Private grope activity; Round-Robin calibration test for High resistance（1GΩ,10GΩ）

（Purpose: technology exchange between companies.）

（1高抵抗(1GΩ,10GΩ）巡回比較測定

This presentation sheets were translated
by Ueyama for Yamari, with the consent of Mr. Yamaguchi.

Azbil Corporation
Toru Yamaguchi, Yosuke Shinzawa

Contents

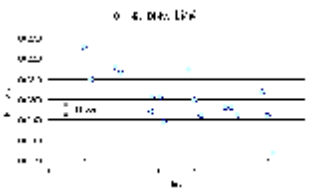
1, Our present recognition for high resistance calibration.
2, Back- ground of Round-Robin calibration test executing
3, Purpose of Round-Robin calibration test executing
4, Method of Round-Robin calibration test executing
（Decisions at meeting）
5, Round-Robin test content
6, Requirement for Participant laboratory agreement on calibration data disclosure
7, Measurement method
8, Round-Robin calibration result
（1GΩ:No1,No2, 10GΩ:,No1,No2）
9, Schedule
10, Conclusion
11, At the end

1. Our present recognition for high resistance calibration

- After executing tasks with paying attentions, it is not difficult to calibrate resistor 100 MΩ with high repeatability.
- Although executing tasks with paying any attentions, it is difficult to calibrate high resistor, more than 1GΩ , with 10 ppm uncertainty.
- After executing tasks with paying attentions and arranging conditions, it is possible to calibrate resistor 1 GΩ with 5 to 10 ppm repeatability.
- After reviewing instrument specification and management, it might be possible to calibrate resistor 1 GΩ with 10 to 20 ppm uncertainty.
- On the condition that calibrating resistor is more than 10 GΩ, the task needs many attentions and it is not easy to judge the resistance value adequate one. The information for standard resistor is poor.

Typical DMM possible to measure resistance of 100MΩ (10^8)

10^4	10^5	10^6	10^7	10^8	10^9	10^{10}	10^{11}
10kΩ	100kΩ	1MΩ	10MΩ	100MΩ	1GΩ	10GΩ	100GΩ



Well-known for method is using sealed box for covering resistors.

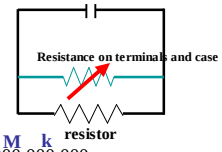
Well-known for method is using sealed cable for wiring.

On the condition of calibration resistor more than 1G(10^9), it needs another idea.

10^4	10^5	10^6	10^7	10^8	10^9	10^{10}	10^{11}
10kΩ	100kΩ	1MΩ	10MΩ	100MΩ	1GΩ	10GΩ	100GΩ

Typical insulation resistance for an insulator is about 10^{14} Ω.

As a example, Teflon has very good insulation resistance of 10^{18}Ω, is used for many application. It is easy to make some static electricity, and collect some dust. As the result, resistance on the Teflon surface is easy to change the resistance. So it is necessary to apply Teflon material to insulator purpose.



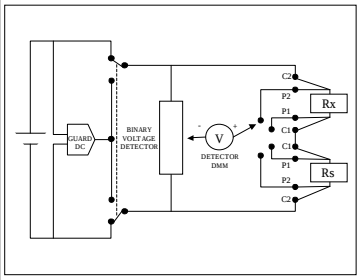
T G M k

Insulation material10^{14} ⇒ 100,000,000,000,000

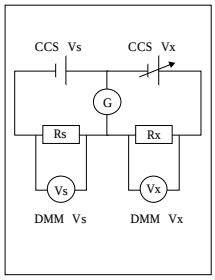
100MΩ	⇒10^8 ⇒	100,000,000 ⇒ 1 ppm
1GΩ	⇒10^9 ⇒	1,000,000,000 ⇒ 10 ppm
10GΩ	⇒10^{10} ⇒	10,000,000,000 ⇒ 100 ppm

On the condition of calibration resistor 1G(10^9), it is possible to use a commercial instrument.

Binary Voltage Divider



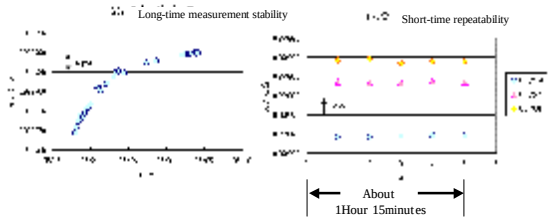
Half Bridge



By the above instruments, it would be possible to calibrate them with about 5 ppm and short-time range repeatability.

Example MI 6000B with 1 GΩ

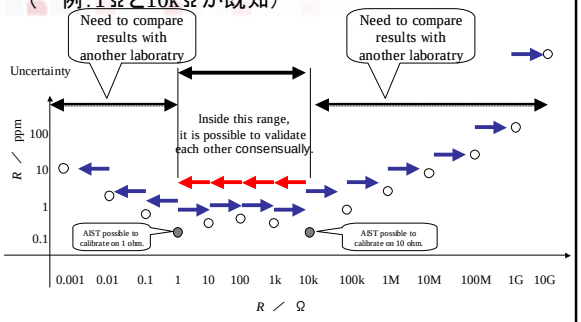
It would be possible to calibrate resistors
with better than 5 ppm and short-time repeatability!



Uncertainty budget sample table on high resistance measurement

不確かさの要因	感度係数	1GΩ 1101052 MΩ	1GΩ 1101371 MΩ	10GΩ 1102185 MΩ	10GΩ 1102186 MΩ
標準にかかる不確かさ					
標準抵抗器の校正の不確かさ	H or $R_x^2/H/Rlo^2$	0.0065	0.0065	0.7150	0.7150
パラレル測定時の標準抵抗器H側の校正の不確かさ	$-Rx^2/Rh^2$			-0.8500	-0.8500
温度変化による抵抗値の変化	H or $Rx^2/H/Rlo^2$	0.0029	0.0029	0.3175	0.3175
パラレル測定時の温度変化による標準抵抗器H側の変化	$-Rx^2/Rh^2$			-0.1786	-0.1786
標準抵抗器の経年変化	H or $Rx^2/H/Rlo^2$	0.0012	0.0012	0.1270	0.1270
パラレル測定時の標準抵抗器H側の経年変化	$-Rx^2/Rh^2$			-0.2887	-0.2887
標準抵抗器の電圧特性	H or $Rx^2/H/Rlo^2$	0.0000	0.0000	0.0000	0.0000
パラレル測定時の標準抵抗器H側の電圧特性	$-Rx^2/Rh^2$			0.0000	0.0000
Bridgeの抵抗比測定の不確かさ	Rref or $Rx^2/H^2/Rlo$	0.0014	0.0014	0.6351	0.6351
Bridgeの直線性の不確かさ	Rref or $Rx^2/H^2/Rlo$	0.0000	0.0000	0.0003	0.0003
標準器において考慮しなければならないその他の影響				0.0000	0.0000
被生熱起電力の影響	Rref or $Rx^2/H^2/Rlo$	0.0000	0.0000	0.0000	0.0000
ノイズレベルの影響	1	0.0003	0.0003	0.1328	0.0361
測定環境において考慮しなければならないその他の影響					
被校正器にかかる不確かさ					
抵抗値の校正結果のバラツキ	1	0.0030	0.0028	0.1834	0.0525
校正環境で校正対象が受ける温度の影響	Rx	0.0042	0.0036	0.2664	0.2323
校正対象において考慮しなければならないその他の影響				0.0000	0.0000
合成標準不確かさ（MΩ）		0.0090	0.0086	1.4112	1.3883
自由度		496	530	24553	∞
包含係数		1.96	1.96	1.96	1.96
拡張不確かさ（MΩ）		0.0176	0.0170	2.7660	2.7208

Japan Resistance calibration scheme
（一例：1ΩとΩが既知）



2. Back-ground of Round-Robin calibration test executing

then・・・

※MI：Measurements International Electrical instrument maker

- About 1 year ago, some engineers familiar with resistance measurements hold a meeting with MI. Main engineers were MI instrument users.
- At the meeting, some engineers showed their experience to feel anxious on calibrating high resistance, asked for MI cooperation.
- MI proposal was,executing Round-Robin calibration test with their standard high resistor, which was calibrated by MI.
- Yamari of MI agent was working as an organizer for gathering members who were interested in high resistance calibration.

3.Purpose of Round-Robin calibration test executing

- To confirm the calibration data of high resistance by participants and the consistency to companies.
- To realize the technical meeting place exchanging for companies.
  - Want to share the useful instrument information of many suppliers and types.
  - Want to share the calibration method and conditions for getting expected value
- To prepare,(or exercise) the skill test, for future JCSS skill test.
- To make a presentation of our Round-Robin calibration test results, after participants agreement.

Our activity purpose is as same as the staring point of our Japan NCSLI.(Please refer to HomePage)
http://www.ncsli-j.org/j/welcome.html

4. Method of Round-Robin calibration test executing

- The project purpose is realizing the meeting place of technical exchange for many company engineers.
  Our project content is not executing test according to conventional way, similar to JCSS skill test.
  ※ After dividing participants to 2 groups, and executing Round-Robin test.
  Group-a : agree their calibration Data dissemination.
  (executing till Jun 2012)
  Group- b : not agree their calibration Data dissemination.
  (executing till Jun 2012)
  ※ Round-Robin test sequence
  Group-a starts the Round-Robin calibration test.
  After competing Group-a,
  Group-b executes the Round-Robin test.

【Action assignment】
For the official skill test, it needs the good reference resistor, which has very good stable specification for a few years.
For the official skill test, it needs the official calibration data.

5.Round-Robin test detail contents

Group	Data dissemination	Round-Robin method	Period	Fee	Requirement for Activity Participation	Requirement for Meeting Participation
Group-a	Agree	After setting MI calibration data as reference. executing Round-Robin test	Till Jun	Shipping cost Plus Insurance fee	Agree Our polity	Nothing
Group-b	Not agree	Ditto	Till Dec	Ditto	Nothing	Nothing

6. Requirement for Participant laboratory agreement on calibration data disclosure

【A Laboratory MUST】
- Open their calibration method.(doesn't need detail contents)
  - Need their instrument model number(instrument & resistor)
  - Need their traceability document
- Defray the shipping cost and insurance fee for the artifact (resistor).

【A Laboratory possible】
- To evaluate the uncertainty from their calibration data.
- To evaluate the measurement system performance from their instrument specification (accuracy)
  ⇒ to evaluate what uncertainty they would be able to measure the resistor by their instrument.

7.Measurement method

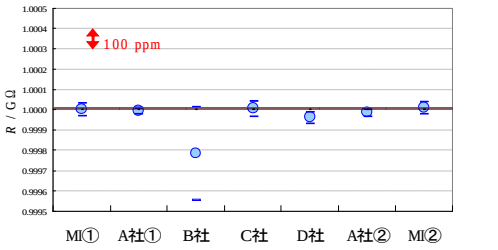
Lab	Measurement method
MI	comparative calibration by a Bridge 1GΩ, Using Binary Voltage divider 10GΩ(At First time) a commercial meter 10GΩ(At Second time) Binary Voltage divider
A	comparative calibration by a Bridge Using Binary Voltage divider
B	Using a commercial meter
C	Using original Wheatstone bridge made by themselves
D	comparative calibration by a Bridge Using Binary Voltage divider

9.Round-Robin calibration result (1GΩ No.1)

:MI①:reference value before Round-Robin test
:MI②:reference value after Round-Robin test

1GΩ S/N 1101052

※For confirming the artifact good performance, only company A has executed to calibrate it before and after Round-Robin test.

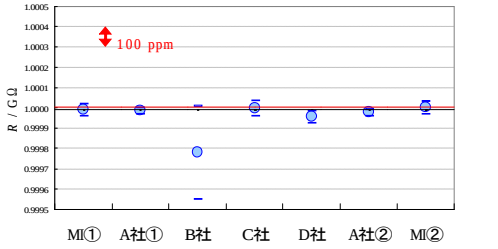


9.Round-Robin calibration result (1GΩ No. 2)

:MI①:reference value before Round-Robin test
:MI②:reference value after Round-Robin test

1GΩ S/N 1101371

※For confirming the artifact good performance, only company A has executed to calibrate it before and after Round-Robin test.

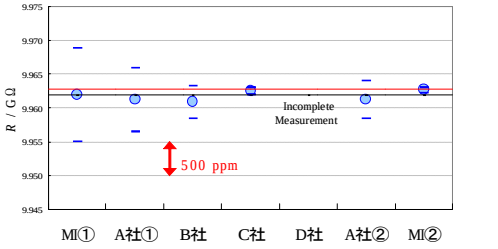


9.Round-Robin calibration result (10GΩ No.1)

:MI①:reference value before Round-Robin test
:MI②:reference value after Round-Robin test

10GΩ S/N 1102185

※For confirming the artifact good performance, only company A has executed to calibrate it before and after Round-Robin test.

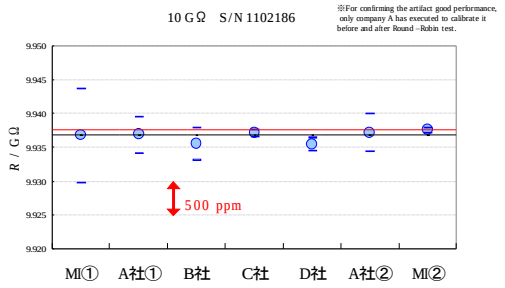


9.Round-Robin calibration result （10GΩ　No.2）

azbil

—— :MI①:reference value before Round-Robin test

—— :MI②:reference value after Round-Robin test



 19

10.schedule

azbil

- 2011/12　関係者への声かけ、MIにて仲介器準備（校正）
- 2012/04　第一回会合（巡回方法や簡単なルール決定）
- 2012/04　aグループの各社、巡回測定
- 2012/06　bグループの各社、巡回測定
- 2012/06　aグループのデータ持ち寄り確認会合
- 2012/06　データ集計
- 2012/08　MIにて仲介器の再校正
- 2012/09　データ集計
- 2012/09　日本NCSLI発表資料作成（関係者に再確認）
- 2012/10　第二回会合予定（情報交換が目的）
- 2012/11　日本NCSLI発表
- 2012/12　他社製品の抵抗器を巡回するための会合
- 2013/04　巡回開始
  - ・
  - ・

 20

11.Conclusion

azbil

- After confirming the calibration resistance data by participants and the consistency to companies, we can recognize they are according to the calibration uncertainty,and meet their calibration ability.
- For managing the measurement standard,
  - Staff needs the valuable experience. Rely on limited engineers.
  - Related information is kept in a closed organization. Each organization must experience them by themselves.
  - Need time, money and intelligent engineer.
    ⇒ Average company supervisors might be hard to understand this idea.
- Technical exchange is very effective for many company engineers.
  - When getting the adequate (,valid) information, Each engineer' s work might be down half.
  - When talking with engineers, an engineer might take an idea that his knowledge and experience is inferior to another.
  - Whether intelligent engineer is or not is the company staff, an engineer might take a hint??

Every company might have good cost merit on this idea?
Economic effect?

 21

12.At the end

azbil

We appreciate that we have worked valuable jobs on a societal level that goes beyond individual corporate frameworks

and made the interesting presentation as NCSLI Japan staff.

 22