Welcome to the “The pros and cons of amplified force sensors” Webinar

The presentation will begin at 1pm Eastern time

All attendees microphones are muted for the entire webinar session. Be sure your speaker is active and join the audio conference.

If you have a question, please send it to the host using the “Q&A” function. Questions will be answered at the end of the presentation.

Host: Bernadette Humm
Presenter: Chris Novak

Organizational Information

- All participants' **microphones** are **muted** during the webinar.
- Please do not forget to **activate** your PC **speakers** to enable **audio** or connect **headphones** to your PC. You may have to take the step of joining the audio conference to hear sound.
- Please type any questions you have into the WebEx Q&A dialog
- You can open the Q&A window by selecting the “Q&A” icon in the WebEx toolbar at the top of your screen:

- Today’s presentation will be E-mailed to all attendees. The webinar will also be posted on our website: http://www.hbm.com/en/3157/webinars/
- If you have additional technical questions, feel free to contact our technical support team at support@usa.hbm.com

Chris Novak

- Bachelor’s degree in Electrical Engineering from Cleveland State University
- Business Development Manager with HBK
- Previously – Global Applications Engineer with Honeywell for Test & Measurement

The pros and cons of amplified force sensors

Host: Bernadette Humm
Presenter: Chris Novak

Amplified Force Sensors

1. Strain gauge based load cells: A short introduction
2. Output signal of passive load cells
3. Amplified load cells
4. Pros and cons

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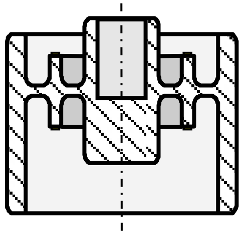
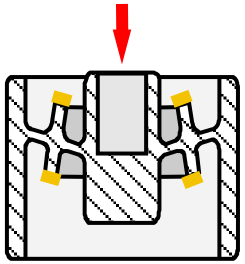
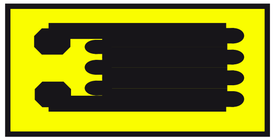
Strain gauge based sensors: The principle

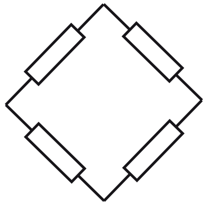


Spring body





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:	200 Mpa
Material:	Steel (200 Gpa)
Strain $\varepsilon = \sigma/E$ =>	0.001 (= 0.1 %)
Usual "Unit":	µm/m = 10^{-6}

Strain gauge resistance 350 Ohm Strain 1000 µm/m:
0.7 Ω change of resistance

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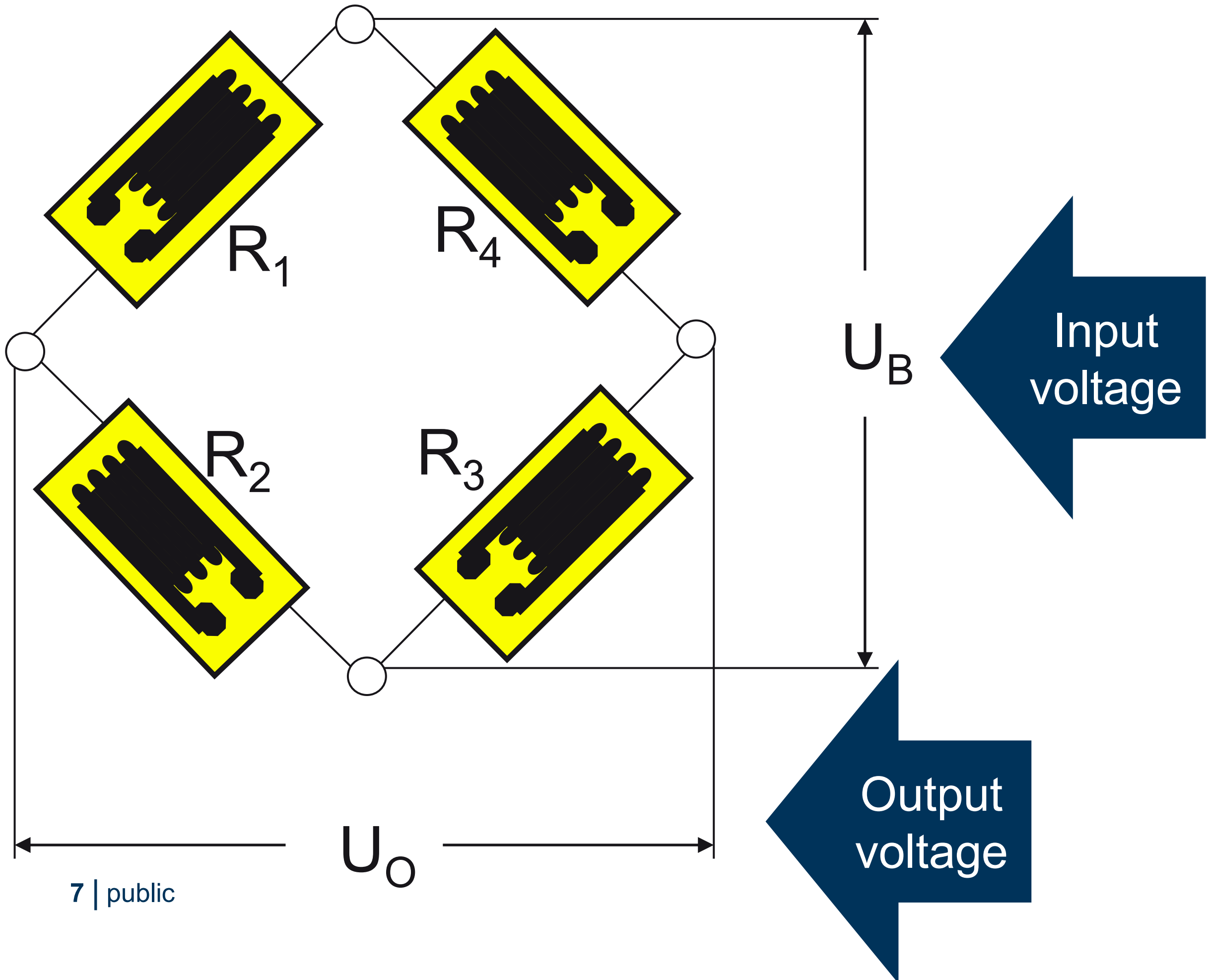
Strain gauge based sensors: The principle

Strain is 1000 µm/m, strain gauge resistance is 350 Ώ, gauge factor is 2 => change in resistance **0.7 Ώ**



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

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

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

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

$$\frac{U_O}{U_B} = 2\ mV/V$$

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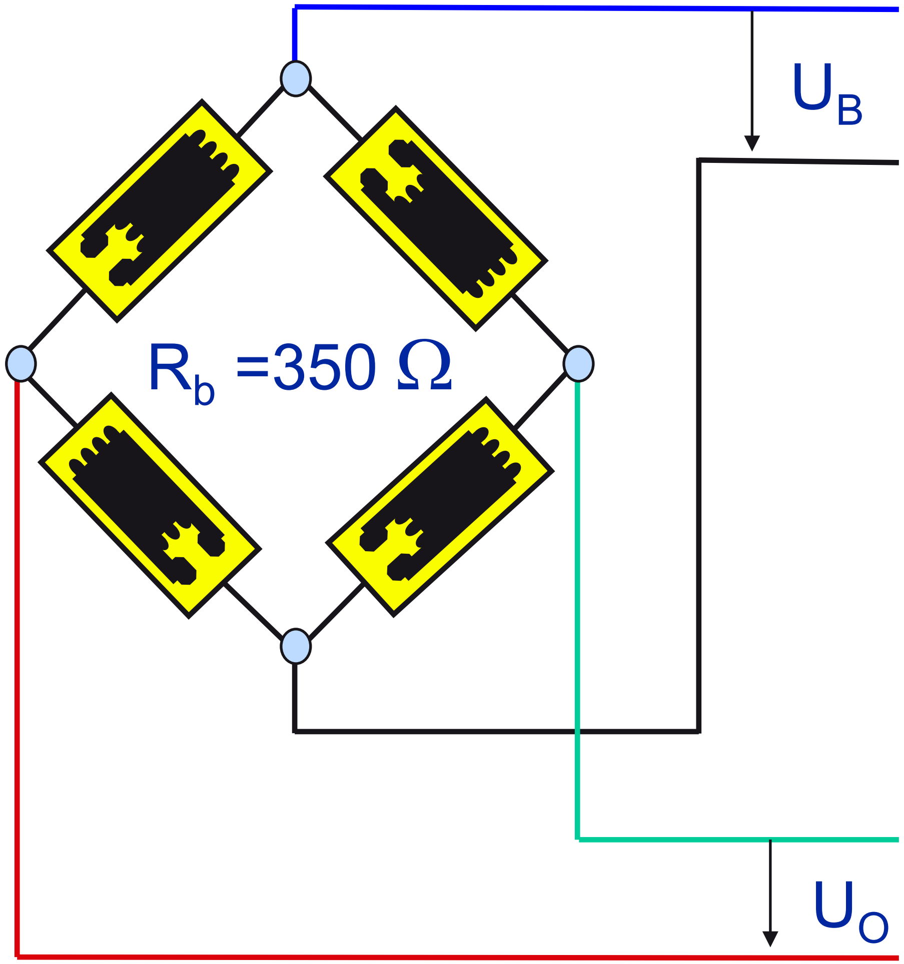
4 – wire circuit



$$\frac{U_O}{U_B} = 2\,mV/V$$

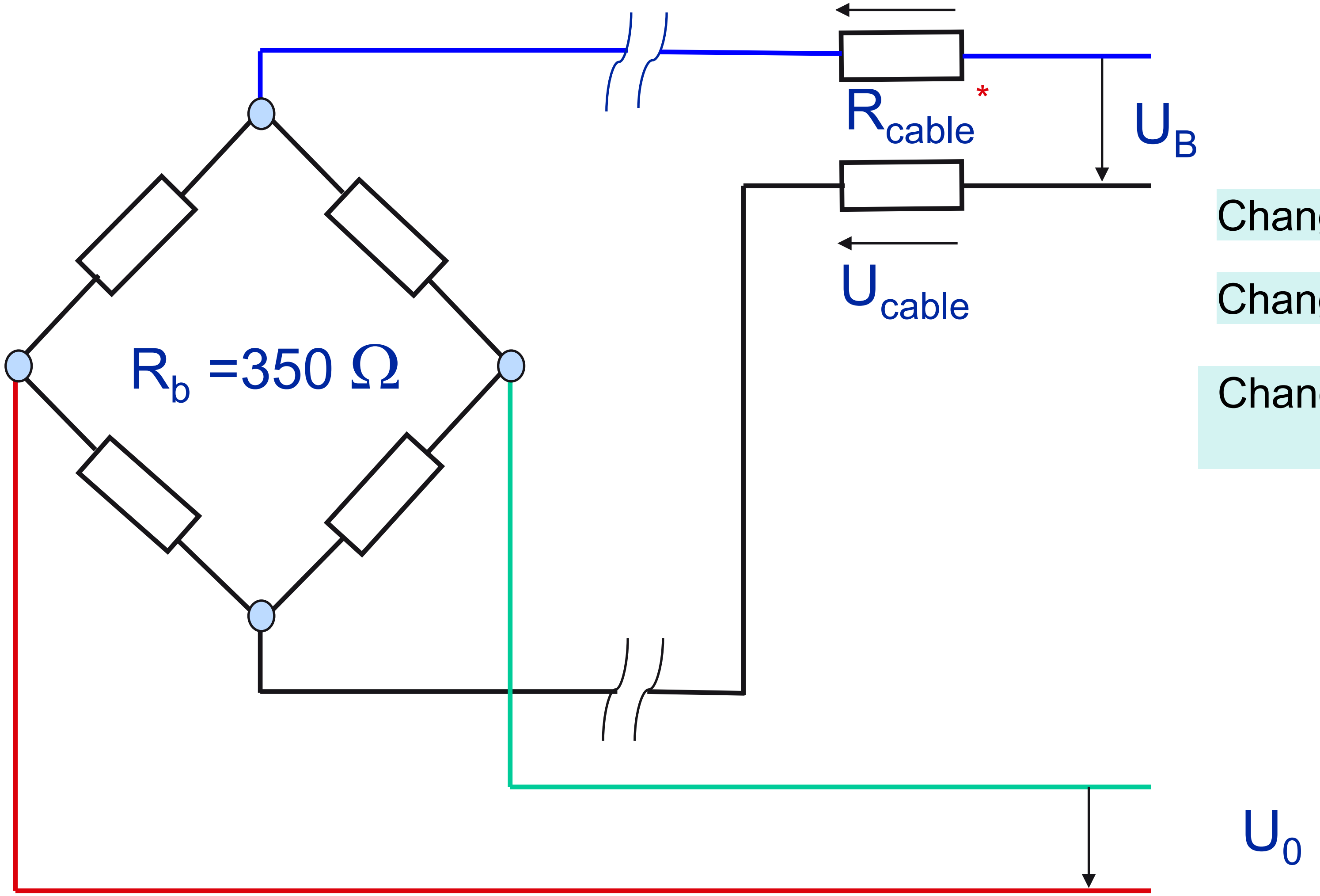
U_B is the excitation voltage.
In many cases: 5 – 10 V

Example:

Sensor under full load
Rated output is 2 mV/V
U_B is 5 V => 10 mV
U_B is 10 V => 20 mV

Sensor under 50 % load
Rated output is 2 mV/V
U_B is 5 V => 5 mV
U_B is 10 V => 10 mV

4 – wire circuit



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

Change in cable resistance leads to

Change of voltage drop at the cable

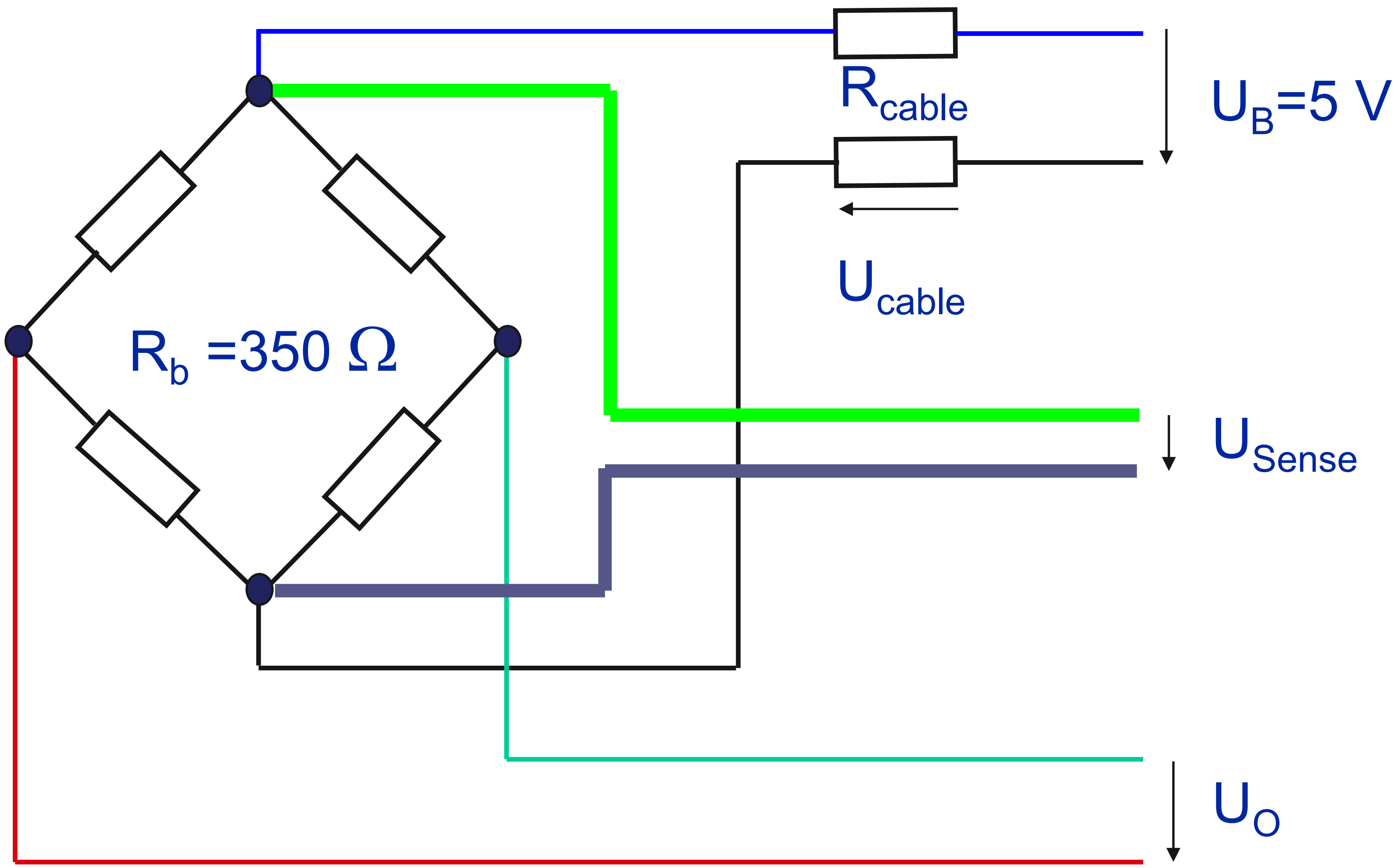
Change of voltage at the Wheatstone bridge

Change of output signal

The sensitivity of a "4 wire" sensor is depending on the cable length and the temperature

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

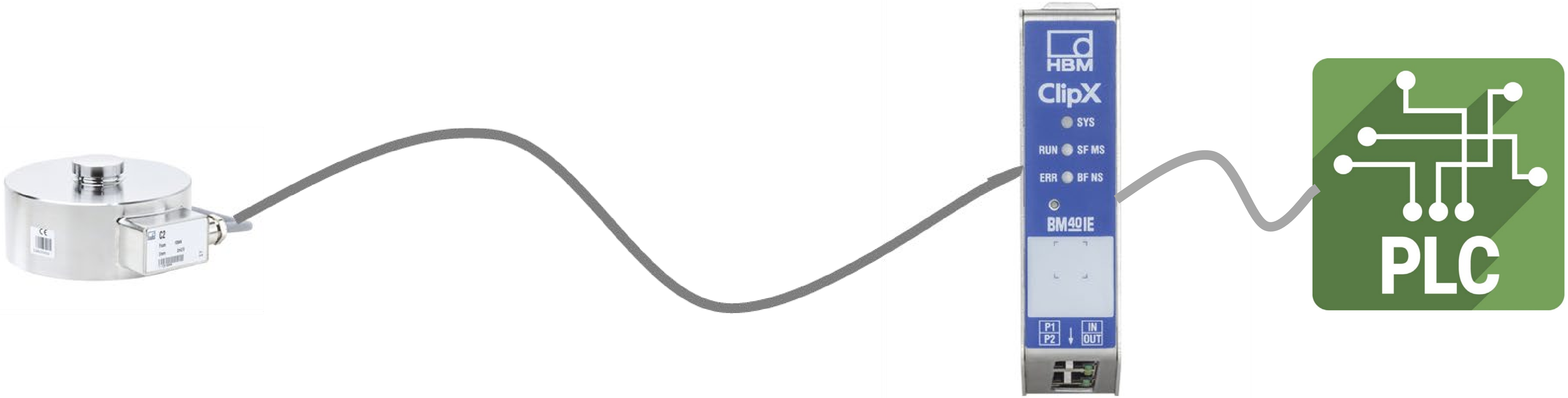
6 – wire circuit



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

State of the art load cell / instrument combination



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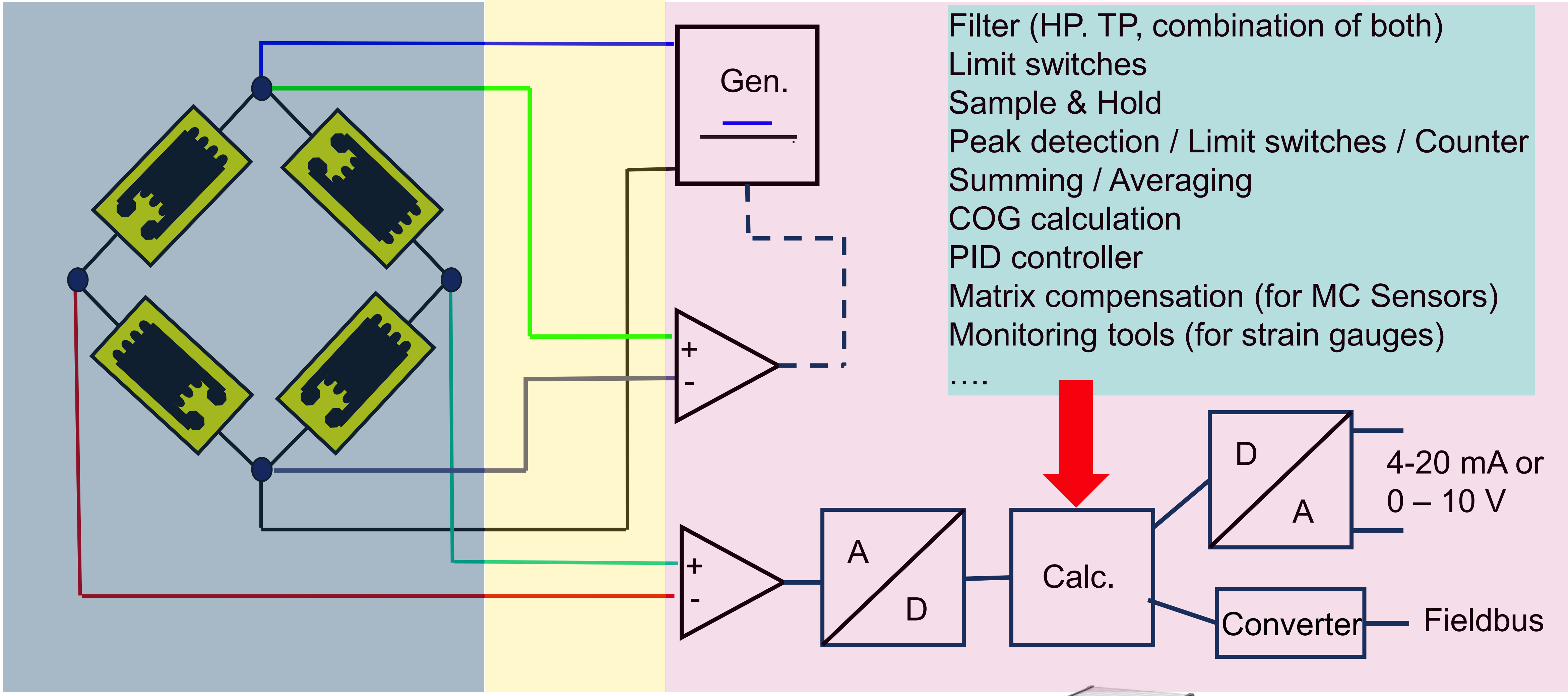
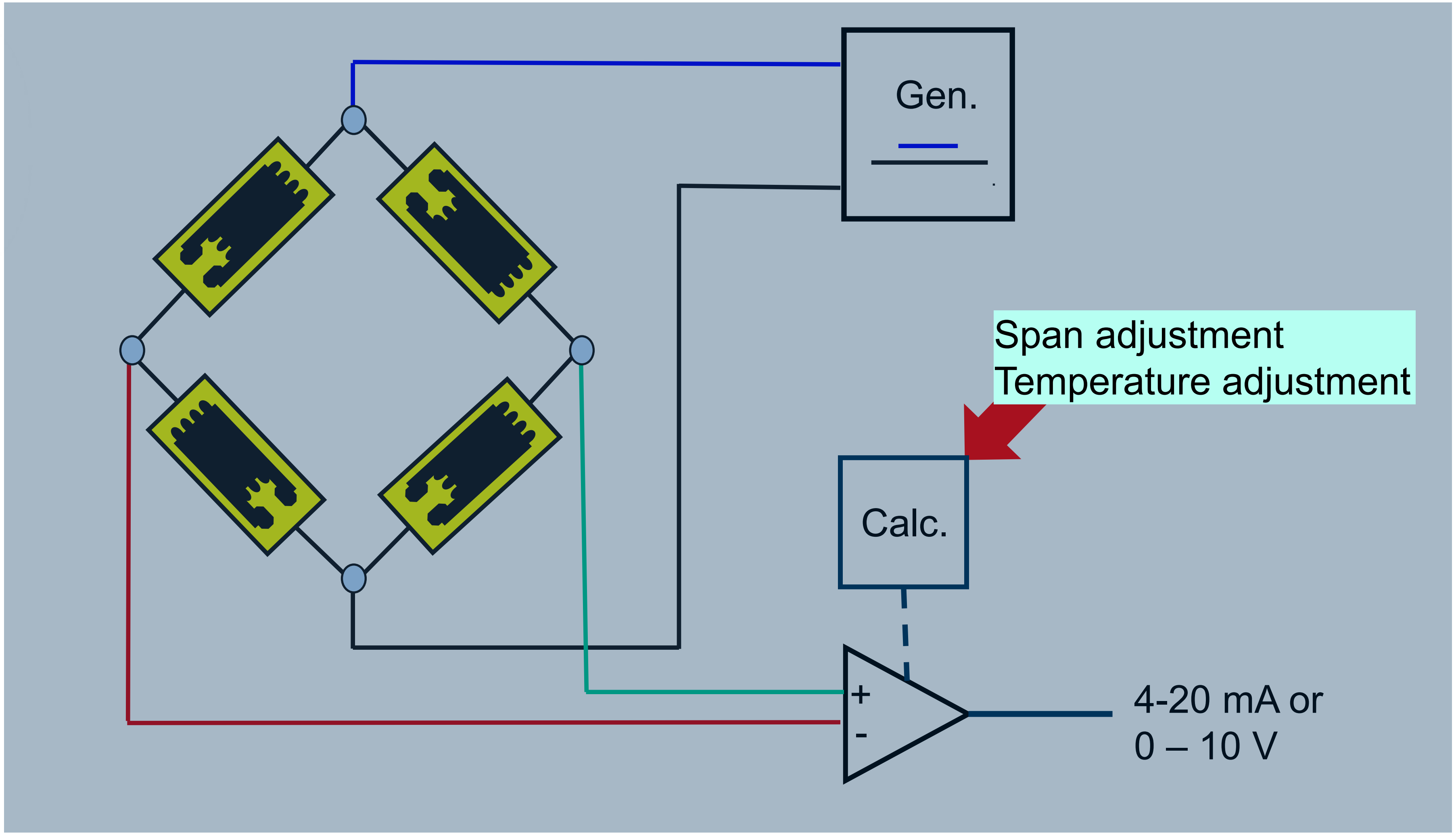
State of the art load cell / instrument combination



Amplified load cells / strain transducers



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The output signal

Output signal of a load cell at full scale:	2 mV/V
Supply voltage:	5 V
Output voltage at full scale:	10 mV
Resolution requirement	100,000 d
1 digit	0.1 µV

Comparison:

Height of the Empire State Building:	443 m
1/100,000	4.43 mm

Height of a vinyl record (CD jewel case)

Wiring should be done with shielded cabled, dedicated to strain gauge technology

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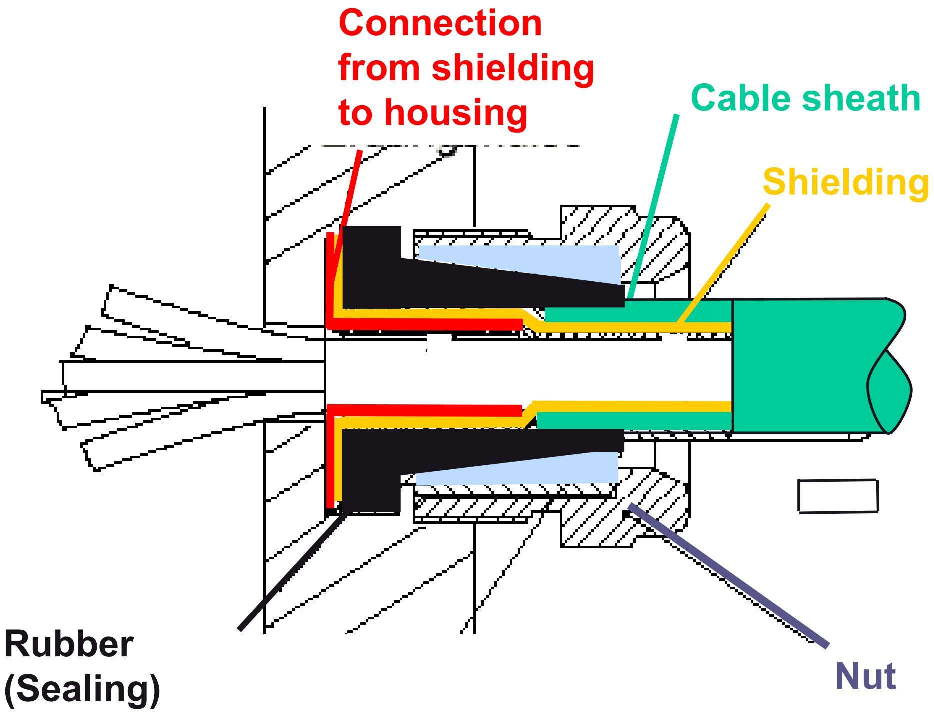
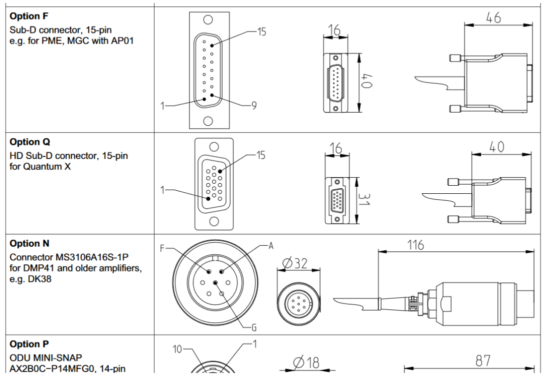
Cabling of load cells (not amplified)



Some of the requirements requested for load cell cables

- Shielded to ensure a Faraday's cage
- Low capacity
- Symmetric
- 4- or 6 – wires
- Stable electrical properties in the complete temperature range



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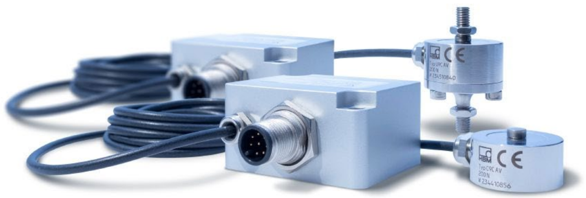
Connection cable for HBM force transducer

Amplified force and strain sensors

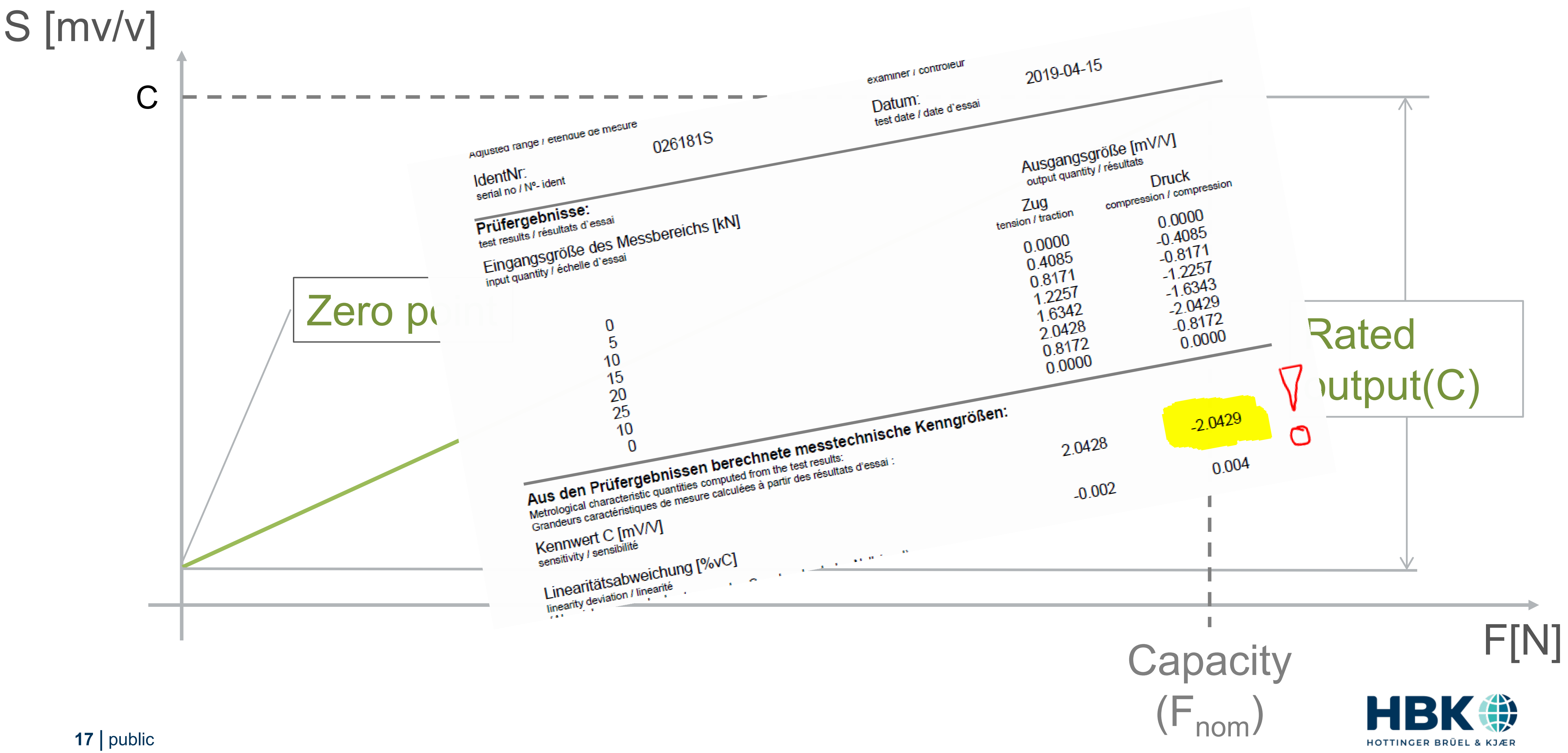


Output signal:	10 V
Supply voltage:	19 -30 V
Output voltage at full scale:	10 V
Resolution:	100,000 d
1 digit	100 µV

Alternative: 4 – 20 mA output

An integrated or hard wired amplifier converts the low output signal to a robust analogue voltage or current signal. Amplification is typically 500 – 2000. (Depending on the raw output of the load cell)

Adjustment of sensors without amplification: Two point scaling



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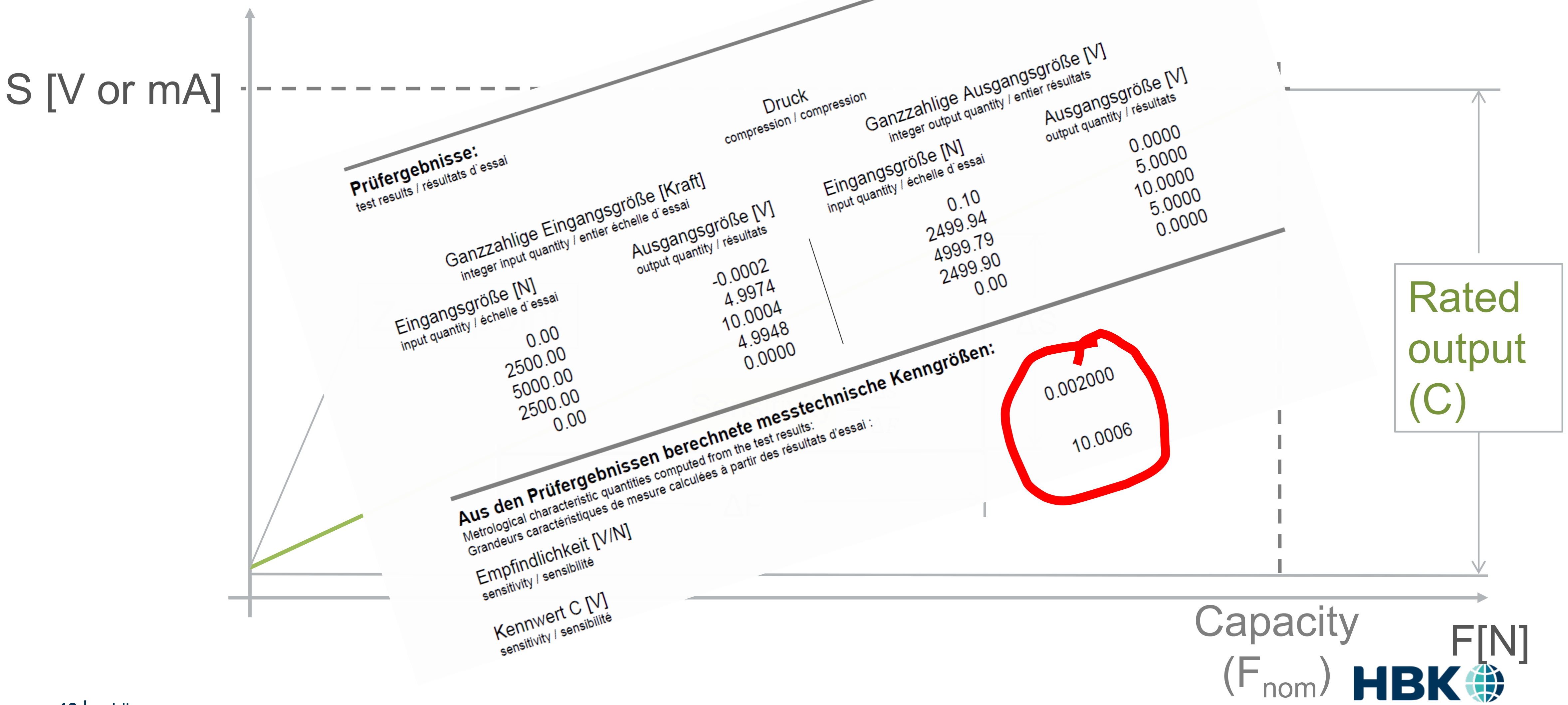
Adjustment of sensors with amplification: Two point scaling or sensitivity



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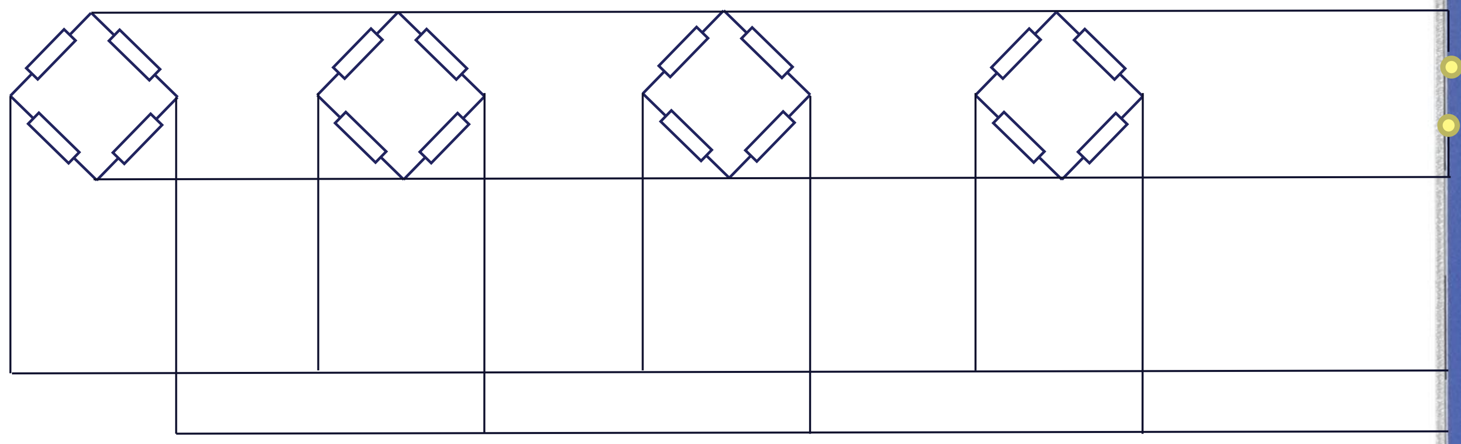
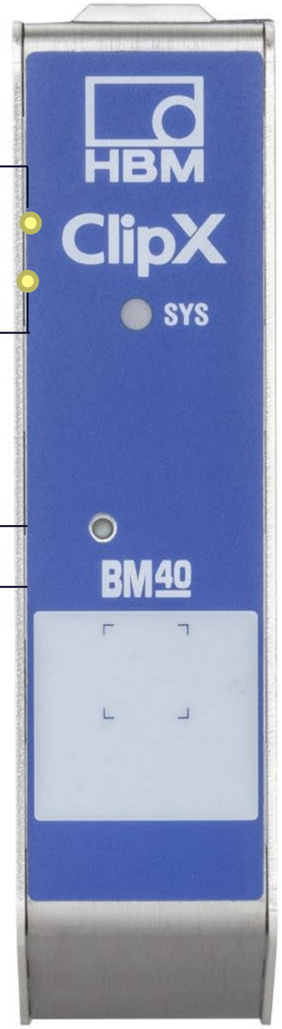
Parallel Setup





The number of load cells to be connected to a channel are limited by the Minimum output resistance of the instrument.

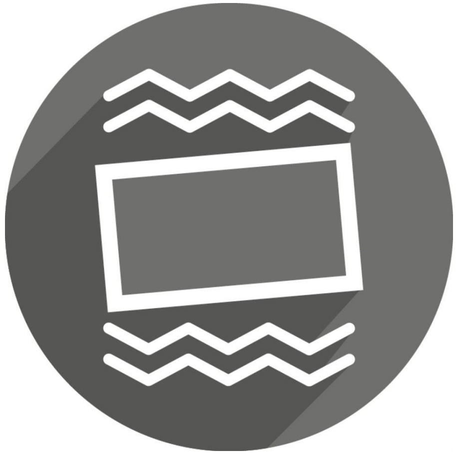
Robustness

Shock / Vibration

No difference between amplified or conventional load cells.

Testing conditions (In accordance with IEC 60068):

- Mechanical shocks: 1000 times, 100 g
- Vibrations: 5 – 65 Hz, 15 g

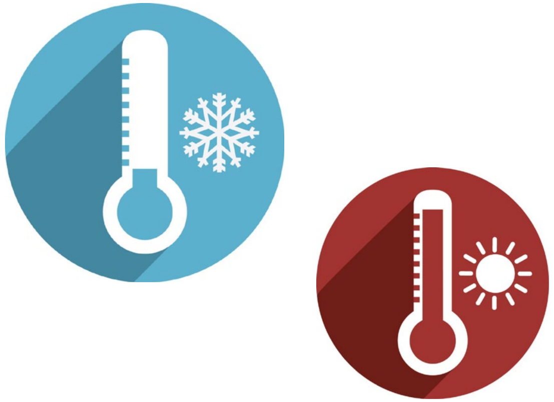


Temperature

The onboard amplifier limits the (upper) temperature range

- Operation temperature range with integrated amplifier:

  -20 °C to 60 °C



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Pros and cons of amplified load cells

	Amplified	Sensor and instrument
EMC immunity	Robust output 10 V or 4 .. 20 mA	Cables designed for strain gauge sensors required. Shielding pretty much important (Faraday´s cage)
Easy to use	No parametrization of an instrument required.	Parametrization is required. (TEDS may help here)
Parallel setup of sensors	-	Easy to do if load cells with R/C adjustment are chosen
Online Mathematics	-	Lot of calculation possible, for one channel as well as calculations taking multiple channels into account
Accuracy	A certain type of load cell has the same accuracy no matter if amplified or passive	High end accuracy up to an uncertainty of a view ppm

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Pros and cons of amplified load cells

	Amplified	Sensor and instrument
Space required	Same outer dimensions, no matter if amplified or passive technology.	Space in the cabinet required
Shocks / vibration	Amplified load cells have the same withstanding against shocks and vibrations as the passive models	Just like the passive models
Humidity / Degree of protection	No difference	No difference
Temperature	Lower with integrated electronic (up to 60 °C operation temperature limit)	120 °C achievable without problems

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Where to find more information?

https://www.hbm.com/index.php?id=10621

Available Products:

	MINIATURE	STANDARD	LARGE FORCES	STRAIN SENSOR
NOMINAL CAPACITIES	50 N... 50 kN	0.5 kN... 200 kN	200 kN... 10 MN	n.a.
COMPRESSION	C9C	C2	C6B	SLB700A/06VA
TENSION AND COMPRESSION	U9C	U2B	*	SLB700A/06VA
				

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Thank you!

Chris Novak
Chris.novak@hbkworld.com