System and Driver Impedance
Audioholics

By mark — March 04, 2008

1a. System Impedance: Magnitude & Phase

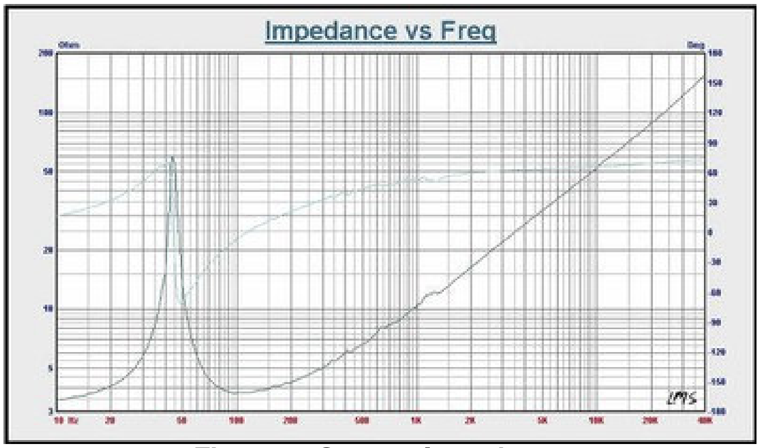

Figure 1: System Impedance

Purpose: To determine: (1) the characteristics of the impedance load placed on a power amplifier by the system across a defined frequency spectrum segment; (2) various system parameters; and (3) the identification of any anomalies/pathologies that are reflected back to the electrical domain.

Value: Impedance curves provide an assessment of the impedance the system presents to the driving amplifier. When presented with phase data it provides further insight into the ease or difficulty a given amp may face in driving the system. Impedance curves also are useful in indicating system parameters such as resonance frequencies, system rated or nominal impedance and so forth. In some cases, they can also provide evidence of a variety of system anomalies/pathologies, such as pronounced standing-wave resonances arising within the air enclosed by the cabinet.

Method of Measurement: Measure the driver's Revc and the system's impedance (with driver still in cabinet & any internal power amp and/or processors disconnected from the driver), then remove the driver from the cabinet and proceed to Section 2, *Driver Impedance, Magnitude & Phase*. Except where it is noted otherwise or simply not applicable, the suggested frequency spectrum is 10 Hz to 320 Hz.

For maximum accuracy, remove test lead and/or amp-to-sub cable impedance from all measured driver/system impedance curves. One method of accomplishing this is by measuring each beforehand and subtracting them from the driver/system measured impedance curve. Also, impedance measurements should be done in an environment as noise & vibration free as possible. Prior to making any acoustical or electrical measurements of the system, be sure to inspect all fittings, fixtures, hardware, etc to be certain that all are bolted down securely: leaks, loose hardware and so forth can and will effect measurement data.

Signal Used: Constant voltage (preferred) or constant current, downward swept sine wave, MLS or impulse signal. Regarding the swept sine wave, unless otherwise required, use as low a test signal drive level as possible that can repeatedly produce clean data.

Metric Specification: Nominal or rated impedance (Znom): should be stated such that the minimum impedance is no less than 80% of the stated nominal or rated impedance.

As per IEC 60268-5 standard practice, the value of Znom is specified based on the minimum value of the system's modulus of impedance (Zmin) such that Znom is no more than 1.25*Zmin. In practical terms this means a system with a Zmin value as low as 6.4 Ω could be considered an 8Ω system, systems with a Zmin value as low as 12.8Ω could be considered a 16Ω system, and systems with a Zmin as low as 3.2Ω could be considered a 4Ω systems.

Nominal System Impedance, (10 – 320 Hz): A.A Ohms
Local minimum(s): X.X Ohms (Mag. & Phase) @ Y.Y Hz
Local maximum(s): W.W Ohms (Mag. & Phase) @ Z.Z Hz

1b. Driver Impedance: Magnitude & Phase

Figure 2: Driver Impedance

Purpose: To determine: (1) various driver/system parameters, and (2) the identification of any driver anomalies/pathologies reflected back to the electrical domain.

Value: Driver impedance curves provide for a great deal of useful information, in addition to an assessment of the impedance presented by the system's raw driver. Driver impedance curves are useful for deriving Thiele-Small parameters. In some cases, they can also provide evidence, as already mentioned of driver anomalies/pathologies or other noteworthy characteristics.

Method of Measurement: Measure the driver's Revc and the diameter of the driver, including $1/3^{rd}$ to ½ the surround.
With the driver out of the cabinet and secured in place or otherwise restrained from any possible movement, remeasure the impedance. This is the driver free-air impedance. Then using either the delta-mass (i.e., added-mass) or delta-compliance (i.e., added compliance) perturbation technique, remeasure the driver's impedance. From this and the previously taken free-air

impedance curve, derive the Thiele-Small parameter values. The change in mass or compliance should be large enough so that the driver's resonance frequency is altered by at least 30%.

As with the system impedance measurements outlined above, for maximum accuracy, remove test lead and amp-to-sub cable impedance (where applicable) from all measured driver impedance curves. Do this by measuring each beforehand and subtracting them from the driver's measured impedance curve. Also, unless otherwise required, set the test voltage or current value to the lowest possible that still provides clean, repeatable measurement data.

Signal Used: Constant voltage (preferred) or constant current, downward swept sine wave, MLS or impulse signal. Unless otherwise required, use as low a test signal drive level as possible that can repeatedly produce clean
data. Driver impedance measurements are measurement signal-level dependent and the driver parameters derived from impedance measurements done at different test signal levels will show differences.

Metric Specification: Driver T/S Parameter Table (See below).

Σngineers Note #1… **Determining Raw Driver Thiele/Small Parameters**

From Measured Impedance Curves
As expertly demonstrated by Thiele, Small, Benson, Novak and others, a great deal of useful information can be derived from a driver's impedance curve. Collectively, the information gleaned from the raw data are formulated as defined parameters, a subset of which is commonly known as the "Thiele/Small" (T/S) parameters. Working up a small table populated with various T/S parameter values helps to round out the objective portion of a subwoofer assessment and provide a check against other measurements to ensure all around accuracy. At left is an example of a commercially available speaker parameter utility at work. Two further graphics are presented each illustrating how to mathematically derive an estimate of a driver's parameters from impedance data if you don't have access to a program such as that shown at left. (See Bibliography ref. #38 in Part II for an in-depth discussion of both techniques)

PARAMETER	***VALUE***
Revc (Ω)	3.225
fs (Hz)	29.11
Qts (-)	0.338
Vas (l)	88.46
Efficiency (%)	.600
Sensitivity (dB/1W/1m)	89.76

To illustrate the utility of the parameter chart, we could now, for xample, check both the measured midband sensitivity of the system or work up an estimate of the system's half-space max dB spl, at a given distance, given a particular wattage amplifier using the formula:

$$\text{dB spl} = \text{dBW} + \text{Sensitivity (dB)} - 20 * \text{Log}(D2/1\text{m})$$

*Where dBW = 10 * Log(amplifier electric Watts out)*

D2 = measurement distance, meters