

User Manual

LSUM 086R4C 0093F EA

History

| Version | Date | Change Description | Author |
|---------|-----------------|--|--------|
| V00 | 29 . Aug . 2016 | First version | SW Son |
| V01 | 07 . Aug . 2018 | Temp. monitoring (NTC Thermistor->PT100) | SW Son |
| V02 | 26 . Nov . 2021 | New format | SH Kim |
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1. Overview

The LS 86.4V / 93F Ultracapacitor Module has high energy and low ESR to meet energy storage and power delivery requirements.

The cells used in the module have 2.7 V maximum voltage rating and are connected in series to get higher operating voltage of modules. To meet the long cycle life requirements, the cells operate under 2.7V. In addition, all the cells are balanced by balancing circuit connected parallel to each cell.

2. Identification of features



<Fig. 1> Product Image

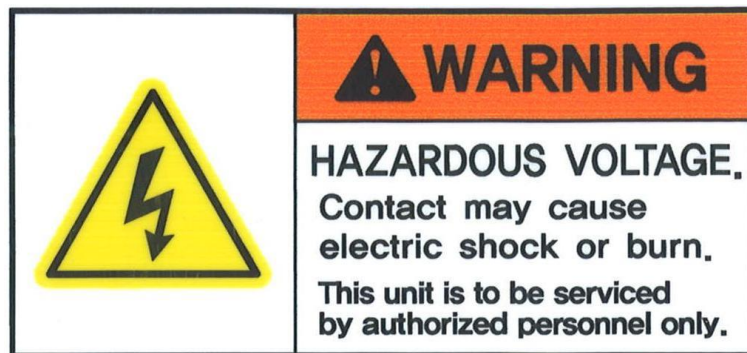
3. Unpacking

Inspect the shipping carton for signs of damage prior to unpacking the module. Damage to the shipping carton or module should be reported to the carrier immediately.

Remove the module from the shipping carton and retain the shipping materials until the unit has been inspected and is determined to be operational.

NOTE: The original shipping materials are approved for both air and ground shipment. The module should be removed from the shipping carton by lifting the body of the module.

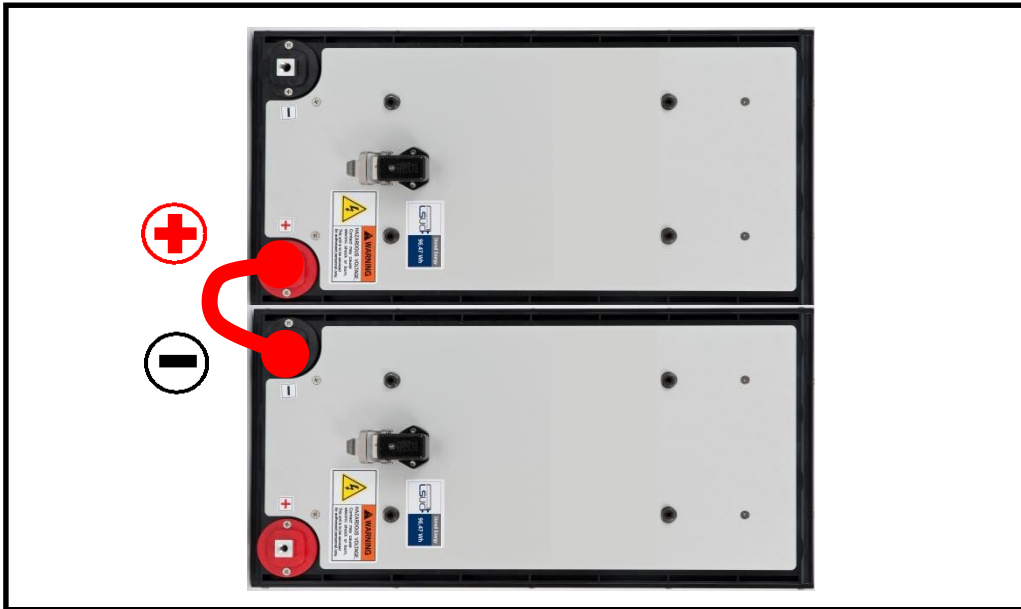
4. Safety



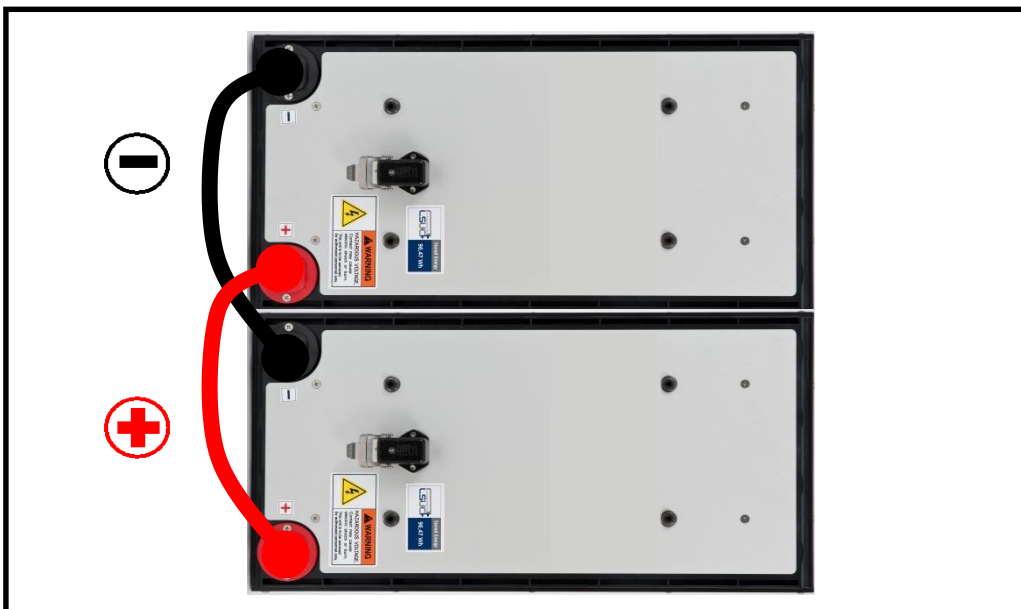
- Do not operate above specified voltage.
- Do not operate above specified temperature rating.
- Do not touch terminals with conductors while charged. Serious burns, shock, or material fusing may occur.
- Protect surrounding electrical components from incidental contact.
- Provide sufficient electrical isolation when working above rated voltage.
- Prior to installation and removal from the equipment, it is mandatory to fully discharge the module.

5. Module to module connection

- There are series and parallel connection for High power



<Fig. 2> Series Connection of Modules



<Fig. 3> Parallel Connection of Modules.

6. Output terminal connection

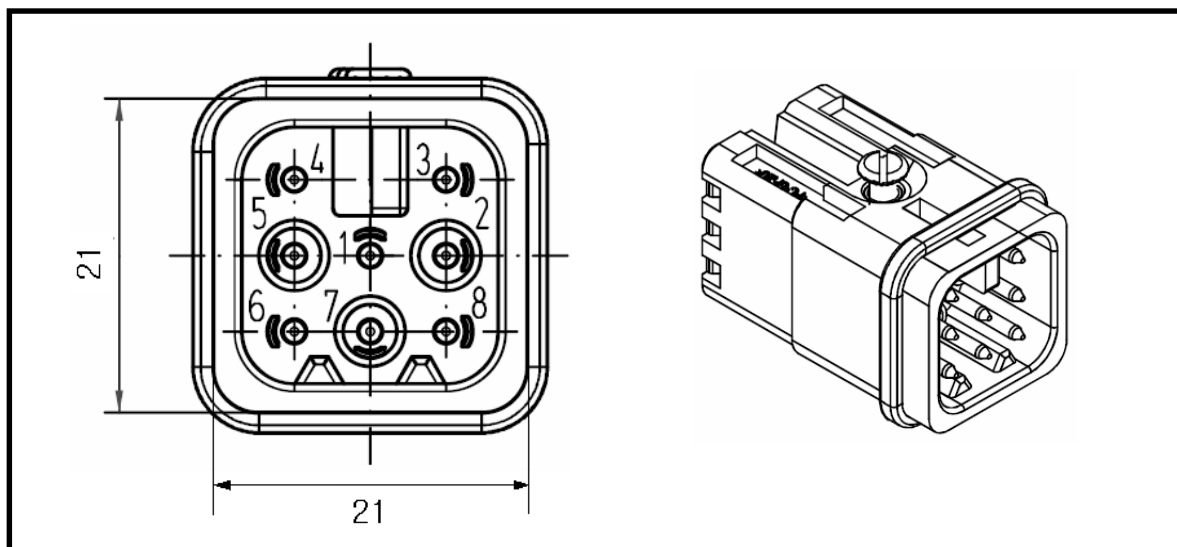
The LS 86.4V / 93F Ultracapacitor Modules are designed to connect directly to a ring or a bus bar. The positive and negative terminals have each hole for the screw. The positive terminal threaded size is M8 and negative terminal is M10. Wave washers are required to ensure long term, reliable connections.

When tightening the terminal bolt, a torque of 20 N-m for the M8 bolt should be used.(30N-m for the M10 bolt) Because the modules have a very low ESR, total ESR will be affected by a ring lug, bus bar or torque. Therefore, it needs more attention to assemble the modules. And appropriate protection and sealing should be used on both module terminals to avoid shock hazards and corrosion.

7. Output connector

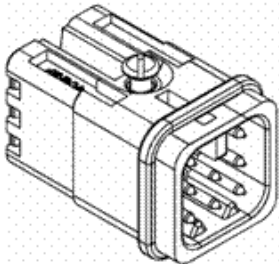
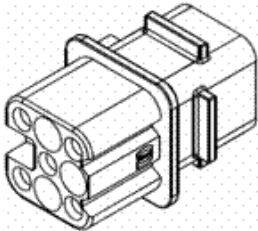
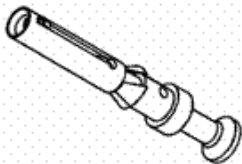
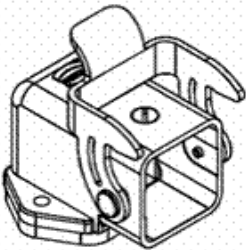
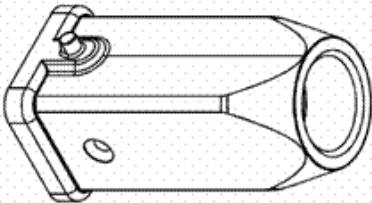
- The output of connector is tabulated below.

| Pin # | Pin out | Pin # | Pin out |
|-------|------------|-------|----------|
| 1 | Not used | 5 | Not used |
| 2 | Not used | 6 | Not used |
| 3 | PT100 pin1 | 7 | Not used |
| 4 | PT100 pin2 | 8 | Not used |



<Fig. 4> Monitoring connector

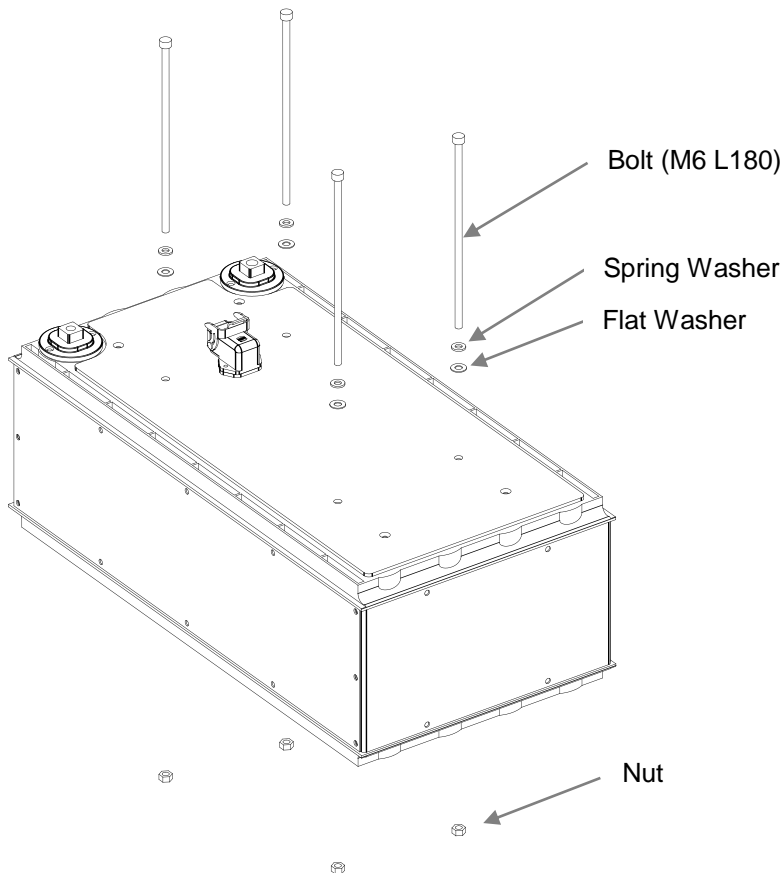
- Pin 3-4 is connected with a PT100 sensor for temperature monitoring. According to temperature variation in the module, the resistance of the thermistor is determined.
- The mating monitoring connector is not supplied by LS. For recommendation, please refer to following table below, and the web page.. www.harting.de. (Connector manufacturer)

| | LS Module | Customer System |
|---------|---|--|
| Insert |  |  |
| | 09 36 008 2632 | 09 36 008 3101 |
| Pin | |  |
| | | 09 15 000 622x |
| Housing |  |  |
| | 09 37 003 0801 | 09 37 003 1440 |

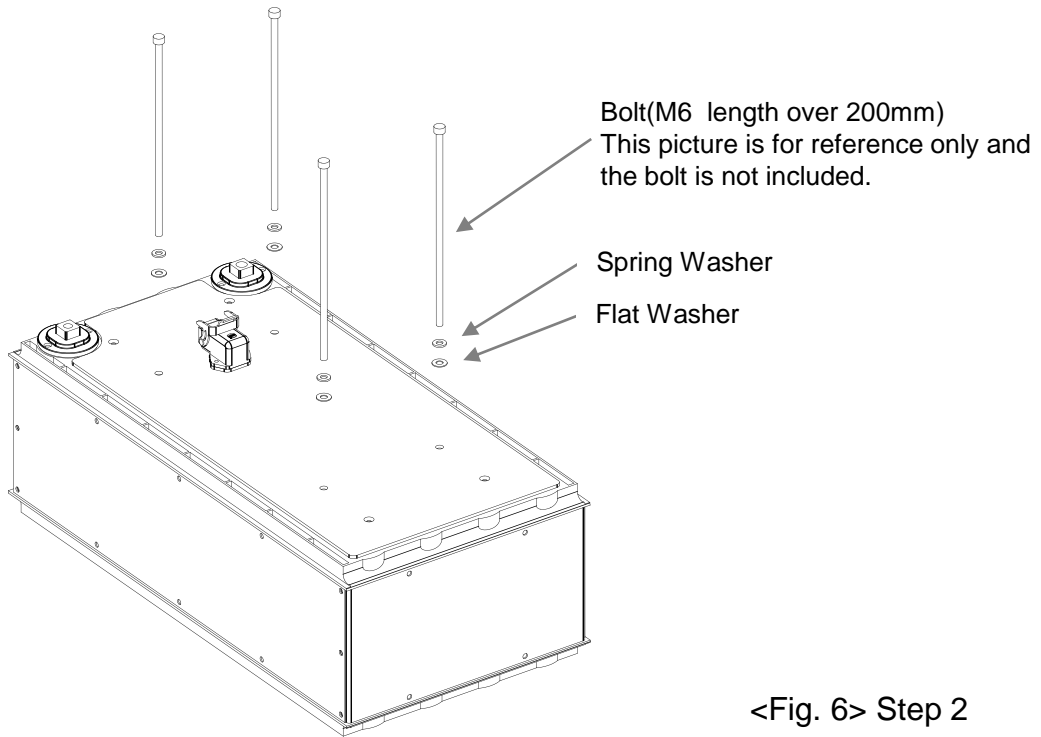
8. Mounting

The modules should not be mounted in locations where they are directly exposed to the environment.

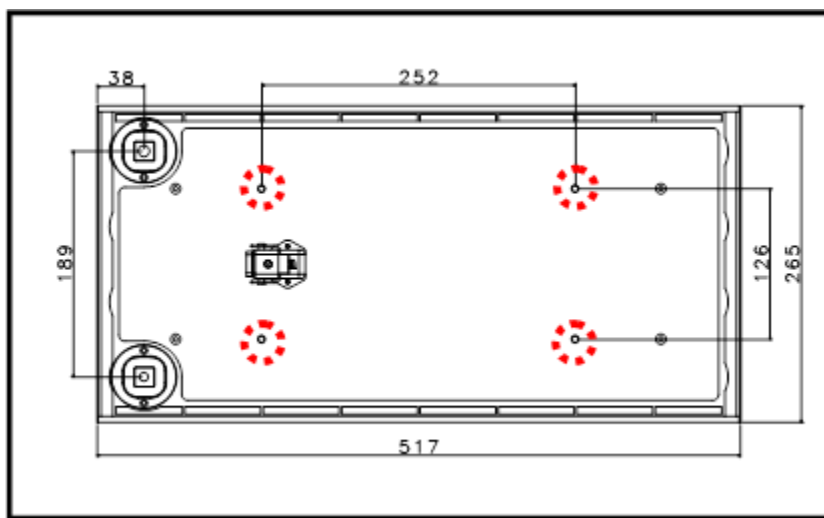
- (1) Fixing the module with mechanical pressure.
 - Impose mechanical pressure on the top, bottom and each side into designated space to fix the module.
- (2) Connecting with thread bolts
 - Step 1 : Unscrew four bolts (M6) on the top cover of the module.
(remove four nuts on the bottom)
 - Step 2 : Insert 4 thread bolts (over 200mm) into the 4 holes on the top cover with spring washers and flat washers, then make connection



<Fig. 5> Step 1



<Fig. 6> Step 2



<Fig. 7> Mounting Positions

9. Maintenance

Power Rating

If the applied voltage is over rated voltage, charging the module should be stopped. And the allowable low voltage level of the module depends on the user's requirements, but full discharging to 0V does not affect the module performance.

Temperature

The module has its optimal operating temperature range of -40 to 65. Over 70°C, charging and discharging should be stopped to preserve its performance and life cycle.

Do not expose to direct sunlight

For installation do not make the module expose to direct sunlight due to temperature increase inside the module.

Maintenance

The module has its projected life over 10years at rated voltage and +25°C. However the life cycle of the module may be decreased in high temperature condition or over voltage charging.

If following abnormal module performances are detected, operation should be stopped and checking the electrical & mechanical connections is recommended.

- Detection of high temperature in normal operating conditions
- Internal resistance increase or initial voltage drop increase
- Deformation of the module case

Appendix I

Reference values to EN 60 751 (ITS 90) in Ohm for Pt100 temperature sensors in 1°C steps

| °C | -0 | -1 | -2 | -3 | -4 | -5 | -6 | -7 | -8 | -9 |
|------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| -200 | 18.520 | - | - | - | - | - | - | - | - | - |
| -190 | 22.825 | 22.397 | 21.967 | 21.538 | 21.108 | 20.677 | 20.247 | 19.815 | 19.384 | 18.952 |
| -180 | 27.096 | 26.671 | 26.245 | 25.819 | 25.392 | 24.965 | 24.538 | 24.110 | 23.682 | 23.254 |
| -170 | 31.335 | 30.913 | 30.490 | 30.067 | 29.643 | 29.220 | 28.796 | 28.371 | 27.947 | 27.552 |
| -160 | 35.543 | 35.124 | 34.704 | 34.284 | 33.864 | 33.443 | 33.022 | 32.601 | 32.179 | 31.757 |
| -150 | 39.723 | 39.306 | 38.889 | 38.472 | 38.055 | 37.637 | 37.219 | 36.800 | 36.382 | 35.963 |
| -140 | 43.876 | 43.462 | 43.048 | 42.633 | 42.218 | 41.803 | 41.388 | 40.972 | 40.556 | 40.140 |
| -130 | 48.005 | 47.593 | 47.181 | 46.769 | 46.356 | 45.944 | 45.531 | 45.117 | 44.704 | 44.290 |
| -120 | 52.110 | 51.700 | 51.291 | 50.881 | 50.470 | 50.060 | 49.649 | 49.239 | 48.828 | 48.416 |
| -110 | 56.193 | 55.786 | 55.378 | 54.970 | 54.562 | 54.154 | 53.746 | 53.337 | 52.928 | 52.519 |
| -100 | 60.256 | 59.850 | 59.445 | 59.039 | 58.633 | 58.227 | 57.821 | 57.414 | 57.007 | 56.600 |
| - 90 | 64.300 | 63.896 | 63.492 | 63.088 | 62.684 | 62.280 | 61.876 | 61.471 | 61.066 | 60.661 |
| - 80 | 68.325 | 67.924 | 67.522 | 67.120 | 66.717 | 66.315 | 65.912 | 65.509 | 65.106 | 64.703 |
| - 70 | 72.335 | 71.934 | 71.534 | 71.134 | 70.733 | 70.332 | 69.931 | 69.530 | 69.129 | 68.727 |
| - 60 | 76.328 | 75.929 | 75.530 | 75.131 | 74.732 | 74.333 | 73.934 | 73.534 | 73.134 | 72.735 |
| - 50 | 80.306 | 79.909 | 79.512 | 79.114 | 78.717 | 78.319 | 77.921 | 77.523 | 77.125 | 76.726 |
| - 40 | 84.271 | 83.875 | 83.479 | 83.083 | 82.687 | 82.290 | 81.894 | 81.497 | 81.100 | 80.703 |
| - 30 | 88.222 | 87.827 | 87.432 | 87.038 | 86.643 | 86.248 | 85.853 | 85.457 | 85.062 | 84.666 |
| - 20 | 92.160 | 91.767 | 91.373 | 90.980 | 90.586 | 90.192 | 89.798 | 89.404 | 89.010 | 88.616 |
| - 10 | 96.086 | 95.694 | 95.302 | 94.909 | 94.517 | 94.124 | 93.732 | 93.339 | 92.946 | 92.553 |
| 0 | 100.000 | 99.609 | 99.218 | 98.827 | 98.436 | 98.044 | 97.653 | 97.261 | 96.870 | 96.478 |

| °C | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|-----|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 0 | 100.000 | 100.391 | 100.781 | 101.172 | 101.562 | 101.953 | 102.343 | 102.733 | 103.123 | 103.513 |
| 10 | 103.903 | 104.292 | 104.682 | 105.071 | 105.460 | 105.849 | 106.238 | 106.627 | 107.016 | 107.405 |
| 20 | 107.794 | 108.182 | 108.570 | 108.959 | 109.347 | 109.735 | 110.123 | 110.510 | 110.898 | 111.286 |
| 30 | 111.673 | 112.060 | 112.447 | 112.835 | 113.221 | 113.608 | 113.995 | 114.382 | 114.768 | 115.155 |
| 40 | 115.541 | 115.927 | 116.313 | 116.699 | 117.085 | 117.470 | 117.856 | 118.241 | 118.627 | 119.012 |
| 50 | 119.397 | 119.782 | 120.167 | 120.552 | 120.936 | 121.321 | 121.705 | 122.090 | 122.474 | 122.858 |
| 60 | 123.242 | 123.626 | 124.009 | 124.393 | 124.777 | 125.160 | 125.543 | 125.926 | 126.309 | 126.692 |
| 70 | 127.075 | 127.458 | 127.840 | 128.223 | 128.605 | 128.987 | 129.370 | 129.752 | 130.133 | 130.515 |
| 80 | 130.897 | 131.278 | 131.660 | 132.041 | 132.422 | 132.803 | 133.184 | 133.565 | 133.946 | 134.326 |
| 90 | 134.707 | 135.087 | 135.468 | 135.848 | 136.228 | 136.608 | 136.987 | 137.367 | 137.747 | 138.126 |
| 100 | 138.506 | 138.885 | 139.264 | 139.643 | 140.022 | 140.400 | 140.779 | 141.158 | 141.536 | 141.914 |
| 110 | 142.293 | 142.671 | 143.049 | 143.426 | 143.804 | 144.182 | 144.559 | 144.937 | 145.314 | 145.691 |
| 120 | 146.068 | 146.445 | 146.822 | 147.198 | 147.575 | 147.951 | 148.328 | 148.704 | 149.080 | 149.456 |
| 130 | 149.832 | 150.208 | 150.583 | 150.959 | 151.334 | 151.710 | 152.085 | 152.460 | 152.835 | 153.210 |
| 140 | 153.584 | 153.959 | 154.333 | 154.708 | 155.082 | 155.456 | 155.830 | 156.204 | 156.578 | 156.952 |
| 150 | 157.325 | 157.699 | 158.072 | 158.445 | 158.818 | 159.191 | 159.564 | 159.937 | 160.309 | 160.682 |
| 160 | 161.054 | 161.427 | 161.799 | 162.171 | 162.543 | 162.915 | 163.286 | 163.658 | 164.030 | 164.401 |
| 170 | 164.772 | 165.143 | 165.514 | 165.885 | 166.256 | 166.627 | 166.997 | 167.368 | 167.738 | 168.108 |
| 180 | 168.478 | 168.848 | 169.218 | 169.588 | 169.958 | 170.327 | 170.696 | 171.066 | 171.435 | 171.804 |
| 190 | 172.173 | 172.542 | 172.910 | 173.279 | 173.648 | 174.016 | 174.384 | 174.752 | 175.120 | 175.488 |
| 200 | 175.856 | 176.224 | 176.591 | 176.959 | 177.326 | 177.693 | 178.060 | 178.427 | 178.794 | 179.161 |
| 210 | 179.528 | 179.894 | 180.260 | 180.627 | 180.993 | 181.359 | 181.725 | 182.091 | 182.456 | 182.822 |
| 220 | 183.188 | 183.553 | 183.918 | 184.283 | 184.648 | 185.013 | 185.378 | 185.743 | 186.107 | 186.472 |
| 230 | 186.836 | 187.200 | 187.564 | 187.928 | 188.292 | 188.656 | 189.019 | 189.383 | 189.746 | 190.110 |
| 240 | 190.473 | 190.836 | 191.199 | 191.562 | 191.924 | 192.287 | 192.649 | 193.012 | 193.374 | 193.736 |
| 250 | 194.098 | 194.460 | 194.822 | 195.183 | 195.545 | 195.906 | 196.268 | 196.629 | 196.990 | 197.351 |
| 260 | 197.712 | 198.073 | 198.433 | 198.794 | 199.154 | 199.514 | 199.875 | 200.235 | 200.595 | 200.954 |
| 270 | 201.314 | 201.674 | 202.033 | 202.393 | 202.752 | 203.111 | 203.470 | 203.829 | 204.188 | 204.546 |
| 280 | 204.905 | 205.263 | 205.622 | 205.980 | 206.338 | 206.696 | 207.054 | 207.411 | 207.769 | 208.127 |
| 290 | 208.484 | 208.841 | 209.198 | 209.555 | 209.912 | 210.269 | 210.626 | 210.982 | 211.339 | 211.695 |
| 300 | 212.052 | 212.408 | 212.764 | 213.120 | 213.475 | 213.831 | 214.187 | 214.542 | 214.897 | 215.252 |

The reference values have been calculated according to the International Temperature Scale ITS 90.
(For Pt500 or Pt1000 temperature sensors, the reference values have to be multiplied by 5 or 10 respectively).

Appendix I

Reference values to EN 60 751 (ITS 90) in Ohm for Pt100 temperature sensors in 1°C steps

| °C | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|-----|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 310 | 215.608 | 215.962 | 216.317 | 216.672 | 217.027 | 217.381 | 217.736 | 218.090 | 218.444 | 218.798 |
| 320 | 219.152 | 219.506 | 219.860 | 220.213 | 220.567 | 220.920 | 221.273 | 221.626 | 221.979 | 222.332 |
| 330 | 222.685 | 223.038 | 223.390 | 223.743 | 224.095 | 224.447 | 224.799 | 225.151 | 225.503 | 225.855 |
| 340 | 226.206 | 226.558 | 226.909 | 227.260 | 227.612 | 227.963 | 228.314 | 228.664 | 229.015 | 229.366 |
| 350 | 229.716 | 230.066 | 230.417 | 230.767 | 231.117 | 231.467 | 231.816 | 232.166 | 232.516 | 232.865 |
| 360 | 233.214 | 233.564 | 233.913 | 234.262 | 234.610 | 234.959 | 235.308 | 235.656 | 236.005 | 236.353 |
| 370 | 236.701 | 237.049 | 237.397 | 237.745 | 238.093 | 238.440 | 238.788 | 239.135 | 239.482 | 239.829 |
| 380 | 240.176 | 240.523 | 240.870 | 241.217 | 241.563 | 241.910 | 242.256 | 242.602 | 242.948 | 243.294 |
| 390 | 243.640 | 243.986 | 244.331 | 244.677 | 245.022 | 245.367 | 245.713 | 246.058 | 246.403 | 246.747 |
| 400 | 247.092 | 247.437 | 247.781 | 248.125 | 248.470 | 248.814 | 249.158 | 249.502 | 249.845 | 250.189 |
| 410 | 250.533 | 250.876 | 251.219 | 251.562 | 251.906 | 252.248 | 252.591 | 252.934 | 253.277 | 253.619 |
| 420 | 253.962 | 254.304 | 254.646 | 254.988 | 255.330 | 255.672 | 256.013 | 256.355 | 256.696 | 257.038 |
| 430 | 257.379 | 257.720 | 258.061 | 258.402 | 258.743 | 259.083 | 259.424 | 259.764 | 260.105 | 260.445 |
| 440 | 260.785 | 261.125 | 261.465 | 261.804 | 262.144 | 262.483 | 262.823 | 263.162 | 263.501 | 263.840 |
| 450 | 264.179 | 264.518 | 264.857 | 265.195 | 265.534 | 265.872 | 266.210 | 266.548 | 266.886 | 267.224 |
| 460 | 267.562 | 267.900 | 268.237 | 268.574 | 268.912 | 269.249 | 269.586 | 269.923 | 270.260 | 270.597 |
| 470 | 270.933 | 271.270 | 271.606 | 271.942 | 272.278 | 272.614 | 272.950 | 273.286 | 273.622 | 273.957 |
| 480 | 274.293 | 274.628 | 274.963 | 275.298 | 275.633 | 275.968 | 276.303 | 276.638 | 276.972 | 277.307 |
| 490 | 277.641 | 277.975 | 278.309 | 278.643 | 278.977 | 279.311 | 279.644 | 279.978 | 280.311 | 280.644 |
| 500 | 280.978 | 281.311 | 281.643 | 281.976 | 282.309 | 282.641 | 282.974 | 283.306 | 283.638 | 283.971 |
| 510 | 284.303 | 284.634 | 284.966 | 285.298 | 285.629 | 285.961 | 286.292 | 286.623 | 286.954 | 287.285 |
| 520 | 287.616 | 287.947 | 288.277 | 288.608 | 288.938 | 289.268 | 289.599 | 289.929 | 290.258 | 290.588 |
| 530 | 290.918 | 291.247 | 291.577 | 291.906 | 292.235 | 292.565 | 292.894 | 293.222 | 293.551 | 293.880 |
| 540 | 294.208 | 294.537 | 294.865 | 295.193 | 295.521 | 295.849 | 296.177 | 296.505 | 296.832 | 297.160 |
| 550 | 297.487 | 297.814 | 298.142 | 298.469 | 298.795 | 299.122 | 299.449 | 299.775 | 300.102 | 300.428 |
| 560 | 300.754 | 301.080 | 301.406 | 301.732 | 302.058 | 302.384 | 302.709 | 303.035 | 303.360 | 303.685 |
| 570 | 304.010 | 304.335 | 304.660 | 304.985 | 305.309 | 305.634 | 305.958 | 306.282 | 306.606 | 306.930 |
| 580 | 307.254 | 307.578 | 307.902 | 308.225 | 308.549 | 308.872 | 309.195 | 309.518 | 309.841 | 310.164 |
| 590 | 310.487 | 310.810 | 311.132 | 311.454 | 311.777 | 312.099 | 312.421 | 312.743 | 313.065 | 313.386 |
| 600 | 313.708 | 314.029 | 314.351 | 314.672 | 314.993 | 315.314 | 315.635 | 315.956 | 316.277 | 316.597 |
| 610 | 316.918 | 317.238 | 317.558 | 317.878 | 318.198 | 318.518 | 318.838 | 319.157 | 319.477 | 319.796 |
| 620 | 320.116 | 320.435 | 320.754 | 321.073 | 321.391 | 321.710 | 322.029 | 322.347 | 322.666 | 322.984 |
| 630 | 323.302 | 323.620 | 323.938 | 324.256 | 324.573 | 324.891 | 325.208 | 325.526 | 325.843 | 326.160 |
| 640 | 326.477 | 326.794 | 327.110 | 327.427 | 327.744 | 328.060 | 328.376 | 328.692 | 329.008 | 329.324 |
| 650 | 329.640 | 329.956 | 330.271 | 330.587 | 330.902 | 331.217 | 331.533 | 331.848 | 332.162 | 332.477 |
| 660 | 332.792 | 333.106 | 333.421 | 333.735 | 334.049 | 334.363 | 334.677 | 334.991 | 335.305 | 335.619 |
| 670 | 335.932 | 336.246 | 336.559 | 336.872 | 337.185 | 337.498 | 337.811 | 338.123 | 338.436 | 338.748 |
| 680 | 339.061 | 339.373 | 339.685 | 339.997 | 340.309 | 340.621 | 340.932 | 341.244 | 341.555 | 341.867 |
| 690 | 342.178 | 342.489 | 342.800 | 343.111 | 343.422 | 343.732 | 344.043 | 344.353 | 344.663 | 344.973 |
| 700 | 345.284 | 345.593 | 345.903 | 346.213 | 346.522 | 346.832 | 347.141 | 347.451 | 347.760 | 348.069 |
| 710 | 348.378 | 348.686 | 348.995 | 349.303 | 349.612 | 349.920 | 350.228 | 350.536 | 350.844 | 351.152 |
| 720 | 351.460 | 351.768 | 352.075 | 352.382 | 352.690 | 352.997 | 353.304 | 353.611 | 353.918 | 354.224 |
| 730 | 354.531 | 354.837 | 355.144 | 355.450 | 355.756 | 356.062 | 356.368 | 356.674 | 356.979 | 357.285 |
| 740 | 357.590 | 357.896 | 358.201 | 358.506 | 358.811 | 359.116 | 359.420 | 359.725 | 360.029 | 360.334 |
| 750 | 360.638 | 360.942 | 361.246 | 361.550 | 361.854 | 362.158 | 362.461 | 362.765 | 363.068 | 363.371 |
| 760 | 363.674 | 363.977 | 364.280 | 364.583 | 364.886 | 365.188 | 365.491 | 365.793 | 366.095 | 366.397 |
| 770 | 366.699 | 367.001 | 367.303 | 367.604 | 367.906 | 368.207 | 368.508 | 368.810 | 369.111 | 369.412 |
| 780 | 369.712 | 370.013 | 370.314 | 370.614 | 370.914 | 371.215 | 371.515 | 371.815 | 372.115 | 372.414 |
| 790 | 372.714 | 373.013 | 373.313 | 373.612 | 373.911 | 374.210 | 374.509 | 374.808 | 375.107 | 375.406 |
| 800 | 375.704 | 376.002 | 376.301 | 376.599 | 376.897 | 377.195 | 377.493 | 377.790 | 378.088 | 378.385 |
| 810 | 378.683 | 378.980 | 379.277 | 379.574 | 379.871 | 380.167 | 380.464 | 380.761 | 381.057 | 381.353 |
| 820 | 381.650 | 381.946 | 382.242 | 382.537 | 382.833 | 383.129 | 383.424 | 383.720 | 384.015 | 384.310 |
| 830 | 384.605 | 384.900 | 385.195 | 385.489 | 385.784 | 386.078 | 386.373 | 386.667 | 386.961 | 387.255 |
| 840 | 387.549 | 387.843 | 388.136 | 388.430 | 388.723 | 389.016 | 389.310 | 389.603 | 389.896 | 390.188 |
| 850 | 390.481 | - | - | - | - | - | - | - | - | - |

The reference values have been calculated according to the International Temperature Scale ITS 90.

(For Pt500 or Pt1000 temperature sensors, the reference values have to be multiplied by 5 or 10 respectively).

Appendix II

