INDOOR LIGHTING CONDITIONS – Placement of Solar Powered Sensor Units

Indoor Lighting Conditions

EnOcean's indoor photovoltaic panel powered radio sensor modules are generally self-powered modules comprised of energy generator and storage, ultra-low-power timer, A/D sensor inputs, a microprocessor to assess input values and low-power radio. They enable OEMs to develop wireless and maintenance free sensors. Attached small indoor photovoltaic panels supply the required energy. An integrated energy store allows unrestricted functionality for several days in total darkness; the duration depends upon user programmable cyclic sending rates. The module performance is assured by optimal placement of the module where enough, optimal light is present.

This application note should help to find a suitable indoor placement with sufficient average illumination for your specific application.

Brightness is a term that describes how intense a light source is perceived by the human eye. Brightness is measured in units called lux (lx). The human eye may perceive different sources of light of the same brightness as equal; however, PV cells conversion efficiency may be quite different depending on manufacturing technology and light wavelength. For outdoor solar cells for example, the best light source is daylight, while fluorescent lamps (cold light) are the "worst case". Indoor PV cells however are optimized rather for indoor conditions; while conventional expensive outdoor solar cells are more efficient in optimum conditions (solar light) indoor cells win on the 24-hour energy cycle because they can use also the early morning and evening light.

During daytime, the light indoors will be a mixture of daylight and artificial lamp light varying throughout the day, weather and season. The amount of available sunlight is minimal in midwinter. Therefore, the total amount of daylight during the months November until January should be considered as worst case. In case of doubt, an "all day" operating system should be designed with the worst case. Illuminance at vertical and horizontal surfaces also differs; horizontal surfaces are better than vertical, except the ceiling.

Please Note: This Application Note contains additional information to the appropriate specific User Manuals.

1. Minimum Indoor Illumination

The following minimum illumination times of the indoor PV panel need to be guaranteed at the mounting location in order to reload the device:

1. Check the device initialization parameters as described in the user manual.
2. Check light type sources and their (daily averaged) availability at intended place.
3. Define the minimum brightness and duration in worst case (averaged over day).
4. Check long term light conditions at the intended installing place of the module under worst case conditions (e.g. winter time)

Further Notes:

- The value of the product between illuminance (lux) and time (hours), known as lux hours (lxh) can be roughly taken as a constant at illuminations levels over 100 lx: e.g. 200 lx illumination for 2 hours are equivalent to 400 lx for 1 hour (=400 lxh).
- When the average illuminance drops under the above-specified values, then the sender does not abruptly fail but lowers its periodical sending rate and it will send accordingly at randomly variable intervals.

2. Advices for Unit Mounting

- Identify the best compromise position between sensor's best illuminance and location requirements.
- Indoor sensors should be mounted with the solar cell facing the window, but avoiding long-term direct sunlight if possible.
- A recess that is not sufficiently illuminated during the course of the day should be avoided.
- With regard to the future use of the room, the mounting place should be selected in a way that cannot be shadowed by the user (e.g. filing cabinets).

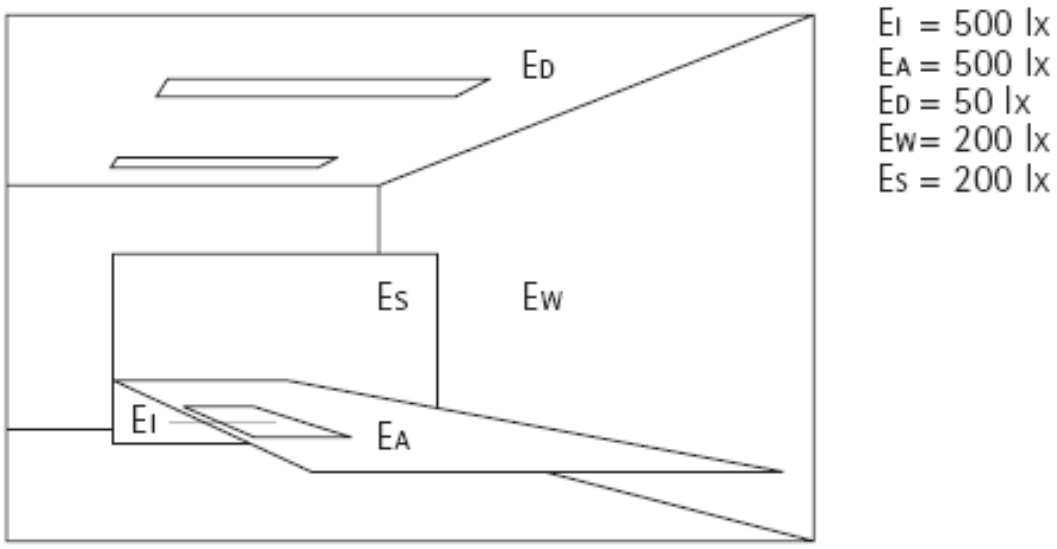

Fig. 1: Examples of brightness levels at different spots
in a typical office room (worktable EA=500 lx)

3. Initial Sensor Operation

The solar-powered energy storage must be recharged first after a long storage in darkness (e.g. initial installation). This occurs automatically from the beginning of operation in daylight. If the initial charging is not sufficient, the sensor will reach its full operating state after 3 to 4 days at the most. Then the sensor will have enough energy to function in darkness (i.e. to cover nights or weekends, up to 90 hours in darkness, depending on the preset/configured sending rate).

4. Defining of Lighting Conditions

In the following, you find a list of illumination values that will help you to assess typical environments. The given numbers are reference values only. Please use an illuminometer (lux meter) to verify a particular case.

Illumination Area	Type Destination / Workspace	Typical Brightness
Home	Usually	100 – 500 lx
Schools	Corridor	100 – 300 lx
	Classroom in general	300 – 750 lx
	Reading room, laboratory	500 – 1500 lx
Offices	PC room, working at PC	200 – 500 lx
	Meeting room	300 – 700 lx
	Canteen	150 – 300 lx
	Corridors	50 – 100 lx
	Reception	300 – 700 lx
	Restroom	100 – 300 lx
Factories	Production hall	500 – 1500 lx
	Development, office	300 – 750 lx
	Design CAD	500 – 1500 lx
	Laboratory, inspection work	750 – 1500 lx
	Packaging of products	150 – 500 lx
	Storage	100 – 300 lx
Hospitals	Visitor room	300 – 500 lx
	First aid, surgery	500 – 1500 lx
	Bedroom	100 – 300 lx
	Pharmacies	500 – 1000 lx
	Wash rooms	150 – 300 lx
Hotels	Reception	200 – 500 lx
	Entrance area	100 – 300 lx
	Restaurant	150 – 300 lx
	Restroom	100 – 300 lx
	Bars	50 – 150 lx
	Corridors	50 – 100 lx
	Staircases	50 – 150 lx
Stores	Saleroom	300 – 1000 lx
	Show room	500 – 1500 lx
	Packaging area	200 – 300 lx
	Lounge	300 – 500 lx
	Conference room	300 – 700 lx
Trade Show	Booth	300 – 500 lx
Sports Arena	Indoor area	200 – 500 lx

Tab. 1: Typical Indoor Brightness Levels (Lux)