Electronics
1st year LM, 10 credits

Prof. Alessandro Spinelli
DEIB, Politecnico di Milano
Bld. 22, 4th floor, Via Golgi 42
Tel. (02 2399) 4001
alessandro.spinelli@polimi.it
home.deib.polimi.it/spinelli
Outline

• Electronics in Engineering physics
• For the Telecom eng. guys
• What is all about?
• General information
• Final recommendation...
WHY?
What does «Electronics» Mean to You?
And what about «Physics»?
"There does not exist a category of science to which one can give the name applied science. There are sciences and the applications of science, bound together as the fruit of the tree which bears it".

Louis Pasteur, 1871
Who are They?

A. Fert, P. Grünberg
Nobel 2007 in physics
“for the discovery of Giant Magnetoresistance”

W. S. Boyle, G. E. Smith
Nobel 2009 in physics
“for the invention of an imaging semiconductor circuit – the CCD sensor”
And Besides...

A. Geim, K. Novoselov

Nobel 2010 in physics “for groundbreaking experiments regarding the two-dimensional material graphene”
Bell Labs, December 1947
Intel 4004 (1971)

Technology: 10 µm

Transistor count: 2300

Size: 12 mm²

Frequency: 740 kHz
Intel Broadwell (2015)

Technology: 14 nm

Transistor count: 1.9 billion

Chip size: 133 mm$^2$

Frequency: 2.5 – 3.4 GHz
IMFT Flash Memory (2016)

Technology: 3D (32 layers)

Capacity: 384 Gb (48 GB)

Transistor count: > 128 billion

Chip size: 175 mm²
Moore Law

Scaling

1 \mu m – 1990

90 \text{ nm} – 2003

25 \text{ nm} – 2010

Scaling limit?
What comes next?
Further Insight

Electron devices course, 1st semester LM

Prof. C. Monzio Compagnoni
Enabling Technologies
in medicine/surgery
Enabling Technologies in physics/optics
Enabling Technologies in physics/astronomy

Hubble telescope
Motivation

• Sensors, instrumentation and data acquisition are key issues in all fields (not just in physics)
• Data acquisition systems always have electronics at their heart
• The acquisition chain must be
  – Sized
  – Designed
• An *engineer* must (should...) know how to deal with these problems
For the Telecom Eng. guys

• Links between telecom and electronics are countless; however...

• This course is not about telecom circuit design (others take care of that)

• This course deals with signal recovery. We use the same techniques employed at the receiver side of a transmission channel, but for signals coming from sensors
What’s going on?
GW Detector

- GW signal shifted arms length by a fraction of the diameter of a proton
- Detectors pick up noise from earthquakes, trucks, ocean waves, bicycle riding,...
Signal Conditioning
Course Sections

• OA Circuits
  – Feedback, impedances, parameters,...
  – Linear applications: instrumentation amps, active filters,...
  – Frequency response, stability and compensation
  – Noise

• Instrumentation
  – Sensors (temperature, strain,...)
  – Signal recovery from noise
  – A/D conversion
Operational Amplifiers

- Analysis and design of simple circuits
- Emphasis on application to data acquisition
Stability
Real OA: Parameters
Sensors

Termocouples

Thermistors

Strain gages
Signal and Noise
White Noise
1/f Noise

Systolic blood pressure

Radio signal for different kind of music
What you learn

• To analyze and design simple circuits using OAs
• To understand and solve simple problems in data acquisition involving
  – Sensors
  – Preamplification
  – Noise filtering

• Overall, an “engineering” approach to simple yet realistic problems
Structure

• Lessons
  – Theory and basic concepts
  – Few numerical examples

• Drills
  – Numerical examples
  – Exam test solution

• Office hours: always (just send me an email)

• Your opinion IS important!
Lecture slides

• Available on home.deib.polimi.it/spinelli ⇒ Teaching ⇒ Electronics

• (Very) useful for schemes, equations, figures,…

• Hint: print them ahead of time and take (plenty of) notes alongside

• Don’t forget in any case to read/study on the textbooks!
Textbooks (@ faculty library)

• Operational Amplifiers

• Sensors, noise and filtering
  – S. Cova, “Appunti e bibliografia per il corso di sensori, segnali e rumore”, CLUP (in italian)
Exercise books

• No English book available

• Introductory Italian texts are
  • A. Bonfanti, A. Lacaita, «L’amplificatore operazionale», Esculapio, 2005
  • A. Tosi, «Esercizi di elettronica», Esculapio, 2011 (85 pages on OA)

• Exam solutions for the last nine years (more than 200 exercises!) are available on
  home.deib.polimi.it/spinelli ⇒ Teaching ⇒ Electronics.
  Last year solutions are in English
### Timetable

<table>
<thead>
<tr>
<th>Time</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.15 – 9.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.15 – 10.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>10.15 – 11.15</strong></td>
<td>T01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.15 – 12.15</td>
<td>T01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.15 – 13.15</td>
<td>T01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>13.15 – 14.15</strong></td>
<td>EG3</td>
<td></td>
<td>S16 (ex.)</td>
<td></td>
</tr>
<tr>
<td>14.15 – 15.15</td>
<td>EG3</td>
<td></td>
<td>S16 (ex.)</td>
<td></td>
</tr>
<tr>
<td>15.15 – 16.15</td>
<td></td>
<td></td>
<td>S16 (ex.)</td>
<td></td>
</tr>
<tr>
<td>16.15 – 17.15</td>
<td></td>
<td></td>
<td>S16 (ex.)</td>
<td>10.30</td>
</tr>
</tbody>
</table>

**Expected end of lessons:** mid-June
Prerequisites

• Linear networks (Kirchhoff, Thevenin and Norton theorems, superposition principle, impedance calculations,...)
• Fourier and Laplace transforms and linear systems (incl. Bode plot)
• If not already, you must get familiar with these basic concepts as soon as possible
Final examination

• Written test only
• Two exercises (4 questions each)
  – OA and noise
  – Filtering and signal conditioning
• One question
• To get 30/30 you need to **correctly** solve 75% of the test
• The **numerical result**, not just the method, matters
Exam dates

• July 4
• July 21
• September 5
• September 23

• At: 13:00
• Span: 3 hours
Recommendations

YOU TALKIN’ TO ME?
Myth debunking...

• The exam **IS NOT** difficult
  – More than 50% of attendees pass it
• It is (perhaps) a bit different from what you are used
  – You must **solve** simple problems, not just say how you would
  – I ask you to **show your understanding** of the topic, **not to learn everything by heart**
Hints – 1

• Do make use of instructor office hours to ask questions
• Do **NOT** learn $10^n$ exam tests by heart hoping to find a similar one.
  First, make sure you understand the theory; then, move to exercises
• Do **NOT** thrive on last-minute cramming.
  Learning requires time; **there is no shortcut!**
Hints – 2

1. If you want a high mark, don’t just “give it a try”; you are wasting your time

2. Be conscious about your true preparation

3. Please, please, please... DO NOT leave this exam last
The Unlikely Event of Troubles

- In the unlikely event that you have trouble with the exam, trace it back to something you don’t understand in the theory/slides, and ask about it
- If you feel that you understand lecture/slide material but do not pass the exam, there is a contradiction. If you can’t pass the exam, then, by definition, you do not understand all the lecture/slide material
- Adopting the attitude that you do understand but cannot pass the exam is unproductive. It makes it harder for you to help yourself, and makes it harder for me to help you
- If you can’t pass the exam, draw the conclusion that you actually don’t understand the material, even if you think you did. Now you know what you have to do and where you can get help
Final suggestions

• If you don’t understand something during the lesson, just **ask**!
  – You are welcome to use English or Italian

• Don’t be shy: your questions may be important for others, too
  – Let’s try to have some interaction during the lessons and not all the questions at the end

• Try to get the most out of your staying in the class
Your Instructor

- Laurea in Electronics Eng., 1992
- Ph.D. in Electronics Eng., 1995
- Visiting Scholar (UTSI, USA), 1995
- Consultant for STMicroelectronics, 1996
- Teaching Assist. at Politecnico di Milano, 1997
- Associate Prof. at Univ. of Como, 1998
- Visiting Professor (ENSERG, Francia), 2001
- Trasfer to Politecnico di Milano, 2004
- Full Prof. at Politecnico di Milano, 2006
- Research activity: nano-electronic devices
The ascent begins!

Next lesson: negative feedback and amplifiers