PRODUCT DATA

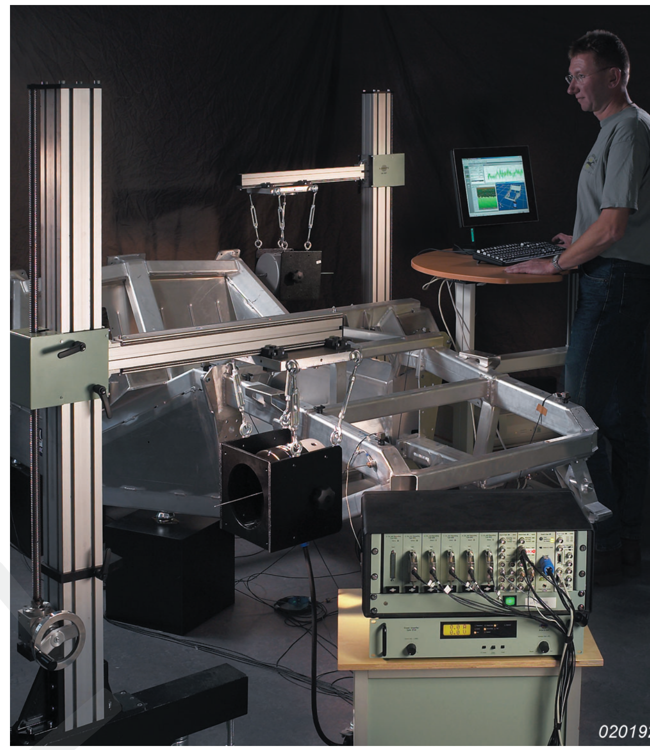
Structural Dynamic Test Consultants

PULSE Modal Test Consultant Types 7753 and 7753-A
PULSE Operating Deflection Shapes Test Consultant Types 7765, 7765-A and 7765-B

Modal Test Consultant™ (MTC) and Operating Deflection Shapes Test Consultant™ (ODSTC) are PULSE™ LabShop applications developed to simplify and dramatically reduce the time required to perform structural dynamic measurements. Together they are referred to as Structural Dynamic Test Consultants.

MTC supports both classical modal analysis using hammer or shaker excitation and operational modal analysis based on output-only measurements. ODSTC supports time ODS, spectral ODS and run-up/down ODS.

The Structural Dynamic Test Consultants are graphically driven linking the measurement directly to the on-screen test object geometry. These features, together with highly effective tools for setup, measurement and validation, make testing fast and reliable. ODS results can be animated directly in ODSTC and FRFs directly in MTC. For both Structural Dynamic Test Consultants, the data generated (time, spectra, geometry and DOF information) can be used directly by leading post-processing packages, for example, BK Connect® Modal Analysis, BK Connect ODS Analysis, PULSE Operational Modal Analysis or Test for I-deas.



Uses and Features

Uses

- Complete solution for time ODS, spectral ODS and run-up/down ODS using ODS Test Consultant
- Integrates PULSE LabShop and a PC-based structural dynamics post-processing package into a streamlined testing solution for classical modal analysis and operational modal analysis
- Export of geometry, measurement data and degrees of freedom (DOF) information, to structural dynamics post-processing packages

Features

- Task-oriented user interface
- Easy-to-use geometry drawing tools
- Import of geometry in standard formats
- Geometry-driven measurement setup for data acquisition and analysis in structural dynamics related measurements
- Automated measurement sequence generation
- Audible status and visual notification during setup and measurement
- Real-time analysis or post-processing based on recorded time histories (shaker testing, ODS, OMA testing)
- Automated bookkeeping of DOFs
- Part of a complete solution available from Brüel & Kjær, which includes:
  - Modal exciter systems, impact hammers, transducers and accessories
  - Conditioning, measurement and analysis using LAN-XI data acquisition hardware
  - A range of structural dynamics post-processing packages

Brüel & Kjær

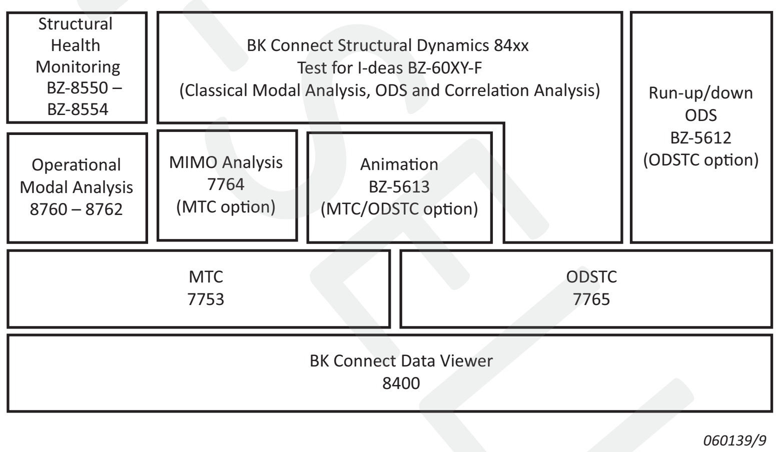
Introduction

In performing a structural dynamics test and analysis, a substantial amount of time is used on measurement setup, data acquisition and data validation. Often, less time is used on the subsequent analysis. Using the Structural Dynamic Test Consultants (SDTCs), consisting of Modal Test Consultant and ODS Test Consultant, Brüel & Kjær modal transducers, impact hammers and modal exciters, together with a range of accessories, time can be saved in every area of the measurement process.

The SDTCs work with PULSE LabShop to provide a dedicated measurement environment for structural dynamic measurements. They guide you through the measurement process in simple steps, giving you an intuitive graphical interface that links setup and DOF information to the on-screen test object geometry.

Users of existing structural dynamics post-processing packages will be able to expand their testing and analysis capabilities through the SDTCs while continuing to use their existing packages. Those new to structural dynamic testing will appreciate the guidance provided by the SDTC interface, the highly integrated environment for final analysis (using ODSTC), and the freedom to choose a structural dynamic post-processing package to suit their needs. All users will benefit from the speed with which structural dynamic tests can now be set up and executed.

Fig. 1
Schematic overview of the PULSE-based system for ODS analysis, classical modal analysis, operational modal analysis and correlation analysis



Upgrades

MTC and ODSTC's common environment, including setup and geometry definition, makes it possible to easily upgrade for added structural dynamic test functionality:

- **BZ-5455:** Upgrade from ODSTC Type 7765 to include MTC Type 7753
- **BZ-5457:** Upgrade from MTC Type 7753 to include ODSTC Type 7765

ODSTC with BZ-5455 upgrade is identical to MTC with BZ-5457 upgrade. Both upgrades allow access to the standard functionality of both ODSTC and MTC.

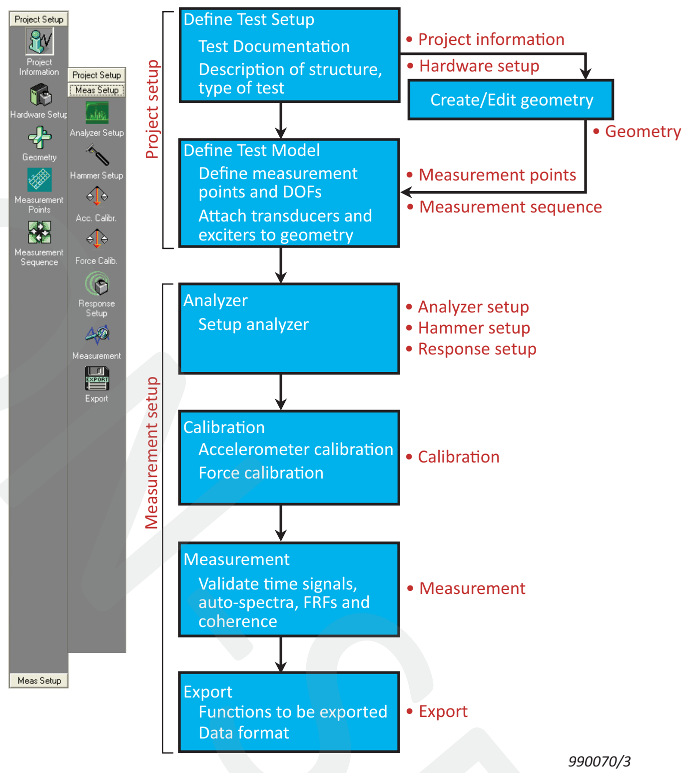
Interface and Layout

The SDTCs have user interfaces that are generic Windows® interfaces, each equipped with a task bar down the left-hand side of the screen. The task bar takes the form of one or more menus (task groups) in the left-hand column. Each menu has a series of tasks associated with it. These are activated from icons in the task bar. A basic set of tasks comes with the templates. Additional tasks can be created, rearranged or removed giving you the option of customising the measurement sequence and removing unnecessary tasks when, for example, repeated measurements are being made on the same item.

These features make the measurement process both linear and intuitive. By simply working your way through associated tasks, you automatically perform all the necessary setup and measurement tasks. This is a bonus for new and infrequent users as they can quickly acquaint themselves with the system. Experienced users will appreciate the option of customising the task bar so that only those tasks specific to a particular measurement are visible.

An example, showing a typical hammer measurement, has been provided in Fig. 2.

Fig. 2
Example of the task bar in Modal Test Consultant Type 7753. The outline to the right of the task bar shows the typical sequence of tasks in a hammer test. In this example, the task bar is split into two task groups – Project Setup and Measurement Setup



Common Features

The following features and functionality are common to both MTC and ODSTC.

Hardware Setup

The hardware, including transducers, is easily set up using the standard PULSE Hardware Setup table. This provides easy overview and editing across several channels simultaneously. If TEDS (transducer electronic data sheet) transducers are used, the hardware table is automatically updated. If non-TEDS transducers are used, the hardware table can be updated manually. The Hardware Setup table is linked to the PULSE Transducer Database making manual updating quick and easy. DOFs entered into the Hardware Setup table are automatically added to the geometry.

Geometry

The SDTCs contain powerful and intuitive drawing tools that allow you to create 3D models of your test object. You can work with points, lines, surfaces or basic shapes (for example, boxes, cylinders and hemispheres) that you edit and combine to rapidly build up realistic test object geometries. More complex geometry objects can be imported in UFF format or from Microsoft® Excel® in .csv format.

The geometry is parametric, which means it has structure, physical properties and values that you can change, for example, the diameter of a cylinder or dimensions of a box. The geometry updates itself, automatically adjusting to incorporate new dimensions.

The measurement degrees of freedom (DOFs) are automatically added to the test object geometry if defined in the Hardware Setup table. DOFs can also be predefined in a csv file containing the transducers' serial numbers. During file import of the .csv file, the predefined DOFs are added to the geometry and linked to hardware and transducers using the serial numbers. In addition DOFs can be added by pointing and clicking with the mouse or using an entry form. It is also possible to automatically add selected transducers to all points, depending on the measurement method, using the Autofill feature. The measurement points relate to specific transducers and can be force transducers (for excitation) or accelerometers and microphones (for response). In ODS and OMA measurements, a tacho probe can also be applied to measure the rotational speed of the test object.

The process is very intuitive because you do the same on screen as you do on the physical test object. Simply select the transducer for a measurement point from a list that contains all transducers used in the measurement, as defined in the Hardware Setup table. The transducers will be shown on the geometry as icons at their defined angles (skewed angles are supported).

Three coordinate systems are used, Cartesian, cylindrical and spherical. When a transducer is added to a part of the test object geometry, the coordinate system of that particular transducer automatically assumes the coordinate system of that part, whether it be Cartesian, cylindrical or spherical.

Fig. 3 shows the measurement DOFs of a car frame, including four shakers and 20 triaxial accelerometers, during multiple-input multiple-output (MIMO) testing.

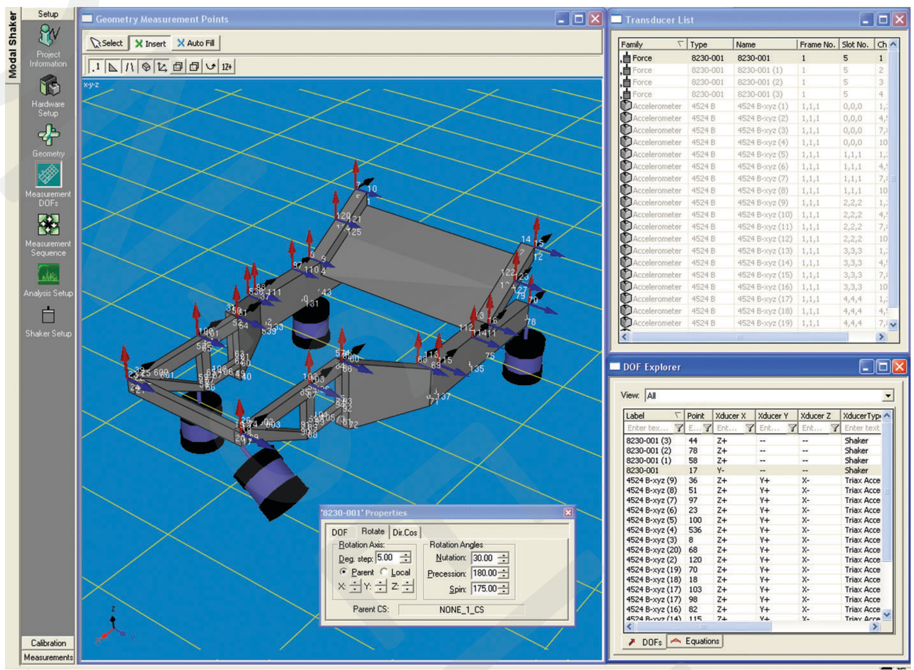


Fig. 3
Example of multi-shaker measurement on a car frame also illustrating the use of surfaces

Once the DOFs have been attached to the geometry, a measurement sequence can be defined when multiple measurements are performed. The measurement sequence can be based on the following methods:

- Automatic, according to the sequence you assigned the transducers to the DOFs
- Automatic, according to the measurement point numbering
- Automatic, according to the closest point patch
- Manual, user-defined

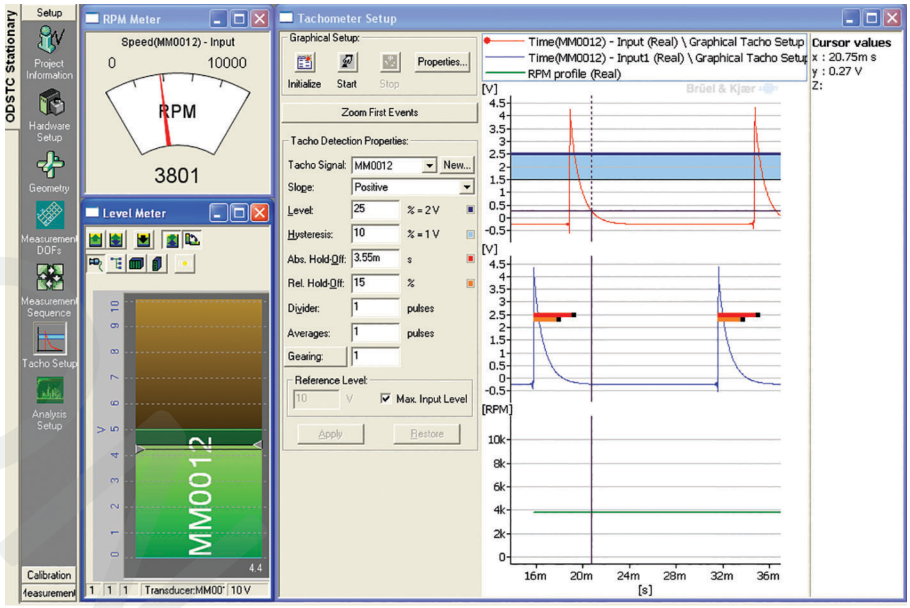
Tacho Setup

A graphical tacho setup makes it easy to correctly detect and condition the tacho signal used for spectral ODS when based on order components, run-up/down ODS, or for indication of RPM during operational modal analysis measurements. The untriggered tacho signal is shown in one of three graphs. As this signal is not triggered, it will be ‘running’. By dragging and dropping relevant curves, parameters like Level, Hysteresis and Hold-off are adjusted and reflected on the second graph with the triggered tacho signal ‘stabilized’. The last graph then shows the RPM profile calculated from the triggered tacho signal.

A number of tacho parameters are available including Tacho Divider, Gearing and Averaging.

In many situations, a direct tacho signal might not be available or difficult to access; in other situations, the use of a dedicated tacho is not allowed due to potential interference problems or safety regulations. In such cases, autotracking is often beneficial. With autotracking, the fundamental frequency is indirectly extracted from a measurement signal, rather than directly from a tacho probe signal.

Fig. 4
The tacho signal is easily conditioned using a graphical tacho setup (ODS or OMA measurements)

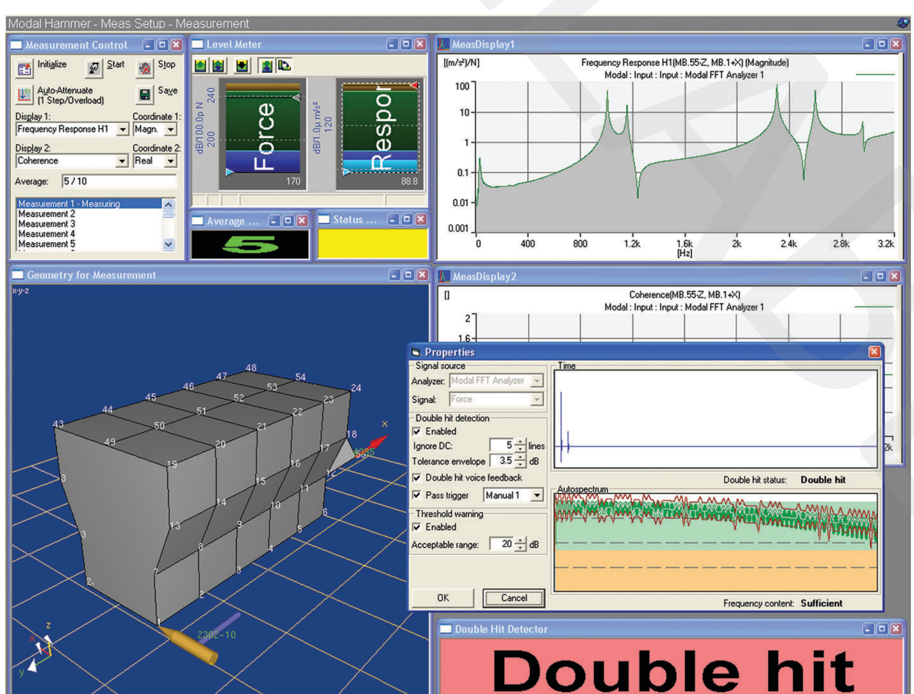


Measurement

Once the geometry and measurement sequence have been defined and analyzer parameters set up, data acquisition can begin. When making measurements using a SDTC, the first measurement positions are automatically highlighted on the object geometry. The status of the analyzer is shown and, for the individual channels, you have on-screen indications of level, including potential overload. As the test object may be some distance from the PC, the SDTCs provide audible indicators such as 'overload' or 'triggered', along with a scalable channel status monitor and level meter.

Fig. 5 shows an example of graphic indicators during a hammer test. The hammer icon indicates where you need to excite the structure and the transducer icon (arrow) shows where you need to measure the response (DOF) for the particular measurement you are making. On saving the measurement data, the transducers automatically move on to the next measurement positions showing you, once again, where to excite and where to measure. If during the measurement, multiple or 'double' hits of the hammer are detected, the system can be set up so that a warning is generated. The system can be set up to automatically reject measurements where double hits have been detected.

Fig. 5
Example of a typical measurement task layout for hammer testing



The SDTCs enable you to perform structural dynamic measurements as you wish by allowing you to choose the sequence in which you perform the measurement tasks. If required, the tasks can be rearranged or, in the case of ‘individualized’ tasks, added and deleted. In addition, a variety of PULSE tools, such as Level Meter, can be used alongside the SDTC tools.

Animation and Post-analysis

For ODS measurements, data can be animated immediately in ODSTC using the Animation Option BZ-5613. There is no need to export the data to a separate post-processing package, though this is also possible.

For classical and operational modal analysis, measurement data can be validated in MTC[*] and then the DOF-labelled functions and geometry can be seamlessly exported to your chosen post-processing software, such as BK Connect Modal Analysis, PULSE Operational Modal Analysis or Test for I-deas.

Modal Test Consultant Types 7753 and 7753-A

Uses

- Autotracking for fundamental frequency extraction directly from measurement signal (for OMA measurements)
- Supports classical modal analysis and operational modal analysis (OMA) data acquisition and validation
- Speed profile of the fundamental frequency from tacho probe or autotracker (for OMA measurements)

Features

- Consistency check by comparing selected FRFs across measurements, for example, for local solve curve-fitting
- Complete guidance through all stages of hammer, shaker and OMA measurements
- FRF animation for validation of test setup and preliminary investigation of ‘mode shapes’
- Freely perform measurements in terms of how to rove excitations and responses for hammer and shaker measurements
- Time ODS animation during OMA measurements for validation before analysis
- Possibility to do time data recordings without predefined geometry (OMA measurements)
- Single, overlaid, difference and side-by-side FRF and time ODS animation
- Graphical force trigger, force weighting and response weighting setup for hammer testing
- AVI file generation for reporting
- Graphical setup of excitation for shaker testing
- Shape table for documentation and comparison of FRF shapes
- Force calibration, ensuring correct mobility measurements
- Short-time Fourier transform for validation of OMA measurement data before analysis
- Automatic double-hit detection and rejection
- Seamless integration with leading structural dynamics post-processing packages like BK Connect Modal Analysis and Test for I-deas
- Supports multiple shaker excitation via multiple-input multiple-output analysis (MIMO)
- Export of geometry, measurement data and DOF information to structural dynamics post-processing packages
- Graphical tacho setup for conditioning of the tacho signal (for OMA measurements)
- Support of PULSE Data Manager Type 7767 for easy storage and retrieval of geometry and FRF shapes

* Including FRF animation in classical modal analysis and time ODS animation in operational modal analysis with Animation Option BZ-5613

Introduction

Modal analysis is the process of obtaining a mathematical model of the dynamic properties and behaviour of a structure. The model contains a set of mode shapes, each with an associated natural frequency and modal damping. These modal parameters can be obtained by experimental means, called model testing or experimental modal analysis (EMA), or by analytical means using finite element analysis (FEA).

There are two types of modal testing – classical modal analysis and operational modal analysis. In classical modal analysis, the structure under test is excited with measurable forces and the response/excitation ratio is determined. The modal parameters are then extracted using curve-fitting techniques.

Classical modal analysis ranges from a simple mobility test with an impact hammer to multi-shaker testing of large and complex structures with hundreds of response accelerometers. In operational modal analysis (OMA), only the response of the structure is measured. Ambient and operating forces acting on the structure are not measured. OMA is used instead of classical modal analysis for accurate modal identification under actual operating conditions and in situations where it is difficult or impossible to artificially excite the structure.

Modal Test Consultant Type 7753 guides you through the measurement process in simple intuitive steps tailored to perform fully flexible hammer, shaker or OMA testing. Analysis can be performed in real time or as post-processing of recorded time histories from shaker, ODS or OMA measurements. Time data can be simultaneously recorded to the disk, for post-processing, while real-time analysis is being performed.

Modal Test Consultant can be upgraded with Animation Option BZ-5613 for FRF animation during classical modal analysis testing and time ODS animation during operational modal analysis testing.

Classical Modal Analysis

Hammer Testing

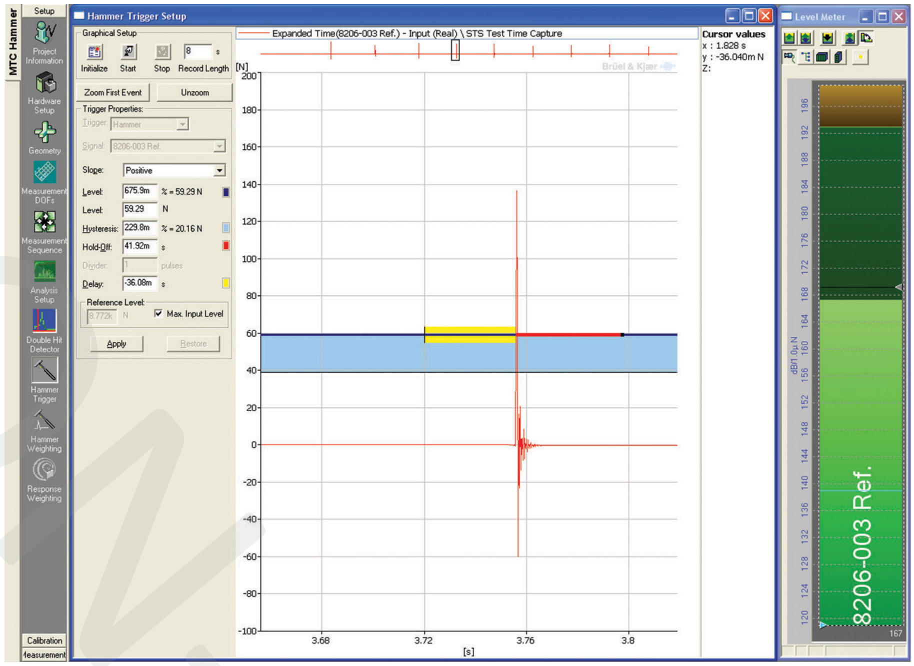
A typical measurement using hammer excitation is outlined in Fig. 2. It shows the basic tasks and the order in which you might choose to perform them. MTC provides a dedicated screen layout for each of the tasks, most of which are geometry-driven, graphically driven, or are tables with intelligent drop-down lists for ease-of-use.

The PULSE templates for MTC are divided into two task groups: Project Setup (setup of the hardware, geometry, DOFs, etc.) and Measurement Setup (performing and validating the measurement and exporting data). In each of these task groups, there are subtasks to guide you through the complete modal test.

For hammer testing, special tools are available for setting up of the force and response signals. Fig. 6 shows how the impact force from the hammer easily can be set up graphically by dragging the relevant curves and cursors with the mouse. This greatly simplifies the task by letting you see, for example, the triggering level and move the triggering level cursor on the screen. In a similar way, the correct time-weighting can be graphically applied to the excitation and response signals.

MTC supports single reference as well as multiple reference hammer testing. When FRFs are exported to BK Connect Modal Analysis, a correction factor is included to fully compensate for the effects of exponential weighting on the response signals, thereby ensuring correct damping estimates.

Fig. 6
Hammer Trigger setup showing the conditioning of the impact force signal

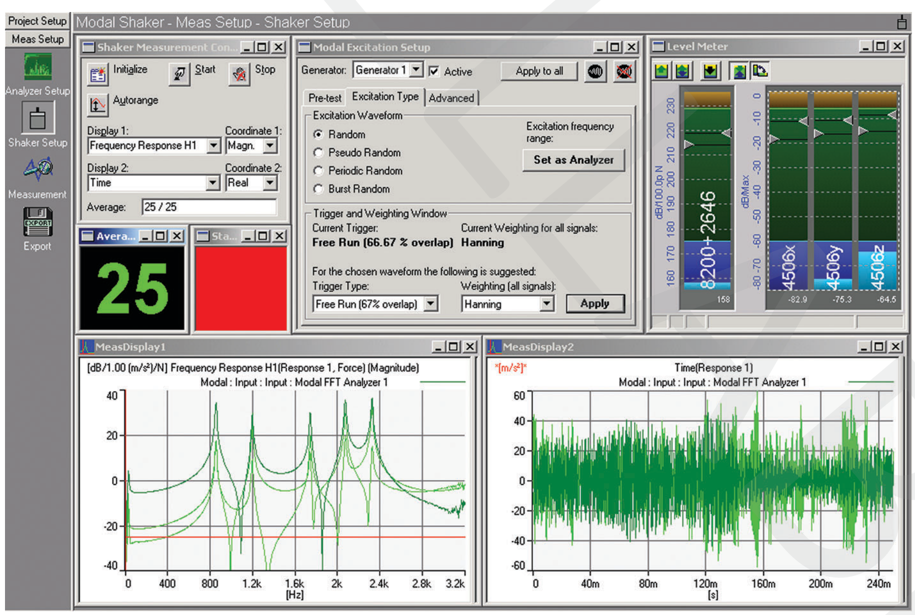


Shaker Testing

For shaker testing you can perform pre-tests with various excitation signals in order to check for linearity, etc., to set the correct amplitude and to check that the cables, etc., are properly connected (see Fig. 7).

For triggering and weighting conditions, MTC provides suggested settings, but you can also enter your own parameters. Once you start the measurement, you can check that the shaker excitation is working correctly and that the excitation spectrum contains energy at all frequencies in the range of interest.

Fig. 7
Shaker setup showing the excitation options



After calibrating the accelerometers, a force calibration can be done. This is automatically performed, by measuring a sample mass and calibrating the force channel such that the ratio of force divided by acceleration (equal to the mass) is correct (calibrated). Assuming the accelerometer is already calibrated, the force channel is therefore also calibrated. This is applicable for both hammer and shaker testing.

MTC supports both single-input multiple-output (SIMO) and multiple-input multiple-output (MIMO) analysis with shaker testing. MIMO analysis is a widely used variant of multi-reference testing. With this technique, the structure is simultaneously excited at two or more DOFs with uncorrelated random noise and the output measured in two or more response DOFs.

In addition to the general advantages of multi-reference testing, MIMO analysis has the following advantages:

- **Distribution of sufficient energy over the complete structure.** Large structures, heavily damped structures and structures exhibiting local modes require multi-point excitation to get sufficient energy distributed over the entire structure
- **Avoidance of non-linear behaviour.** Distributing the energy over the structure using multi-point excitation reduces the force level at the different excitation DOFs, thereby avoiding driving the structure into non-linear behaviour that would deteriorate the FRF estimation
- **Better simulation of real-life operation.** Excitation of the structure at multiple points often provides a better representation of the excitation forces that load the structure during real-life operation
- **Reduced force drop-offs at resonance frequencies.** Using multiple, smaller shakers instead of one large one requires less massive armatures thereby leading to smaller drop-offs at resonance frequencies
- **Reduced test time.** Simultaneous use of multiple shakers and multiple accelerometers reduces the test time. This can be of paramount importance for tests that have to be completed with a minimum of on-structure time

If more than one shaker is used in the measurement, MTC automatically detects that MIMO analysis is requested and uses the proper algorithms for calculating the coherence and FRF functions.

Operational Modal Analysis

OMA is based on acquired time histories. During data acquisition, FFT analysis of selected responses can be performed and shown as either spectra or in contour plots as functions of time or RPM. If a tacho signal is acquired it can easily be conditioned using a graphical tacho setup (see Fig. 4) and the speed profiles shown during measurement.

Results

Using MTC for classical modal analysis with Animation Option BZ-5613, frequency response functions (FRFs) can be animated as single, overlaid, difference or side-by-side views. This is very useful for validation of test setups, such as identifying cable breaks and incorrectly mounted transducers. For structures with lightly damped and well-separated modes, the FRF shapes will resemble mode shapes. Shapes can be saved in a shape table for easy retrieval and comparison. PULSE Data Manager is supported for easy storage and retrieval of geometry and shapes.

A variety of animation types are supported including wire frame, surface contour, point and arrow animation. For better visualization in situations where not all defined DOFs have been measured, the non-measured DOFs can be interpolated using a user-defined number of nearest measured DOFs or by using slave node equations. The animations can be recorded as AVIs and included in reports using Microsoft® Word and PowerPoint®. Using MTC for OMA measurements, time ODS animation can be performed.

Export of Results

Measurement data, calculated functions and geometry can be exported in different data formats. Everything is laid out in easy-to-use menus, so all you need to do is choose the geometry and DOF-labelled functions and export format you want and click ‘Export’ to export data to a post-processing package, ready for analysis and animation.

MTC fully integrates with BK Connect Modal Analysis Type 8420/8420-A for classical modal analysis. If the analysis software is not already open, MTC automatically starts it up and creates a new project. If the program is already open, it transfers the data into the existing project. The measurement data and geometry are automatically converted into the native data format of the program, for immediate post-processing of the data. This, in effect, turns MTC and BK Connect Modal Analysis into a single application.

A tight interface with Test for I-deas is made using ASCII and binary UFF formats. Furthermore, data can be exported to other post-processing packages with open data interfaces in a number of standard formats. MTC also fully integrates with PULSE Operational Modal Analysis Type 8760 – 8762 for operational modal analysis. It uses short time Fourier transforms with a colour contour plot to give an overview of the time data for validation and response signal selection before transferring geometry and DOF-labelled time data to Type 8760 – 8762.

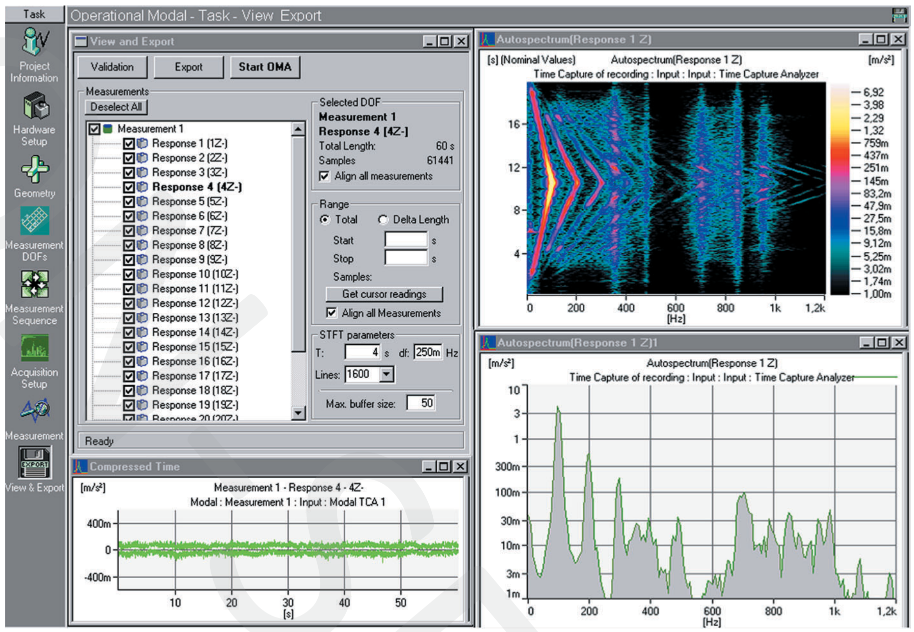


Fig. 8
With operational modal analysis templates in MTC, part of the time signals for the various channels can be selected and a short-time Fourier transform shown as a contour plot, for validation of the data before exporting to PULSE Operational Modal Analysis

Operating Deflection Shapes Test Consultant Types 7765, 7765-A and 7765-B

Uses

- Time ODS, spectral ODS and run-up/down ODS analysis

Features

- Complete guidance through all stages of time, spectral and run-up/down ODS measurements
- Time ODS for analysing structural vibrations in a given frequency range as a function of time
- Spectral ODS for analysing structural vibrations for a specific frequency or order component under stationary, or almost stationary, conditions
- Run-up/down ODS for analysing structural vibrations for specific order components as a function of rotational speed
- Single, overlaid, difference and side-by-side animation – no ODS post-processing package needed
- AVI file generation for reporting
- Shape table for documentation and comparison of shapes
- Ratio-based phase assigned spectra (PAS), giving the average ODS when using multiple data sets
- Possibility to do time data recordings without predefined geometry
- Supports multiple references including the use of a tachometer as a reference
- Graphical tacho setup for conditioning of the tacho signal (for order-based spectral ODS or run-up/down ODS)
- Autotracking for fundamental frequency extraction directly from measurement signal
- Speed profile of the fundamental frequency from tacho probe or autotracker
- Seamless integration with leading structural dynamics post-processing packages like BK Connect ODS Analysis and Test for I-deas
- Export of geometry, measurement data and DOF information to structural dynamics post-processing packages
- Support of PULSE Data Manager Type 7767 for easy storage and retrieval of geometry and shapes

Introduction

Operating deflection shapes (ODS) analysis is used for determination of the vibration pattern of a structure under given operating conditions. Vibration measurements are performed at different points and directions on the structure and the vibration pattern 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 conditions, which for machinery could be influenced by engine speed, load, pressure, temperature, flow, etc. Ambient forces from waves, wind and traffic might also apply for civil engineering structures.

ODS Test Consultant guides you through the measurement process in simple intuitive steps tailored to perform time ODS and spectral ODS. ODSTC uses the unique geometry driven concept similar to MTC. The ODSTC can be upgraded with options for animation (BZ-5613) and run-up/down ODS (BZ-5612). Analysis can be performed in real-time or as post-processing of recorded time histories. Time data can, simultaneously with the real-time analysis, be recorded to disk for later post-processing.

Time ODS

Time ODS is used to investigate the vibration pattern of a structure as a function of time. In contrast to spectral ODS and run-up/down ODS, where the vibration pattern of a single frequency or order is investigated, time ODS includes all frequencies in the analysed frequency range. Time ODS is very useful in giving an overall ODS at a given point in time whether the signal is stationary or non-stationary, such as in transient signals. A portion of the time signal can be selected for analysis.

Spectral ODS

Spectral ODS is used to investigate the vibration pattern of a structure for specific frequency or order components. For frequency component investigations, FFT analysis is used and the conditions must be stationary. In order component investigations, order analysis (tracking) is used to eliminate 'smearing' of spectral components in cases of almost stationary conditions. The ODS of different spectral components (frequencies or orders) is subsequently extracted, shown in a shape table and animated.

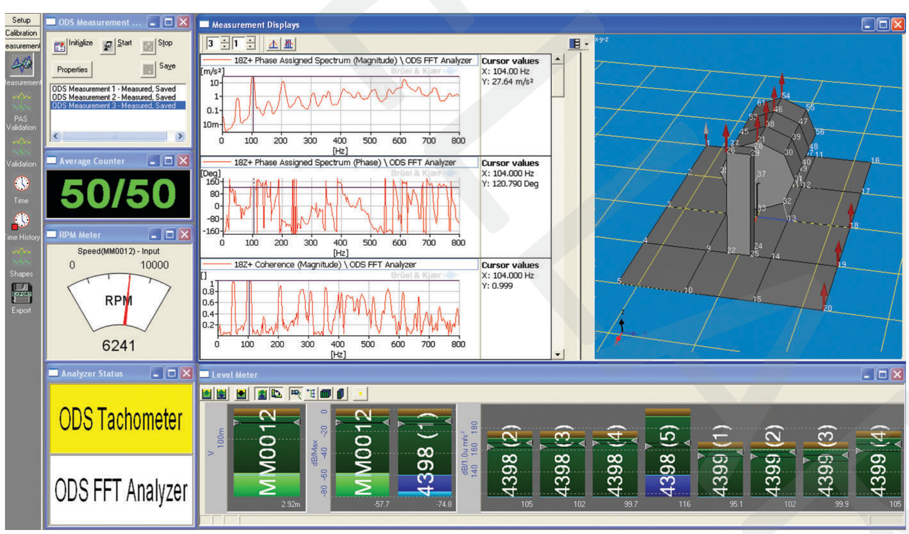


Fig. 9
Measurement of frequency-based spectral ODS data using a tacho probe as reference

Run-up/down ODS

Run-up/down ODS is used to investigate the vibration pattern of a structure for specific order components as a function of rotational speed. The order components can either be defined beforehand (pre-slices) and/or taken out as slices from contour and waterfall plots (post-slices). Run-up/down ODS is very useful in relating a structure's noise and vibration behaviour to its rotational parts.

Results

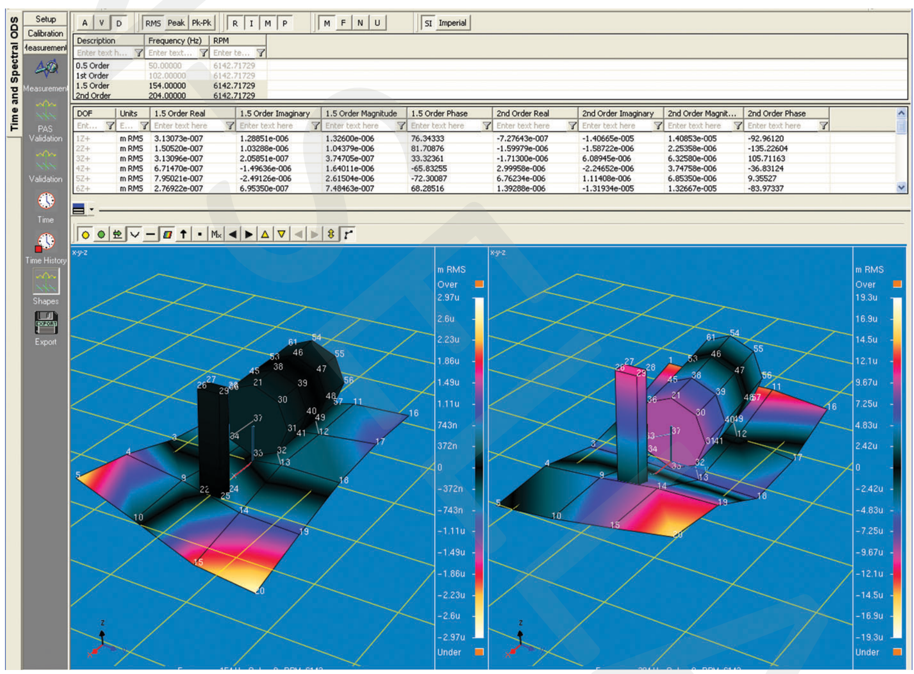
Measurements can be performed using real-time analysis, or time data can be recorded to disk for later post-processing. Typically a geometry is defined and DOFs attached before the measurements are done. However, in cases where no geometry is available – for example when a complex geometry is not available as a decimated finite element model and/or there is no time to draw the geometry – time data recordings can be done without a predefined geometry and the measurements can later be attached to the geometry before the ODS analysis.

Measurements are done using phase assigned spectra (PAS). Ratio-based PAS giving the average ODS can be used when the measurement is done using multiple data sets. Also multiple references, including the use of the tachometer as reference, can be used in order to select the best one for each ODS frequency/order component.

With Animation Option BZ-5613, ODS results can be shown as single, overlaid, difference or side-by-side animations. A variety of animation types are supported including wire frame, surface contour, point and arrow animation. For better visualization in situations where not all defined DOFs have been measured, the non-measured DOFs can be interpolated using a user-defined number of nearest measured DOFs or by using slave node equations. The animations can be recorded as AVI files and included in reports using Microsoft® Word and PowerPoint®.

Shapes can be saved in a shape table for easy retrieval and comparison. Using BZ-5613, you do not need a separate ODS post-processing package. PULSE Data Manager is supported for easy storage and retrieval of geometry and shapes.

Fig. 10
Comparison of two ODS using a shape table and side-by-side animation with individual scaling



Export of Results

While ODS results can be animated directly in ODSTC using Animation Option BZ-5613, it is also possible to export time ODS and spectral ODS measurement data, calculated functions and geometry in different data formats ready for animation to other post-processing packages.

Spectral ODS PAS functions can be exported to BK Connect ODS Analysis for immediate animation of the operating deflection shapes and creation of ODS shape tables. As with MTC, ODSTC has been designed to provide a smooth interface with Test for I-deas. Standard formats are also supported for interfacing to other post-processing packages.

Complete Measurement Chain

Brüel & Kjær supplies the complete range of equipment needed for structural dynamic measurements, including transducers, hammers, force transducers, modal exciters, power amplifiers, cables, conditioning equipment, front ends and software for measurement, analysis and test-FEA integration.

BK Connect is the latest sound and vibration software platform from Brüel & Kjær. It provides measurements, analysis and test-FEA integration in a consistent, modern and intuitive user interface environment. BK Connect Structural Dynamics is used for pre-test planning, ODS measurement and analysis, classical modal measurement and analysis, operational modal analysis measurement, correlation analysis of two modal models (for example, finite element model versus test model) and shock response analysis.

- For more information on BK Connect Structural Measurements – Hammer and Shaker Type 8411 and BK Connect Advanced Sine Measurements Type 8412, see product data BP 1524
- For more information on PULSE Operational Modal Analysis Types 8760 – 62, see product data BP 2567
- For more information on BK Connect ODS Analysis, see product data BP 0018
- For more information on BK Connect Modal Analysis Types 8420 and 8420-A, see product data BP 1523
- For more information on BK Connect Correlation Analysis Type 8421 and BK Connect Finite Element Interface Types 8400-D, 8400-E and 8400-F, see product data BP 2577
- For more information on BK Connect Shock Response Analysis Type 8429, see product data BP 2578

Specifications – Modal Test Consultant Types 7753 and 7753-A and Operating Deflection Shapes Test Consultant Types 7765, 7765-A and 7765-B

SYSTEM REQUIREMENTS
- PULSE v. 23 or later
  Note: PULSE 23 is the last version that supports Modal Test Consultant Type 7753 and ODS Test Consultant Type 7765
- 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® 2017 or SQL Server® 2019
  Note: Microsoft SQL Server 2017 is included in BK Connect installation

MTC SOFTWARE REQUIREMENTS*
- PULSE FFT & CPB Analysis Type 7700 (Type 7700 licence is embedded in BK Connect Data Processing Type 8403)
- MIMO analysis requires PULSE Multiple-Input Multiple-Output Type 7764 (Type 7764 licence is embedded in BK Connect Advanced Frequency Analysis Option Type 8405-B)
- FRF animation and shape tables, or time ODS animation in OMA, require Animation Option BZ-5613 (included in PULSE Modal Test Consultant with FRF Animation Type 7753-A)

ODSTC SOFTWARE REQUIREMENTS*
- PULSE FFT & CPB Analysis Type 7700 (Type 7700 licence is embedded in BK Connect Data Processing Type 8403)
- Order-based spectral ODS or run-up/down ODS requires PULSE LabShop Order Analysis Type 7702 (Type 7702 licence is embedded in BK Connect Order Analysis Option Type 8405-E and Order Tracking Option Type 8405-F)
- Run-up/down ODS requires Run-up/down ODS Option BZ-5612 (included in PULSE Run-up/down Operating Deflection Shapes Type 7765-B)
- Animation and shape tables require Animation Option BZ-5613 (included in PULSE Operating Deflection Shapes Type 7765-A and PULSE Run-up/down Operating Deflection Shapes Type 7765-B)
- Editing of time data requires PULSE Time Type 7789 (Type 7789 licence is embedded in BK Connect Time Data Recorder Type 8402)

RECOMMENDED PC
- Intel® Core™ i7, 3 GHz processor or better
- 32 GB RAM
- 480 GB Solid State Drive (SSD) with 20 GB free space, or better
- 1 Gbit Ethernet network†
- Microsoft® Windows® 10 Pro or Enterprise (x64) with CB
- Microsoft® Office 2016 (x32)
- Microsoft® SQL Server® 2017
- Screen resolution of 1920 × 1080 pixels (full HD)

User Interface

Microsoft® Windows®-based with task bar

3D Modelling Specifications

Structural Dynamic Test Consultants Geometry Generator contains a range of tools for creating test object geometry. You can import geometry in UFF file formats or create it from scratch using basic drawing objects and lines combined into the desired structure
Geometry Import Formats: UFF data set types 15, 82 or 2411, ME'scopeVES native geometry format v.5 (*.str), and Microsoft® Excel® (.csv)
Geometry Export Formats: UFF data set types 15, 18 or 82, ME'scopeVES native geometry format v.5 (*.str), and Microsoft® Excel® (.csv)
Views: Three 2D views: Plan View, Side View and Front View, Isometric view, and user-defined 3D views
Split screen views combining 2D and 3D views
Hidden lines and transparency
Pan, zoom and rotate options for viewing geometry
All views scalable
Full dynamic rotation of test object geometry including auto-rotation
Drawing: Creation of points, lines, faces and basic 3D shapes including surfaces. Drawing using mouse, or by inputting coordinates. Automatic mesh generation for basic shapes. Easy object rotation and adjustment in 3D space including:
Cartesian, spherical and cylindrical coordinates
Local coordinate systems
Geometry components
Geometry Explorer:

* BK Connect Data Viewer Type 8400 is a prerequisite for all BK Connect software. For Type 8405 options, you must also have a BK Connect Data Processing Type 8403 or 8404 licence

† 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

Tabular displays of elements and points used to make up the geometry
Tabular displays of lines and faces
Table Functionality:
Editable point labels
Editable lines and faces labels
Filtered display of points using alphanumeric filters
Filtered display of lines and surfaces using alphanumeric filters
Automated point numbering
Partial or complete semi-automated point renumbering
Fully configurable display (choice of columns to be displayed, drag and drop column labels, scalable column widths and fully scrollable display window)
Point display on geometry options including text labels, prefixes for point numbers and hide/show features
Element Display: Hierarchical tree view for substructures of geometry

Measurement Setup

The front-end hardware is automatically detected. Transducer information is held in the PULSE transducer database allowing transducers to be selected both by type, by name or by serial number. When using PULSE and TEDS equipped transducers, the information is automatically retrieved from the transducer and entered into the hardware setup table. DOFs entered into the Hardware Setup table are automatically added to the geometry.
DOFs can be predefined in a csv file containing the transducers serial numbers. During the csv file import, the predefined DOFs are added to the geometry and linked to the hardware and transducers.

EXCITATION OPTIONS
Classical Modal Analysis: Hammer and shaker excitation using single or multiple references. Full flexibility in terms of how to rove excitations and responses
OMA and ODS: Natural excitation

MEASUREMENT DOFS
All measurement points and directions (DOFs) viewable on geometry and displayed as icons showing the type of transducer being used
Geometry Driven Addition Of:
- Transducer type
- DOF information

Geometry Based:
- Indication of DOF direction using colour coded indicators
- Full support for DOFs mounted at skewed angles
- Automatic DOF alignment to cylindrical/spherical coordinate systems

Editable Table Views:
- Measurement point information
- System hardware setup and properties

ANALYZER SETUP OPTIONS
Graphically Driven:
- Tacho and autotracker setup for order-based spectral ODS, run-up/down ODS, and OMA measurements
- Force trigger and weighting setups for hammer testing
- Response weighting setup for hammer testing

Audible status/error warnings during setup and measurement
Visual status monitoring for channel overloads

DOUBLE HIT DETECTION (MTC)
Automatic detection and rejection of double hits, before averaging, according to user definable settings. Includes visual and audible notification

SHAKER SETUP (MTC)
Setup of generator signals provided for the shaker

CALIBRATION AND FORCE CALIBRATION
Semi-automatic calibration and force calibration (MTC) with most recent calibration viewable in tabular format for all channels

Measurement and Analysis

DATA ACQUISITION
- Measurements done in real-time or as post-processing of recorded time histories (ODS, shaker testing, OMA)
- **Classical Modal Analysis (hammer and shaker testing with single/multiple references):** Time data, autospectra, cross-spectra, FRF, impulse response, coherence and correlation functions
- **Operational Modal Analysis:** Time data, FFT-analysis of responses during time recording including 3D contour plots
- **ODS (time ODS, spectral ODS and run-up/down ODS):** Time data, phase assigned spectra/orders, and ratio-based phase assigned spectra/orders

VALIDATION
Speed profile of fundamental frequency (ODS, OMA)
Selection, filtering and sorting of functions to display. Includes PAS validation for display and animation of phase assigned spectra (ODS), time ODS animation (ODS, OMA) and FRF validation for display and animation of FRFs (classical modal analysis)
Consistency check of FRFs across measurements

ANIMATION
Single, overlaid, difference and side-by-side animation
Wireframe, contour, points and arrow animation
Interpolation of non-measured DOFs
Slave node equations
AVI file generation
Shape table

DATA EXPORT
UFF and Test for I-deas, MODENT Suite, STARModal and ME'scopeVES v.5 native data formats for measurement functions, data and geometry

Export to BK Connect Modal Analysis Type 8420/8420-A and PULSE Operational Modal Analysis Type 8760 – 8762: Automatic start-up of program and new project creation. Data inserted directly into new project ready for analysis
Storage and retrieval of geometry and results data in PULSE Data Manager Type 7767

Note: From PULSE v. 22.0, BK Connect is a prerequisite for the PULSE LabShop software modules listed below. Some modules are only available through equivalent BK Connect products. For more information, please contact your local Brüel & Kjær sales representative.

Type 7753-X	**PULSE Modal Test Consultant†**
Type 7753-A-X	**PULSE Modal Test Consultant with FRF Animation†**
Type 7765-X	**PULSE Operating Deflection Shapes Test Consultant**
Type 7765-A-X	**PULSE Operating Deflection Shapes**
Type 7765-B-X	**PULSE Run-up/down Operating Deflection Shapes**

Accessories

Different sensitivities, for accelerometers with or without TEDS fitted, are available. Please contact Brüel & Kjær for details.

Type 4326-A	Miniature Triaxial Piezoelectric Charge Accelerometer
Type 4393	Piezoelectric Charge Accelerometer
Type 4397	Miniature Piezoelectric IEPE Accelerometer
Type 4507-B	Miniature Piezoelectric IEPE Accelerometer
Type 4508-B	Miniature Piezoelectric IEPE Accelerometer
Type 4524-B	Miniature Triaxial IEPE Piezoelectric Accelerometer
Type 4529-B	Triaxial CCLD Accelerometer
Type 4575	DC Response Accelerometer (variable capacitance)
Type 8001	Impedance Head
Type 8203	Force Transducer/Impact Hammer (for light structures)
Type 8204	Miniature Impact Hammer
Type 8206	Impact Hammer
Type 8208	Modal Sledge Hammer
Type 8230	CCLD Force Transducer
Type 8340	Piezoelectric IEPE Accelerometer (seismic)
Type 8344	Piezoelectric IEPE Accelerometer (seismic)
Type 2647	Charge to CCLD Converter (used with Type 8001)
Type 4294	Accelerometer Calibrator

Type 2981	CCLD Laser Tacho Probe
MM-0012	Photoelectric Tachometer Probe
MM-0024	Photoelectric Probe
Type 3624	100 N Modal Excitation System
Type 3625	200 N Modal Excitation System
Type 3626	400 N Modal Excitation System
Type 3627	650 N Modal Excitation System
Type 3628	1000 N Modal Excitation System
UA-1607	Small Lateral Modal Exciter Stand
UA-1608	Large Lateral Modal Exciter Stand
Type 4808	Small Vibration Exciter (112 N)
Type 4809	Small Vibration Exciter (44 N)
Type 4810	Small Vibration Exciter (10 N)
Type 5961	Hand-held Vibration Excitation Unit
Type 2718	Power Amplifier (75 VA)
Type 2719	Power Amplifier (180 VA)
Type 2720	Power Amplifier (500 VA)
Type 2721	Power Amplifier (1250 VA)
Type 2732	Power Amplifier (120 VA)

Post-processing Software

Type 8400-X	BK Connect Data Viewer
Type 8400-D/E/F	BK Connect Finite Element Interfaces (Nastran, Ansys, Abaqus)
Type 8410-X	BK Connect Geometry‡
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
Type 8760-X	PULSE Operational Modal Analysis Basic
Type 8760-A-X	PULSE Operational Modal Analysis Basic Academic
Type 8761-X	PULSE Operational Modal Analysis Basic to Standard Upgrade
Type 8761-A-X	PULSE Operational Modal Analysis Basic to Standard Academic Upgrade
Type 8761-XS	PULSE Operational Modal Analysis Standard
Type 8761-A-XS	PULSE Operational Modal Analysis Standard Academic
Type 8762-X	PULSE Operational Modal Analysis Standard to Pro Upgrade
Type 8762-A-X	PULSE Operational Modal Analysis Standard to Pro Academic Upgrade
Type 8762-XS	PULSE Operational Modal Analysis Pro
Type 8762-A-XS	PULSE Operational Modal Analysis Pro Academic

BZ-8550-X	PULSE Data Manager Base Module for OMA Pro
BZ-8550-A-X	PULSE Data Manager Base Module for OMA Pro Academic
BZ-8551-X	PULSE Automatic File Upload Module for OMA Pro
BZ-8551-A-X	PULSE Automatic File Upload Module for OMA Pro Academic
BZ-8552-X	PULSE Modal Parameter History Module for OMA Pro
BZ-8552-A-X	PULSE Modal Parameter History Module for OMA Pro Academic
BZ-8553-X	PULSE Damage Detection Module for OMA Pro
BZ-8553-A-X	PULSE Damage Detection Module for OMA Pro Academic
BZ-8554-X	PULSE Drift Analysis Module for OMA Pro
BZ-8554-A-X	PULSE Drift Analysis Module for OMA Pro Academic
BZ-6000-F**	Test for I-deas Core Test
BZ-6015-F**	Test for I-deas Comprehensive Modal
BZ-6016-F**	Test for I-deas Basic Modal
BZ-6017-F**	Test for I-deas Advanced Modal
BZ-6019-F**	Test for I-deas Structural Modification
BZ-6020-F**	Test for I-deas Correlation

* 'X' = licence model, either N for node-locked or F for floating
† Licence embedded in BK Connect Structural Measurements – Hammer and Shaker Type 8411. Animation is provided through BK Connect Geometry Type 8410
‡ Opens up for BK Connect ODS Analysis
** 'F' stands for floating licence. The licence is only available as floating

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