

Standard MCAP-CR Loudspeaker System Simulator Program Document

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0. Purpose of Distribution

This program is distributed for ones who are interested in bass-reflex loudspeaker technologies.

Used algorithm in this program is spring-mass based equation of motion model, so that it does not model continuum substances like loudspeaker membrane. It means that basic knowledge of physics is required to evaluate simulation results.

Ones who wish to evaluate solely quality or preference of sound without having interested in technology itself are not allowed to use this program.

1. Terms and Conditions to Use this Program

It is assumed that anyone who use this program agreed to following terms and conditions.

- i. Users understand and agrees to limitations of mathematical models and algorithms used in this program.
- ii. Users understand that there are unknown bugs in this program.
- iii. Users do not claim for any loss incurred by using this program.
- iv. Users do not use this program for commercial purpose.
- v. Users do not redistribute this program or revised program code by themselves without written permission of original copyright holder.
- vi. Users understand that it is the most important to keep consistency that program does not depend on particular platform. In order to this purpose, users do not convert this program code to any Microsoft Visual Studio codes.
- vii. Users agrees that this program is not used for purpose to evaluate quality or preference of sounds.

2. Functions of this Program

- This program computes displacements of masses, i.e. driver's membrane and masses of airs involved in ducts of standard MCAP-CR loudspeaker system.
- Users have option to compute Discrete Fourier Transform
- Input signal is assumed force rather than power, current, or voltage. Sinusoidal wave, linear sweep or random signal is prepared to use as signal input.
- Calculated results are stored in ASCII text files.

User needs to read the program code “mcapcr-cui-dft_release01.0.cpp” if one need to know more details.

Note: Revision by Users

Users are allowed to revise this program code if one wishes under Terms and Conditions in Chapter 1.

3. Standard Use of this Program

Users have to compile this program code by themselves in order to get execution file.

This program is written in C language (and a little bit C++ grammar) , so that it can be compiled using right compilers.

This source code was checked using Linux GNU Compiler and MinGW.

Users who want to use with Mac OS need to set up gcc.

Microsoft C++ is not at all recommended to use with. It creates native code that is not compliant with standard C or C++ language.

Free BSD, UNIX or VMS may be used to compile this program, but not tested by developer.

Where to Get Compilers

GNU Compiler Collection	http://gcc.gnu.org/
MinGW Projects	http://www.mingw.org/

3.1 Preparation for Compiling

Linux

GNU C Compiler (GCC) is generally pre-installed. Check using the following command (rpm system only).

```
$ rpm -qa|grep gcc
```

Windows

Users need to install MinGW, in case any modification is desired. Much information is available through internet.

Binary executable file for x86 is also enclosed, so that users do not have to compile the source code unless modification is desired.

3.2 Compiling Program Code

Linux

- Common throughout all distributions -

Copy decompressed source file to working directory.

Start up terminal (i.e. X Term) windows and move to working directory.

Enter gcc command to compile the code.

- Examples -

Vine Linux 6.0

```
$ g++ mcapcr-cui-dft_release01.0.cpp
```

“a.out” is given execution file name and users may give any name if operating system allows.

Windows

Copy decompressed source file to working directory.

Start up command prompt window and move to working directory.

MinGW

```
g++ mcapcr-cui-dft_release01.0.cpp
```

MinGW compiler generates “a.exe” file.

3.3 Running the Program (Linux/Windows)

3.3.1 Prepare Condition Setting File

Create “parameters.txt” in the working directory using text editor. This file is must to run the program. Please note parameters.txt is different from input file that is used for previous version.

Example of parameters.txt

Notes:

Any letters or tabs or linefeed may not be placed prior to data value.

Linefeed code may be any if compiler recognizes. Notepad.exe may be used for Windows system.

Only one tab code must be inserted between data values in a line.

Only numbers in ASCII code may be used as data.

7th line and below do not affect program. Comments are written in sample file.

```
7.0 5.47 45
3 32 1 0.1
15 10 14 16
21.16 21.16 21.16 15.21 15.21 15.21
50 92 110 120 150 240
0 0 0 0 0 0 0
// -- Below this line does not affect calculation.
// 1st row: m0[g], radius of membrane[cm], f0[Hz]
// 2nd row: number of chambers(n), division, thermal condition, amplitude of force
// 3rd row: V[0], ..., V[2n] in litre
// 4th row: A[1], ..., A[2n] in sq-cm
// 5th row: L[1], ..., L[2n] in mm
// 6th row: C[0], ..., C[2n] in kg/s
```

1 st line	m0 (in gram unit), effective membrane radius (in cm unit), f0 (in Hz unit)
2 nd line	number of sub-chambers (integer: 1 - 12), number of divisions in one cycle (integer), thermal condition (1.0 for isothermal, 1.4 for adiabatic), amplitude of applied force (in N unit)
3 rd line	Volume of each chamber (in litre unit)
4 th line	Cross-sectional area of each duct (in square cm unit)
5 th line	Effectice length of each duct (in mm unit)
6 th line	Damping coefficient of membrane and each duct (in kg/s unit)

Refer to the following document for algorithm.

http://mcap.web.fc2.com/documents/MCAP008J_S-MCAP-CR_simulation_r0.pdf

Note that program has been updated after above document was issued.

Notes

32(5bit), 64(6bit), or 128(7 bit) is recommended for “number of divisions in one cycle”. 32(5 bit) is generally enough for simulation; however, in case you suspect result is somewhat appropriate, try 64 or 128. This number greatly affect calculation time.

3.3.2 Program Execution

Once source code was compiled, execution file may be used for other PC if platform is identical.

Move to working directory where binary executable file is located. Then type execution command to run the program.

Linux (assuming execution file name is “a.out”)

\$./a.out↵

Windows (assuming execution file name is “mcapdft.exe”)

mcapdft↵

Analysis Options

There are following options for analysis.

(1) vector sum option

This is prepared to use for Fourier Transform analysis that is not included in this program. If option 0 is chosen, sum value of displacements and velocities use all values of ducts. If option 1 is chosen, effects of internal ducts are ignored.

It is difficult question which option should be chosen. It is up to users.

```
[0] values and parameters calculation done!  
Choose vector sum option  
      0: All ducts, 1: ignore internal ducts  
Your choice =
```

(2) Processing Option

Users may choose “Sequential Processing:0” or “One Time Processing” option.

```
Choose Sequential Processing or One time Processing  
      Sequential Processing: 0  
      One Time Processing: 1  
You choose :
```

0: Sequential:

Software computes the following if you choose this option:

1. Software set 10Hz and calculate dft value at 10Hz, then the value is recoded to “dft_sequential_calculation_result.csv”
2. Software set 10+1Hz and execute the same process as 1.
3. Software repeats adding 1Hz and execute same process up to 400Hz.

1: One Time Processing

Software prompts input signal option as below:

(3) Input Signal Option

Users may choose sinusoidal wave, linear sweep, or random input.

0: Sinusoidal wave in specified frequency

1: Linear sweep in specified frequency range

2: Random input signal

0:Sinusoidal

Specify frequency in Hz unit then hit Enter key. No more option if this is chosen.

1:Linear Sweep

Specify final sweep frequency in Hz unit and sweep rate in Hz/s unit.

Maximum Frequency: 100 - 200 may be input. 200 is suggested value.

2:Random

If this option is chosen, sampling frequency is set as 100 x number of divisions in a cycle.

No more input is required if this option is chosen.

Users should modify program code if other option is required.

3.3.3 Viewing Calculation Results

Output Files

Files given in Table-1 will be written in ASCII format.

Table-1 List of Output Files

File Name	Description	Note
dft_sequential_calculation_result.csv	Frequency[Hz], SPL[dB] converted from dynamic pressure [Pa], phase[degree] at frequency, Real part of DFT, Imaginary part of DFT	This is generated if user chose "Sequential Processing Option.
dft_result.csv	Frequency[Hz], SPL[dB] converted from dynamic pressure [Pa], phase[degree] at frequency, Real part of DFT, Imaginary part of DFT	This is generated if user chose "One Time Processing Option.
normalized_x_vectors.csv	Time[s], Weighted sum of displacements[mm], displacement of membrane[mm], weighted displacement of air mass in a duct[mm],...	See below for definition of normalization
normalized_v_vectors.csv	Time[s], Weighted sum of velocities[m/s], velocity of membrane[m/s], weighted velocity of air mass in a duct[m/s],...	See below for definition of normalization
matrices.csv	Standard stiffness matrix, actual stiffness matrix and intermediate matrix are stored.	Used for diagnostics.
dftv.txt	1 st line: number of datapoints 2 nd line: time resolution 3 rd line and below: normalized sum of velocities	Used for Fourier Transform

Definition of Normalization

Following definitions are used for normalization.

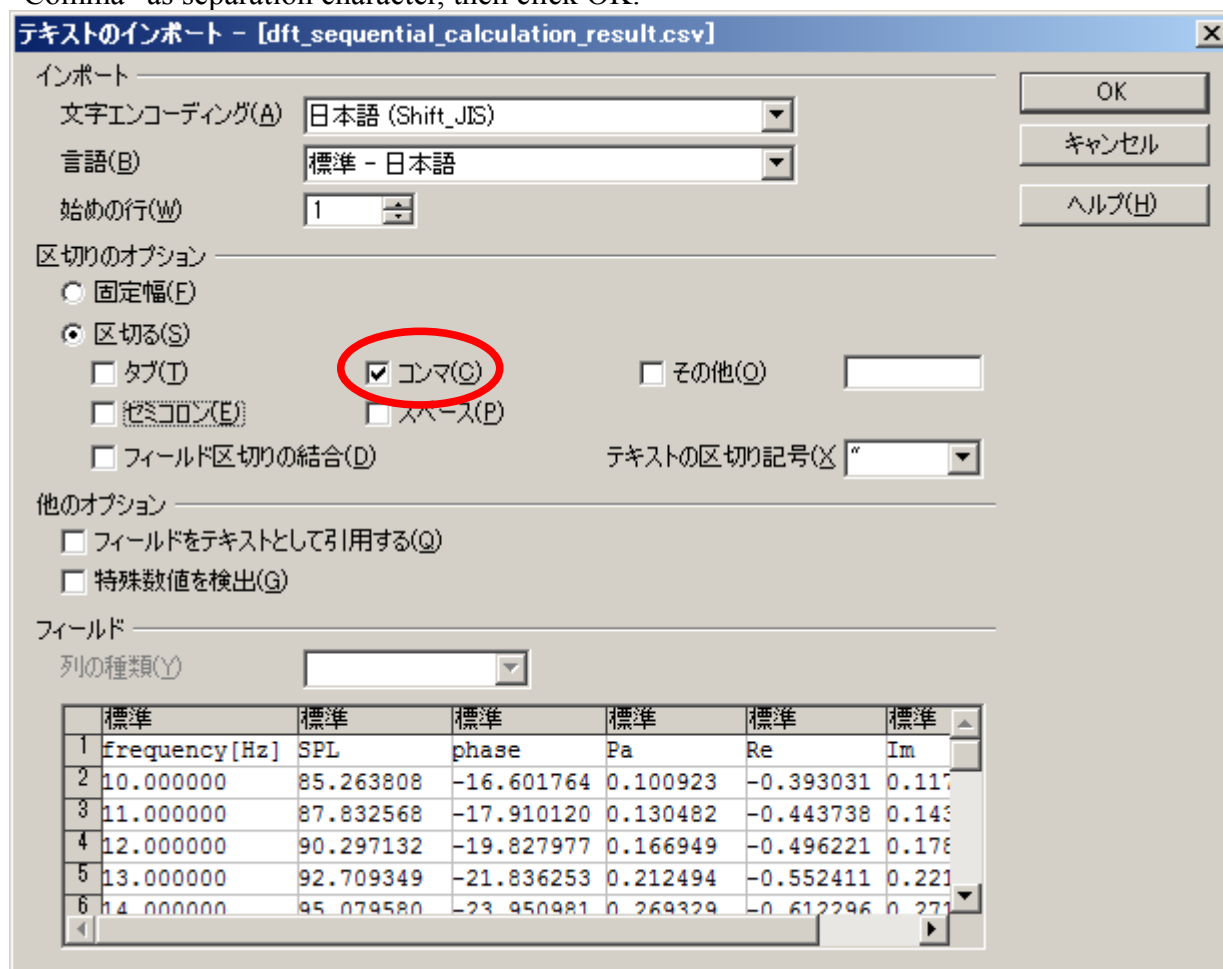
$$x_j^* = r_j x_j = \frac{a_j}{a_0} x_j \quad \text{Displacement} \qquad v_j^* = r_j v_j = \frac{a_j}{a_0} v_j \quad \text{Velocity}$$

Plotting Data

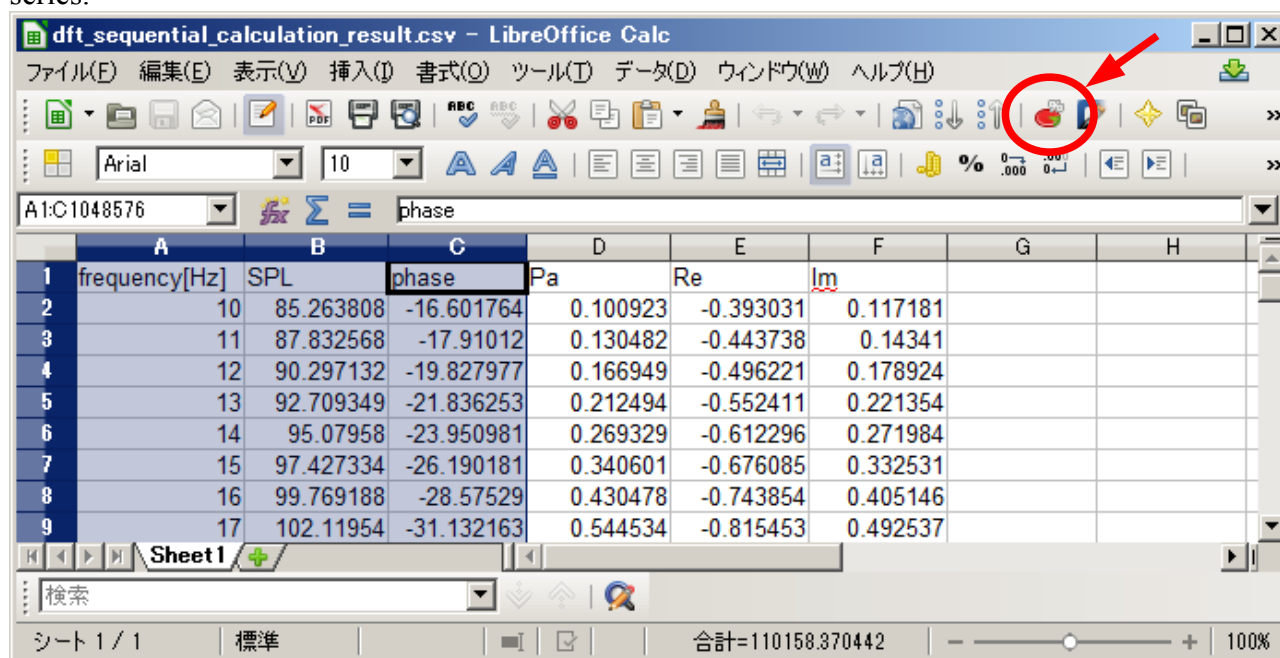
This program does not have plotting function. Users may use LibreOffice Calc or other application software to view data.

Example to Use LibreOffice Calc

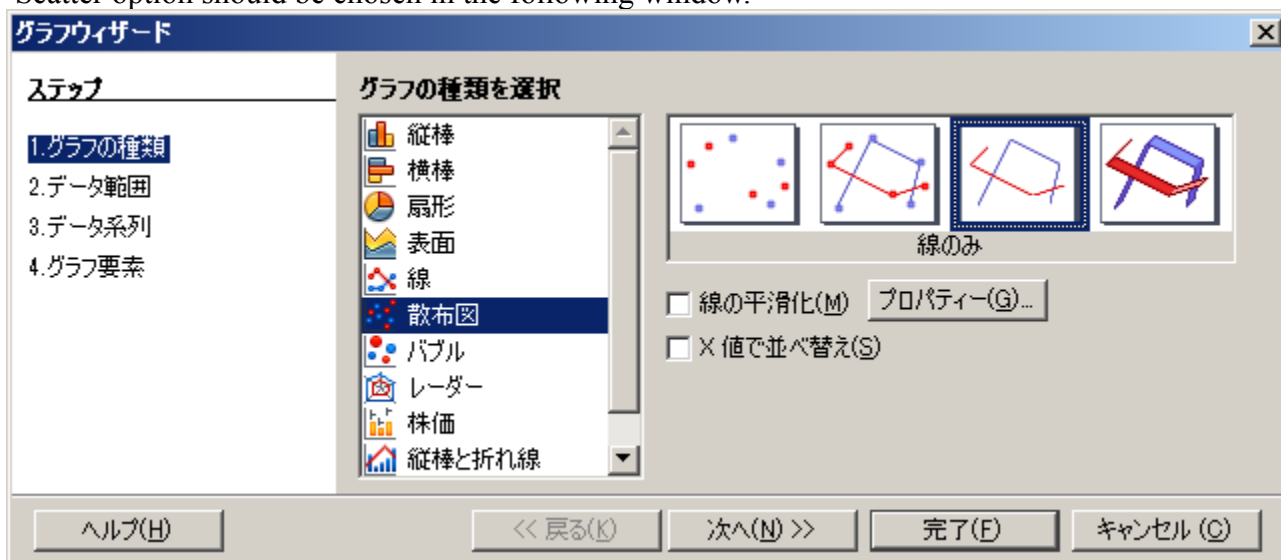
Open working directory using Windows Explorer or X Window Dolphin and double-click “normalized_v_vectors.csv”. Calc starts up and display the following window, then select “Comma” as separation character, then click OK.



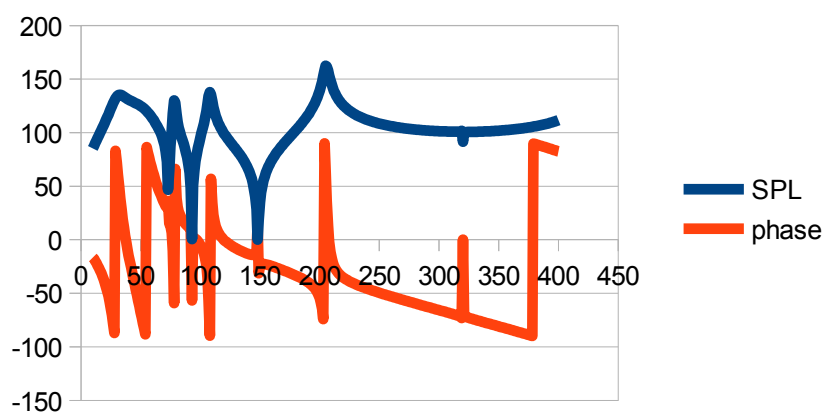
Highlight necessary columns and click plot icon. Column A needs to be highlighted to view in time series.



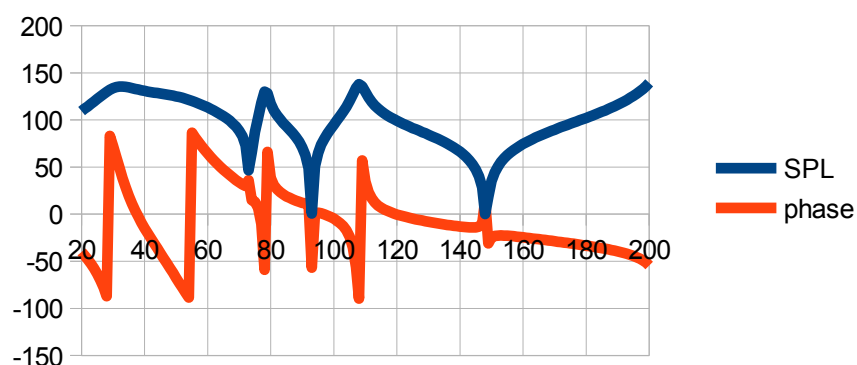
Scatter option should be chosen in the following window.



Following plot then appears.



Adjust frequency range as you want to view.



Note that this is suitable to find characteristic frequencies, but not suitable for simulating frequency response.

Refer to LibreOffice Help as you require. LibreOffice is satisfactory freeware.

Report any bugs to following email address, although it is not required.

mcapspeakers@gmail.com