

# Measuring impedance and T/S with ARTA/LIMP

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## Revision History:

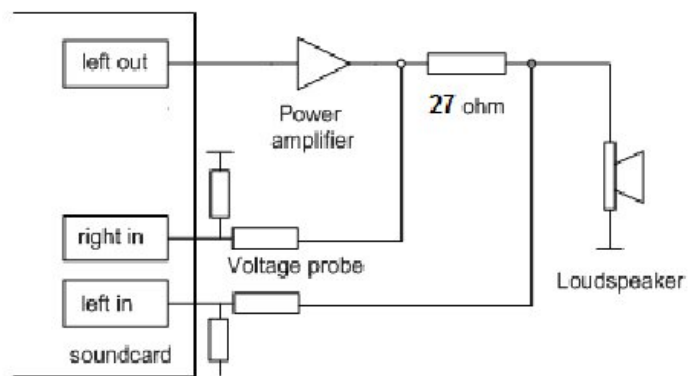
Date	Description
Jan 4, 2022	Initial Release

With a simple jig, loudspeaker impedance and T/S parameters can be easily measured with LIMP. The same jig may also be used to measure component value for resistors, capacitors, and inductors, as well as measure transfer functions of passive and active filters.

The setup is quite simple, the following diagram is taken from the LIMP manual:

<https://artalabs.hr/download/LIMP-user-manual.pdf>

**Figure 3.2** General measurement setup for loudspeaker impedance measurements



This instruction is following what is in the LIMP manual linked above, which I would also suggest reading through for more detailed information.

1. Before you start measuring with LIMP, there is a basic calibration process that should be completed. First, go to setup -> audio devices and make sure LIMP is configured to use the Steinberg audio interface, on my UR22mkii it says "Yamaha Steinberg USB ASIO". There is a "control panel" button here that will open the settings for the Stienberg ASIO driver, it should be fairly straightforward here, please make sure that "loopback" remains unchecked at all times in the driver settings. On the USB interface, the "mix" knob should always be fully clockwise to the "DAW" for our purposes. I usually start with each input gain knob at the 12 o'clock position.
2. Go to setup -> measurement. Here you enter the reference channel, the resistor value, sample rate, FFT size, averaging, etc. Set the resistor value as 10 ohm or the specific resistance as measured with your multimeter, sample rate of 96kHz, and the other options as desired.

3. Press the "CAL" button in LIMP. This calibration process will adjust for the difference in gain between left and right input channels. Anytime the gain knobs are touched, or if the FFT size or sampling rate is adjusted in LIMP, the calibration process must be completed. Simply connect the probes as shown in the above diagram, but leave the speaker disconnected. In the calibration window, there is a "generate" button that will create a tone so you can set the level of the test signal, then simply press the calibrate button. It should provide you with a success notification as well as the channel difference.
4. It is important to compensate for the test leads from the jig to the speaker. This is detailed in section 4.7.2 of the LIMP manual for reference. To compensate for the test leads from the impedance measurement probe to the driver, simply disconnect the driver and short the leads together. Your amp will be safe with this operation as long as the 10 ohm resistor is connected as it should be, so the shorted leads will still be 10 ohms across the amp output. Now we simply run the measurement, select "PN PINK" under the generator drop down, Fstart of 10Hz, Fstop of 40000Hz, then press the red "play" button. This will measure roughly 0 ohms, but there will be some resistance and inductance of the test leads. Click on the graph at 1kHz to set the cursor location, then press the "RLC" button, which will provide you with the lead resistance and inductance parameters. Write these numbers down.
5. Now, press the "cable compensation" button, which is just to the right of the "CAL" button. Enter the resistance and inductance measured, and check the box to enable the compensation. Now, if you rerun the shorted lead test, the measurement should be incredibly close to 0 ohms across the entire spectrum.

You are now fully set up and ready to measure speakers, or resistors, capacitors and inductors too! Just connect the driver or component as shown in the diagram above and run the measurement. PN PINK noise test is quick, however lacks some accuracy at very low frequencies, so if you find your measurement is noisy at low frequency, you may have to run the stepped sine instead. In LIMP, unfortunately it is a slow process, but the accuracy is very high.

For driver free-air T/S measurement, it is important that motor vents are unobstructed, so placing face up on a desk may not be the best solution without some block spacers to keep the vent open. For complete driver T/S, we must complete two measurements with added cone mass to determine the VAS of the driver. For this process, simply take the first measurement and export it as the driver free air impedance, then also select overlay -> set as overlay curve. Now we must add some mass to the driver cone so get out your kitchen scale. If you have a spec sheet for the driver, the added mass should be about equal to the driver Mms or "moving mass", so we are doubling the moving mass for this process. If you don't have the datasheet for the driver, I would use the Mms of a driver of similar size and cone material. The idea is to lower the Fs of the driver by 25% so use that as a guide on the mass requirement as well. Run the measurement again, you will see the added mass measurement now as well as the free air overlay. export this measurement as well.

The T/S parameters can be calculated within LIMP, or the exported measurements can be used directly in VituixCAD to complete the calculations there as well.

In ARTA, simply select analyze - loudspeaker parameters - added mass method. The voice coil resistance can be estimated by the software, but we must enter the driver diameter and added mass used. The diameter here is determining the "Sd" parameter for radiating surface area, and it is generally measured as the cone diameter + half of the surround. In the "nonlinear LSE optimization" section of this window, check all 3 boxes, and in the dropdown for the lossy inductor model, select " $L_e + L_2 || R_2 || K$ " which is more commonly known as the "semi-inductance" model, and in VituixCAD it is referred to as the "Extended Z model".

One convenient feature here is that you don't have to manually enter these values into VituixCAD. If you press the "copy parameters" button here, then in VituixCAD enclosure section, press the + button to create a new driver, you will find a "paste" button in the lower left corner to simplify the process.

If you were to use the measured data and determine T/S parameters directly in VituixCAD, you will require all the same information. 2 measurements of free-air and added mass, and you must enter the specific added mass and driver diameter. When you create a new driver in VituixCAD, simply press the "calculate T/S" button, and enter in all the necessary information. I won't go into great detail here as I feel it is fairly straight forward.