NFS Baffle Measurement AN 71

Application Note of the KLIPPEL R&D System (Document Revision 1.0)

FEATURES • SPL in 3D half-space at any point in near and far field • Sound power, sensitivity, directivity index • Polar plot, directivity balloon, contour plot **APPLICATION** • Single transducers • In-wall speakers	(insert picture of the baffle here)

DESCRIPTION

Acoustical measurements of transducers are usually performed with the system mounted on a baffle to get rid of the acoustic shortcut between to front and rear side. However, measuring a system in a baffle can be quite challenging because of the baffle diffraction step from the edges, and usually requires a particular setup inside a dedicated room such as an anechoic chamber.

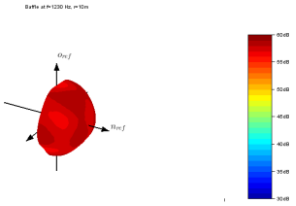
The near-field scanner allows to get rid of these constrains by using the spherical wave expansion approach and the field separation technique. In the end the measurement system provides the Sound Pressure output at any point in the 3D half-space. The measurement can be performed in a normal room and the effects of the non-infinite baffle can be eliminated.

Article number	

CONTENT

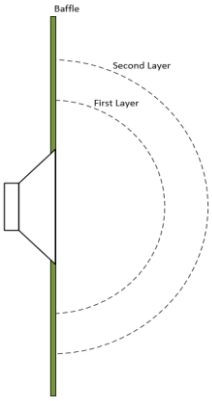
1 Overview

1.1 Principle



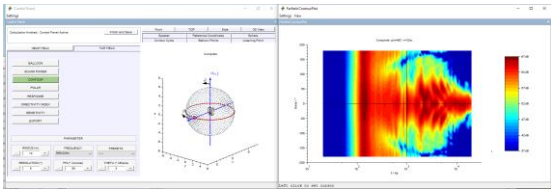
1 – Measurement

The automatic measurement is performed by the robotics. The positions of the baffle and of the speaker are automatically calculated from the configuration.



2 – Field separation / identification

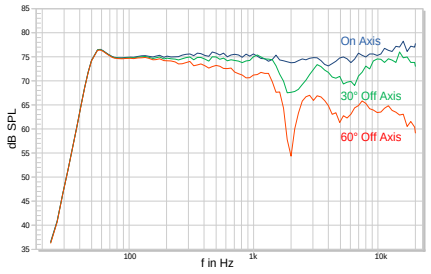
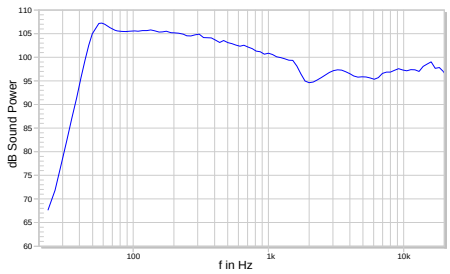
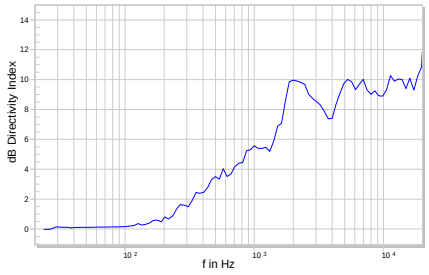
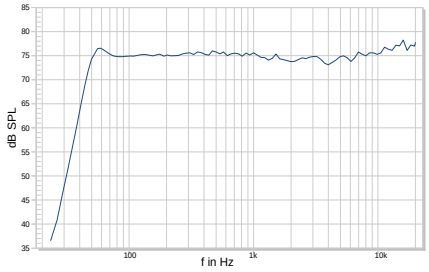
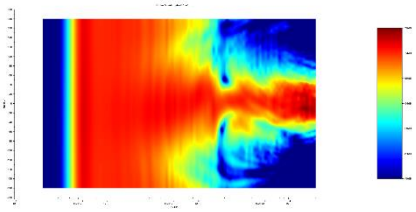
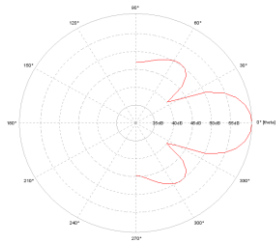
After the measurement, the direct sound field is identified by spherical wave expansion. Scanning on 2 layers allows to separate the direct sound field from incoming waves, removing the room and baffle influence from the measurement.

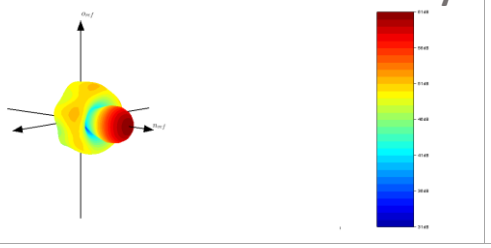


3 – Visualization

In the visualization module the results of the measurement can be analyzed. This module provides common sound field characteristics such as directivity index, balloon plot, SPL response. It also allows computing the far field of the source at any distance.

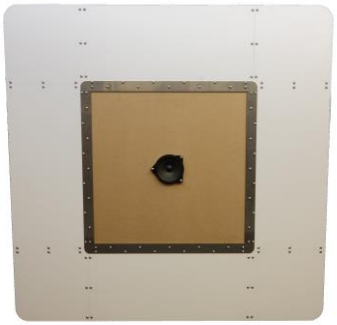
1.2 Measurement Results

SOUND PRESSURE LEVEL		*Sound Pressure Level* over frequency at any position in 3D space.
SOUND POWER		Total radiated *Sound Power* of the device under test. *Sound power* characterizes the integrated sound pressure level over all radiation angles.
DIRECTIVITY INDEX		The *Directivity Index* summarizes the relation between the sound pressure levels of all radiation angles compared to the On-Axis sound pressure level. An omnidirectional source has a directivity index of 0.
SENSITIVITY		On-Axis sound pressure level referenced to 1m distance and 1W electrical input power (2.83V for 8Ω)
CONTOUR PLOT		The contour plot visualizes the radiation behavior over frequency and the polar angle theta. The color scale indicates the Sound Pressure Level.
POLAR PLOT		Polar plots visualize the radiation pattern over the polar angle theta for a specific frequency.

DIRECTIVITY BALLOON		The balloon plot shows the radiation behaviour over phi and theta for a specific frequency.

2 Requirements

2.1 Hardware

NEAR FIELD SCANNER 3D		3D microphone positioning system comprising Hardware, Measurement Software and Visualization Software. [1]	C8
KLIPPEL ANALYZER		The Klippel Analyzer 3 is the hardware platform for the R&D modules that performs the data acquisition and real time processing. [2]	H3
BAFFLE HARDWARE		The baffle hardware with the calibration cone holder.	
MICROPHONE		Free field microphone with omnidirectional directivity characteristic over the desired measurement bandwidth.	A4
AMPLIFIER (OPTIONAL)		Amplifier with a flat frequency response over the desired measurement bandwidth	

2.2 Software

TRF MODULE (S7)	The Transfer function (TRF) is a dedicated PC software module for measurement of the transfer behavior of a loudspeaker. [3]
NEAR FIELD SCANNER SYSTEM (C8)	Basic NFS package includes the measurement control, the basic post processing for anechoic measurements and the standard far field visualizations.

KLIPPEL ROBOTICS	The Robotics Software manages the data acquisition. That means it moves the NFS Hardware and performs the measurements.
NFS BAFFLE MEASUREMENT	NFS Baffle Measurement package including measurement control, grid control, calibration point checking and far field visualization.

3 Performing a measurement

3.1 Introduction

Targets

In the following the measurement of a transducer mounted in a baffle will be performed. The following questions will be addressed:

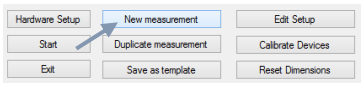
- How to perform a measurement using a baffle?
- What are the baffle setup points?

Please also see the ***NFS Software Manual*** for further information

3.2 Start Klippel Robotics and create a new measurement

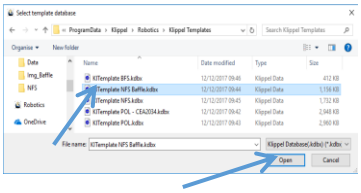
1) Start Klippel Robotics:

Open Robotics Software and click: "***New Measurement***"



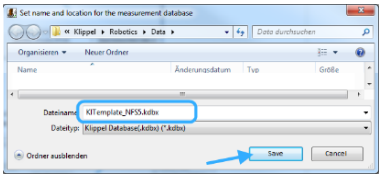
2) Select Template:

Choose "klTemplate_NFS_Baffle.kdbx".



3) Select Results Path:

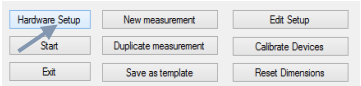
Select a folder and a name for the measurement database.



3.3 Hardware Setup

1) Open Hardware Setup:

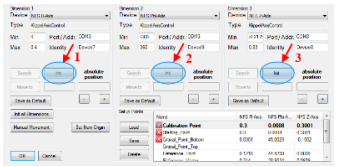
Click: "***Hardware Setup***" to open the hardware dialog window.



In case of problem during the hardware setup, please see Trouble Shooting

2) Initialize Axes:

Click the "***Init***" Button of each axis.



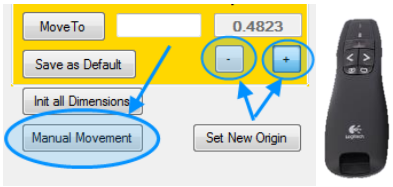
Please consider the correct order:

1st: R-Axis (Dimension 1)
2nd: Phi-Axis (Dimension 2)
3rd: Z-Axis (Dimension 3)

When initializing the Phi-Axis, make sure that the robotics will not hit the baffle.

3) Activate Remote Control:

Click "***Manual Movement***" to activate the Remote Control



Now you can move the axes with the remote control or the - / + buttons, which is needed for the next steps.

4) Setup the microphone calibration points:

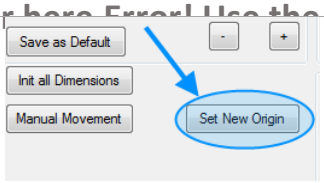
Clicking "***Set New Origin***" will open a calibration dialog

1) Origin (1st Calibration)

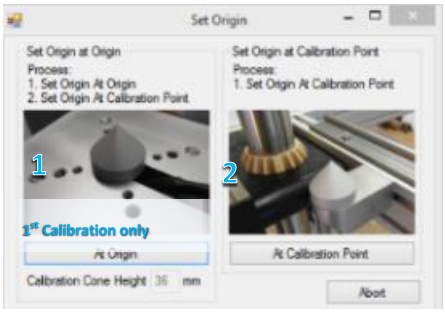
Put the cone to the Origin

2) Calibration Point

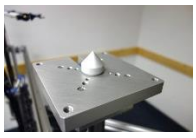
Put the cone to the Calibra-



The microphone must be calibrated either at "Origin" (required for 1st calibration) or at "Calibration Point".

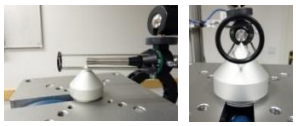


(center of plate)



Drive the microphone to the tip of the cone

(using the remote)

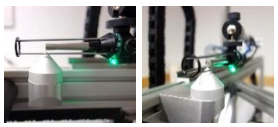


Confirm the position by clicking: "***At Origin***"

tion point.

Drive the microphone to the tip of the cone

(using the remote)



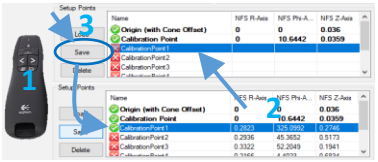
Confirm the position by clicking: "***At Calibration point***"

⚠ Drive the microphone close to the tip of the cone, but **do not hit the calibration cone.**

5) Setup the baffle reference points

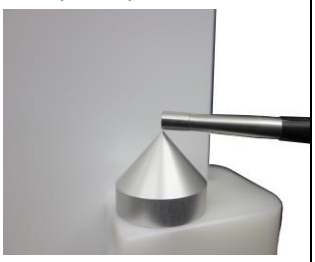
Mount the baffle on the Near Field Scanner and setup the 5 required baffle calibration points. Do the following procedure:

1) Drive microphone to the point
2) Select the point in the list ("***BaffleCalPt1-5***")
3) Press "***Save***"

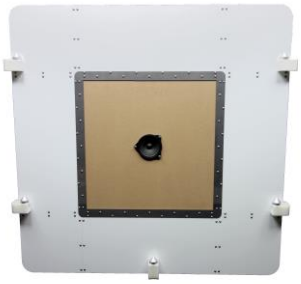


The points should be placed evenly around the speaker, and at the same distance *d* from the baffle. Place the calibration cone onto the holder to help you with the setup.

Baffle calibration points – microphone position



Position of baffle calibration points – front view



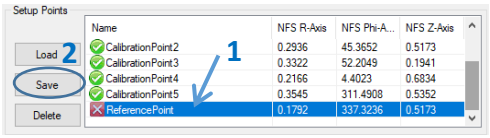
Calibration cone holder

⚠ Please ensure that all calibration points have the same distance *d* from the baffle

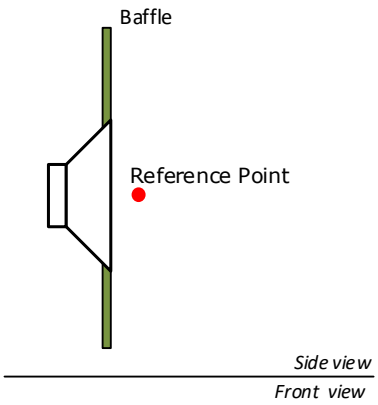
6) Setup the transducer reference point

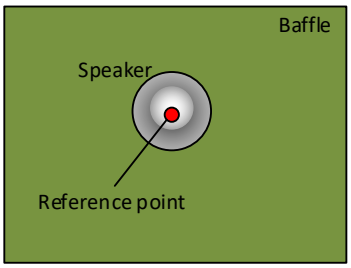
Save the position of the transducer.

1) Scroll down the Setup Points List to see the point called "***ReferencePoint***"

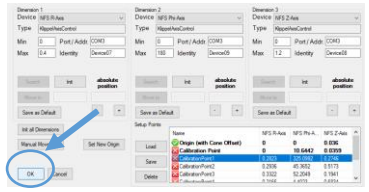
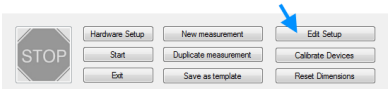
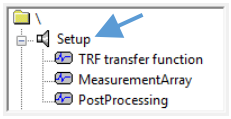


2) Drive the microphone in front of the transducer (using the remote) and save the position.



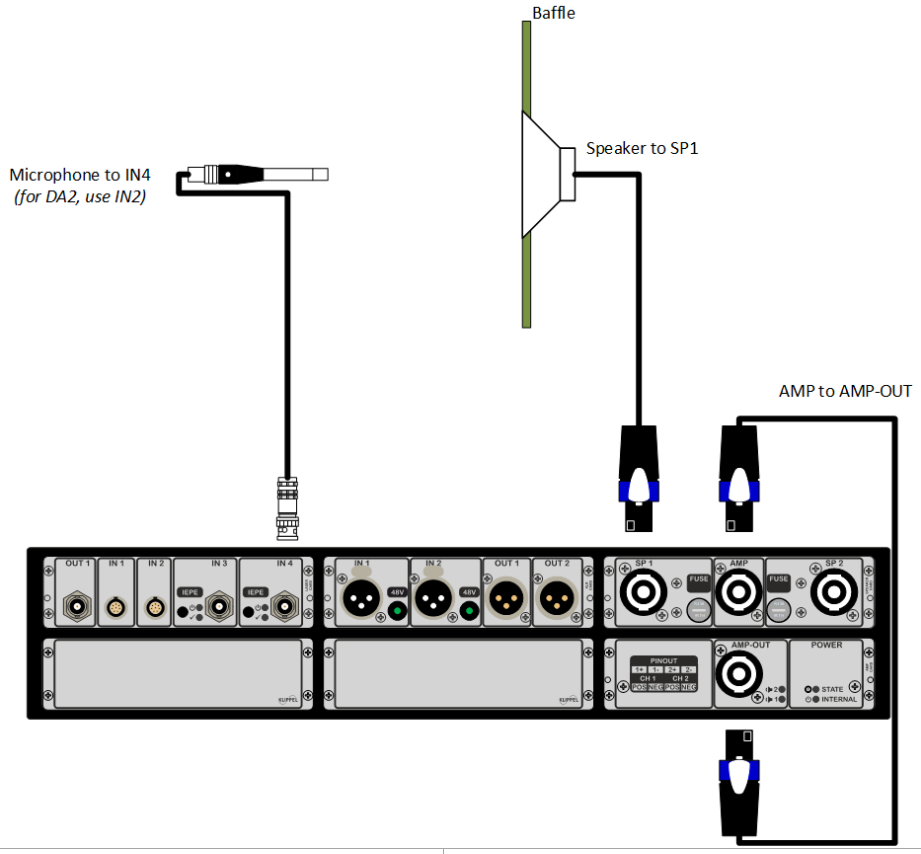


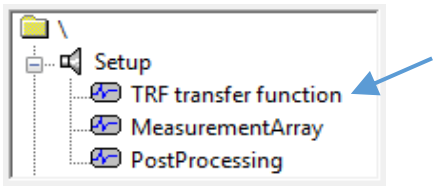
3.4 Save Hardware Settings and Open Measurement Database

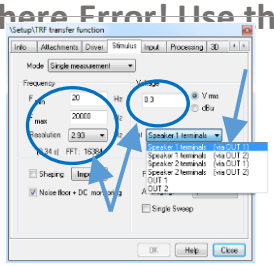
1) Confirm Hardware Settings:	2) Open Database:	3) Select Setup Object:
Click "***OK***" to confirm your Settings 	Click "***Edit Setup***" to open the database. 	Select the Object "***Setup***". This Object consist of 3 Operation for the measurement configuration 

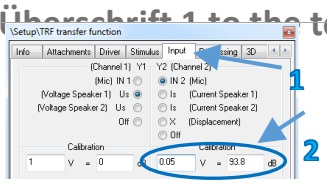
3.5 Measurement operation – TRF transfer function

1) Connect Hardware

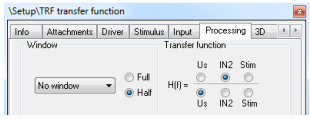


2) Select operation	3) Property Page
Select the operation: "***TRF transfer function***" 	Open "***Property Page***" to configure the measurement operation. 
4) Configure Stimulus	**5) Define Channels and H(f)**
Select the "***Stimulus***" tab and define: • "***Speaker 1 terminals (via OUT1)***" Configure Parameters: • Frequency Range (f_{min}, f_{max}) • Frequency ***Resolution*** • Input ***Voltage***	1) Select the "***Input***" tab and define: • ***Channel 1 – (Voltage Speaker 1) Us*** • ***Channel 2 - IN 2 (Mic)*** 2) Insert the **calibration factor** of the mic





3) Select the "***Processing*** „Tab and define: ***H(f)= IN2 / Us***



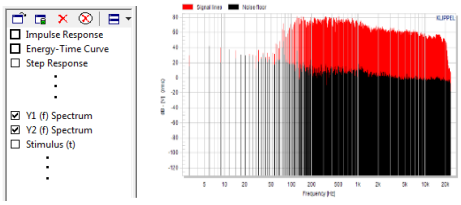
6) Run Operation

Run the TRF operation by clicking on the green arrow.

The measurement should be performed in front of the loudspeaker. Move the microphone to the On-Axis position.

7) Check SNR

Open the Result Windows "***Y1(f) Spectrum***" and "***Y2(f) Spectrum***". Check if the microphone signal has a Signal to Noise Ratio (SNR) of at least 40dB in the frequency range.



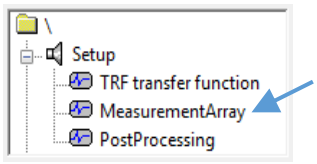
If the SNR is lower increase the voltage of the Stimulus or apply averaging.

3.6 Measurement Array

1) Select Operation

Select the operation:

"***MeasurementArray***"

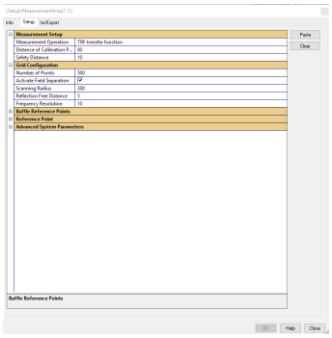


and open the Property Page.

2) Measurement Setup

Open the "***Setup***" tab to configure the Parameter, listed under the "***Measurement Setup***" section. Please define:

- ***Distance of calibration plane***
- ⚠ ***Safety distance***



3) Grid configuration

In the "***Grid Configuration***" section, define:

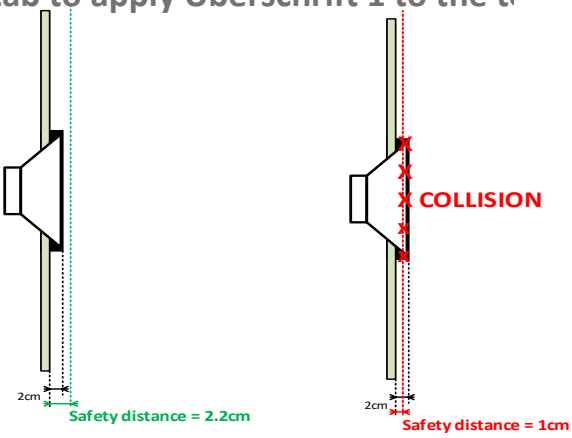
- ***Number of Points***
- ***Activate field Separation***
- ***Scanning Radius***
- ***Reflection Free Distance***
- ***Frequency Resolution***

Grid Configuration	
Number of Points	500
Activate Field Separation	☑
Scanning Radius	300
Reflection Free Distance	5
Frequency Resolution	10

See the "***Documentation***" window, for information about the parameters.

4) ⚠Safety distance

The safety distance is a critical parameter to avoid collisions between the microphone and the DUT. It should be greater than the distance between the baffle and any object sticking out of the baffle (the speaker, screw heads, a grid …).



5) Run Operation

Run the Measurement Array operation by clicking on the green arrow.

After running the operation the measurement points are shown in a table in the Result window ***Measurement Points Table.***

NUMBER OF POINTS: 490

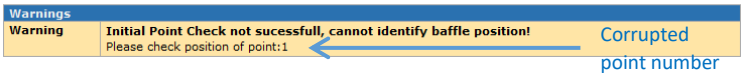
N	r in m	phi in degree	z in m
1	.316	56.55	.444
2	.324	54.021	.586
3	.334	53.157	.506
4	.298	53.121	.372
5	.263	51.51	.614
6	.281	50.227	.469
7	.257	50.088	.302
8	.298	49.93	.681
9	.339	49.698	.575
10	.269	49.502	.615
11	.285	49.45	.561
12	.244	48.833	.75
13	.346	48.574	.482
14	.273	48.401	.422
15	.329	47.466	.402
16	.263	46.782	.297
17	.291	46.02	.582
18	.338	45.009	.631
19	.309	44.965	.347
20	.302	44.896	.511

6) Very the baffle calibration

Open the window ***Baffle Calibraiton Check*** and verify the calibration setup.

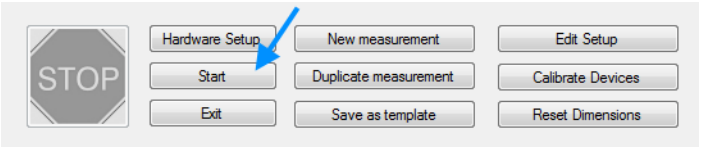
If your calibration points were setted up corectly, no error or warning should be generated and you can start the measurement.

If you see an error message or a warning, please check the corrupted calibration point. Close the dB-lab software, go back to the ***Harware Setup*** in the robotics program, and edit the corrupted point.



3.7 Start Measurement

Close database to get back to the Robotics and Press "***Start***"

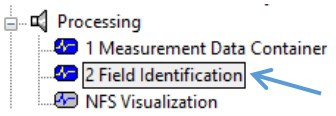


Press "***Continue***" to Start the measurement. In the following, the Robotics Software will control the automatic measurement.

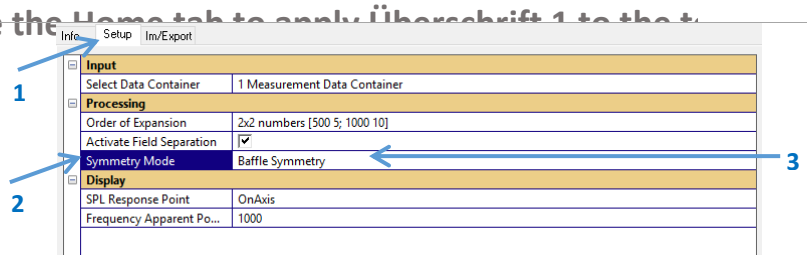
4 Analysis

1) Field identification

In the "***Processing***" object, select the "***Field identification***" operation.

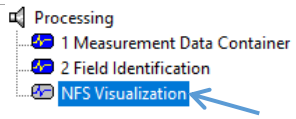


Open the ***properties*** page. In the "***setup***" tab, under the "***Processing***" section, make sure that the "***Symmetry Mode***" setting is set to "***Baffle Symmetry***"

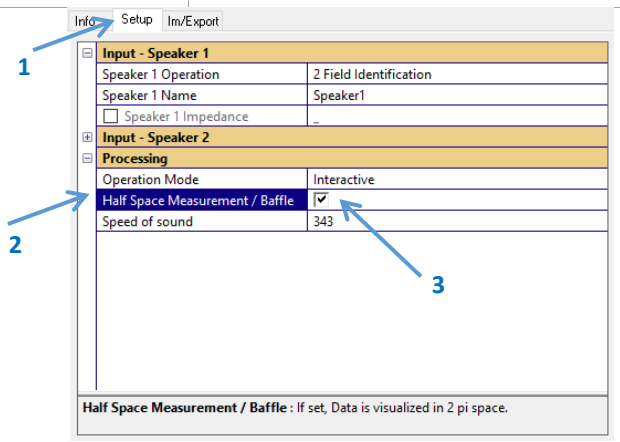


2) NFS visualization

In the "***Processing***" object, select the "***NFS Visualization***" operation.

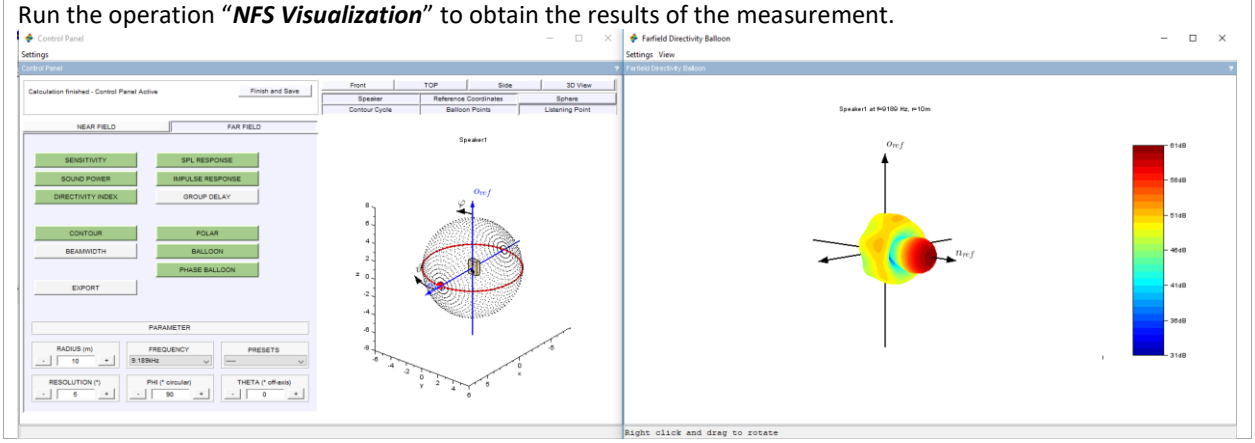


Open the ***properties*** page. In the "***setup***" tab, under the "***Processing***" section, make sure that the "***Half Space Measurement / Baffle***" setting is selected.



3) Run the NFS visualization

Run the operation "***NFS Visualization***" to obtain the results of the measurement.



5 References

5.1 Related Modules	[1] *Near Field Scanner 3D (NFS)*, Specification C8, 2016 Klippel GmbH, www.klippel.de [2] *Klippel Analyzer 3,* Specifications H3, 2017 Klippel GmbH, www.klippel.de [3] *Transfer function (TRF)*, Specification S7, 2016 Klippel GmbH, www.klippel.de
5.2 Manuals	[4] User Manual *Near Field Scanner 3D (NFS)*, included in NFS Software installation [5] User Manual TRF Transfer function, included in dB-Lab Software installation
5.3 Publications	[6] W. Klippel, C. Bellmann: *Holographic Nearfield Measurement of Loudspeaker Directivity*, AES 2016 - 141th Convention, Audio Engineering Society [7] C. Bellmann, W. Klippel, D. Knobloch: *Holographic loudspeaker measurement*

based on near field scanning, DAGA 2015 - 41th Convention, DEGA e.V.

[8] X. Zeng, C. Bellmann, W. Klippel: *Holographic Measurement of Electroacoustic Transducers in a Baffle*, DAGA 2017 – 43th Convention

5.4 Standards

[9] IEC (E) 60268-21: *Acoustical (Output based) Measurements*, 2015 International Electrotechnical Commission

[10] IEC 62777 Ed.1: *Quality Evaluation Method for the Sound Field of Directional Loudspeaker Array System*, 2014 International Electrotechnical Commission

Find explanations for symbols at:
http://www.klippel.de/know-how/literature.html
Last updated: June 25, 2018