Acoustics Engineering

TN013

Technical Note

The Zircon system for EN 1793 measurements

Version 1.1

March 2021

Contents

Introduction

This document is based on the EN 1793-5 standard of March 2016 (including the corrigendum of August 2018) for the in-situ measurement of sound reflection of road traffic noise reducing devices. Compared to the 2003 version of the standard, numerous changes have been introduced, the most prominent of which are the use of a 9-microphone array, and modified calculations.

In this document, we will describe a procedure for using the Zircon system and Dirac to produce results in compliance with the new standard. Familiarity with EN 1793-5:2016 and Dirac is assumed.

The last chapter shortly describes by comparison a similar procedure for the in-situ measurement of sound insulation of road traffic noise reducing devices according to EN 1793-6:2018.

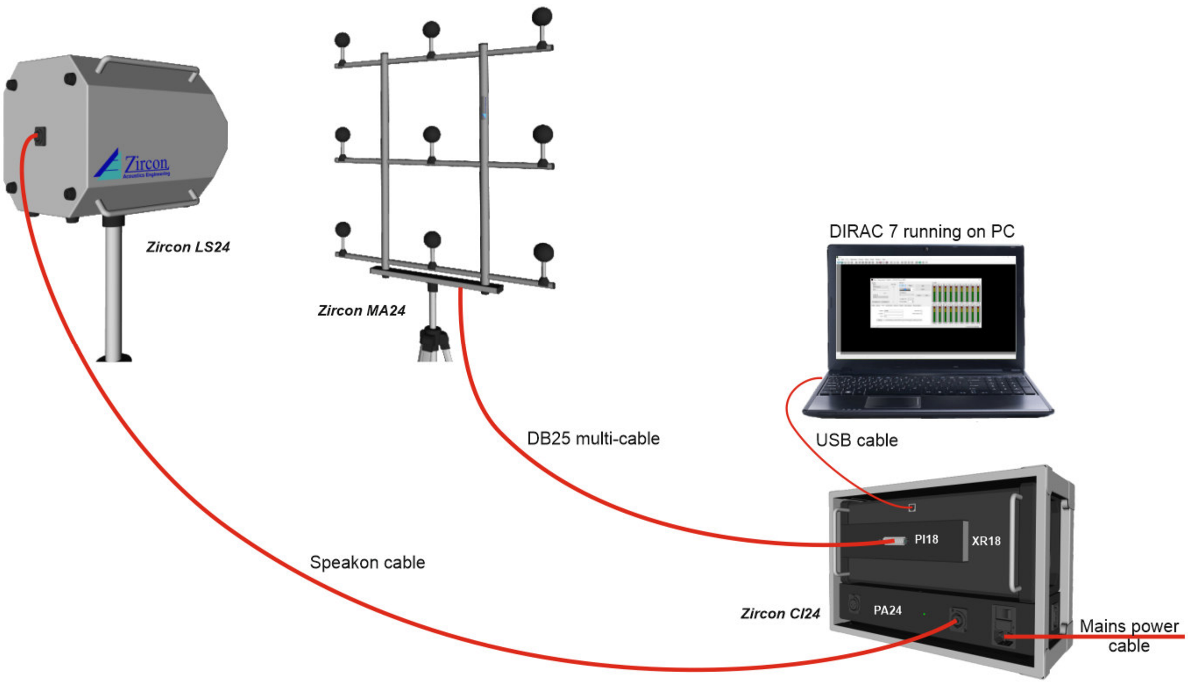
The Zircon system

A previous technical note (TN012) describes the use of Dirac version 6 for EN 1793-5/6 measurements. Due to the lack of multi-channel support in Dirac 6, TN012 suggested the use of a B&K LAN-XI module, and Type 7708 software for multi-channel data capture. This setup resulted in a rather laborious measurement procedure, requiring resampling and multiple measurement import actions in Dirac.
With the new Zircon hardware and Dirac version 7, multi-channel support is built-in, and the system can make use of the MA24 microphone array and the CI24 multi-channel interface that were developed specifically to provide a complete system for EN 1793-5/6 measurements.

This technical note TN013, describes the use of these new components for much faster EN 1793-5/6 measurements.

System setup

The measurement system can be depicted as follows:

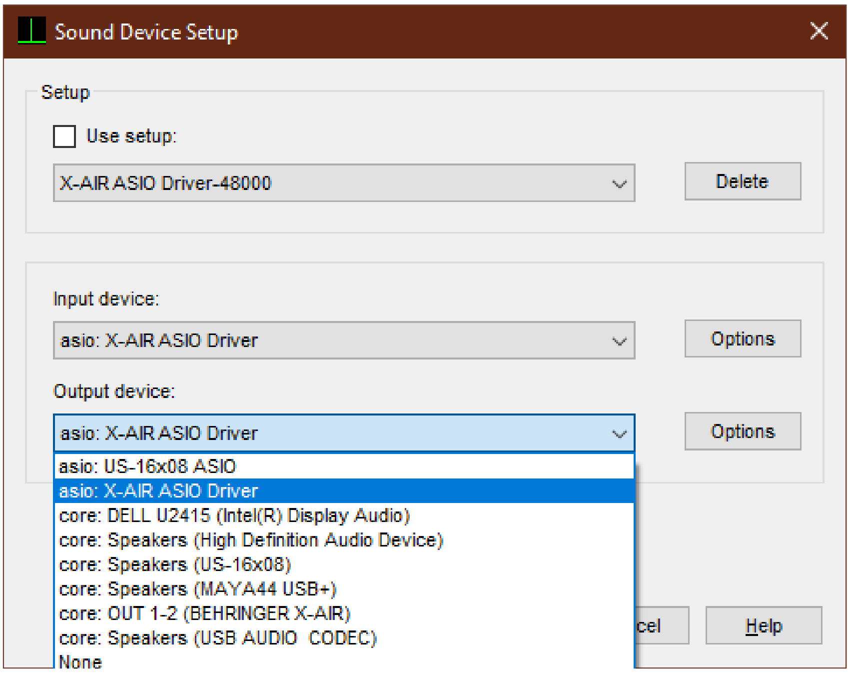


Dirac 7 running on the PC will generate a stimulus signal that is sent to the CI24 which acts as a sound device for Dirac. The CI24 amplifies the signal and sends it to the LS24 loudspeaker. The emitted (and reflected) signals are picked up by the 9 microphones of the MA24 microphone array, and amplified[1] and sampled by the CI24. Dirac 7 then processes the signals captured by the CI24 into impulse responses.

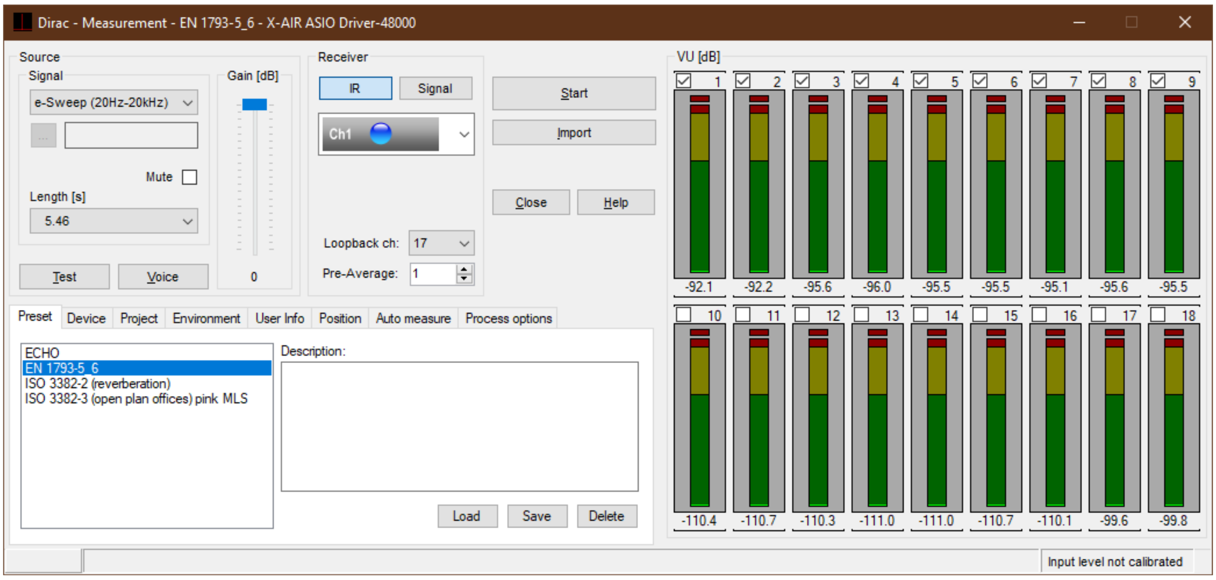
To be able to use the CI24, a sound device driver needs to be installed on the PC. The driver for the Behringer XR18 that is contained in the CI24 can be found on the Behringer website at https://www.behringer.com/product.html?modelCode=P0BI8. Make sure to install the latest Windows driver.

Once the driver is installed, connect the CI24 to the PC and open Dirac 7. In Dirac open the Sound Device Setup window and select the line **asio: X-AIR ASIO Driver** for both input and output. Click 'OK' to save this setup under an appropriate name.

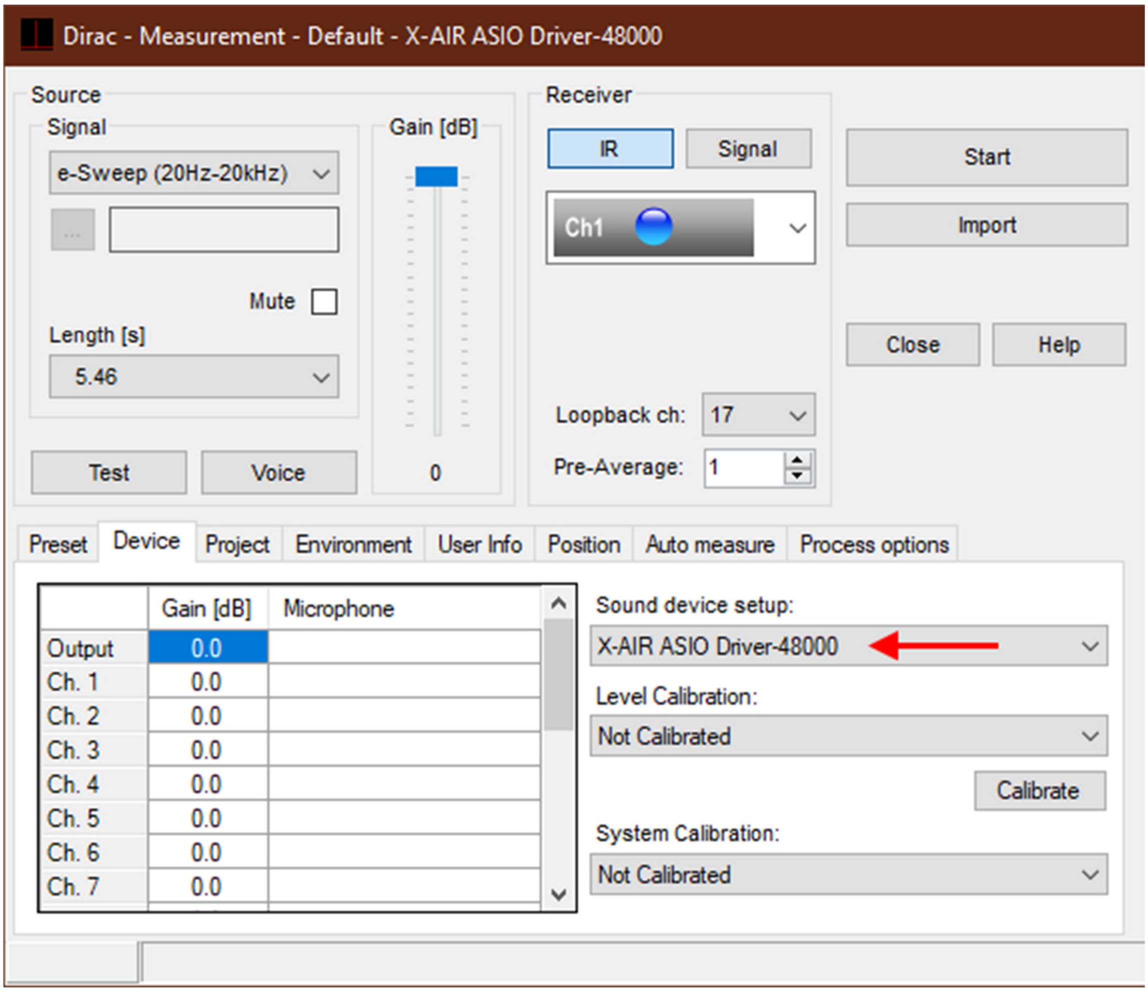
[1] The input gains are pre-programmed in the Behringer XR18 to 20 dB for typical ½" microphones, but can be changed if necessary. For instance 30 dB input gains may better suit ¼" microphones.



The measurement window should now display the VU meters for all 18 channels of the XR18.

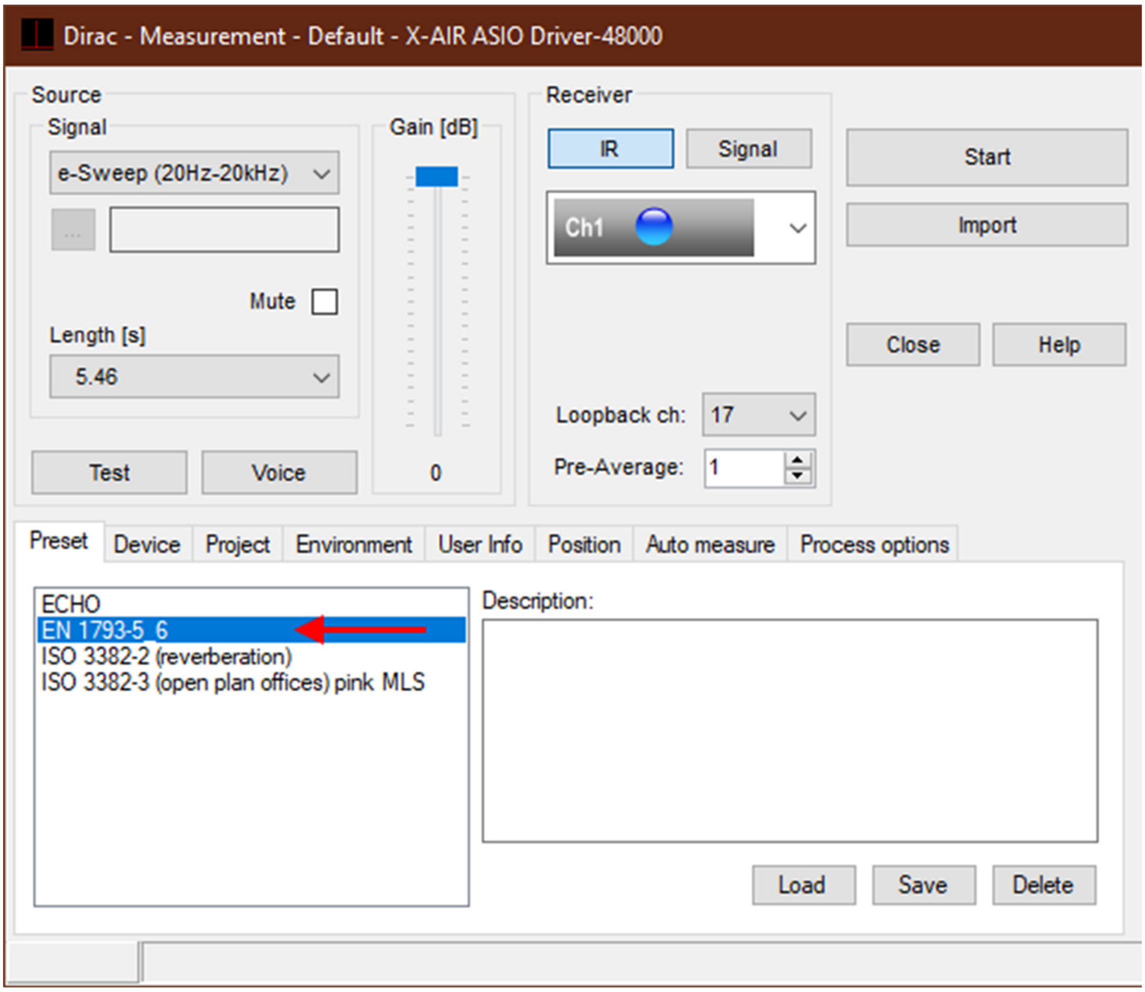


If not, go to the **Device** tab and select the device setup that was created earlier:



Note that no level calibration is required for this type of measurement because the reflected signal is compared with the free-field signal and only their relative levels are important.

On the **Preset** tab, select the **EN 1793-5_6** setup:

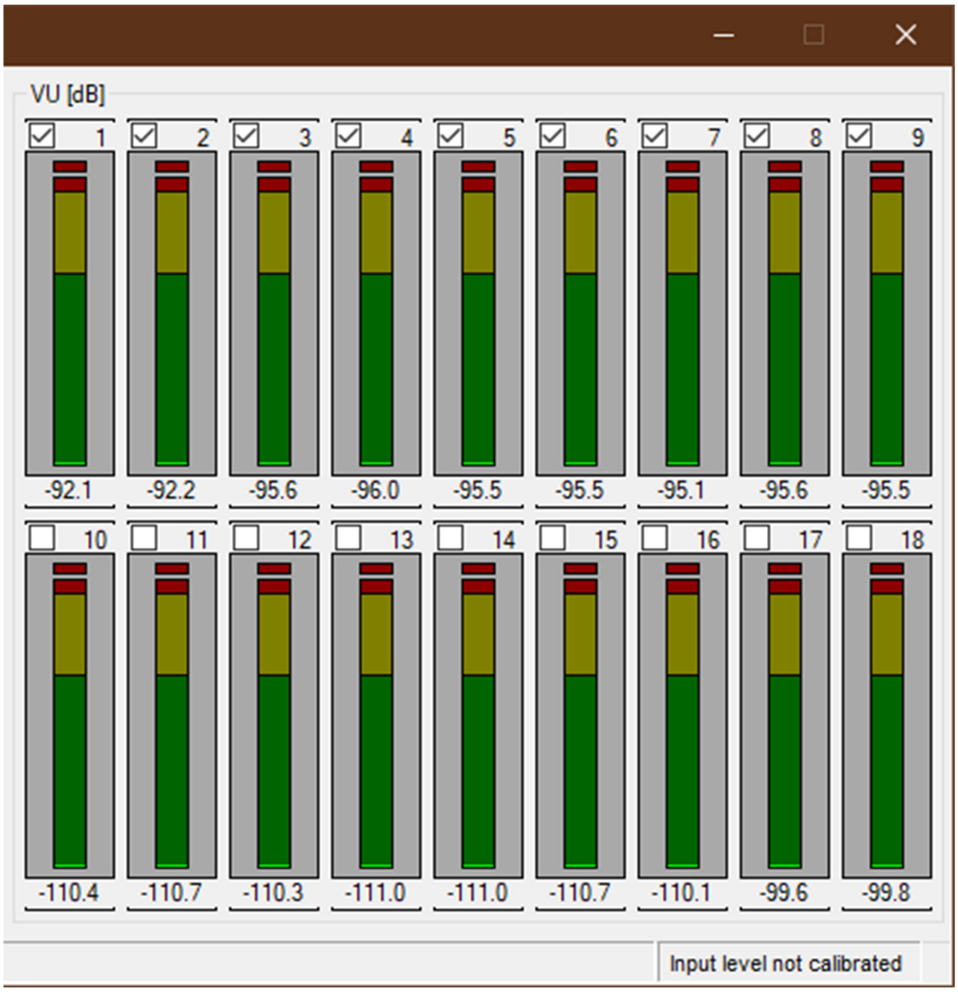


Note that the **loopback channel** is set to 17. This guarantees accurate source-receiver distance measurements.

For the time being, the e-sweep (20-20 kHz) should be used as stimulus, because it has been found to give the best results. Eventually, the e-sweep (125-4 kHz) will be optimized for use in this application. Longer stimulus lengths and/or pre-averaging will likely have little effect on the quality of the measurements.

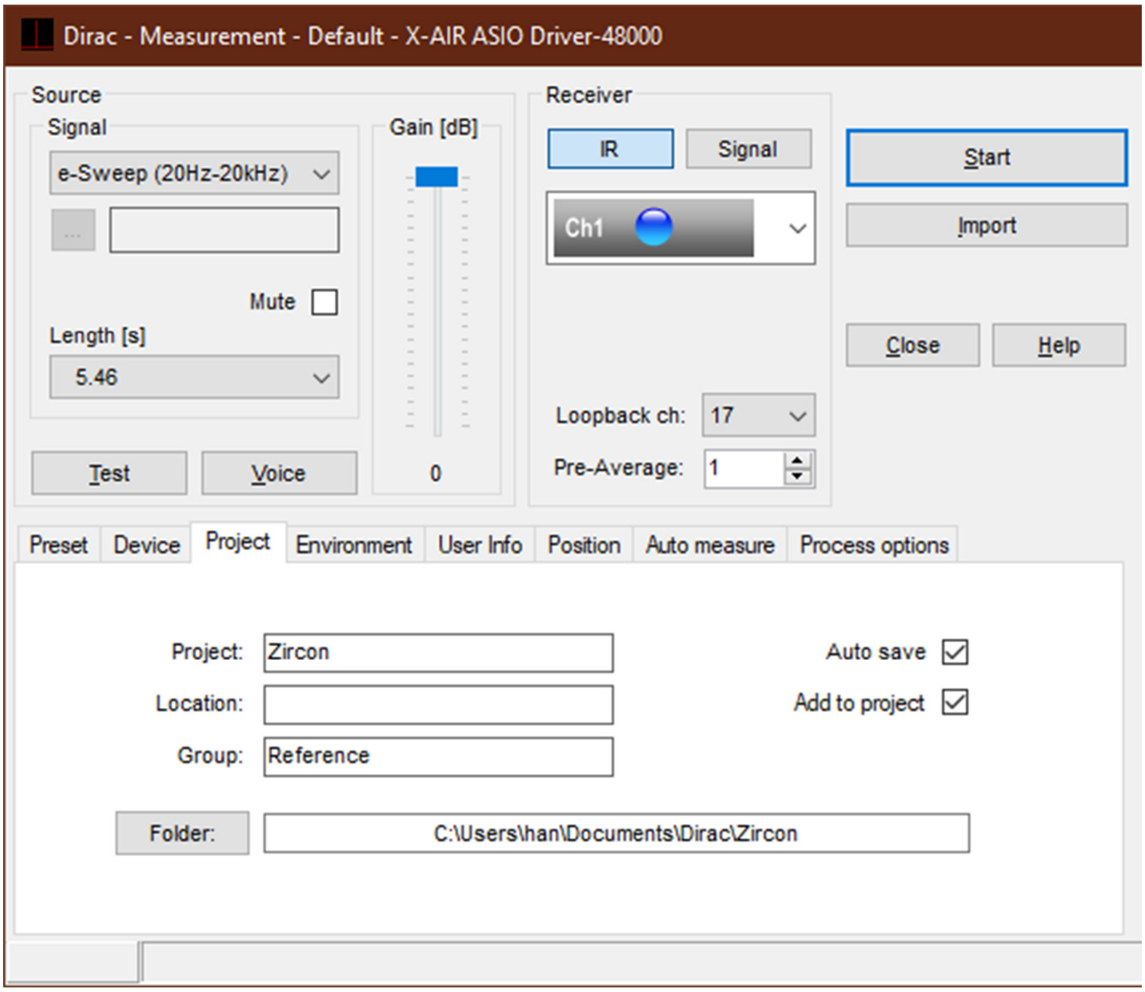
Note also, that on the **Process options** tab the **Cut e-sweep** option is checked. This will automatically cut the tail containing distortion components from the IR, resulting in improved INR values.

Finally, check the channels 1 thru 9 in the VU meter section:



Measurements

For each measurement session and each separate measurement, the **Project** tab needs to be filled in.



The Project name will be part of the file names that eventually appear in the Project folder. For a Reference measurement, make sure the **Group** name is set to **'Reference'**. For a reflection or transmission measurement, set the **Group** name to **'Measurement'**.

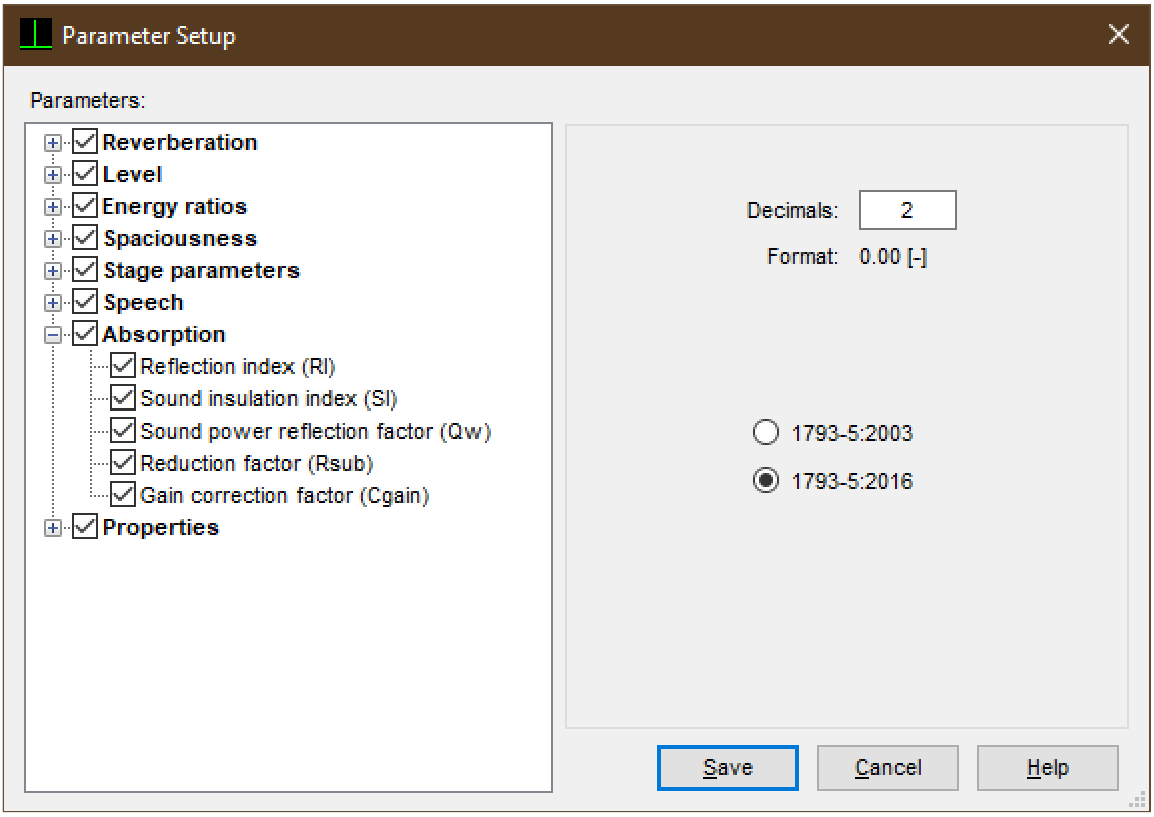
Note that in each file the **Receiver** number as found in the **File Properties** is set to the microphone/channel number. This number is also visible in the file name. It is necessary to have the **Receiver** number set correctly, and to have it correspond to the microphone number as defined in EN 1793-5:2016. This means that microphone 1 should be recorded to channel 1, microphone 2 to channel 2 etc. Using the Zircon system with the provided setup guarantees the correct microphone/channel numbering.

Note that if you select (tick checkmark) channel 17 (the loopback channel) together with the actual microphone signals, the result on that channel should be a perfect Dirac pulse. You can verify this by opening the file in **Impulse Response view**.

With the setup as described you can now perform the measurements.

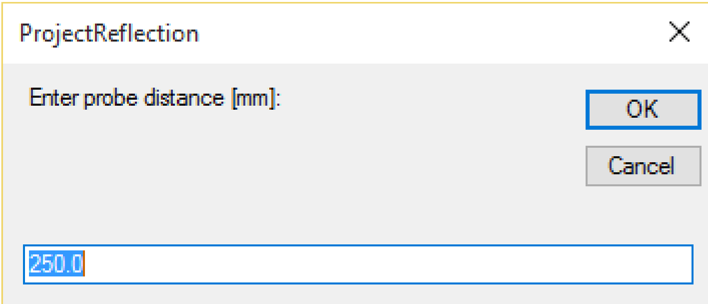
Processing the measurements

Because the calculations in EN 1793-5:2016 have changed, Dirac needs to be setup so that it uses the correct procedures. This can be done in the **Parameter Setup** window, which can be found on the **Setup** menu.



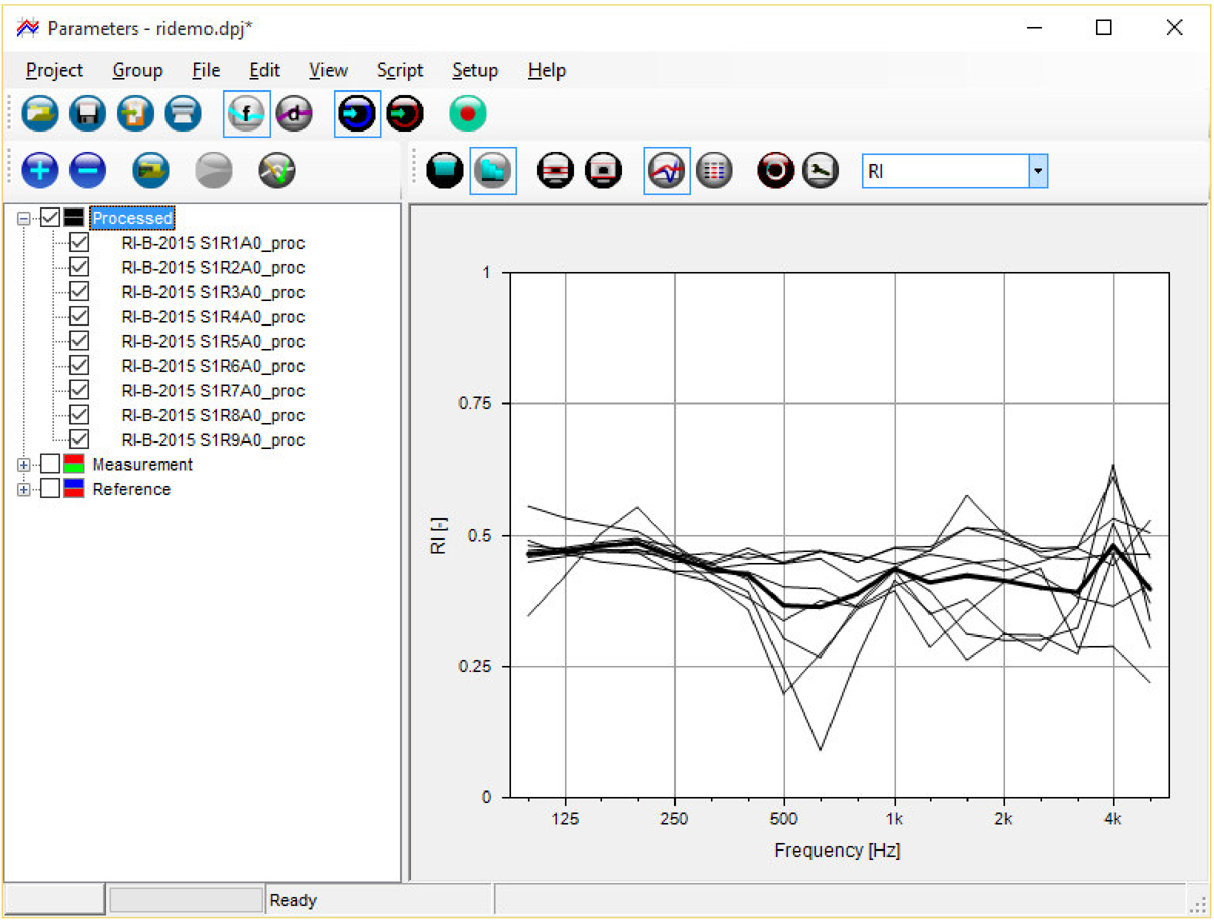
Select the **1793-5:2016** option for the calculations from the standard.

The current version of Dirac supports the subtraction technique for single measurements only, as explained in the help file. For the purpose of the new standard, a script was developed to perform the subtraction technique on all 9 measurements. The script is named **ProjectReflection** and is available on the **Script menu** in the project window after the script file 'ProjectReflection.py' is copied to the **Plugins** folder. The script will execute the subtraction method on the files in the project. It expects to find a group named **Measurement** and a group named **Reference**, each containing at least 9 files with **Receiver** numbered from 1 thru 9.



When you start the script you will first be prompted to enter the distance between the microphone array and the surface under test in mm.

The result is a new group called **Processed** in the project containing 9 files, each with a channel for the result of the subtraction and a second channel for the reference. Each of these files has the name of the corresponding reflection measurement file with the suffix '_proc' appended.

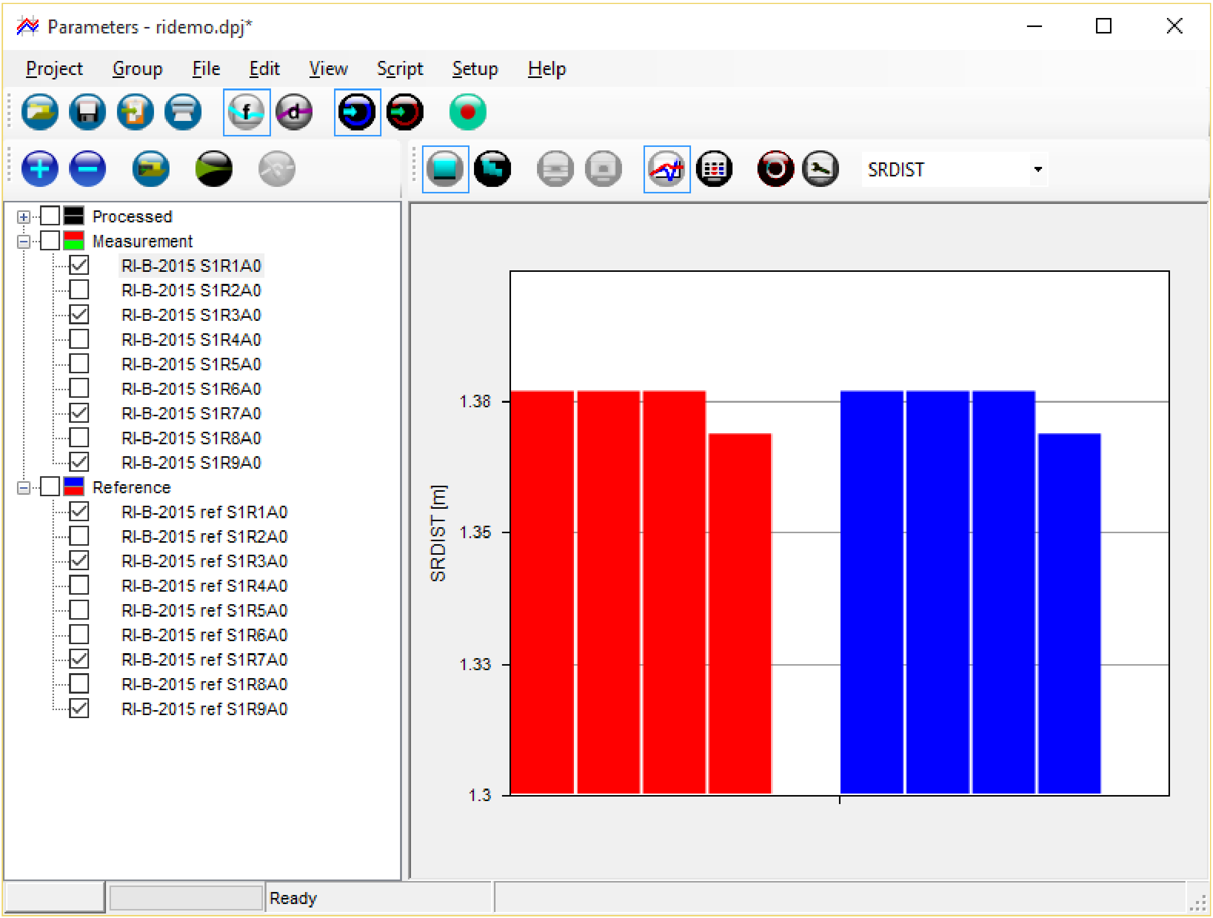


Checking the measurements

In EN 1793-5:2016 several checks are described to verify the correct positioning of the microphone array and the quality of the signals.

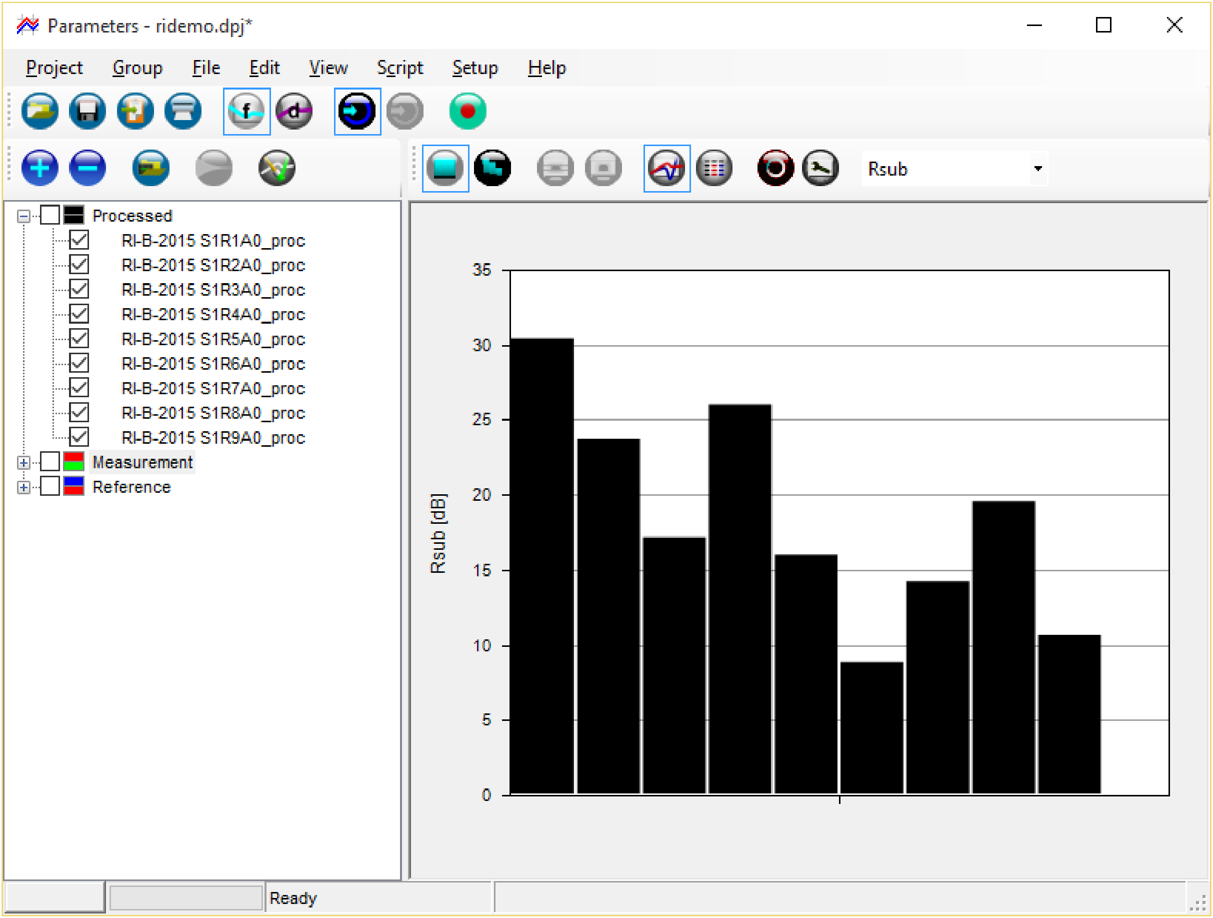
Source-Receiver distance

To check the correct positioning of the microphone array in relation to the sound source, we can look at the source receiver distances calculated from the impulse responses. Select the SRDIST parameter and select a bar graph. Only microphones 1, 3, 7 and 9, at the corners of the array, need to be considered. The source-receiver distance for these microphones should be 1.37 m ± 0.025 m.
Note that this check should be performed on the **Measurement** and **Reference** groups, not on the **Processed** group.



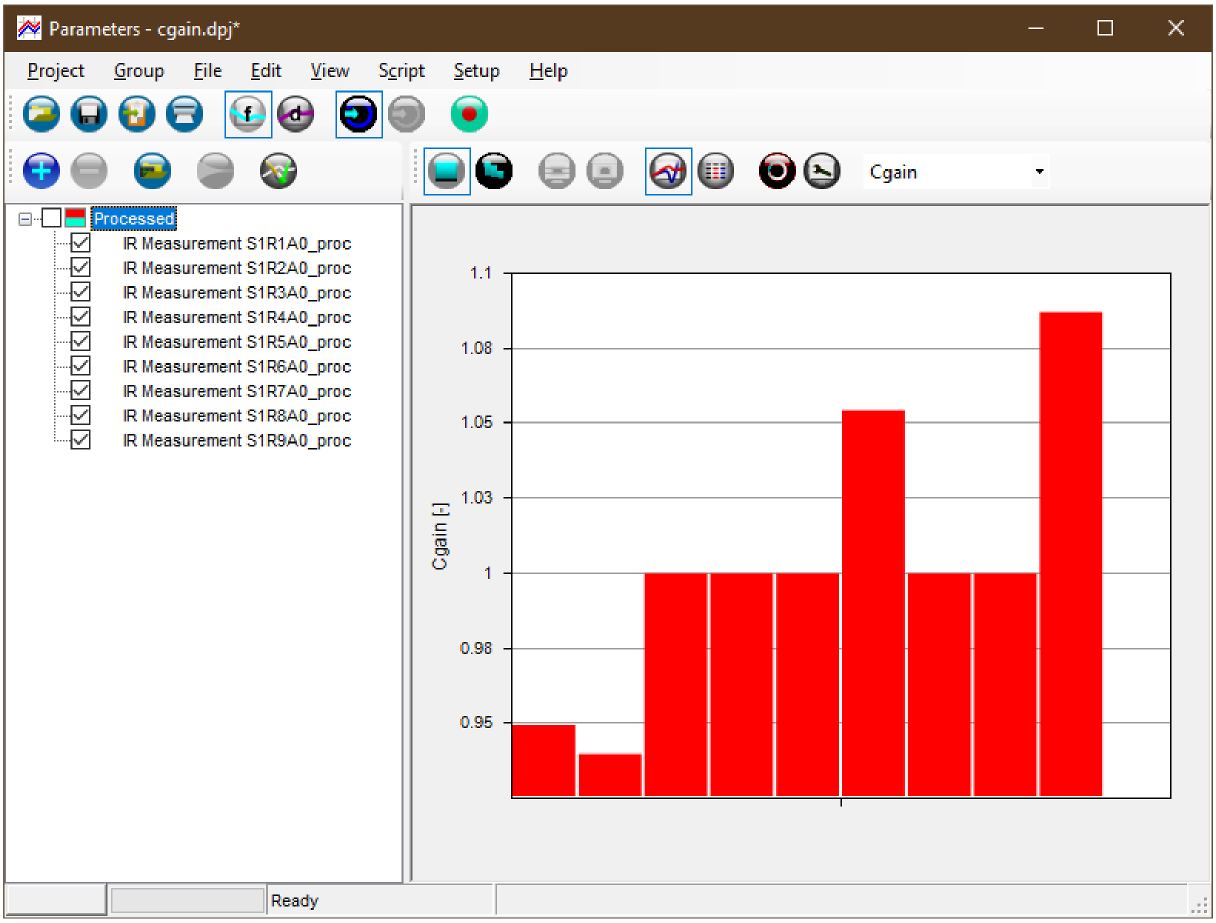
Reduction factor

The quality of the subtraction result can be judged with the help of the Rsub parameter. It should be calculated for the **Processed** group, and each file should have an Rsub higher than 10 dB.



Gain correction factors

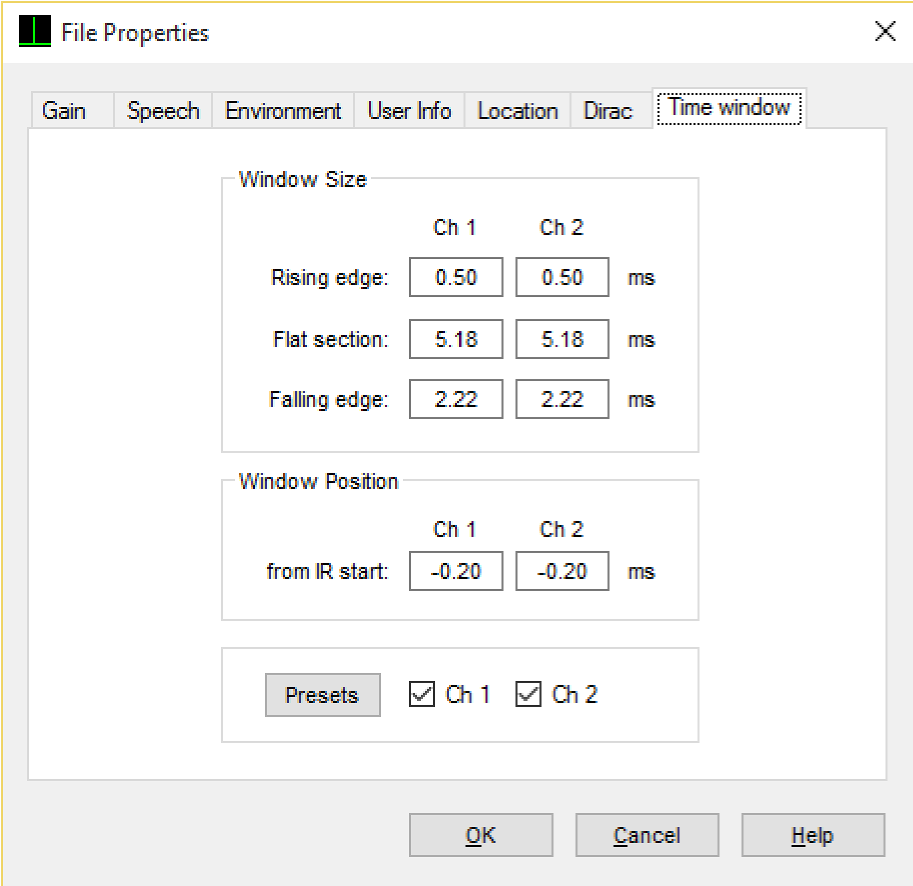
Any intentional gain change between reference and reflection measurements can be entered on the **Gain** tab of the **File Properties**, as usual in Dirac. The EN 1793-5:2016 standard introduces a new parameter (Cgain) to check for accidental level differences between incident components of both reference and reflection measurements. The parameter Cgain which represents the ratio between the incident waves should not deviate more than 20% from unity. If large deviations (>20%) are found, the measurement setup should be checked, and the measurements performed anew. Deviations smaller than 5% are ignored, and for these the Cgain is set to 1.



Setting the time windows

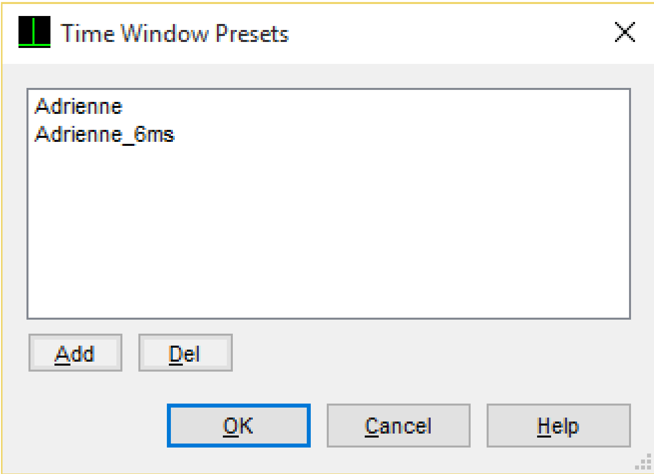
While performing the subtraction technique, Dirac assigns the default 7.9 ms Adrienne window to all resulting files. In most cases microphones 7, 8 and 9 also need to be evaluated with a shorter, 6 ms, Adrienne window. To set the time windows for all processed files at once, make sure they are all check marked and select **File Properties** from the **Edit menu** of the Project window.

On the **Time window** tab any Adrienne type time window can be specified. In most cases both channels will have the same time window. The default 7.9 ms Adrienne window is set after the subtraction processing.



To set another time window, modify the values on the **Time window** tab, or select a preset time window. To apply the preset to both channels, make sure that the check marks for CH1 and Ch2 are set. Then click **Presets** and select one of the preset windows.

You can add a new preset by setting the desired values on the **Time window** tab, and then click **Add** in the **Presets window**.



Using the EN 1793-5 spreadsheet

To average the calculated RI values for the 9 microphones, and to calculate the single number quantity $\mathbf{DL_{RI}}$, a spreadsheet can be used. The spreadsheet uses the partial RI values calculated by Dirac and combines them with geometric correction factors, gain factors and source directivity values.

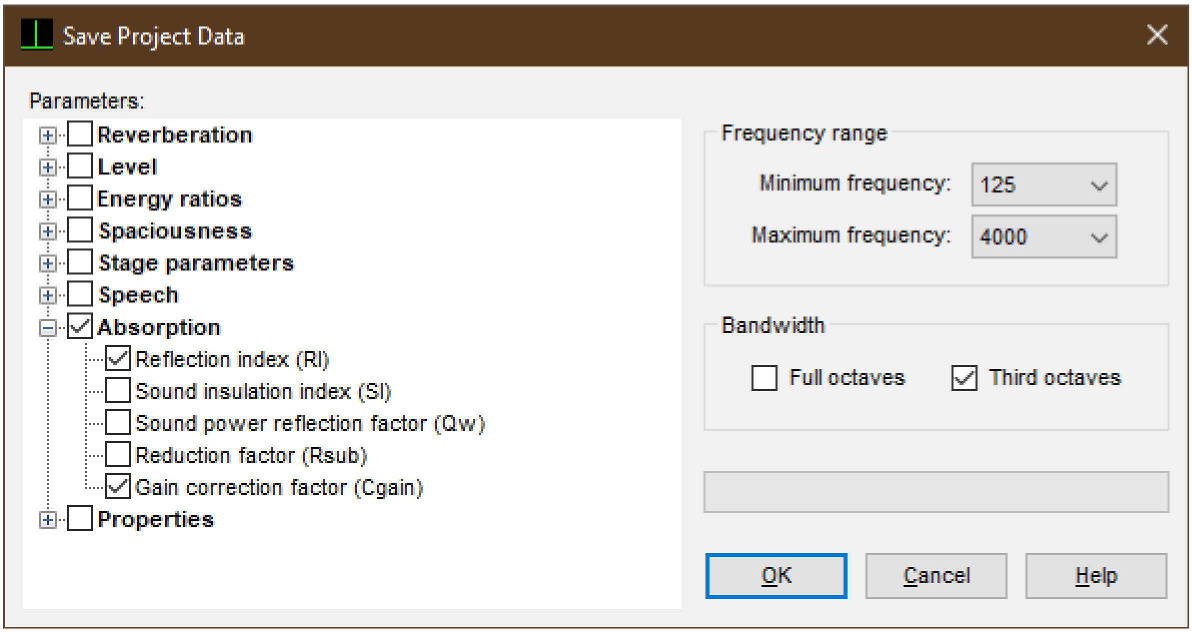
Three sets of data need to be transferred to the spreadsheet. The first is a set of the 9 partial RI values calculated with the standard 7.9 ms Adrienne window, and the second is a set of the 9 partial RI values calculated with a shortened Adrienne window of 6 ms.

	Default Adrienne	*Shortened Adrienne*
Rising edge [ms]	0.50	0.50
Flat section [ms]	5.18	3.85
Falling edge [ms]	2.22	1.65
Position from IR start [ms]	-0.20	-0.20

In addition to the partial RI values, the Cgain correction factors can be exported.

Exporting the results

To transfer the values calculated by Dirac into the spreadsheet the **Save Data** option on the **Project menu** should be used. First make sure the **Reference** and **Measurement** groups are unchecked (or removed), with the **Processed** group checked. Then select the **Save Data** option and select only the RI and Cgain parameters. Set the third-octave frequency range from 125 to 4000 Hz. This will export the data from the 100 Hz to the 5000 Hz third octave band.



The file containing the results calculated with the default Adrienne window should be imported into the sheet **Long**. The file containing the results calculated with the short Adrienne window should be imported into sheet **Short**.

Note that the spreadsheet will use the Cgain values from the **Short** sheet.

Source directivity

New in the standard is the use of source directivity data in the RI calculations. The spreadsheet contains a table with the directivity values of the Zircon. These values were the result of measurements performed in an anechoic room.

EN 1793-6:2018

The workflow described above can also be used for sound insulation measurements following EN 1793-6:2018.

The same hardware setup can be used to acquire 9 insulation measurements and 9 reference measurements.
The script named **ProjectTransmission** can be used, which is available on the **Script menu** in the project window after the script file 'ProjectTransmission.py' is copied into the **Plugins** folder. This script will use the files in the **Measurement** and **Reference** groups to produce 9 new files in the **Processed** group.

The calculated **SI** values can be exported using the **Save Data** option on the **Project** window, and the resulting file can be imported into the EN 1793-6 spreadsheet to calculate the **DL**$_{SI}$.

Further reading

- EN 1793-5, March 2016, “Road traffic noise reducing devices – Test method for determining the acoustic performance – Part 5: Intrinsic characteristics – In situ values of sound reflection under direct sound field conditions”.
- EN 1793-5:2016/C1:2018, August 2018, Corrigendum concerning the Cgain calibration.
- EN 1793-6:2018, June 2018, “Road traffic noise reducing devices – Test method for determining the acoustic performance – Part 6: Intrinsic characteristics – In situ values of airborne sound insulation under direct sound field conditions”.
- M. Garai, P. Guidorzi, “Sound reflection measurements on noise barriers in critical conditions”, accepted for the publication on Building and Environment, (2015). DOI: http://dx.doi.org/10.1016/j.buildenv.2015.06.023.
- M. Garai, E. Schoen, G. Behler, B. Bragado, M. Chudalla, M. Conter, J. Defrance, P. Demizieux, C. Glorieux, P. Guidorzi, “Repeatability and reproducibility of in situ measurements of sound reflection and airborne sound insulation index of noise barriers”, Acta Acustica united with Acustica, 100, 1186-1201, (2014). DOI:http://dx.doi.org/10.3813/AAA.918797.
- P. Guidorzi, M. Garai, “Advancements in sound reflection and airborne sound insulation measurement on noise barriers”, Open Journal of Acoustics, 3(2A), 25-38, (2013). DOI: http://dx.doi.org/10.4236/oja.2013.32A004.

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