

# Welcome to the Webinar

## Setting up a Force Measurement Chain in Test & Measurement Applications - From Sensor to Result

**The presentation will begin at 3pm CET / 9am EST**

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Questions will be answered at the end of the presentation.

# Organizational Information

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# The Presenters

## Thomas Kleckers

- Engineer for Physical Technology
- Product Manager Force Sensors at HBK – since 2009
- Previously – strain gauge development at HBK



## Christof Salcher

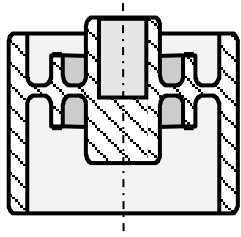
- Engineer Electrical & Information Technology, Technical University Munich
- Product Manager Test & Measurement at HBK since 2007
- Previously – different roles in automotive software engineering



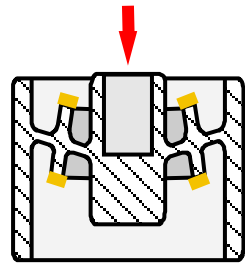
# Agenda

- Basics
- Wiring and input schematics
- Live setup and measurement
- Summery
- Questions & Answers

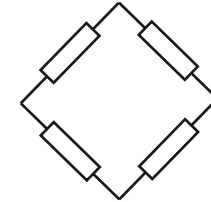
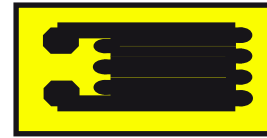
# Strain gauge based sensors: The principle



Spring body



If a load is introduced, strain appears. Strain gauges convert the strain into a change of resistance



The Wheatstone bridge converts the changes in resistance into a measurable voltage

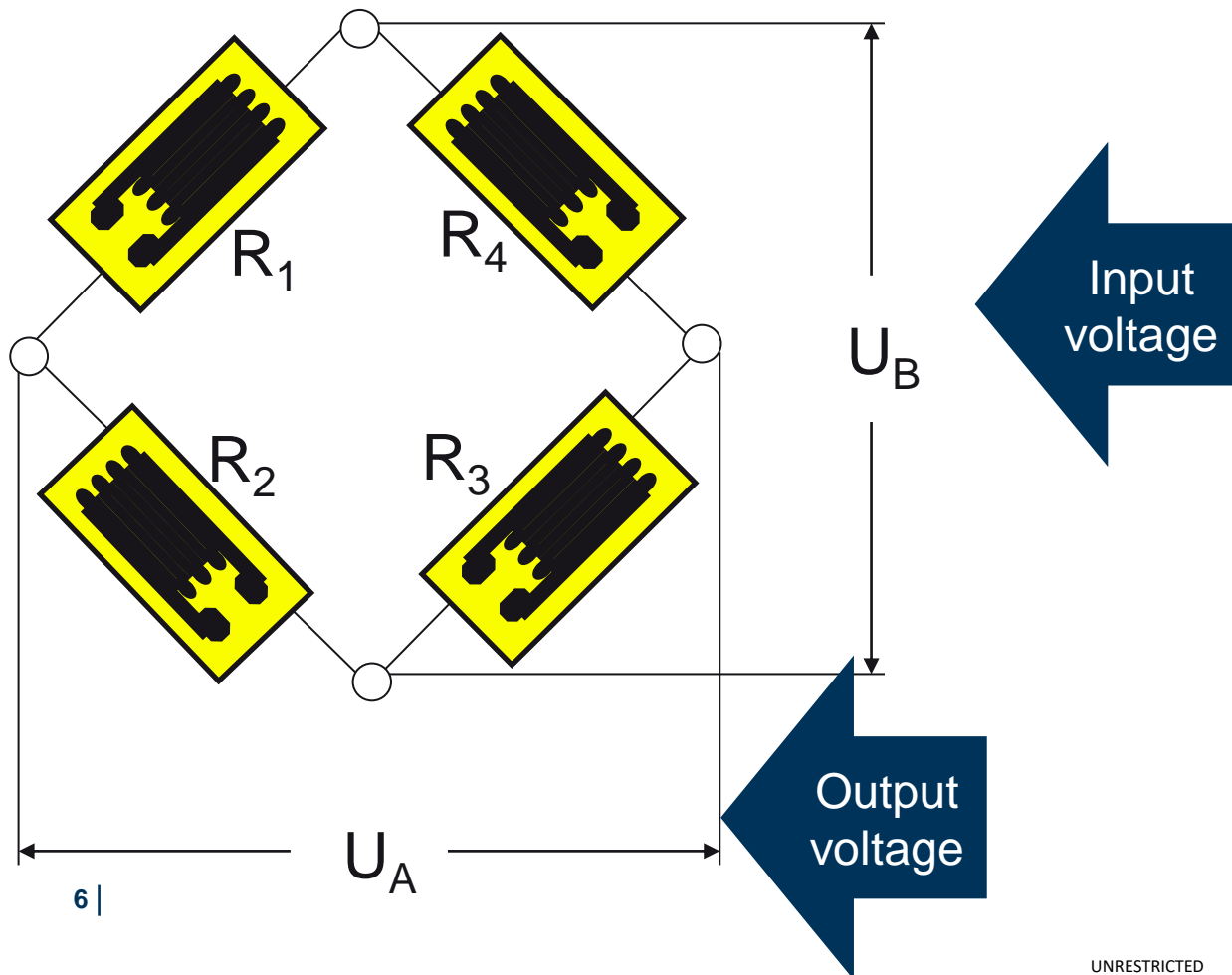
Typical:

Mech. Stress:	2	200 Mpa
Material:		Steel (200 Gpa)
Strain $\epsilon = \sigma/E \Rightarrow$		0,001 (= 0,1 %)
Usual "Unit":		$\mu\text{m}/\text{m} = 10^{-6}$

Strain gauge resistance  
350 Ohm Strain 1000  
 $\mu\text{m}/\text{m}$ :  
0,7  $\Omega$  change of resistance

# Strain gauge based sensors: The principle

Strain is 1000  $\mu\text{m}/\text{m}$ , strain gauge resistance is 350  $\Omega$ , gauge factor is 2  $\Rightarrow$  change in resistance **0.7  $\Omega$**



$$\frac{U_A}{U_B} = \frac{R_1}{R_1 + R_2} - \frac{R_4}{R_3 + R_4}$$

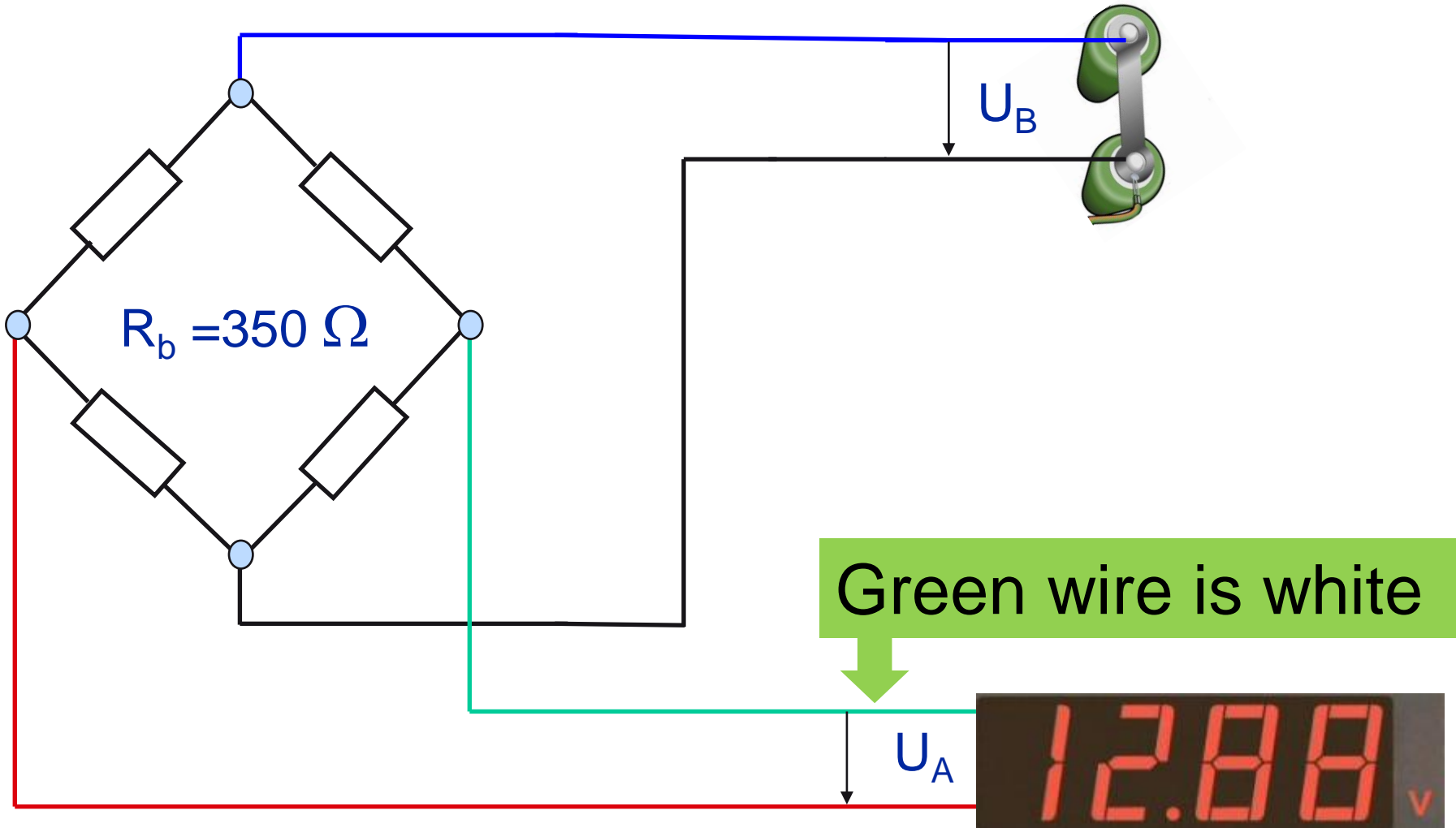
$$\frac{U_A}{U_B} = \frac{1}{4} \cdot \left( \frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4} \right)$$

$$\frac{U_A}{U_B} = \frac{1}{4} \cdot \left( \frac{0,7 \Omega}{350 \Omega} - \frac{-0,7 \Omega}{350 \Omega} + \frac{0,7 \Omega}{350 \Omega} - \frac{-0,70 \Omega}{350 \Omega} \right)$$

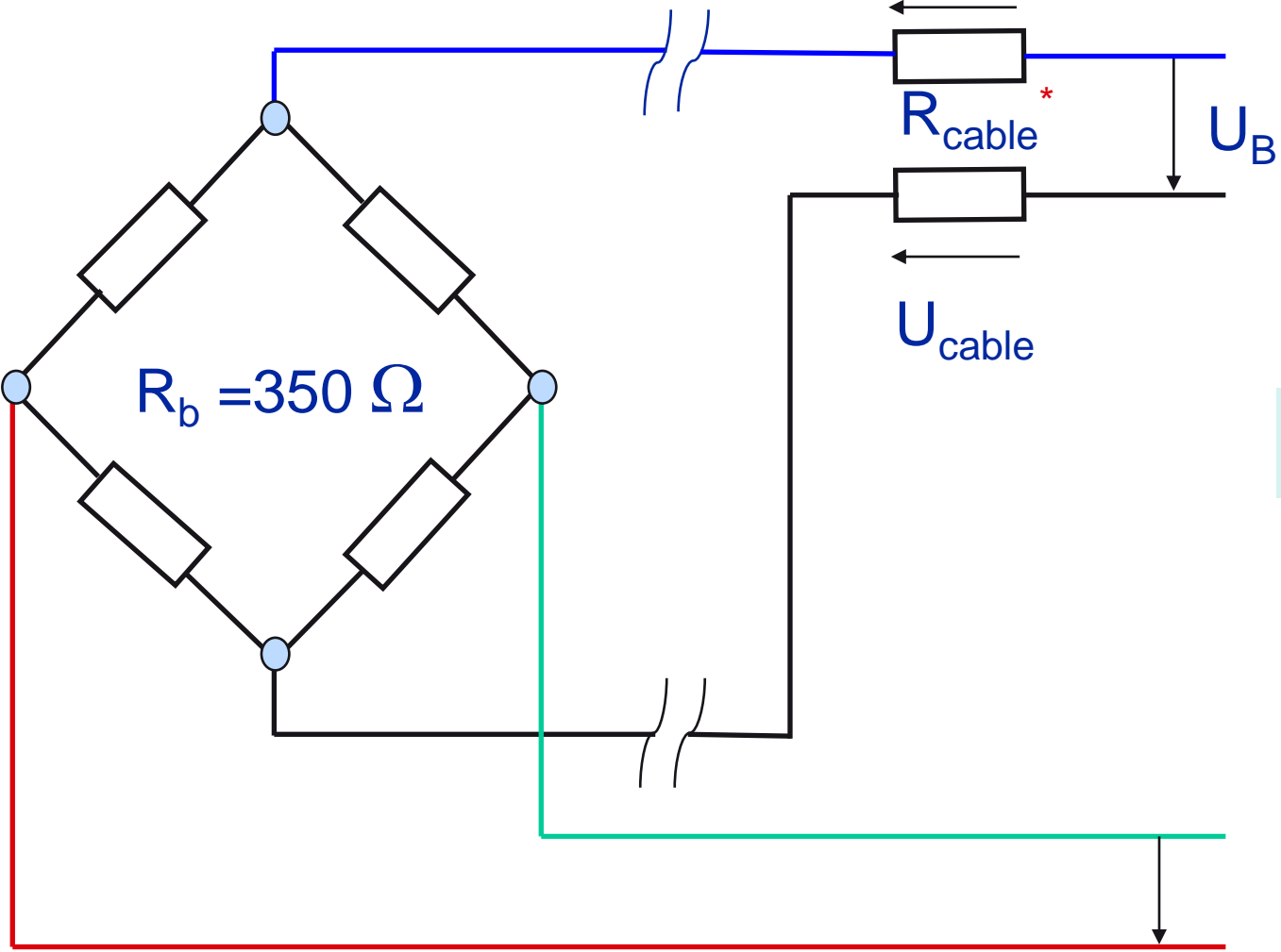
$$\frac{U_A}{U_B} = 0,002$$

$$\frac{U_A}{U_B} = 2 \text{ mV/V}$$

# 4 – wire circuit



# 4 – wire circuit



$$F_{mess} \sim \frac{\Delta l}{l} \sim \frac{\Delta R}{R} \sim \frac{U_A}{U_B}$$



Change in cable resistance leads to

Change of voltage drop at the cable

Change of voltage at the Wheatstone bridge

Change of output signal

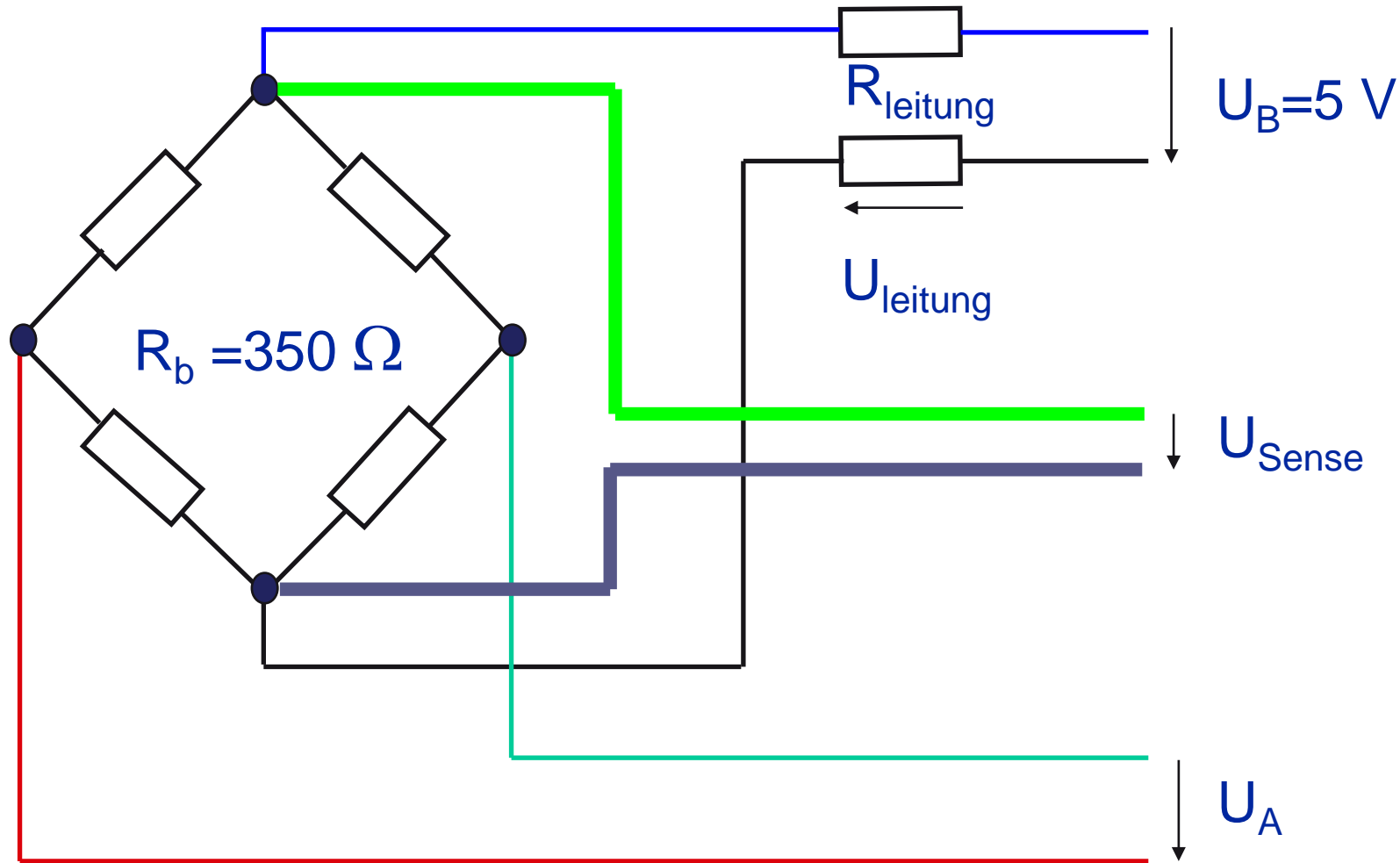
**The sensitivity of a “4 wire” sensor is depending on the cable length and the temperature**

$U_A$

No influence of the resistance of the output wires (red and white) on the results due to high input resistance of amplifier

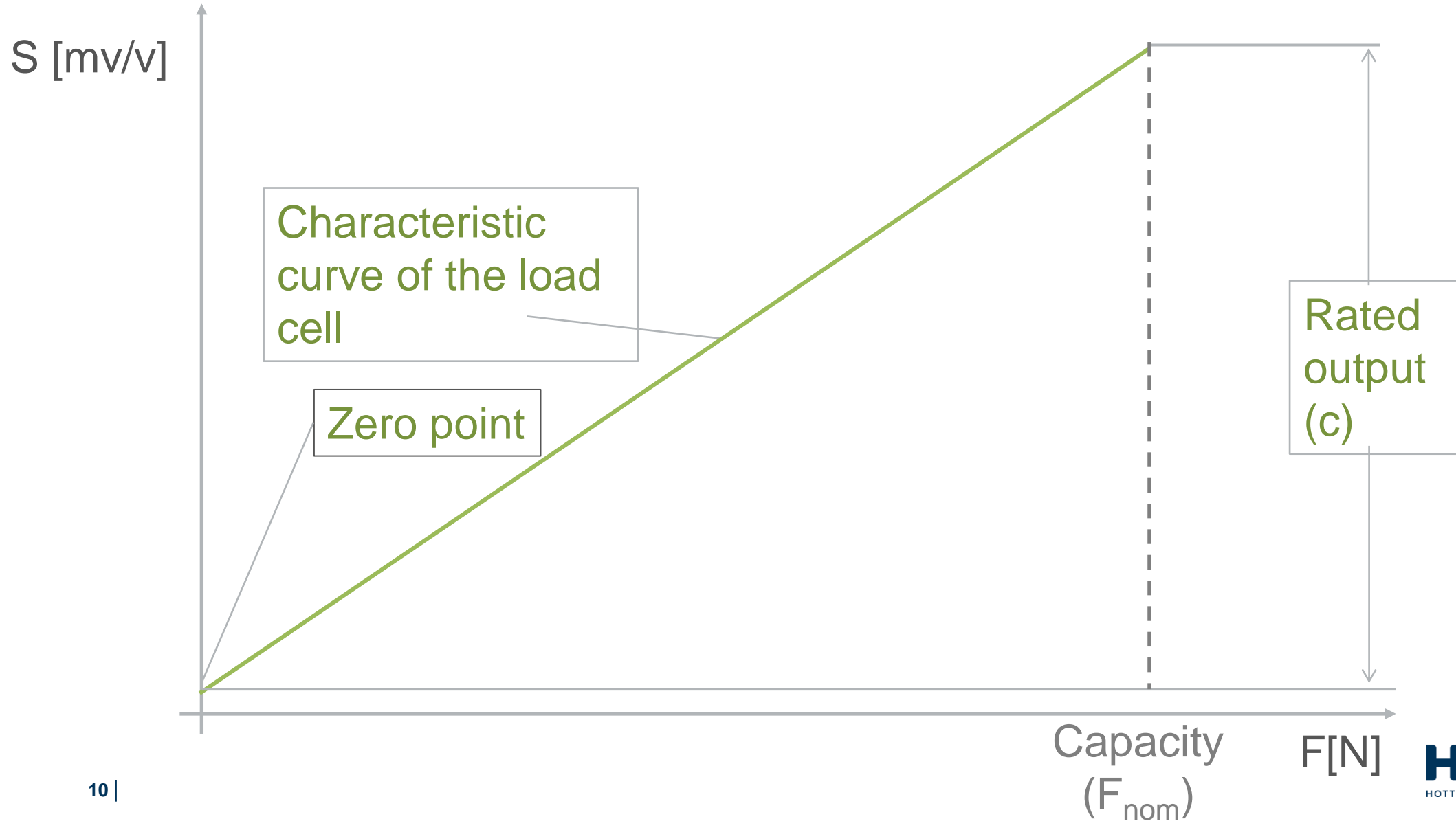


## 6 – wire circuit



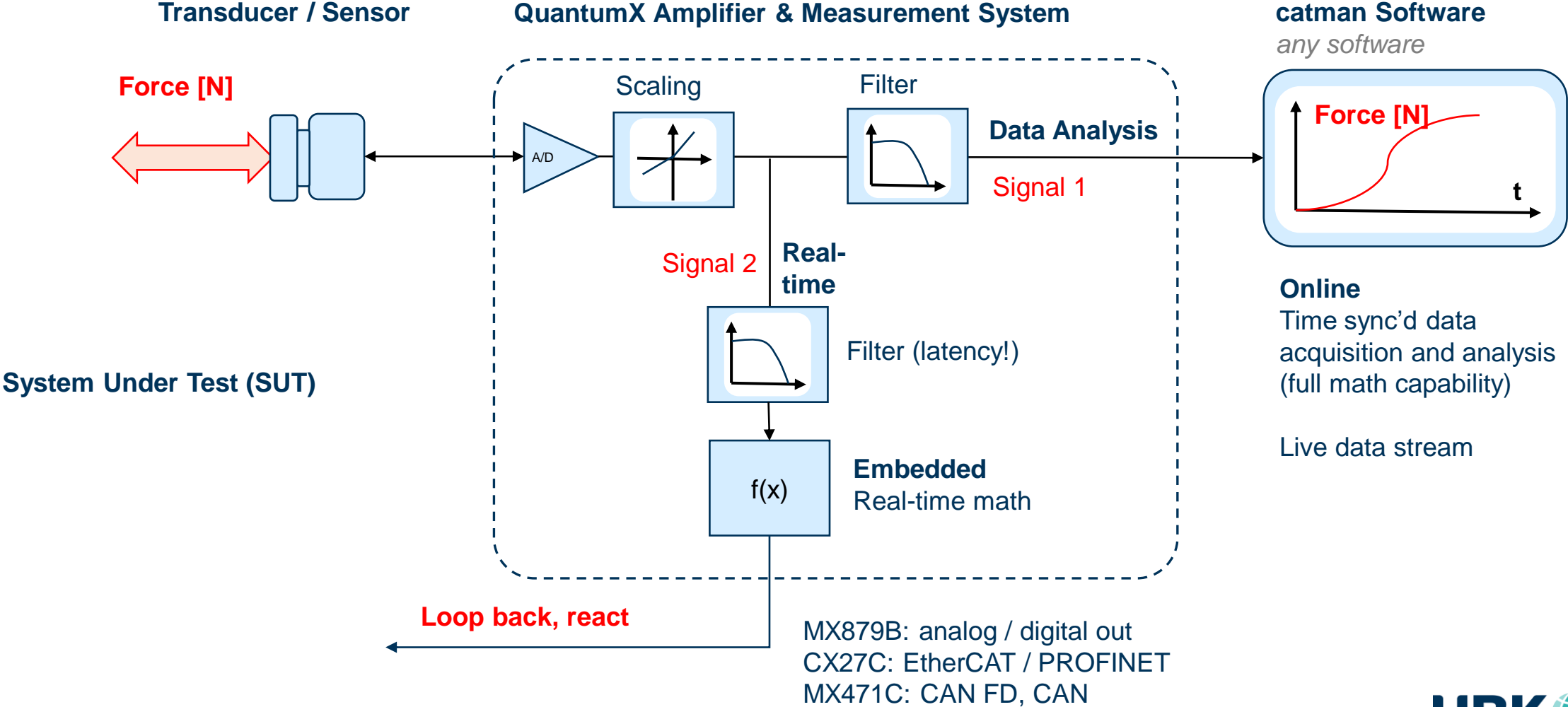
**6 – wire circuit:**  
Measurement of the voltage at the Wheatstone bridge by using additional sense lines, adjustment if required, for example in case of changes in temperature

# Calibration / Adjustments



# LIVE DEMO

# “With full force” : more than a complete measurement chain



# Questions?

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# Thank You

Any questions?