

Apparent Temperature (Heat Index) Determined Using the HS-100 Humidity Sensor and the TM-100 Temperature Sensor

Background

The moisture content of the atmosphere can significantly affect biological processes taking place in some organisms by altering the thermoregulation needed to maintain the optimal temperature range for reactions taking place in cells.

For example, the majority of energy consumed during dynamic exercise is transformed to heat, in a manner that is proportional to the metabolic rate of the subject and the amount of work performed. The additional heat generated during exercise can produce stress on the body unless the heat is exchanged between the body and environment. The primary way by which heat is dissipated from the body is sweating, which is known more scientifically as **evaporative cooling**.

During evaporative cooling, the water in sweat evaporates and carries away the heat generated by the body. If the rate of evaporation is optimal, the temperature of the body is regulated within the normal range. If the moisture content of the atmosphere is high, then the amount of evaporative cooling that can place on the skin is reduced, the amount of heat dissipated by the body is reduced, and the core temperature of the body increases. Conversely, when the relative humidity is low, evaporative cooling is high, and heat loss is high. In either situation, water must be consumed to prevent dehydration.

The moisture content of the atmosphere is commonly expressed as **relative humidity (RH)**, which is a ratio of the moisture content of the atmosphere to its saturated moisture content at the same temperature and pressure. The measurement of relative humidity has been made easy by the development of specialized polymer-based capacitive sensors like the HS-100 humidity used in this application.

Equations with multiple terms have been derived to relate the relative humidity and the dry air temperature to the **apparent temperature** sensed by the body. The apparent temperature is also known as the **heat index**, the **humiture**, or the **humidex**. A table (Table HS-100-1 on page 3) demonstrates the relationship between dry air temperature, relative humidity, and apparent temperature.

This article includes the necessary directions to incorporate the HS-100 humidity sensor into an existing lab exercise in which the relative humidity is a variable that affects the results of the experiment. Some of the measurements that can be influenced by relative humidity include: the effects of exercise on core temper-

ature of endoderms; the effect of apparent temperature on the behavior of ectoderms; and the effect of air moisture and temperature on water movement (transpiration) in plants.

Equipment Required

- PC Computer
- IWX/214 data acquisition unit
- USB cable
- IWX/214 power supply
- HS-100 Humidity sensor with extension cable
- TM-100 Temperature sensor with extension cable

Start the Software

- 1 Click the **Windows Start menu**, move the cursor to **Programs** and then to the **iWorx** folder and select **LabScribe**; or click on the **LabScribe icon** on the Desktop
- 2 When the program opens, select **Load Group** from the **Settings menu**.
- 3 From the dialog box, select **AddedLabs.iws**. Click **Load**.
- 4 Click on the **Settings menu** again and select the **Apparent Temperature** settings file.
- 5 After a short time, **LabScribe** will appear on the computer screen as configured by the **Apparent Temperature** settings. Open the **View menu** and select **Voltmeter** to display the current relative humidity and temperature levels on the **Main window**.

HS-100 Humidity Sensor and TM-100 Temperature Sensor Setup

- 1 Insert the male DIN8 connector on the end of the HS-100 humidity sensor (Figure HS-100-1 on page 1) into female DIN8 connector on the end of a DIN8 extension cable.



Figure HS-100-1: The HS-100 humidity sensor.

- 2 Insert the male DIN8 connector on the end of this DIN8 extension cable into Channel 3 of the IWX/214 (Figure HS-100-3 on page 2).
- 3 Insert the male DIN8 connector on the end of the TM-100 temperature probe (Figure HS-100-2 on page 2) into female DIN8 connector on the end of a DIN8 extension cable.

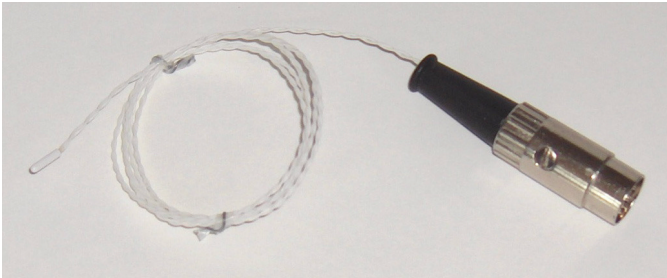


Figure HS-100-2: The TM-100 temperature sensor.

- 4 Insert the male DIN8 connector on the end of this DIN8 extension cable into Channel 4 of the IWX/214 (Figure HS-100-3 on page 2).



Figure HS-100-3: The HS-100 humidity sensor and the TM-100 temperature sensor connected to an IWX/214

Calibration of the HS-100 Humidity Sensor

- 1 The settings file, **Heat Index**, programs **LabScribe** to express the units on the Y-axis of the **Rel. Humidity channel** as **% RH**.
- 2 If the recording software needs to be programmed to convert the voltage recorded on the **Rel. Humidity channel** to the percent relative humidity:
 - Click on the **Start button** and record for about ten seconds. Click on the **Stop button**. Two cursors should appear on the **Main window**.
 - **Right-click** on the recording area of the **Rel. Humidity channel** to open the channel's **right-click menu**. Select **Units** from this menu and **Simple** from the submenu to open the **Units Conversion dialogue window**.
 - Pull down the menu in the upper left corner of the dialogue window and select **slope & offset**. Set the **slope** equal to **38.92**, the **offset** equal to **-42.017**, and the **Name** of the units on the Y-axis equal to **% RH**. Put a **check** in the box next to **Apply Units to All Blocks**. Click on the **OK button**.

- 3 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).

Calibration of the Temperature Probe

- 1 Make sure the temperature probe is plugged into Channel 4 of the iWorx unit. Click **Start** and begin recording.
- 2 Place the tip of the probe in cold water of a known temperature ($\sim 10^{\circ}\text{C}$). Record the voltage until the trace reaches a plateau; this usually takes about 20 seconds.
- 3 Without stopping the recording, move the tip of the probe to warm water of a known temperature ($\sim 40^{\circ}\text{C}$). Again, record the change in voltage until a plateau is reached. Click the **Stop** button.
- 4 Compress the image on the screen using the **Double Display Time** icon on the **LabScribe** toolbar until both plateau appear on the same screen.
- 5 Click the **2-Cursor** icon and position the first cursor on the plateau of the first (cold) temperature and the second cursor on the plateau of the second (warm) temperature.
- 6 **Right-click** the **Skin Temp (CH 4)** window. Select the units conversion function from the **right-click** menu. The voltages for the two positions of the cursors will have been entered in the voltage windows.
- 7 Change the values in the boxes to the right of the voltages to the temperatures used for calibration and change the units ($^{\circ}\text{C}$). Click **OK** and the units will change on the y-axis.
- 8 Select **Save** in the **File menu**.

Recording the Relative Humidity and Temperature

- 1 After completing the calibration of the humidity and temperature sensors, place the sensors in the environment where the relative humidity and temperature need to be measured.
- 2 Pull down the **View menu** on the **LabScribe Main window** and select **Voltmeter**. A digital readout of the relative humidity and temperature being measured will appear on the left side of the **Main window**.
- 3 Click on the **Start** to begin recording. Record until the output on both recording channels reaches a stable level.
- 4 Click **Stop** to halt the recording.
- 5 Select **Save** in the **File menu**.

Determination of the Apparent Temperature

- 1 Place the recording of the relative humidity and temperature on the **Main window**.
- 2 Use the **Display Time icons** in the **LabScribe** toolbar (Figure HS-100-4 on page 3) to adjust the width of data to fit in the **Main window**. The **Display Time** can also be adjusted on the **Channels page** of the **Preferences dialogue window**.

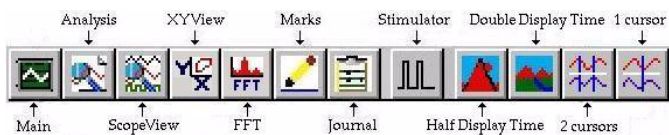


Figure HS-100-4: The LabScribe toolbar.

- 3 Click **AutoScale** on both channels displayed on the **Main window**.
- 4 Select the **1-cursor icon** on the LabScribe toolbar. Place the cursor on the stable output levels of each sensor recorded on its channel.

- 5 Read the values for the relative humidity and the temperature from the digital readouts on the left side of the recording window, or from the values on the upper right margin of each channel window.
- 6 Use the values for the temperature and relative humidity determined in Step 5 to determine the apparent temperature from Figure HS-100-1 on page 3.
- 7 Select the **Journal icon** on the LabScribe toolbar to open the **Journal**. Record the relative humidity and the temperatures in the **Journal** by typing the name and the value of each parameter in the window.
- 8 Select **Save** in the **File** menu.

Table HS-100-1: Apparent Temperatures or Heat Indices for Dry Air Temperatures and Percentages of Relative Humidity.

Dry Air Temp	Percent Relative Humidity																					
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	
135 57	120 49	126 52																				
130 54	117 47	122 50	131 55																			
125 52	111 44	116 47	123 51	131 55	141 61																	
120 49	107 42	111 44	116 47	123 51	130 54	139 59	148 64															
115 46	105 41	107 42	111 44	115 46	120 49	127 53	135 57	143 62	151 66													
110 43	99 37	102 39	105 41	108 42	112 44	117 47	123 51	130 54	137 58	143 62	150 66											
105 41	95 35	97 36	100 38	102 39	105 41	109 43	113 45	118 48	123 51	129 54	135 57	142 61	149 65									
100 38	91 33	93 34	95 35	97 36	99 37	101 38	104 40	107 42	110 43	115 46	120 49	126 52	132 56	138 59	144 62	150 66						
95 35	87 31	88 31	90 32	91 33	93 34	94 34	96 36	98 37	101 38	104 40	107 42	110 43	114 46	119 48	124 51	130 54	136 58	140 60	150 66			
90 32	83 28	84 29	85 30	86 30	87 31	88 31	90 32	91 33	93 34	95 35	96 36	98 37	100 38	102 39	106 41	109 43	113 45	117 47	122 50	126 52	131 55	
85 30	78 26	79 26	80 27	81 27	82 28	83 28	84 29	85 30	86 30	87 31	88 31	89 32	90 32	91 33	93 34	95 35	97 36	99 37	102 39	105 41	108 42	
80 27	73 23	74 23	75 24	76 24	77 25	77 25	78 26	79 26	79 26	80 27	81 27	81 27	82 28	83 28	84 29	85 30	86 30	87 31	88 31	89 32	90 32	
75 24	69 21	69 21	70 21	71 22	72 22	72 22	73 23	73 23	74 23	74 23	75 24	75 24	76 24	76 24	77 25	77 25	78 26	78 26	79 26	79 26	80 27	
70 21	64 18	64 18	65 18	65 18	66 19	66 19	67 19	67 19	68 19	68 20	69 21	69 21	70 21	70 21	70 21	70 21	71 22	71 22	71 22	71 22	72 22	

*Apparent temperatures in °Celsius are rounded up to the closest integer.

