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 for this purpose, users do not convert this program code to any Microsoft Visual Studio codes.
vii. Users agree 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.
- 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 “mcap-cr_simulator_public_rev01.cpp” if one need to know more details.

Note: Revision by Users

Users are allowed to revise this program code if ones wish 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 Collection(GCC), MinGW, and Borland C++ Compiler V5.5.

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 (recommended) or Borland C++ Compiler. Much information is available through internet.

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

```
$ gcc -lm -lstdc++ -o mcaps.out mcap-cr_simulator.cpp⏎
```

“mcaps.out” is given execution file name and users may give any name if operating system allows.
“-o mcaps.out” may be omitted. In this case, gcc compiler generates execution file “a.out”.

OpenSUSE 12.1

```
$ gcc -lm -o mcaps.out mcap-cr_simulator.cpp⏎
```

-o option may be omitted.

Windows

Copy decompressed source file to working directory.
Start up command prompt window and move to working directory.

MinGW

```
gcc -lm -o mcaps.out mcap-cr_simulator.cpp⏎
```

-o option may be omitted like Linux GCC compiler, then it generates “a.exe” file.

Borland C++ Compiler

```
bcc32 mcap-cr_simulator_public_rev01.cpp⏎
```

It generates following files:

“mcap-cr_simulator_public_rev01.exe”	Execution file
“mcap-cr_simulator_public_rev01.obj”	
“mcap-cr_simulator_public_rev01.tds”	

3.3 Running the Program (Linux/Windows)

3.3.1 Prepare Condition Setting File

Create “input_parameters.txt” in the working directory using text editor. This file is must to run the program.

Example of input_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    10   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), cycles, 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
```

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

10 or smaller value is recommended for “number of cycles”. Greater numbers make calculation time longer.

128(7 bit) or smaller is recommended for “number of divisions in one cycle”. 32(5 bit) is generally enough for simulation. 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.

Type execution command to run the program.

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

$ ./mcaps.out⏎

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

mcaps⏎

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.

```
ssuzuki@linux-qo0c:~/simulator> ll
total 48
-rwxr--r-- 1 ssuzuki users   462  1月 28 16:00 input_parameters.txt
-rwxr--r-- 1 ssuzuki users 13765  1月 28 16:45 mcap-cr_simulator_public_rev01
.cpp
-rwxr-xr-x 1 ssuzuki users 25786  1月 28 17:43 mcaps.out
ssuzuki@linux-qo0c:~/simulator> ./mcaps.out
[0] values and parameters caluculation done!
Choose vector sum option for later Fourier Transform analysis.
        0: All ducts, 1: ignore internal ducts
Your choice =
```

(2) Input Signal Option

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

0: Sinusoidal wave in specified frequency

1: Linear sweep in specified frequency range

2: Random input signal

```
Choose Sinusoidal, Sweep or Random
Sweep option may take long to calculate.
       0:Sinusoidal, 1:Linear Sweep, 2:Random
Your choice =
```

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 - 1000 may be input. 300 is suggested value.

Sweep Rate: 10 - 200 may be input. Users will be prompted to input same value as above. This is for a reason in case Fourier Transform analysis follows.

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
x_vectors.csv	Time[s], Applied Force[N], Displacement of Membrane[mm], displacement of air mass in a duct[mm],...	
v_vectors.csv	Time[s], Applied Force[N], Velocity of Membrane[m/s], velocity of air mass in a duct[m/s],...	
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.
ftv.txt	1st line: number of datapoints 2nd line: time resolution 3rd line and below: normalized sum of velo1ocities	Used for Fourier Transform

Definition of Normalization

Following definitions are used for normalization.

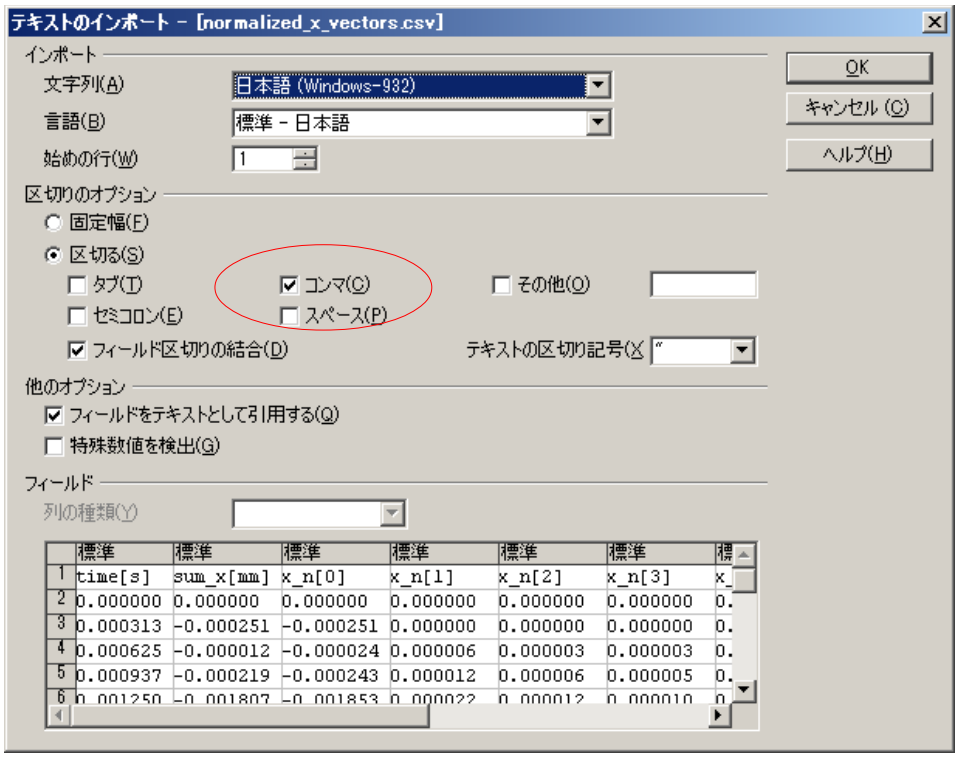
$x_j^* = r_j x_j = \frac{a_j}{a_0} x_j$ Displacement $v_j^* = r_j v_j = \frac{a_j}{a_0} v_j$ Velocity

Plotting Data

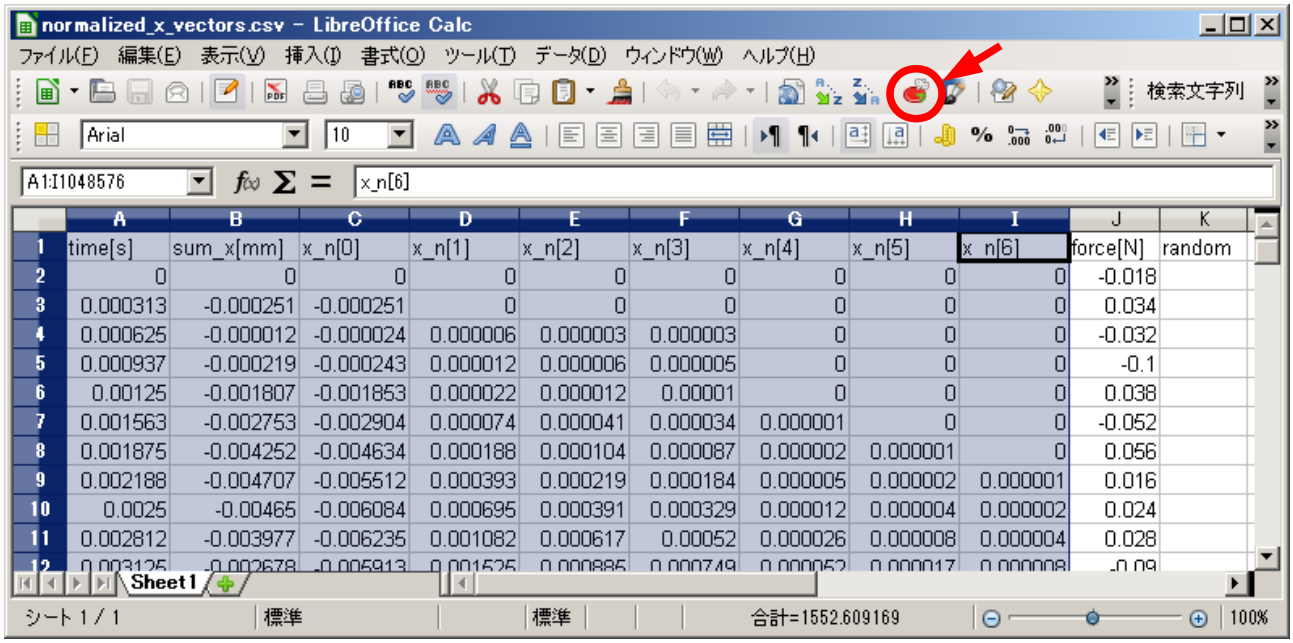
This program does not have plotting function. Users may use LibreOffice Calc or other application software to view data.

Example to Use LibreOffice Calc

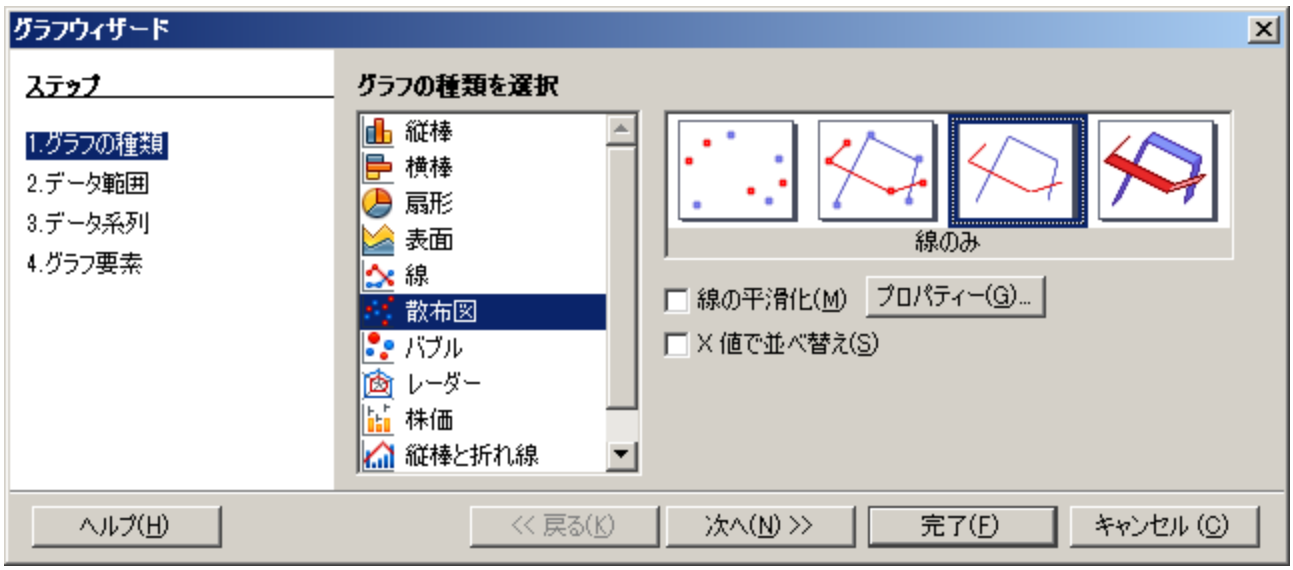
Open working directory using Windows Explorer or X Window Dolphin and double-click “normalized_v_vectors.csv”. Calc starts up and display the following window, then select “Comma” as separation character, then click OK.



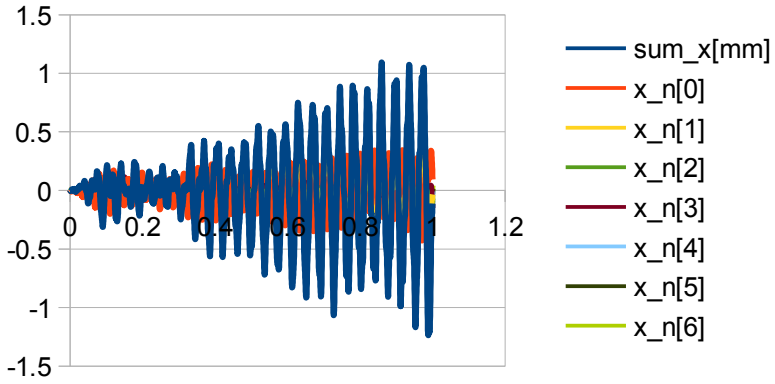
Highlight necessary columns and click plot icon. Column A needs to be highlighted to view in time series.



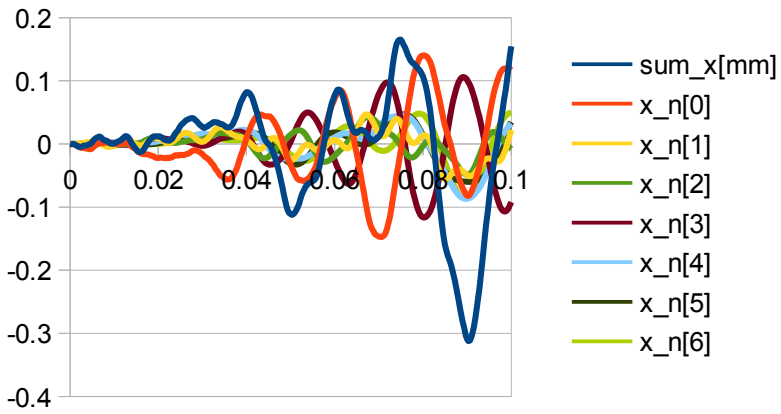
Scatter option should be chosen in the following window.



Following plot then appears.



Adjust time range as you want to view.



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