Wireless Sensor Networks

Understanding Complex-Engineered Systems By Example

Module 4: Analog-to-Digital Conversion

muse

WSN's - The Eyes and Ears of the Internet: Sensing the Physical World

- Wirelessly networked embedded systems
- Mission: Transduce a parameter of the physical environment into a number on your desktop

- First task: choose/understand transducers
- Second task: interface a network node with transducers

Themes

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  - From physical world to measurement
  - From measurement to knowledge
  - *Bridging the physical and cyber worlds*

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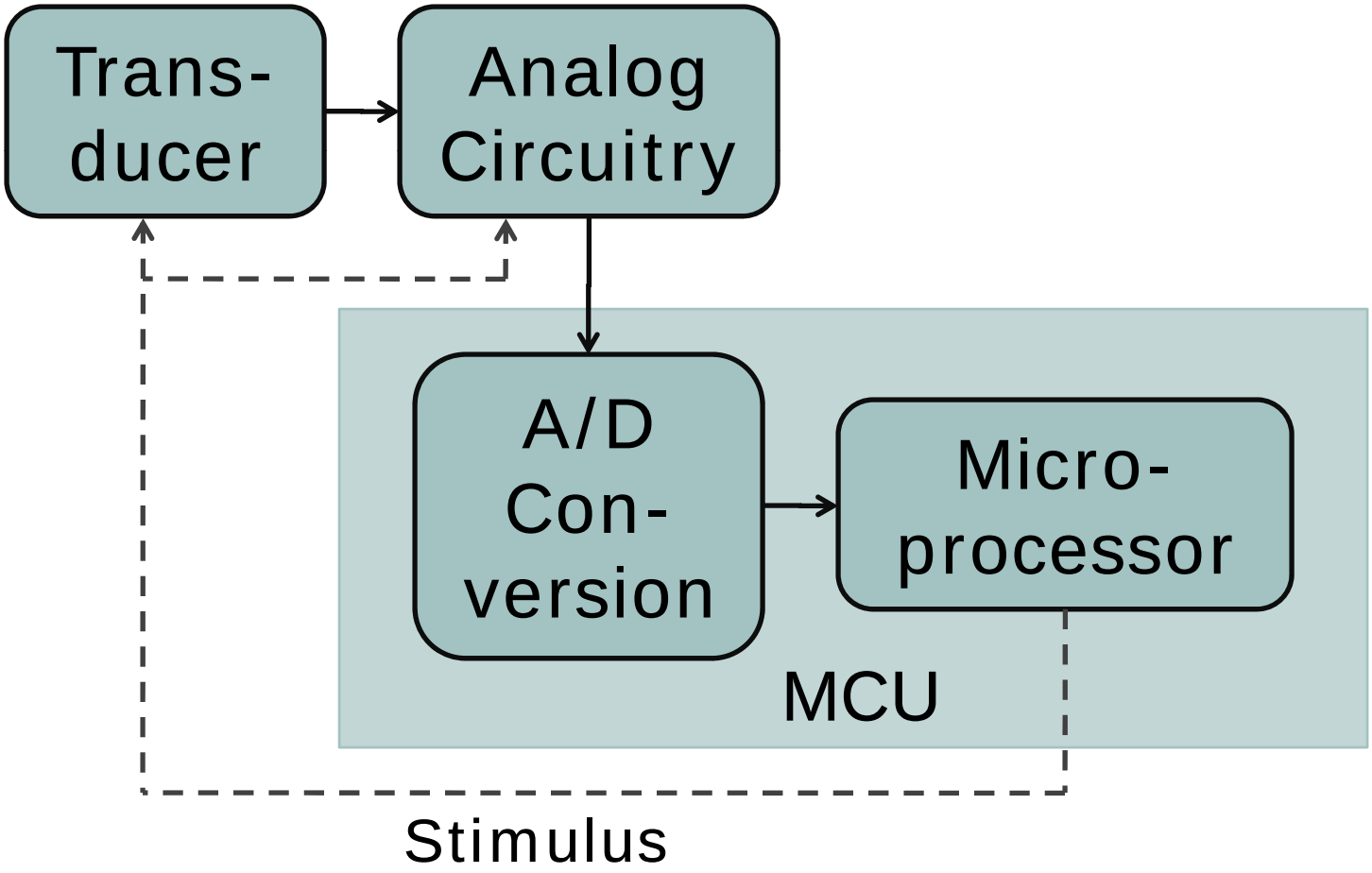
  - Analog signal processing
  - Digital and statistical signal processing
- Error sources
  - Transducer and electronic noise
  - Analog-to-digital conversion

Connections

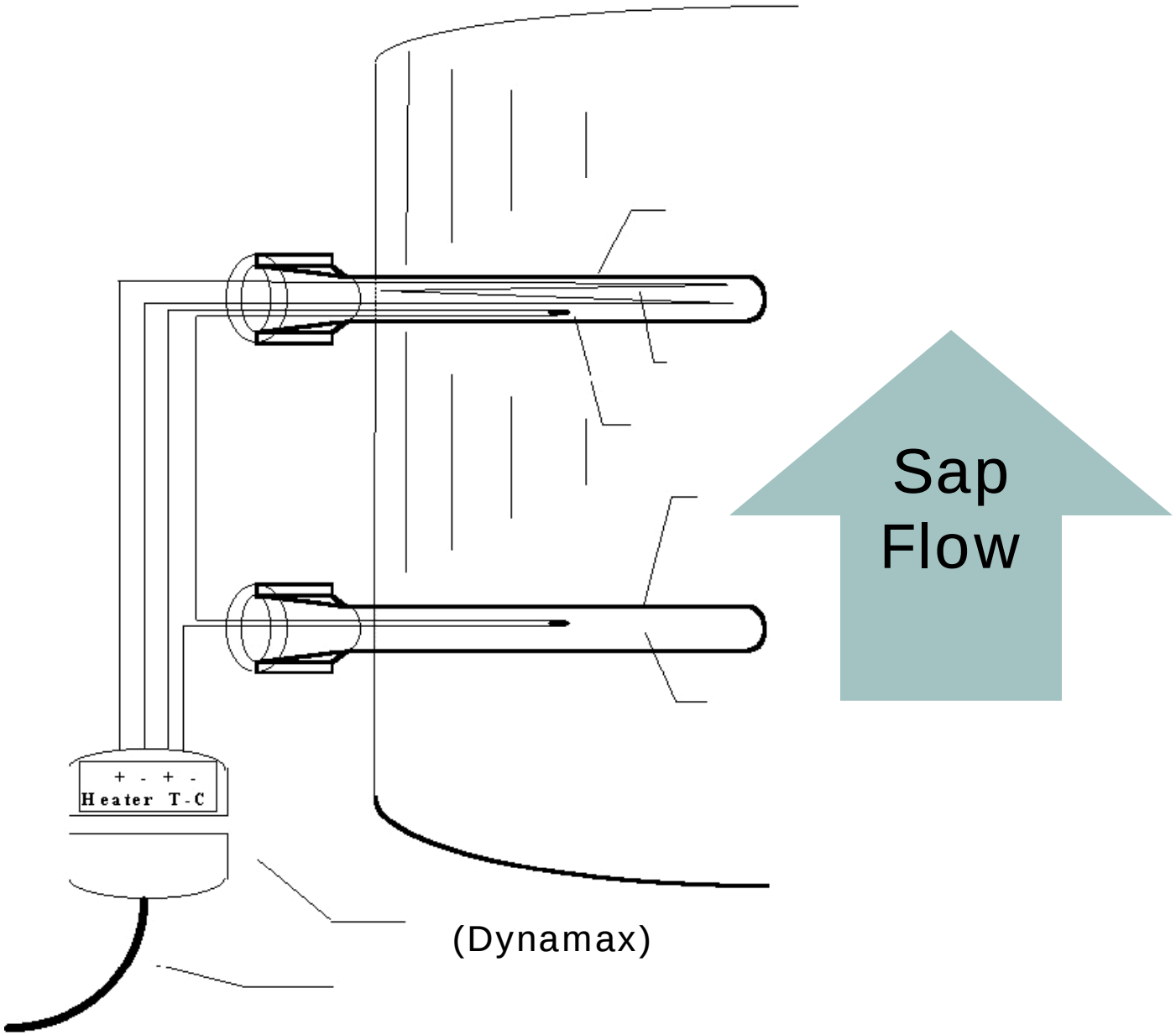
- Analog circuit design
  - Signal conditioning, amplification, filtering
- Mixed signal circuit design
  - analog-to-digital conversion. Conversion speed, quantization noise, dynamic range, and linearity
- Signals and systems, DSP
  - Filtering, sampling rate, linearity
- Statistical signal processing
  - Transducer noise and bias, quantization noise, interference

From physical parameter to number



A Biotic Response: Sap Flux

Granier method



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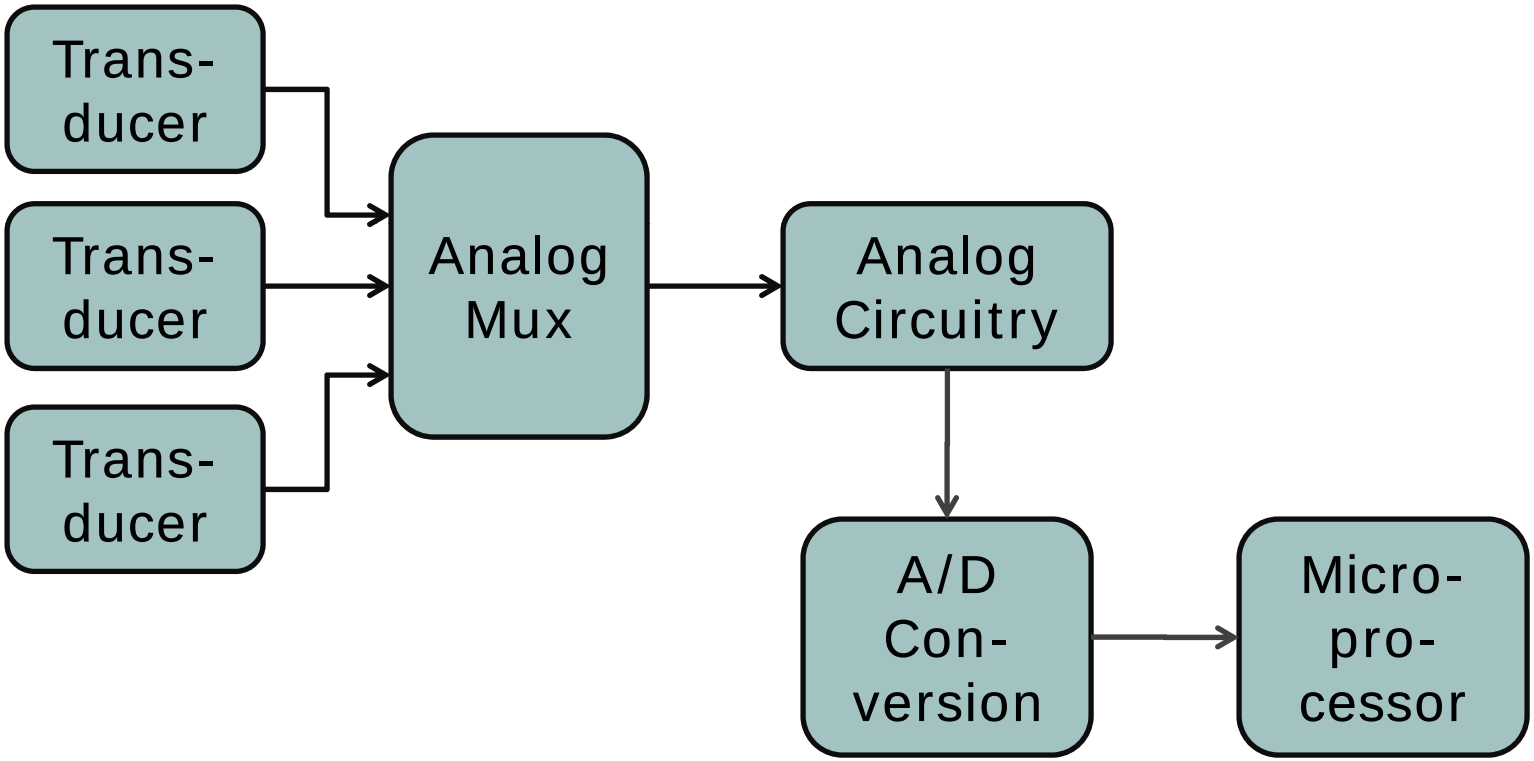

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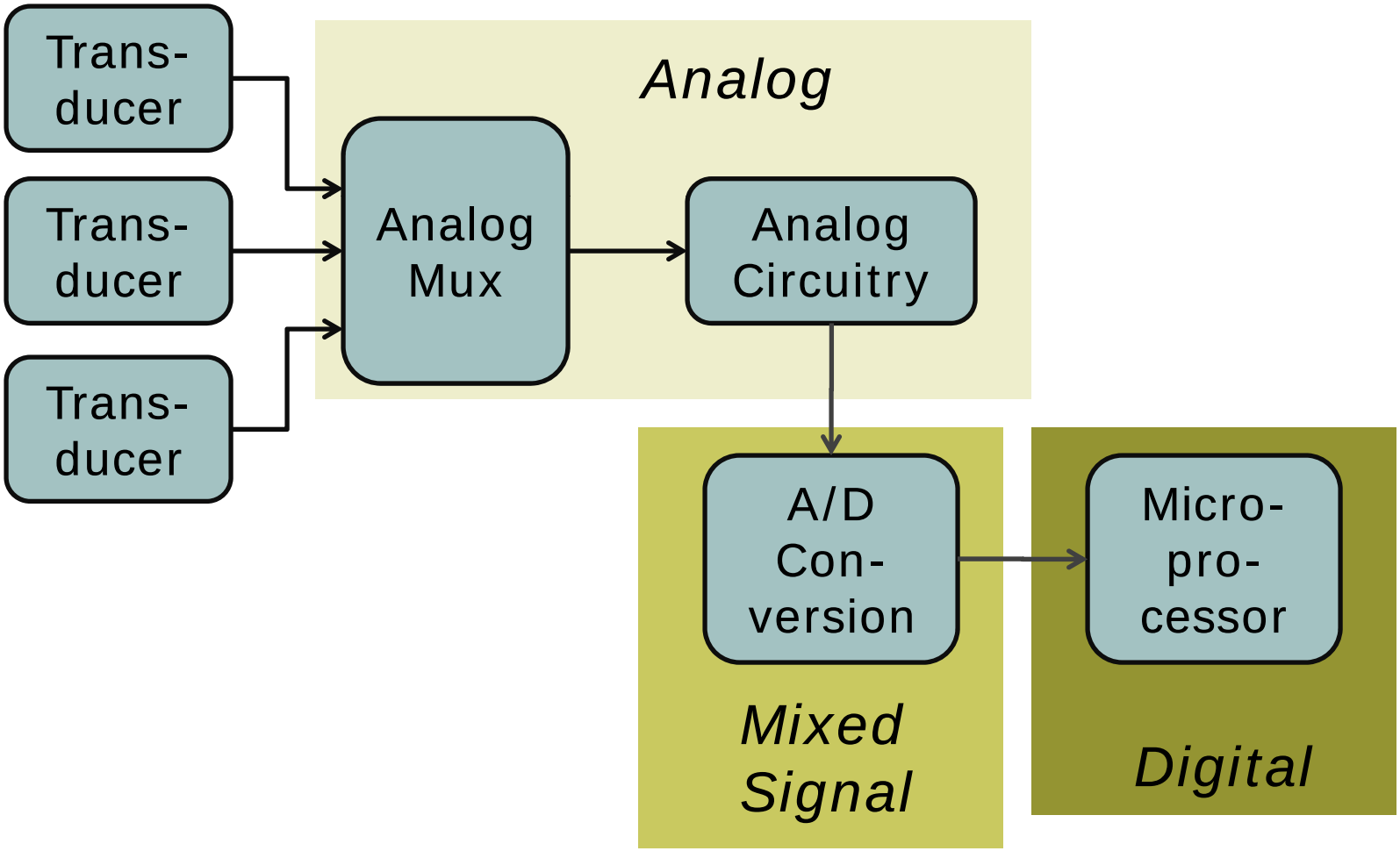

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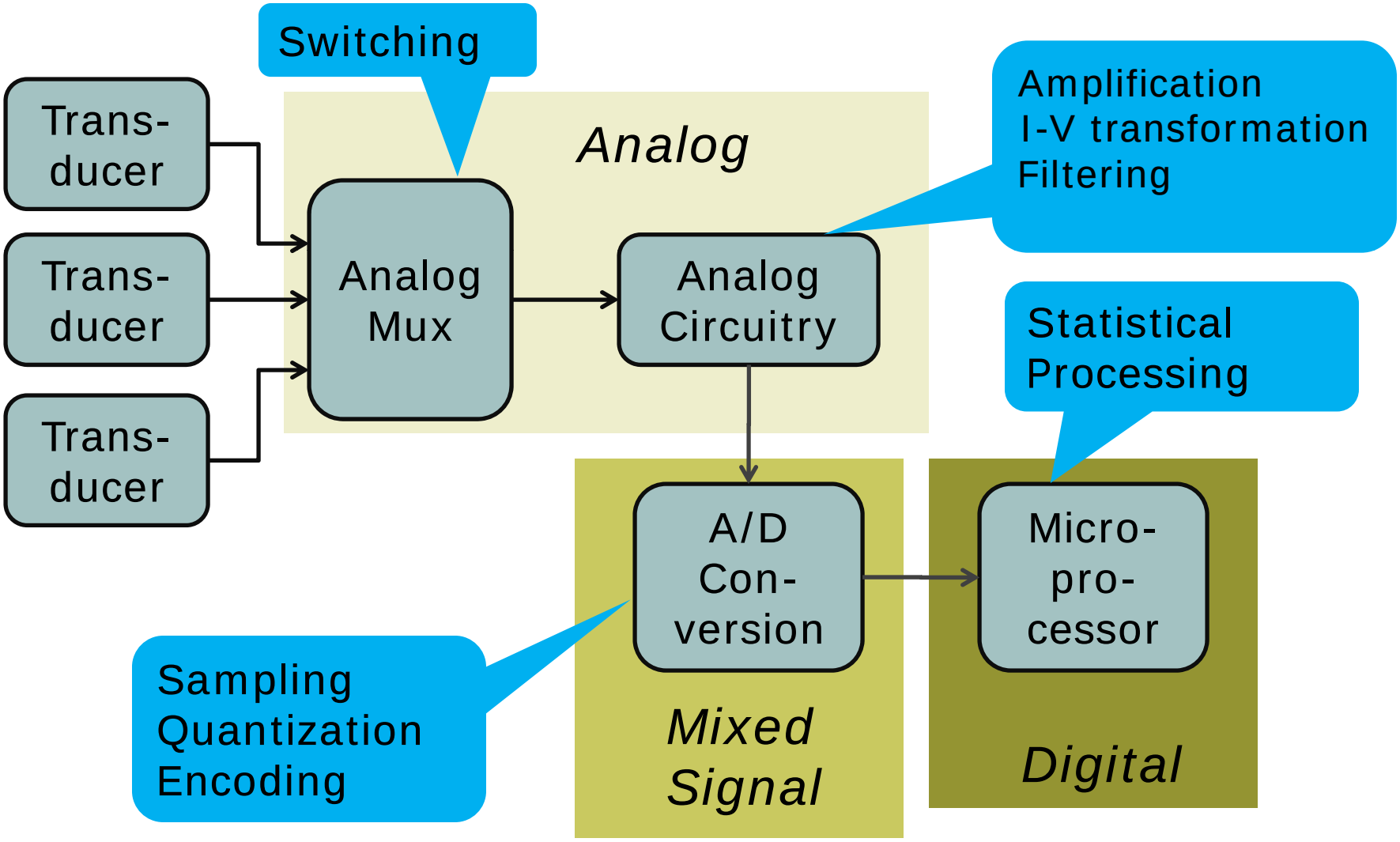

Getting a handle on data fidelity

- Accuracy
- Precision
- Resolution

How good is the sensed data?
Part I: transducer signal

Analog measurement y of data x^* from the transducer is uncertain.

Error $\beta + \epsilon$ is the sum of a bias (offset) β and noise ϵ:

$$y = x^* + \beta + \epsilon$$

$$\epsilon \sim (0, \sigma^2)$$

large $\lvert\beta\rvert$	=> low accuracy
large σ^2	=> low precision

How do we deal with noise?

Tasks

1. Evaluate and Calibrate
   a) Determine accuracy – find the bias
   b) Determine precision – find the noise variance (power)

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   a) Determine accuracy – find the bias
   b) Determine precision – find the noise variance (power)
2. Design algorithms to get desired performance

   --- manage the noise

1a. Estimate the bias

1a. Estimate the bias (ii)

1b. Estimate the measurement noise

2. Manage the noise

2. Manage the noise (ii)

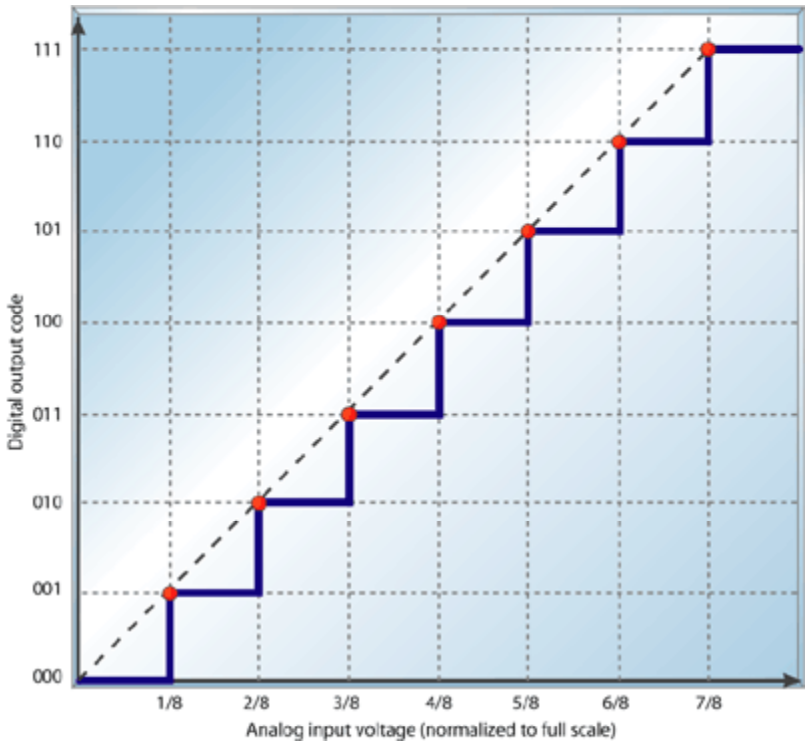
How good is the sensed data?
Part II: A/D conversion

A/D conversion can distort the value.

Error types:

- Resolution
- Noise
- Nonlinearities

High resolution does <u>not</u> imply high precision or accuracy!



L. Staller. Understanding analog to digital converter specifications. Embedded Systems Design (02/24/05, 05:24:00 PM EST)

A/D converter: SP model

How many A/D bits do I need?

How much does another bit buy?

Modeling the quantization error

Calculating the Improvement

Remaining Questions

- How often to sample
- Where to sample
- How to encode the information for transmission
- How to use the information for the construction of predictive models