EECS 247

Analog-Digital Interface Integrated Circuits

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Administrative

- Course web page:
  http://www.eecs.berkeley.edu/~boser
  (link to EECS 247)
- Overview
  - Scope of course
  - Reference texts
  - Grade and homework policy
- Office hours
  - Tuesday 2 to 3pm
  - Friday 11am to noon

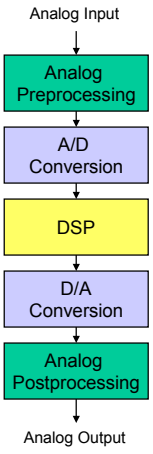
Acknowledgement

- "Introduction to System Design and Modeling" course, developed by Eric Swanson
- Notes from Prof. Gray for an earlier version of this course
- Countless books and articles

Analog-Digital Interface Circuits

Anatomy of analog processor

- analog pre/post processing
- A/D and D/A converters
- digital signal processor



Why Digital Processing?

- Digital circuitry:
  - Cost/function decreases by 29% each year
  - That's 30X in 10 years
- Analog circuitry:
  - Cost/function is constant
  - Dropping supply voltages threaten feasibility
- Transition to DSP is inevitable!

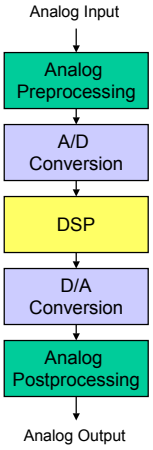
Ref: International Technology Roadmap for Semiconductors, http://public.itrs.net

Why Analog Processing?

- The "real" or "physical" world is analog
- Examples:
  - Digital Audio
  - RF receiver
  - Wireline communications

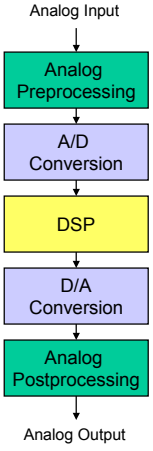
Example: Digital Audio

- Goal
  - Lossless archival and transmission of audio signals
- Circuit functions:
  - Preprocessing
    - Amplification
    - Anti-alias filtering
  - A/D Conversion
    - >16Bits, >41kHz
  - DSP
    - Storage
    - Processing (e.g. recognition)
  - D/A Conversion
  - Postprocessing
    - Smoothing
    - Amplification



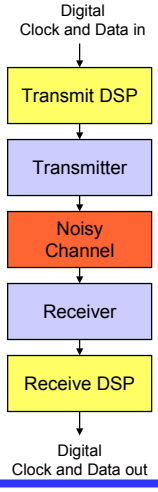
Example: RF Receiver

- Goals
  - Wireless communication
  - Minimizing use of bandwidth
  - Immunity to interference
- Circuit functions:
  - Preprocessing
    - Filtering
    - Amplification
    - Frequency translation
  - A/D Conversion
  - DSP
    - Demodulation
    - Decoding
  - D/A Conversion
  - Postprocessing
    - Smooting
    - Amplification



Example: Modem

- Goals
  - Transmit data over inexpensive, noisy channel
  - Maximize distance, minimize errors
- Circuit functions
  - Transmit DSP
    - Bandwidth efficient and error tolerant data encoding
  - Transmitter
    - Pulse shaping (minimize ISI)
    - Line driver
  - Noisy Channel
    - Frequency (and time) dependent attenuation
    - Noise
  - Receiver
    - Equalization
    - Clock recovery, slicing
  - Receive DSP
    - Decode data



Signal Processing Fundamentals

- EECS 247
  - Filtering
  - Data Conversion
  - Data detection, timing recovery
- EECS 142, 242
  - RF amplification, mixing
  - Oscillators
  - Nonlinear circuits

System Modeling

- Top-down design
  - Abstraction
  - Key for dealing with complexity (> 10^6 transistors)
  - Each level establishes requirements for next level down in the hierarchy
- Challenges
  - Unrealizable blocks
  - Physical constraints
  - Modeling errors
  - Number and complexity of blocks
  - Verification

Challenge of IC Fabrication

- No other EE discipline is less forgiving of errors
  - You can change PLD's or software in a day
  - You can build and test a printed circuit board in a week
  - It takes months to tape out and fabricate a chip
  - Debugging and characterizing a (defective) chip also takes months
- State-of-the-art chips are never perfect
  - But they have to be good enough for someone to buy them
  - If you want to sell bugs, try a career in software (quote from Eric Swanson)

Modeling Tools

- This is not a tool-centric course
  - Knowledge of design fundamentals lives through many generations of tools
  - Behavioral modeling tools are not always effective: long learning curve
- Tools we will use
  - MATLAB / Simulink (student version is adequate)
  - SPICE
  - MathCAD, Excel, …

EECS 247 versus 240

- EECS 247
  - Macro-models, behavioral simulation, large systems
  - Signal processing fundamentals
  - High level of abstraction: physical constraints (e.g. finite gain, supply, noise) added where appropriate
  - Matlab
- EECS 240
  - Transistor level, building blocks
  - Device and circuit fundamentals
  - Little abstraction
  - SPICE