



## Tech Note

## TM-100 Temperature Sensor

### Overview

The TM-100 is a sensor that can monitor temperatures between 15 oC above and 15 oC below room temperature. The TM-100 is capable of responding to changes in temperature within a few seconds because of its small size (1mm x 3mm) and mass. The TM-100 is suitable for monitoring nasal airflow, changes in skin temperature that indicate evaporative cooling, and changes in atmospheric temperature and temperature in environmental chambers. Since the sensor element is water-resistant, the tip of the TM-100 can be immersed in aqueous solutions, including saline solutions, for a few hours.

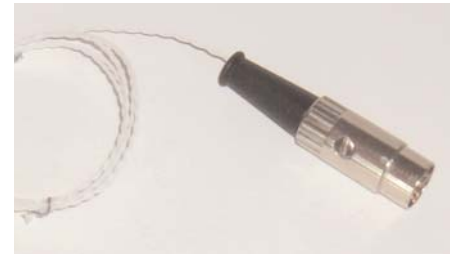


Figure 1: TM-100 Temperature Sensor

### How it Works

The sensor element in the TM-100 that responds to temperature changes is a thermistor, which is a type of resistor that changes resistance with changes in temperature. The thermistor in the TM-100 has a negative temperature coefficient (NTC) which means that the resistance of the thermistor decreases as the temperature goes up. Thermistors with positive temperature coefficients also exist. Table 1 shows the resistances of the thermistor in the TM-100 over a range of temperatures from 0°C to 50°C.

**Table 1: Resistances of the Thermistor Used in the TM-100 Temperature Sensor at Different Temperatures**

Temp (°C)	Resistance (Ω)	Temp (°C)	Resistance (Ω)	Temp (°C)	Resistance (Ω)
0	32650.5	17	14321.6	34	6808.36
1	31032.1	18	13679.8	35	6531.31
2	29499.9	19	13070.4	36	6265.75
3	28052.4	20	12491.6	37	6016.47
4	26684.6	21	11941.6	38	5776.05
5	25391.2	22	11418.9	39	5546.53
6	24168.2	23	10922.0	40	5327.34
7	23011.2	24	10449.5	41	5117.97
8	21916.3	25	10000.0	42	4917.94
9	20879.8	26	9572.32	43	4726.77
10	19898.3	27	9165.29	44	4543.91
11	18968.6	28	8777.79	45	4369.33
12	18087.6	29	8408.68	46	4200.84
13	17252.6	30	8057.31	47	4040.81
14	16460.9	31	7722.43	48	3889.51
15	15710.0	32	7403.29	49	3743.17
16	14997.7	33	7098.42	50	3603.10

The thermistor in the TM-100 is wired into the circuit of the sensor as one leg of a Wheatstone bridge. On the other three legs of the bridge circuit, selected resistors are used to give the TM-100 a linear output over a range that is 15 oC above and below room temperature.

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### Equipment Set-up

1. Insert the male DIN8 connector on the end of the TM-100 temperature sensor into female DIN8 connector on the end of a DIN8 extension cable.
2. Insert the male DIN8 connector on the end of this DIN8 extension cable into a DIN8 Input on an iWorx data acquisition unit or amplifier.



Figure 2: The TM-100 temperature sensor connected to an IWX/214.

### Calibration of the TM-100 Temperature Sensor

1. Prepare two beakers of water, one at 10°C, and the other at 40°C. Measure the temperature of the cold water with a thermometer just before the TM-100 temperature sensor is placed in the beaker.
2. Place the tip of the TM-100 temperature sensor in the center of the beaker of cold water.
3. Click the **Start button** on the **Main window** of the LabScribe software and begin recording. Type **Calibration at <Cold Water Temperature>** on the comment line to the right of the **Mark button** on the LabScribe **Main window**.
4. After about twenty seconds in the cold water, the output of the TM-100 temperature sensor displayed on the recording channel should reach a stable level. Press the **Enter key** on the keyboard to mark the recording. Continue recording.
5. Measure the temperature of the warm water with a thermometer just before the TM-100 temperature sensor is placed in the beaker. Type **Calibration at <Warm Water Temperature>** on the **comment line**.
6. Continue recording as the tip of the temperature sensor is moved from the cold water to the warm water.
7. After about twenty seconds in the warm water, the output of the TM-100 temperature sensor displayed on the recording channel should reach a stable level. Press the **Enter key** on the keyboard to mark the recording.
8. Click **Stop** to halt the recording.
9. Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file (e.g. the **iWorx** or class folder). Click the **Save button** to save the file (as an **\*.iwd** file).
10. Compress the data from the calibration recording onto the same computer screen by clicking on the **Double Display Time icon** on the LabScribe **toolbar**. The output of the sensor at the two temperatures should be positioned on the same screen.



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11. Click the **2-Cursor icon** and position the first cursor on the plateau of the first temperature ( $\sim 10^{\circ}\text{C}$ ) and the second cursor on the plateau of the second temperature ( $\sim 40^{\circ}\text{C}$ ).
12. **Right-click** in the recording window of the temperature channel. Select the **Units...** function from the **right-click menu** to open the **Units Conversion dialogue window**.
  - Select **2 point cal** from the pull-down menu in the upper-left corner of the window.
  - Put a check mark in the box next to **Apply Units to All Blocks**.
  - Notice that the voltages from the positions of the cursors are automatically entered into the value equations.
  - Enter the **cold water temperature** in the corresponding box to the right of the voltage recorded when the sensor was in the cold water. Enter the **warm water temperature** in the corresponding box to the right of the voltage recorded when the sensor was in the warm water.
  - Enter the name of the units,  $^{\circ}\text{C}$ , in box below the temperatures. Click on the **OK button** in the upper right corner of the window to activate the unit conversion.

### Operating the TM-100 Temperature Sensor

- Once the TM-100 temperature sensor is calibrated, it can be immersed in aqueous solutions, including saline solutions, for a few hours. **The TM-100 is not designed for long-term immersion or chronic implantation.**
- The rugged Teflon jacket over the sensor can also be attached to a surface to be measured with tape or glue.
- The TM-100 is a low impedance ( $\sim 10\text{k}$ ) sensor, so its cable can be extended to nearly any length without signal degradation.

**Do not attempt to measure temperatures above  $125^{\circ}\text{C}$ . Temperatures above this limit will damage the sensor.**

### Care of the TM-100 Temperature Sensor

Since the jacket covering the element and the insulation on the wires are made Teflon and they may be cleaned with just about any cleaner.

### Experiments

Experiments that use the TM-100 can be found in the iWorx Physiology Lab Manual.



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