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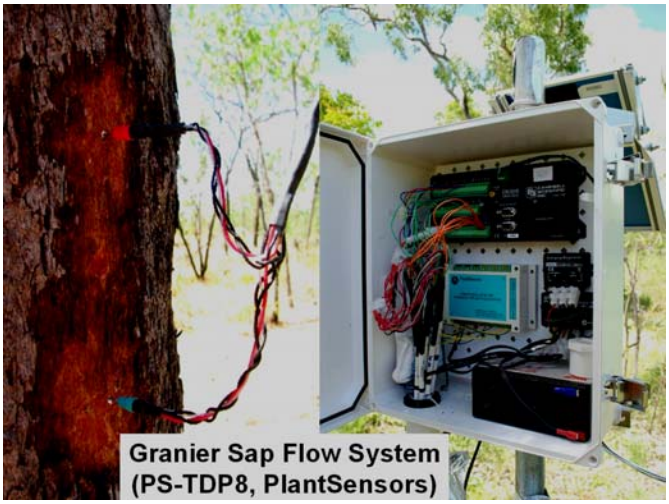
PlantSensors PS-TDP8 Sap Flow System

System: **Granier sap flow system**
Model: **PS-TDP8**
Configuration: **CR1000 datalogger + 8 sensors**
Producer: **PlantSensors (Australia)**


Granier Sap Flow System
(PS-TDP8, PlantSensors)

Granier sap flow system is one of the most popular methods for measurement of whole-tree sap flow (transpiration). Since 1994, PlantSensors has provided researchers worldwide with the genuine type of the Granier sensors and complete sap flow system.

Granier sap flow probe, also known as thermal dissipation probe (TDP), was invented by French scientist Andre Granier (1985, INRA, France). Granier system is now widely used in woody plant ecophysiological and hydrological studies worldwide, thanks to its simplicity and versatility. Since 2006, more than half of the sap flow studies on woody plants published worldwide have employed the Granier system (ISI Web of knowledge).

PlantSensors' Granier sensors are made by following strictly Granier's original design, therefore perfectly fit the calibration published by Granier in 1985. **PlantSensors guarantees that you will use the same system (sensor probes, power regulators and loggers in terms of quality and configuration) as Granier himself uses. PS-TDP is the only true Granier system available in the market.**

PlantSensors endeavors to provide you with quality and genuine Granier sap flow system, at a very competitive price. Our Granier sensor probes are made according to Granier's original design, so do our power regulators at constant current. This is different from all other TDP system suppliers. Therefore, Granier's original calibration equation can be readily used to convert the signal from our system into sap flux density. Our customers include national and international research agencies (CSIRO, CIRAD, Oak Ridge National lab), universities and state research agencies in Australia, France, China, South Africa, Israel and USA. Results from many studies in which our sensors and sap flow systems were used, have been published in international journals.

The great advantage of the original Granier's sap flow system is its simplicity and robustness. We are keen to keep the system as transparent as possible to make it easily understandable by users.

High quality of our sap flow system is assured by using 1) fully water-tight, genuine Granier sensor probes; 2) the most reliable logger available on the market (Campbell Scientific CR1000), and 3) military-grade key component for the power regulator PS-PS12 at constant current. Therefore, the PlantSensors' Granier system is inherently highly reliable. The failure rate is extremely low, if it does fail, most faults could be easily identified and rectified by the users themselves with the help of the user-friendly manual and readily available expert support.

System set up and theory

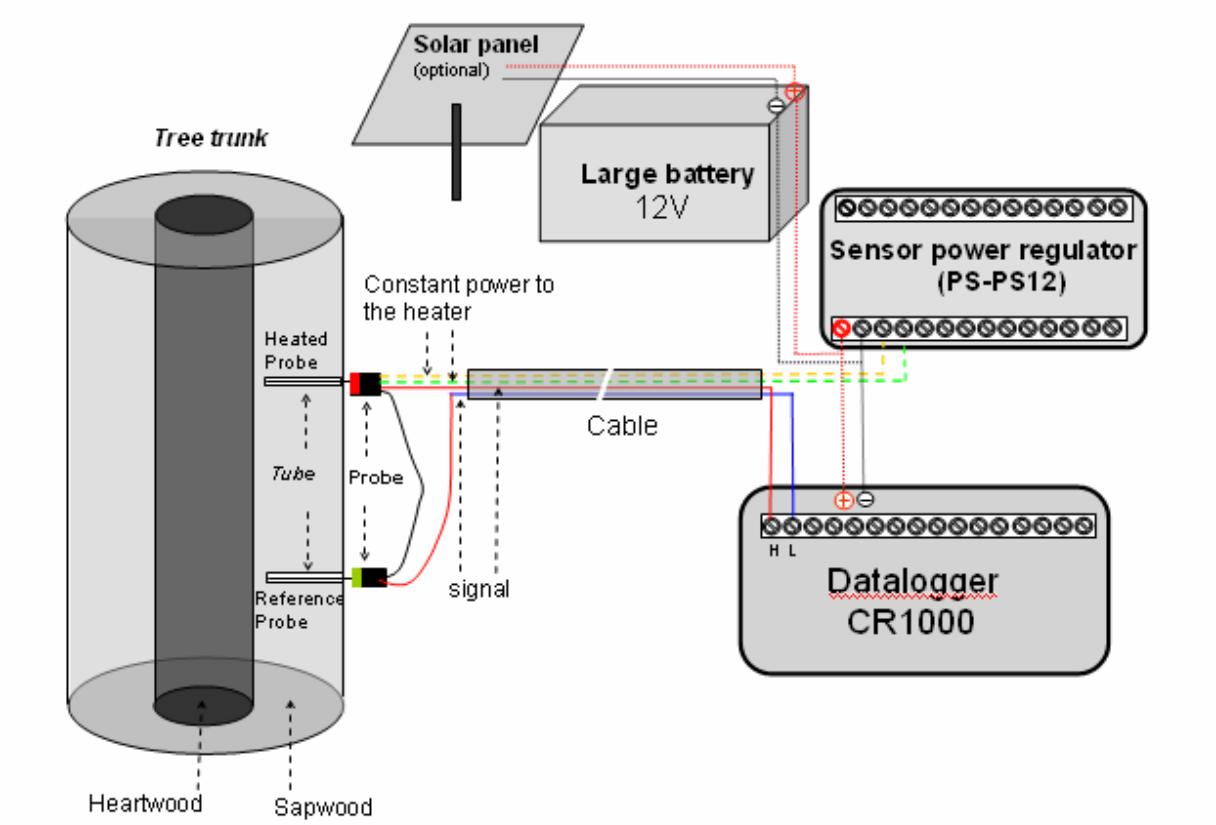
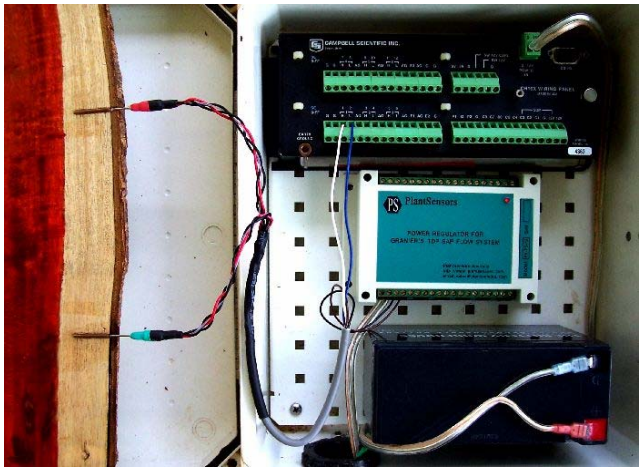


Figure 1. Setup of PlantSensors' PS-TDP8 Granier sap flow system.

Granier's sap flow system stands for its simplicity and reliability. Figure 1 shows the installation of the sensor in a tree trunk and the set-up of the PS-TDP sap flow-system. The complete PS-TDP8 Granier system includes sensor probes, heat-averaging brass tubes, metal shielded cable containing 4 cores, power regulator, datalogger and external battery or solar panel.

The Granier sensor consists of two physically and structurally identical sensor probes (Fig. 1). Each probe consists of a heating element (which also represents the effective sensing part of the probe, typically 20 mm long), wound around a steel needle containing a T-type fine-wire thermocouple (copper-constantan), with the thermocouple tip located in the middle of the heating element. The constantan ends of the two thermocouples are soldered together to measure the temperature difference between the two probes at the ends of the copper wires. The two probes are typically inserted radially

into the stem 10-15 cm apart, in pre-inserted heat-distributing tubes made of copper/brass. The downstream (upper) probe is continuously heated by a constant power (0.2W, at a constant current) while the upstream (lower) probe is left unheated to measure the ambient temperature of the wood tissue and acts as a reference probe. Temperature difference between the two probes is influenced by the heat dissipation effect of sap flow in the vicinity of the heated probe. The temperature difference is highly related to the sap flux density and their relationship is found to be independent of tree species or wood anatomy (Granier, 1985). **Therefore, in principle, the sensors can be used on any tree species without need for re-calibration.**



A complete set of PlantSensors PS-TDP8 sap flow measurement system includes:

- PlantSensors' standard Granier TDP sensor **(PS-GS),**
- PlantSensors' Power Regulator for sensors **(PS-PS12)**,
- Campbell Scientific CR1000 datalogger **(PS-CR1000)**,
- Metal shielded, 4-core-communication cables
- Large marine battery and/or solar panels for the power regulator **(PS-PS12)**

Key features

1. **Genuine type of Granier sensor probes** (heating wire wounded around a needle, this is different from other producer's line heater);
2. Campbell Scientific's CR1000 datalogger is a general purpose logger and the mostly used logger for environmental research in the world. It can directly measure 8 sap flow sensors or a mixture of Granier sensors and other environmental sensors. Its analogue channels can be expanded using a multiplexer.
3. Both saved data and program in the datalogger will not be lost at events of external power failure, providing increased data security.
4. **The sensors are powered by the most energy efficient power regulator (PS-PS12)** which supplies the sensors **with a constant current.** This design avoids the problem of fluctuation in electrical resistance of the cables and other parts of the sap flow system to ensure the constant power/heating output of the sensor probe, **thus best quality signals**.
5. The probe fits tightly into brass tubes, which ensures stable and correct signals. Probes can be retrieved while the brass tubes left in the stem.
6. Long-term (1-2 years) maintenance-free measurements can be achieved using large solar panels. For fast growing trees, the probes may need to be repositioned/re-installed every year.
7. Logger and PS-PS12 Power Regulator share the same power source which provide on-going monitoring of the performance of the power source to the sensors, thus improve our ability to interpret sap flow signal values.
8. The PS-TDP8 system is very robust and reliable with minimum soldering points and no plugs, which facilitates user's understanding, installation and testing of the system. The

system is transparent to the users, therefore, it is much easy for fault diagnosis and trouble-shooting.

Specifications

- **Standard sensor probes**: total length of the needle is 33mm, effective sensing part of 20mm long, wounded heating wire, 0.2 W;
- **Campbell Scientific CR1000 data logger**: 4MB memory, directly measures 8 sensors, expandable using multiplexers.
- **Power regulator for sensor probe (PS-PS12):** 12VDC input, constant 130mA output, can provide constant power to up to 12 TDP sensors**.**
- **Sensor power consumption**: 390mA (measuring 7-9 sensors simultaneously). 260mA for 6 sensors, or 130mA for 3 sensors.

System expansion and configuration

We can expand the number of the sensors measured by a datalogger using a multiplexer to up to 36 sensors or more. However, for measurements in the field over a large area, in particularly when involving multiple treatments, we recommend to use several standalone PS-TDP8 systems. This setup will substantially increase the data security of the project, and also the flexibility of the project for managing changes, such as measuring different trees or measuring other environmental sensors. This setup also minimise the total length of the cables deployed and makes installation and transport of the equipment more convenient. Short cables in the field always means less troubles caused by animals or physical (fire, wind) damages, thus better data safety and security.

References (please visit www.plantsensors.com for more references)

Lu P, Urban L, Zhao P. 2004. Granier's thermal dissipation probe (TDP) method for measuring sap flow in trees: theory and practice. Acta Botanica Sinica. 46, 631-646. SCI citation: 41 (Dec 2010). (This review paper can be downloaded from www.plantsensors.com).

Granier, A. 1985. Une nouvelle mehode pour la mesure du flux de seve brute dans le tronc des arbres. Ann. Sci. For. 42:193-200.

Granier, A. 1987. Evaluation of transpiration in a Douglas-fir stand by means of sap flow measurements. Tree Physiology. 3:309-320.

Technical Support

All enquiries will be answered within 48 hours, and mostly within 24 hours.

Support available in English, French and Chinese languages.