# APPLYING ADVANCED TECHNIQUES FOR HIGH RESISTANCE MEASUREMENTS

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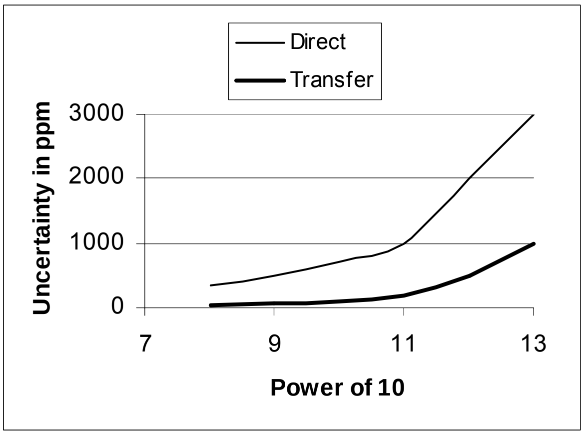
## Abstract

This paper describes results in developing advanced techniques for measuring resistances in the range of $10^8$ to $10^{15}$ ohms. The use of transfer methods with a Teraohmmeter is discussed, with detailed analysis of the factors influencing uncertainty.

## Introduction

Commercial Teraohmmeters provide typical uncertainties of 350 to 10000 ppm in the measurement range of $10^8$ to $10^{15}$ Ohms. An Expanded Transfer Method has been developed which provides measurement uncertainties of 25 to 5000 ppm for the same resistance range.

Chart 1: Reduction in Measurement Uncertainty




## Applying the Transfer Principal

A brief review of a particular Teraohmmeter technology is presented, providing a basis for a subsequent discussion of these transfer measurement techniques.

Direct measurement is described and analyzed with regards to factors affecting uncertainties. The need for a better measurement technique will be demonstrated.

The transfer method is described in detail. Results are provided which support the reduction in uncertainties. The data also identifies further areas for improvement, including a discussion which describes the need and application for a double transfer method.

The double transfer method is presented and used to further reduce measurement variations. Results are given and discussed. This technique is then used to accurately measure temperature coefficients (TC's) for resistances of $10^8$ to $10^{12}$.

Chart 2: Typical TC Data Using Direct Measurement

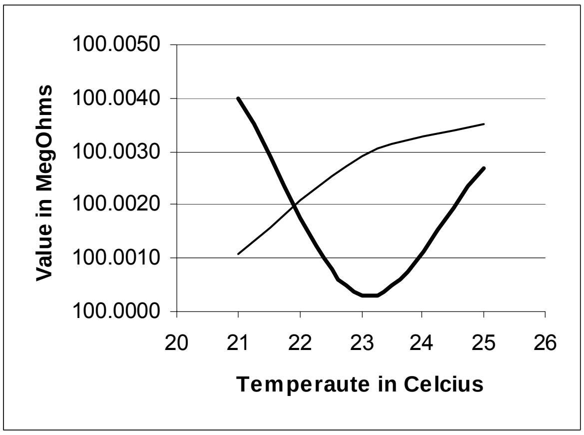
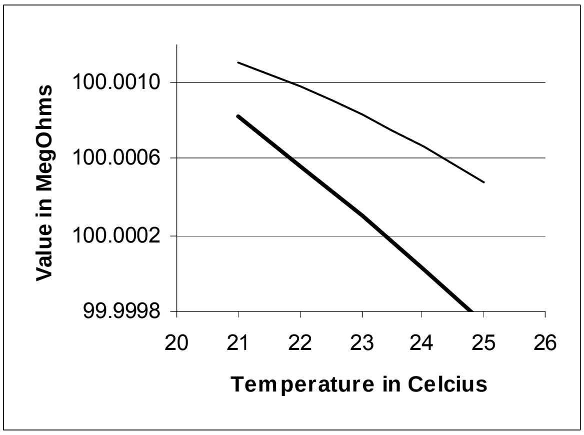



Chart 3: TC Data After Applying Transfer Method




Supporting data for $10^8$ Ohms is provided using a DCC Bridge. This improved measurement capability provides the basis for development of resistors with lower TC's. Providing accurate Temperature coefficient data for a standard resistor allows the commercial laboratory to further reduce uncertainty.

The double transfer method is now applied to the Teraohmmeter under tightly controlled conditions to provide a better characterization of the meter. Conclusions from this data suggest another development area to improve measurement precision. The temperature-controlled enclosure for the electrometer is discussed.

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With a higher level of measurement stability and use of standards with known temperature coefficients the Teraohmmeter can now be more accurately calibrated. Reduced uncertainties allow for more precise calculation of the Teraohmmeter's internal calibration coefficients, resulting in reduced systematic errors and lower direct measurement uncertainties. This improved measurement capability can now be applied to routine calibrations. The reduction in error and uncertainty provides for more accurate repeat calibrations, resulting in a more accurate history of the standard and lowering projected uncertainties based on historical deviation from a trend line.

Supporting data is presented and uncertainties are analyzed, including repeatability and stability factors. Benefits and limitations of this technique are also reviewed.

## Conclusions

The improved measurement capability provided by using a double transfer method can be utilized by commercial laboratories to reduce uncertainties. This principle has been applied to generate more precise standard resistors and Teraohmmeters. The uncertainties associated with direct measurement have been improved.