A fully automated system for ultrasonic power measurement and simulation accordingly to IEC 61161:2006

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Abstract. The ultrasonic power measurement, worldwide accepted, standard is the IEC 61161, presently in its 2nd edition (2006), but under review. To fulfil its requirements, considering that a radiation force balance is to be used as ultrasonic power detector, a large amount of raw data (mass measurement) shall be collected as function of time to perform all necessary calculations and corrections. Uncertainty determination demands calculation effort of raw and processed data. Although it is possible to be undertaken in an old-fashion way, using spread sheets and manual data collection, automation software are often used in metrology to provide a virtually error free environment concerning data acquisition and repetitive calculations and corrections. Considering that, a fully automate ultrasonic power measurement system was developed and comprehensively tested. A 0.1 mg of precision balance model CP224S (Sartorius, Germany) was used as measuring device and a calibrated continuous wave ultrasound check source (Precision Acoustics, UK) was the device under test. A 150 ml container filled with degassed water and containing an absorbing target at the bottom was placed on the balance pan. Besides the feature of automation software, a routine of power measurement simulation was implemented. It was idealized as a teaching tool of how ultrasonic power emission behaviour is with a radiation force balance equipped with an absorbing target. Automation software was considered as an effective tool for speeding up ultrasonic power measurement, while allowing accurate calculation and attractive graphical partial and final results.

1. Introduction

Automated systems (software) are to be used to help data acquisition, conditioning and manipulation, as well as instruments (hardware) controlling and setting up. This paper presents software to be used in Ultrasonic Power and Radiation Conductance Measurement (USPRCM) automation. It was developed in LabVIEW 2009 (National Instruments, Austin, TX, USA), and tested in both simulation and real condition data acquisitions.

The software was developed in compliance with IEC 61161 [1]. It has been tested using absorbing and reflecting targets, so that it is prepared to calculate power measurement for both targets. The software can be freely distributed after a proper agreement of use.
2. Basic requirements and specifications

2.1. Power measurement

Ultrasound propagation in a medium will result in a radiation force which can be measured, for instance, using a regular microbalance. However, as the level of the force in many cases is very low, and also because heating due to ultrasound absorption of some propagation media (water, target for instance), the reading during ultrasound radiation is usually not stable. Further, ultrasonic radiation could diverge regarding different distances from the acoustic center of the radiation device, its characteristic, and reception target. All those aspects are detailed in [1] and other references referred therein.

2.2. An acceptable approach

Any medium where ultrasound propagates through will absorb some energy and so ultrasound will heat up that medium. The same happens with the target. As a consequence buoyancy may vary significantly during sonification. The microbalance which is used to measure the radiation force of an ultrasound wave observes continuously during the ultrasonic power measurement and shows the variation in its reading. The force could be measured just by observing and/or “manually” collecting the output data from the balance, but due to the instabilities this is not worthwhile. If measurements were undertaken automatically, especially if data is processed at a glance, it would be even better.

USPRCM software developed has the main feature of being able to process data from a raw mass measurement into a power measurement (assessment). Figure 1 shows results of a final measurement with that software. It shows “raw” (already processed) data in the graph in its upper right corner. It shows mass converted into power, and also regression points considered. The fat spots in the graph are those points where power sonification would start, disregarding flutter of “power on”.

![Figure 1 – Front Panel for final power measurement results](image)

Numerical values are also depicted in that same front panel window. One can observe that both “average” and “regression” final results are disclosed. The first one, in the lower part of right hand side of that screen, is basically used for absorbing target or if close different distances were used. The...
“from regression” power is also disclosed to be used if reflecting target was used or if absorbing due propagation are of concern. On the lower left hand side of the screen of Figure 1, there are 3 “Average Power” boxes. The topmost one is for a fixed distance from the target to the source and for a defined “wavelength”. Basically, the values depicted there are obtained from the graph (top right in the figure). The second one is the average of different “wavelength”, if there is more than one. In the example illustrated, there are two different “wavelengths”. The lowest one is the average within a repetition, i.e., for different distances.

The approach used herein was to have the possibility of performing measurements in at least 2 different separations from target to output device. For each distance, it is possible to perform up to 3 different measurements in a micro adjustment, called “1/4 wavelength”, to avoid, for instance, incorrect measurement due to standing waves. Each measurement is to be repeated, so a number of “Repetitions” shall be undertaken. All those settings are to be adjusted in the window as disclosed in Figure 2.

All accessories inputs shall be done in that window (Fig. 2). “Instrumentation” is to be settled to adjust what and which measurement instruments are to be used.

2.3. Measurement Front Panel

Figure 3 discloses the Front Panel that is shown during a measurement preset. It is possible to evaluate values of Mains voltage, Temperature (room and inside the water bath), Source output voltage (rms) as well as its waveform. All those measurement are available if proper instrumentation is plugged and settled in the window presented in Fig. 2.

In this same window (see Fig. 3), it is possible to adjust the actual distances where the measurements were done, and also to confirm (check-up) the total number of measurements done and those to be done.
3. Conclusion
The system for USPRCM, as developed, is able to be used in a wide range of instruments and standards (balances). It is rapidly adaptable to different power measurement approaches and mountings, as far as they were accordingly to [1]. Because of its simplicity on being used, it can be explored as a teaching tool. That feature could be welcome for newborn laboratories dealing with power measurement. It can be freely distributed for partners of the owners.

References
[1] IEC 61161:2006, Ultrasonics – Power measurement – Radiation force balances and performance requirements, International Electrotechnical Commission, Geneva, Switzerland, 97pp.