Hukseflux
Thermal Sensors

Digital pyranometer grounding / safety

Good installation contributes to safety and reliability

This note explains how to properly install and ground digital pyranometers and how this contributes to personnel- and system safety as well as to measurement reliability. The explanation may be applied to Hukseflux SR-D digital pyranometers: i.e. models SR20-D, SR22-D, SR25-D, SR30-D, SR15-D, SR05-D.

- a pyranometer body conducts electricity and is connected to its cable shield
- in traditional applications we recommend to mount pyranometers on a metal mast that also is used to ground to the readout equipment connected to it
- safety risks associated with pyranometer installation, in particular when used in the PV industry, are larger than generally expected
- users should not mount pyranometers onto or close to high voltage / high current sources such as PV systems

Executive summary

Introduction

Pyranometers must be properly installed and grounded. This is necessary in order to:

- avoid safety risks for personnel, for example during cleaning and replacement of pyranometers or during connection of equipment to its wiring or cable shield.
- avoid temporary failure or permanent damage to the pyranometer and the equipment connected to it
- avoid unnecessary signal interruptions or complete loss of signal.

Safety risks associated with pyranometer installation, in particular when used in the PV industry, are larger than generally expected. The pyranometer metal body is electrically conductive and electrically connected to the cable shield, therefore:

- do not let the pyranometer share its mounting frame with high-power high-voltage sources such as large PV arrays.

Although not mentioned in the text, this note is also applicable to digital pyrheliometers.

Warnings

Pyranometer body and cable shield are interconnected electrical conductors. Do not use pyranometers physically or electrically connected to a high-voltage source or its mounting structure, such as a PV Array mounting frame. Pyranometer body and cable shield should not be connected to different grounds.

SR–D digital pyranometers must be used within rated operating conditions, and installed taking proper precautions.

Only use original Hukseflux-supplied signal cables. Preferably use short 5 m cabling. When using standard Hukseflux cabling, do not use cables longer than 40 m.

Digital pyranometer electrical schematics

The SR-D body is made of aluminium, which is electrically conducting. The body is connected to the cable shield via the connector. The body is usually mounted on a metal frame. We assume that this frame is grounded and that the pyranometer body is electrically connected to this metal frame. This frame acts as *ground at the point of pyranometer installation* or *"pyranometer body ground"*.
The electrical connection of the body to the mounting structure is made through the bolts connecting the pyranometer to the mounting structure.

In the preferred configuration, using short cables in the order of 5 to 10 m, the body is mounted on a metal frame which then essentially is the same ground as the ground of the shield at the cable end.
The cable shield is then left unconnected.
Use cable ties to fix the pyranometer cable to the mounting structure or use a metal conduit so that the impact of electromagnetic disturbances is minimised.

The *digital signal ground* (also called *signal common*) is electrically insulated from the pyranometer body or shield. The *power supply ground* is usually connected to the digital signal ground. The difference between digital signal ground and pyranometer body ground must be kept within rated operating conditions. In more detail, the digital signal ground and pyranometer body ground are connected by the pyranometer internal electronic circuit to improve immunity to external interference and overall sensor signal quality.

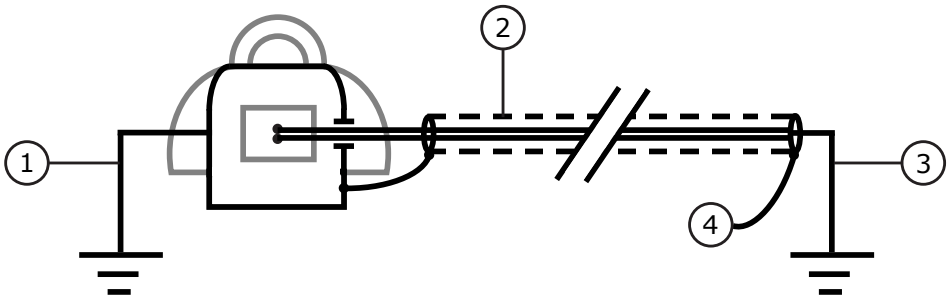

Figure 1 *a reliable connection through the bolts and mounting frame at (1) provides the pyranometer body ground; the digital signal ground and power supply ground are provided at (3). The voltage difference between grounds (1) and (3) must be within rated operating conditions. The cable shield at 4 is usually left disconnected.*

Mounting pyranometers near high-voltage PV arrays

PV modules generate electricity when exposed to light. On large-scale PV power plants where pyranometers are mostly used, arrays of many modules are put in series to generate voltages in excess of 600 V at potentially very high currents. Even small-scale PV systems may generate relatively high voltages. For humans, exposure can cause burns and lethal shock. At a system level, such voltages and currents may cause overheating of electrical wiring and may set off sparks and cause ignition.

For pyranometers or any other measuring instrument, sharing the mounting structure with a high-power and high-voltage source such as a PV array is not good engineering practice.

Mounting a pyranometer on a PV array framework creates a:

- situation where servicing and cleaning of the pyranometer is not safe because of its proximity to a high voltage / high current source.
- potentially hazardous situation at the pyranometer body and cable end, because of the proximity of the pyranometer body to a high voltage / high current source and the electrical connection of this body to the cable shield.

Connecting to an RS-485 network

SR-D pyranometers are designed for a two-wire (half-duplex) RS-485 network. In such a network, SR-D acts as a slave, receiving data requests from the master. An example of the topology of an RS-485 two-wire network is shown in the figure 2 below. SR-D is powered from 8 to 30 VDC. The power supply is not shown in Figure 2. The VDC [-] power supply ground must be connected to the digital signal ground (also called common) of the network.

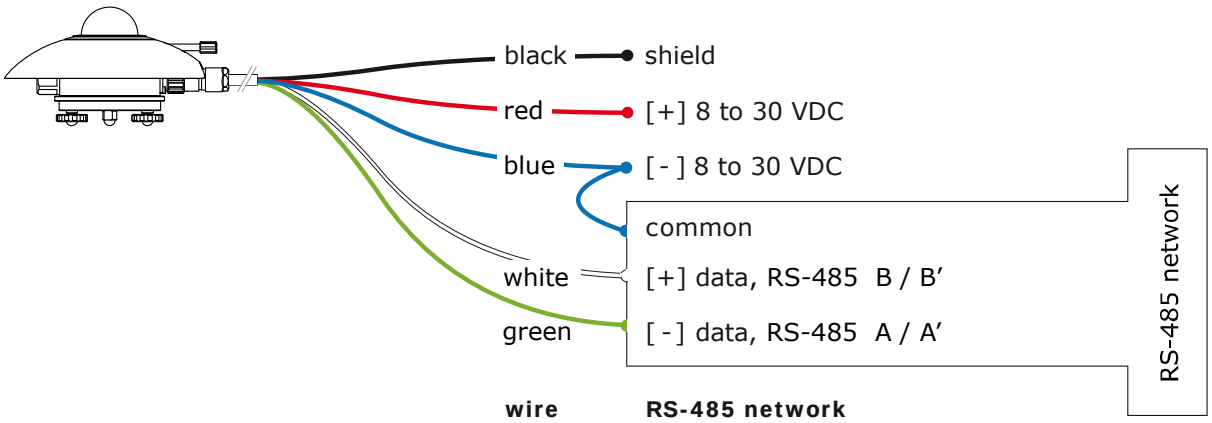

Figure 2 *Connection of a typical SR-D to an RS-485 network. SR-D is powered by an external power supply of 8 to 30 VDC. Consult the product manual for details.*

Digital pyranometer rated operating conditions

The rated voltage difference between the digital signal ground and pyranometer body ground is 100 V.

General rules for grounding a digital pyranometer

Users are responsible to keep the voltage difference between the pyranometer body ground and the digital signal ground smaller than 100 V:

- to avoid temporary failure or permanent damage to the sensor.
- to avoid unnecessary signal interruptions, or complete loss of signal.

In PV monitoring applications, do not mount on a PV array mounting frame as this creates a:

- situation were servicing and cleaning of the pyranometer is not safe because of its proximity to a high voltage / high current source.
- potentially hazardous situation at the pyranometer body and cable end (wires as well as shield), because of the proximity of the pyranometer body to a high voltage / high current source and the electrical connection of this body to the cable shield.

The main guidelines are:

- reduce risk for personnel and instruments: keep the sensor away from high-voltage or high-current sources (for example large PV arrays, high-voltage and high-power equipment, transformers), strong emitting sources (for example radars and communication antennas).
- keep cables short; we recommend to use the standard 5 m cable only, possibly extended to 10 m; for use of longer cables see the Appendix.
- keep it simple: connect or refer all system components to the same ground. This keeps voltage differences between pyranometer body ground and digital network ground within the rated operating range. Use the sensor with a dedicated power supply, with its ground referred, but not connected, to the same ground 1 in Figure 3. Make sure the digital signal ground (for example of RS-485) is

referred, but not connected, to the same ground 1 in Figure 3. Often there is no voltage difference between RS-485 ground and the power supply ground. In that case, the RS-485 digital signal ground (also called common) is connected to the power supply [-].

- keep it simple: combine installation of data acquisition / digital network, power supply and instrument on a single locally grounded, electrically conducting (metal) mounting frame such as a mast or a pole, ground 1 in Figure 3.
- reduce risk: mount on a small frame; This frame should be "stand-alone" and not electrically connected other larger electrically conducting structures such as a large metal fence a or a PV array mounting structure that may act as conductors for surges, direct or indirect lightning strikes etc.
- reduce risk: do not allow gaps between different connections to ground; use cable ties to fix the pyranometer cable to the mounting structure, or use a metal conduit, to minimise the surface area between the two and thereby minimise the impact of electromagnetic disturbances.

See next page for a visual overview of the preferred method to electrically ground and mechanically mount an SR-D digital pyranometer, and, in contrast, what not to do.

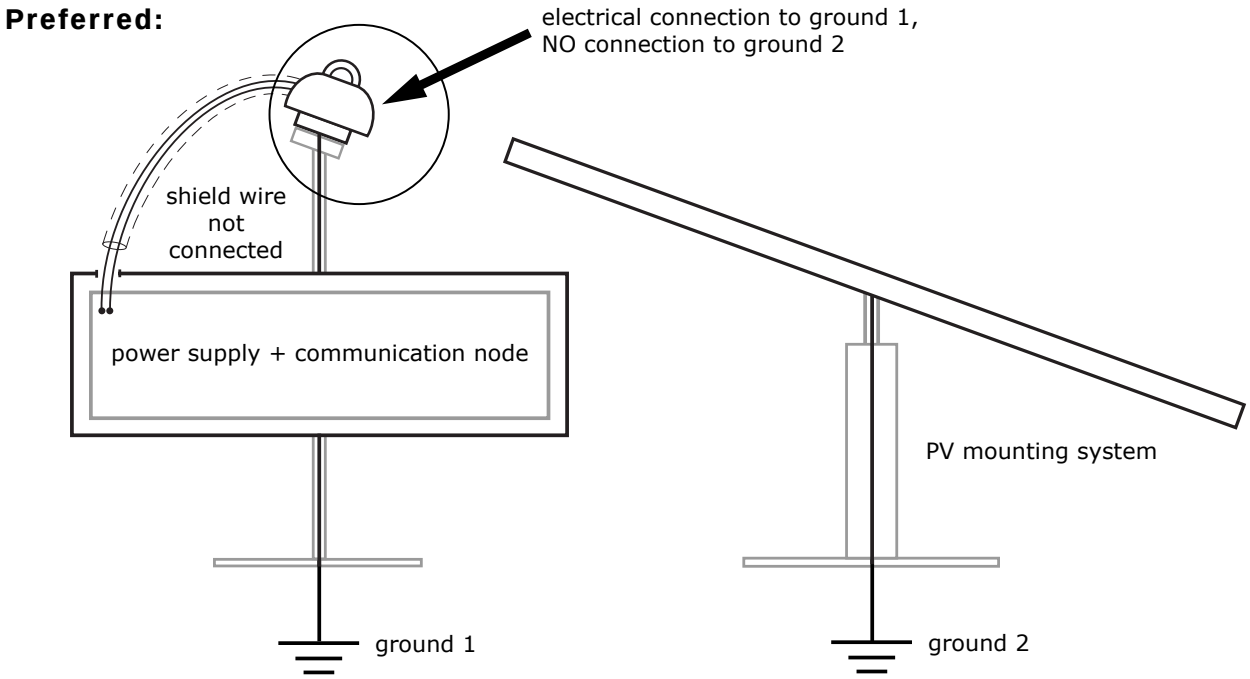

Figure 3 *Preferred method to electrically ground and mechanically mount an SR-D digital pyranometer*

What not to do

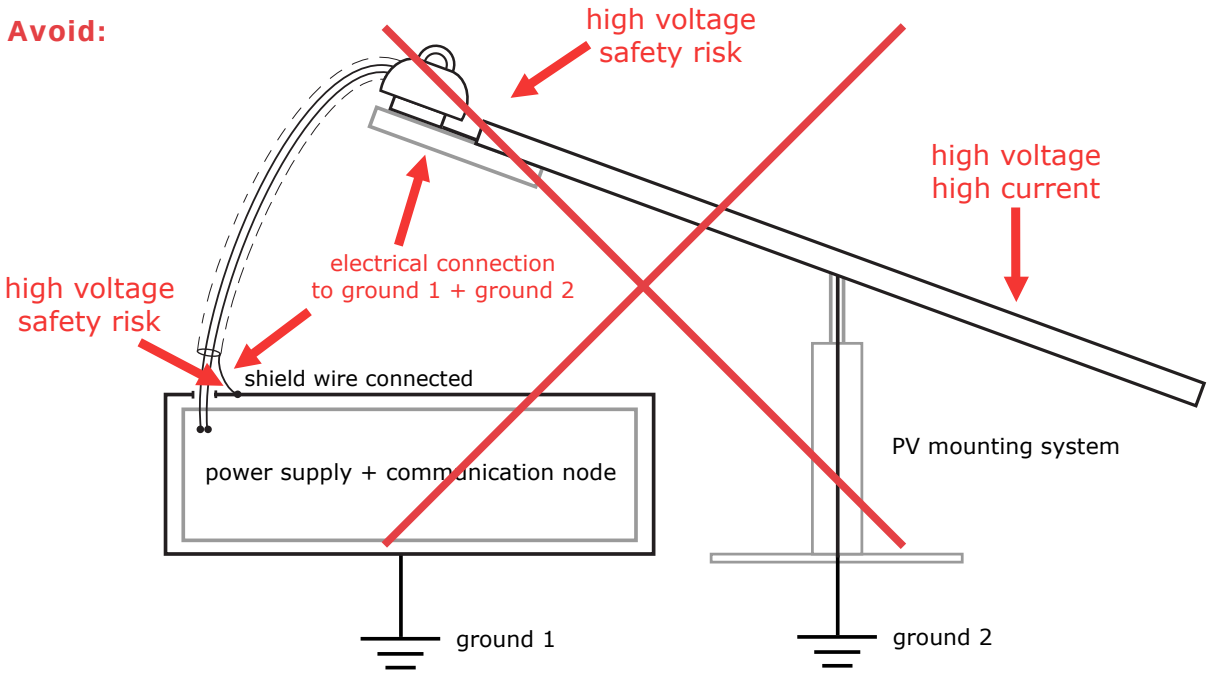

Figure 4 *Do not electrically connect an SR-D pyranometer as in the above picture. The PV array generates large voltages and currents. The array mounting frame is usually electrically conducting. In case the array is damaged or in case of indirect or direct surges, the conducting electrical path frame-pyranometer body-cable shield poses a safety risk to personnel and other parts of the system. In addition, it may result in an unreliable measurement or complete loss of signal.*

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Appendix: cabling requirements for digital pyranometers

When connecting SR-D pyranometers to a digital network, cables must comply with the following requirements:

- using Hukseflux supplied cables, do not use this standard cable at lengths > 40 metres.
- using longer cables, consult Hukseflux; The cabling requirements depend on power use of the sensor (heating, ventilation) and the operating environment.
- never use cables longer than 100 metres, as this may result in damage to the sensor.
- when extending the cable, use industrial grade, well-shielded signal cable < 100 m, preferably use a cable with twisted conductor pairs and a minimum peak voltage rating of 1000 V.

Appendix: when to connect the cable shield

The SR20-D cable shield is connected to the pyranometer body via the connector. In most cases, the shield is left unconnected at the cable end because it is already connected to ground via the pyranometer body. The shield may be connected to ground if:

- the pyranometer body is mounted electrically insulated and not connected to ground, for example when the pyranometer is installed on electrically insulated mount. This is not often the case, but may occur in a laboratory, when mounting on wooden or painted structures or on badly grounded solar trackers.

About this note

Hukseflux Thermal Sensors is a manufacturer of solar radiation sensors. Our product range includes pyranometers, pyrheliometers and pyrgeometers. This review intends to provide objective information about applications and use of our products. We appreciate suggestions for improvement of this note.

About Hukseflux

Hukseflux Thermal Sensors offers measurement solutions for the most challenging applications. We design and supply sensors as well as test & measuring systems, and offer related services such as engineering and consultancy. With our laboratory facilities, we provide testing services including material characterisation and calibration. Our main area of expertise is measurement of heat transfer and thermal quantities such as solar radiation, heat flux and thermal conductivity. Hukseflux is ISO 9001 certified. Hukseflux sensors, systems and services are offered worldwide via our office in Delft, the Netherlands and local distributors.

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