Area 3: Analog and Digital Electronics

D.A. Johns

1970 – 2012 Tech Advancements

- Everything but Electronics:
- Roughly factor of 2 improvement
  - Cars and airplanes: 70% more fuel efficient
  - Materials: up to 50% lighter

- Electronics:
  - Transistors/chip improvement: 500,000
  - Clock speed of microprocessor: 30,000
  - Signs of slowing down but still much more to go

Integrated Circuits 1950-60

- Transistor invented 1947 (Bell Labs)
- Discrete components during 1950s
- Integrated circuit invented in 1959
  - Jack Kilby (Texas Instruments)
  - Robert Noyce (Fairchild) (then Intel)
- 1961 was first manufactured IC
- Bell Labs thought putting multiple transistors together in same device a bad idea due to increased failure rate

Integrated Circuits 1970s

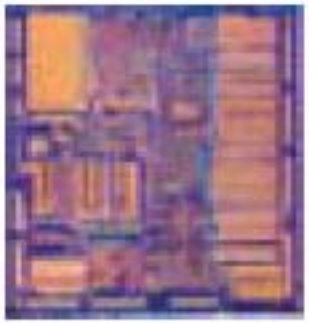
Intel® 4004 processor
Introduced 1971
Initial clock speed
108 KHz
Number of transistors
2,300
Manufacturing technology
10µ

Intel® 8080 processor
Introduced 1974
Initial clock speed
2 MHz
Number of transistors
4,500
Manufacturing technology
6µ

Intel® 8088 processor
Introduced 1979
Initial clock speed
5 MHz
Number of transistors
29,000
Manufacturing technology
3µ

Integrated Circuits 1980s

Intel® 286 processor
Introduced 1982
Initial clock speed
6 MHz
Number of transistors
134,000
Manufacturing technology
1.5µ



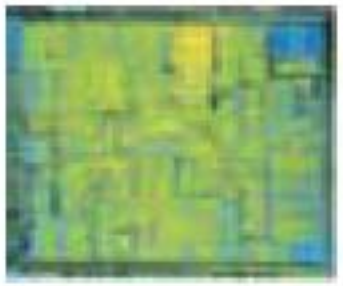
Intel386™ processor
Introduced 1985
Initial clock speed
16 MHz
Number of transistors
275,000
Manufacturing technology
1.5µ

Intel486™ processor
Introduced 1989
Initial clock speed
25 MHz
Number of transistors
1,200,000
Manufacturing technology
1µ

Integrated Circuits 1990s

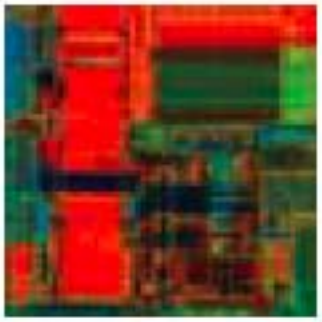
Intel® Pentium® processor
Introduced 1993
Initial clock speed
66 MHz
Number of transistors
3,100,000
Manufacturing technology
0.8µ

Intel® Pentium® II processor
Intel® Pentium II Xeon® processor
Introduced 1997
Initial clock speed
300 MHz
Number of transistors
7,500,000
Manufacturing technology
0.25µ



Intel® Pentium® III processor
Intel® Pentium® III Xeon® processor
Introduced 1999
Initial clock speed
500 MHz
Number of transistors
9,500,000
Manufacturing technology
0.18µ

Integrated Circuits 2000s



Intel® Itanium® 2 processor
Introduced 2002
Initial clock speed

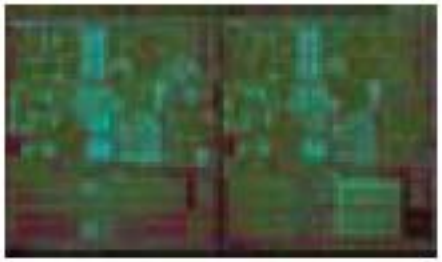
1 GHz

Number of transistors

220,000,000

Manufacturing technology

0.13µ



Intel® Pentium® D processor
Introduced 2005
Initial clock speed

3.2 GHz

Number of transistors

291,000,000

Manufacturing technology

65nm

Quad-Core Intel® Xeon® processor (Penryn)
Dual-Core Intel® Xeon® processor (Penryn)
Quad-Core Intel® Core™2 Extreme processor (Penryn)
Introduced 2007
Initial clock speed

> 3 GHz

Number of transistors

820,000,000

Manufacturing technology

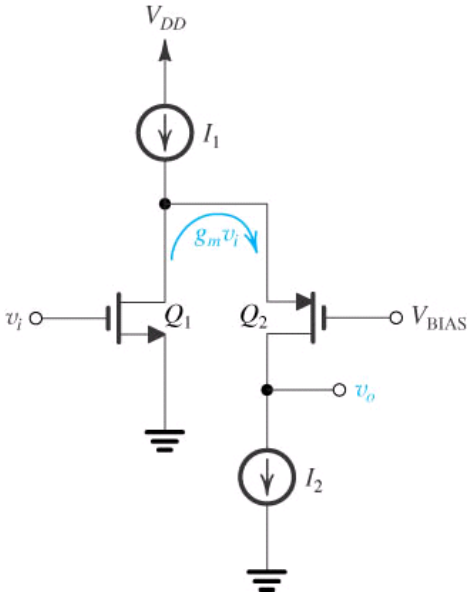
45nm

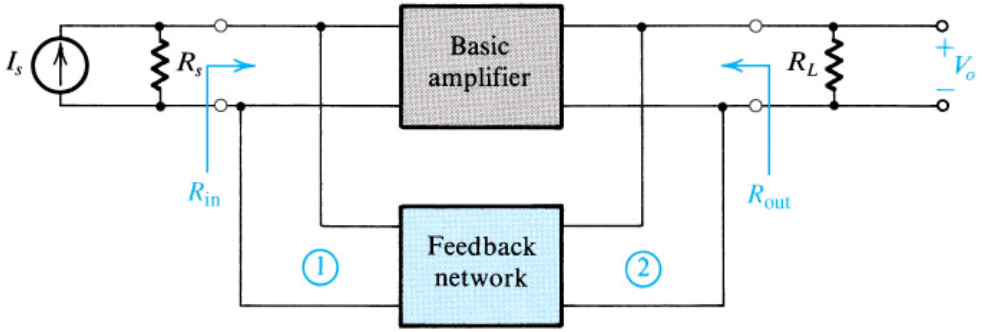
Integrated Circuits 2012

- Intel Ivy Bridge quad core
- 3.5 GHz clock speed
- 1.4B transistors
- 22nm technology (tri-gate)
- 77W of power

Analog Electronics

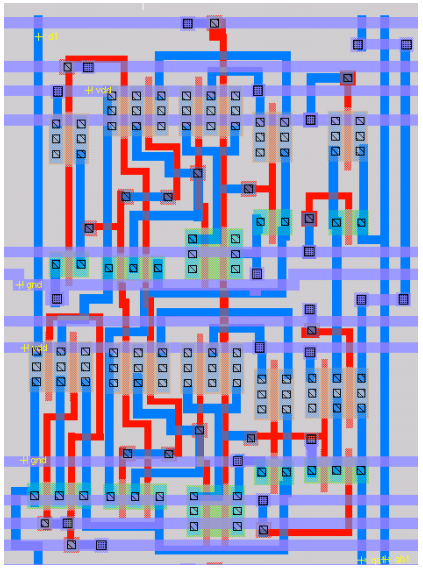
- Learn basics of analog circuit design at transistor and board level
- Much more of the world is analog than people realize
- Most integrated circuits have significant analog

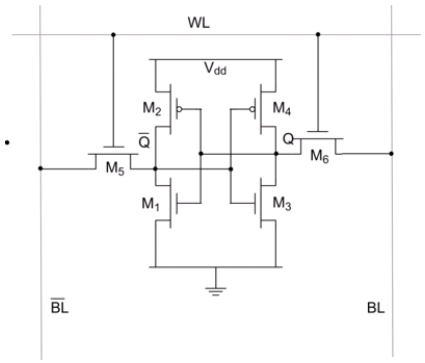


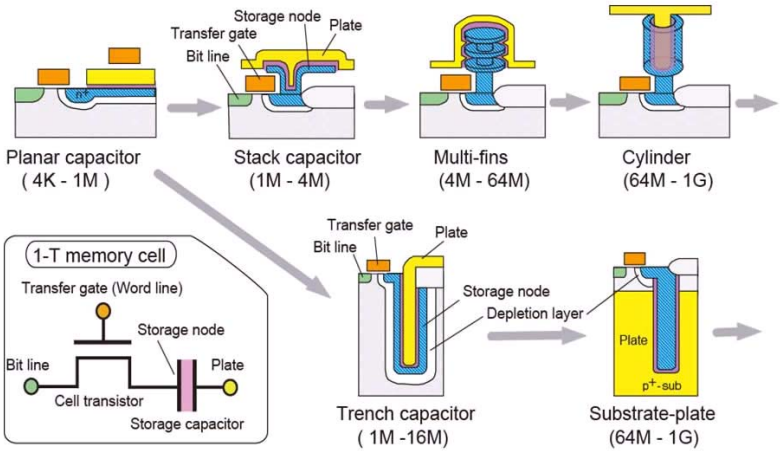


Digital Electronics

- Learn basics of digital system design at transistor and architecture levels
- Required skill for anyone thinking of hardware career







Career Opportunities

- Graduate School: Circuit design is a rich area of Electronics with many research challenges and opportunities.
- Join industry: Anywhere in the world: Canada, US, Europe, Japan, China

www.micron.com

www.intel.com

www.national.com

www.vishay.com

www.st.com

www.infineon.com

www.fairchildsemi.com

www.renesas.com

www.toshiba.co.jp

www.irf.com

www.onsemi.com

www.nxp.com

Courses

AREA 3 - ANALOG & DIGITAL ELECTRONICS

Fall Term - Year 3 or 4			Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES						
Analog Electronics	ECE331H1	F	3	1.50	1	0.50
Digital Electronics	ECE334H1	F	3	1.50	1	0.50
TECHNICAL ELECTIVES						
Sensory Communication	ECE446H1	F	3	1.50	1	0.50
Analog Signal Processing Circuits	ECE512H1	F	3	-	2	0.50
Integrated Circuit Engineering	ECE534H1	F	3	3	-	0.50

Winter Term - Year 3 or 4			Lect.	Lab.	Tut.	Wgt.
KERNEL COURSES						
Analog Electronics	ECE331H1	S	3	1.50	1	0.50
Digital Electronics	ECE334H1	S	3	1.50	1	0.50
TECHNICAL ELECTIVES						
VLSI Systems and Design	ECE451H1	S	3	3	-	0.50
Analog Integrated Circuits	ECE530H1	S	3	1.50	1	0.50
Digital Systems Design	ECE532H1	S	3	3	-	0.50

Electronics – Kernel Courses

- ECE331: **Analog Electronics**
  (extension of 2'nd year analog electronics course)
  - Transistor amplifiers (inside an opamp)
  - Biasing techniques
  - Frequency response
  - Feedback analysis and stability

- ECE334: **Digital Electronics**
  (Transistor and gate level circuit design)
  - Transistor models and spice simulation
  - IC fabrication basics and layout
  - CMOS gate design and transient response
  - Latches, registers, adder cells
  - Memory design (SRAM, DRAM, ROM, FLASH)

Electronics – Depth Courses

- ECE530: Analog Integrated Circuits (analog)
  - Opamp design, comparators, A/D and D/A converters
- ECE512: Analog Signal Processing Circuits (analog)
  - Filters, oversampling, noise in analog circuits.
- ECE451: VLSI Systems and Design (digital)
  - Complex digital systems (eg. Microprocessor)
- ECE532: Digital Systems Design (digital)
  - Hard/software interfacing, memory interfaces, ...
- ECE534: Integrated Circuit Eng. (analog or digital)
  - IC fabrication, modelling, packaging, yield, …

Analog Electronics – Related Courses

- ECE334 Digital Electronics (kernel)
  - most integrated circuits contain both digital and analog

- ECE302 Probability & Applications
- ECE431 Digital Signal Processing
- ECE316 Communication Systems
  Signal processing and communications closely related

- ECE335 Introduction to Electronic Devices
- ECE535 Advanced Electronic Devices

Possible Analog Path

- 3rd year
  - ECE316 Communication Systems (k)
  - ECE331 Analog Electronics (k)
  - ECE335 Introduction to Electron Dev (k)
  - ECE320 Fields & Waves (k)
  - ECE302 Probability & Applications (d)
  - ECE334 Digital Electronics (k)
  - ECE311 Dynamic Systems & Control (k)
  - ECE472 Engineering Economic Analysis

Possible Analog

- 4th year
  - ECE496 Design Project
  - ECE512 Analog Signal Processing (d)
  - ECE534 Integrated Circuit Engin (d)
  - ECE431 Digital Signal Processing (d)
  - ECE451 VLSI Systems and Design (d)
  - ECE530 Analog Integrated Circuits (d)
  - ECE422 Radio and Microwave Wireless Systems (d)
  - ECE496 Design Project

Digital Electronics – Related Courses

- ECE342 Computer Hardware
- ECE452 Computer Architecture
  Digital design at the upper architecture level

- Any number of software courses. Digital chips these days are done with verilog/VHDL, system C, etc.
- Good digital designers are good software designers (but they can't make errors – even more rigorous testing)

Possible Digital Path

- 3rd year
  - ECE316 Communication Systems (k)
  - ECE344 Operating Systems (k)
  - ECE334 Digital Electronics (k)
  - CSC444 Software Eng I (d)
  - ECE361 Computer Networks (k)
  - ECE 342 Computer Hardware (k)
  - ECE345 Algorithms and Data Structures (k)
  - ECE472 Engineering Economic Analysis

Possible Digital Path

- 4th year
  - ECE496 Design Project
  - ECE534 Integrated Circuit Eng (d)
  - ECE552 Computer Architecture (d)
  - ECE454 Computer Systems Programming (d)
  - ECE431 Digital Signal Processing (d)
  - ECE451 VLSI Systems and Design (d)
  - ECE532 Digital Systems Design (d)
  - ECE496 Design Project