# Measurement Systems

An Open-Source Summary

Thomas Debelle

KU LEUVEN

September 26, 2025

# Contents



> **Note**
>
> This summary will only be based on the slides and lectures. No figures or copy from the cursus book is permitted due to copyrights.
>
> Nonetheless, it is recommended to also go through the cursus book as it may go more in depth than this summary

# 1 Introduction

## 1.1 Why is measuring important ?

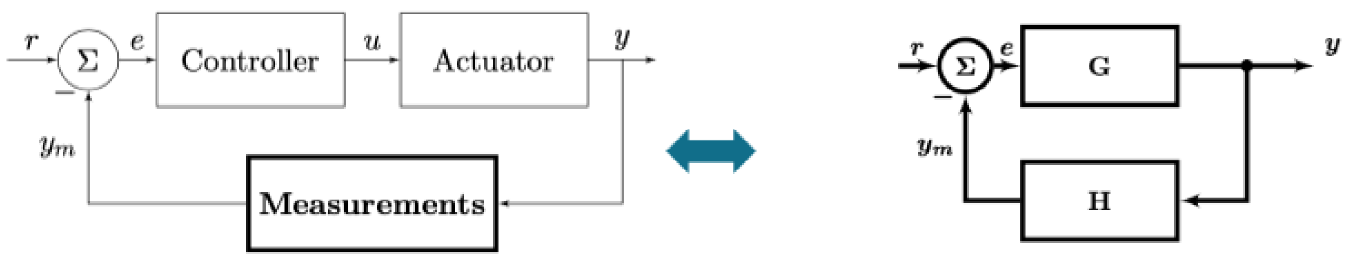


**Figure 1:** Typical system

In a feedback system, we want some input to transform in a specific output. Later, we want to measure this output to adapt the control and see how effective this is.

Using the standard $G$ and $H$ notation we can find that:

$$y = \frac{G}{1+GH}r \qquad e = \frac{1}{1+GH}r \tag{1}$$

$$y = \lim_{G\to\infty} \frac{G}{1+GH}r \approx \frac{1}{H}r \tag{2}$$

## 1.2 General principles

> Building a measurement system is transforming energy/information from one domain to another.

We first start by building the physical knowledge (build physical quantity model), mathematical reasoning (find how accurate we can make the model to reflect the system) and finally we must take noise and other limits into consideration.

In a system, at a high-level, there is 2 forms of variables:

1. **Across Variables:** describe the *state*, in **parallel** with the terminal. Effort to change the state
2. **Through Variables:** describe the *flow*, in **series** with the terminal.

Then combining those two can give us some fundamental quantities: - $A \cdot T$: **power** generated or dissipated in the element - $A/T$: **impedance** of the system. Describes how an element transforms an $A$ into a $T$

## 1.3 Modelling a system : the physical model

We usually want to map the IO behavior based on physical knowledge. Each model tries to represent reality but will always introduce errors or not take into account higher order phenomena.

For example, we can model a pressure change using a diaphragm to a capacitance change. If we take a simple spring model we don't take second order term into account which introduces errors.

**Table 1:** Strength and weaknesses of physical approach

| Strength | Weakness |
|---|---|
| Good insight | Error due to approximations |
| System optimization is possible | Derivation of this formula is not always straightforward/possible |
| Calibration techniques can be easily derived | Errors due to tolerances in fabrication |

## 1.4 Correlation

### 1.4.1 Freshen up of Laplace transform

## 1.5 The Measurement Chain

### 1.5.1 4 major components

# 2 License

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License (CC BY-NC-ND 4.0).

You are free to:

- **Share** — copy and redistribute the material in any medium or format.

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:

- **Attribution** — You must give appropriate credit, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.
- **NonCommercial** — You may not use the material for commercial purposes.
- **NoDerivatives** — If you remix, transform, or build upon the material, you may not distribute the modified material.
- **No additional restrictions** — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.

For the full legal text of the license, please visit: https://creativecommons.org/licenses/by-nc-nd/4.0/legalcode

## 2.1 Contributions

Contributions to improve the original work are welcome via the official Github repository. Please note that while you can propose changes to the source material (e.g., via pull requests), this license does not permit you to distribute your own modified versions of this work elsewhere.

---