Status report of KRISS AUV for the 11th CCAUV meeting

September 2017

Korea Research Institute of Standards and Science (KRISS)
267 Gajeong-ro, Yuseong-gu, Daejeon 34113, Republic of Korea
e-mail: chowanho@kriss.re.kr

1. Organization

The Korea Research Institute of Standards and Science (KRISS) is the National Metrology Institute of the Republic of Korea and a signatory to the CIPM MRA. KRISS has chosen to self-declare the state of its quality system for calibration and measurement services without third-party accreditation.

In September 2017, the research part of KRISS was fully re-organized into 3 divisions and 2 institutes. The tasks and members related acoustics, ultrasound, and vibration were separated into three different centers. Each part of AUV group is involved as follows:

- Acoustics in Air: Center for Optical Metrology, Div. of Physical Metrology
  Contact: Dr. Wan-Ho Cho, chowanho@kriss.re.kr
- Ultrasound: Center for Medical Convergence Metrology, Div. of Chemical and Medical Metrology
  Contact: Dr. Yong-Tae Kim, ytkim@kriss.re.kr
- Vibration: Center for Mechanical Metrology, Div. of Physical Metrology
  Contact: Dr. Yong-Bong Lee, lyb@kriss.re.kr

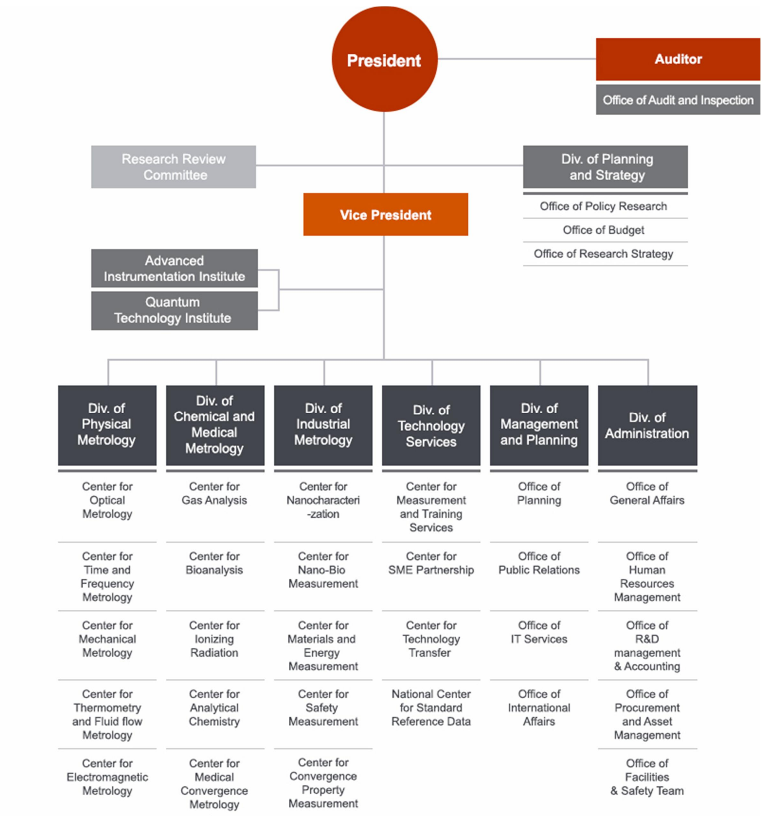

Figure 1 - New organization of KRISS.

2. Activities on the Standards

CMC update

The updated CMC was approved at April 2017 and it is now available on the BIPM KCDB. The major updated items are like below:

- Acoustics in Air: Whole previously existing items are re-approved.
- Ultrasound: The items of ultrasonic power are newly added
- Vibration: Whole previously existing items of linear vibration are re-approved and the items of angular vibrations are newly added.

Peer review in AUV

The peer review for KRISS AUV parts is scheduled as 18^{th} – 20^{th} October. As the reviewer for the Acoustics and Ultrasound branches, Dr. He Longbiao at NIM, China is invited and Mr. Yu-Chung Huang is invited for the branch of Vibration. The items to be newly approved are like below:

- Acoustic in Air: The items for free-field microphone sensitivity for the frequency range of 1 kHz - 31.5 kHz are newly added based on the results of CCAUV.A-K4.
- Ultrasound: The items of ultrasonic power are updated and the uncertainties are updated.
- Vibration: The frequency ranges of items of linear vibration are extended to 0.5 Hz. The items of angular vibration are updated and the uncertainties are updated.

3. Research Activities on the Metrology

Acoustics

- Research on the Diffuse-field sensitivity calibration

The research to establish the diffuse-field sensitivity calibration system has been conducted from 2015. Two different approaches, the reciprocity method and the random incidence method are compared and investigated the detailed method to achieve stable and repeatable results. For the reciprocity method, a scaled-reverberation chamber having un-parallel surfaces is designed and the directivity measurement system is designed for the random incidence sensitivity measurement (Fig. 2). With these systems, the sensitivity of LS2P microphone is measured and compared with the pressure and free-field sensitivity measured by the reciprocity method (Fig. 3). In this result, it is observed that the both results of diffuse-field sensitivity estimated by the different methods are placed in between the pressure and free-field sensitivity. This is reasonable result because the pressure type microphone including LS microphone has the highest sensitivity at the frontal direction.

Figure 2 - System to measure the diffuse-field sensitivity of microphone: (LEFT) Directivity measurement system for the random incidence, (RIGHT) Scaled reverberation chamber of 2.8 m^3 for the reciprocity method.

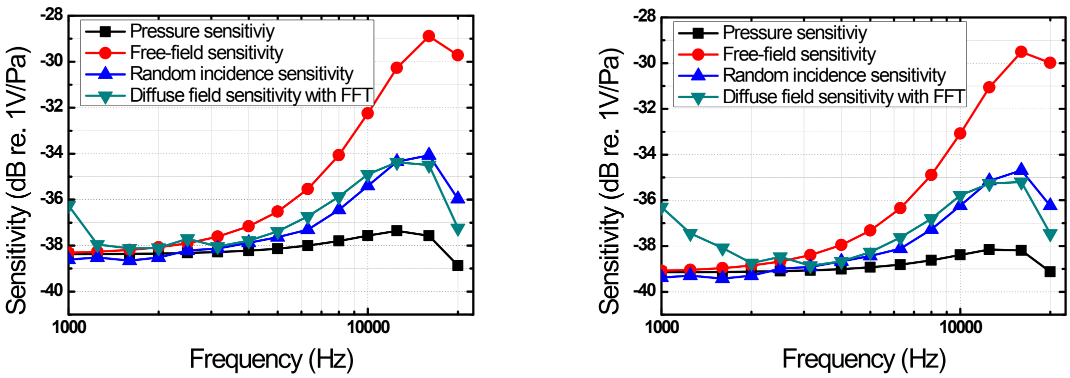

Figure 3 – Comparison of the measured sensitivities of LS microphone according to the types of sound field: (LEFT) 4180.2208287, (RIGHT) 4180.2341431.

- Research on the sound measurement by optical method for the future primary standard

Setup of the calibration system based on the optical method for the free-field sound-in-air is conducted as a reference system for research on the new primary standard of sound pressure. For the purpose of comparison with the reciprocity calibration, the system was installed in the small anechoic chamber which is capable to be used as the primary standard system of free-field calibration. The preliminary measurement with the gated-photon correlation method was conducted and the feasibility of system was checked. The collection of measurement data and the detailed investigation to establish a new acoustic standard are on-going.

This works was conducted by collaborating with Dr. T. Koukoulas a former principal research scientist at NPL and visited from November 2016 to April 2017 as a visiting research scientist of KRISS.

Figure 4 – System for the sound measurement by optical method: (LEFT) anechoic chamber with a light slit, (RIGHT) Optical parts.

Ultrasound

The study of ultrasound metrology has been carried out more closely related to the customer's demand. We also actively supported the domestic customer’s demands for medical ultrasound metrology and the colleagues in APMP to build up their measurement system and procedure. We also started to help medical doctors to solve the medical measurement problems. We conducted two informal ultrasound power measurement comparisons, and donated KRISS-made ultrasonic transducers to other NMIs who started to setup the measurement system.

- High ultrasonic power measurement

Temperature increase of water during ultrasonic power measurement delays repeated measurement at appropriate water temperature range. It is also difficult to evaluate the effect of the temperature of the ultrasonic transducer due to the phenomenon of reaching the thermal equilibrium with the temperature. For this reason, we introduced a water circulation jacket for temperature control in the water tank, as shown in Figure 5.

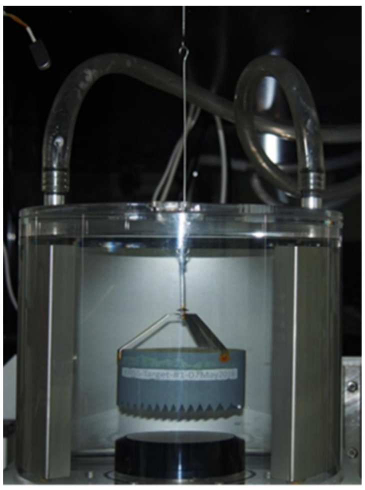

Figure 5 - Water tank with cooling water circulator.

We developed a sound-absorbing target for radiation force balance measurement that can withstand high intensity ultrasound. The developed sound-absorbing target was optimized for performance by fabricating many specimens based on the technology of controlling the characteristic acoustic impedance of the 3-phase composite. In addition to the control of the characteristic acoustic impedance, we have also developed a technique for predicting the heat capacity and the thermal conductivity, and then the temperature increase due to ultrasonic absorption can be optimized through the selection of the compounding material. The maximum target temperature of 43 ^{o}C was reached when a maximum of 340 W of ultrasound was applied to the target sample prepared by inserting the temperature sensor using the optimized blend material and ratio, and the target did not suffer damage at this temperature. This target is designed to have a high density rather than water, and consequently has an anti-streaming effect at high power.

We also add a 1-kW power amplifier for ultrasonic power of 300 W or more in the RFB system. Also, high power ultrasonic transducers with circular planar surface were also prepared by in-house fabrication. These transducers are expected to be used in high ultrasonic power measurement comparison pilot studies within APMP.

The demand for high-intensity focused ultrasound technology is increasing in domestic, and it is required to develop the technology to cope with it. In the focusing method ultrasonic waves, we succeeded in developing a flat ultrathin type acoustic lens using a new acoustic metamaterial, which is now being prepared for publication in a journal.

We also have developed a high intensity focus ultrasonic phantom that changes color irreversibly according to temperature. This phantom was tested for various ultrasonic exposures. We observed a non-thermal phenomenon at very high intensities, which was enough to liquefy the material of the phantom. These results are also being submitted to the Scientific Journal for review.

- Pilot study for Key Comparison

We have piloted informal international comparisons to help NMIs in the APMP yet lack of preparedness set up the ultrasonic power measurement system well. The report of one of them was submitted to the SCI journal and is currently under review. In some cases, KRISS donated ultrasound transducers to monitor whether their measurements have reached normal conditions. We also tried to share our experiences with them within the timeframe.

The schedule of APMP.U-K1 RMO Key Comparison is accepted by the participants as the Table 1.

Table 1 - Time schedule of APMP.U/K-1 accepted by the participants.

No.	Calibration Laboratory	Starting date	Finishing date	Dispatch date	Reporting date
1	KRISS, Korea	8-Jan-18	5-Feb-18	12-Feb-18	26-Feb-18
2	NMIJ, Japan	26-Feb-18	26-Mar-18	2-April-18	23-April-18
3	NIMT, Thailand	23-April-18	21-May-18	28-May-18	18-Jun-18
4	KRISS, Korea	18-Jun-18	16-July-18	23-July-18	13-Aug-18
5	PTB, Germany	13-Aug-18	10-Sep-18	17-Sep-19	8-Oct-2018

Vibration

- Research on the seismic monitoring system to make it traceable to the national standard system

Recently, the number of relatively large scale of earthquake higher than magnitude 4.0 has been increased in Korea. From this reason, the interest on the reliability of the seismic monitoring system is also increasing. As a part of the activity to improve the reliability of national monitoring system, KRISS start the project funded by Korea Metrological Administration to make the seismic monitoring system traceable to the national standard system. The detailed objectives of project are like below:

- ✓ Selection of essential items for all inspection before installation at monitoring site
- ✓ Development of the calibration process for seismic sensor and data recorder concerning the traceability
- ✓ Revision of the related regulations
- ✓ Suggestion of the education and management plan of secondary calibration laboratory
- ✓ Planning for establishing the national standard system to cover the whole required range for seismic monitoring system

4. Recent Selected Publications (2015-2017)

Journal Papers:

- ✓ J.-W. Lee, W.-S. Ohm, and Y.-T. Kim, "Development of disposable membrane hydrophones for a frequency range from 1 MHz to 10 MHz," Ultrasonics, Vol. 81, pp. 50-58, 2017.
- ✓ S. Chun, J. Jin, and W.-H. Cho, "Construction of the prediction model between pressure and flow rate for pulsating flows based on the Greenfield-Fry model concerning wave dispersion," Experiments in Fluids, Vol. 58:37, 2017.
- ✓ H.-S. Kwon and J.-Y. Kim, "An analytical filter design method for guided wave phased arrays," Mechanical Systems and Signal Processing, Vol. 81, pp. 433-446, 2016.
- ✓ J. Haller, C. Koch, Rodrigo P.B. Costa-Felix, P. K. Dubey, G. Durando, Y. T. Kim, and M. Yoshioka, "Final report on key comparison CCAUV.U-K3.1", Metrologia, Tech-Supp. Vol. 53. 90202, 2016.
- ✓ H. J. Lee, H. S Lee, P. S. Ma, and Y. Y. Kim, "Effective material parameter retrieval of anisotropic elastic metamaterial with inherent nonlocality", J. Appl. Phys. Vol. 120, 104902, 2016.
- ✓ S.-G. Park S.-B. Yang, M.-S. Ahn, Y.-J. Oh, Y. T. Kim and K.-H. Jeong, "Plasmon enhanced photoacoustic generation from volumetric electromagnetic hotspots", Nanoscale, Vol. 8, No. 2, pp. 757-761, 2015.
- ✓ Doh, H. K. Lim, and B. Ahn, "Calibration of oscillometric non-invasive devices for monitoring blood pressure", Metrologia, Vol. 52, No. 2, pp. 291-296, 2015.
- ✓ H. J. Lee, J. K. Lee, and Y. Y. Kim, "Elastic Metamaterial-based Impedance-varying Phononic Bandgap Structures for Bandpass Filters", J. Sound Vib. Vol. 353, No. 20, pp.58-74, 2015.
- ✓ W.-H. Cho, J. G. Ih, and T. Toi, "Positioning actuators in efficient locations for rendering the desired sound field using inverse approach," Journal of Sound and Vibration, Vol. 358, pp. 1-19, 2015.
- ✓ Y. Asahi, W.-H. Cho, A. Arimitsu, and T. Toi, "Modification of impact sound by adjusting the excitation input for comfortable design of punch press machine sound," Noise Control Engineering Journal, Vol 63, pp. 598-607, 2015

Conference Papers:

- ✓ W.-H. Cho, H.-S. Kwon, and J.-H. Chang, “Comparison of the methods to calibrate the diffuse field sensitivity of laboratory standard microphone,” Proc. of the 24th International Congress on Sound and Vibration, July 2017, London, UK.
- ✓ J. K. Sim, I. Doh, and Y. T. Kim, “A Wearable Force Regulator for Reducing the Contact Force Effect on Photoplethysmographic Signals”, EMBC2017, Jeju, Korea, 2017
- ✓ J. Hyun, Y. T. Kim, I. Doh, B. Ahn, “Finite element analysis of temperature rise induced by the high-intensity focused ultrasound (HIFU)”, 2017 Joint Conference by KSNVE, ASK, and KSME (DC).
- ✓ Y. T. Kim and B. Ahn, “Measurement of High Ultrasound Power by Radiation Force Balance Method”, 2017 Joint Conference by KSNVE, ASK, and KSME (DC).
- ✓ J. Hyun, Y. T. Kim, I. Doh, B. Ahn, K. Baik, and S. Kim, “Topological optimization of the planar ultrasonic acoustic lens for focusing acoustic energy”, 2017 Joint Conference by KSNVE, ASK, and KSME (DC)
- ✓ D. Ma, Y. T. Kim and S.-W. Kim, “Temperature-Responsive Tissue Mimicking Phantom for High Intensity Focused Ultrasound Therapy”, KSUM (Korean Society of Ultrasound in Medicine) open 2017
- ✓ Y. T. Kim and B Ahn, “2016_KRISS_HITU_power_by_RFB_and KC preparation”, APMP2016 TCAUV meeting
- ✓ Y. T. Kim and B. Ahn, “2016_KRISS_HITU_power_by_RFB_and KC preparison”, APMP Medical Focused group and TCAUV meeting, DaNang. Vietnam, 2016
- ✓ Y. T. Kim and B. Ahn, “KRISS activity of Medical Metrology 2016”, APMP Medical Focused group and TCAUV meeting, DaNang. Vietnam, 2016
- ✓ Y.-G. Kim, N. S. Jo, D. J. Yoon, and B. Ahn, “Determination of Crack Tip Location by using Tip Diffraction and Geometric Calculation”, WCNDT 2016, Munchen, Germany, 2016
- ✓ W.-H, Cho, “Sound source modelling and synthesis by the equivalent source method for reproducing the spatial radiation characteristics,” Proc. of the 2016 AES International Conference on Sound Field Control, July 2016, Guildford, UK.
- ✓ P. Petchpong, Y. T. Kim, “Investigation of fabricated 1 MHz lithium niobate transfer standard ultrasonic transducer at NIMT”, XXI IMEKO World Congress. Vol. 1, No. 1, pp. 1353-1357, Prague, Czech Republic, 2015
- ✓ H. J. Lee, H. S. Lee, P. S. Ma, J. K. Lee, and Y. Y. Kim, "Effective Material Parameter Retrieval of Anisotropic Elastic Metamaterials", PHONONICS2015, Paris, France, 2015
- ✓ W.-H. Cho, S.-W. Hong, and J.-G. Ih, “Robust source array configuration for minimizing the effect of reflection in an interior space,” Proc. of the Noise and Vibration – Emerging Technologies, April 2015, Dubrovnik, Croatia.