Aalto University
School of Science

On the development of the digital world

Memories of signal processing research with Yrjö

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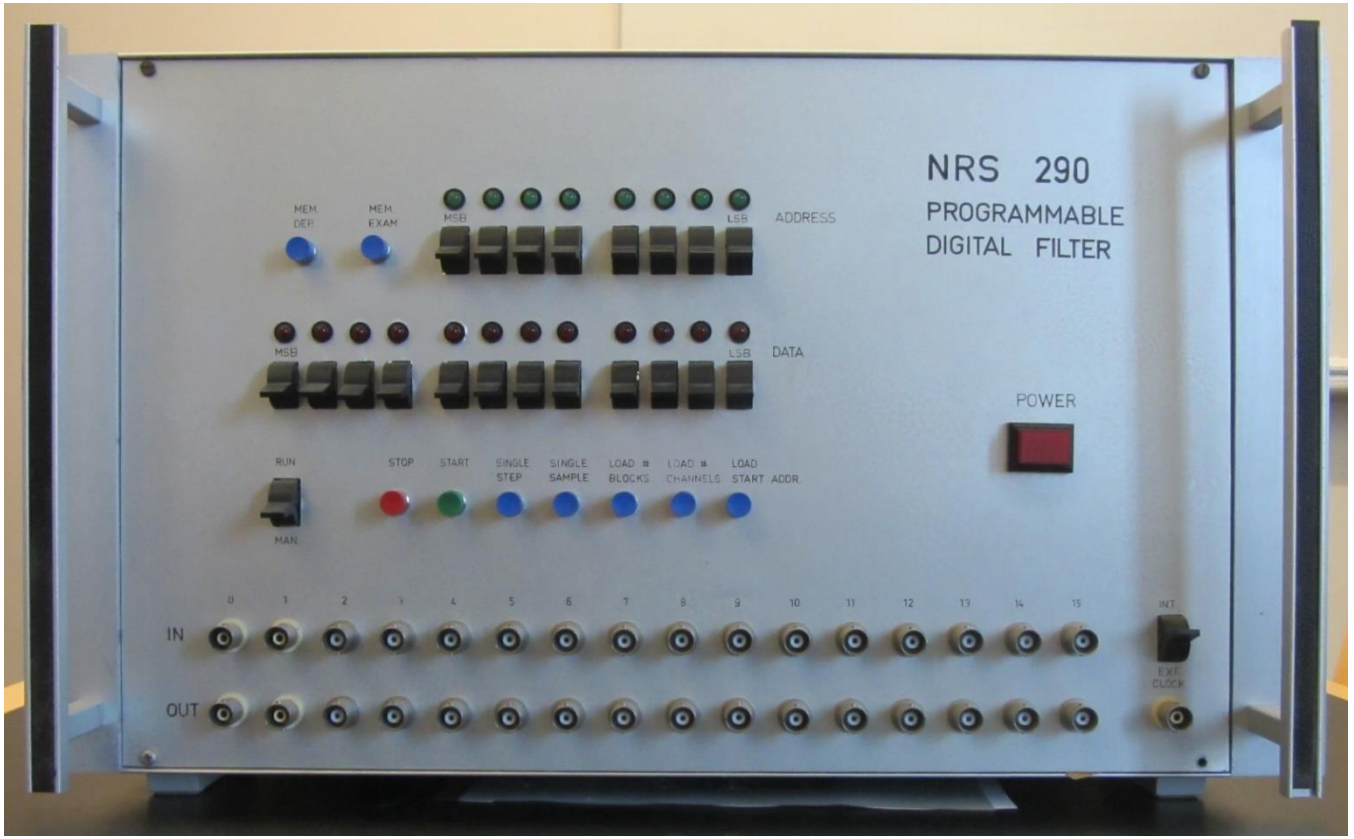
Beginning of the DSP research

- In mid 1970s active research on computationally efficient digital filter structures was started at Helsinki University of Technology, TKK:
  - Yrjö had returned from USA at the end of 1973
  - I had finished my Master's Thesis on DSP in January 1974
  - In January 1974, we formed the DSP group at the Department of Technical Physics
  - I started doctoral studies under Yrjö's supervision

Main goals of the reseach

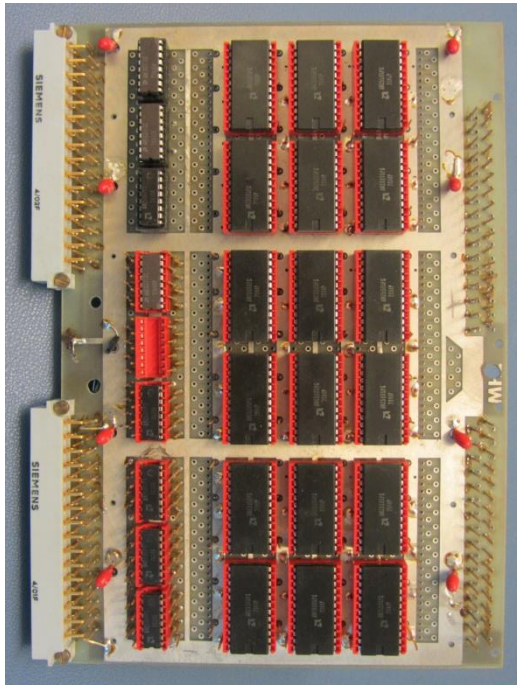
- Design of computationally efficient digital filter structures
  - Low coefficient sensitivities
  - Small number of multiplications
- Hardware implementation of digital filters
  - Real time implementations needed for industrial applications
  - Fast microprocessor circuits suitable for DSP became available in 1970s

NRS 290 Microprogrammable Digital Filter

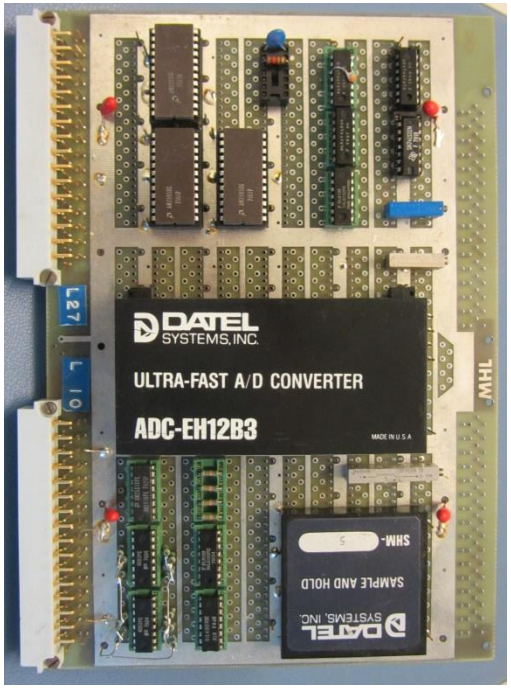


- **NRS** stands for the design team: **N**euvo, **R**opponen, **S**imula
- **290** stands for Am2900 circuit family by Advanced Micro Devices in 1975

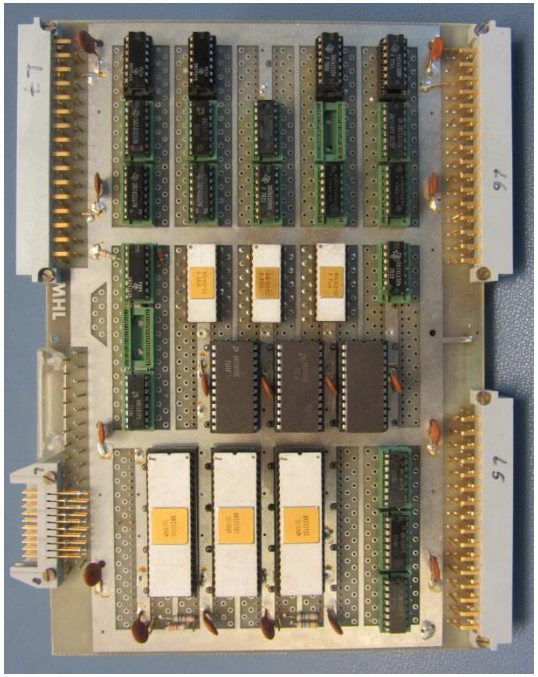
Examples of NRS 290 circuit boards



Multiplier



ADC + MUX



CPE ALU and DATA RAM

NRS 290 Microprogrammable Digital Filter

- Design objectives:
  - High performance
  - Ease of programming a variety of modular DSP algortihms
- Design specifications:
  - Efficient microprogrammed implementation of a basic filter module
  - Filter realization form defined in the microprogram
  - Higher order filters implemented by looping the basic module
  - Basic module multiplexed up to 16 channels to implement a filter bank

NRS 290 performance measurements

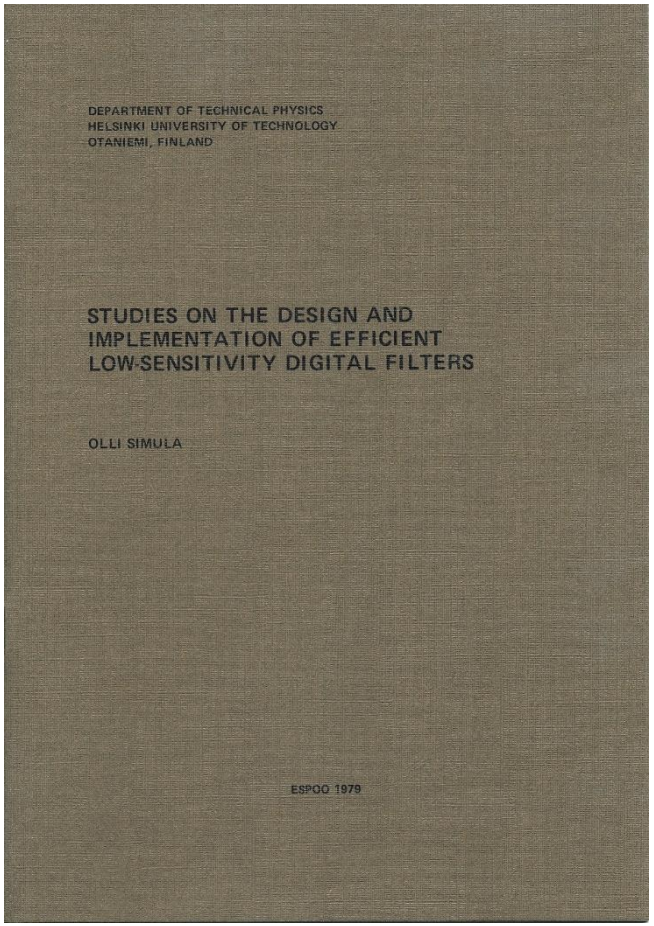
- Measured microinstruction cycle time 195 ns which was 35 ns less than estimated
- Computation time of 4,1 μs for a standard 2nd order block was obtained
- For a full filter bank of 16 4th order filters the computation time of 131 μs was achieved
- The corresponding sampling rates for the 2nd order block and the full filter bank were 244 kHz and 7,63 kHz
- The performance was well comparable to high-speed hardware digital filters of the 1970s

Impact of NRS 290 project

- The research cooperation between industry and universities was important for the future development of telecommunications and mobile phone industry

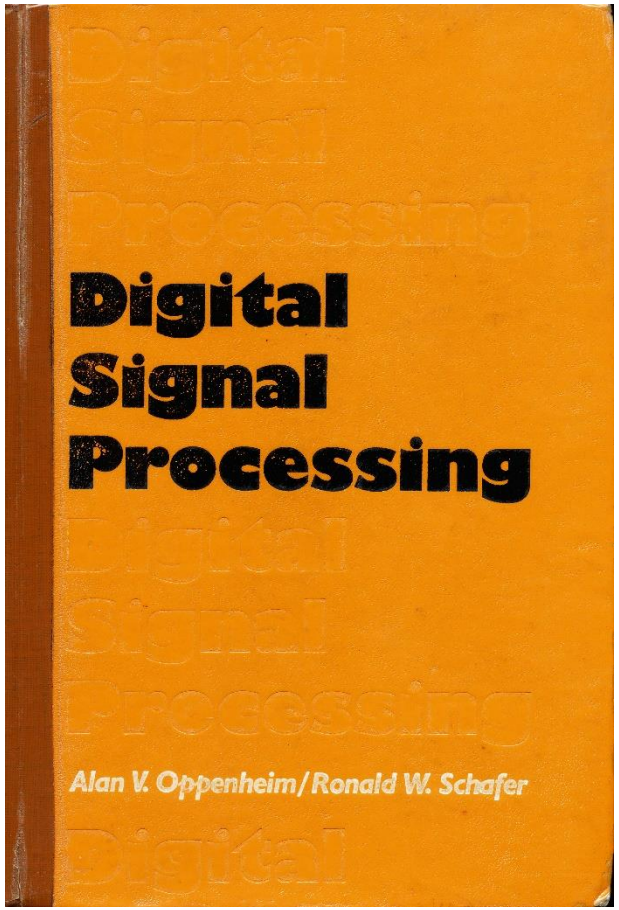
Academic output of early DSP research

- The first doctoral thesis on DSP supervised by Yrjö came out in 1979
- It was followed by several DSP dissertations at Tampere University of Technology, e.g., by Tapio Saramäki, Markku Renfors, Kari-Pekka Estola etc.



Teaching DSP

- In 1974 Yrjö started a basic course in DSP
- The course was based on the manuscript of the classical textbook by Oppenheim and Schafer (1975)
- I continued the teaching after Yrjö left to Tampere, until my retirement in 2013



Nordic cooperation in DSP research and education

- Strong Nordic cooperation in 1970s and 1980s
- Main participants:
  - Helsinki & Tampere Universities of Technology (Neuvo, Simula)
  - Linköping University (Fjällbrant, Wanhammar, Eriksson)
  - Norwegian Institute of Technology, Trondheim (Ramstad)
- Several symposia and conferences were organized jointly starting from the 1970s
- Nordic intensive courses on DSP algorithms for doctoral students, e.g., in Trondheim 1986

1988 IEEE International Symposium on Circuits and Systems, ISCAS-88


THANK YOU YRJÖ !