Merging Near and Far Field Measurements AN39

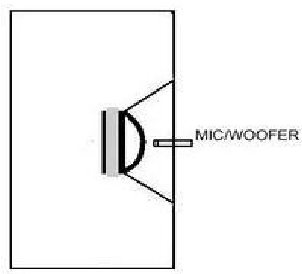
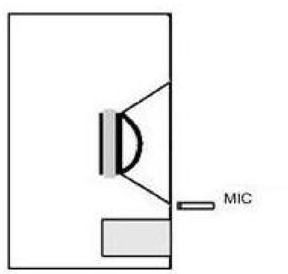
Application Note to the KLIPPEL ANALYZER SYSTEM (Document Revision 1.0)

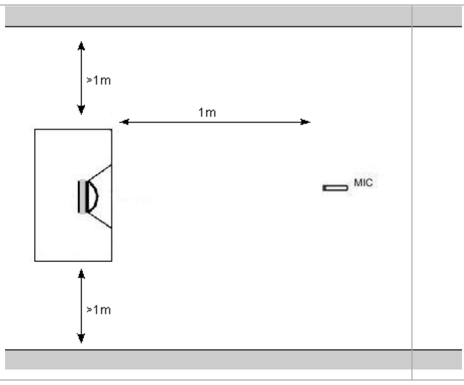
The far field response of a loudspeaker is usually measured under free field conditions. If an anechoic room is not available the far field response can be calculated by combining the results of a far and near field measurements. The effect of early reflections and standing waves can be removed in the results of far field measurement at higher frequencies by applying a proper time windowing of the impulse response. This technique gives good results at higher frequencies but fails at low frequencies where the window is too short for providing sufficient frequency resolution. However, no windowing is required if the low frequency response is measured in the near field of the driver. A complete far field response can be determined by merging the result of the near field and far field transfer function.

This application is a step by step introduction for measuring loudspeakers in normal rooms using the template 'SPL Merging Near / Farfield'.

CONTENT

1 Terms and Definitions

Pressure on Axis	$p_R = \frac{2\rho_0 c U_0}{\pi \cdot a^2} \sin\left[\frac{k}{2}\left(\sqrt{r^2+a^2}-r\right)\right]$ $p_F = \frac{\rho_0 ckU_0}{2\pi \cdot r}$ $p_N = \frac{\rho_0 ckU_0}{\pi \cdot a} = \frac{2r}{a} p_F$	If we consider a loudspeaker as a flat circular piston of radius a in a flat baffle the peak sound pressure magnitude p_R depends on the volume velocity U_0 caused by the piston and the measuring distance r. The reference transfer function of a loudspeaker is defined in far field with $r>>a$. For low frequencies ($ka < 1$) the sound pressure converges to p_F . On the center of the piston the pressure $p_N = p_R(r=0)$ is directly proportional to the far field sound pressure p_F.
Upper frequency limit of Near Field Measurements	$f_{NF\max}[\text{Hz}] = \frac{c}{2\pi \cdot a} = \frac{5475}{a[\text{cm}]}$	At higher frequencies some sound components will cause interferences in the near-field. Hence the upper frequency limit for the near field approach is given by $ka = 1$ (k = wave number)
Near Field Measurement	 	**Closed box** The measurement microphone should be placed normal and as close as possible to the center of the dust cap to ensure a quasi-anechoic measurement caused by the high level differences between direct sound and room reflections. By keeping the micro-phone distance less than 11% of the effective cone radius a, the measurement error will be less than 1dB. To prevent damage to the driver or the microphone, the maximum excursion should be determined first and considered while placing the microphone. **Vented box** On a vented box the driver and the port are both involved in sound generation. The optimal position of the microphone is then on the axis between driver and port, where the sound pressure contributions of the driver and the port cancel out each other at very low frequencies.
Far Field Measurement		Usually the far field response of loudspeakers is measured at a distance between 1m distance. Due to early room reflections, the first 3 ms of the impulse response is extracted by windowing and provides meaningful data above 300 Hz (min 1m distance to the walls). To exclude all reflections from the measurement, make sure that the speaker and the microphone are more than 1m away from all walls.

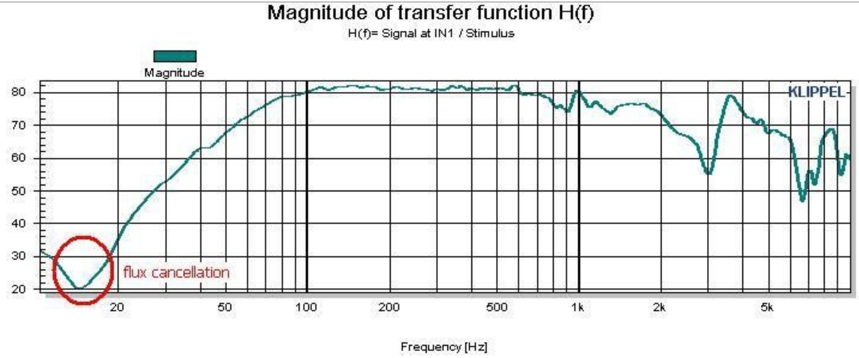
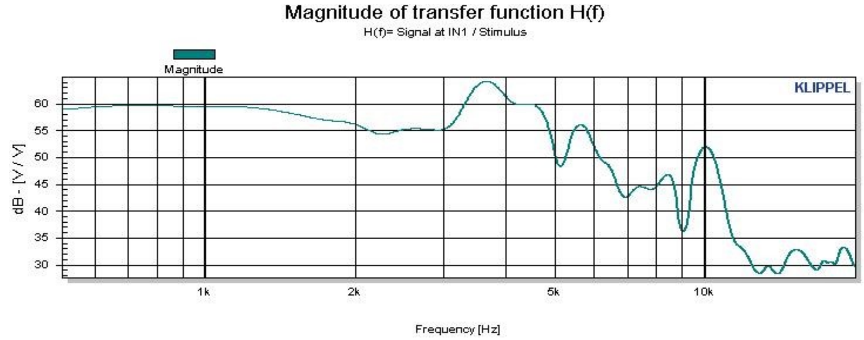


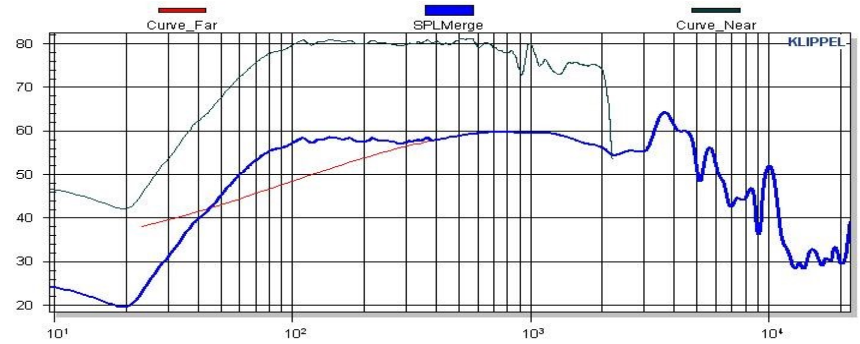
2 Requirements

Start Up	To measure and merge Near and Far Field Transfer Functions the following equipment is required: Install the RnD Analysis Software on your computer Create a new object and select the *SPL Merging Near / Farfield* template to start the analysis Enter the sensitivity of the microphone in property page Input for both the *TRF Near Field* and the *TRF Far Field* or use a pistonphone to calibrate the microphone.

3 Measurement Procedure

Near Field SPL response (closed box)	**Motivation:** We start with the near field response of the driver which provides an almost free field characteristic pattern for low frequencies and is quite simple to measure. **How to do it:** Adjust the measurement microphone normal to the drivers dustcap as per description. Use a wide window in the *Impulse response* to measure the SPL at very low frequencies and run the *TRF Near Field* operation. You may stop the measurement after one sweep.
Near Field SPL response (vented box)	**Motivation:** In a vented box system both the driver and the port are involved in sound generation. A sufficient approximation of the total near field response considering both sources can be measured at a particular cancellation point which is between driver and port. This point can be found by searching for minimal sound pressure at very low frequencies. **How to do it:** Adjust the measurement microphone normal to the box between the driver and one of the vents and detect the microphone location where the sound pressure is minimal at very low frequencies (f < 20 Hz). At this place the sound pressure components generated by the driver and the vent have the same amplitude but opposite phase and cause a dip in the sound pressure response (see figure below). Use no or a wide window for gating the impulse response to have enough resolution of the SPL response at very low frequencies. Operate the TRF measurement in a continuous loop to get a permanent updating of the SPL response while searching for the cancellation point.

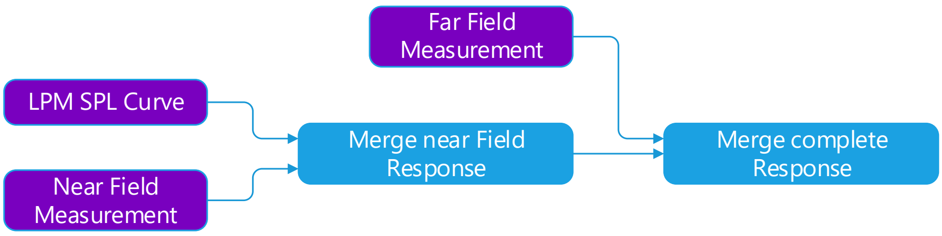
	
Far Field SPL response	**Motivation: The** far field response is usually measured in an anechoic environment. Measurements of the far field response can also be accomplished in normal rooms if sufficiently narrow windowing is applied to the impulse response. However, the frequency resolution is significantly reduced to 300 Hz. **How to do it:** Place the measurement microphone at 1 m distance and just run the *TRF far field* measurement. Select the half hanning window under property page PROCESSING and set the time cursors in the window IMPULSE RESPONSE to suppress any reflections from the walls. 
Splicing the curves	**Motivation:** Adding the levels of each radiator returns the overall transfer function of the box which is almost equal with its free field measured response. **How to do it:** Select *H (f) + Total phase* in *Properties* → *Im/Export* of the near field measured curve and Export them to Clipboard. Open the *Splice SPL Curve* Calculation, select *Curve_Near* in *Properties* → *Input* and press *Paste*. Repeat this step for the far field measured curve. Determine the splicing frequency where the far field measurement is not affected by room reflections and enter frequency range *SpliceFreqMin and SpliceFreqMax,* in which the two curves are matched in its level, by adjusting the sensitivity of the near field response (default is 400-500 Hz). After adjustment of the sensitivity the near field response is blended into far field response in this frequency range. Check the RMS error between both curves in one octave band around the splicing frequency, which allows you to optimize the frequency.



Additional Accuracy

Motivation: due to external influences the adjustment of the near field response to match the Level of the far field response at the splicing frequency can always experiences external influences. Therefore it is of high value, if there is a possibility get a ‘second opinion’ about the level of the adjusted near field response. The LPM Measurement Module offers this ‘second opinion’. From the T/S Parameters gained in the LPM Measurement, and the accurately measured S_d, the drivers SPL at 1W in 1m distance in a baffle is calculated, as it behaves as a rigid piston.

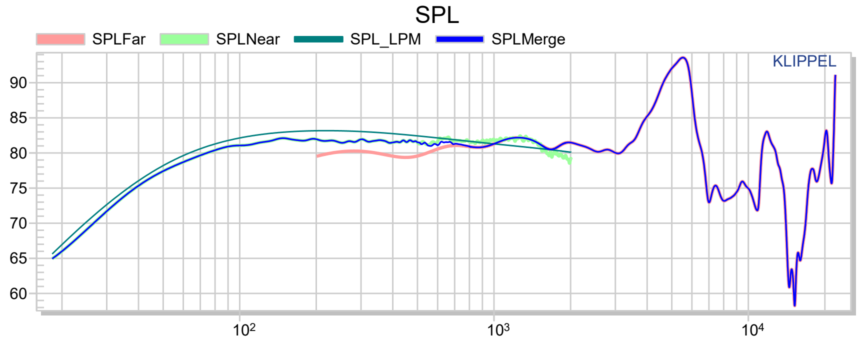
Disclaimer: Please be aware, that the generating a fitted SPL response using the LPM module is very sensitive to the Laser calibration and the absolute correct effective S_d. Please read through [4] and [3] about further requirements. The highest precision is reached by Scanning the radiation area [2]



How to do it: Select the LPM Measurement: *3 LPM with accurate Sd* and enter a very accurate S_d and the drivers nominal impedance in the property page *driver*.

Now copy the curve *Fitted* from the *SPL* window, and paste it into the LPM_SPL Parameter of the *4 CAL Splice SPL curve* operation. Please double check, the correlated voltage found in the caption of the *SPL* window matches the voltage used in the far field response measurement.

To adjust the near field response according to the SPL response from the LPM Measurement, enter the frequency range over which the correct adjustment is calculated by specifying *LPMLevelingFreqMin* and *LPMLevelingFreqMax.* If there is a discrepance between the level defined by the LPM measurement and the level defined by the far field response, the parameter *WeightLPM* defines in percent, which adjustment will dominate.

	Enter 0, if you want to disregards the LPM level, 50 to use the average, 100 to disregard the level of the near field response in the splicing frequency range. 

4 Limits of the Near Field Measurement

2 or more way systems	Note that the Near Field measured TRF considers the behavior of one (sub)woofer. This response may be influenced by the crossover. Ensure that the crossover frequency is higher than the splicing Frequency.
Multiple equivalent drivers	If both drivers are driven by the same signal below SpliceFreq (e.g. D'Appolito Box), just one of the drivers has to be regarded in the Near Field measurement. The other driver will just cause a +6dB shift in the level over the full bandwidth, which does not matter, because the absolute level of the Near Field TRF is not used while fitting to the Far Field Curve. If a system uses an active and a passive radiator place the microphone between the two radiators as described for a vented box system.
Location of the port	In some arrangements it is almost impossible to find the ideal placement of the cancellation point, especially when the port and the driver are not located in the same baffle. In this case use the alternative technique as described in Application Note AN 38 [1]

5 More Information

Literature	J. D'Appolito, "Testing Loudspeakers", Audio Amateur Press, Peterborough, NH, 1998 D. B. Keele "Low Frequency Loudspeaker Assessment by Nearfield Sound-Pressure Measurement", J. of the Audio Eng. Soc., April 1974, Vol. 22, No. 3
Application Note	[1] AN 38 Near Field measurement with multiple drivers and ports [2] Measurement: Area of radiation: http://www.klippel.de/measurements/sound-radiation-and-propagation/area-of-radiation.html [3] AN 32 Effective Radiation Area S [4] AN 25 Maximizing LPM Accuracy

Find explanations for symbols at:

http://www.klippel.de/know-how/literature.html

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