

# AN 216: Using FIR and RTA

## Introduction

The ALLCONTROL Software provides FIR calculation functions for hardware that supports FIR filters, and an RTA (Real Time Analyzer) option that can be used in combination with the FIR filter, but is independent from the hardware. This document describes the use of both options. It is assumed that you know what a FIR filter is, what the difference between IIR and FIR filters is and that you understand the concepts of truncating, convolution, group delay and related topics, as well as transfer function, power compression, directivity etc.

## Using the RTA function

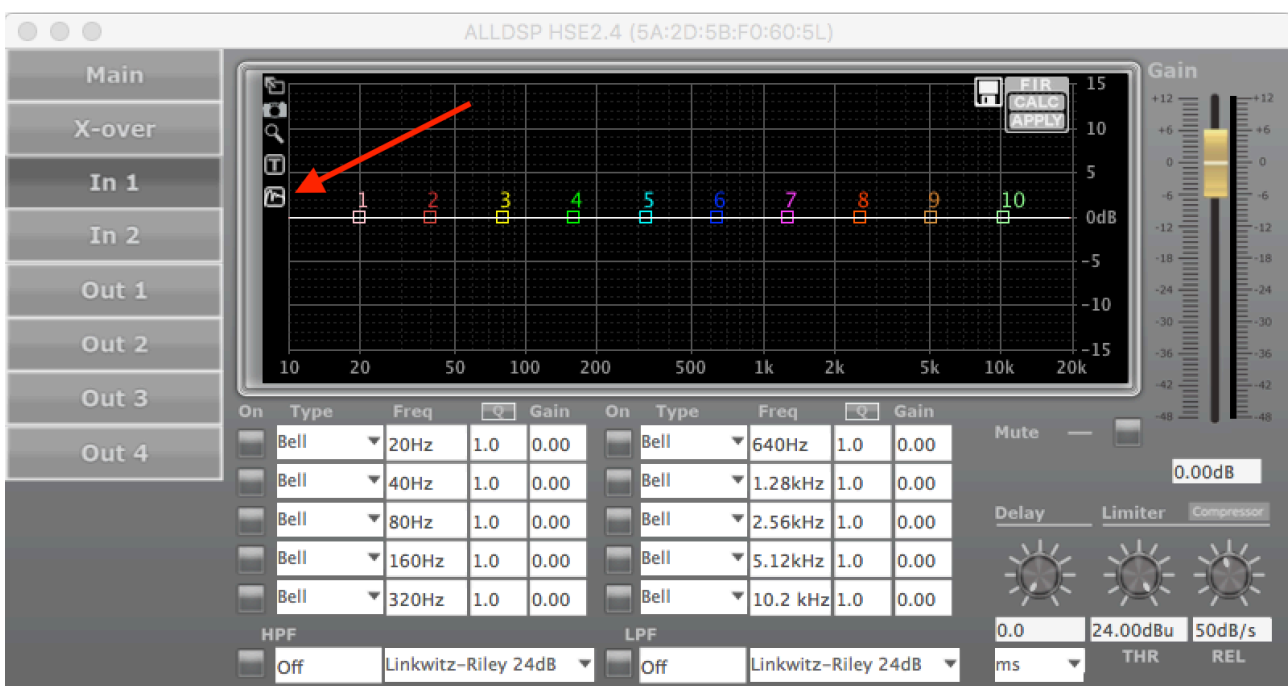
The RTA enables you to visualise the spectrum of the audio signal. By using this to measure the output of the loudspeaker producing white noise, you can find the transfer curve of the loudspeaker. Although other applications exist, we will focus on this application.

To measure a transfer curve, connect a signal generator playing white noise, or select "White Noise" from the input selection drop-down in the ALLCONTROL software (selected hardware only). Adjust the volume to a reasonable level; there is no need for high SPL measurements unless you want to test power compression.

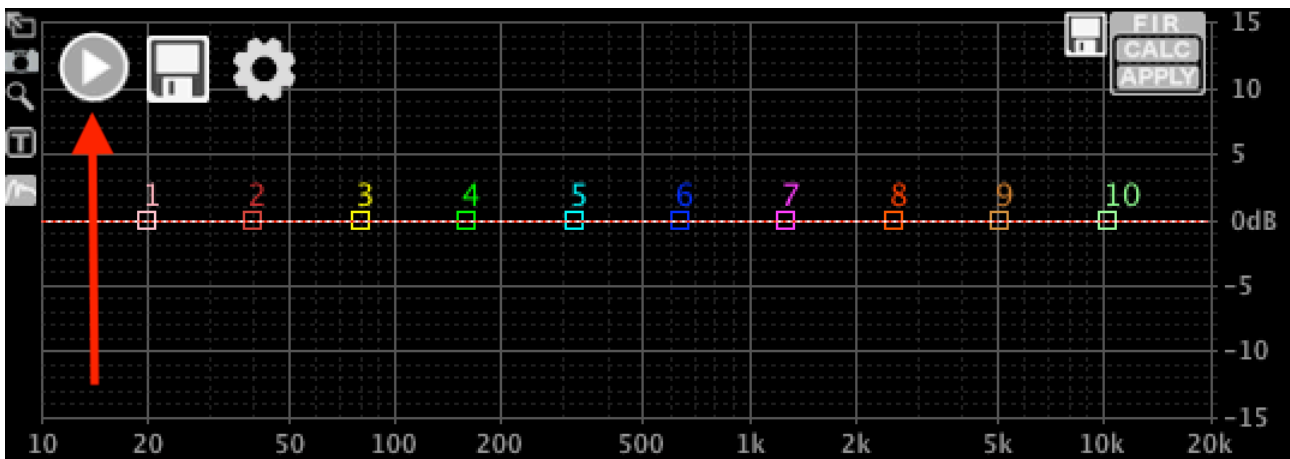
Now go into the channel you want to adjust. For a 2-way system this may be the HF or LF channel, or it may be the input channel to adjust the overall transfer function. If you plan to use the RTA measurement to control a FIR filter, choose a channel that supports FIR.

## STARTING A MEASUREMENT

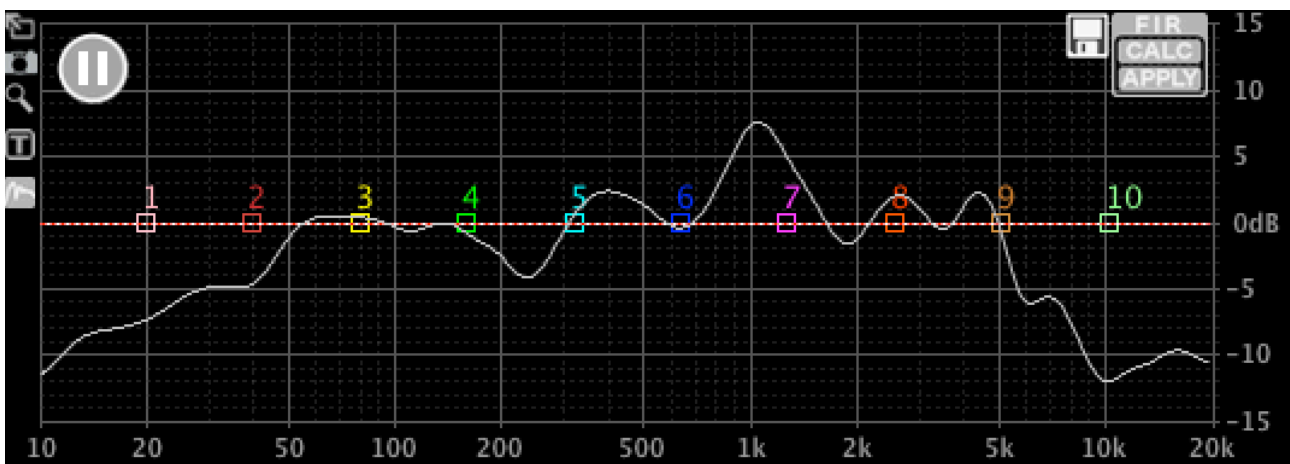
First you need to enable the RTA function. To do so, click the RTA icon in the graphical window.



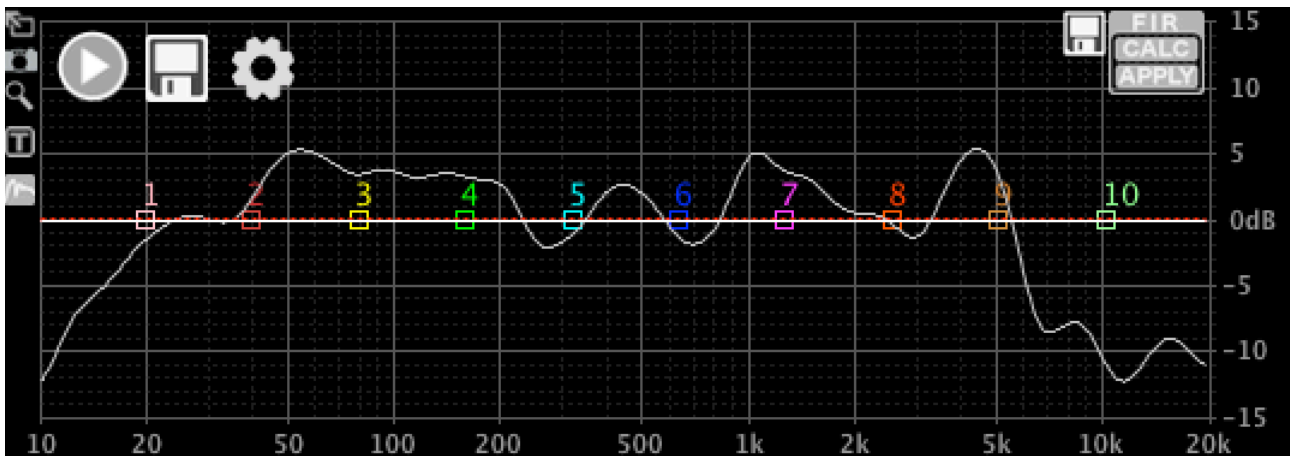
The RTA function will be enabled. To start the measurement, click Play:



This will start the RTA with the default settings. A measured response will be shown:

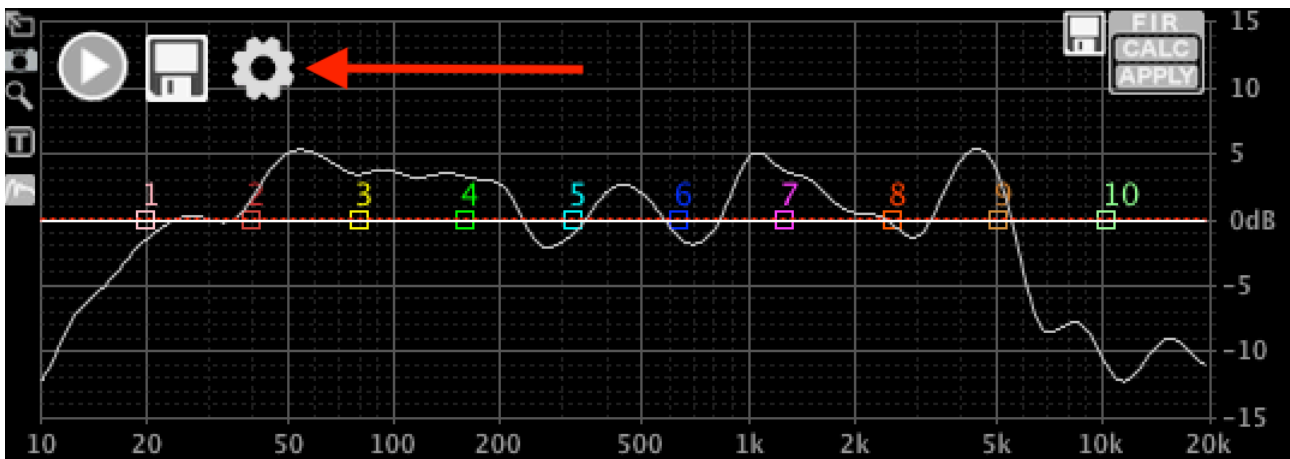


Click Pause to stop measuring:

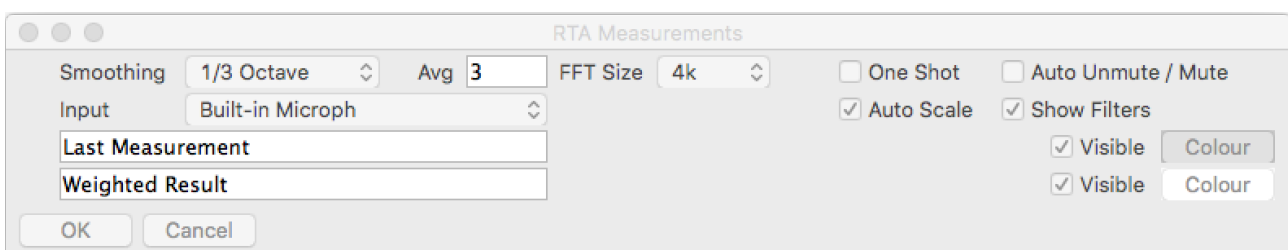


## MEASUREMENT OPTIONS

Now that you have made a first measurement, let's have a look at the measurement options. Click the Settings button:



A window will open with the measurement options:



- **Smoothing:** Choose the frequency smoothing. For manual measurements and settings, 1/6th or 1/3 Octave is recommended. For automatic FIR adjustment, this may lead to unexpected results due to room interference; in this case, a setting of 1/2 to 1 Oct is recommended.
- **Avg:** Choose the number of measurements that are averaged. The averaging function is a moving average over Avg samples. For fast indications, 1 to 5 is OK; for accurate measurements, you may want to increase this value to 10 or more.
- **FFT size:** The size (length) of the sampled data. With a size of 4k, lower frequencies are not accurately measured, but the measurement is fast. Larger size leads to more accuracy in the low region, but longer measurement times. To see the accuracy, try setting the smoothing to "Off"; then you will see the actual data points.
- **One Shot:** When selected, one reading consisting of "Avg" measurements will be taken. When deselected, the measurement is continuous.
- **Auto Mute / Unmute:** When selected, the software will automatically mute the hardware at the end of each measurement, and unmute it before the next measurement. Use this in combination with the One Shot setting to go easy on your neighbours.
- **Input:** Select the source for the measurement. A proper measurement microphone is recommended; the measurement is only as good as the microphone.
- **Auto Scale:** Manual scale is not supported yet. Please leave this check box selected.

- Show Filters: When deselected, the filter (PEQ, HPF, LPF, FIR) response curves will not be drawn.

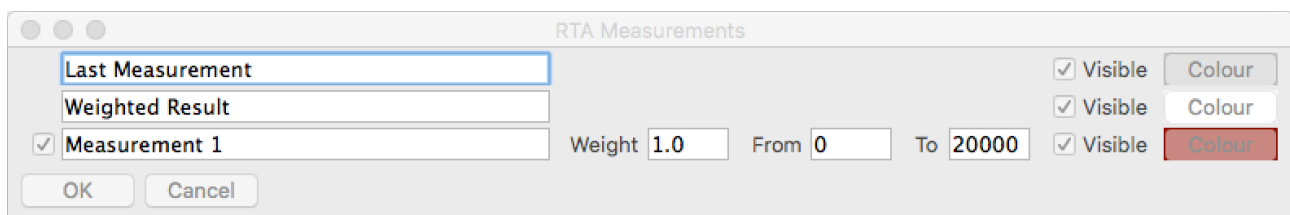
Below the options, a list of saved measurements appears. When no measurements have been saved yet, only the default curves are listed:

- Last Measurement: This is the as-yet-not-saved measurement. Select if it is visible or not by clicking "Visible"; select the colour by clicking "Colour".
- Weighted Result: When saving multiple measurements, these can be combined into one Weighted Result. Select visibility and colour here.

Feel free to play around; it will not explode.

### SAVING AND COMBINING MULTIPLE MEASUREMENTS

After making a measurement, look at the curve and see if it is plausible. Measurements can be distorted by nearby objects (walls, floor, people, bookshelves). Try measurements in different places to see what happens. When you are satisfied with a measurement, click the Save button.

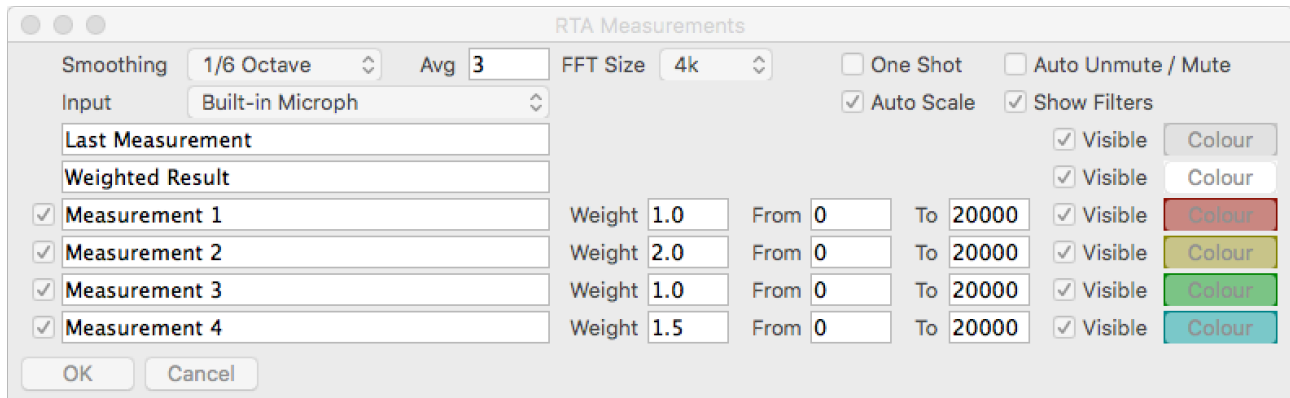


One more line is added to the measurements. You can set some options:

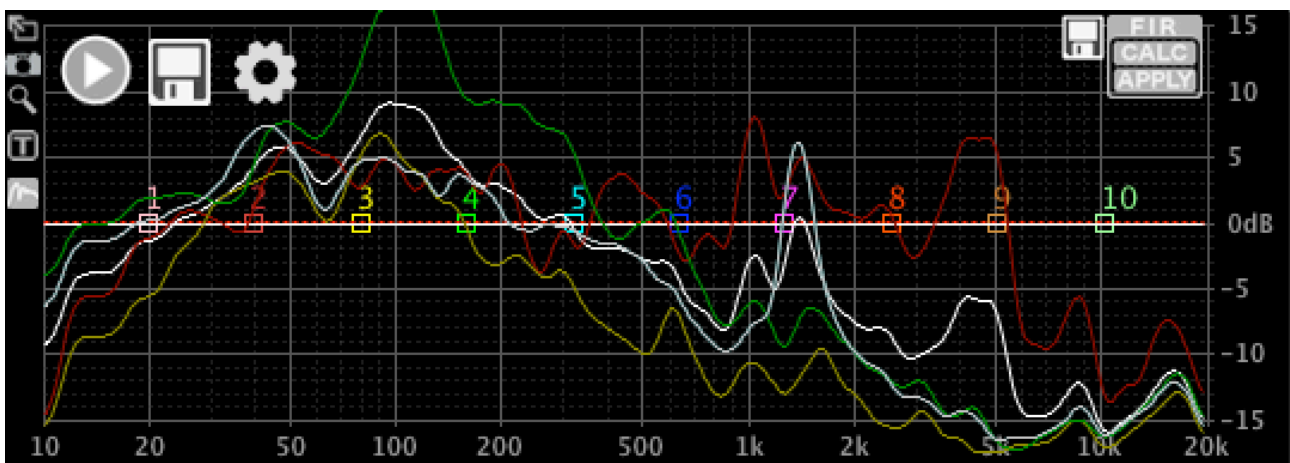
- Enabled: When deselected, this measurement will not be visible and will not be taken into account for the weighted result.
- Name: You can set the name for each measurement.
- Weight: The weight of each measurement determines the relative importance of each measurement when calculating the weighted result. For instance: When you have one measurement with weight 2 and another with weight 1, the first measurement will be twice as influential in the result. Choose any number other than zero.
- From: The bottom end of the frequency range where this measurement is used. More on this on the next page.
- To: The top end of the frequency range where this measurement is used. More on this on the next page.
- Visible: When deselected, the measurement will not be visible, but will still be taken into account for the weighted result.
- Colour: Select the colour of the displayed curve plot.

Normally, one would make several measurements, e.g. for different listening positions to take the room into account, or from different angles w.r.t. the loudspeaker to take the directivity of the loudspeaker into account. I will not go into the details of why and how to measure for optimal results; that is not the scope of this document, and there is plenty of information on that in the Internet.

After saving several measurements, the Settings window looks like this:

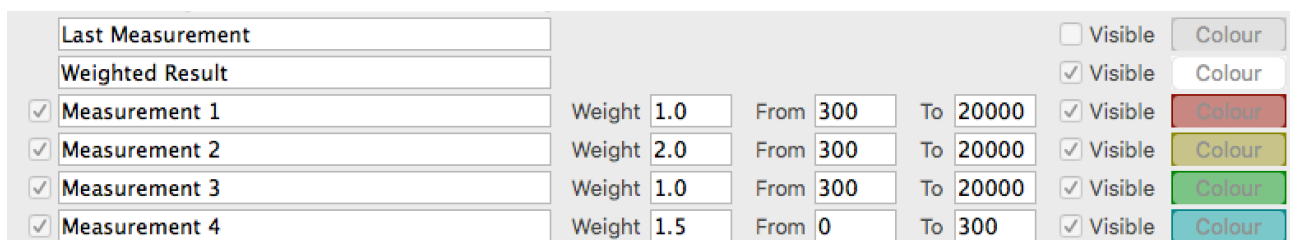


And the graphical window like this:



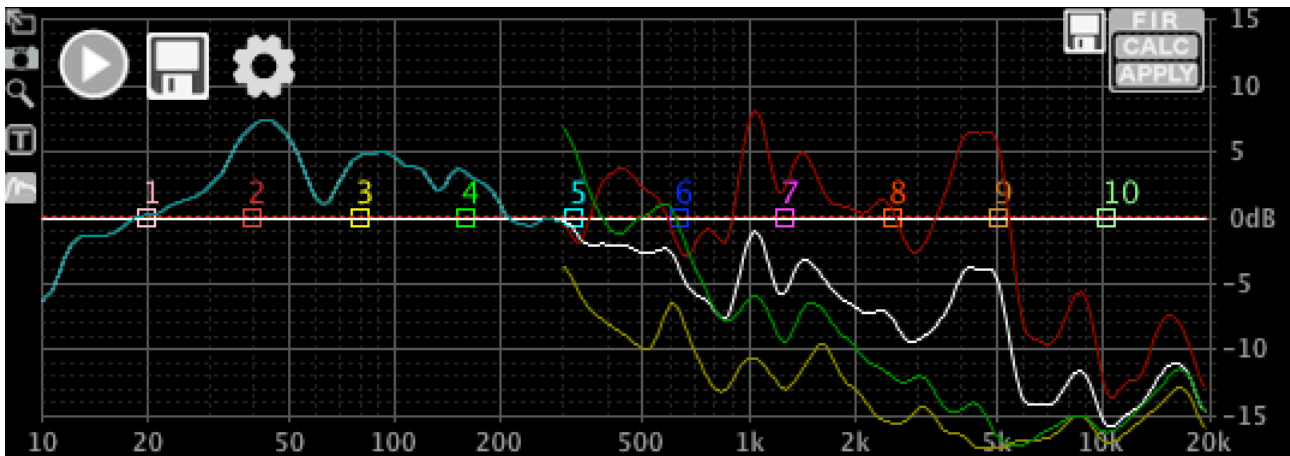
Now you can combine these measurements into one averaged result. In the image above, measurements 2 and 4 have a greater weight than the other two; these would be e.g. on-axis results, or my favourite listening position.

Now let's assume that measurement 4 (the blue one, also the last one, so shown light grey here) was done close to the woofer, and I think this data is very useful for the low end up to 300Hz, but irrelevant for the rest of the frequency spectrum; and the other measurements are relevant for 300Hz and higher. I can see the "From" and "To" fields like this:

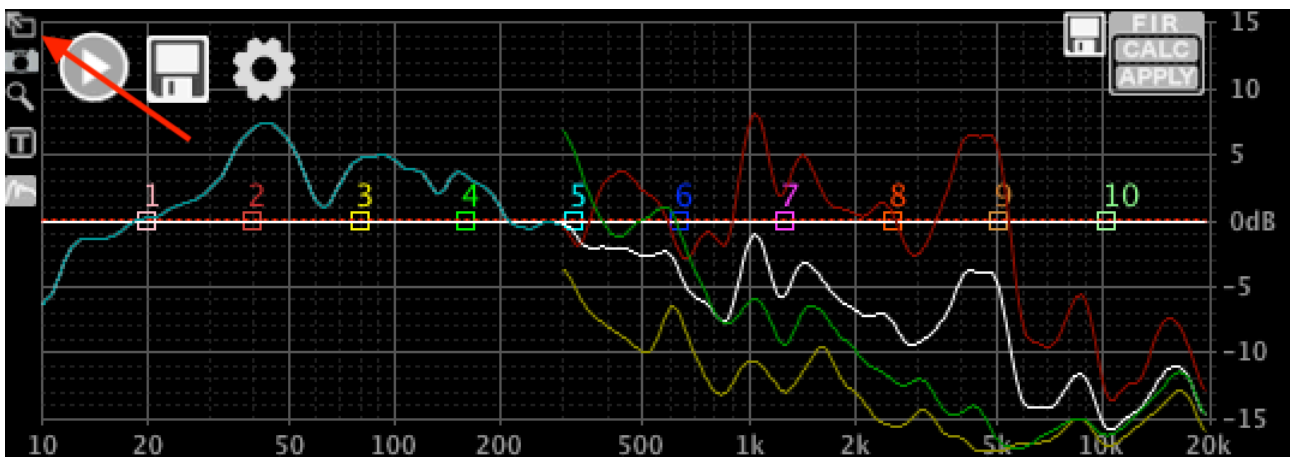


I also set the Last Measurement to invisible so as not to be in the way, since I am done measuring for now.

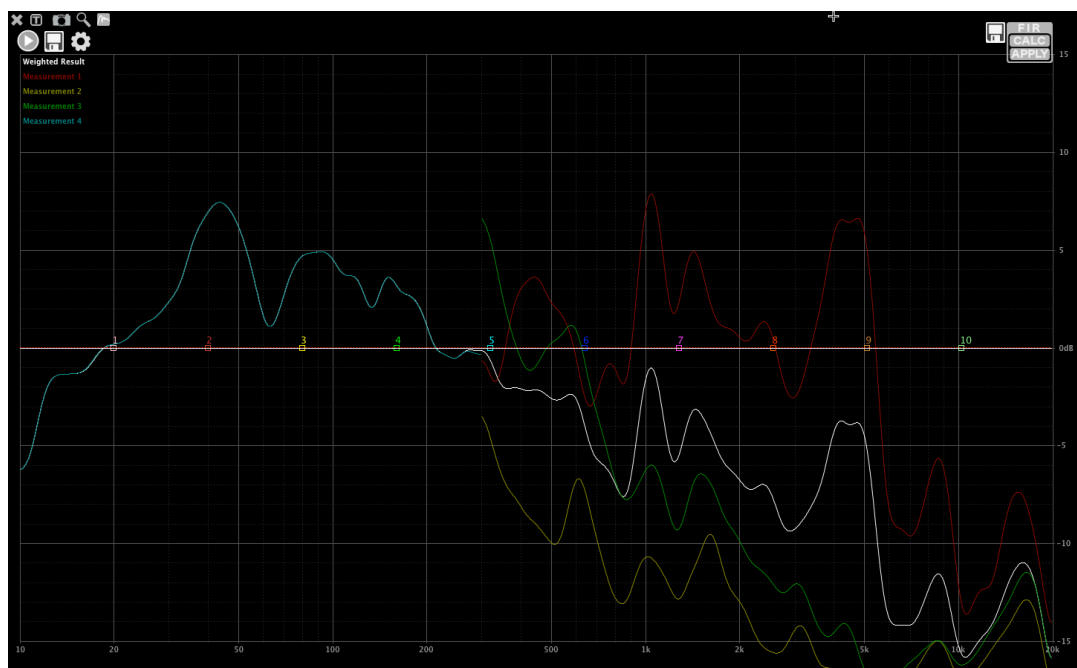
The graphical window will look like this:



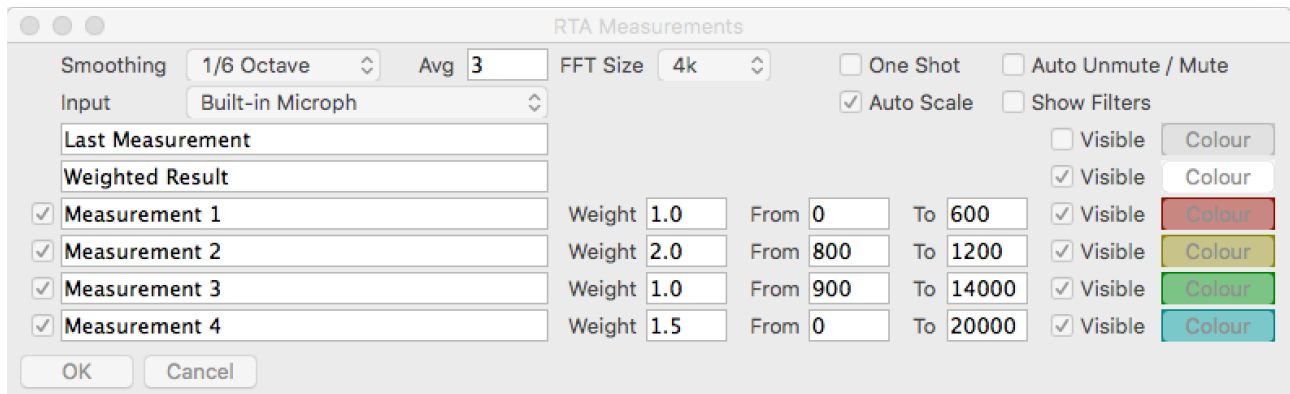
For more detail, I will go to Full Screen Mode. Click the Full Screen button:



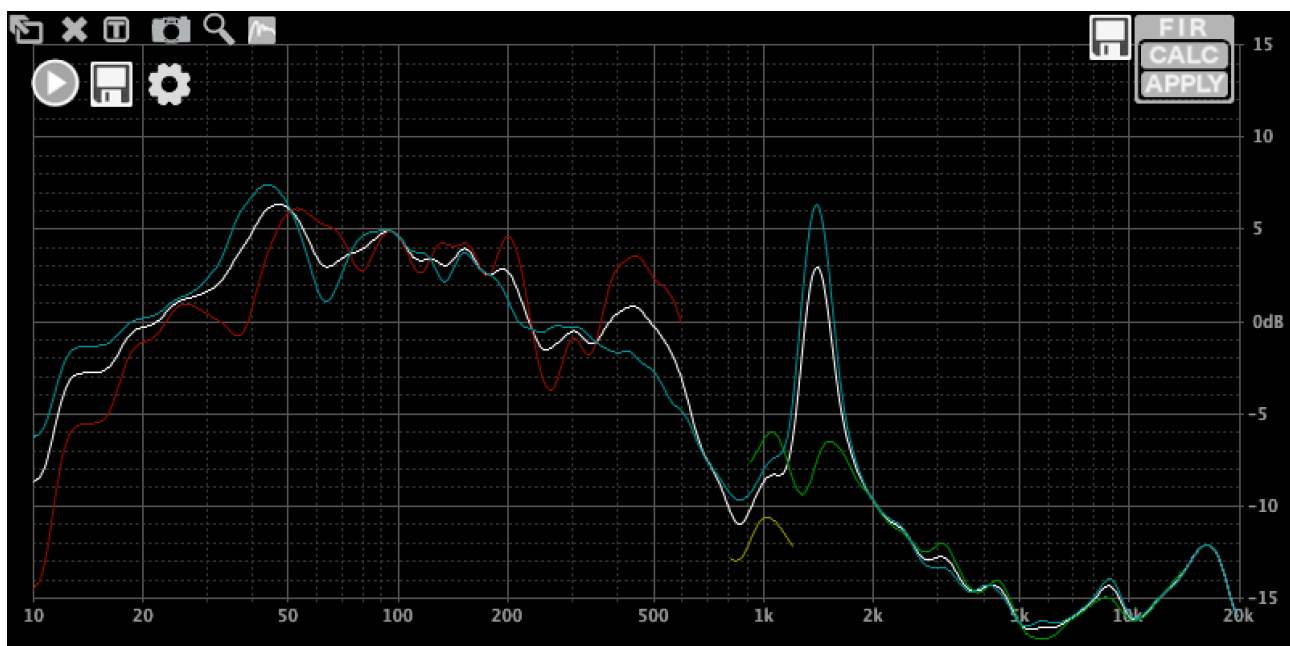
The graphical window will fill the size of the unit panel. Click the same button again to use the whole display area for maximum detail.



You can play around with different frequency and weight settings to reach the desired weighted result. One more example: Settings:



And the result:



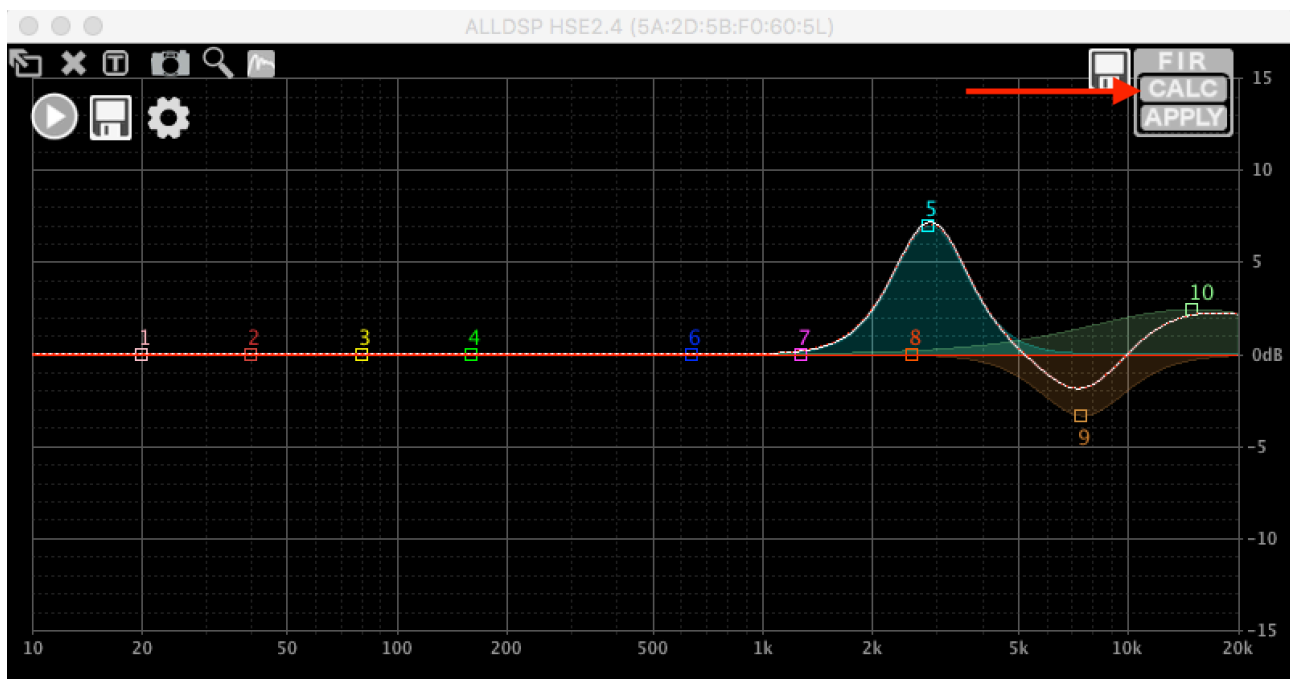
## Using FIR filters

There are 3 ways to define a FIR filter in ALLCONTROL: Load from a file, create by using PEQs and crossovers to draw a target response, and by inverting the RTA measurement.

When a unit is connected, the filter that is loaded will be shown on the display as a white line. In this example, no FIR filter has been loaded yet. Let's change that, shall we?

### CREATING A FILTER FROM PARAMETRIC EQUALISERS

First, set some PEQs to create a target response, then click "CALC" in the FIR corner:



A pop-up window will appear with some options:

- **Number of taps:** You can select how many taps of the FIR filter are used. More taps means more accuracy in the low end, but also means that the filter will cause more latency. The filters we generate are all linear phase with a symmetrical impulse response, and the latency is therefore equal to half of the filter length.
- **Currently active filter:** You can add to the filter that is currently active in the hardware, or you can start from scratch by deselecting this option.
- **HPF, LPF and PEQs:** You can choose which filter will be converted to FIR and which will be ignored. It is common practice to use IIR for low frequencies and FIR for higher frequencies to keep the latency down to a minimum.
- **Track changes:** The FIR calculation will be updated automatically as you change PEQs.
- **Invert RTA measurement:** We will come to that later.
- **Data from File:** We will come to that later.

Select the items you would like to include in the filter:

Number of Taps:  (0.01ms latency)

☒ Currently active FIR filter (unchecked to reset FIR filter)

☒ High Pass Filter

☒ Low Pass Filter

☒ PEQ 1

☒ PEQ 2

☒ PEQ 3

☒ PEQ 4

☒ PEQ 5

☒ PEQ 6

☒ PEQ 7

☒ PEQ 8

☒ PEQ 9

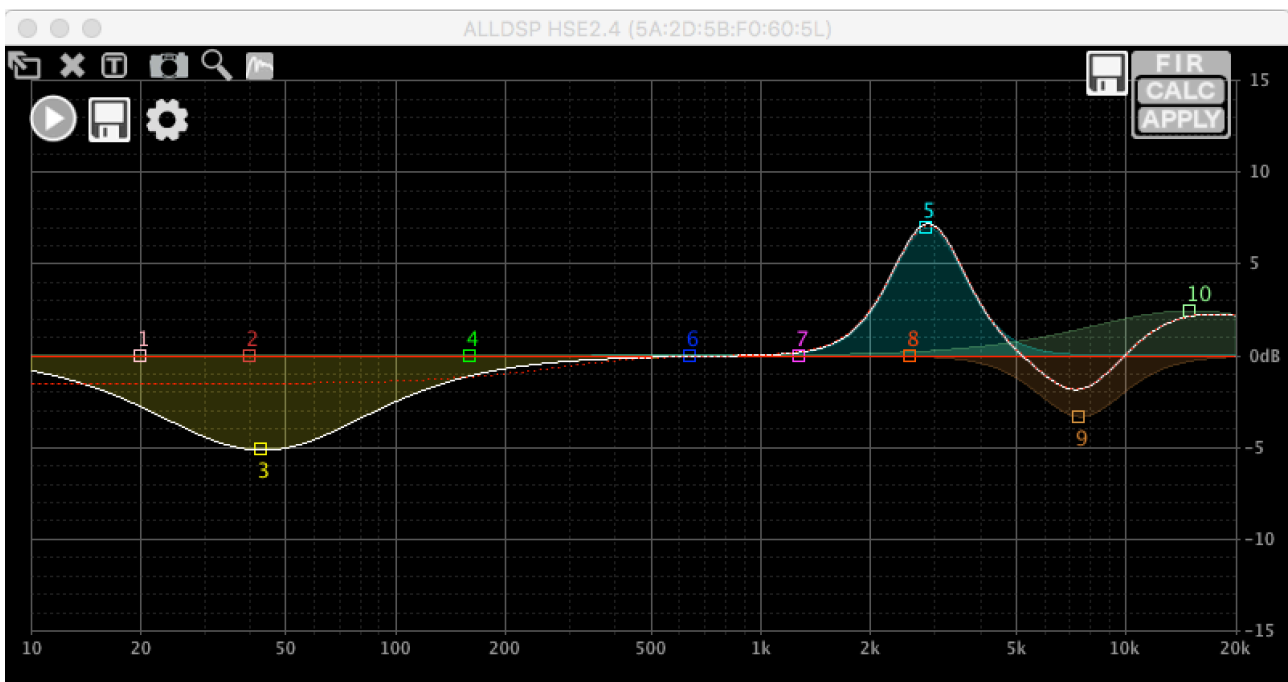
☒ PEQ 10

☒ Track Changes

☐ Invert RTA Measurement

☐ Data from File

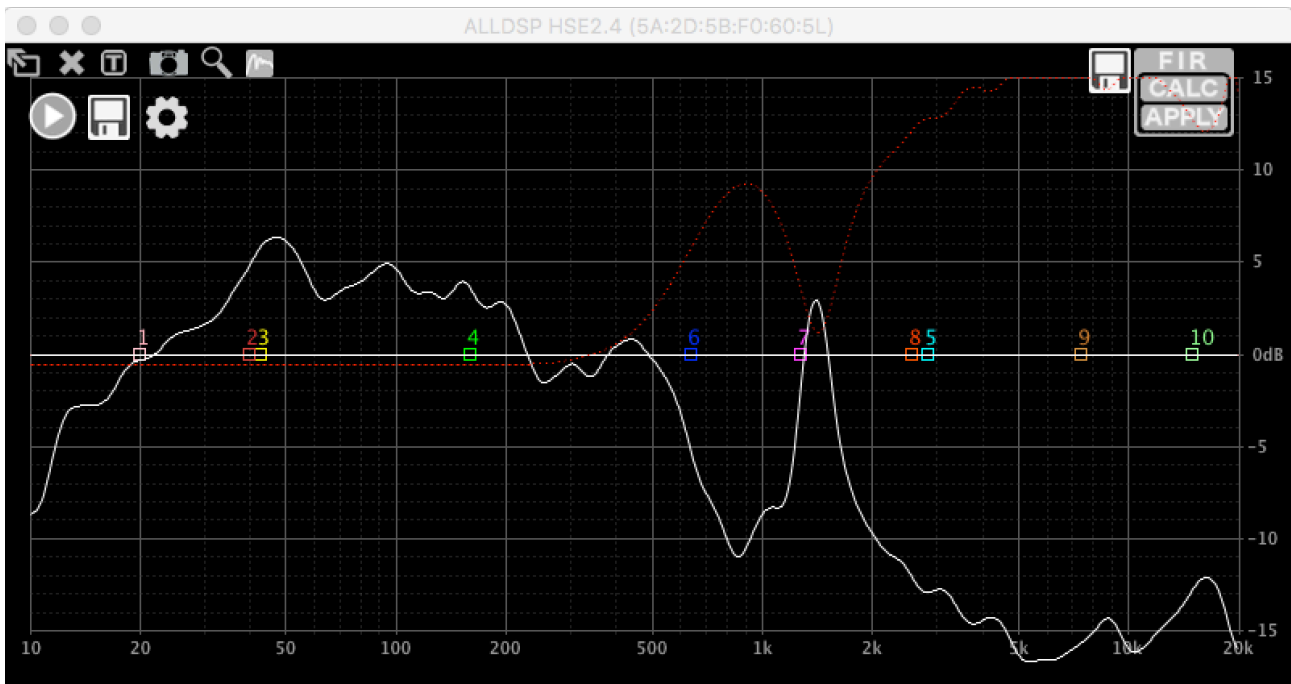
Select 256 taps (the maximum number for the hardware that is used for this example), deselect "Currently Active FIR filter" and click OK. In the graphical screen you will see a dotted red line indicating the calculated FIR response. As you can see in the screenshot above, it is perfect as far as the display resolution allows us to see. The red dotted line is the calculated response from the FIR coefficients; so any deviations will be visible here. This becomes clear when we try to use this FIR filter to change the low frequency response:



As you can see, the deviation below 200Hz is quite serious. In other words: A 256 tap FIR filter is useless in this frequency region. Which is to be expected, it is caused by the "finite" in the name FIR. You can use the red dotted line to see the result of the approximation.

## INVERTING THE RTA MEASUREMENT

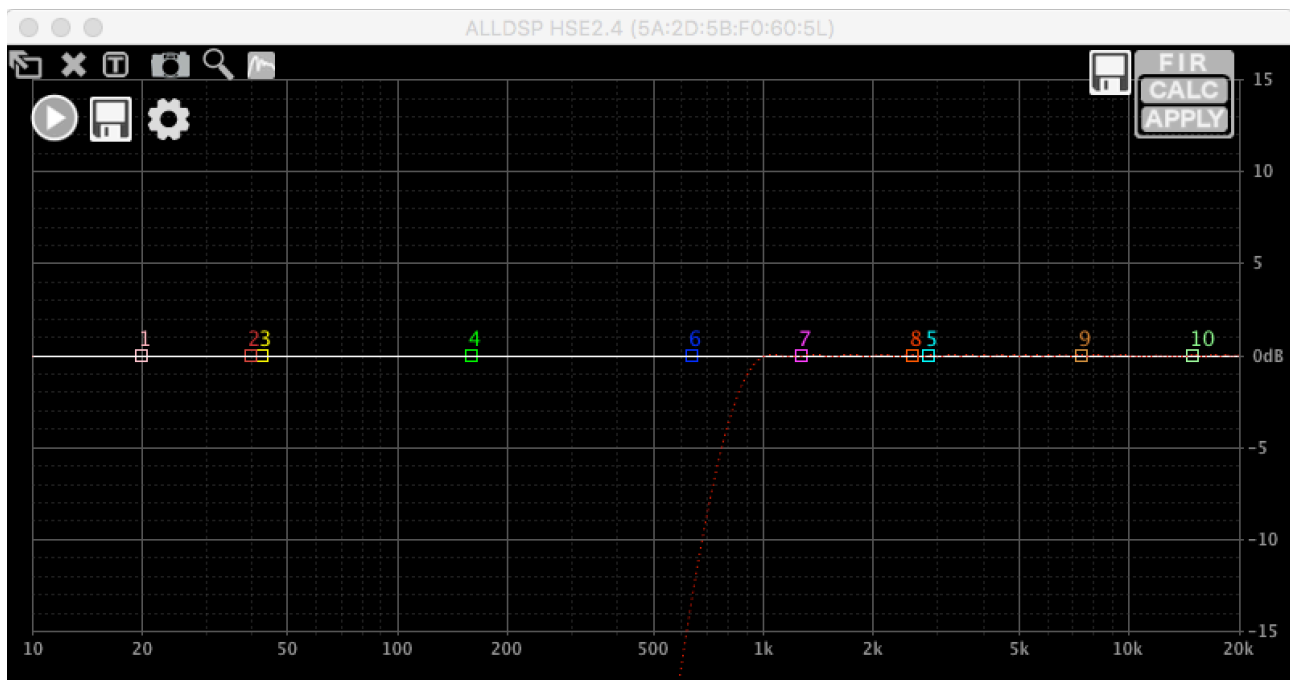
We can also create a filter by inverting the RTA measurement. Using the measurement we did in the previous chapter, the result looks like this:



As you can see, it only works above appr. 300Hz. Below that, the response is automatically reduced, taking the amount of taps into account. The red dotted line again shows the expected response.

### LOADING A FILTER FROM A FILE

Click CALC, then "Load File". Select your file. If the number of taps in the file fit in the FIR filter, it will be loaded automatically. If the number of taps exceeds the available filter size, the filter will be truncated. ALLCONTROL supports 24 and 32 bit fixed point files, and floating point files. Any lines that do not contain a number (such as comments) will be ignored. You can generate FIR files with many 3rd party programs, or even online. Here is a 1k HPF, generated with ScopeFIR:

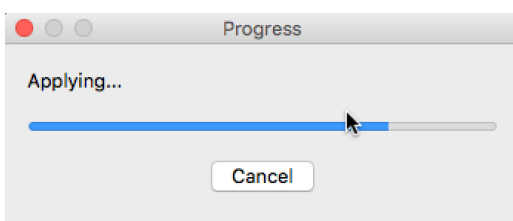
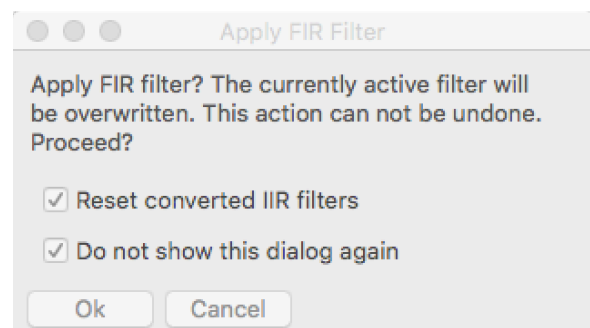


Again, the dotted red line indicates the calculated frequency response.

### SENDING A FILTER TO THE HARDWARE

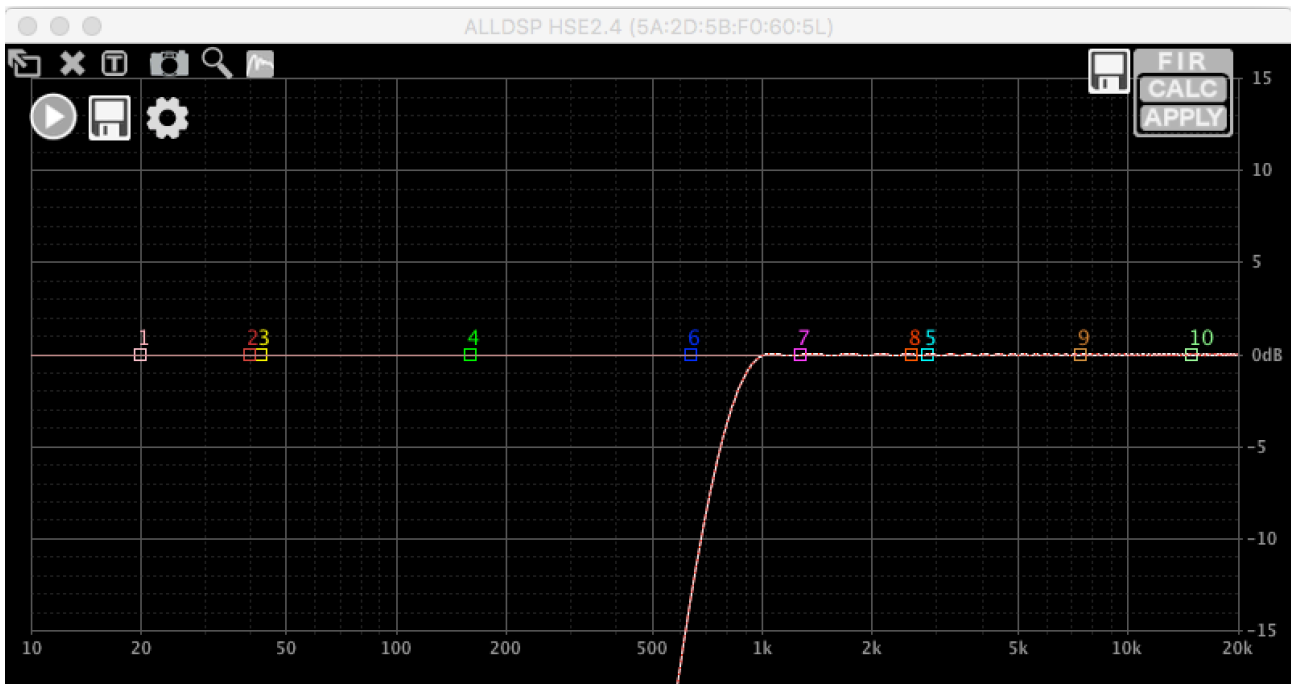
When you are satisfied with the response indicated by the red dotted line, click APPLY to send the filter to the hardware. A window will appear with two options:

- Reset converted IIR filters: When selected, the software will automatically disable the IIR filters that were converted to FIR.
- Do not show this dialog again: Speaks for itself, doesn't it?



The communication can take some time to complete, depending on filter size and connection speed.

If no other filters are active, the response will be shown as a white line:



When you add PEQs now, you will see the white line will follow the PEQs, as well as the red dotted line; the red dotted line is the newly calculated FIR filter, following the changes you are doing with PEQs, and the white line is the overall frequency response. If some PEQs are not taken into account in the FIR calculation, the white line will include them (because that is the overall frequency response) but the red dotted line will not. There will also be a solid red line, which is the response of the FIR filter that is currently loaded in the hardware:



## SAVING FILES

Click the disk icon next to the FIR block to save a filter as a text file. The filter that is loaded in the hardware will be saved to disk, and can be loaded into other channels or saved for later use. Here is the FIR file of this example (omitting most coefficients):

FIR filter generated by ALLDSP ALLCONTROL software. Sample rate: 48828Hz, 255taps

```
-0.00251117721317
0.000136785209243
0.000140666030413
0.000148858875106
0.000161494128481
0.000177634880029
0.000197263434621
0.000219509005649
0.00024409592163
0.000270059332377
0.000297261402149
0.00032448116705
0.000351532362565
0.000377209857282
0.000401332974621
0.000422636978525
0.000440970994737
0.000454998575363
0.000464653596498
0.000468616374055
0.000467024743774
0.000458568334793
0.000443564728109
0.00042071472873
0.00039056222904
0.000351847149596
0.000305717811131
0.000250644981978
0.000188274309127
0.000117114745135
3.95923853105e-05
-4.697032275e-05
-0.000135075300995
-0.000237385742477
-0.000340500846664
-0.000444556586651
-0.000553787686189
-0.000663964078139
-0.000775675289694
-0.000885844231064
-0.000994163565801
-0.00109791569463
-0.00119658745881
```

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## Conclusion

We believe that these functions provide you with powerful tools to use FIR filters and RTA measurements conveniently. Development is ongoing (as always), so functionality will be added in the future.

The examples in this document were made with software version 3.8.23 build 117010. Earlier software versions will have more limited functionality. Please always upgrade to the latest version as found on <https://www.alldsp.com/software.html>