

# JustMLS

## users guide

ver 0.13

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## 1 Introduction

justMLS is a measurement system especially aimed for those who wish to become more familiar with loudspeaker measurements. Loudspeaker measurement systems are generally quite expensive. justMLS does basic measurement of:

- Transfer function with phase, a popular rewriting is perhaps sound pressure level. It is however possible to measure e.g the transfer function of an amplifier also.
- Impedance with phase measure.

**Please note that justMLS is NOT freeware or shareware or any other no cost alternative.**

The suggested retail price for LspCAD standard version is about USD129 and that also includes the right to use justMLS. Taking into consideration what other software dedicated for measurement purposes only cost it is very good deal. The recommended price for the professional version is about USD495.

## 2 Technical data

MLS size: 32764,16384,8192 and 4096

FFT size: 8192, 1024 and 256 point, used in different frequency bands

Sample rates: (96000,)48000,44100,32000,22050,16000and 11025Hz. 96000Hz sample rate is not fully tested.

Smoothing :  $1/12^{\text{th}}$  ,  $1/6^{\text{th}}$  and  $1/3^{\text{rd}}$  octave.

Window: Hanning

## 3 Necessary hardware

justMLS is designed to be as hardware free as possible, yet there are a few things that may be needed.

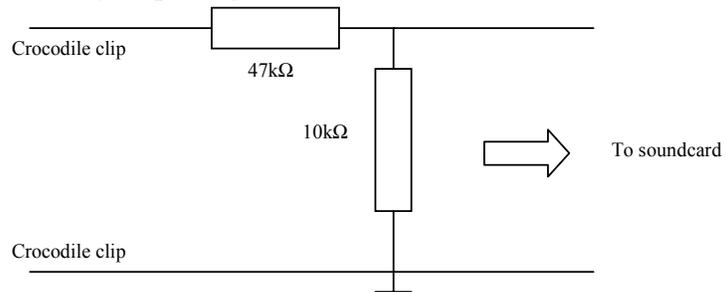
### 3.1 Soundcard

A decent soundcard is needed, key factors for success are low distortion and low noise, especially for the mic input. There is however no need for an extreme soundcard, an SB16 card may be enough. One warning about portable PC's though, they tend to have very lousy soundcards !.

### 3.2 Input probes

Input probes may be needed to protect the input from e.g. the high output voltage of a power amplifier. Input probes are easy to put together. What is needed is the below items.

- 4 Alligator clips
- 2  $47\text{k}\Omega$   $\frac{1}{4}\text{W}$  1% resistors
- 2  $10\text{k}\Omega$   $\frac{1}{4}\text{W}$  1% resistors
- + some wire



The simple schematic shows how a probe is built. In cases with higher voltages it may be necessary to replace the  $47\text{k}\Omega$  resistor with a higher value (e.g.  $470\text{k}\Omega$ ). The attenuation ratio is not critical as justMLS anyway cannot measure absolute values.

### 3.3 Microphone

A decent microphone is needed for this purpose. Depending on the accuracy that one wants one can either put together a microphone capsule or buy a measurement microphone. A purchased microphone comes with a calibration data file, something that is necessary if you wish to measure frequency and phase accurately. See below a list of companies that sell calibrated microphones (only one name for the moment):

Kim Girardin  
Wadenhome Sound  
1400 Homer Rd. Suite 2  
Winona, MN, 55987, USA  
507-454-8844  
kmgrdn@luminet.net

### 3.4 Power amplifier

Pretty obvious, there is not need for a high tech power amplifier though. Any 20W power amp will do.

## 4 Getting started

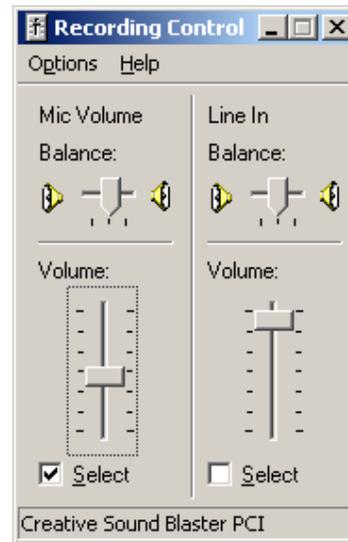
### 4.1 Selecting soundcard

If you have several soundcards in your PC, make sure that you have the correct soundcard devices selected in justMLS, that you can see to the right of the **Start** button.

### 4.2 Selecting input

First of all, before doing anything else, one must make sure that the mixer is set so that the correct input is selected. If one wish to measure the frequency response of a loudspeaker unit then the microphone is connected to the microphone input. You need to open the mixer device (double click on the small loudspeaker icon on the taskbar). In the mixer device, select menu *Options|Properties* and click on **Recording + OK**.

Here you will (most likely) see a trackbar volume control for the microphone and the line input. Select the appropriate input.



### 4.4 Setting sample rate

The sample rate can be set to a number of different values between 48000Hz and 11025Hz. The latter can be used for measurements on bass units.

### 4.3 Setting the level

The level is tested by clicking on the **Test levels** button. The level should be set so that the yellow area of the level bars is lighthed, the red area should not be lit. Do this procedure and adjust the level in the mixer so that the level is correct. Keep in mind that different loudspeaker units will cause different levels on the input, it is therefore good practice to set the level according to the strongest loudspeaker unit and keep it throughout all measurements (not necessary for impedance measurements).

### 4.5 Calibrating soundcard input

Now that you have selected what input to use, you first need to calibrate the frequency response of the soundcard. This is done by connecting a cable between the output and the selected input of the soundcard. When the mic input is to be used, it may possible that one may have to attenuate the output first. Set the levels correctly and press the Soundcard cal. button. Note that the justMLS does not remember the soundcard calibration between sessions, you have to calibrate the soundcard every time you start the program or change input.

## 4.6 Exporting measurements

Measurements are exported in ASCII format by clicking on the **Export measurement** button. Below is an example of an exported file.

Freq	Mag	Phase
10.77	54.9	-5.9
21.53	61.8	-46.3
32.30	65.8	-154.6
43.07	62.3	137.1
53.83	78.3	179.3
64.60	81.2	141.1
75.37	83.4	118.0
86.13	85.2	97.7
96.90	86.3	79.8
.		
.		
19121.48	48.3	80.8
19293.75	46.8	71.6
19466.02	45.6	64.8
19638.28	44.4	57.7
19810.55	43.6	47.4
19982.81	42.9	40.4
20155.08	41.9	19.6
20327.34	39.5	3.1
20499.61	36.1	0.4
20671.88	34.1	3.5
20844.14	33.2	-4.3

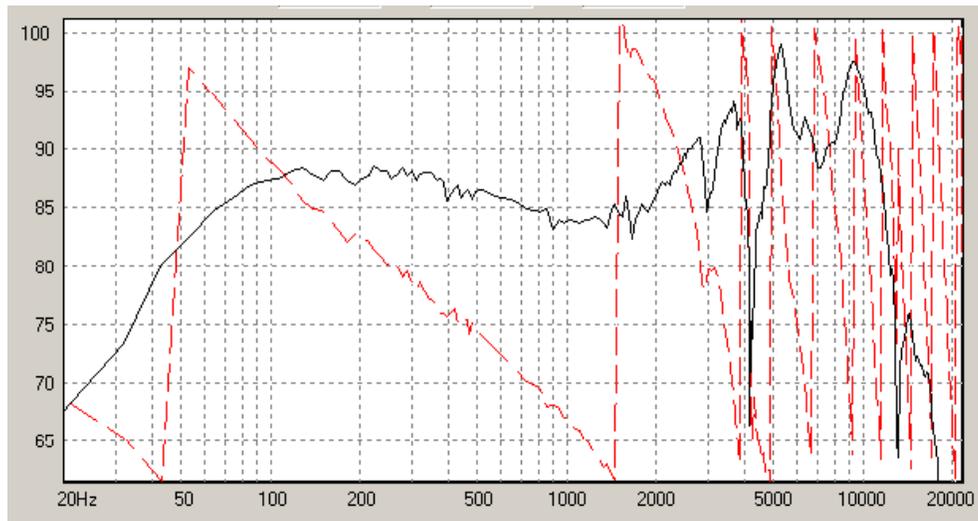
Note that the number of frequency points differ depending on whether **Full length FFT** is checked or not. If **Full length FFT** is checked then the number of frequency points is 3892 otherwise it is about 307 (can differ slightly depending on sample rate). Note that the frequency points closest to half the sample rate are not exported, the reason is that these points are not useful.

## 5 Frequency response measurements

Measurement of frequency response is done by selecting the **SPL** tab. A few controls that are related to frequency response measurements are visible here. In some case the microphone may be inverted, if this is the case one may check the **Invert** checkbox. The input signal must be on the left channel, if this is not the case then **the Swap left-right** checkbox must be checked. If you have a mic calibration file, then you can import it by clicking the **Import** button. This mic calibration file will be loaded every time you start the program.

Once the necessary settings are done (soundcard calibrated, levels are set correctly), press the **Start** button and wait for the result.

Hopefully the result looks something like the figure below. To see this you will have



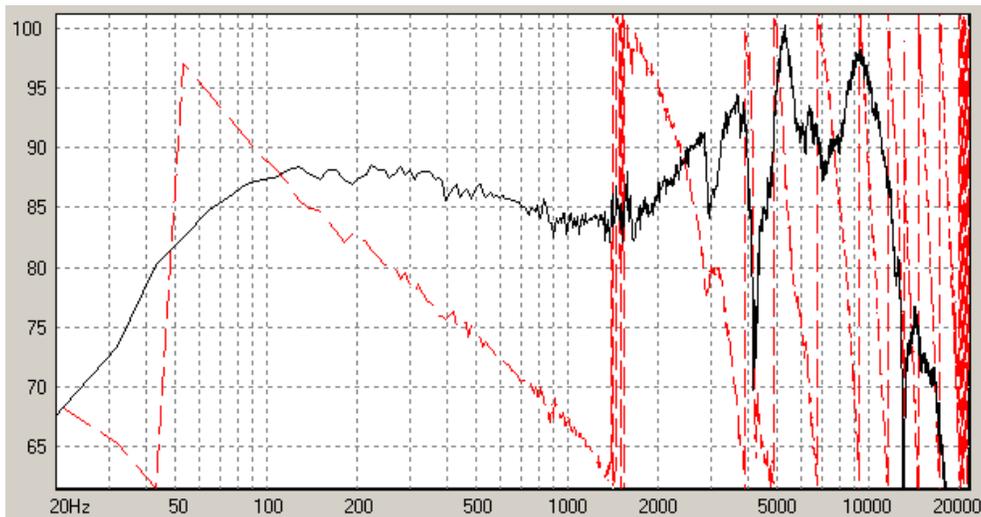
to click on the **Freq. Domain** tab.

justMLS makes use of three different FFT's. In the frequency response 0-550Hz a 8192 point FFT is used, between 550Hz and 5500Hz a 1024 point FFT is used, above 5500Hz finally a 256 point FFT is used. The 550Hz and 5500Hz breakpoints apply to 44100Hz sampling rate. The frequencies at which the FFT length is switched depends on the sample rate and is according to the table below.

Sample rate (Hz)	Lower switch freq. (Hz)	Upper switch freq. (Hz)
48000	600	6000
44100	550	5500
32000	400	4000
22050	275	2750
16000	200	2000
11025	140	1400

Why is this methodology used?, simple answer is noise immunity. At high frequencies most of the energy is in the beginning of the impulse response, therefore it is not necessary to use a 8192 FFT for those frequencies.

It is possible to use the 8192 point FFT for the whole frequency range. Click on the **Full length FFT** checkbox for this. The result then is like the below figure.



It is also possible to perform cyclic measurements, check the **Cyclic** checkbox before you click in the **Start** button. When you click in the **Start** button it's caption will change to **Stop** meaning that you should click on it to stop the cyclic measurement.

The **Length** setting can be used to exclude e.g room reflections from the measurement. A neat idea is to set the length, click on the recalculate button and watch the impulse response window. If the arrow up/down keys are pressed while this control is in focus the window length will change by +/- 20 samples. Holding down the Control key also while pressing the arrow up/down keys will change the window length by +/- 200 samples.

The **Start** setting can be most often be left as is. Here it is possible to move that starting point of the FFT window forward and backward to, and also be able to fine adjust it to the beginning of the impulse response. If the arrow up/down keys are pressed while this control is in focus the window length will change by +/- 1 samples.

When doing measurements it is possible that the phase response might differ between measurements, What justMLS does is that it searches for the largest peak in the impulse response, then rewinds back and searches forward until the level is at least  $1/10^{\text{th}}$  of the peak level. The starting point of the FFT window is set 10 samples behind that point. The starting point may thus differ between measurements and that will affect the measured phase response simply because different amounts of delay is added. This is a sort of side effect of the hardware free approach of justMLS.

The above methodology means that the user must find out the acoustical centers of the loudspeaker units. The simplest way to do this is to measure all loudspeaker units individually, then measure them all connected in parallel and model that in a loudspeaker crossover CAD such as LspCAD. In LspCAD one will then have to tweak with the dZ values until a match is found. Below is a more detailed description how this is done with the help of LspCAD (extracted from the tutorial section of the LspCAD manual).

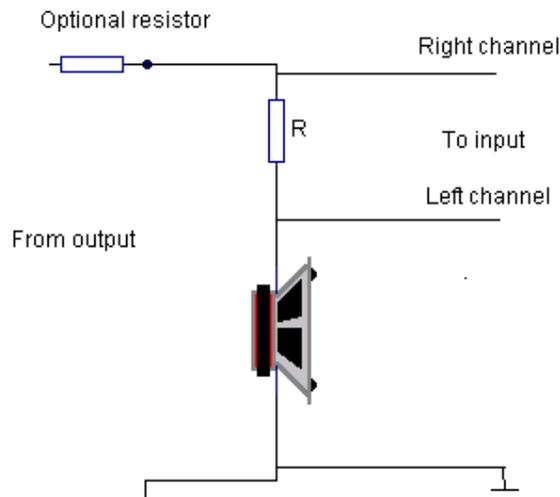
"The measured frequency response must be verified in some way. A method commonly used is to do a final measurement with all driver units connected together and the microphone placed in front of the treble unit (at some distance). The measured response will look awful but don't let that scare you off. Create an advanced passive crossover and import both the measured frequency response and impedance data. Remember also to set the positions of all the drivers to the positions relative to the location of the treble unit, let  $dZ=0$  for all driver units. This of course means that the position of the treble unit is  $dX=dY=dZ=0$ . Moreover set the measurement distance (in the General menu) to be the same as the distance between the microphone and the baffle.

Now take a look at the *Summed frequency response* diagram, does it look similar to the real measurement ?. If yes then we can continue with the crossover construction. If no, then we have to set the  $dZ$  values for some of the driver units. Often it is possible to get  $dZ$  by measuring the depth of the driver cone i.e how recessed the dust cap is relative to the rim of the cone.

Afraid of destroying your treble units with this exercise? Put a capacitor in series with the treble unit, remember though to add the capacitor in LspCAD as well."

## 6 Impedance measurements

For impedance measurements a resistor is needed, click on the **Z** tab. The resistor and the loudspeaker unit should be connected according to the figure below.



It is recommended to use a power amplifier to drive the setup, this also means that it IS HIGHLY RECOMMENDED to use the probes also!

In some cases it is possible to use the line output from the soundcard, then an extra "optional resistor" of  $1k\Omega$  is also recommended. The connection of the left and right channels is not critical as justMLS will figure out the connection anyway. The recommended procedure is to select the input (preferably line input), calibrate the soundcard, set the levels and press the **Start** button. It is important to do a calibration as a very small difference between the channels may reflect largely on the impedance measurement.

The below example shows the impedance curve for a Phillips AD70655 loudspeaker unit. In this case the sample rate was 11025 Hz just to get better frequency resolution. For mid and treble units it is however better to use the higher sample rate.

