

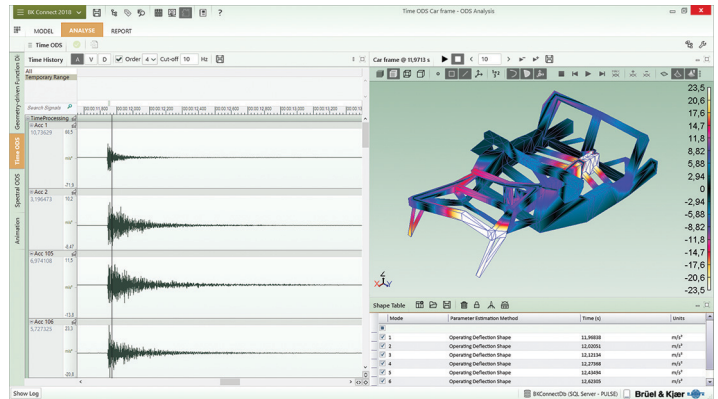
# BRÜEL & KJÆR® Structural Dynamics Solutions

## BK Connect Structural Dynamics BK Connect ODS Analysis – Time, Spectral and Run-up/down ODS BK Connect OMA Measurements

Operating deflection shapes (ODS) analysis is used to determine and visualize the vibration patterns of a structure under given operating conditions. This type of structural dynamics analysis provides a good understanding of the vibration patterns of a structure under actual operating, boundary and environmental conditions, which is essential to improve the structure's vibration and noise behaviour. And, unlike modal analysis, no model of the structure is created. Consequently, there are no assumptions of a linear and time-invariant model, or on the characteristics of the input forces. ODS analysis can, therefore, be used in situations where modal analysis (classical or operational) is not possible.

In BK Connect®, all three types of ODS analysis are supported:

- Time ODS – to determine vibration patterns as a function of time for an analysed frequency range
- Spectral ODS – to determine vibration patterns for specific frequency or order components
- Run-up/down ODS – to determine vibration patterns as a function of rotational speed for specific frequency or order components



The modular structure of BK Connect software allows you to build the ODS solution that is best for you. You can, therefore, make the most of the software's powerful, modern and integrated interface to measure, observe, analyse and document the dynamic behaviour of structures using a single platform.

## Uses and Features

### Uses

- Determination of the vibration patterns of structures under given operating conditions
- Analysis of:
  - Machines running at fixed or slightly varying speeds
  - Transient phenomena
  - Non-linear systems and frequency-variant analysis
  - Civil engineering structures loaded by ambient forces
- OMA measurements for analysis in PULSE™ OMA Types 8760, 8761 and 8762

### Features

- Vibration patterns shown as animated geometry models and in a shape table (displacement, velocity and acceleration)
- Results shown with SI or imperial units
- ODS analysis using either the BK Connect ODS Analysis, Modal Analysis or Data Processing application
- Measurements with or without geometry-guidance
- Tear-off of panels such as Geometry, Shape Table and Time History and view on other PC monitors

### Time ODS:

- Sweep animation
- Decimation factor to skip time samples during animation
- High-pass integration filter to remove low-frequency effects. The cut-off frequency and filter order can be set
- Selectable time range for the animation
- Shape table: degrees of freedom (DOFs) at discrete time instances

### Spectral ODS:

- ODS using frequency or order spectra
- Results shown as rms, peak or peak-peak
- Shape table: DOFs at discrete frequencies or order components

### Run-up/down ODS:

- Frequency or order spectra as a function of rotational speed or time
- Results shown as rms, peak or peak-peak
- Shape table: DOFs as a combination of frequency or order and rpm or time

### OMA Measurements:

- OMA measurements with or without geometry-guidance

With ODS, vibration measurements are performed at different points and directions on the structure (DOFs). The vibration patterns can be shown as an animated geometry model of the structure and listed in a shape table. Any ODS is a combination of the forcing function acting on the structure and the dynamic properties of the structure. The forcing function depends on the operating, boundary and/or environmental conditions. For machinery, this can be engine speed, load, pressure, temperature, flow, etc. For civil engineering structures, this can be ambient forces from waves, wind or traffic.

ODS analysis can be divided into three groups: Time, Spectral and Run-up/down.

### Time ODS

Time ODS is used to investigate the vibration patterns of a structure as a function of time. Time ODS includes all frequencies in the analysed frequency range and is very useful for showing overall ODS at a given point in time for either stationary or non-stationary signals, such as transient signals.

### Spectral ODS

Spectral ODS is used to investigate the vibration patterns of a structure for specific frequency or order components. For frequency component investigations, FFT analysis is used and the conditions must be stationary. For order component investigations, order tracking is used and the conditions can be slightly quasi-stationary. For example, a slightly varying engine speed. The ODS of different spectral components is subsequently extracted, shown in a shape table and animated.

### Run-up/down ODS

Run-up/down or non-stationary ODS is used to investigate the vibration patterns of a structure for specific frequency or order components as a function of rotational speed or time. Results are based on FFT analysis or order tracking. Run-up/down ODS is very useful for identifying which noise and vibration behaviour is related to rotational and which to fixed parts of running machinery.

## ODS Measurement and Analysis

---

### ODS Measurements

Make time measurements for Time ODS or for post-processing to spectral ODS or run-up/down ODS using one of the following:

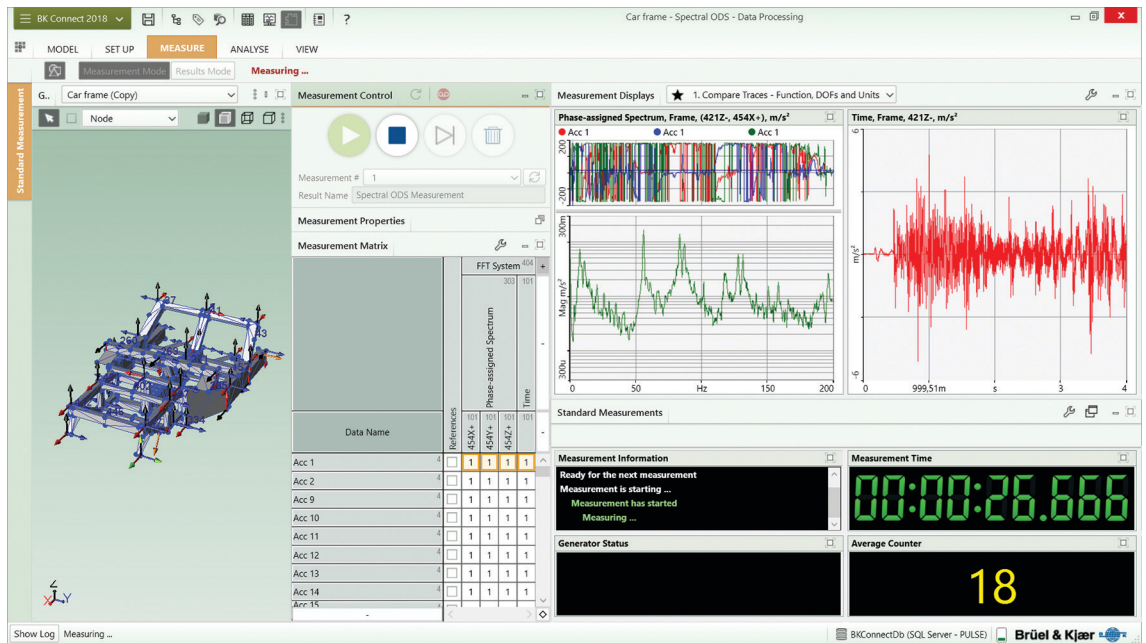
- Monitor recorder (BK Connect Hardware Setup Type 8401)
- BK Connect Time Data Recorder Type 8402
- Background recorder in Standard Measurement (BK Connect Data Processing Type 8403)

Real-time spectral ODS measurements with FFT-based phased-assigned spectra (PAS) can be performed using the Standard Measurement task in the BK Connect Data Processing application.

Except when using the monitor recorder, all measurements can be done with geometry-guidance, where the measurement sequencing is set up in the DOF Setup task. Using the monitor recorder or in cases where no geometry is available – for example when a complex geometry is not available as a decimated finite element model and/or there is no time to draw the geometry – measurements can be done without a predefined geometry and the measurements can later be attached to the geometry before the ODS analysis. When geometry-guided measurements are not performed, the DOFs are easily defined in the HW Setup Table.

Spectral ODS with order-tracked PAS or run-up/down ODS with FFT-based or order-tracked PAS is obtained by post-processing time data using BK Connect Data Processing 8403 and 8403-A combined with one or both options, BK Connect Order Analysis Option Type 8405-E and BK Connect Order Tracking Option Type 8405-F (see [Specifications](#)).

**Fig. 1**  
Geometry-guided spectral  
ODS measurement of a  
sports car frame in  
BK Connect Data  
Processing



### ODS Analysis

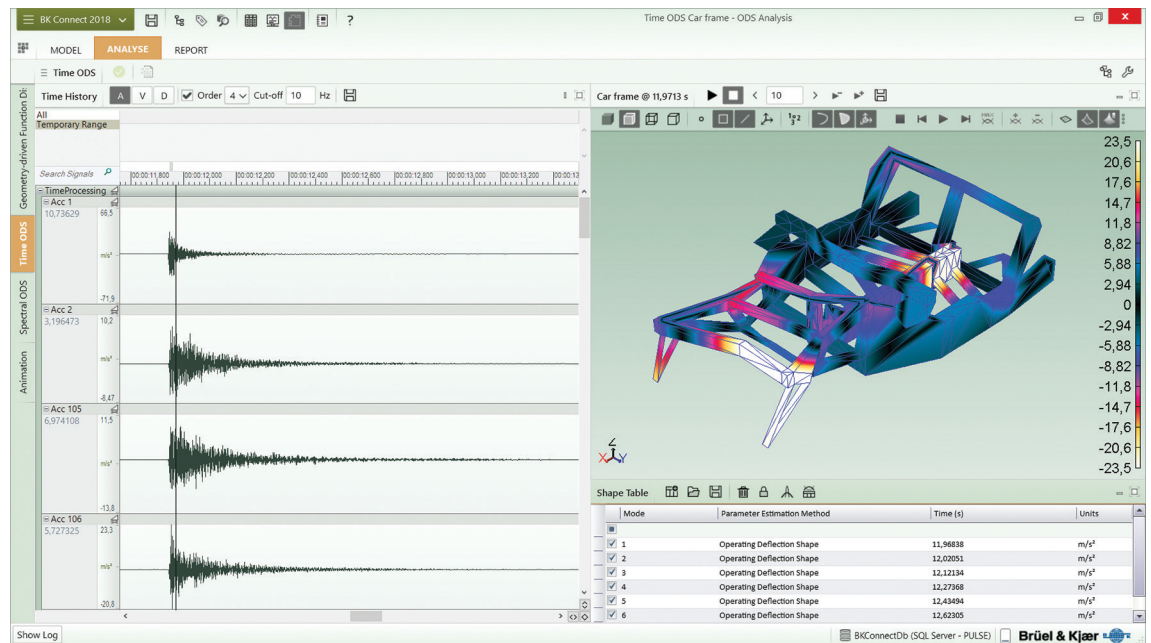
Time, spectral and run-up/down ODS analysis can be performed using the following:

- **BK Connect ODS Analysis**  
This application is included for free when you combine BK Connect Geometry Type 8410 with BK Connect Data Viewer Type 8400. Time ODS requires BK Connect Time ODS Option Type 8410-B.
- **Measurement Validation**  
This task is available in BK Connect Modal Analysis Type 8420 and BK Connect Data Processing Type 8403 with BK Connect Geometry Type 8410. Time ODS requires BK Connect Time ODS Option Type 8410-B.

### Time ODS

A time range can be selected and swept through while animating the vibration patterns. A decimation factor can be applied to skip samples. The vibration at the various DOFs can be saved at discrete time instances in a shape table.

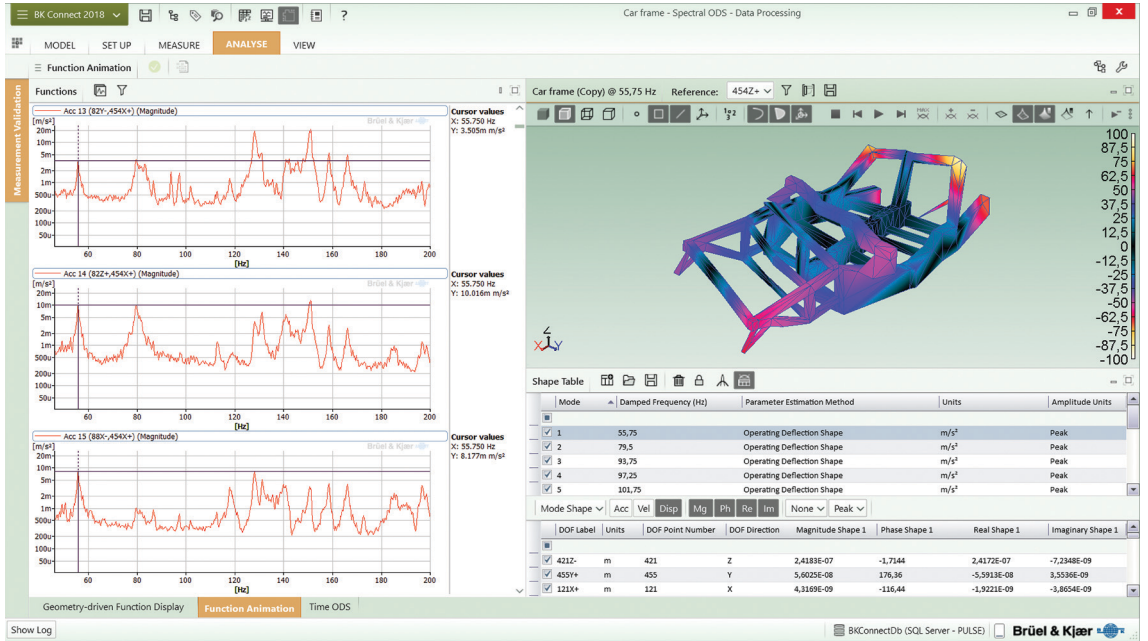
**Fig. 2**  
Time ODS in BK Connect  
ODS Analysis



### Spectral ODS

Shapes are animated by selecting frequencies/orders in the spectra and the vibration patterns are documented in a shape table for easy retrieval and comparison. The vibration at the various DOFs can be shown as acceleration, velocity or displacement with peak, peak-to-peak or rms scaling.

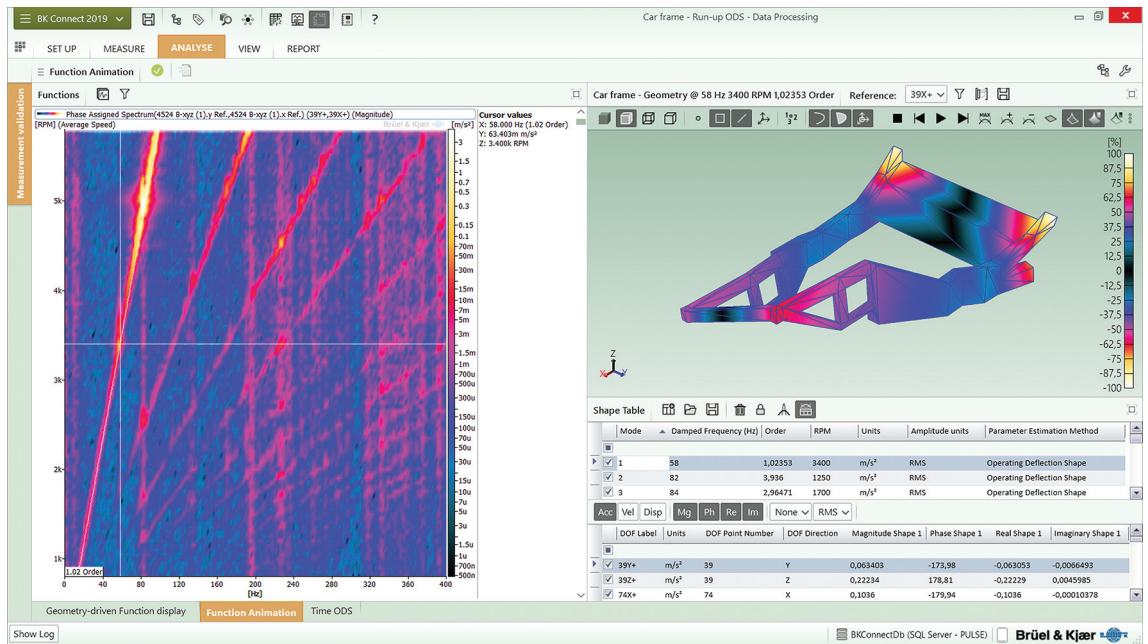
**Fig. 3**  
Spectral ODS in BK Connect Data Processing



### Run-up/down ODS

Shapes are animated by selecting combinations of frequency/order and rpm/time in a contour plot. As for Spectral ODS, the vibration patterns can be documented in a shape table.

**Fig. 4**  
FFT-based Run-up ODS in BK Connect Data Processing.  
Left: The oblique lines in the contour plot represent the orders, and the vertical lines represent structural resonances.  
Right: Animation and shape table.



### Vibration Patterns

The vibration patterns can be shown as single, overlaid and difference animations with single, side-by-side, top-bottom and quad view lay-outs. A variety of animation types are supported including wire frame, surface contour, point and arrow animation. Animations can be exported as .avi and .gif movie files.

### OMA Measurements

OMA measurements are quite similar to ODS measurements as only responses are measured. The difference is that when performing ODS measurements a single DOF is used as reference, whereas in OMA measurements no references are used, if all DOFs are measured simultaneously, whereas typically multiple reference DOFs are used for roving measurements to separate closely-coupled modes.



The input to PULSE OMA Types 8760 – 8762 is time measurements and OMA measurements can therefore be performed using the same tools as for ODS measurements. The DOF Setup sub-task used for measurement sequence generation supports definition of multiple reference transducers, for example, by selecting several uniaxial accelerometers and/or one or more triaxial accelerometers as Fixed.

## Software Packs

### **BK Connect Time and Frequency ODS Measurement and Analysis Pack Type 8410-C**

This pack provides geometry-guided Frequency ODS (FFT-based Spectral ODS) and OMA measurements using the DOF Setup task in BK Connect Geometry Type 8410 for measurement sequence generation and the Standard Measurement task in BK Connect Data Processing Type 8403 for the measurements. PAS functions are measured for Frequency ODS and OMA time recordings can be made using the background recorder in the Standard Measurements task. The Frequency ODS results can be displayed in the ODS application included in Geometry Type 8410 or in the Measurement Validation task in the Data Processing application. The OMA measurements can be exported to PULSE OMA for subsequent modal analysis.

Time ODS measurements can be performed using the HW Setup Table for DOF definition and the Monitor recorder for data acquisition, which are both included in BK Connect Hardware Setup Type 8401. The Time ODS task in Type 8410-B is available for analysis. Geometry and time files can be exported in UFF format for use in, for example, PULSE OMA for subsequent modal analysis.

Type 8401 supports up to two hardware modules (up to 24 input channels). By adding Hardware Setup (advanced) Type 8401-A, there is no limitation to hardware module support.

### **Time, Frequency and Run-up/down ODS Measurement and Analysis Pack Type 8410-D**

This pack adds advanced measurement and post-processing capabilities to the above configuration. BK Connect Time Data Recorder Type 8402 can be used for Time ODS and OMA measurements as well as time recordings for subsequent post-processing based on process chains. Geometry-guided measurements, triggered start and stop of recordings, adding markers during recordings and the ability to trim recordings are supported as well as additional setup features such as Accelerometer Mounting Check.

Run-up/down Frequency ODS is provided with BK Connect Data Processing Type 8403 and BK Connect Order Analysis Option Type 8405-E by post-processing time data. If you add BK Connect Order Tracking Option Type 8405-F to the pack, you will also be able to perform Spectral ODS and Run-up/down Spectral ODS based on order-tracked PAS functions.

Note that post-processing will require at least one BK Connect Data Processing (advanced) Type 8403-A licence to create the necessary process chains and templates. Users without Type 8403-A can then perform simple operator processes based on these templates while Type 8403-A users will be able to run more advanced test engineer setups.

There is no hardware module limitation.

**Table 1**  
BK Connect ODS  
measurement and  
analysis packs

	PACKS	
	TIME AND FREQUENCY ODS MEASUREMENT AND ANALYSIS TYPE 8410-C-S	TIME, FREQUENCY AND RUN-UP/DOWN ODS MEASUREMENT AND ANALYSIS TYPE 8410-D-S
<b>Comprises:</b>		
Data Viewer Type 8400	•	•
Hardware Setup Type 8401	•	•
Hardware Setup (advanced) Type 8401-A		•
Time Data Recorder Type 8402		•
Data Processing Type 8403	•	•
Order Analysis Option Type 8405-E		•
Geometry Type 8410	•	•
Time ODS Option Type 8410-B	•	•

Software packages can be added to the predefined packs for increased functionality.

**System Requirements**

- Microsoft® Windows® 10 Pro or Enterprise (x64) with either Current Branch (CB) or Current Branch for Business (CBB) servicing model
- Microsoft® Office 2016 (x32 or x64) or Office 2019 (x32 or x64)
- Microsoft® SQL Server® 2019

**SOFTWARE REQUIREMENTS**

- BK Connect 2021.1 or later
- Required BK Connect applications for ODS measurement and analysis:

	GEOMETRY-GUIDED MEASUREMENTS		
	TIME ODS	SPECTRAL ODS	TIME, SPECTRAL AND RUN-UP/DOWN ODS
Data Viewer Type 8400	•	•	•
Hardware Setup Type 8401	•	•	•
Data Processing Type 8403		•	•
Data Processing (advanced) Type 8403-A			•*
Order Analysis Option Type 8405-E			•†
Order Tracking Option Type 8405-F			•‡
Geometry Type 8410	•	•	•
Time ODS Option Type 8410-B	•		•

- \* For creation of process chains and templates
- † For run-up/down ODS using FFT-based order analysis
- ‡ For run-up/down ODS using order tracking

**NOTE:** Using BK Connect Time Data Recorder Type 8402 (instead of the monitor recorder or background recorder) adds measurement capabilities including geometry-guided measurements, triggered start and stop of recordings, adding markers during recordings and the ability to trim recordings

**RECOMMENDED PC**

- Intel® Core™ i9, 3 GHz processor or better
- 32 GB RAM
- 1 TB Solid State Drive (SSD) with 100 GB free space, or better
- 1 Gbit Ethernet network\*
- Microsoft® Windows® 10 Pro or Enterprise (x64) with CB
- Microsoft® Office 2019 (x32)
- Microsoft® SQL Server® 2019
- Screen resolution of 1920 × 1080 pixels (full HD)

**Geometry Support**

Requires BK Connect Geometry Type 8410

**GEOMETRY CREATION AND EDITING**

- Basic geometries using nodes, trachelines, triangle and quad elements
- Geometries based on built-in CAD models:
  - Curves: Circle, Circular Arc, Ellipse, Elliptical Arc, Hyperbolic, Parabolic, Line, Polyline, Interpolation Spline and Control Points Spline
  - Surfaces: Circular, Circular Arc, Ellipse, Elliptical Arc, Hyperbolic, Parabolic, Triangular, Rectangular, Polygon, Interpolation Spline and Control Points Spline
  - Solids: Cylinder, Hemisphere, Sphere, Box, Cone and Conical Frustum

**GEOMETRY IMPORT FORMATS**

UFF data set types 15, 18, 82, 2411 or 2412, Microsoft® Excel® (.csv), UFF, Nastran (MSC, NX, NEi), Ansys and Abaqus FE models (requires Type 8400-D/E/F)

**GEOMETRY EXPORT FORMATS**

UFF data set types 15, 18, 2412 or 82, and Microsoft® Excel® (.csv)

**GEOMETRY VIEWS**

- Single, Side-by-Side, Top-Bottom and various Quad views
- Definition of front, back, left, right, top and bottom view axis
- Isometric view
- Perspective, orthographic and stretched projections of geometry
- Hidden lines and transparency
- Pan, zoom and rotate options for viewing geometries
- Symbols for shaker, impact hammer, force transducer, accelerometer and reference accelerometer positions shown on geometry with customized colours and sizes

**ANIMATION**

- Deformed and undeformed animation with Max. Deformation
- Single, overlaid and difference animation
- Wireframe, contour (solid/solid edge), points and arrow animation
- Animation of non-measured DOFs using interpolation equations
- GIF and AVI file generation with selectable codec

**Measurement and Analysis**

Vibration patterns shown as animated geometry models and listed as displacement, velocity and acceleration in a shape table

- Results shown with SI or imperial units
- ODS analysis can be performed using either the BK Connect ODS Analysis, Modal Analysis or Data Processing application
- Measurements can be done with or without geometry-guidance

**TIME ODS**

- Sweep animation
- Decimation factor to skip time samples during animation
- High-pass integration filter to remove low-frequency effects
- The cut-off frequency and filter order can be set
- Selectable time range for the animation
- Shape table with ODS values at the individual DOFs at discrete time instances

**SPECTRAL ODS**

- Using phased-assigned frequency or order spectra
- Results shown as rms, peak or peak-peak
- Shape table with ODS values at the individual DOFs at discrete frequencies or order components

**RUN-UP/DOWN ODS**

- Phased-assigned frequency or order spectra shown as a function of rotational speed or time
- Results shown as rms, peak or peak-peak
- Shape table with ODS values at the individual DOFs as a combination of frequency or order and rpm or time

\* A dedicated data acquisition network (LAN or WAN) is recommended. A network that only handles data from the front end improves the stability of the data

## Ordering Information\*

### SOFTWARE FOR ODS MEASUREMENT AND ANALYSIS

Type 8403-X	BK Connect Data Processing – for Spectral ODS and Run-up/down ODS
Type 8403-A-X	BK Connect Data Processing (advanced) – for order-tracked Spectral ODS and Run-up/down ODS
Type 8405-E-X	BK Connect Order Analysis Option – for FFT-based Run-up/down ODS
Type 8405-F-X	BK Connect Order Tracking Option – for order-tracked Spectral ODS and order-tracked Run-up/down ODS
Type 8410-X	BK Connect Geometry
Type 8410-B-X	BK Connect Time ODS Option – for Time ODS

### PREREQUISITE SOFTWARE

Type 8400-X	BK Connect Data Viewer
Type 8401-X	BK Connect Hardware Setup

### ADDITIONAL SOFTWARE FOR MEASUREMENT

Type 8400-A-X	BK Connect Data Viewer (advanced)
Type 8401-A-X	BK Connect Hardware Setup (advanced)
Type 8402-X	BK Connect Time Data Recorder (for additional time recording capabilities)

## Brüel & Kjær Structural Dynamics Applications, Applets and Packs

### BK CONNECT APPLICATION SOFTWARE

Type 8400-D-X	BK Connect Nastran Interface
Type 8400-E-X	BK Connect Ansys Interface
Type 8400-F-X	BK Connect Abaqus Interface
Type 8411-X	BK Connect Structural Measurements – Hammer and Shaker
Type 8412-X	BK Connect Advanced Sine Measurements
Type 8420-X	BK Connect Modal Analysis
Type 8420-A-X	BK Connect Modal Analysis (advanced)
Type 8421-X	BK Connect Correlation Analysis
Type 8429-X	BK Connect Shock Response Analysis

### BK CONNECT PACKS

Type 8410-C-XS	BK Connect Time and Frequency ODS Measurement and Analysis Pack
Type 8410-D-XS	BK Connect Time, Frequency and Run-up/down ODS Measurement and Analysis Pack
Type 8411-XS	BK Connect Structural Measurements and Analysis
Type 8411-A-XS	BK Connect Structural Measurements and Analysis (advanced)
Type 8420-XS	BK Connect Modal Analysis
Type 8420-A-XS	BK Connect Modal Analysis (advanced)

### PULSE OPERATIONAL MODAL ANALYSIS

For an overview, visit the [PULSE OMA](#) page on our website.

### BK CONNECT APPLETS

Type 8491-A-N-SYS BK Connect Hammer Impact Applet

Table 2 Overview of BK Connect structural dynamics packs

Comprises:	PACKS					
	TIME AND FREQUENCY ODS MEASUREMENT AND ANALYSIS TYPE 8410-C-S	TIME, FREQUENCY AND RUN-UP/DOWN ODS MEASUREMENT AND ANALYSIS TYPE 8410-D-S	STRUCTURAL MEASUREMENTS AND ANALYSIS TYPE 8411-S	STRUCTURAL MEASUREMENTS AND ANALYSIS (ADVANCED) TYPE 8411-A-S	MODAL ANALYSIS TYPE 8420-S	MODAL ANALYSIS (ADVANCED) TYPE 8420-A-S
Data Viewer Type 8400	•	•	•	•	•	•
Hardware Setup Type 8401	•	•	•	•		
Hardware Setup (advanced) Type 8401-A		•		•		
Time Data Recorder Type 8402		•				
Data processing Type 8403	•	•				
Order Analysis Option Type 8405-E		•				
Geometry Type 8410	•	•	•	•	•	•
Time ODS Option Type 8410-B	•	•				
Structural Measurements – Hammer and Shaker Type 8411			•	•		
Modal Analysis Type 8420			•	•	•	•
Modal Analysis (advanced) Type 8420-A				•		•

\* 'X' = license model, either N for node-locked or F for floating.

---

## Software Maintenance and Support Agreements

M1-8400-X	Agreement for Type 8400	M1-8410-C-XS	Agreement for Type 8410-C-XS
M1-8400-A-X	Agreement for Type 8400-A	M1-8410-D-XS	Agreement for Type 8410-D-XS
M1-8400-D-X	Agreement for Type 8400-D	M1-8411-X	Agreement for Type 8411
M1-8400-E-X	Agreement for Type 8400-E	M1-8411-XS	Agreement for Type 8411-S
M1-8400-F-X	Agreement for Type 8400-F	M1-8411-A-XS	Agreement for Type 8411-A-S
M1-8401-X	Agreement for Type 8401	M1-8412-X	Agreement for Type 8412
M1-8401-A-X	Agreement for Type 8401-A	M1-8420-X	Agreement for Type 8420
M1-8402-X	Agreement for Type 8402	M1-8420-A-X	Agreement for Type 8420-A
M1-8403-X	Agreement for Type 8403	M1-8420-XS	Agreement for Type 8420-S
M1-8403-A-X	Agreement for Type 8403-A	M1-8420-A-XS	Agreement for Type 8420-A-S
M1-8405-E-X	Agreement for Type 8405-E	M1-8421-X	Agreement for Type 8421
M1-8405-F-X	Agreement for Type 8405-F	M1-8429-X	Agreement for Type 8429
M1-8410-X	Agreement for Type 8410	M1-8491-A-N-SYS	Agreement for Type 8491-A-N-SYS
M1-8410-B-X	Agreement for Type 8410-B		

---

## Other BK Connect Products

For an overview of all Brüel & Kjær Structural Dynamics applications, visit the [Structural Dynamics](#) software page. For an overview of BK Connect data acquisition software, visit the [BK Connect](#) page.



Teknikerbyen 28 · DK-2830 Virum · Denmark  
Telephone: +45 77 41 20 00 · Fax: +45 45 80 14 05  
[www.bksv.com](http://www.bksv.com) · [info@hbkworl.com](mailto:info@hbkworl.com)  
Local representatives and service organizations worldwide

To learn more about all HBK offerings, please visit [hbkworl.com](http://hbkworl.com)

Although reasonable care has been taken to ensure the information in this document is accurate, nothing herein can be construed to imply representation or warranty as to its accuracy, currency or completeness, nor is it intended to form the basis of any contract. Content is subject to change without notice – contact HBK for the latest version of this document.

Brüel & Kjær and all other trademarks, service marks, trade names, logos and product names are the property of Hottinger Brüel & Kjær A/S or a third-party company.