

## The Subwoofer DIY Page v1.1

### Dipole Bass Systems

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Dipole subwoofers are quite different to the other subwoofer systems described on this site because of the way they treat the driver's output. Your typical subwoofer driver produces sound from both the front and the rear of the cone, and the output from the rear is out of phase with the output from the front, which results in very reduced response levels, unless the rear wave is treated in some fashion. The other subwoofer systems described on this site all employ some means of dealing with the driver's rear radiation to improve overall low frequency response, the result being a "monopole" bass system that theoretically has the same response characteristics in all directions. However, for dipole bass systems, the rear radiation is left untreated, and instead the overall response of the system is adjusted by varying the size of the baffle and the "Q" of the system to achieve the best overall response characteristics.

#### Driver Characteristics

The drivers used in dipole systems tend to be quite different to those in "monopole" bass systems. The driver's  $Q_{ts}$  tends to be particularly high (in some cases, as high as 2.0), the idea being to introduce a "bump" in the driver's frequency response around  $F_s$  that will compensate for the 6dB/oct rolloff in the response that will occur when the driver is mounted in an open baffle. Alternatively, a "normal" driver can be used in a dipole bass system, but a considerable amount of equalization may have to be used to make up for the loss in low frequency performance.

#### Response Characteristics

A dipole bass system has a "figure of eight" response pattern, which is entirely different to the "spherical" response pattern of your typical "monopole" subwoofer. The system's output is most powerful directly in front and behind the baffle, and decreases to zero at the sides, where the front and rear waveforms cancel each other. This response characteristic is said to be one of the major advantages of a dipole bass system, as the restricted dispersion results in fewer boundary reflections, which in turn is supposed to result in a smoother in-room response.

#### Drawbacks

Dipole bass systems tend to be rather large, employing multiple drivers, primarily to make up for the output reduction due to the 6dB/oct baffle loss. This is not the type of system to use if you've got a small living room, and it's certainly not suitable for car audio!

#### Baffle Size

The response of the system will be affected by a 6dB/oct drop in output below a particular frequency referred to as  $F_{equal}$ , that's directly dependent on the size of the baffle. At  $F_{equal}$ , the magnitude response (SPL) of the baffled driver will be the same as its infinite baffle response. Above  $F_{equal}$ , the response will rise to a 6dB peak at  $F_{peak}$  (approximately equal to  $3 \cdot F_{equal}$ ), and at higher frequencies, the response will depend largely on the shape of the baffle. A completely circular baffle will produce the worse response characteristics, with deep nulls at multiples of  $F_{peak}$ .

The following table demonstrates the relation between the baffle's effective diameter (i.e. the diameter of a circular baffle that has the same radius as the smallest dimension of the baffle),  $F_{peak}$ , and  $F_{equal}$ :

Speed of sound, $c=344$ m/s		
Diameter (metres)	Fp (Hz)	Fe (Hz)
0.43	800	267
0.57	600	200
1.15	300	100
1.43	240	80
1.56	220	73
1.72	200	67

From the table, it's plain to see that it's nearly impossible to push  $F_{\text{equal}}$  much lower than 80 Hz unless a fairly large baffle is used. The tradeoff here is efficiency; the smaller the baffle, the lower the final efficiency of the dipole system. OTOH, the larger the baffle, the higher the efficiency, but response at the upper end of the passband could get somewhat irregular as  $F_{\text{peak}}$  is reduced.

Almost all dipole bass designs incorporate some means of boosting the response at low frequencies to compensate for the baffle loss. Typically one or more of the following methods are used:

1. A high-Q driver is employed (the high Q results in a peak in the driver's free-air response at its resonance frequency).
2. The Q of the system is increased by employing a series resistor ( $Q_{\text{es}}$  is increased, which results in an increase in  $Q_{\text{ts}}$ ).
3. Active equalization is used to boost the low frequency response.
4. Active or line-level filtering is used to cut the higher frequency levels to match the low frequency response.

#### Related Links:

- [Linkwitz Lab Phoenix - Dipole Woofer](#)
- [John Forasiepi's Dipole Bass subwoofers](#)
- [Geert Meddens' Contrapunt subwoofer](#)

Special thanks to the following for corrections, links and other assistance with this page:

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#### Further References:

- R.J Newman, "Dipole Radiator Systems", JAES Jan/Feb 1980
- [Linkwitz Lab - Models for a dipole loudspeaker design](#)

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