Object Temperature Calculation By Linear Interpolation Based On 3D Data Array

Data Array

The data array is determined by sensor output voltages measured at different object and ambient temperatures. It is preferred to keep a temperature constant while varying the other temperature.
It results in the following functions:

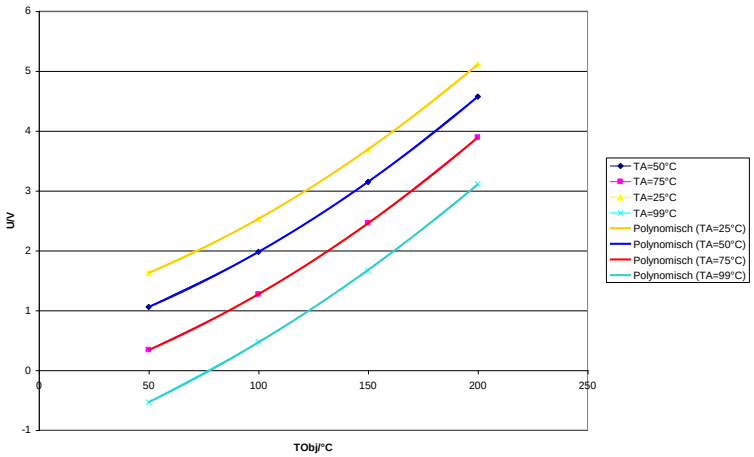

Figure 1: Sensor output voltage at different object temperatures (parameter: ambient temperature)

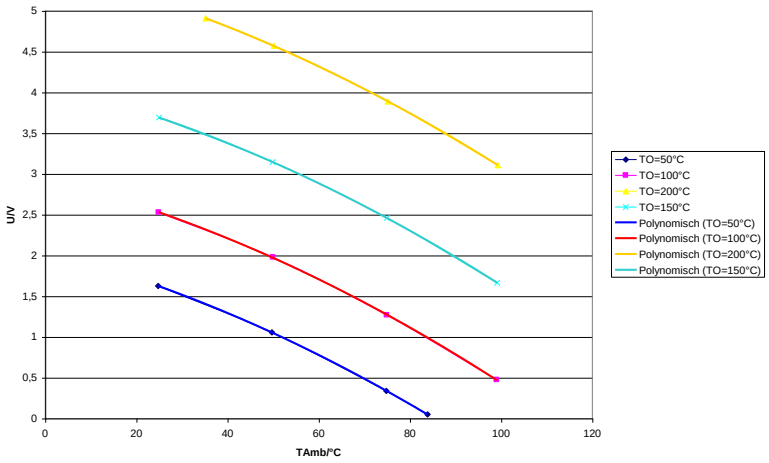

Figure 2: Sensor output voltage at different ambient temperatures (parameter: object temperature)

Using polynomial regression the data array can be defined with the measuring results.

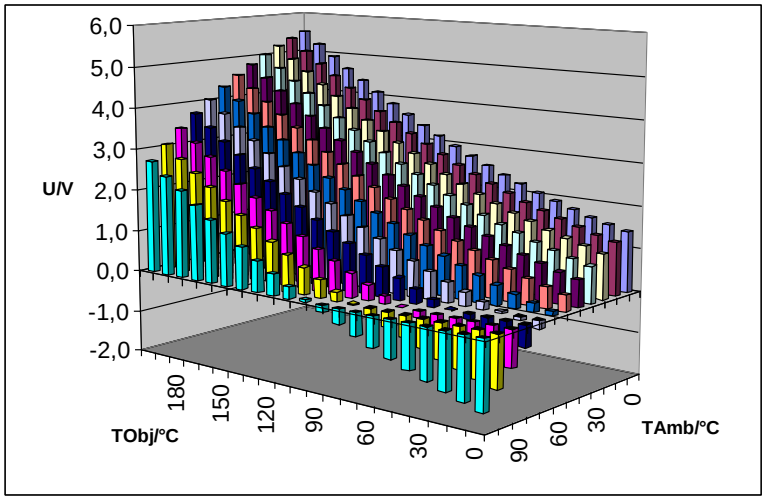

Figure 3: Sensor output voltage in relation to ambient and object temperature

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Calculation Of The Object Temperature Derived From 4 Sampling Points Using Linear Interpolation

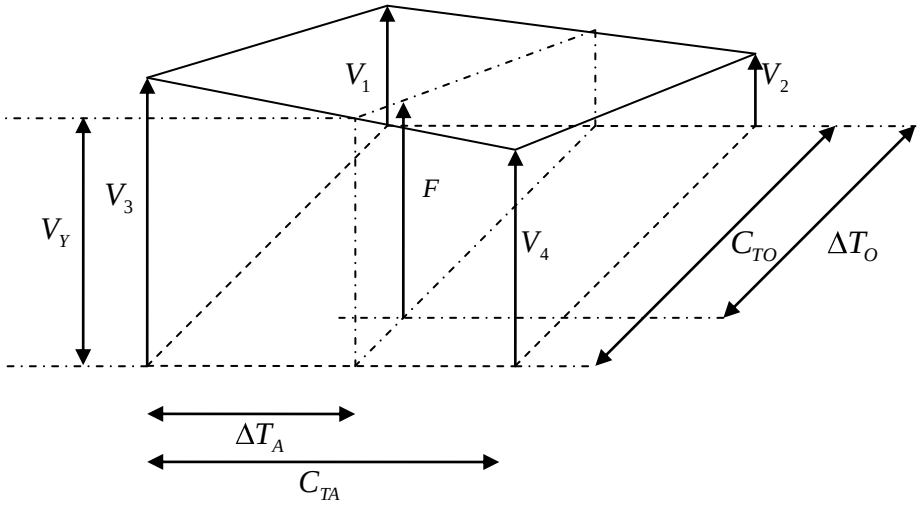

Figure 4: Sketch to define the object temperature on 4 sampling points of a 3D-array

Selection of 4 sampling points (sensor voltages) V_1, V_2, V_3 and V_4 can be done according to following principle :

Measurement of the thermopile voltage and temperature reference signal. Determination of the actual sensor temperature derived from the measured temperature reference signal. The calculated sensor temperature is used to find the bordering ambient temperature rows in the data array. Now the sampling points for the interpolation can be defined, if one of the array data isn't the value looked for accidentally. The values of the selected rows are searched for the largest value less than the measured thermopile voltage.
The search starts at the lowest object temperature row in the two selected ambient temperature rows. The following equation helps to find the right points e.g. by a software program. The right sampling points have been selected, if the condition "V_Y > *F" is complied*. „F" stands for the measured thermopile voltage.

$$V_Y = \frac{V_4 - V_3}{C_{TA}} \Delta T_A + V_3$$

V_1, V_2, V_3, V_4 -> Sampling points from the data array

F -> Thermopile voltage

C_{TO} -> Step range of the object temperature axis (temperature difference between 2 rows)

C_{TA} -> Step range of the ambient temperature axis

ΔT_A -> Difference between sensor temperature and axis temperature related to the sampling points

ΔT_O -> Difference between calculated object temperature and axis temperature related to the sampling points

The object temperature can be calculated by linear interpolation using following equation :

$$\frac{\Delta T_O}{C_{TO}} = \frac{F - \left(\frac{\Delta T_A}{C_{TA}} * (V_1 - V_2) + V_2 \right)}{\left(\frac{\Delta T_A}{C_{TA}} * (V_3 - V_4) + V_4 \right) - \left(\frac{\Delta T_A}{C_{TA}} * (V_1 - V_2) + V_2 \right)}$$

The object temperature is determined by the temperature difference ΔT_O and the axis temperature related to the sampling points.