Repeatability & Reproducibility Analysis of RTC Measurement SystemFor Single Hole Measurement

RTC 测量系统重复性和再现性（R&R）分析-单孔测试

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BACKGROUND

背景

Recent updates to RTC requirements have necessitated a change from measuring daisy chain based coupons comprised of many holes to a single hole 4-wire measurement. Daisy chain measurements included both the holes and connecting circuits and were measured in the .1 to .5 Ohm range. Most measurement systems are easily capable of repeatability and accuracy in this "daisy chain" range and are not affected by minor drift in the measurement system. The move to single-hole test vehicles dropped the resisance measured by a factor of 50-100 and limited the possible test instruments capable of making this ultra low resistance measurement to a very small number.At these ultra low resistances, issues of temperature drift in the measurement tool, switching matrix, cables and connection points now have a magnitude which exhibits influence on the overall measurement that was not apparent in daisy chain measurements.

最近RTC测量要求的升级迫使测量方法从过去的多孔测试板的菊花链测量变成现在的单孔四线测试法。菊花链测量包括孔和连接电路的测量，测量阻值范围是0.1-0.5欧姆。在这种菊花链的范围，大多数的测量系统都能够很容易的做出重复性和准确性分析并且不受测量系统微小漂移的影响。而今单孔测量将测量阻值降低了50-100倍，因此只有很少的测试设备才可以进行极低阻值的测量。在这种极低阻值的测量条件下，测量工具、交换矩阵、电缆和接点因环境温度变化产生的问题对整个测量产生了不同程度的影响。这些问题在传统菊花链测量中是不会出现的。

This study was undertaken to determine the gage R&R and Cg/Cgkof the measurement system when looking at single holes. In the gage R&R study the results are shown after correcting for measurement system drift using copper calibration circuits. The upward trend of the single hole resistance towards actual failure during the test cycles (change in actual Gage) was not taken into account and may be a contributing factor to the gage R&R percentage calculated for the test holes measured.

当我们看单孔测试时，这份研究是为了评估测试设备的GRR和Cgk指数。在GRR研究中，得出的结果是修正后的值，是使用铜校正电路校准系统漂移后得出的数值。在整个试验循环，随着试验时间延长单孔电阻值上升的一个趋势并没有得到重视，这也许就是在孔的测试中对计算GRR百分比起作用的因素。

In order to account for measurement system drift, a calibration coupon consisting of a 2 copper circuits in a similar resistance range to the single holes being measurements was placed in the chamber along with the test coupons. The resistance change in this copper circuit, over the test cycles was used to calculate measurement system drift. This calculated measurement system drift value was then subtracted from the actual measured values of the single holes creating "corrected" measurement values for each cycle.

为了解释测量系统的漂移，测试时，一个参考板与测试板一起放置在箱子内，参考板包含2个与被测试的单孔具有相同阻值的铜电路。在整个测试循环，铜电路阻值变化被用来计算测试系统的漂移。将计算出的测试系统漂移值从实际的测量值中减去即得

出每个循环的单孔修正值。

In addition to running a Gage R&R study, we also evaluated the Cg/Cgkof the measurement system using 50 measurements for each evaluation measured in rapid succession.We performed the analysis on a number of sigle hole sample resistances in different resistance ranges. Cg/Cgk results greater that 1.33 are generally accepted as being adequate for a measurement system.
除了进行GRR研究，我们还对测试系统进行了Cgk评估，对每次评估都进行了50次持续快速检测。我们对一些单孔样品阻值进行的分析，基于不同的阻值范围。Cg/Cgk值高于1.33是普遍可接受的，对测量系统来说是足够的。

TEST SPECIMENS

测试样品

GAGE R&R:
6 samples with 3 Single through holes per sample. Each of the 3 single holes per specimen was of a different size and actual measured resistance. 1 calibration coupon with 2 copper calibration circuits.
6个样品，每个样品有3个单通孔。每个样品的3个单通孔都具有不同的孔径和真实的测量电阻值。1个校准板包含2个铜校正电路。
Cg /Cgk:
Sample 1 with 4 different average resistances (.23, .30, .54 & 1.44 milliohm) and Sample 2 with 3 different average resistances (.32, .48 & .82 milliohm).
样品1有4种不同的平均阻值(.23, .30, .54 & 1.44 milliohm)，样品2有3种不同的平均阻值(.32, .48 & .82 milliohm)。

METHODS

方法

GAGE R&R:

Test and calibration coupons were placed into a Weiss RTC chamber and wired to the measurement system in 4-wire configuration. The coupons were then subjected to 30 minutes at -40C then 30 minutes at 125C for 100 complete cycles. After each stabilization at 125C, 4-wire resistance measurements were made of all test holes and calibration circuits. The “RAW” resistances were recorded for each cycle and are included in this report.

将测试板和校准板放入Weiss RTC 冲击箱，采用四线连接电阻测试技术与测试系统连接起来。测试板在-40℃运行30分钟，在125℃运行30分钟，完成100次完全循环。125℃每次稳定时间后，完成所有测试孔和校准电路的4线连接电阻测试。在报告中记录每次循环的原始电阻值。

Resistance measurements were made for each cycle after test sample stabilization at the high temperature of 125℃by using current of 1.1A through the measurement system. At the end of the test, the overall average resistance for the calibration circuits for 100 cycles was calculated and the variation from this average was determined for each cycle. These cycle by cycle measurement system drift variations in the calibration coupon were then subtracted from the RAW measurements of each of the single hole data point from the 100 cycles. The measurement system drift for the calibration circuit with the resistance closest to the raw data for the test hole was used for correction. The corrected measurements were then used to calculate Gage R&R.

在125℃高温下稳定测试样品30分钟后，用1.1A的电流穿过测试系统测量每次循环的电阻值。在试验的最后，计算出100次循环后校正电路的平均电阻值，测量每次循环的变化值。然后从每个单孔数据点的原始测量值中减去校准板的系统漂移变化值，选择最接近测试孔原始数据的校正电路的系统漂移电阻值去做修正。修正后的测量值用于计算GRR。

Cg/Cgk:

Test and calibration coupons were placed into a Weiss RTC chamber and wired to the measurement system in 4-wire configuration as we would wire up RTC test samples. 50 resistance measurements were made in rapid sucession for each test circuit at room temperatureby using current of 1.1A through the measurement system. At the end of the test, the overall average resistance for the test circuits was calculated and reported along with the Cg/Cgk values.

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ANALYSIS RESULTS

分析结果

GAGE R&R: The samples were tested by the methods given above and Gage R&R was calculated for each of the 18 Single Holes tested utilizing the measurement system drift corrected values.The percentage of Gauge Repeatability and Reproducibility on the measurement system drift corrected test values ranged between 1.36% and2.82%. We observed a trend of increasing resistance over the 100 cycles that may have contributed to a real change in the measured gage that would negatively affect the Gage R&R percentages reported. The gage R&R of the uncorrected calibration circuit was 4.35% and 4.8% showing actual measurement system drift (after correction 0%). After evaluation of the test data and results contained herein, we believe that the corrected results calculated are acceptable for single hole RTC measurements in the range we are measuring and our standard procedure for measureing single hole RTC samples will include a calibration circuit to correct for measurement system drift.See attached test data for actual test results.

按照上述方法对样品进行测试，利用测量系统漂移修正值分别计算出了 18 个孔的 GRR 值。系统漂移修正值的 GRR 百分比范围在 1.36% 和 2.82%之间。我们观察到随着循环时间的延长电阻值有上升的趋势，也许会导致测量仪器发生变化并且会消极影响到 GRR 百分比。未修正的校准电路的 GRR 百分比在 4.35% 和 4.8%之间显示了真实的系统漂移值。在对试验数据和结果进行评估后，我们认为在我们的测量范围内，我们计算出的修正值范围是符合单孔 RTC 测量要求的，并且在我们的单孔 RTC 标准测量流程中，将包含一个校正电路用于修正系统漂移。

Cg/Cgk: The samples were tested by the methods given above and Cg/Cgk was calculated for each of the 7 resistance specimens. After evaluation of the test data and results contained herein, we believe that the Cg/Cgk of all tested circuits was >1.33 d are acceptable for single hole RTC measurements in the range we are measuring.

按照上述方法对样品进行测试，并分别计算出 7 个电阻值样品的 Cg/Cgk 值。在对试验数据和结果进行评估后，我们认为所有的测试电路的 Cg/Cgk 值均大于 1.33d，在我们的测试范围内，我们的测量结果是符合 RTC 单孔测量要求的。

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