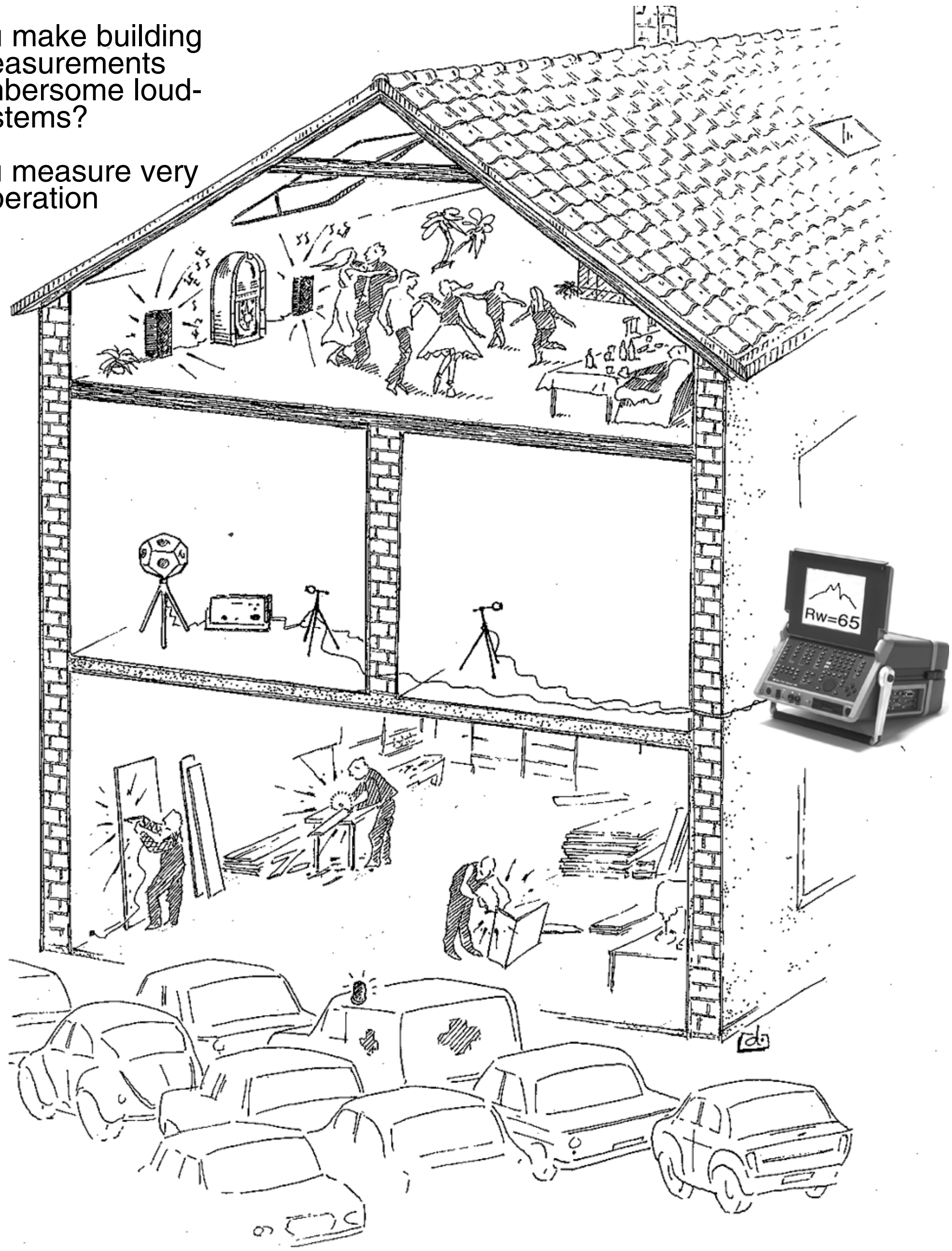
Norsonic

Application Note

– How do you make building acoustic measurements in high background noise?

– How do you make building acoustic measurements without cumbersome loud-speaker systems?

– How do you measure very short reverberation times?



MLS—a revolutionary measurement mode for building acoustics!

AN 840-MLS Ed.1. Rev.I. ENGLISH 05.00

Transmission Loss Measurements

The RTA 840 with the MLS measurement mode is not a luxury option, rarely used. It is the only practical way to measure high sound insulation indices, in high background noise levels, or in rooms where the noise excitation level is insufficient.

With the new ISO 140 series of Standards and the corresponding new EN Standards for sound insulation tests, it is now required in special cases to widen the frequency range at both ends to measure over the entire 50–5000Hz range. With current loudspeaker systems, most engineers will have difficulties measuring below 100Hz due to the limited efficiency of the loudspeakers and the high background noise at these frequencies. Similarly, at the high frequency bands when testing good sound insulation products it is often difficult to measure received sound levels at least 10dB above the background noise.

The following examples clearly show how an RTA 840 with the MLS mode improves the measurement possibilities. The system used was a *Norsonic RTA 840* analyser, the *Norsonic Power Amplifier Type 235* and the *Norsonic Dodecahedron Loudspeaker Type 229.* The transmission loss index R’w of the wall being tested was nearly 60dB.

The background noise level in all the examples was 30–40dB across the frequency range.

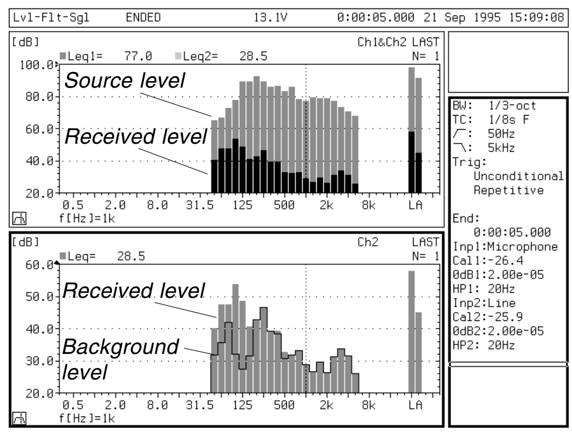
Example 1: Broadband noise and parallel frequency analysis.

The described measurement system gave a noise excitation level of between 70dB and 90dB for the individual frequency bands. These relatively low levels were due to the volume and absorption area of the source room.

The upper window shows both the measured levels in the source room (channel 1) and the received excitation noise in the receiving room (channel 2).

The lower window shows the received excitation noise again as well as the measured background noise of the receiving room. It is obvious that the received levels measured at the medium and high frequency bands are incorrect as they are masked by the background noise. The requirement for 10dB difference between the received levels and the background noise is only fulfilled at the lowest frequencies.

Broadband pink noise excitation and the parallel frequency analysis can only be used for cases with low transmission loss indices or when it is a low background noise.



Should the results measured in this example be used incorrectly in the computation of the R’w index, then the R’w-calculation would give an R’w = 44dB.

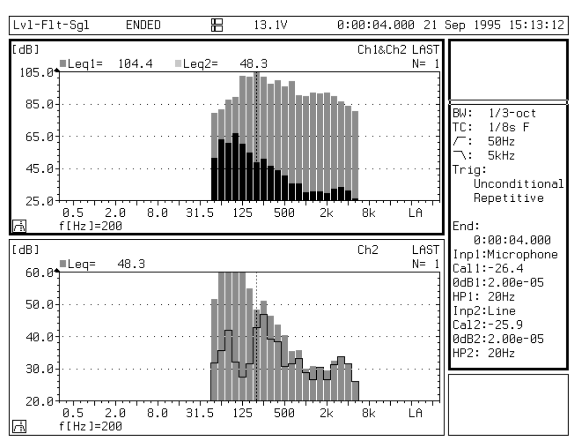
Example 2: 1/3-octave noise and serial frequency analysis

By using the serial scanning capability of the RTA 840 in combination with the correct 1/3 octave filter in the noise generator, the excitation energy of the measured frequency bands is improved by approx. 12–15dB.

Due to the serial noise excitation and the serial measurement, the measurement system will now also measure correctly for the medium frequencies. At the highest frequency bands the received levels are still hidden in the background noise—as can be seen in the lower window of the results display.

This example would have given an R’w = 52 dB, but would still be incorrect due to the high background noise on the upper frequencies.

Both the parallel measurement and the serial measurement fail to give correct results for the relatively simple test described in example 1 and in example 2. Without using a much more powerful loudspeaker and power amplifier system, it would have been impossible to measure the R’w correctly!



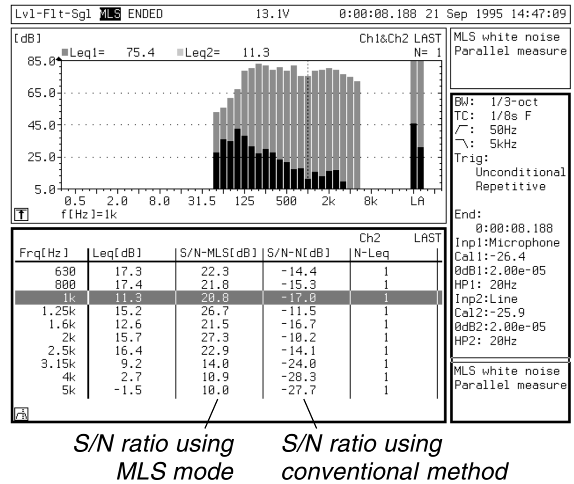
Example 3: Broadband noise and parallel MLS frequency analysis

The same 'wall' was measured using the MLS mode in the RTA 840. In this mode, the analyser is able to measure the S/N ratios and display them in a table—both for the special MLS measurement and for the traditional measurement method.

In the lower window it is clearly shown that the full frequency range was measured correctly. The correct measuring results give an R'w = 56dB which is 12dB different from the incorrect results measured in the first example, and 4dB different from the incorrect results in example 2.

It was necessary to make 58 MLS averages which required approx. 8 minutes of measurement time in order to give the 10dB S/N ratio in the receiving room for all the frequencies up to 3150Hz. This is the normal upper frequency limit for transmission loss measurement. Should this test have been done with the optional extended frequency range up to 5000Hz, it would have been necessary to increase the number of averages. Although this increases the measurement time, there are very few alternatives.

Also, as can be seen from the S/N table, the background noise is well below the correct measured receiving levels for most of the frequency bands, so even measurements in a much higher background noise (i.e., above a restaurant or discotheque) are now possible. Even if the partition wall had a transmission loss index R'w in much greater than 60dB, it would still have been possible to measure it as long as the background noise is lower, or the number of MLS averages is increased further.



The RTA 840 with MLS mode offers further possibilities of measuring under difficult conditions. Firstly, the broadband white noise may be changed to *red excitation noise* to give more power at the lower frequencies where the S/N ratios are a problem, i.e. loudspeaker systems in the 50–100Hz range. Secondly, parallel MLS measurement may be divided in two, or more, selected frequency ranges which later are combined in the AVRG register. This method enables the user to measure correctly under the most stringent measurement conditions with extreme background noise and very high R'w indices.

Applying MLS to Transmission Loss Calculations

The technique of *maximum length sequence* (MLS) is actually based on a few well-known facts. These are:

- The measurement object is excited by means of impulses
- Any deformation (time-smearing) of the impulses originates from what the measurement object did to the impulses
- Repeated excitation will average out background noise.

The noise generator of the RTA 840 has been designed to output a very special signal when used with the MLS extension. This signal consists of a train of impulses, each of the same amplitude (normalised to 1), but with the polarity varying in a certain pattern (i.e. amplitude is then +1 or –1).

The spectrum of the MLS signal looks like white noise, but it doesn't have the statistical properties of a white noise signal, as the amplitude is either +1 or –1 and not Gaussian distributed.

The auto-correlation of this train of impulses is an impulse at t = 0, i.e. again a sort of white noise look-alike.

When making sound insulation measurements the impulses are fed to a loudspeaker which is placed in the sending room. For most practical purposes, the room will distort each impulse much more than the loudspeaker so that the contribution from the loudspeaker is not significant.

The distorted impulse is called the *impulse response* of the room since it expresses the way the room responds to an impulse. When we excite the room with a train of impulses, we'll end up with a train of impulse responses as well.

The RTA 840 MLS excitation signal consists of periods each consisting of $2^{17} - 1$ impulses equidistantly spaced along the time axis. The impulse frequency is a function of the highest frequency band you set up the analyser to measure in.

Each impulse response is captured and retained by the analyser and then summed with the next impulse response to arrive. In this way all the impulse responses within an MLS signal period are time-shifted (so that they seem to occur simultaneously) and summed together.

The result of this averaging is in turn averaged with the average of the next MLS signal period. Thus we get a time-synchronously averaged impulse response. This broadband impulse response is then fed to the filters of the RTA 840 to obtain an impulse response for each frequency band.

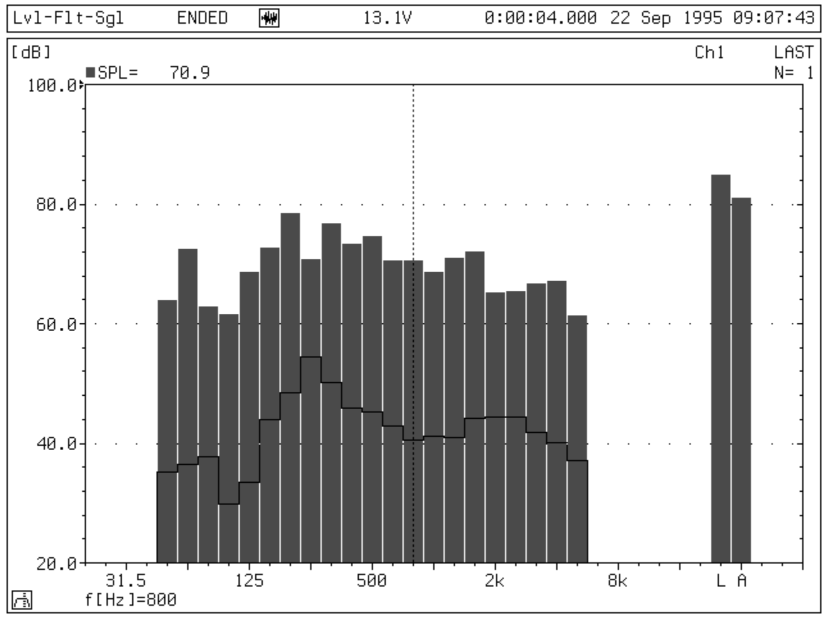
For transmission loss calculations the RTA 840 simply calculates the mean signal energy to get the Leq values per frequency band for each channel.

Reverberation Time Measurements

MLS is also very useful when measuring reverberation times. The difficulties with high background noise or insufficient excitation power are dramatically reduced by use of this new RTA 840 feature. The following three examples demonstrate the effect.

All tests were measured in the same room. Due to the volume and absorption area of the test room, the loudspeaker and power amplifier only gave about 60–70dB noise excitation level, while the background noise was in the 40–50dB range. As shown below, the S/N ratio is 20–25dB.

The normal requirements for RT-measurements of T30 require a 45dB S/N ratio. We arrive at this figure as follows; 5dB down from the top of the RT-curve, then 30dB calculation range, and finally 10dB clearance to the background noise. For T20 calculations, a S/N ratio of 35dB is sufficient.

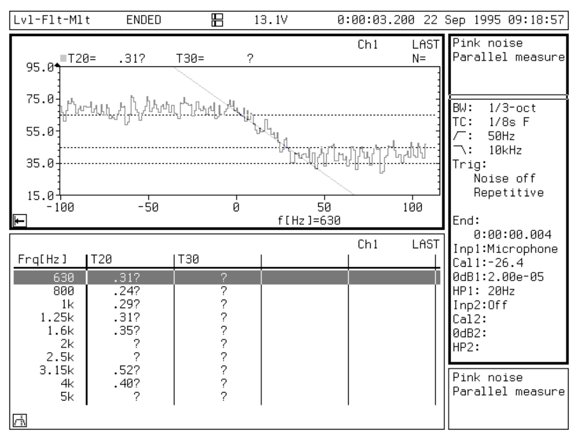


Example 4: Broadband noise and parallel frequency analysis

The most common problem is to achieve a high enough excitation level for all the measured frequency bands simultaneously.

In the upper window, the measured decay curve at the 630Hz frequency band shows that the generator excitation level is around 70dB and the background noise level is around 45dB. The decay is relatively straight, but due to the S/N ratio the calculation of T30 is impossible as indicated by the ?-mark. The T20 is calculated, but the background noise is too high—as the ?-mark indicates.

The lower window shows the calculated reverberation times table for the upper frequency range. Obviously, the excitation power is insufficient for most of the frequency bands, and therefore an RT-measurement cannot be made under these circumstances.



Applying MLS to Reverberation Time Calculations

As explained in *Applying MLS to Transmission Loss Calculations* (see the previous page), the MLS method is—the way the RTA840 uses it—a way of obtaining the impulse response of a room.

While for transmission loss calculations the analyser simply calculates the Leq of the impulse response, the reverberation time calculations are made in a slightly different way.

Firstly, the analyser regards the impulse response obtained by means of MLS as any other decay obtained by means of impulse excitation. Secondly, the RTA840 makes use of the multi-spectrum measurement mode in order to be able to “split up” the impulse response and calculate a multitude of short time Leq values. This Leq values describe the decay and the calculation of the reverberation time is carried out in the same way as for conventional (non-MLS) measurements.

The beauty of the MLS is that it is just an extension of the normal measurement modes of the RTA840—once the signal has “left” the MLS part, it is treated like any other signal acquired by conventional means.

The catch is that MLS takes more time than conventional methods, but this is normally a fair price to pay when the alternative would have been no measurement at all.

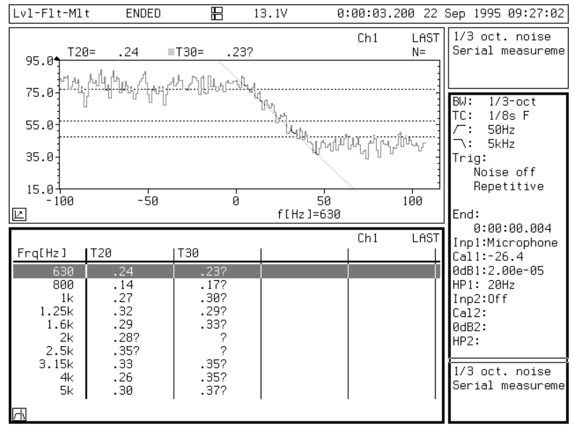
Example 5: 1/3-octave noise and serial frequency analysis

Using the serial scanning capability of the RTA 840 in combination with the correct 1/3 octave filter in the noise generator, the excitation levels of the measured frequency bands are improved.

In the upper window, the measured decay curve at the 630Hz frequency band shows that the generator excitation level now is in excess of 80dB while the background noise level is still around 45dB. The decay is relatively straight, but as the S/N ratio still is worse than the required 45dB, the correct calculation of T30 is impossible as indicated by the ?-mark. The T20 value is now, however, correctly calculated.

The lower window shows the calculated reverberation times table for the upper frequencies. Although most of these frequency bands are correctly calculated for the T20, two of the frequency bands still have ?-marks indicating a high background noise. The T30 calculations are still impossible for all the frequency bands.

The conclusion for this measurement is that by accepting T20 as good enough and by accepting the high background noise at 2000Hz and 2500Hz, this R.T.-measurement could be accepted. However, with a slight increase in the background noise, even the T20 R.T.-values would be unacceptable.



Example 6: Broadband noise and parallel MLS frequency analysis

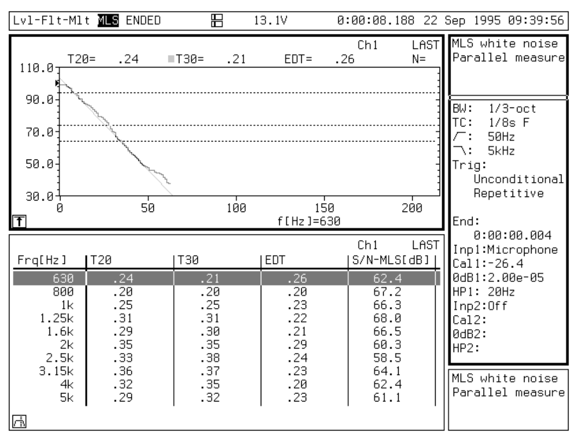
In this example, the MLS mode of the RTA 840 is used to measure reverberation times. In order to fulfill the S/N requirement of 45dB for all the bands in the 50–5000Hz frequency range, then 23 MLS averages are necessary. This gives a measurement duration of approx. 3 minutes.

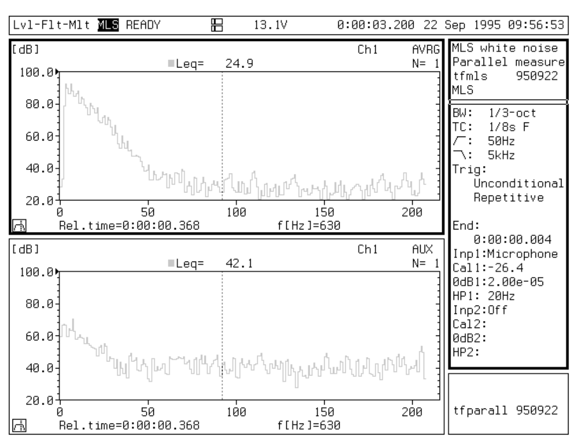
In the upper window, the calculated backward integrated decay is shown together with a straight line indicating the calculated R.T. value for the 630Hz band. Both the T20 and the T30 as well as the EDT value are all correctly measured, although the background noise in the room was as high as in the two previous examples.

In the lower window, the table for all the upper frequencies shows that they are all calculated correctly. The S/N ratio for each band in the right hand column clearly shows that the MLS technique would easily have functioned even for higher background noise as the S/N exceeds the 45dB requirements by 15–20dB.

The effect of the MLS mode on making R.T. measurements may be illustrated by comparing the measured decay for the traditional pink noise excitation with parallel measurement, as done in example 4, with the similar measured decay from the MLS measurement in example 6.

The bottom window shows the small difference between the excitation level (approx. 70dB) and the background noise level (approx. 50dB) using the traditional method. Whereas in the upper window, the dramatic increase in calculated excitation level (approx. 90dB) combined with the much lower calculated background noise level (approx. 35dB) clearly indicates that this new MLS mode is a most powerful tool.





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Very Short Reverberation Times

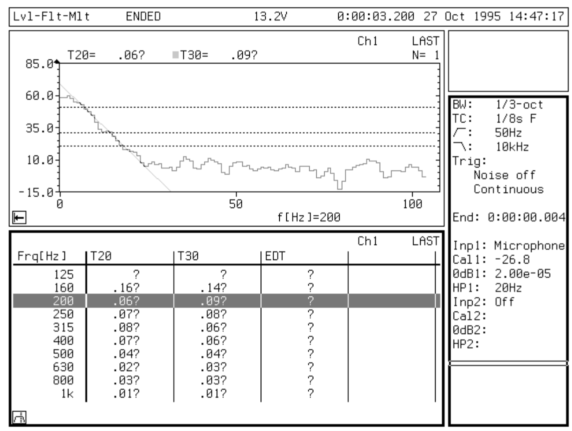
Measurements of very short reverberation times associated with small chambers, cars, etc. are normally impossible in the lower frequency bands by traditional techniques. This is due to the fact that the internal decay times of the filters used, limit the shortest possible measurable decay. The shortest measurable reverberation time at 20Hz and 200Hz are—for normal 1/3 octave band analysers—1.2s and 0.15s respectively.

Norsonic have overcome this problem using the MLS mode in the RTA 840 by introducing the *reversed decay mode*. By reversing the digital filter calculation, starting from the last sample and ending by the first sample, the effect of the internal decay time of the filter itself is dramatically reduced (5–10 times). Hence, reverberation times down to 0.05s and 0.021s, for 20Hz and 200Hz respectively, may be measured using this technique. Another dramatic advantage of the MLS system!

Example 7: Broadband noise and parallel frequency analysis

The upper window shows the measured decay. It is a straight forward decay, but the RTA 840 internal 'check' of the calculated reverberation time indicates that the calculated RT is shorter than the limit for this filter band.

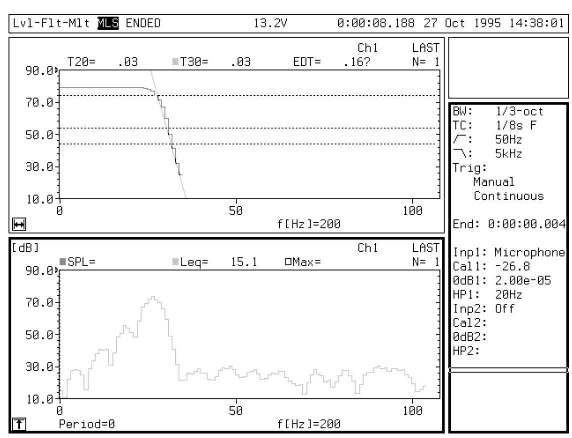
In the lower window, the numerical table shows the same problem for several frequency bands.



Example 8: Broadband noise and parallel reversed MLS frequency analysis

The upper window shows the measured decay. It is now much steeper than in the last example, and the 'automated check' of the calculated reverberation time does not indicate that the calculated reverberation time is shorter than the filter time constant.

In the bottom window the reversed filtered room-impulse is shown. It can been seen that the decay on the right-hand side used for the RT calculation is much steeper than the decay on the left-hand side which is influenced by the internal decay time of the filter itself.



Rating of Airborne Insulation

The results of sound insulation measurements between two rooms combined with the reverberation times for the receiving room may be used to calculate the airborne sound insulation—the R'w—in accordance with the ISO717 Standard.

Using the results from example 3 together with the corresponding reverberation time values, the RTA840 calculates R'w in an easy and convenient way by means of separate software running on the internal PC. This software—called NOR-SIC—is available separately and may do all your airborne and impact sound insulation calculations, supporting international and national Standards.

The NOR-SIC program produces predefined printouts of the final results as shown below.

Apparent sound reduction ISO 140/717

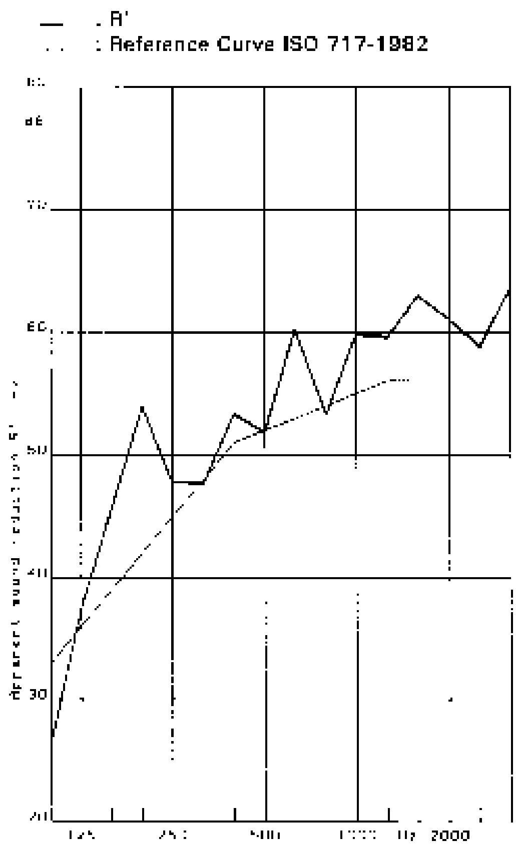
Project: Testb of working chamber

Size of speciem: 12.5 m^2

Test speciem description:
Double insulated HighTL plates

Source room
Volume V_S = 235.0 m^3
Condition: O.K.
Type: Conference room
Location: Adm.dept.

Receiving room
Volume V_S = 47.5 m^3
Condition: Well
Type: Working chamber
Location: South wing



R'$_w$ = 56 dB
Max.Dev.: 10.5dB at 100 Hz

Frequency [Hz]	R' [dB]
100	26.5
125	37.5
160	45.6
200	53.9
250	47.8
315	47.7
400	53.3
500	51.9
630	60.2
800	53.3
1000	59.8
1250	59.6
1600	63.0
2000	61.0
2500	58.8
3150	63.7

Rating : ISO 717
Measurement: ISO 140

Noise type. White MLS
Recv. filter: 1/3 oct.

Customer: A.B.Hansen
Projectnumber: 4663.6

Date: 21.09.1995
Signature:

Norsonic

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