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PlantSensors PS-TDP8 Sap Flow System

Product: PlantSensors PS-TDP8 Sap Flow System

Method: Authentic Granier Sap Flow Method

Model: PS-TDP8

Producer: PlantSensors (Australia)

Configuration: CR1000X datalogger + 8 sensors

The Granier sap flow probe, also known as the thermal dissipation probe (TDP), was invented by French scientist André Granier (1985, INRA, France).

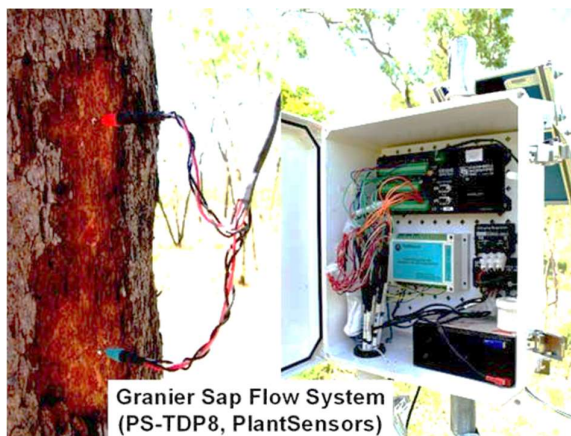
The Granier sap flow system is the most used method for measuring whole-tree sap flow (transpiration) thanks to its simplicity and versatility. Since 2006, more than half of the sap flow studies on woody plants published worldwide have employed the Granier system (ISI Web of Knowledge).

Since 1994, PlantSensors has provided researchers worldwide with **the genuine type of Granier sensors** and a complete sap flow system.

Our customers include **national and international research agencies** and universities in 27 countries/regions across 6 continents: USA (incl. Oak Ridge, Los Alamos, Lawrence Berkeley and Pacific Northwest National Labs, Smithsonian Institution), UK (incl. Imperial College, London), France (incl. CNRS, INRA, CIRAD), Sweden, Israel, Spain, Belgium, Greece, Reunion, China, Hong Kong, Taiwan, Australia (incl. CSIRO, University of Queensland, SARDI), Singapore, Indonesia, Malaysia, South Africa, Nigeria, Brazil, Chile, Panama, Guadeloupe, French Guiana, Puerto Rico, Republic of Congo, Rwanda and Morocco.

PlantSensors' Granier sensors are made by following strictly Granier's original design and, therefore perfectly fit with 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 design, configuration, and quality) as Granier himself uses.** Granier himself and his colleagues at INRA-Nancy use our products too. PS-TDP is the only true Granier system available in the market. We also provide you with expert advice from the time you request a quote. From the very first contact with us, you will see the difference in our customer service from other businesses.

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, and so is our power supply unit at constant current (PS-PS12). This is different from all other TDP system suppliers. Therefore, Granier's original calibration equation can readily convert the signal



from our system into sap flux density.

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-proof, genuine Granier sensor probes; 2) the most reliable logger available on the market (Campbell Scientific CR1000X), and 3) military-grade key components for the PS-PS12 at constant current. Therefore, the PlantSensors' Granier system is the most robust and reliable in the field. The failure rate is extremely low (no report of failure during the warranty period), if it does fail, most faults could be easily identified (mostly due to animals and tree reaction/growth itself) and rectified by the users themselves with the readily available expert support at PlantSensors. So the downtime will be low. PlantSensors is proud of the quality of our system we had no warranty claim ever with tens of thousands of units sold worldwide and used in projects from the Gobi desert to the Amazon rainforest.

Genuine 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, a metal shielded cable containing 4 cores, a power supply unit PS-PS12, a datalogger, and an external battery or solar panel.

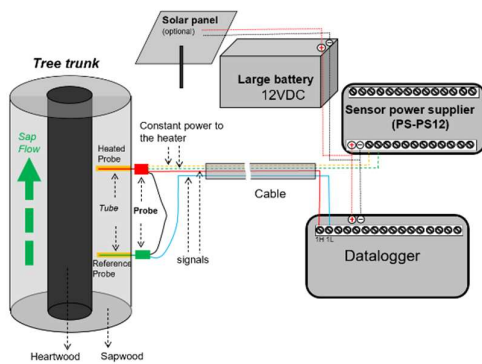
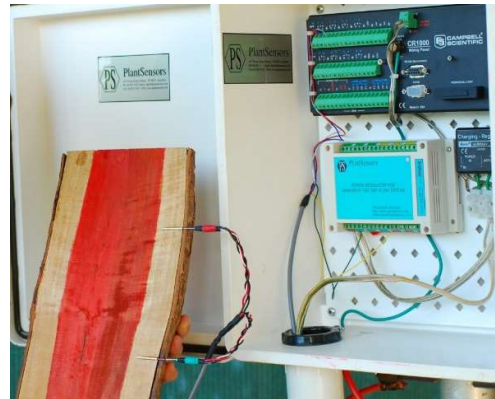


Fig. 1. Setup of PS-TDP Granier sap flow system (PlantSensors, Australia).



Our 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 allow measurement of the temperature difference between the two probes from the ends of the two copper wires.

The two probes are typically inserted radially into the stem 10-15 cm apart, in pre-inserted heat-averaging tubes made of copper or 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. The 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; Lu et al. 2004). **Therefore, in principle, the sensors can be used on any woody species without**

the need for re-calibration. It can also be used on non-woody species such as bananas.

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

- PlantSensors' standard Granier TDP sensor (**PS-GP3.5x2**) or other lengths
- PlantSensors' Power supply unit for sensors (**PS-PS12**)
- Campbell Scientific CR1000X datalogger (**PS-CR1000X**)
- Metal shielded, 4-core-communication cables (**PS-cable**)
- Large truck/marine battery (12V) and/or solar panels (**users supply**)

Key features

1. **Genuine type of Granier sensor probes** (heating wire wound around a needle, this is different from other producers' line heaters). Probes of various lengths of 3.5-10.0cm are available.
2. Campbell Scientific's CR1000X 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 analog 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 and high-precision power supply unit (PS-PS12) which supplies the sensors with a constant current.** This design eliminates the problem of natural 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 producing the best quality signals that are true to the plant's physiology.**
5. The probe fits right into the specially made brass tubes, which ensures stable and quality signals. **Sensors are generally considered to be single-use. Probes may be retrieved safely under some limited situations, but not always. If cannot be retrieved effortlessly, then one shall not attempt to retrieve it. Permanent damage will destroy the probe. Damage due to retrieval is not covered by the warranty.**
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. This configuration provides ongoing monitoring of the performance of the power source to the sensors, thus improving our ability to monitor the performance of the system and interpret recorded sap flow signals.
8. The PS-TDP8 system is very robust and reliable with minimum soldering points and no plugs, which facilitates the user's understanding, installation, and testing of the system. The system is transparent to the users, therefore, it is much easier for fault diagnosis and troubleshooting.

Technical Specifications

- **Standard Granier sensors (Model: PS-GP3.5x2)**
 - Type: Original Granier design (Dual needles, external constant heating)
 - Size: The total length of the needle is 35mm, with a 20mm effective sensing part
 - Heating: external, with wound heating wire, 0.2 W
 - Signal Output: 100-800 μ VDC, conditioned by constant 130mA, supplied by PS-PS12 high precision power supply unit
 - Cable: 30 cm long lead with 4 cores, extendable to 50 m (refer to Appendix 3).

Further information on PS-PS12 Precision Power Supply Unit at Constant Current). It is preferable to keep the cable to be <20m for better data safety. Long cables need to change the system configuration, contact PlantSensors.

- Logger requirement: 1 Differential channel (analog measurement for Voltage)
 - Tree size: with diameter >4 cm
 - Needle spacing: 10-15 cm, no need to be strictly a fixed spacing
 - Needle alignment: no need to be strictly vertical
- **High precision power supply unit for sensor probes (Model: PS-PS12):**
 - Type: heating at a Constant current
 - Input: 12V DC
 - Output: constant current at 130mA (as long as the total resistance of the 3 sensors (including their extension cables) for each module is <= 62 Ohms)
 - Capacity: can provide constant power to up to 12 PS-GP3.5x2 sensors
 - Size: 14.5x9.0x4 cm, 340 g
 - Power consumption: 390mA (when measuring 7-9 sensors simultaneously). 260mA for 4-6 sensors, or 130mA for 1-3 sensors, or 520mA for 10-12 sensors

System expansion and configuration

We can expand the number of 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, particularly when involving multiple treatments, we recommend using several standalone PS-TDP8 systems. This setup will substantially increase the data safety 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 minimizes the total length of the cables deployed and makes installing and transporting the equipment more convenient. Short cables in the field always mean less trouble caused by animals or physical (fire, wind) damages, thus better data safety and security.

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

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

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. **(Free download from www.plantsensors.com).**

Technical Support

In-house expert: Dr. Ping Lu, ex-colleague and PhD student of the Inventor Dr. Granier. All inquiries will be answered within 48 hours, and mostly within 24 hours.

Support languages: available in English, French, and Chinese.

(Picture on the right showing Dr. Jeff Warren installing PS-TDP sap flow system at the SPRUCE project site of the Oak Ridge National Lab, USA).

