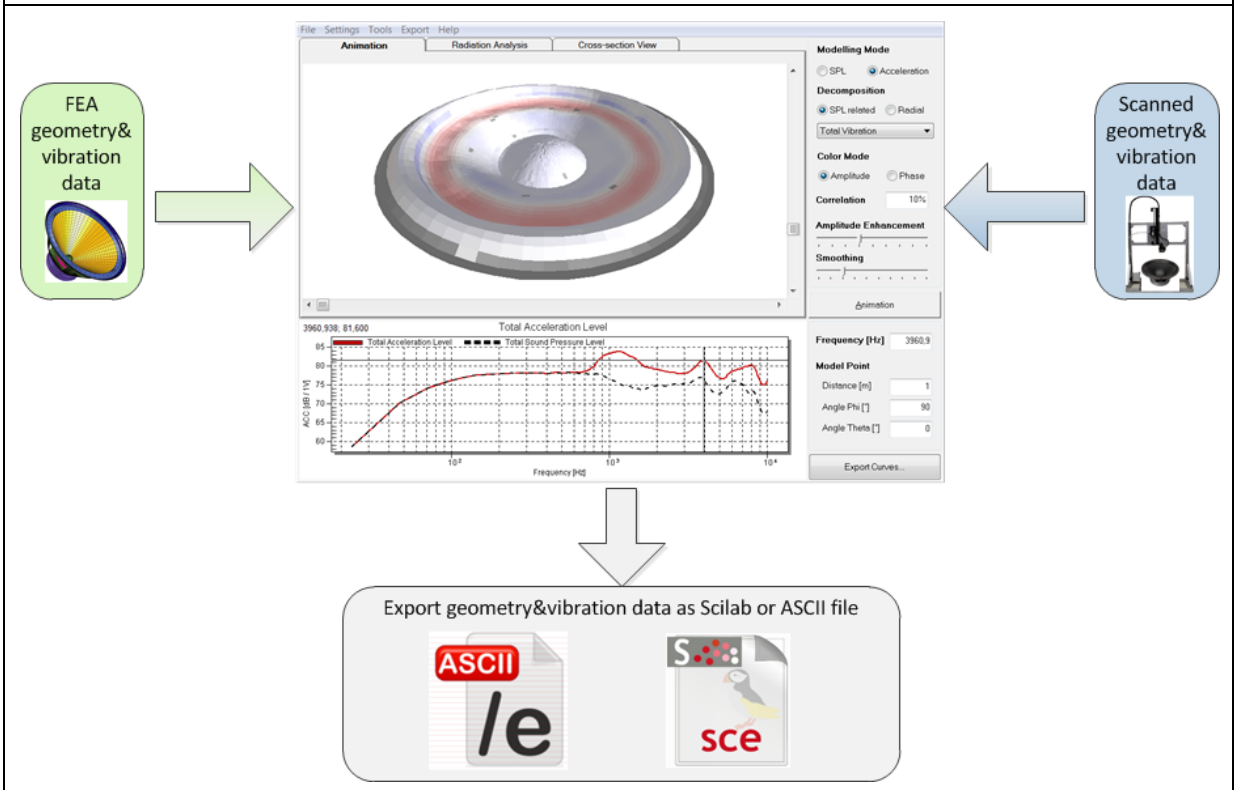
FEA/BEA interface for SCN **AN 55**

Application Note to the KLIPPEL R&D SYSTEM

The FEA/BEA interface is a text file based data interface providing various import and export features. Geometry and vibration data of a scanned speaker can be exported in high precision as an ASCII or SCILAB Script file. External geometry and vibration data generated by simulation tools or from external measurements can be imported for Analysis. The import is based on a text file format which can be processed by SCILAB. Especially data which has been exported in SCILAB Export File format can be directly imported again. A detailed description of the SCILAB export file format can be found in paragraph Restrictions in section Interface Description of this application note.

The interface can be used to apply pre-processing for data generated by simulation tools or from external measurements. Also it is possible to simulate speaker vibration directly within the Klippel Scanning Software using the SCILAB programming language.



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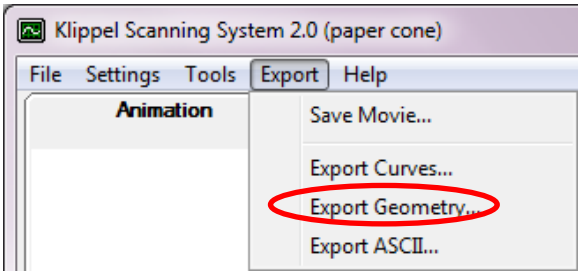
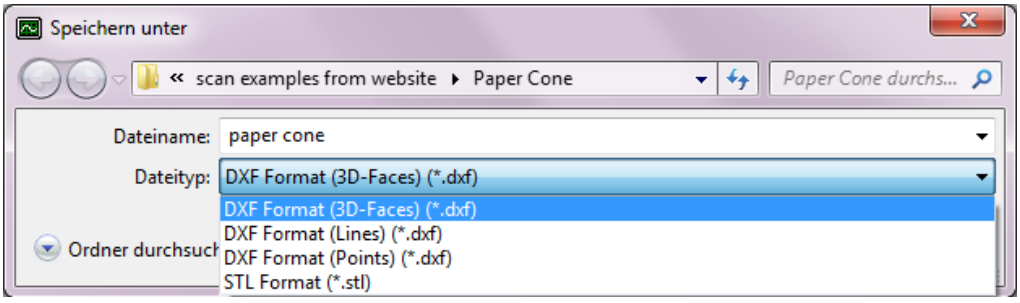
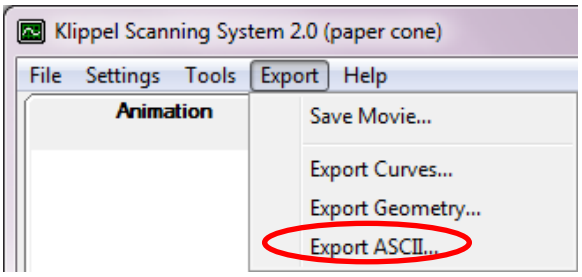
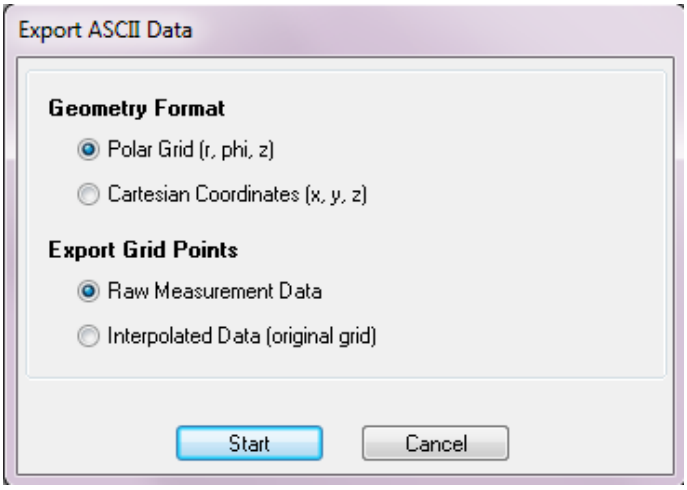
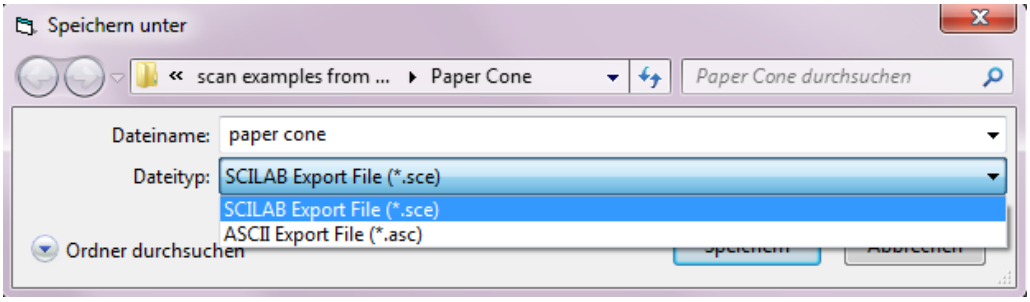
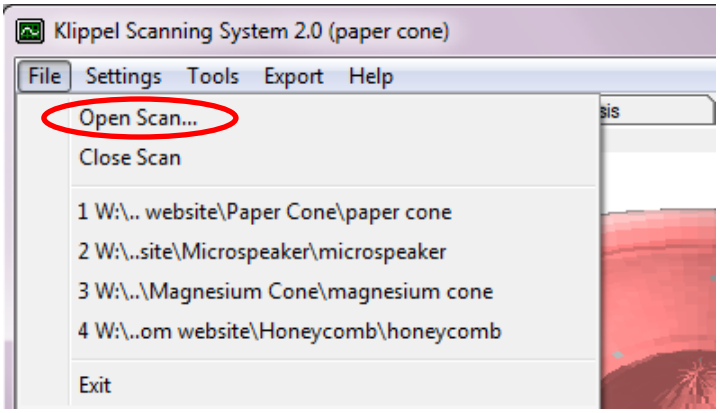
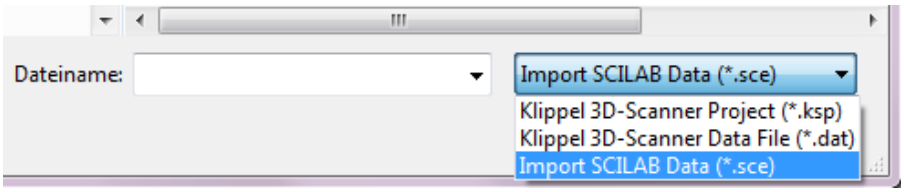
Requirements

Klippel Scanning System	The SCN interface for FEA/BEA is integrated in the SCN Analysis Software and can be downloaded from http://www.klippel.de/dm/?page=details&pid=170 The interface specifications announced in this document apply for the Klippel Scanning System Version 2.0 or newer.
Interface FEA/BEA	Use of the SCN interface for FEA/BEA requires a special License. Please contact support@klippel.de to activate the interface features of the Scanning software.

Interface Description

High precision Geometry Scanning	The module Interface for FEA / BEA is an optional Add-On for the SCN Analysis Software. It provides access to the geometry of a 3D object scanned from one side at high precision. This data is very useful for loudspeaker development and quality control. Here some examples: 1. Measuring the shape of loudspeaker parts (cones, horn geometries) where no specification is available 2. Checking the geometry of a prototype in R&D and production samples in Quality Control 3. Provide input for FEA analysis
Geometry Export	Export of the measured geometry in high precision.  Three different DXF (Drawing Exchange Format) export options are supported: 

	1. **3D Faces**: All points are connected to a mesh to reproduce the surface of the measured cone. 2. **Lines**: The surface of the cone is given by single lines connecting the measured points 3. **Points**: Only the measured points are included in the DXF export There is also the option to export the geometry in STL (stereo lithography) format.
Geometry and Vibration Export	Geometry and vibration data can be exported into text file in ASCII or SCILAB Export File format. The data may be used for enhanced sound radiation modeling (BEA) and any other kinds of post processing.   The geometry may be provided in: 1. **Polar Coordinates** (angle Φ, radius r, height z) or in 2. Cartesian Coordinates (x,y,z). The vibration data is provided as a transfer functions Hx(f)=X(f)/U(f) between voltage U(f) in Volt at the terminals and displacement X(f) in mm at each measured point. The transfer function consists of an amplitude response (0dB = 1mm /V) and the phase response (rad). There are the following options: 1. Export of the **Raw Data**: The original data is provided without applying any kind of correction. 2. Export of the **Interpolated Data**: The SCN Analysis Software is used to interpolate missing data points, for smoothing the data and for applying error correction if an optical error is identified.

	The start button in the Export ASCII Data Dialog opens a save-file dialog where the data export file format can be selected.  EXAMPLE: please see AN_55_export_example.sce in attached .zip-file
Geometry and Vibration Import	External geometry and vibration data can be imported for Analysis. That can be used to import data generated by simulation tools or from external measurements. The import is based on a text file format which can be processed by SCILAB. Especially data which has been exported in SCILAB Export File format can be directly imported again.   Certain restrictions apply for a SCILAB script to comply with the import functionality of the Klippel Scanning System. EXAMPLE: please see AN_55_import_example.sce in attached .zip-file

Restrictions

1. All lines starting with // are comments
2. The complete file has to be executable without errors by SCILAB 3.1
   - SCILAB command : exec("<filename>.sce");
3. After execution the following variables should be accessible by SCILAB:
   - %SCN_FILE_VERSION = 1.1;
   - geometry(n, 4)
   - frequency(f) // optional
   - amplitude(n, f) // optional
   - phase(n, f) // optional
- with n is the number of grid points and f the number of frequencies

4. By now the geometry of the grid is limited to ordered polar grids as created by the SCN software. An interpolation will be required for arbitrary FEM grids.
5. The geometry points should be ordered with increasing radius and increasing angle. A single center point is allowed.

Structure of geometry array (example referring to AN_55_import_example.sce):

- first column = point number
- second column = radius in [mm]
- third column = angle in [rad]
- fourth column = height in [mm]

```
geometry=[
1 0 0 0;                    center point
2 10 0 2;
3 10 0.7855 2;
4 10 1.571 2;
5 10 2.356 2;
6 10 3.1415 2;              r1 = 10mm
7 10 3.927 2;
8 10 4.7125 2;
9 10 5.498 2;
10 20 0 3;
11 20 0.7855 3;
12 20 1.571 3;
13 20 2.356 3;
14 20 3.1415 3;             r2 = 20mm
15 20 3.927 3;
16 20 4.7125 3;
17 20 5.498 3;
];
```

$\varphi(r_1 = 10mm)$

$\varphi(r_2 = 20mm)$

Structure of amplitude and phase array (example referring to AN_55_import_example.sce):

```
amplitude = [
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-20     -32     -44
-10     -32     -44
];
```

Index of measurement points as defined in geometry array

frequency(1) frequency(2) frequency(3)

```
phase = [
0       0       0
0       0       0
0       1/4*%pi 1/4*%pi
0       1/2*%pi 2/4*%pi
0       1/4*%pi 3/4*%pi
0       0       4/4*%pi
0       7/4*%pi 5/4*%pi
0       3/2*%pi 6/4*%pi
0       7/4*%pi 7/4*%pi
0       0       0
0       1/4*%pi 1/4*%pi
0       1/2*%pi 2/4*%pi
0       1/4*%pi 3/4*%pi
0       0       4/4*%pi
0       7/4*%pi 5/4*%pi
0       3/2*%pi 6/4*%pi
0       7/4*%pi 7/4*%pi
];
```

Index of measurement points as defined in geometry array

frequency(1) frequency(2) frequency(3)

Each column of the amplitude and phase array contains all measured points associated with one frequency from the frequency array.

Options

Data Export Format	Data can be exported in • ASCII file format • SCILAB file format Please see section **Geometry and Vibration export** for more details

Data Import Format

To import geometry and vibration data into Klippel Scanning system the data has to be provided and structured as specified in section **Restrictions** (Interface Description) but there are various ways to generate the text based export files by using script code.

Important: scripts have to be executable by SCILAB 3.1.

An example that generates amplitude and phase matrices using iterative responses for each measured frequency is shown below.

Example referring to AN_55_iterative_scn_export.sce

Measured amplitude and phase response at frequency(1) = 100Hz:

```
response = [
1    -20    0
2    -20    0
3    -20    0
4    -20    0
5    -20    0
6    -20    0
7    -20    0
8    -20    0
9    -20    0
10   -20    0
11   -20    0
12   -20    0
13   -20    0
14   -20    0
15   -20    0
16   -20    0
17   -20    0
];
```

Index of measurement points as defined in geometry array

Responses are transferred to amplitude and phase array:

```
amplitude = [
-20
-20
-20
-20
-20
-20
-20
-20
-20
-20
-20
-20
-20
-20
-20
-20
-10
];
```

frequency(1)

```
phase = [
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
];
```

frequency(1)

Index of measurement points as defined in geometry array

Measured amplitude and phase response at frequency(2) = 200Hz:

response = [		
1	-32	0
2	-32	0
3	-32	0.7854
4	-32	1.5708
5	-32	0.7854
6	-32	0
7	-32	5.49779
8	-32	4.71239
9	-32	5.49779
10	-32	0
11	-32	0.7854
12	-32	1.5708
13	-32	0.7854
14	-32	0
15	-32	5.49779
16	-32	4.71239
17	-32	5.49779
];		

Responses are transferred to amplitude and phase array:

amplitude = [	
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-20	-32
-10	-32
];	

frequency(1) frequency(2)

phase = [	
0	0
0	0
0	0.7854
0	1.5708
0	0.7854
0	0
0	5.49779
0	4.71239
0	5.49779
0	0
0	0.7854
0	1.5708
0	0.7854
0	0
0	5.49779
0	4.71239
0	5.49779
];	

frequency(1) frequency(2)

Following the example file mentioned above this procedure is repeated for the responses at every measured frequency until amplitude and phase array are complete.

The FEA/BEA interface can also be used to simulate speaker vibration within the Klippel Scanning Software using commands from the SCILAB programming language.

Please see AN_55_simulate_piston_noise.sce in attached .zip-file for an example of a simulated speaker.

Minimize file size and loading time	In order to minimize file size and loading time simulation data can be stored and loaded as binary data. To save data as binary please add the following SCILAB command at the end of your script: exec(CreateCompressedFile); (a .ksp .sce file named <filename>_bin.ksp and <filename>_bin.sce using the compressed data is generated automatically by the scanner software when you load the uncompressed data with the scanning software for the first time)

Troubleshooting

Load in Scilab	If any error occurs while loading your exported data it might be useful to examine your export data script in detail using SCILAB. The scanning software is based on SCILAB 3.1, to open SCILAB go to: Start menu -> Klippel Analyzer -> Scilab 3 To access the variables defined in your script it has to be loaded into SCILAB first using the command: exec("<filename>.sce");
Useful Scilab Commands	• size(<name>) -> size of object <name> • whos()-> listing of variables in long form • help <command> -> show help for command • clear -> kills variables
Hints	• Check for correct unit definition of amp/phase
Contact Klippel	If you have problems to generate or load your export data file with the Klippel Scanning software please contact our support at support@klippel.de and attach your export data file.

More Information

Software Documentation	[1] Specification of the SCN Software, see www.klippel.de [2] Manual of SCN Software

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