Iulian Mihai

Analyses for equivalent ratio model in measurements of high standard resistance bridges

R.T. 35/2022 November 2022

I.N.RI.M. TECHNICAL REPORT

Abstract

At the National Institute of Metrological Research (INRiM), a first evaluation of an exploratory method in the equivalent ratio model for a commercial dual source, high resistance bridge has been made using restrictive metrological triangulation rules. The study was performed observing the ratios measurements of a commercial bridge for the standard resistors in the range from 10 TΩ to 1 PΩ.

Keywords: High resistance measurements, equivalent ratio model, measurement uncertainty, self-calibration process, measurement noise.

Sommario

Presso l'Istituto Nazionale di Ricerca Metrologica (INRiM) è stata effettuata una prima valutazione esplorativa di un modello a rapporto equivalente per un ponte commerciale a doppia sorgente utilizzando regole di triangolazione metrologica restrittive. Lo studio è stato condotto osservando le misure di rapporto di resistenze campione nel campo da 10 TΩ a 1 PΩ.

Keywords: Misure di resistori campioni di alto valore, modello equivalente di rapporto di resistenze, incertezza di misura, test di compatibilità, misure affette da rumore.

Opinions and comments from the experts on this technical report

Richard Timmons, P.Eng.
President, Guildline Instruments, Canada

The Triangulation rules presented in this paper will enable high ohmic resistors to be calibrated with lower uncertainties.

Duane Brown, Senior Member IEEE
CEO, Measurements International, Canada

I have been asked to write an opinion on a report titled

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of high standard resistance bridges By Iulian Mihai /INRiM
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The report is based on the future aims of the work presented in Metrological triangulation rules in ratio measurements of high standard resistance bridges, By Iulian Mihai, I.N.R.I.M. TECHNICAL REPORT, May 2022. The extension covers the range from 10 TΩ to 1 PΩ using a Measurements International Model 6600A Dual Source Resistance Bridge where the 10 TΩ was characterized on the INRiM dual source bridge and the 100 TΩ was characterized through an international comparison in Europe. The paper covers the general guidelines for technical papers covering Abstract, Introduction, Hypothesis, Data sampling including Results and Discussions, Conclusion, and References.

This technical report also exploits future uses of the 10 TΩ and 100 TΩ resistors calibrated by other national laboratories with independent methods, for example in a bilateral laboratory comparison, to support the real utility of an equivalent ratio model and to improve

the uncertainty of the commercial bridge 6600A or to extend it until 1 PΩ. This explorative method of equivalent ratio model uses all the ratios of the commercial bridge (1:1; 1:10 and 1:100) and in general can be applied to a modified Wheatstone bridge.

Finally, the current detector can be replaced by a short circuit, but the triboelectric noise or other interferences can unbalance the measurement bridge and lose the control of the system. From a practical point of view, we need a more accurate current detector with resolution in the range of femtoampere or lower and check for the white noise regime to improve on the measurements.

Marcus Vinícius Viegas Pinto, MSc. Eng.
Researcher in metrology and quality, Division of electrical metrology, Inmetro, Brasile

I am very interested in calibration of high resistance standards and measuring bridges because of my Ph.D. thesis. I am interested in collaborating with INRiM on these topics, possibly in a co-tutela program of Ph.D. The triangulation rules are pretty interesting and should allow the calibration of resistance standards of high values with lower uncertainties, in addition to being a way to guarantee the validity of the results, as recommended by the ISO/IEC 17025 standard.

SUMMARY

1. INTRODUCTION

The previous technical reports explore metrological triangulation rules in ratio measurements using also the technique of Allan variance and the power spectral density, familiar in the time and frequency metrology, in order to improve the performance in high resistance measurement systems and to solve the systematic errors or functioning errors of the commercial bridge MI 6600A. In this work a first evaluation of an exploratory method in the equivalent ratio model for a commercial dual source high resistance bridge has been made using restrictive metrological triangulation rules, from the previous work, and other new comparisons. The study was performed observing the ratios measurements of a commercial bridge for the standard resistors in the range from 10 TΩ to 1 PΩ.

To perform this work, a free software such as Stable32 and Calibration Curves Computing – CCC Software were used but also Excel files to check for errors.

The predominantly aim of this work is to identify a method of measurement more efficient and more reliable, with respect to the traditional method, in order to successively carry out calibration services in terms of the ISO 17025 or, for example, measurements of bulk resistors or the insulation materials of composite structures of the thermal shields in the range from 100 kΩ to 1 PΩ.

The author wishes to express his profound thanks to Mr. **Duane Brown** from Measurements International, Canada for his help with the 6600A bridge's operation and many useful suggestions and to Mr. **Richard Timmons**, President of Guildline Instruments, Canada for the fruitful collaboration. Special thanks to Mr. **Marcus Vinícius Viegas Pinto** from Inmetro, Brasile for his comments and suggestions to improve the quality of this technical report with uses of the software R in Appendix 2. Special thanks to my colleague from INRiM, Mrs. **Francesca Romana Pennecchi** for the useful suggestions with the software Calibration Curves Computing – CCC Software.

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