WAN_0218

Implementing ReTune™ with Wolfson Audio CODECs

INTRODUCTION

ReTune™ is a technology for compensating for deficiencies in the frequency responses of loudspeakers and microphones and the housing they are mounted in. The implementation of ReTune™ on a Wolfson Microelectronics IC is in the form of a special filter. In order to achieve the desired results, it is necessary to program this filter with a set of coefficients which are tailored to the specific product. This process is non-trivial, but is largely automated by the Wolfson Interactive Setup and Configuration Environment (WISCE™) tool.

The process does however require some user involvement, as it is necessary to set up the correct hardware to allow some acoustic measurements to be made on a product prototype. The acoustic measurements are made by WISCE™ itself, via a soundcard interface. This document focuses on the setup and calibration process for the ReTune™ measurement.

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APPLICATIONS

The two primary application areas for ReTune™ are microphone equalisation and speaker equalisation. It is possible to incorporate both of these functions into a product, although it may not be possible to implement both simultaneously. Similarly, mono or stereo modes of operation are both possible although stereo operation may use the same coefficients for both channels depending on the device. If there is only one set of coefficients for both channels then the average of the measurements for each channel should be used (average of the coefficients).

Other applications are also possible, as it is possible to equalise any signal processing chain with ReTune™.

ReTune™ cannot correct for non-linear behaviour, such as rattling due to loosely fitted components, or speaker distortion. These aspects should be attended to prior to using ReTune™. It is recommended that any resonance in the speaker or microphone frequency response be removed using a notch filter before running ReTune™. If required, WISCE™ can be used to find the resonances in the microphone or speaker by running the ReTune™ measurement.

ReTune™ is intended to be used as a design and development tool and is not intended to be used in a production environment. The product being tested should have all the other components of the product present, although they do not need to function. This is necessary as an empty shell will have different acoustic properties to the final product.

EQUIPMENT REQUIRED

The following equipment is required for the measurement of microphones and speakers.

1. Reference Microphone: Behringer ECM8000 or equivalent. http://www.behringer.com/EN/Products/ECM8000.aspx
2. Mic pre-amp and Soundcard: M-Audio Mobile Pre USB Soundcard. http://www.m-audio.com/products/en_us/MobilePreUSB.html
3. Speaker: Sony SRS M50

   http://www.sony.co.uk/product/cpp-speakers/srs-m50 (Speaker includes integrated amplifier)
4. Stands/tripods for the reference microphone and device under test (DUT) as required.
5. Stands for reference speaker as required
6. Cables : Mic to soundcard: XLR-XLR (male to female)
7. Wolfson Evaluation software – WISCE™, version 2.0 or higher.
8. Software to view Audio files such as Audacity or Adobe Audition. If the Indirect method of measurement is used then software to convert video files to audio files in Windows WAV format and to convert Windows WAV format to audio/video format to suit the format of the (DUT). This should be supplied by the Customer.

Note: If only a product speaker is required to be equalised then the Reference (REF) speaker is not required.

SPEAKER EQUALISATION

This section describes how to set up the acoustic measurement environment so that WISCE™ can make measurements for speaker equalisation. Also described is the hardware set-up and the rules which must be followed in order to get satisfactory results. Running the various test modes will be covered in the Measurement Procedure section.

There are two methods of measuring the speaker response; the Direct method where wires are connected to the speaker mounted in the housing and the wires routed out of the housing to a power amplifier or soundcard; and the Indirect method where the test files are stored on a storage card that can be read by the DUT e.g. SD card, and used in the DUT to complete the measurement. The advantage of the Indirect method is that the housing does not have to be modified to get wires in and out of the housing which could affect the acoustic performance of the housing.

To ensure correct operation of the ReTune™ measurement all features in the product likely to modify the frequency response or gain such as dynamic range control (DRC), automatic gain control (ALC), EQ filters, etc should be disabled. Note that if a notch filter is used to reduce the amplitude of any speaker resonances then these should be enabled.

DIRECT METHOD

The REF microphone is connected to the pre-amplifier and the output from the pre-amplifier connected to the soundcard LEFT input channel. The DUT speaker inside the prototype is connected using a cable to a power amplifier connected to the LEFT output channel of the soundcard, as shown in Figure 1. Note that this power amplifier may be part of the product being tested or it can be a Wolfson customer evaluation board set for analogue input to analogue output. The wires should be screened to prevent interference. It is important when wiring to the speaker that the acoustics are not changed by the presence of the wire, or any holes or channels which are made to accommodate it.

For a product with stereo speakers, each speaker can be characterised in turn by running the ReTune™ design process for each speaker separately. If there is only one set of coefficients in the CODEC then the coefficients can be averaged manually to get the values to use in the CODEC.

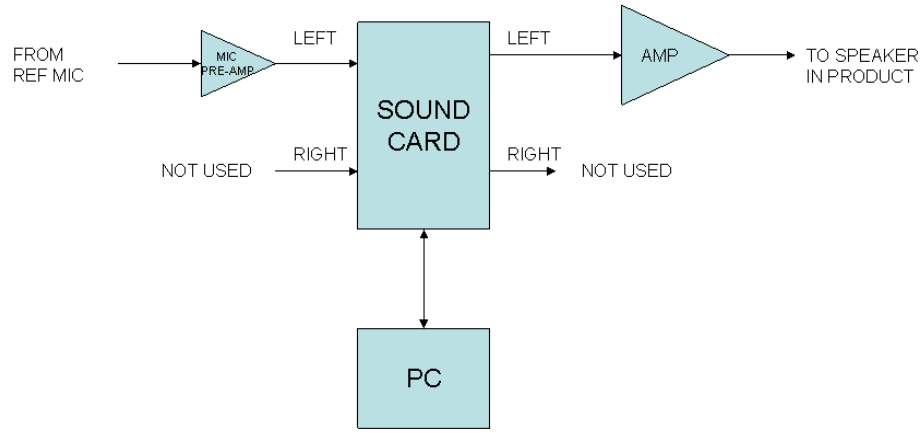


Figure 1 Direct Speaker Measurement

There are four important rules to obey:

Rule 1: The microphone should be positioned at a position at which the optimum equalisation is required. For example, in a DUT that has a speaker mounted on top of the camera, the microphone should not be held above the camera, since this is not the primary direction of interest. Instead, the camera should be held in its normal upright position, and the microphone should be behind the camera, at a distance that the user would normally be.

Rule 2: The distance from the microphone to the DUT should be as small as possible, consistent with Rule 1, in order to maximise the direct-path signal. A good rule is that the spacing between the microphone and DUT should be around 4 times the width of the DUT, as shown in Figure 2.

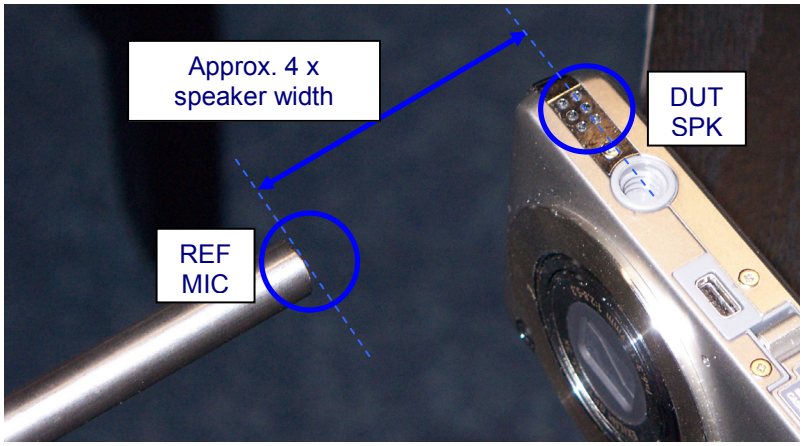


Figure 2 Microphone Positioning for Speaker Measurement

Rule 3: Reflecting surfaces should be kept as far away from the DUT and microphone as possible. Ideally, the DUT and microphone should each be mounted on a separate tripod and positioned in the centre of the room, at a height which is equidistant from the floor and ceiling. This maximises the time before the first room reflection is received. WISCE™ removes the effects of room reflections, but it is best to minimise these at source.

Rule 4: The room should be as quiet as possible.

INDIRECT METHOD

In the indirect method, the potential problems of wiring to the speaker are avoided, but this method can only be used if the DUT has the ability to playback audio from a memory card, for example an SD-card, to the speaker. In this mode, the measurement process is similar to the direct method, except that the speaker signal is recorded on the memory card by WISCE™. The memory card is inserted into the DUT and the file played back through the DUT speaker. WISCE™ deals with the lack of synchronisation automatically.

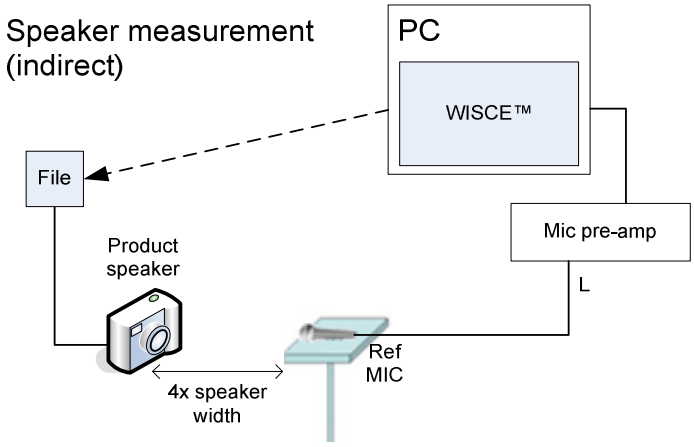


Figure 3 Direct Speaker Measurement

Note that the file format used by WISCE™ is the standard Windows WAV format and any recorded file to be played back in the DUT will have to be converted to a suitable audio or video format before completing the WISCE™ measurement. Suitable software is required for this.

The recording format used should maintain the highest possible quality. In general, uncompressed audio formats are preferred, but if lossy compression is used (for example MP3 or MPEG4), the highest bit-rate option (largest file size) should be chosen.

MICROPHONE EQUALISATION

This section describes how to set up the acoustic measurement environment so that WISCE™ can make measurements for the DUT microphone equalisation.

There are two methods of measuring the microphone response;

- Direct method where wires are connected to the microphone mounted in the housing and the wires routed out of the housing to the soundcard. The advantage of the direct method is that the speaker can be driven directly from the soundcard.
- Indirect method where the recorded file is stored on a memory card that can be written to by the DUT e.g. SD card, and used by WISCE™ to complete the measurement. The advantage of the Indirect method is that the housing does not have to be modified to get wires out of the housing which could affect the acoustic performance of the housing.

To ensure correct operation of the ReTune™ measurement when using the indirect method all features in the product likely to modify the frequency response or gain such as dynamic range control (DRC), automatic gain control (ALC), EQ filters, etc should be disabled.

DIRECT METHOD

The basic principle of the Direct method of measurement implemented by WISCE™ is shown in Figure 4. The DUT microphone is connected to a pre-amplifier connected to the RIGHT input channel of the soundcard. Note that this pre-amplifier may be part of the product being tested or can be a Wolfson customer evaluation board configured for analogue input to lineout. The wires should be screened to prevent interference. The pre-amplifier should also provide any bias for the microphone. Ideally, the microphone bias circuit should be identical to that which will be used in the product. It is important when wiring out the microphone that the acoustics are not changed by the presence of the wire, or any holes or channels which are made to accommodate it.

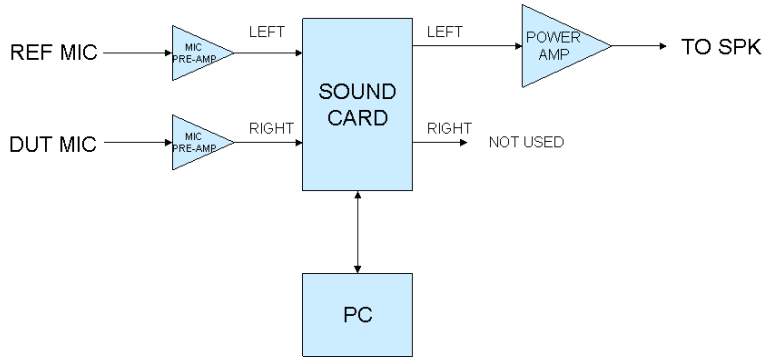


Figure 4 Direct Microphone Measurement

A second Reference (REF) microphone is positioned very close to the DUT microphone (as shown in Figure 5) and is connected to the PC via the LEFT channel of the soundcard.

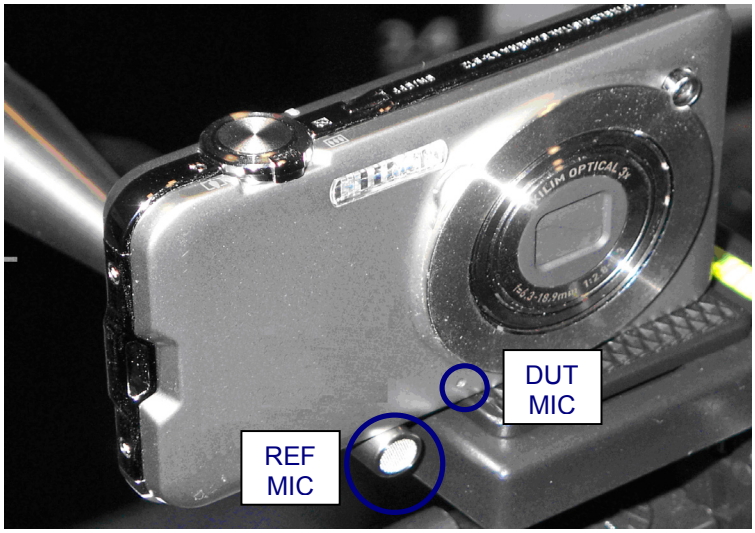


Figure 5 Speaker Positioning for Microphone Measurement

For a product with stereo microphones, each of the microphones should be measured in turn, with the full ReTune™ design process being run for each separately. If there is only one set of coefficients in the CODEC then the coefficients can be averaged to get the values to use in the CODEC.

A LEFT audio output from the PC is connected to the reference speaker (REF).

There are four important rules to obey:

Rule 1: The speaker should be positioned so that it points towards the DUT from the angle at which the optimum equalisation is required. For example, in a Digital Stills Camera (DSC) that has a microphone mounted on top of the camera, the speaker should **not** be held above the camera and pointed down at it, since this is not the primary direction of interest. Instead, the camera should be held in its normal upright position, and the speaker should be in front of the camera, pointing back towards it.

Rule 2: The distance from the speaker to the DUT should be as small as possible, in order to maximise the direct-path signal, but should not be so close that the speaker ceases to be a reasonable approximation to a point source. A good rule is that the spacing between the speaker and prototype should be around 4 times the width of the speaker, as shown in Figure 6.

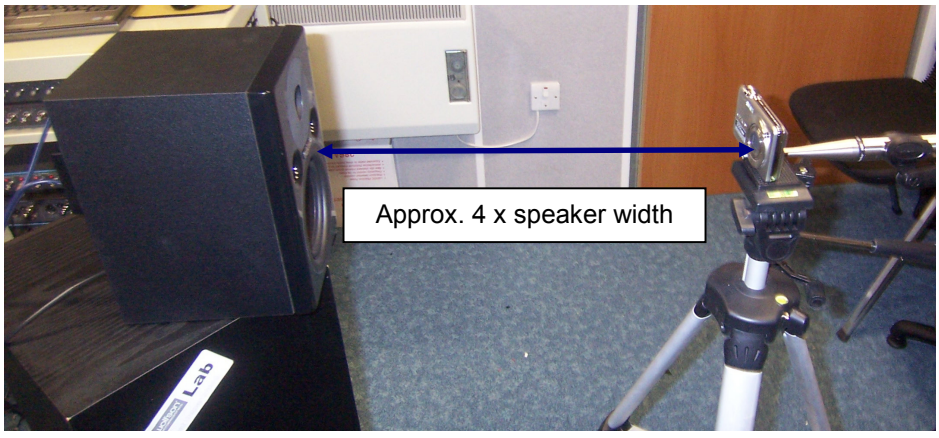


Figure 6 Speaker Positioning for Microphone Measurement

Rule 3: Reflecting surfaces should be kept as far away from the prototype and speaker as possible. Ideally, the prototype and speaker should each be mounted on a separate tripod and positioned in the centre of the room, at a height which is equidistant from the floor and ceiling. This maximises the time before the first room reflection is received. WISCE™ removes the effects of room reflections, but it is best to minimise these at source.

Rule 4: The room should be as quiet as possible.

INDIRECT METHOD

In the indirect method, the potential problems of wiring out the microphone are avoided, but this method can only be used if the prototype has the ability to record audio from the microphone onto a storage card, for example an SD-card. In this mode, the measurement process is similar to the direct method, except that the microphone signal is recorded on the storage card and processed by WISCE™ as a separate step. WISCE™ deals with the lack of synchronisation automatically.

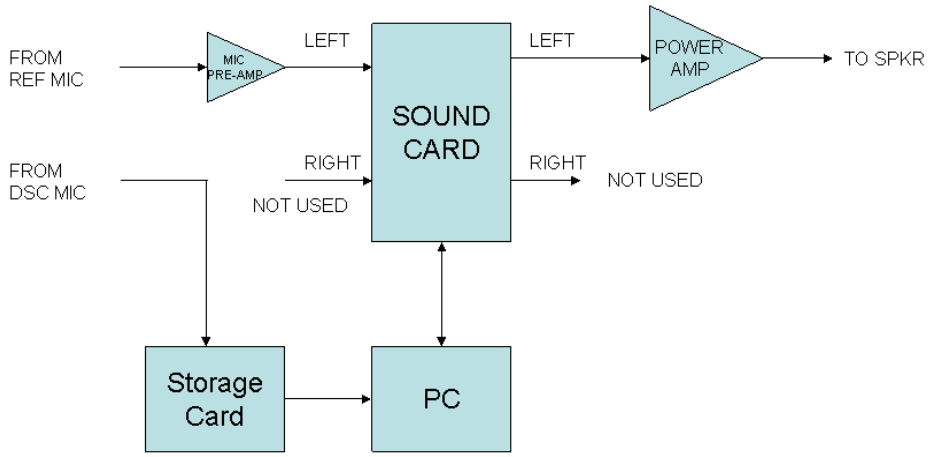


Figure 7 Indirect Microphone Measurement

The recording format used should maintain the highest possible quality. In general, uncompressed audio formats are preferred, but if lossy compression is used (for example MP3 or MPEG4), the highest bit-rate option (largest file size) should be chosen.

Note that the file format used by WISCE™ is the standard Windows WAV format and any recorded file from the DUT will have to be converted to this format before completing the WISCE™ measurement. The customer should have suitable software available for this.

PRE-AMPLIFIER SETUP

The hardware arrangements for measuring microphones and speakers are very similar and are described in this section. The equipment referred to is the equipment detailed in the Required Equipment section at the beginning of this document.

The microphone should be connected to the CH1 MIC XLR connector input on the back of the soundcard using the XLR cable as shown in Figure 8. The other end is connected to REF microphone (female).

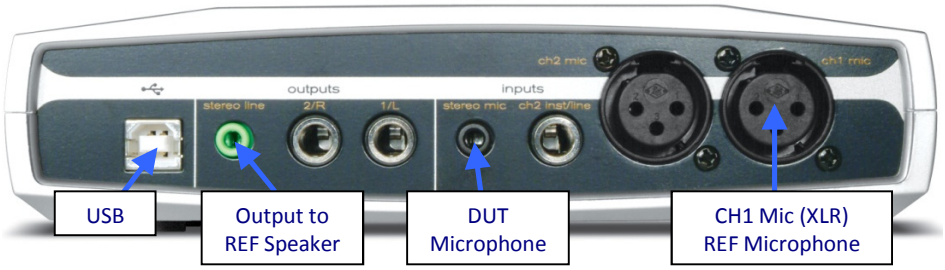


Figure 8 Microphone and Speaker Connection to the Soundcard

For microphone measurements the REF Speaker is connected to the Stereo Line output and the DUT microphone should be connected to the Stereo Mic input using the Right channel on the back of the soundcard as shown in Figure 8.

For speaker measurement the Stereo line output can be used to drive a power amplifier as this output cannot drive the speaker directly. Alternatively, the headphone output can be used to drive the power amplifier if a volume control is required (see Figure 9).

Note that a Wolfson customer evaluation board can be used as the power amplifier or as the microphone preamplifier. This should be configured to route an analogue input signal to the speaker driver or lineout (for microphones).

Figure 9 Soundcard Front Panel Connections and Microphone Volume Controls

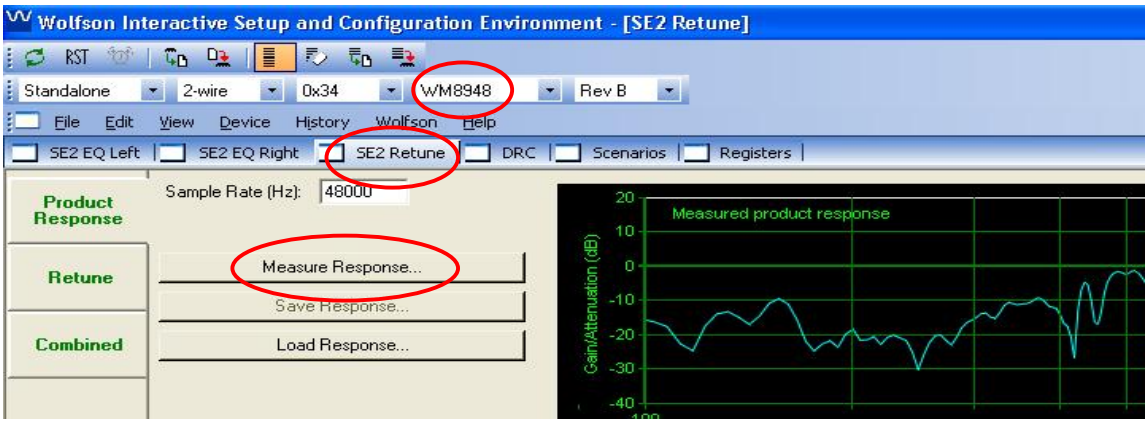
The soundcard is connected to the PC using a USB cable as shown in Figure 8. Check the Audio setup of the PC to make sure the M-Audio soundcard is selected for record and playback.

SETTING UP GAINS

This procedure assumes that WISCE™ has been successfully installed and is functional and the correct Device type has been selected (refer to WISCE™ Quick Start Guide which is installed in the same folder as WISCE was installed to, usually C:\Program Files\Wolfson Evaluation Software).

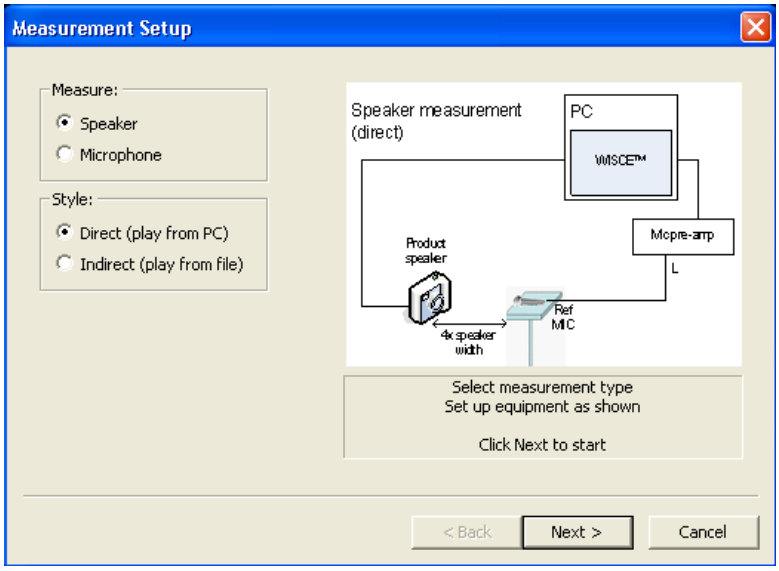
The gains must be set up correctly in the soundcard and on the DUT before running the ReTune™ measurement. This can be done using the WISCE™ software to generate the test signal and use Audacity or Adobe Audition or similar software to check the recorded sound levels. Ensure that the required equipment is set up as detailed in the previous section.

1. Set the PC playback volume to mid-range. Switch off any filtering that may be set for the analogue output.
2. Set the PC record volume at a low setting. Switch off any filtering or mic boost settings for the microphone.
3. Set the speaker volume control.
    a. If performing microphone measurement, set the REF speaker volume control to mid-range.
    b. If performing DUT speaker measurement, the DUT volume should be set to 0dB or maximum gain such that the speaker does not clip or cause the sound to be distorted. The Headphone volume on the soundcard can also be adjusted to control the volume.
4. Run WISCE™.
5. Ensure that the correct device is selected. If not load the device using the Device -> Load Device... and select the correct file.

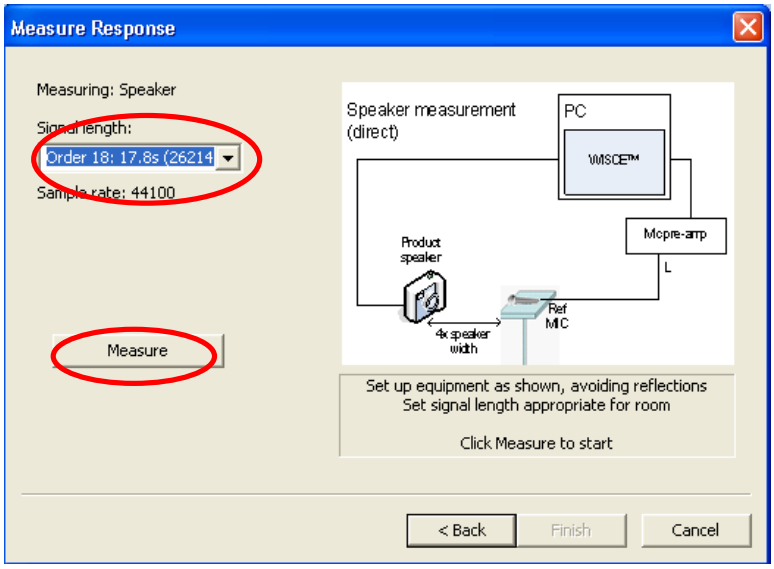


6. Select the 'SE2 Retune Filter' tab. The ReTune™ measurement is selected by clicking on the 'Measure Response' button.

7. Select 'Speaker' and 'Direct (play from PC)' and click 'Next'.



8. Select the burst signal length from the drop-down menu. Select a longer value as this gives more time to set the gain levels.



9. Click on the 'Measure' button and the burst signal should be heard through the speaker.
10. Adjust the soundcard Channel 1 volume control for the REF microphone so that the signal level recorded by Audacity, or similar software, is near the maximum level but is not clipping. It may be necessary to adjust the speaker volume and/or the record volume on the PC as well. The same process should be used to adjust the signal level from the DUT microphone if required.
11. After the burst has finished, WISCE™ the burst signal length should be set back to the required level for the measurement.
12. Click on 'Finish' to complete the WISCE™.
13. If using the indirect measurement then check the recorded file for clipping using Audacity or similar software. If the file is clipped then reduce the volume levels and repeat steps 10 to 13 until the recorded file shows no clipping.

MEASUREMENT PROCEDURE

The same basic measurement principle is used for microphone and speaker measurement. A special test signal consisting of a short burst of audio signal is generated by WISCE™. This is either output to the REF speaker for product (DUT) microphone measurement or to the product (DUT) speaker for speaker measurement. Alternatively, if Indirect speaker measurement is used the burst is written to the storage card and used by the product (DUT).

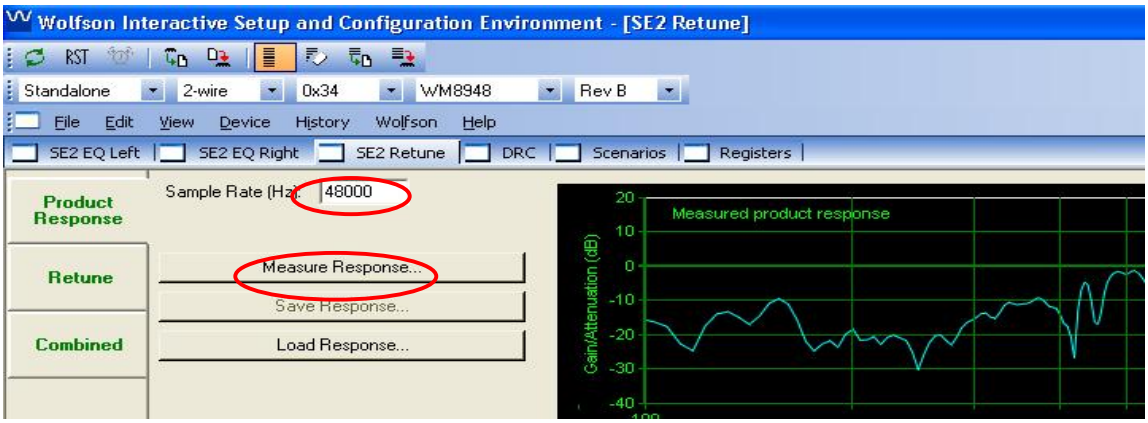
INITIAL SETUP

The following common steps should be performed first for all measurement modes.

1. Set up the measurement hardware as described in previous sections.
2. Disable any advanced audio features of the soundcard, such as 3D stereo effects, equalisation, AGC, bass boost etc.
3. Select the required output for the speaker and MIC input for the reference microphone.

WISCE™ SETUP

1. Run WISCE™.
2. Ensure that the correct device selected. If not load the device using the Device -> Load Device... and select the correct device.
3. Select the 'SE2 Retune Filter' tab.
4. Select the 'Sample rate (Hz)' for the measurement. This should match the settings for the product to be measured.

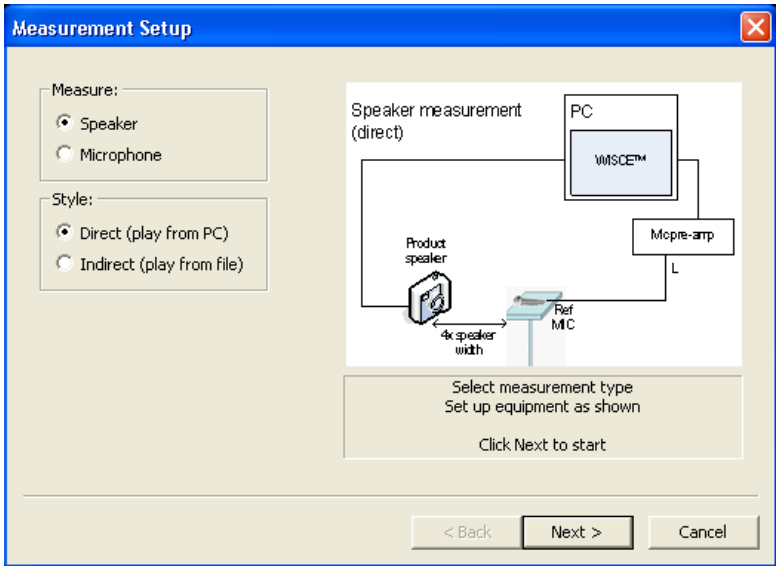


5. The ReTune™ measurement is selected by clicking on the 'Measure Response' button.

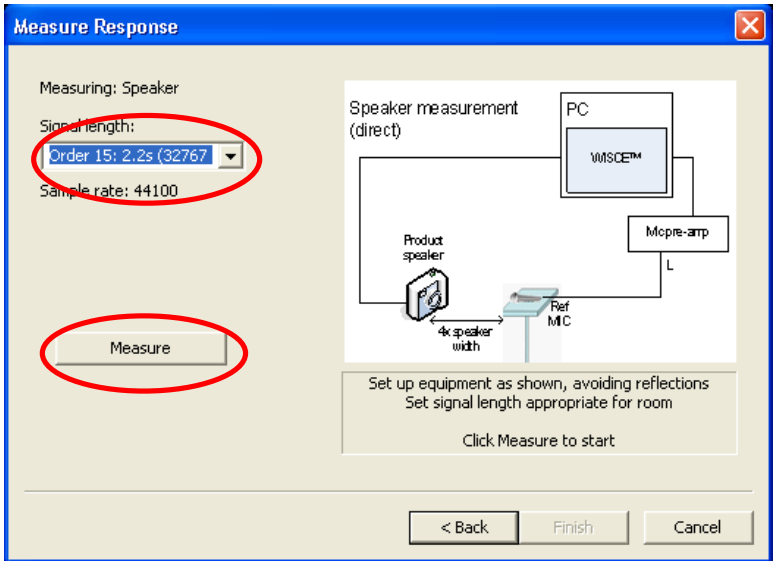
The Measurement Setup window will be displayed. This allows the measurement type and method to be selected. The options available are described in the following sections.

SPEAKER, DIRECT METHOD

1. Select 'Speaker' and 'Direct (play from PC)' and click 'Next'.



2. Select the burst signal length from the drop-down menu. Start with a value about 2 to 3 seconds. Short burst lengths can be used for quieter environments but for noisier environments a longer burst length should be used. Note that the values in the pull-down menu will change with the sample rate selected.

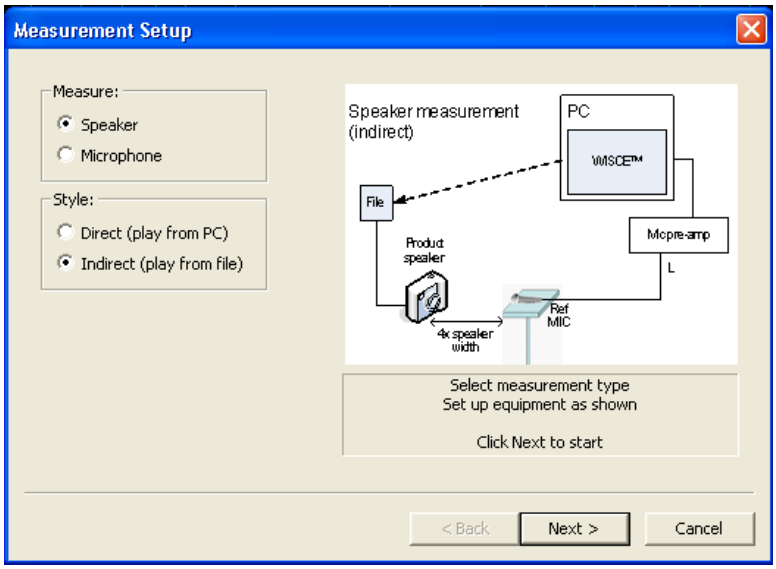


3. Ensure that the room is as quiet as possible before starting the measurement. Click on the 'Measure' button to start the measurement.
4. After the burst has finished, WISCE™ will plot the measured response. This may take several seconds depending on the burst length selected (longer bursts take longer to process).
5. Click on 'Finish' and WISCE™ will calculate the coefficients required and will plot the results.

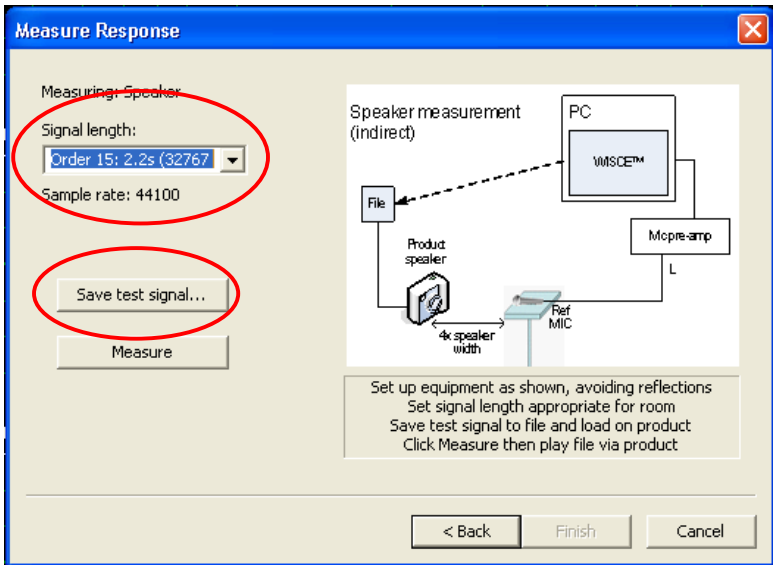
The coefficients can be saved in decimal or hexadecimal format (see Saving Coefficients section) or can be written directly to the Customer Evaluation board.

SPEAKER, INDIRECT METHOD

1. Select 'Speaker' and 'Indirect (play from file)' and click 'Next'.



2. Select the 'Signal length'. Start with a value about 2 to 3 seconds.



3. Select ‘Save test signal’ to save the audio burst file to the Media card that is to be used with the product (DUT) or copy to the DUT memory.

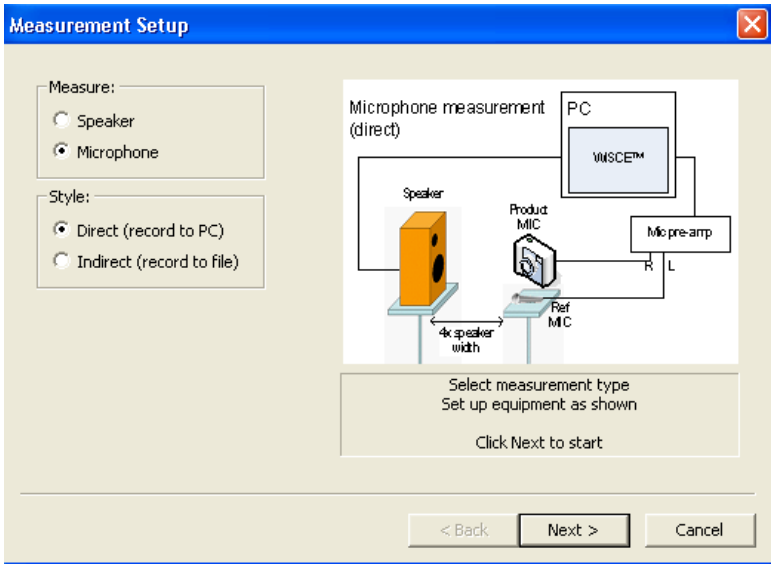
Note: WISCE™ generates standard Windows WAV files and these may have to be converted into the correct format for the DUT to play the file. WISCE™ does not support this conversion and the customer should provide suitable software for this purpose.

4. Insert the media card into the DUT and power ON the DUT. Setup the DUT in playback mode.
5. Ensure that the room is as quiet as possible before starting the measurement. Click on the ‘Measure’ button to start the WISCE™ measurement and then start the DUT playback. The synchronisation of the two signals is taken care of by WISCE™.
6. After the burst has finished, the DUT can be stopped. WISCE™ will plot the measured response. This may take several seconds depending on the burst length selected (longer bursts take longer to process).
7. Click on ‘Finish’ and WISCE™ will calculate the coefficients required and will plot the results.

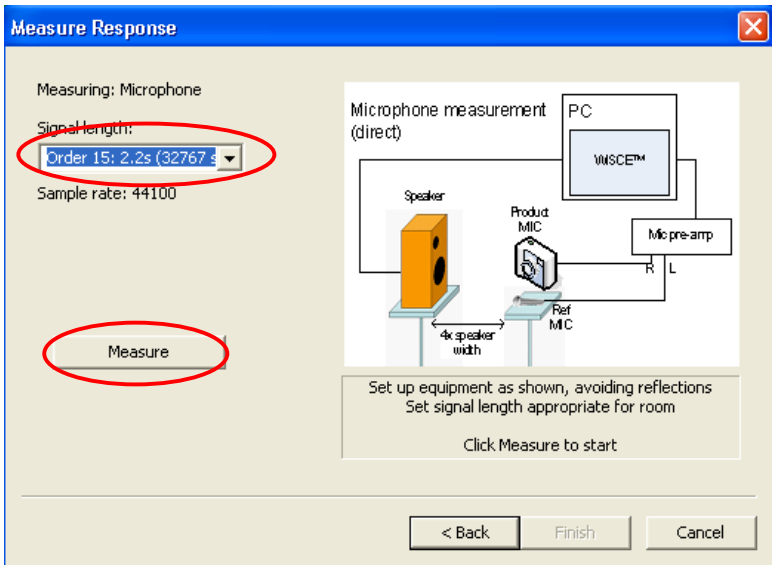
The coefficients can be saved in decimal or hexadecimal format (see Saving Coefficients section) or can be written directly to the Customer Evaluation board.

MICROPHONE, DIRECT METHOD

1. Select ‘Microphone’ and ‘Direct (play from PC)’ and click ‘Next’.



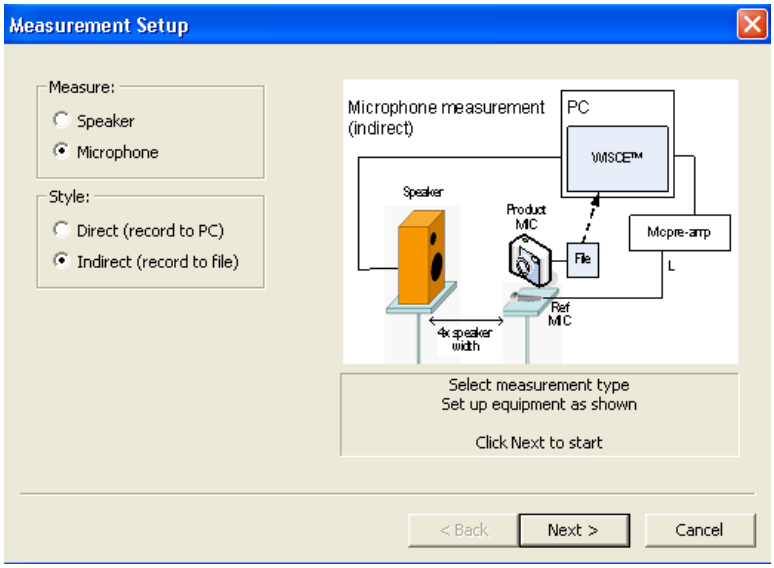
2. Select the burst signal length from the drop-down menu. Start with a value about 2 to 3 seconds. Note that the values in the pull-down menu will change with the sample rate selected.



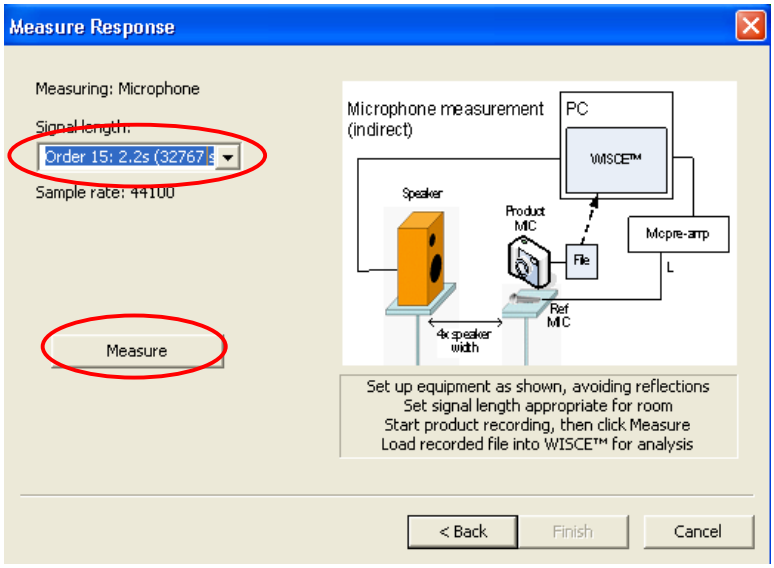
3. Ensure the room is as quiet as possible before starting the measurement. Click on the 'Measure' button to start the measurement.
4. After the burst has finished, WISCE™ will plot the measured response. This may take several seconds depending on the burst length selected (longer bursts take longer to process).
5. Click on 'Finish' and WISCE™ will calculate the coefficients required and will plot the results.

MICROPHONE, INDIRECT METHOD

1. Select ‘Microphone’ and ‘Indirect (play from file)’ and click ‘Next’.



2. Select the ‘Signal length’. Start with a value about 2 to 3 seconds.



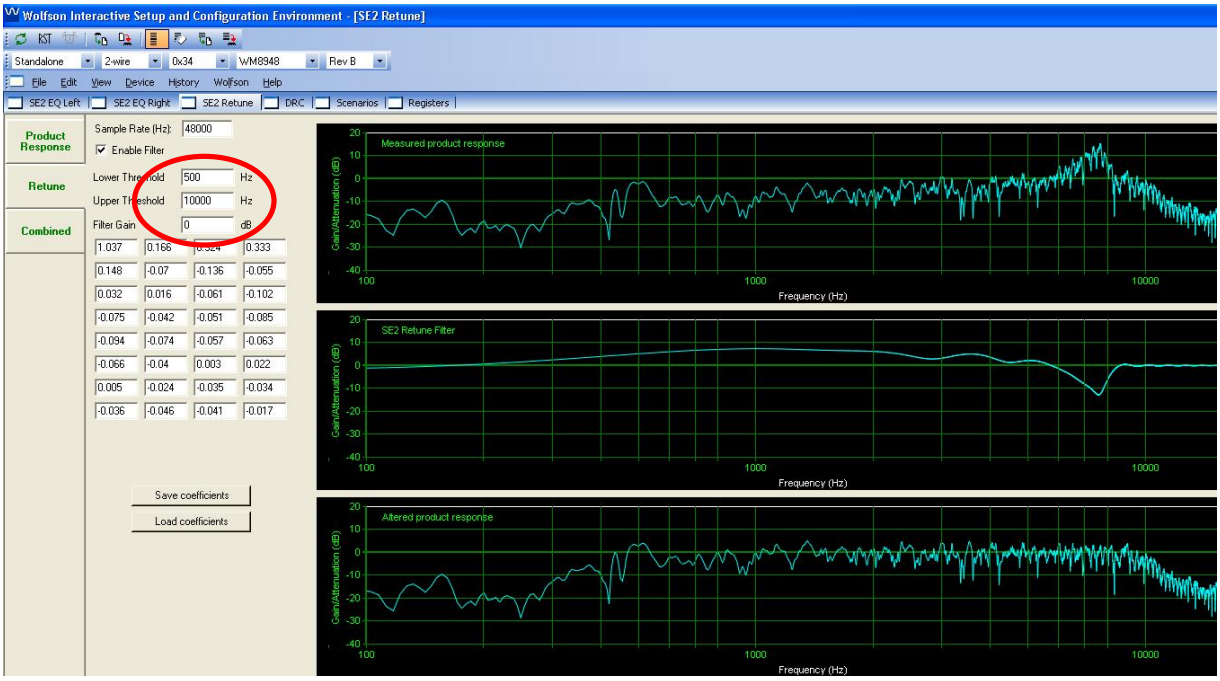
3. Insert a Media card into the DUT and setup the DUT ready to record.
4. Ensure that the room is as quiet as possible before starting the measurement. Start the DUT recording then click on the ‘Measure’ button to start the WISCE™ measurement. The synchronisation of the two signals is taken care of by WISCE™.
5. After the burst has finished the DUT can be stopped and a window is displayed asking for the Recorded file. The DUT can then be stopped. Remove the Media card from the DUT or connect the DUT to the PC and convert the recorded file to an audio file in Windows WAV format (if required – this depends on the DUT).
6. WISCE™ will plot the measured response. This may take several seconds depending on the burst length selected (longer bursts take longer to process).
7. Click on ‘Finish’ and WISCE™ will calculate the coefficients required and will plot the results.

BANDWIDTH LIMITING THE MEASUREMENT

For smaller speakers the bandwidth of the measurement may be too high and the ReTune™ filter will increase the gain at high frequencies. This limits the max signal amplitude that can be applied to the ReTune™ filter to avoid saturation. The bandwidth of the ReTune™ measurement can be limited to prevent the ReTune™ filter from increasing the gain at high frequencies.

Similarly at low frequencies the bandwidth can be limited to prevent overdriving the speaker and potentially causing damage to the speaker.

The Upper and Lower Threshold (Hz) fields are used to limit the range of the ReTune™ filter. These can be set independently.



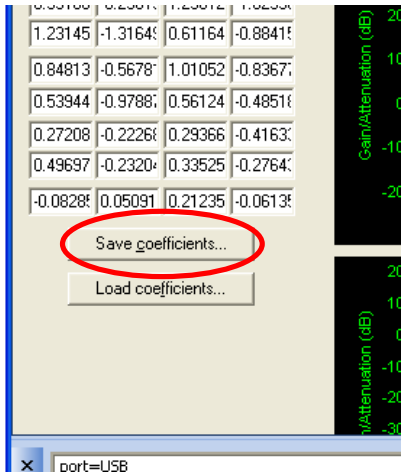
The overall gain of the filter can be changed by setting a gain or attenuation (dB) in the Filter Gain box. This will scale the coefficients to reduce the gain of the filter so that at the maximum filter gain the signal amplitude does not exceed the maximum allowed level for the device and supply voltages.

SAVING/LOADING THE FILTER COEFFICIENTS

The coefficients calculated by WISCE™ can be saved in either decimal format or in hexadecimal format for loading into the device on the Customer Evaluation board.

DECIMAL FORMAT

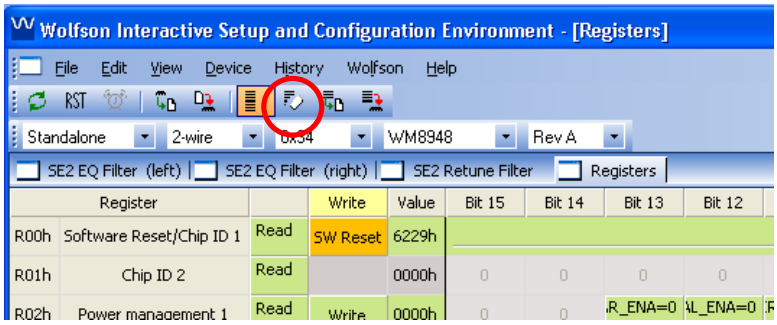
The coefficients for the ReTune™ filter can be saved as a text file (decimal format) by clicking on 'Save_coefficients…' in the main display.



Select the required file name and folder, then click 'Save'.

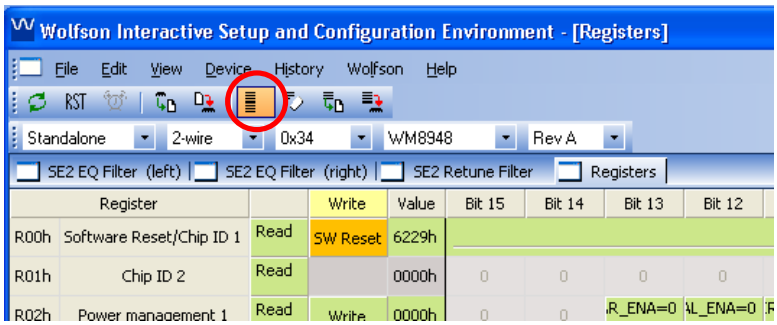
HEXADECIMAL FORMAT

The coefficients can be saved in hexadecimal format for download to the Customer Evaluation board. Make sure that the Write Changes Immediately option is not selected (File>Preferences). Select the 'Registers' tab. At the top select the 'Clear history' button.

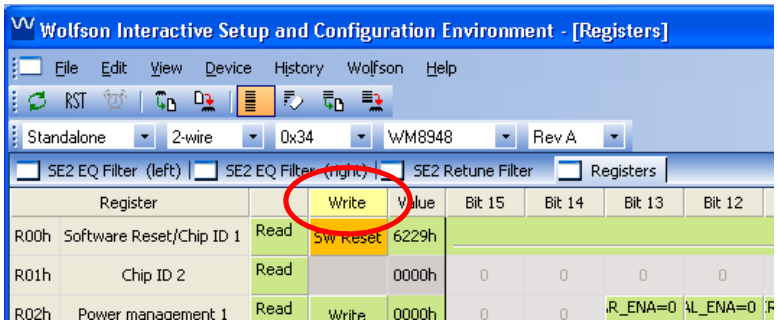


If this is not visible then go to the View menu and select History or click the 'Enable history' button.

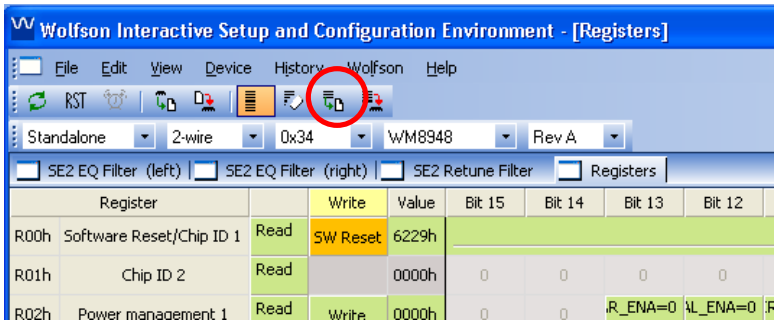
Run the ReTune™ measurement and the registers will be highlighted yellow.



Click the yellow 'Write' box and this will write the values to the History window.



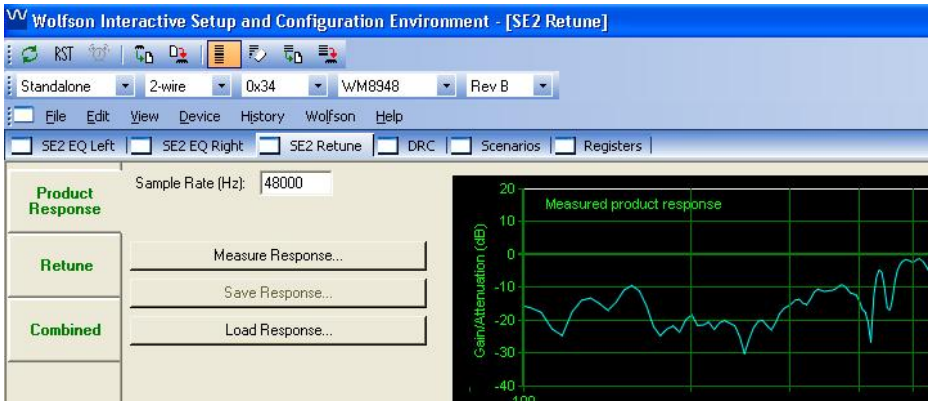
Select 'Save history' and select the required file name and folder to save the data to.



Note that reloading the Response file will reload the coefficients into the Register tab from the saved measurement.

SAVING/LOADING WISCE™ RESPONSE FILES

The response files can be saved and reloaded using the 'Save response…' and 'Load response…' buttons.



The 'Save response…' option will save the WISCE™ files for the measured response, the filter response and the altered product response. The filter coefficients are also saved.

The 'Load response…' option will load the saved file in to WISCE™. This also reloads the Register tab with the saved coefficients to allow the Evaluation board to be updated.

TECHNICAL SUPPORT

If you require more information or require technical support, please contact the nearest Wolfson Microelectronics regional office:
http://www.wolfsonmicro.com/contact

or one of our global distributors:
http://www.wolfsonmicro.com/distribution

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