USER MANUAL

Brüel & Kjær®
Electroacoustics Engine BZ-7852

for use with
Production Test USB DAQ Type 3670

BN 2589 – 11
English

Electroacoustics Engine
BZ-7852

for use with:
Production Test USB DAQ Type 3670

User Manual

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Chapter 1

Introduction

1.1 About this manual

This manual provides instructions for installing and using Electroacoustic Engine BZ-7852 (EA Engine) and describes the technical background of the technology and its application. Details are provided for the network environment configuration that is needed to run the software.

This manual is divided into two parts:

1) Description of the process flow to prepare the EA Engine and Production Test USB DAQ Type 3670 to perform electroacoustic measurements
2) Reference material with the commands and command syntax

For information regarding the installation and use of Type 3670 data acquisition system on a PC, please refer to the appropriate manual downloadable from the website.

1.2 About Electroacoustics Engine BZ-7852 (EA Engine)

The EA Engine is intended as a toolbox of complete electroacoustic tests designed to be driven from user-defined third-party software. Its purpose is to generate electroacoustic measurement data, primarily in a production QA environment, that can be further manipulated by other, user-defined software to evaluate the audio quality of products and enable pass/fail decisions.

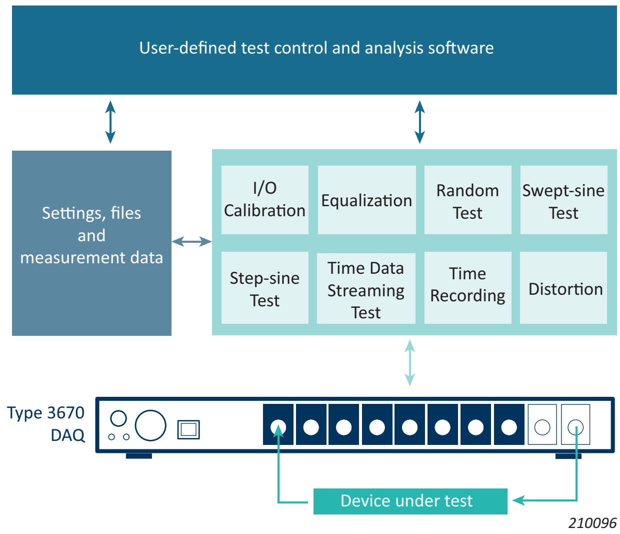
The software is entirely command driven and has no user interface. It can be executed manually from a Windows® command prompt but is intended to be automated from software issuing the same commands as a client.

In general, the measurement parameters are controlled by values stored in dedicated XML files on the host computer and these can be edited manually in a text editor or programmatically from a user-defined application.

The software only works with the Production Test USB DAQ Type 3670 and requires the host computer to be connected to recognised hardware before it can be initialised.

The key concept and the interaction of the main functional elements are shown in the diagram in Fig. 1.1.

Fig. 1.1 *The interaction between the EA Engine and Type 3670*

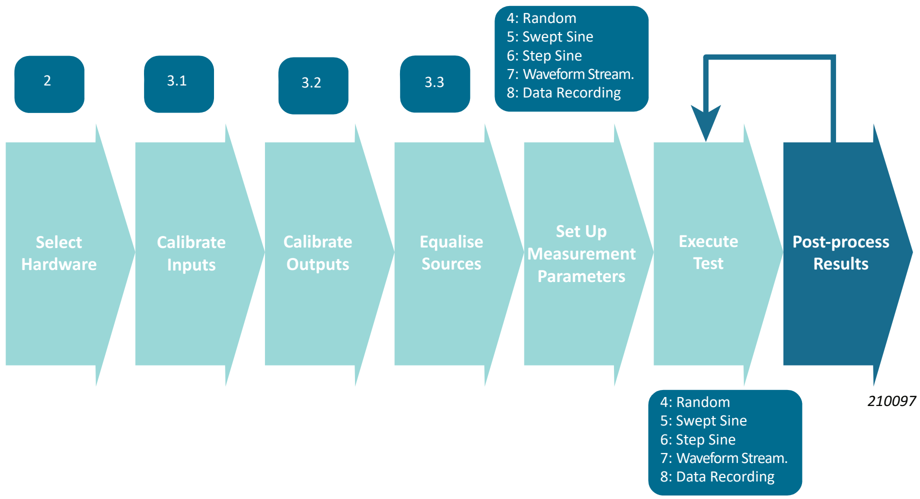


1.3 Process overview

The diagram in Fig. 1.2 is intended as a guide to the process of obtaining accurate electroacoustic measurements with the EA Engine and Type 3670. Individual test requirements may vary but the overall process should be maintained whether executed manually or programmatically.

The numbers in the elements relate to the sections in this manual which deal with the specific part of the process below. The blue elements indicate external, user-defined software not included in the scope of this manual.

Fig. 1.2 *The measurement process using the EA Engine*



1.4 XML files

Setup of the software requires editing of XML files.

An XML (extensible markup language) file consists of one or more elements. Each element consists of three parts:

- a start tag – for example *<p>* for the start of a paragraph
- content – for example *This is some text*
- a end tag – for example *</p>* for the end of a paragraph

Both the start tag and the end tag are enclosed between angled brackets and are identical apart from the / that precedes the end tag. The content is the part between the start tag and end tag.

Elements can be nested where they become child elements and refer to some sub-content of the parent.

A detailed description of XML files can be found at https://www.w3.org/TR/xml/.

1.4.1 EA Engine setting files

In the XML setup files used with the EA Engine, in general, only content should be edited, and the start and end tags should not be changed.

An example of an element in a setting file:

<Name>test</Name>

Hint: It is strongly recommend to use Notepad++ (freeware program) to edit these files. Conveniently, Notepad++ highlights the start and end tags in blue text and the content in **black text**.

Chapter 2

Preparing the EA Engine for Use

The EA Engine license is installed in Production Test USB DAQ Type 3670 at HBK*.

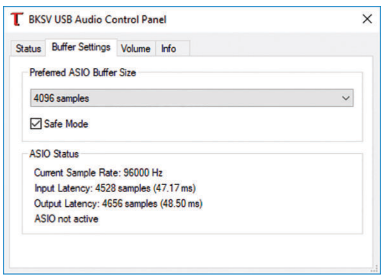
With the Type 3670 data acquisition hardware attached to the host PC via USB and its driver software installed, the system is ready to be configured. If you need help installing the hardware, see the user manual that is included with Type 3670 for connection and installation instructions. The manual can also be downloaded from our website.

2.1 Configure Type 3670

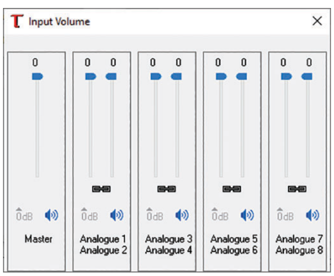
Before starting, it is important that the Type 3670 hardware is configured correctly for use with the EA Engine. Because Type 3670 appears to the Windows® operating system like a sound card, it is possible for other software applications to interact and modify the settings of the device.

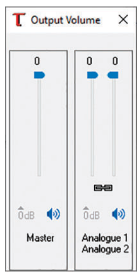
To ensure the settings are correct:

1) From the Windows start menu go to **BKSV** > **BKSV USB Audio Control Panel**.
2) Open the **Buffer Settings** tab and ensure that the settings are as shown below:



3) Go to the **Volume** tab and ensure that the input and output sliders are at maximum as shown below:





Type 3670 is now configured for use.

* With a licensed version of Type 3670 data acquisition hardware.

2.2 Locate and set up the working directories

There are three directories that are important to the functionality of the EA Engine software:

- Installation directory
- Control XML directory
- Data storage directory

You should know where to find them and how to edit as needed.

2.2.1 Installation directory

This is the software installation directory which, by default is:

C:\Program Files\Bruel and Kjaer\EA Engine

To operate the EA Engine software requires a command to the executable EA Engine in this directory with the appropriate command parameters.

1) Open the Command Prompt (in the Windows Start menu type **CMD**).
2) Navigate to the installation directory:
   a) Type:
      `cd C:\Program Files\Bruel and Kjaer\EA Engine`
   b) Press <**Enter**>.
3) The working directory will be changed to the software installation directory, and you should see this string returned:
   `C:\Program Files\Bruel and Kjaer\EA Engine`
4) Test the software installation by typing
   `EA_Engine Version`
   The software should respond with a string like this:

```
C:\Program Files\Bruel and Kjaer\EA Engine>EA_Engine Version
EA Engine - Version 1.2.6.2111
```

Hint:

- When contacting HBK support it is very important to have the installed version information available. Use the `EA_Engine Version` command to find the version number
- When updating the software to a new version or changing the hardware attached to the PC, it is advisable to first make a backup of the Control XML directory (see below) and then enter the command:
  `EA_Engine.exe Reset_Settings`
  to create new control files which will be compatible with any changes implemented in the new version of the software
- To interrupt any EA Engine operation, simply enter <**Ctrl**+**C**> in the command window

5) To use the software, you need to first identify then initialise the Type 3670 hardware:
   a) In the same directory type:
      `EA_Engine Detect_Devices`
      The software will return a list of ASIO compatible devices connected to the host computer.

```
C:\Program Files\Bruel and Kjaer\EA Engine>EA_Engine.exe Detect_Devices
List of detected devices:
Index 1: 3670-A-082 (Production Test with 8 Input, 2 Output)
Index 2: iRig Device
Index 3: Realtek ASIO
```

b) To select and initialise Type 3670, type:
`EA_Engine Select_Device 1 true`

Hint: The parameter `true` in this case initialises all the control XML files returning them to the default values. This is necessary for the first time of use but if you want to retain the previous settings in the files use `false` in place of `true` in the command.

The software will respond and confirm the selection together with the device status information.

```
Selected device:
Index 1: 3670-A-082 (Production Test with 8 Input, 2 Output)

Selected device capabilities:
Sample rate (Hz): 96000
Buffer size: 4096
Input latency (samples): 4528
Input latency (ms): 47.17
Output latency (samples): 4656
Output latency (ms): 48.50
```

2.2.2 Control XML directory

This directory contains all the setup files that control the functionality of the EA Engine. The directory and default setup files are automatically created with the following command:

`EA_Engine Select_Device 1 true`

See example above.

Hint: To avoid overwriting the setup files and losing your previous configuration when reinitialising Type 3670, use the command:

`EA_Engine Select_Device 1 false`

The default location for this directory is:

C:\Users\USERNAME\AppData\Roaming\Bruel and Kjaer\EA Engine

where *USERNAME* is the current Windows user account name.

Once created, if you navigate to the directory, you will see the following list of XML files:

- Calibation Settings.xml
- Detected Devices.xml
- Distortion Analysis Settings.xml
- Engine Setting.xml
- Input Channels.xml
- Output Calibration Settings.xml
- Random Noise Test Settings.xml
- Selected Device Capabilities.xml
- Step Sine Test Settings.xml
- Swept Sine Test Settings.xml

- Time Data Recording Settings.xml
- Waveform Streaming Test Settings.xml

We will describe how to edit these documents in the following sections of this manual. A full description of the parameters, and their function, in each of the files can be found in Appendix A.

2.2.3 Data storage directory

This is the default location for storage of all measurement and analysis data created by the EA Engine. Data can be stored in several formats depending on the type of test and the user preferences set in the control files.

The default location of the Data Storage Directory is:

C:\Users\USERNAME\Documents\EA Engine

where *USERNAME* is the current windows user account name.

The location of the data storage directory can be customized by editing the setting in the *Engine Settings.xml* file by changing the value of the DataFolder element:

<DataFolder>**C:\Users\USERNAME\Documents\EA Engine**</DataFolder>

Time data recordings can be stored as WAV, MATLAB® or HDF5 format files. Files stored as WAV include an input channel XML status file.

Measurement data can be stored as CSV or XML files.

Chapter 3

System Calibration

System calibration includes, in process order, input channel calibration, output channel calibration and, optionally, output equalization. These will be described separately but together they represent the total system calibration.

3.1 Input channel calibration

This process calibrates the selected input channels together with the transducers and signal conditioning attached to it and is required to make objective measurements.

Files used in input channel calibration are:

- *Input Channels.xml*
- *Calibration Settings.xml*

The process includes editing these two XML files to match the calibration setup and then applying a known physical excitation to the transducer or signal conditioning before executing the following command:

```
EA_Engine.exe Calibrate_Input_Channel x
```

where `x` is the channel to be calibrated.

3.1.1 Editing the Input Channels.xml file

1) From the Control XML directory, open the *Input Channels.xml* file using a text editor such as Notepad++.

   In the file, for each input channel is a group of InputChannel parent elements with nested elements bounded by the <InputChannel> and </InputChannel> start and end tags.

```
<InputChannel>
  <Number>1</Number>
  <Name>Input Channel 1</Name>
  <IsActive>true</IsActive>
  <ReferenceChannelName>None</ReferenceChannelName>
  <Sensitivity>50.84711447079134</Sensitivity>
  <SensitivityUnit>mV/Pa</SensitivityUnit>
  <CalibrationDate>2021-12-01T16:09:19.2051309+01:00</CalibrationDate>
  <dBRef>1</dBRef>
  <VMax>5.32</VMax>
  <Latency>0</Latency>
  <EQFile />
</InputChannel>
```

2) Make the following edits to the file:
   a) Set the <Active> element to **true**.
   b) (Optional) Edit the <Name> element to something relevant.
   c) Set the <SensitivityUnit> according to the physical device attached to the input. For a microphone this would normally be **mV/Pa**, for an accelerometer **mV/ms^{-2}** or **mV/g**.
   d) Set the <dBRef> element to reflect the physical quantity being measured. For sound pressure measurements the dB reference is **2E-05**, for acceleration this is typically **1**.

Please note: The <Sensitivity> element does not need to be set or edited as it will be altered by the software.

3) Save the file.

3.1.2 Editing the Calibration Settings.xml file

1) From the Control XML directory, open the *Calibration Settings.xml* file using a text editor such as Notepad++.

   There are a number of settings that can be edited – some more advanced than others. The most important parameters to edit perform calibration are listed below:

   <ReferenceFrequency>**1000**</ReferenceFrequency>

   <ReferenceLevel>**1**</ReferenceLevel>

   <ReferenceUnit>**V**</ReferenceUnit>

   <Duration>**10**</Duration>

2) Set the <ReferenceFrequency> element to the relevant value of the calibration source. A single frequency calibration is assumed, **1000** Hz is typical for acoustic calibration, but a pistonphone will calibrate at **250** Hz and accelerometers are usually calibrated at even lower frequencies, typically **159.15** Hz (1000 rad/s).
3) Set the <ReferenceLevel> to the rms level of the calibration signal which, for Sound Calibrator Type 4231, is **1** Pa for 94 dB and **10** Pa for 114 dB, but can vary depending on the adapter used.
4) Define the <ReferenceUnit>, which is applied to the subsequent calibration result and measurements.
5) Define the <Duration>, which is the nominal measurement time in seconds.
6) Save the file.

Please note: The *Calibration Settings.xml* file contains some advanced features, which are documented in the appendices.

3.1.3 Performing input calibration

Once the *Input Channels.xml* and *Calibration Settings.xml* files have been set correctly and saved, the input calibration can be performed.

1) Apply the appropriate signal to the transducer attached to the relevant channel.
2) Open the Command Prompt and type:

   `EA_Engine.exe Calibrate_Input_Channel x`

   where `x` is the channel to be calibrated.

   The software will initiate a calibration measurement on the selected channel and will respond with the settings read from the *Calibration Settings.xml* file and display a counter for the elapsed time of the measurement as shown below for a calibration on channel 2:

```
C:\Program Files\Bruel and Kjaer\EA Engine>EA_Engine.exe Calibrate_Input_Channel 2
Calibration settings:
Reference Frequency = 1000 Hz
Reference Level = 1 Pa rms
Duration = 10 s
Result file format = XML

Calibration running on input channel 2:
Time elapsed: 10.00 s
```

   When completed, the program will return with the calculated sensitivity in mV/EU (millivolts per engineering unit) from the measurement:

```
Calculating new sensitivity...
Input channel 2 calibrated. New sensitivity = 50.8471447079134 mV/Pa
```

   The result of the calibration is automatically stored back in the *Input Channels.xml* file for the relevant channel together with the new calibration date:

   <Name>**Input Channel 2**</Name>

   <Sensitivity>**50.84711447079134**</Sensitivity>

   <SensitivityUnit>**mV/Pa**/SensitivityUnit>

   <CalibrationDate>**2021-12-01T16:09:19.2051309+01:00**</CalibrationDate>
3) Repeat the input calibration sequence for all active input channels.

3.2 Output channel calibration

Output calibration is optional and is only required if you want to define the effective output levels in terms of a physical quantity other than volts.

If you want to use a voltage definition, open the *Output Channels.xml* file using a text editor such as Notepad++ and ensure that the <Sensitivity> element is set at **1** (the default value) and do not do an output calibration.

To perform an output calibration requires editing of two settings files:

- *Output Calibration Settings.xml*
- *Output Channels.xml*

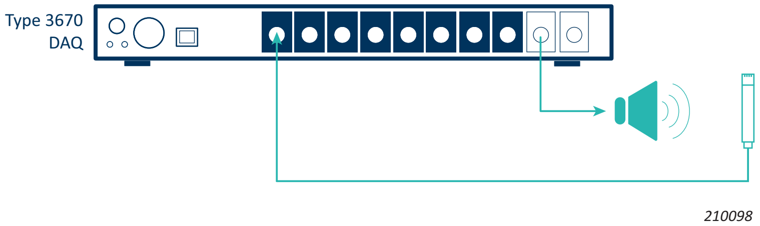
To accurately calibrate an output:

1) You must first calibrate at least one input channel with the physical quantity (such as SPL in Pa or acceleration in m/s^2) before performing the output calibration.
2) Mount the transducer at a location you would consider to be the reference position, such as a microphone mounted at the lip plane of a Head and Torso Simulator (HATS).

   This source is used to measure the output sensitivity of your source (in physical quantity per volt) and stored in the *Output Channels.xml* file for the relevant output channel.

   Fig. 3.1 graphically indicates the setup for a source on output 1 and a microphone on input 1.

Fig. 3.1
Setup of the source and microphone



3.2.1 Editing the Output Channels.xml file

1) From the Control XML directory, open the *Output Channels.xml* file using a text editor such as Notepad++.

   In the file, for each output channel are multiple parent elements with several nested elements bounded by the <OutputChannel> and </OutputChannel> start and end tags. The parameters needed for calibration are within the first nest of child elements:

```
<OutputChannel>
  <Number>1</Number>
  <Name>Generator 1</Name>
  <IsActive>true</IsActive>
  <ReferenceChannelName>None</ReferenceChannelName>
  <Sensitivity>1</Sensitivity>
  <SensitivityUnit>V/V</SensitivityUnit>
  <CalibrationDate>1990-01-01T00:00:00</CalibrationDate>
  <dBRef>1</dBRef>
  <VMax>3.5</VMax>
  <EQFile />
  <SignalType>Sine</SignalType>
  ...
</OutputChannel>
```

2) Make the following edits to the file:
   a) Set the <Active> element of the output channel being used as a source **true**.
   b) Set the <SignalType> element **Sine**.
3) Save the file.

3.2.2 Editing the Output Calibration Settings.xml file

1) From the Control XML directory, open the *Output Calibration Settings.xml* file using a text editor such as Notepad++.

   There are a number of settings that can be edited, the most important parameters to edit perform calibration are listed below:

   <Frequency>**1000**</Frequency>

   <Level>**0.01**</Level>

   <Duration>**5**</Duration>

2) For the <Frequency> element, in general, it is optimal to use the same frequency for the output calibration as was used for the input calibration of the reference transducer.
3) Set the <Level> to the rms level in engineering units of the calibration signal.
4) Define the <Duration>, which is the nominal time in seconds, of the calibration signal.
5) Save the file.

3.2.3 Performing output calibration

1) Ensure that both the source and reference transducer are active.
2) Open the Command Prompt and type

   `EA_Engine.exe Calibrate_Output_Channel x y`

   where `x` is the input channel connected to the reference transducer and `y` is the output channel connected to the source to be calibrated.

   The software will respond by executing the output calibration and will report the status of the time through the test requested:

```
C:\Program Files\Bruel and Kjaer\EA Engine>EA_Engine.exe Calibrate_Output_Channel 1 1
Calibration settings:
Frequency = 1000 Hz
Level = 0.5 V peak
Duration = 5 s

Output channel 1 settings:
Signal Type = Sine
Level = 0.5 V peak
Frequency = 1000 Hz
Duration = 5 s

Calibration running on input channel 1 and output channel 1:
Time elapsed: 5.00 s
```

   Once the measurement is complete, the software will calculate the effective output sensitivity in physical quantity per volt, using the <SensitivityUnit> setting from the reference input channel

```
Calculating new sensitivity...

Output channel 1 calibrated. New sensitivty = 13.35 Pa/V
```

   and updates the <Sensitivity>, <SensitivityUnit> and <CalibrationDate> fields for the appropriate output channel in the *Output Channels.xml* file. For example:

   <Sensitivity>**13.349958493715924**</Sensitivity>

   <SensitivityUnit>**Pa/V**</SensitivityUnit>

   <CalibrationDate>**2021-04-21T10:49:18.5871534+02:00**</CalibrationDate>

3.3 Source equalisation

Most acoustic and vibration sources are non-linear with frequency. This may not be important if you are using Frequency Response Function (FRF) measurements for your results but spectra and Constant Percentage Bandwidth (CPB) measurements will show the nature of the non-linearity. If you need to have a flat output from your source, then you first need to equalise the source.

The principle of equalisation is to measure the response of the source to a linear input as a function of frequency and then create an equalisation FRF that is the inverse of the measured response to create a linear output.

The method of application depends on the signal type used. For random and swept sine tests the equalisation function is used as a signal scaling function using an FIR filter. For step sine the equalisation FRF is used as a scaling function of the sine waves for each step.

The hardware setup is identical to the output calibration measurement. Usually a reference transducer, placed close to the source is used as the numerator of the FRF and the linear output signal is used as the denominator.

An example of spectra from a reference microphone with unequalised and equalised outputs is shown in Fig. 3.2.

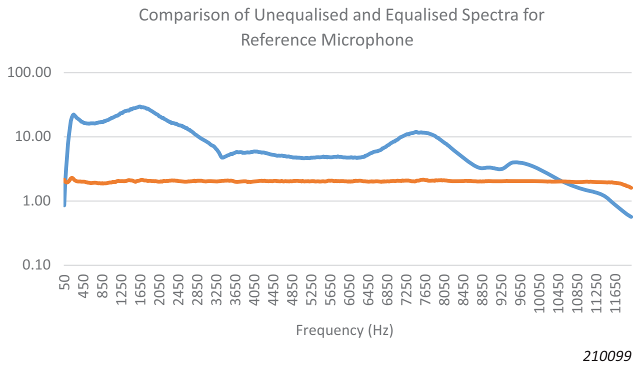


Fig. 3.2
Spectra from a reference microphone comparing uneqalised and eqalised outputs

Assuming that the reference transducer input channel has already been correctly set up and calibrated then the only two files requiring editing are *Output Channels.xml* and *Equalization Settings.xml*.

3.3.1 Editing the Output Channels.xml file

The default file used for equalisation is referenced by the EQFile element in the *Output Channels.xml* file and the setting is blank when the system is initialised:

<EQFile />

The element value is automatically updated once the equalisation test is successfully completed.

1) From the Control XML directory, open the *Output Channels.xml* file using a text editor such as Notepad++. At a minimum, the <SignalType> and corresponding <Level> elements need to be edited.
2) Set the <SignalType> element to one of the following:
   - **White** (for random excitation)
   - **Sweep**
   - **Step**

Please note: For more information on optimizing the settings for these signal types, please refer to Chapter 4 (Random Noise Testing), Chapter 5 (Swept Sine Testing) and Chapter 6 (Step Sine Testing).

3) Then depending on your selection of <SignalType>, find the test parent element further down in the file and define the test's <Level> element. It needs to be set to a value that can produce a measurable output throughout the selected frequency range.

   The following shows example settings for a step sine test, that is when <SignalType> is defined as **Step**:

```
<StepSine>
    <Level>0.01</Level>
    <StartFrequency>20</StartFrequency>
    <EndFrequency>20000</EndFrequency>
    <ResolutionType>UserDefined</ResolutionType>
    <MinCycles>6</MinCycles>
    <MinDuration>0.003</MinDuration>
    <StepMode>Linear</StepMode>
    <StepIncrement>1</StepIncrement>
    <SettlingPeriods>5</SettlingPeriods>
    <TransitionPoints>100</TransitionPoints>
</StepSine>
```

4) Save the file.

3.3.2 Editing the Equalization Settings.xml file

In the *Equalization Settings.xml* file the <StartFrequency> and <EndFrequency> elements need to be set. These settings overwrite the current settings in the *Output Channels.xml* file when an equalisation measurement is performed.

1) From the Control XML directory, open the *Equalization Settings.xml* file using a text editor such as Notepad++.
2) Set the <FrequencyStart> and <FrequencyEnd>, respectively, lower and higher (that is, so they can create a wider frequency range) for the equalisation measurement than for the subsequent measurements. They cannot be narrower than the final testing limits.
3) (Optional) Set the <ReferenceFrequency> element. With a valid frequency, the resulting equalisation curve will be normalised (set to a value of **1**) at that frequency. If the value is set to **–1** then the result is not normalised.

4) Save the file.

The example below indicates the settings for an equalisation test between 70 Hz and 10 kHz with the result normalised at a frequency of 1000 Hz:

<ReferenceFrequency>**1000**</ReferenceFrequency>
<FrequencyStart>**70**</FrequencyStart>
<FrequencyEnd>**10000**</FrequencyEnd>

3.3.3 Performing equalisation

Once the *Output Channels.xml* and *Equalization Settings.xml* files have been set correctly and saved, the equalisation test can be performed.

1) Open the Command Prompt and type

```
EA_Engine.exe Equalize_Output_Channel x y
```

where `x` is reference input channel and `y` is the output channel to be calibrated.

The software will respond with a summary of the test settings and a running counter of the elapsed test time:

```
Equalization running on input channel 1 and output channel 1:
Time elapsed: 2.55 s
```

At the completion of the test, the EA Engine calculates the latency between the input and output channels and the equalisation FRF which is stored as an XML file in the default measurement directory:

```
Removing input & output latencies (device characteristics) from input...
Calculating and removing latency between input and output...
Latency (samples): 155

Concatenating input & output in the same file...
Calculating FRF between input and output...


Output channel 1 equalized. Equalization file is Output Channel Equalization - 2021.04.29 - 13.54.25 - Generator 1 - Inp
ut Channel 1 - Equalization FRF.xml
```

The location of the default measurement directory is at:

C:\Users\USERNAME\AppData\Documents\EA Engine

where *USERNAME* is the current windows user account name.

Hint: The data location can be redefined to a more convenient location by editing the <DataFolder> element in the *Engine Setting.xml* file

The EQFile element in the *Output Channels.xml* is also updated with the name of the new equalisation file. For example:

<EQFile>**Output Channel Equalization – 2021.04.29 – 13.54.25 – Generator 1 – Input Channel 1 – Equalization FRF.xml**</EQFile>

2) To apply equalisation during a measurement the value of the <ApplyEqualization> in the appropriate test XML file (*Random Noise Test Settings.xml*, *Step Sine Test Settings.xml*, *Swept Sine Test Setting.xml* or *Waveform Streaming Test Settings.xml*) should be switched from **false** to **true**.

For more information on applying equalisation to a specific test, see the relevant test chapter in this manual.

Chapter 4

Random Noise Testing

The Random Noise Test can be used to make frequency-based measurements (spectra, CPB (1/n-octave), FRF, cross-spectra, phase-assigned spectra, etc.) using a random excitation source from one or more of the system outputs.

The system can generate white noise (nominally flat over the full frequency range), or pink noise (having a – 6 dB slope over the frequency range).

Please note: Due to the nature of the generated signal, the maximum rms signal level will be significantly lower than the nominal 3.79 V that can be achieved with sine testing.

Before performing a random noise test, input, output and (optionally) equalisation calibrations should be performed.

To set up for random noise testing, using a text editor such as Notepad++, go to the Control XML directory and open and edit the following files:

- *Output Channels.xml*
- *Random Noise Test Settings.xml*

for either spectra or CPB (1/n-octave) results.

4.1 Edit the Random Noise Test Settings.xml file

In the *Random Noise Test Settings.xml* file, you must review and edit the top seven elements:

<MeasurementModeType>**Spectra**</MeasurementModeType>
<Duration>**30**</Duration>
<Filename>**Random Test**</Filename>
<MeasureAndRemoveExtraLatency>**true**</MeasureAndRemoveExtraLatency>
<ResultFileFormatType>**CSV**</ResultFileFormatType>
<ApplyEqualization>**false**</ApplyEqualization>
<Recording>**false**</Recording>

For <MeasurementModeType>, set the measurement mode to one of the following settings:

- **Spectra** – where autospectra are calculated based on the settings in the <AnalysisFFTSettings> element, further down in the file, for each of the active input channels
- **PhaseAssignedSpectra** – where autospectra are calculated based on the settings in <AnalysisFFTSettings> element, further down in the file, and then assigned a phase relative to the defined reference channel
- **FRF** – where FRFs are calculated based on the settings in <AnalysisFFTSettings> element, further down in the file, based on each of the active input channels and the defined reference channel

- **CPB** – (also known as 1/n-octave) where filter-based CPB autospectra are calculated based on the settings in <AnalysisCPBSettings> element further down in the file
- **CPBSynthesis** – where FFT-based CPB autospectra are calculated based on the settings in <AnalysisCPBSynthesisSettings> element further down in the file

Please note: The **PhaseAssignedSpectra** and **FRF** settings require the definition of a reference channel while **Spectra**, **CPB** and **CPBSynthesis** settings do not.

For <Duration>, set the duration of the test in seconds.

Please note:
- The averaging time, when <AveragingType> is set to **Linear**, will be slightly adjusted automatically to accommodate the specific analysis settings
- The setting of the <Duration> element in the *Output Channels.xml* file is ignored in this test

For <Filename>, enter a name that will be appended to the measurement result files. The example below shows the output for the settings shown above:

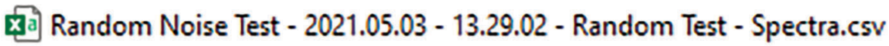


Fig. 4.1
A CSV file name with measurement results. The file name is based on the first seven elements defined in the Random Noise Test Settings file

By default, the internal latency between input and output channels is removed automatically. However, in some circumstances, it is desirable to also remove the latency (delay) due to the physical distance between devices such as reference and response microphones. If this is required, then for <MeasureAndRemoveExtraLatency> set the value to **true**. If not, set it to **false**.

The <ResultFileFormatType> determines the file type used for the measurement results. Valid setting options are:

- **XML** – extensible markup language (.xml)
- **CSV** – comma separated values (.csv)
- **MATLAB** (.mat)

The <ApplyEqualization> applies equalisation to the active output channels using the function defined in the EQFile element in the *Output Channels.xml* file (see below). An error is generated if the file is undefined. Set as either **true** or **false**.

For <Recording>, set **true** to create an optional time recording of all the input and output channels for further post-processing in third-party programs. Set **false** if you do not want a recording.

Save the file when done.

4.1.1 Additional settings

In addition to the primary settings above, you should also modify the settings in the relevant calculation settings section(s) of this file:

- <AnalysisFFTSettings>
- <AnalysisCPBSettings>
- <AnalysisCPBSynthesisSettings>
- <TimeDataRecordingSettings>

to obtain the desired format of the results. See the section A.7 for a detailed review of the valid setting options.

Please note: Some settings are mutually dependent on each other and, where possible, will be automatically modified by the software to comply with the requested settings. In general, the last dependent element read takes precedence.

Save the file when done.

4.2 Edit the Output Channels.xml file

After you have reviewed and saved the *Random Noise Test Settings* file, edit and review the *Output Channels.xml* file.

Edit the following elements for the required output channels:

```
<IsActive>true</IsActive>
<SignalType>White</SignalType>
<Random>
    <Level>0.4</Level>
    <IsFiltered>true</IsFiltered>
    <HiPassFrequency>20</HiPassFrequency>
    <LoPassFrequency>16000</LoPassFrequency>
    <Slope>0</Slope>
    <Duration>30</Duration>
</Random>
```

The <IsActive> must be set to **true**.

The <SignalType> must be set to **White** for true random or **Pink** for pink noise.

For <Level>, set the rms output level in units defined by the <SensitivityUnit> element in the *Output Channels.xml* file. If equalisation is defined, then the value is corrected by the equalisation curve. Bear in mind that, due to the nature of the signal, the rms value has to be significantly lower than the maximum output level to avoid overloads. The program will produce a warning if the requested level clips the output.

For <IsFiltered>, set to either:

- **false** – the signal generated will be over the full bandwidth of the device (approximately 5 Hz to 40 kHz)
- **true** – the output is filtered according to the <HiPassFrequency> and <LoPassFrequency> elements

For <HiPassFrequency>, set the high-pass (low-cut) frequency of the signal.

For <LoPassFrequency>, set the low-pass (high-cut) frequency of the signal.

The <Slope> is used to switch between true random (white noise), which has a flat spectrum, and a – 6 dB slope with frequency referred to as pink noise. Valid settings for this element are **0** for white noise or **6** for pink noise. You can also set the slope using the <SignalType> element.

For <Duration>, set the length of the test in seconds. This setting is overridden by the Duration setting in the *Random Noise Test Settings.xml* file.

Save the file when done.

4.3 Perform a random noise test

Once the settings have been reviewed and the XML files saved, open the Command Prompt and type:

```
EA_Engine.exe Random_Noise_Test
```

to run the random noise test.

If the elements have been set correctly in appropriate files, the EA Engine will respond with a summary of the requested test, initiate output of the random signal from the selected output and count the progress through the test in seconds.

Fig. 4.2
Example of the random noise test summary

```
C:\Program Files\Bruel and Kjaer\EA Engine>EA_Engine.exe Random_Noise_Test
Random noise test settings:
Measurement Mode = Spectra
Duration = 20 s
Filename = Random Test
Result file format = CSV
Measure and remove latencies = False
Apply EQ = False
Sampling Frequency = 96000 Hz
Frequency Lines = 4096
Frequency Resolution = 11.71875 Hz
Block Size = 8192
Averaging Type = Linear
Averages = 1167
Averaging Time = 20 s
Overlap = 0.8
Reference(s) Weighting Window = Hanning
Response(s) Weighting Window = Hanning

Random noise test running on input channels 7, with output channels 1:
Time elapsed: 20.22 s
```

The EA Engine then calculates the requested results and stores the result files (CSV or XML) in the Data Storage directory.

Fig. 4.3
Example showing the storing of test results

```
Removing input & output latencies (device characteristics) from inputs...
Reading and removing latency from inputs...
Concatenating inputs & outputs in the same file...
Calculating Spectra...
Current average: 1165 / 1165
Random noise test finished.
```

The contents of the results files depend on the requested measurement. The examples below show the format of the results in the CSV files.

When <MeasurementModeType> is set at **Spectra** – the result file contains the autospectra for the generator output and all active inputs:

Comment1	Random Noise Test	Random Noise Test
Comment2	Autospectrum - Power [ms-2^2]	Autospectrum - Power [(ms-2)^2]
Frequency [Hz]	Amplitude [ms-2^2]	Amplitude [(ms-2)^2]
11.71875	0.00393609	0.001632839
23.4375	0.005760286	0.001583591
35.15625	0.00617195	0.00672825
46.875	0.006229977	0.021145327
58.59375	0.00627549	0.048365834
70.3125	0.006220116	0.072050527
82.03125	0.006047133	0.078636848
93.75	0.006120294	0.076903302
105.46875	0.005886611	0.067050983

When <MeasurementModeType> is set at **FRF** – the result file contains the FRFs for the selected reference and active responses expressed in real and imaginary parts as well as amplitude and phase:

Name	Input Channel 4 - Input Channel 7			
Comment1	Random Noise Test			
Comment2	FRF - [(ms-2)/(m/s²)]			
Frequency [Hz]	Real [(ms-2)/(m/s²)]	Imaginary [(ms-2)/(m/s²)]	Amplitude [(ms-2)/(m/s²)]	Phase [degrees]
11.72	0.1282	-1.3936	1.3995	-84.7424
23.44	1.1843	0.3459	1.2338	16.2806
35.16	1.0978	0.1176	1.1041	6.1158
46.88	1.0415	0.0092	1.0415	0.5038
58.59	1.0082	-0.0620	1.0101	-3.5190
70.31	0.9808	-0.1234	0.9885	-7.1728
82.03	0.9715	-0.1827	0.9885	-10.6484
93.75	0.9647	-0.2484	0.9962	-14.4384
105.47	0.9509	-0.3097	1.0001	-18.0409

Chapter 5

Swept Sine Testing

The Swept Sine Test can be used to make frequency-based measurements (spectra, CPB (1/n-octave), FRF, cross-spectra, phase-assigned spectra, etc.) using a continuous swept-sine excitation source from one or more of the system outputs.

Before performing a swept sine test, input, output and (optionally) equalisation calibrations should be performed.

To set up for swept sine testing, using a text editor such as Notepad++, go to the Control XML directory and open and edit the following files:

- *Output Channels.xml*
- *Swept Sine Test Settings.xml*

for either spectra or CPB (1/n-octave) results.

5.1 Edit the Swept Sine Test Settings.xml file

In the *Swept Sine Test Settings.xml* file, you must review and edit the top seven elements:

<MeasurementModeType>**Spectra**</MeasurementModeType>
<Duration>**60**</Duration>
<Filename>**Swept Sine Test**</Filename>
<MeasureAndRemoveExtraLatency>**true**</MeasureAndRemoveExtraLatency>
<ResultFileFormatType>**CSV**</ResultFileFormatType>
<ApplyEqualization>**false**</ApplyEqualization>
<Recording>**false**</Recording>

For <MeasurementModeType>, set the measurement mode to one of the following settings:

- **Spectra** – where autospectra are calculated based on the settings in the <AnalysisFFTSettings> element, further down in the file, for each of the active input channels
- **PhaseAssignedSpectra** – where autospectra are calculated based on the settings in <AnalysisFFTSettings> element, further down in the file, and then assigned a phase relative to the defined reference channel
- **FRF** – where FRFs are calculated based on the settings in <AnalysisFFTSettings> element, further down in the file, based on each of the active input channels and the defined reference channel
- **CPB** – (also known as 1/n-octave) where filter-based CPB autospectra are calculated based on the settings in <AnalysisCPBSettings> element further down in the file
- **CPBSynthesis** – where FFT-based CPB autospectra are calculated based on the settings in <AnalysisCPBSynthesisSettings> element further down in the file

Please note: The **PhaseAssignedSpectra** and **FRF** settings require the definition of a reference channel while **Spectra**, **CPB** and **CPBSynthesis** settings do not.

For <Duration>, set the duration of the test in seconds.

Please note:

- The averaging time, when <AveragingType> is set to **Linear**, will be slightly adjusted automatically to accommodate the specific analysis settings
- The setting of the <Duration> element in the *Output Channels.xml* file is ignored in this test

For <Filename>, enter a name that will be appended to the measurement result files. The example below shows the output for the settings shown above:

Fig. 5.1
A CSV file name with measurement results. The file name is based on the first seven elements defined in the Swept Sine Test Settings file

By default, the internal latency between input and output channels is removed automatically. However, in some circumstances, it is desirable to also remove the latency (delay) due to the physical distance between devices such as reference and response microphones. If this is required, then for <MeasureAndRemoveExtraLatency> set the value to **true**. If not, set it to **false**.

The <ResultFileFormatType> determines the file type used for the measurement results. Valid setting options are:

- **XML** – extensible markup language (.xml)
- **CSV** – comma separated values (.csv)
- **MATLAB** (.mat)

The <ApplyEqualization> applies equalisation to the active output channels using the function defined in the EQFile element in the *Output Channels.xml* file (see below). An error is generated if the file is undefined. Set as either **true** or **false**.

For <Recording>, set **true** to create an optional time recording of all the input and output channels for further post-processing in third-party programs. Set **false** if you do not want a recording.

Save the file when done.

5.1.1 Additional settings

In addition to the primary settings above, you should also modify the settings in the relevant calculation settings section(s) of this file:

- <AnalysisFFTSettings>
- <AnalysisCPBSettings>
- <AnalysisCPBSynthesisSettings>
- <TimeDataRecordingSettings>

to obtain the desired format of the results. See section A.10 for a detailed review of the valid setting options.

Please note: Some settings are mutually dependent on each other and, where possible, will be automatically modified by the software to comply with the requested settings. In general, the last dependent element read takes precedence.

Save the file when done.

5.2 Edit the Output Channels.xml file

After you have reviewed and saved the *Swept Sine Test Settings* file, edit and review the *Output Channels.xml* file.

Edit the following elements for the required output channels:

```
<IsActive>true</IsActive>
<SignalType>Sweep</SignalType>
<SweepSine>
    <Level>1</Level>
    <StartFrequency>20</StartFrequency>
    <EndFrequency>20000</EndFrequency>
    <SweepMode>Linear</SweepMode>
    <SweepTime>60</SweepTime>
    <Repetitions>0</Repetitions>
    <Silence>0</Silence>
    <FadeMode>Cosine</FadeMode>
    <FadeIn>0.01</FadeIn>
    <FadeOut>0.01</FadeOut>
</SweepSine>
```

The <IsActive> must be set to **true**.

The <SignalType> must be set to **Sweep**.

For <Level>, set the rms output level in units defined by the <SensitivityUnit> element in the *Output Channels.xml* file. If equalisation is defined, then the output signal is compensated for the equalisation curve. The program will produce a warning if the requested level clips the output.

For <StartFrequency>, set the start frequency for the test. Bear in mind that the <FadeIn> setting (see below) will determine when the requested test level is achieved. If a flat response is required over the full range, then this setting should be compensated for by setting the start frequency lower than required or shortening the <FadeIn> time.

Please note: The <StartFrequency> does not have to be lower than the <EndFrequency>. If you prefer to perform sweep down test then reverse the default settings and make the <StartFrequency> your maximum.

For <EndFrequency>, set the end frequency for the test. Bear in mind that the <FadeOut> setting (see below) will determine when the requested test level starts to drop. If a flat response is required over the full range, then this setting should be compensated for by setting the end frequency higher than required or shortening the <FadeOut> time.

For <SweepMode>, set to **Linear** or **Logarithmic**.

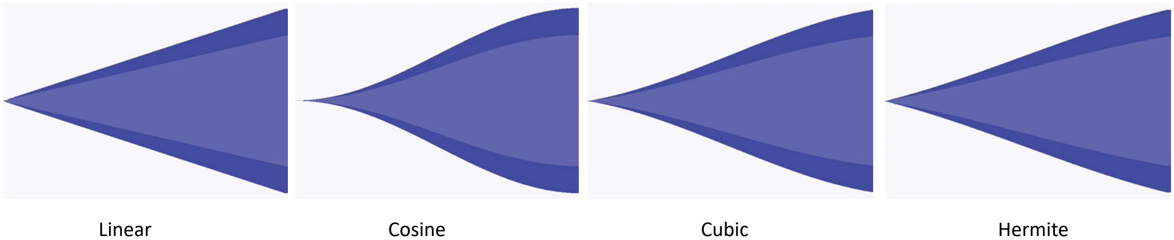
For <SweepTime>, set the length of the test in seconds. This setting is overridden by the Duration setting in the *Swept Sine Test Settings.xml* file.

For <Repetitions>, set the number of times the sweep is performed. This is used in combination with the <Silence> element to create a gap between successive sweeps.

For <Silence>, if you are using multiple sweep repetitions, then set the gap (silence) between the sweeps as a value in seconds here.

For <FadeMode>, set the way the amplitude of the output signal is faded in and out. The options are: **Linear**, **Cosine**, **Cubic** or **Hermite**.

Fig. 5.2 *Illustration of the fade mode options*



For <FadeIn>, set the length of time in seconds for the output signal to reach the requested level at the beginning of the test.

For <FadeOut>, set the length of time in seconds for the output signal to reduce to zero from the requested level at the beginning of the test.

Save the file when done.

5.3 Perform a swept sine test

Once the settings have been reviewed and the XML files saved, open the Command Prompt and type:

```
EA_Engine.exe Swept_Sine_Test
```

to run the swept sine test.

If the elements have been set correctly in appropriate files, the EA Engine will respond with a summary of the requested test, initiate output of the swept sine signal from the selected output and count the progress through the test in seconds.

Fig. 5.3
Example of the swept sine test summary

```
C:\Program Files\Bruel and Kjaer\EA Engine>EA_Engine.exe Swept_Sine_Test
Swept sine test settings:
Measurement Mode = Spectra
Duration = 60 s
Filename = Swept Sine Test
Result file format = CSV
Measure and remove latencies = True
Apply EQ = False
Sampling Frequency = 96000 Hz
Frequency Lines = 4096
Frequency Resolution = 11.71875 Hz
Block Size = 8192
Averaging Type = Linear
Averages = 3511
Averaging Time = 60 s
Overlap = 0.8
Reference(s) Weighting Window = Hanning
Response(s) Weighting Window = Hanning

Swept sine test running on input channels 7, with output channels 1:
Time elapsed: 60.27 s
```

The EA Engine then calculates the requested results and stores the result files (CSV or XML) in the Data Storage directory.

Fig. 5.4
Example showing the storing of test results

```
Removing input & output latencies (device characteristics) from inputs...
Calculating and removing latency between inputs and the first active output...
Latency for Input Channel 7 / Generator 1 (samples): 243570

Concatenating inputs & outputs in the same file...
Calculating Spectra...
Current average: 3374 / 3374
Swept sine test finished.
```

The contents of the results files depend on the requested measurement. The examples below show the format of the results in the CSV files.

When <MeasurementModeType> is set at **Spectra** – the result file contains the autospectra for the generator output and all active inputs:

Name	Generator 1	Input Channel 4
Comment1	Swept Sine Test	Swept Sine Test
Comment2	Autospectrum - Power [ms-2^2]	Autospectrum - Power [(ms-2)^2]
Frequency [	Amplitude [ms-2^2]	Amplitude [(ms-2)^2]
5.86	0.000	0.001
11.72	0.002	0.000
17.58	0.005	0.000
23.44	0.006	0.001
29.30	0.006	0.003
35.16	0.006	0.007
41.02	0.006	0.013
46.88	0.006	0.022
52.73	0.006	0.037
58.59	0.006	0.051
64.45	0.006	0.063

When <MeasurementModeType> is set at **FRF** – the result file contains the FRFs for the selected reference and active responses expressed in real and imaginary parts as well as amplitude and phase:

Name	Input Channel 4 - Velocity Coil			
Comment1	Swept Sine Test			
Comment2	FRF - [(ms-2)/(m/s²)]			
Frequency [Hz]	Real [(ms-2)/(m/s²)]	Imaginary [(ms-2)/(m/s²)]	Amplitude [(ms-2)/(m/s²)]	Phase [degrees]
5.86	-0.001	-3.172	3.172	-90.022
11.72	0.832	1.191	1.453	55.046
17.58	1.002	0.720	1.233	35.694
23.44	1.056	0.486	1.163	24.710
29.30	1.056	0.373	1.120	19.482
35.16	1.060	0.294	1.100	15.518
41.02	1.046	0.218	1.069	11.750
46.88	1.015	0.166	1.028	9.272
52.73	0.981	0.151	0.993	8.767
58.59	0.963	0.153	0.975	9.057

Chapter 6

Step Sine Testing

The Step Sine Test can be used to make frequency-based measurements (spectra, CPB (1/n-octave), FRF, cross-spectra, phase-assigned spectra, etc.) using a steps-sine excitation source from one or more of the system outputs.

Step sine tests offer additional options over random and swept sine tests, such as logarithmic spectra and FRFs and calculation of distortion (total harmonic distortion (THD) and rub & buzz).

Before performing a step sine test, input, output and (optionally) equalisation calibrations should be performed.

To set up for step sine testing, using a text editor such as Notepad++, go to the Control XML directory and open and edit the following files:

- *Output Channels.xml*
- *Step Sine Test Settings.xml*

In the *Step Sine Test Settings.xml* file there are less control elements than in the random and sweep sine tests and more control is placed in the *Output Channels.xml* file.

Please note: Time recording cannot be implemented for the step sine tests.

6.1 Edit the Step Sine Test Settings.xml file

In the *Step Sine Test Settings.xml* file, you must review and edit the top five elements:

<MeasurementModeType>**Spectra**</MeasurementModeType>
<Filename>**Step Sine Test**</Filename>
<MeasureAndRemoveExtraLatency>**true**</MeasureAndRemoveExtraLatency>
<ResultFileFormatType>**CSV**</ResultFileFormatType>
<ApplyEqualization>**false**</ApplyEqualization>

For <MeasurementModeType>, set the measurement mode to one of the following settings:

- **Spectra** – where autospectra are calculated for each of the active input channels
- **PhaseAssignedSpectra** – where autospectra are calculated then assigned a phase relative to the defined reference channel
- **FRF** – where FRFs are calculated based on each of the active input channels and the defined reference channel

Please note: The **PhaseAssignedSpectra** and **FRF** settings require the definition of a reference channel while **Spectra** settings do not.

For <Filename>, enter a name that will be appended to the measurement result files. The example below shows the output for the settings shown above:

Fig. 6.1
A CSV file name with measurement results. The file name is based on the first seven elements defined in the Step Sine Test Settings file

Step Sine Test - 2021.05.28 - 14.20.23 - Step Sine Test - Spectra.csv

By default, the internal latency between input and output channels is removed automatically. However, in some circumstances, it is desirable to also remove the latency (delay) due to the physical distance between devices such as reference and response microphones. If this is required, then for <MeasureAndRemoveExtraLatency> set the value to **true**. If not, set it to **false**.

The <ResultFileFormatType> determines the file type used for the measurement results. Valid setting options are:

- **XML** – extensible markup language (.xml)
- **CSV** – comma separated values (.csv)
- **MATLAB** (.mat)

The <ApplyEqualization> applies equalisation to the active output channels using the function defined in the EQFile element in the *Output Channels.xml* file (see below). An error is generated if the file is undefined. Set as either **true** or **false**.

Save the file when done.

6.2 Edit the Output Channels.xml file

After you have reviewed and saved the *Step Sine Test Settings* file, edit and review the *Output Channels.xml* file.

Edit the following elements for the required output channels:

```
<IsActive>true</IsActive>
<SignalType>Step</SignalType>
<StepSine>
    <Level>2</Level>
    <StartFrequency>31.5</StartFrequency>
    <EndFrequency>16500</EndFrequency>
    <ResolutionType>R40</ResolutionType>
    <MinCycles>20</MinCycles>
    <MinDuration>0.1</MinDuration>
    <StepMode>Linear</StepMode>
    <StepIncrement>1</StepIncrement>
    <SettlingPeriods>25</SettlingPeriods>
    <TransitionPoints>100</TransitionPoints>
</StepSine>
```

The <IsActive> must be set to **true**.

The <SignalType> must be set to **Step**.

For <Level>, set the rms output level in units defined by the <SensitivityUnit> element in the *Output Channels.xml* file. If equalisation is defined, the output signal may still exceed the maximum output voltage from the generator. The program will produce a warning if the requested level clips the output.

For <StartFrequency>, set the start frequency for the test.

Please note: The <StartFrequency> does not have to be lower than the <EndFrequency>. If you prefer to perform sweep down test then reverse the default settings and make the <StartFrequency> your maximum.

For <EndFrequency>, set the end frequency for the test.

For <ResolutionType>, set to either:

- **User Defined** – the frequency increment and settling time are controlled by the <StepMode>, <StepIncrement> and <SettlingPeriods> elements below
- A classical fractional octave steps such as **R10**, **R20**, **R40** or **R80** – the frequency increments are predefined, and the time used for each step is defined by the <MinCycles> and <MinDuration> elements below

For <MinCycles>, set the minimum number of complete sine wave cycles at each step of the test when the <ResolutionType> is **R10**, **R20**, **R40** or **R80**. The minimum may be overridden by the <MinDuration> element if that value results in a larger number of cycles.

For <MinDuration>, set the minimum time, in seconds, spent in measuring any individual step when the <ResolutionType> is **R10**, **R20**, **R40** or **R80**. The minimum may be overridden by the <MinCycles> element if that value results in a longer time.

<StepMode> is only active when <ResolutionType> is **User Defined**. Set to:

- **Linear**
- **Logarithmic**
- **Octave**

<StepIncrement> is only active when <ResolutionType> is **User Defined**. Set the number of frequency steps between the <StartFrequency> and <EndFrequency>. The unit is determined by the <StepMode> setting:

- When <StepMode> is **Linear** – set the frequency steps in Hz
- When <StepMode> is **Logarithmic** – set the frequency steps in the number of frequency increments per decade
- When <StepMode> is **Octave** – set the frequency steps in the number of frequency increments per octave

For <SettlingPeriods>, set the number of cycles of the signal are output before measurement starts after the generator transitions to a new step.

For <TransitionPoints>, set the number of samples used to move from one frequency to the next step.

Save the file when done.

6.3 Perform a step sine test

Once the settings have been reviewed and the XML files saved, open the Command Prompt and type:

```
EA_Engine.exe Step_Sine_Test
```

to run the step sine test.

If the elements have been set correctly in appropriate files, the EA Engine will respond with a summary of the requested test, initiate output of the step sine signal from the selected output and count the progress through the test in seconds.

Fig. 6.2
Example of the step sine test summary

```
C:\Program Files\Bruel and Kjaer\EA Engine>EA_Engine.exe Step_Sine_Test
Step sine test settings:
Measurement Mode = Spectra
Filename = Step Sine Test
Result file format = CSV
Measure and remove latencies = True
Apply EQ = False

Step sine test running on input channels 6, with output channel 1:
Duration: 17.60 s
Time elapsed: 17.60 s
```

The EA Engine then calculates the requested results and stores the result files (CSV or XML) in the Data Storage directory.

Fig. 6.3
Example showing the storing of test results

```
Removing input & output latencies (device characteristics) from inputs...
Calculating and removing latency between inputs and the first active output...
Latency for Input Channel 6 / Generator 1 (samples): 65

Concatenating inputs & outputs in the same file...
Calculating Harmonic Spectra...
Frequency: 16000.000 Hz - Step 109/109
Calculating Spectra...

Step sine test finished.
```

The contents of the results files depend on the requested measurement. The examples below show the format of the results in the CSV files.

When <MeasurementModeType> is set at **Spectra** – the result file contains the autospectra for the generator output and all active inputs:

Name	Generator 1	Input Channel 6
Comment1	Step Sine Test	Step Sine Test
Comment2	Autospectrum - Power [Pa^2]	Autospectrum - Power [Pa^2]
Frequency [Hz]	Amplitude [Pa^2]	Amplitude [Pa^2]
31.5	5.58820	0.00348
33.5	5.58820	0.00486
35.5	5.58820	0.00649
37.5	5.58820	0.00853
40	5.58820	0.01166
42.5	5.58820	0.01558
45	5.58820	0.02019
47.5	5.58820	0.02626
50	5.58820	0.03429
53	5.58820	0.04411
56	5.58820	0.04799
60	5.58820	0.06310

When <MeasurementModeType> is set at **FRF** – the result file contains the FRFs for the selected reference and active responses expressed in real and imaginary parts as well as amplitude and phase:

Name	Input Channel 6 - Generator Ref			
Comment1	Step Sine Test			
Comment2	FRF - [Pa/V]			
Frequency [Hz]	Real [Pa/V]	Imaginary [Pa/V]	Amplitude [Pa/V]	Phase [degrees]
31.5	3.04E-08	2.61E-08	4.00E-08	40.63106
33.5	3.70E-08	2.90E-08	4.70E-08	38.08467
35.5	4.46E-08	3.15E-08	5.45E-08	35.21239
37.5	5.26E-08	3.34E-08	6.24E-08	32.39739
40	6.37E-08	3.53E-08	7.29E-08	29.01077
42.5	7.53E-08	3.80E-08	8.43E-08	26.7467
45	8.81E-08	3.92E-08	9.65E-08	23.97352
47.5	1.02E-07	4.05E-08	1.10E-07	21.72249
50	1.19E-07	4.14E-08	1.26E-07	19.25866
53	1.40E-07	3.11E-08	1.43E-07	12.54562
56	1.45E-07	2.61E-08	1.47E-07	10.1955
60	1.66E-07	3.65E-08	1.70E-07	12.43169

6.4 Perform distortion calculations

In addition to the standard spectral data, the Step Sine Test also provides the option to calculate standard distortion results simultaneously.

Two types of commonly used distortion are provided:

- **Total harmonic distortion (THD):** Defined as the sum of the modulus of a range of selected harmonics divided by the sum of the total unfiltered signal as shown in the equation below:

$$\%THD = 100\frac{power\ sum\ of\ included\ harmonics}{unfiltered\ total\ output}$$

$$\%THD = 100\sqrt{\frac{(A_2)^2 + (A_3)^2 + \ldots + (A_n)^2}{(A_1)^2 + (A_2)^2 + (A_3)^2 + \ldots + (A_n)^2}}$$

$$A_n = amplitude\ of\ n^{th} product$$

  Typically, the harmonics included in the calculation are 2nd to 5th but can vary. The result is expressed as a percentage
- **Rub & buzz:** An identical calculation to THD, but the range of harmonics used in the calculation is different and higher in frequency, typically 10th to 15th. However, the fundamental (order one) is always included in both calculations.

  As with the THD calculation, the results are expressed in %

Please note: Harmonics will only be included in the calculation if they are within the acquisition range of the hardware, in this case 48 kHz. This is particularly relevant to rub & buzz measurements at high frequencies.

6.4.1 Set up the distortion calculation

To include distortion in the results of a test, the <DistortionAnalysisSettings> parent element of the *Step Sine Test.xml* file must be edited using a text editor such as Notepad++:

```
<DistortionAnalysisSettings>
  <CalculateTHD>true</CalculateTHD>
  <HarmonicsTHD>2,3</HarmonicsTHD>
  <CalculateRubAndBuzz>true</CalculateRubAndBuzz>
  <HarmonicsRubAndBuzz>10,11,12,13,14,15</HarmonicsRubAndBuzz>
</DistortionAnalysisSettings>
```

For <CalculateTHD>, set to **true** to include the THD calculation in the results of the step sine test.

For <HarmonicsTHD>, set the harmonics that are to be included in the numerator part of the THD calculation. The fundamental frequency (harmonic 1) is automatically included and does not need to be entered. Valid entries are any real numbers separated by commas. The entries do not need to consecutive.

For <CalculateRubAndBuzz>, set to **true** to include the rub & buzz calculation in the results of the step sine test.

For <HarmonicsRubAndBuzz>, set the harmonics that are to be included in the numerator part of the rub & buzz calculation. The fundamental frequency (harmonic 1) is automatically included and does not need to be entered. Valid entries are any real numbers separated by commas. The entries do not need to be consecutive.

Save the file when done.

6.4.2 Run the distortion calculation

Once the required values have been set, and the *Step Sine Test.xml* file has been saved, the step sine test can be initiated as described above, open the Command Prompt and type:

```
EA_Engine.exe Step_Sine_Test
```

The EA Engine will add up to two lines to the status feedback while running the test

Fig. 6.4
Example of status message during distortion calculation

```
THD calculated with harmonics 1, 2, 3
Rub & Buzz calculated with harmonics 1, 10, 11, 12, 13, 14, 15
```

and some additional calculations once the test has completed.

Fig. 6.5
Example of added calculations

```
Concatenating inputs & outputs in the same file...
Calculating Harmonic Spectra, THD Harmonics and Rub & Buzz Harmonics...
Frequency: 16000.000 Hz - Step 109/109
Calculating THD...
Calculating Rub & Buzz...
Calculating FRFs...
```

Two additional result files are written to the Data Storage directory including the THD and/or the Rub & Buzz results:

Fig. 6.6
Example of all result files when a distortion calculation is performed

Step Sine Test - 2021.06.02 - 17.06.22 - Step Sine Test - FRFs.csv
Step Sine Test - 2021.06.02 - 17.06.22 - Step Sine Test - Rub & Buzz Calculation.csv
Step Sine Test - 2021.06.02 - 17.06.22 - Step Sine Test - Spectra.csv
Step Sine Test - 2021.06.02 - 17.06.22 - Step Sine Test - THD Calculation.csv

The data stored in the files contains the levels of the harmonics and the distortion calculation for each frequency step and for each active channel

Fig. 6.7
Example of a result file

Comment1	THD Calculation	THD Calculation	THD Calculation	THD Calculation	THD Calculation	THD Calculation	THD Calculation	THD Calculation	THD Calculation	THD Calculation
Comment2	Harmonic 1 Autospectrum - Power [Pa^2]	Harmonic 2 Autospectrum - Power [Pa^2]	Harmonic 3 Autospectrum - Power [Pa^2]	Total Distortion [Pa]	THD [%]	Harmonic 1 Autospectrum - Power [V^2]	Harmonic 2 Autospectrum - Power [V^2]	Harmonic 3 Autospectrum - Power [V^2]	Total Distortion [V]	THD [%]
Frequency [Hz]	Amplitude [Pa^2]	Amplitude [Pa^2]	Amplitude [Pa^2]	Amplitude [Pa]	Amplitude [%]	Amplitude [V^2]	Amplitude [V^2]	Amplitude [V^2]	Amplitude [V]	Amplitude [%]
100	0.7216	0.0030	0.0196	0.1504	17.43	21972.8368	1013.5770	105.4695	33.4522	0.00
106	0.9536	0.0033	0.0197	0.1516	15.34	21973.1830	2028.0355	39.1230	45.4660	0.00
112	1.2685	0.0041	0.0177	0.1476	13.00	21974.9564	2935.1887	952.6904	62.3529	0.00
118	1.6634	0.0044	0.0182	0.1503	11.58	21974.3917	229.4704	550.3380	27.9250	0.00
125	2.1948	0.0048	0.0215	0.1621	10.88	21972.3426	849.3169	122.4001	31.1724	0.00
132	2.8896	0.0036	0.0200	0.1538	9.01	21972.4715	430.1131	9.7920	20.9739	0.00
140	3.7955	0.0034	0.0191	0.1502	7.69	21973.8004	1608.3010	759.2264	48.6572	0.00
150	4.7243	0.0036	0.0224	0.1612	7.40	21972.9164	3878.7846	301.4779	64.6550	0.00
160	6.4868	0.0042	0.0216	0.1607	6.30	21971.9145	734.5541	33.1727	27.7079	0.00
170	8.5497	0.0045	0.0212	0.1604	5.48	21973.4628	1695.9491	469.4282	46.5336	0.00
180	10.9623	0.0044	0.0200	0.1561	4.71	21972.2292	141.8932	92.8644	15.3218	0.00
190	12.9037	0.0045	0.0160	0.1432	3.98	21971.7946	757.2195	11.4653	27.7252	0.00
200	16.4294	0.0031	0.0129	0.1267	3.12	21973.0037	1880.5834	321.3800	46.9251	0.00
212	16.9568	0.0035	0.0079	0.1069	2.59	21971.9465	747.3729	95.0877	29.0252	0.00
224	20.0863	0.0028	0.0032	0.0775	1.73	21972.9474	831.9435	267.2393	33.1539	0.00
236	20.5245	0.0018	0.0013	0.0553	1.22	21971.9923	873.6807	44.3455	30.2989	0.00
250	21.9330	0.0011	0.0008	0.0432	0.92	21973.0307	869.6419	165.1271	32.1678	0.00
265	17.9382	0.0007	0.0013	0.0449	1.06	21972.4112	905.7826	63.7235	31.1369	0.00
280	18.0744	0.0005	0.0017	0.0462	1.09	21973.1134	553.8142	133.5557	26.2177	0.00
300	18.2690	0.0007	0.0018	0.0501	1.17	21972.5335	908.0824	86.4693	31.5365	0.00
315	17.5898	0.0007	0.0016	0.0473	1.13	21973.1720	1160.5386	3.7962	34.1224	0.00

Chapter 7

Waveform Streaming

The Waveform Streaming test allows you to output an arbitrary time history from Production Test USB DAQ Type 3670 outputs to drive a speaker or another type of exciter and measure the response to the applied signal. This is useful in tests requiring response to speech or transient types of response. Multiple outputs can be driven with independent source files.

The format of the source file must be *.wav and sampled at 96 kHz.

The results from the test can be frequency-based measurements (spectra, CPB (1/n-octave), FRF, cross-spectra, phase-assigned spectra, etc.) and additionally time recordings of the input channels.

Before performing a waveform streaming test, input, output and (optionally) equalisation calibrations should be performed.

To set up for waveform streaming testing, using a text editor such as Notepad++, go to the Control XML directory and open and edit the following files:

- *Output Channels.xml*
- *Waveform Streaming Test Settings.xml*

for either spectra or CPB/1-n-octave results.

7.1 Edit the Waveform Streaming Test Settings.xml file

The *Waveform Streaming Test Settings.xml* file is similar to the random and swept sine settings files with the exception that duration is defined by the length of the source .wav file.

You must review and edit the top six elements:

<MeasurementModeType>**Spectra**</MeasurementModeType>
<Filename>**speaker test**</Filename>
<MeasureAndRemoveExtraLatency>**true**</MeasureAndRemoveExtraLatency>
<ResultFileFormatType>**CSV**</ResultFileFormatType>
<ApplyEqualization>**false**</ApplyEqualization>
<Recording>**false**</Recording>

For <MeasurementModeType>, set the measurement mode to one of the following settings:

- **Spectra** – where autospectra are calculated based on the settings in the <AnalysisFFTSettings> element, further down in the file, for each of the active input channels
- **PhaseAssignedSpectra** – where autospectra are calculated based on the settings in <AnalysisFFTSettings> element, further down in the file, and then assigned a phase relative to the defined reference channel

- **FRF** – where FRFs are calculated based on the settings in <AnalysisFFTSettings> element, further down in the file, based on each of the active input channels and the defined reference channel
- **CPB** – (also known as 1/n-octave) where filter-based CPB autospectra are calculated based on the settings in <AnalysisCPBSettings> element further down in the file
- **CPBSynthesis** – where FFT-based CPB autospectra are calculated based on the settings in <AnalysisCPBSynthesisSettings> element further down in the file

Please note: The **PhaseAssignedSpectra** and **FRF** settings require the definition of a reference channel while **Spectra**, **CPB** and **CPBSynthesis** settings do not.

For <Filename>, enter a name that will be appended to the measurement result files. The example below shows the output for the settings shown above:

Fig. 7.1
A CSV file name with measurement results. The file name is based on the first seven elements defined in the Random Noise Test Settings file

Waveform Streaming Test - 2021.08.26 - 10.26.30 - Speaker 4 retest 1 - Spectra.csv

By default, the internal latency between input and output channels is removed automatically. However, in some circumstances, it is desirable to also remove the latency (delay) due to the physical distance between devices such as reference and response microphones. If this is required, then for <MeasureAndRemoveExtraLatency> set the value to **true**. If not, set it to **false**.

The <ResultFileFormatType> determines the file type used for the measurement results. Valid setting options are:

- **XML** – extensible markup language (.xml)
- **CSV** – comma separated values (.csv)
- **MATLAB** (.mat)

The <ApplyEqualization> applies equalisation to the active output channels using the function defined in the EQFile element in the *Output Channels.xml* file (see below). An error is generated if the file is undefined. Set as either **true** or **false**.

For <Recording>, set **true** to create an optional time recording of all the input and output channels for further post-processing in third-party programs. Set **false** if you do not want a recording.

Save the file when done.

7.1.1 Additional settings

In addition to the primary settings above, you should also modify the settings in the relevant calculation settings section(s) of this file:

- <AnalysisFFTSettings>
- <AnalysisCPBSettings>
- <AnalysisCPBSynthesisSettings>
- <TimeDataRecordingSettings>

to obtain the desired format of the results. See section A.12 for a detailed review of the valid setting options.

Please note: Some settings are mutually dependent on each other and, where possible, will be automatically modified by the software to comply with the requested settings. In general, the last dependent element read takes precedence.

Save the file when done.

7.2 Edit the Output Channels.xml file

After you have reviewed and saved the *Waveform Streaming Test Settings* file, edit and review the *Output Channels.xml* file.

Edit the following elements for the required output channels:

```
<IsActive>true</IsActive>
<SignalType>WaveformStreaming</SignalType>
<WaveformStreaming>
    <Filename>C:\Source Time Data\Distortion tests\Test 23.wav</Filename>
    <ChannelIndex>1</ChannelIndex>
    <Level>2</Level>
</WaveformStreaming>
```

The <IsActive> must be set to **true**.

The <SignalType> must be set to **WaveformStreaming**.

For <Filename>, set the full path description of the file that will be used as the streaming source. The file needs to be a .wav file with a sample rate of 96 kHz.

<ChannelIndex> is only required when reading from a multi-channel source .wav file. Define the track number within the file to be used. For a single channel file, the setting should be retained at **1**.

For <Level>, the EA Engine attempts to stream the output file at the correct, calibrated level. If the file was produced by the EA Engine, or other engineering software such as BK Connect®, then the floating-point values in the file are automatically stored in engineering units. If the output channel has also been calibrated, then the streamed data will be output at the expected calibrated level in engineering units. If equalisation is applied to the output signal, the level is compensated to achieve the correct sound pressure level.

If the data in the .wav file comes from an uncalibrated source, it may be necessary to adjust the <Level> value here to achieve the desired level. For example, if the output level is 6 dB too low with a Level setting of 1, the output can be corrected by editing the value to **2**.

Save the file when done.

7.3 Perform a waveform streaming test

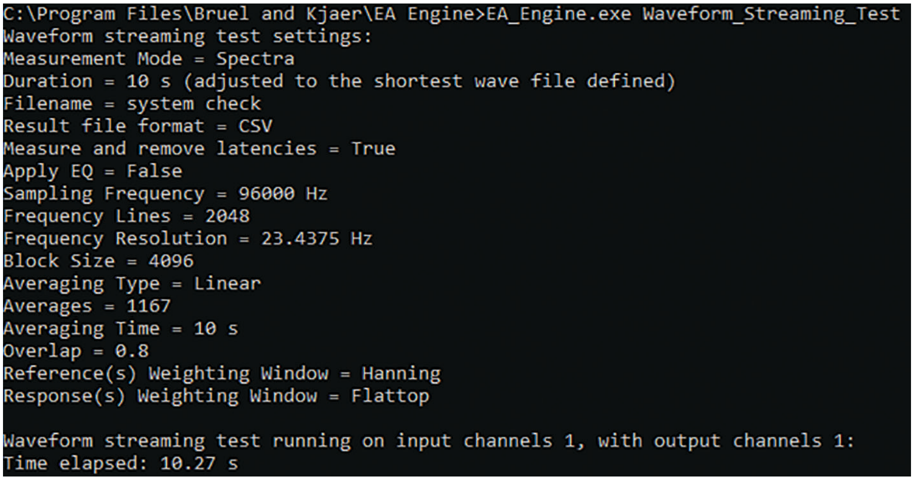
Once the settings have been reviewed and the XML files saved, open the Command Prompt and type:

```
EA_Engine.exe Waveform_Streaming_Test
```

to run the waveform streaming test.

If the elements have been set correctly in appropriate files, the EA Engine will respond with a summary of the requested test, initiate output of the waveform signal from the selected output and count the progress through the test in seconds.

Fig. 7.2
Example of the waveform streaming test summary

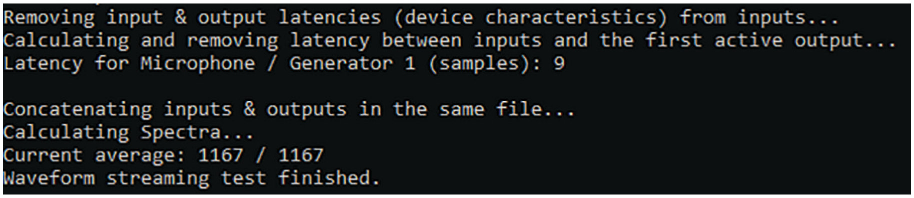


```
C:\Program Files\Bruel and Kjaer\EA Engine>EA_Engine.exe Waveform_Streaming_Test
Waveform streaming test settings:
Measurement Mode = Spectra
Duration = 10 s (adjusted to the shortest wave file defined)
Filename = system check
Result file format = CSV
Measure and remove latencies = True
Apply EQ = False
Sampling Frequency = 96000 Hz
Frequency Lines = 2048
Frequency Resolution = 23.4375 Hz
Block Size = 4096
Averaging Type = Linear
Averages = 1167
Averaging Time = 10 s
Overlap = 0.8
Reference(s) Weighting Window = Hanning
Response(s) Weighting Window = Flattop

Waveform streaming test running on input channels 1, with output channels 1:
Time elapsed: 10.27 s
```

The EA Engine then calculates the requested results and stores the result files (CSV or XML) in the Data Storage directory.

Fig. 7.3
Example showing the storing of test results



```
Removing input & output latencies (device characteristics) from inputs...
Calculating and removing latency between inputs and the first active output...
Latency for Microphone / Generator 1 (samples): 9

Concatenating inputs & outputs in the same file...
Calculating Spectra...
Current average: 1167 / 1167
Waveform streaming test finished.
```

The contents of the results files depend on the requested measurement. The examples below show the format of the results in the CSV files.

When <MeasurementModeType> is set at **Spectra** – the result file contains the autospectra for the generator output and all active inputs:

Name	Generator 1	Microphone
Comment1	Waveform Streaming Test	Waveform Streaming Test
Comment2	Autospectrum - Power [Pa^2]	Autospectrum - Power [Pa^2]
Frequency [Hz]	Amplitude [Pa^2]	Amplitude [Pa^2]
0	2.74E-10	2.87E-05
23.4375	5.20E-10	5.36E-05
46.875	3.09E-10	2.38E-05
70.3125	1.55E-10	2.16E-06
93.75	1.41E-10	1.51E-08
117.1875	1.42E-10	1.44E-10
140.625	1.44E-10	1.46E-10
164.0625	1.46E-10	1.47E-10
187.5	1.49E-10	1.51E-10
210.9375	1.51E-10	1.52E-10
234.375	1.55E-10	1.56E-10
257.8125	1.58E-10	1.60E-10

When <MeasurementModeType> is set at **FRF** – the result file contains the FRFs for the selected reference and active responses expressed in real and imaginary parts as well as amplitude and phase:

Name	Microphone - Generator 1			
Comment1	Waveform Streaming Test			
Comment2	FRF - [Pa/Pa]			
Frequency [Hz]	Real [Pa/Pa]	Imaginary [Pa/Pa]	Amplitude [Pa/Pa]	Phase [degrees]
0	0.5438	0.0000	0.5438	0.0000
23.4375	1.4340	-0.0053	1.4340	-0.2121
46.875	0.7074	0.0278	0.7079	2.2520
70.3125	1.0840	-0.0152	1.0841	-0.8046
93.75	0.9897	0.0082	0.9898	0.4758
117.1875	0.9986	0.0048	0.9986	0.2746
140.625	0.9933	0.0069	0.9933	0.3975
164.0625	1.0016	0.0077	1.0016	0.4399
187.5	0.9925	0.0086	0.9926	0.4970
210.9375	1.0011	0.0099	1.0011	0.5688
234.375	0.9941	0.0104	0.9941	0.5985
257.8125	1.0000	0.0114	1.0001	0.6543
281.25	0.9938	0.0129	0.9939	0.7434
304.6875	1.0003	0.0130	1.0004	0.7439

Chapter 8

Time Data Recording

If you want to make a recording of data to be analysed in a third-party software, the EA Engine gives you the opportunity to record calibrated time data from Production Test USB DAQ Type 3670. Time recording is also an option for all the measurement tests except the step sine test.

During time data recording, calibrated time data files for all the active channels defined in the *Input Channels.xml* file are created. It is only necessary to perform an input calibration for each of the required channels prior to making a recording.

To set up for time data recording, using a text editor such as Notepad++, go to the Control XML directory and open and edit the *Time Data Recording Settings.xml* file.

8.1 Edit the Time Data Recording Settings.xml file

In the *Time Data Recording Settings.xml* file, you can review and edit all elements, but only need to edit the top three elements:

<Filename>**Test Recording**</Filename>
<RecordingFileFormatType>**WAV**</RecordingFileFormatType>
<AutoIncrementFilename>**false**</AutoIncrementFilename>
<TriggerType>**Manual**</TriggerType>
<TriggerChannel>**1**</TriggerChannel>
<TriggerLevel>**50**</TriggerLevel>
<RecordingTime>**10**</RecordingTime>

For <Filename>, enter the recording's file name.

Please note: Time recordings are stored in the Data Storage directory defined by the <DataFolder> element in the *Engine Settings.xml* file.

For <RecordingFileFormatType>, set the file format for the time recording. The options are:

- **WAV**
- **MATLAB**
- **HDF5**

For <AutoIncrementFilename>, when set to true, adds an integer to the filename, which is automatically incremented with each subsequent recording.

Save the file when done.

The other settings

- <TriggerType>: Currently only 'Manual' (that is, starts immediately when the command is issued) trigger is implemented.
- <TriggerChannel>: Not implemented.
- <RecordingTime>: The length of the recording in seconds

8.2 Perform a time data recording

Once the settings have been reviewed and the XML file saved, open the Command Prompt and type:

```
EA_Engine.exe Time_Data_Recording
```

to run the time data recording.

The EA Engine will respond with a summary of the requested test, initiate the measurement and count the progress through the test in seconds.

Fig. 8.1
Example of the recording summary

```
C:\Program Files\Bruel and Kjaer\EA Engine>EA_Engine.exe Time_Data_Recording
Time data recording settings:
Filename = Test Recording
Recording File Format = WAV
Auto Increment Filename = False
Trigger = Manual
Recording Time = 10 s

Time data recording running on input channels 6, 8:
Time elapsed: 10.00 s
```

At completion of the recording, the EA Engine calculates and removes the latency in the recorded data and stores the final recording.

Fig. 8.2
Example of recording completion

```
Removing input latency (device characteristics) from inputs...
Time data recording finished.
```

For every recording, two files are written to the Data Storage directory. The first is the calibrated time recording file and the second contains a summary of the input channel setup information.

Fig. 8.3
Example of the resulting files

Wave format:

Test Recording.wav
Test Recording.wav - Input Channels Setup.xml

MATLAB format:

Test Recording.mat
Test Recording.mat - Input Channels Setup.xml

HDF5 format:

Test Recording.h5
Test Recording.h5 - Input Channels Setup.xml

Chapter 9

Special Functions

9.1 Cross-channel calculations

The EA Engine provides significant flexibility in calculating cross-channel data. This flexibility leads to some complexity in the setup of these measurements. Typically, cross-channel measurements are for the calculation of FRFs or phase-assigned spectra.

For cross-channel measurements, a reference channel needs to be defined for each input channel. The EA Engine allows for multiple, independent references to be defined. This does not constitute a MIMO (multiple input, multiple output) calculation but a recognition that a measurement may contain multiple references which may, or may not, be correlated.

9.1.1 Define a reference channel

Both input and output channels can be used as references.

To create a reference channel:

- It must first be given a unique identifier by changing the <Name> element in either the *Input Channels.xml* or *OutputChannels.xml* files
- The value assigned to the <Name> element of the required reference channel must then be the same as the <ReferenceChannelName> element for the required response input channel in the *Input Channel.xml* file

For example, to calculate an FRF using channel 6 as the response (numerator) and output channel 1 as the reference channel:

1) Set the <Name> of output channel 1 to something unique. In this case **Ref Signal 1**:

```
<OutputChannel>
  <Number>1</Number>
  <Name>Ref Signal 1</Name>
```

Please note: It is not necessary to change the name at all since, by default, the name is unique but the <Name> will be attached to all the corresponding measurement data so using a relevant Name will make it easier to uniquely identify the data.

2) Change the <ReferenceChannelName> for channel 6 in the *Input Channels.xml* file to the same value as the output channel 1 name:

```
<InputChannel>
  <Number>6</Number>
  <Name>Input Channel 6</Name>
  <IsActive>true</IsActive>
  <ReferenceChannelName>Ref Signal 1</ReferenceChannelName>
```

3) Set the <MeasurementModeType> element in the *Random Noise*, *Swept Sine* or *Step Sine Test Settings* XML file to **FRF** or **PhaseAssignedSpectra** to activate the cross-channel measurement.
   <MeasurementModeType>**FRF**</MeasurementModeType>
4) Save all the edited files.

9.1.2 Run the cross-channel calculation

Once the settings have been reviewed and the XML files saved, open the Command Prompt and execute the appropriate test command (random, swept sine or step sine) as normal.

At the completion of the test, two result files will be written to the Data Storage directory, one for the spectra and one for the cross-channel functions:

Fig. 9.1
Example result files

Swept Sine Test - 2021.05.05 - 10.40.31 - dummy - FRFs.csv
Swept Sine Test - 2021.05.05 - 10.40.31 - dummy - Spectra.csv

The format of the 'Spectra' file is as described earlier in the separate test chapters.

The 'FRFs' file contains the FRF data expressed in both real and imaginary and in amplitude and phase.

Fig. 9.2
Example of a FRF result file

Name	Input Channel 6 - Ref Signal 1			
Comment1	Step Sine Test			
Comment2	FRF - [Pa/V]			
Frequency [Hz]	Real [Pa/V]	Imaginary [Pa/V]	Amplitude [Pa/V]	Phase [degrees]
31.5	3.04E-08	2.61E-08	4.00E-08	40.63106
33.5	3.70E-08	2.90E-08	4.70E-08	38.08467
35.5	4.46E-08	3.15E-08	5.45E-08	35.21239
37.5	5.26E-08	3.34E-08	6.24E-08	32.39739
40	6.37E-08	3.53E-08	7.29E-08	29.01077
42.5	7.53E-08	3.80E-08	8.43E-08	26.7467
45	8.81E-08	3.92E-08	9.65E-08	23.97352
47.5	1.02E-07	4.05E-08	1.10E-07	21.72249
50	1.19E-07	4.14E-08	1.26E-07	19.25866

For a phase assigned spectra calculation, only one file is written containing the autospectra and the phase relative to the reference for both the reference and the response channel(s), expressed both in real and imaginary (squared) and amplitude (squared) and phase:

Fig. 9.3
Example of a phase-assigned spectra result file

Name	Ref Signal 1				Input Channel 6 - Ref Signal 1				
Comment1	Step Sine Test				Step Sine Test				
Comment2	Phase Assigned Spectrum - Power [Pa^2]				Phase Assigned Spectrum - Power [Pa^2]				
Frequency [Hz]	Real [Pa^2]	Imaginary [Pa^2]	Amplitude [Pa^2]	Phase [degrees]	Real [Pa^2]	Imaginary [Pa^2]	Amplitude [Pa^2]	Phase [degrees]	
100	0.6876	0.0000	0.6876	0.00	0.0512	0.0316	0.0602	31.69	
103	0.6876	0.0000	0.6876	0.00	0.0591	0.0378	0.0702	32.62	
106	0.6876	0.0000	0.6876	0.00	0.0693	0.0433	0.0817	31.99	
109	0.6876	0.0000	0.6876	0.00	0.0809	0.0496	0.0948	31.51	
112	0.6876	0.0000	0.6876	0.00	0.0945	0.0565	0.1101	30.84	
115	0.6876	0.0000	0.6876	0.00	0.1099	0.0636	0.1270	30.07	
118	0.6876	0.0000	0.6876	0.00	0.1273	0.0708	0.1457	29.09	
122	0.6876	0.0000	0.6876	0.00	0.1538	0.0810	0.1738	27.77	
125	0.6876	0.0000	0.6876	0.00	0.1742	0.0881	0.1952	26.83	
128	0.6876	0.0000	0.6876	0.00	0.1984	0.0971	0.2209	26.09	

Multiple references can be defined and assigned to different channels.

For example, if you have a reference microphone in channel 6 that you want to be referenced to generator 1 (set up with the name **Ref Signal 1** as the example above) and an ear simulator in channel 4 that needs to be referenced to the reference microphone, then the settings for channels 4 and 6 in the *Input Channels.xml* file would look like this:

For channel 4:

<InputChannel>

<Number>**4**</Number>

<Name>**Right Ear**</Name>

<IsActive>**true**</IsActive>

<ReferenceChannelName>**Ref Microphone**</ReferenceChannelName>

For channel 6:

<InputChannel>

<Number>**6**</Number>

<Name>**Input Ref Microphone**</Name>

<IsActive>**true**</IsActive>

<ReferenceChannelName>**Ref Signal 1**</ReferenceChannelName>

Please note: The names can be any string The important thing is to ensure that the <Name> and the <ReferenceChannelName> are consistent.

A step sine test with these settings would produce an FRF file with the following format:

Fig. 9.4
Example of a step sine FRF result file

Name	Right Ear - Ref Microphone				Ref Microphone - Ref Signal 1			
Comment1	Step Sine Test				Step Sine Test			
Comment2	FRF - [Pa/Pa]				FRF - [Pa/Pa]			
Frequency [Hz]	Real [Pa/Pa]	Imaginary [Pa/Pa]	Amplitude [Pa/Pa]	Phase [degrees]	Real [Pa/Pa]	Imaginary [Pa/Pa]	Amplitude [Pa/Pa]	Phase [degrees]
100	-0.0785	-0.0011	0.0785	-179.21	0.2450	0.1589	0.2920	32.97
103	-0.0916	-0.0001	0.0916	-179.94	0.2715	0.1744	0.3227	32.71
106	-0.0926	0.0043	0.0927	177.35	0.2912	0.1860	0.3456	32.57
109	-0.0973	-0.0009	0.0973	-179.47	0.3139	0.1964	0.3703	32.04
112	-0.1004	-0.0019	0.1004	-178.92	0.3426	0.2085	0.4010	31.33
115	-0.1051	-0.0005	0.1051	-179.75	0.3672	0.2186	0.4273	30.76
118	-0.1093	0.0023	0.1094	178.78	0.4013	0.2269	0.4610	29.49
122	-0.1113	0.0091	0.1117	175.33	0.4409	0.2386	0.5013	28.42
125	-0.1087	0.0131	0.1095	173.11	0.4727	0.2501	0.5348	27.88
128	-0.1088	0.0126	0.1095	173.38	0.5056	0.2577	0.5675	27.00
132	-0.1133	0.0134	0.1141	173.28	0.5601	0.2664	0.6203	25.44
136	-0.1193	0.0197	0.1209	170.61	0.6197	0.2685	0.6754	23.43

9.2 Settling time

The <SettlingTime> element in the *Engine Settings.xml* file provides an additional time of the initial signal output at the start of a test and before measurement is started, to provide for stabilisation of the system.

This is important for systems that contain closed-loop feedback elements such as vibration controllers, where the input signal is only used as a reference and the amplitude is controlled by an internal loop in the control system itself.

Any positive numeric value, in seconds, is valid for this setting. For swept and step sine tests, the system will add the number of seconds of the requested initial frequency. For random noise tests, it simply extends the length of the signal. Measurement of the inputs does not start until the end of the settling time.

9.3 Integration/Differentiation

For measurements using vibration transducers, it is sometimes useful to be able to convert acceleration to velocity or displacement (or vice versa) in the calculated data. The <IntegrateDifferentiate> element in the *Engine Settings.xml* provides that functionality for calculated spectra and cross-channel functions.

Valid settings and the corresponding transformations are listed below:

- −2 = Double Integration
- −1 = Integration
- 0 = No action
- 1 = Differentiation
- 2 = Double Differentiation

The action is only applied to channels that have the following units defined in the <SensitivityUnit> in the *Input Channels.xml* file:

- mV/m
- mV/(m/s) or mV/m/s
- mV/(m/s^2), mV/m/s^2, mV/(m/s^2) or mV/m/s^2

Or, for outputs, where <SensitivityUnit> in the *Output Channels.xml* file is:

- V/m
- V/(m/s) or V/m/s
- V(m/s^2), V/m/s^2, V/(m/s^2) or V/m/s^2

The EA Engine checks if integration or differentiation makes sense, depending on the defined unit (for example, acceleration cannot be differentiated) and no action will be taken or warning given.

These operations are performed on autospectra, phase assigned spectra and FRFs only.

Appendix A

Control File References

A.1 Calibration Settings.xml

ELEMENT	ALLOWABLE VALUES	COMMENT
<ReferenceFrequency>	Positive real number	Frequency of calibration signal in Hz
<ReferenceLevel>	Positive real number	RMS amplitude of the calibration signal
<ReferenceUnit>	Text	Engineering units to be entered as the denominator of the <SensitivityUnit> element of the channel being calibrated
<Duration>	Positive real number	Nominal measurement time in seconds
<ResultFileFormatType>	**CSV** **XML** **MATLAB**	File format for the calibration spectra
<AnalysisFFTSettings>	–	Element group for FFT calculation
<SamplingFrequency>	**96000**	Fixed for Type 3670 DAQ
<FrequencyLines>	2^N (positive integer)	Number of spectral lines used for the FFT. Dependent on <BlockSize> and <FrequencyResolution>
<FrequencyResolution>	(96000/2)/<FrequencyLines>	Dependent on <FrequencyLines> and <BlockSize>
<BlockSize>	2^N (positive integer)	<FrequencyLines>*2. Dependent on <FrequencyLines> and <FrequencyResolution>
<AveragingType>	**Linear** **Exponential** **MaxHold**	Sets the mode of averaging for the FFT

ELEMENT	ALLOWABLE VALUES	COMMENT
<Averages>	Positive integer	Calculated automatically from <Duration> element value
<ExpAverages>	Positive integer	Calculated automatically from <Duration> element value
<AveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<ExpAveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<Overlap>	Positive real number between **0** and **1**	Fraction of the time block used to overlap with the next block, that is, 0.5 = 50% overlap. Automatically set to **0** by the calibration command
<FRFEstimator>	**H1** **H2**	Estimator method used for FRF calculation. Not used in calibration
<ReferenceWeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the reference. Not used in calibration
<ResponseWeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the reference. Automatically set to **Flattop** by the calibration command
<CalcCrossSpectrum>	**true** **false**	If set to **true**, cross-spectra between the reference and response is calculated and stored as well as autospectra for both reference and response
<CalcPhaseAssignedSpectrum>	**true** **false**	If set to **true**, phase-assigned spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcFRF>	**true** **false**	If set to **true**, FRFs and cross-spectra between the reference and response are calculated and stored as well as autospectra for both reference and response

ELEMENT	ALLOWABLE VALUES	COMMENT
<CalcOrdinaryCoherence>	**true** **false**	If set to **true**, FRFs, ordinary coherence and cross-spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcPrincipalForce>	**true** **false**	Not used
</AnalysisFFTSettings>	–	End of element group for FFT calculation

A.2 Engine Settings.xml

ELEMENT	ALLOWABLE VALUES	COMMENT
<DataFolder>	Folder path	Storage location for measurements
<PressEnter>	**true** **false**	Determines whether the user needs to press enter at the completion of a command. Normally set to **true** for manual operation and **false** if used programmatically
<SettlingTime>	Positive real number	Sets an additional time for the initial output of the generator signal before measurement is started

ELEMENT	ALLOWABLE VALUES	COMMENT
<IntegrateDifferentiate>	**–2** **–1** **0** **1** **2** Recognized units for input channels are: **mV/m** **mV/(m/s)** **mV/m/s** **mV/(m/s^2)** **mV/m/s^2** **mV/(m/s^2)** **mV/m/s^2** **V/m** **V/(m/s)** **V/m/s** **V(m/s^2)** **V/m/s^2** **V/m/s^2** **V/(m/s^2)**	Perform integration or differentiation for all channels marked with vibration units. **–2** = Double Integration **–1** = Integration **0** = No action **1** = Differentiation **2** = Double Differentiation

A.3 Equalization Settings.xml

ELEMENT	ALLOWABLE VALUES	COMMENT
<ReferenceFrequency>	**1 – 48000 Hz**	Sets the normalisation frequency (unity gain) for the equalisation function. This is normally the calibration frequency for the input channels in use
<FrequencyStart>	**1 – 48000 Hz**	Sets the lower limit of the equalisation frequency range
<FrequencyEnd>	**1 – 48000 Hz**	Sets the upper limit of the equalisation frequency range
<FilterLength>	(2^N)+1	
<MeasureAndRemoveExtraLatency>	**true** **false**	Measures the additional external latency between the sound source and the response and removes it for cross channel calculations

ELEMENT	ALLOWABLE VALUES	COMMENT
<ResultFileFormatType>	**CSV** **XML** **MATLAB**	File format for the calibration spectra
<AnalysisFFTSettings>	–	Element group for FFT calculation
<SamplingFrequency>	**96000**	Fixed for Type 3670 DAQ
<FrequencyLines>	**96000**	Number of spectral lines used the FFT. Dependent on <BlockSize> and <FrequencyResolution>
<FrequencyResolution>	2^N (positive integer)	Dependent on <FrequencyLines> and <BlockSize>
<BlockSize>	(96000/2)/<FrequencyLines>	<FrequencyLines>*2. Dependent on <FrequencyLines> and <FrequencyResolution>
<AveragingType>	2^N (positive integer)	Sets the mode of averaging for the FFT
<Averages>	Linear Exponential MaxHold	Calculated automatically from <Duration> element value
<ExpAverages>	Positive integer	Calculated automatically from <Duration> element value
<AveragingTime>	Positive integer	Calculated automatically from <Duration> element value
<ExpAveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<Overlap>	Positive real number	Fraction of the time block used to overlap with the next block, that is, 0.5 = 50% overlap. Automatically set to zero by the calibration command
<FRFEstimator>	Positive real number between **0** and **1**	Estimator method used for FRF calculation. Not used in calibration
<ReferenceWeightingType>	**H1** **H2**	Sets the windowing type for the reference. Not used in calibration
<ResponseWeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the reference. Automatically set to **Flattop** by the calibration command

ELEMENT	ALLOWABLE VALUES	COMMENT
<CalcCrossSpectrum>	**true** **false**	If set to **true**, cross-spectra between the reference and response is calculated and stored as well as autospectra for both reference and response
<CalcPhaseAssignedSpectrum>	**true** **false**	If set to **true**, phase-assigned spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcFRF>	**true** **false**	If set to **true**, FRFs and cross spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcOrdinaryCoherence>	**true** **false**	If set to **true**, FRFs, ordinary coherence and cross-spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcPrincipalForce>	**true** **false**	Not used
</AnalysisFFTSettings>	–	End of element group for FFT calculation

A.4 Input Channels.xml

The following collection of elements are repeated for each input channel of the selected device.

ELEMENT	ALLOWABLE VALUES	COMMENT
<InputChannel>	–	Input channel element group
<Number>	Positive integer	A value of **1** to N where N is the number of input channels on the selected device
<Name>	Text string	The name of the selected channel
<IsActive>	**true** **false**	Sets the state of the input channel defined by <Number> as active or inactive

ELEMENT	ALLOWABLE VALUES	COMMENT
<ReferenceChannelName>	Text string	Defines an input or output channel to be used in cross-channel calculations. Must be identical to the <Name> element of an active input/ output channel
<Sensitivity>	Positive real number	The calibration value of the input channel with units defined by the <SensitivityUnit> element. The value can be set manually but is automatically updated after the execution of an input calibration measurement on the relevant channel
<SensitivityUnit>	Text in the format of mV/****	Where **** represents the physical quantity of the input signal. Typically, Pa (pascals) for acoustic measurements or m/s^2 for vibration measurements but the value is only what is appended to the data stored in the results file. Note: The only exception to this is when the <IntegrateDifferentiate> element in the *Engine Settings.xml* file is set to a non-zero value. Then, for integration or differentiation to be applied, the units must be formatted in one of the following ways: • mV/m • mV/(m/s) or mV/m/s • mV/(m/s^2), mV/m/s^2 or mV/m/s^2
<CalibrationDate>	Long date format	The date and time corresponding to the last input calibration test performed on the relevant channel
<dBRef>	Positive real number	The dB reference value for the <Sensitivity> value for the relevant channel. Typically, **2e–5** for sound pressure measurements and **1** for vibration measurements in m/s^2 or m/s^2
<VMax>	Positive real number	The maximum input voltage level for the relevant channel. By default, this is **5.32** and should not be changed

ELEMENT	ALLOWABLE VALUES	COMMENT
<Latency>	Positive integer	The total latency between the output and the selected input channel. If <MeasureAndRemoveExtraLatency> is set to true then the latency is the combined internal delay of Type 3670 plus the external latency between the output and the input
<EQFile>	File path	Absolute file path for EQ file
</InputChannel>	–	End of input channel element group

A.5 Output Calibration Settings.xml

ELEMENT	ALLOWABLE VALUES	COMMENT
<Frequency>	Positive real number	The frequency of the calibration signal
<Level>	Positive real number	The rms level in engineering units of the calibration signal
<Duration>	Positive real number	The nominal time, in seconds, of the calibration signal
<AnalysisFFTSettings>	–	Element group for FFT calculation
<SamplingFrequency>	**96000**	Fixed for Type 3670 DAQ
<FrequencyLines>	2^N (positive integer)	Number of spectral lines used for the FFT. Dependent on <BlockSize> and <FrequencyResolution>
<FrequencyResolution>	(96000/2)/<FrequencyLines>	Dependent on <FrequencyLines> and <BlockSize>
<BlockSize>	2^N (positive integer)	<FrequencyLines>*2. Dependent on <FrequencyLines> and <FrequencyResolution>
<AveragingType>	**Linear** **Exponential** **MaxHold**	Sets the mode of averaging for the FFT
<Averages>	Positive integer	Calculated automatically from <Duration> element value

ELEMENT	ALLOWABLE VALUES	COMMENT
<ExpAverages>	Positive integer	Calculated automatically from <Duration> element value
<AveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<ExpAveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<Overlap>	Positive real number between **0** and **1**	Fraction of the time block used to overlap with the next block, that is, 0.5 = 50% overlap. Automatically set to **0** by the calibration command
<FRFEstimator>	**H1** **H2**	Estimator method used for FRF calculation. Not used in calibration
<ReferenceWeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the reference. Not used in calibration
<ResponseWeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the reference. Automatically set to **Flattop** by the calibration command
<CalcCrossSpectrum>	**true** **false**	If set to **true**, cross-spectra between the reference and response is calculated and stored as well as autospectra for both reference and response
<CalcPhaseAssignedSpectrum>	**true** **false**	If set to **true**, phase-assigned spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcFRF>	**true** **false**	If set to **true**, FRFs and cross-spectra between the reference and response are calculated and stored as well as autospectra for both reference and response

ELEMENT	ALLOWABLE VALUES	COMMENT
<CalcOrdinaryCoherence>	**true** **false**	If set to **true**, FRFs, ordinary coherence and cross-spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcPrincipalForce>	–	Not used
</AnalysisFFTSettings>	–	End of element group for FFT calculation

A.6 Output Channels.xml

The following collection of elements are repeated for each output channel of the selected device.

ELEMENT	ALLOWABLE VALUES	COMMENT
<OutputChannel>	–	Element group for selected output channel
<Number>	Positive integer	A value of **1** to N where N is the number of output channels on the selected device
<Name>	Text string	The name of the selected channel
<IsActive>	**true** **false**	Sets the state of the input channel defined by <Number> as active or inactive
<ReferenceChannelName>	Input or output channel <Name>	Must exactly match a valid input or output channel name
<Sensitivity>	Positive real number	The calibration value of the input channel with units defined by the <SensitivityUnit> element. The value can be set manually but is automatically updated after the execution of an input calibration measurement on the relevant channel

ELEMENT	ALLOWABLE VALUES	COMMENT
<SensitivityUnit>	Text in the format of V/****	Where **** represents the physical quantity of the input signal. Typically, Pa (pascals) for acoustic measurements or m/s^2 for vibration measurements but the value is only what is appended to the data stored in the results file. Note: The only exception to this is when the <IntegrateDifferentiate> element in the *Engine Settings.xml* file is set to a non-zero value. Then, for integration or differentiation to be applied, the units must be formatted in one of the following ways: • V/m • V/(m/s) or V/m/s • V(m/s^2), V/m/s^2 or V/m/s^2
<CalibrationDate>	Long date format	The date and time corresponding to the last input calibration test performed on the relevant channel
<dBRef>	Positive real number	The dB reference value for the <Sensitivity> value for the relevant channel. Typically, **2e–5** for sound pressure measurements and **1** for vibration measurements in m/s^2
<Vmax>	Positive real number	The maximum output voltage level for the relevant channel. By default, this is **3.5** and should not be changed
<EQFile /	File path	Absolute file path for EQ file
<SignalType>	**Sine** **Sweep** **White** **Pink** **Step** **WaveformStreaming**	Sets the signal type for the requested test. This element must be correctly set for the relevant test to avoid the software generating an error
<Random>	–	Element group for random output signal type
<Level>	Positive real number	Output level in engineering units defined by the <Sensitivity> element

ELEMENT	ALLOWABLE VALUES	COMMENT
<IsFiltered>	**true** **false**	Activates the bandpass filtering with limits determined by the settings in the <HiPassFrequency> and <LoPassFrequency>
<HiPassFrequency>	Positive real number	Minimum frequency of passband if <IsFiltered> is set to **true**
<LoPassFrequency>	Positive real number	Maximum frequency of passband if <IsFiltered> is set to **true**
<Slope>	**0** **6**	Sets the slope of spectral content of the signal in the passband. **0** for white noise, **6** for pink noise
<Duration>	Positive real number	Only valid for EQ measurements, for random noise test operations, the test duration is controlled by the element in the *Random Noise Test Settings.xml* file
</Random>	–	End of element group for random output signal type
<FixedSine>	–	Element group for fixed sine output signal type
<Level>	Positive real number	The output level in engineering units defined by the <Sensitivity> element
<Frequency>	Positive real number	The frequency of the output signal in Hz
<Duration>	Positive real number	The duration of the output signal in seconds
</FixedSine>	–	End of element group for fixed sine output signal type
<SweepSine>	–	Element group for swept sine output signal type
<Level>	Positive real number	The output level in engineering units defined by the <Sensitivity> element
<StartFrequency>	Positive real number	The output frequency at the start of the test in Hz. Note: The value for the <EndFrequency> can be higher than the <StartFrequency>

ELEMENT	ALLOWABLE VALUES	COMMENT
<EndFrequency>	Positive real number	The output frequency at the end of the test in Hz. Note: The value for the <StartFrequency> can be higher than the <EndFrequency>
<SweepMode>	**Linear** **Logarithmic** **Octaves**	Frequency transition in Hz/sec, decades/sec, octaves/sec dependant on the <SweepTime> and sweep range defined by <StartFrequency> and <EndFrequency>
<SweepTime>	Positive real number	Nominal test time to complete the sweep. The exact time will depend on the analysis options selected
<Repetitions>	**0** Positive integer	The number of times to repeat the sweep
<Silence>	Positive real number	An optional output of silence at the start of the test in seconds
<FadeMode>	**Linear** **Cosine** **Cubic** **Hermite**	Interpolation mode for fade-in/fade-out of the output signals at the beginning and the end of the test
<FadeIn>	Positive real number	Fade-in time in seconds
<FadeOut>	Positive real number	Fade-out time in seconds
</SweepSine>	–	End of element group for swept sine output signal type
<StepSine>	–	Element group for step sine output signal type
<Level>	Positive real number	The output level in engineering units defined by the <Sensitivity> element
<StartFrequency>	Positive real number	The output frequency at the start of the test in Hz. Note: The value for the <EndFrequency> can be higher than the <StartFrequency>

ELEMENT	ALLOWABLE VALUES	COMMENT
<EndFrequency>	Positive real number	The output frequency at the end of the test in Hz. Note: The value for the <StartFrequency> can be higher than the <EndFrequency>
<ResolutionType>	**R10** **R20** **R40** **R80** **UserDefined**	Determines the incremental frequency mode of the step sine test. **R10** = 1/3-octave **R20** = 1/6-octave **R40** = 1/12-octave **R80** = 1/24-oOctave Setting **UserDefined** uses the values in <StepMode>, <StepIncrement> and <SettlingPeriods> to define the profile of the test
<MinCycles>	Positive integer	Minimum number of cycles to be used for measurement for each step Note: Will be overridden if <MinDuration> exceeds <MinCycles>
<MinDuration>	Positive real number	Minimum duration (in seconds) to be used for measurement for each step Note: Will be overridden if <MinCycles> (in seconds) exceeds <MinDuration>
<StepMode>	**Linear** **Logarithmic** **Octaves**	Interprets the value in <StepIncrement> in Hz, decades or octaves, respectively. Note: Only active when <ResolutionType> is set to **UserDefined**
<StepIncrement>	Positive real number	Defines the frequency resolution of the successive steps in Hz, decades or octaves depending on the value of <StepMode>
<SettlingPeriods>	Positive integer	Number of cycles of the output signal at each step before data is used for measurement
<TransitionPoints>	Positive integer	The number of samples used in the output signal used to transition between steps

ELEMENT	ALLOWABLE VALUES	COMMENT
</StepSine	–	End of element group for step sine output signal type
<WaveformStreaming>	–	Element group for waveform streaming output signal type
<Filename />	File path and name	Absolute file path and name for source time file. Note: The sample rate needs to conform to 96 kHz
<ChannelIndex>	Positive Integer	Only required for multichannel files. Where the number indicates the channel number to be used for the output signal
<Level>	Positive real number	Output level in units defined by the <Sensitivity> element and scaled by the equalisation function if selected
</WaveformStreaming>	–	End of element group for waveform streaming output signal type
</OutputChannel	–	End of element group for selected output channel

A.7 Random Noise Test Settings.xml

ELEMENT	ALLOWABLE VALUES	COMMENT
<MeasurementModeType>	**Spectra** **PhaseAssignedSpectra** **FRF** **CPBSynthesis** **CPB**	For **PhaseAssignedSpectra** and **FRF** measurements, reference channels need to be defined for all active input channels
<Duration>	Positive real number	Nominal test time in seconds. Will be adjusted to match specific measurement requirements
<Filename>	Text string	Base file name to be used for calculated results. The files are stored in the location defined by the <DataFolder> element in the *Engine Settings.xml* file and the base file name is appended with the date, time, and calculation description text

ELEMENT	ALLOWABLE VALUES	COMMENT
<MeasureAndRemoveExtraLatency>	**true** **false**	Activates calculation and application of external latency due to the physical distance between the source and the response signals
<ResultFileFormatType>	**XML** **CSV** **MATLAB**	Sets the format for the calculated result data
<ApplyEqualization>	**true** **false**	Determines whether frequency equalisation, defined by the <EQFile> element in *Output Channel Settings.xml*, is applied to the output signal
<Recording>	**true** **false**	Determines whether a time recording is made in addition to the calculated spectral results. The time file format and location are determined by the settings in the <TimeDataRecordingSettings> element group
<AnalysisFFTSettings>	–	Element group for FFT calculation
<SamplingFrequency>	**96000**	Fixed for Type 3670 hardware
<FrequencyLines>	2^N (positive integer)	Number of spectral lines used for the FFT. Dependent on <BlockSize> and <FrequencyResolution>
<FrequencyResolution>	(96000/2)/<FrequencyLines>	Dependent on <FrequencyLines> and <BlockSize>
<BlockSize>	2^N (positive integer)	<FrequencyLines>*2. Dependent on <FrequencyLines> and <FrequencyResolution>
<AveragingType>	**Linear** **Exponential** **MaxHold**	Sets the mode of averaging for the FFT
<Averages>	Positive integer	Calculated automatically from <Duration> element value
<ExpAverages>	Positive integer	Calculated automatically from <Duration> element value
<AveragingTime>	Positive real number	Calculated automatically from <Duration> element value

ELEMENT	ALLOWABLE VALUES	COMMENT
<ExpAveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<Overlap>	Positive real number between **0** and **1**	Fraction of the time block used to overlap with the next block, that is, 0.5 = 50% overlap. Automatically set to **0** by the calibration command
<FRFEstimator>	**H1** **H2**	Estimator method used for FRF calculation. Not used in calibration
<ReferenceWeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the reference (denominator). Not used in calibration
<ResponseWeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the response (numerator). Automatically set to **Flattop** by the calibration command
<CalcCrossSpectrum>	**true** **false**	If set to **true**, cross-spectra between the reference and response is calculated and stored as well as autospectra for both reference and response
<CalcPhaseAssignedSpectrum>	**true** **false**	If set to **true**, phase-assigned spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcFRF>	**true** **false**	If set to **true**, FRFs and cross-spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcOrdinaryCoherence>	**true** **false**	If set to **true**, FRFs, ordinary coherence and cross-spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcPrincipalForce>	–	Not used
</AnalysisFFTSettings>	–	End of element group for FFT calculation

ELEMENT	ALLOWABLE VALUES	COMMENT
<AnalysisCPBSettings>	–	Element group for CPB calculation
<SamplingFrequency>	**96000**	Fixed for the Type 3670 DAQ
<BandwidthType>	**One** **Third** **Sixth** **Twelfth** **TwentyFourth**	Bandwidth definition for CPB filters
<LowFrequency>	Positive real number >5	Lower limit of the measuring range of Type 3670
<HighFrequency>	Positive real number <24000	Maximum measurement frequency of Type 3670
<AveragingType>	**Linear** **Exponential** **MaxHold**	Sets the mode of averaging for the CPB results
<AveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<ExpAveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<Tau>	**1** **0.125**	Slow or fast response
<AcousticWeightingType	**A** **B** **C** **D** **Linear**	Linear or acoustic weightings conforming to IEC
<SkipFiltersSettlingData>	**true** **false**	Determines whether recommended filter settling times for accurate results are used
</AnalysisCPBSettings>	–	End of element group for CPB calculation
<AnalysisCPBSynthesisSettings>	–	Element group for CPB Synthesis calculation
<SamplingFrequency>	**96000**	Fixed for Type 3670 hardware
<FrequencyLines>	2^N (positive integer)	Number of spectral lines used in the FFT calculation for CPB synthesis. Dependent on <BlockSize> and <FrequencyResolution>

ELEMENT	ALLOWABLE VALUES	COMMENT
<FrequencyResolution>	(96000/2)/<FrequencyLines>	Dependent on <FrequencyLines> and <BlockSize>
<BlockSize>	2^N (positive integer)	<FrequencyLines>*2. Dependent on <FrequencyLines> and <FrequencyResolution>
<AveragingType>	**Linear** **Exponential** **MaxHold**	Sets the mode of averaging for the FFT used for CPB synthesis
<Averages>	Positive integer	Calculated automatically from <Duration> element value
<ExpAverages>	Positive integer	Calculated automatically from <Duration> element value
<AveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<ExpAveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<Overlap>	Positive real number between **0** and **1**	Fraction of the time block used to overlap with the next block in the FFT calculation, that is, 0.5 = 50% overlap. Automatically set to **0** by the calibration command
<WeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the input FFT calculation
<MinimumLinesCriterion>	Positive integer >1	Sets the minimum number of spectral lines to be used in the CPB calculation for any frequency band
<AcousticWeightingType>	**A** **B** **C** **D** **Linear**	Acoustic weighting applied to the spectral data
</AnalysisCPBSynthesisSettings>	–	End of element group for CPB synthesis calculation
<TimeDataRecordingSettings>	–	Element group for time data recording

ELEMENT	ALLOWABLE VALUES	COMMENT
<Filename>	Text string	Base file name to be used for calculated results. The files are stored in the location defined by the <DataFolder> element in the *Engine Settings.xml* file and the base file name is appended with the date, time and calculation description text
<RecordingFileFormatType>	**WAV** **MATLAB** **HDF5**	Sets the file type for time recording
<AutoIncrementFilename>	**true** **false**	Adds an integer as text to the filename which is automatically incremented with each subsequent recording.
<TriggerType>	**FreeRun** **InputChannel**	Sets the trigger type for the recording
<TriggerChannel>	Positive integer	Sets the channel to be used for trigger detection
<TriggerLevel>	Positive real number	In engineering units
<RecordingTime>	Positive real number	Recording time in seconds. Is automatically overwritten by the <Duration> element value
</TimeDataRecordingSettings>	–	End of element group for time data recording

A.8 Selected Device Capabilities.xml

No user editable values.

A.9 Step Sine Test Settings.xml

ELEMENT	ALLOWABLE VALUES	COMMENT
<MeasurementModeType	**Spectra** **PhaseAssignedSpectra** **FRF**	For **PhaseAssignedSpectra** and **FRF** measurements, reference channels need to be defined for all active input channels
<Filename>	Text string	Base file name to be used for calculated results. The files are stored in the location defined by the <DataFolder> element in the *Engine Settings.xml* file and the base file name is appended with the date, time, and calculation description text
<SettlingTime>	**true** **false**	Allows for compensation in the distortion calculation for transient phenomena due to the high-pass filter of Type 3670 outputs
<MeasureAndRemoveExtraLatency>	**true** **false**	Activates calculation and application of external latency due to the physical distance between the source and the response signals
<ResultFileFormatType>	**XML** **CSV** **MATLAB**	Sets the format for the calculated result data
<ApplyEqualization>	**true** **false**	Determines whether frequency equalisation, defined by the <EQFile> element in *Output Channel Settings.xml*, is applied to the output signal
<FRFEstimator>	**H1** **H2**	Estimator method used for FRF calculation. Not used in calibration
<DistortionAnalysisSettings>	–	Element group for distortion analysis settings
<CalculateTHD>	**true** **false**	Activates the calculation of total harmonic distortion during the step sine test

ELEMENT	ALLOWABLE VALUES	COMMENT
<HarmonicsTHD>	Comma separated list of positive real numbers	Lists the harmonics to be used in the THD calculation. Harmonic 1 (fundamental) is assumed included by default
<CalculateRubAndBuzz>	**true** **false**	Activates the calculation of rub & buzz during the step sine test
<HarmonicsRubAndBuzz>	Comma separated list of positive real numbers	Lists the harmonics to be used in the rub & buzz calculation. Harmonic 1 (fundamental) is assumed included by default
</DistortionAnalysisSettings>	Comma separated list of positive real numbers	End of element group for distortion analysis settings

A.10 Swept Sine Test Settings.xml

ELEMENT	ALLOWABLE VALUES	COMMENT
<MeasurementModeType>	**Spectra** **PhaseAssignedSpectra** **FRF** **CPBSynthesis** **CPB**	For **PhaseAssignedSpectra** and **FRF** measurements, reference channels need to be defined for all active input channels
<Duration>	Positive real number	Nominal test time in seconds. Will be adjusted to match specific measurement requirements
<Filename>	Text string	Base file name to be used for calculated results. The files are stored in the location defined by the <DataFolder> element in the *Engine Settings.xml* file and the base file name is appended with the date, time, and calculation description text
<MeasureAndRemoveExtraLatency>	**true** **false**	Activates calculation and application of external latency due to the physical distance between the source and the response signals
<ResultFileFormatType>	**XML** **CSV** **MATLAB**	Sets the format for the calculated result data

ELEMENT	ALLOWABLE VALUES	COMMENT
<ApplyEqualization>	**true** **false**	Determines whether frequency equalisation, defined by the <EQFile> element in *Output Channel Settings.xml*, is applied to the output signal
<Recording>	**true** **false**	Determines whether a time recording is made in addition to the calculated spectral results. The time file format and location are determined by the settings in the <TimeDataRecordingSettings> element group
<AnalysisFFTSettings>	–	Element group for FFT calculation
<SamplingFrequency>	**96000**	Fixed for Type 3670 hardware
<FrequencyLines>	2^N (positive integer)	Number of spectral lines used the FFT. Dependent on <BlockSize> and <FrequencyResolution>
<FrequencyResolution>	(96000/2)/<FrequencyLines>	Dependent on <FrequencyLines> and <BlockSize>
<BlockSize>	2^N (positive integer)	<FrequencyLines>*2. Dependent on <FrequencyLines> and <FrequencyResolution>
<AveragingType>	**Linear** **Exponential** **MaxHold**	Sets the mode of averaging for the FFT
<Averages>	Positive integer	Calculated automatically
<ExpAverages>	Positive integer	Calculated automatically
<AveragingTime>	Positive real number	Calculated automatically
<ExpAveragingTime>	Positive real number	Calculated automatically
<Overlap>	Positive real number between **0** and **1**	Fraction of the time block used to overlap with the next block, that is, 0.5 = 50% overlap. Automatically set to **0** by the calibration command
<FRFEstimator>	**H1** **H2**	Estimator method used for FRF calculation. Not used in calibration

ELEMENT	ALLOWABLE VALUES	COMMENT
<ReferenceWeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the reference. Not used in calibration
<ResponseWeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the reference. Automatically set to **Flattop** by the calibration command
<CalcCrossSpectrum>	**true** **false**	If set to **true**, cross-spectra between the reference and response is calculated and stored as well as autospectra for both reference and response
<CalcPhaseAssignedSpectrum>	**true** **false**	If set to **true**, phase-assigned spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcFRF>	**true** **false**	If set to **true**, FRFs and cross-spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcOrdinaryCoherence>	**true** **false**	If set to **true**, FRFs, ordinary coherence and cross-spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcPrincipalForce>	–	Not used
</AnalysisFFTSettings>	–	End of element group for FFT calculation
<AnalysisCPBSettings>	–	Element group for CPB calculation
<SamplingFrequency>	**96000**	Fixed for Type 3670 DAQ
<BandwidthType>	**One** **Third** **Sixth** **Twelfth** **TwentyFourth**	Bandwidth definition for CPB filters

ELEMENT	ALLOWABLE VALUES	COMMENT
<LowFrequency>	Positive real number >5	Lower limit of the measuring range of Type 3670
<HighFrequency>	Positive real number <24000	Maximum measurement frequency of Type 3670
<AveragingType>	**Linear** **Exponential** **MaxHold**	Sets the mode of averaging for the CPB results
<AveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<ExpAveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<Tau>	**1** **0.125**	Slow or fast response
<AcousticWeightingType>	**A** **B** **C** **D** **Linear**	Linear or acoustic weightings conforming to IEC
<SkipFiltersSettlingData>	**true** **false**	Determines whether recommended filter settling times for accurate results are used
</AnalysisCPBSettings>	–	End of element group for CPB calculation
<AnalysisCPBSynthesisSettings>	–	Element group for CPB Synthesis calculation
<SamplingFrequency>	**96000**	Fixed for Type 3670 DAQ
<FrequencyLines>	2^N (positive integer)	Number of spectral lines used in the FFT calculation for CPB synthesis. Dependent on <BlockSize> and <FrequencyResolution>
<FrequencyResolution>	(96000/2)/<FrequencyLines>	Dependent on <FrequencyLines> and <BlockSize>
<BlockSize>	2^N (positive integer)	<FrequencyLines>*2. Dependent on <FrequencyLines> and <FrequencyResolution>

ELEMENT	ALLOWABLE VALUES	COMMENT
<AveragingType>	**Linear** **Exponential** **MaxHold**	Sets the mode of averaging for the FFT used for CPB synthesis
<Averages>	Positive integer	Calculated automatically from <Duration> element value
<ExpAverages>	Positive integer	Calculated automatically from <Duration> element value
<AveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<ExpAveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<Overlap>	Positive real number between **0** and **1**	Fraction of the time block used to overlap with the next block in the FFT calculation, that is, 0.5 = 50% overlap. Automatically set to **0** by the calibration command
<WeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the input FFT calculation
<MinimumLinesCriterion>	Positive integer >1	Sets the minimum number of spectral lines to be used in the CPB calculation for any frequency band
<AcousticWeightingType>	**A** **B** **C** **D** **Linear**	Acoustic weighting applied to the spectral data
</AnalysisCPBSynthesisSettings>	–	End of element group for CPB synthesis calculation
<TimeDataRecordingSettings>	–	Element group for time data recording
<Filename>	Text string	Base file name to be used for calculated results. The files are stored in the location defined by the <DataFolder> element in the *Engine Settings.xml* file and the base file name is appended with the date, time, and calculation description text

ELEMENT	ALLOWABLE VALUES	COMMENT
<RecordingFileFormatType>	WAV **MATLAB** **HDF5**	Sets the file type for time recording
<AutoIncrementFilename>	**true** **false**	Adds an integer as text to the file name which is automatically incremented with each subsequent recording
<TriggerType>	**FreeRun** **InputChannel**	Sets the trigger type for the recording
<TriggerChannel>	Positive integer	Sets the channel to be used for trigger detection
<TriggerLevel>	Positive real number	In engineering units
<RecordingTime>	Positive real number	Recording time in seconds. Is automatically overwritten by the <Duration> element value
</TimeDataRecordingSettings>	–	End of element group for time data recording

A.11 Time Data Recorder Settings.xml

ELEMENT	ALLOWABLE VALUES	COMMENT
<Filename>	Text string	Base file name to be used for calculated results. The files are stored in the location defined by the <DataFolder> element in the *Engine Settings.xml* file and the base file name is appended with the date, time, and calculation description text
<RecordingFileFormatType>	**WAV** **MATLAB** **HDF5**	Sets the file type for time recording
<AutoIncrementFilename>	**true** **false**	Adds an integer as text to the file name which is automatically incremented with each subsequent recording
<TriggerType>	**FreeRun** **InputChannel**	Sets the trigger type for the recording

ELEMENT	ALLOWABLE VALUES	COMMENT
<TriggerChannel>	Positive integer	Sets the channel to be used for trigger detection
<TriggerLevel>	Positive real number	In engineering units
<RecordingTime>	Positive real number	Recording time in seconds

A.12 Waveform Streaming Test Settings.xml

ELEMENT	ALLOWABLE VALUES	COMMENT
<MeasurementModeType>	**Spectra** **PhaseAssignedSpectra** **FRF** **CPBSynthesis** **CPB**	For **PhaseAssignedSpectra** and **FRF** measurements, reference channels need to be defined for all active input channels
<Filename>	Positive real number	Nominal test time in seconds. Will be adjusted to match specific measurement requirements
<MeasureAndRemoveExtraLatency>	Text string	Base file name to be used for calculated results. The files are stored in the location defined by the <DataFolder> element in the *Engine Settings.xml* file and the base file name is appended with the date, time, and calculation description text
<ResultFileFormatType>	**true** **false**	Activates calculation and application of external latency due to the physical distance between the source and the response signals
<ApplyEqualization>	**XML** **CSV** **MATLAB**	Sets the format for the calculated result data
<Recording>	**true** **false**	Determines whether frequency equalisation, defined by the <EQFile> element in *Output Channel Settings.xml*, is applied to the output signal

ELEMENT	ALLOWABLE VALUES	COMMENT
<AnalysisFFTSettings>	**true** **false**	Determines whether a time recording is made in addition to the calculated spectral results. The time file format and location are determined by the settings in the <TimeDataRecordingSettings> element group
<SamplingFrequency>	**96000**	Fixed for Type 3670 DAQ
<FrequencyLines>	2^N (positive integer)	Number of spectral lines used for the FFT. Dependent on <BlockSize> and <FrequencyResolution>
<FrequencyResolution>	(96000/2)/<FrequencyLines>	Dependent on <FrequencyLines> and <BlockSize>
<BlockSize>	2^N (positive integer)	<FrequencyLines>*2. Dependent on <FrequencyLines> and <FrequencyResolution>
<AveragingType>	**Linear** **Exponential** **MaxHold**	Sets the mode of averaging for the FFT
<Averages>	Positive integer	Calculated automatically
<ExpAverages>	Positive integer	Calculated automatically
<AveragingTime>	Positive real number	Calculated automatically
<ExpAveragingTime>	Positive real number	Calculated automatically
<Overlap>	Positive real number between **0** and **1**	Fraction of the time block used to overlap with the next block, that is, 0.5 = 50% overlap. Automatically set to **0** by the calibration command
<FRFEstimator>	**H1** **H2**	Estimator method used for FRF calculation. Not used in calibration
<ReferenceWeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the reference. Not used in calibration
<ResponseWeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the reference. Automatically set to **Flattop** by the calibration command

ELEMENT	ALLOWABLE VALUES	COMMENT
<CalcCrossSpectrum>	**true** **false**	If set to **true**, cross-spectra between the reference and response is calculated and stored as well as autospectra for both reference and response
<CalcPhaseAssignedSpectrum>	**true** **false**	If set to **true**, phase-assigned spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcFRF>	**true** **false**	If set to **true**, FRFs and cross-spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcOrdinaryCoherence>	**true** **false**	If set to **true**, FRFs, ordinary coherence and cross-spectra between the reference and response are calculated and stored as well as autospectra for both reference and response
<CalcPrincipalForce>	–	Not used
</AnalysisFFTSettings>	–	End of element group for FFT calculation
<AnalysisCPBSettings>	–	Element group for CPB calculation
<SamplingFrequency>	**96000**	Fixed for Type 3670 DAQ
<BandwidthType>	**One** **Third** **Sixth** **Twelfth** **TwentyFourth**	Bandwidth definition for CPB filters
<LowFrequency>	Positive real number >5	Lower limit of the measuring range of Type 3670
<HighFrequency>	Positive real number <24000	Maximum measurement frequency of Type 3670
<AveragingType>	**Linear** **Exponential** **MaxHold**	Sets the mode of averaging for the CPB results

ELEMENT	ALLOWABLE VALUES	COMMENT
<AveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<ExpAveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<Tau>	**1** **0.125**	Slow or fast response
<AcousticWeightingType>	**A** **B** **C** **D** **Linear**	Linear or acoustic weightings conforming to IEC
<SkipFiltersSettlingData>	**true** **false**	Determines whether recommended filter settling times for accurate results are used
</AnalysisCPBSettings>	–	End of element group for CPB calculation
<AnalysisCPBSynthesisSettings>	–	Element group for CPB synthesis calculation
<SamplingFrequency>	**96000**	Fixed for Type 3670 DAQ
<FrequencyLines>	2^N (positive integer)	Number of spectral lines used in the FFT calculation for CPB synthesis. Dependent on <BlockSize> and <FrequencyResolution>
<FrequencyResolution>	(96000/2)/<FrequencyLines>	Dependent on <FrequencyLines> and <BlockSize>
<BlockSize>	2^N (positive integer)	<FrequencyLines>*2. Dependent on <FrequencyLines> and <FrequencyResolution>
<AveragingType>	**Linear** **Exponential** **MaxHold**	Sets the mode of averaging for the FFT used for CPB synthesis
<Averages>	Positive integer	Calculated automatically from <Duration> element value
<ExpAverages>	Positive integer	Calculated automatically from <Duration> element value
<AveragingTime>	Positive real number	Calculated automatically from <Duration> element value

ELEMENT	ALLOWABLE VALUES	COMMENT
<ExpAveragingTime>	Positive real number	Calculated automatically from <Duration> element value
<Overlap>	Positive real number between **0** and **1**	Fraction of the time block used to overlap with the next block in the FFT calculation, that is, 0.5 = 50% overlap. Automatically set to **0** by the calibration command
<WeightingType>	**Hanning** **Uniform** **KaiserBessel** **Flattop**	Sets the windowing type for the input FFT calculation
<MinimumLinesCriterion>	Positive integer >1	Sets the minimum number of spectral lines to be used in the CPB calculation for any frequency band
<AcousticWeightingType>	**A** **B** **C** **D** **Linear**	Acoustic weighting applied to the spectral data
</AnalysisCPBSynthesisSettings>	–	End of element group for CPB synthesis calculation
<TimeDataRecordingSettings>	–	Element group for time data recording
<Filename>	Text string	Base file name to be used for calculated results. The files are stored in the location defined by the <DataFolder> element in the *Engine Settings.xml* file and the base file name is appended with the date, time and calculation description text
<RecordingFileFormatType>	**WAV** **MATLAB** **HDF5**	Sets the file type for time recording
<AutoIncrementFilename>	**true** **false**	Adds an integer as text to the file name which is automatically incremented with each subsequent recording.
<TriggerType>	**FreeRun** **InputChannel**	Sets the trigger type for the recording

ELEMENT	ALLOWABLE VALUES	COMMENT
<TriggerChannel>	Positive integer	Sets the channel to be used for trigger detection
<TriggerLevel>	Positive real number	In engineering units
<RecordingTime>	Positive real number	Recording time in seconds. Is automatically overwritten by the <Duration> element value
</TimeDataRecordingSettings>	–	End of element group for time data recording

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