IMEKO 20th TC3, 3rd TC16 and 1st TC22 International Conference
Cultivating metrological knowledge
27th to 30th November, 2007. Merida, Mexico.

The Bilateral Comparison for Charge Sensitivity of Standard Accelerometer between NIMT and NMIJ

P. RATTANANGKUL[1], B. THUMMAWUT[1], V. PLANGSANGMAS[1], A. OHTA[2], T. USUDA[2]

[1]National Institute of Metrology (Thailand), NIMT, Bangkok, Thailand
[2]National Metrology Institute of Japan, (NMIJ/AIST), Tsukuba, Japan

Abstract

The Bilateral Comparison between National Institute of Metrology (Thailand), NIMT and National Metrology Institute of Japan, (NMIJ) was conducted in order to confirm the capability of NIMT. The calibration of charge sensitivity of the accelerometer was carried by interferometry method according to ISO 16063-11. The calibration results were then compared at the frequency range of 50Hz to 5000Hz. The reference standard accelerometer Bruel & Kjaer 8305 was assigned as the artifact.

The calibration methods of NMIJ were according to the Fringe-Counting Method at the frequency range of 20Hz – 80Hz and Sine Approximation Method at the frequency range of 100Hz – 5000Hz. While the calibration methods of NIMT were according to the Fringe-Counting Method at the frequency range of 50Hz – 800Hz and Minimum Point Method at the frequency range of 1000Hz - 5000Hz.

The comparison results were agreeable which the EN value was less than 1.0 for the entire frequency range.

Key words: control, Accelerometer, Charge Sensitivity, Vibration Transducer Calibration, Bilateral Comparison, NMIJ, NIMT, JICA Project.

1. Introduction

The vibration standard in Thailand was established in 2000. In April the same year, National Measurement Laboratory (NML - Australia) organized the bilateral comparison under AusAid Project and the aim is to access the calibration capability of NIMT's staff. The calibration results and the uncertainty calculations show the capability of determining the charge sensitivity of an accelerometer, using the method of comparison with a reference accelerometer according to ISO 16063-21 at standard equipment to a first level National – Institute.

In October 2001, NIMT has been supported by NMIJ under JICA Project. The target is that NIMT should have been accredited as a reliable national metrology institute. In September to November 2005, The bilateral comparison between NMIJ and NIMT is perform to confirm the agreement of calibration results, uncertainty budget computation and measurement capability of NIMT, for charge sensitivity of standard accelerometer, using interferometry method according to ISO 16063-11[1]

2. Test Instrument Interface

For this comparison, a standard accelerometer (Bruel & Kjaer, type 8305) is assigned as the artifact. It is transported between two laboratories by hand carrying. Each laboratory determined the charge sensitivity of standard accelerometer and uncertainty budget of measurement according to ISO16063-11. primary vibration calibration by laser interferometry and GUM respectively. Measurement frequencies were between 50 Hz to 5000Hz.

2.1 Calibration system and methodology at NMIJ

NMIJ has developed four primary vibration calibration systems for the national standard of vibration acceleration. They calibrate accelerometers as a transfer of vibration acceleration standard to the users. All of the systems are in compliance with ISO 16063-11. They are classified for their calibration frequency range as follows.

System 1; Very low frequency range: 0.1 Hz- 2 Hz

System 2; Low frequency range: 1 Hz-200 Hz

System 3: Middle frequency range: 20 Hz-5 kHz

System 4: High frequency range: 5 kHz-10 kHz

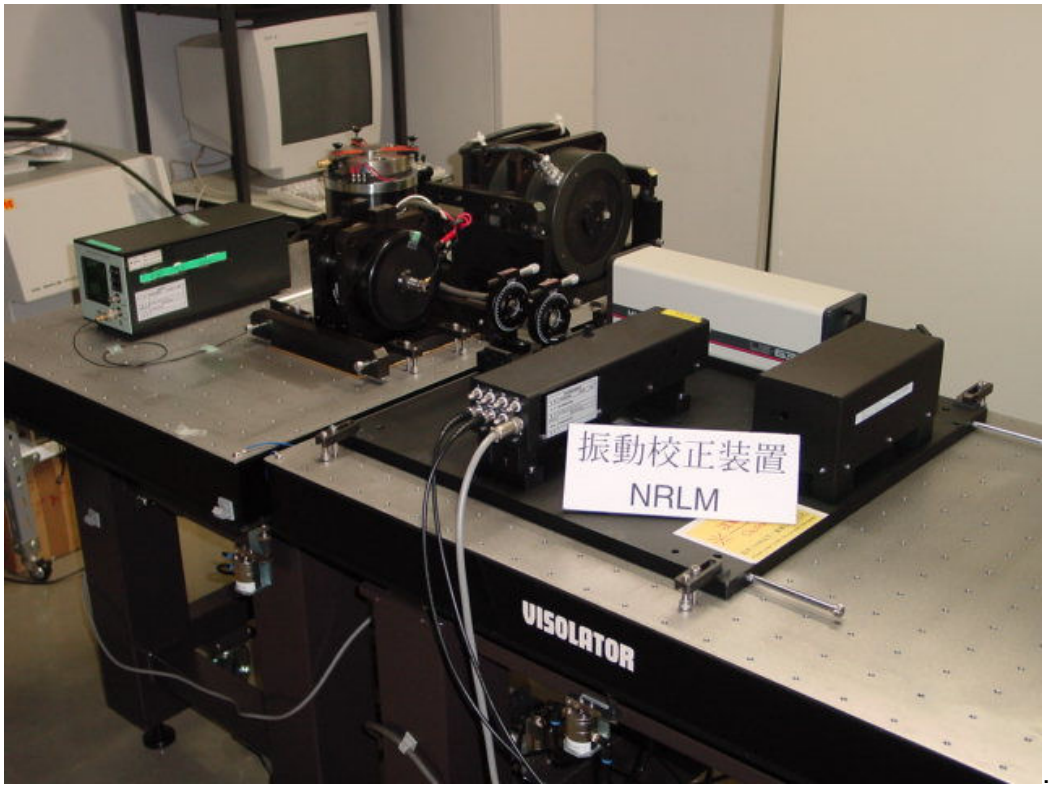

Figure 1 Apparatus of the system for middle frequency range in NMIJ

In these systems, the system 3 for middle frequency range was applied for this comparison. Figure 1 shows the apparatus of the system 3. It is realized by a combination of modified Michelson laser interferometer and an electro dynamic vibrator. The motion of vibrator is horizontal direction. As shown in Figure 2, the modified Michelson laser interferometer was specially designed to apply the sine-approximation method and to realize high signal-to-noise ratio, robustness to acoustics and vibration noise, high frequency response, and easy operation for optical alignment [2]. The system can also perform fringe-counting method as well as sine-approximation method. The fringe-counting method is applied for the frequency range of 20 Hz to 80 Hz. While sine-approximation method is applied for the frequency range of 100 Hz to 5 kHz.

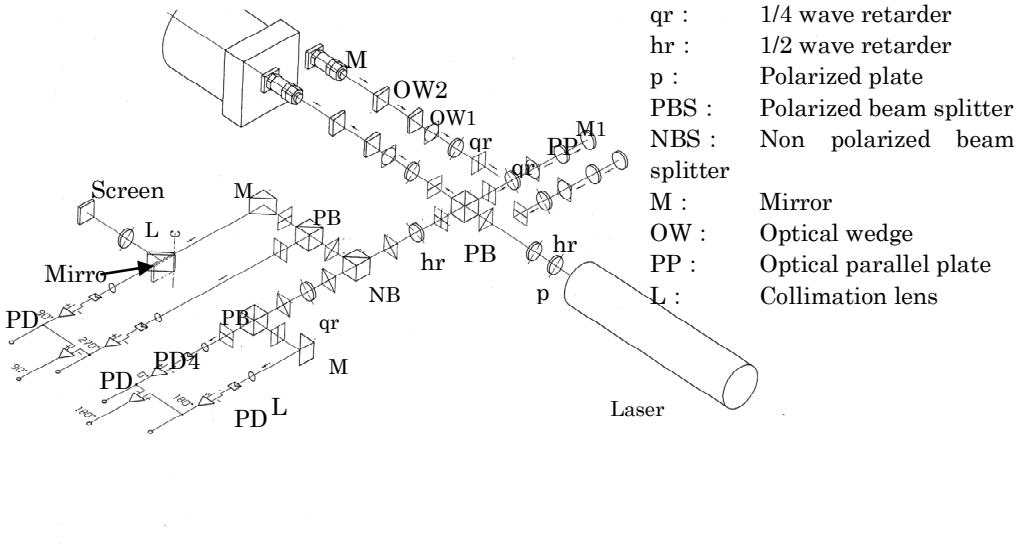

Figure 2 Laser interferometer optical design

2.2 Calibration system and methodology at NIMT

The Primary Vibration Transducer Calibration System of NIMT is Bruel & Kjaer, type 9636[3]. This calibration system can be used for middle frequency range (50-5000 Hz). Figure 3 shows the apparatus of the system. This system is a common Michelson laser interferometer with a single detector and an electro dynamic vibrator follows the guidelines given in ISO16063-11. The motion of vibrator is in the horizontal direction. Figure 4 shows the common Michelson laser interferometer. The calibration methods of NIMT using the fringe-counting method at the frequency range of 50 Hz – 800 Hz and using minimum point method at the frequency range of 800 Hz – 5000 Hz.

Figure 3 Primary Vibration Transducer Calibration System of NIMT

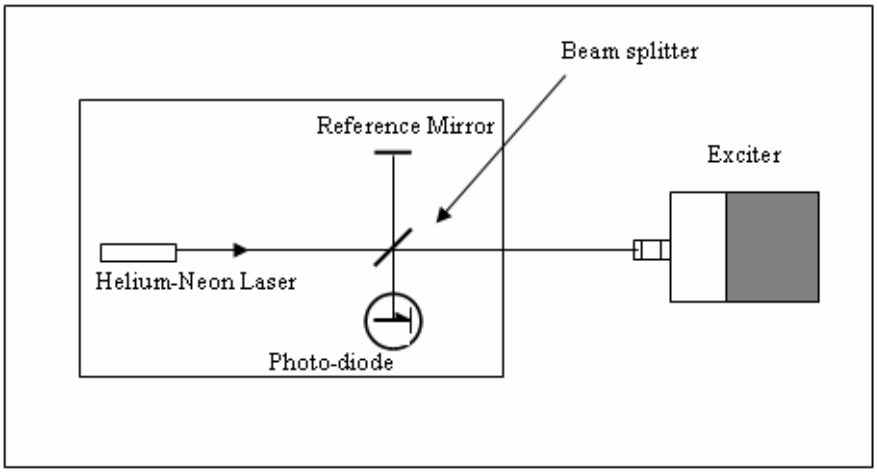

Figure 4 The common Michelson Laser Interferometer

3. Comparison results [5]

The charge sensitivity of the standard accelerometer (B&K type 8305) between two laboratories are shown in Table 1. The value of charge sensitivity are approximately 0.1271 (pC/ms2) from 50 Hz to 1000 Hz and there exist some deviation of the value from 1000 Hz to 5000 Hz

Table 1 The result of charge sensitivity of accelerometer between NMIJ and NIMT

Frequency (Hz)	Sensitivity (pC/ms^2)	
	NMIJ	NIMT
50	0.1271	0.1270
63	0.1271	0.1271
80	0.1271	0.1271
100	0.1271	0.1271
125	0.1271	0.1271
160	0.1271	0.1271
200	0.1270	0.1271
315	0.1273	0.1270
400	0.1270	0.1270
500	0.1270	0.1269
630	0.1269	0.1268
800	0.1271	0.1270
1000	0.1270	0.1271
2000	0.1273	0.1272
5000	0.1283	0.1298

The uncertainty budget of measurement for charge sensitivity with the coverage factor of k=2 between two laboratories were shown in Table 2. The expanded uncertainty is between 0.42 % – 1.35% for NIMT and between 0.13 % – 1.20% for NMIJ.

Table 2 Uncertainty budget for charge sensitivity (coverage factor of k = 2)

Frequency (Hz)	Uncertainty (%)	
	NMIJ	NMIT
50	0.19	1.35
63	0.19	0.45
80	0.27	0.44
100	0.32	0.44
125	0.13	0.42
160	0.16	0.43
200	0.17	0.44
315	0.14	0.55
400	0.19	0.50
500	0.16	0.44
630	0.16	0.56
800	0.16	0.56
1000	0.23	0.78
2000	0.44	0.78
5000	1.20	0.78

The Figure 5 shows the results of charge sensitivity between two laboratories. The maximum difference between two laboratories is 0.15 pC/m/s2 at frequency 5000 Hz. The EN value[4] was defined as the following equation and introduced to assess the calibration proficiency of NIMT.

$$E_n = \frac{M_{lab} - M_{ref}}{\sqrt{U_{lab}^2 + U_{ref}^2}}$$

where : M_{lab} and M_{ref} are the measured charge sensitivity of standard accelerometer done by NIMT and NMIJ respectively.
U_{lab} and U_{ref} are expanded uncertainty of measurement declared by NIMT and NMIJ respectively with the coverage factor = 2

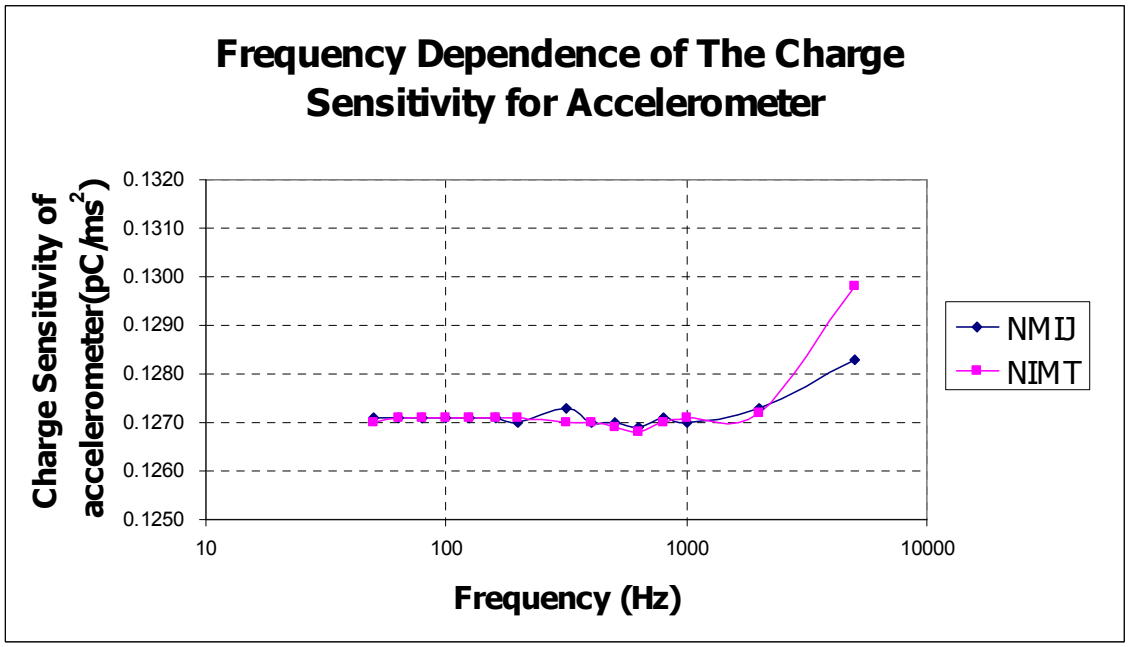

Figure.5 Frequency dependence of the charge sensitivity for accelerometer

The calculated EN values are shown in Table 3, the values are indicated between 0.01 – 0.81.

Table 3 EN ratio of the result between NMIJ and NMIT

Frequency (Hz)	EN Value
50	0.06
63	0.02
80	0.11

100	0.01
125	0.03
160	0.03
200	0.13
315	0.42
400	0.01
500	0.07
630	0.13
800	0.16
1000	0.08
2000	0.06
5000	0.81

4. Conclusion

According to this bilateral comparison for charge sensitivity of accelerometer. The calculated EN values were shown in Table 3. The EN value is less than 1.0 for entire frequency range. Therefore, the charge sensitivity calibrated by NIMT is regarded as satisfactory, according to the recommendation described in ISO/IEC Guide 43-1.

We should note that the comparison was carried out as a part of technology transfer from NMIJ to NIMT. Thus the comparison results can not be linked to any key or supplementary comparison presented in KCDB[6] for the moment. NIMT shall participate intercomparison in the near future to perform the calibration capability.

ACKNOWLEDGMENT

The calibration facility in NIMT are installed under corporation of JICA (Japan International Corporation Agency).

We are very grateful for the nice cooperation between NMIJ and NIMT for this comparison.

We also wish to give a special thank to Dr.Yoshiaki Akimoto and the JICA Project Team of NIMT.

5. References

[1] International Standard ISO16063-11 Methods for the calibration of vibration and shock transducer, part 11: Primary vibration calibration by laser interferometry.

[2] T. Usuda, E. Furuta, A. Ohta, H. Nakano, Development of laser interferometer for a Sine-approximation method, Proc. of SPIE Vol.4827, pp.29-36, 2002.

[3] Bruel & Kjaer: Technical documentation : Primary Vibration Transducer Calibration System Type 9636.

[4] International Standard ISO/IEC Guide 43-1, Proficiency testing by interlaboratory comparisons Part1: Development and operation of proficiency testing schemes(1997).

[5] Report of Training at NIMT, Vibration and Acceleration Standard by JICA Expert
Mr.Akihiro OHTA, (November7, 2005 – December2, 2005)
[6] BIPM Key Comparison Database, http://kcdb.bipm.org/