
ANALYZER SYSTEM USER'S GUIDE 分析仪系统用户指南

Transfer Function

传递函数

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TRF Tutorial TRF 教程

Overview 概况

The TRF module measures up to two signals simultaneously (< 48 kHz) to calculate transfer function and the harmonic distortion of a system excited by a logarithmic sweep. Bandwidth, amplitude and frequency shape of the stimulus as well as averaging of the periodic response may be varied by the user. Purification of the linear impulse response from nonlinear artifacts, windowing and other post processing such as cumulative spectral decay or sonographs are provided.

TRF 模块可同时测量多达 2 个小于 48kHz 的信号，以求出由对数扫频信号激励出的传递函数及系统谐波失真。驱动信号的带宽，振幅和频率波形以及平均周期响应可以由用户自行变更。模块还提供了，从非线性伪迹中提取线性脉冲响应，视窗化，及其它一些后置处理，如累积频谱衰减或使用声谱仪。

It is used to perform typical measurements such as acoustical measurements, impedance measurements but also sensitivity and frequency response of the displacement of the cone.

它被用来执行一些典型的测量，如声学测量，阻抗测量，并且同样可用于灵敏度以及振膜位移频率响应测量。

What is the goal of this tutorial?

教程的目标是什么？

This tutorial makes you familiar with the TRF module.

该教程让你熟悉 TRF 模块。

The tutorial is divided into three parts.

教程分为 3 个部分。

1. In the first part *Viewing TRF Results* we will show you how to view TRF results already stored in the example database.

在第一部分 *Viewing TRF Results (查看 TRF 结果)* 中，我们将会给你展示，怎样查看已保存在例样数据库中的 TRF 结果。

2. The next part of the tutorial *Performing a new TRF* provides a step-by-step recipe to measure the sound pressure response and the electrical impedance of a loudspeaker.

教程的下一部分 *Performing a new TRF* (执行一个新的 TRF) 提供了测量扬声器声压响应及电阻抗的分步介绍。

3. In the final section *Customizing TRF* we discuss modifications of the setup parameters to improve the performance of the measurement and show how to use more sophisticated features.

在最后章节 *Customizing TRF* (定制 TRF) 中，我们将会讨论，怎样进行设置参数的修改，以至于改善测量性能，并展示怎样使用更多高级特征。

In the chapter *TRF-Reference* you will find more information on the basics of the signal processing used as well as a detailed description of the result windows and the setup configuration of the property pages.

在章节 *TRF-Reference* 中，你可以找到有关基本的信号处理以及结果窗口详细描述和性能页面设置配置的更多相关信息。

Viewing TRF Results (Part 1) 查看 TRF 结果

Open the *Example_Database*, select the object *first example driver* and open the operation *TRF transfer function*.

打开 *Example_Database*，选择对象 *first example driver*，并开启操作 *TRF transfer function*。

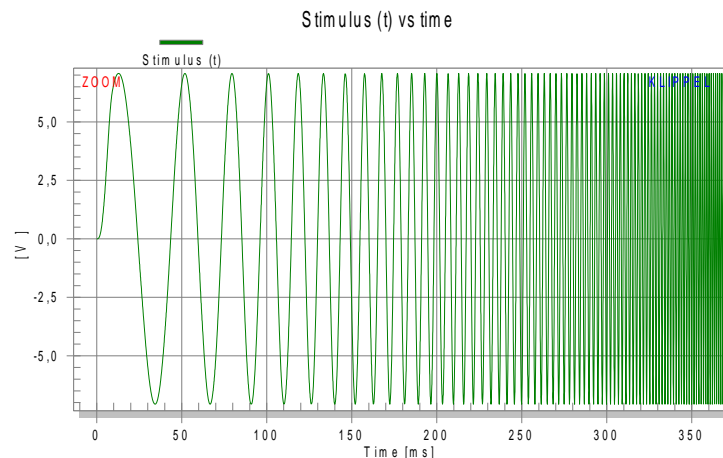
Double click *TRF transfer function* to open the default windows. More information on how to navigate within dB-Lab you can find in the dB-Lab section of the manual.

双击 *TRF transfer function* 来打开默认窗口。更多有关怎样使用 dB-Lab 的信息，你可以在手册章节 dB-Lab 中找到。

Stimulus 驱动信号 (time domain 时域)

The time characteristic of the excitation signal that is used to stimulate the system (result window *Stimulus (t)*) reveals some fundamental properties of the transfer function measurement. The excitation signal is a sine wave that frequency varies continuously from the frequency F_{min} to the frequency F_{max} . At every discrete time step only one unique frequency is present. As frequency increases exponential with time (logarithmic sine sweep), each single frequency is mapped to one unique time step. This means that the linear time axis in the figure below could be replaced by a logarithmic frequency axis showing the instantaneous frequency of the sweep.

用来驱动系统的激励信号时间特征(结果窗口 *Stimulus (t)*)，展现了一些传递函数测量的基本特性。激励信号是一个正弦波信号，其频率从 F_{min} 到 F_{max} 之间呈连续变化。在每一个离散的时间步长上只表现一个唯一的频率。频率随时间以指数形式增加(对数的正弦扫频)，每个单频映射一个唯一的时间步长。这意味着，下图显示的线性时间轴可以由一个显示扫频瞬时频率的对数频率轴来替代。



The picture above is zoomed in to get better resolution. To zoom just draw a window around the region of interest. For more information check the dB-Lab manual section.

上面的图片被缩放，以得到更好的分辨率。要缩放图片，只要根据兴趣在你所需要的区域周围框出一窗口图形即可。更多的信息参看 dB-Lab 手册。

The main advantage of the log sweep is the ability to separate the linear response of the system from nonlinear (harmonic) response. Intermodulation distortions are not excited as the stimulus contains one frequency at a particular time step.

对数扫频最主要的优点是，可以从非线性(谐波)响应中分离系统的线性响应。当驱动信号在特定的时间步长上只包含一个频率点时，互调失真不被激励。

Literature: Müller, S. and Massarani, P. *Transfer-Function Measurements with Sweeps* J. Audio Eng. Soc., Vol. 49, No. 6, 2001 June.

文献: Müller, S. and Massarani, P. *Transfer-Function Measurements with Sweeps* J. Audio Eng. Soc., Vol. 49, No. 6, 2001 June.

First channel : Sound pressure response

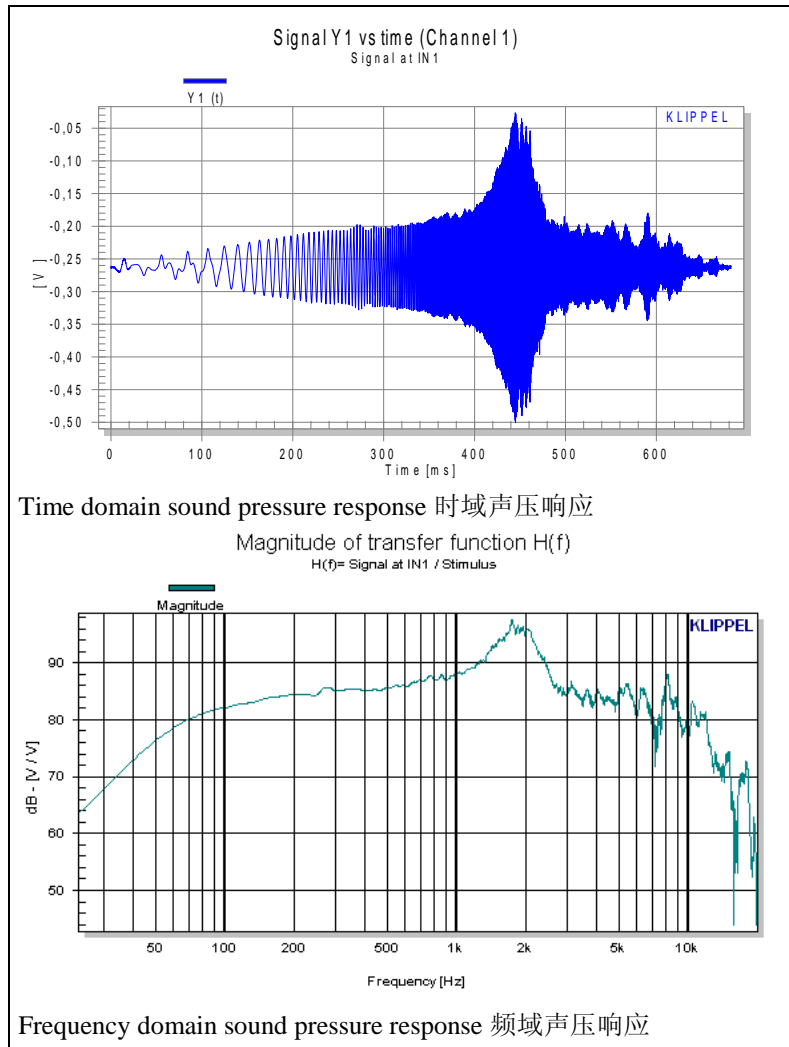
第一频道:声压响应

The TRF module is a true 2-channel data acquisition system. Various input signals may be used to measure transfer functions such as external signal related to excitation signal but also external signal related to another external signal. In this example two external signals are recorded. The sound pressure level measured by a microphone is acquired on input channel Y1 and the displacement signal of the voice coil (measured by laser) is acquired on input channel Y2.

TRF 模块是一个真正的双频道数据采集系统。各种输入信号都可以用来测量传递函数，如与激励信号有关的外来信号或者也可以是与另一个外来信号有关的外来信号。在这个例子中，两个外来信号被记录。通过测量麦克风所得到的声压级将在输入频道 Y1 上获得，音圈位移信号(通过激光测量得到)在输入频道 Y2 上获得。

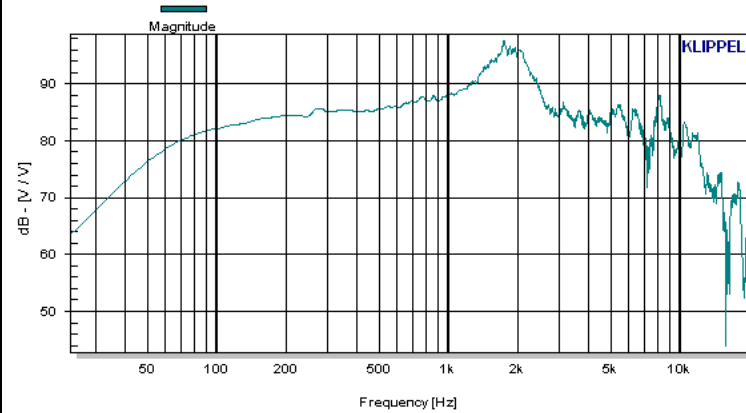
Due to the specific stimulus the envelope of the time domain signal of the transfer response is equivalent to the frequency response.

由于特定的驱动信号，传递响应时域信号包络等于频率响应。



Time domain sound pressure response 时域声压响应

Magnitude of transfer function $H(f)$
 $H(f) = \text{Signal at IN1} / \text{Stimulus}$



Frequency domain sound pressure response 频域声压响应

Please note the different scaling of the y-axis (linear in upper graph while log in lower graph).

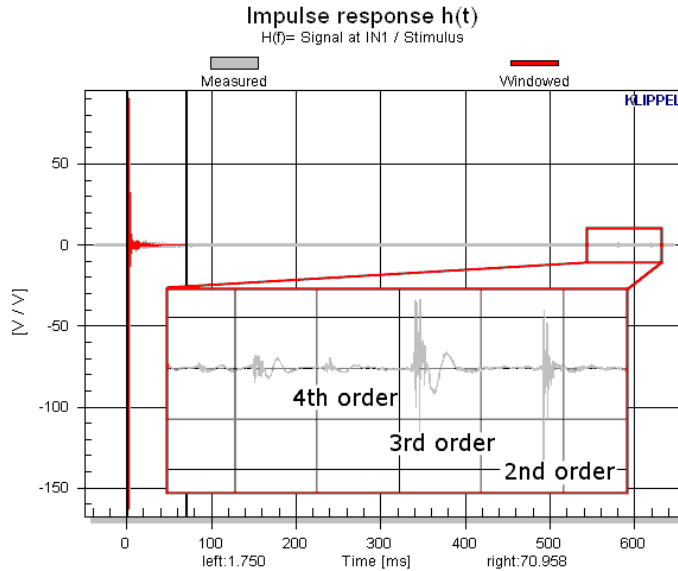
请注意 Y 轴的不同刻度 (上图是线性刻度, 下图是对数刻度)。

Impulse Response

脉冲响应

The figure below shows the impulse response calculated from the sound pressure response.

下图展示了从声压响应中计算出的脉冲响应。



At the end of the time axis some minor artifacts can be noticed. These little peaks are the harmonic distortion information. Due to the very special excitation signal the individual harmonic distortion components are mapped to a narrow region of the time axis. This effect generates the little artifacts in the above plot. This allows accurate separation of the linear and nonlinear responses as well as the extraction of the harmonic distortion for further analysis much faster as with stepped sine wave excitation technique.

在时间轴的末端，一些小的伪迹被注意到。这些小的峰值就是谐波失真信息。由于非常特殊的激励信号，单个的谐波失真成分映射在时间轴上的一个狭窄区域内。这个效应生成了上图中那些小的伪迹。这使得，线性响应和非线性响应的准确分离，以及谐波失真的提取，在带加强正弦波励磁技术的情况下，对于更进一步的分析，要快得多。

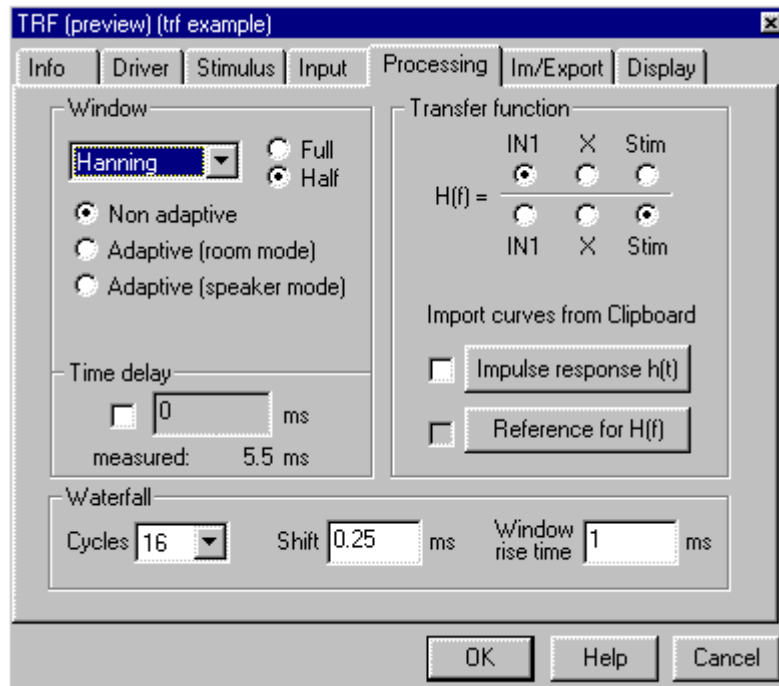
Windowing 视窗

The section of the impulse response that is used for further analysis can be selected (windowed) with two markers (e.g. to isolate direct radiation from early room reflections, diffuse field response and nonlinear artifacts etc.). This way quasi-anechoic measurements can be performed. The part of the impulse response to be analyzed is marked by red color. The easiest way to shift the markers is using the mouse for dragging. Alternatively, press [SHIFT] move the mouse to the desired marker position of the left marker and press the left mouse button. Press [CTRL] instead of [SHIFT] to move the right marker.

作更进一步分析使用的脉冲响应段可被 2 个标记所选择 (例如，从早期室内反射中隔离直接辐射，扩散场响应和非线性伪迹等)。这样，准消声测量也是可以的。这部分被分析的脉冲响应被标示为红色。最简单的，移动标记的方法就是用鼠标拖着走。或者，也可以使用 [shift] 键移动鼠标到左标记理想位置，然后点击鼠标左键。按 [CTRL] 键代替 [SHIFT] 键来移动右标记。

If the position of the window is changed, all derived results will be recalculated without a new measurement.

如果窗口位置改变，不需要新的测量，所有已得到的数据将重新计算。



There are various applicable window shapes. Open the *Processing* Property Page and watch the *Window* setting. *Half* (typical used for driver measurements) and *Full* (for isolating harmonic distortion or room modes) shape is provided as well as various shape forms. See reference section for more and detailed information.

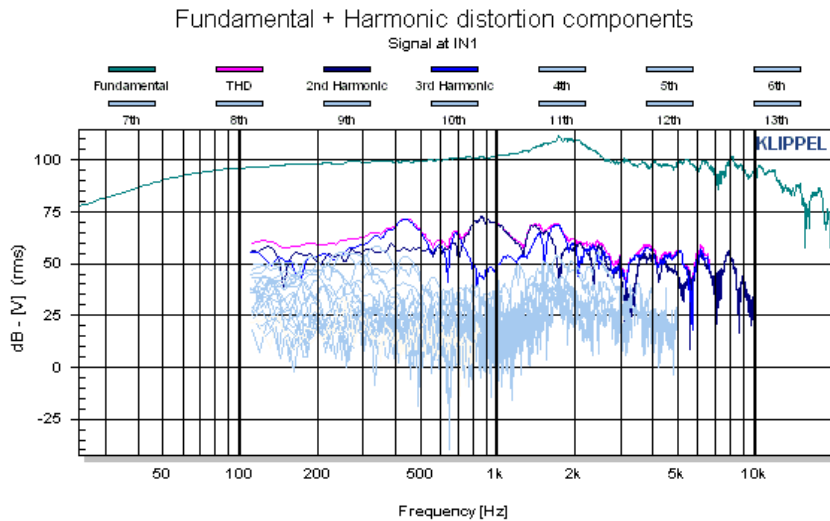
有各种适用的窗口形状。打开属性页 *Processing*，并且查看 *Windows* 设定。*Half* (典型用于扬声器单元测量)和 *Full* (对隔离谐波失真或室内模式)形状以及各种形状样式被提供。更多细节信息查看 *Reference*。

Fundamental + Harmonics

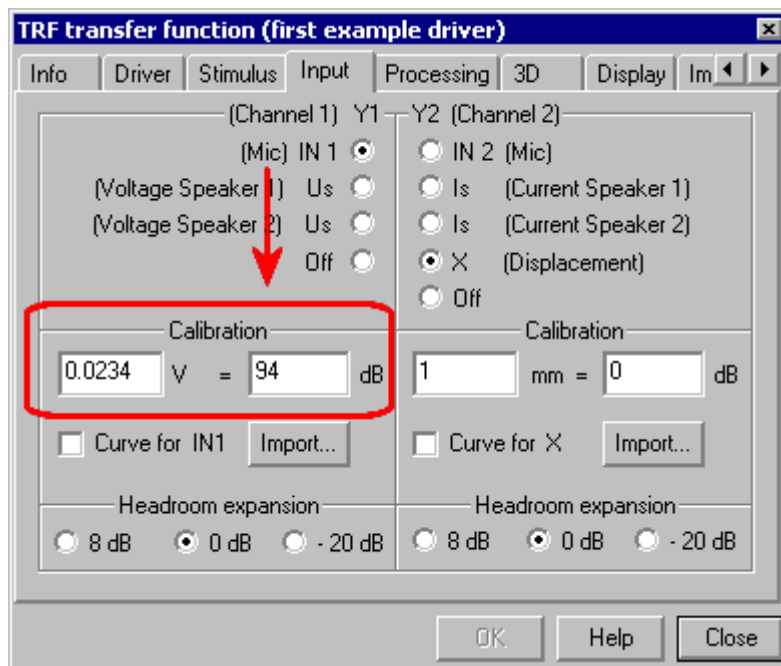
基波+谐波

This result window shows the fundamental and the harmonic distortion components of the sound pressure signal in absolute SPL. It is calculated using the current window setting (position and shape of selected window of impulse response).

结果窗口显示了绝对声压级上，声压信号的基波和谐波失真成分。使用当前的窗口设定来进行计算(脉冲响应已被选择的窗口位置及形状)。



However the Fundamental is not divided by the stimulus thus meaning absolute SPL. The correct SPL level is calculated if in the property page *Input* the microphone sensitivity is specified (See 3rd part of tutorial, section *Calibration*). 然而，基波并没有被驱动信号所划分，因此意味着绝对声压级。如果在属性页 *Input* 中，麦克风的灵敏度被指明，那么正确的声压级可被计算出来 (参看教程第 3 部分，小节 *Calibration*)。



H(f) Magnitude

H(f) 幅值

The result windows *H(f) Magnitude* is a true transfer function, meaning that the sound pressure signal is divided by the stimulus signal (in frequency domain). The result is a relative curve in dB independent on the magnitude of the excitation (holds valid for linear systems only). The graph is already included above.

Second Channel: Displacement

第 2 频道: 位移

结果窗口 $H(f)$ Magnitude 显示的是一个真正的传递函数，表示了声压信号被驱动信号所划分(在频域范围内)。结果是一个以 dB 为单位的相对曲线，与激励信号的幅值无关(只对线性系统有效)。参看上图。

Until now all results are discussed for the microphone input signal (routed to Y1, left side in property page *input*). Since the TRF is a two-channel system the second input signal Y2, recorded in parallel, may be investigated too. In the example a laser displacement sensor is routed to channel 2. Check the input property page for the current routing.

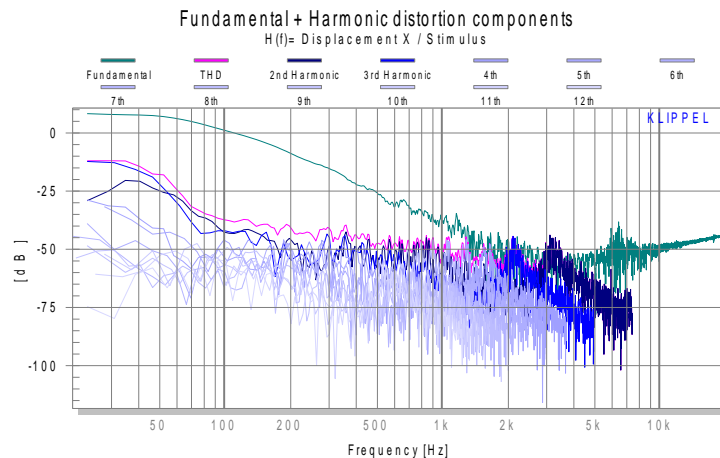
到现在，所有讨论的结果都是有关麦克风输入信号的。(路由到 Y1，属性页左边 *input*)。由于 TRF 是一个双频道系统，被平行纪录的第 2 个输入信号 Y2，可能也会被审查。在例子中，激光位移传感器路由到频道 2 上。对当前路由，检查输入属性页。

To avoid too many result windows the results are shown for channel 1 or channel 2. To view the results of the second channel select $H(f)=X/Stim.$ on the property page *Processing*. Pressing OK results in updated result windows. Watch now the $H(f)$ Magnitude. The speaker clearly has a constant displacement below its resonance frequency f_s and a 12 dB roll-off above f_s .

避免过多的结果窗口对频道 1 或频道 2 显示结果。选择属性页 *Processing* 中的 $H(f)=X/Stim.$ ，来查看第 2 频道的结果。点击 OK，结果将在已更新的结果窗口中显示。观察 $H(f)$ 的幅值，很明显地在谐振频率 f_s 以下，拥有一个恒位移，在谐振频率 f_s 以上，有个 12dB 的下降。

Open now the result window *Fundamental + Harmonic*. Now the harmonic distortion components are plotted. Note that at low frequencies where the driver has significant displacement the harmonic distortion are much higher than above 100 Hz. This nonlinear characteristic is measured very fast due the logarithmic sine sweep excitation.

现在打开结果窗口 *Fundamental+Harmonic*。谐波失真成分被绘制出来。注意，在扬声器具有明显位移的低频处，谐波失真要比在频率 100Hz 以上大得多。由于对数扫频激励，非线性特征可以非常快地被测量出。



Above 500 Hz the laser resolution becomes poor as the used laser has a cut-off frequency of 1kHz.

在频率 500Hz 以上，激光分辨率变低，就像被使用的激光有一个为 1kHz 的截至频率一样。

Performing a new TRF (Part 2) 执行一个新的 TRF (第 2 部分)

In this part of the tutorial you are guided to perform your first two measurements. As typical examples we will measure the SPL and the electrical impedance. Please follow the steps carefully and feel free to play with the set up afterwards.

在教程的这一部分中，你将在指导下执行你首次的 2 个测量。作为典型的例子，我们将测量声压级和电阻抗。请小心地跟随下列步骤，在完成设置后，轻松的进行"游戏"。

SPL Measurement

声压级测量

The following equipment is required: 下面的设备是必要的

- Distortion Analyzer 1 (Power Monitor 8 Hardware does not support TRF measurements)
失真分析仪 (硬件 Power Monitor 8 不支持 TRF 测量)
- Microphone connected to input **IN1** of the hardware unit
麦克风连接到硬件单元的输入端 **IN1** 上
- Driver mounted in laser stand
扬声器安装在激光器支架上
- Power Amplifier
功放

Hardware Setup

硬件安装

1. Connect the Distortion Analyzer 1 (DA1) with the amplifier (Amplifier cable to connect **OUT1** output with amplifier input and amplifier output with **Amplifier** input of the DA1). You will find more information in the chapter *Hardware* within the manual. Please note that this cable is not distributed by Klippel by default since the input connector of the Amplifier is not standardized.
将失真分析仪 Distortion Analyzer 1 (DA1)与功放连接起来 (功放接线将输出端 **OUT1** 与功放输入端，以及被标示为 **Amplifier** 的功放输出端与 DA1 的输入端，连接起来)。你将在手册章节 *Hardware* 中找到更多的详细信息。请注意，由于功放的输入接头类型没有被规范，因此在默认情况下，这条接线不由 Klippel 配发。
2. Connect DA1 with driver (use Speaker cable and connect **Speaker 1** output with driver terminals).
将 DA1 与扬声器单元连接起来(使用扬声器接线，将输出端 **Speaker1** 与扬声器单元端口连接起来)。
3. Connect microphone signal output to **IN1**.
将麦克风信号输出连接到 **IN1**。

Note: The Distortion Analyzer 1 hardware does not support ICP or phantom power microphones. Please use an external power supply for the microphone (as available from Klippel and many others). The line input level is $\pm 10V$ peak.

注释: 硬件失真分析仪 1 不支持 ICP 或幻像供电麦克风。请对麦克风使用外部电源 (像 Klippel 适用的或其它一些)。电线的输入级峰谷值应为 $\pm 10V$ 。

4. Connect DA1 via USB to a Computer .
通过 USB 将 DA1 和计算机连接起来。
5. Connect power supply to DA1.
将电源与 DA1 连接起来
6. Switch hardware unit on
打开硬件单元

Create Operation

创建操作

It is recommended to use a new database. This leaves your example database unchanged.

建议使用新的数据库。这样使得你的例样数据库不变更。

Create a new database. Insert a new object and make a new TRF operation (Template *Default*). Detailed instructions are given in the dB-Lab manual section.

创建一个新的数据库。插入一个新的对象，并制作一个新的 TRF 操作 (模板 *Default*)。细节介绍在 dB-Lab 手册中给出。

Now customize the setup for your first TRF measurement. Open the property page *Info* and *Driver* and fill in the required geometrical and nominal parameters as well as the additional information. These two pages are identical for all operations of the same object.

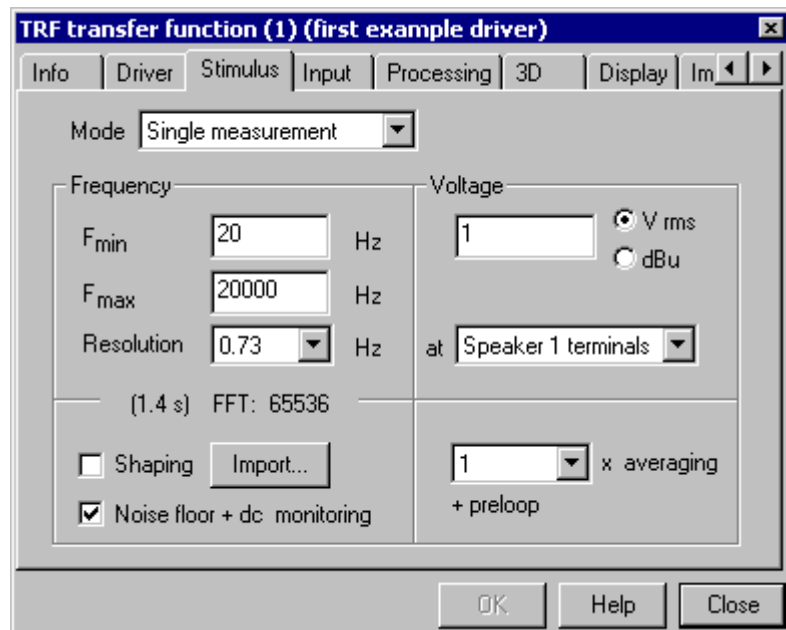
现在定制你首次的 TRF 测量设置。打开属性页 *Info* 和 *Driver*，并填入要求的几何参数和标定参数以及附加信息。这 2 个页面对相同对象的所有操作是一样的。

Measurement Setup

测量设置

Open the property page *Stimulus*. Specify the frequency range, resolution, excitation level, number of averaging and the measurement mode.

打开属性页 *Stimulus*。指定频率范围，分辨率，激励级，平均数目和测量模式。



The input routing is set in the page *Input*. Specify *(Mic) IN1* for input channel Y1. Set Y2 to *Off*. You may enter the microphone sensitivity if known. Please refer to part 3 of the Tutorial on how to specify the microphone sensitivity. However, it is not required for this first measurement to know the exact sensitivity. You may use the default setting (this yields an incorrect SPL, but this does not matter for learning).

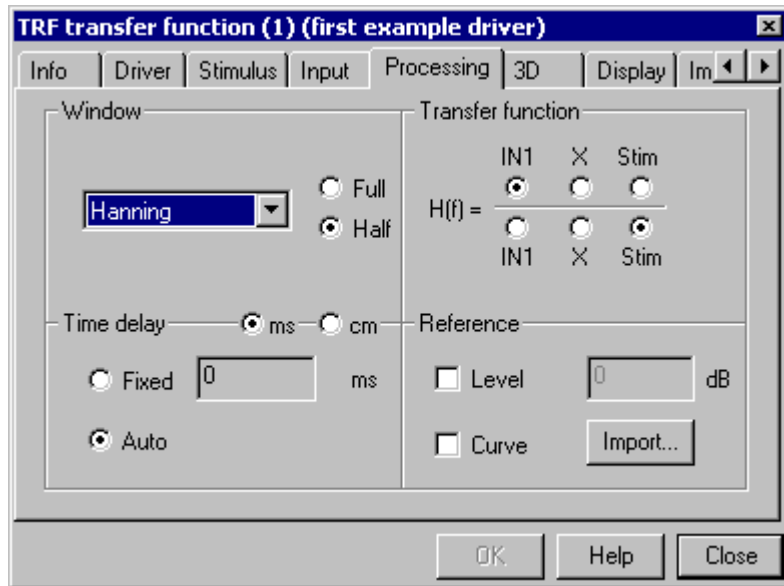
输入路由在页面 *Input* 中被设定。指定 *(Mic) IN1* 为输入频道 Y1。将 Y2 设置为 *Off*。如果已知，可以输入麦克风的灵敏度。请参看教程的第 3 部分，怎样指定麦克风灵敏度。然而，对于首次测量，不要求知道准确的灵敏度。你可以使用默认设定(这将产生不正确的声压级，但不影响学习过程)。

Note: The *Stimulus* and *Input* property pages are measurement setup pages. That means that you will lose your data if you change setup parameters. This way any inconsistency between setup and data is avoided. The *Processing*, *3D*, *Display* and *I-Dist* page contain post processing setup parameters. These values may be altered without losing data. The results are recalculated when new settings are confirmed with *OK*.

注释: 属性页 *Stimulus* 和 *Input* 是测量设置页面。这表示，如果改变设置参数，你将会丢失数据。这样就避免了设置和数据之间的一致性。页面 *Processing*, *3D*, *Display* 和 *I-Dist* 包含了后置处理设置参数。在不丢失数据的情况下，这些值也可能被改变。当新设定被确认为 *OK*，结果值将被重新计算。

The *Processing* page determines the post processing of the data. The data windowing as well as the numerator and denominator of the transfer function are specified here. Use the default setting. Do not use any reference. Refer to section *Using References / Comparing results* in part 3 of the Tutorial for more information.

页面 *Processing* 确定了数据的后置处理。数据窗口以及传递函数的分子和分母将在这里被指定。使用默认设定。不要使用任何参考。更多信息，可查看教程第 3 部分中的小节 *Using References / Comparing results*。




We do not use the *3D* property page in this part of the Tutorial.

在教程的这一部分中，我们不使用属性页 *3D*。

Start Measurement


开始测量

Make sure that the specified in property page *Stimulus* will not destroy your driver. Start the measurement after checking all connections by clicking on the start button .

请确认在属性页 *Stimulus* 内指定的设置将不会损坏你的扬声器单元。在检查完所有硬件连接之后，点击按钮 *Start*，开始测量。

Viewing results

查看数据

Open the default result windows by double clicking on the current TRF operation. Rearrange the result windows (horizontal tile) by selecting *Window / Horizontal Tile* in the menu or by clicking on the icon  above the result window list.

通过双击当前的 *TRF* 操作打开默认结果窗口。通过选择菜单里的 *Window / Horizontal Tile* 或点击结果窗口列表上方的图标来重置结果窗口(水平条)。

Select the *Impulse Response* window and select the section of direct radiation with the two markers (several ways to position the markers are described in part 1 of the Tutorial). Make sure that the main impulse is within the window and that the peak of the main impulse is not attenuated too much.

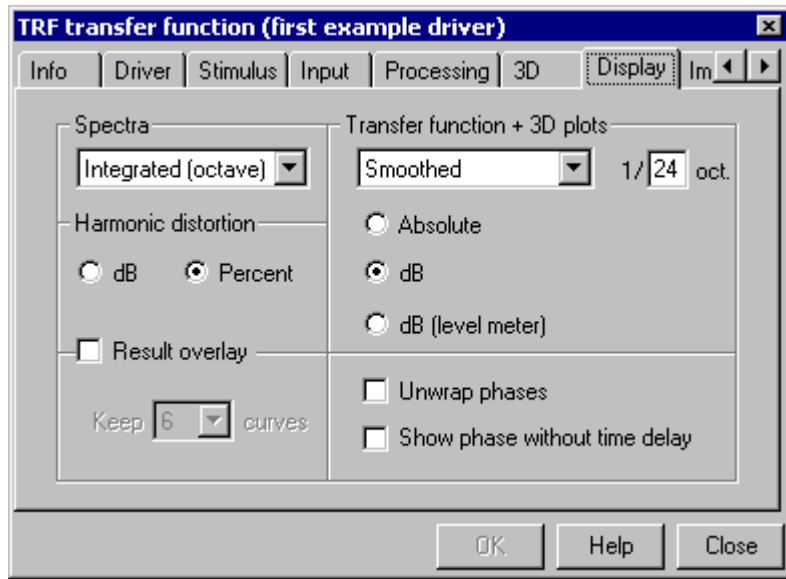
选择窗口 *Impulse Response*，并选择带 2 个标记的直接辐射段(定义标记位置的一些途径在教程第一部分里有描述)。确保主脉冲在窗口以内并且主脉冲的峰值不要衰减得太多。

Note: Normally the markers have to be placed in a very narrow section of the impulse response. This range depends on the geometry of your lab and on the distance between microphone and speaker. First place the marker roughly around the desired section of the impulse response. Press the *F9* key to zoom between the markers and place the markers precisely.

注释: 通常标记都必须标示在脉冲响应一段非常狭窄的区域内。这个范围是根据你的实验室的几何形状以及麦克风和扬声器之间的距离来决定的。首先, 将标记大致标示在脉冲响应的理想段范围中。按键 *F9* 来缩放标记之间的距离, 并将标记标示精确。

Open the result window *Fundamental + Harmonics*. The results are massively influenced by the setting of the property page *Display*. Set the values as shown below.

打开结果窗口 *Fundamental+Harmonics*。测量结果在很大程度上受到属性页 *Display* 中的设定的影响。按下面所示, 设定数值。



However, a variety of different options is available. Please take some time to explore the effect of different setting. Try at least the following options within the circled area:

然而, 不同选择的多样性是可行的。请花些时间来探索不同设定的影响。在周期范围内尝试至少以下选择。

- *No post processing / Averaged (1/3 oct) / Smoothed* with some different bandwidth settings
No post processing / Averaged (1/3 oct) / Smoothed 带一些不同的带宽设定
- *dB / dB (level meter)*
dB / dB (level meter)

In case of problems, please refer to the *TRF Reference* for detailed information. 如有问题, 请参看 *TRF Reference* 中的详细信息。

Using Template

使用模板

This measurement is quite standard and therefore the complete setup was entered manually instead of using some Operation Template. When creating new TRF operation some predefined setups may be selected. You can load the setting for the above example by choosing *TRF SPL + harmonics* operation Template.

Impedance Measurement

阻抗测量

Hardware Setup

硬件设置

Create Operation

创建操作

In the dB-Lab manual section the idea and the Handling of Operation templates is explained in detail.

这个测量是相当规范的，因此要手动输入完整的设置来替代使用一些操作模板 (Operation Template)。当创建新的 TRF 操作，可以选择一些预定义设置。你可以通过选择 *TRF SPL + harmonics* 操作模板，来载入上面例样中的设定。在 dB-Lab 手册中，有关操作模板的理念及操作解释得很详细。

The second example is the measurement of the electrical input impedance of a driver. This time we use a predefined template to load the complete setup.

第 2 个例子是扬声器单元电输入阻抗的测量。这次，我们使用预定义模板来载入完整的设置。

The following equipment is required: 以下的设备是必要的

- Distortion Analyzer (Power Monitor 8 Hardware does not support TRF measurements)
失真分析仪 (硬件 Power Monitor 8 不支持 TRF 测量)
- Driver mounted in laser stand
扬声器单元安装在激光器支架上
- Power Amplifier
功放

You may use the identical hardware setup as in the SPL example except the microphone. You don't need any external sensor since the DA1 comprises current and voltage sensor to measure the impedance.

你可以使用除了麦克风以外，与声压级例子中相同的硬件设置。你不需要任何外部传感器，硬件 DA1 已包含了电流和电压传感器，来测量阻抗。

Starting with hardware version 1.2 of the Distortion Analyzer (see label on back side) the unit has two different sensitivities for the speaker channels. The measurement of large signal parameter as well as the measurement of distortion require high voltage and current measurement capability. Contrary to this linear (small signal) measurements require a much more sensitive sensor characteristics to provide sufficient signal to noise ratio. Therefore the DA1 version 1.2 is equipped with a high power, low sensitivity sensor on Speaker Channel 1 and a low power, high sensitivity sensor on Speaker Channel 2 .

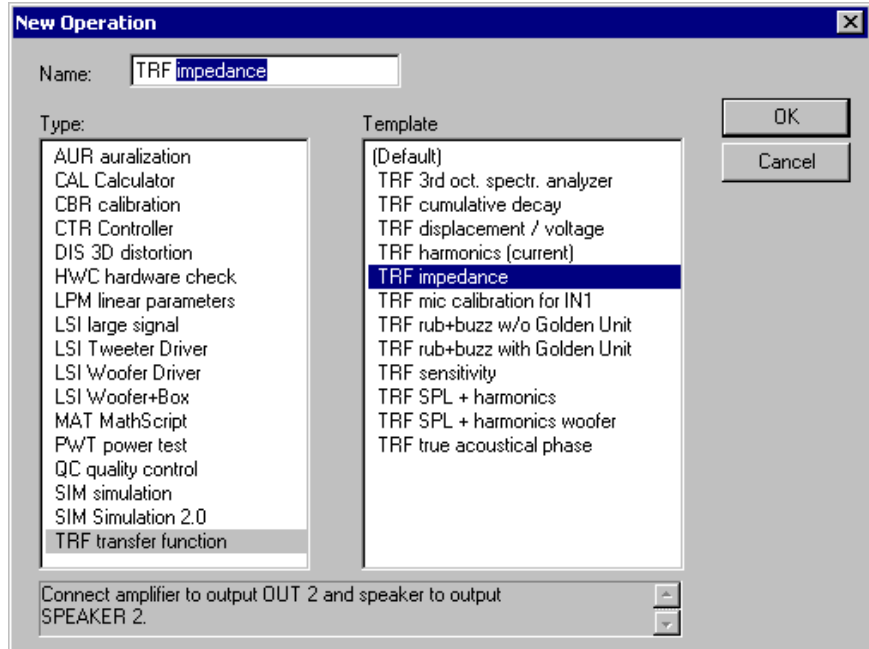
随失真分析仪硬件版本 1.2 开始进行 (看背面的图标)，对扬声器频道，单元含有 2 个不同的灵敏度。大信号参数测量以及失真测量要求高电压及高电流测量能力。相对于此，线性(小信号)测量要求更为灵敏的传感器特性，以提供足够的信噪比。因此，DA1 版本 1.2 在 Speaker Channel 1 上配备了大功率，低灵敏度传感器，在 Speaker Channel 2 上配备了小功率，高灵敏度传感器。

Note: For linear measurements (such as LPM and TRF) the Speaker Channel 2 is strongly recommended.

注释: 对于线性测量(如 LPM 和 TRF)，强烈建议使用 Speaker Channel 2。

Use the database you created above and insert a new TRF operation. Use the Operation Template *TRF impedance* when inserting the operation. Enter a new name for the inserted operation. Detailed instructions on templates are given in the dB-Lab manual section.

使用你上面创建的数据库并插入新的 TRF 操作。当插入操作时，使用操作模板 *TRF impedance*。对插入的操作，键入一个新名字。在 dB-Lab 手册章节中有相关的模板细节介绍。



The operation template is described in the *Comment* field of the *Info* property page. You can read the comment after inserting the operation. Please refer to this field if the template name gives not sufficient explanation.

操作模板被描述在属性页 *Info* 的注解栏中。你可以在插入操作后阅读注解。如果模板名没有给出足够的解释，请参阅此栏。

Measurement Setup

测量设置

Please check the setup configuration from the template. The impedance will be measured from 1Hz up to 20kHz using Speaker Channel 2. Electrical measurements will be falsified by windowing. Therefore the window shape is set to *Rectangular* and the whole impulse response is selected for analysis (check the marker positions in result window *Impulse Response*; the markers will be displayed together with the impulse response).

请从模板中检查设置配置。阻抗将使用 Speaker Channel 2，在 1Hz 到 20kHz 的范围中进行测量。改变窗口会歪曲电气测量。因此窗口形状被设置为 *Rectangular* (矩形)，为了更好的分析，整个脉冲响应都被选用 (在结果窗口 *Impulse Response* 中检查标记位置，标记将与脉冲响应一起被显示出)。

Result windows

结果窗口

Open the result window *H(f) Magnitude*. It shows the magnitude of the impedance in Ohm. The result window *H(f) Phase* shows the phase response. Please note, that no small signal (linear) parameters are derived from the impedance by the TRF software. To determine the Thiele-Small parameters, use the LPM software.

打开结果窗口 *H(f) Magnitude*。它显示了以欧姆为单位的阻抗幅值。结果窗口 *H(f) Phase* 显示了相位响应。请注意，不会有小信号(线性)参数通过

TRF 软件从阻抗测量中获得。要确定 Thiele-Small 参数，请使用软件 LPM。

Property page Display **属性页显示**

Since the magnitude of the impedance has a linear scale, *Absolute* is selected in the group *Transfer function*. For impedance measurements it is recommended to apply some smoothing (e.g. with a bandwidth of 1/24 octave). The spectral lines are very dense at higher frequencies (the number of lines increases for a constant relative bandwidth due to the equidistant spacing of the spectral lines), in fact far too dense to be displayed. This property can however be utilized to attenuate higher frequency noise by averaging over neighboring spectral lines (smoothing).

由于阻抗幅值具有线性刻度，因此在组 *Transfer function* 中被设置为 *Absolute*。对于阻抗测量，建议使用平滑度(例如,带 1/24 倍频的带宽)。在高频段，频谱线非常密集(由于频谱线间的等距间隔，谱线数量以恒定相对带宽增加)，实际上，显示出来更密集。这个特性可以被利用，通过平均相邻谱线，来减弱高频噪音(平滑度)。

Customizing TRF (Part 3) 定制 TRF (第 3 部分)

In this part of the tutorial various advanced aspects are discussed to use more powerful features and improve the performance of the TRF measurement.

在教程的这一部分，各种先进的方面被讨论来使用更强有力的特性并提高 TRF 测量的性能。

You should read this part of the Tutorial if you are familiar with the basic functionality of dB-Lab and of the TRF operation (Tutorial Part 1 and 2).

你应该阅读教程的这一部分，如果你已经熟悉了 dB-Lab 以及 TRF 操作的基本功能(教程部分 1 和 2)。

SPL Calibration

声压级校准

This section describes how to calibrate the TRF module for acoustical measurements. There are two methods to calibrate the system for SPL measurement.

这一节描述了，对于声学测量，怎样来校准 TRF。对于声压级测量，有 2 种方法来对系统进行校准。

Note: The SPL calibration is not a hardware calibration for the in- and output channels. Calibration as explained here means determining a software setup to display the correct SPL (conversion to dB as well as correcting the measured spectra during post processing).

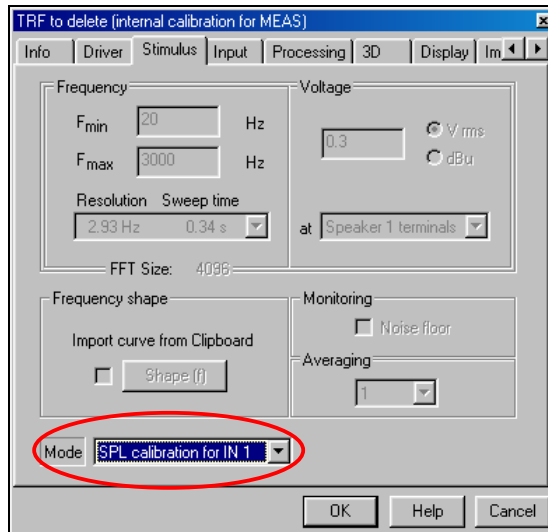
注释: 声压级校准不是一个对输入，输出频道的硬件校准。此处阐释的校准意味着确定软件设置来显示正确的声压级 (转换为 dB 以及在后置处理期间校正已测量的频谱)。

Using a Pistonphone

使用活塞发声器

If a pistonphone (or calibrator) is available, an automatic procedure may be used to determine the sensitivity of the microphone. To perform this procedure open the property page *Stimulus*


如果活塞发声器(或校准器)适用，一个自动化程序可以被用来确定麦克风的灵敏度。要执行这一程序，打开属性页 *Stimulus*



and select the *SPL calibration for IN 1* mode. There is also an option for calibrating input channel 2.

并选择 *SPL calibration for IN 1* 模式。此处同样也有对于校准输入频道 2 的选择。


Do the following steps 进行以下步骤:

1. Connect the output of the microphone preamp with connector **IN 1**
将麦克风前置放大器的输出端与接头 **IN 1** 连接起来
2. Connect the pistonphone with the microphone.
将活塞发声器与麦克风连接起来。
3. Start the SPL calibration mode by clicking .
点击图标，开始声压级校准模式。
4. Enter the SPL produced by the pistonphone.
键入由活塞发声器产生的声压级。
5. Choose *Calibrate* to set the measured sensitivity. You may also verify the current setting by selecting *Validate current calibration*.
选择 *Calibrate* 来设定测量的灵敏度。你也可以通过选择 *Validate current calibration* 来对当前设定进行检验。
6. Put the pistonphone into operation and click OK.
将活塞发声器放入操作，并点击 OK。
7. You will get a message if the SPL calibration was successful. The calibration routine will set the according calibration parameters for *IN 1* in property page *Input*.
如果声压级校准成功，你将得到一条信息。校准程序将在属性页 *Input* 中，根据校准参数，对 *IN 1* 进行设定。

If the SPL calibration failed check the result windows *YI(t)* and

YI (f) Spectrum and go back to step 3 after you have checked the hardware connections.

如果声压级校准失败，检查结果窗口 *YI(t)* 和 *YI (f) Spectrum*，在你检查完硬件连接后，返回到步骤 3。

8. It is good practice to verify the calibration before you start measuring. For this start the SPL calibration again by clicking . Select *Validating current calibration*. Check whether the pistonphone is still working and click OK.

在你开始测量之前，对于检验校准，这是一个很好的练习。通过点击图标，再次开始声压级校准。选择 *Validating current calibration*。检查该活塞发声器是否工作正常，然后点击 OK。

You will get a message box that shows the SPL measured via **IN 1**. Does it correspond to the SPL produced by the pistonphone? If not, check the result windows *YI(t)* and *YI (f) Spectrum* and go back to step 3 after you have checked the hardware connections.

你将接收到一个消息框，它显示了由 IN1 测得的声压级。这个结果和由活塞发声器生成的声压级是相应的吗？如果不，检查结果窗口 *YI(t)*和 *YI (f) Spectrum*，在你检查完硬件连接后，返回到步骤 3。

How to specify the Microphone Sensitivity ?

如何指定麦克风灵敏度？

If you don't have a pistonphone or calibrator you may simply enter the microphone sensitivity as given by the manufacturer. Open property page *Input*, select *(Mic) IN 1* or *IN 2(Mic)* enter the sensitivity in group *Calibration* (for instance $0.0134 \text{ V} = 94 \text{ dB}$ for a sensitivity of 13.4mV/Pa). Note that 1 Pa equals 94 dB .

如果你没有活塞发声器或校准器，你可以直接键入由制造商给出的麦克风灵敏度。打开属性页 *Input*，选择 *(Mic) IN 1* 或 *IN 2(Mic)*，在组 *Calibration* 中键入灵敏度（比如，对灵敏度为 13.4mV/Pa ， $0.0134 \text{ V} = 94 \text{ dB}$ ）。注意， 1 Pa 等于 94 dB 。

How to load a Microphone Correction Curve ?

怎样载入麦克风校正曲线？

To load a microphone correction curve do the following steps 要载入麦克风校正曲线，请进行以下步骤：

1. Open property page *Input*. Select *(Mic) IN1* if you want to connect the microphone to input **IN 1** (alternatively select *(Mic) IN2* if the microphone is connected to **IN 2**).

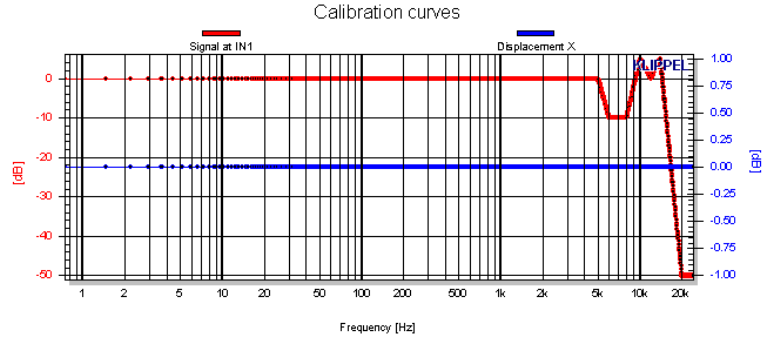
打开属性页 *Input*。如果你想将麦克风连接到输入端 **IN1** 上，选择 *(Mic) IN1* (如果麦克风被连接到 **IN2** 上，选择 *(Mic) IN2*)。

2. Click on the **Import...** button in the corresponding group **Calibration**. This will open an dialog where you can import the microphone correction curve. Click **Load...** in order to load the file with the correction curve (see section *Curve importing and export* in the *TRF Reference* for further information about the required format).

在相应组 **Calibration** 中点击按钮 **Import...**。这样会打开一个可以引进麦克风校正曲线的对话框。点击 **Load...** 以载入带校正曲线的文件 (更多有关格式要求信息，参看 *TRF Reference* 中的章节 *Curve importing and export*)。

3. Check the proper import and activation of the correction curve in result window *Calibration Curves*. The window shows the correction curves actually used for the measurement.

在结果窗口 *Calibration Curves* 中检查适当的引进，及校正曲线的活化。此窗口显示了实际运用在测量中的校正曲线。



Note: The calibration curve are displayed for the frequency range only specified in property page *Stimulus*. For each spectral line of measured signal a correction value is calculated by linear interpolation. Select *Mark Data Points* in the context menu of the result window *Calibration Curves* to view the individual points.

注释:校正曲线只在属性页 *Stimulus* 中已被指定的频率范围内被显示。对被测信号的每一根频谱线，一个校正值将通过线性插值被计算出来。选择在结果窗口 *Calibration Curves* 中，上下文菜单里的 *Mark Data Points* 来查看个别点。

Measuring Driver Sensitivities

测量扬声器单元灵敏度

This section describes how to measure the sensitivity in dB SPL / 1 W / 1 m. The sensitivity is defined as the ratio of the measured SPL in 1 meter distance (on axis) and the nominal input power. Since the Analyzer is a true two channel system the voltage at the speaker terminals and the SPL in 1 m distance can be measured simultaneously.

这一节描述了怎样测量以 dB SPL/1W/1m 为单位的灵敏度。灵敏度被定义为，在 1 米距离 (轴向)的实测声压级与额定输入功率之间的比率。由于分析仪是一个真正的双频道系统，因此在扬声器终端的电压以及 1 米距离处的声压级可以同时被测量。

Connect your Microphone to input **IN 2**. Calibrate the microphone as outlined in the section *SPL Calibration*.

将你的麦克风连接到输入端 **IN 2** 上。在小节 *SPL Calibration* 中，作为轮廓，校准麦克风。

Open property page *Input*. Select *IN 2 (Mic)* and *Us (Voltage Speaker 1)* or *Us (Voltage Speaker 2)* according to the speaker output you are using.

打开属性页 *Input*。根据你所使用的扬声器输出，选择 *IN 2 (Mic)*和 *Us (Voltage Speaker 1)* 或者 *Us (Voltage Speaker 2)*。

Note: Starting with Distortion Analyzer version 1.2 (see label on back side) the sensors of Speaker Channel 2 have an increased sensitivity (useful for linear measurements such as LPM and TRF) while Speaker Channel 1 can handle high power signals (for LSI, PWT or DIS).

注释: 与失真分析仪版本 1.2 一起开始(看背面的标签), Speaker Channel 2 的传感器具有增长的灵敏度(对像 LPM 和 TRF 的线性测量有益), Speaker Channel 1 能够处理高功率信号(用于 LSI, PWT 或 DIS)。

The input power P can be expressed in terms of the input voltage U and the nominal impedance Z_n

$$P = U^2 / Z_n$$

输入功率 P 可以表达为输入电压 U 及额定阻抗 Z_n 之间的项。

From this, we get an expression for the input voltage U that will yield an input power P of 1W for a given nominal impedance:

$$U = \text{Sqrt}(Z_n) / 1 \text{ W}$$

由此, 我们得到一个输入电压 U 的表达式, 它对于给定的额定电阻, 将产生一个 1W 的输入功率。

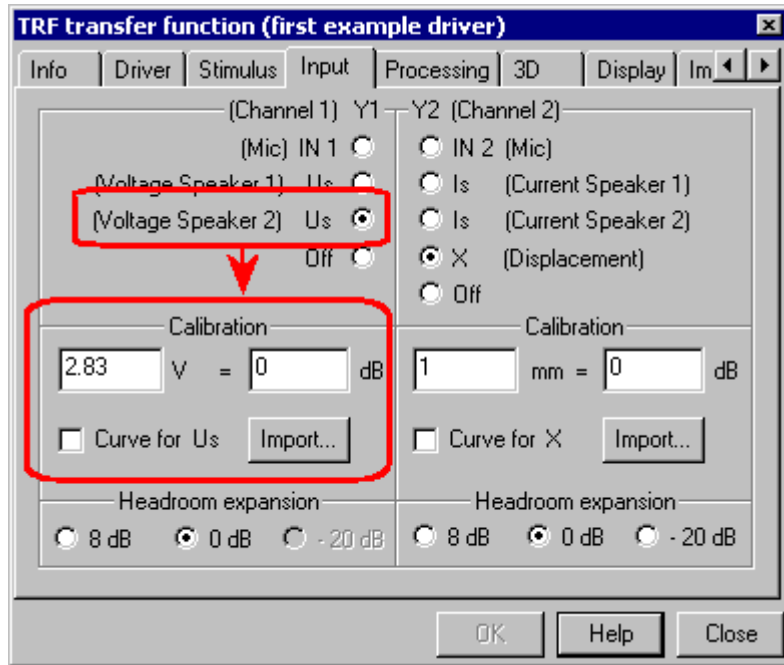
The following table lists the required input voltage for some common values of the nominal impedance.

下面的表格列举了对于一些额定阻抗公共值所要求的输入电压值。

Nominal Impedance Z_n in Ω 额定阻抗	Input voltage 输入电压
8	2.83
6	2.45
4	2
2	1.41
1	1

Use the input voltage that corresponds to the nominal impedance of your driver as calibration factor for the channel 1. For instance enter 2.83 V = 0 dB for an 8 Ω driver (see figure below).

使用与扬声器单元额定阻抗相对应的输入电压作为频道 1 的校准因子。比如, 对于一个 8 欧姆的扬声器单元, 键入 2.83 V = 0 dB (参看下图)。



Install the microphone on axis in 1m distance. Pay attention to possible reflections from the surrounding walls, the ceiling and the floor.

在轴向 1 米距离处安装麦克风。请注意可能由周围墙体，天花板和地板所产生的反射。

Open the property page *Processing* and select $H(f) = IN2 / Us$ in group *Transfer function*.

打开属性页 *Processing*，并选择组 *Transfer function* 中的 $H(f) = IN2 / Us$ 。

Open the property page *Display* and select *dB* or *dB (level meter)* in the group *Transfer function*. The result window *H(f) Magnitude* shows now the sensitivity in dB SPL / 1W / 1m. Smoothing is recommended for attenuating higher frequency noise. Select *Smoothed* with a relative bandwidth of 1/24 octave.

打开属性页 *Display*，并在组 *Transfer function* 中，选择 *dB* 或 *dB (level meter)*。结果窗口 *H(f) Magnitude* 现在显示了以 dB SPL/1W/1m 为单位的灵敏度。建议使用平滑度来减少高频噪音。选择 *Smoothed*，带 1/24 倍频的相对带宽。

Arbitrary microphone distances can be used if the results are corrected afterwards. The magnitude of the transfer function has to be decreased by $20 \cdot \log_{10}(d)$ dB for a microphone distance of d meter. The following table lists the correction factor for some common microphone distances.

如果结果此后被更正，任意的麦克风距离是可以使用的。在麦克风距离为 d 米的情况下，传递函数的幅值必须减小 $20 \cdot \log_{10}(d)$ dB。下面的表格列举了与麦克风距离公共值相对应的校正因子。

Distance <i>d</i> from microphone to speaker in meter 麦克风到扬声器之间以米为单位的距离 <i>d</i>	Correction factor in dB 以 dB 为单位的校正因子
0.2	14
0.5	6
2	-6
3	-9.5
5	-14

The correction factor may be set directly in the property page *Processing*. To do so, open the *Processing* page and enter the correction factor in the edit field *Level* in the group *Reference* after you have selected the adjoined check box (enter for instance -6 dB for a microphone distance of 2 meter).

校正因子可以直接在属性页 *Processing* 中被设置。在你已经选择好毗连的检测箱之后，打开属性页 *Processing*，并在组 *Reference* 的编辑栏 *Level* 中输入校正因子(比如，输入-6dB，麦克风距离为 2 米)。

Export Transfer Function Data

输出传递函数数据

The export of transfer function data to post processing tools such as simulation software is essential for a seamless design cycle.

传递函数数据的输出到后置处理工具，如仿真软件对于无缝设计周期一样，是必不可少的。

The transfer function data is exported to the clipboard in a three-column format (see section *Curve import and export* in the Reference). The first column contains the frequency in Hz. The second and the third column list the magnitude (in dB or real physical unit) and the phase in degree.

传递函数数据以三栏并列格式被输出到剪贴板上(参看章节 *Curve import and export*)。第一栏包含了以赫兹为单位的频率。第 2 栏和第 3 栏列出了幅值(以 dB 为单位或真实物理单位)，以及以度为单位的相位。

Note: The unit for the magnitude column is controlled by the unit combo box in group *Transfer function* in property page *Display*. The magnitude is exported in real physical units (like V, A, V/V, etc.) if *Absolute* is selected. For the options *dB* and *dB (level meter)* the magnitude is exported in dB. The unit for the phase column is always degree.

注释: 幅值栏单元由属性页 *Display* 里组 *Transfer function* 中的单元综合框来控制的。如果选择设置为 *Absolute*，幅值以真实物理单位(像 V, A, V/V 等)被输出。对于选择 *dB* 和 *dB (level meter)*，幅值以 dB 为单位被输出。相位栏总是以度为单位。

There are several options for the transfer function export. The user can export either the

传递函数的输出有几种选择。用户可以要么输出

- Magnitude of the true transfer function $H(f)$ (result window *H(f) Magnitude*) or the 真正的传递函数 $H(f)$ 的幅值 (结果窗口 *H(f) Magnitude*) 或
- Magnitude of the Fundamental of the numerator signal (result window *Fundamental + Harmonics*). 分子信号的基波幅值 (结果窗口 *Fundamental + Harmonics*)。

The magnitudes can be combined with the 幅值可以同以下一起结合


- Total phase (result window *H(f) Phase*) the 总相位 (结果窗口 *H(f) Phase*),
- Minimal phase (result window *H(f) Minimal Phase*) and the 极小相位(结果窗口 *H(f) Minimal Phase*)
- Excess phase (result window *H(f) Excess Phase*) 超相位 (结果窗口 *H(f) Excess Phase*) 。

The number frequency points of the transfer function points can be log-reduced. For some simulation software only a view hundred (logarithmically spaced) points are needed. The user can specify the desired number of frequency points per octave. If the checkbox *Log-reduce* is activated only the specified number of points (picked logarithmically) will be exported.

传递函数点的频率点数可以由对数形式减少。对于一些仿真软件来说，只需要观察 100 个点(以对数形式间隔)。用户可以自定义每个倍频中的理想频率点数量。如果检查箱 *Log-reduce* 被激活，那么只有指定的频率点数将被输出。

To export the transfer function data to the clipboard open the property page *Im/Export* and click the button *Export to Clipboard*. The button will be disabled if no transfer function data is available. The button will be enabled as soon as the transfer function is calculated.

要将传递函数数据输出到剪贴板上，打开属性页 *Im/Export*，点击按钮 *Export to Clipboard*。如果没有适合的传递函数数据，按钮是不可用的。一旦传递函数被计算出来，按钮即刻被激活。

Open the clipboard editor (double click  icon in the right part of the status bar). Click *Save...* in order to save the data in a plain text file. The decimal delimiter is a "." (point) for Matlab compatible data format. See Technical Note 002 *Clipboard Data Format* for more information (available on the Web).

打开剪贴板编辑(双击状态栏右下部分的图标)。点击 *Save...*，将数据保存到纯文本文档中。对 Matlab 兼容的数据格式，小数分界符为"." (点)。更多信息，参看技术注释 002 *Clipboard Data Format* (可在网上查阅)。

Using Result Overlay 使用结果覆盖

For the result windows 对结果窗口

- *Step Response* 阶跃响应
- *H(f) Magnitude* $H(f)$ 幅值
- *Fundamental + Harmonics* 基波+谐波

- *H(f) Phase* *H(f)相位*
- *H(f) Nyquist* *H(f)奈奎斯特*
- *H(f) Minimal Phase* *H(f)极小相位*
- *H(f) Excess Phase* *H(f)超相位*
- *H(f) Excess Delay* *H(f)差分时延*
- *H(f) Total Delay* *H(f)总时延*

an overlay feature is provided. The results of the previous measurement is kept if a new measurement is started. This is useful for comparing previous measurements with the current one.

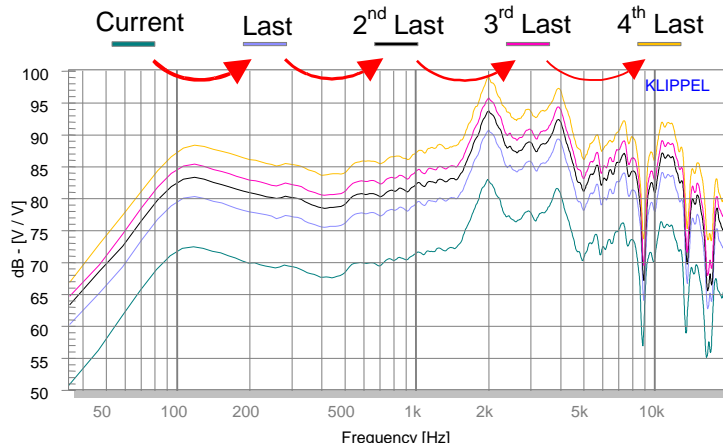
一个覆盖特性被提供。当下一个新测量开始，先前的测量结果将会保留。这样对于先前测量结果及当前测量结果之间的比较是很有益的。

To activate the result overlay, open the *Display* page and enable the *Result Overlay* button. The number of curves to be tracked may be chosen between 1 and 20.

激活结果覆盖，打开页面 *Display*，并点击按钮 *Result Overlay*。被观测的曲线数量可被选择在 1 到 20 之间。

Note: The result overlay applies to open result windows only! Sufficient calculation time between successive measurements must be provided to display the curves. Specify sufficient *Time between measurements* if you run the TRF in the *Continuous loop* mode (see section *Modes of Operation*).

注释: 结果覆盖只提供给打开结果窗口!连续测量中，必须提供足够的计算时间，来显示曲线。如果你在 *Continuous loop* 模式下运行 TRF，指定足够的 *Time between measurements* (参看章节 *Modes of Operation*)。



The overlay curves are displayed in the following sequence

覆盖曲线将以下面的次序被显示出来:





- The *top left* curve is always the *current* result
左上方曲线一直表示当前结果
- The *overlay curves* are sorted in time sequence from *top left* to *bottom right*.
覆盖曲线从最左上到右下，以时间次序分类。

- The colors and the labels of the overlay curves are retained. Only the position will change!
覆盖曲线的颜色及图标将被保留。只是位置改变!
- Curves *inserted* manually with the *Paste* command are always sorted to the end of the curve sequence.
用粘贴指令手动插入的曲线将总是分类在曲线次序的最末端。

Modes of Operation 操作模式

Four different *Mode* may be selected in the *Input* page

4 种不同的模式可以在页面 *Input* 中被选择：

<p><i>Single measurement</i> 单一测量</p>	<p>Default setting. A single measurement will be performed and the results stored in the database.</p> <p>默认设定。执行单一测量，测量结果会保存在数据库中。</p>
<p><i>Continuous loop</i> 连续循环</p>	<p>This setting allows repetitive measurements without starting each measurement individually. The loop is started by clicking on the  icon. The loop may be terminated by clicking on the  icon. This way the loop is paused after the measurement has finished. Clicking on the  icon stores the results of the last measurement in the database. If you use the  icon during a measurement the data will be discarded.</p> <p>这个设定允许重复测量，而不用每次单独地开始每个测量。点击图标，开始循环。点击该图标，中止循环。在测量结束后，循环暂停。点击该图标，储存最后一次测量结果到数据库中。如果你在测量过程中使用此图标，所有数据将被废弃。</p> <p>Options: 选择 The parameter <i>Time between measurements</i> specifies the time between the individual measurements. Please note that this time should be sufficient for calculating and updating the open result windows. If not, blank result windows will occur.</p> <p>参数 <i>Time between measurements</i> 指定了个体测量之间的时间。请注意，该时间应足够长，以满足计算和更新开放的结果窗口。如果不，空白的结果窗口将出现。</p>
<p><i>SPL calibration for IN1</i> 对 IN1 的声压级校准</p>	<p>Mode for calibrating the first input channel for acoustical measurements. See section <i>SPL Calibration Using a Pistonphone</i>.</p> <p>声学测量第一个输入频道校准模式。参看章节 <i>SPL Calibration Using a Pistonphone</i>.</p>
<p><i>SPL calibration for IN2</i> 对 IN2 的声压级校准</p>	<p>Mode for calibrating the second input channel for acoustical measurements. See section <i>SPL Calibration Using a Pistonphone</i>.</p> <p>声学测量第二个输入频道校准模式。参看章节 <i>SPL Calibration Using a Pistonphone</i>.</p>

Using References / Comparing results

使用参考/比较结果

It is very easy within the TRF module to use reference curves e.g. for comparing results and determining deviations between measurements.

在 TRF 模块里使用参考曲线是非常容易的，例如，对比测量间的结果及确定测量偏差。

Lets assume that you want to know the deviation the 30° off axis response from the on axis response.

假设，我们现在要知道从轴向响应中偏离了 30° 的离轴响应。

1. Create a new TRF operation. Enter a setup according to your needs. You can speed up this process considerably if you use a template.

创建一个新的 TRF 操作。根据你的需要，键入设置。如果你使用模板，可以大大地加速进程。

2. Measure the on axis response.

测量轴向响应。

3. Create a second TRF operation with identical setup. Use the according template or export and import the setup via the clipboard (property page *Im/Export*)

使用相同的设置，创建第 2 个 TRF 操作。使用相应的模板，或通过剪贴板输出和引进设置(属性页 *Im/Export*)。

4. Export the transfer function data of the first TRF to clipboard. Click on the *Export to clipboard* button in page *Im/Export*. Alternatively copy the *Magnitude* curve from result window *H(f) Magnitude* to the clipboard (mark the curve by clicking on the curve label and select *Copy Curve* in the context menu). Note that no phase information will be exported in this case.

把第一个 TRF 传递函数数据输出到剪贴板。点击页面 *Im/Export* 上的按钮 *Export to clipboard*。或者从结果窗口 *H(f) Magnitude* 中复制 *Magnitude* 曲线到剪贴板 (点击曲线，标示出曲线，然后在上下文菜单中选择 *Copy Curve*)。注意，在这种情况下，没有相位信息输出。

5. Open property page *Processing* of the second TRF, click on the *Import...* button in group *Reference*. This will open a dialog for importing the reference curve. Click *Paste* to import the curve from the clipboard. Note that the reference curve will only be used if this check box is selected.

打开第 2 个 TRF 的属性页 *Processing*，在组 *Reference* 中点击按钮 *Import...*。这样就开启了引进参考曲线的对话框。点击 *Paste*，从剪贴板中引进曲线。注意，只有在此检查箱被选择的情况下，参考曲线才可用。

6. Open the result window *Reference for H(f)* and check the correct import of the reference curve.

打开结果窗口 *Reference for H(f)*，并检查参考曲线是否正确引进。

7. Adjust your microphone to a 30° position. Measure the off axis response.

调整麦克风到 30° 的位置。测量离轴响应。

8. Open property page *Display* and select *dB* or *dB (level meter)*. The result window *H(f) Magnitude* shows now the deviation of the 30° off axis response from the on axis response in dB.

打开属性页 *Display*，并选择 *dB* 或 *dB (level meter)*。结果窗口 *H(f) Magnitude* 显示了从轴向响应中偏离了 30° 的离轴响应。

How to View Higher Order Harmonics ?

如何查看高阶谐波？

The TRF module measure the harmonic distortion components up to the 24th order. For clarity reasons only the 2nd and 3rd harmonics are displayed by default. If you want to view the higher order harmonics, right click and select *Customization Dialog... | Subsets* from the popup menu. Select the harmonics you are interested in and click *OK*.

TRF 模块可测量高达 24th 的谐波失真成分。为了更明确的分析原因，只有 2nd 和 3rd 谐波被设置为默认显示。如果你想查看更高阶的谐波，点击右键，从窗口菜单中选择 *Customization Dialog... | Subsets*。选择你感兴趣的谐波，然后点击 *OK*。

How to Speed up Marker Placement ?

如何加快标记安放？

Normally the markers have to be placed in a very narrow section of the impulse response. This range depends on the geometry of your lab and on the distance between microphone and speaker. First place the marker roughly around the desired section of the impulse response. Press the *F9* key to zoom between the markers and place the markers precisely.

一般来说，标记都必须标示在脉冲响应一段非常狭窄的区域内。这个范围是根据你的实验室的几何形状以及麦克风和扬声器之间的距离来决定的。首先，将标记大致标示在脉冲响应的理想段范围中。按键 *F9* 来缩放标记之间的距离，并将标记标示精确。

How to measure instantaneous distortion

如何测量瞬时失真

Instantaneous distortion can be measured with the *TRF Pro* Module. For detailed information about the measurement procedure see application notes *AN22 - Rub & Buzz Detection without Golden Unit* and *AN23 - Rub and Buzz Detection with Golden Unit*

瞬时失真可以由 *TRF Pro* 模块进行测量。有关测量程序更多的细节信息，参看应用须知 *AN22 - Rub & Buzz Detection without Golden Unit* 和 *AN23 - Rub and Buzz Detection with Golden Unit*