How to measure a driver for use as a dipole

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Introduction

Dipole speakers constructed using dynamic drivers, such as the NaO and are becoming more popular due to their perceived open and natural sound. Do it yourself (DIY) dipole projects, as a result, are also becoming more popular. However, design of such system is complicated by the need to have reasonably accurate data for SPL that extends well beyond the intended bandwidth over which the driver is to be used. Such data is needed to design crossover filters and equalization to compensate for the dipole roll off. The problem is complicated because most DIY speaker builders do not have access to large anechoic chambers in which such measurements can be made. Obtaining measurements outside is an alternative for those who live in more remote locations where outside noise levels may be low and large open spaces are present. However, such is not the case for many who would attempt such a project.

In the case of the more common box speaker the problem of low frequency measurements can be circumvented through a series of measurements. A near field measurement of the response can be obtained and then modified to account for baffle step effects which can be modeled fairly accurately using a variety of codes such as Sound Easy or the BDS (Baffle Diffraction Simulator) code available at the FRDC (Frequency Response Data Consortium). The diffraction corrected near field data can then be spliced to a gated far field measurement, typically between the 200 and 400 Hz frequency range. However, when working with dipole systems we don't have the conventional baffle diffraction effects so what are we to do? In this brief article I present a fairly straight forward approach obtaining accurate on axis, full range SPL data for use in the design of dipole system.

Making the measurements

In this example I use the IMP from Liberty Instruments. It is an old but reliable measurement system and I find its simplicity of operation very effective. We begin by taking a near field measurement of the driver. The absolute level doesn't matter because we will be adjusting the gain to match the far field, higher frequency measurement. The result is shown in Figure 1. Next we measure the baffle width and thickness. In this example the baffle is 11" wide and 1" thick. Thus, the differential path length between the front and rear radiation is 5.5 + 1 = 6.5 inches. The speed of sound is nominally 1130 feet per second at 70 F. Thus 6.5" corresponds to a delay of 6.5/1130/12 = 0.4794 msec. In the far field the rear response from the driver will sum with the front response after being delayed by this amount. Thus, to obtain the low frequency response of the dipole we first invert the past of the near field data and then add the delay corresponding to the baffle delay and sum the result to the original near field measurement. This is shown in Figure 2 where the summed response is shown in blue and the original near field result is in gray. Note the dipole cancellation (nulls) in the response above 1k Hz. These will not be present in the on axis response because the driver becomes directional at higher frequencies and the front and rear radiation do not interact (sum and cancel).

The next step is to obtain a standard 1 meter measurement of the driver's SPL response. In this example the impulse response was windowed to 3 msec yielding data to 330 Hz as shown in Figure 3. Excess phase has been removed so that the phase response is referenced to the baffle surface. This data will be merged with the low frequency dipole response generated by summing the near field result at 330 Hz. Note that the 1 M data shows a level of 89 dB at 330 Hz. Thus, when merging the two data sets the low frequency data must be scaled to 89 dB at 330 Hz. The summed near field data, shown in Figure 2, has a level of 97 dB at 330 Hz. Thus it must be scaled down by 8 dB. When scaled and merged with the 1 M data the result is as shown in Figure 4. Note here that I made no attempt to match the phase at 330 Hz although I could have by adjusting the delay for the low frequency data. I know that above 330 Hz the phase is referenced to the baffle surface and when I import the data to my CAD program, Sound Easy, I can reconstruct the phase through a Hilbert transformation. So long as I match the phase above 330 Hz I can be assured that the reconstructed phase below 330 Hz will be consistent. The response shown in Figure 4 is thus suitable for design use. For reference, all the curves are overlaid in Figure 5.

Closing remarks

At this point it should be apparent that obtaining good low frequency data for drivers used in dipole system is actually much easier than it is for conventional box speaker. There is no need to model diffractions effects. All that is required is to sum the near field data to a phase inverted, delayed version of itself where the delay corresponds to the propagation delay over a distance given by ½ the baffle width plus the baffle thickness. The method outlined here is designed for drivers intended for use as midranges. For woofers, where the useful response is typically below the on axis dipole peak, only the near field data need be measured and the appropriate sum performed with the SPL scaled to appropriate distance. Hopefully you will fine this brief discussion useful in your quest for dipole speakers.

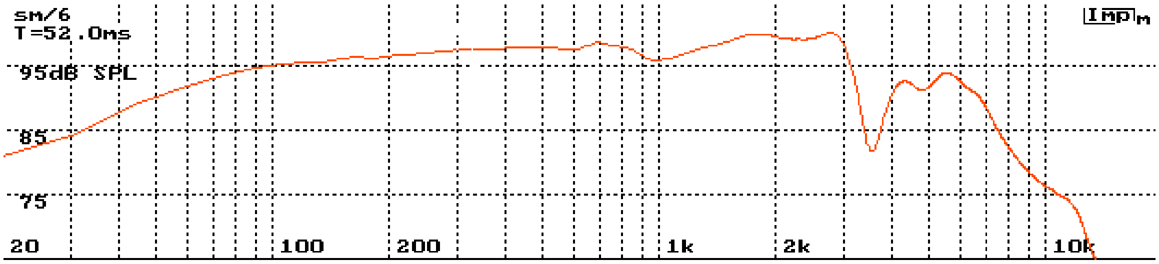

Figure 1. Near field measurement of driver.

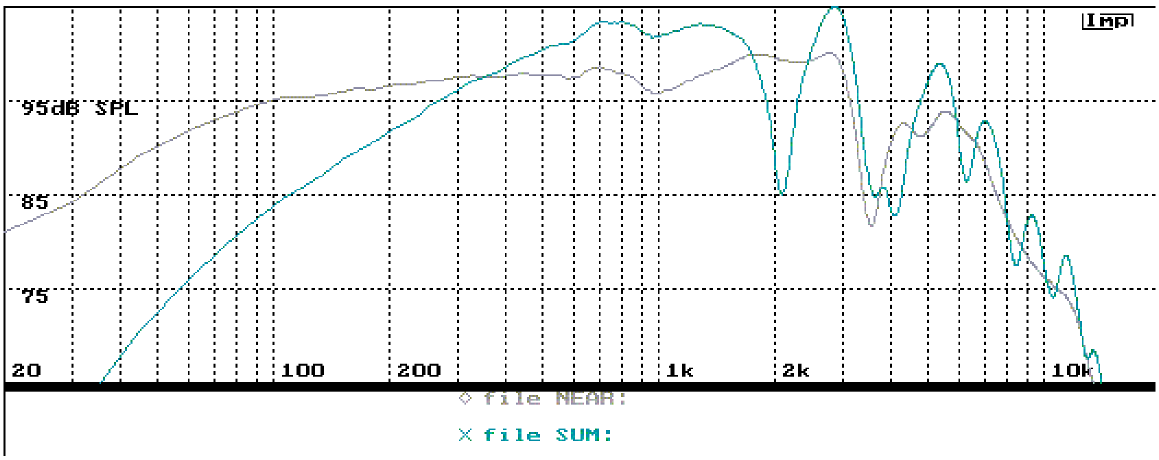

Figure 2. Near field data summed with phase inverted, delayed near field data. The low frequency portion of the result yields a good representation of the low frequency dipole response for the driver.

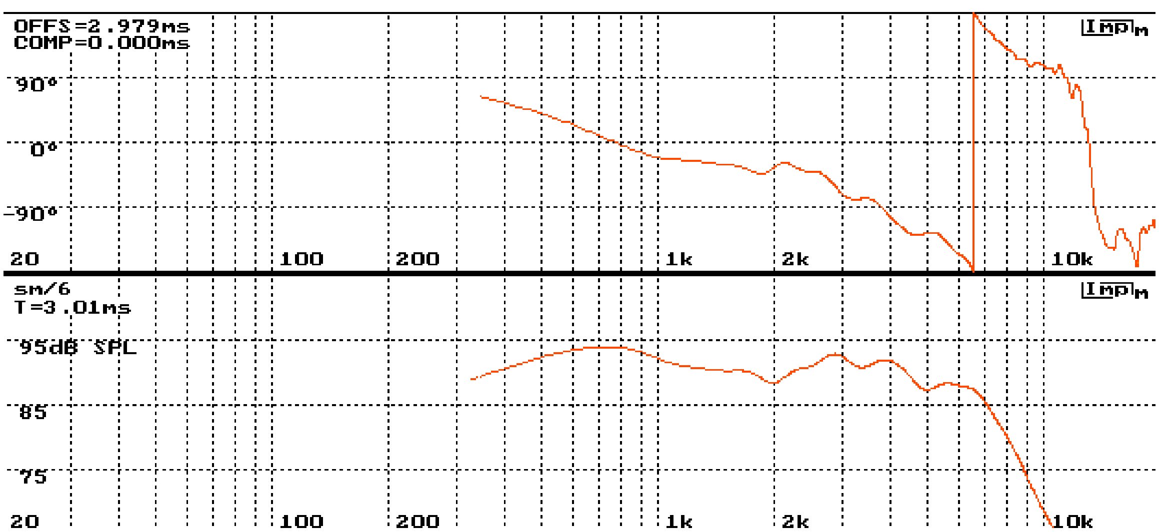

Figure 3. 1 meter, gates SPL response on axis.

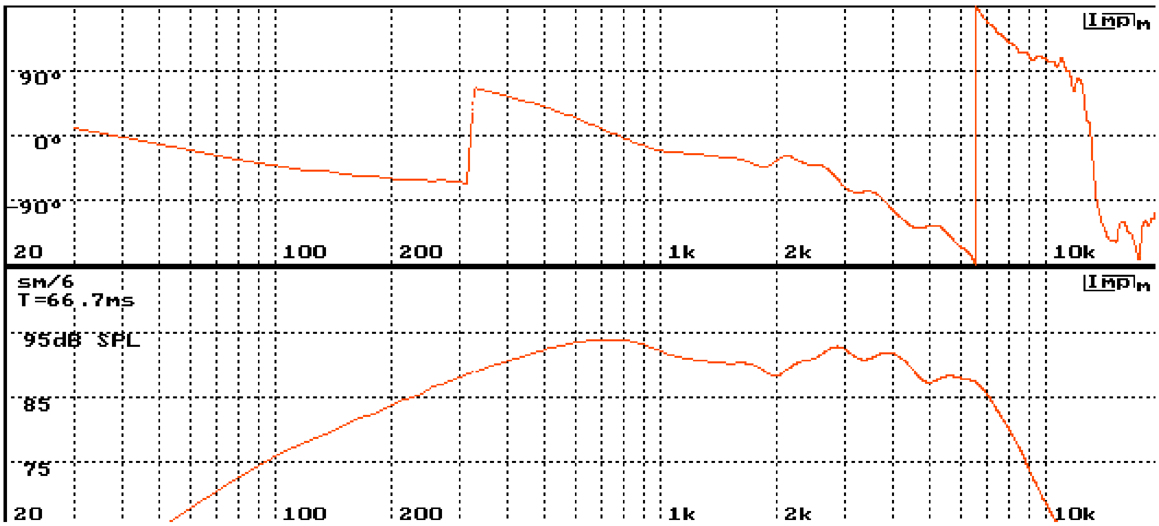

Figure 4. Merged near response.

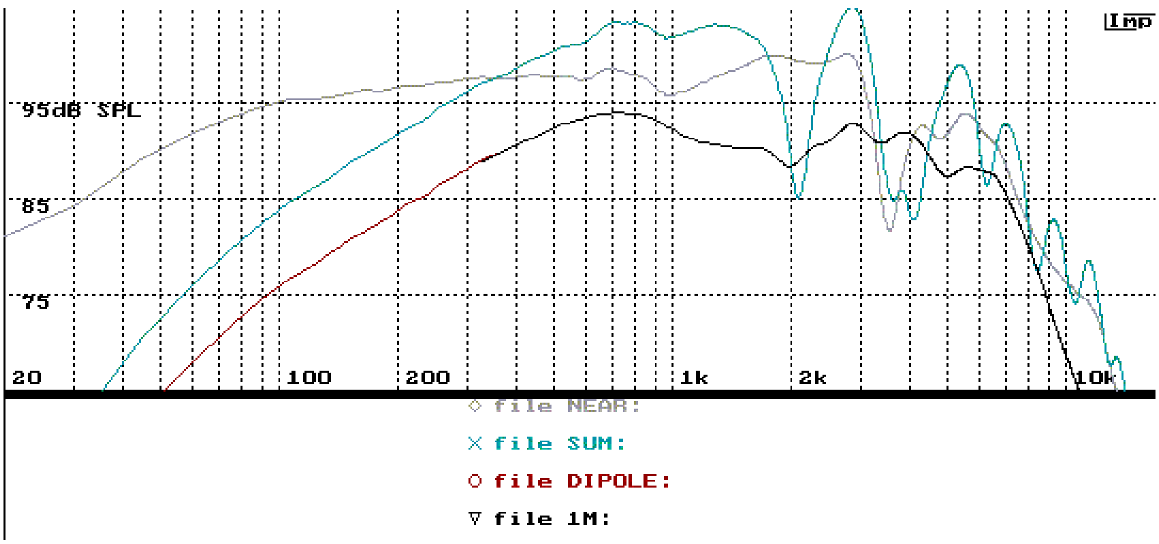

Figure 5. Overlay of data. Notice the smoothness of the merged result about 330 Hz.