
- Mutual inductance

- power source
- Op-Amp = Operational Amplifier
- diode
- Bipolar Junction Transistor (BJT)
- MOSFET



Pysical structure
Basic characteristics
DC analysis
Locate the bias point
SIMPLIFIED HYBRID-π MODEL
SIMPLIFIED T MODEL
Analysis skills
Small-signal models
model taking body effect into account
High frequency model
AC analysis
Frequency Response
Single transistor amplifier
Current mirror circuits
Useful transistor pairings
Differential pair
CMOS Digital circuits
Oscillators & Waveform-shaping Circuits
Applications
Resistor
Capacitor
Inductor
Comparison
Mutual inductance
power source
Op-Amp = Operational Amplifier
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Bipolar Junction Transistor (BJT)
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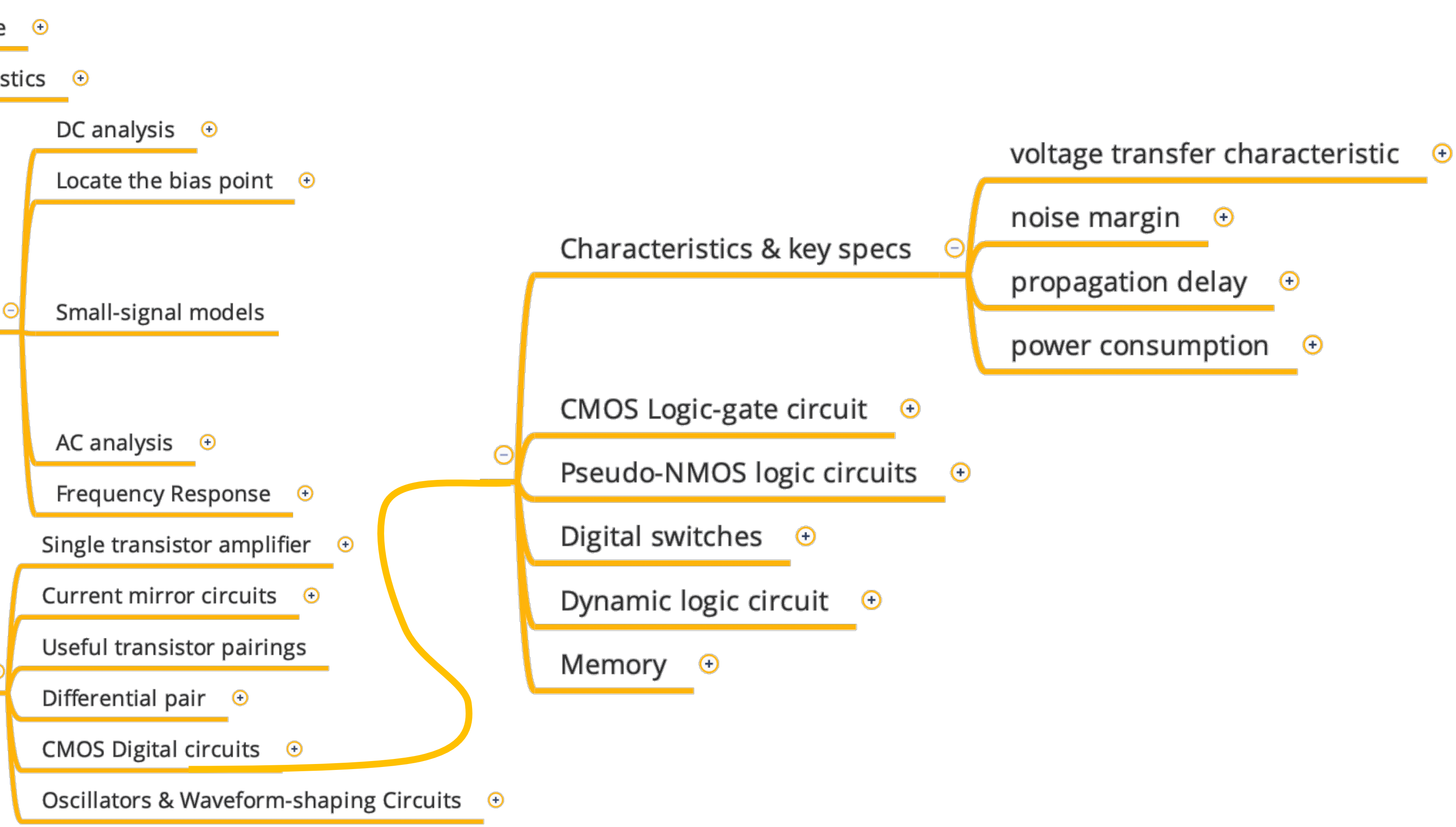
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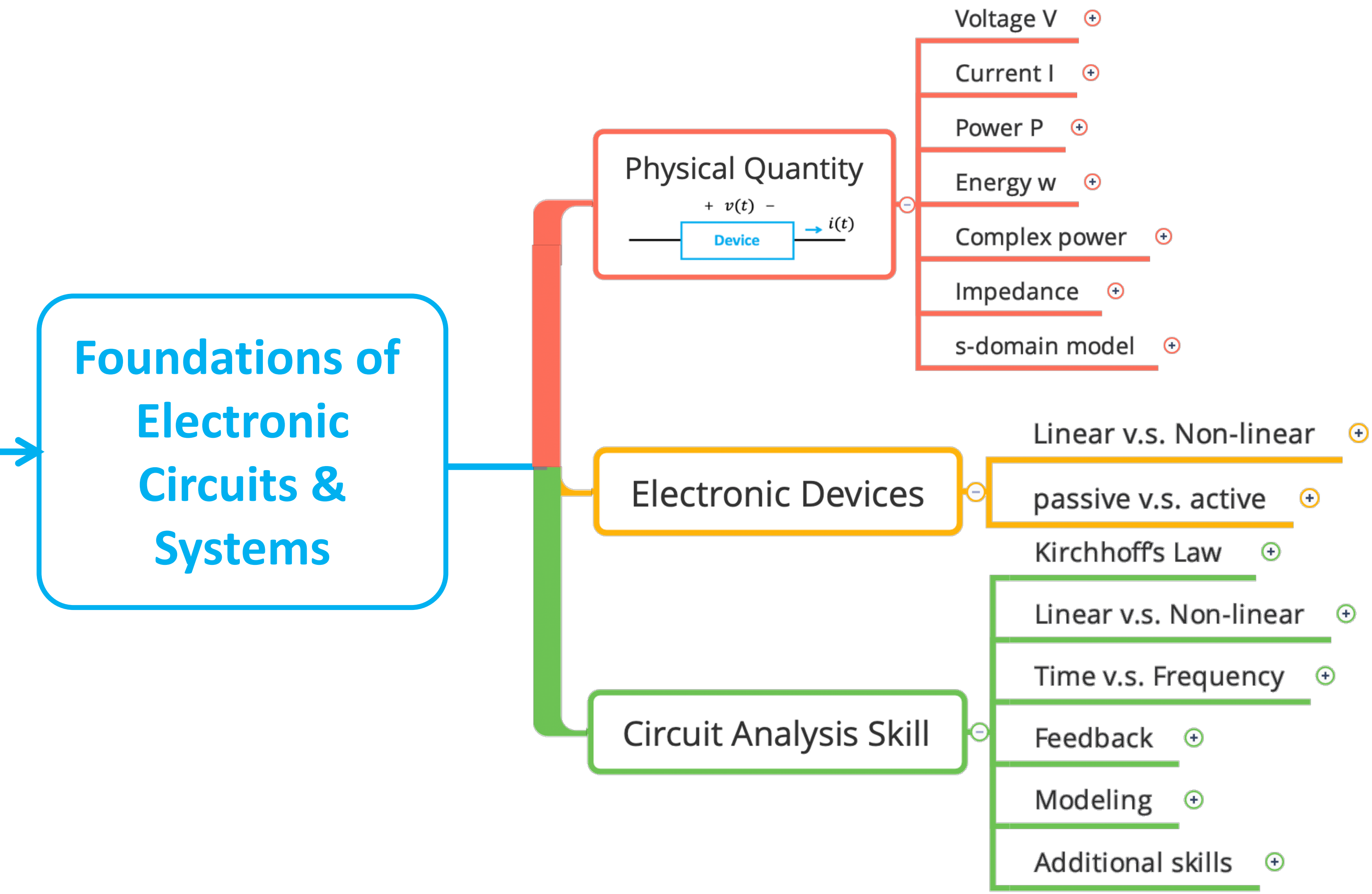
DC analysis
Locate the bias point
Small-signal models
AC analysis
Frequency Response
Single transistor amplifier
Current mirror circuits
Useful transistor pairings
Differential pair
CMOS Digital circuits
Oscillators & Waveform-shaping Circuits
Characteristics & key specs
voltage transfer characteristic
noise margin
propagation delay
power consumption
CMOS Logic-gate circuit
Pseudo-NMOS logic circuits
Digital switches
Dynamic logic circuit
Memory

- e
- stics
- Small-signal models
  - DC analysis
  - Locate the bias point
  - AC analysis
  - Frequency Response
- Single transistor amplifier
- Current mirror circuits
- Useful transistor pairings
- Differential pair
- CMOS Digital circuits
- Oscillators & Waveform-shaping Circuits
  - How to generate an oscillation
    - negative resistance
    - Devices with negative resistance
    - Circuits with negative resistance
  - Linear Oscillator
    - LC oscillator
    - crystal oscillator
    - Op-Amp-RC oscillator
  - Non-linear oscillator
    - Bistable circuit
    - Astable Multibibrators



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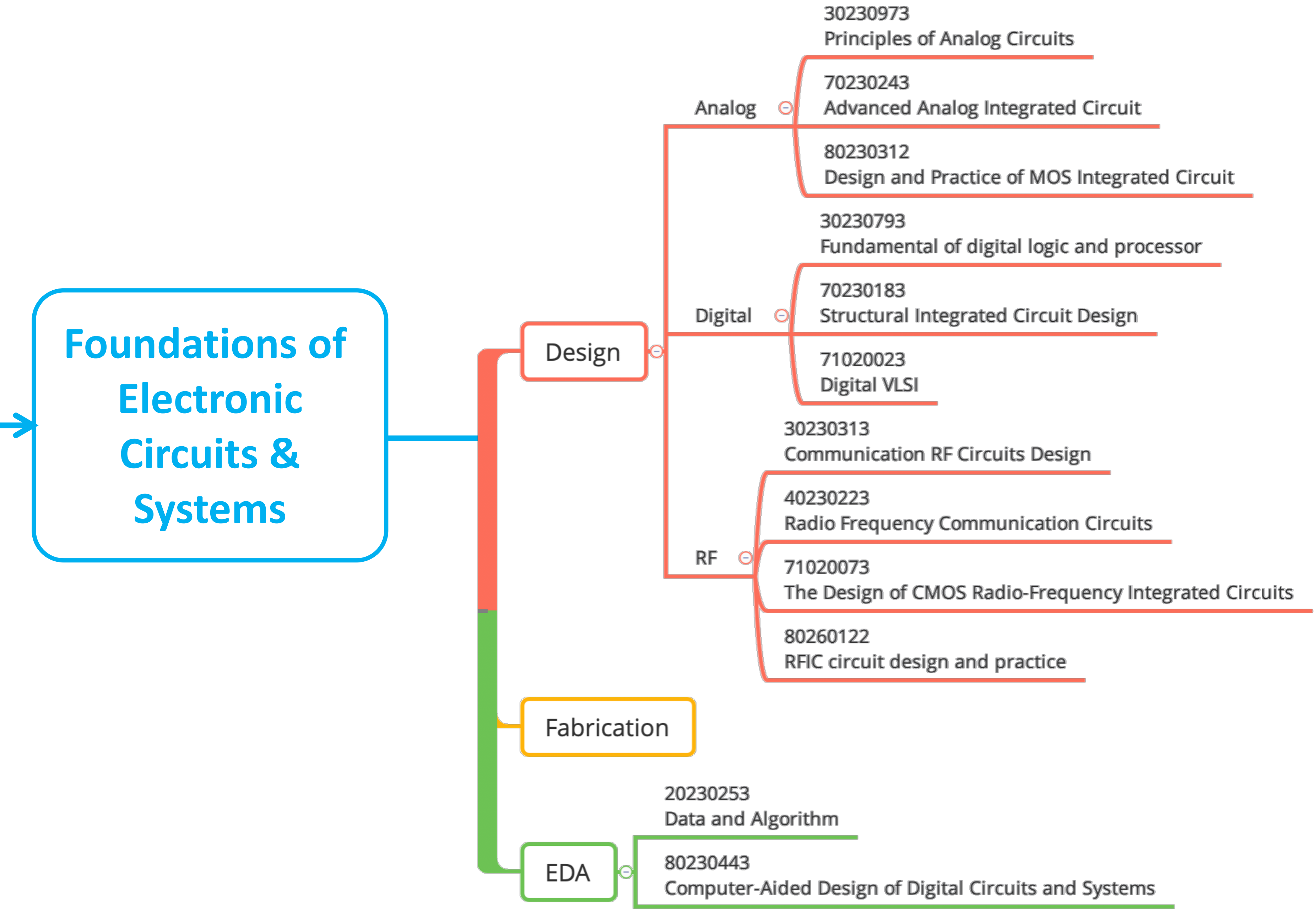
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80230312
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Structural Integrated Circuit Design
71020023
Digital VLSI
RF
30230313
Communication RF Circuits Design
40230223
Radio Frequency Communication Circuits
71020073
The Design of CMOS Radio-Frequency Integrated Circuits
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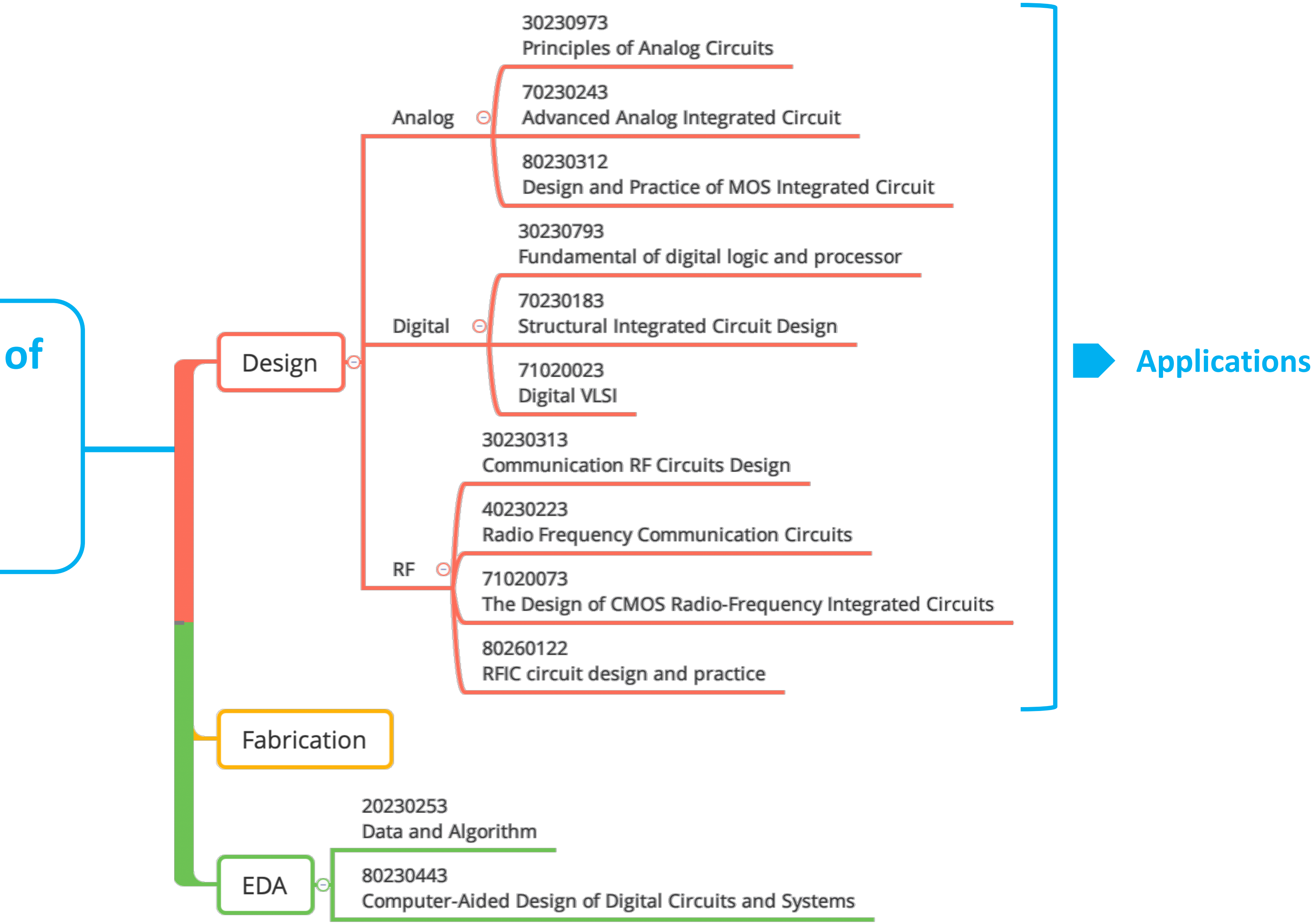
RFIC circuit design and practice
Fabrication
EDA
20230253
Data and Algorithm
80230443
Computer-Aided Design of Digital Circuits and Systems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80260122
RFIC circuit design and practice
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EDA
20230253
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80230443
Computer-Aided Design of Digital Circuits and Systems
Applications

High Performance IP & New Devices

Nan Sun

Huaqiang Wu

Xueqing Li

System	Device	IP	Made in China %
Computing	Server	MPU	0%
	PC	MPU	0%
	For industry	MCU	2%
General Purpose	Programmable	FPGA/EPLD	0%
	DSP	DSP	0%
Communication	Mobile	Application processor	18%
		Communication Processor	22%
		Embedded MPU	0%
		Embedded DSP	0%
	Network	NPU	15%
Memory	Semiconductor Memory	DRAM	0%
		NAND Flash	0%
		NOR Flash	5%
Display	TV	Image processor	5%
		Display driver	0%

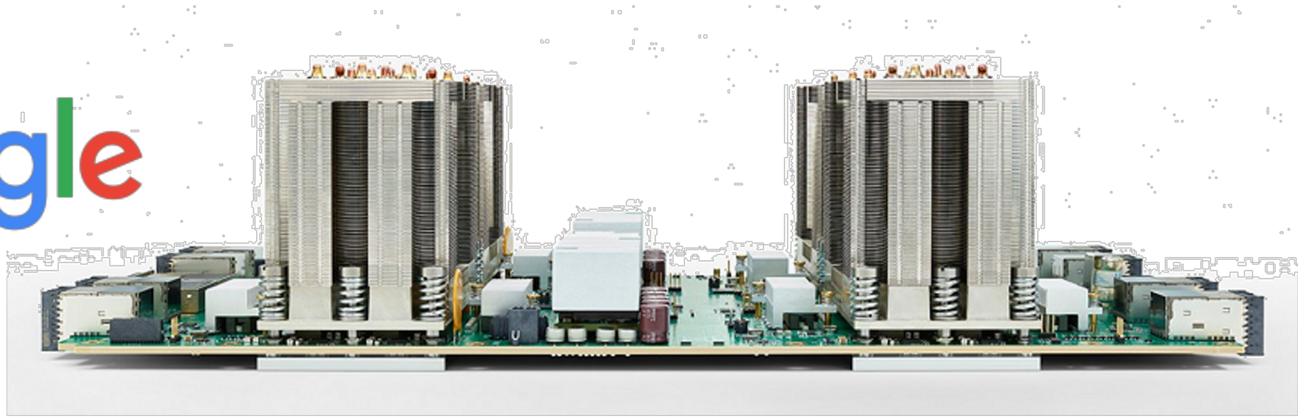
Processing Unit (PU) & AI


Yu Wang


Yongpan Liu


Leibo Liu


Shouyi Yin



TO ENABLE HIGHER PERFORMANCE BY IMPROVE THE PU HARDWARE DESIGNS

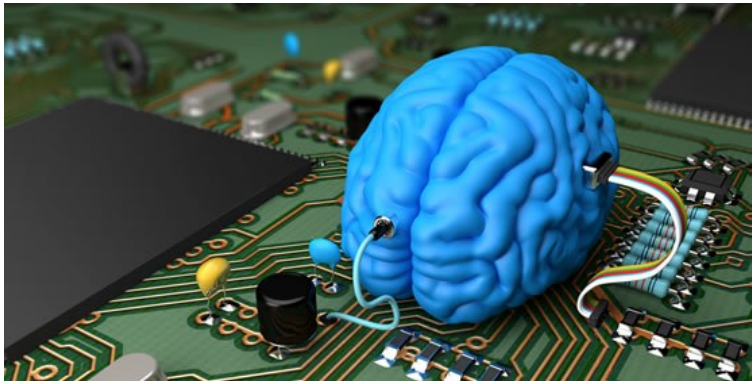
Intelligent Micro-System

Huazhong Yang

Tianling Ren

Milin Zhang

Smaller volume size
Higher capability
Higher performance



NEURALINK

To bridge the brain to man-made devices

Smart Sensing

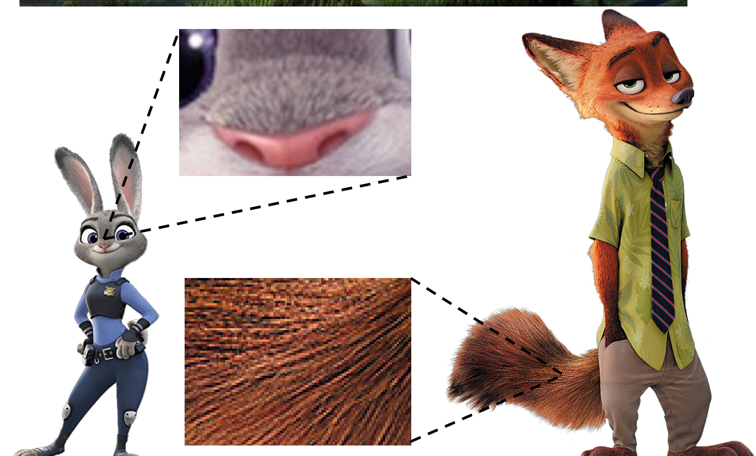
Fei Qiao

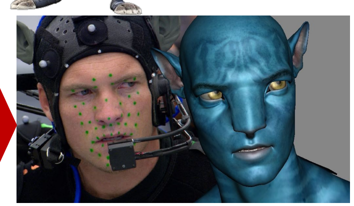
Xiang Xie

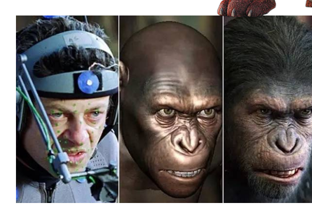
1990s

Smart imager enables higher image processing capability

2010s







Bio-Medical & Healthcare

Guolin Li

Zhihua Wang

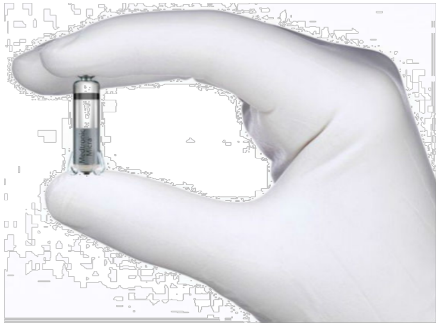
Hanjun Jiang

Hong Chen

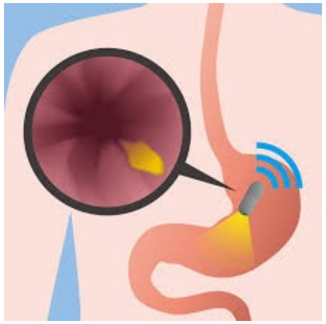
Compact smart device for clinical practice

A better life for everyone

Medtronic



V.S.

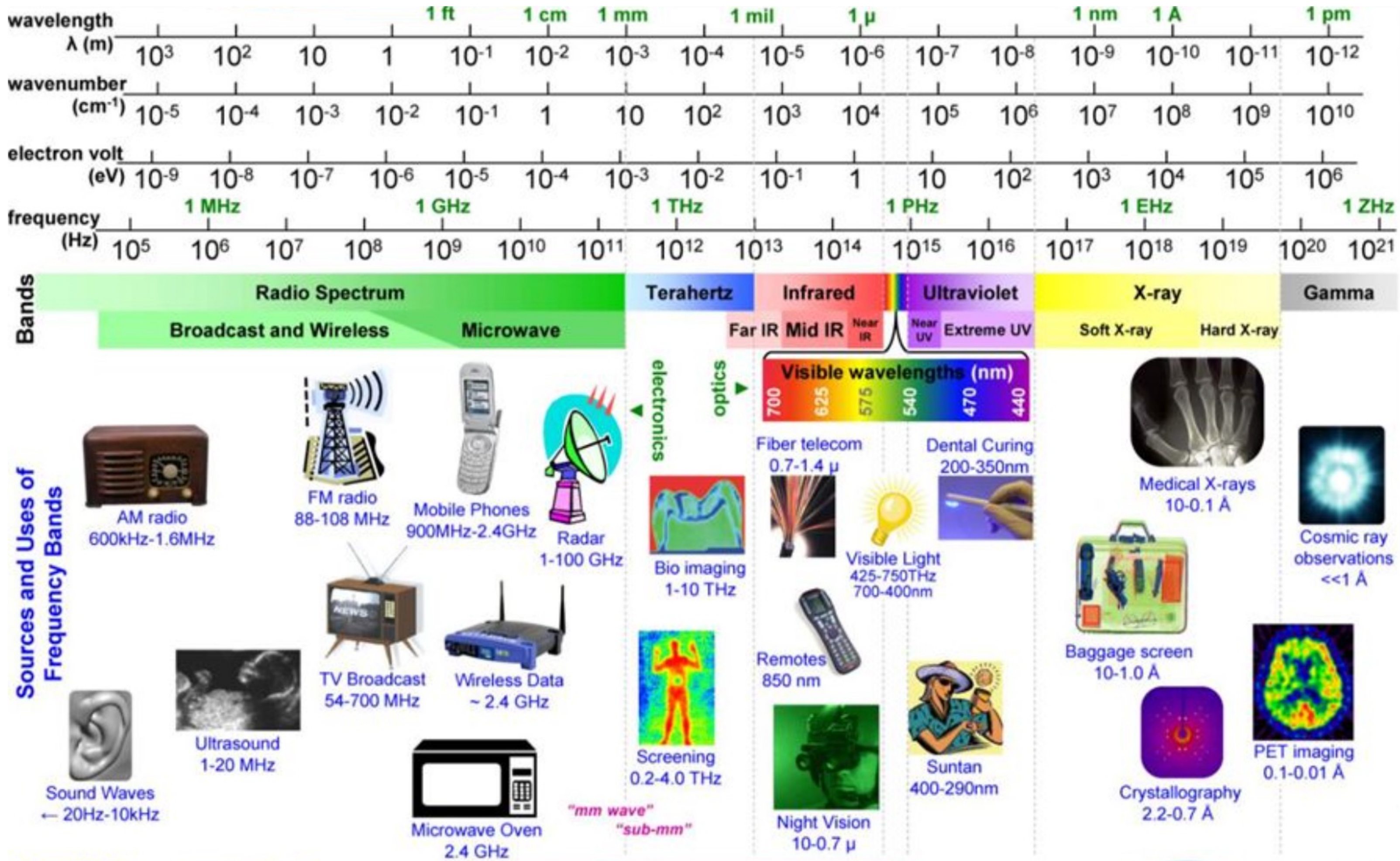


Radio Frequency Circuits & Application

Baoyong Chi

Woogeun Rhee

Yan Wang



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Final Exam

- Date: Jan 6th 2022
- Time: 9:00am – 11:00am
- Location: 6A203