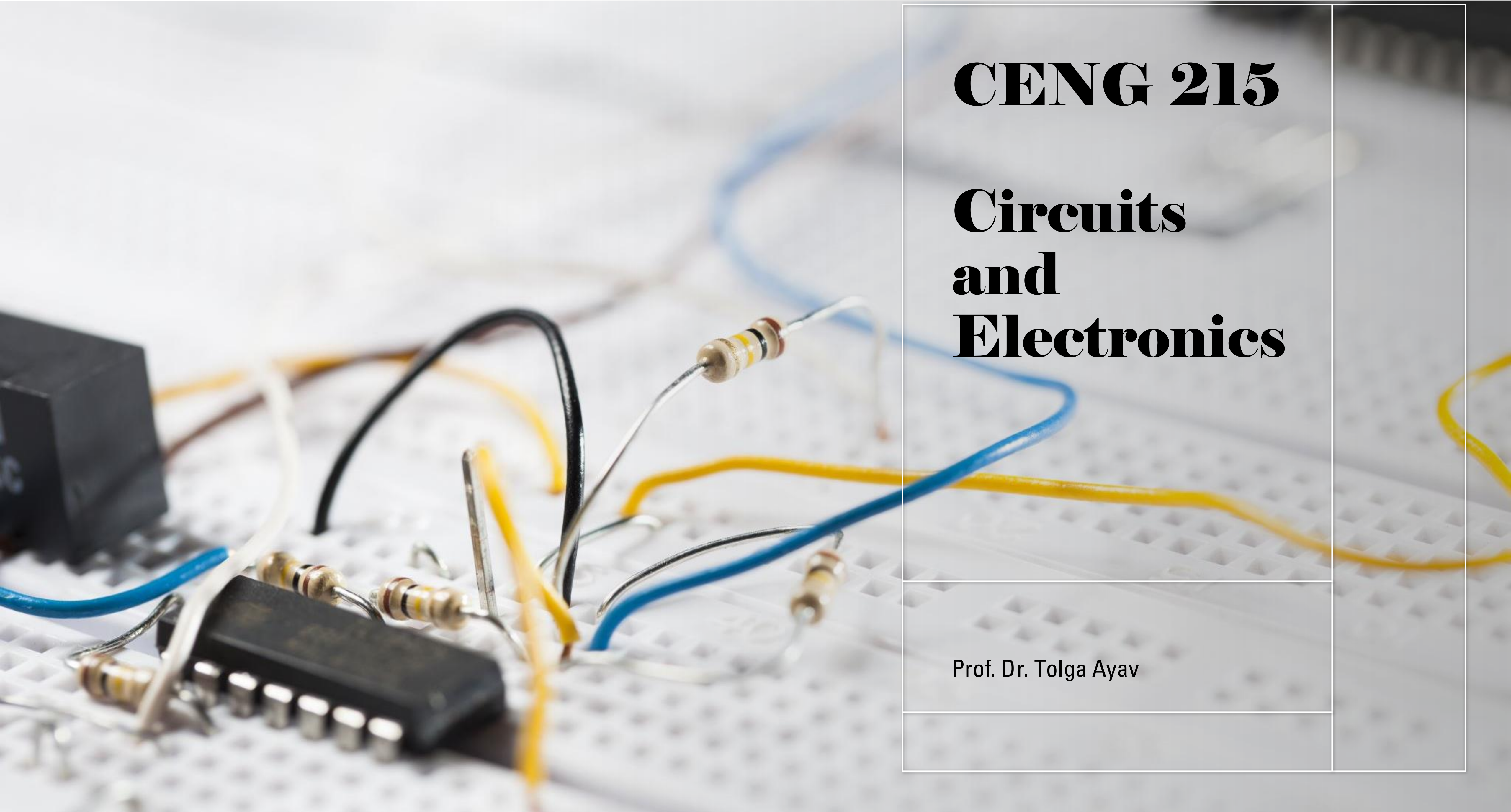


CENG 215

Circuits and Electronics

Prof. Dr. Tolga Ayav

Syllabus

- **Homepage:** http://www.iyte.edu.tr/~tolgaayav/courses/ceng215
- **Lecture:** Monday 9:45, Wednesday: 13:30 (Lecture),
  - Wednesday 8:45 – 12:30 (Lab - 2 Sessions)
- **Credits:** 3+2
- **Instructor:** Prof. Dr. Tolga AYAV
- **Lab Assistants:** Burak Korcuklu
- **MS-Teams Code:** s0znooi
- No prerequisite course but basic knowledge of physics and calculus is required.

Schedule

Theoretical:

Introduction: Circuit Abstraction

Resistive Networks (Basic analysis, Kirchhoff's Laws, Dependent Sources)

Resistive networks cont'd

Energy Storage Elements

First-order Circuits

Second-order Circuits

Second-order Circuits

Diodes and Applications

Transistors - Integrated Circuits

The MOSFET Switch, Logic Gates

Amplifiers, OPAMP abstraction

Digital Abstraction, Analog-to-Digital Conversion

Discrete-time Systems and Z-transform

Laboratory:

10 Lab Works

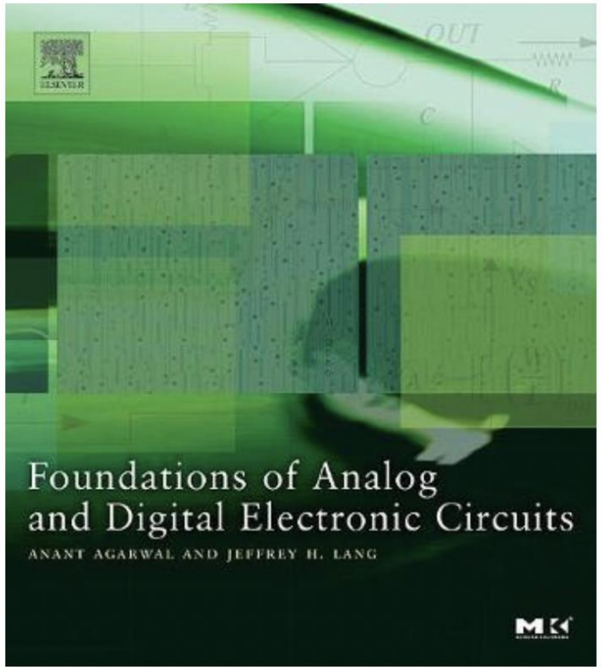
2 Projects linked to grading

Grading

- Written Midterm Exam : %35
- Project Studies: %20
- Written Final Exam: %45

Textbook

- Anant Agarwal, Jeffrey H. Lang *Foundations of Analog and Digital Electronic Circuits* . 2005. Morgan Kaufmann Pub



Foundations of Analog and Digital Electronic Circuits

3.98 (123 ratings by Goodreads)
Paperback | The Morgan Kaufmann Series in Computer Architecture and Design | English
By (author) Anant Agarwal , By (author) Jeffrey Lang

Share

Unlike books currently on the market, this book attempts to satisfy two goals: combine circuits and electronics into a single, unified treatment, and establish a strong connection with the contemporary world of digital systems. It will introduce a new way of looking not only at the treatment of circuits, but also at the treatment of introductory coursework in engineering in general.
Using the concept of "abstraction," the book attempts to form a bridge between the world of physics and the world of large computer systems. In particular, it attempts to unify electrical engineering and computer science as the art of creating and exploiting successive abstractions to manage the complexity of building useful electrical systems. Computer systems are simply one type of electrical systems.

Circuit Simulation

Modules:

matplotlib
numpy
pyspice
scipy
…

https://pyspice.fabrice-salvaire.fr/releases/v1.5/installation.html

PySpice

PySpice 1.5

Search docs

4. Installation

You must install a Python environment and the Ngspice/Xyce simulator to use PySpice on your computer. Since there are many ways to do this, we will only explain the easiest ones in details.

In Python, the standard way is to use a **Virtual Environment** and the **pip** tool, look at this guide for further information.

But if you are mainly doing data science, the **easiest solution** is probably to install the Anaconda Distribution which is specialised for this purpose. You can also prefer its lightweight counterpart Miniconda.

Anaconda has the advantage to provide a self consistent environment to the user, for example it installs automatically Ngspice for you when you install PySpice. But for this reason, especially on Linux, an Anaconda distribution will require much more disk space than a virtual environment.

> **Note**
>
> **We recommend that you read the documentation in this order, first Windows to get the novice story, then Linux to get the Unix OS story and finally OSX if you are concerned.**

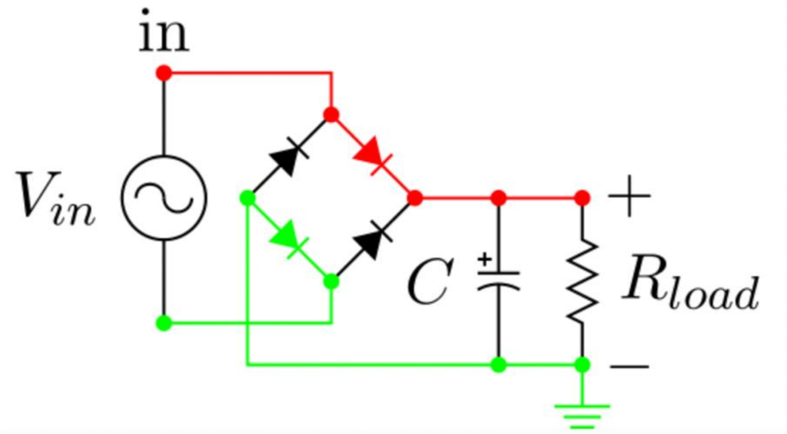
4.1. PySpice Packages

Note to Linux Packagers: Please do not create a PySpice package, PyPI and Anaconda do the job.

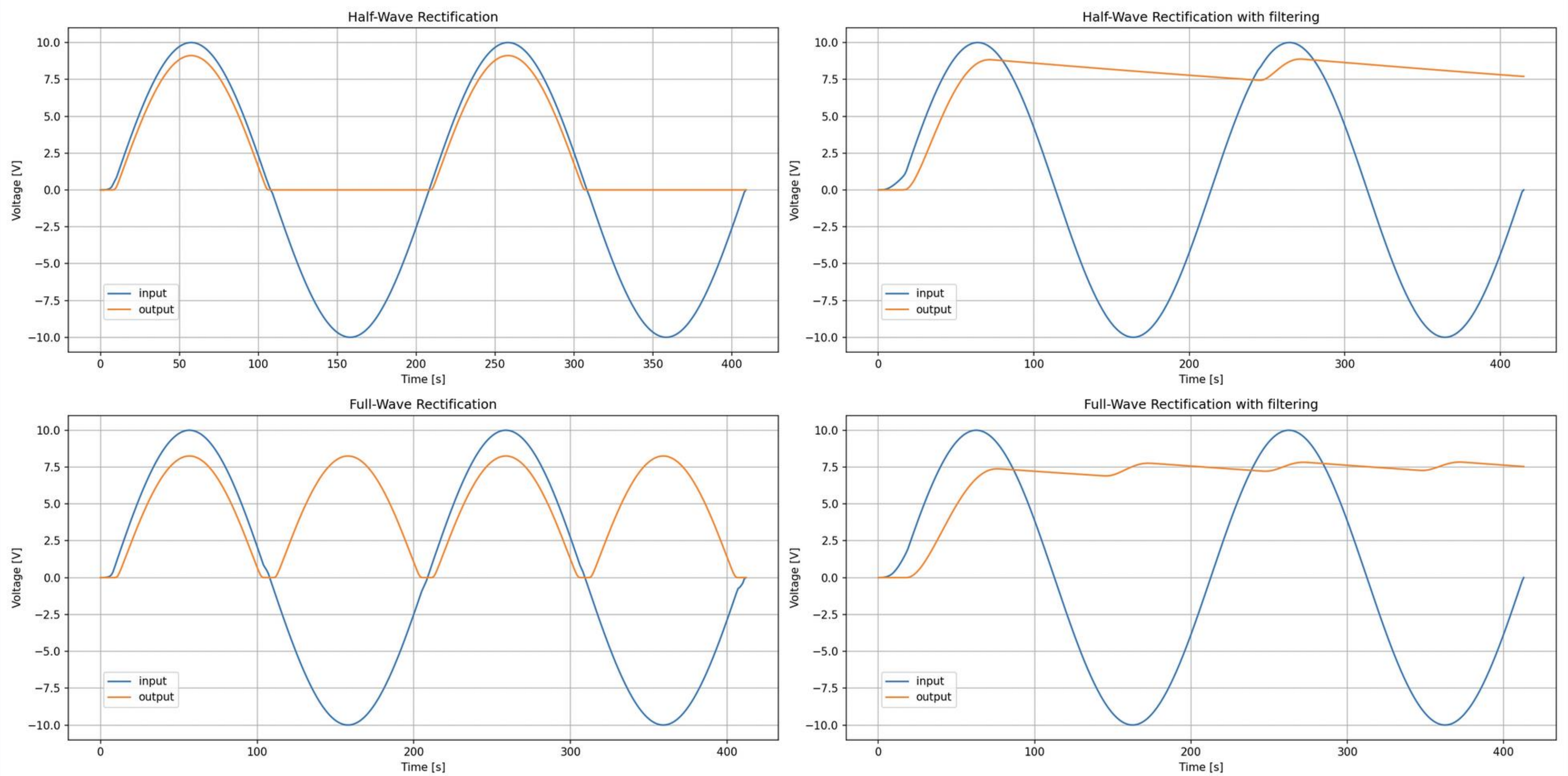
PySpice is available as a Anaconda and PyPI package. For Anaconda there is two channels, the official one is *conda-forge*, the second one *fabricesalvaire* **is only used for testing.**

Pyspice example program

```
import matplotlib.pyplot as plt
from posixpath import join
import PySpice.Logging.Logging as Logging

logger = Logging.setup_logging()

from PySpice.Doc.ExampleTools import find_libraries
from PySpice.Probe.Plot import plot
from PySpice.Spice.Library import SpiceLibrary
from PySpice.Spice.Netlist import Circuit
from PySpice.Unit import *


libraries_path = find_libraries()


PySpice_examples_path = "/Users/ayav/repos/PySpice/examples/"
libraries_path = join(PySpice_examples_path, 'libraries')

spice_library = SpiceLibrary(libraries_path)

circuit = Circuit('half-wave rectification')
circuit.include(spice_library['1N4148'])
source = circuit.SinusoidalVoltageSource('input', 'in', circuit.gnd, amplitude=10@u_V, frequency=50@u_Hz)
```



Pyspice output



Definitions and Laws

Table 1-1 Basic Quantities

Quantity	Symbol	Unit	Abbreviation
Length	l	meter	m
Mass	m	kilogram	kg
Time	t	second	s
Temperature	τ	kelvin	K
Current	i	ampere	A
Luminous intensity	I	candela	cd

Table 1-2 Important Derived Quantities

Quantity	Symbol	Definition	Unit	Abbreviation	(Alternate)
Force	f	push or pull	newton	N	($kg \cdot m/s^2$)
Energy	w	ability to do work	joule	J	($N \cdot m$)
Power	p	energy/unit of time	watt	W	(J/s)
Charge	q	quantity of electricity	coulomb	C	($A \cdot s$)
Current	i	rate of flow of charge	ampere	A	(C/s)
Voltage	v	energy/unit charge	volt	V	(W/A)
Electric field strength	ε	force/unit charge	volt/meter	V/m	(N/C)
Magnetic flux density	B	force/unit charge momentum	tesla	T	(Wb/m^2)
Magnetic flux	ϕ	integral of magnetic flux density	weber	Wb	($T \cdot m^2$)

Decimal Notation

Multiplier	Prefix	Abbreviation	Pronunciation
10^{12}	tera	T	tĕr′ ȧ
10^{9}	giga	G	jĭ′ gȧ
10^{6}	mega	M	mĕg′ ȧ
10^{3}	kilo	k	kĭl′ ō
10^{2}	hecto	h	hĕk′ tō
10^{1}	deka	da	dĕk′ ȧ
10^{-1}	deci	d	dĕs′ ĭ
10^{-2}	centi	c	sĕn′ tĭ
10^{-3}	milli	m	mĭl′ ĭ
10^{-6}	micro	μ	mī′ krō
10^{-9}	nano	n	năn′ ō
10^{-12}	pico	p	pē′ cō
10^{-15}	femto	f	fĕm′ tō
10^{-18}	atto	a	ăt′ tō

DEFINITIONS

ENERGY. An object requiring a force of 1 newton to hold it against the force of gravity (i.e., an object "weighing" 1 newton) receives 1 joule of potential energy when it is raised 1 meter. A mass of 1 kilogram moving with a velocity of 1 meter per second possesses $\frac{1}{2}$ joule of kinetic energy.

POWER. Power measures the rate at which energy is transformed. The transformation of 1 joule of energy in 1 second represents an average power of 1 watt. In general, instantaneous power p and average power P are defined by

$$p = \frac{dw}{dt} \quad \text{and} \quad P = \frac{W}{T} \tag{1-1}$$

CHARGE. The quantity of electricity is electric charge, a concept useful in explaining physical phenomena. Charge is said to be "conservative" in that it can be neither created nor destroyed. It is said to be "quantized" because the charge on 1 electron (1.602×10^{-19} C) is the smallest amount of charge that can exist. The coulomb can be defined as the charge on 6.24×10^{18} electrons, or as the charge experiencing a force of 1 newton in an electric field of 1 volt per meter, or as the charge transferred in 1 second by a current of 1 ampere.

CURRENT. Electric field effects are due to the presence of charges; magnetic field effects are due to the motion of charges. The current through an area A is defined by the electric charge passing through the area per unit of time. In general, the charges may be positive and negative, moving through the area in both directions. The current is the *net rate* of flow of *positive* charges, a scalar quantity. In the specific case of positive charges moving to the right and negative charges to the left, the net effect of both actions is positive charge moving to the right; the instantaneous current to the right is given by the equation

$$i = \frac{dq}{dt} = +\frac{dq^+}{dt} + \frac{dq^-}{dt} \tag{1-2}$$

In a neon light, for example, positive ions moving to the right and negative electrons moving to the left contribute to the current flowing to the right. In a current of 1 ampere, charge is being transferred at the rate of 1 coulomb per second.

VOLTAGE. The energy-transfer capability of a flow of electric charge is determined by the electric potential difference or voltage through which the charge moves. A charge of 1 coulomb receives or delivers an energy of 1 joule in moving through a voltage of 1 volt or, in general, instantaneous voltage is defined by

$$v = \frac{dw}{dq} \tag{1-3}$$

ELECTRICAL POWER AND ENERGY

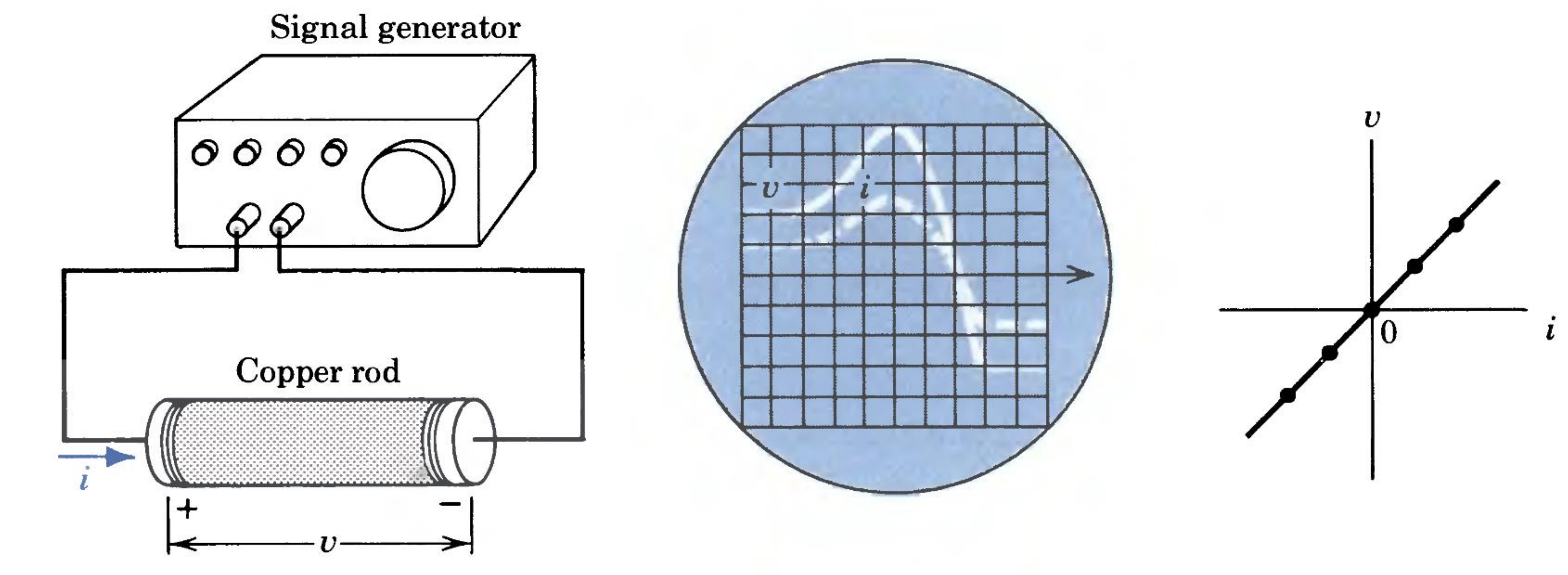
A common problem in electric circuits is to predict the power and energy transformations in terms of the expected currents and voltages. Since, by definition, $v = dw/dq$ and $i = dq/dt$, instantaneous power is

$$p = \frac{dw}{dt} = \frac{dw}{dq}\frac{dq}{dt} = vi \tag{1-8}$$

Therefore, total energy is

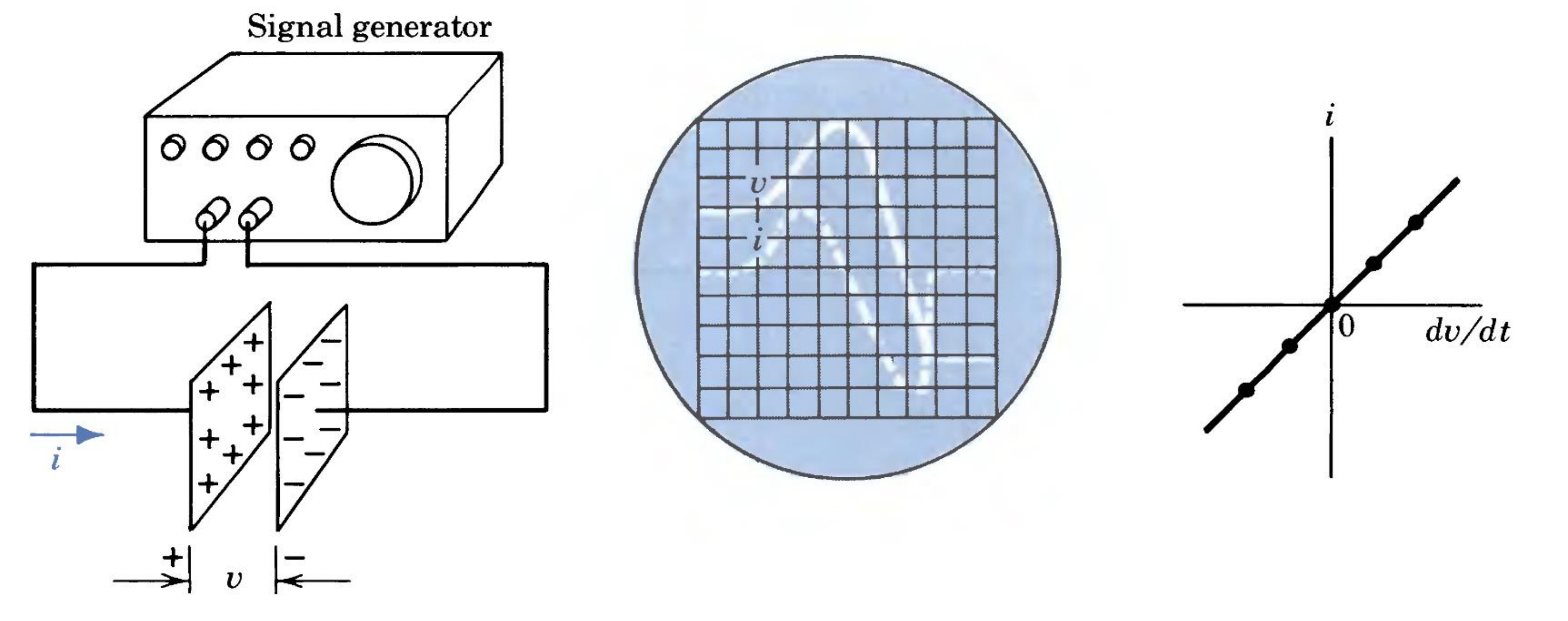
$$w = \int p\, dt = \int vi\, dt \tag{1-9}$$

RESISTANCE



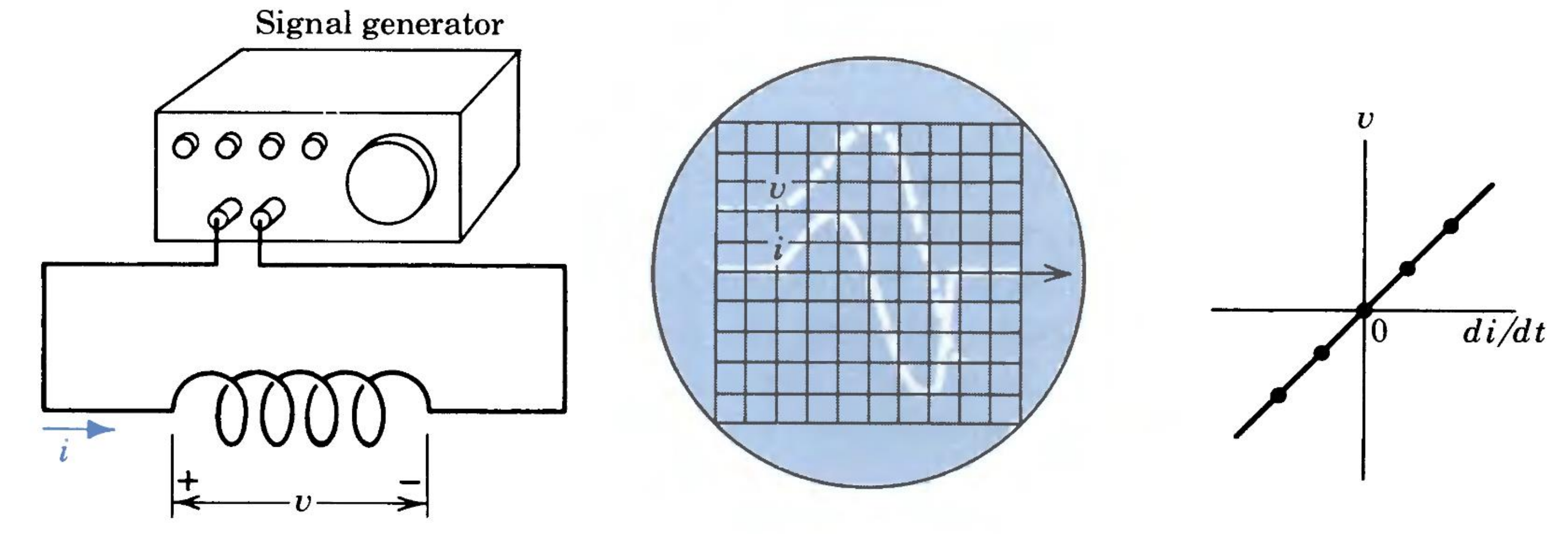
$$v \cong Ri$$

CAPACITANCE



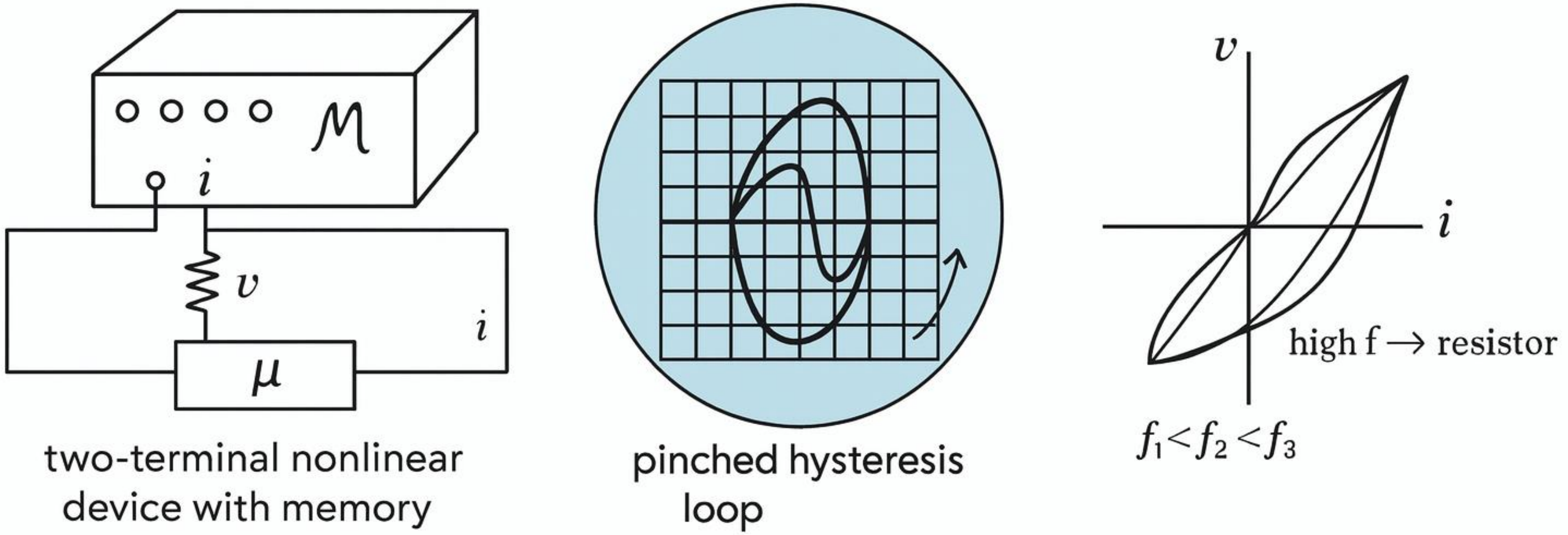
$$i \cong C \frac{dv}{dt}$$

INDUCTANCE



$$v \cong L \frac{di}{dt}$$

MEMRISTOR



$$\boxed{v = M(q)\cdot i = \frac{d\varphi}{dq}}$$

memristance
$M(q) = d\varphi/dq$

Other Elements