Data Sheet of Flossgraben Bridge Measurements

Large-scale experiment on a bridge structure for load study using vibration-based output-only SHM

File Management

The conducted experiments result in one dataset. Due to the nature of the setup, the data is recorded while being influenced by varying excitation and conditions. A mass perturbation study was conducted for the structure.

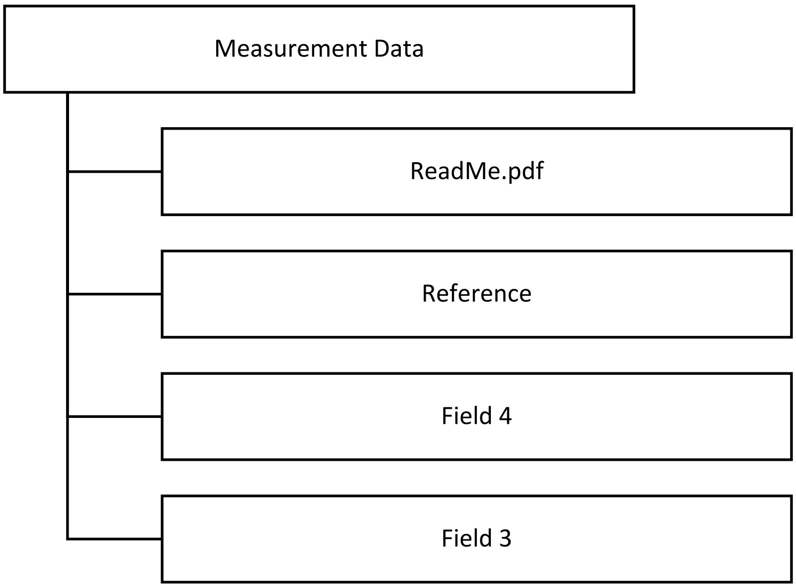


Figure 1: File Organization Structure.

All data is saved in hierarchical data format (HDF5) and sorted chronologically in a folder structure. The File is named by 'YYYY-MM-DD_Messung_Zeitz_hhmm.h5' for all measurements.

Catalog

A catalog over the dataset is accompanying each dataset. They are designed to help the user to orient in the large datasets. They provide a number of information of the measurements, additional masses and about occurring EOC. An overview over the information provided, a translation of the information and further information about them is provided in Table 1.

Table 1: Overview of information provided in catalogs.

Field	*Definition*
Error	Number of errors if any occurred
Error Documentation	Error documentation as bit state (see BitStates)
Date	Time and date of measurement
Name	Filename
Project	Title of project or ensemble
Duration	Duration of measurement in seconds
Ry0_Ch3	Average process power of channel 3
Ry0_Ch11	Average process power of channel 11
Ry0_Ch19	Average process power of channel 19
Ry0_Ch27	Average process power of channel 27
Ry0_Ch35	Average process power of channel 35
Ry0_Ch43	Average process power of channel 43
Ry0_Ch51	Average process power of channel 51
Surface Temperature (°C)	Temperature at the surface of the bridge
Delta Mass	Additional mass in [kg]
Position of Delta Mass	Position of additional mass
Indoor Temperature (°C)	Air temperature inside the bridge
Indoor Humidity (%)	Relative air humidity inside the bridge
Outdoor Temperature (°C)	Air temperature outside the bridge
Outdoor Humidity (%)	Relative air humidity outside the bridge
Dew Point (°C)	Air dew point
Wind (m/s)	Mean velocity of wind
Wind variance (m/s)	Variance of wind velocity
Gust (m/s)	Mean velocity of wind gusts
Wind Direction (°)	Average wind direction*
Std. of Wind Direction (°)	Standard deviation of wind direction
ABS Pressure (hpa)	Absolute air pressure
Solar Rad. (w/m^2)	Solar radiation
Hourly Rain (mm)	Amount of hourly rain fall
Event Rain (mm)	Amount of event rain fall
CH1 Temperature (°C) **	Air temperature of channel 1
CH1 Dewpoint (°C) **	Dewpoint of air of channel 1
CH1 Humidity (%) **	Relative air humidity of channel 1
CH2 Temperature (°C) **	Air temperature of channel 2
CH2 Dewpoint (°C) **	Dewpoint of air of channel 2
CH2 Humidity (%) **	Relative air humidity of channel 2
CH3 Temperature (°C) **	Air temperature of channel 3
CH3 Dewpoint (°C) **	Dewpoint of air of channel 3
CH3 Humidity (%) **	Relative air humidity of channel 3

* magnetic north is at 350° and along the bridge axis
** data was recorded using three sensors inside the bridge. Their location is provided in Table 2.

Table 2: Location of meteorological sensors inside the bridge.

Sensor	*Location inside of bridge*
CH1	On crossing of field 4 and 5
CH2	On crossing of field 2 and 3
CH3	In middle of field 5

Structure of Data

Each file contains the Group '/', with the dataset 'RecBuff'. This contains the Attributes of the measurement and the data, consisting of timestamp, the acceleration measurement data, and the control values *BitStates* (see Figure 3).

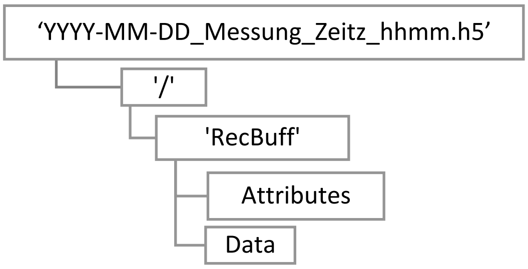


Figure 2: Data organization in file structure.

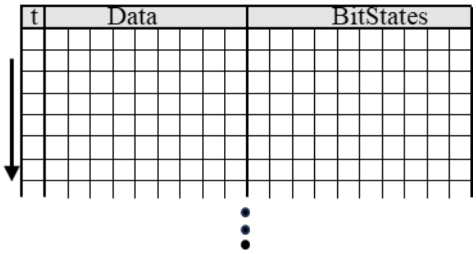


Figure 3: Organization of Dataset.

Attributes

The attributes are automatically written based on the settings of a measurement campaign. They are originally created in german language, a translation and definition are shown in Table 3.

Table 3: Table of attributes, their translation and definition.

Attribute	*Translation*	*Definition*
Ersteller	Creator	Person overseeing the measurement
Projektname	Project Name	Name of Project or ensemble
Ort	Location	Location
Kommentar	Comments	Additional comments
Datum	Date	Time and date of creation
Anregung	Excitation	Main Excitation occurring
Messdauer	Time of Measurement	Duration of one measurement
Einschwingzeit	Settling time	Duration between first parametrization of measurement system and start of recording for a the first measurement of a group
Anzahl Kanaele	Number of Channels	Number of measurement channels (excluding EOC)
Sampletime	Sampletime	Number of samples per second (sample frequency)
Decimierungsfaktor	Decimation factor	Factor by which downsampling was applied afterwards
dM	Delta Mass	Mass change in [kg]
dM_Pos	Delta Mass Position	Position of applied mass change

Data

Timestamp

The timestamp is stored in the first column of the data (see Figure 3) and in microseconds [µs]. The sample frequency of the measurements is 1 kHz (one sample was recorded for every 100 µs).

Data

The presented acceleration data is in [m/s²], all quantification factors and sensitivities are already factored in. The channels are sorted by columns, the first channel (Ch1) is in the second column (after the timestamp) and the last channel (Ch56) is stored in column 57 (see Figure 3). The used EtherCAT Terminal (ELM3602 by Beckhoff) are equipped with an inbuild low-pass filter, to prevent aliasing, and a parameterizable FIR high-pass filter, to filter the influences of IEPE Bias Currents (AcCoupling). The combined transfer function is shown in Figure 4.

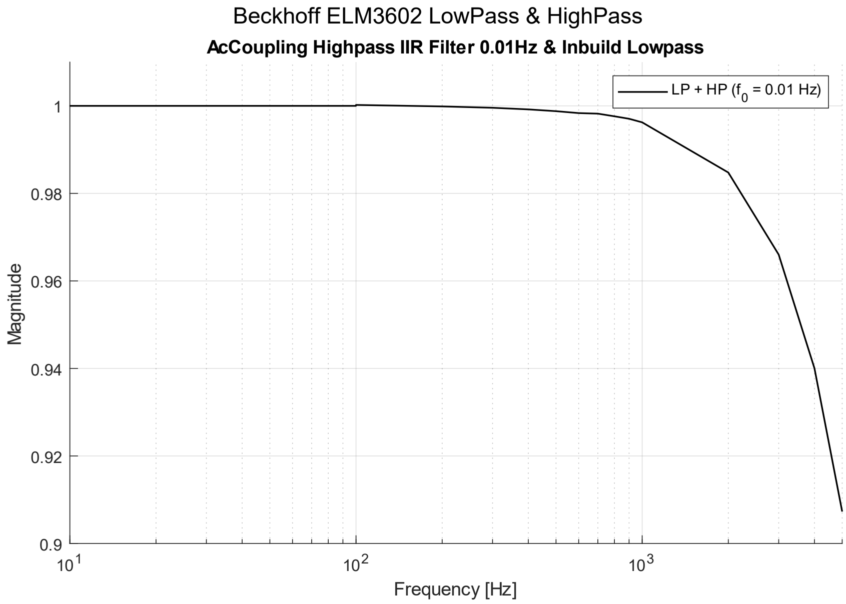


Figure 4: Transfer function of the ELM3602 terminal.

Downsampling

The initial sample rate of 10 000 Hz resulted in a large dataset. To decrease the size of the dataset, the number of samples was reduced. To downsample the time series data from 10 kHz to 1 kHz, a lowpass FIR filter with zero-phase filtering was designed. The filter employs a Kaiser window with a passband frequency of 500 Hz. The stopband attenuation is set at 55 dB, preventing aliasing (see Figure 5).

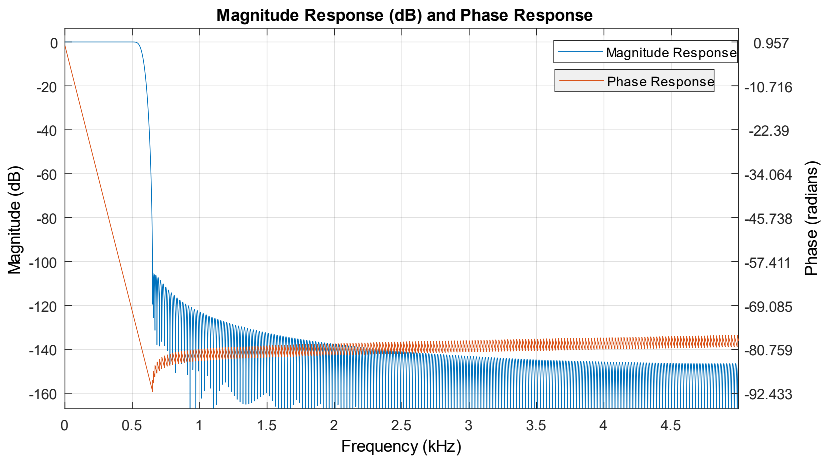


Figure 5: FIR-Filter used for anti-aliasing downsampling.

Datasets with the original sample rate of 10 000 Hz can be provided individually upon request!

Meteorological Channel

The surface temperature is stored in an additional channel (shown in Table 3). Additional meteorological data was recorded and stored in the Data table (see Table 1).

Table 4: Meteorological channels.

Channel	Value	Unit
58	Surface Temperature*	° Celsius

***Sensor is attached on the eastern side at the top of the pillar between span 3 and 4.**

BitStates

The BitStates store information for every sample of every channel recorded. The format is in 8Bit, where the first four bits contain information about possible errors of the measurement system at that moment the sample has been recorded, and the last four bits state the quantification range of the channel. All measurements provided are free of any errors, and the quantification range is already calculated into the acceleration data. Therefore, this information is about channel sensitivity and for further analysis of the influence of quantification noise.

‚00001001‘

Error State Range State

Table 5: BitStates values.

BitState	Error
10000001	Range Error
01000001	Channel Error
00100001	Communication Error
00010001	Invalid CoE channel configuration + Jitter
BitState	**Quantification Range**
00000000	Invalid
00000001	10 V
00000010	5 V
00000011	2.5 V
00000100	1.25 V
00000101	0.64 V
00000110	0.32 V
00000111	0.16 V
00001000	0.08 V
00001001	0.04 V
00001010	0.02 V

Translation of sensor position and channel number

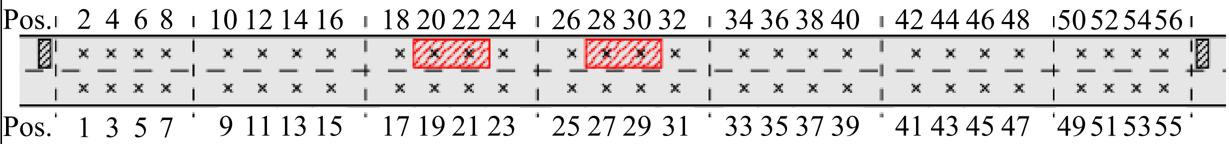
The sensor position does not correspond directly to the channel number. When working with the data, a mapping between sensor positions and channel numbers is required to determine which sensor corresponds to each entry in the dataset. This mapping is provided in Table 5.

Table 6: Table for translation of channel number and sensor position.

Position	Ch.-Nr.	North	Position	Ch.-Nr.
1	41	Field 1	2	42
3	43	Field 1	4	45
5	45	Field 1	6	46
7	47	Field 1	8	48
9	33	Field 2	10	34
11	35	Field 2	12	36
13	37	Field 2	14	38
15	39	Field 2	16	40
17	25	Field 3	18	26
19	27	Field 3	20	28
21	29	Field 3	22	30
23	31	Field 3	24	32
25	49	Field 4	26	50
27	51	Field 4	28	52
29	53	Field 4	30	54
31	55	Field 4	32	56
33	1	Field 5	34	2
35	3	Field 5	36	4
37	5	Field 5	38	6
39	7	Field 5	40	8
41	9	Field 6	42	10
43	11	Field 6	44	12
45	13	Field 6	46	14
47	15	Field 6	48	16
49	17	Field 7	50	18
51	19	Field 7	52	20
53	21	Field 7	54	22
55	23	Field 7	56	24
		South		

Dataset: Bridge Setup (~358 m)

Sensor Positions



Location:	51°03'25.3"N, 12°05'56.8"E		
Excitation:	Traffic		
Acceleration Sensors:	PCB393A03		
Number of Measurements:	273	Size of Dataset:	142 GB
Time period:	10. Sep. – 12. Sep 2024	Duration per Measurement	600 s
Sample Frequency:	1 kHz	Channels:	56
Ensembles:	1 Reference & 2 Mass Perturbations		

Day	No. of Meas.	Time [24h]	Event
10.09.2024 *Reference Day*	114	09:30 10:00	Set up road blockage Start measurements reference day
11.09.2024 $\Delta_M = 39t\ in\ Field\ 4$	115	07:45 08:00	Cargo Trucks positioned in field 4 Start measurements load case 1
12.09.2024 $\Delta_M = 39t\ in\ Field\ 3$	44	07:30 07:45 14:15 15:15	Cargo Trucks positioned in field 3 Start measurements load case 2 Departure of trucks End of experiment