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PRACTICAL MEASUREMENT SOLUTIONS FOR SOUND POWER DETERMINATION

O. Olivieri Brüel & Kjær Sound & Vibration Measurement A/S, Nærum, Denmark

1 INTRODUCTION

Sound Power determination, when made in conformity with International Standards, irrespective of the method chosen, is always a matter of following a flowchart-like procedure consisting of repetitive measurements, step-by-step controls and calculations. Therefore, it is particularly suitable to be implemented with automatic processes. That's why sound analyzer manufacturers have always strived to develop solutions that could automatically perform such procedures.

The first real-time analyzers used autosequences, embedded in the operating system of the instrument, which offered user predefined measuring setups to be followed in sequence. When the first types of analyzers with PC interfaces were introduced, PC software was promptly developed that remotely controlled the analyzer according to the measurement procedure.

Nowadays, new software technologies support the integration of different applications and share data easily. This paper aims to show how a solution, which integrates a PC-based real-time analyzer and commercial off-the-shelf application software for managing data and generating reports, can be very helpful in the everyday work of laboratories measuring Sound Power.

2 PRODUCT MANUFACTURERS DEMANDS

The increasing volume of product types, and shorter time to market, require product manufacturers to speed up development, production, and also laboratories performing Sound Power test measurements. Therefore, measurement times have to be efficiently optimised; faster measurements and efficient management of the procedural steps. Additionally, it's important to provide laboratory staff with tools that allow them to manage their everyday work in the most efficient way, such as:

- provide user-friendly, intuitive, easy-to-use software and instrumentation
- speed up report generation
- reduce time spent in exchanging and sharing measurement data among different users or laboratories
- use efficient measurement database
- minimise risk of measurement mistakes
- minimise instrument training requirements

3 SOUND POWER SOLUTIONS

Some years ago Microsoft® introduced a new software technology named OLE (Object Linking and Embedding) to provide application integration. OLE is based on Microsoft COM (Component Object Model) technology that provides standard interfaces and communication between different applications. Through COM, an application may use the features of any other application: COM allows applications and systems to be built from components supplied by different software suppliers; applications that interact and share data. In recent years an increasing number of applications have been developed supporting this technology. Additionally, some PC-based instrument manufacturers have provided this technology for their products.

This new technology can be used to build up a system for Sound Power determination that can meet the above mentioned goals. The idea is to integrate, through a COM interface, three different applications:

- a PC-based measuring instrument
- a custom program interacting with the instrument and provided with an interface to guide users through the measurement procedures
- a common application for organising measurement data and generating reports

The instrument will be the server application; it will be configured and controlled by the custom application according to the different measurement requirements. The custom program controlling the instrument will be provided by a familiar user interface. A Microsoft Windows 95/98/NT® type program is chosen because it is a well known software environment, and so makes the program easier and faster to use. Microsoft Excel can be used for organising measurement data and for generating reports.

Such a solution offers several advantages; openness, flexibility and customisation. It allows for software component upgrades without affecting the operation of the overall solution. It means that the instrument software and the application organising the data can always be updated with the latest version. The custom application can be modified and upgraded when changes in the procedures are required.

The COM interface focuses developers on measurement routines and not on specific instrument requirements. Therefore, it doesn't limit development to instrument manufacturers.

PC-based instruments supporting the COM interface will definitely remove all the problems associated with proprietary instrument driver software that, historically, has been the major headache in system integration.

The use of some widespread application for managing data will cut training time and make it easy to exchange data between different users and laboratories.

Some years ago Brüel & Kjær introduced a PC-based multi-analyzer named PULSE™. Being a PC-based platform means that, apart from signal conditioning and A/D conversion performed by a dedicated front-end, analysis configuration, real-time analysis performance and real-time data visualisation are carried out by the software. Also, it supports the COM technology and therefore can be used as a server for custom application programs.

Based on this approach, a few years ago, the application program Type 7748 was developed. Using PULSE and COM interface, it offers a tool for automating Sound Power measurements in semi-anechoic rooms according to ISO 3744, ISO 7779 and ISO 11201 or user-defined settings. It uses a graphical interface that shows the flowchart of the selected Standard.

Further developments have led to a new application software package for Sound Power determination, named PULSE Value Pack for Sound Power, BZ5305. At the time of writing, it groups two applications for Sound Power determination:

- Sound Power determination in Reverberation Rooms using the comparison method according to
  - ISO 3741:1999
  - ISO 3743:1994 Parts 1 and 2
- Sound Power determination using Sound Intensity according to
  - ISO 9614-2:1996, measurement by scanning
  - ECMA-160:1992.

Applications consists of custom Microsoft Excel templates containing Microsoft Visual Basic® for Applications (VBA) macros which activate user interfaces, control PULSE operation, perform calculations and fill in Excel worksheets with measurement data and results. The final report is a customised worksheet.

3.1 Sound Power in Reverberation Rooms according to ISO 3741:1999 (comparison method) and ISO 3743:1994 Parts 1, 2

The comparison method uses a reference sound source. This is a stable sound source having a known sound power as a function of frequency. The assumption is that when the reference sound source is placed in the reverberant field, the difference between the sound pressure produced by it and its sound power will be the same as for any other sound source. Notice that, in theory, the sound pressure distribution in the reverberation room should be uniform. In practice there will be some variations, and therefore some spatial averaging is required. This can be achieved by averaging at discrete points across an array of microphone positions, or along a continuous path using a traversing microphone. The following formula is used:

$$LW(DUT) = LW(RSS) - Lp(RSS) + Lp(DUT)$$

Quantities are expressed in dB and as a function of frequency. LW(DUT) and Lp(DUT) are respectively the calculated sound power and the measured average sound pressure of the device under test (DUT). LW(RSS) is the sound power of the reference sound source (RSS) as read from its calibration chart and Lp(RSS) is its measured average sound pressure. If necessary, Lp(RSS) and Lp(DUT) should be corrected for the background noise.

The PULSE Value Pack for Sound Power application, BZ5305, supports both a microphone array and a traversing microphone. It has dialog windows that guide the user, and which may include moving the microphones and the test object between measurements. Dialog windows are designed in such a way that the user gets the maximum freedom allowed by the selected Standard in managing the measurement steps. Differences between measured levels (DUT and RSS) and background levels are determined and corrections, as necessary, are made. Error indication for excessive background noise is provided.

Where the sound pressure due to the DUT has significant narrow band content, a further complication occurs in the form of standing waves. This will require measurements to be averaged over multiple source positions. The application detects the presence of narrow bands/discrete tones and, as necessary, calculates the number of additional microphone positions and/or source positions required to fulfil the Standard.

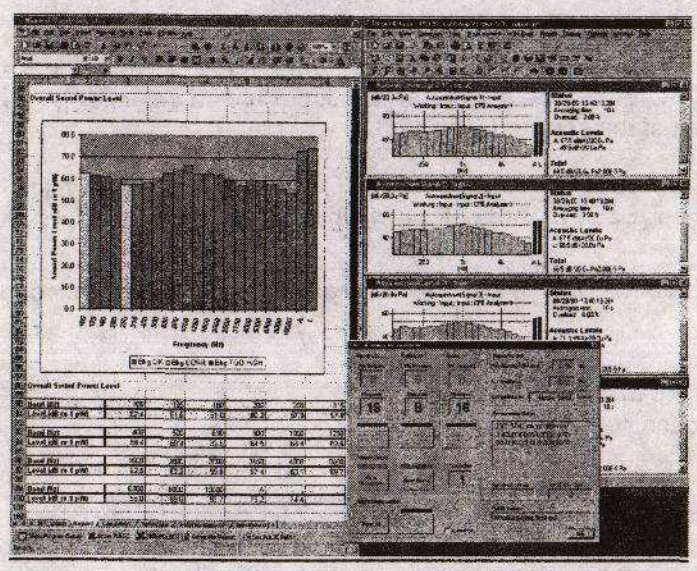

Figure 1 - PULSE™ Value Pack for Sound Power in Reverberation Rooms

3.2 Sound Power using Sound Intensity according to ISO 9614-2:1996 (scanning method) and ECMA-160:1992

In theory, when using intensity techniques, it is only necessary to integrate the intensity passing through a closed measurement surface enclosing the device under test to determine its sound power. No special acoustic test facility is necessary. Using the scanning method, the intensity passing through the measurement surface is integrated by dividing the surface into segments, and then scanning (or sweeping) an intensity probe over each segment.

In practice, imperfections, both in the measurement equipment and user technique, make it necessary to incorporate checks in the measurement procedure. This is to ensure that the measuring equipment is capable of handling the ambient background noise conditions and that the integration of the intensity passing through the measurement surface is performed with sufficient accuracy. Standards require the calculation of some quantities, called field indicators, for each single segment and the verification that they don't exceed certain limits. If not, adjustments to the measurement surface segments may become necessary to reduce the influence of background noise or improve the accuracy of the integration.

The PULSE Value Pack for Sound Power application, BZ5305, offers a Windows-NT like tree structure that summarises the arrangement of the measurement surfaces and their sub-segmentations. For each single segment, partial-power repeatability and field indicator checks are displayed. Segmenting of a previously defined segment can be performed during data acquisition up to 7 times. That's why intensity measurements often require an iterative procedure; measurements have to be repeated more times with different segment arrangements before a result with the desired grade of accuracy is obtained.

Sound power and field indicator values are shown in the tree structure as well as in the Excel worksheet for each segment, and for the measurment surface as a whole.

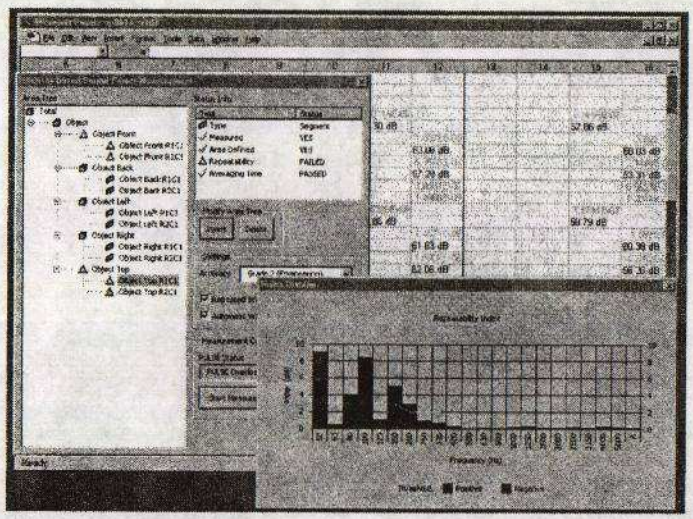

Figure 2 - PULSE™ Value Pack for Sound Power using Sound Intensity

4 SUMMARY

Solutions for Sound Power determination based on integration of a PC-based real-time analysis platform and Microsoft Excel templates using Microsoft COM technology have been discussed. It was shown that COM technology provides trouble-free installation and maintenance; no proprietary drivers/devices have to be installed on the PC and separate component upgrades don't affect the operation of the overall solution. Open codes and standard COM interface provide openness and flexibility; codes controlling the measurement procedures can be accessed and customised. Familiar Excel provides a friendly software environment for collecting and storing data, generating customised reports and easily exchanges data among different users or laboratories.

5 REFERENCES

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