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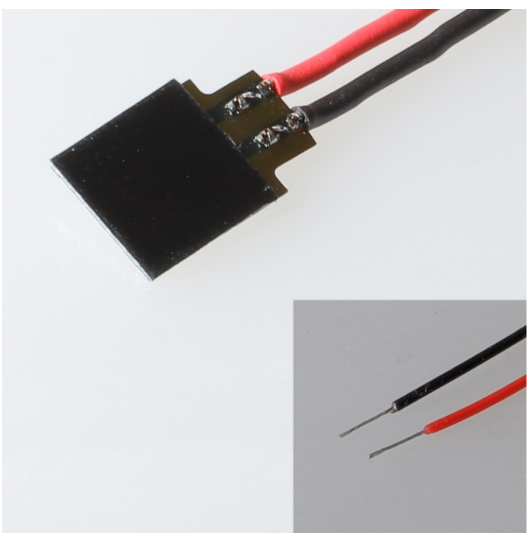
greenTEG

gSKIN® Application Note: Solar radiation

Measure solar radiation with thermal sensors to trigger and control your application

Solar radiation has a crucial influence on the environment and on our wellbeing. To accurately measure and manage the amount of solar radiation is therefore important and can also be used to trigger numerous properties in many applications. Examples range from building systems (smart heating and lighting, maintenance of PV systems) to meteorological research and applications in agriculture (regulate water and light for optimized plant growth).
greenTEG's gSKIN® radiation sensors quickly measure solar radiation and with high precision, enabling a wide range of applications.

The sensor's features are:



Easy to integrate
"The gSKIN® sensors are flat, thin, small and can be glued or fitted to any surface."

Measures all wavelengths
"The gSKIN® picks up solar energy independent of the incident wave-lengths.
This gives a more reliable and reproducible control."

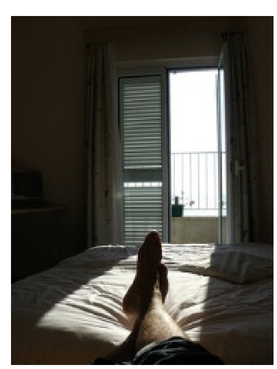
Precision
"The high sensitivity and linearity as well as the homogeneity of the gSKIN®'s surface ensure the precision of your triggered property."

Fast reaction time
"The sensor's response time is < 1sec, enabling accurate results even with changing radiation conditions."

gSKIN® sensors are available in different sizes. Contact options, coatings, and cable lengths can be adapted to specific needs. Contact gSKIN@greenTEG.com for more information.

Applications

Automated Heating in Buildings

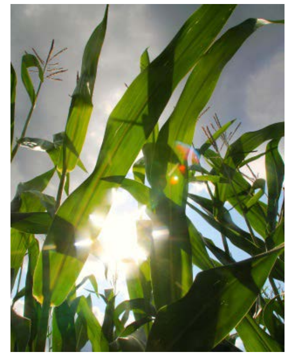


An increase in solar radiation can result in an unwanted increase of the ambient temperature (e.g. in a room). The incident radiation can be used to trigger a smart climate system. The sensors pick up the energy from the radiation and send a signal to either an air-conditioning unit, ventilation system or automated blinds (shadowing) to reduce the unwanted effects from solar radiation.

- Energy saving: rooms are only heated when necessary.
- In winter, solar radiation can be an important source of heating energy. By measuring the solar radiation in a room, the heating system can be suspended for a certain time which reduces heating costs.
- In summer, the sensors can keep the room temperature constant by controlling adjustable blinds and/or an air-conditioning system.
- Long-term stability: due to their solid state nature gSKIN® sensors require no maintenance.

Greenhouse control and agriculture

In greenhouses the gSKIN® helps to control and optimize climate and radiation parameters



- Complete understanding of solar irradiation and energy loss through the hull of greenhouses.
- Optimization of the growth conditions of plants by controlling their overall solar energy intake with automated shadowing systems.
- Determination of the amount of photosynthetically active radiation available using sensors specifically designed to measure this spectral region.

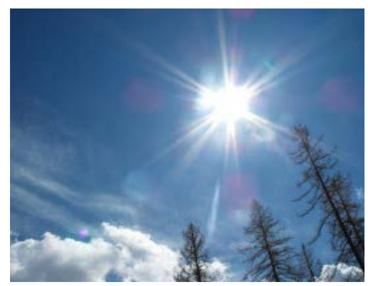
Automated Lighting

gSKIN® sensors convert IR radiation (heat) as well as visible and UV light into a voltage signal. Therefore, they can act as very sensitive light sensors:

- Depending on the time of the day, the gSKIN® can match the light level of rooms to your liking.
- Smart sensors trigger a car's light system according to ambient brightness levels (overcast sky, nightfall, entering a tunnel).

Meteorological research

Because sunlight has a great impact on almost all meteorological processes and phenomena, accurate data on solar radiation is an important pillar for research in meteorology.



The gSKIN® measure global solar radiation, i.e. direct and scattered solar radiation. When solar rays hit the black coated sensor they are converted into an output voltage by the sensor. To calculate the solar radiation, the output voltage is divided by the sensor's sensitivity.

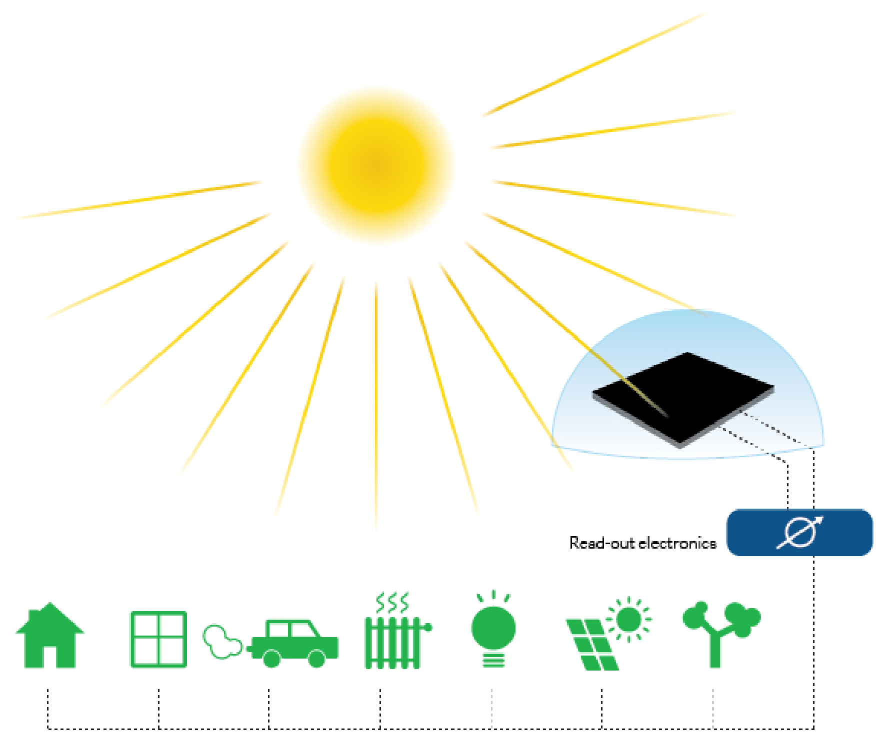
The spectral range of sunlight relevant for meteorological research lies between 300nm to 3000nm where most of the solar energy is concentrated. In contrast to photodiodes and photomultiplier tubes a gSKIN® with special coatings can cover the complete energy spectrum of the radiation (direct or indirect) and transforms it into a measurable voltage signal.

Photovoltaic installations

The sensitivity of the gSKIN® allows precise measurements enabling high levels of efficiency, for example in photovoltaic (PV) systems. The efficiency of these systems greatly depends on the alignment towards the sun at any given time. Using gSKIN® sensors in PV installations has the following advantages:

- Prediction of power output of PV systems according to changes in solar radiation caused by meteorological phenomena.
- Monitoring and optimizing the efficiency of PV systems by integrating the sensor in the PV positioning structure.
- Maintenance determination of PV systems is facilitated due to the direct influence of impurities and dirt on the solar measuring of the gSKIN sensor (quality control).

Measurement set-up



Control and trigger different applications depending on the presence/absence of sunlight. For example: heating, lighting, ventilation, and shading of buildings or vehicles, the optimal alignement of PV intallations towards the sun or watering (agriculture and garden).

1. **Read-out electronics:**
   The output signal of gSKIN® sensors is an analog voltage response. Silver-plated copper wires are used as electrical connection cables.
   For read-out of the analog voltage signals and to couple the response to a triggering system for further data manipulation, greenTEG read-out solutions are available. The resolution of the read-out electronics has a big influence on the measurement resolution. The following table compares the two read-out options.

Option	Description
Your read-out electronics	For automation systems (buildings, lighting, etc.), the combination with specifically adapted electronics is necessary. The adaption to the specific system strongly depends on the overall design.
greenTEG electronics	We provide custom fabricated electronics to couple the solar sensors to your application. Contact us for more information.

Table 1: Options for electronic read-out

The wavelength independent solar power measurement is proportional to the measured voltage V_{out}:

$$P_{solar} = V_{out} / S_L \qquad [W]$$

where S_L is the sensitivity of the gSKIN® sensor in V/W. The calibration constant S_L a unique value that is sensor specific (specified in each sensor's documentation).

2. **Temperature stability:**

Incoming solar radiation and the successive absorption of the energy by the sensor surface creates a temperature difference across the sensor. The sensor is typically mounted onto a thermal stabilizer which acts as a heat sink. There are two possibilities to measure the solar radiation:

a) To correct the change in temperature over time the temperature on both sides of the sensor are measured.
b) The heat sink is kept at a constant temperature using a thermoelement or cooling system in order to maintain a constant reference

For solar radiation measurements in meteorological research, the sensor is typically protected by a glass dome in order to isolate it from environmental influences such as wind and rain.

Appendix 1: Sensor specifications

The thermal sensor consists of axially aligned semiconductor thermocouples connected in series. These thermocouples are embedded in a polymer matrix.
Many properties of the sensor can be customized to your specific system and application requirements.

	Solar sensor
Detector type	Thermal absorber
Dimensions[1] [mm x mm]	8.5 mm x 8.5 mm
Spectral range	300 to 2800 nm
Maximum operational irradiance	4000 W m-2
Response Time (0-95%) [s]	0.8 s
Sensitivity S_L [2] [mV/W]	~ 30 mV/W
Humidity	0-100%
Operating Temperature Range Min / Max [°C]	-50 °C / 150 °C
Cooling method	Conduction, convection
Calibration Accuracy [%]	+/- 5 %
Homogeneity [%]	+/- 1 %
Linearity [%]	+/- 1 %
Expected output range	0 to 25 mV

Document information

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Pictures by greenTEG AG, Flickr, Pixelio

[1] Sensor dimensions correspond to the absorbing area.
[2] Sensitivity S_L is determined by thermal calibration (see corresponding datasheet for detailed information). For most accurate results, we recommend an optical calibration once the sensor is integrated into your system.