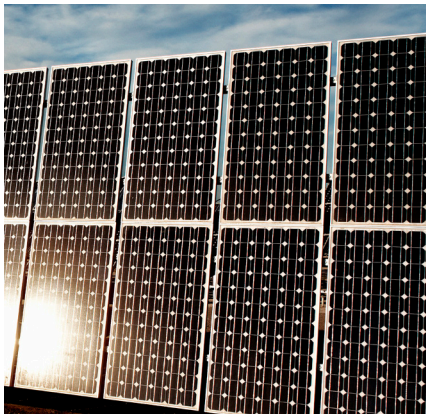
Ammonit Soiling Measurement Kit SD2100

- Determine PV performance losses due to soiling
- Calculation of the Soiling Loss Index (SLI) and Soiling Ratio (SR)
- Measurement of short circuit current and module surface temperature



Soiling significantly affects the energy production of PV power plants. Effects of soiling on PV modules should be assessed site-specific due to variations in soil type, location and weather patterns. Implementing an Ammonit soiling measurement kit helps you to:

- Analyse soiling losses in the PV module performance
- Quantify site-specific impacts of soiling on PV energy production
- Optimize cleaning routines for best return-on-investment
- Determine typical soiling rates for forecasting models

Soiling is the accumulation of dust, dirt and other contaminants on the surfaces of PV modules. The amount of dust is extremely dependent on the location of the PV power plant, e.g., desert valley with sand storms. In absence of significant rain events or regular cleaning, production losses due to soiling effects increase. Measuring soiling effects provides important details about the PV power plant production, e.g., how much dust can be on the modules before any problem occurs and how does the dust affect transparency and efficiency of the modules.

Plane of Array (POA) irradiance, Soiling Ratio (SR) and Soiling Loss Index (SLI)

The temperature-corrected short-circuit current of a clean PV module is proportional to the irradiance. After measuring short-circuit current and temperature of the PV module, the **POA irradiance** can be determined using the following equation:

$$G = \frac{G_0 \cdot I_{SC} \cdot \left(1 - TK_{Isc} \cdot (T - T_0)\right)}{I_{SC0}}$$

G:	POA irradiance reaching the solar cells
G_0:	Irradiance at reference conditions
I_{SC}:	Measured short circuit current of the PV module
$I_{SC,0}$:	Short circuit current of the reference PV module
T:	Surface temperature of the PV module
T_0:	Surface temperature of the reference PV module
TK_{Isc}:	Temperature coefficient of short circuit current

The **Soiling Ratio SR_{Isc}** index is a metric for the loss in the irradiance reaching the PV modules due to soil accumulation, reducing the transmission of the PV glass (SR I_{SC} = 1 when clean). It compares the actual measured value of the soiled PV module with the expected output.

$$SR_{Isc} = \frac{I_{SC}^{Soiled}}{I_{SC0} \cdot \left(1 + TK_{Isc} \cdot (T^{Soiled} - T_0)\right) \cdot \left(\frac{G}{G_0}\right)}$$

G:	POA irradiance of the clean PV module
I^{Soiled}_{SC}:	Measured short circuit current of the soiled PV module
T^{Soiled}:	Measured temperature of the soiled PV module

The **Soiling Loss Index SLI** is a metric for the loss in the irradiance, based as well on the measurement of PV module short-circuit current and surface-temperature, expressed as a percentage (SLI = 0% when clean). The SLI is calculated from the irradiance of a clean and a soiled modules as follows:

$$SLI = \left(1 - \frac{G_{Clean}}{G_{Soiled}}\right) \times 100$$

G_{Clean}:	POA irradiance of the clean PV module
G_{Soiled}:	POA irradiance of the reference PV module

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Measuring soiling effects

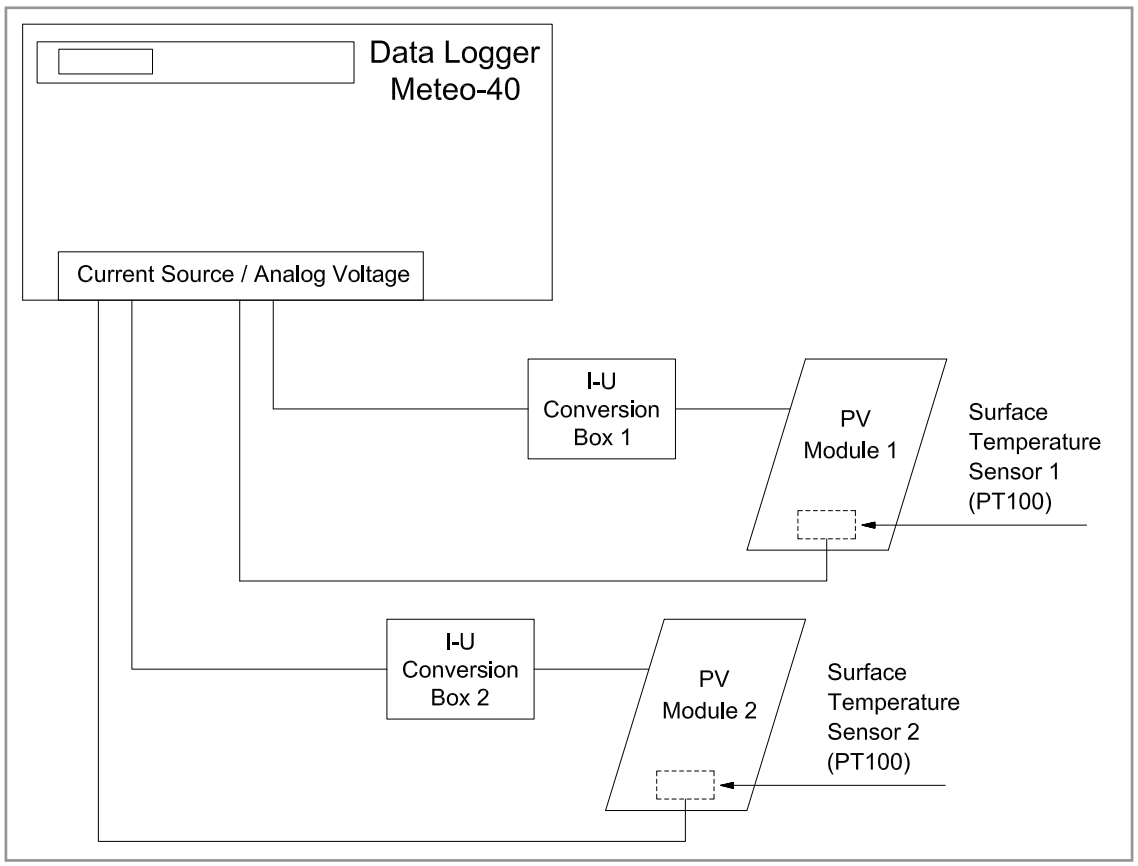
The Ammonit soiling measurement kit compares power output and surface temperature of a naturally-soiled PV module with the data of a clean reference PV module. The measurement station determines local solar irradiation for power output parameter evaluation as well as the module surface temperature from the backside of each PV module.

The Ammonit soiling measurement kit includes the following components:

Amount	Component	Order No.
2	Ammonit I-U Conversion Box	CM8281
2	Surface Temperature Sensor	S68920
2	PV Module (50 W)	M51052

Furthermore, we recommend measuring type and amount of precipitation as well as environmental factors such as pollution. The tilt angle of the PV modules should also be considered in the calculations, as well as existing cleaning plans.

Scheme of Ammonit Soiling Measurement Solution



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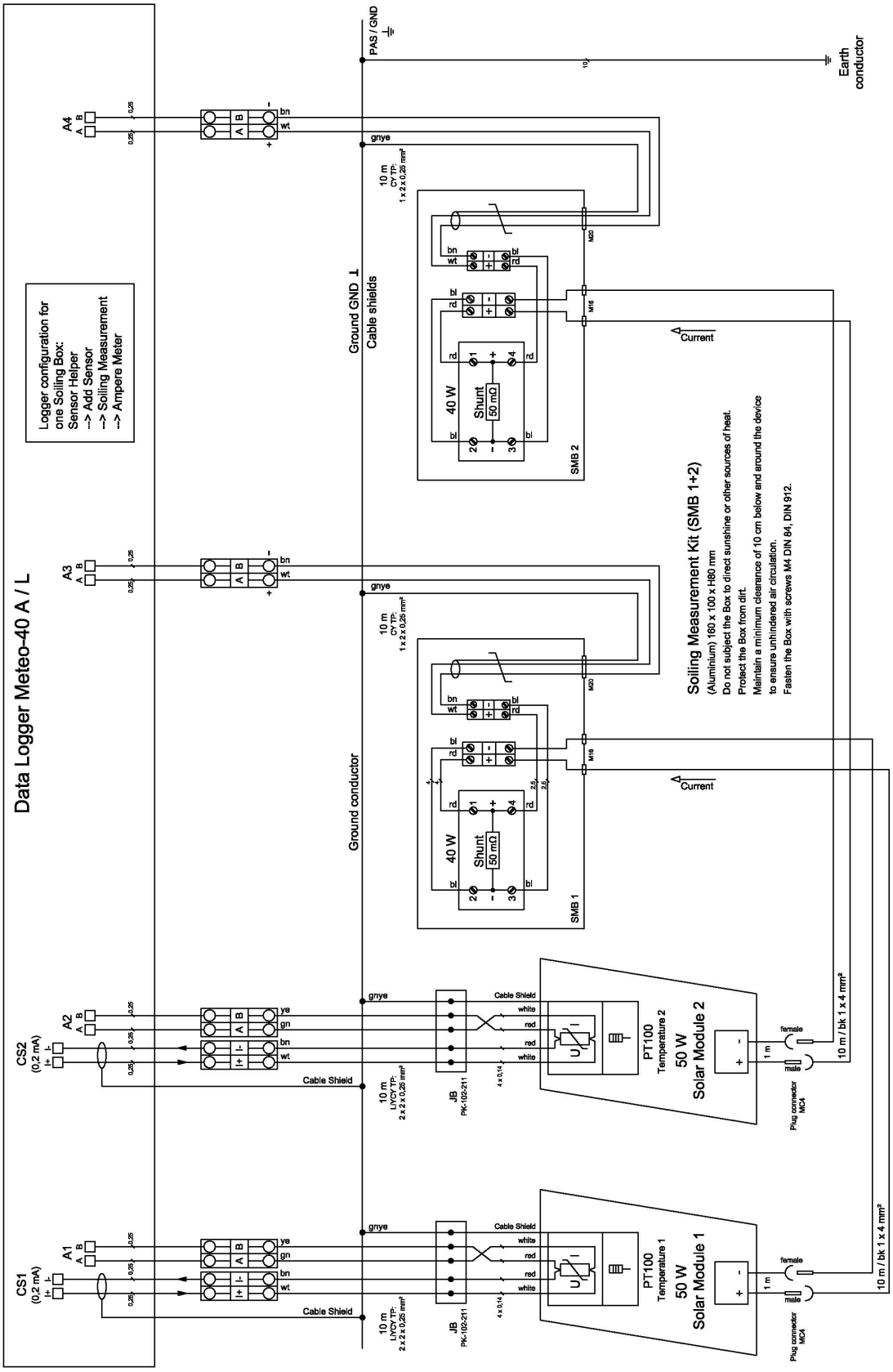

Legend:
wt = white / bn = brown / gn = green / ye = yellow / gr = grey / pi = pink / bl =blue / rd = red / bk = black / vio = violet / gnye = green-yellow

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Specifications

I-U Conversion Box
Order No. CM 8281

Characteristic	Description
Continuous current*	15 A
Peak current	40 A
Shunt resistance	50 mΩ**
Shunt tolerance	1 %
Shunt temperature coefficient	< 50 ppm/K (20 ... 60 °C)
Max. input voltage ***	48 V
Max. operating temperature @ 16 A	60 °C (if ventilated)
IP class	IP65
Dimensions	160 x 100 x 81 mm

* Corresponding to max. short circuit curent of a solar module
** Other values are possible according to technical requirements
*** Corresponding to the max. open circuit voltage of a solar module

The **I-U Conversion Box** contains a shunt resistor of 50 mΩ (default configuration). According to Ohm's law, the max. continuous current of 15 A results in an output voltage of 0.75 V.

- In order to achieve best match to the output voltage of the CM8281, the Ammonit Meteo-40 data logger must be set to the ±1.0 V range.

Surface Temperature Sensor
Order No. S68920

Characteristic	Description
Sensor type	Pt 100 class B
Sensor capture	Silicon rubber patch
Temperature range	-50 ... 150 °C
Dimensions	40 x 13 x 5 mm

Solar Module (50 W / 12 V)
Order No. M51052

Characteristic	Description
Module type	Monocrystalline
Standard Test Conditions (STCs) Solar irradiance Cell temperature	 1000 W/m² 25 °C
Peak Power (Pmax)	50 W
Short circuit current	(Isc) 3.07 A
Temperature coefficient of Isc (TK I_{SC})	0,081 %/°C
Dimensions	650 x 505 x 35 mm

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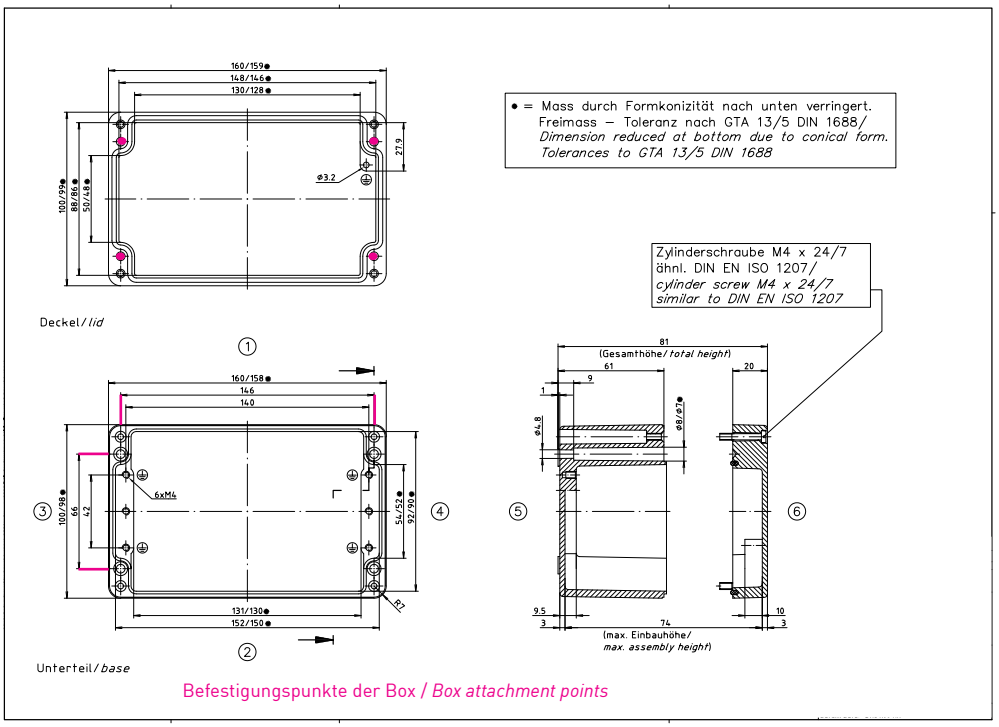
I-U Conversion Box



Befestigungspunkte der Box / *Box attachment points*

Screenshot Sensor Helper: Configuration of the Soiling Kit – 2x CM8281 & 2x PT100

Sensor type: Soiling Measurement
Sensor: Ampere Meter (CM8281)
Installation height (m): 0.0
Label: Isc soiled
Serial number:
Analog Current Isc Shunt Resistance (Ω): 0.05
Measurement period: 1 s
Voltage range: ±1 V
Analog Channel: A2

Sensor type: Hygro/Thermo
Sensor: PT100 (S41200)
Installation height (m): 0.0
Label: T soiled
Serial number:
Temperature Offset (°C): 0
Temperature Slope (°C/Ω): 1
Measurement period: 1 s
Analog Channel: A4
Current Source: CS1

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Screenshot Sensor Helper: Configuration of the I-U Conversion Box / Ampere Meter SD2100
(Both boxes must be configured)

Label	Type	Model	Order No.	Height	Serial No.	Rate	Channels	Change	Delete
T clean	Hygro/Thermo	PT100	S41200	0.0		1 s	A5, CS1	Change	Delete
T soiled	Hygro/Thermo	PT100	S41200	0.0		1 s	A4, CS1	Change	Delete
Isc clean	Soiling Measurement	Ampere Meter	CM8281	0.0		1 s	A3	Change	Delete
Isc soiled	Soiling Measurement	Ampere Meter	CM8281	0.0		1 s	A2	Change	Delete

Screenshot Evaluation Helper: Calculation of the Soiling Ratio (Calculation see page 1)

Formula: Soiling ratio Isc

Soiling Ratio Isc index

Analog Current Isc Soiled: Isc soiled Analog Current Isc

Temperature Soiled: T soiled

Analog Current Isc Clean: Isc clean Analog Current Isc

Temperature Clean: T clean

Short Circuit Current Reference (A): 3.07

Surface Temperature Reference (°C): 25

Temperature Coeficient at Isc (%): 0.081

Label:

Save

Delete

Formula: POA irradiance

Plane of Array irradiance

Analog Current Isc: Isc soiled Analog Current Isc

Temperature: T soiled

Short Circuit Current Reference (A): 3.07

Reference Condition Irradiance (W/m²): 1000

Surface Temperature Reference (°C): 25

Temperature Coeficient at Isc (%): 0.081

Label: POA irradiance Soiled

Save

Delete

Formula: Soiling loss index

POA Irradiance Ref: POA irradiance Clean

POA Irradiance Soil: POA irradiance Soiled

Label:

Save

Delete

Evaluation Configuration Overview for SD2100

Label	Evaluation	Origin	Value	Unit	Slope	Offset	Shunt Resistance	Short Circuit Current	Reference Condition Irradiance	Surface Temperature	Temperature Coeficient at Isc	Change
Other Sensor	Analog Voltage	A1	-0.0037	V	1	0						Change
Isc soiled	Analog Current Isc	A2	---	A			0.05					Change
Isc clean	Analog Current Isc	A3	---	A			0.05					Change
T soiled	Temperature	A4, CS1	-280.791386	°C	1	0						Change
T clean	Temperature	A5, CS1	-281.463448	°C	1	0						Change
POA irradiance Clean	POA Irradiance	Isc clean, T clean	---	W/m²				3.07	1000	25	0.081	Change
Soiling ratio Isc	Soiling Ratio	Isc soiled, T soiled, Isc clean, T clean	---					3.07		25	0.081	Change
POA irradiance Soiled	POA Irradiance	Isc soiled, T soiled	---	W/m²				3.07	1000	25	0.081	Change
Soiling loss index (@0.0 m)	Soiling Loss Index	POA irradiance Clean, POA irradiance Soiled	---	%								Change

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