

Temperature sensor resistance values						
Temperature [°F]	-22	-4	-14	32	50	68
Temperature [°C]	-30	-20	-10	0	10	20
Resistance [Ω]	882	922	961	1000	1039	1078
Temperature [°F]	86	104	122	140	158	176
Temperature [°C]	30	40	50	60	70	80
Resistance [Ω]	1117	1155	1194	1232	1271	1309
Temperature [°F]	194	212	230	248	266	284
Temperature [°C]	90	100	110	120	130	140
Resistance [Ω]	1347	1385	1423	1461	1498	1536
Temperature [°F]	302	320	338	356		
Temperature [°C]	150	160	170	180		
Resistance [Ω]	1573	1611	1648	1685		

Blue values are added to °C value, correspondind resistance value is intersection of line and column

°C	0	-1	-2	-3	-4	-5	-6	-7	-8	-9
200	185.200	-	-	-	-	-	-	-	-	-
190	228.250	223.970	219.670	215.380	211.080	206.770	202.470	198.150	193.840	189.520
180	270.960	266.710	262.450	258.190	253.920	249.650	245.380	241.100	236.820	232.540
170	313.350	309.130	304.900	300.670	296.430	292.200	287.960	283.710	279.470	275.520
160	355.430	351.240	347.040	342.840	338.640	334.430	330.220	326.010	321.790	317.570
150	397.230	393.060	388.890	384.720	380.550	376.370	372.190	368.000	363.820	359.630
140	438.760	434.620	430.480	426.330	422.180	418.030	413.880	409.720	405.560	401.400
130	480.050	475.930	471.810	467.690	463.560	459.440	455.310	451.170	447.040	442.900
120	521.100	517.000	512.910	508.810	504.700	500.600	496.490	492.390	488.280	484.160
110	561.930	557.860	553.780	549.700	545.620	541.540	537.460	533.370	529.280	525.190
100	602.560	598.500	594.450	590.390	586.330	582.270	578.210	574.140	570.070	566.000
-90	643.000	638.960	634.920	630.880	626.840	622.800	618.760	614.710	610.660	606.610
-80	683.250	679.240	675.520	671.200	667.170	663.150	659.120	655.090	651.060	647.030
-70	723.350	719.340	715.340	711.340	707.330	703.320	699.310	695.300	691.290	687.270
-60	763.280	759.290	755.300	751.310	747.320	743.330	739.340	735.340	731.340	727.350
-50	803.060	799.090	795.120	791.140	787.170	783.190	779.210	775.230	771.250	767.260
-40	842.710	838.750	834.790	830.830	826.870	822.900	818.940	814.970	811.000	807.030
-30	882.200	878.270	874.320	870.380	866.430	862.480	858.530	854.570	850.620	846.600
-20	921.600	917.670	913.730	909.800	905.860	901.920	897.980	894.040	890.100	886.160
-10	960.860	956.940	953.020	949.090	945.170	941.240	937.320	933.390	929.460	925.530
0	1000.000	996.090	992.180	988.270	984.360	980.440	976.530	972.610	968.700	964.780
°C	0	1	2	3	4	5	6	7	8	9
0	1000.000	1003.910	1007.810	1011.720	1015.620	1019.530	1023.430	1027.330	1031.230	1035.130
10	1039.030	1042.920	1046.820	1050.710	1054.600	1058.490	1062.380	1066.270	1070.160	1074.050
20	1077.940	1801.820	1085.700	1089.590	1093.470	1097.350	1101.230	1105.100	1108.980	1112.860
30	1116.730	1120.600	1124.470	1128.350	1132.210	1136.080	1139.950	1143.820	1147.680	1151.550
40	1155.410	1159.270	1163.130	1166.990	1170.850	1174.700	1178.560	1182.410	1186.270	1190.120
50	1193.970	1197.820	1201.670	1205.520	1209.360	1213.210	1217.050	1220.900	1224.740	1228.580
60	1232.420	1236.260	1240.090	1243.930	1247.770	1251.600	1255.430	1259.260	1263.090	1266.920
70	1270.750	1274.580	1278.400	1282.230	1286.050	1289.870	1293.700	1297.520	1301.330	1305.150
80	1308.970	1312.780	1316.600	1320.410	1324.220	1328.030	1331.840	1335.650	1339.460	1343.260
90	1347.070	1350.870	1354.680	1358.480	1362.280	1366.080	1369.870	1373.670	1377.470	1381.260
100	1385.060	1388.850	1392.640	1396.430	1400.220	1404.000	1407.790	1411.580	1415.360	1419.140
110	1422.930	1426.710	1430.490	1434.260	1438.040	1441.820	1445.590	1449.370	1453.140	1456.910
120	1460.680	1464.450	1468.220	1471.980	1475.750	1479.510	1483.280	1487.040	1490.800	1494.560
130	1498.320	1502.080	1505.830	1509.590	1513.340	1517.100	1520.850	1524.600	1528.650	1532.100
140	1535.840	1539.590	1543.330	1547.080	1550.820	1554.560	1558.300	1562.040	1565.780	1569.520
150	1573.250	1576.990	1580.720	1584.450	1588.180	1591.910	1595.640	1599.370	1603.090	1606.820
160	1610.540	1614.270	1617.990	1621.710	1625.430	1629.150	1632.860	1636.580	1640.300	1644.010
170	1647.720	1651.430	1655.140	1658.850	1662.560	1666.270	1669.970	1673.680	1677.380	1681.080
180	1684.780	1688.480	1692.180	1695.880	1699.580	1703.270	1706.960	1710.660	1714.350	1718.040
190	1721.730	1725.420	1729.100	1732.790	1736.480	1740.160	1743.843	1747.520	1751.200	1754.880
200	1758.650	1762.240	1765.910	1769.590	1773.260	1776.930	1780.600	1784.270	1787.940	1791.610
210	1795.280	1798.940	1802.600	1806.270	1809.930	1813.590	1817.250	1820.910	1824.560	1828.220
220	1831.880	1835.530	1839.180	1842.830	1846.480	1850.130	1853.780	1857.430	1861.070	1864.720
230	1868.360	1872.000	1875.640	1879.280	1882.920	1886.560	1890.190	1893.830	1897.460	1901.100
240	1904.730	1908.360	1911.990	1915.620	1919.240	1922.870	1926.490	1930.120	1933.740	1937.360
250	1940.980	1944.600	1948.220	1951.830	1955.450	1959.030	1962.680	1966.290	1969.900	1973.510
260	1977.120	1980.730	1984.330	1987.940	1991.540	1995.140	1998.750	2002.350	2005.950	2009.540
270	2013.140	2016.740	2020.330	2023.930	2027.520	2031.100	2034.700	2038.290	2041.880	2045.460
280	2049.050	2052.630	2056.220	2059.800	2063.380	2066.960	2070.540	2074.110	2077.690	2081.270
290	2084.840	2088.410	2091.980	2095.550	2099.120	2102.690	2106.260	2109.820	2113.390	2116.950
300	2120.520	2124.080	2127.640	2131.200	2134.750	2138.310	2141.870	2145.420	2148.970	2152.520

Resistance thermometers: Pt1000 Ohm DIN EN 60751, Class B

(Abstract of a manufacturer information of Jumo company)

Construction and application of resistance thermometers

Temperature-dependent resistance

The variation of the electrical resistance of metals with temperature is very often employed for the electrical measurement of temperature. Since the electrical resistance increases with increasing temperature, we speak of a positive temperature coefficient or PTC (in platinum temperature sensors, for example).

In order to employ this effect for temperature measurement, the electrical resistance of the metal must vary in a reproducible manner depending on temperature. The characteristics of the metal must not change during operation, as this would introduce measurement errors. The temperature coefficient should be as independent as possible of temperature, pressure and chemical effects.

Standardized platinum temperature sensors

Platinum has established itself as the resistance material of choice in industrial instrumentation. Its advantages include high chemical stability, relatively easy workability (especially in wire manufacture), its availability in highly pure form, and the good reproducibility of its electrical properties. In order to ensure universal interchangeability, these properties are defined in the standard EN 60751.

This standard lays down the electrical resistance and the permitted tolerances at different temperatures. Additional definitions cover the nominal value of the temperature sensor and the temperature range. The calculation makes a distinction between the two temperature ranges -200 to 0°C and 0 to 850°C.

The range from -200 to 0°C is covered by the third-order polynomial:

$$R(t) = R_0(1 + A \times t + B \times t^2 + C \times (t - 100^\circ\text{C}) \times t^3)$$

A second-order polynomial applies to the range 0 to 850°C ...

$$R(t) = R_0(1 + A \times t + B \times t^2)$$

...with the coefficients:

$$\begin{aligned} A &= 3.9063 \times 10^{-3} \text{ } ^\circ\text{C}^{-1} \\ B &= -5.775 \times 10^{-7} \text{ } ^\circ\text{C}^{-2} \\ C &= -4.183 \times 10^{-12} \text{ } ^\circ\text{C}^{-4} \end{aligned}$$

The term  $R_0$  is referred to as the nominal value, and represents the resistance at 0°C.

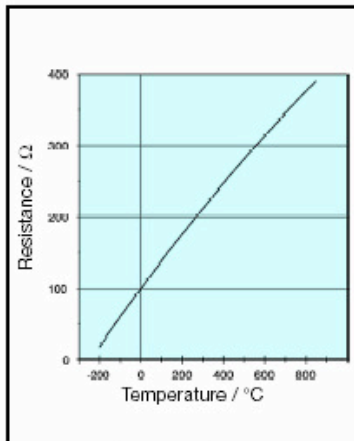


Fig. 1: Pt100 characteristic

According to EN 60751, the nominal value is 100.000 Ω at 0°C. We therefore speak of a Pt100 temperature sensor. Temperature sensors with nominal values of 500 and 1000Ω are also available. Their advantage is a higher sensitivity, i.e. a larger variation of their resistance with temperature.

The resistance change in the temperature range up to 100°C is approximately: 0.4Ω/°C for Pt100 temperature sensors 2.0Ω/°C for Pt500 temperature sensors 4.0Ω/°C for Pt1000 temperature sensors As an additional parameter, the standard defines a mean temperature coefficient between 0°C and 100°C. This represents the average change in resistance, referred to the nominal value at 0°C:

$$\alpha = \frac{R_{100} - R_0}{R_0 \times 100^\circ\text{C}} = 3.850 \times 10^{-3} \text{ } ^\circ\text{C}^{-1}$$

$R_0$  and  $R_{100}$  are the resistances at the temperatures 0°C and 100°C respectively.

Calculating the temperature from the resistance

In its application as a thermometer, the resistance of the temperature sensor is used to calculate the corresponding temperature. The formulae above represent the variation of electrical resistance with temperature.

For temperatures above 0°C it is possible to derive an explicit expression from the characteristic according to EN 60751:

$$t = \frac{-R_0 \times A + [(R_0 \times A)^2 - 4 \times R_0 \times B \times (R_0 - R)]^{1/2}}{2 \times R_0 \times B}$$

R = measured resistance in Ω  
t = calculated temperature in °C  
 $R_0, A, B$  = parameter as per IEC 751

Tolerance limits

EN 60751 distinguishes between two tolerance classes:

Class A:  $\Delta t = \pm (0.15 + 0.002 \times |t|)$

Class B:  $\Delta t = \pm (0.30 + 0.005 \times |t|)$

t = temperature in °C (without sign)

The formula for calculating the tolerance  $\Delta R$  in Ω at a temperature of  $t > 0^\circ\text{C}$  is:

$$\Delta R = R_0(A + 2 \times B \times t) \times \Delta t$$

For  $t < 0^\circ\text{C}$  it is:

$$\Delta R = R_0(A + 2 \times B \times t - 300^\circ\text{C} \times C \times t^2 + 4 \times C \times t^3) \times \Delta t$$

Tolerance Class A applies for temperatures between -200 and +600°C.

Tolerance Class B covers the entire definition range of -200 to +850°C.

Extended tolerance classes

It is frequently found that the two tolerance classes specified in the standard are not adequate to meet particular requirements. On the basis of the standard tolerances, JUMO have defined additional classes in order to meet the different requirements of the market.

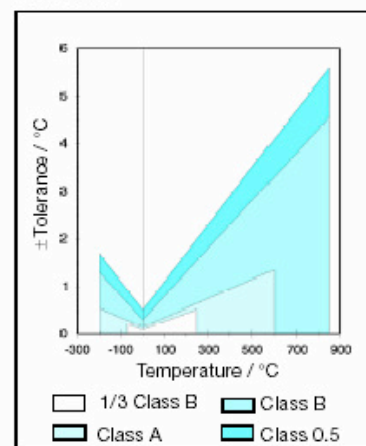


Fig. 2: Tolerance variation, depending on measurement temperature

Tolerance class	Temperature range	Tolerance in °C	Tolerance at	
			t = 0°C	t = 100°C
1/3Class B	- 70 to +250°C	$\pm (0.10^{\circ}\text{C} + 0.0017 \times  t )$	$\pm 0.10^{\circ}\text{C}$	$\pm 0.27^{\circ}\text{C}$
Class A	-200 to +600°C	$\pm (0.15^{\circ}\text{C} + 0.0020 \times  t )$	$\pm 0.15^{\circ}\text{C}$	$\pm 0.35^{\circ}\text{C}$
Class B	-200 to +850°C	$\pm (0.30^{\circ}\text{C} + 0.0050 \times  t )$	$\pm 0.30^{\circ}\text{C}$	$\pm 0.80^{\circ}\text{C}$
Class 0.5	-200 to +850°C	$\pm (0.50^{\circ}\text{C} + 0.0060 \times  t )$	$\pm 0.50^{\circ}\text{C}$	$\pm 1.10^{\circ}\text{C}$

Table 1: Tolerance classes

|t| = measured temperature in °C, without sign

Pt 100 / Pt 500 /Pt 1000 Temperature resistor

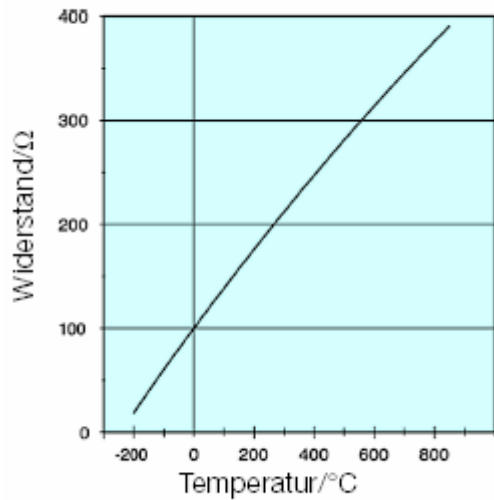


Diagram: Pt 100 characteristic

**Item1:**

Pt 100: 100 ohm at 0°C

Pt 500: 500 ohm at 0°C

Pt1000: 1000 ohm at 0°C

**Item2:**

Change in resistor up to 100°C is nearly:

0,4 ohm/Kelvin with Pt 100 sensor

2,0 ohm/Kelvin with Pt 500 sensor

4,0 ohm/Kelvin with Pt 1000 sensor

**Pt 1000  
Resistor table**

Präzisionselektronik  
Solarelektronik  
Batterie-Ladesysteme  
Kabeltechnik



**Pt 1000: Temperature / resistor table**

	0	1	2	3	4	5	6	7	8	9	0
-80	683,25	687,27	691,29	695,3	699,31	703,32	707,33	711,34	715,34	719,34	723,35
-70	723,35	727,35	731,34	735,34	739,34	743,33	747,32	751,32	755,3	759,29	763,28
-60	763,28	767,26	771,25	775,23	779,21	783,19	787,17	791,14	795,12	799,09	803,06
-50	803,06	807,03	811	814,97	818,94	822,9	826,87	830,83	834,79	838,75	842,71
-40	842,71	846,66	850,62	854,57	858,53	862,48	866,43	870,38	874,33	878,27	882,22
-30	882,22	886,16	890,1	894,04	897,99	901,92	905,86	909,8	913,73	917,67	921,6
-20	921,6	925,53	929,46	933,39	937,32	941,24	945,17	949,09	953,02	956,94	960,86
-10	960,86	964,78	968,7	972,61	976,53	980,44	984,36	988,27	992,18	996,09	1000
0	1000	1003,9	1007,8	1011,7	1015,6	1019,5	1023,4	1027,3	1031,2	1035,1	1039
10	1039	1042,9	1046,8	1050,7	1054,6	1058,5	1062,4	1066,3	1070,2	1074	1077,9
20	1077,9	1081,8	1085,7	1089,6	1093,5	1097,3	1101,2	1105,1	1109	1112,9	1116,7
30	1116,7	1120,6	1124,5	1128,3	1132,2	1136,1	1140	1143,8	1147,7	1151,5	1155,4
40	1155,4	1159,3	1163,1	1167	1170,8	1174,7	1178,6	1182,4	1186,3	1190,1	1194
50	1194	1197,8	1201,7	1205,5	1209,4	1213,2	1217,1	1220,9	1224,7	1228,6	1232,4
60	1232,4	1236,3	1240,1	1243,9	1247,8	1251,6	1255,4	1259,3	1263,1	1266,9	1270,8
70	1270,8	1274,6	1278,4	1282,2	1286,1	1289,9	1293,7	1297,5	1301,3	1305,2	1309
80	1309	1312,8	1316,6	1320,4	1324,2	1328	1331,8	1335,7	1339,5	1343,3	1347,1
90	1347,1	1350,9	1354,7	1358,5	1362,3	1366,1	1369,9	1373,7	1377,5	1381,3	1385,1
100	1385,1	1388,8	1392,6	1396,4	1400,2	1404	1407,8	1411,6	1415,4	1419,1	1422,9
110	1422,9	1426,7	1430,5	1434,3	1438	1441,8	1445,6	1449,4	1453,1	1456,9	1460,7
120	1460,7	1464,4	1468,2	1472	1475,8	1479,5	1483,3	1487	1490,8	1494,6	1498,3
130	1498,3	1502,1	1505,8	1509,6	1513,3	1517,1	1520,8	1524,6	1528,3	1532,1	1535,8
140	1535,8	1539,6	1543,3	1547,1	1550,8	1554,6	1558,3	1562	1565,8	1569,5	1573,3
150	1573,3	1577	1580,7	1584,5	1588,2	1591,9	1595,6	1599,4	1603,1	1606,8	1610,5
160	1610,5	1614,3	1618	1621,7	1625,4	1629,1	1632,9	1636,6	1640,3	1644	1647,7
170	1647,7	1651,4	1655,1	1658,9	1662,6	1666,3	1670	1673,7	1677,4	1681,1	1684,8
180	1684,8	1688,5	1692,2	1695,9	1699,6	1703,3	1707	1710,7	1714,3	1718	1721,7
190	1721,7	1725,4	1729,1	1732,8	1736,5	1740,2	1743,8	1747,5	1751,2	1754,9	1758,6
200	1758,6	1762,2	1765,9	1769,6	1773,3	1776,9	1780,6	1784,3	1787,9	1791,6	1795,3
210	1795,3	1798,9	1802,6	1806,3	1809,9	1813,6	1817,2	1820,9	1824,6	1828,2	1831,9
220	1831,9	1835,5	1839,2	1842,8	1846,5	1850,1	1853,8	1857,4	1861,1	1864,7	1868,4
230	1868,4	1872	1875,6	1879,3	1882,9	1886,6	1890,2	1893,8	1897,5	1901,1	1904,7
240	1904,7	1908,4	1912	1915,6	1919,2	1922,9	1926,5	1930,1	1933,7	1937,4	1941
250	1941	1944,6	1948,2	1951,8	1955,5	1959,1	1962,7	1966,3	1969,9	1973,5	1977,1
260	1977,1	1980,7	1984,3	1987,9	1991,5	1995,1	1998,7	2002,3	2005,9	2009,5	2013,1
270	2013,1	2016,7	2020,3	2023,9	2027,5	2031,1	2034,7	2038,3	2041,9	2045,5	2049
280	2049	2052,6	2056,2	2059,8	2063,4	2067	2070,5	2074,1	2077,7	2081,3	2084,8
290	2084,8	2088,4	2092	2095,6	2099,1	2102,7	2106,3	2109,8	2113,4	2117	2120,5
300	2120,5	2124,1	2127,6	2131,2	2134,8	2138,3	2141,9	2145,4	2149	2152,5	2156,1