

# Proceedings of the Institute of Acoustics

## PRACTICAL APPLICATIONS OF THE MLS TECHNIQUE TO MEASUREMENTS OF SOUND INSULATION

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### 1 - SUMMARY

The theoretical basis of the Maximum Sequence Length procedure was described in some detail by Bjor (1) along with the way in which it could be incorporated into a practical measuring instrument. The MLS technique offers a means of considerably improving the signal to noise ratio available in any given measurement location. The objective of this paper is to report on the advantages that MLS offers in practical measurement situations.

The quantification of sound insulation of structures presents a number of practical problems, most of which are not apparent until the team arrives on site to commence the work. Being prepared for anything is, therefore, often a prime determinant of the ultimate cost of performing the work. Key information on the dynamic range that is available for the measurement is not readily available prior to commencing work as it is a function of the back ground noise level at the site, the transmission loss of the partition under test and the performance of the excitation system in the acoustic conditions found on site. The problems are compounded by the fact that the highest background noise levels are usually found in the bands where the generated levels are the lowest! Current electronics offer the ability to automate the measurements and care must be taken to ensure that they do not allow "error" situations to be accepted into a measurement sequence due to inadequate signal to noise ratios being achieved. Careful planning of these automatic measurements is therefore needed to ensure that acceptable results are obtained.

A series of measurements have been undertaken in typical commercial situations to determine the parameters required to calculate the sound insulation of a party wall. Three series of measurements were made; the first two were performed using the conventional methods of serial and parallel measurements followed by a series using the MLS technique. The results showed that in the determination of reverberation time it was only possible to obtain the  $RT_{20}$  using the conventional methods due to the limited excitation levels available whilst MLS yielded both the  $RT_{20}$  and  $RT_{30}$ . The values for the transmission loss  $R'_w$  yielded by the series of measurements became progressively more accurate due to the improving signal to noise figures obtained using the three various measurement protocols.

In all cases the time to perform the test varied. The parallel method showed the prospect of being the quickest but needed very careful setting up to avoid errors. Serial testing had the most straight forward set up procedure and produced results within the dynamic range available on the site. MLS will produce a result under almost any measurement conditions with the simple trade off being between signal to noise requirements and measurement duration. Serial analysis methods had the lowest equipment costs followed by the parallel systems with MLS being the most expensive.

### 2 - MEASUREMENT LOCATIONS

With the new ISO (2) series of standards along with their EN counter parts it is now required, in special conditions, to widen the frequency range to measure over the range of 50 - 5kHz. With current loudspeaker systems most would have problems at the lower frequencies due to the limited efficiency and high background noise levels in this range. Similarly at high frequencies the improving attenuation of the partitions results in transmitted levels that are close to the back ground levels. The traditional cure for these problems has been to increase the power available in the excitation system or to make the measurements at night when the background levels are lower. Both of these solutions bring their own problems and to overcome them the MLS procedure has been proposed. Tests were carried out to determine the sound transmission between a conference room and an adjacent work area. The construction was from a twin leaf high transmission loss panel giving a design goal of nearly 60 dB for the R<sub>w</sub>. The back ground noise levels in the receiving room was in the range of 30 to 40 dB across the frequency range. The generated level for the individual frequency bands in the source room was limited to a range of 70 - 90 dB due to its size and high absorption levels. Tests were carried out using a Norsonic NOR-840 Real Time Analyser with the MLS and other building acoustics options and a 100W power amplifier and dodecahedron loudspeaker.

### 3 - TRANSMISSION LOSS MEASUREMENTS

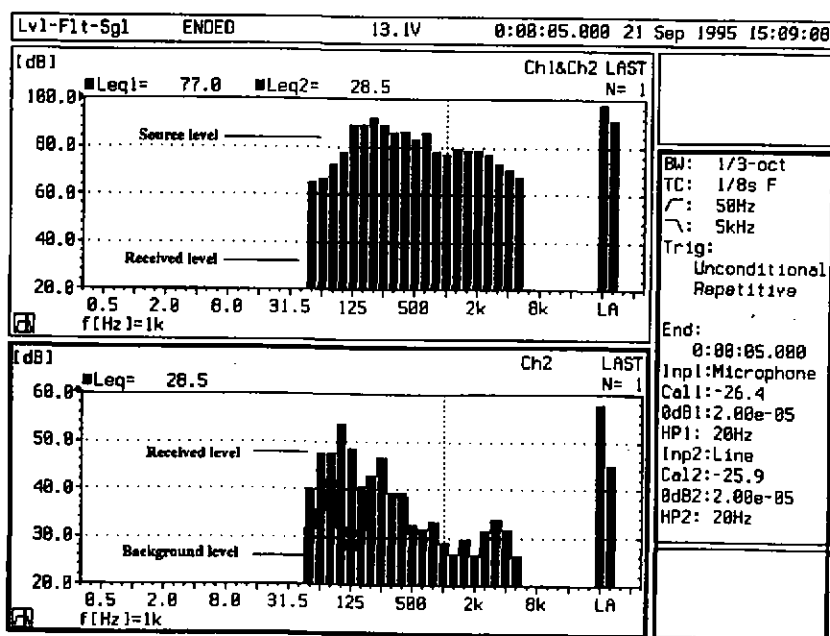


Figure 1.  $L_d$  using Broad Band Noise and Parallel Frequency Analysis

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### 3.1 Broad band noise and parallel frequency analysis

The results of this approach are shown in figure 1. The upper trace shows the source room level in channel 1 and the received level in channel 2 with the excitation on. The lower trace superimposes the background onto the levels transmitted from the source room. It is obvious that the received levels are incorrect as they are masked by the background noise. The requirement for a 10 dB difference between the received levels and the background noise is only fulfilled at the lowest frequencies. If these incorrect results had been used in a calculation of the R'w index a result of 44 dB would have been obtained. These results confirm that broad band pink noise excitation and parallel frequency analysis can only be used in cases of low transmission loss indices or where the background noise levels are low.

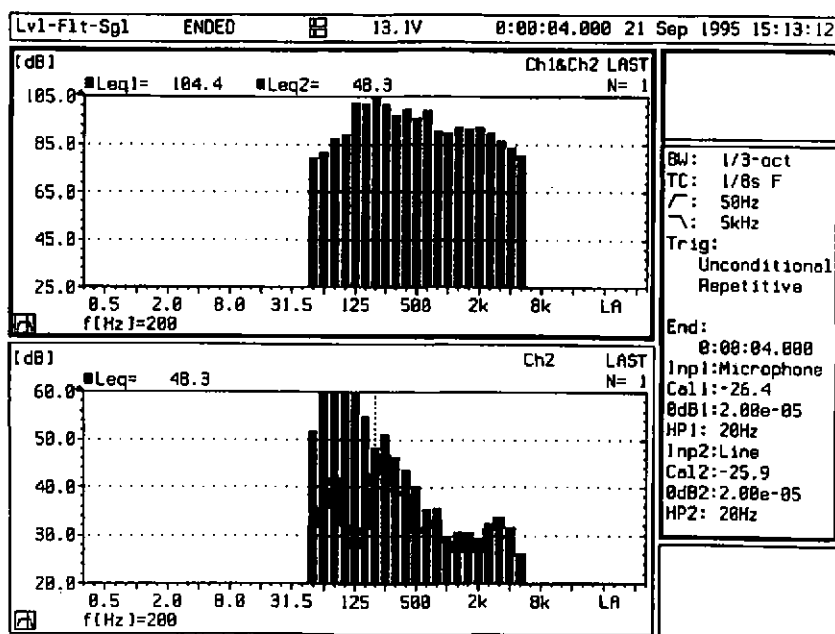


Figure 2.  $L_q$  using Band Filtered Noise and Serial Frequency Analysis.

### 3.2 Band filtered noise and serial frequency analysis

Simply using a filter in the noise generator will increase the levels generated in each third octave band by some 12 to 15 dB. Adding synchronous filters to the source and receive room measurement channels, brings about an improvement in the dynamic range to such an extent that the signal to noise requirement is now met for the mid frequency range. The results are shown in figure 2 which again has the source and received levels in the top window and the received and background levels in the lower view.

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Using these results the calculated R'w would now be 52 dB, but this would still be wrong due to the signal to noise requirement not being met at all frequencies.

### 3.3 Broad band noise and parallel MLS frequency analysis

The results using the MLS technique are presented as Figure 3 and in this case the lower window contains a table that gives the signal to noise ratio in tabular form for both the normal and MLS methods. From this it can be seen that the requirement for a ratio of 10 dB is met over the full frequency range.

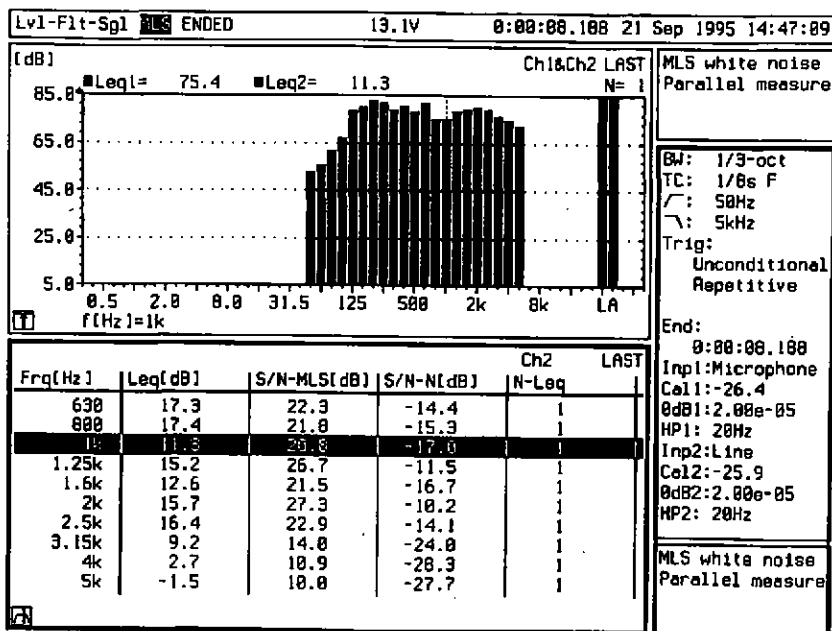


Figure 3.  $L_d$  using Broad Band Noise and Parallel MLS Frequency Analysis

To achieve the required confidence figures for frequencies up to 3.15kHz it was necessary to make 58 MLS averages and this required a measurement duration of approximately 8 minutes, to extend to 5kHz a longer measurement would be necessary. The data provided by this measurement allowed an accurate calculation of the R'w value for the structure at 56 dB.

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### 4 - REVERBERATION TIME MEASUREMENTS

As the receiving room in the previous example did not present a very demanding situation a new location was chosen for this part of the project. The noise excitation equipment was relocated into a room where due to its size and absorption the maximum levels available were in the range of 70 dB with background levels of 40 to 50 dB. Figure 4 shows the detail and it can be seen that the dynamic range available is in the range of 20 to 25 dB.

#### 4.1 Broad band noise and parallel frequency analysis

The problem is the inability to achieve a high enough excitation level in all the bands simultaneously to provide the minimum decay in each. With the requirement for a 5 dB headroom and a 10 dB signal to noise ratio using this approach it was not even possible to provide an  $RT_{20}$ . The situation is detailed in figure 5. The upper window shows the result for the 630 Hz band where the dynamic range requirements are right on the limit of 35 dB. In the lower window the results are tabulated and it can be seen that the error warning appears against the  $RT_{20}$  results and that the  $RT_{30}$  values are suppressed.

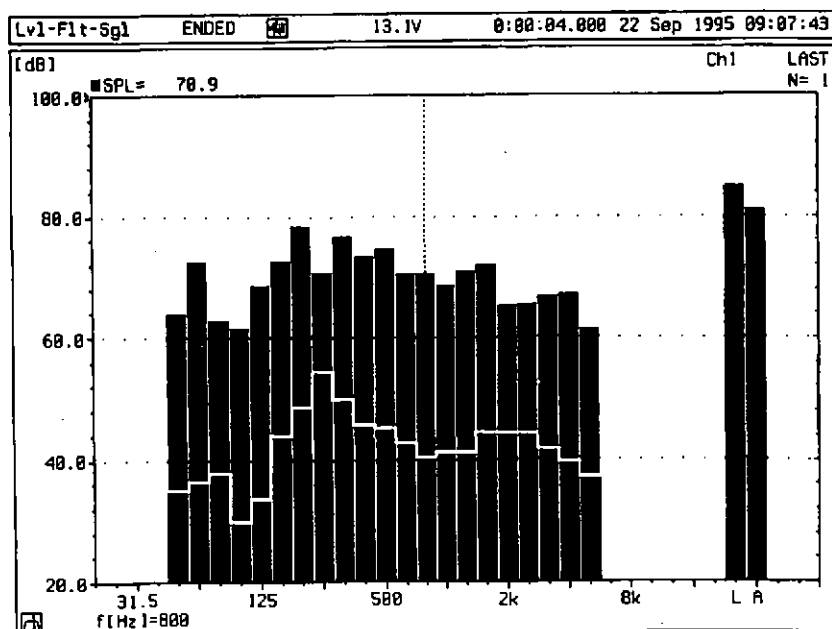


Figure 4. Dynamic Range Available for the RT Measurements

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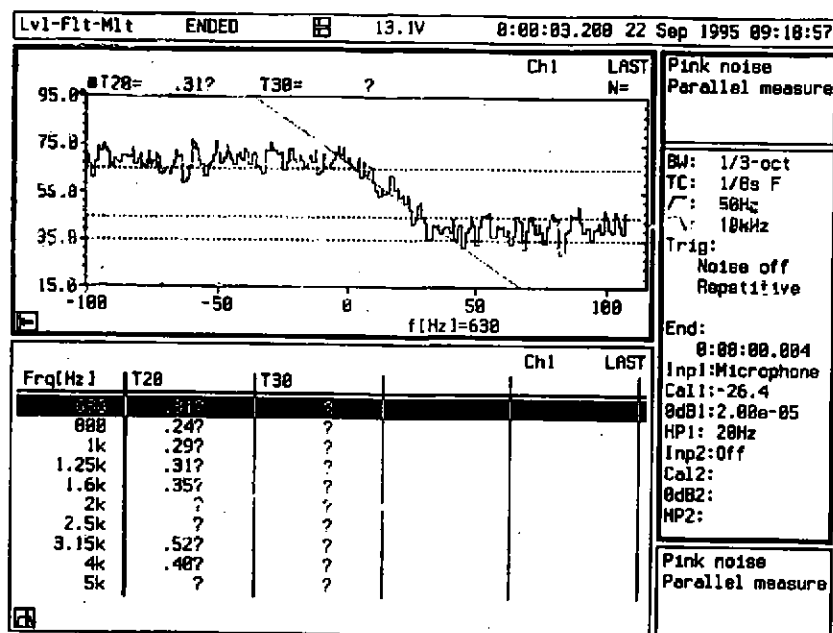


Figure 5. RT using Broad Band Noise and Parallel Frequency Analysis

To progress using this measurement method a significant increase in amplifier power (by a factor of 15) would be needed or the measurement programme delayed until more advantageous background noise levels persisted.

## 4.2. Band filtered noise and serial frequency analysis.

Whilst the background noise remains at 45 dB the improvement in generated levels, referred to in the section dealing with the transmission loss measurements, provides enough amplifier power to increase the generated levels to around 80 dB. This gives sufficient dynamic range to allow for the calculation of the  $RT_{20}$  in most of the bands but there is still a significant uncertainty in respect of the  $RT_{30}$  values, the details are in figure 6.

In this case if  $RT_{20}$  can be accepted the values provided by this method would be good enough, however it has to be accepted that even a small increase in the background noise levels would, in this case, invalidate the technique.

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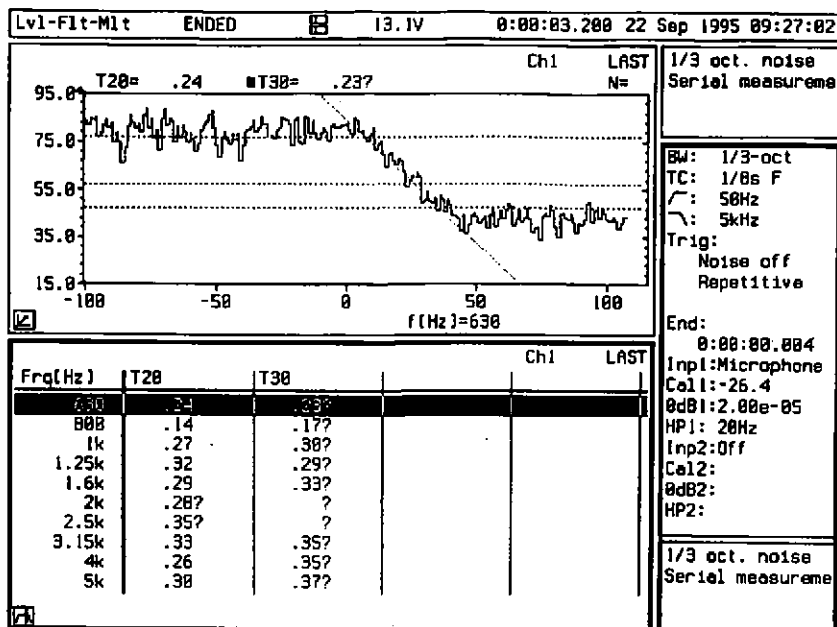


Figure 6. RT using Band Filtered Noise and Serial Frequency Analysis

### 4.3 Broad band noise and parallel MLS frequency analysis

In order to fulfil the dynamic range requirement of 45 dB for a  $RT_{30}$  measurement it was necessary to programme the instrument for 23 MLS averages. This gives a measurement duration of around 3 minutes. In the upper window of figure 7 the calculated backward integrated decay is shown together with a straight line indicating the calculated RT decay for the 630 Hz band. This information is of course available for each frequency band. The table in the lower window shows that the  $RT_{20}$  and  $RT_{30}$  has been provided along with the EDT for all the bands from the one measurement sequence. This is in spite of the fact that the background noise was just as high as in the previous examples.

The dramatic effect of the MLS mode of making RT measurements can be shown by displaying the results of conventional parallel measurements with those obtained using the MLS technique. The lower curve in figure 8 shows the conventional results where the generated levels are around 70 dB and the noise floor at 50 dB. Contrast this with a similar measurement configuration that employs MLS, shown in the upper window, and it can be seen that the generated levels have increased to around 90 dB and the noise floor has fallen to approximately 35 dB to give a significant improvement in the dynamic range.

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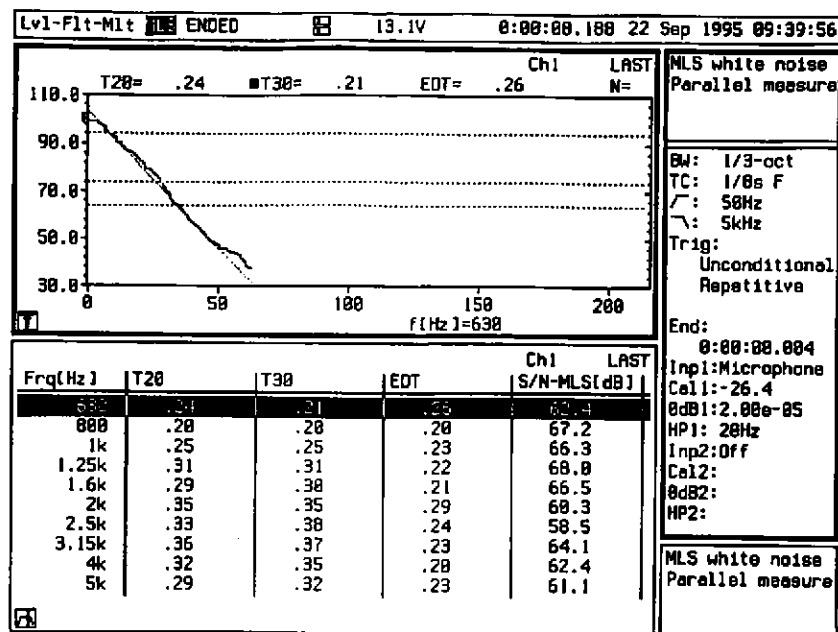


Figure 7. RT using Broad Band Noise and Parallel MLS Frequency Analysis

## 5 - CONCLUSIONS

As with all things it is a question of "horses for courses". In ideal conditions it is possible to take advantage of the speed that conventional parallel measurements provide. As more typical situations come to be considered then the balance moves in favour of sequential and MLS approaches. It is certainly true that MLS will always provide an answer, even in difficult cases such as the measurement of sound insulation between rooms above a discotheque. It is a question of trading measurement time against the signal to noise requirement, if sufficient time is available it is even possible to obtain a result under noise to signal conditions. In considering the question of measurement time we tend to think in terms of the run time for the measurement, the true time is however from arriving on site to departing again with the required results accurately logged to disc. When viewed this way, getting the equipment to the measurement location and preparing it for use is the largest single element. Add to this the necessary relocation of the microphones then the actual run time of the measurements does not seem so important. The over-riding factor must be the need to come away with the results required accurately logged to disk to avoid losing the investment made in committing to the measurement sequence in the first place. In this area MLS will always ensure a result.



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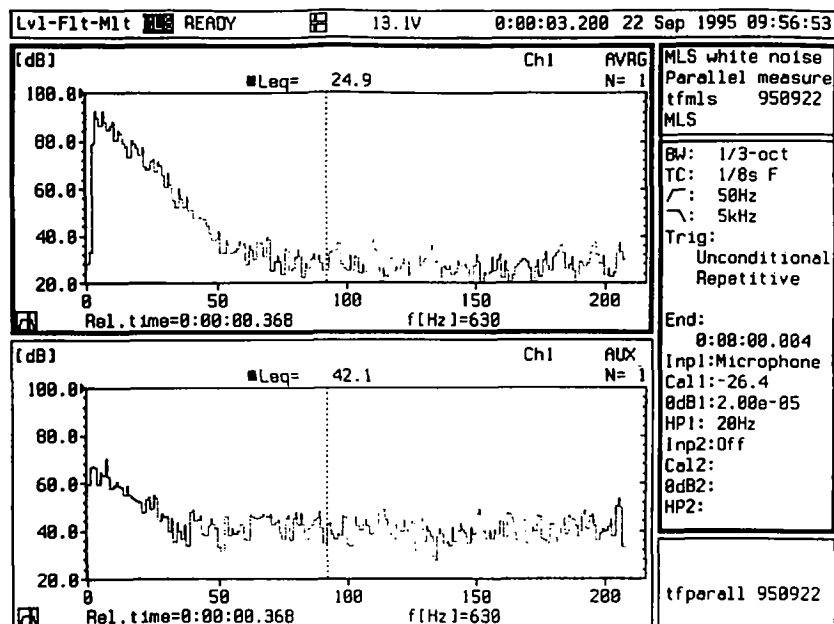


Figure 8. Improvements in Dynamic Range obtained by using MLS

### References.

- (1) - Proc. IOA Vol. 17 Part 5 (1995) p 101-110.
- (2) - BS EN 20140 Measurement of the Sound Insulation in Buildings and of Building Elements

