WAVES

TRACT
System Calibration

User Guide

Contents

Introduction

In a live sound setting, the PA system needs to be calibrated so that the FOH mixer can create a mix without having to compensate for the performance of the PA system. This lets the FOH mixer work in a predictable and relatively comfortable manner, which undoubtedly results in a better mix. PA calibration involves playing a reference signal through selected speakers, capturing and analyzing the sound, and then tuning the PA system accordingly. This setup process is normally the responsibility of the **system engineer**. While it's clearly valuable to have a system engineer to set up the PA system, it's not always possible. That's where TRACT comes into play.

TRACT (**T**ime and **R**esponse **A**uto-**C**orrection **T**ool) is a plugin from Waves that helps FOH mixers set up the PA system. It provides automatic or manual compensation of EQ as well as overall delay control, which can be applied to any output bus. While nothing can replace a professional system engineer, TRACT is the next best thing.

Typical uses of TRACT

- Tune the PA system's EQ
- Time-align Front Fill and PA speakers
- Phase-align Subs/Tops
- Use TRACT's advanced IIR parametric EQ for mixing and problem solving

PA setup involves two steps:

- Perform acoustic measurements and gather data
- Calibrate the PA system using this information

Measurement

TRACT uses a third-party application called **Smaart** to analyze room acoustics.[1] Smaart provides real-time spectrum analysis of audio signals, transfer-function analysis of sound system response, and acoustical impulse response measurement and analysis. Smaart and TRACT are linked for control and data streaming using Smaart's built-in Application Program Interface (API).

Workflow

- TRACT uses two types of measurements from Smaart: **Spectrum** (single measurement source) and **Transfer** (dual measurement source).

- Using a mic and a reference signal, TRACT captures Smaart measurements. A capture is a snapshot of a measurement under certain conditions (e.g., changed mic position).

- A FIR filter curve is computed to correct the measured response as influenced by a selected reference curve. The FIR filter curve can be modified by selecting a different reference curve, by controlling the amount of frequency-smoothing, or by setting constraints on the FIR's frequency and amplitude to control the effect on the corrected signal.

- A custom reference curve can be generated by saving a user-defined parametric IIR filter curve or a captured measurement.

- You can further supplement the FIR filter curve using TRACT's parametric Infinite Impulse Response (IIR) EQ.

- The plugin contains a delay section and a master output gain control.

When used without Smaart, TRACT's IIR EQ provides high-quality system EQ.
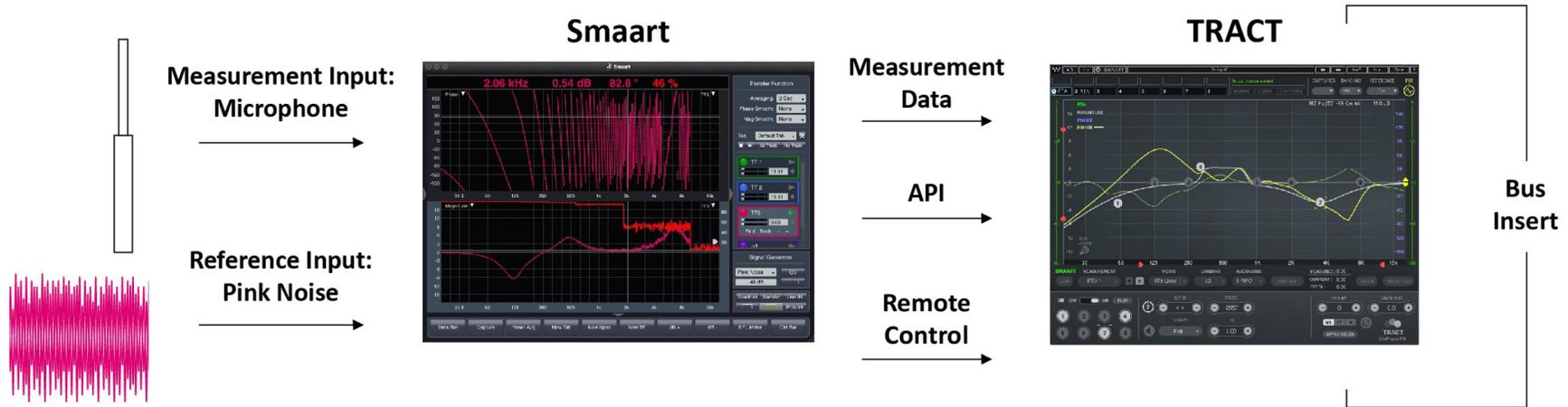
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[1] Smaart is a product of Rational Acoustics: http://www.rationalacoustics.com/smaart/

Setting Up Smaart

To use Smaart as an analysis tool for TRACT, you should first configure Smaart's inputs and enable the API. This enables TRACT to stream measurements from Smaart and remotely control it.

Signal Flow

There are two models of Smaart: Smaart v8 and Smaart Di v2. Before you configure Smaart and integrate it with TRACT, we recommend that you read the relevant Smaart user guide:

Smaart v8: Smaart v8 User Guide   Smaart Di v2: Smaart Di v2 Quick Start Guide

The Two Basic Measurements

There are two primary measurement types: **spectrum** and **transfer**.

Spectrum

Spectrum is a single-input measurement, usually made with one measurement microphone.

Spectrum measurement type displays:

> **Real Time Analyzer** (**RTA**)
>
> **Spectrograph (SPG)**

Transfer

Transfer provides a dual-input measurement that shows the difference between two measurement channels:

Channel 1 is the Measurement input (usually the measurement microphone)

Channel 2 is a Reference input (usually pink noise)

Transfer measurement type displays:

> **Magnitude** (difference in Frequency response between Measurement and Reference channels)
>
> **Phase** (phase difference between Measurement and Reference channels)
>
> **Delay** (time difference between Measurement and Reference channels)

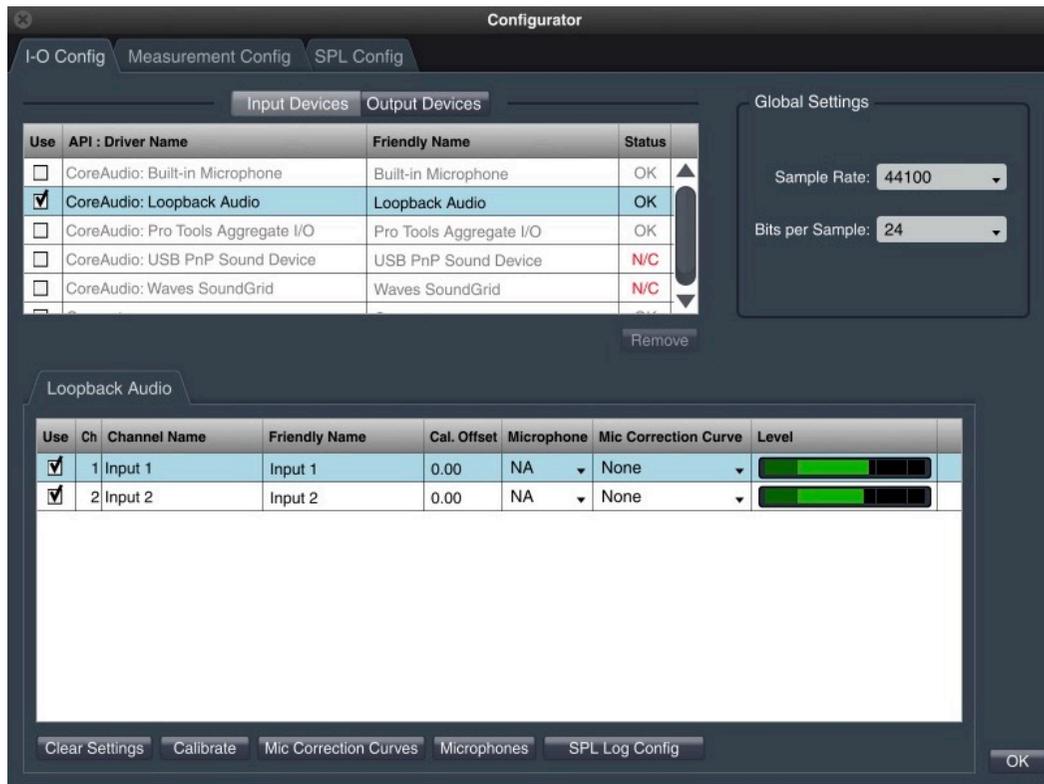## Configuring Smaart

Smaart v8 Setup

Smaart v8 Main Window

Enable Audio Device

This process is the same for Spectrum and Transfer measurements.

1. Select **I-O Config** from the Config drop-down menu at the top of the Smaart Main window.

2. Enable the **Audio Device** that will be used for the measurement microphone.

3. Enable the **Input Channel** that will be used for the measurement microphone. Devices and inputs can be renamed in the "Friendly Name" cells.

4. Load a **Mic Correction Curve** for the input channel that you will use for the measurement microphone. The correction curve file is provided by the microphone manufacturer.

New Spectrum Measurement

For Smaart to provide measurement data for TRACT calculations, you must first create and configure measurements in the Measurement Configuration page. These measurements are the basis of the captures that TRACT uses to make FIR filter curves.

1. Select the **Measurement Config** tab at the top of the Configurator page and add a **New Spectrum Measurement** (New Spec).

2. Select the input device and the channel that will be used to connect your measurement microphone. Give a unique name to this measurement (in this example, "My Mic").

3. Click **OK**. A new spectrum measurement is created with this name. Note that the measurement, "My Mic," now appears in the Measurements list.

4. Click on a measurement to edit its attributes.

This list of measurements will appear in the TRACT Measurement drop-down menu. You must select a measurement here in order to see an input signal in TRACT.

New Transfer (TF) Measurement:

Create a new Transfer measurement in the same manner as with Spectrum measurements. The only difference is that there are two inputs.

Enable audio devices as described above:

1. Select **IO Config** from the Config drop-down menu.
2. Enable the audio device (top) and the input channel that will be used for the measurement microphone.
3. Load a **Mic Correction Curve** to the input channel that will be used for the measurement microphone.

Create Transfer Measurement

4. Select the Measurement Config tab and add a **New Transfer Measurement**.
5. Choose the input that will be used to connect your Measurement microphone (Mea Ch), as well as the input that you will use to connect your Reference (pink noise).
6. Assign a unique name to the New TF Measurement.
7. Click OK. A new spectrum measurement is created.

About the Reference Channel

In most cases, pink noise is used as the reference signal. A pink noise generator is available in Smaart or the Waves eMo generator, as well as in almost every digital console.

Note: It is important to route the pink noise so that it is output simultaneously to your loudspeakers and to Smaart's Ref Channel. Smaart can then compare the difference between the direct ref input pink noise and the pink noise played through loudspeakers and then picked up by the measurement microphone.

Configuring Smaart Di v2

Enable audio devices in the same manner as with Smaart v8:

1. Select **IO Config** from the Config drop-down menu.
2. Enable the audio device (top) and the input channel that will be used for the measurement microphone.
3. Load a **Mic Correction Curve** to the input channel that will be used for the measurement microphone.

Smaart Di v2: Create input pair for a transfer measurement
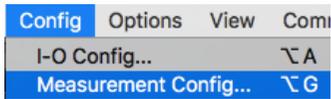
1. Open **Measurement Config** from the Config drop-down menu.
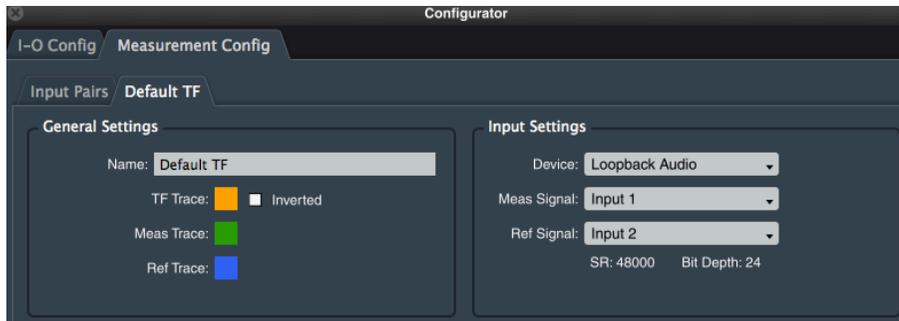
2. Configure the Default Pair: Choose an input device and assign inputs to the **Measurement Signal** channel (microphone) and **Ref Signal** (pink noise).

3. Click OK. A new Default TF pair is created.

Enabling the Smaart API

To connect TRACT and Smaart you need to enable Smaart's API, select **API** from the **Options**
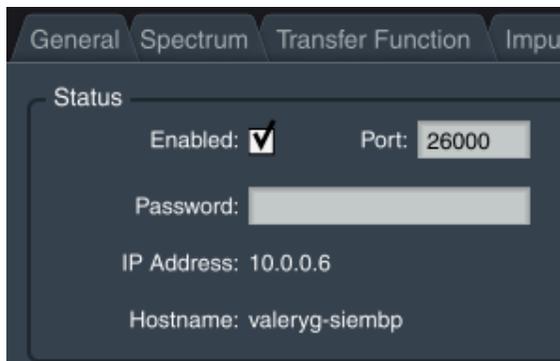
Check the **Enabled** box. An IP address will appear. This IP address will be used by TRACT to connect to Smaart.

Note: When changing FFT (under Transfer Function General Settings) from Default MTW to *any other setting*, you must to restart API by unchecking and rechecking the API Enabled box.

TRACT

Interface Overview

Smaart connection panel

Measurement captures
management panel

FIR controls

Display graph

Smaart remote
controls

IIR controls

Output controls

TRACT (Minimal Phase mono component)

Components

There are four TRACT components: TRACT Minimal Phase mono or stereo, and Track Linear Phase mono or stereo. An ID at the bottom right indicates whether an instance is Minimal Phase or Linear Phase. Latency times are shown below:
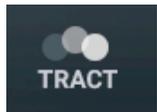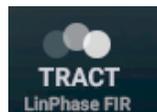
	Component/Latency	44.1 kHz	48 kHz	96 kHz
	Minimal Phase FIR (+ *IIR*)	0.15 ms	0.14 ms	0.07 ms
	Linear Phase FIR (+ *IIR*)	11.7 ms	10.8 ms	5.4 ms
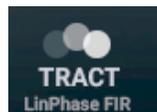
Graph Legend

The Graph displays several color-coded traces. Scaled is indicated on the left and right sides of the graph.

Trace	Color code	Scale/Range	Description
RTA/Spectrum	Green	-80 dB to 0 dB Same as Input meters	Moving line: Current real-time measurement Static line: Captured measurement. Click to select a capture in the Measurement Management panel.
Magnitude	Off-white	-18 dB to +18 dB	Magnitude/EQ/FIR scale, same as EQ scale
Phase	Purple	+/-180 degrees Purple scale on the right	Indicates phase
FIR+IIR curves	FIR: Yellow IIR: Off-white Total (FIR+IIR): Yellow	-18 dB to +18 dB	Displays the FIR and IIR filter curves
Reference	Dashed purple	-18 dB to +18 dB	Displays the selected reference curve

Connecting TRACT and Smaart

Insert TRACT on a mono or stereo channel in the host application.

Click the ✿ **SMAART** button on the WaveSystem Toolbar to reveal the Smaart connection panel.

When Smaart and TRACT are not connected, the displayed IP address is not valid and "Smaart not Connected" is shown in the status cell.

This is the normal startup condition.

Click the **Refresh** button.
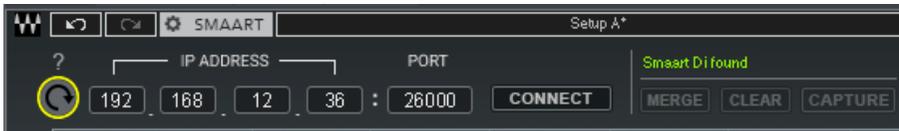
Refresh locates Smaart's API IP address. When the scan is complete, the correct IP address and port are indicated in the panel.

It's possible that more than one instance of Smaart is available on the network, even if you are unaware of it. This can cause the Refresh routine to select the wrong instance. When Refresh detects multiple instances, the control will toggle through IP address options." Click the Refresh button repeatedly until you see the IP address from the Smaart API. You can also manually enter the IP address details on the Smaart Network Client page.

Click the **Connect** button.

"Smaart Connected" is indicated in the status cell. Click the ✿ **SMAART** button to close the panel.

Consult the Smaart user guide for additional information about network connections.

Using TRACT and Smaart Over a SoundGrid Network

If TRACT is running on a SoundGrid host (e.g., SoundGrid Studio, eMotion LV1, MultiRack SoundGrid, or StudioRack SG) and Smaart is on a separate/discrete computer, Smaart remote functions cannot be controlled over the SG network. Smaart must use a dedicated network adapter that is independent of the SoundGrid network adapter.

> Note: We do not recommend using Wi-Fi for connecting to Smaart. This connection is possible, but it can degrade the performance of SoundGrid applications, such as MultiRack SG, eMotion LV1, SoundGrid Studio.

Smaart is now set up for measurements.

Controlling Smaart from TRACT
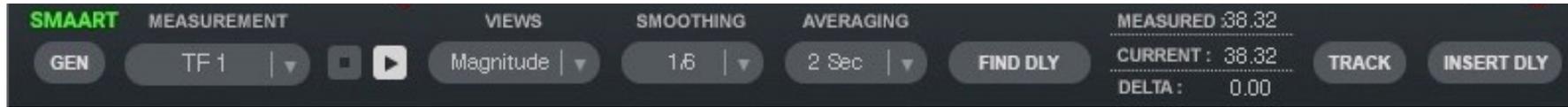
The **Remote Control** panel provides remote control over essential Smaart functions.

Note: These controls precisely reflect Smaart functions, so it's important to understand how they function in Smaart. We recommend that you refer to the Smaart user guide for in-depth explanations of these controls.

GEN

Activates Smaart's generator.

Measurement

Use the Measurement menu to choose among the measurements that you created in Smaart's Measurement Configuration page.

TRACT Measurement menu

Smaart Measurement Config page

Start/Stop Analysis

 Turns Smaart analysis on or off. Enables/disables viewing Smaart data in the TRACT display.

Views menu

RTA measurement
Bars view
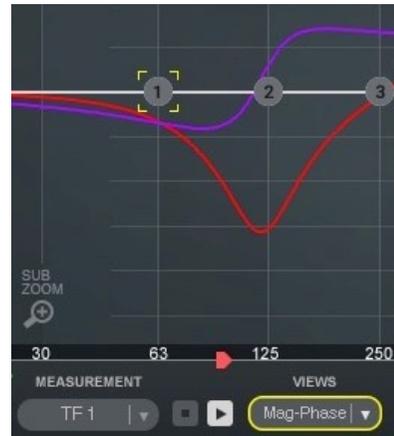
TF measurement
Mag+Phase view

Selects the display format. View options vary depending on the measurement type.

RTA measurement: RTA bars, RTA lines, or Spectrograph

TF measurement: Magnitude, Phase, or Magnitude+Phase

Spectrograph view (RTA measurement only)
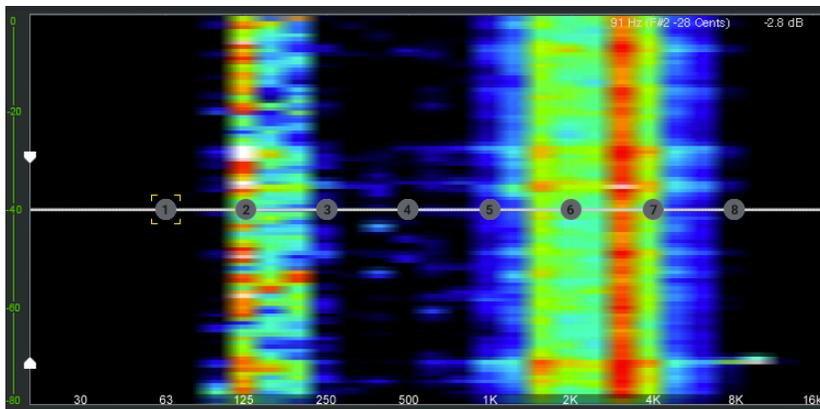
The Spectrograph view displays frequency response over time.

The dynamic range of the spectrograph is controlled by the two white controls on the left side of the Graph. The top control sets the maximum threshold; the bottom one sets the minimum. The spectrograph scales its color spectrum between these two extremes.

Spectrograph captures are marked **SPG** in the Captures Management panel. Spectrograph capture cells can be

viewed only one at a time. Selecting another spectrograph capture cell will clear the previously selected cell and replace it with the selected one. All other selected capture cells will be deselected. You cannot calculate a FIR filter curve from a Spectrograph capture cell.

> Note: Viewing a previously-captured SPG measurement will disrupt real time measurement. To see the real time measurement, deselect the SPG capture cell.

Banding and Averaging

These drop-down menu items dictate how measurement signals relate to the graphic display.

Banding (Spectrum) / Smoothing (Transfer)

Range (Spectrum and Smoothing): octave to 1/48 octave

On a **banded** RTA or spectrograph display, each fractional octave band represents the summation of the power at all frequencies that fall within that band. Banded spectra are a way of reconciling how we *hear* with what we *see* on the analyzer screen. By summing FFT multiple bins into each band, you get a display that's smoother and more stable than watching the individual bins jumping around.

> Note: This Banding menu sets the resolution of *captures*, while the resolution of the *FIR* is set with the Banding menu in the FIR section. The banding resolution of the FIR is limited by the banding resolution of the measurement data captured into each Capture Cell.

Smoothing places each frequency data point at the center of its own "band," rather than collecting the bins into a fixed number of bands at fractional octave intervals. In this case, each "band" is a center-weighted smoothing window that expands as you ascend in frequency. Using larger fractional octave bands can help reduce visual "noise" and make larger trends in the spectrum of a signal more obvious, but at the expense of limiting how much detail you can see.

Averaging

Averaging is the speed at which measurement data are updated. This helps separate useful information from extraneous factors such as noise, reverberation, and position-dependent acoustical anomalies.

For PA tuning, 1 or 2 second averaging is recommended. If the current active measurement uses the Global Spectrum Settings for spectrum averaging, then the *Averaging* selector on the Remote Control bar controls the global setting. Otherwise, it applies only to the active measurement.

Averaging settings:

None	No averaging
FIFO 2–16 frames	The first four choices in the list are for an equal-weighted simple moving average of the most recent 2, 4, 8 or 16 frames of data. In this type of average, the oldest frame falls completely out of the measurement when a new frame comes in (hence the name "FIFO," for "First In, First Out").
1 sec–10 sec	Variable averaging settings that combine the most desirable characteristics of FIFO and exponential moving averages.
Infinite	A cumulative, equal-weighted average with no set duration. It will keep averaging until you stop or restart the measurement. You can average over a period of several minutes, or even hours if you like, to get the cleanest possible picture of the response of a steady state system or find the long-term average spectrum of a dynamic signal such as speech or music.
Fast/Slow	First-order exponential averages with time constants of 0.125 and 1.0 seconds respectively.

Please refer to the Smaart user guide for detailed information about Banding and Averaging.

Delay Measurement and Correction

The *reference* signal, regardless of its source, arrives at the measurement point almost instantly. The *measurement* signal is the output of the system under test. It is subject to delay from filtering, throughput delay, intentional alignment delay, and in the case of acoustical measurements, the realities of the speed of sound.

All of this can introduce tens of milliseconds of time offset between the reference and measurement signals and we must compensate for that offset by delaying the reference signal to match the arrival time of the measurement signal. Every two-channel transfer function measurement has a built-in delay line for just that purpose.

Delay controls (available in Transfer Measurement mode only)

Find DLY

Activates Smaart's Delay Finder function, an automated routine for finding the delay time for the active transfer function measurement. The Measured signal delay value updates each time the button is clicked.

Measured/Current/Delta (view only) Displays the measured vs. current delay values. It is used in calculating delay offset.

Measured	Displays the delay value when the **Find DLY** button is clicked.
Current	Displays time delay value in real time.
Delta	Displays the time difference between the Measured and Current delay values.

Track

Follows and compensates for real-time delay changes between the reference and measured signals. It controls Smaart's delay alignment function, which adjusts the reference signal delay to align with the measured signal. It's designed to keep transfer function measurements aligned in situations where the delay time may change from one measurement update to the next—for example, when measuring in windy conditions or while the microphone is being moved to a new location.

Insert Delay

Inserts the **Measured** delay time to the **Current** measurement value box.

Captures

A capture is a snapshot of a selected measurement's state. Captures vary within a measurement due to mic positions and other variables. To capture real-time data, click the **Capture** button. You can capture up to eight measurements for FIR processing. The capture will be saved in the empty Capture Cell with the lowest number. You can give the capture a unique name in the cell above it.

Select a Capture Cell to display its capture on the graph. You can display as many captures as you like, but only the single capture selected in the Captures drop-down menu is used to calculate the FIR filter curve (see next section). To delete a capture, select one or more Capture Cells and click **Clear**.

Several captures can be merged to create a new, averaged capture. You can merge data from one or more Capture Cells of same measurement type: Merge Spectrum captures with other Spectrum captures (except Spectrograph), or Magnitude captures with other Magnitude captures (except Phase), or Phase with Phase. But you cannot merge Spectrum captures with Magnitude or Phase captures.

We recommend that you disconnect TRACT from Smaart once you complete your captures. This will reduce CPU load, which may make the host computer more responsive. Click the **Disconnect** button to end the connection.

Calculating the FIR Filter Curve

The FIR filter curve is calculated by subtracting a capture from the reference curve. Additional adjustments are made in the IIR section, which is described later.

Captured Measurements These are the captures made from Smaart measurements.

Reference Curve This is a target curve, the desired sound of the PA system.

The FIR filter curve is calculated in the FIR section. The images below illustrate how a reference curve influences

the calculated FIR filter curve.
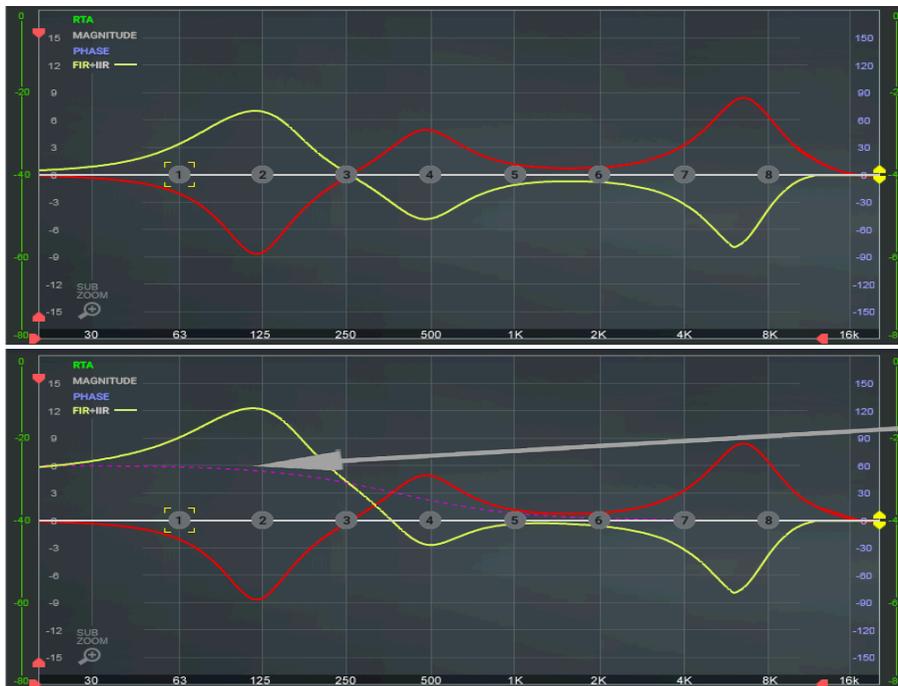
TOP: Reference Curve Flat

Yellow = FIR
Red = magnitude measurement and capture

Note that the FIR is inversely proportional to the capture.

Bottom: Reference Curve +6 LF Boost

Dotted purple = reference curve

Note that at frequencies where the LF boost reference filter is active, the correction curve amplitude increases proportionally to the amplitude of the reference. It is unaffected at higher frequencies since the reference is not active there.
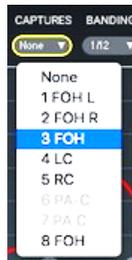
FIR Controls
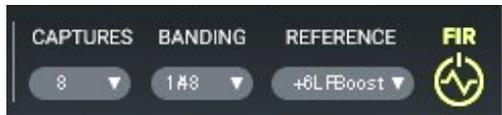
A reference curve is calculated in the FIR section. It can be calculated from any capture except Spectrograph and Phase. The FIR section is turned on or off with the FIR icon on the right.

Creating the FIR filter curve involves these menus:

1 – Captures menu

The Captures menu shows the captures from the Captures Management panel. Select the capture that will be used to calculate a FIR filter.

When a capture is selected, its series number is highlighted. You cannot clear a capture that is selected here. The yellow FIR filter curve will appear on the graph.

2 – Banding menu

The banding menu sets the resolution of the FIR. It determines the smoothness vs. detail of the FIR curve. It also controls the filter's appearance on the graph. Maximum FIR resolution is limited by the source cell banding selection in the Remote Control panel (i.e., the Banding/Smoothing menu). For example, if Banding is set to 1/3 octave in the Remote Control panel, then the FIR resolution cannot be higher. You can, however, use the FIR Banding control to reduce the resolution of a high-resolution capture.

Range: 1 octave to 1/48 octave.

3 – Reference Curve

Reference curves are target equalization curves used in calculating the FIR filter curve. They are defined as the reference curve value minus the capture.

The reference curve is indicated by a purple dotted line.

There are four factory reference curves

- Flat
- +6 dB low frequcncy boost
- +9 dB low frequcncy boost
- X-curve

You can also create a reference curve from a capture or an IIR curve. This is described in the User Reference Curves section.

Constraining the FIR

You can limit the range—amplitude and/or frequency—in which the FIR acts upon the signal. This does not affect the structure of the curve, rather, it restricts the amplitude or frequency range in which the curve is active.

Move the red markers on the left side of the window to limit FIR filter curve activity within a defined amplitude. The red markers at the bottom limit FIR filter curve activity to within a specified frequency range.
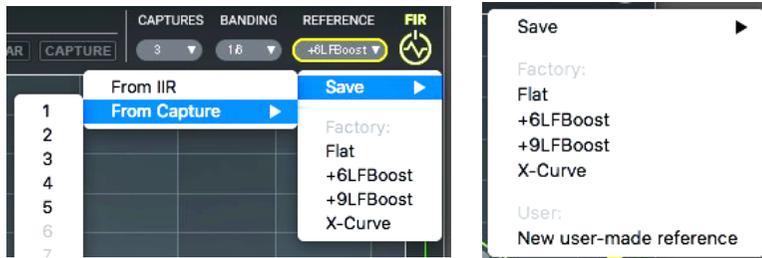
To change the limits, move the controls manually or double-click on a control and enter a value.
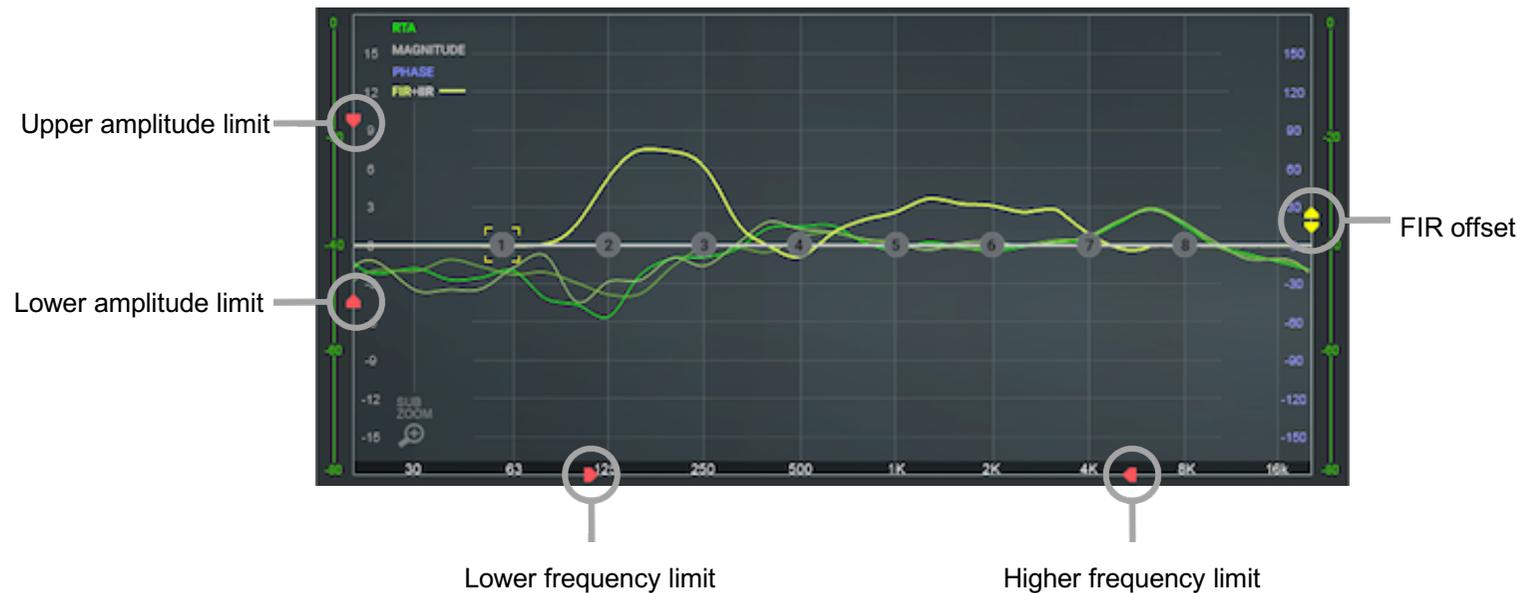
Use the yellow FIR amplitude offset marker on the right side to move the curve up and down within the limits defined by the upper and lower limit markers.

User Reference Curves

  You can save and load user-defined reference curves derived from captures or IIR settings.

User-made references appear at the bottom of the menu.

Create a new user reference curve

From Capture	Choose a capture cell number in the "From Captures" submenu. You will be prompted to name the new curve.
From IIR	Draw a curve using IIR Filter section. Select "From IIR" in the submenu. You will be prompted to name the new curve. IIRs are described in the next section.

User Reference curves are saved as part of the TRACT plugin preset.

IIR Filter Section

The IIR section is an eight-band paragraphic equalizer that is placed after the FIR filter curve in the signal flow. It has three uses:

- It supplements the FIR filter curve with an additional EQ curve.
- It provides a quality freestanding parametric EQ when you are not using TRACT as a measurement tool.
- It can be used to create a custom reference curve from an IIR.

Select a band by clicking on its band number on the graph (graph markers 1–8), or by clicking the corresponding band number in the Band Selector section.

A band can be turned on or off by double-clicking on its graph marker or band selector, or by single-clicking the ON/OFF switch in the Filter Control section.

Adjust band parameters by dragging a marker or parameter value box. To fine-tune a parameter, select a value box and then click **+** or **–**.

Filter Controls

Shape
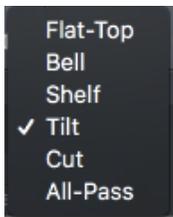
All bands have six filter shape options. Available parameter controls vary by shape selection.

Flat-Top

Controls: Gain (-15 dB to 15 dB), Frequency (20 Hz to 20 kHz), Width (0.50 to 6.00)

There are two Q controls: one for the beginning of the plateau (Q-LOW) and one for the end (Q-Hi). Range: 0.50 to 1.00

Bell

Controls: Gain (-15 dB to 15 dB), Frequency (20 Hz to 20 kHz), Q (0.10 to 60)

The Bell shape at narrow Q settings will become a "peak filter" for positive dB values and a "notch filter" for negative dB values.
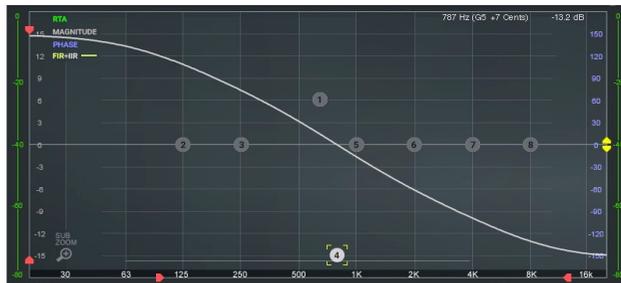
Shelf

Controls: Gain (-15 dB to 15 dB), Frequency (20 Hz to 20 kHz), Shelf type (low-shelf or hi-shelf), Q (0.05 to 1.00)
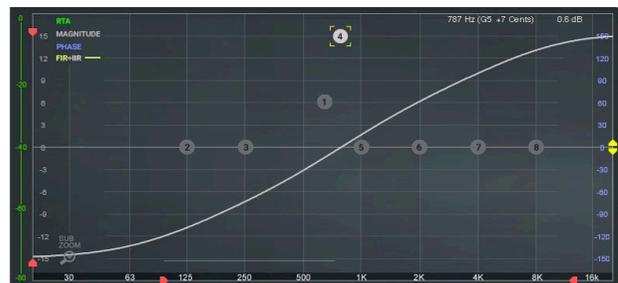

Tilt

As gain changes, the EQ graph pivots around the selected marker. In this example, the curve pivots around the selected frequency of Marker 4.

Controls: Gain (-15 dB to 15 dB), Frequency (20 Hz to 20 kHz), Q (0.05 to 1.00)
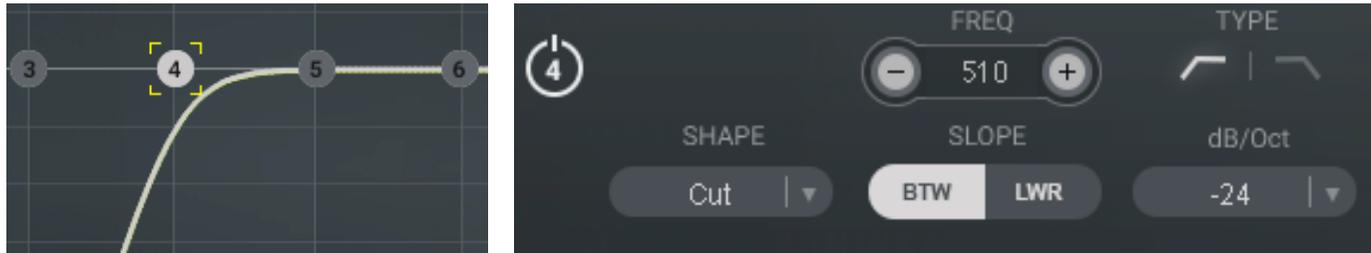

Gain: -15 dB

Gain: +15 dB

Cut

Controls: Frequency (20 Hz to 20 kHz), Type (LPF/HPF), Slope (Butterworth BTW or Linkwitz-Riley, and dB/octave (-48 dB/octave to -6 dB/octave)


Note: LWR (Linkwitz-Riley) Slope does not support dB/Oct values of -6 or -18. When selecting these values while using LWR slope, the BTW (Butterworth) slope will be used for the filter.

All Pass

The "All Pass" filter shape is a "phase-only filter," with phase response depending on the Frequency and Q parameters (Q sets the slope at which the phase changes around the cutoff frequency). Note the AP symbol that appears on the band marker when All Pass is selected.

Controls: Frequency (20 Hz to 20 kHz), Q (0.3 to 10.0)
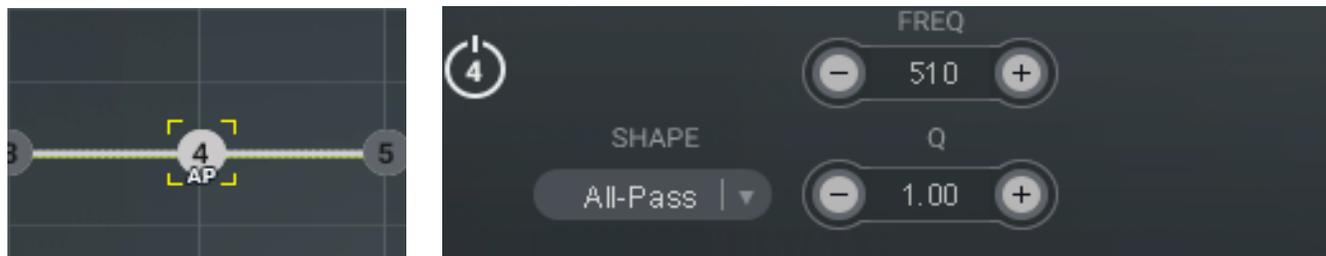
Note: The All-Pass filter type does not create a trace on the graph since there is no amplitude value. Route the signal through Smaart to understand how the signal phase is affected by this filter.

Master Section

Delay

Time delay that is applied at the output of the plugin. You can adjust the value manually using different scales:

MS   milliseconds

FT   feet

M   meters

Changing between these scales does not affect the time delay time, only the display.

Apply Delta

Click here to apply the Delta value from the Transfer Find DLY function (in the Remote Control panel above).

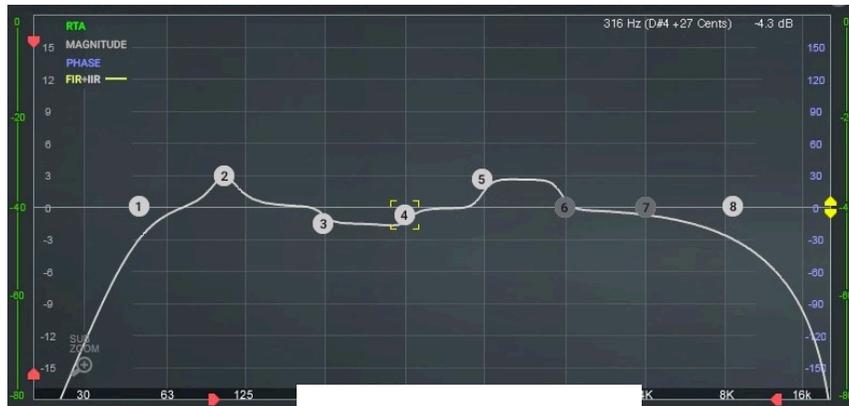**Phase**

This flips plugin's output phase 180 degrees.

Gain Out
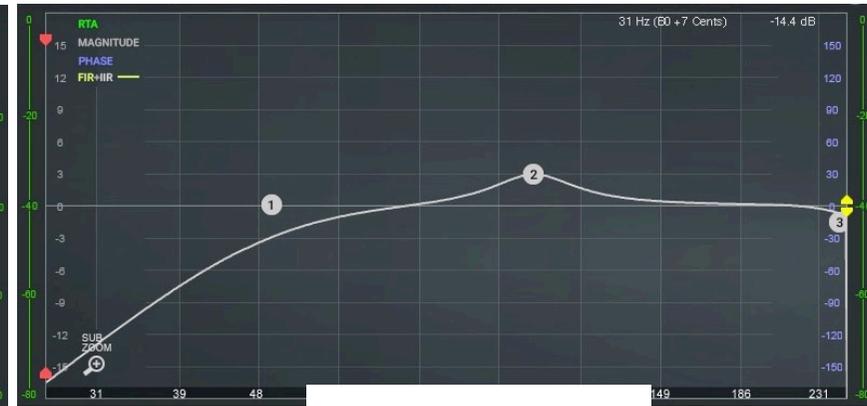
Adjusts plugin's output level.

Sub Zoom

Sub Zoom is a focused view that shows the frequency range from 27 Hz to 240 Hz. This helps to closely view low frequencies when aligning subs. Sub Zoom is disabled when viewing a Spectrograph in Real Time or a Spectrograph Capture.
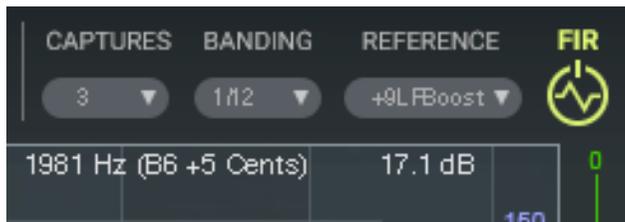

Full View

Sub Zoom View

Cursor Coordinates

When the cursor is moved, its coordinates are displayed beneath the FIR control panel.

Displays: Frequency, Note and Magnitude/EQ/FIR dB value at cursor position.

Using Workflow Examples

The following examples demonstrate how TRACT is used to address three different correction and alignment issues.

    Case A: Frequency correction—Tops/Full-Range
    Case B: Time alignment—Front Fills
    Case C: Phase alignment—Subs

In all cases, start with these steps:

1. Configure Transfer/Pair in Smaart (Measurement: Microphone, Reference: Pink Noise)
2. Load TRACT as an insert on the buss output that you would like to correct.
3. Connect to Smaart.
4. Choose Transfer measurement and click Play.

Case A: Frequency Correction—Tops/Full-Range

1. Select Magnitude view from the Views menu.
2. Select 1/3 or 1/6 smoothing under the Smoothing menu.
3. Select 2 sec from the Averaging menu
4. Place your measurement microphone at the FOH position.
5. Adjust the gain of your measurement microphone and/or pink noise generator so that the Real-Time Transfer trace is as close to 0 dB on the graph as possible.
6. Click Capture.
7. Move your microphone to a new position and perform another capture.
8. Capture 3–4 different microphone positions.

9. At this point you can stop Real-Time Measurement and mute the pink noise.

10. Make sure all relevant capture cells are selected/visible.

11. Click Merge to create an average capture. A new capture, MRG, will be added to the Captures list. In this example, the new capture is in cell 5 and we named it "FOH."

12. Go to the FIR section and select Cell 5/FOH from the Captures menu.

13. From the Reference menu, choose your target curve (e.g., flat).

14. Click the FIR switch.

15. The FIR curve is calculated and looks like a mirror image of MRG capture.

16. You can cycle through and test other reference curves by selecting them from the Reference menu. The FIR curve will update in real time.

17. Use the Range limit controls (Frequency and Amplitude axis) to limit FIR correction.

18. Use the FIR offset control to move the FIR filter curve up or down the scale, if needed.

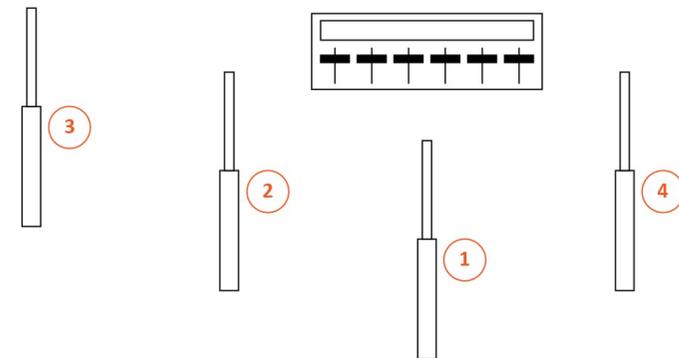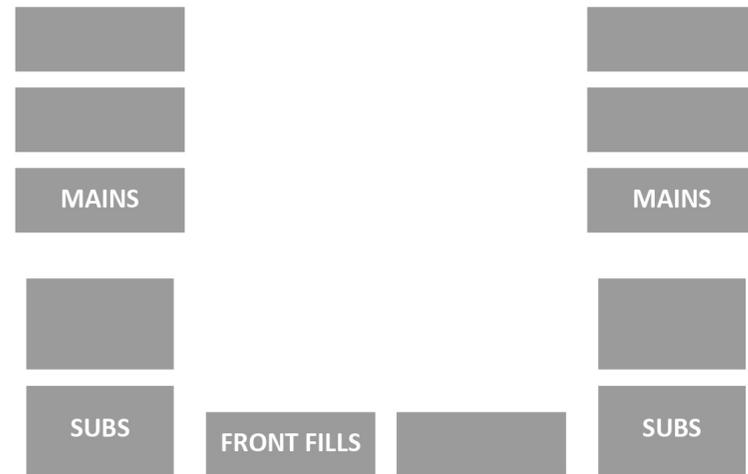19. Use IIR EQ bands to supplement the FIR filter curve.

Diagram A: Multiple mic position measurements for frequency correction of Tops/Full-Range loudspeakers.

Case B: Time Alignment—Front Fills

1. Insert TRACT on the Front Fills Matrix Output.

2. Place your measurement microphone at the first row, at the intersection where sound waves from the Front Fills and the Main PA collide.

3. Route pink noise to the Front Fill

4. Click FIND DLY and wait 1–2 seconds. You will see the result in the MEASURED line.

5. Click INSERT DLY to apply this value to reference channel. This value is displayed next to the CURRENT line

6. Route pink noise to the Mains.

7. Again, click FIND DLY. Wait 1–2 seconds. You will see the result in the MEASURED line.

8. Take a look at the DELTA value. This value displays the difference between Measured and Current values. This is the delay time between Mains and the Front Fills.

9. In the Master section click APPLY DELTA. The time difference is applied to the plugin's output. This delays the Front Fills output and time-aligns when sound arrives to a measured point between the Mains and Front Fills.

10. At this point you can stop Real-Time measurement and mute the pink noise.

MAINS

FRONT FILLS
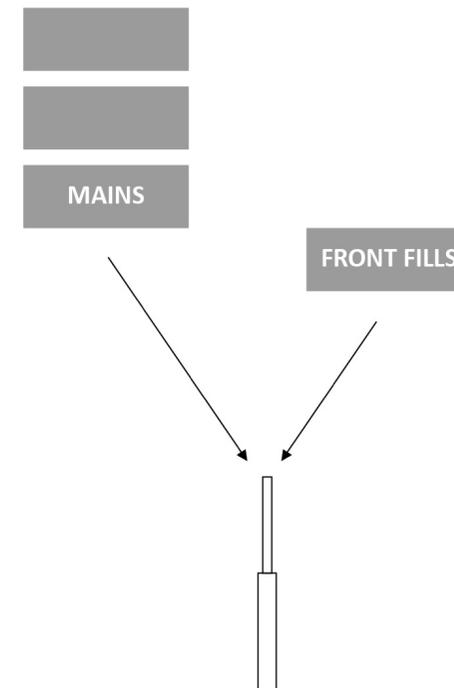
Case C: Phase alignment—Subs

1. Insert TRACT on the SUB Matrix Output.

2. Place your measurement microphone relatively close to your subs (e.g., between a third and halfway into audience).

3. Place the microphone low on the floor, on a soft cushion/sponge to avoid floor rumbling.

4. Select Magnitude + Phase view from the Views menu.

5. Select 1/3 or 1/6 smoothing under the Smoothing menu.

6. Select 2 sec. from the Averaging menu.

7. Route pink noise to Mains.

8. Adjust the gain of your measurement microphone and/or pink noise so that the Real-Time Transfer trace is as close to the 0 dB line on the graph as possible.

9. Click FIND DLY and wait 1–2 seconds. You will see the result in the MEASURED line.

10. Click INSERT DLY to apply this value to the reference channel. This is displayed next to the CURRENT line

11. Click Capture.

12. Route pink noise to the SUBS.

13. Click SUB ZOOM to focus on the alignment range.

14. Adjust SUB Matrix Output to desired level. Usually the Sub's magnitude curve should be 3–6 dB above Mains' magnitude.

15. Now pay attention to the Phase traces of the Sub relative to the Mains at the Crossover Frequency only. The Crossover Frequency is where Mains and Subs Magnitude are meeting/crossing each other.

16. Using the Delay Controls, increase Delay time slowly—click by click.

17. Note how the SUB Phase trace begins to move.

18. Your goal is to move the Sub's phase trace as close as possible to the Main's Phase trace at the crossover point.

19. When the Sub's phase trace is overlaying the Mains phase trace at the crossover point, Subs and Mains are phase aligned.

20. At this point you can turn off the SUB ZOOM, stop Real-Time measurement and mute the pink noise.

21. Advanced users can use the All-Pass filter to align Subs instead of Delay.