Structured design of electronic information processing systems

Structured analog design

- Hierarchically structured design process
  * Solid theoretical base
  * Focus on operating mechanisms and desired behavioral modifications
  * Technology-independent
  * Detailed knowledge of operating mechanisms and design techniques

- Ranking, classification and orthogonalization of:
  * Performance aspects
  * Design strategies / methods / techniques

- Possible showstoppers become evident at an early stage of the design process

- Circuit design based on design rules and techniques

- Derivation of design equations using computer-based symbolic analysis (SLiCAP):
  * Models for performance aspects of interest
  * Model complexity levl increases during design process
  * Allows separate design of signal path and biasing

- Solid basis for design automation

SLiCAP

Symbolic Linear Circuit Analysis Program
- Tool for deriving/solving circuit design equations
  * Design of noise performance
  * Design of bandwidth and frequency response
  * Design of
DC temperature stability and offset (statistical)

Traditional analog design

- Heuristic design approach
  * Experienced-based rules of thumb
  * Focus on topological modifications
  * Technology-dependent
  * Detailed knowledge of circuit topologies isolated from their environment and application

- Experience-based ranking of:
  * Performance aspects
  * Topologies
  * Rules of thumb

- Experience-based awareness of showstoppers

- Evolutionary, analysis-based circuit design

- Simulation with complete device-level models at all stages of the design does not allow separation of signal path and biasing

- Basis for design optimization

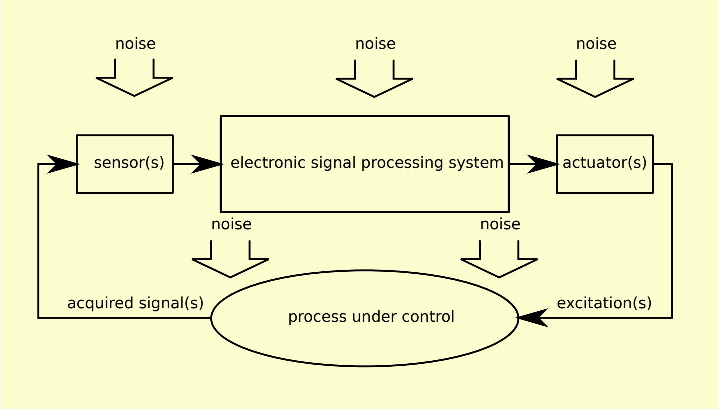
Structured Electronic Design @ TUDelft

EE3C11:
- Introduction to structured electronic design
- Design of application-specific amplifiers with OpAmps
- Device physics

EE4C09:
- Transistor-level design of application-specific amplifiers
- Device modeling

Processing of electrical signals in noisy environments

Architecture information processing system



Signal
- physical quantity that contains meaningful data

Data
- properties or details of the signal that represent the information

Noise
- physical quantity whose data is meaningless

Information
- the meaning of the data

Signal processing
- performance of operations on the signal, while preserving the information contained in it

Information handling capacity

Shannon (1948)
The number of information processing errors can be kept arbitrarily low if the amount of information transported over a channel is equal or less than its channel capacity C:

Channel signal power limit in [W]

$$C = B\log_2 \frac{S+N}{N} \text{ [bit/s]}$$

Channel (white) noise power in [W]

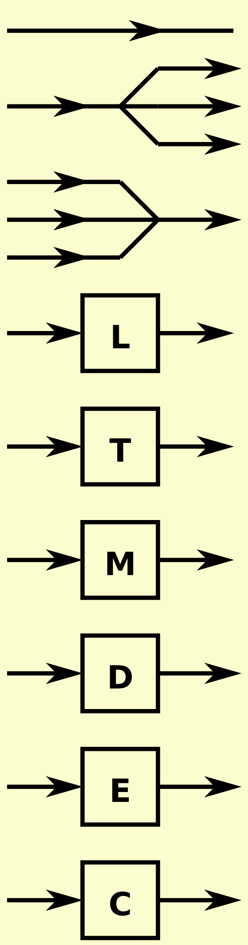
Channel bandwidth in [Hz]

Basic functions

The functional decomposition of any electronic signal processing system requires a limited number of basic signal processing functions only.

Physical and technological limitations

The performance of real-world information processing systems will be limited as a result of
- the physical limitation of noise, speed and power
- the imperfections of the physical mechanisms that are used for the implementation of the basic functions: technological limitations



Basic signal processing functions		Basic electronic signal processing functions		Associated basic electronic signal processing objects
Transportation	Bring the information to a different location	Transportation	Bring the electrical signal to a different location	Channel wires / traces / cables / EM fields
Distribution	Provide multiple observers with the same information	Distribution	Provide multiple loads with the same electrical signal	Distributer wires / traces / cables / distributers / EM fields
Combination	Provide an observer with information from multiple sources	Combination	Provide a load with the sum of different electrical signals	Combiner wires / traces / cables / combiners / EM fields
Level change	Change the level of the signal	Amplification Attenuation Impedance matching	Increase the available power Decrease the available power Optimize the power transfer	Amplifier Attenuator Impedance transformer transformers / matching networks
Memorization	Store the information (time-shift)	Memorization	Store the signal	Memory
Modification	Modify the data (not the information)	**Functions**	**Domains**	**Domain** / **Selector** / **reference**
Detection	Notice the occurence of specific data	Selection Reference generation	- voltage / current - frequency - time - space	- voltage - current / - Comparator / Limiter / - DC ref. (V / I) - frequency / - Filter (LP, HP, BP, BS) / - Oscillator - time / - Switch / - Timer - space / - n.e. / - n.e.
Estimation	Quantify the amount of specific data	Nonlinear operation		Element with nonlinear V-I relation
Conversion	Change the physical signal representation	Transducers, sensors and actuators are not strictly considered as *electronic* information processing funcions		

Error reduction techniques

The quality of information processing, or the performance-to-cost ratio of an information processing system can be improved through the application of a limited number of so-called 'error reduction techniques'.

Error reduction techniques with data preservation

Compensation techniques
- Additive / multiplicative
- Automatic / non-automatic

- anti-series and complementary series connection
- anti-parallel and complementary parallel connection
- cascade connection (pole-zero compensation)
- error-feedforward
- negative feedback
- auto-zero

Error reduction through data modification

Coding
- Change of data

Modulation
- Change frequency range / spectral contents

Digitization (sampling + quantization)
- Use discrete-time and discrete-value representation

Figure of merit

Measure for performance-to-cost ratio
Helps in makig design decisions

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