

Welcome to the “Strain Gauge Measurements with Bridge Amplifier” Webinar

The presentation will begin at 10am Central time

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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.

Organizational Information

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- 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

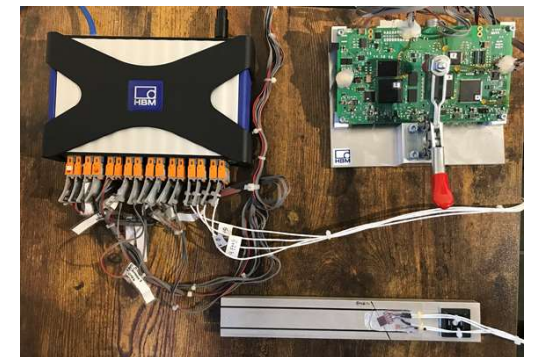
Brian Lovdahl

- ▲ Western Region Field Application Engineer with HBK – Portland, OR
- ▲ Previously – Sales & Support for HBM / SOMAT mobile data acquisition for 12-years
- ▲ Electrical Engineering history starting with ITT - St. Louis, MO
- ▲ Enjoy woodworking, hiking and biking



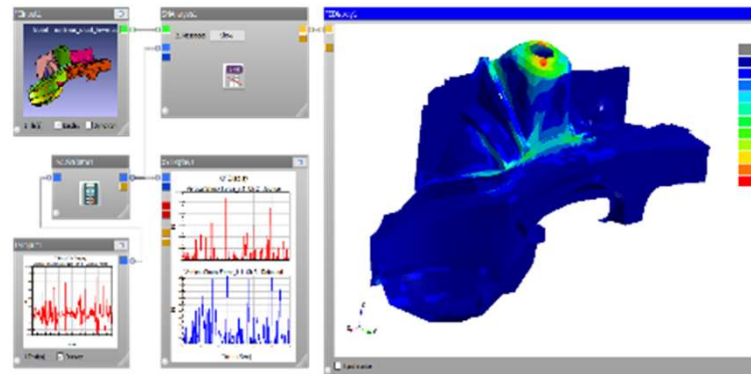
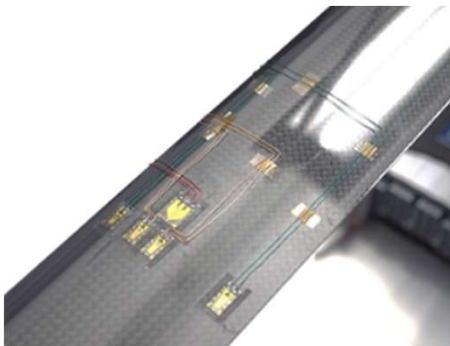
Agenda

1. Strain measurement Introduction
2. Measurement challenges and approaches
3. Live Demo – Setting up a strain measurement project



Strain gauge applications

- ▲ R&D (Product Development)
- ▲ Commercial vehicle testing
- ▲ Design Verification
- ▲ Monitoring of infrastructure
- ▲ Transducers
- ▲ ...



Different solutions for measuring strain

▲ Electrical and optical strain measurement solutions of HBK

- + Low cost
- + Easy installation
- + Maximum flexibility
- + Well-proven
- + Usable with many DAQ systems

- + Hostile environments (moisture)
- + High voltages/magnetic fields
- + Many strain measurement points/channel
- + Long distances without signal loss



The strain gauge measurement chain



- ▲ + thermocouples/RTDs
- ▲ + Force sensors
- ▲ + accelerometers
- ▲ + GPS/GNSS
- ▲ + Digital bus – CAN/CAN FD

Challenges during your strain measurement project

Measurement project Setup

- ✓ Handle many strain channels
- ✓ Organize sensor parameters
- ✓ Set sample rates+ filters/ Excitation voltage
- ✓ Ensure that strain values are valid
- ✓ Built up specific test cases (triggers and alarms...)
- ✓ Traceability of measurement data



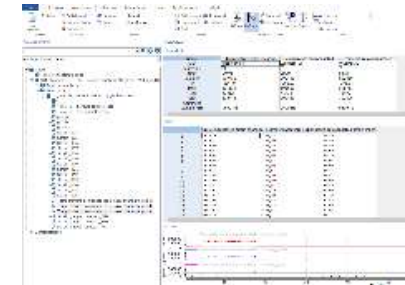
Data acquisition

- ✓ Temperature compensation (apparent strain needs to be suppressed)
- ✓ Perform online calculations on signals
- ✓ (Rosette calculations...)
- ✓ Live visualization (+ Video)
- ✓ Stability of measurement

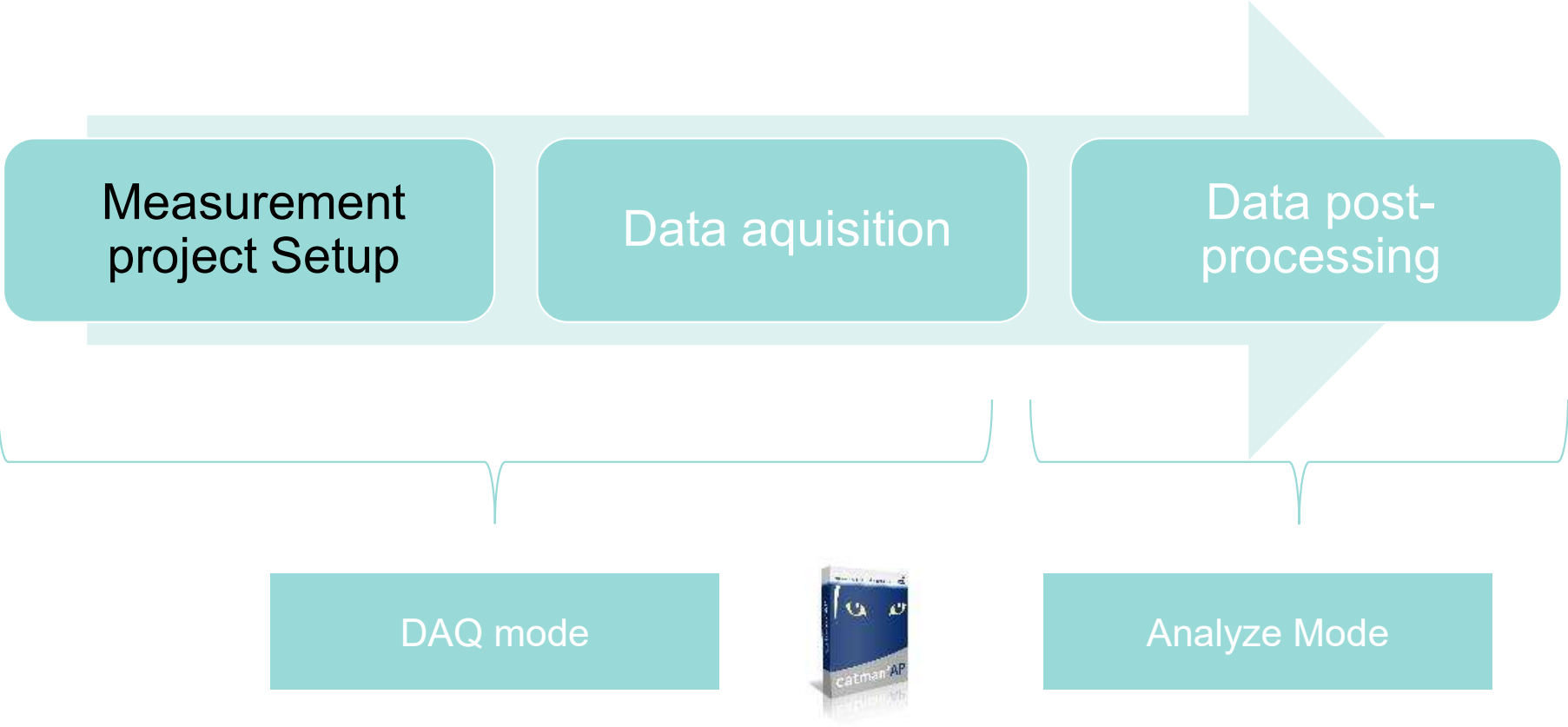


Data post-processing

- ✓ Organize measurement data
- ✓ Corrections on measurement data
- ✓ Export of data
- ✓ Access test meta data



Catman software architecture



Measurement project Setup

Data acquisition

Data post-processing

▲ **What to do if I have many strain channels to measure?**

- ▲ Use MX1615B module with 16 channels + catman software (can be scaled for > 500 channels, or use optical measurement solution with 16 sensors/channel= 128 signals/module)
- ▲ (Synchronization via FireWire, PTP, NTP, IRIG-B)



▲ **How to organize sensor parameters?**

- ▲ Digital sensor data base to store all sensor related parameters (gauge factor, bridge excitation, bridge factor etc.)

▲ **How to set sample rate & filter?**

- ▲ Depends on test case and signal bandwidth which will be measured.

Rule of thumb for sample rate: 10x signal bandwidth


Rule of thumb for filters: $f_{cutoff} = 5 \times f_{signalbandwidth}$ (static)

$f_{cutoff} = 1.5 \times f_{signalbandwidth}$ (dynamic)

Current sensor settings

Sensor-ID	441465378587963	
Name/Description	SG_Long_beam_RY91-1.5/350_A	
Comment	Long Beam Rosette_A	

General **Transducer settings**

 Single strain gage 4 wire 350 ohms

2.5	Excitation in V	350	Bridge resistance (Ω)
4-wire	Sensor wiring	Leave this field empty if the resistance is unknown, required for shunt calibration. By default a value of: will be assumed.	
Auto	Carrier frequency		
µm/m	Unit		
1.94	Gage factor		
4000	Measuring range (µm/m)		

Measurement project Setup

Data acquisition

Data post-processing

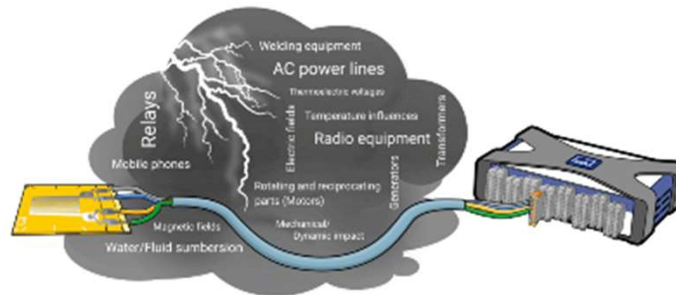
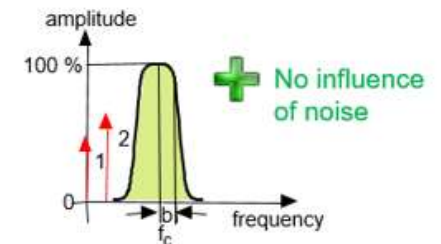
- How can I check that my strain sensor values are plausible?
Channel check (Shunt calibration). catman gives feedback if value is in an expected range without loading of test article

DC or carrier frequency?

- Rule of thumb:
- If possible use carrier frequency! For most test cases carrier frequency is the best choice to minimize EMI on the measurement signal
- For high precise static measurements without EMI, short analog sensor lines: DC voltage
- For dynamic measurements at high frequency >1kHz: DC voltage

DAQ channels							
	Channel name	Reading	SensorFunction	Zero value	Measured unbalance	Nominal unbalance	Shunt test OK/NOK
1	MX1615						
5	Rosette_1_grid_a	-1.144 mV/V	PCB Strain Gaugi	-2291.9 µm/m	0.2998 mV/V	0.2984 mV/V	OK
6	Rosette_1_grid_b	-1.019 mV/V	PCB Strain Gaugi	-2038.7 µm/m	0.3000 mV/V	0.3002 mV/V	OK
7	Rosette_1_grid_c	-0.9493 mV/V	PCB Strain Gaugi	-1898.7 µm/m	0.2999 mV/V	0.2999 mV/V	OK
8	Rosette_2_grid_a	-1.444 mV/V	PCB Strain Gaugi	-2888.9 µm/m	0.2996 mV/V	0.3000 mV/V	OK
9	Rosette_2_grid_b	-0.9317 mV/V	PCB Strain Gaugi	-1862.3 µm/m	0.3001 mV/V	0.3000 mV/V	OK
10	Rosette_2_grid_c	-1.629 mV/V	PCB Strain Gaugi	-3255.5 µm/m	0.2999 mV/V	0.2997 mV/V	OK
11	Rosette_3_grid_a	0.2724 mV/V	SG 3 wire 120 Oh	544.71 µm/m	0.2989 mV/V	0.2987 mV/V	OK
12	Rosette_3_grid_b	0.5810 mV/V	SG 3 wire 120 Oh	1162.0 µm/m	0.2992 mV/V	0.2989 mV/V	OK
13	Rosette_3_grid_c	0.3666 mV/V	SG 3 wire 120 Oh	733.08 µm/m	0.2993 mV/V	0.2993 mV/V	OK
14	Rosette_4_grid_a	0.8375 mV/V	SG 3 wire 120 Oh	1674.9 µm/m	0.2990 mV/V	0.2994 mV/V	OK
15	Rosette_4_grid_b	-0.1275 mV/V	SG 3 wire 120 Oh	-255.23 µm/m	0.2993 mV/V	0.2990 mV/V	OK
16	Rosette_4_grid_c	-0.2992 mV/V	SG 3 wire 120 Oh	-598.40 µm/m	0.2989 mV/V	0.2992 mV/V	OK
17	Beam_Rosette_A	0.3407 mV/V	SG_Long_beam	702.38 µm/m	0.8734 mV/V	0.8733 mV/V	OK
18	Beam_Rosette_B	0.1161 mV/V	SG_Long_beam	235.19 µm/m	0.8730 mV/V	0.8733 mV/V	OK
19	Beam_Rosette_C	-0.3130 mV/V	SG_Long_beam	-635.17 µm/m	0.8731 mV/V	0.8732 mV/V	OK
20	Temperature_PT100	22.75 °C	TT-3/100	0.00000 °C		NA	

Carrier Frequency Excitation (CF)



Measurement project Setup

Data acquisition

Data post-processing

How to get an overview of measurement channels?

- Channel list allows filtering of channels:
- (Activate or deactivate channels, detect channels with sensor)
- Reading, filter by name etc..

Which meta data is stored for traceability ?

- Depends on sensor type, but all channel information is available in the analysis data of the measurement project

How can I design my measurement project efficiently?

- Use Daq jobs to set start, stop triggers and storage mode of project
- Alarms/Warnings (Popup Message, Email, Push Notification...)
- Events (Camera Screenshot, switch digital output, activate CAN-channel...)
- Storage: Stream data, store data in specific time intervals, increase measurement resolution on specific events, store data from different channels in different files (Parallel Recording)

Configure DAQ channels				Devices: 1	Hardware channels: 16	Computation channels:
		Channel name	Reading	Sample rate/Filter		
1		MX1615				
5		Rosette_1_grid_a	1.1 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
6		Rosette_1_grid_b	1.9 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
7		Rosette_1_grid_c	0.1 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
8		Rosette_2_grid_a	1.6 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
9		Rosette_2_grid_b	0.9 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
10		Rosette_2_grid_c	-0.2 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
11		Rosette_3_grid_a	-1.1 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
12		Rosette_3_grid_b	0.7 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
13		Rosette_3_grid_c	0.0 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
14		Rosette_4_grid_a	-0.8 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
15		Rosette_4_grid_b	-0.5 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
16		Rosette_4_grid_c	1.2 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
17		Beam_Rosette__A	2.2 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
18		Beam_Rosette__B	2.0 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
19		Beam_Rosette__C	1.6 $\mu\text{m/m}$	200 Hz / BE 20 Hz (Auto)		
20		Temperature_PT100	22.57 $^{\circ}\text{C}$	200 Hz / BE 20 Hz (Auto)		

Promise: No programming skills needed with catman!

Measurement project Setup

Data acquisition

Data post-processing

How to establish temperature compensation?

- Create online computation in catman and enter values from data sheet
- Attention:** Consider 2-wire cable influences and ensure that you use strain gauges having the best fit to your CTE of substrate material!

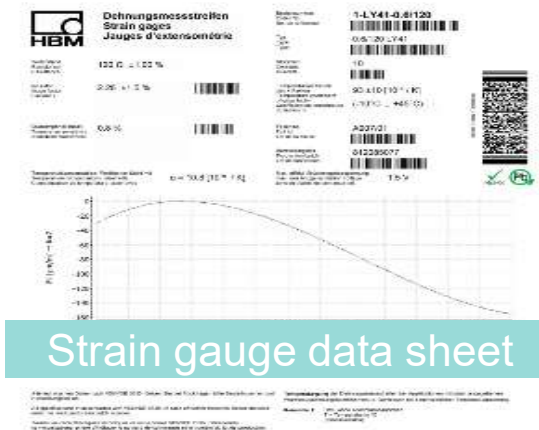
I want to measure principal strain/stress values and angles. How can I do this?

- Catman offers strain gauge rosette calculation for different types of rosettes
- Attention:** Enter direction of strain gauge grids a,b,c correctly so that the angle is calculated correctly from reference!

I want to compensate temperature of uniaxial grids and calculate principal stresses? (Use case: Rosette gauge used at low/high temperatures)

- Two steps needed:

- First create calculation channels with temperature compensation. This will generate new software channels
- Use these software channels for a further computation (Corrected results are visible during measurement!)



Strain gauge data sheet

The screenshot shows the 'Create computation' dialog box in the Catman software. The 'Rosettes' tab is active, and the 'Name' field is set to 'Rosett_Calculated_Channels'. Under 'Strain channels', three channels are listed: 'a) Beam_Rosette_A', 'b) Beam_Rosette_B', and 'c) Beam_Rosette_C'. The 'Automatically complete' checkbox is checked. The 'Type of rosette' is set to '45°/90°'. Material properties are set to '200000 N/mm²' for Young's modulus and '0.3' for Poisson's ratio. Transversal sensitivity is set to '0.1' for all grids. The 'Create computation channels' list on the right includes 'Angle', 'Principal nominal stress 1', 'Principal nominal stress 2', 'Shear stress', 'Reference stress (v. Mises)', 'Stress X', 'Stress Y', 'Principal strain 1', 'Principal strain 2', 'Strain X', 'Strain Y', and 'Shear strain', with 'Angle', 'Principal strain 1', 'Principal strain 2', and 'Shear strain' checked.

Measurement project Setup

Data acquisition

Data post-processing

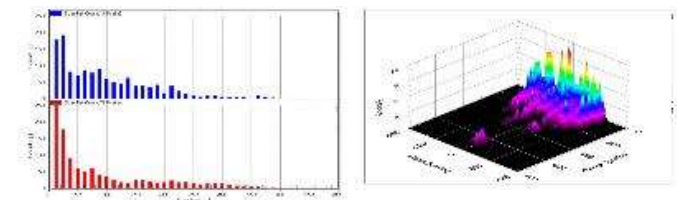
▲ Which possibilities do I have to get a live view of my strain data?

▲ Many visualization objects tailored for strain measurements available:

- XY-Graph
- Polar diagram
- Table
- Meta Table
- Statistics table
- FFT (strain sensors can be used for vibration)
- Cameras (USB + Ethernet/IP)

▲ I am performing a long-time measurement. How can I trust that my measurement values are correct over time and don't drift?

QuantumX/SomatXR and catman software support an Autocalibration Routine. In this routine the channels perform *A health-check* at a specified interval.



Channel	Sample	Unit	Min	Max
Beam_Rosette__A	2.964	µm/m	-30.34	25.19
Beam_Rosette__B	2.823	µm/m	-209.10	315.01
Beam_Rosette__C	2.311	µm/m	-177.78	263.47
Strain_Rate_Beam_Rosette__A	12.35	µm/m/s	-614.08	502.22
Strain_Rate_Beam_Rosette__B	12.85	µm/m/s	-3912.0	5761.8
Strain_Rate_Beam_Rosette__C	-1.836	µm/m/s	-3323.1	4855.0

HD Webcam eMeet C960 No Audio %TestFile%_Camera.avi
Frames captured: 1728 - Frames dropped: 0 - Capture time: 00:00:58 - File size: 25.7 MB - Fps: 30.0



Measurement project Setup

Data acquisition

Data post-processing

▲ **I have collected tons of measurement data. How can I get a good overview?**

- ▲ Use catman Test Explorer
- ▲ Filter for channel names
- ▲ Preview of measurements (Data Viewer)

▲ **I need to create a report for my boss?**

- ▲ catman uses bookmarks in Word for test reports

▲ **I have some measurement artifacts I want to delete from my measurement. How can I do this?**

Use catmans data cleansing tool

▲ **I want to save only part of the measurement data. How is this done?**

- ▲ Use of catman cut out tool

Will be demonstrated in Live session!



MX1615B – Bridge Amplifier

16 inputs measure

▲ Strain gauge bridges



▲ full bridge, 6-wire technology



▲ ½ bridge, 5-wire technology



▲ ¼ bridge (120 or 350 Ω), 3- or 4-wire



▲ Voltage

+/- 10 V (no internal sensor supply)



▲ Potentiometer



▲ RTC

PT100, PT500 or PT1000



▲ Resistance

(up to 1 kΩ / 5 kΩ)

• Additional Features

- Sample rates

- HBM Classic

- 0.1 to 19,200 Samples/s per channel

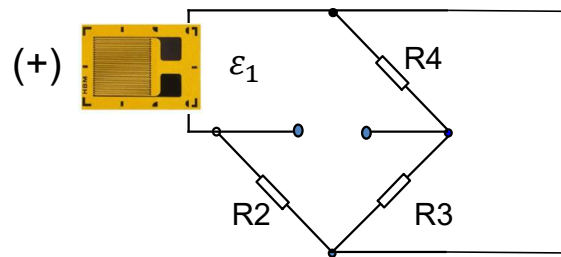
- Decimal

- 0.1 to 20,000 Samples/s per channel

- Linearization: 2-point or gain and offset



Wheatstone Bridge basics



- ▲ The basic formula of the Wheatstone bridge considers all four resistances

$$\frac{U_0}{U_I} = \frac{R_1}{R_1 + R_2} - \frac{R_4}{R_3 + R_4} \equiv \frac{R_1 R_3 - R_2 R_4}{(R_1 + R_2)(R_3 + R_4)}$$

- ▲ From $R_1 = R_2 = R_3 = R_4$ or $R_1 : R_2 = R_4 : R_3$ follows $\frac{U_0}{U_I} = 0$ and the bridge is balanced.

Use of Wheatstone bridges in...



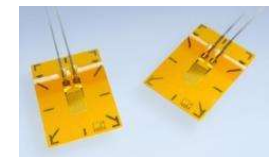
force transducers



load cells

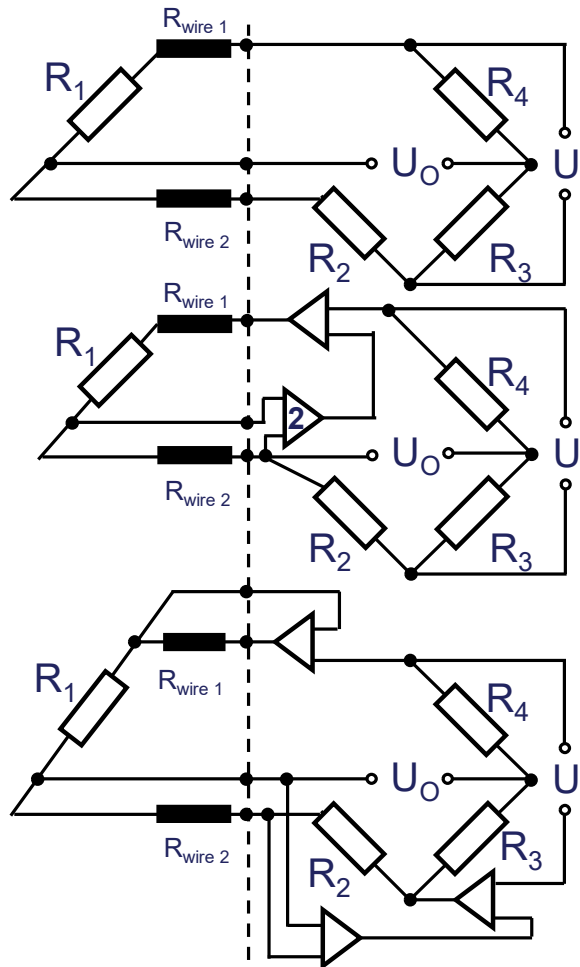
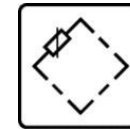


torque transducers



experimental stress analysis

Compensation of wire resistances: quarter bridge



standard 3-wire configuration

- +: no zero offset if wire resistances are symmetric
- : compensation with unsymmetrical wires is not possible
- sensitivity is changed


HBM 3-wire configuration

- +: full compensation if wire resistances are symmetrical
- : compensation with unsymmetrical wires is not possible

4-wire configuration

- +: full compensation of wire resistances

Strain Gauge details



Dehnungsmessstreifen
Strain gages
Jauges d'extensométrie

Bestellnummer
Order No.
No. de référence

1-LY41-6/120A

Typ
Type
Type

6/120A LY41

Stückzahl
Contents
Quantité

10

Temperaturkoeffizient
des k-Faktors
Temperature coefficient
of gage factor
Coefficient de température
du facteur k

93 ±10 [10⁻⁶ / K]
(-10°C ... +45°C)

Folienlos
Foil lot
Lot de la feuille

A413/10

Herstellungslot
Production batch
Lot de fabrication

812078233

Mit Applikationshilfe
With application aid
Avec support d'aide
à l'application

Dein / Date / Données

RoHS

Widerstand
Resistance
Résistance

120 Ω ±0.30 %

k-Faktor
Gage factor
Facteur k

2.05 ±1.0 %

Quersensitivität
Transverse sensitivity
Sensibilité transversale

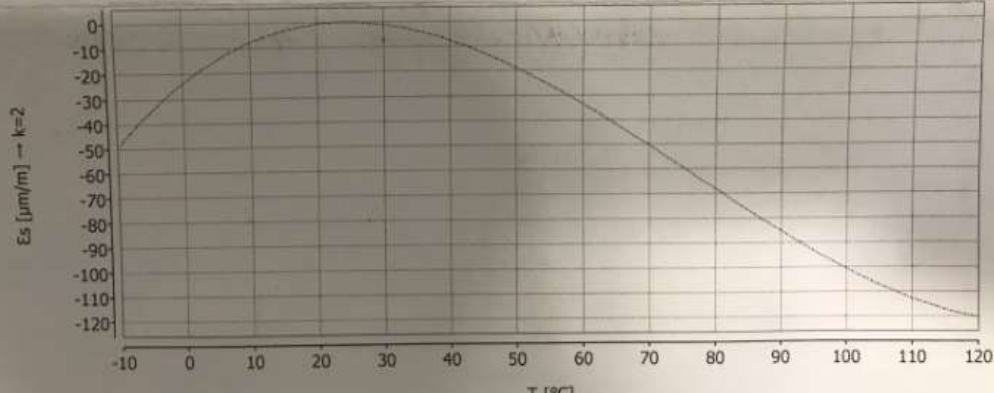
-0.1 %

Temperaturkompensation: Ferriticher Stahl mit
Temperature compensation: steel with
Compensation de température: acier avec

α = 10.8 [10⁻⁶ / K]

Max. effeld. Brückenspannung
max. rms bridge excitation voltage
tension d'alim. de pont max. eff.

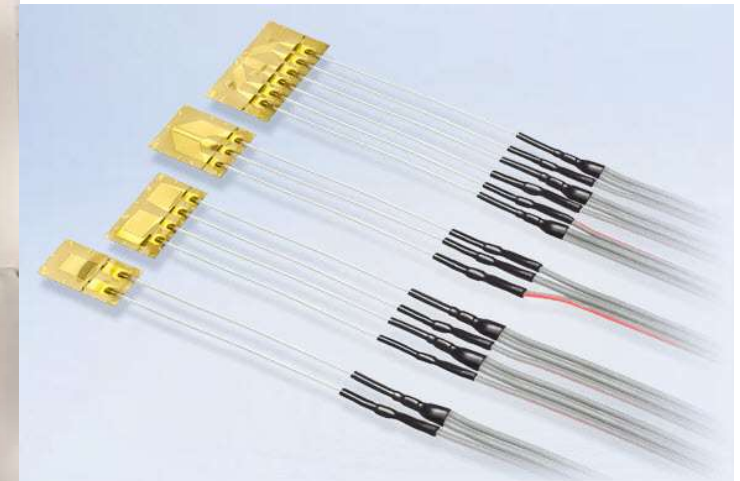
7.0 V

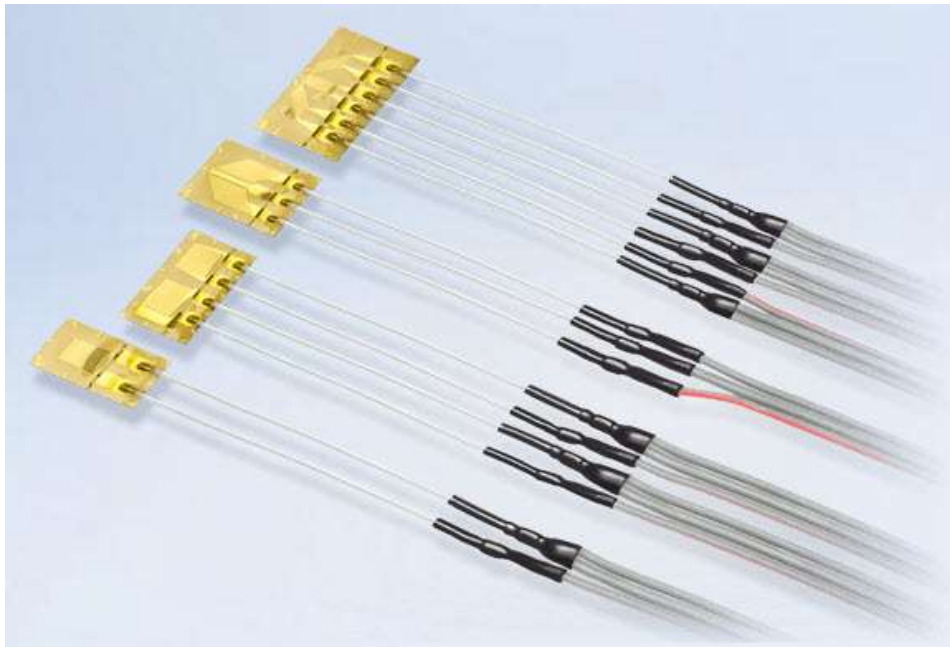


Es [µm/m] → k=2

T [°C]

Curve 1





Configure sample rate groups and filters

Decimal (e.g. 10, 100, 1000 Hz) Sample rate domain

Sample rate groups

[Useful sample rates...](#)

Slow sample rate 10 Hz

Default sample rate 200 Hz

Fast sample rate 10000 Hz

Channel: Rosette_2_grid_b

Use current device settings
Filter is set via TEDS or Setup Assistant.

Use automatic Anti-Alias filters
The frequency will be determined before DAQ start based upon the sample rate. Usually a Bessel characteristic will be selected.

Working without filter

Choose characteristics and frequency
If the frequency selected is not supported by the device the best possible frequency will be selected.

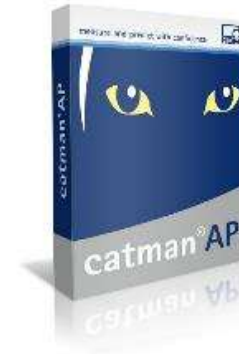
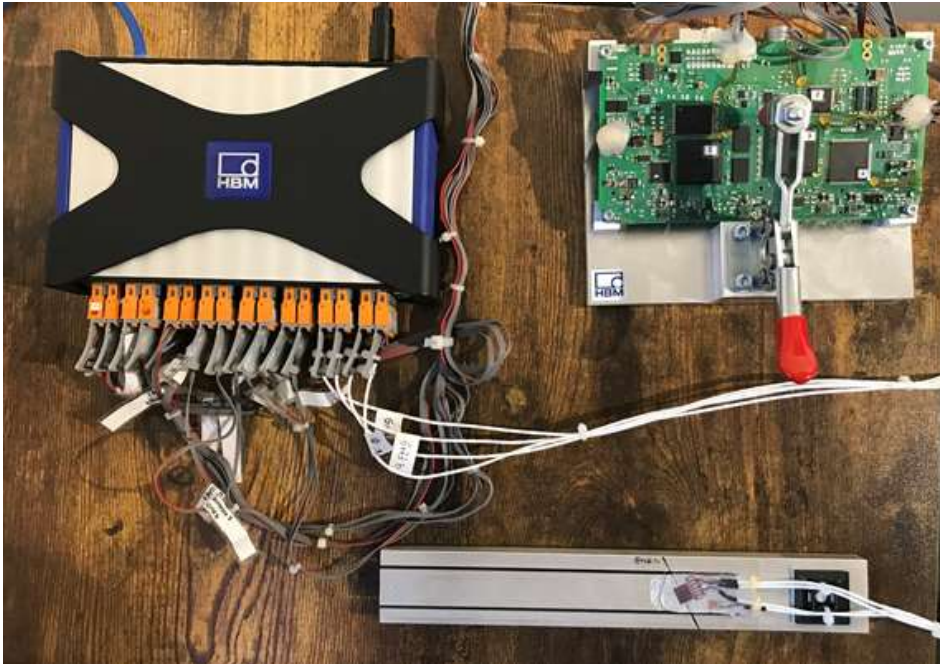
Bessel 0.2 Hz
Bessel 0.5 Hz
Bessel 1 Hz
Bessel 2 Hz
Bessel 5 Hz
Bessel 10 Hz
Bessel 20 Hz
Bessel 50 Hz
Bessel 100 Hz
Bessel 200 Hz
Bessel 500 Hz

[Help about filter settings](#)

OK Cancel

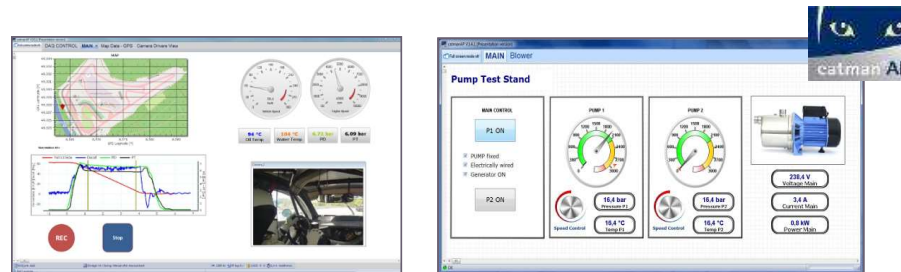
Webinar live demo example

- ▲ PCB with (0/45/90°) strain gauge rosettes – RF91
- ▲ Universal DAQ module QuantumX MX1615B
- ▲ catman AP software for data acquisition

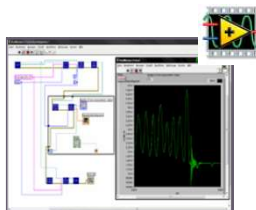


QuantumX – 3rd Party integration

catman®AP from HBM: *review in the field or lab*



Or integrate QuantumX into...



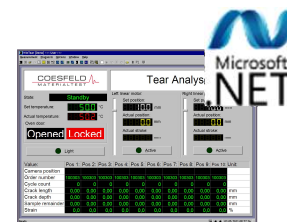
LabVIEW



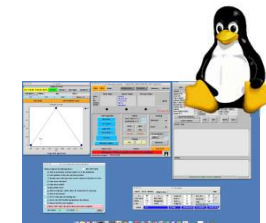
DIAdem
(German only)



CANape



Visual Studio .NET
(HBM common API)



Any OS
(on request)

Additional information

More information can be found on our website:

<https://www.hbm.com/en/7074/strain-gauge-fundamentals/>



Strain Gauge Fundamentals

Strain gauges have been around for almost 80 years and continue to be key assets for measuring fatigue and testing materials for productivity and safety reasons. But how do I calculate material stress from strain? How can I select the right strain gauge and install it correctly? Our experts dug deep to provide the best answers for you about all the important questions regarding strain measurement using strain gauges. Click an option below to direct you to the content on the page.

1. Basics of Strain Measurements and Experimental Stress Analysis
2. Selecting the Right Strain Gauges: Achieving Consistent Results and More
3. Installation of Strain Gauges: All There is to Know
4. Reducing and Elimination of Measurement Errors
5. Applying Data with the Right Hardware and Software
6. Training Webinars and References of Strain Measurements

1. Basics of Strain Measurements and Experimental Stress Analysis

Strain measurement glossary

You can benefit from our practical on-line glossary by looking up the most important technical terms in the field of strain measurement.



Experimental Stress Analysis (ESA) using strain gauges

The principle of **Experimental Stress Analysis (ESA)** consists in using strain gauges to measure the strain on a component's surface. The absolute value and direction of the mechanical stress is determined from the measured strain.



<https://www.hbm.com/en/3164/tips-tricks-measurement-tasks/>

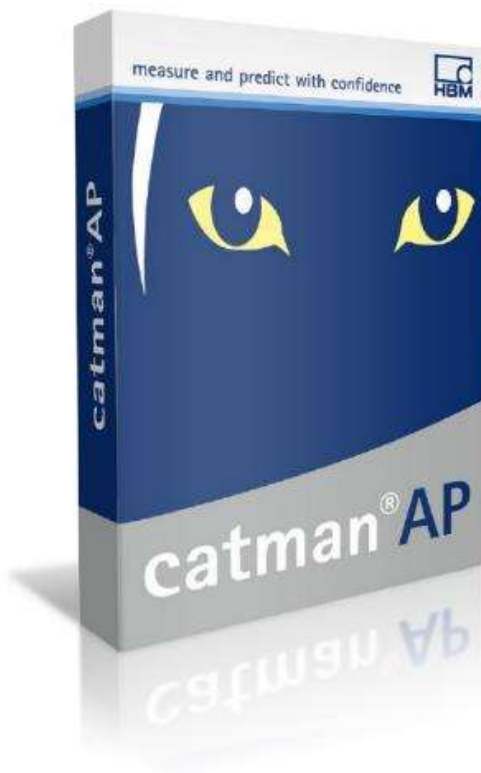


catman Knowledge Base: Videos. Tech Notes. Case Studies.

New Video Tutorials and Tech Notes	Video Tutorials: DAQ Mode	Video Tutorials: Analysis Mode	Tech Notes
DAQ Jobs Overview	Online Visualizations	Calculations in Analysis Mode	

<https://www.hbm.com/en/6896/strain-measurement-basics/>

Catman on a glance



- ▲ Intuitive Handling – no programming skills necessary
- ▲ Script Module for advanced tasks
- ▲ Acquire vehicle bus (CAN/CAN FD) and analog measured data in parallel and synchronously
- ▲ Integrated sensor database/[TEDS support](#)
- ▲ Create individual sensors and calibration
- ▲ Support of [optical interrogators](#)
- ▲ DIAO-interface for different DAQ hardware

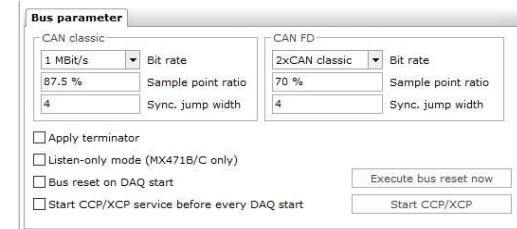
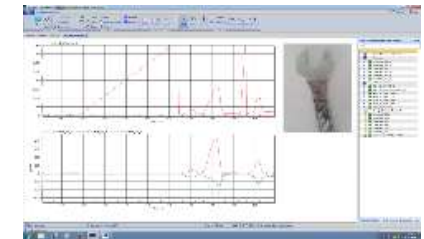
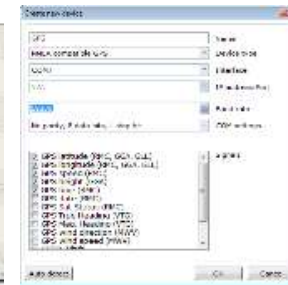
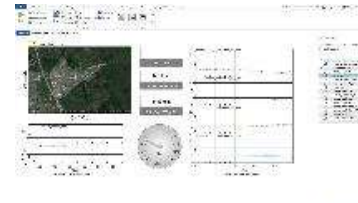
- ▲ Numerous data visualization possibilities e.g. relating to time, frequency, angular range
- ▲ GPS data visualization on maps
- ▲ Video support: Up to four cameras in parallel
- ▲ Online calculation for [structural and durability testing](#) (e.g. filters, rainflow)
- ▲ Multi-Panel support
- ▲ catman Webserver
- ▲ Event monitoring and Action release

- ▲ Powerful post-processing tools
- ▲ Adjust, filter and compare data sets
- ▲ Take long-term measurements over several days, weeks and months
- ▲ Save data in the Cloud (Power BI) or on FTP-Server
- ▲ Standardized measurement reporting
- ▲ Support of many different data formats (ASCII, Excel, DIAdem, MATLAB etc.)



Integration of other hardware

- ▲ Video cam (USB or Ethernet)
- ▲ GPS via USB and RS232 (NMEA compatible)
- ▲ Weather Station via USB and RS232: Vaisala WXT520
- ▲ Wheel force sensor Kistler RoaDyn (Ethernet)
- ▲ GOM Aramis 3D motion and deformation sensor
- ▲ Devices with CAN interface, e.g. wheel force sensors, IMU, Temperature



Questions?

- Please type any questions you have into the WebEx Q&A dialog
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Thank you for your attention!