TFE4188 - Lecture 1

Advanced Integrated Circuits
Introduction

Source

Who

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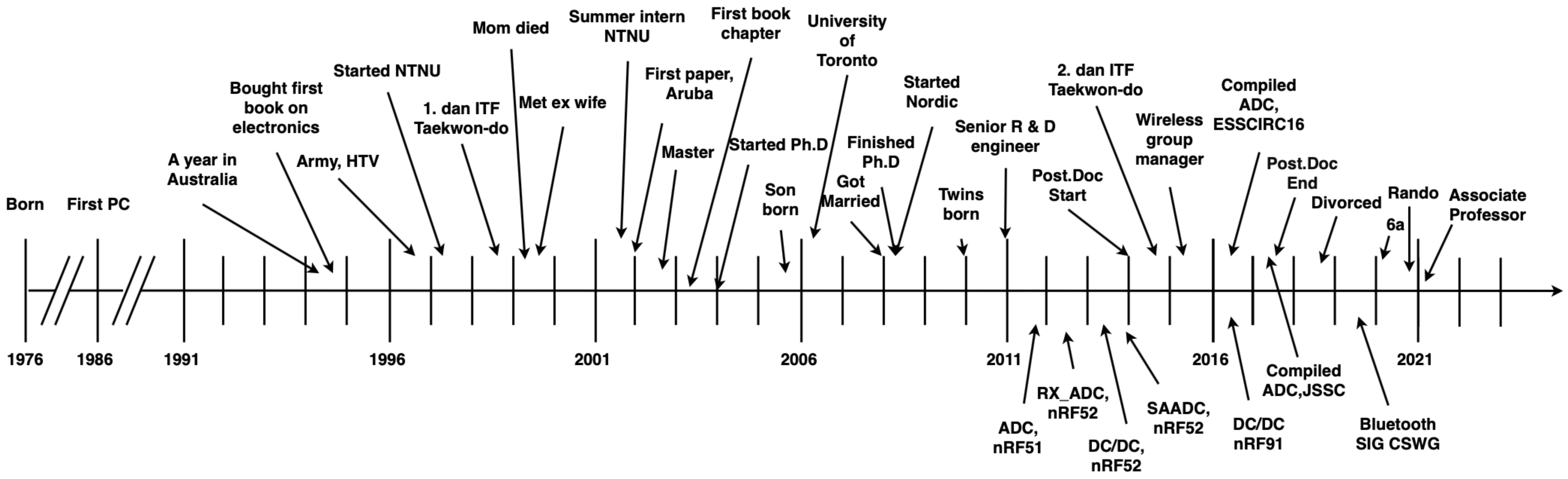


Teaching assistants

- Fredrik Esp Feyling
- Simen Fossum Morken

Why

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

Insights · Tech The Future

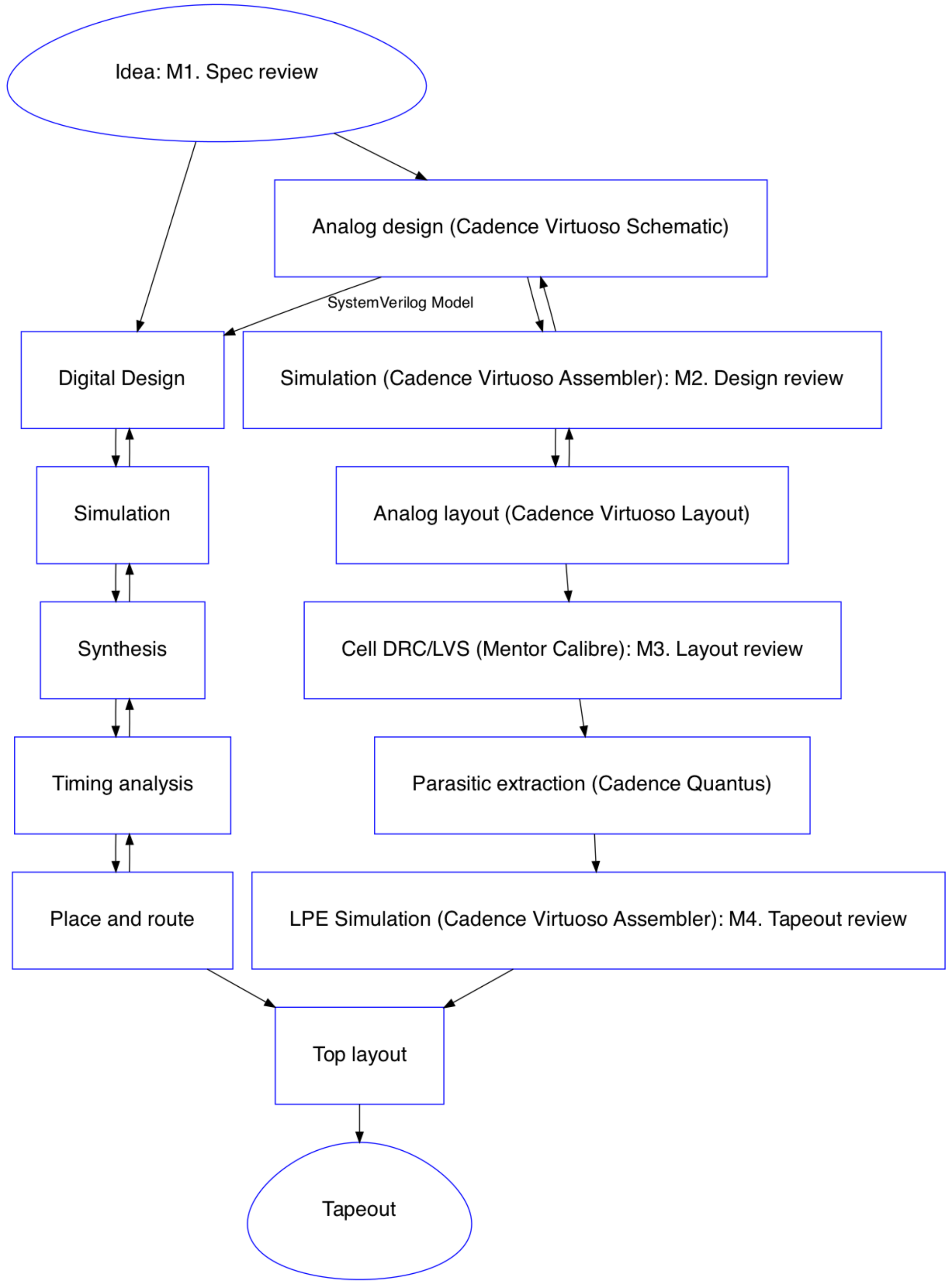
The World Is Analog

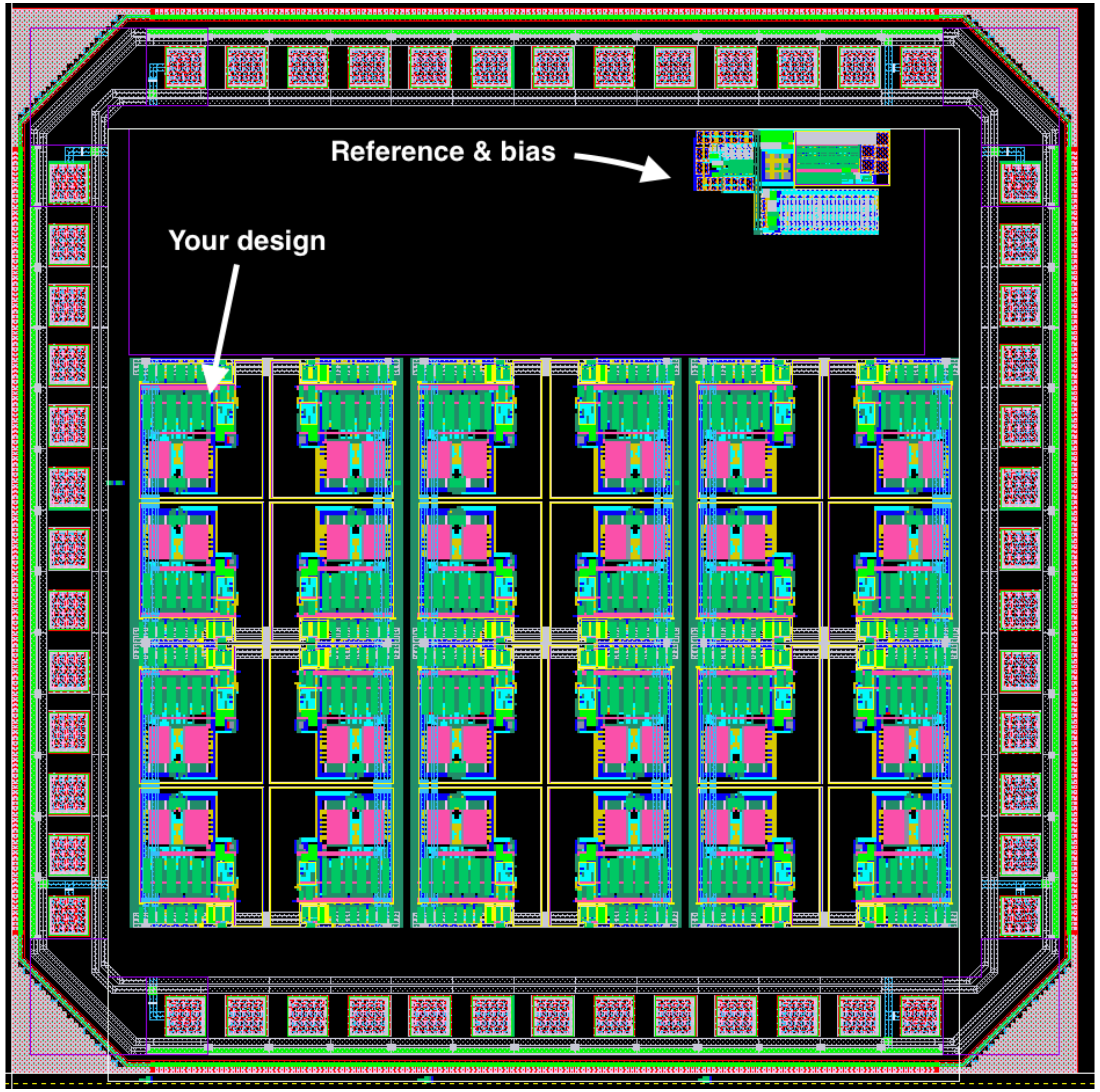
10/28/2014

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/





I want us to tapeout an IC

But I'm not sure we'll make it this year

We need:

- Infrastructure (bias, supply, reset, clocks)
- IO (input, output, ESD)
- Control interface
- Your design

- *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

Find a problem that you really want to solve, and learn programming to solve it. There is absolutely 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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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.

Course

Plan

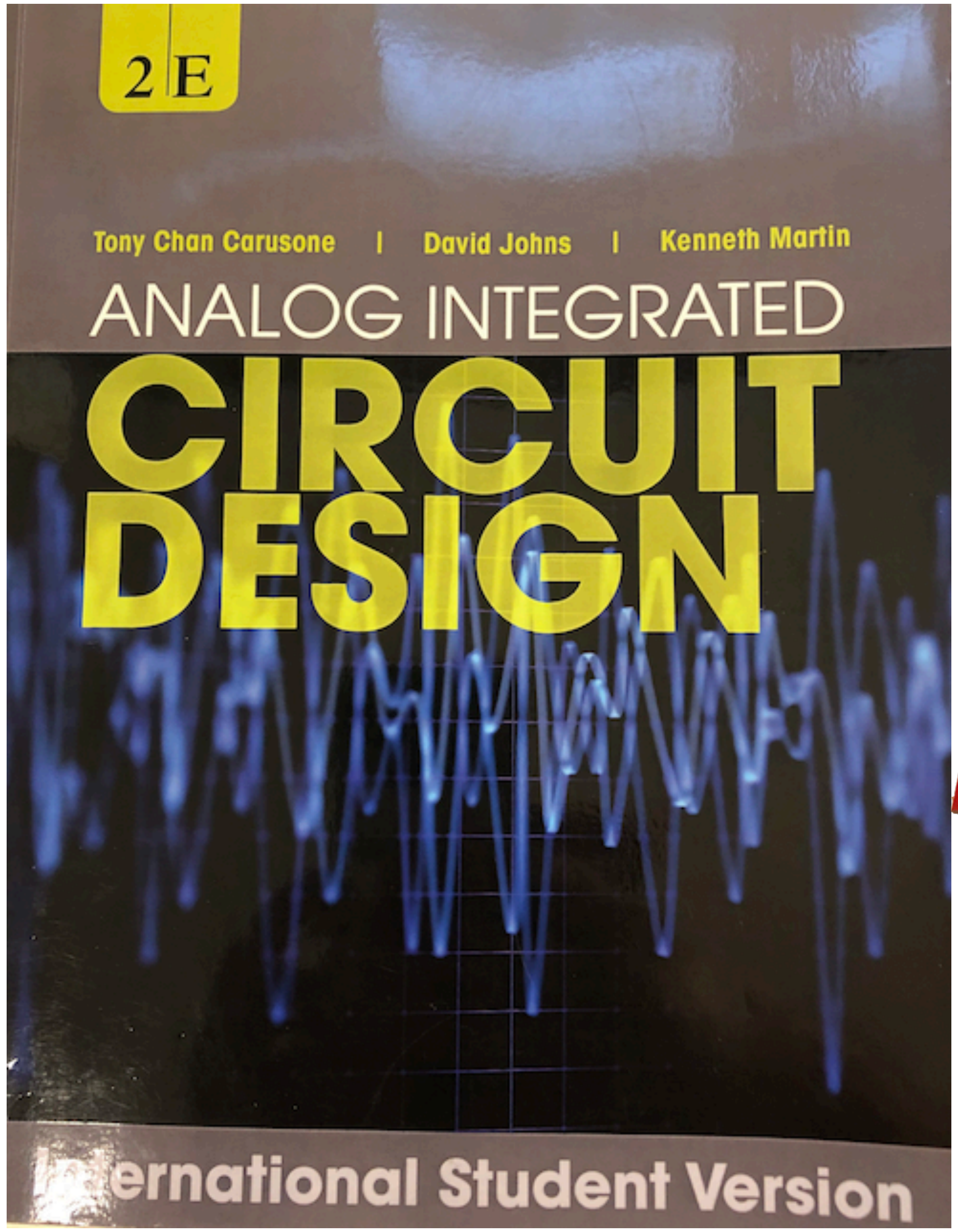
Lecture Monday's at 10:15 - 12:00 (for now, it's digital)

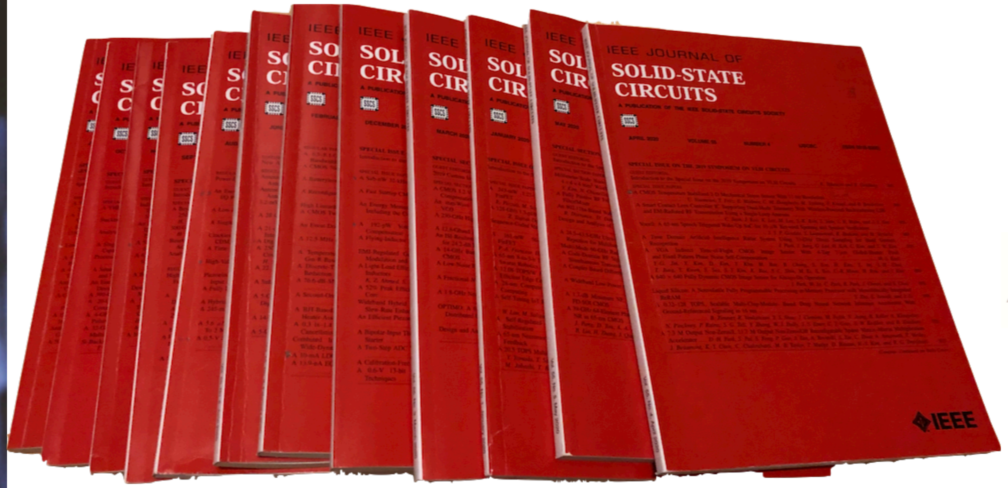
First Hour: Monolog from me (although please ask questions)

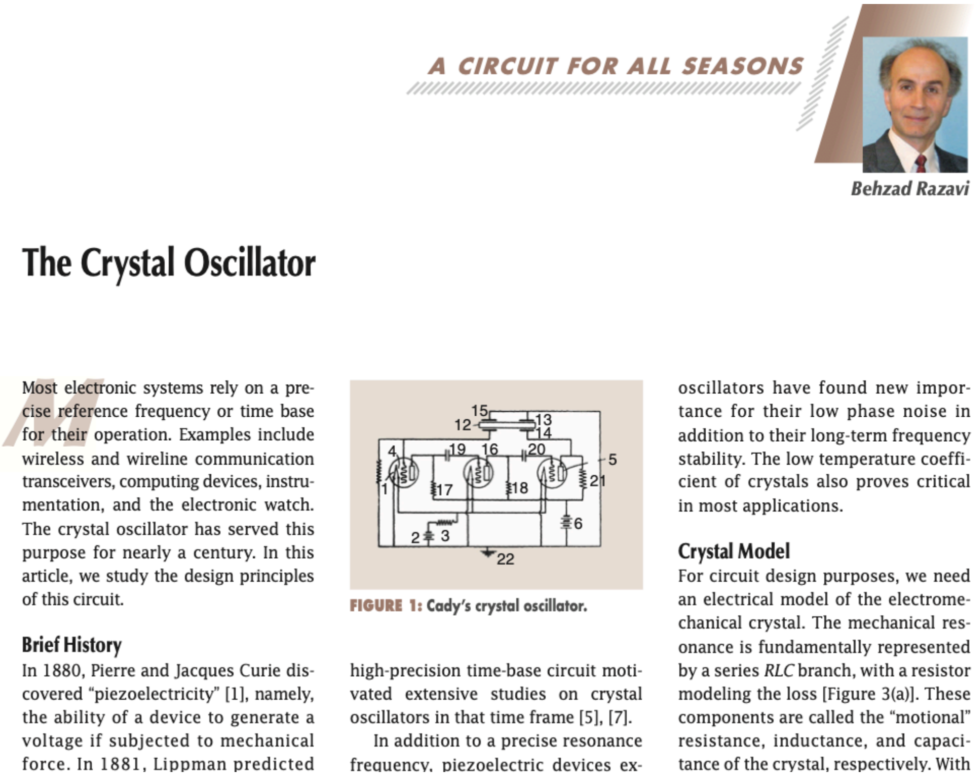
Second Hour: Discuss article and discuss project

Description

Time schedule







A CIRCUIT FOR ALL SEASONS

Behzad Razavi

The Crystal Oscillator

Most electronic systems rely on a precise reference frequency or time base for their operation. Examples include wireless and wireline communication transceivers, computing devices, instrumentation, and the electronic watch. The crystal oscillator has served this purpose for nearly a century. In this article, we study the design principles of this circuit.

Brief History

In 1880, Pierre and Jacques Curie discovered "piezoelectricity" [1], namely, the ability of a device to generate a voltage if subjected to mechanical force. In 1881, Lippman predicted

FIGURE 1: Cady's crystal oscillator.

high-precision time-base circuit motivated extensive studies on crystal oscillators in that time frame [5], [7].

In addition to a precise resonance frequency, piezoelectric devices ex-

oscillators have found new importance for their low phase noise in addition to their long-term frequency stability. The low temperature coefficient of crystals also proves critical in most applications.

Crystal Model

For circuit design purposes, we need an electrical model of the electromechanical crystal. The mechanical resonance is fundamentally represented by a series *RLC* branch, with a resistor modeling the loss [Figure 3(a)]. These components are called the "motional" resistance, inductance, and capacitance of the crystal, respectively. With

- slides and videos

Week	Book	Monday	Project plan
2	CJM 1-6	Course intro, what I expect you to know, project	Specification
3	Slides	ESD and IC Input/Output	Specification
4	CJM 7,8	Reference and bias	M1. Specification review
5	CJM 12	Analog Frontend	Design
6	CJM 11-14	Switched capacitor circuits	Design
7	JSSC, CJM 18	State-of-the-art ADCs	Design
8	Slides	Low power radio recievers	M2. Design review
9	Slides	Communication standards from circuit perspective	Layout
10	CJM 7.4, CFAS,+DC/DC	Voltage regulation	Layout
11	CJM 19, CFAS	Clock generation	M3. Layout DRC/LVS clean
12	Paper	Energy sources	Layout Parasitic Extracted simulation
13	Slides	Chip infrastructure	Layout Parasitic Extracted simulation
14		Tapeout review	M4. Tapeout review
15		Easter	
16		Easter	
17		Exam repetition	

Exam

- May/June 2022?
- 4 hours
- D aids code - No handwritten or printed aids allowed. Preapproved calculator, in accordance to the exam regulations, allowed. Digital exam
- 55% of the final grade
- A - F grade (F = Fail)

Time to take responsiblity for your own future

Exercises

- Exercises on blackboard now
- Solutions on blackboard after the deadline
- Two options:
    - Don't do the exercises, don't get feedback
    - Do the exercises, hand them in within deadline, get feedback
- The TA's will only support the exercises in the marked weeks

Date	Week	Topic
2022-01-21	3	Transistors
2022-02-04	5	Bandgap
2022-02-17	7	Noise
2022-03-04	9	Discrete time
2022-03-18	11	PLL
2022-04-01	13	LDO

Project

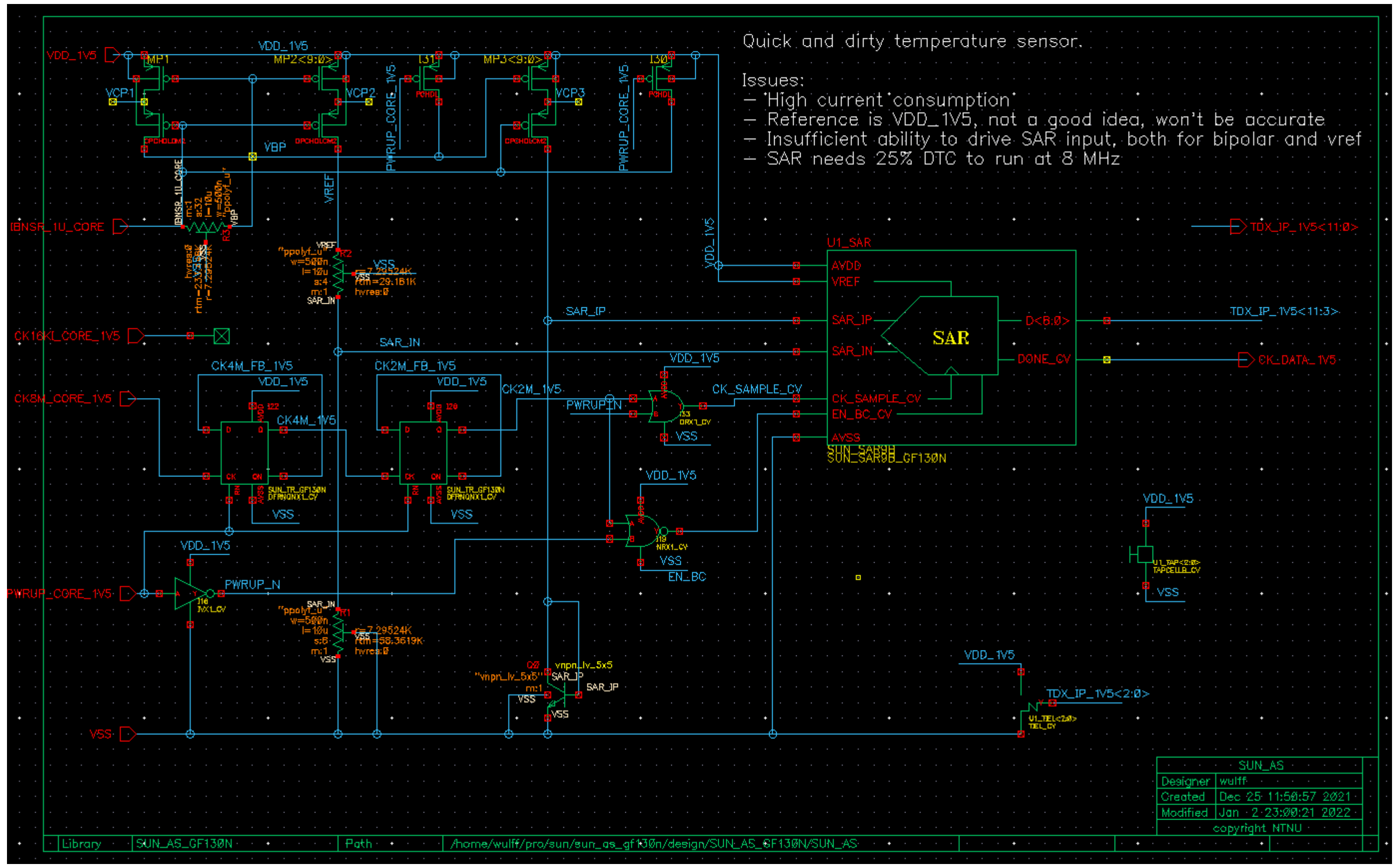
45 % of final grade

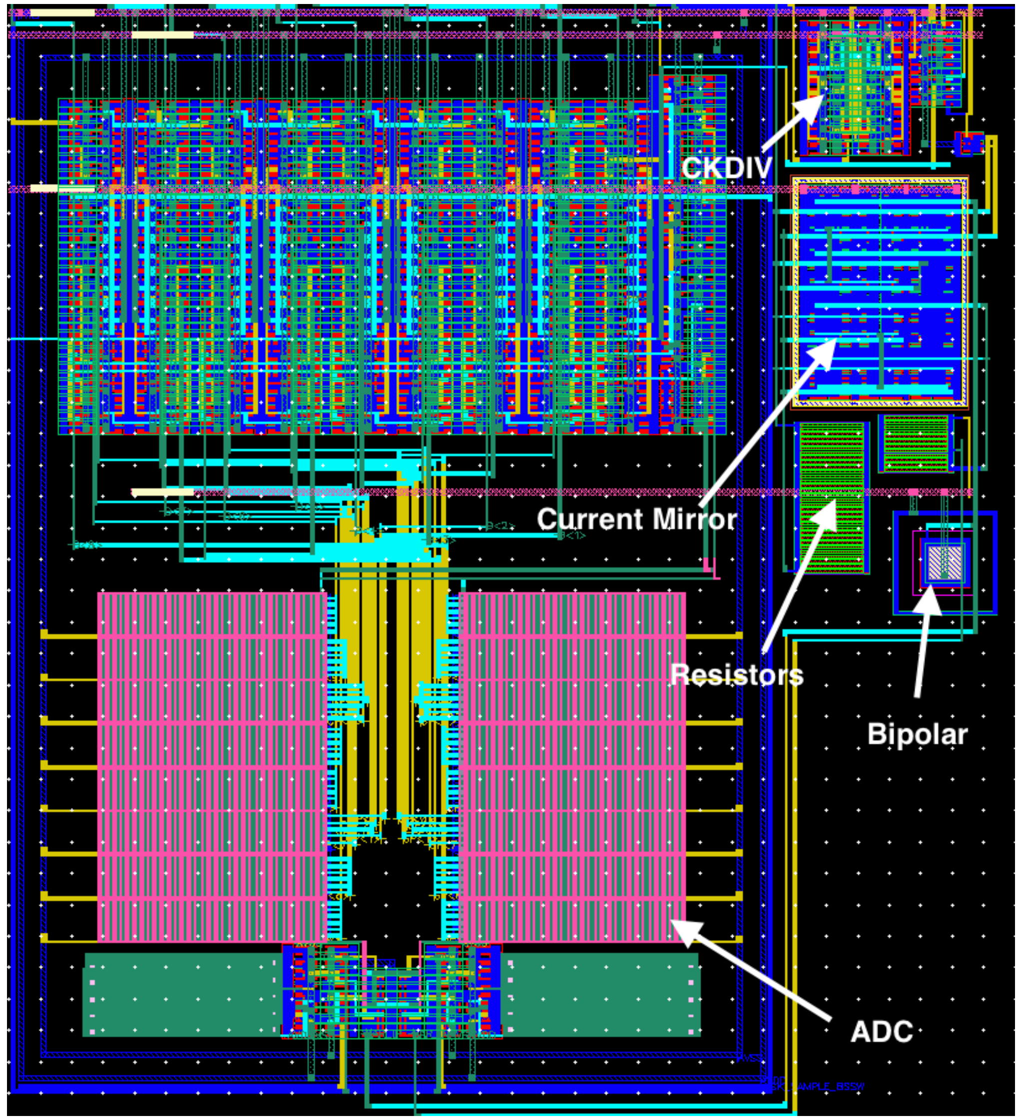
Deadline: 22 of April

Strict deadline, if you hand in 23 of April at 00:00:01, then it's a fail.

SUN (2022) "It's not you, it's me, I don't like you." – Ayrun Sun, Farscape

Design a circuit that senses something from the real world and provides a digital value.





Project Report ⇒ Paper

A Compiled 9-bit 20-MS/s 3.5-fJ/conv.step SAR ADC in 28-nm FDSOI for Bluetooth Low Energy Receivers

IEEE journal template, Example

Must use `\documentclass[journal,11pt,letterpaper]{IEEEtran}`

Strict page limit for report, max 8 pages (excluding bio and references). More than 8 pages ⇒ Fail

Software

Linux servers: aurora, jupiter, venus

If you don't have access, contact me

Getting Started

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. Don't ask about future exercises
- ask in the teams channels
- come to the office (B311) on Mondays

Thanks!