

Sheet1

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Rover Coolant Temperature Sensor  
 Resistance VS Temperature Test  
 Elmwood Sensor ES120-4

Measured Data

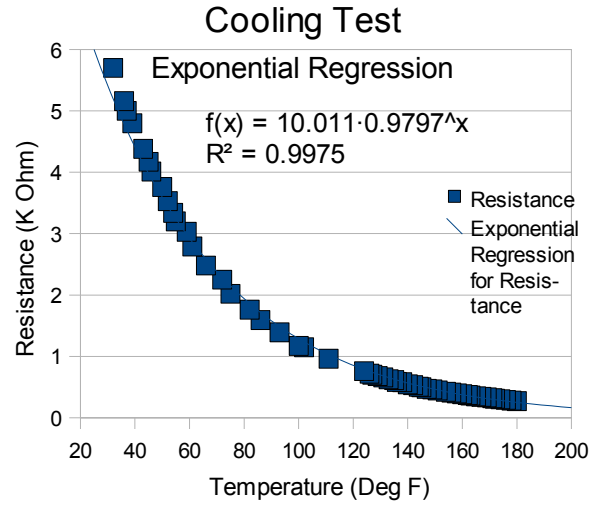
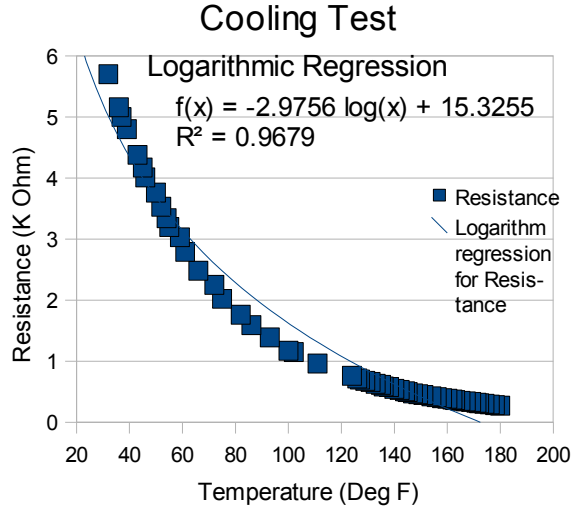
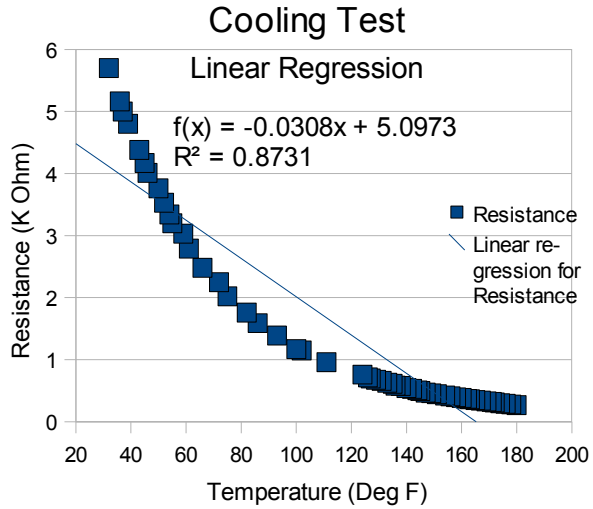
|              | K ohm<br>Resistance | deg F<br>Temperature |
|--------------|---------------------|----------------------|
| Heating Test | 5.72                | 32                   |
|              | 5.62                | 34                   |
|              | 5.45                | 36                   |
|              | 3.85                | 48                   |
|              | 2.88                | 61                   |
|              | 2.34                | 68                   |
|              | 1.98                | 77                   |
|              | 1.63                | 86                   |
|              | 1.45                | 91                   |
|              | 1.32                | 95                   |
|              | 1.03                | 108                  |
|              | 0.96                | 111                  |
|              | 0.92                | 113                  |
|              | 0.89                | 115                  |
|              | 0.74                | 124                  |
|              | 0.67                | 129                  |

Measured Data

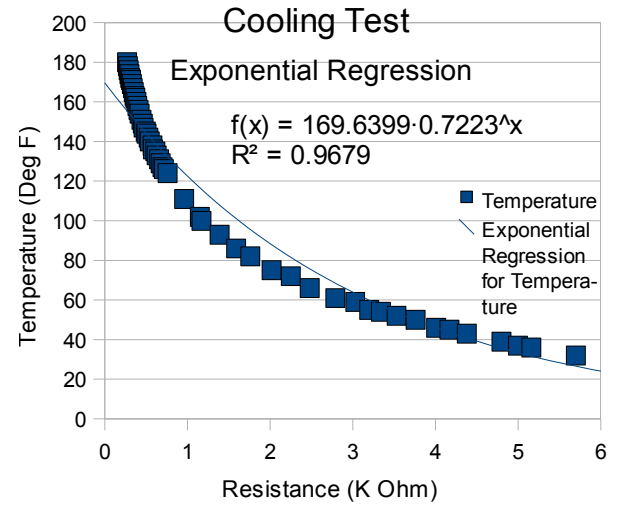
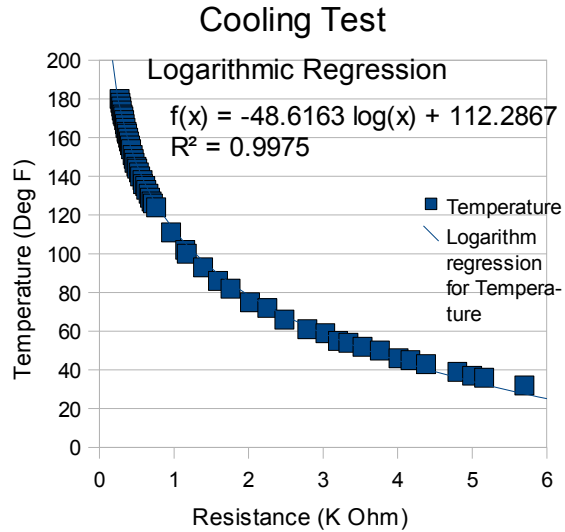
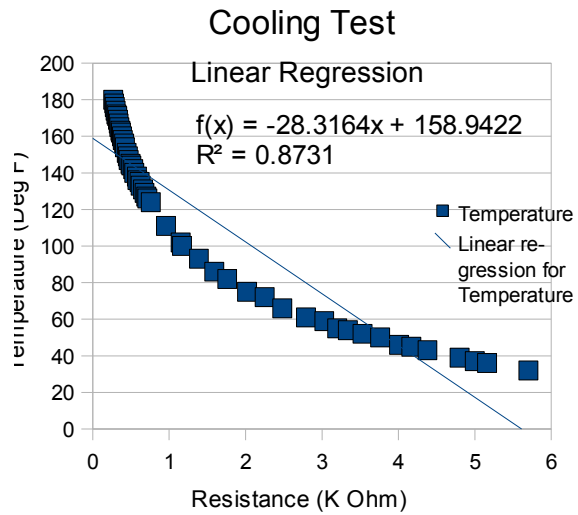
|              | K ohm<br>Resistance | deg F<br>Temperature |     |       |
|--------------|---------------------|----------------------|-----|-------|
| Cooling Test | 0.27                | 180                  | 129 | 0.678 |
|              | 0.28                | 178                  | 127 | 0.7   |
|              | 0.29                | 176                  | 126 | 0.716 |
|              | 0.3                 | 174                  | 124 | 0.76  |
|              | 0.31                | 172                  | 111 | 0.96  |
|              | 0.32                | 171                  | 102 | 1.15  |
|              | 0.33                | 169                  | 100 | 1.17  |
|              | 0.34                | 167                  | 93  | 1.39  |
|              | 0.35                | 165                  | 86  | 1.59  |
|              | 0.362               | 163                  | 82  | 1.76  |
|              | 0.37                | 162                  | 75  | 2.02  |
|              | 0.384               | 160                  | 72  | 2.25  |
|              | 0.395               | 158                  | 66  | 2.48  |
|              | 0.41                | 156                  | 61  | 2.79  |
|              | 0.423               | 154                  | 59  | 3.03  |
|              | 0.445               | 151                  | 55  | 3.2   |
|              | 0.46                | 149                  | 54  | 3.34  |
|              | 0.47                | 147                  | 52  | 3.53  |
|              | 0.495               | 145                  | 50  | 3.76  |
|              | 0.507               | 144                  | 46  | 4.01  |
|              | 0.53                | 142                  | 45  | 4.17  |
|              | 0.545               | 140                  | 43  | 4.38  |
|              | 0.578               | 138                  | 39  | 4.8   |
|              | 0.584               | 136                  | 37  | 5     |
|              | 0.613               | 135                  | 36  | 5.16  |
|              | 0.628               | 133                  | 32  | 5.7   |
|              | 0.658               | 131                  |     |       |

Temperature Resistance

|     |       |
|-----|-------|
| 180 | 0.27  |
| 178 | 0.28  |
| 176 | 0.29  |
| 174 | 0.3   |
| 172 | 0.31  |
| 171 | 0.32  |
| 169 | 0.33  |
| 167 | 0.34  |
| 165 | 0.35  |
| 163 | 0.362 |
| 162 | 0.37  |
| 160 | 0.384 |
| 158 | 0.395 |
| 156 | 0.41  |
| 154 | 0.423 |
| 151 | 0.445 |
| 149 | 0.46  |
| 147 | 0.47  |
| 145 | 0.495 |
| 144 | 0.507 |
| 142 | 0.53  |
| 140 | 0.545 |
| 138 | 0.578 |
| 136 | 0.584 |
| 135 | 0.613 |
| 133 | 0.628 |
| 131 | 0.658 |
| 129 | 0.678 |
| 127 | 0.7   |
| 126 | 0.716 |
| 124 | 0.76  |
| 111 | 0.96  |
| 102 | 1.15  |
| 100 | 1.17  |
| 93  | 1.39  |
| 86  | 1.59  |



The charts below have had inverted tables to get temperature as a function of resistance



Sheet1

Calculated Resistance in K Ohm

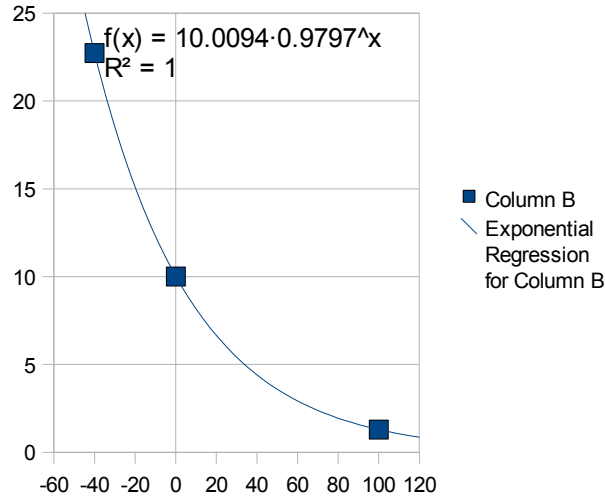
| Temperature | Linear  | Logarithmic | Exponential |
|-------------|---------|-------------|-------------|
| -70         | 7.2533  | Err:502     | 42.0688     |
| -60         | 6.9453  | Err:502     | 34.2682     |
| -50         | 6.6373  | Err:502     | 27.914      |
| -40         | 6.3293  | Err:502     | 22.738      |
| -30         | 6.0213  | Err:502     | 18.5218     |
| -20         | 5.7133  | Err:502     | 15.0874     |
| -10         | 5.4053  | Err:502     | 12.2898     |
| 0           | 5.0973  | Err:502     | 10.011      |
| 10          | 4.7893  | 8.4739      | 8.1547      |
| 20          | 4.4813  | 6.4114      | 6.6426      |
| 30          | 4.1733  | 5.2049      | 5.4109      |
| 40          | 3.8653  | 4.3489      | 4.4076      |
| 50          | 3.5573  | 3.6849      | 3.5903      |
| 60          | 3.2493  | 3.1424      | 2.9246      |
| 70          | 2.9413  | 2.6837      | 2.3823      |
| 80          | 2.6333  | 2.2863      | 1.9406      |
| 81          | 2.6025  | 2.2494      | 1.9012      |
| 90          | 2.3253  | 1.9359      | 1.5807      |
| 100         | 2.0173  | 1.6224      | 1.2876      |
| 110         | 1.7093  | 1.3388      | 1.0489      |
| 120         | 1.4013  | 1.0798      | 0.8544      |
| 130         | 1.0933  | 0.8417      | 0.696       |
| 140         | 0.7853  | 0.6211      | 0.5669      |
| 150         | 0.4773  | 0.4159      | 0.4618      |
| 160         | 0.1693  | 0.2238      | 0.3762      |
| 170         | -0.1387 | 0.0434      | 0.3064      |
| 180         | -0.4467 | -0.1267     | 0.2496      |
| 190         | -0.7547 | -0.2875     | 0.2033      |
| 200         | -1.0627 | -0.4402     | 0.1656      |
| 210         | -1.3707 | -0.5854     | 0.1349      |
| 220         | -1.6787 | -0.7238     | 0.1099      |
| 230         | -1.9867 | -0.856      | 0.0895      |
| 240         | -2.2947 | -0.9827     | 0.0729      |
| 250         | -2.6027 | -1.1042     | 0.0594      |

Note: Both the Linear and Logarithmic analysis produces bad data at high and low temperatures

1.90 K Ohm

\*\*This is the resistance that you want to use for resistors R4 and R7 on the board instead of the supplied 2.49Kohm. Doing this will save you from having to remember to update megatune

MegaTune's coolant sensor analysis assuming they used exponential equation to generate the data



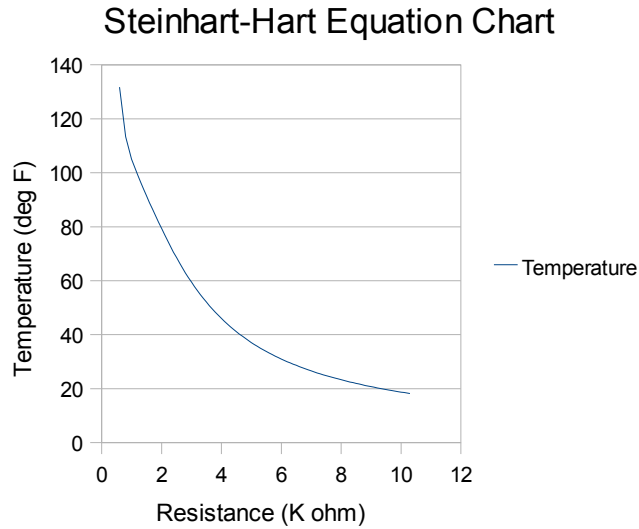
Three Point Input

| Resistance | Temperature |
|------------|-------------|
| 22.73      | -40         |
| 10.011     | 0           |
| 1.2876     | 100         |

| temperature | Resistance |
|-------------|------------|
| -40         | 22.7344    |
| -30         | 18.5189    |
| -20         | 15.085     |
| -10         | 12.2879    |
| 0           | 10.0094    |
| 10          | 8.1534     |
| 20          | 6.6416     |
| 30          | 5.4101     |
| 40          | 4.4069     |
| 50          | 3.5897     |
| 60          | 2.9241     |
| 70          | 2.3819     |
| 80          | 1.9402     |
| 90          | 1.5805     |
| 100         | 1.2874     |
| 110         | 1.0487     |
| 120         | 0.8542     |
| 130         | 0.6958     |
| 140         | 0.5668     |
| 150         | 0.4617     |
| 160         | 0.3761     |
| 170         | 0.3064     |
| 180         | 0.2496     |
| 190         | 0.2033     |
| 200         | 0.1656     |
| 210         | 0.1349     |
| 220         | 0.1099     |
| 230         | 0.0895     |
| 240         | 0.0729     |
| 250         | 0.0594     |

\*\*\* this is the resistance that would be stated if you used only 3 points of data to build this graph.

Megatune's SteinHart-Hart temperature Calculator



| Steinhart-Hart Equation Calc |         | Resistance |         | Temperature |       |
|------------------------------|---------|------------|---------|-------------|-------|
| K ohm                        | Deg F   | Resistance | Deg F   | Resistance  | Deg F |
| 3.8                          | 48.31   | 7.4        | 25.1669 |             |       |
| 3.9                          | 47.158  | 7.5        | 24.8351 |             |       |
| 4                            | 46.0529 | 7.6        | 24.5122 |             |       |
| 4.1                          | 44.9924 | 7.7        | 24.1979 |             |       |
| 4.2                          | 43.9744 | 7.8        | 23.892  |             |       |
| 4.3                          | 42.9969 | 7.9        | 23.594  |             |       |
| 4.4                          | 42.0579 | 8          | 23.3038 |             |       |
| 4.5                          | 41.1556 | 8.1        | 23.021  |             |       |
| 4.6                          | 40.2881 | 8.2        | 22.7454 |             |       |
| 4.7                          | 39.4538 | 8.3        | 22.4766 |             |       |
| 4.8                          | 38.6511 | 8.4        | 22.2145 |             |       |
| 4.9                          | 37.8785 | 8.5        | 21.9588 |             |       |
| 5                            | 37.1344 | 8.6        | 21.7093 |             |       |
| 5.1                          | 36.4176 | 8.7        | 21.4658 |             |       |
| 5.2                          | 35.7267 | 8.8        | 21.2281 |             |       |
| 5.3                          | 35.0605 | 8.9        | 20.9959 |             |       |
| 5.4                          | 34.4178 | 9          | 20.7691 |             |       |
| 5.5                          | 33.7976 | 9.1        | 20.5476 |             |       |
| 5.6                          | 33.1987 | 9.2        | 20.331  |             |       |
| 5.7                          | 32.6202 | 9.3        | 20.1194 |             |       |
| 5.8                          | 32.0612 | 9.4        | 19.9124 |             |       |
| 5.9                          | 31.5208 | 9.5        | 19.71   |             |       |
| 6                            | 30.9981 | 9.6        | 19.512  |             |       |
| 6.1                          | 30.4924 | 9.7        | 19.3183 |             |       |
| 6.2                          | 30.0028 | 9.8        | 19.1287 |             |       |
| 6.3                          | 29.5288 | 9.9        | 18.9432 |             |       |
| 6.4                          | 29.0696 | 10         | 18.7615 |             |       |
| 6.5                          | 28.6245 | 10.1       | 18.5837 |             |       |
| 6.6                          | 28.193  | 10.2       | 18.4094 |             |       |
| 6.7                          | 27.7746 | 10.3       | 18.2387 |             |       |
| 6.8                          | 27.3686 |            |         |             |       |
| 6.9                          | 26.9745 |            |         |             |       |
| 7                            | 26.5919 |            |         |             |       |
| 7.1                          | 26.2202 |            |         |             |       |
| 7.2                          | 25.8591 |            |         |             |       |
| 7.3                          | 25.5082 |            |         |             |       |

| Steinhart-Hart Equation Calc |          | Resistance |         | Temperature |         |
|------------------------------|----------|------------|---------|-------------|---------|
| K ohm                        | Deg F    | Resistance | Deg F   | Resistance  | Deg F   |
| 0.6                          | 131.7492 | 4.1        | 44.9924 | 7.7         | 24.1979 |
| 0.8                          | 113.3916 | 4.2        | 43.9744 | 7.8         | 23.892  |
| 1                            | 105.0504 | 4.3        | 42.9969 | 7.9         | 23.594  |
| 1.2                          | 99.1841  | 4.4        | 42.0579 | 8           | 23.3038 |
| 1.3                          | 96.5469  | 4.5        | 41.1556 | 8.1         | 23.021  |
| 1.3                          | 96.5469  | 4.6        | 40.2881 | 8.2         | 22.7454 |
| 1.4                          | 93.9883  | 4.7        | 39.4538 | 8.3         | 22.4766 |
| 1.5                          | 91.4738  | 4.8        | 38.6511 | 8.4         | 22.2145 |
| 1.6                          | 88.9897  | 4.9        | 37.8785 | 8.5         | 21.9588 |
| 1.7                          | 86.5339  | 5          | 37.1344 | 8.6         | 21.7093 |
| 1.8                          | 84.1103  | 5.1        | 36.4176 | 8.7         | 21.4658 |
| 1.9                          | 81.7251  | 5.2        | 35.7267 | 8.8         | 21.2281 |
| 2                            | 79.3857  | 5.3        | 35.0605 | 8.9         | 20.9959 |
| 2.1                          | 77.0987  | 5.4        | 34.4178 | 9           | 20.7691 |
| 2.2                          | 74.8702  | 5.5        | 33.7976 | 9.1         | 20.5476 |
| 2.3                          | 72.7048  | 5.6        | 33.1987 | 9.2         | 20.331  |
| 2.4                          | 70.6063  | 5.7        | 32.6202 | 9.3         | 20.1194 |
| 2.5                          | 68.5769  | 5.8        | 32.0612 | 9.4         | 19.9124 |
| 2.6                          | 66.6182  | 5.9        | 31.5208 | 9.5         | 19.71   |
| 2.7                          | 64.7306  | 6          | 30.9981 | 9.6         | 19.512  |
| 2.8                          | 62.914   | 6.1        | 30.4924 | 9.7         | 19.3183 |
| 2.9                          | 61.1676  | 6.2        | 30.0028 | 9.8         | 19.1287 |
| 3                            | 59.4901  | 6.3        | 29.5288 | 9.9         | 18.9432 |
| 3.1                          | 57.8798  | 6.4        | 29.0696 | 10          | 18.7615 |
| 3.2                          | 56.3348  | 6.5        | 28.6245 | 10.1        | 18.5837 |
| 3.3                          | 54.8529  | 6.6        | 28.193  | 10.2        | 18.4094 |
| 3.4                          | 53.432   | 6.7        | 27.7746 | 10.3        | 18.2387 |
| 3.5                          | 52.0696  | 6.8        | 27.3686 |             |         |
| 3.6                          | 50.7634  | 6.9        | 26.9745 |             |         |
| 3.7                          | 49.511   | 7          | 26.5919 |             |         |

| Three Point Inpt |            | Deg F       |            |
|------------------|------------|-------------|------------|
| Temperature      | Resistance | Temperature | Resistance |
| T1               | 36         |             |            |
| T2               | 59         |             |            |
| T3               | 100        |             |            |

| Coefficients |        |
|--------------|--------|
| Label        | Value  |
| c11          | 1.6409 |
| c12          | 4.4185 |
| c13          | 0.0278 |
| c21          | 1.1086 |
| c22          | 1.3623 |
| c23          | 0.0169 |
| c31          | 0.157  |
| c32          | 0.0039 |
| c33          | 0.01   |

Sheet1

SteinHart-Hart temperature Calculator VS Measured Resistances

Steinhart-Hart Equation Calc

|     |                 | K ohm      | Deg F    | Deg F       | Deg F       | Deg F      |
|-----|-----------------|------------|----------|-------------|-------------|------------|
|     | Resistance      | Resistance | Measured | Logarithmic | Exponential | Steinhart  |
| N   |                 | 0.27       | 180      | 175.9416    | 155.3752    | -849.1946  |
| 1   | 5.16            | 0.28       | 178      | 174.1736    | 154.8706    | -1926.3645 |
| 2   | 3.03            | 0.29       | 176      | 172.4676    | 154.3676    | 11455.306  |
| 3   | 1.17            | 0.3        | 174      | 170.8194    | 153.8662    | 1545.8825  |
|     |                 | 0.31       | 172      | 169.2253    | 153.3665    | 858.9365   |
| c11 | 1.6409          | 0.32       | 171      | 167.6818    | 152.8684    | 608.4997   |
| c12 | 4.4185          | 0.33       | 169      | 166.1858    | 152.3719    | 478.9473   |
| c13 | 0.0278          | 0.34       | 167      | 164.7344    | 151.877     | 399.8455   |
| c21 | 1.1086          | 0.35       | 165      | 163.3252    | 151.3837    | 346.5778   |
| c22 | 1.3623          | 0.362      | 163      | 161.6863    | 150.7939    | 301.906    |
| c23 | 0.0169          | 0.37       | 162      | 160.6236    | 150.402     | 279.4949   |
| c31 | 0.157           | 0.384      | 160      | 158.818     | 149.7185    | 249.4082   |
| c32 | 0.0039          | 0.395      | 158      | 157.4449    | 149.1837    | 231.3939   |
| c33 | 0.01            | 0.41       | 156      | 155.6329    | 148.4575    | 212.1765   |
|     |                 | 0.423      | 154      | 154.1153    | 147.831     | 199.0623   |
|     | Deg F           | 0.445      | 151      | 151.6504    | 146.7768    | 181.9597   |
|     | Three Point Inp | 0.46       | 149      | 150.0387    | 146.0623    | 172.8937   |
|     | Temperature     | 0.47       | 147      | 148.9931    | 145.5879    | 167.7142   |
| T1  | 36              | 0.495      | 145      | 146.4736    | 144.4087    | 157.0526   |
| T2  | 59              | 0.507      | 144      | 145.309     | 143.846     | 152.8433   |
| T3  | 100             | 0.53       | 142      | 143.1521    | 142.7737    | 146.0076   |
|     |                 | 0.545      | 140      | 141.7953    | 142.0787    | 142.2489   |
| C   | 0.003           | 0.578      | 138      | 138.9373    | 140.5616    | 135.436    |
| B   | 0.003           | 0.584      | 136      | 138.4352    | 140.2875    | 134.372    |
| A   | 0.0095          | 0.613      | 135      | 136.079     | 138.9703    | 129.8222   |
|     |                 | 0.628      | 133      | 134.9037    | 138.2938    | 127.7951   |
|     |                 | 0.658      | 131      | 132.6351    | 136.9507    | 124.2677   |
|     |                 | 0.678      | 129      | 131.1794    | 136.0625    | 122.2368   |
|     |                 | 0.7        | 127      | 129.6269    | 135.0922    | 120.2431   |
|     |                 | 0.716      | 126      | 128.5282    | 134.3909    | 118.9279   |
|     |                 | 0.76       | 124      | 125.6288    | 132.4809    | 115.7829   |
|     |                 | 0.96       | 111      | 114.2713    | 124.1358    | 106.4161   |
|     |                 | 1.15       | 102      | 105.492     | 116.6953    | 100.5526   |

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|      |     |          |          |         |
|------|-----|----------|----------|---------|
| 1.17 | 100 | 104.6538 | 115.9385 | 100     |
| 1.39 | 93  | 96.2772  | 107.9308 | 94.2418 |
| 1.59 | 86  | 89.7417  | 101.1321 | 89.2369 |
| 1.76 | 82  | 84.8032  | 95.691   | 85.0755 |
| 2.02 | 75  | 78.1047  | 87.9301  | 78.9239 |
| 2.25 | 72  | 72.8623  | 81.5911  | 73.7794 |
| 2.48 | 66  | 68.1305  | 75.709   | 68.9771 |
| 2.79 | 61  | 62.4044  | 68.4463  | 63.0925 |
| 3.03 | 59  | 58.3925  | 63.3056  | 59      |
| 3.2  | 55  | 55.7386  | 59.8997  | 56.3348 |
| 3.34 | 54  | 53.6569  | 57.2328  | 54.2774 |
| 3.53 | 52  | 50.9671  | 53.8023  | 51.672  |
| 3.76 | 50  | 47.8984  | 49.9236  | 48.7844 |
| 4.01 | 46  | 44.7688  | 46.0241  | 45.9449 |
| 4.17 | 45  | 42.8667  | 43.6898  | 44.2755 |
| 4.38 | 43  | 40.4781  | 40.8048  | 42.2427 |
| 4.8  | 39  | 36.0264  | 35.5937  | 38.6511 |
| 5    | 37  | 34.0418  | 33.3516  | 37.1344 |
| 5.16 | 36  | 32.5104  | 31.66    | 36      |
| 5.7  | 32  | 27.6717  | 26.5594  | 32.6202 |

|        |    |         |         |
|--------|----|---------|---------|
| 1.8461 | 81 | 82.4812 | 83.0055 |
| 1.903  | 82 | 81.0054 | 81.6542 |
| 1.9308 | 83 | 80.3004 | 80.9994 |

Note: 1.85Kohm for measured  
 1.90 Kohm for exponential  
 1.93Kohm for Steinhart

