Capacitor tuning

Some loudspeaker designs call for relatively small sealed enclosures, though in theory this may not always seem ideal. Typical examples are compact subwoofers that don't allow for a sufficiently large port to fit inside the enclosure (hence, a vented enclosure is not an option) or small high-Q wideband drives that won't look good in the otherwise relatively large (sealed) enclosure required to obtain the desired low frequency response.

Don't worry, there is a well-known trick that will get you a nice flat response with good low frequency extension in a sealed box that apparently is too small. Simply put a large value capacitor directly in series with the driver. This variable load high-pass filter combined with the high-Q box tuning results in a flat low frequency response that extends a little below the cut-off frequency you would normally get with a larger enclosure Butterworth tuning.

Here is what you do. Calculate a sealed box volume to give you a Qtc of 1. Ideally, the volume is calculated as (not considering box losses or additional series resistance):

$$V_{box} = \frac{V_{as}}{\left(\frac{Q_{tc}}{Q_{ts}}\right)^2 - 1}$$

Now calculate the value of the capacitor [F] as:

$$C = \frac{Q_{ts}}{\pi \cdot R_e \cdot f_s}$$

This value may need a little tweaking, as the above equation neglects the effect of voice coil inductance.

Besides from equalizing the low frequency response, the high-pass filter also provides protection, as cone movement below the cut-off frequency is limited.