**Week 4 – Measuring Accuracy and Errors**

*Worked Example Solutions using the same table structures as in the PDF*

## Reading results – two separate resistors

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| reading 1.1 | symb | R1 [unit] | symb | R2 [unit] |
| label value: | R1L | 1000 Ω | R2L | 100 Ω |
| measuring range: | R1R | 6 kΩ | R2R | 600 Ω |
| measured: | R1M | 997.3 Ω | R2M | 99.6 Ω |
| absolute measuring error: (incl. formula and calculation) | ΔR1M | 9.98 Ω = 0.7%·R1M + 3·1Ω | ΔR2M | 1.50 Ω = 1.0%·R2M + 5·0.1Ω |
| relative meas. error: (incl. formula and calculation) | εR1M | 1.00 % | εR2M | 1.50 % |
|  |  |  |  |  |

## Calculations – two separate resistors added up

|  |  |  |
| --- | --- | --- |
| reading 1.1 | symb | RvB [unit] |
| calculated: | RsC | R1M + R2M = 997.3 Ω + 99.6 Ω = 1096.9 Ω |
| absolute error: | ΔRsC | ΔR1M + ΔR2M = 9.98 Ω + 1.50 Ω = 11.48 Ω |
| relative error: | εRsC | ΔRvB / RvB × 100 % = 11.48 / 1096.9 × 100% = 1.05 % |

## Control reading Rs (= series connection of R1 and R2)

|  |  |  |
| --- | --- | --- |
| reading 1.1 | symb | RvM [unit] |
| based on label values: | RsL | R1L + R2L = 1000 Ω + 100 Ω = 1100 Ω |
| measuring range: (DMM range) | RsR | 6 kΩ |
| measured: | RsM | 1096.5 Ω |
| measuring error abs.: (formula + completion % + calculation) | ΔRsM | 0.7% rdg + 3 d = 0.7%·1096.5Ω + 3·1Ω = 10.68 Ω |
| measuring error rel.: (formula + calculation) | εRsM | ΔRvB / RvB × 100 % = 10.68 / 1096.5 × 100% = 0.97 % |

## Summary – error bands

|  |  |  |
| --- | --- | --- |
| reading 1 | symb | value ranges (error bands) |
| 1.1 calculated | RsC | from 1085.4 Ω to 1108.4 Ω |
| 1.2 measured | RsM | from 1085.8 Ω to 1107.2 Ω |

## Assessment

|  |  |
| --- | --- |
| Overlapping (percentage of smallest error band) | 100.0 % |
| Conclusion / Recommendations | Bands overlap – readings consistent. If not, re-check ranges, leads, setup, and specs. |

## 4.3.2 Reading 2 – Using a voltage and a current meter

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| reading 2 | symb | V [unit] | symb | I [unit] |
| label values: | UL | 11 V | IL | 10 mA |
| measuring range: (DMM range) | Ur | 20 V | IR | 60 mA |
| measured: | UM | 10.965 V | IM | 10.00 mA |
| absolute measuring error: (incl. formula and calculation) | ΔUM | 0.0075 V = 0.05%·UM + 2·0.001V | ΔIM | 0.040 mA = 0.10%·IM + 3·0.01mA |
| relative measuring error: (incl. formula and calculation) | εUM | 0.068 % | εIM | 0.400 % |
|  |  |  |  |  |
|  |  |  |  |  |

## Calculations – R measurement through voltage and current

|  |  |  |
| --- | --- | --- |
| reading 2 | symb | RB [unit] |
| calculated: | RC | UM / IM = 10.965 V / 10.00 mA = 1096.50 Ω |
| absolute error: | ΔRC | 5.13 Ω |
| relative error: | εRC | 0.468 % |

## 4.4 Compare and final conclusion

|  |  |  |
| --- | --- | --- |
| Reading 1 or 2 | symb | value ranges (error bands) |
| 1 measured R | RsM | from 1085.82 Ω to 1107.18 Ω |
| 2 calculated R | RC | from 1091.37 Ω to 1101.63 Ω |

|  |  |
| --- | --- |
| Overlapping (percentage of smallest error band) | 100.0 % |
| Conclusion / Recommendations | Agreement within uncertainties (U/I vs series). If not, review wiring, burden voltage of ammeter, and ranges. |