How to Calibrate a Temperature Sensor

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Introduction

Field Calibration of EpiSensor temperature sensor nodes can be achieved using the EpiSensor Gateway. This functionality is supported both on the EpiSensor Gateway User Interface and in the EpiSensor Gateway API.

Recent versions of EpiSensor's TES, HTS, ZHT and ZTS product lines support this functionality.

Related Documents

Related installation and configuration documents are listed in the following table:

Document	Reference No.
Gateway User Guide	EPI-075-03
Gateway API User Guide	EPI-009-10

Supported Hardware

Field calibration functionality is supported on the following EpiSensor hardware products, with node firmware versions **2.72** and higher.

EpiSensor Product	SKU
Probe Temperature Sensor	TES-2X
Ambient Temperature & Humidity Sensor	TES-1X, HTS-1X, ZHT-1X
Environmental Sensor	ZTS-1X

Gateway software version **V04.01.00.01** or higher is required.

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Calibration Functionality Overview

Calibration constants are stored in non-volatile flash memory on the EpiSensor node. When a temperature reading is taken, the value is adjusted based on these constants before being sent onwards to the Gateway.

The calibration table in the node is populated during a calibration procedure that is initiated from the Gateway.

The start calibration mode, join a node to your EpiSensor Gateway, log into the Gateway's web interface, go to the "Nodes" link on the top menu, and click Action > More > Start Calibration.

After sending the Start Calibration command, go to Action > Settings to view the node settings page.
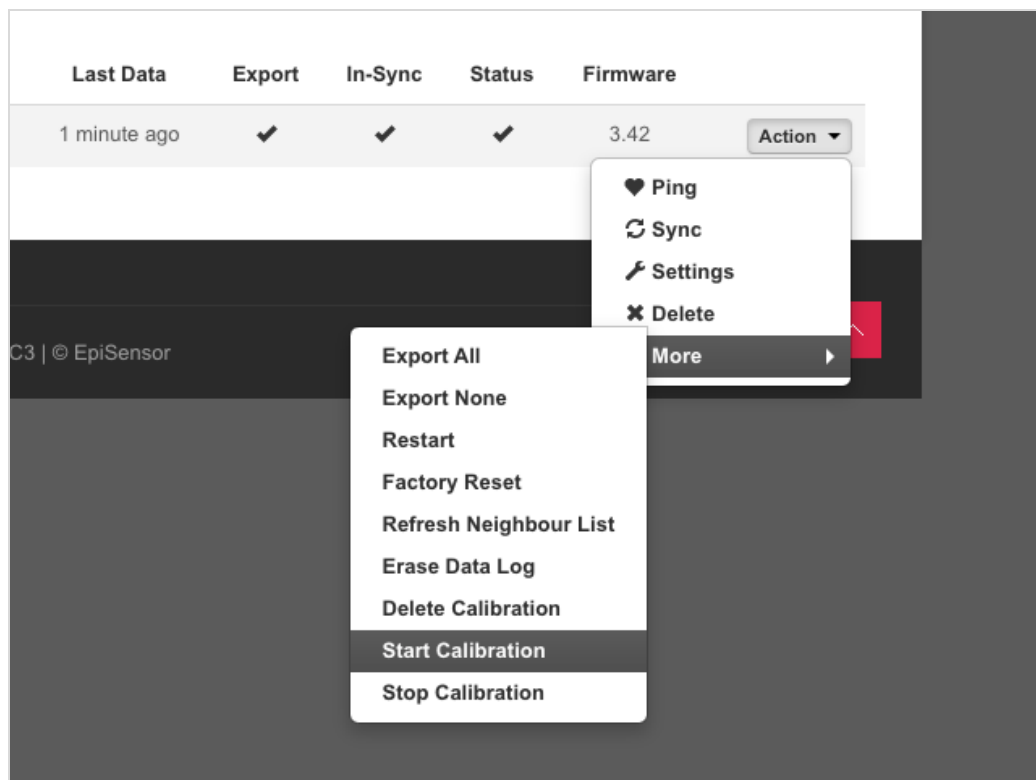
Note: If the node does not support calibration, the start / stop / delete calibration menu items will not be visible in the drop-down list. However if the node firmware has been upgraded, issuing a Sync command, could result in new menu items being added to this drop-down list for the upgraded node.

On the Node settings page, scroll down to the list of sensors, and click Action > Settings to go to the sensor settings page.

When the 'Start Calibration' command has been processed, the node will switch to Calibration Mode where it will produce data approximately every 5 seconds, which will be listed in a "Sensor Calibration Points" table on the sensor settings page, the the most recent data at the top of the table. The purpose of this data view is to show the user calibrating the sensor when the measured values have settled.

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When the measured values have stabilized, use the "Set Sensor Value" input to add a calibration point to the nodes calibration table.

Important
➔   The value entered in the "Set Sensor Value" input should be the <u>expected temperature reading</u>, not the <u>offset</u>. The offset will be calculated by the node.

If for example a value of 27.0 $^\circ$C is entered in 'set sensor value' input and the most recent measurement is 26.97 $^\circ$C (as shown in the screenshot above) a Calibration Offset of 0.03 $^\circ$C will be calculated and stored in the node for that sensor.

What is a typical lab and field calibration setup?

If lab calibration is required, which may be needed for pharmaceutical or other business critical monitoring, the EpiSensor nodes can be sent to a laboratory with the relevant industry accreditation (e.g. UKAS) for temperature calibration.

Depending on the application, you will need to agree a calibration approach with the lab to define the acceptable error for pass/fail, the number of calibration points, the temperature range, and the test setup / procedure.

For field calibration, it's possible to follow a similar procedure with portable instruments or if the application requires calibration around 0 $^\circ$C, and ice-bath in a Thermos flask can provide an accurate and stable reference temperature for a single-point calibration.

How many calibration points can be stored for each sensor?

There are 10 calibration points in each calibration table and there is <u>one</u> calibration table <u>per sensor</u>. For example, a TES-21 (single channel probe temperature sensor) has one calibration table and a TES-22 (dual channel probe temperature sensor) has two calibration tables.

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What does the 10-point calibration table look like?

During calibration, the probe of the temperature sensor is typically inserted into a lab-calibrated instrument, which provides an accurate reference temperature.

Actual Temperature	-20℃	-15℃	-10℃	-5℃	-0℃	5℃	10℃	15℃	20℃	25℃
Measured Value	-20.2℃	-15.1℃	-10.4℃	-4.8℃	-0.1℃	4.9℃	10.2℃	15.3℃	20.4℃	25.3℃
Calibration Offset	+0.2℃	+0.1℃	+0.4℃	-0.2℃	+0.1℃	+0.1℃	-0.2℃	-0.3℃	-0.4℃	-0.3℃

What happens if more than 10 calibration points are added?

If more than 10 calibration points are added, the new entry is inserted at the appropriate point in the table, and either a lower or higher calibration value will be 'pushed out' of the table.

If the new entry is for a temperature higher than the highest existing value, it simply replaces the existing 10th position in the table.

How is interpolation handled for one or many calibration points?

When there is only one entry in the calibration table, every temperature reading is offset by the 'Calibration Offset' (which is the difference measured between the 'Actual Temperature' and 'Measured Value' during calibration).

When there are multiple entries in the table, the first and last entries in the table will be used as offsets for all values above and below those entries. Values between the calibration points are calculated on a slope between the two calibration points either side.

Example calculation of the calibration offset applied to a measured temperature of -13.2℃ with calibration points at -15℃ and -10℃:

Actual Temperature	-20℃	-15℃	?	-10℃
Measured Value	-20.2℃	-15.1℃	-13.2℃	-10.4℃
Calibration Offset	+0.2℃	+0.1℃	**+0.22℃**	+0.4℃

(Calibration offset at -10°C) - (Calibration offset at -15°C) = 0.4°C - 0.1°C = **0.3**$^{\circ}$**C**

(Measured value -13.2°C) - (Measured value -15.1°C) / [(Measured value -10.4°C) - (Measured value at -15.1°C)] = **0.404**

Calibration offset applied at -13.2°C = Calibration offset at -15°C + (**0.3**$^{\circ}$**C** * **0.404**) = **+0.22**$^{\circ}$**C**

Will the calibration be erased during node software upgrades or factory resets?

Over-The-Air upgrades and Factory Resets do <u>not</u> affect the calibration tables. However, if a node is reprogrammed with a "Mass Erase" option, then the calibration table is deleted. During EpiSensor's manufacturing process, Nodes are programmed with the "Mass Erase" option as the default. A special instruction is required when reprogramming to skip the "Mass Erase" step. If you are returning nodes to EpiSensor for refurbishment, battery replacement or firmware upgrade, please specify if the calibration table needs to be maintained - by default, the calibration table will be erased.

When will it expire?

Calibration Mode lasts for 5 minutes. To extend the time, simply repeat the procedure by sending a "Start Calibration" command from the Nodes page on the Gateway's web interface.

Can the existing calibration constants be queried once set?

Yes, but this feature is not available through the Gateway's web interface or API. For information on querying a sensor's existing calibration table, or for backup and restore of a calibration table, please contact EpiSensor support.

Calibrating from the Gateway API

If a node supports calibration, the calibration commands it accepts will be listed in the command list property. The currently available calibration related commands are SET_CALIBRATION and DELETE_CALIBRATION.

SET_CALIBRATION can be used to start and stop calibration mode on the node. The SET_CALIBRATION command takes a parameter to indicate whether calibration is to be started or stopped. DELETE_CALIBRATION is used to delete the existing calibration table on the node.

These commands may be issued using the EpiSensor Gateway API or the EpiSensor Gateway User Interface. From the Gateway API, the calibration commands may be issued by posting to the following endpoints:

Command	Description	Endpoint Example
startCalibration	Start calibration mode on the node.	/api/nodes/<node_serial>/command/startCalibration
stopCalibration	Stop calibration mode on the node.	/api/nodes/<node_serial>/command/stopCalibration
deleteCalibration	Delete the calibration table on the node (and stored calibration points on the gateway)	/api/nodes/<node_serial>/command/deleteCalibration

In addition, the calibration data points received per sensor per node may be retrieved by a GET call to the following endpoint:

/api/nodes/<node_serial>/sensors/<sensor_id>/calibration/data