Ideal and real transfer function of the SF-4 and SF-5 sensors

Method of sap flow measurement realized in both SF-4 and SF-5 sensors is illustrated in the Fig. 1. below. A small heater warms a certain part of stem up. A pair of miniature temperature probes is located equidistantly from the heater. The output voltage of the sensor is proportional to temperature difference between probes. In case of no flow, temperature distribution along the stem is symmetrical. It is illustrated by green curve in Fig. 1. Temperatures T1 and T2 are equal so that T2-T1=0.

When sap is moving along then stem, it brings more heat to the upstream probe and less to the downstream one. As the result of this, temperature T2 becomes higher than T1 that is illustrated by red curve in Fig. 1.

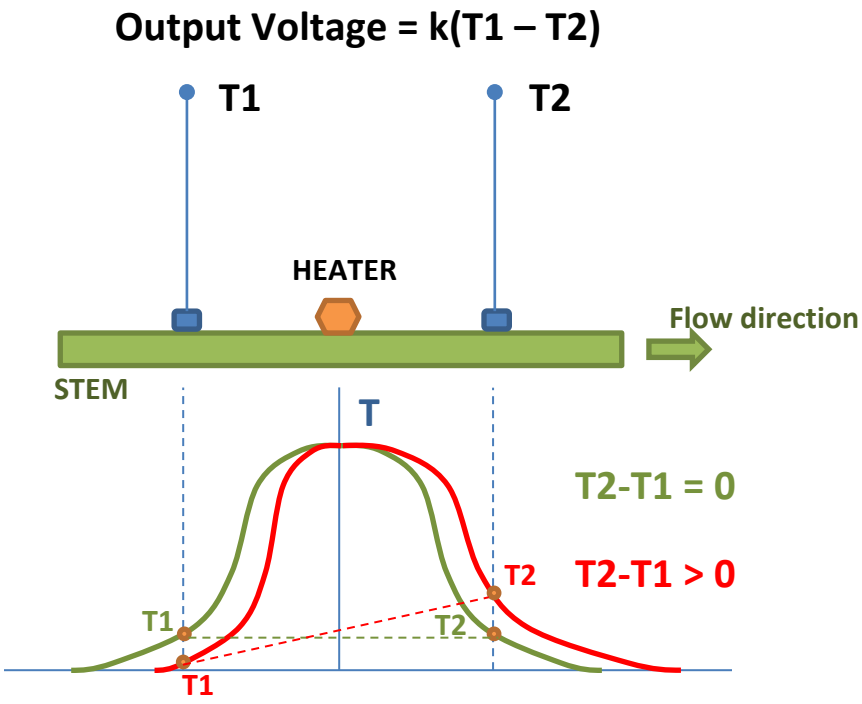

Fig. 1.

The temperature difference (T2-T1) is proportional to sap flow rate in a certain extent. On a stem simulator, proportionality was observed in both sap flow directions from 0 to 12 ml/h approximately. Such technique enables monitoring of low sap flow rates in small stems and petioles.

At designing the appropriate sensors, two aspects were taken into account. At first, sap flow may be actually bidirectional in some plant organs, in fruit stalks for instance. Second, geometry and properties of both sensor and stem are not ideal. Therefore, the initial temperature distribution may be asymmetrical so that the starting value of (T2-T1) may differ from zero significantly, also to negative value. However, a unipolar amplifier is not able to operate with negative input signals. To solve the

problem, the amplifier has a zero offset equal to 0.5 V. In other words, if (T2-T1=0), the actual output voltage is 0.5 V. The ideal transfer function of the SF-4/5 sensor is shown in Fig. 2 below.

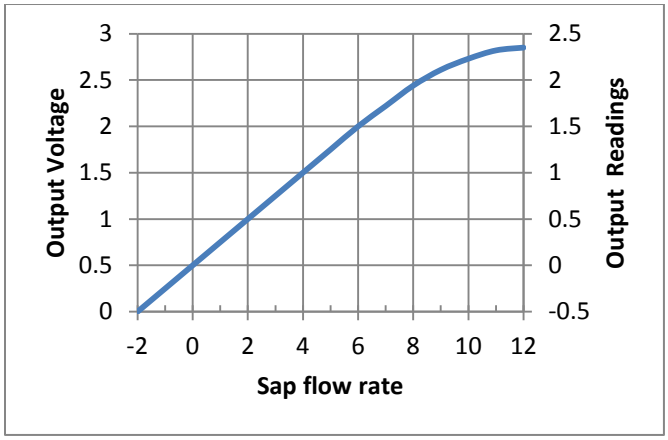

Fig. 2. Ideal transfer function of the SF-4 and SF-5 senors.

Because of the above-mentioned non-uniformity of stem, the 'zero' value of (T2-T1) may not be equal to zero, and, moreover, may have either positive or negative shift. The probable negative shift of -0.2 V is illustrated by red curve in the Fig. 3 below.

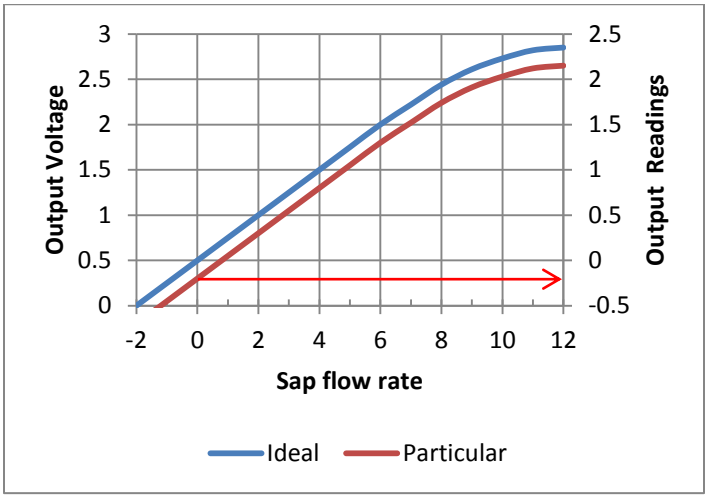

Fig. 3. Example of a particular transfer function of the sensor.

In this example, the sensor may show negative sap flow rate at zero flow and at positive flow rates below 1 ml/h.

To conclude with, we may say that the output value of the SF-4/5 sensors is meaningless. The sensor was designed for monitoring diurnal variations of sap flow rather than for evaluation of sap flow or comparison of flow rates between plants. Please find more details in the document named as 'Interpretation of SFI'.