

ECE 422/522

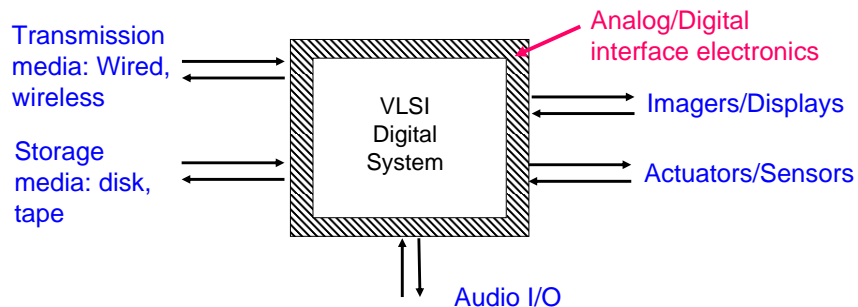
Fall 2009

Electronic Gadgets

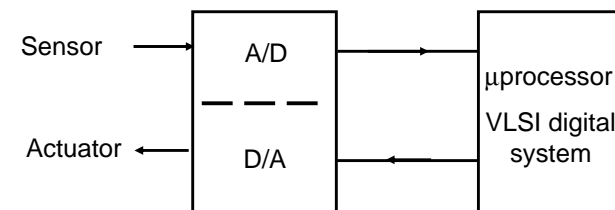


Analog CMOS Integrated Circuits

- Why analog circuits in the digital VLSI era?
 - Physical world is analog in nature
 - Audio signal, video signal
 - Digital systems cannot operate in a vacuum



Sensing/Actuation Example



- Automobile air bag
 - Sense acceleration
 - Deploy airbag if acceleration exceeds a threshold

Why CMOS Technology?

- **CMOS is a preferred technology for digital VLSI applications**
 - Low power
 - High density
 - Easier fabrication
 - Low cost
- ⇒ **CMOS is the technology for implementing mixed analog/digital systems**

Our focus is on Analog Design – Why?

- **Analog circuits provide high performance for digital systems**
 - Read channel of a disk drive
 - Continuous time filters
 - Automatic gain control circuits (AGC)
 - Phase-locked loops (PLLs)
- **At very high frequencies digital circuits behave more analog in nature**
 - Clock recovery
 - Sense and amplify minute voltage differences
 - Efficient buffers

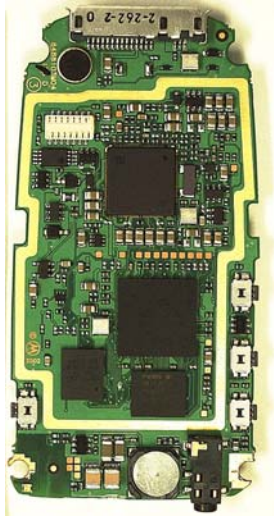
Analog/Digital Interfaces

- **A/D, D/A converters**
- **Signal conditioning**
 - Amplification
 - Filtering: anti-aliasing or smoothing
 - Sample and holds
 - ...

Why Integrate Analog and Digital Circuits on the Same Chip?

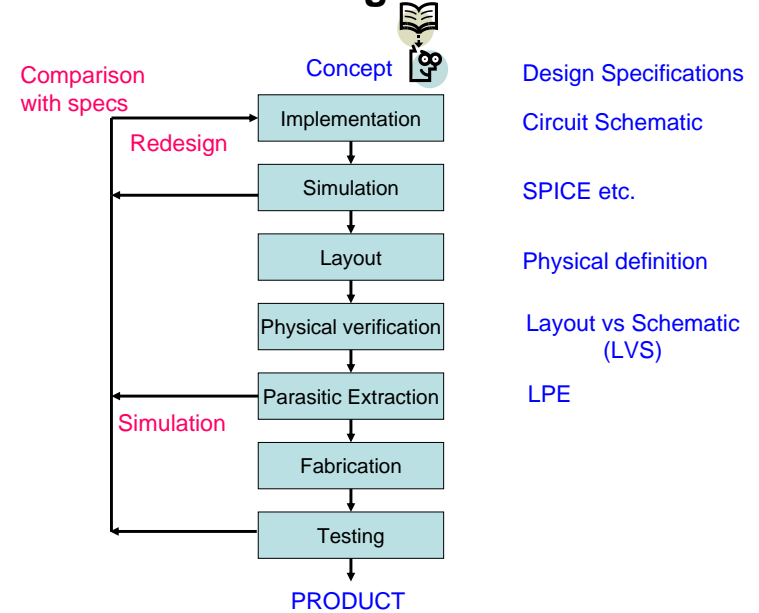
- **Why not use two chips that are interconnected?**
- **Advantages of a single-chip implementation**

Cell Phone Example: RF/Analog/Mixed-Signal

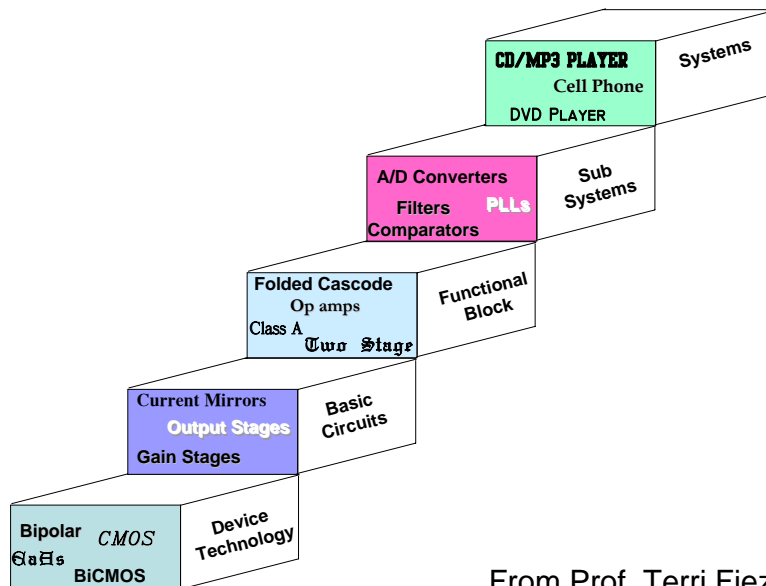


- RF circuits
 - LNAs
 - Mixers
- Filters
- Data converters
 - Analog-to-digital
 - Digital-to-analog
- IO links
- Noise coupling
- Power management

Design Flow



Basic Building Blocks of Analog Systems



From Prof. Terri Fiez

Challenges in Analog Design (and Mixed Analog/Digital Design)

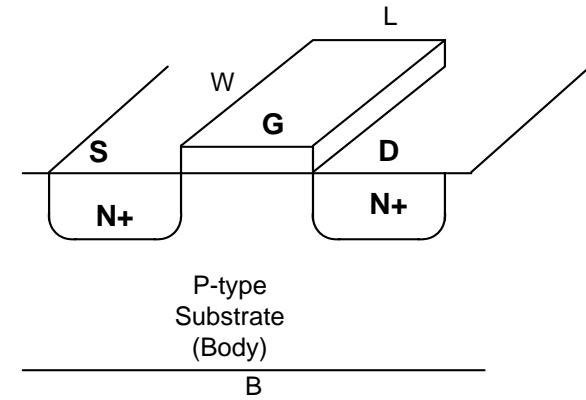
- Analog circuits rely on **details** of device characteristics
 - Need very accurate device models and a good understanding of these models
- Analog circuit design is complicated; many degrees of freedom
 - Speed, power, gain, linearity, precision
- Layout techniques are important
 - Matching of devices
 - Sensitivity to noise, crosstalk
- Lack of standard design styles
 - Longer design cycle
- Analog design has a large testability problem
- Design automation tools for analog far behind those for digital design

This Course

- **MOSFET device**
- **Basic building blocks**
 - Current mirrors
 - Gain stages
- **Operational amplifier**
 - Two stage
- **Frequency response**
- **Stability**

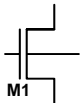
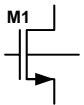
MOSFET

Enhancement mode N-channel MOSFET (NMOSFET)

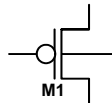
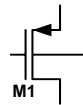


MOSFET Symbols

N-channel
FETs



P-channel
FETs



If bulk is connected to proper power supply:

