Data Sheet of Testing Field Measurements

Two parted experimental structure for studies on the effects of environmental and operational conditions (EOC) affect vibration-based output-only SHM

File Management

The two folded nature of the experimental testing field results in two main datasets. The datasets are recorded from the laboratory setup, and from the field setup. While the laboratory setup provides measurements under constant conditions, the field setup is under the influence of changing excitation and conditions. Similar and comparable mass perturbation studies were conducted for both structures.

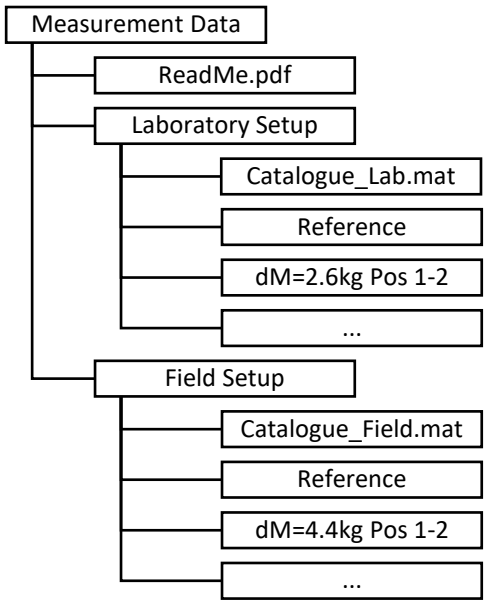


Figure 1: File Organization Structure.

All data is saved in hierarchical data format (HDF5) and chronological sorted in a folder structure. The File is named by 'YYYY-MM-DD_Messung_dM_hhmm.h5' for laboratory measurements and 'YYYY-MM-DD_Live_Monitoring_hhmm.h5' for measurements from the field setup.

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 (for field setup only). Originally the catalog was designed in german language and not all were translate. A 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 calatogs.

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
Temperature	Air temperature (field setup)
Surface Temperature	Temperature at the surface of structure (field setup)
Wind velocity	Mean velocity of wind (field setup)
Wind variance	Variance of wind velocity (field setup)
Wind direction	Average wind direction (field setup)
Wind direc SD	Standard deviation of wind direction (field setup)
Humidity	Relative air humidity (field setup)
Rain	Rain event (YES/NO) (field setup)
Delta Mass	Additional mass in [kg]
Position of Delta Mass	Position of additional mass

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* stored.

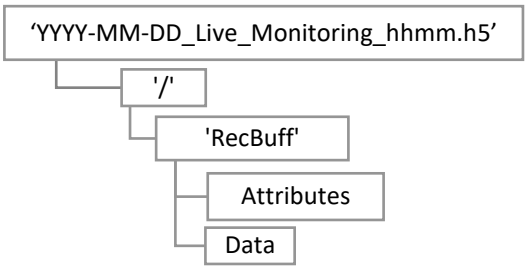


Figure 2: Data organization in file structure.

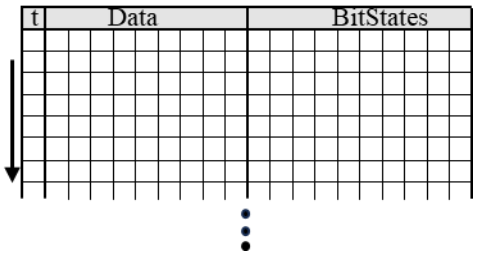


Figure 3: Organization of Dataset.

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 is shown in Table 2.

Table 2: 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 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 (Ch24) is stored in column 25 (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.

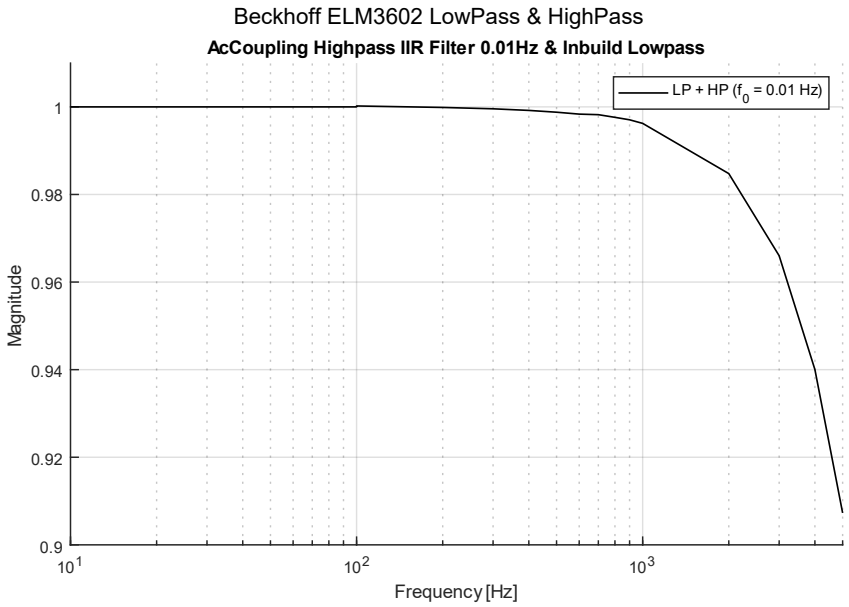


Figure 4: Transfer function of the ELM3602 Terminal.

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).

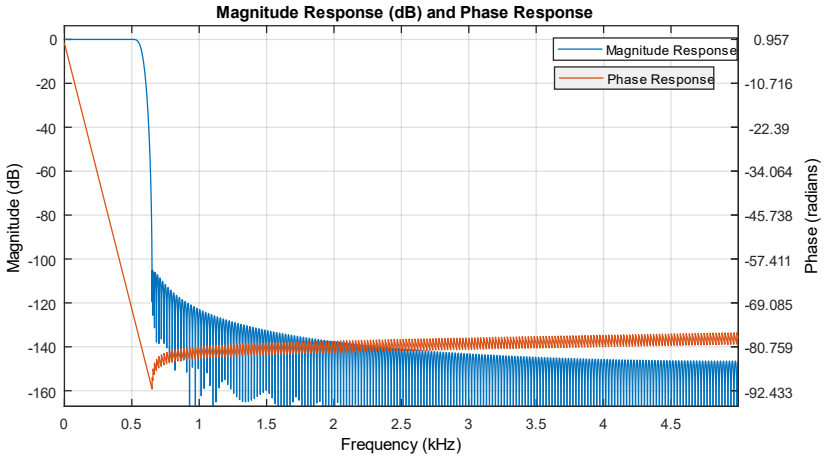


Figure 5: FIR-Filter used for anti-aliasing downsampling.

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

Meteorological Channels

For the field setup the meteorological data is also stored in additional channels. The channel numbers and the associated meteorological data is shown in Table 3.

Table 3: Meteorological Channels

Channel	Value	Unit
25	Surface Temperature*	° Celsius
26	Wind direction**	° Degree (Angle)
27	Wind speed	m/s
28	Rel. Air Humidity	%
29	Rain (Precipitations)	True (=1) or False (=0)

***Sensor is attached on the eastern side, 20 cm above ground.**
****Note to Wind direction: Magnetic north is at 190 °!**

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.

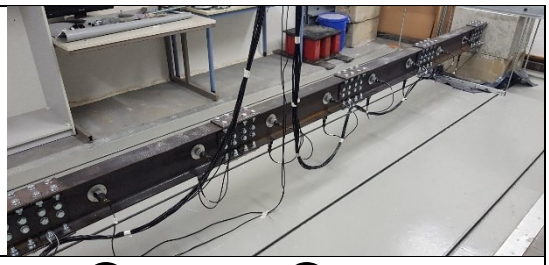
‚00001001‘

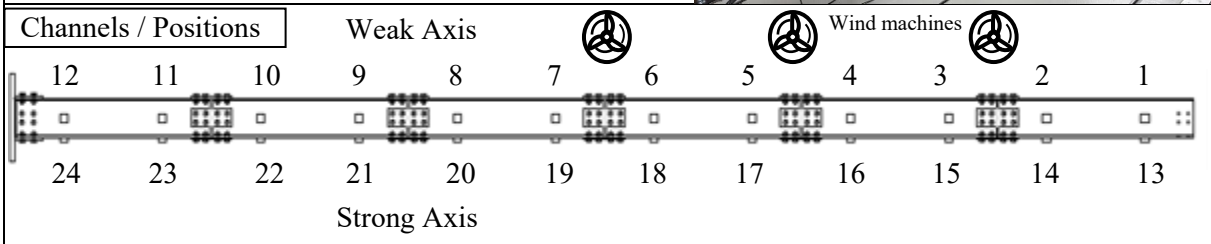
Error State Range State

Table 4: 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

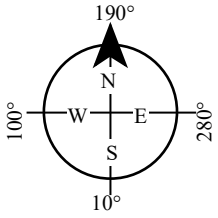
Dataset 1: Laboratory Setup (IPE200, ~6 m)





Location:		Laboratory for Structural Dynamics of the Institute for Statics, Structural Dynamics, System Identification, and Simulation (I4S) at the University of Applied Sciences Leipzig		
Excitation:		Wind machines		
Acceleration Sensors:		PCB393A03		
Number of Measurements:		225	Size of Dataset:	24 GB
Time period:		17. Apr. – 10. June 2023	Duration per Measurement	600 s
Sample Frequency:		1 kHz	Channels:	24
Ensembles:		14 Mass Perturbations & 1 Reference		
Position of Mass	ΔM [kg]	Number of Meas.	Time period	
1 – 2	2,62	15	14. May 2023	
	4,24	15	17. Apr. 2023	
	7,14	15	18. Apr. 2023	
	5,68	15	19. Apr. 2023	
	8,75	15	19. Apr. 2023	
	11,32	15	21. Apr. 2023	
	19,92	15	12. May 2023	
5 – 6	2,62	15	15. May – 16. May 2023	
	4,21	15	06. May – 07. May 2023	
	7,14	15	04. May – 05. May 2023	
	5,68	15	05. May – 06. May 2023	
	8,75	15	25. Apr. 2023	
	11,32	15	07. May – 08. May 2023	
	19,92	15	10. May – 11. May 2023	
Reference Measurement	0	15	12. May – 13. May 2023	

Dataset 2: Field Setup (IPE200, ~6 m)



Location:		Roof of Nieper-Building at the University of Applied Sciences Leipzig	
Excitation:		Ambient Excitation	
Acceleration Sensors:		PCB393A03	
Number of Meas.:		3673	
Size of Dataset:		394.5 GB	
Time period:		05. Apr. – 21.Sep. 2023	
Duration per Meas.:		600 s	
Sample Frequency:		1 kHz	
Channels:		24 Acceleration + 5 Meteorological	
Ensembles:		6 Mass Perturbation & 1 Reference	
Position of Mass	ΔM [kg]	Number of Meas.	Time period
5 – 6	13,4	568	05. Apr. – 01. May 2023
5 – 6	8,0	758	02. May – 30. May 2023
5 – 6	4,2	234	30. May – 13. June 2023
1 – 2	8,1	1004	12. July – 10. Aug. 2023
1 – 2	12,4	207	12. Aug. – 14. Sep. 2023
1 – 2	4,4	213	15.Sep. – 21. Sep. 2023
Reference Measurement	0	689	13. June – 12. July 2023

Channels / Positions