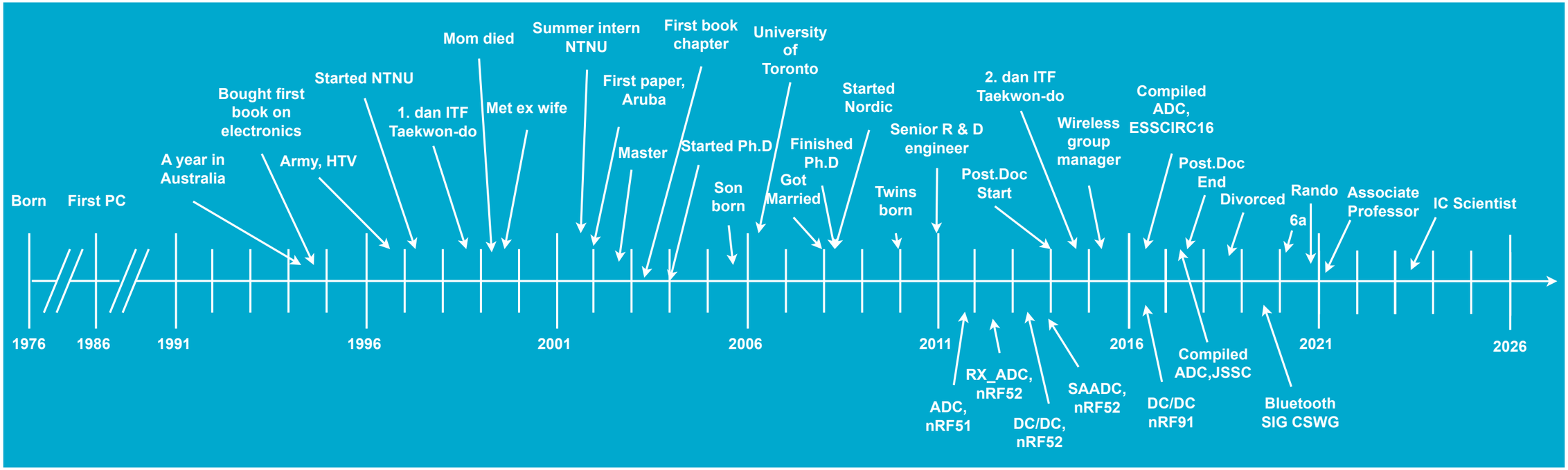
date: 2024-01-12

TFE4188 - Advanced Integrated Circuits

Lecture 1 - Introduction

Who

Carsten Wulff carstenw@ntnu.no



Teaching assistant

- Jonathan Sæthre Ege

Why

I want you to learn the skills necessary to make your own ICs

Insights · Tech The Future

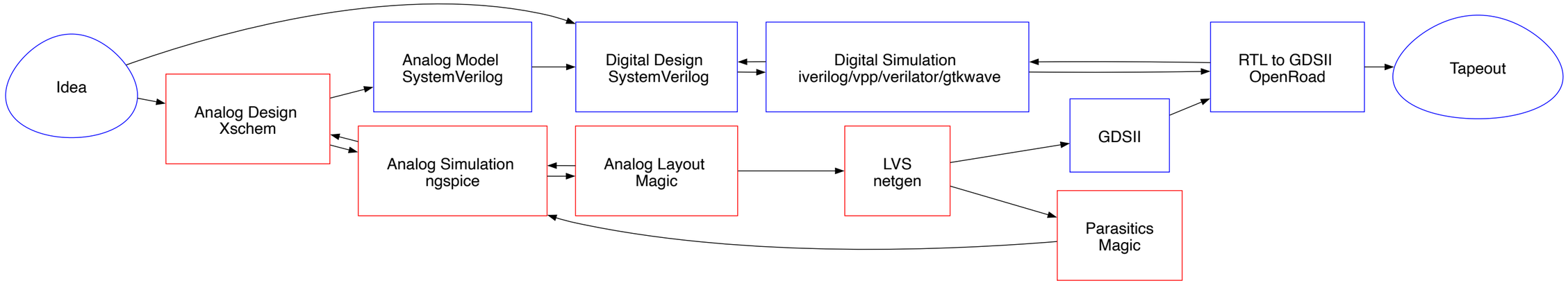
The World Is Analog

10/28/2014

Written by Peter Kinget

The world we live in is analog. We are analog. Any inputs we can perceive are analog. For example, sounds are analog signals; they are continuous time and continuous value. Our ears listen to analog signals and we speak with analog signals. Images, pictures, and video are all analog at the source and our eyes are analog sensors. Measuring our heartbeat, tracking our activity, all requires processing analog sensor information.

https://circuitcellar.com/insights/tech-the-future/kinget-the-world-is-analog/


Idea
Analog Design
Xschem
Analog Model
SystemVerilog
Digital Design
SystemVerilog
Digital Simulation
iverilog/vpp/verilator/gtkwave
RTL to GDSII
OpenRoad
Tapeout
Analog Simulation
ngspice
Analog Layout
Magic
LVS
netgen
GDSII
Parasitics
Magic

Will you tape-out an IC?

https://analogicus.com/aic2024

- *Project flow support*: **Confluence**, JIRA, risk management (DFMEA), failure analysis (8D)
- *Language*: **English**, **Writing English (Latex, Word, Email)**
- *Psychology*: Personalities, convincing people, presentations (Powerpoint, Deckset), **stress management (what makes your brain turn off?)**
- *DevOps*: **Linux**, bulid systems (CMake, make, ninja), continuous integration (bamboo, jenkins), **version control (git)**, containers (docker), container orchestration (swarm, kubernetes)
- *Programming*: Python, Go, C, C++, Matlab Since 1999 I've programmed in Python, Go, Visual BASIC, PHP, Ruby, Perl, C#, SKILL, Ocean, Verilog-A, C++, BASH, AWK, VHDL, SPICE, MATLAB, ASP, Java, C, SystemC, Verilog, and probably a few I've forgotten.
- *Firmware*: signal processing, algorithms
- *Infrastructure*: **Power management**, **reset**, **bias**, **clocks**
- *Domains*: CPUs, peripherals, memories, bus systems
- *Sub-systems*: **Radio's**, **analog-to-digital converters**, **comparators**
- *Blocks*: **Analog Radio**, Digital radio baseband
- *Modules*: Transmitter, **receiver**, de-modulator, timing recovery, state machines
- *Designs*: **Opamps**, **amplifiers**, **current-mirrors**, adders, random access memory blocks, standard cells
- *Tools*: **schematic**, **layout**, **parasitic extraction**, synthesis, place-and-route, **simulation**, (System)Verilog, **netlist**
- *Physics*: transistor, pn junctions, quantum mechanics

Zen of IC design (stolen from Zen of Python)

- Beautiful is better than ugly.
- Explicit is better than implicit.
- Simple is better than complex.
- Complex is better than complicated.
- Readability counts (especially schematics).
- Special cases aren't special enough to break the rules.
- Although practicality beats purity.
- In the face of ambiguity, refuse the temptation to guess.
- There should be one **and preferably only one** obvious way to do it.
- Now is better than never.
- Although never is often better than *right* now.
- If the implementation is hard to explain, it's a bad idea.
- If the implementation is easy to explain, it may be a good idea.

Find a problem that you really want to solve, and learn programming to solve it. There is no point in saying "I want to learn programming", then sit down with a book to read about programming, and expect that you will learn programming that way. It will not happen. The only way to learn programming is to do it, a lot.

— Carsten Wulff

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s/programming/analog design/ig
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My Goal

- Enable you to read the books on integrated circuits
- Enable you to read papers (latest research)
- Correct misunderstandings on the topic
- Answer any questions you have on the chapters

Plan

Lectures:
Friday at 08:15 - 10:00

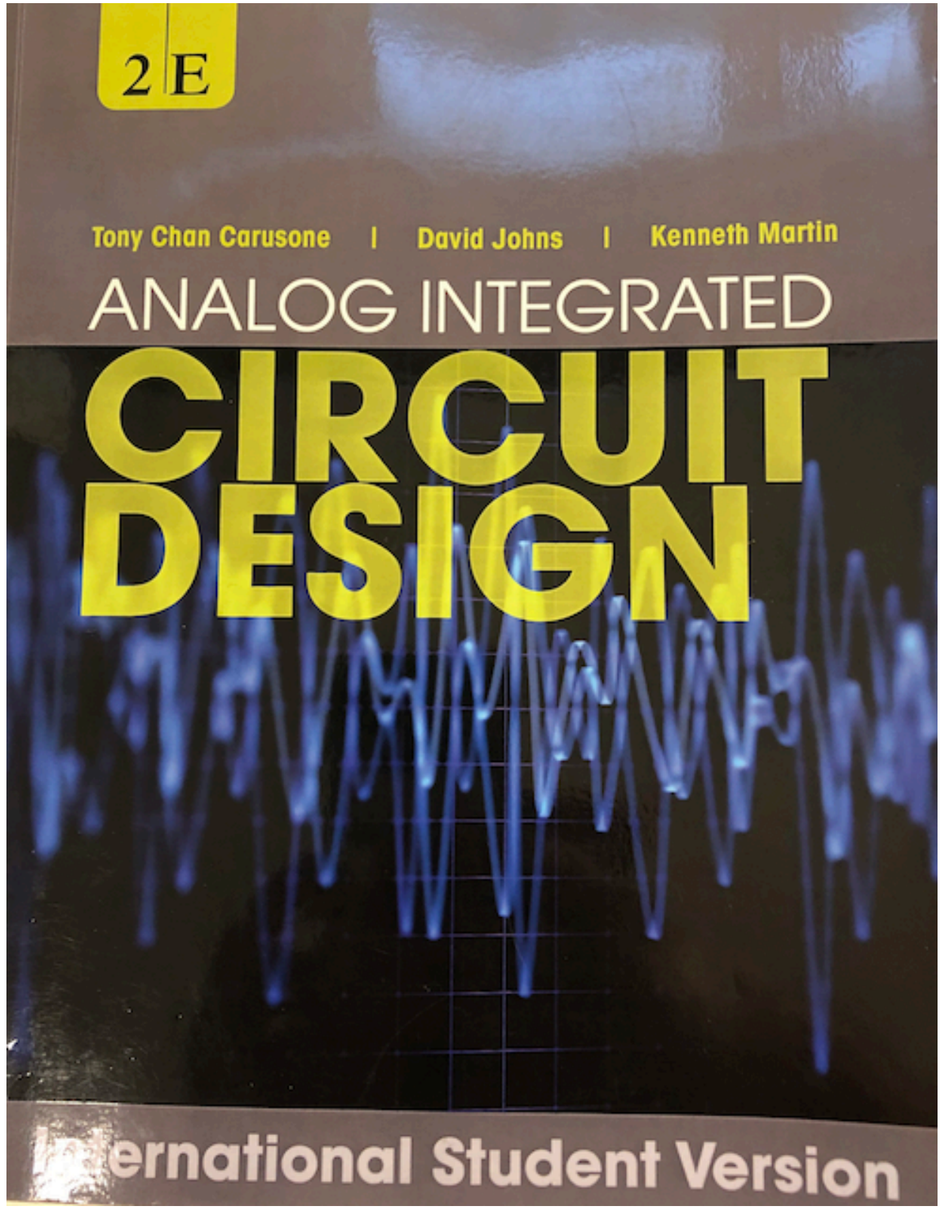
Read the introduction before the lectures at aic2024

The "lectures" will be Q & A's on the topic. If no questions, then I'll ramble on.

Project Hours:
Friday at 10:15 - 12:00

Groups meet, and work on project.

- Description
- Time schedule
- Lecture plan
- Syllabus
- Youtube Videos


2E
Tony Chan Carusone | David Johns | Kenneth Martin
ANALOG INTEGRATED
CIRCUIT
DESIGN
International Student Version

Exam

- June 2022
- 4 hours
- A - F grade (F = Fail)
- Counts for 55 % of the grade

Time to take responsibility for your own future

Exercises

- Exercises on blackboard now
- Solutions on blackboard after the deadline
- **One compulsory exercise: Exercise 0 - Skywater 130nm tutorial**
- For the rest, two options:
  - Don't do the exercises, don't get feedback
  - Do the exercises, hand them in within deadline, get feedback
- The TA will only support the exercises in the marked weeks

Project

Counts for 45 % of the grade

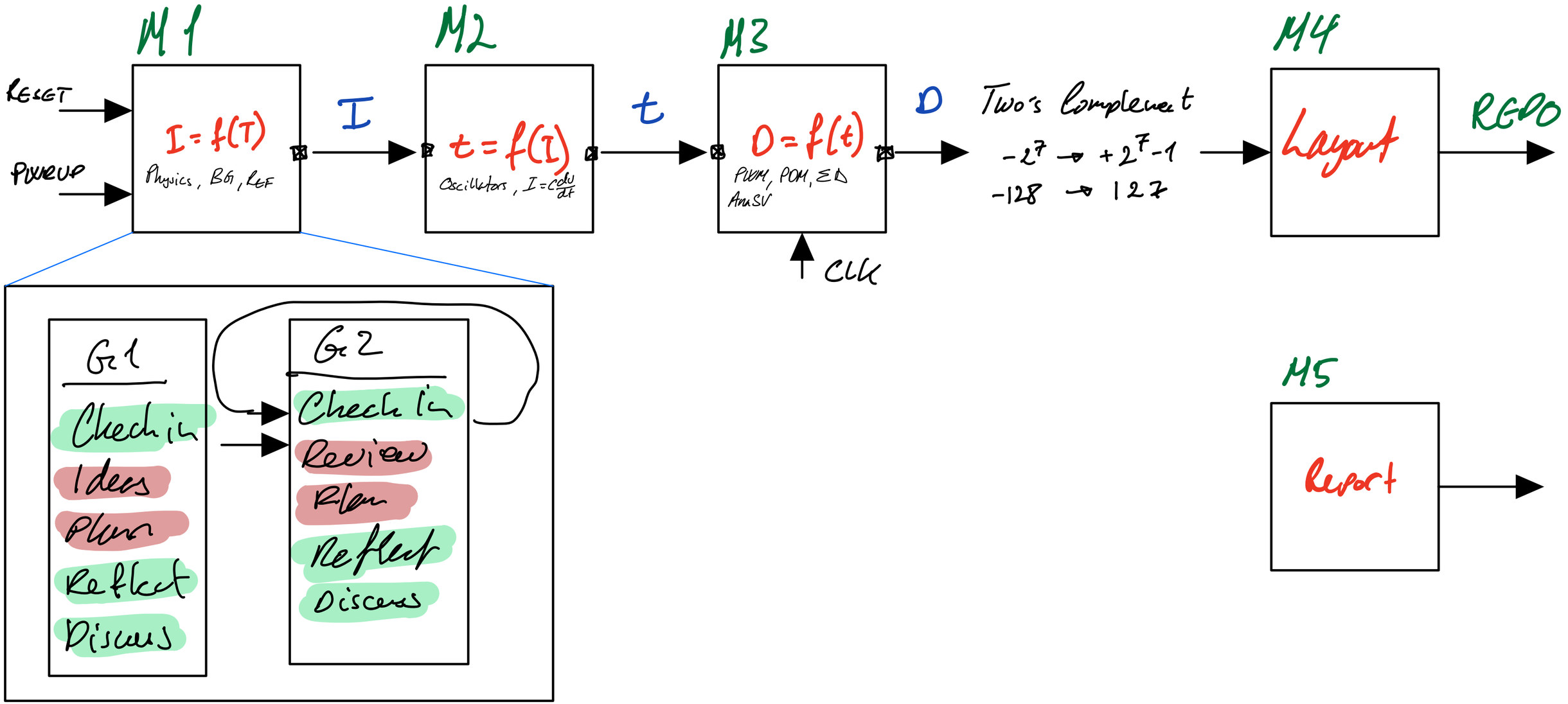
No exam without project.

Strict deadline 29 of April. If you hand in 30 of April at 00:00:01, then you fail the course.

CNR (2024)

"In an insane world, it was the sanest choice." - Sarah Connor, Terminator 2: Judgment Day

Design a integrated temperature sensor with digital read-out


M1
RESET
PWRUP
I = f(T)
Physics, BG, REF
I
M2
t = f(I)
Oscillators, I = C dU/dt
t
M3
D = f(t)
PWM, POM, ΣΔ
AmSV
CLK
D
Two's Complement
-2^7 → +2^7-1
-128 → 127
M4
Layout
RGB0
M5
Report
Gr1
Check in
Ideas
Plan
Reflect
Discuss
Gr2
Check in
Review
Plan
Reflect
Discuss

Grading

Software

Open source software (xschem, ngspice, sky130B PDK, Magic VLSI, netgen)

Skywater 130 nm Tutorial

aicex

Lower your expectations on EDA software

Expect that you will spend at least 2π times more time than planned *(mostly due to software issues)*

Questions

Do

- google
- ask a someone in your class
- use the "øvingstime and labratorieøvelse" to talk to teaching assistants and hopefully me. Don't ask about future exercises
- come to the office (B311)

Thanks!