SPEECH INTELLIGIBILITY ASSESSMENT USING CLIO 11

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INTRODUCTION

The quality of speech transmission in electrical and acoustic transmission channels depends on many phenomena. The Speech Transmission Index STI is a well known single index parameter which is used to estimate the ability of a communication channel to transmit the speech message.

The STI is standardized by IEC 60268-16:2011 (we will refer to this document as the "standard") which is in its fourth edition [1]. The standard is a very recommended reading for everyone attempting to perform speech intelligibility measurements[1].

Speech can be modeled as a pink noise carrier intensity modulated by a low frequency sine wave. The modulation should resemble the typical fluctuations of the speech signal which are in fact carrying the most relevant information related to the transmitted message.

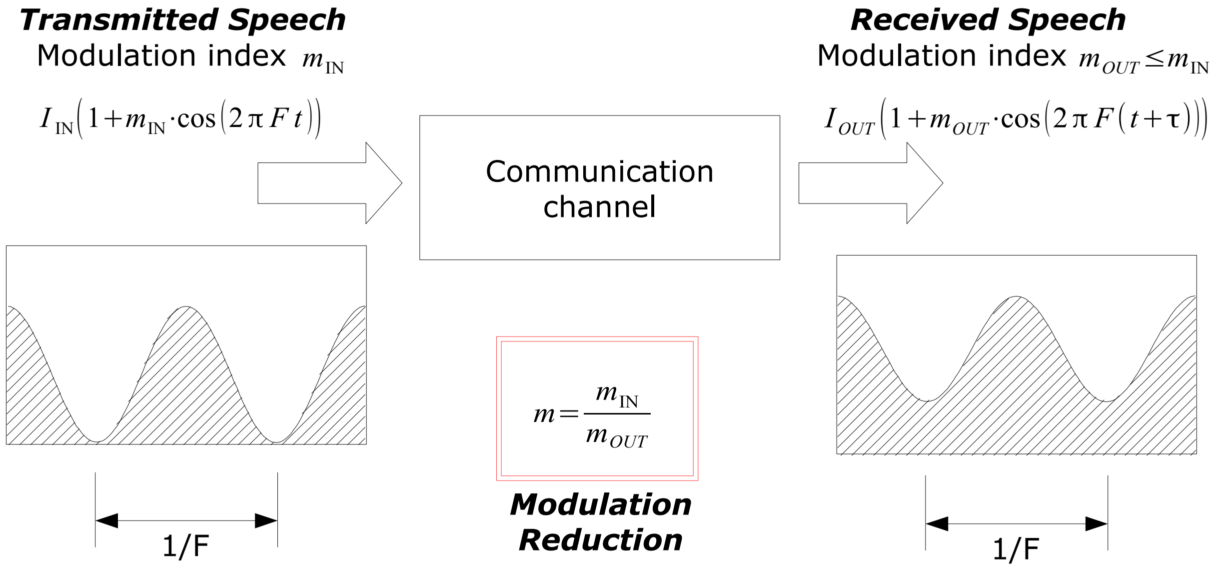


Figure 1: Modulation reduction as depicted in the IEC standard

1 The reduction of the speech transmission and human reception in a single number index is an highly complex task. The IEC standard features a good introduction to the background and the development of the STI method.

A loss in modulation in the transmission channel is a good estimate of a loss of intelligibility in the speech transmission; thus the whole concept around the STI revolves around the analysis of the modulation reduction due to the transition through the transmission channel. Reverberation, noise, distortion, are all taking part in the reduction of the speech intelligibility and are all in fact affecting the modulation.

In order to evaluate the whole speech spectrum and consider variations in frequency of spoken words, 7 carriers of an half-octave width with center frequencies of 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz and 8 kHz have been selected together with 14 modulation frequencies ranging from 0.63 Hz up to 12.5 Hz.

	125	250	500	1k	2k	4k	8k
0.63	$m_{0.63}(125)$	$m_{0.63}(250)$	...			...	$m_{0.63}(8k)$
0.80	$m_{0.80}(125)$	...					...
1.00	...						
1.25							
1.60							
2.00							
2.50							
3.15							
4.00							
5.00							
6.30							
8.00							
10.00	...						...
12.50	$m_{12.50}(125)$	...				...	$m_{12.50}(8k)$

STI

Figure 2: STI 98 elements MTF matrix

A total of 98 modulation are thus used to attain a single number index (STI) which is an estimation of the speech transmission quality. The combination of the 98 elements of the Modulation Transfer Function MTF matrix into a single index involves the addition of psycho-acoustics effects such as hearing threshold and adjacent band masking.

STIPA

Due to the complexity of the STI measurement, a simplified version tailored for Public Addressing sound systems STIPA has been derived. STIPA is a stripped down version of the complete STI which uses only two modulation frequencies for each noise carrier, for a total of 14 modulations.

The big advantage of the STIPA method is that is possible to use a single signal to send all the 14 modulations together and measure the modulation reduction in a single acquisition. This is not possible with the complete STI which require the reproduction and acquisition of 98 modulated signals. This may be a cumbersome and very time consuming process, which is seldom possible in reality[2].

2 The measurement time for all the 98 modulations can exceed 30 minutes, during this time the measurement context are likely to change, causing an high level of uncertainty to be associated to the STI estimate.

DIRECT VS INDIRECT METHOD

An alternative to the reproduction and acquisition of the modulated signal, which is indicated by the standard as the *direct method*, is the so called *indirect method*.

The indirect method takes advantage of the fact that it is possible to calculate the modulation reduction starting from the impulse response[3] of the communication channel using the following formula [2]:

$$m_k(f_m) = \frac{\left| \int_0^\infty h_k(t)^2 e^{-j2\pi f_m t} dt \right|}{\int_0^\infty h_k(t)^2 dt} \quad (1)$$

Where $h_k(t)$ is the impulse response filtered for the k -th carrier noise band, and f_m is the m -th modulation frequency.

The MTF calculated using the above formula can be integrated by the effects due to the signal level of the speech signal and noise ambient level by adding the following term:

$$m_k'(f_m) = m_k(f_m) \frac{1}{1+10^{\frac{-SNR_k}{10}}} \quad (2)$$

Where SNR_k is the signal to noise ratio in dB for the k -th carrier noise band.

Then the STI index can be calculated from the MTF matrix in the same way as for the direct method.

Using the indirect method it is also possible to calculate the STIPA index, in this case the result should be called STIPA(IR) to differentiate from the direct method results.

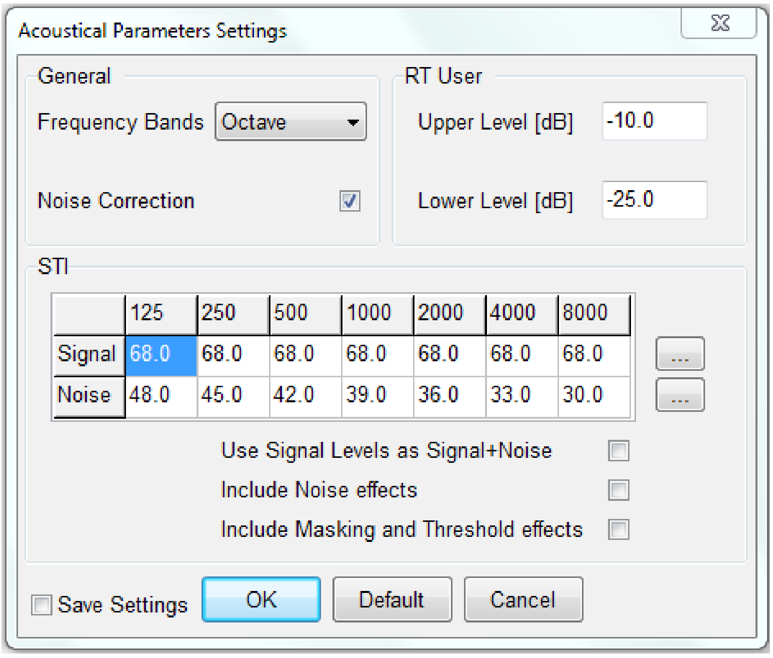
MEASURING STI USING INDIRECT METHOD IN CLIO 11

CLIO 11 implements in the Acoustical Parameters menu the calculation of STI according to the indirect method as per IEC 60268-16:2011 standard.

The impulse response of the communication channel has to be loaded by the Acoustical Parameters menu and the STI indexes are calculated alongside acoustical parameters. The visualization of the STI indexes and of the MTF matrix can be activated by pressing the STI button on the Acoustical Parameters menu toolbar.

By default the calculation of the MTF is done without noise and corrections, using the formula (1). In order to activate the effects of the noise and the psycho-acoustics corrections the options should be selected from the Acoustical Parameters Settings dialog.

3 The impulse response is a descriptor which is valid only for linear systems. Non linear transmission channels cannot be measured using the indirect method.



The octave band sound pressure levels are shown in tabular format on the STI panel.

Values can be edited manually or data can be loaded from FFT RTA files. The FFT RTA files shall be in SPL units and with 1 octave band resolution.

The Include Noise effects check-box activates the correction shown in formula (2) to the calculation of the MTF.

Include Masking and Threshold effects option activates the psycho-acoustics correction of the MTF calculation. Details on corrections applied can be found in the IEC standard.

Use Signal Level as Signal+Noise is an handy feature in case the source of background noise cannot be deactivated during Signal level measurement. Under the assumptions that the noise is stationary and not correlated to the Signal it is possible to estimate the Signal level without the effects of the present noise by a simple subtraction of levels.

A little digression on typical communication channels which can be encountered in STI and STIPA measurement is mandatory at this point. In fact the STI method can be applied in theory to any kind of communication channel.

We would like here to address the three most plausible cases that can arise for in-room measurements:

A) Human speaker in room without PA or sound reinforcement system

B) PA system with recorded announcements and/or without microphone inputs

C) PA systems with microphone

In the first A) and last case C) the system under test has an acoustical input port, i.e. the system cannot be directly driven by CLIO outputs. A proper electro-acoustical source is needed to measure the response of the communication channel. The standard dictates the use of an ITU-T P.51 compliant artificial mouth or a small loudspeaker mounted in a box[4].

4 Use of a small loudspeaker with a maximum diameter of 10 cm is allowed by the standard, but since the directivity can differ from that of an artificial mouth, some care must be taken. Possible uses are mostly limited to near field excitation of PA system microphones.

Figure 3: A Gras 44AA artificial mouth used for the tests

In the first case A) the path is entirely acoustic, from the source to the receiver. The source is placed in the position where the talker is supposed to be, and the measurement microphone is placed in the receiver's position.

In the second case B), the communication channel has an electrical input, the PA system can be directly driven by the CLIO fw-01 output. The electrical input is then amplified by means of an electro-acoustic system and there are loudspeakers which are covering a given audience area. The receiver is again acoustic, and a measurement microphone should be used.

In the third case C), the PA system has a microphone as input. In this case the source shall be again a loudspeaker transducer which shall be placed in front of the microphone at the typical operating distance.

In all cases the impulse response of the communication channel shall be measured using LogChirp method with a impulse length at least of 1.6 s and not less half the reverberation time of the room.

Using CLIO 11 this means that at least a 128k size[5] shall be selected for the MLS&LogChirp stimulus.

The impulse response measurement do not require any particular equalization of the source as we will see later. The best signal to noise ratio is desirable and also averaging techniques can be used.

5 At sampling frequency of 48 kHz.

STI MEASUREMENT OF A MEETING ROOM

Let's see a practical example which can help to shed some light on the complex STI measurement process.

In our example we put ourselves in the first case A) described above, and we decided to measure the STI in one of our offices: our meeting room. In particular we put the talker at one end of the room and measured the STI in a position at the meeting table in the same room and in a position right outside the room, in the adjacent corridor.

We used a Gras 44AA artificial mouth mounted on a microphone stand, pointed towards the center of the room, where the meeting table is and we placed the measuring microphone over one of the chairs.

The artificial mouth here simulates a human talker standing in the position shown in figure 4.

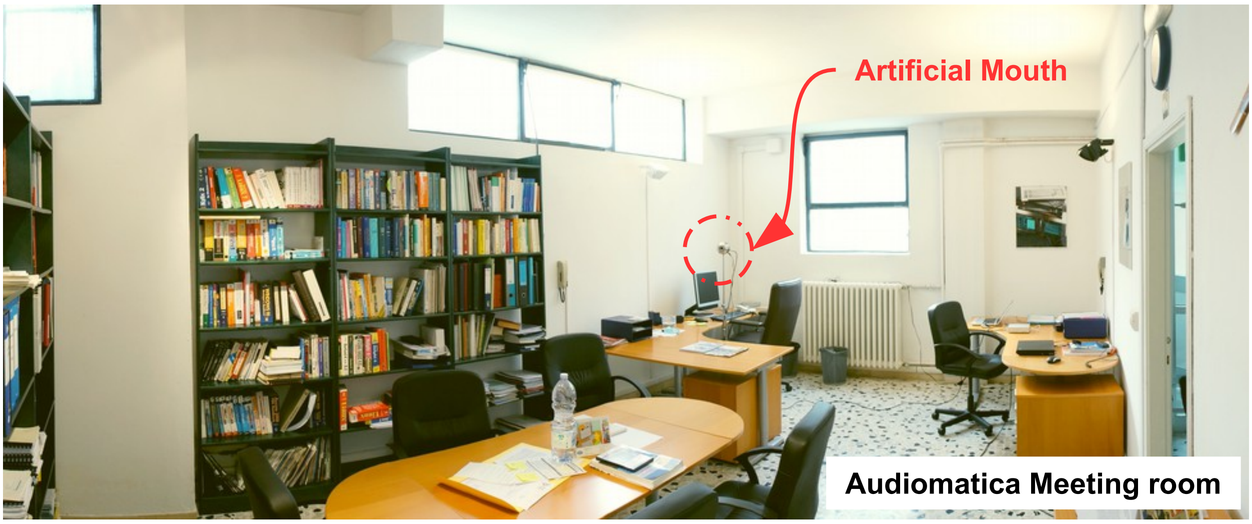


Figure 4: Picture of the Meeting Room with Artificial Mouth

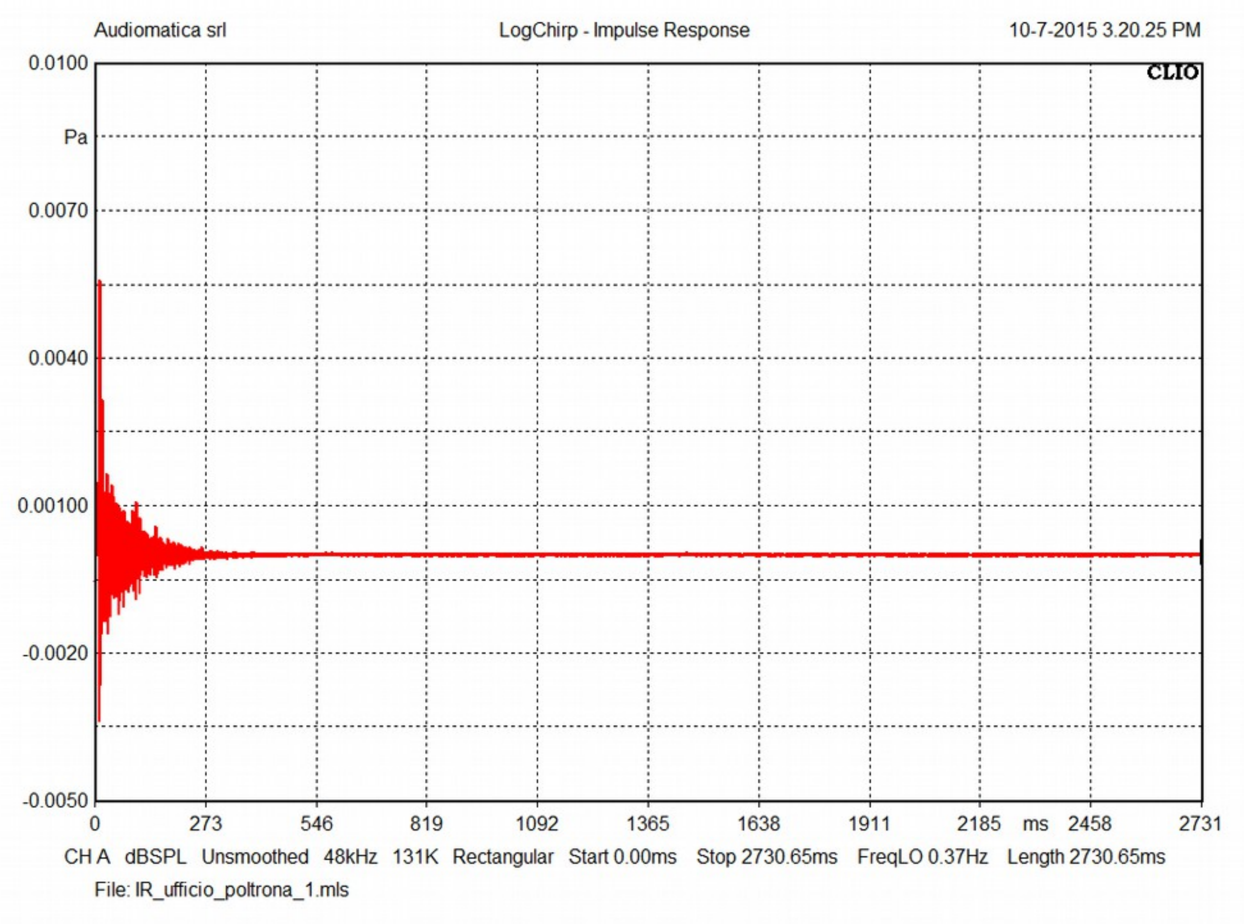


Figure 5: Impulse response between artificial mouth and chair position in room

Impulse response measurement

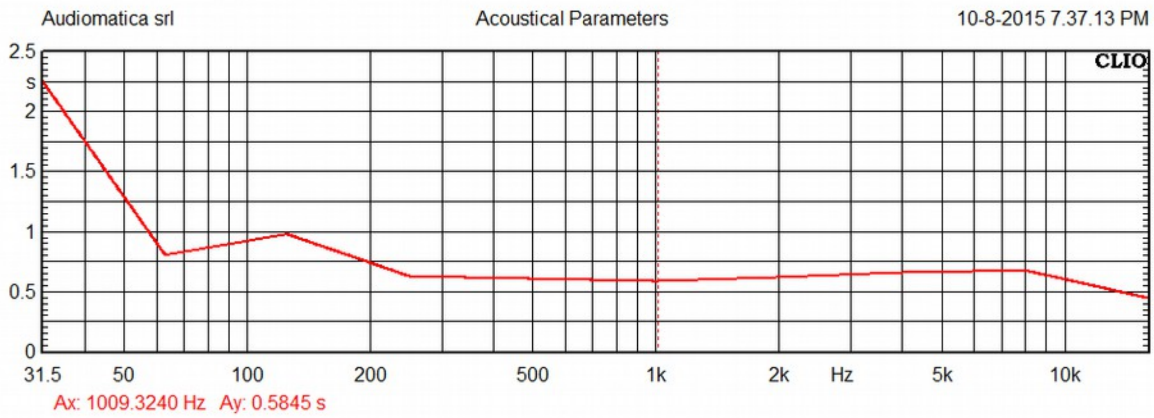
We measured the room impulse response using CLIO MLS&LogChirp menu. We chose a 128k size stimulus and we set the output level to the highest level while avoiding source distortion[6].

The acquired impulse response which can be seen in figure 5, has a typical shape for such a kind of room. The main pulse is followed by the multiple reflections coming from room boundaries and the reverberation tail.

If we analyze the response with the CLIO Acoustical Parameters tool we immediately find that the reverberation has a value of about 0.6 s at mid frequencies[7].

6 We took advantage of the Generator Control panel of CLIO 11 and we put an high pass filter at 80 Hz on the generator. The CLIO generated LogChirp stimulus starts at very low frequency, and this can cause distortions at the Artificial Mouth.

7 It should be noted that the data outside the 125 Hz to 8 kHz range is not relevant to STI calculations. We must also consider that the 31.5 Hz and 63 Hz band reverberation results should be disregarded due to the insufficient signal to noise ratio.



Frequency[Hz]	LIN	31.5	63	125	250	500	1000	2000	4000	8000	16000	A
Signal[dBSPL]	64.3	29.1	26.1	40.2	49.8	57.1	60.9	51.9	54.3	54.0	54.0	63.3
Noise[dBSPL]	46.7	22.3	22.0	19.0	21.0	24.5	26.6	32.1	37.7	42.5	40.5	43.8
C50[dB]	2.07	-23.53	-1.74	0.84	2.85	3.48	1.44	3.45	3.25	5.73	12.14	1.60
C80[dB]	5.96	-22.88	4.18	4.42	8.38	6.43	4.78	7.12	7.25	9.45	16.64	5.36
D50[%]	61.7	0.4	40.1	54.8	65.9	69.0	58.2	68.9	67.9	78.9	94.2	59.1
TS[ms]	72.3	2016.9	545.7	74.5	42.8	45.2	52.3	54.1	77.0	139.6	82.6	69.5
EDT[s]	0.674	20.867	0.777	0.793	0.568	0.651	0.732	0.645	0.585	0.476	0.197	0.689
RT20[s]	0.597	2.255	0.803	0.975	0.624	0.604	0.584	0.616	0.656	0.673	0.443	0.600
R(RT20)	-0.999	-0.930	-0.945	-0.996	-0.992	-0.998	-0.998	-1.000	-0.999	-0.993	-0.994	-0.999
RT30[s]	0.608	2.061	0.721	1.317	0.685	0.625	0.644	0.623	6.157	5.944	6.005	0.658
R(RT30)	-0.999	-0.938	-0.940	-0.961	-0.995	-0.998	-0.997	-1.000	-0.688	-0.810	-0.700	-0.997
RTU[s]	0.593	1.970	0.598	1.002	0.606	0.625	0.562	0.611	0.679	0.728	0.477	0.593
R(RTU)	-0.999	-0.882	-0.930	-0.993	-0.985	-0.997	-0.997	-1.000	-0.999	-0.992	-0.993	-0.999

Data: MLS RTU(-10.0;-25.0) Stop 2730.6ms Noise Correction ON

File:

Figure 6: Acoustical parameters measured in office room

The STI parameters are calculated alongside the Acoustical Parameters. By default the effects of signal to noise ratio and level masking are not active.

Viewing STI results

The STI calculation and resulting parameters can be viewed by pressing the STI button on the Acoustical Parameters toolbar.

A memo box with the results of the latest calculation is shown[8]:

```
---------------------------------------------------------------------
MTF
---------------------------------------------------------------------
Oct.Band   125   250   500   1k    2k    4k    8k
f1=0.63    0.964 0.984 0.984 0.981 0.974 0.962 0.912
f2=0.80    0.949 0.975 0.975 0.969 0.966 0.956 0.918
f3=1.00    0.928 0.963 0.963 0.955 0.951 0.942 0.902
f4=1.25    0.897 0.943 0.942 0.929 0.931 0.925 0.893
f5=1.60    0.862 0.920 0.917 0.899 0.905 0.904 0.880
f6=2.00    0.805 0.876 0.871 0.843 0.858 0.863 0.849
f7=2.50    0.753 0.830 0.821 0.782 0.807 0.818 0.815
f8=3.15    0.688 0.763 0.749 0.696 0.737 0.758 0.773
f9=4.00    0.602 0.676 0.650 0.582 0.646 0.676 0.712
```

8 Note that the MTF matrix values are shown with 3 decimal digits while STI with 2 decimal digits, this has been done in accordance to all the examples reported in the standard. It should be taken into account that the standard at section 5.4 reports that the maximum deviation on a direct measurement is 0.02 and Just Noticeable Difference for the STI is usually set to 0.03. Thus the results for the STI indexes are rounded to two decimal digits (Nicola Prodi, personal communication, Dec, 2015).

```
f10=5.00   0.519 0.598 0.554 0.481 0.564 0.599 0.653
f11=6.30   0.444 0.526 0.455 0.385 0.485 0.518 0.594
f12=8.00   0.368 0.433 0.371 0.310 0.414 0.438 0.537
f13=10.00  0.325 0.283 0.315 0.283 0.360 0.372 0.487
f14=12.50  0.257 0.197 0.266 0.267 0.323 0.317 0.441
---------------------------------------------------------------
MTI        0.645 0.694 0.688 0.661 0.687 0.686 0.679

STI Male=0.68    rated C
STI Female=0.68  rated B
STIPA(IR)=0.68   rated B
```

As stated before, this calculation takes into account the reduction of the modulation due only to temporal evolution of the response in the path between the artificial mouth and the measurement microphone.

The MTF is calculated using the previously seen Schroeder formula (1).

The STI parameters are calculated from MTF matrix following a series of steps:

1. First the MTF is converted in another matrix called the Transfer Index TI matrix;
2. Then the columns of this TI matrix are averaged to get a set of 7 MTI Modulation Transfer Indexes.
3. The MTI indexes are combined using a weighted sum to get the STI Male and STI female parameters

The memo box reports all the 98 values of the MTF matrix and the MTI values per octave band. Final calculation of the STI Male, Female and STIPA is also reported.

The STIPA(IR) is calculated averaging a subset of the cells of the TI matrix, using only two modulation frequencies for each octave band[9].

Alongside the numerical result for the STI indexes the qualification bands (shown in figure 7) are reported as indicated in the Annex F of the standard.

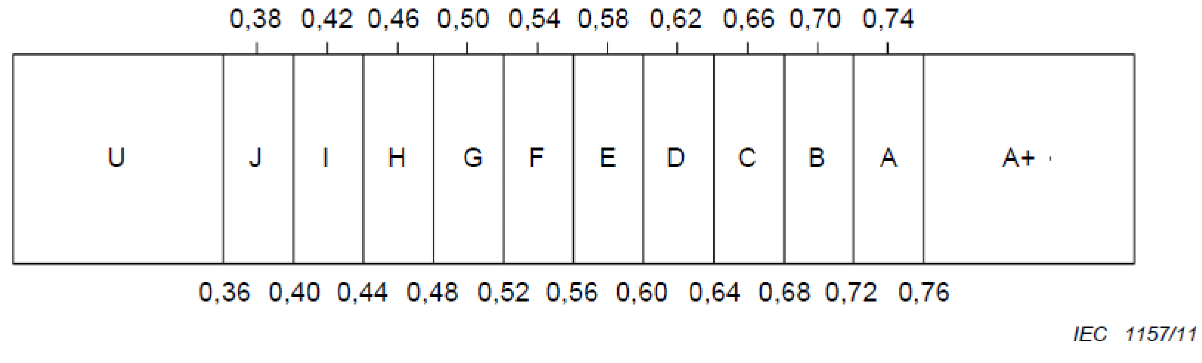


Figure 7: STI Nominal Qualification Bands

Until this point the STI is calculated without the effects of the Signal level and background noise, the reduction of the MTF is only due to temporal evolution of the impulse response.

To add the effects of noise and masking, the effective signal and noise level shall be measured. This signal level shall be measured at receiver position, using as a stimulus a proper signal with a given level and sending it through the

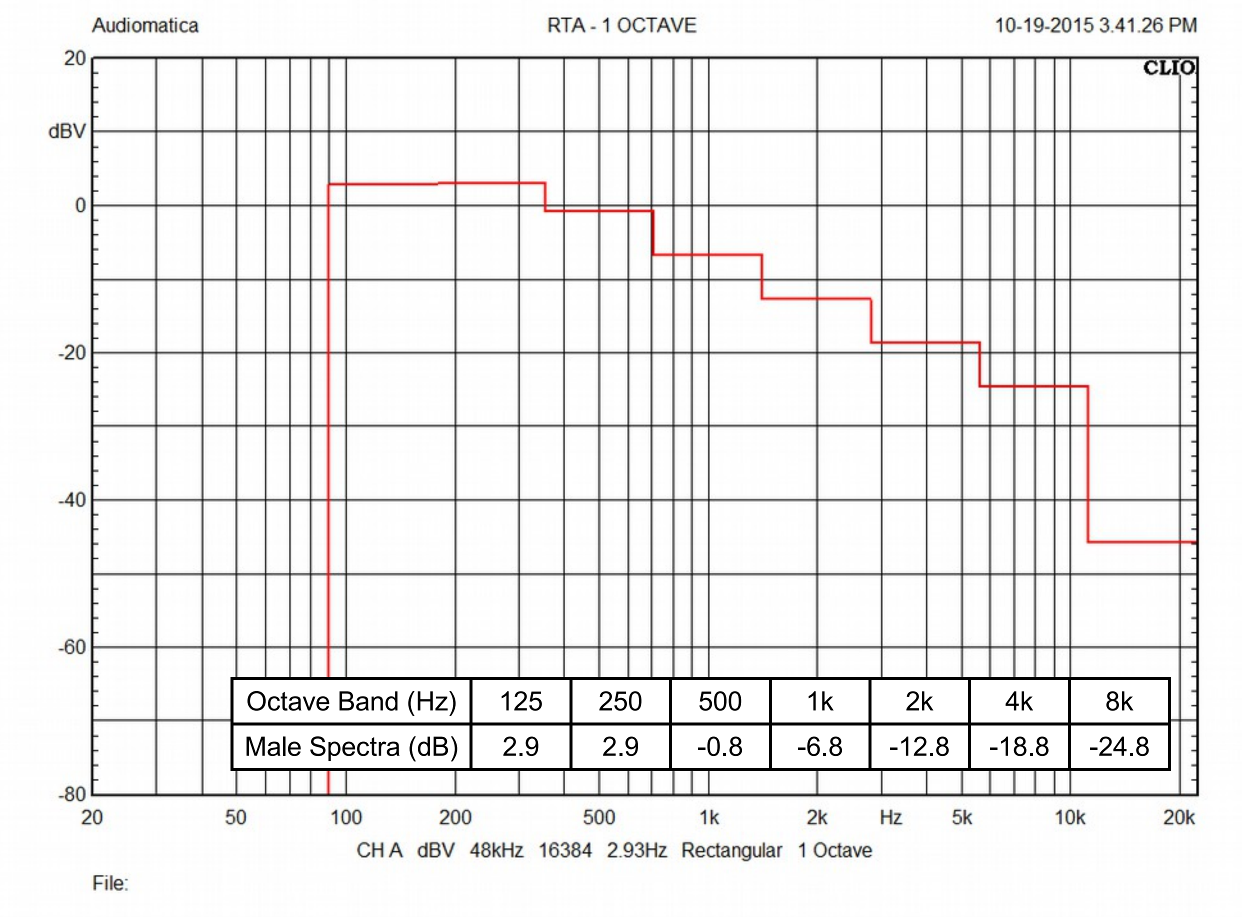
9 In fact when using the indirect method there is no any advantage to use the reductions of the STIPA method. The STIPA(IR) index is calculated only to compare it with measurements made with the direct method. The (IR) suffix is added exactly to highlight the different method used to calculate the STIPA.

communication channel.

Measuring Signal Level

The Signal level should represent the average speech level measured at the receiver position. The IEC standard specify an octave spectra for Male and Female speech signal cases.

To comply with the IEC standard Male spectra and to measure a stable signal level we created by additive synthesis a pseudo-casual pink noise with the proper spectral content[10]. The RTA analysis of the signal is shown in figure 8 alongside the IEC Male octave band spectra values.



Octave Band (Hz)	125	250	500	1k	2k	4k	8k
Male Spectra (dB)	2.9	2.9	-0.8	-6.8	-12.8	-18.8	-24.8

Figure 8: Male signal octave band spectra

This is the spectral IEC Male content that should be present in anechoic conditions in front of the acoustical source.

Equalization of the source

If the artificial mouth or test loudspeaker does not exhibit a flat frequency response, the device shall be equalized before using it into the STI test in order to get the above desired spectra.

The IEC standard states that “[...]If necessary, adjust the equalization (if any) of the artificial mouth or test loudspeaker to satisfy this requirement.”.

The Gras 44AA we used for these tests is not equalized nor has a flat frequency

10 A set of noise files with the IEC pink noise male spectra are available as download alongside this application note. The files have different lengths which should be matched to the FFT size used.

response. CLIO 11 Acoustical Parameters module feature a tool which applies a pre-equalization on the stimulus signal before sending it to the artificial mouth in order to correct the transducer response.

As a first step we measured the response of the artificial mouth in simulated anechoic conditions using CLIO 11 MLS&LogChirp analysis tool.

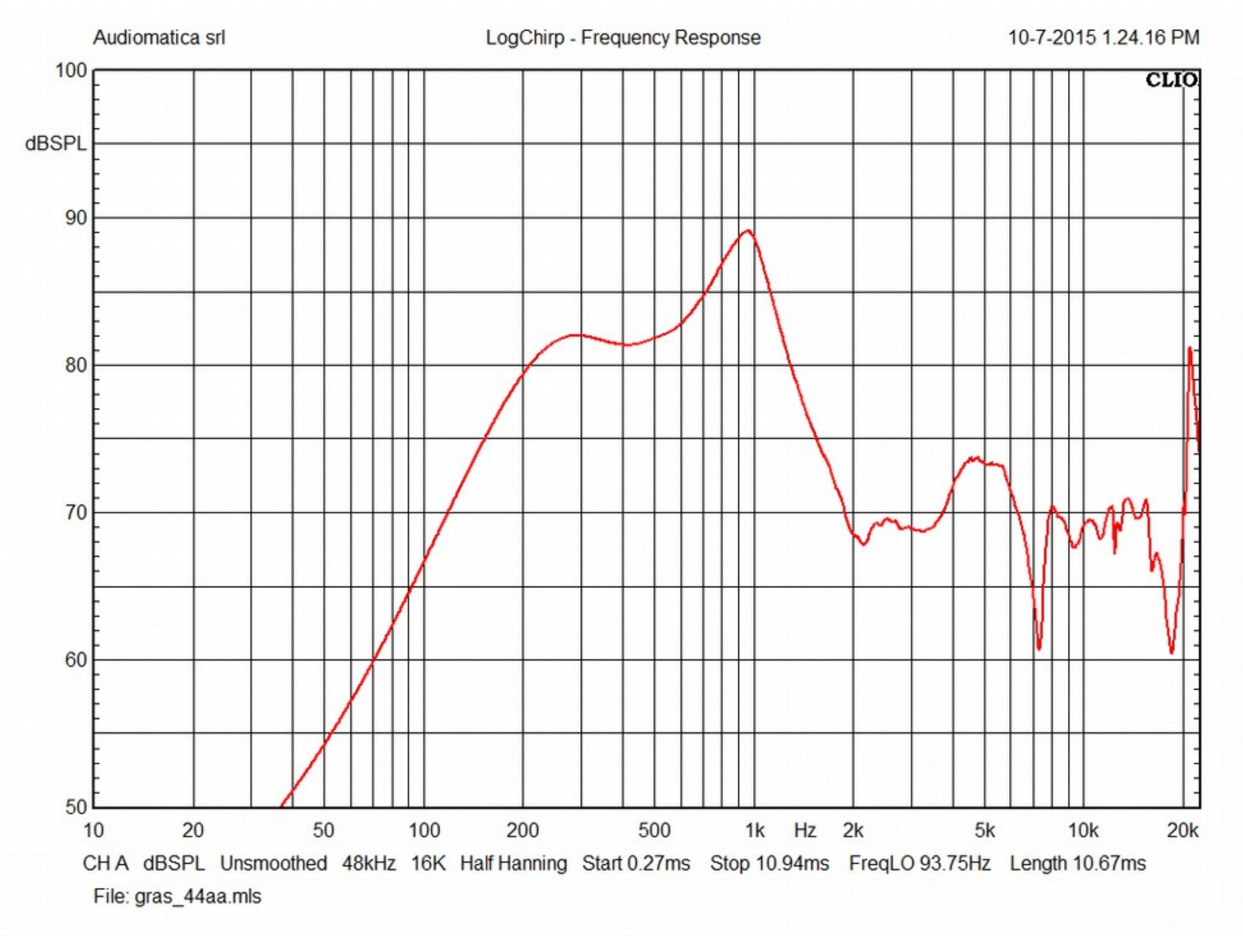


Figure 9: Anechoic response of Gras 44AA artificial mouth

With the above response open in the MLS&LogChirp menu, we then selected the Acoustical Parameters menu.

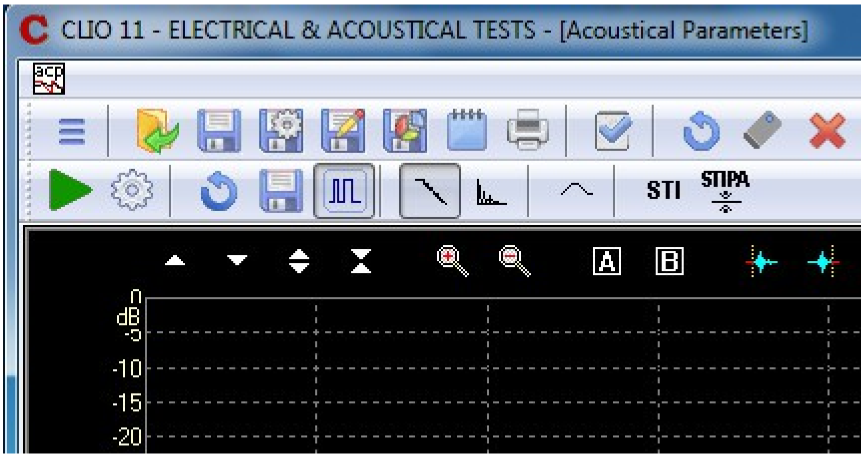


Figure 10: Acoustical Parameters Menu Toolbar

The STIPA EQ button STIPA can be found on the rightmost part of the Acoustical Parameters menu toolbar.

This button allows to equalize an audio file with an inverse filter of the active

MLS&LogChirp response[11].

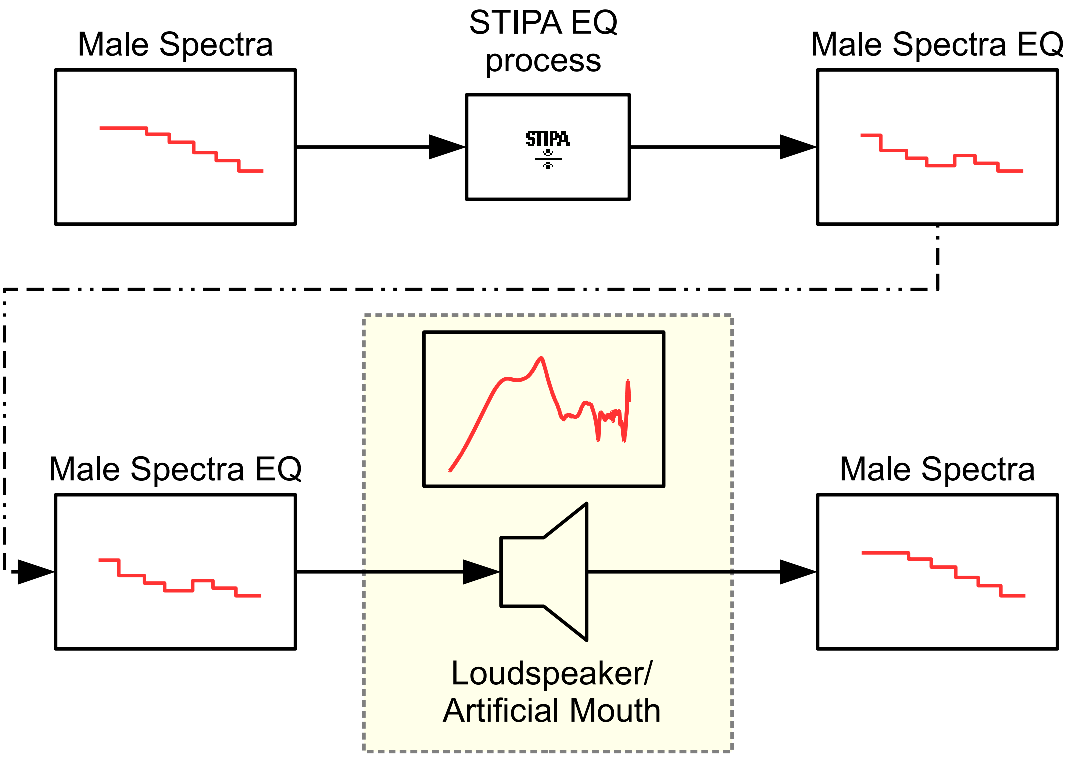
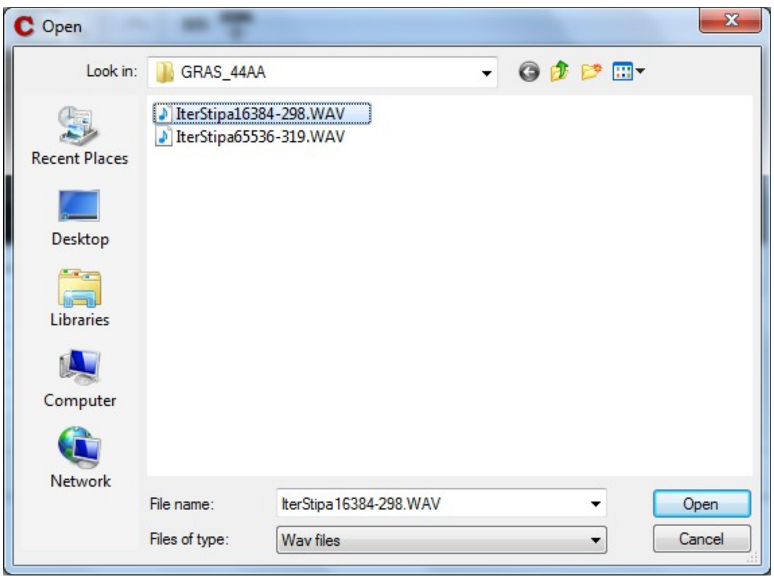


Figure 11: Equalization process

Figure 11 helps to summarize the situation; the standard requests that a Male Spectra signal is reproduced by a flat response loudspeaker. In our approach we use predistortion and apply convolution of the inverse response of the loudspeaker to the Male Spectra signal.

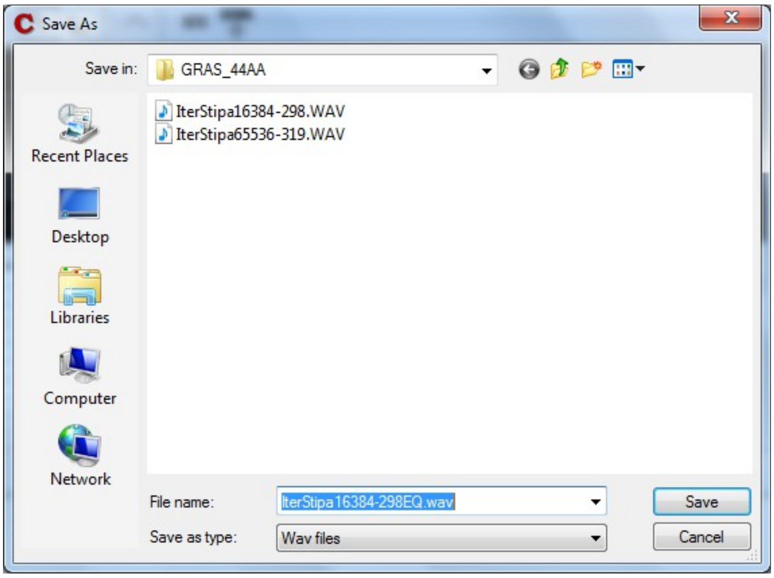
A Male Spectra shaped noise STILEVMALE65536.WAV with 64k size is available in the CLIO signal directory.

Pressing the STIPA EQ button will show a file open dialog which should be used to choose the wave file to be equalized.



11 Wave file and MLS&LogChirp response shall have the same length. The impulse response to be equalized shall be open in the MLS&LogChirp measurement menu.

Then a save dialog prompts where to store the equalized waveform in a new file:



Using the above corrected signal we set the CLIO output level to get the desired Sound Pressure Level[12] of 60 dBA at 1 meter distance[13] from the source and we measured the octave band spectra of the signal at the receiver position.

The noise spectra can be measured using the CLIO FFT measurement menu in octave band RTA mode using a proper number of averages in order to get a stable measurement.

Measuring noise level

Following the signal level measurement, leaving the microphone at the same receiver position, we measured the ambient background noise level using the same RTA tool.

The following figure 12 shows the signal and noise levels measured at the receiver position in the meeting room.

12 The IEC standard states that the signal level should be set "[...] at the microphone position to the operational speech level that will be used by the system[...]", but this is the case where the system has an acoustical-electrical (a microphone) input. Our case differs and fits with the following sentence of the standard "[...] a default equivalent level of 60 dBA at 1 m […] should be used for the source.".

13 This simulates the directivity, spectra and sound pressure level produced by a male talker in the condition of "normal" vocal effort as defined in the ISO9921 standard[3].

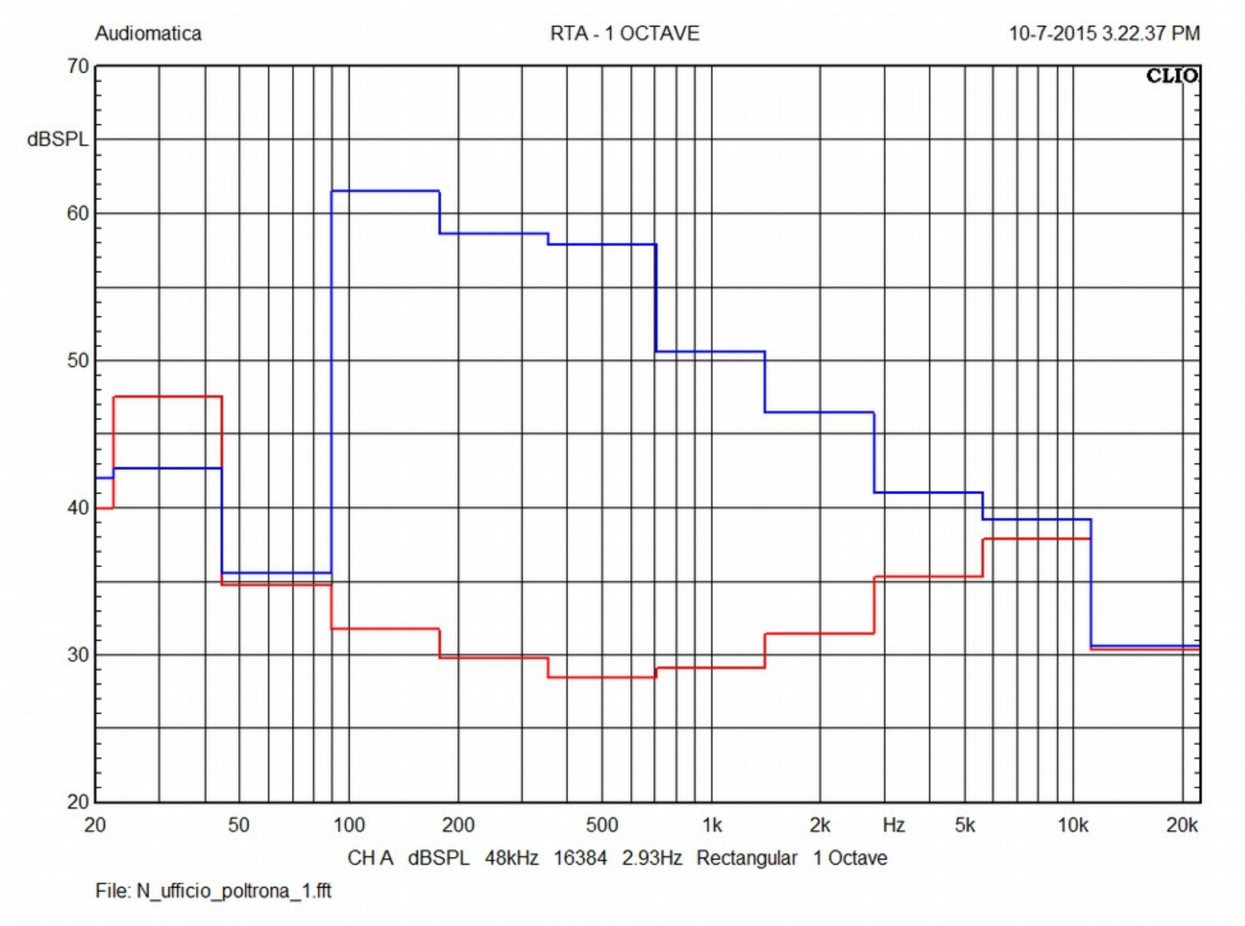
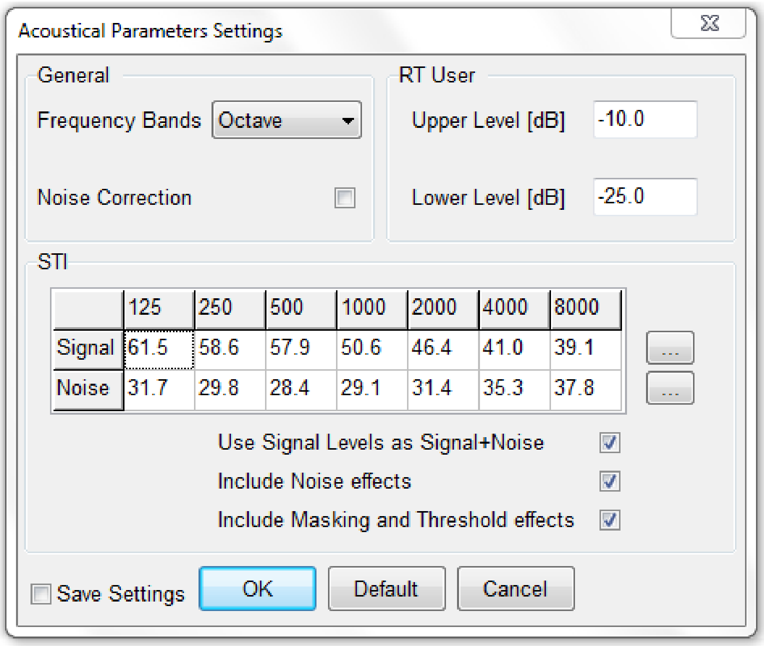


Figure 12: Signal (blue) and noise (red) levels measured at receiver position

Inserting the Signal and Noise spectra in the Acoustical Parameters Settings dialog it is possible to calculate the STI index with the effects of the signal to noise ratio, adjacent bands level masking and bands level threshold.



The results of the calculation using the above levels is:

```
-----------------------------------------------------------------------
MTF (with Noise + Masking)
-----------------------------------------------------------------------
Oct.Band   125   250   500   1k    2k    4k    8k
f1=0.63    0.937 0.981 0.983 0.973 0.943 0.702 0.236
f2=0.80    0.922 0.972 0.973 0.961 0.935 0.698 0.237
f3=1.00    0.901 0.960 0.961 0.947 0.921 0.688 0.233
f4=1.25    0.871 0.940 0.940 0.921 0.901 0.676 0.230
f5=1.60    0.838 0.917 0.916 0.891 0.876 0.660 0.227
f6=2.00    0.782 0.874 0.870 0.836 0.831 0.630 0.219
f7=2.50    0.731 0.827 0.820 0.776 0.782 0.597 0.210
f8=3.15    0.668 0.761 0.748 0.690 0.714 0.554 0.200
f9=4.00    0.585 0.674 0.649 0.577 0.625 0.494 0.184
f10=5.00   0.504 0.596 0.554 0.477 0.546 0.437 0.169
f11=6.30   0.431 0.525 0.455 0.382 0.470 0.378 0.153
f12=8.00   0.357 0.432 0.370 0.307 0.401 0.320 0.139
f13=10.00  0.315 0.282 0.315 0.280 0.348 0.271 0.126
f14=12.50  0.250 0.197 0.266 0.264 0.313 0.232 0.114
-----------------------------------------------------------------------
MTI        0.619 0.692 0.687 0.652 0.651 0.514 0.287
-----------------------------------------------------------------------
Signal Leq 61.5  58.6  57.9  50.6  46.3  39.6  33.2
Noise Leq  31.7  29.8  28.4  29.1  31.4  35.3  37.8

STI Male=0.59   rated E
STI Female=0.58 rated E
STIPA(IR)=0.60  rated E
```

It can be noted that the MTF matrix has lower values than its noiseless counterpart, due to modulation reduction caused by signal to noise ratio and adjacent band level masking.

The STI Male level goes down to 0.59 from the 0.68 of the noiseless case. Similarly the STIPA(IR) is 0.60 down from 0.68.

It should be also noted that since we used a Male shaped spectra for the source, only the STI Male and STIPA(IR) values, which are both based on the Male spectra, are valid. To get the STI Female value we should have used an IEC Female shaped signal spectra.

In our calculation we selected the option “Use Signal Level as S+N”. This is because the noise source, in our case made up from noises coming from the neighboring production facilities could not be interrupted, then the noise level should be considered when calculating the Signal to Noise ratio.

We then repeated the measurements introducing a fictitious source of noise during the signal measurements: a fairly old and noisy portable electrical screwdriver. We activated the screwdriver continuously during the measurements to simulate a source of stable noise.

As a result the STI indexes are lower:

```
-----------------------------------------------------------------
MTF (with Noise + Masking)
-----------------------------------------------------------------
Oct.Band   125   250   500   1k    2k    4k    8k
f1=0.63    0.938 0.981 0.961 0.581 0.086 0.326 0.021
f2=0.80    0.923 0.972 0.952 0.574 0.085 0.324 0.021
f3=1.00    0.902 0.960 0.940 0.565 0.084 0.320 0.021
f4=1.25    0.872 0.940 0.920 0.550 0.082 0.314 0.020
f5=1.60    0.838 0.917 0.896 0.532 0.080 0.307 0.020
f6=2.00    0.783 0.873 0.851 0.499 0.075 0.293 0.019
f7=2.50    0.732 0.827 0.802 0.463 0.071 0.277 0.019
f8=3.15    0.669 0.761 0.731 0.412 0.065 0.257 0.018
f9=4.00    0.585 0.673 0.635 0.345 0.057 0.229 0.016
f10=5.00   0.504 0.596 0.541 0.285 0.050 0.203 0.015
f11=6.30   0.432 0.525 0.445 0.228 0.043 0.176 0.014
f12=8.00   0.358 0.432 0.362 0.183 0.036 0.149 0.012
f13=10.00  0.316 0.282 0.308 0.167 0.032 0.126 0.011
f14=12.50  0.250 0.197 0.260 0.158 0.028 0.108 0.010
-----------------------------------------------------------------
MTI        0.620 0.691 0.663 0.429 0.099 0.328 0.000
-----------------------------------------------------------------
Signal Leq 61.6  58.5  57.7  51.1  40.1  43.6  28.4
Noise Leq  31.8  31.3  41.4  49.5  50.3  46.5  44.7

STI Male=0.34   rated U
STI Female=0.32 rated U
STIPA(IR)=0.43  rated I
```

It should be noted that the signal level in the 2k and 8k band is very low and way under the noise level, this results in an MTI=0.099 for the 2k band and MTI=0 for the 8k band.

This is clearly a limit case and an artificial situation. In this case, the STIPA(IR) value deviates greatly from the STI Male, this is due to the fact that there are some MTI values which are nearly zeroed.

We then repeated the measurements with a second receiver position placed slightly outside the door of the meeting room; we acquired an Impulse Response and again the RTA spectra of the signal and the background noise.

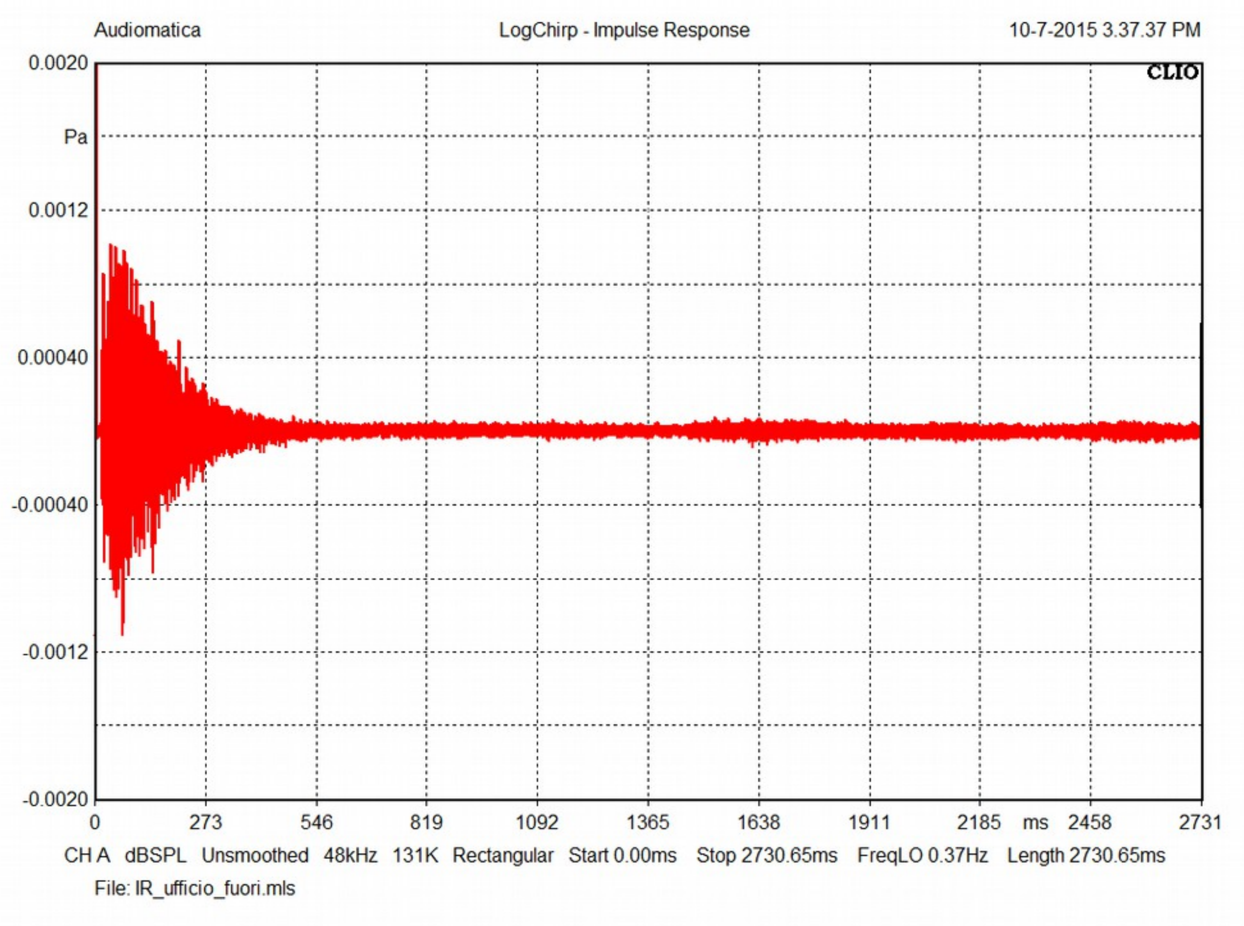


Figure 13: Impulse response with microphone outside meeting room door

The calculated STI parameters in this case are:

```
STI Male=0.40    rated I
STIPA(IR)=0.43   rated I
```

As expected in this case STI values are lower than previous case. In this case the difference in modulation reduction MTF is due to both impulse response and Signal to Noise levels.

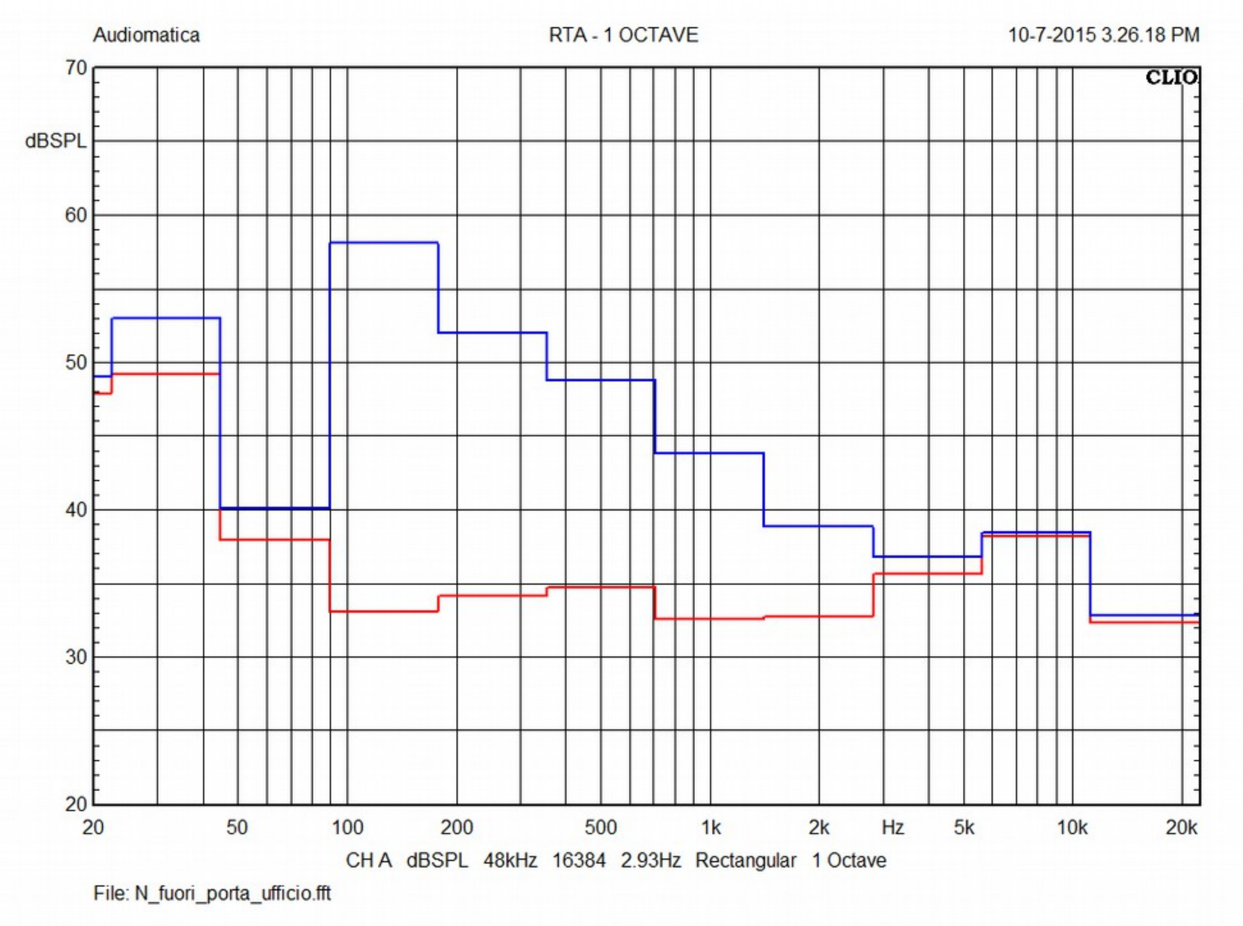


Figure 14: Signal (blue) and Noise (red) measured outside the meeting room door

CONCLUSIONS

With CLIO 11 it is possible to measure the Speech Intelligibility Index using the indirect method.

The STI evaluation require a set of data to be analyzed:

1. Channel impulse response
2. Speech signal level at the receiver
3. Ambient background noise level at the receiver

While the measurement of the Impulse Response and Noise are simple to carry out using CLIO, the speech level measurement can be more challenging to achieve.

The speech level measurement require the use of a speech signal with a given spectra and a specific sound source with directivity resembling a human talker and possibly with flat frequency response in the speech bandwidth.

In our example we used as a speech signal a pseudo-random pink noise shaped according to the IEC standard Male spectra, the file is available as download together with this document.

The file with the equalized version for the Gras 44AA artificial mouth is also available.

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