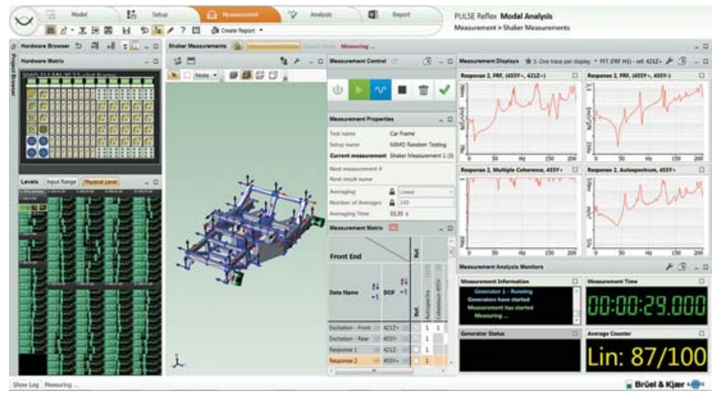
PULSE Reflex Measurements

PULSE Reflex Spectral Analysis Type 8729-A, PULSE Reflex Structural Measurements – Hammer and Shaker Type 8729-B, PULSE Reflex Structural Measurements – Stepped Sine Type 8729-C and PULSE Reflex Geometry Type 8719

PULSE Reflex™ real-time measurements are designed to take advantage of Brüel & Kjær's unique coverage of the complete measurement chain, from transducers and front-end hardware to data acquisition, analysis and reporting. The emphasis is on scalability, from small (single-module) systems to large (multi-module) systems, and high productivity in the traditionally most time-consuming aspects of data measurement:

- *Setting up transducers, channel tables, excitation and analysis parameters*
- *Post-processing, displaying and reporting results*

All measurements are directly accessible by the PULSE Reflex post-processing applications: PULSE Reflex Core for general purpose post-processing, PULSE Reflex Modal Analysis for modal parameter estimation and PULSE Reflex Correlation Analysis for test-FEA model correlation.



Uses and Features

Uses

- Standard FFT data acquisition
- Modal data acquisition and validation
- Impact hammer FRF measurements
- Single- or multi-shaker FRF measurements
- Mechanical impedance or mobility measurements
- Linearity checks and analysis
- Time data recording during measurements
- Integrated solution from structural measurements to FEM correlation with PULSE Reflex Modal Analysis Types 8720 and 8721 and PULSE Reflex Correlation Analysis Type 8722

Features

- Live Monitor showing levels and spectra for all active channels once the system is activated
- Geometry-guided modal data acquisition using PULSE Reflex Modal Analysis or PULSE Reflex Core
- Interactive graphical representation of the front-end hardware using the Hardware Matrix, with coloured light rings to indicate channel status, for example, overloads, just as on the actual LAN-XI hardware
- Easy management and overview of large channel counts
- Automatic detection of TEDS-enabled transducers as well as auto-import of TEDS data
- Integrated transducer manager and database
- Quick assignment of non-TEDS transducers by simple drag and drop (singly or in groups) from database to specific channels
- Transducer verification/calibration with automatic detection of calibration signals and optional automatic application of gain adjustment
- Powerful test geometry creation tools
- Decimation of FE models to test geometries
- Intuitive hammer and shaker setup and measurement tasks
- Wide range of excitation signals including random (continuous, burst, periodic and pseudo), periodic chirp, sine and stepped sine
- Voice feedback during hammer setup and measurement
- Result Matrix tool (as in PULSE Reflex post-processing) for easy display, comparison and reporting of results
- Support of SI and imperial units and acceleration in 'g'
- Support of accelerometers, displacement and velocity transducers for response measurements

Brüel & Kjær

PULSE Reflex Spectral Analysis Type 8729-A lets you set up PULSE Reflex for real-time measurements and spectral analysis. Measurements can be performed either in PULSE Reflex Modal Analysis or PULSE Reflex Core applications.

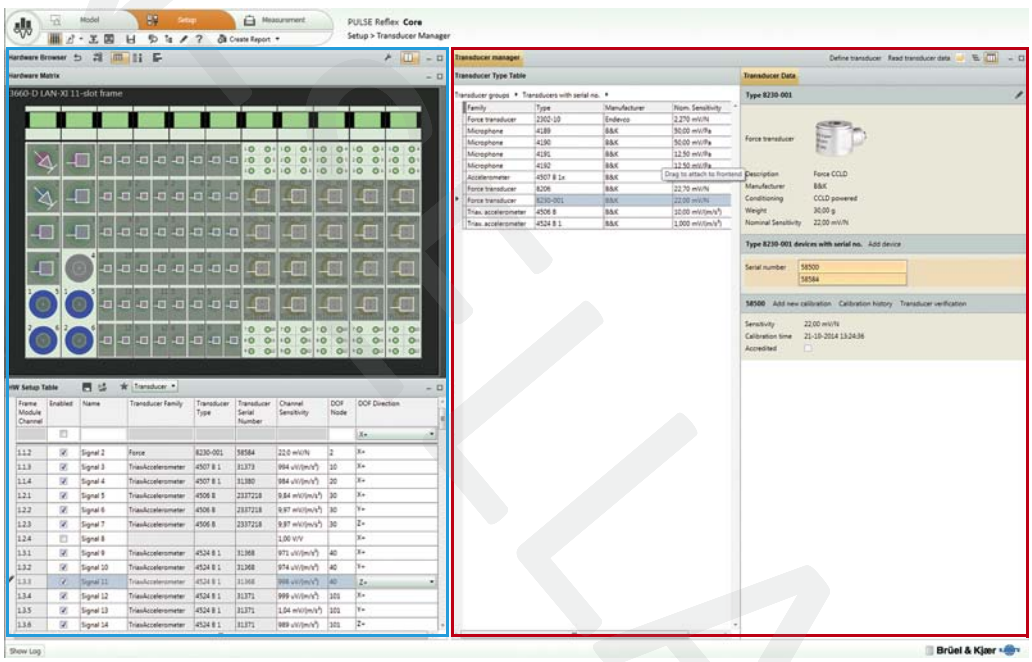
Note:
Connection to the front end requires PULSE Front-end Driver Type 3099-A.

Data Acquisition

Your data acquisition hardware is displayed in the Hardware Browser (Fig. 1, blue frame), graphically using the Hardware Matrix and as a list using the Hardware (HW) Setup Table.

The Hardware Matrix is an interactive graphical representation of the physical hardware that functions both as a channel selector, for choosing channels of interest, and as a status indicator for the measurement system. It can provide useful information for troubleshooting error states such as overloads and cable breaks. The LED rings on the physical LAN-XI front end are reproduced in the Hardware Matrix to provide insight into the physical state of the system. Transient overloads are latched to enable the root cause to be investigated.

Fig. 1
Setup of data acquisition hardware using the Hardware Browser and Transducer Manager. TEDS transducers are recognized automatically, while non-TEDS are easily handled using drag and drop



The Transducer Manager (Fig. 1, red frame) comes with an established database of Brüel & Kjær transducer types. You can easily create new transducer types and new devices of specific types, and add them to the database, making it simple to register your equipment for later use. Triaxial accelerometers are explicitly recognized as a transducer type so that sensitivity data for the three axes is kept together in one device. Images of each transducer type make identification and selection much easier. A calibration history is stored with each transducer making it easy for you to check when the next calibration is due.

When TEDS transducers are present, they are automatically detected. The HW Setup Table automatically updates the hardware list with the TEDS information and the Hardware Matrix indicates, per channel, each transducer with a type-specific symbol. Non-TEDS transducers are not auto-detected, but can easily be assigned to individual channels by dragging and dropping them from the Transducer Manager to the Hardware Matrix. This can be done one-by-one or collectively for a group of channels. If desired, you can instrument a system of 1000 channels or more in one go using transducers of nominal sensitivity.

Simplifying Large System Setup

We know that setting up large systems can be cumbersome, so with PULSE Reflex Measurements we have enabled both single or multiple channel selection in the Hardware Matrix for setup, management and editing. You can even select one or more front-end modules. Channels can be displayed in an abstract, non-physical view, sorted according to channel state, transducer type, or error state. This enables, for example, grouping of overloaded channels for easy troubleshooting.

You can store HW Setup tables and reload them later to restore a known setup. The default file format is XML, but import and copy/paste from Microsoft® Excel® is also supported as well as Universal Dataset number 1808 (Channel Table), enabling offline setup outside PULSE Reflex if desired.

Smart Setup of Transducers via App

PULSE Reflex Measurements interfaces to Brüel & Kjær's Transducer Smart Setup app, making transducer setup as simple, safe and automated as possible. Using the camera on your iOS 8.0 device (or later), you can scan any Brüel & Kjær transducer with a laser-engraved data matrix code for quick and easy reading of transducer data and orientation. If needed, the data matrix code can also give you instant access to specifications, documentation and calibration data. With the transducer information, you can start building a transducer setup project that can be seamlessly exported to the HW Setup table in PULSE Reflex Measurements using a cloud service, an email account or iTunes (via wired transfer).

Fig. 2
Using the Transducer Smart Setup app to scan the data matrix code on the transducer and the label next to the transducer ensures fast and correct DOF information for the measurement

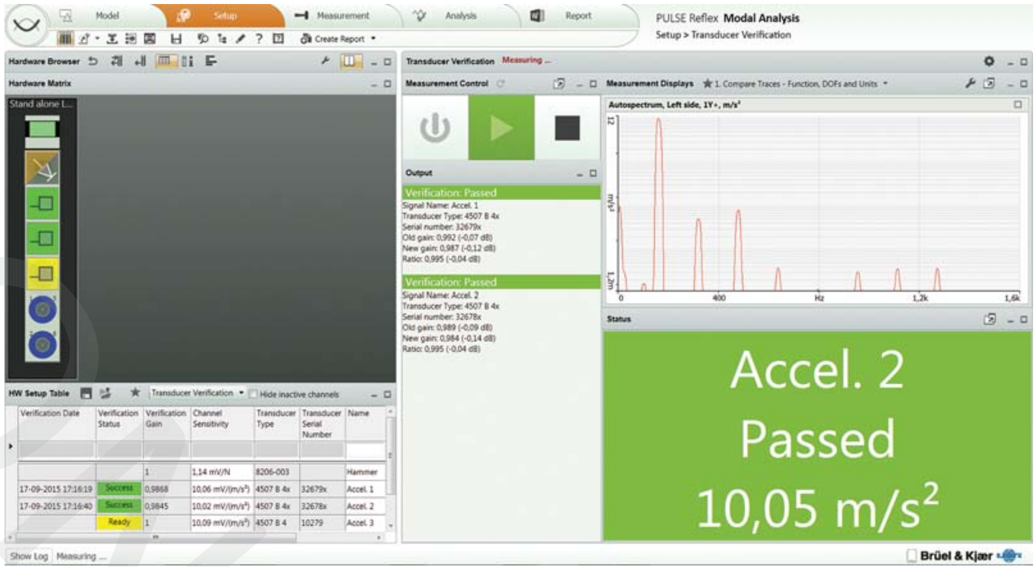
The app can also scan non-Brüel & Kjær 2D matrix codes. This allows you to attach your own customized labels with transducer position (Component ID) and node ID that the app will read and add to a setup project.

If you do not have a transducer with a Brüel & Kjær data matrix code, you can still use the app to build a transducer setup project and transfer it to PULSE Reflex Measurements. You can either select the transducer from a list or type in the transducer data. You get the transducer orientation by aligning the drawing of the transducer in the app with the camera's view.

Verification of Transducers

The Transducer Verification task can be used, together with a hand-held calibrator, for checking the operation of transducers and, optionally, to apply gain adjustment factors for transducers that deviate from their last calibrated sensitivities. More than one calibrator can be used at a time. The software automatically detects the calibration signals and shows the result using a simple green-yellow-red colour coding to indicate pass, in progress, or fail. The colours are latched in the HW Setup Table and the Hardware Matrix to provide an overview of verification/calibration status.

Fig. 3
The Transducer Verification task



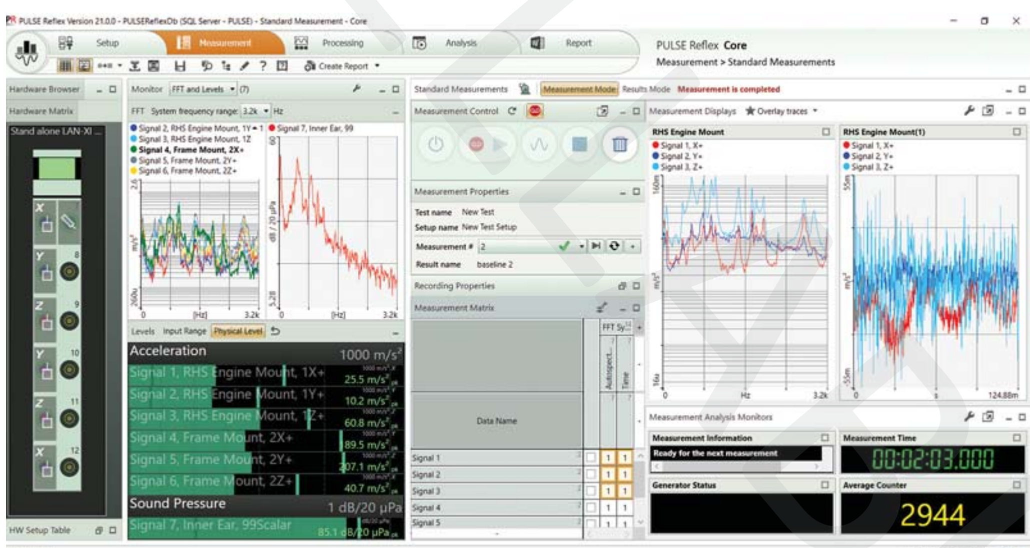
Spectral Analysis

The following stationary FFT spectral measurements are possible:

- Ensemble averaged auto- and cross-spectra, FRF (H1, H2, H3, Hv), and coherence
- MIMO calculation of FRFs and coherence
- Free running or signal triggered

All test setup occurs in the Standard Measurements interface, including triggering, bandwidth, resolution, number of averages, selection of reference signals, and defining output. You can validate the setup using the Level and FFT monitors. These unique monitors are immediately active as soon as the front end is connected and a channel is enabled in the hardware table. They give you quick access to information before, during and after testing.

Fig. 4
Spectral analysis using the Standard Measurements task for real-time FFT measurements and simultaneous recording.
Live spectra and rms levels can be monitored continuously



Once you are satisfied with the setup, start measuring or enable the recording functionality, which allows you to record time data directly to a user-definable folder on your hard drive, for simultaneous recording and measurements.

Real-time measurements are controlled and monitored from a matrix-based user interface. Multiple data sets, for example different measurements, test conditions, or test item build states are easily compared immediately after each measurement. Control buttons for initializing, starting and stopping the measurement and recording are in a separate panel that can be detached and scaled for optimum visibility and ease of use.

When a measurement is complete, you can review it in Results Mode (Fig. 5), which has an almost identical user interface to the Result Matrix viewer in the post-processing software (see PULSE Reflex Base product data). This makes it easy to compare successive measurements where perhaps a key parameter or test item condition has been modified. Measurement data is automatically stored to the Project Browser.

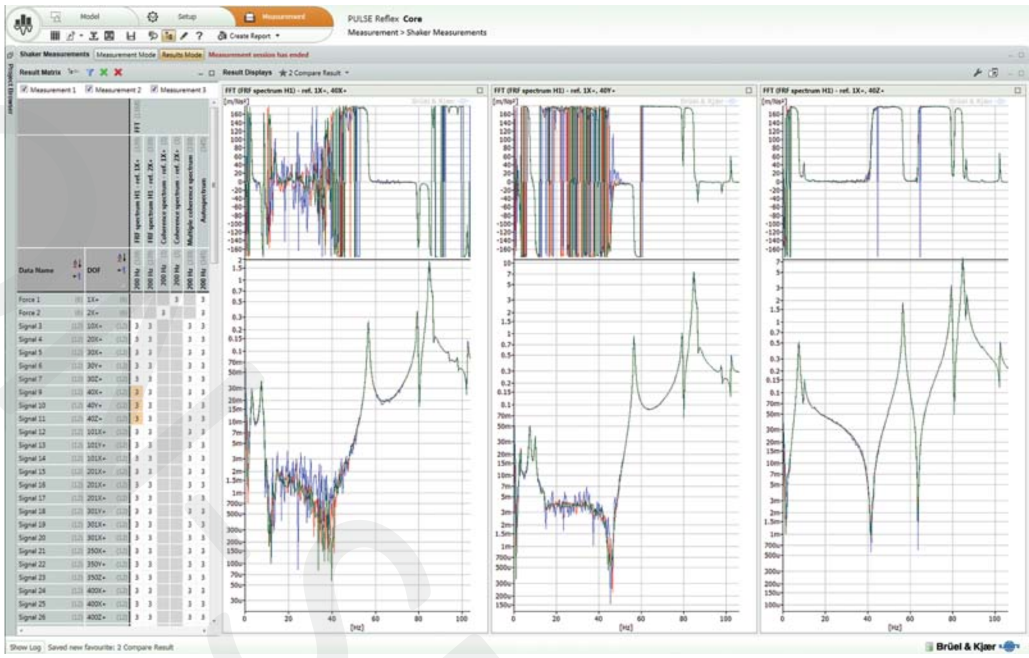


Fig. 5
Three measurements from four separate signals are overlaid and displayed by simply selecting the appropriate cells in the Result Matrix (left). Once set up, a report is only one button click away

For extra data security or extensive analyses, you can record streamed time data during measurement and analyse the recording in detail using a PULSE Reflex post-processing application. The system can even be set up to initiate post-processing immediately after a measurement. For example, you could set up batch processing in PULSE Reflex Core to perform a completely different set of calculations to the real-time measurement, in parallel to the measurement. The results, both from the real-time measurement and the automated post-processing, could then be viewed alongside one another using the Result Matrix.

Performing Modal Analysis

In principle, you can set up and perform modal data acquisition in Type 8729-A. However, as there is no generator control, hammer trigger/response setup or DOF setup in this module, it is highly recommended to use PULSE Reflex Structural Measurements – Hammer and Shaker Type 8729-B for measurements with either shaker or hammer excitation. If stepped sine measurements are to be performed, PULSE Reflex Measurements – Stepped Sine Type 8729-C must be used. For more information on these structural measurement applications, see below.

PULSE Reflex Structural Measurements – Hammer and Shaker Type 8729-B

Type 8729-B adds five dedicated tasks to PULSE Reflex Spectral Analysis Type 8729-A:
- DOF Setup
- Hammer Setup
- Hammer Measurements
- Shaker Setup
- Shaker Measurements

These tasks are dedicated measurements of FRFs and related functions using either hammer or shaker excitation. All other features for hardware setup and post-measurement review and data storage are the same as in Type 8729-A.

Geometry-guided Measurements

Hammer and shaker measurements can be performed based on:

- DOF entries in the HW Setup Table and Auto Increment features in the measurement tasks
- A DOF Sequence table created in the DOF Setup task

When a DOF sequence is defined, geometry-guided measurements can be performed with indication on the geometry which DOFs should be included in the next measurement, which DOFs are currently being measured, which are already measured, and so on. Geometry-guided measurement is, in particular, beneficial when roving excitation and/or response DOFs are used, for example, due to the limited number of available transducers.

The DOF Sequence Task

The DOF Sequence task lets you create a measurement sequence for both hammer and shaker testing. Using a geometry as guidance is generally recommended, but not mandatory. When a geometry is used, transducers from the Transducer Table can be dragged and clicked onto the geometry´s nodes. If a geometry is not present, the DOFs can be defined manually.

You can work with the transducers shown in the HW Setup Table, transducers you have defined as favourites in the Transducer Manager or generic descriptions that are later mapped to the specific transducers used.

The DOF sequence can be generated based on:

- The chronological order the DOFs have been defined
- Increasing node number
- The path through the closest nodes (requires use of geometry)
- Manual selection of DOFs

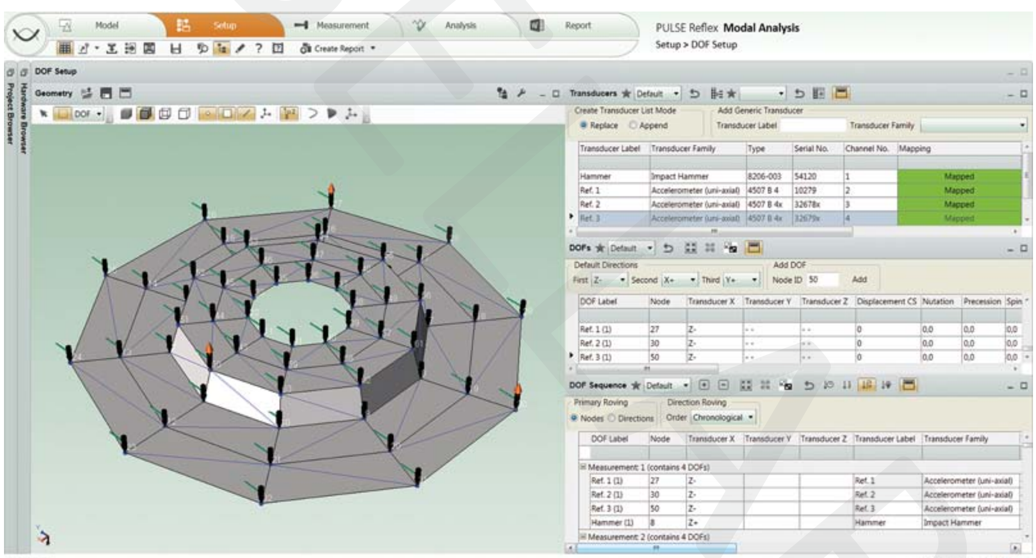


Fig. 6
DOF Setup: Creation of a measurement sequence is flexible and easily performed in the DOF Setup task

Structural Measurements with an Impact Hammer

Single impact as well as random impact testing is supported. With single impact testing, the structure is hit once in a given DOF per FFT time record. With random impact testing, the structure is hit randomly in time multiple times for a given DOF per FFT time record. Random impact testing allows for injecting more energy into the structure per time record. This is useful for large structures (long time records) giving a better signal-to-noise ratio.

The Hammer Setup task helps you to set up hammer triggering and response weighting windows for optimal measurements, when doing single impact testing. For random impact testing, predefined values are used.

The trigger setup is performed by recording a series of typical hammer impacts and with them, interactively setting the signal trigger parameters using special cursors (Fig. 7) for best possible conditioning of the trigger signal.

Response weighting windows help minimize noise and improve the accuracy of the measurement. Dedicated data displays enable you to fine-tune the windows for both the force and the response by typing in the parameters or using graphical grippers (Fig. 8).

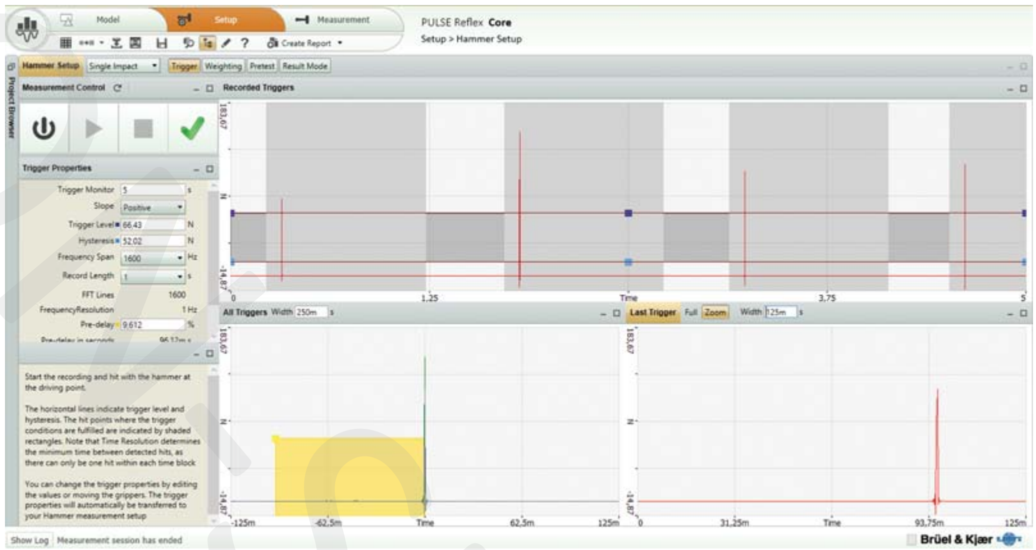


Fig. 7
Hammer Setup: The trigger level and hysteresis are set up using a series of trial impacts (upper graph) and the effects of varying trigger settings, like pre-delay, are observed interactively (lower graphs). The Auto Adjust functionality automatically sets the trigger level and hysteresis

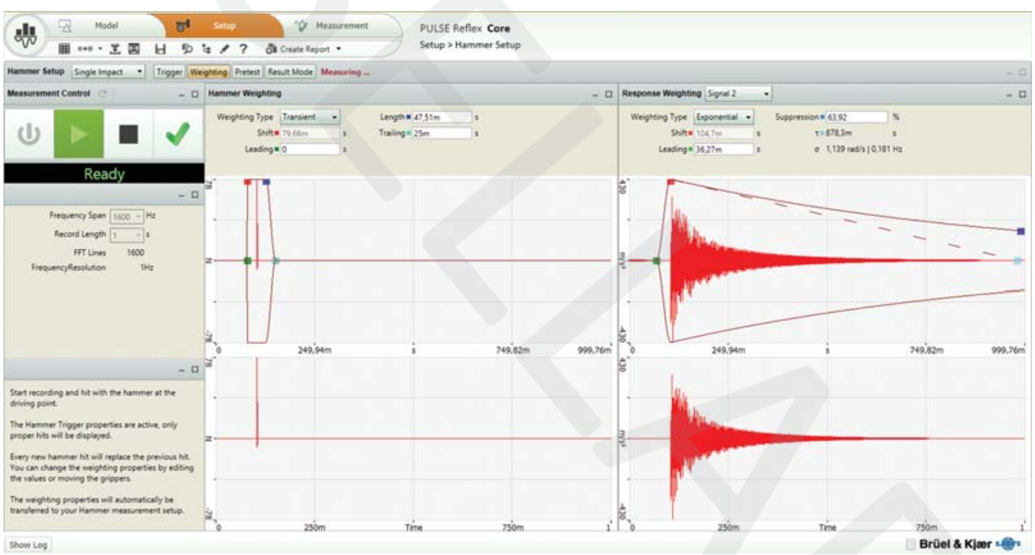
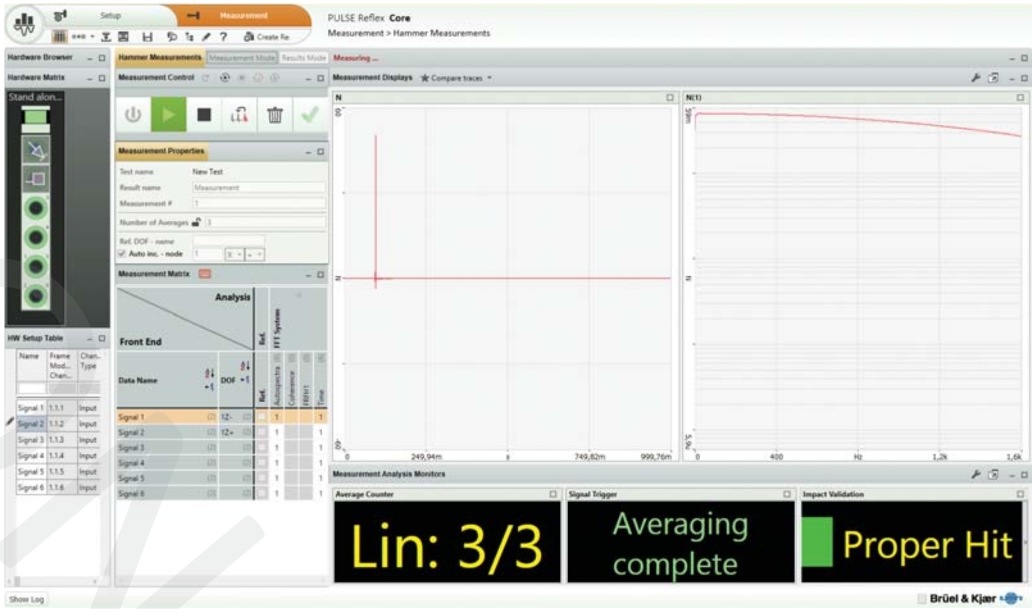


Fig. 8
Hammer Setup: Time weighting can be set up interactively. Raw input force and acceleration response (upper graphs) are compared with weighted data (lower graphs

Once the trigger parameters and weighting windows are set up, there is a pretest mode for verifying that the overall measurement setup is correct. You can store these measurements if desired.

The Hammer Measurements task inherits the settings from the Hammer Setup task and lets you make repeated measurements. It includes a feature for undoing the last average, which can be very helpful when measurement conditions are difficult. Using the Impact Validation monitor, you can easily detect potential double hits, soft hits and unacceptable force level roll-offs, so any unwanted measurements can be avoided. Voice feedback during setup and measurement is also supported with audible alerts such as “ready”, “triggered”, “double-hit” and “overload”, that you keep you aware of measurement events even if you cannot see the screen.

Fig. 9
Hammer Measurement task showing time signal and frequency response of the hammer impact



Structural Measurements with One or More Shakers

The Shaker Setup task lets you prepare for shaker measurements by setting up one or more generators for fixed sine, continuous random, burst random, periodic random, pseudo-random or periodic chirp excitation. For random excitation, the signals are automatically uncorrelated with one another. Key parameters for the generator signals are set using interactive graphical tools for easy adjustment and visualization.

Fig. 10
The Shaker Setup on the right provides interactive controls for the generator signals, in this case two-channel, uncorrelated, continuous random excitation

Once the generator and analysis parameters are set up, there is a pretest mode for verifying that the overall measurement setup is correct. You can store these measurements if desired.

The Shaker Measurements task inherits the settings from the Shaker Setup task and lets you make repeated measurements. The generators are automatically ramped up before averaging starts and automatically ramped down on completion of the last average. This minimizes exposure of the test item to unwanted excitation input.

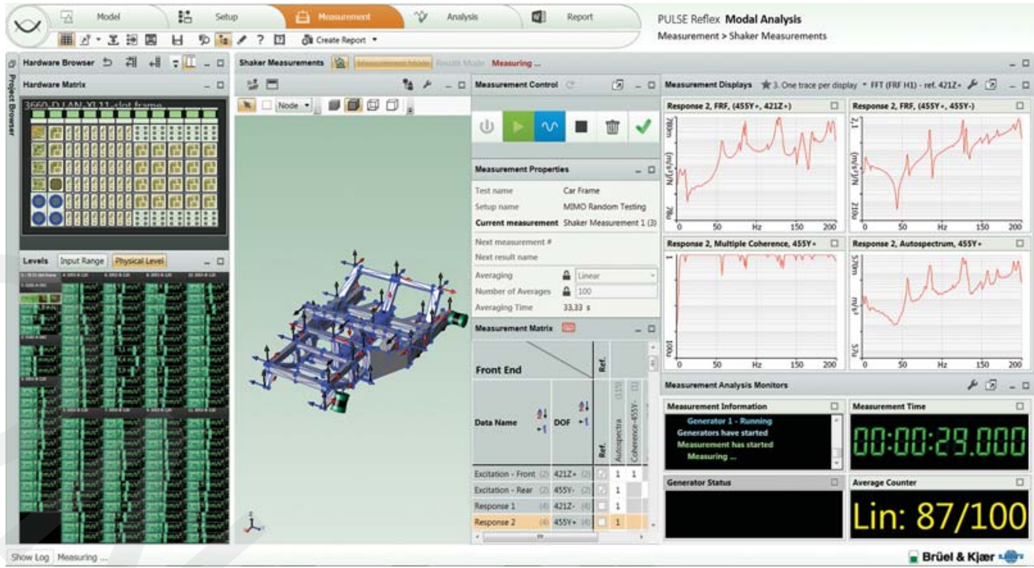


Fig. 11
Shaker Measurements task for easy setup and monitoring of time and frequency functions

PULSE Reflex Structural Measurements – Stepped Sine Type 8729-C

Type 8729-C adds three tasks to PULSE Reflex Spectral Analysis Type 8729-A:
- DOF Setup
- Stepped Sine Setup
- Stepped Sine Measurements

These tasks are dedicated measurements of FRFs and related functions using stepped sine excitation. Geometry-guided measurements can be performed as seen with Hammer and Shaker Type 8729-B measurements. All other features for hardware setup and post-measurement review and data storage are the same as in Type 8729-A.

Stepped Sine Measurements

Stepped sine measurement is a technique where sine excitation and corresponding measurements are made at predefined fixed frequencies (step frequencies). After the measurement at each step frequency, the frequency is swept to the next step frequency. The step type, the step frequency interval and the step direction(s) are user-defined.

Advantages of stepped sine testing includes:
- High signal-to-noise ratio
- Low crest factor of the excitation signal
- Possibility to control excitation and response amplitude
- Concentration of energy allowing smaller shakers to be used compared to broadband testing

Applications of stepped sine measurements include:
- Leakage-free FRF measurements as input to very accurate modal analysis
- Resonance surveys
- Forced response ODS analysis
- Control and study of non-linearities

Performing Stepped Sine Measurements

With Type 8729-C, stepped sine measurements can be performed with single-shaker excitation (SIMO) and multi-shaker excitation (MIMO). For multi-shaker excitation, the calculation of the MIMO FRFs requires more stepped sine sweeps, where the phases between the excitation forces are changed for each sweep.

Type 8729-C can be set up to perform a classical full MIMO sweep series with *N* shakers consisting of 2(*N-1*) independent sweeps, where the excitation phases are either in-phase or out-of-phase. In addition, a more time efficient optimal MIMO sweep series of only *N* sweeps can be performed using a more efficient phase distribution scheme.

Type 8729-C supports closed-loop control. Each generator, with corresponding shaker, can be set up to attempt control of the amplitude and/or the phase of a selected control signal. The control signal can be a force signal or a response signal. A target RMS and/or phase with corresponding tolerance is specified. The phase to be controlled is the relative phase between the control signal and a selected reference force signal. This allows for measurements where an excitation force or a response signal is controlled and attempted to be kept constant at a target RMS and/or phase at all frequencies during the stepped sine sweep (or sweeps in cases of multiple shakers).

In order to protect the test item and avoid high response levels during the measurements, alarm and abort levels for each signal can be specified in the HW Setup table. The levels are taken directly from your LAN-XI front-end hardware to avoid any software delays.

If alarm levels are exceeded, a warning is given in the Level Meter and, if an abort level is exceeded, the measurement will stop and the generators will shut down.

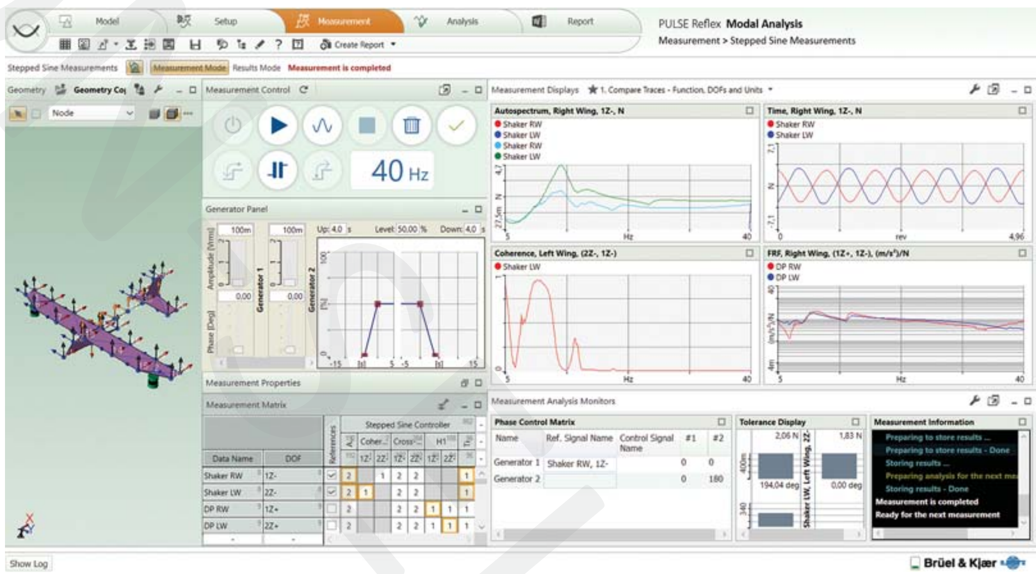


Fig. 12
The Stepped Sine Measurements task contains various tools for controlling the measurements and generators, monitoring status information and viewing data

PULSE Reflex Geometry Type 8719

PULSE Reflex Measurements also provides you with the tools to quality-check your measurement results. With the Measurement Validation task (Fig. 13) you can animate the measured FRFs to validate the setup and troubleshoot errors in DOF assignment or transducer sensitivity. Often an error is immediately visible and you can quickly correct it before performing the analysis. You can also select on the geometry the DOFs that you want to use for the functions to be displayed. Data can be sorted and filtered to easily select individual functions.

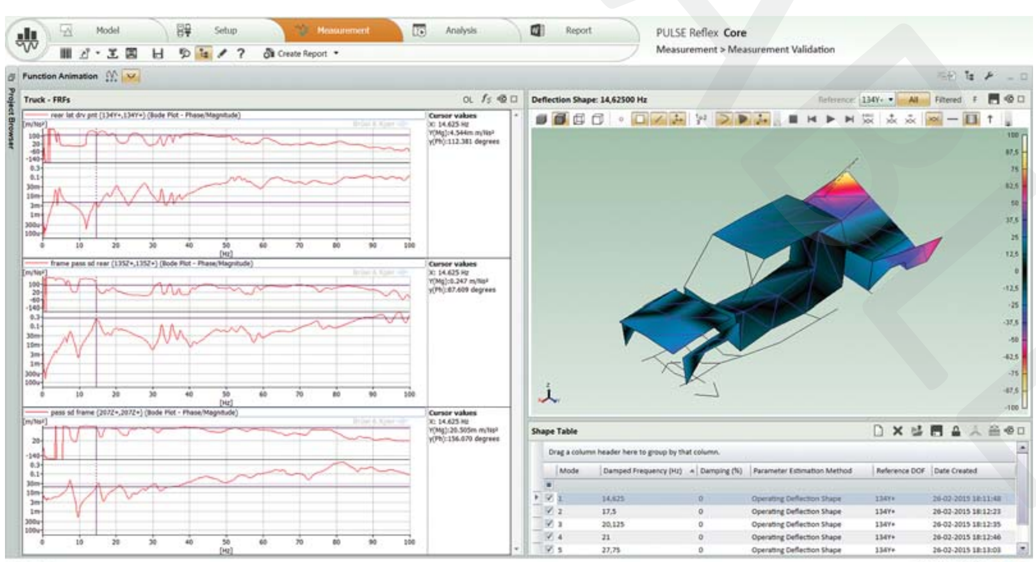


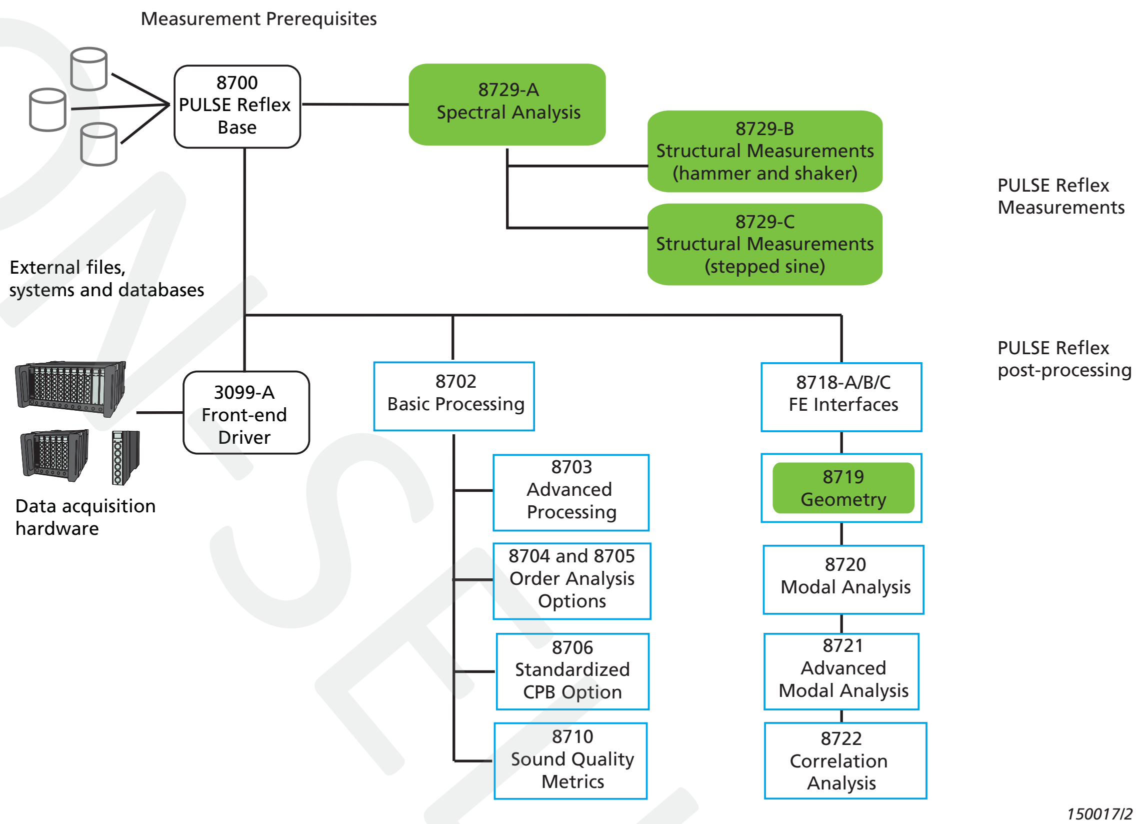
Fig. 13
Measurement Validation: Animation of the amplitude and phase of measured FRFs at a cursor-selected frequency

To perform the Measurement Validation task, you must have the PULSE Reflex Geometry Type 8719 module.

With PULSE Reflex Geometry, you can also create a geometry from scratch, import the geometry or extract the test geometry by decimating an imported finite element model (UFF, Nastran, ANSYS or ABAQUS finite element model formats supported)*.

Product Structure

Fig. 14
Product structure for PULSE Reflex products – from measurement to test-FEA integration



Spectral Analysis Type 8729-A includes the following tasks:

- Transducer Manager
- Transducer Verification
- Standard Measurements

Structural Measurements – Hammer and Shaker Type 8729-B adds the following tasks to Type 8729-A:

- DOF Setup
- Hammer Setup
- Hammer Measurements
- Shaker Setup
- Shaker Measurements

Structural Measurements – Stepped Sine Type 8729-C adds the following tasks to Type 8729-A:

- DOF Setup
- Stepped Sine Setup
- Stepped Sine Measurements

Geometry Type 8719 adds the following tasks to Type 8700:

- Geometry Editor
- Geometry Decimation
- Measurement Validation

* Nastran (MSC, NX and NEi), ANSYS and ABAQUS finite element model import is supported with PULSE Reflex FE Interface Types 8718-A, B and C, respectively.

Prerequisites for Measurement

PULSE Reflex Type 8700

PULSE Reflex Base Type 8700 is the prerequisite for all PULSE Reflex applications. It provides project file and data import, metadata and general test data management, offline calculations on stored data, graphical displays, and integrated reporting tools.

PULSE Front-end Driver Type 3099-A

Front-end Driver Type 3099-A is required to acquire data from PULSE data acquisition hardware, including LAN-XI data acquisition modules and frames.

Post-processing in PULSE Reflex

All measurements are directly accessible by the PULSE Reflex post-processing applications.

The PULSE Reflex post-processing platform brings together a range of generic post-processing tools for immediate and offline analysis and processing of measurement data. Data viewing, storage and reporting are built into the workflow with immediate traceability via an SQL database. Special tools and features allow for quick data overviews and automatic report creation based on user-definable templates – the aim is to make the task of data processing and reporting as simple and straightforward as possible, giving testers and engineers more time to focus on result interpretation

PULSE Reflex Core Types 8702, 8703, 8704, 8705, 8706 and 8710

PULSE Reflex Core is a general purpose sound and vibration signal analysis and reporting application, enabling engineers to perform a range of signal analysis types with high productivity. The tools are built into a framework that provides for fully automated operation, including batch processing and the ability to create project templates to standardize and simplify repetitive processes.

For more information, see the product data for PULSE Reflex Core.

PULSE Reflex Modal Analysis

Modal Analysis Type 8720 is an application designed for single-reference modal analysis with a basic, yet comprehensive, set of mode indicator functions (MIFs), curve-fitters and analysis validation tools. For use with single shaker FRF data and single reference hammer testing data.

Advanced Modal Analysis Type 8721 adds polyreference modal analysis capabilities and advanced mode indicator functions, curve-fitters and analysis validation tools to the Modal Analysis application. For use with shaker MIMO (multiple input multiple output) FRF data, polyreference hammer testing data or for advanced analysis and validation of both single- and polyreference data.

Type 8729-A/B/C tasks can be executed inside PULSE Reflex Modal Analysis. There is no switching between applications when going from setup, measurement and on to analysis – simply progress to the next task.

For more information, see the product data for PULSE Reflex Modal Analysis.

PULSE Reflex Test-FEA Integration

FE Interfaces Type 8718-A/B/C enables you to import FE models from Nastran®, ANSYS® and ABAQUS®. Correlation Analysis Type 8722 adds the ability to correlate two modal models: FEM vs test, test vs test or FEM vs FEM.

For more information, see the product data for PULSE Reflex Correlation Analysis.

System

SYSTEM REQUIREMENTS

- PULSE v.21 or later
- Microsoft® Windows® 10 Pro or Enterprise (x64), Windows® 8.1 Pro or Enterprise (x64), or Windows® 7 Pro, Enterprise or Ultimate (SP1) (x64) operating system

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
- DVD-RW drive
- 1 Gbit Ethernet network
- Microsoft® Windows® 10 Pro or Enterprise (x64)
- Microsoft® Office 2016 (x32)
- Adobe® Reader® 11
- Microsoft® SQL Server® 2014 Express (SP1) (included in installation)

Software Prerequisites

Type 8729-A requires PULSE Reflex Base Type 8700 and PULSE Front-end Driver Type 3099-A (to connect to a PULSE front end)

Hardware Configuration

The software automatically detects the front-end hardware and configures the system. If IEEE 1451.4 capable transducers (with standardized TEDS) are being used, these are detected and attached automatically to the correct input channels.

HARDWARE BROWSER

The Hardware Browser combines an interactive display of the front-end hardware, called the Hardware Matrix, and a channel list called the HW Setup Table. These two components, working together, provide a highly efficient way to work with any size system

Header bar buttons in the Hardware Browser allow for:

- Resetting of channel status
- Reconnecting the front end
- Display of either the HW Setup Table, the LAN-XI home page, or an overall level meter for all channels

HARDWARE MATRIX

The Hardware Matrix has the following functionality:

- Signal levels indicated using coloured rings
- Channel overload status, using different symbols for different types of overload
- Transducer status, using symbols to identify each transducer type
- Calibration/verification status when used in the Transducer Verification task
- Drop destination for transducers dragged from the Transducer Manager
- Channel selector for the HW Setup Table and overall level meter
- Automatic indication of TEDS transducers

Available Matrix Display Styles:

- Physical: A visually representative display of the physical front-end hardware
- Logical: Channels shown as coloured rings in the same configuration as the physical hardware

Hardware Monitor

MONITORS

FFT Monitor: Monitors spectra for all active channels or selected channels, grouped automatically based on the physical quantity

Levels Monitor: Monitors the overall levels displayed in voltage or physical quantity for all active or selected channels

LAYOUT VIEWS

- Square Grid: Completely dynamic. Signals form a best-fit grid in the available screen space using coloured rings to display signal amplitude
- Bar Grid: Completely dynamic. Signals form a best-fit grid in the available screen space using bars to display signal amplitude

Note that the grid displays can be sorted according to Signal Name, Maximum Level, Minimum Level and Level Range

HW SETUP TABLE

The HW Setup Table contains all information about the front-end hardware and any transducers connected to it. The number of rows displayed in the table depends on the channel selection made in the Hardware Matrix, the default being all channels. The size of the table updates dynamically according to which channels are selected in the Hardware Matrix, making it very easy to focus on subsets of channels when needed

Editing the Table:

- Manual editing of channel information
- Update from an external XML or UFF 1808 (Channel Table) file or from Microsoft® Excel®
- Save HW Setup Table contents to an external XML or UFF 1808 (Channel Table) file for later use
- Create different (favourite) views to tailor which columns should be shown

TRANSDUCER MANAGER

The Transducer Manager works with a Microsoft® Access® database (as used by PULSE LabShop) to manage transducer specifications and calibration information. A full set of Brüel & Kjær transducer types, with nominal sensitivities, is provided with all PULSE installations, but more can be added using the Transducer Manager. Each transducer type can have a number of devices of that type, each with its own unique calibration history

Adding Transducers: Individual devices, or groups of devices, can be dragged and dropped onto the Hardware Matrix to add transducers to the configuration and/or add calibration/sensitivity information:

- Drag a transducer type to many (or all) channels. The HW Setup Table applies the nominal sensitivity for that type to the selected channel(s)
- (Typical) Drag specific devices to individual channels where they are known to be physically connected

Transducer Verification

Transducer Verification (under Setup) can be used either to verify that transducers are functioning correctly, or to make a new calibration

A transducer calibrator is used to apply the necessary excitation for either verification or calibration. Multiple calibrators can be used simultaneously

The software automatically detects the calibrator signal and performs the verification/calibration, with coloured status indicators in the Hardware Matrix and HW Setup Table showing In Progress, Failed or Passed. At the end of the procedure, the Transducer Manager is updated along with the HW Setup Table and calibration information is added to the device's calibration history

Data Display

PULSE Reflex displays, for general data display and reporting, are described in the PULSE Reflex post-processing software product data, BP 2258. There are additional real-time monitoring displays, designed for speed, in PULSE Reflex Measurements

REAL-TIME MONITORING DISPLAYS
Graph Types: Curve
Superimposed Graphs: A number of functions can be superimposed on the same curve graph
Axes:
- **X-axis Scale:** Linear and logarithmic
- **Y-axis Scale:** Linear and logarithmic
- **Z-axis Scale:** Linear and logarithmic

Complex Displays:
- Real
- Imaginary
- Magnitude
- Phase

Spectral Units:
- Root mean square (RMS)

Measurement Control

AVERAGING
Averaging can be performed either in the frequency or time domain. Averaging types available for the measured signals are:
- Linear (fixed number of blocks)
- Linear All (full time range)
- Exponential
- Maximum hold

Overlap: User-selectable values of 0%, 50%, 66.67%, and 75%; user-editable from 0% to 95%

Measurement

FFT ANALYSIS
Frequency Range:
- Baseband and Zoom: 50 – 102400 lines
- Frequency Span: 1 Hz – 204.8 kHz in 1, 2, 5 … or 2^n (1, 2, 4, 8 …) sequence (depending on hardware)

Signal Type: Continuous Random, Pseudo Random, Transient
Properties are automatically set up to a logical default; for example, when transient type is selected, Signal Trigger is selected as the triggering mode
Triggering Modes:
- Free run
- Signal Trigger: Trigger attributes include level, hysteresis, slope, hold-off, delay and divider

Time Weighting:
- Uniform
- Hanning
- Flat-top
- Kaiser-Bessel

Output: Autospectrum, H1, H2, H3 and Hv FRFs, Coherence, Cross-spectrum, Phase-assigned Spectrum, Signal-to-Noise, Coherent Power, Non-coherent Power, Time, Weighted Time

TIME DATA RECORDING DURING MEASUREMENTS
File Format: Recording in PTI file format
Baseband Frequency Span: 50 Hz – 204.8 kHz in 2^n (1, 2, 4, 8, …) sequence (depending on hardware)

UNITS
SI and imperial units as well as acceleration shown as ‘g’ are supported in the Hardware Browser (Hardware Matrix, HW Setup Table, Level Meter) and in the Setup and Measurement tasks

Type 8729-B adds to the functionality and specifications of PULSE Reflex Spectral Analysis Type 8729-A by adding setup and measurement of FRFs (and related functions) using either hammer or shaker excitation

Prerequisites

Type 8729-B requires PULSE Reflex Base Type 8700, PULSE Front-end Driver Type 3099-A (to connect to a PULSE front end), and PULSE Reflex Spectral Analysis Type 8729-A. PULSE Reflex Geometry Type 8719 is required for geometry-guided measurements

Geometry-guided Measurements

Supported for both hammer and shaker measurements

DOF SETUP
For defining the DOFs to be measured and the DOF Sequence

- Using transducers from the HW Setup Table, favourites transducers defined in the Transducer Manager or generic transducers
- DOFs are defined by dragging transducers to the geometry nodes or by manual definition
- Creation of DOF Sequence based on:
  – Chronological order the DOFs have been defined
  – Increasing node number
  – Path through the closest nodes (requires use of geometry)
  – Manual selection of DOFs

Hammer Setup

For single impact and random impact test setups

TRIGGER
Record a set of experimental hammer impacts and display as time history. Using graphical tools, adjust the trigger parameters directly on the data display, or by direct parameter entry, until the desired trigger behaviour is achieved. An Auto Adjust functionality set the Trigger Level and Hysteresis automatically. The aim is to condition the trigger parameters for maximum success in the actual measurement

WEIGHTING
The hammer signal and a response signal are displayed in graphs with graphical tools for adjusting the type and amount of time weighting to be applied to each. The aim is to use as much of the measured signals as possible whilst minimizing noise

PRETEST
Experiment with different FFT settings (bandwidth, number of spectral lines) and perform trial measurements for display and (optional) storage to the database

RESULT MODE
Pretest measurement results can be viewed and overlaid with previous measurements before storing to the database

Hammer Measurements

The Hammer Measurements user interface is streamlined for typical hammer test scenarios in which the hammer excitation location is roved from point to point or performed at a fixed location. All measurement parameters are inherited from the Hammer Setup.
Key features include:

- Last hit undo
- Double-hit detection
- Frequency content warning (soft hit)
- Auto-increment of the reference DOF after a measurement

MEASUREMENT MODE
Includes a measurement control panel that is detachable and resizable
Control Buttons:

- Initialize analysis system
- Measurement start/stop
- Undo last hit
- Delete last measurement

RESULT MODE
Measurement results can be viewed and overlaid with previous measurements

VOICE FEEDBACK
Audible status/error warnings during hammer testing setup and measurement

Shaker Setup

Set up the generator(s) and FFT properties before measurement

GENERATOR CONTROL
Graphical tools can be used for setting up excitation type, frequency parameters, output level, level ramp up/down times, and whether burst excitation is to be used
Generator Signal Types:

- Sine (fixed frequency)
- Continuous and Burst Random
- Periodic and Pseudo-random
- Periodic chirp

ANALYSIS SETTING
FFT properties are adjusted to match generator settings, but can be independently adjusted if desired. Interface tools are highly interactive, enabling engineers to quickly assess when the settings are appropriate for the structure under test

PRETEST
Experiment with different FFT settings (bandwidth, number of spectral lines) and perform trial measurements for display and (optional) storage to the database

RESULT MODE
Pretest measurement results can be viewed and overlaid with previous measurements before storing to the database

Shaker Measurements

Classical Modal Analysis (with single/multiple references):
Autospectra, Cross-spectra, FRF, Impulse response, Coherence and Correlation functions

MEASUREMENT MODE
Includes a measurement control panel that is detachable and resizable
Control Buttons:

- Initialize analysis system
- Generator start/stop
- Measurement start/stop

The averaging setup can be adjusted from within this mode

RESULT MODE
Measurement the results can be viewed and overlaid with previous measurements

Measurement Validation

Requires PULSE Reflex Geometry Type 8719

GEOMETRY DRIVEN FUNCTION DISPLAYS
Show FRFs based on selected excitation and response DOFs on the geometry

FUNCTION-BASED ANIMATION
Animate geometry using, for example, FRFs or phase-assigned spectra (PAS) for ODS analysis. Saving of shapes in Shape Table

Type 8729-C adds to the functionality and specifications of PULSE Reflex Spectral Analysis Type 8729-A by adding setup and measurement of FRFs (and related functions) using single- or multiple-shaker stepped sine excitation

Prerequisites

Type 8729-C requires PULSE Reflex Base Type 8700, PULSE Front-end Driver Type 3099-A (to connect to a PULSE front end), and PULSE Reflex Spectral Analysis Type 8729-A. PULSE Reflex Geometry Type 8719 is required for geometry-guided measurements

Geometry-guided Measurements

Supported for both hammer and shaker measurements

DOF SETUP

For defining the DOFs to be measured and the DOF Sequence

- Using transducers from the HW Setup Table, favourites transducers defined in the Transducer Manager or generic transducers
- DOFs are defined by dragging transducers to the geometry nodes or by manual definition
- Creation of DOF Sequence based on:
  – Chronological order the DOFs have been defined
  – Increasing node number
  – Path through the closest nodes (requires use of geometry)
  – Manual selection of DOFs

Stepped Sine Setup

Set up the closed loop control, the generator(s) and the analysis parameters before measurement

CLOSED LOOP CONTROL

Software based
Type: None, Amplitude, Phase, Both
Parameters: Amplitude Tolerance, Phase Tolerance, Control Strength (Strong, Balanced, Gentle), Max. Control (Time, Periods), Control Fail Action (Stop, Continue)
Analysis Parameters: Settling Type (Time, Periods), Settling Time

Phase Control Matrix for manually or automatic specification of phase control and showing the phase relations between the excitation signals.
Force and Control Signal Monitor with amplitude and phase readout including tolerance bands

SWEEP MODES

- Optimal Sweep Series: Phases uniformly distributed
- Full MIMO Sweep Series: Phases either 0 or 180 degrees
- Manual: User-defined phases
- Specific Sweep Series: User-defined subset of sweeps

GENERATOR PARAMETERS

Step Type (Linear, Log (Octaves), Log (Decades)), Step Size, Lower Frequency, Upper Frequency, Step Direction (Up, Down, Alternating), Start Frequency (Lower, Upper), Transition Mode (Fixed Time, Automatic)

GENERATOR CONTROL

Graphical tools for setting up master control and individual generators with respect to ramp up/down, amplitude and phase

Stepped Sine Measurements

MEASUREMENT MODE

Includes a measurement control panel that is detachable and resizable
Control Buttons:

- Initialize analysis system
- Generator start/stop
- Measurement start/stop
- Dwell/sweep mode
- Step sine frequency – adjustable when dwelling
- Frequency step upwards/downwards while dwelling

ALARM AND ABORT LEVELS

- Alarm and abort levels for each signal can be specified in the HW Setup Table
- If alarm level is exceeded, a warning is given in the Level Meter
- If abort level is exceeded, the measurement will be stopped and the generators will be shut down
- Detection of alarm and abort levels are detected in the LAN-XI input modules

Geometry Creation, Import and Decimation

GEOMETRY CREATION AND EDITING

- Basic geometries using nodes, tracelines, 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
- CAD models with selectable colour and transparency
- Move (translate, rotate) and copy (linear, radial) operators for CAD models and meshes using interactive handles or manual entry
- Definition of locations with three directions on a CAD model (Sites)
- Definition of locations with three directions on a CAD model (Sites)
- Meshing of built-in CAD models
- Extrusion of CAD models: Curves can be extruded to surfaces. Plane surfaces can be extruded to solids. Preselection of colour is available
- Hierarchical geometry tree view with subfolders for Coordinate Systems, Nodes, Elements, Tracelines and Equations
- Tables for Coordinate Systems, Nodes, Elements, Tracelines and Equations with sorting, filtering, multiple selection and editing
- Support of Cartesian, Cylindrical and Spherical coordinate systems. Local and Global coordinate systems
- Automated point numbering. Partial or complete semi-automated point renumbering

Visual link between selections in Geometry 3D View and Geometry Tree

GEOMETRY IMPORT FORMATS

- UFF data set types 15, 18, 82, 2411 or 2412 and Microsoft® Excel® (*.csv)
- UFF FE models
- Nastran (MSC, NX, NEi), ANSYS and ABAQUS FE models (requires PULSE Reflex FE Interfaces Type 8718)

GEOMETRY EXPORT FORMATS

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

DECIMATION

Imported FE models can be decimated to test models by manually selecting nodes on the FE model or by entering the nodes directly in a table

DYNAMIC POINT NUMBERING

Show more point numbers (IDs) when zooming in on parts of the geometry (user-definable) – also during animation

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, velocity transducer and displacement transducer positions shown on geometry with customized colours and sizes

CUTTING PLANES

Cut through a geometry in three user-definable 2D planes to view the interior or exclude viewing parts of the geometry – also during animation

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
- Geometry legends showing information about the shapes being animated such as shape number, frequency and complexity
- AVI video file generation with selectable codec and geometry legends

Type 8729-A **PULSE Reflex Spectral Analysis**

Prerequisites for Type 8729-A:
- Type 8700-x*: PULSE Reflex Base
- One of the following hardware drivers:
  - Type 3099-A-X: PULSE LAN-XI and IDA^e/IDA Multiple Module Front-end Driver
  - Type 3099-A-X1: PULSE LAN-XI Single Module and IDA^e/IDA Systems Any Size Front-end Driver
  - Type 3099-A-X2: PULSE LAN-XI Dual Module and IDA^e/IDA Systems Any Size Front-end Driver

Type 8729-B **PULSE Reflex Structural Measurements – Hammer and Shaker**

Prerequisites for Type 8729-B:
- Type 8700-x*: PULSE Reflex Base
- One of the following hardware drivers:
  - Type 3099-A-X: PULSE LAN-XI and IDA^e/IDA Multiple Module Front-end Driver
  - Type 3099-A-X1: PULSE LAN-XI Single Module and IDA^e/IDA Systems Any Size Front-end Driver
  - Type 3099-A-X2: PULSE LAN-XI Dual Module and IDA^e/IDA Systems Any Size Front-end Driver
- Type 8729-A: PULSE Reflex Spectral Analysis

Type 8729-C **PULSE Reflex Structural Measurements – Stepped Sine**

Prerequisites for Type 8729-C:
- Type 8700-x*: PULSE Reflex Base
- One of the following hardware drivers:
  - Type 3099-A-X: PULSE LAN-XI and IDA^e/IDA Multiple Module Front-end Driver
  - Type 3099-A-X1: PULSE LAN-XI Single Module and IDA^e/IDA Systems Any Size Front-end Driver
  - Type 3099-A-X2: PULSE LAN-XI Dual Module and IDA^e/IDA Systems Any Size Front-end Driver
- Type 8729-A: PULSE Reflex Spectral Analysis

PULSE REFLEX STRUCTURAL DYNAMICS OPTIONS

Type 8718-A-x*	PULSE Reflex Nastran Interface
Type 8718-B-x*	PULSE Reflex ANSYS Interface
Type 8718-C-x*	PULSE Reflex Abaqus Interface
Type 8719-x*	PULSE Reflex Geometry (required for DOF Setup and Measurement Validation)
Type 8720-x*	PULSE Reflex Modal Analysis
Type 8720-A-x*	PULSE Reflex Modal Analysis Pack
Type 8721-x*	PULSE Reflex Advanced Modal Analysis
Type 8721-A-x*	PULSE Reflex Advanced Modal Analysis Pack
Type 8722-x*	PULSE Reflex Correlation Analysis

ANNUAL SOFTWARE MAINTENANCE AND SUPPORT AGREEMENTS

M1-3099-A-X	Agreement for Type 3099-A-X
M1-3099-A-X1	Agreement for Type 3099-A-X1
M1-3099-A-X2	Agreement for Type 3099-A-X2
M1-8700-x*	Agreement for Type 8700
M1-8718-A-x*	Agreement for Type 8718-A
M1-8718-B-x*	Agreement for Type 8718-B
M1-8718-C-x*	Agreement for Type 8718-C
M1-8719-x*	Agreement for Type 8719
M1-8720-x*	Agreement for Type 8720
M1-8720-A-x*	Agreement for Type 8720-A
M1-8721-x*	Agreement for Type 8721
M1-8721-A-x*	Agreement for Type 8721-A
M1-8722-x*	Agreement for Type 8722
M1-8729-A-x*	Agreement for Type 8729-A
M1-8729-B-x*	Agreement for Type 8729-B
M1-8729-C-x*	Agreement for Type 8729-C

* "x" indicates the license model, either N: Node-locked or F: Floating

BP 2518 – 14 2016-11

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