Creative Electronics

Assignor Information

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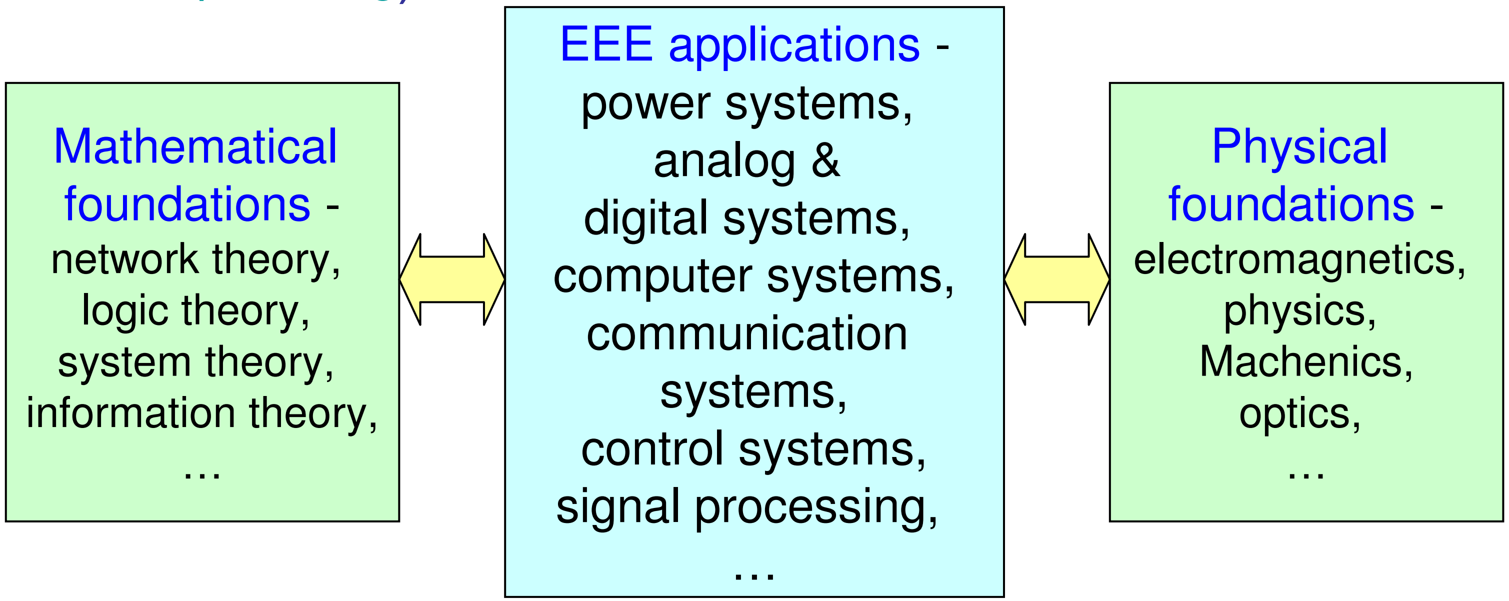
What is Electrical & Electronics Engineering (EEE)?

• EEE is a field of engineering that deals with the study and application of electricity, electronics and electromagnetism (from en.wikipedia.org)

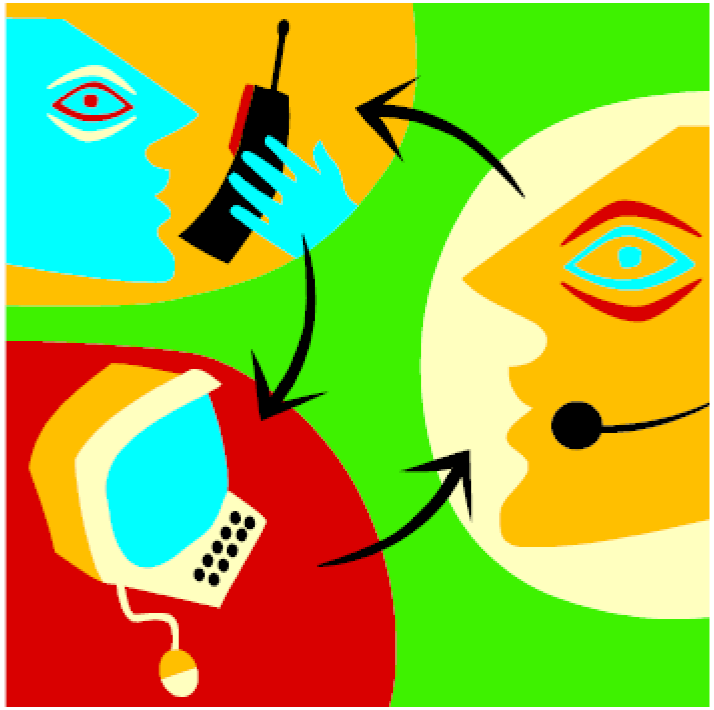


EEE disciplines & their connections to mathematical and physical foundations

Adapted from Figure 1.1, "Principles and applications of electrical engineering", Giorgio Rizzoni, Rev. 4th ed. *Publisher* London : McGraw-Hill, 2004

Why Electronics

- Computers & Internet
- TV & Mobile Phones
- CDs & DVDs
- MP3 & ipod
- GPS navigation
- Digital Cameras
- Robots
- Health Monitoring
- Virtual Reality
- Ambient Intelligence
- …

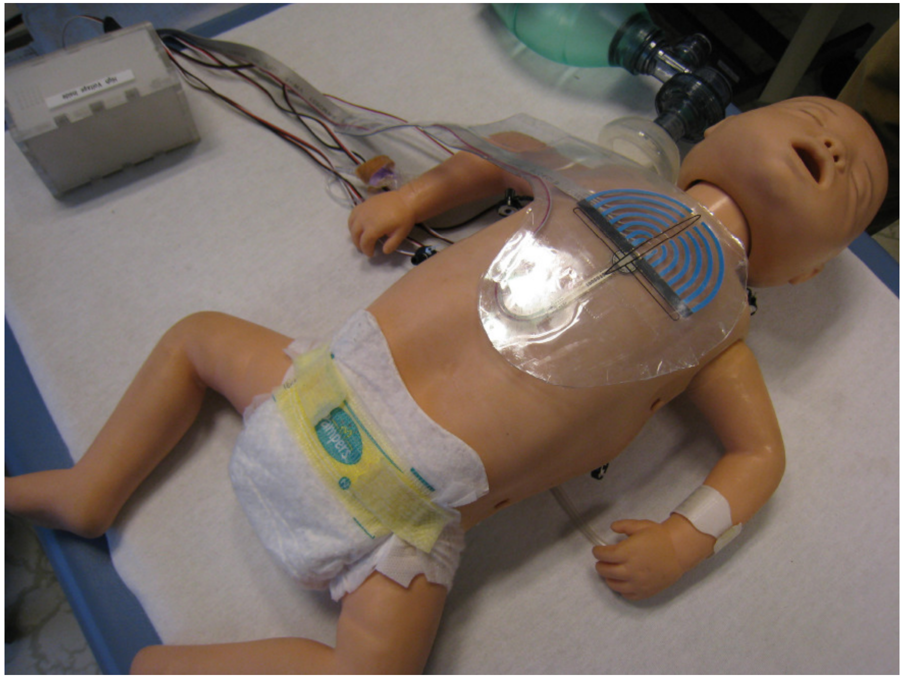


Example Design Project

Sensors,
Actuators,
Transistors,
…

Green street, B1.1 project, designed by Ivo Wouters, Bart van Oorschot, Jasper Blom, Maarten Woudstra, Rick Paffen and Rik Hermans
http://www.youtube.com/watch?v=rOWoT-PJPiI

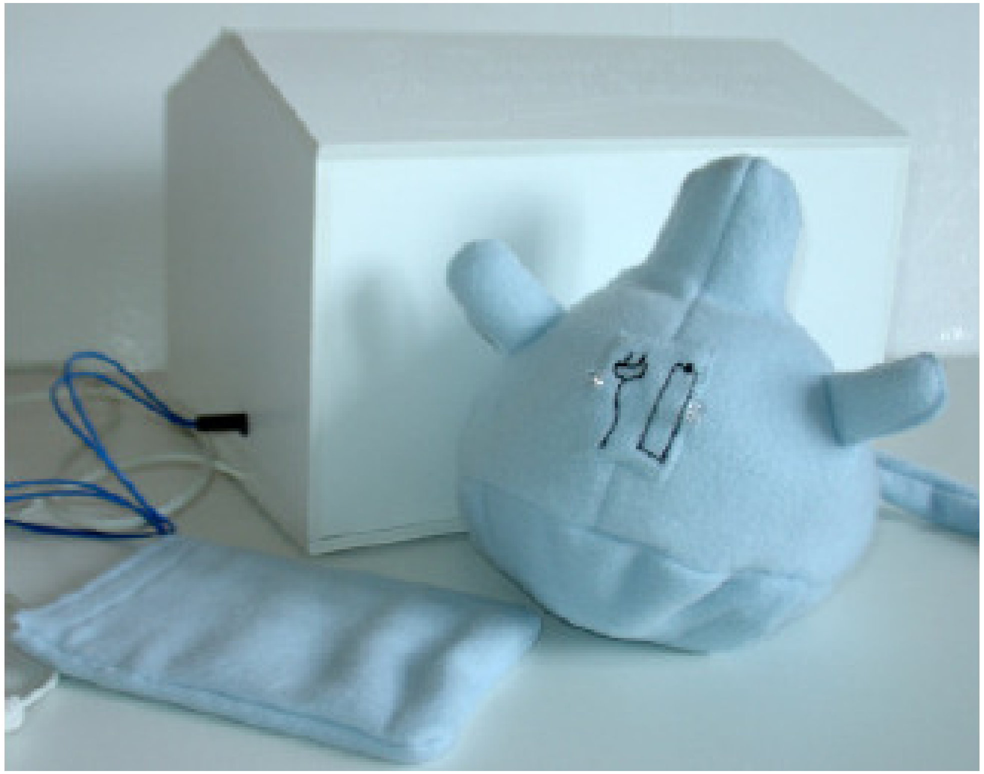
Example Design Project



Sensors,
Actuators,
LEDs,
Computer interface
…

Rhythm of life (I&II), M1.1 and B2.1 project, designed by Floris Kimman, Maarten Geraets, Yening Jin, Nicolas Nelson, Mark Thielen, Yi Xue

Example Design Project



Inductors,
Capacitors,
Circuit analysis,
…

PowerBoy, M1.1 project, designed by Freek Boesten

Example Design Project

sensors,
impedance,
filters,
…

Smart jacket for NICU, M2.2 project, designed by Sibrecht Bouwstra

Objectives of Assignment

- Introduce the most important concepts and knowledge of EEE (what does it stand for?)
- Introduce equipments and methods for practical measurements
- Understand and design simple electronic circuits
- Hands-on skills through practical experiments
- Target competency area 2: Integrating Technology related competency area – D analysing complexity

Good Learning

- Concept: get the idea in the lectures
- Compute: do exercise and questions THINK!
- Compare: work in labs to “convert mind to motion”
- Communicate: work in groups, discuss
- (But) Do <u>not</u> copy or cheat on assessment work

Getting Help

- Lectuers
- Your fellow students
- Reference books:

"Principles and applications of electrical engineering",
Giorgio Rizzoni,
Rev. 4th ed. *Publisher* London : McGraw-Hill, 2004

- Internet
- Nontechnical questions:

- Your coaches
- Study adviser

Getting Help

Google search

http://nl.wikipedia.org/wiki/Wikipedia
http://en.wikipedia.org/wiki/Wikipedia
[Very nice on-line encyclopedia]

http://users.pandora.be/educypedia/electronics/digital.htm
[Very nice site on electronics, with lots of links]

http://www.Hobby-Electronics.info
[Very nice site on electronics, with lots of links and a very useful online 'electronics' course in Dutch as wel in English]

http://www.virtual-oscilloscope.com/
[Beautiful simulation of a real life two channel oscilloscope. You can turn and push every knob and study the effect]

http://www.fontys.nl/werktuigbouwkunde/medewerker/cvanleuken/mechatronica/oscilloscope.htm
[IN DUTCH. Good tutorial on oscilloscopes guided by an explanation of every function knob and button of a real life two channel oscilloscope]

http://www.ee.usyd.edu.au/tutorials_online/topics/labintro/labintro.html
[Online tutorial on DC power supplies, function generators, digital multimeters and oscilloscopes]

http://www.st-andrews.ac.uk/~www_pa/Scots_Guide/intro/electron.htm
[Beautiful and extensive site on electronics]

http://www.circuitsonline.net/
[IN DUTCH. Nice site on electronics. Lots of practical information]

http://www.iguanalabs.com/breadboard.htm
[Short tutorial on how to use a breadboard (socket board)]

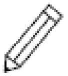
http://www.kpsec.freeuk.com/index.htm
[Nice site on electronics. Lots of practical information]

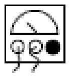
Text Book Icons

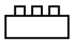
! an important note

? a question which you have to answer

E an example which clearifies the discussed theory

 an optional exercise which will help you in understanding formulas and gaining insights

 a practical assignment which you have to do

 a building block which you have to create

Text book, planning and lecture notes can be found on Oase in the DG291 folder of Handout.

Units

	prefix name	*prefix symbol*	*power-of-ten*
lower case prefix symbols	yocto	y	10^{-24}
	zepto	z	10^{-21}
	atto	a	10^{-18}
	femto	f	10^{-15}
	pico	p	10^{-12}
	nano	n	10^{-9}
	micro	µ	10^{-6}
	milli	m	10^{-3}
	centi	c	10^{-2}
	deci	d	10^{-1}
	[unity]	[none]	10^{0}
	deka	da	10^{+1}
	hecto	h	10^{+2}
	kilo	k	10^{+3}
upper case prefix symbols	mega	M	10^{+6}
	giga	G	10^{+9}
	tera	T	10^{+12}
	peta	P	10^{+15}
	exa	E	10^{+18}
	zetta	Z	10^{+21}
	yotta	Y	10^{+24}

From www.poynton.com/notes/units/index.html

For example:
A, mA

Chapter 2

Voltage, Current and Power

Voltage Current and Power

- Electrical power source
  - Electricity grid (socket)
  - Batteries for small, portable devices (need to be replaced / recharged)

$$P = V \cdot I \tag{2.1}$$

Quantity	Unity	Symbol
Voltage, potential diff.	Volt (V)	V
Current	Ampere (A)	I
Power	Watt (W)	P

Table 2.1: *Electrical quantities with their respective unities and symbols.*

Electrical Power vs. Electrical Energy

- Electrical energy is the power consumed during a period of time.

- Unity: J (Joule)
- Watt-hour (W·h) or the kiloWatt-hour (kW·h)

*“We used *** electric power in this month” or*
*“We used *** electrical energy in this month”?*

A simple calculation:
How much electrical energy will a light bulb use?

Direct Current (DC)

Two types of electrical power sources:

- Batteries
- Electricity grid (socket)

• Direct Current (DC)

- Current always flows in the same direction.

• Alternating Current (AC)

- The direction of current alternates.

Direct Current (DC)

Features of an DC voltage source

- Constant voltages are supplied.
- An ideal DC voltage source:
the voltage is independent of the magnitude and duration of the current.
- Batteries are not the only DC sources. Why?
- DC sources connected to the electricity grid
- Behave like ideal DC-sources.

Direct Current (DC)

! **Note**

When doing experiments which require a constant voltage, you can make use of a DC-power source. These sources have at least two connections: the mass (black) and the positive potential (red). The mass can be seen as the ground and we take its potential as 0 V. The potential difference between the black and red connection is the voltage supplied by the source. In Appendix D you can find more information about the most common sources you will be using at the university.

Figure 19.1: *A laboratory power supply.*

Alternating Current (AC)

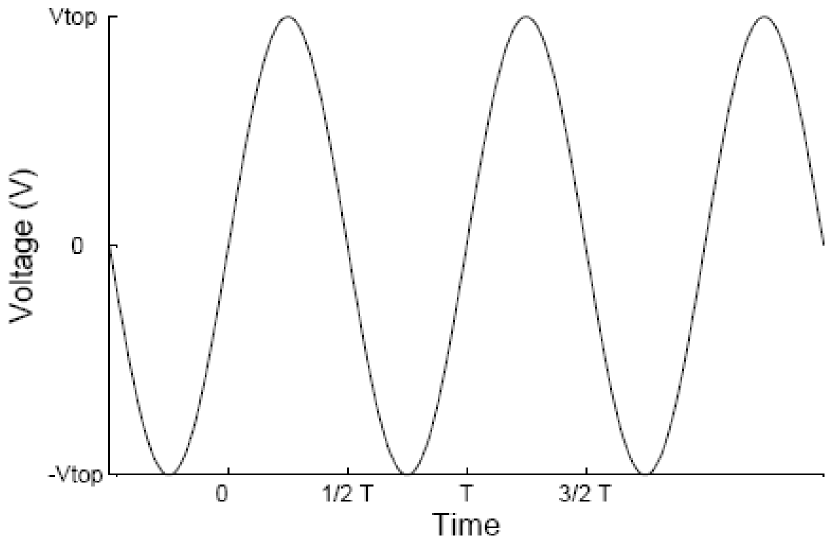


Figure 2.1: *Example of an AC sine waveform.*

- Potential difference between the two plugs of the contact alternates.
- If we put a resistance between the plugs, we could see that the current alternates.

Alternating Current (AC)

$$V(t) = V_{top} \cdot \sin(2\pi \cdot f \cdot t + \varphi)$$

f : frequency of the signal
V_{top} : the peak value or amplitude
t : time
T : the period of the sine wave (T=1/f)
ω : the frequency of rotation (ω = 2· π· f)
φ : phase, can be zero [equation (2.2)].

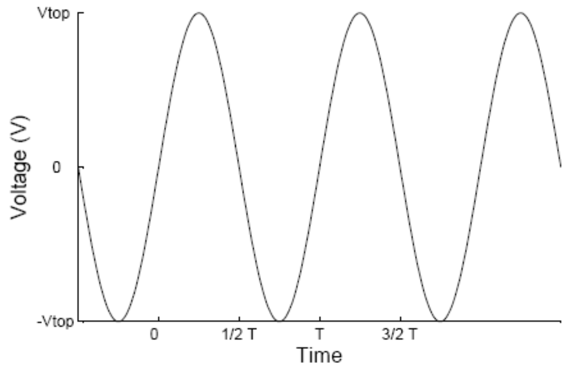


Figure 2.1: *Example of an AC sine waveform.*

- In the Netherlands, f = 50 Hz, V_{top} = 325 V (why not 230 V?)
- A lamp connected to the electricity grid goes on and off twice during one cycle.
- A combination/superposition of an AC voltage (V_{AC}) and a DC (V_{DC}) voltage
  - V_{DC} is called an offset voltage.
  - This will be illustrated later, when you start working with a function generator.

RMS Values

RMS: Root Mean Square

- Why RMS?
  - V_{top} is not a good measure of AC voltages.
  - AC voltage changes all the time.

- RMS value - The effective value of a varying voltage or current. It is the equivalent steady DC (constant) value which has the same heating potential.

- RMS is also called the effective DC value.

RMS Values

$$\frac{V_{RMS}^2}{R} = (\frac{V^2}{R})_{\text{mean of period}} \qquad (2.3)$$

where V_{RMS} is the RMS value (DC equivalent) of $V(t)$. Since R is constant, we get:

$$V_{RMS}^2 = (V^2)_{\text{mean of period}} \qquad (2.4)$$

Since V_{RMS} should be positive, this results in:

$$V_{RMS} = \sqrt{(V^2)_{\text{mean of period}}}\,. \qquad (2.5)$$

The value of $(V^2)_{\text{mean of period}}$ can be calculated by summing up all the instantaneous values of $V^2(t)$ during one period, divided by the number of values $(\frac{1}{N}(V^2(t_1) + V^2(t_2) + ... + V^2(t_N)))$. This can be expressed as follows:

$$(V^2)_{\text{mean of period}} = \frac{1}{T}\int_0^T V(t)^2 dt. \qquad (2.6)$$

RMS Values

!! For a true sine wave

$$V_{RMS} = 0.7 \cdot V_{peak}, \tag{2.7}$$

$$V_{peak} = 1.4 \cdot V_{RMS}. \tag{2.8}$$

RMS is not a simple average!

Sine Waves

• Sine waves are the most common type of AC.
- A dynamo on your bike is a small generator.
- A combination of mechanical and electromagnetic properties generates a sinusoidal signal.

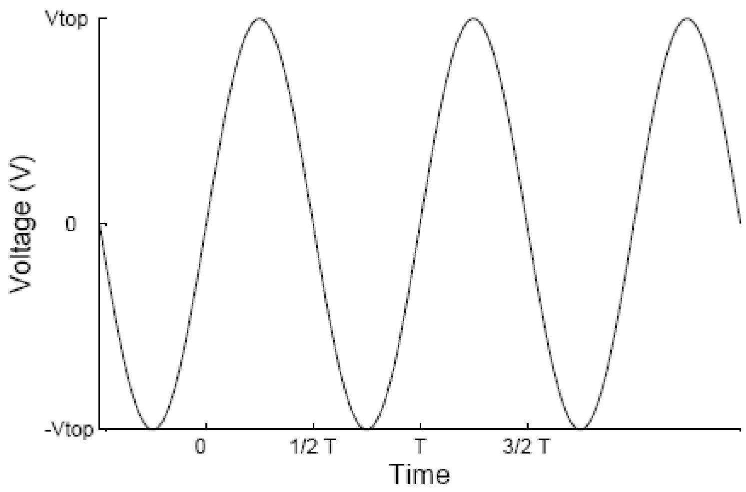


Figure 2.1: *Example of an AC sine waveform.*

$$V(t) = V_{top} \cdot \sin(2 \cdot \pi \cdot f \cdot t) \quad (2.2)$$

Sine Waves

- The rotating field in the generator can be seen as a vector.
- The sine wave is a projection of this vector onto a certain axis.

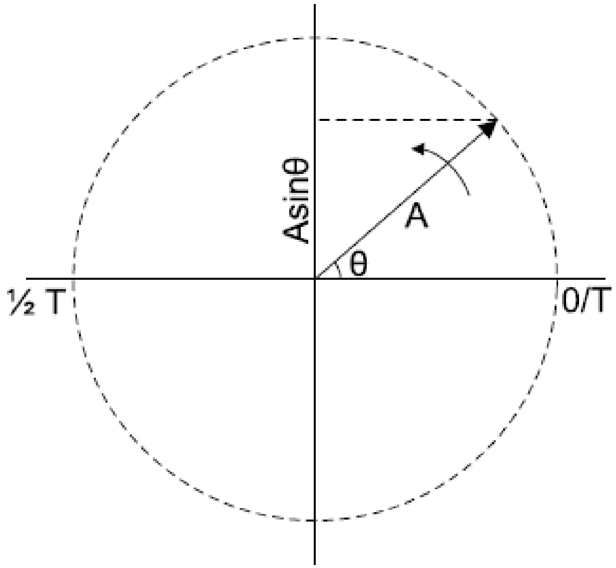


Figure 2.2: *The projection of a rotating vector on the y-axis results in a sine wave.*

The change in θ over time is ω, which is related to the period time T by $\omega = 2\pi/T$.

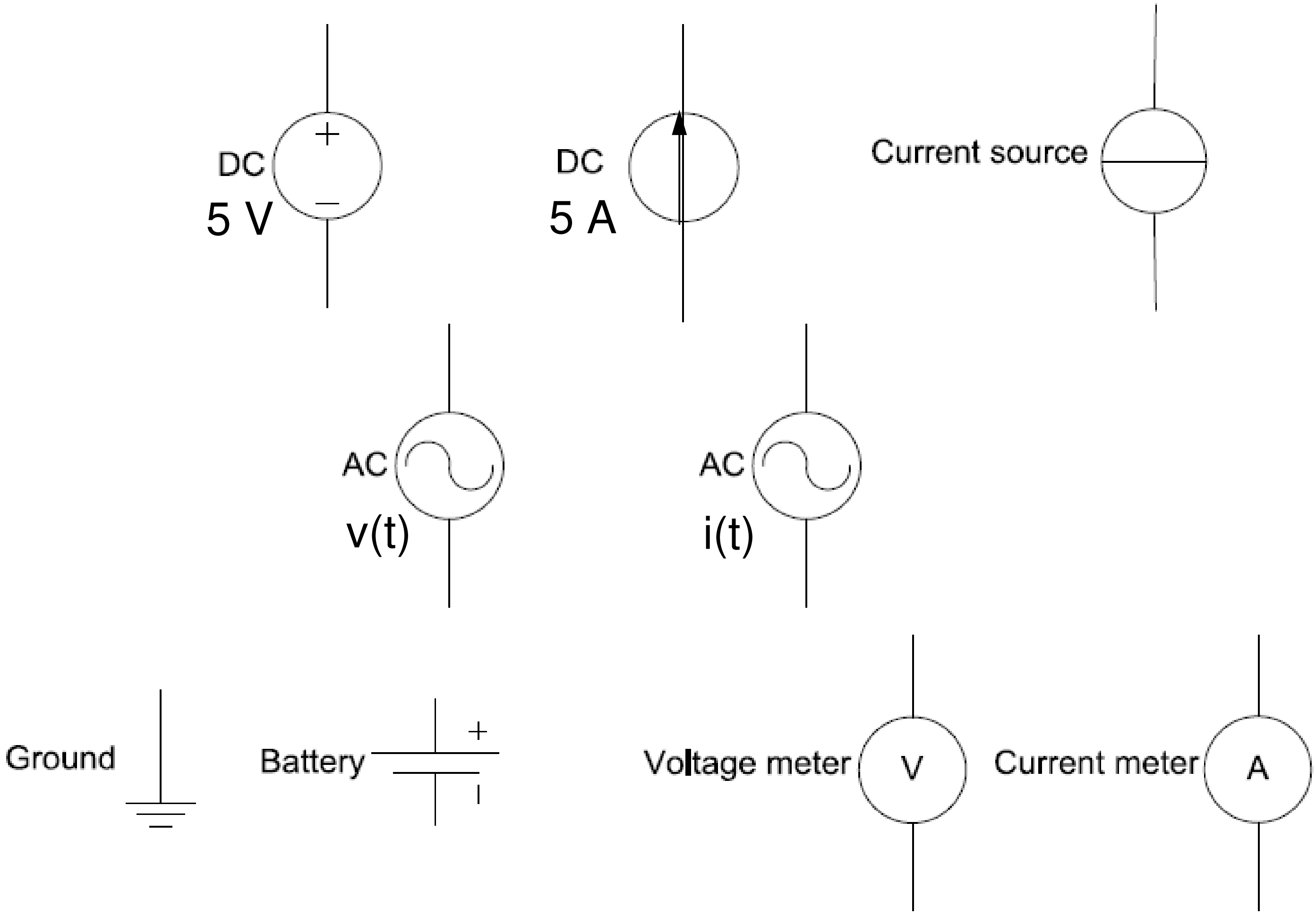
Energy vs. Information

- Voltages and currents are related to the electrical energy consumption of circuits.

- Voltages and currents are also used to transmit / receive information.

- Waveforms (sound wave)
- Digital bits (code)

Symbols of Sources and Meters



Software Programs for Circuit Drawing

- Microsoft Visio

http://w3.tue.nl/en/services/dienst_ict/services/services_wins/software/

Draw circuits professionally for your report!

Exercise – RMS Calculation

For a sinusoidal signal,

$$V(t) = V_{top} \cdot \sin(2 \cdot \pi \cdot f \cdot t) \qquad (2.2)$$

Calculate its RMS by

$$V_{RMS}^2 = \frac{1}{T}\int_0^T V^2(t)dt$$

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^T V^2(t)dt}$$

Exercise – RMS Calculation

Exercise – RMS Calculation

$$V_{RMS}^2 = \frac{1}{T}\int_0^T V_{top}^2 \sin^2(2\pi f t)\,dt$$

$$= \frac{V_{top}^2}{T}\int_0^T \frac{1-\cos(4\pi f t)}{2}\,dt$$

← based on Trigonometric identities

$$= \frac{V_{top}^2}{2T}\left[\int_0^T 1\,dt - \int_0^T \cos(4\pi f t)\,dt\right]$$

$$= \frac{V_{top}^2}{2}$$

Therefore,

$$V_{RMS} = \frac{V_{top}}{\sqrt{2}} \approx 0.7V_{top}$$