

FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS, ISE

# **REPORT ON THE INSPECTION OF THE SOLAR POWER PLANT ESTADIO PITUACU**

# REPORT PMZ940-AP-BK-1201-V1.1

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On behalf of: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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# 1 Summary

The inspection of the solar power plant Estadio Pituacu took place from 19.03.2012 to 23.03.2012. The system was not completely in operation at the time of the inspection. The tests which were carried out comprised the following points:

- Design and function of the components in relation to compliance with established standards and current state of the art.
- Technical construction and concept of the system, including possible defects and abnormalities in the installation.
- Performance of the modules, measured via a representative sample of selected sub-arrays.
- Thermal effects of modules and other electrical components detected by infrared thermography.
- Comparison of technical data from the existing system with assumptions made in the yield assessment (no yield assessment was delivered).

The system concept mainly meets the state of the art. But the installations were not complete and only partly professionally constructed.

Based on a random sample of 32 % of the PVL-144 modules from Uni-Solar, a deviation of -2.4 % from the rated power was calculated. Therefore, the overall module power of the entire sample lies within the given power tolerance.

Based on a random sample of 47 % of the YL265C-30b modules from Yingli Solar, a deviation of -0.1 % from the rated power was calculated. Therefore, the overall module power of the entire sample lies within the given power tolerance.

An examination of approximately 35 % of the PV generator with crystalline silicon modules with an infrared camera did not reveal a single defective module.

Further detailed results of the inspection performed are given in chapter 3.

## 2 System Description

|               |  |
|---------------|--|
| Name:         | Estadio Pituacu  |
| Location:     | Salvador da Bahia  |
| Coordinates:  | 12,95 S 38,41 W  |
| Operator:     | Gesellschaft für Internationale<br>Zusammenarbeit (GIZ) GmbH |
|               | Dag-Hammarskjöld-Weg. 1-5                                    |
|               | 65760 Eschborn   |
|               | Germany  |
| Installed by: | Gehrlicher Ecoluz Solar do Brazil S.A.                       |
|               | Avenida Tancredo Neves 620                                   |
|               | Salvador, Bahia  |
|               | CEP: 41825-904   |
|               | Brazil   |

Table 1: Test Object

### 2.1 Complete System

The PV system's DC rated power is listed below. Neither AC nor DC-side losses were included in the calculation, it simply refers to the sum of the power of all installed modules operating at maximum power as listed on the data sheet.

Rated Power  $P_{N, DC} = 408,016 \text{ kWp}$

| Components               | Number |
|--------------------------|--------|
| Modules                  | 2294   |
| Inverters                | 52     |
| Generator junction boxes | 4      |

Table 2: System Components

## 2.2 Solar Generator

The specific characteristics of the generator field are listed in Table 3. Information about orientation, tilt angle and shading is based on measurements carried out on site, provided that this is feasible in the context of the inspection. Both module shading and soiling are ascertained during the visual inspection which is part of the initial survey of the system.

| Characteristic   | Inspection Results   |
|------------------|--|
| Fixed Tilt Angle | 1 ° or 4 °   |
| Orientation      | -110 ° or +70 ° (Area 3, 4, 7), -20 °(Area 2), -50 °or +10 ° (Area 1 and 6) to the north |
| External Shading | Floodlights in Area 3 and 4, a tree in Area 2, the stand for Area 1 and 6                |
| Soiling          | Minor for the Yingli modules and more for the Uni-Solar modules                          |

**Table 3: Solar Generator Characteristics**

The configuration of the individual inverters is shown in Table 4. The various inverter allocations are listed individually. The resulting string voltages and currents as expected under various conditions at the inverter inputs can be seen from the interconnections.

| Configuration                   | 1              | 2              | 3               | 4               | 5               |
|---------------------------------|----------------|----------------|-----------------|-----------------|-----------------|
| INV-Type                        | SMC<br>7000 HV | SMC<br>7000 HV | STP<br>8000 TL  | STP<br>10000 TL | STP<br>10000 TL |
| Module Type                     | PVL-144        | PVL144         | YL-265C-<br>30b | YL-265C-<br>30b | YL-265C-<br>30b |
| Number of Modules per String    | 12             | 13             | 16              | 21              | 22              |
| Number of Strings               | 4              | 4              | 2               | 2               | 2               |
| Voltage $U_{MPP, STC}$          | 396 V          | 429 V          | 496 V           | 651 V           | 682 V           |
| Voltage $U_{MPP, 70\text{ °C}}$ | 341 V          | 369 V          | 403 V           | 529             | 555 V           |
| Voltage $U_{MPP, 15\text{ °C}}$ | 408 V          | 442 V          | 517 V           | 678 V           | 710 V           |
| Voltage $U_{OC, -10\text{ °C}}$ | 628 V          | 680 V          | 696 V           | 914 V           | 957 V           |
| Input Current $I_{MPP}$         | 18 A           | 18 A           | 17 A            | 17 A            | 17 A            |

**Table 4: Inverter Allocation Configuration**

The PV modules installed in this system along with their rated mechanical and electrical values from the data sheet are listed in Table 5.

System Description

| Module Type    | PVL-144         | YL-265C-30b  |
|----------------|-----------------|--------------|
| Manufacturer   | Uni-Solar       | Yingli Solar |
| Technology     | Triple-aSi      | Mono-Si      |
| Number         | 1652            | 642          |
| $P_{MPP}$      | 144 W           | 265 W        |
| $\Delta P$     | +/-5 %          | +/-3 %       |
| $U_{MPP}$      | 33.0 V          | 31.0 V       |
| $I_{MPP}$      | 4.36 A          | 8.55 A       |
| $U_{OC}$       | 46.2 V          | 39.0 V       |
| $I_{SC}$       | 5.3 A           | 8.93 A       |
| $U_{Sys, Max}$ | 1000 V          | 1000 V       |
| L              | 5486 mm         | 1650 mm      |
| B              | 395 mm          | 990 mm       |
| Frame          | None (Laminate) | Yes          |
| Couplings      | MC 3            | MC 4         |

**Table 5: Installed Solar Modules**

The installed inverters along with the rated electrical values taken from the data sheet are listed in Table 6.

| Type          | SMC 7000 HV        | STP 8000 TL        | STP 10000 TL       |
|---------------|--------------------|--------------------|--------------------|
| Manufacturer  | SMA Technologie AG | SMA Technologie AG | SMA Technologie AG |
| Number        | 33                 | 16                 | 3                  |
| $P_{AC,N}$    | 6650 W             | 8000 kW            | 10000 kW           |
| $U_{AC, N}$   | 180 V – 260 V      | 160 V – 280 V      | 160 V – 280 V      |
| $I_{AC, max}$ | 31 A               | 16 A               | 16 A               |
| $F_N$         | 60 Hz              | 60 Hz              | 60 Hz              |
| $P_{DC,max}$  | 7500 Wp            | 8200 kWp           | 10200 kWp          |
| $U_{MPP}$     | 335 V - 560 V      | 320 V - 820 V      | 320 V - 820 V      |
| $I_{DC,max}$  | 23 A (per string)  | 22 A (per string)  | 22 A (per string)  |
| $U_{DC,max}$  | 1000 V             | 1000 V             | 1000 V             |

**Table 6: Inverters**

The cable type and respective cross section selected can be seen in Table 7 to Table 9.

System Description

#### From String to GJB

|                     |  |
|---------------------|--|
| Cable Type          | Nambei nax Flex HEPR ATOX                                    |
| Cable Cross Section | 16 mm <sup>2</sup> , 25 mm <sup>2</sup> , 35 mm <sup>2</sup> |
| Wiring              | In open cable tray   |

Table 7: DC Cable 1

#### From GJB to Inverter

|                     |   |
|---------------------|---|
| Cable Type          | Not accessible                          |
| Cable Cross Section | Not accessible                          |
| Wiring              | In cable tray (GJB is in inverter room) |

Table 8: DC Cable 2

#### From Inverter to Transformer

|                     |                |
|---------------------|----------------|
| Cable Type          | Not accessible |
| Cable Cross Section | Not accessible |
| Wiring              | In cable tray  |

Table 9: AC Cable

The individual module strings are bundled in generator junction boxes (GJB). Table 10 shows the characteristics of these GJBs.

#### Components

|                        |                              |
|------------------------|------------------------------|
| String Fuses           | 8 A, 16 A                    |
| Overvoltage Protection | Type 2                       |
| DC Activation Type     | None, DC switch in inverters |

Table 10: Generator Junction Box (GJB)

The modules are installed on a substructure, the appearance and workmanship of which is described in Table 11.

#### Characteristics

|           |  |
|-----------|--|
| Type      | On roof (Uni-Solar)/ Elevated (Yingli) |
| Grounding | not connected                          |
| Tracking  | None                                   |

Table 11: Frame/ Substructure



## 3 Detailed Results of Individual Component Tests

### 3.1 System Concept and Technical Construction

The system concept is reviewed according to data provided by the principal. The technical design of the installations is recorded and evaluated during the visual inspection that is part of the on-site visit. Any discrepancies between the documentation and the technical components which have actually been installed are noted. The identified defects and additional comments are listed below.

#### 3.1.1 List of Deficiencies with Photo Documentation

The points which were noted in the review as deficiencies are listed with supporting photo documentation below. It should be mentioned that it was not possible to check every component of the entire plant due to the fact that the installation was not yet completed and only a part of the plant was running for half a day. The following deficiencies were found in the review:

- Cable trays throughout the entire plants were not closed, leaving cables exposed to the atmospheric conditions without any protection apart from their insulation.
- There was no labeling of the components of the plant, for example inverters or strings. The strings were neither labeled in the generator field nor in the inverter room, which they were fed into.
- Data cables were laid in the same cable tray as power cables without any separation.
- Within the infrared camera testing some terminals and fuses in the junction boxes were heated, probably because of loose installation. All terminals in every inverter room have to be checked and refastened, see Figure 17 to Figure 20.
- The operating voltages of the strings of 12 PVL-144 modules from Uni-Solar, which were connected to an SMC 7000 HV inverter from SMA Technologies, will be outside the MPP voltage range if the module temperature exceeds 75 °C. The strings with 13 modules will leave the MPP range by exceeding a temperature of 95 °C, see Table 4. It cannot be proved that these high temperatures of 75 °C or 95 °C will occur, but this calculation is simply made using nominal values from the datasheet. These values are measured with a certain tolerance. A voltage drop from the cable will further reduce the string voltages. Considering the fact that the plant is located in a warm region, a higher string voltage should be used for inverter allocation to avoid yield losses.
- Individual strings in Area 3 and Area 4 had not yet been connected, see Figure 3.
- The laminates in Area 3 and Area 4 were installed very close to the cable tray, which causes shading in the morning and in the evening, see Figure 3.
- There were many remnants of the installation process in Area 3 and Area 4 including cable remnants, cores of cables, stones and plastic waste. This not only causes environmental damage, but in some cases it shaded the generator or could even damage the roof film, see Figure 4 and Figure 5.
- Cable routing in the roof in Area 3 and Area 4 was constructed of non UV-resistant tubing, see Figure 6.
- In some parts of Area 3 and Area 4 the laminates were heavily soiled and should be cleaned, see Figure 7.
- Some laminates in Area 3 and Area 4 were not completely attached to the roof. The parts concerned should be affixed to the roof, see Figure 8.

- Many module connectors in Area 3 and Area 4 were not completely connected, meaning they were not water resistant, see Figure 9.
- In Area 4 one cable connection was installed unprofessionally, a cable was partially melted and is probably not water resistant, see Figure 10.
- The cable for the grounding in Area 4 was curled, which indicates a risk of breakage, see Figure 11.
- Some clamps for fastening the modules in Area 7 were not installed correctly. The clamps concerned did not fully touch the module frame, because the distance between the modules was too large, see Figure 12, Figure 13 and Figure 14.
- In Area 2 documentation of the installation was not correct.
- The reference solar cell in Area 2 was shaded by a tree at certain times and its cable was installed without protection, see Figure 15.
- Cable for grounding was not connected to the substructure, see Figure 16.
- There was an unidentified cable running under the generator. The purpose of this cable was unknown, see Figure 16.
- The overhang used to install the last module line on the substructure was too large in Area 1 and Area 6. This overhang should be no larger than one third of the module in size, see Figure 21.
- Power conducting parts were exposed in the generator junction boxes. There should be a protection against contact, see Figure 18.
- In Area 1 and Area 6 two modules were brighter than the others, probably due to a defect in the anti-reflection layer. Within the power determination no effect could be seen, but it could not be ensured that this will not lead to power loss.



Figure 1: Open cable trays.



**Figure 2: Data cable in same cable tray as power cables.**



**Figure 3: Strings not connected, shading of modules by cable tray.**



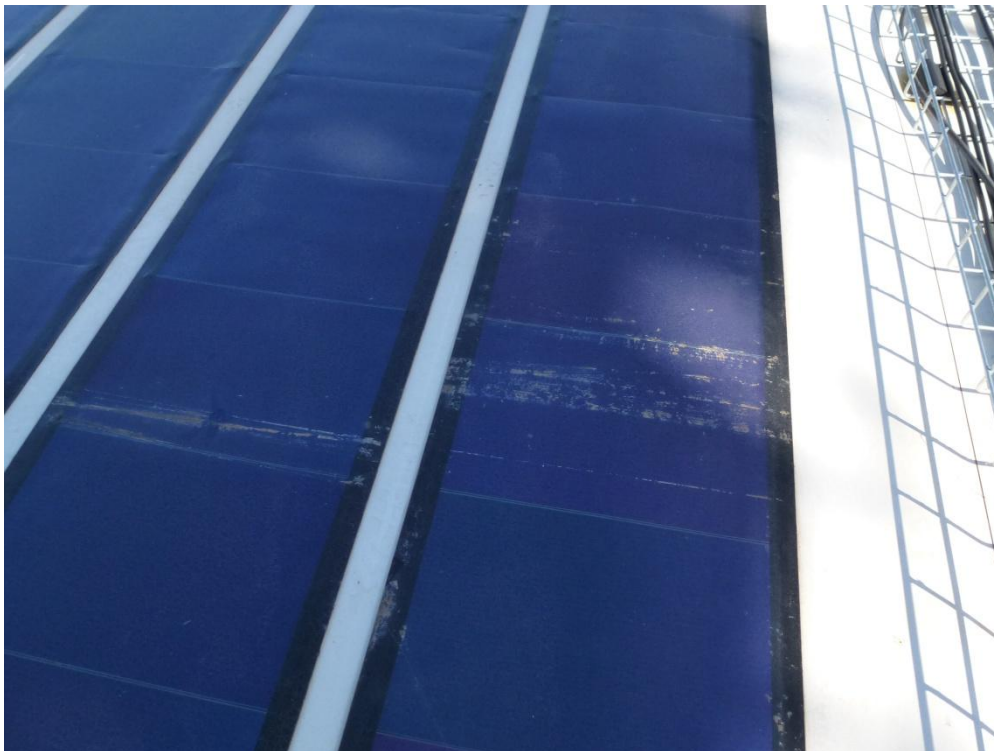
**Figure 4: Cable remnants, cores of cables and waste.**



**Figure 5: Stones on the generator field.**



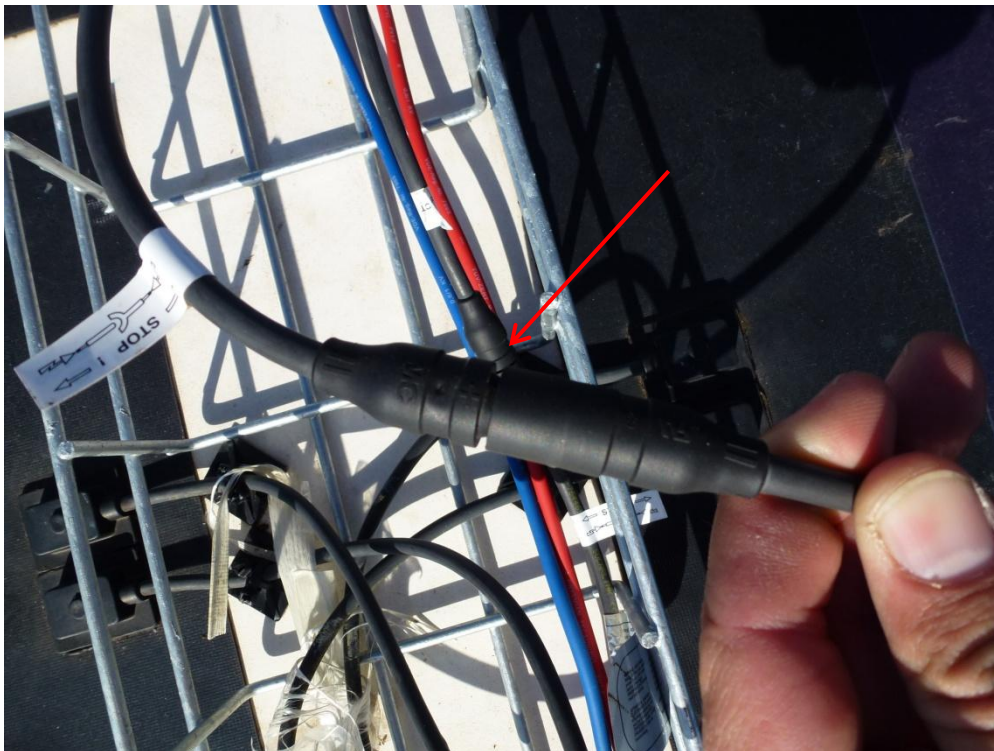
**Figure 6: Cable conduit of non UV resistant material, grounding not connected.**



**Figure 7: Soiled PV laminate.**



**Figure 8: Laminate not completely attached to the roof.**



**Figure 9: Partially connected module connector MC 3.**



**Figure 10: Incorrectly installed cable connection.**



**Figure 11: Tightly curled cable for protective earthing.**

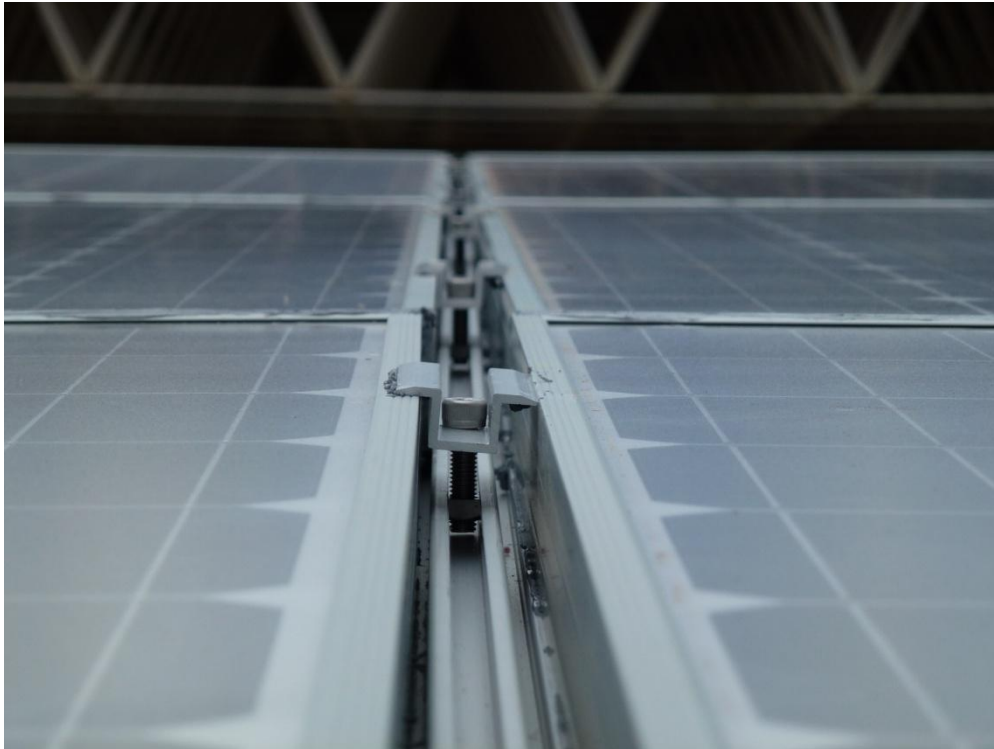


**Figure 12: Incorrectly installed module clamp (1).**



**Figure 13: Incorrectly installed module clamp (2).**





**Figure 14: Incorrectly installed module clamp (3).**



**Figure 15: Position of reference solar cell shaded by tree.**



Figure 16: Grounding not connected in Area 2, unidentified red cable, waste.

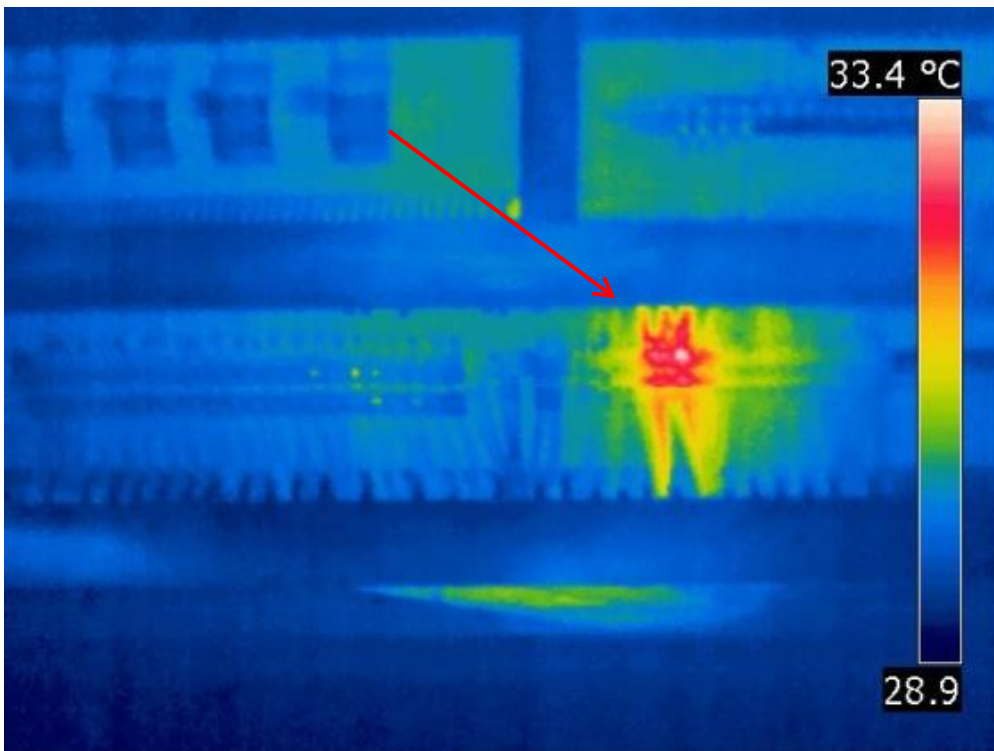
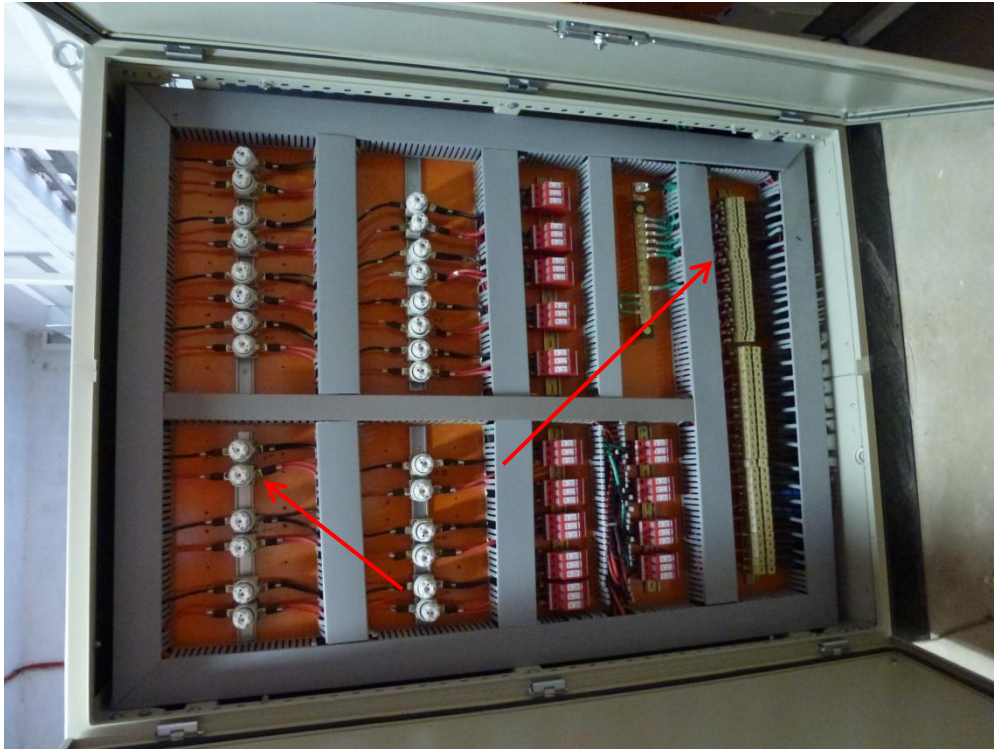
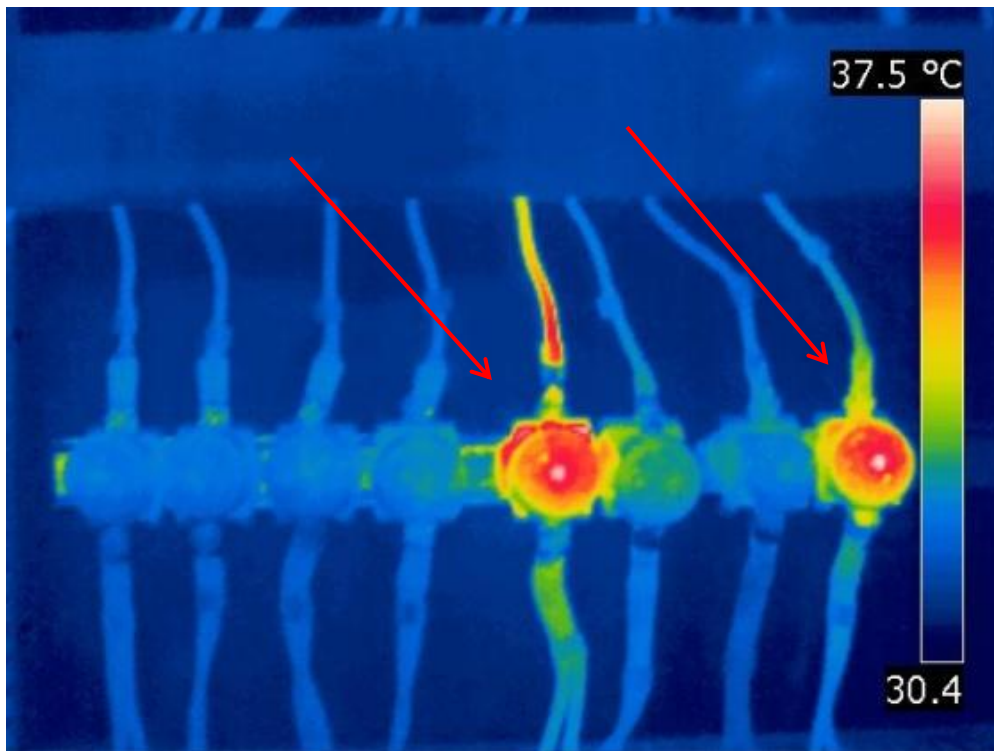


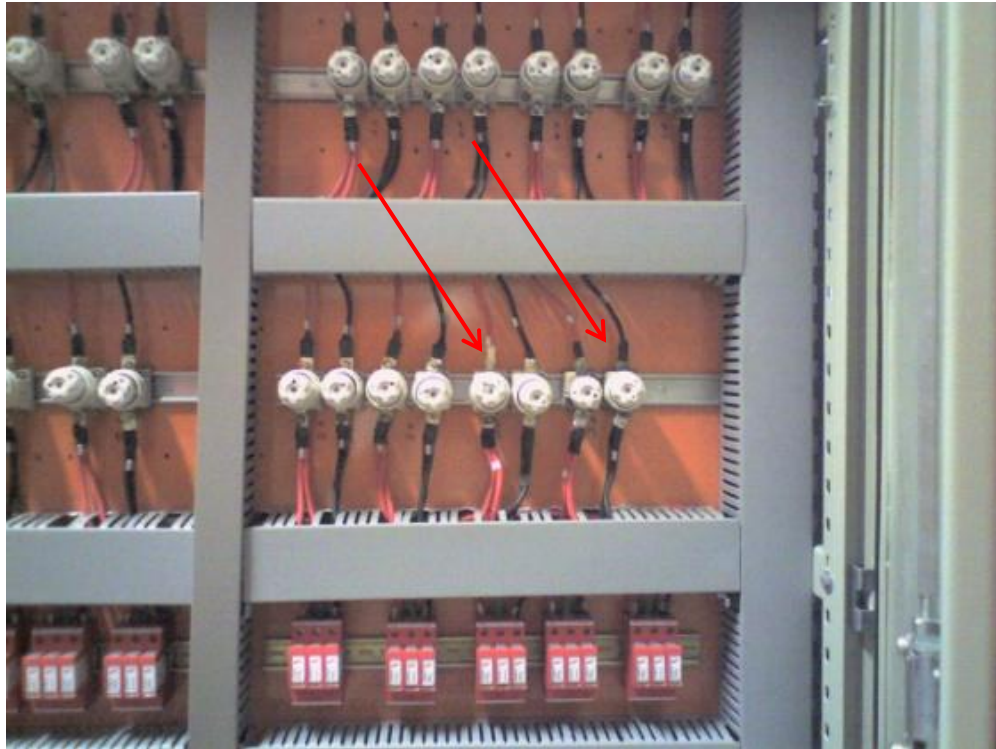
Figure 17: Heated terminal in generator junction box (IR).



**Figure 18: Generator junction box with heated terminals/ missing contact protection.**



**Figure 19: Heated fuses in generator junction box (IR).**



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Detailed Results of Individual  
Component Tests  
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**Figure 20: Generator junction box with heated fuses.**



**Figure 21: Supernatant of module in Area 1.**

### 3.1.2 Additional Remarks

Abnormalities found within the inspection, for which modifications are not absolutely required but recommended.

- A great deal of heat is likely to develop in the inverter rooms should all inverter be running. A cooling system is recommended.
- The inverters were not connected with a data cable for power balancing. When they run an asymmetric load can develop. The local requirements of the grid should be considered.
- In Area 2, Area 1 and Area 6 the wiring was not optimally installed in terms of lighting related to induction.
- The plus and minus terminals of every single string were located next to each other in the generator junction boxes in the inverter rooms. If the terminals were designed for this voltage range, which could not be checked, then this is permissible. To avoid voltage flashover they should be installed with a larger distance between plus and minus.
- The calculated shading losses for the whole plant were about 2 % of the total power. The calculation included a tree for Area 2, the floodlights for Area 3 and Area 4 and the stand for Area 1 and Area 6. The composition of the shading losses can be seen more detailed in Table 12.

| Shading object  | Area | Loss of global irradiation | Affected strings | Power loss of entire plant |
|-----------------|------|----------------------------|------------------|----------------------------|
|                 |      | %                          |                  | %                          |
| Floodlights     | 4    | 19.0                       | 5                | 0.4                        |
| Stand           | 1    | 1.6                        | 8                | 0.1                        |
| Stand           | 6    | 1.8                        | 3                | 0.1                        |
| Stand (2)       | 6    | 2.6                        | 6                | 0.2                        |
| Tree            | 2    | 9.4                        | 2                | 0.3                        |
| Floodlights (1) | 3    | 11.7                       | 10               | 0,5                        |
| Floodlights (2) | 3    | 4.4                        | 14               | 0,3                        |
| Floodlights (3) | 3    | 1.8                        | 8                | 0,1                        |
| <b>Sum</b>      |      |                            |                  | <b>2</b>                   |

**Table 12: Detailed losses due to shading of objects within the plant.**

### 3.1.3 Positive Aspects

The following points left a positive impression after the inspection:

- No hotspots were detected within the infrared camera testing of 34.9 % of the part of the plant with crystalline silicon modules.
- Both the AC and the DC cable cross sections were sufficiently dimensioned.

## 3.2 Infrared Thermography

Approximately 35 % of the part of the PV plant with crystalline silicon modules, 310 YL265-30b modules from Yingli Solar, was examined with a thermal imaging camera as part of the overall inspection. The temperature distribution within a sub-array was examined at this time.

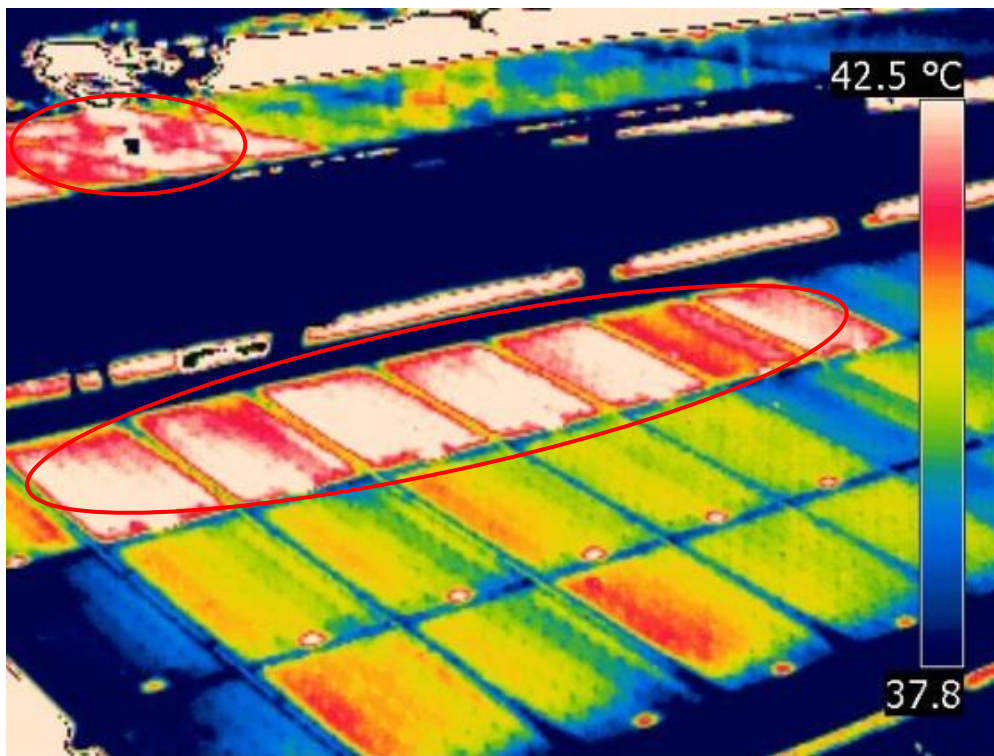
Further the junction boxes and certain connection point in the plant were checked for thermal effects.

Again it is to be mentioned, that only a part of the plant was only running for about two hours, which reduces the significance of all the results of the thermography.

No failures or thermal effects were detected on the examined modules. Only the modules connection boxes are lightly heated which is typical for modules while operating, see Figure 22.

Some terminals and fuses in the junction boxes were heated, probably because of loose installation, see Figure 17 to Figure 20.

The comparison of the cable connections showed equal thermal behavior of the connection by Gehrlicher Solar and the MC3 connection by Multi-Contact AG.



**Figure 22: Infrared picture of a part of Area 7: Temperatures are uniform. The heated modules belong to a inoperative inverter.**

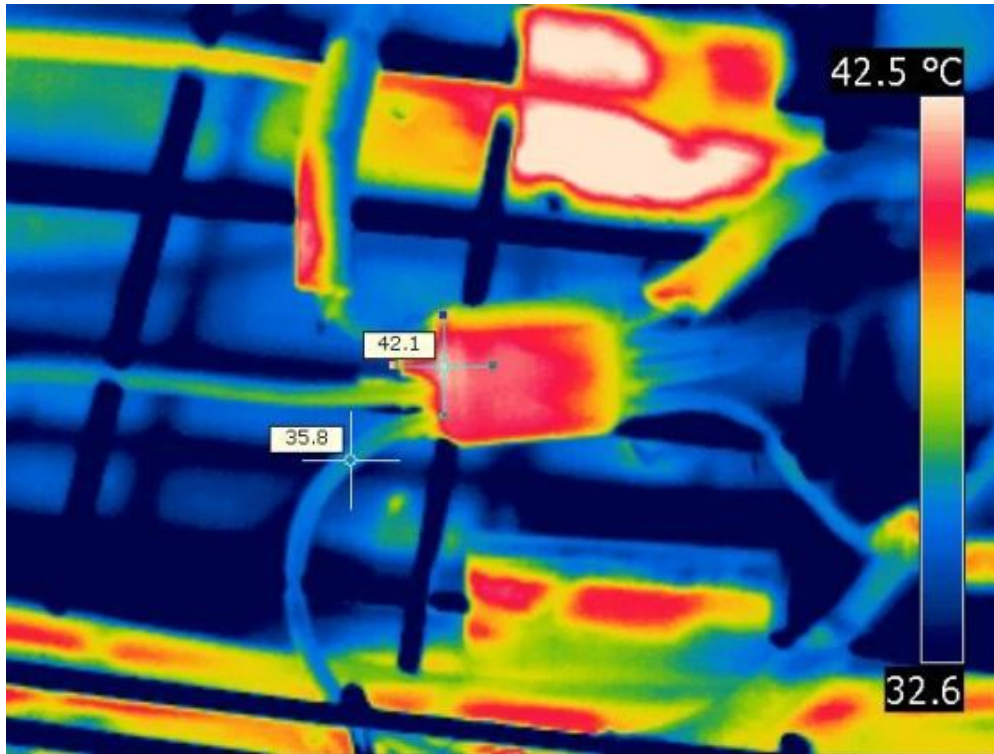


Figure 23: Cable connection by Gehrlicher Solar.

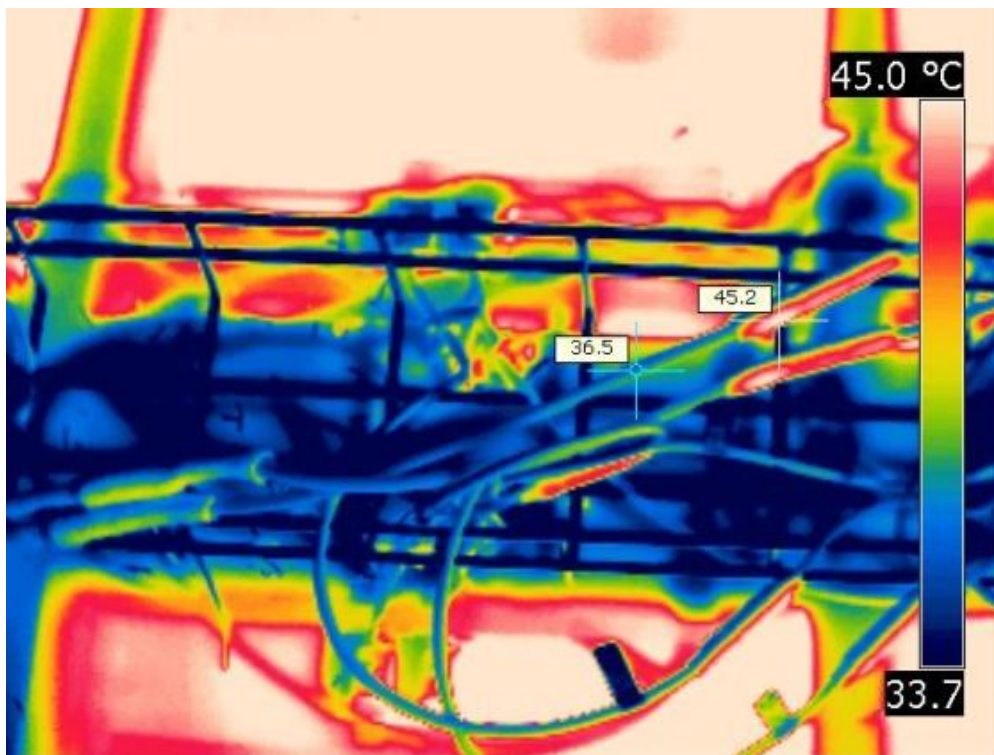


Figure 24: Cable connection MC3 by Multi-Contact AG.

### 3.3 Power Determination

A random sample of 157.606 kWp was measured in order to examine the performance of the solar power plant Estadio Pituacu. This represented approximately 38.6 % of the entire system's power. Measurements of 22 sub-arrays with 1.728 kWp, 20 sub-arrays with 1.872 kWp, 18 sub-arrays with 4.240 kWp and one sub-array with 5.830 kWp rated power each were taken. The sub-arrays are comprised of strings containing 12 and 13 PVL-144 modules manufactured by Uni-Solar or 16 and 22 YL265C-30b modules manufactured by Yingli Solar.

#### Results for PVL-144 modules of Area 3

The calculated power for the entire random sample was 36.133 kWp. After taking the external influences described in Table 13 into consideration, expected power should be 36.647 kWp.

**The variation of -1.4 % from nominal power is within the power tolerance range given.**

#### Results for PVL-144 modules of Area 4

The calculated power for the entire random sample was 34.8 kWp. After taking the external influences described in Table 14 into consideration, expected power should be 36.092 kWp.

**The variation of -3.4 % from nominal power is within the power tolerance range given.**

#### Results for YL265C-30b modules (strings with 16 modules)

The calculated power for the entire random sample was 74.669 kWp. After taking the external influences described in Table 15 into consideration, expected power should be 74.946 kWp.

**The variation of -0.3 % from nominal power is within the power tolerance range given.**

#### Results for YL265C-30b modules (string with 22 modules)

The calculated power for the entire random sample was 5.734 kWp. After taking the external influences described in Table 16 into consideration, expected power should be 5.725 kWp.

**The variation of +0.2 % from nominal power is within the power tolerance range given.**



The results of the measurements of the PVL-144 module sub-arrays in Area 3 are listed in Table 13, of the PVL-144 module sub-arrays in Area 4 in Table 14 and of the YL265C-30b module sub-arrays in Area 1 and Area 6 and 2 in Table 15 and Table 16.  $P_{STC}$  refers to generator power converted to standard test conditions. The deviation  $\Delta$  shows the deviation from  $P_{STC}$  to the target module power in percent, after taking the losses listed in Table 21 into consideration. The current-voltage characteristics of the individual sub-arrays are visible in the Appendix in section 5.2. The measured values listed represent average values of several measurements of each respective sub-array.

| Sub-array      | $G_{tit}$        | $T_{Mod}$ | $P_{STC}$      | Dev. $\Delta$ |
|----------------|------------------|-----------|----------------|---------------|
|                | W/m <sup>2</sup> | °C        | W <sub>p</sub> | %             |
| Z3.1.1         | 979              | 77        | 1669           | 0.2           |
| Z3.1.2         | 1001             | 76        | 1669           | 0.2           |
| Z3.1.3         | 1031             | 75        | 1631           | -2.0          |
| Z3.1.4         | 1030             | 79        | 1629           | -2.1          |
| Z3.2.1         | 1031             | 74        | 1625           | -2.3          |
| Z3.2.2         | 1028             | 77        | 1618           | -2.7          |
| Z3.2.3         | 1019             | 79        | 1629           | -2.1          |
| Z3.2.4         | 1013             | 79        | 1644           | -1.3          |
| Z3.3.3         | 1029             | 75        | 1655           | -0.6          |
| Z3.3.4         | 1032             | 70        | 1638           | -1.6          |
| Z3.4.1         | 984              | 75        | 1662           | -0.2          |
| Z3.4.2         | 983              | 74        | 1670           | 0.2           |
| Z3.4.3         | 1007             | 77        | 1677           | 0.6           |
| Z3.4.4         | 959              | 75        | 1667           | 0.1           |
| Z3.5.1         | 1028             | 76        | 1627           | -2.2          |
| Z3.5.2         | 1032             | 74        | 1619           | -2.7          |
| Z3.5.3         | 1033             | 77        | 1595           | -4.1          |
| Z3.5.4         | 1033             | 77        | 1616           | -2.9          |
| Z3.6.1         | 1008             | 79        | 1625           | -2.4          |
| Z3.6.2         | 1018             | 79        | 1641           | -1.4          |
| Z3.6.3         | 1007             | 77        | 1661           | -0.3          |
| Z3.6.4         | 1003             | 76        | 1664           | -0.1          |
| <b>Ø / Sum</b> | <b>1013</b>      | <b>76</b> | <b>36133</b>   | <b>-1.4</b>   |

**Table 13: Measurement results for the PVL-144 modules in Area 3.**

| <b>Sub-array</b> | <b>G<sub>tit</sub></b> | <b>T<sub>Mod</sub></b> | <b>P<sub>STC</sub></b> | <b>Dev. Δ</b> |
|------------------|------------------------|------------------------|------------------------|---------------|
|                  | <b>W/m<sup>2</sup></b> | <b>°C</b>              | <b>W<sub>p</sub></b>   | <b>%</b>      |
| Z4.11.1          | 1020                   | 63                     | 1681                   | -6,6          |
| Z4.11.2          | 927                    | 66                     | 1741                   | -3,4          |
| Z4.11.3          | 1024                   | 60                     | 1699                   | -5,6          |
| Z4.11.4          | 969                    | 66                     | 1711                   | -5,0          |
| Z4.12.1          | 991                    | 71                     | 1693                   | -6,0          |
| Z4.12.2          | 986                    | 72                     | 1668                   | -7,3          |
| Z4.12.3          | 991                    | 71                     | 1671                   | -7,2          |
| Z4.12.4          | 962                    | 72                     | 1704                   | -5,4          |
| Z4.13.1          | 944                    | 71                     | 1710                   | -5,0          |
| Z4.13.2          | 915                    | 71                     | 1734                   | -3,7          |
| Z4.13.3          | 854                    | 71                     | 1763                   | -2,2          |
| Z4.13.4          | 906                    | 71                     | 1743                   | -3,3          |
| Z4.14.1          | 912                    | 66                     | 1772                   | -1,7          |
| Z4.14.2          | 830                    | 66                     | 1811                   | 0,3           |
| Z4.14.3          | 873                    | 66                     | 1755                   | -2,6          |
| Z4.14.4          | 852                    | 66                     | 1761                   | -2,3          |
| Z4.15.1          | 852                    | 60                     | 1784                   | -1,1          |
| Z4.15.2          | 822                    | 64                     | 1784                   | -1,1          |
| Z4.15.3          | 845                    | 60                     | 1815                   | 0,6           |
| Z4.15.4          | 819                    | 64                     | 1800                   | -0,2          |
| <b>Ø / Sum</b>   | <b>915</b>             | <b>67</b>              | <b>34802</b>           | <b>-3.4</b>   |

Detailed Results of Individual Component Tests

**Table 14: Measurement results for the PVL-144 modules in Area 4.**

| <b>Sub-array</b> | <b>G<sub>tit</sub></b> | <b>T<sub>Mod</sub></b> | <b>P<sub>STC</sub></b> | <b>Dev. Δ</b> |
|------------------|------------------------|------------------------|------------------------|---------------|
|                  | <b>W/m<sup>2</sup></b> | <b>°C</b>              | <b>W<sub>p</sub></b>   | <b>%</b>      |
| Z1.1.1           | 958                    | 63                     | 4171                   | 0.2           |
| Z1.1.2           | 947                    | 62                     | 4144                   | -0.5          |
| Z1.2.1           | 938                    | 55                     | 4118                   | -1.1          |
| Z1.2.2           | 905                    | 59                     | 4137                   | -0.6          |
| Z1.3.1           | 859                    | 58                     | 4176                   | 0.3           |
| Z1.3.2           | 825                    | 53                     | 4210                   | 1.1           |
| Z1.4.1           | 787                    | 54                     | 4191                   | 0.7           |
| Z1.4.2           | 735                    | 54                     | 4193                   | 0.7           |
| Z2.1.1           | 794                    | 55                     | 4162                   | 0.0           |
| Z2.1.2           | 789                    | 49                     | 4188                   | 0.6           |
| Z6.1.1           | 1076                   | 67                     | 4134                   | -0.7          |
| Z6.1.2           | 1079                   | 66                     | 4093                   | -1.7          |
| Z6.2.1           | 1048                   | 65                     | 4132                   | -0.7          |
| Z6.2.2           | 1032                   | 66                     | 4113                   | -1.2          |
| Z6.3.1           | 1036                   | 64                     | 4110                   | -1.3          |
| Z6.3.2           | 1006                   | 65                     | 4154                   | -0.2          |
| Z6.4.1           | 1054                   | 65                     | 4154                   | -0.2          |
| Z6.4.2           | 1076                   | 62                     | 4119                   | -1.1          |
| <b>Ø / Sum</b>   | <b>941</b>             | <b>60</b>              | <b>74699</b>           | <b>-0.3</b>   |

Detailed Results of Individual Component Tests

**Table 15: Measurement results for the YL265C-30b modules (strings with 16 modules).**

| <b>Sub-array</b> | <b>G<sub>tit</sub></b> | <b>T<sub>Mod</sub></b> | <b>P<sub>STC</sub></b> | <b>Dev. Δ</b> |
|------------------|------------------------|------------------------|------------------------|---------------|
|                  | <b>W/m<sup>2</sup></b> | <b>°C</b>              | <b>W<sub>p</sub></b>   | <b>%</b>      |
| Z3.6.4           | 1059                   | 65                     | 5734                   | 0.2           |
| <b>Ø / Sum</b>   | <b>1059</b>            | <b>65</b>              | <b>5734</b>            | <b>0.2</b>    |

**Table 16: Measurement results for the YL265C-30b modules (string with 22 modules).**

The expanded uncertainty with respect to the average conditions during the measurement of sub-arrays with PVL-144 modules in Area 3 can be seen in Table 17, of the PVL-144 modules in Area 4 in Table 18 and of the YL265C-30b in Area 1 and Area 6 and 2 modules in Table 19 and Table 20.

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Detailed Results of Individual  
Component Tests  
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| <b>Test Condition</b>                              | <b>Value</b>                |
|--|-----------------------------|
| Average Irradiation                                | <b>1013 W/m<sup>2</sup></b> |
| Average Module Temperature                         | <b>76 °C</b>                |
| <b>Expanded Uncertainty of Measurement Results</b> | <b>8.7 %</b>                |
| STC Power of Random Sample                         | 36.133 ± 3.156 kWp          |

**Table 17: Expanded Measurement Uncertainty for PVL-144 modules in Area 3.**

| <b>Test Condition</b>                              | <b>Value</b>               |
|--|----------------------------|
| Average Irradiation                                | <b>915 W/m<sup>2</sup></b> |
| Average Module Temperature                         | <b>67 °C</b>               |
| <b>Expanded Uncertainty of Measurement Results</b> | <b>7,1 %</b>               |
| STC Power of Random Sample                         | 34.802 ± 2.460 kWp         |

**Table 18: Expanded Measurement Uncertainty for PVL-144 modules in Area 4.**

| <b>Test Condition</b>                              | <b>Value</b>               |
|--|----------------------------|
| Average Irradiation                                | <b>941 W/m<sup>2</sup></b> |
| Average Module Temperature                         | <b>60 °C</b>               |
| <b>Expanded Uncertainty of Measurement Results</b> | <b>4.1 %</b>               |
| STC Power of Random Sample                         | 74.699 ± 3.035 kWp         |

**Table 19: Expanded Measurement Uncertainty for YL265C-30b modules (strings with 16 modules).**

| <b>Test Condition</b>                              | <b>Value</b>                |
|--|-----------------------------|
| Average Irradiation                                | <b>1059 W/m<sup>2</sup></b> |
| Average Module Temperature                         | <b>65 °C</b>                |
| <b>Expanded Uncertainty of Measurement Results</b> | <b>4.6 %</b>                |
| STC Power of Random Sample                         | 5.734 ± 0.265 kWp           |

**Table 20: Expanded Measurement Uncertainty for YL265C-30b modules (string with 22 modules).**

The target power of the random sample is derived from the rated power of the measured modules minus the losses listed in Table 21 for the sub-arrays with PVL-144 modules in Area 3, listed in Table 22 for the sub-arrays with PVL-144 modules in Area 4 and listed in Table 23 and Table 24 for the YL265C-30b modules in Area 1 and Area 6 and 2.

-----  
 Detailed Results of Individual  
 Component Tests  
 -----

| Influencing Factor         | Loss Value             |
|----------------------------|------------------------|
| Soiling                    | 2.5 %                  |
| Shading                    | 0.0 %                  |
| Connection Losses          | 0.8 %                  |
| Cabling Losses             | 0.3 %                  |
| <b>Total Loss</b>          | <b>3.6 %</b>           |
| Target Random Sample Power | 36.647 kW <sub>p</sub> |

**Table 21: Actual Losses and Target Power of Random Sample for PVL-144 modules in Area 3**

| Influencing Factor         | Loss Value             |
|----------------------------|------------------------|
| Soiling                    | 2.5 %                  |
| Shading                    | 0.0 %                  |
| Connection Losses          | 0.8 %                  |
| Cabling Losses             | 0.3 %                  |
| <b>Total Loss</b>          | <b>3.6 %</b>           |
| Target Random Sample Power | 36.092 kW <sub>p</sub> |

**Table 22: Actual Losses and Target Power of Random Sample for PVL-144 modules in Area 4**

| Influencing Factor         | Loss Value             |
|----------------------------|------------------------|
| Soiling                    | 1.0 %                  |
| Shading                    | 0.0 %                  |
| Connection Losses          | 0.5 %                  |
| Cabling Losses             | 0.3 %                  |
| <b>Total Loss</b>          | <b>1.8 %</b>           |
| Target Random Sample Power | 74.946 kW <sub>p</sub> |

**Table 23: Actual Losses and Target Power of Random Sample for YL265C-30b modules (strings with 16 modules).**

| <b>Influencing Factor</b>  | <b>Loss Value</b>     |
|----------------------------|-----------------------|
| Soiling                    | 1.0 %                 |
| Shading                    | 0.0 %                 |
| Connection Losses          | 0.5 %                 |
| Cabling Losses             | 0.3 %                 |
| <b>Total Loss</b>          | <b>1.8 %</b>          |
| Target Random Sample Power | 5.725 kW <sub>p</sub> |

Detailed Results of Individual Component Tests

**Table 24: Actual Losses and Target Power of Random Sample for YL265C-30b modules (string with 22 modules).**

The measurements were taken using the following devices and sensors:

| <b>Measuring Device</b>         | <b>Description</b> | <b>Testing Instrument</b> |
|---------------------------------|--------------------|---------------------------|
| Characteristic Measuring Device | cetisPV-CT-F1      | 922-AP-210                |
| Load Booster                    | cetisPV-CB1        | 922-AP-211                |
| Reference Cell                  | ISE 061-2010       | 922-AP-253                |
| Temperature Sensor              | PT100              | 922-AP-224                |

**Table 25: Measuring Devices Used.**

## 4 Evaluation Methods and Measurements

### 4.1 Evaluation of Concept and Construction

The visual inspection includes the examination of the **entire system** with the components described below.

The review consists of an inspection of the **generator field** as a whole. Depending on the type of system, individual modules series are typically surveyed, at which time the focus is both on the **laying of the cable** itself and on the **assembly** of the **modules** and the **substructure**.

The relevant design of the system to be adapted on location is measured and verified. This includes, among other things, **tilt, orientation, interconnection, and distance between rows** of modules.

Another significant point is the **shading** of the modules. Shading sources are either identified with special horizon recording devices or, if possible, recorded in the form of height, distance and direction, in order to calculate resulting yield losses in relation to the overall yield of the system. **Row, external, and horizon shading** are all considered at this time.

**Sub-distributions** and **generator junction boxes** are checked for their suitability for their respective locations of operation as well as the dimensioning of the overcurrent protective devices, surge protectors and other components.

The length and cross sections of the **cables and wires** on the AC and DC sides are assessed in terms of voltage and current. The cables and wires should be of sufficient size to prevent larger losses. In addition, the laying of cable is assessed.

The **inverters** are examined individually. In this case, the inverters' yields and operation periods are compared while error messages and warnings are documented.

If present, **transformer** and **power supply stations** are included with the **medium-voltage switchgear** using photo documentation.

The results of visual inspection are compared with both previously determined location-dependent reference values and appropriate **system documentation** from the principal and, if available, with the **assumptions made in the yield reports**.

The desired or expected operating time of the plant is crucial for the assessment of all **installations**.

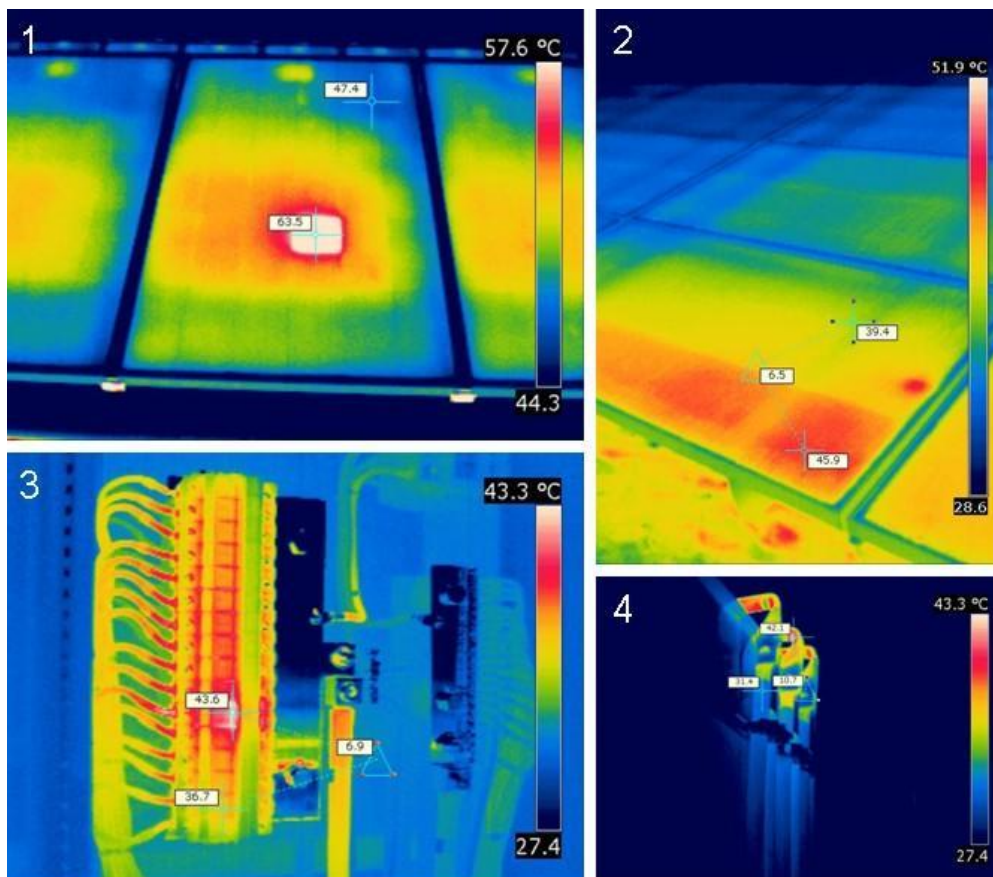
## 4.2 Infrared Thermography

In this case, the PV modules are tested using the thermal imaging camera while in operation. With this method, the temperature sequences are visible within a module and within larger module fields. Damages to modules such as hot spot effects on crystalline silicon modules can be clearly identified from an irradiation of approximately 700 W/m<sup>2</sup>. Other phenomena, such as defective bypass diodes in the module junction box, inactive strings and similar effects can also be detected at lower irradiation.

Hot spot effects occur when a cell or string of a module becomes very hot due to shading or manufacturing defects. The reason for this is that the cell or string behaves like an ohmic resistor in this particular case, through which the current of the remaining intact cells flows.

We recommend the replacement of the affected modules, since these modules affect the performance of the strings and an eventual failure of these modules due to the thermal problems cannot be ruled out.

In addition to the generator field, which is generally checked for about 20 % of the total power, inverters, junction boxes, circuit breakers and power cables are tested for thermal anomalies with an infrared camera.



**Figure 25: Sample Images from Infrared Camera:**  
 1: Hot Spot in a crystalline PV module.  
 2: Defective bypass diode, inactive cell string.  
 3: Heated fuse in junction box.  
 4: AC power cables on inverter output.



## 4.3 Power Determination

Starting with an irradiation of 800 W/m<sup>2</sup>, modules can be measured under real conditions on the DC side and their performance converted to STC conditions. Thus, it can be established whether or not the modules actually possess the power rating listed on the data sheet. About 10 % to 20 % of the system's total rated power is measured as part of the system inspection, depending on the sunshine duration, system size and interconnection.

### **Additional Remarks about the Measurements:**

#### **Measurement:**

The power of PV modules and generators are determined through the measurement of current-voltage characteristics with a halm cetisPV-CT-F1 characteristic measuring device with a cetisPV-CB1 load booster. Since the power of PV modules is dependent on temperature and irradiation, these variables are recorded parallel to the characteristic curve measurement with a PT100 temperature sensor and a silicon solar reference cell.

#### **Analysis:**

Field measurements generally cannot be carried out under standard conditions (STC). STC refers to a module temperature of 25 °C, irradiation on the module plane of 1,000 W/m<sup>2</sup> and a standard spectrum of AM1, 5. Thus, measurement results under real world conditions must be converted to STC using accepted practices. We use the method described in IEC 60891, 2<sup>nd</sup> Edition.

#### **Uncertainty:**

The so-called expanded uncertainty is given, which is calculated according to the "Guide to the Expression of Uncertainty in Measurement," which has the status of an international standard. This uncertainty states that the true value of a measurement lies between the specified limits resulting from the uncertainty with a probability of 95 %. Uncertainties are caused by:

#### Measurements:

Our measurements have the following uncertainties:

|                                  |                   |
|----------------------------------|-------------------|
| Reference Cell:                  | ± 0.6 %           |
| Temperature Sensor:              | ± 0.4 %           |
| Characteristic Measuring Device: | less than ± 0.6 % |

If a result - in this case the power at STC – is influenced by various measurement values – in this case irradiation, temperature, voltage and current - then its uncertainty can be calculated by the so-called law of propagation uncertainty.

#### Conversion to STC:

The more the actual conditions deviate from STC, the larger the uncertainties resulting from the conversion to STC becomes. Average irradiation and module temperature at the time of measurement are used.

#### Spectral Mismatch:

The spectrum of sun and sky radiation observed over the course of a year differs from the standard spectrum (1.5 AM). This effect is not recorded as part of the conversion process; it is, however, taken into account in the uncertainty calculation.

**External Influences:**

Module power in an actual system is reduced by various external influences. Target power is rated power minus losses; the power as determined under STC must be compared to this value, see Table 21 to Table 23. The following losses are taken into account:

Module Soiling

In order to ensure high long-term system yields, modules should be tested for special signs of soiling at regular intervals.  
Soiling losses for individual modules are measured as part of the power determination.

Electrical Mismatch:

The connection of a large number of modules to subgenerators leads to additional losses, due to slight variations in module power parameters. Depending on the power tolerance the losses reach from 0 % to approximately 1 % of the nominal power.

Connection and Cabling Losses:

Cabling losses can be calculated using cable lengths and cross sections. Well-designed systems operating with nominal current have cabling losses lower than 1 %.

## 4.4 Symbols Used in Formulas and Abbreviations

| <b>Symbol</b> | <b>Meaning</b>       | <b>Unit</b>      |
|---------------|----------------------|------------------|
| A             | Surface Area         | m <sup>2</sup>   |
| W             | Width                | m bzw. mm        |
| <i>Eta</i>    | Efficiency           | %                |
| G             | Irradiation (global) | W/m <sup>2</sup> |
| I             | Current              | A                |
| L             | Length               | m bzw. mm        |
| Ø             | Average              | -                |
| P             | Power                | W                |
| PR            | Performance Ratio    | %                |
| S             | Apparent Power       | VA               |
| T             | Temperature          | °C, K            |
| U             | Voltage              | V                |

**Table 26: Formula Symbols**

| <b>Abbreviation</b> | <b>Meaning</b>           |
|---------------------|--------------------------|
| <i>Des</i>          | Description of Sub-array |
| <i>N</i>            | North                    |
| <i>E</i>            | East                     |
| <i>PE</i>           | Protective Earth         |
| <i>PV</i>           | Photovoltaic             |
| <i>STC</i>          | Standard Test Conditions |
| <i>SA</i>           | Sub-array                |
| <i>SS</i>           | Substructure             |
| <i>W</i>            | West                     |
| <i>INV</i>          | Inverter                 |

**Table 27: Abbreviations**

| <b>Indices</b> | <b>Meaning</b>   |
|----------------|--|
| AC             | Alternating Current  |
| DC             | Direct Current   |
| Dif            | Diffuse  |
| Feed           | Feed-in  |
| Gl             | Global   |
| Max            | Maximal  |
| Meas           | Value measured under actual conditions                           |
| Mod            | Module   |
| MPP            | Maximum Power Point  |
| N              | Nominal Value  |
| OC             | Open Circuit   |
| P              | Peak (Value)   |
| Ref            | Reference  |
| SC             | Short Circuit  |
| Spec           | Specific   |
| Target         | Target Value (value to be expected as determined by calculation) |
| STC            | Standard Test Conditions   |
| Sys            | System   |
| Tilt           | Tilted   |
| Theo           | Theoretical Value (simulated value)                              |
| Amb            | Ambient  |
| L              | Loss   |

**Table 28: Indices**

## 5 Appendix

### 5.1 Photos of the Photovoltaic System

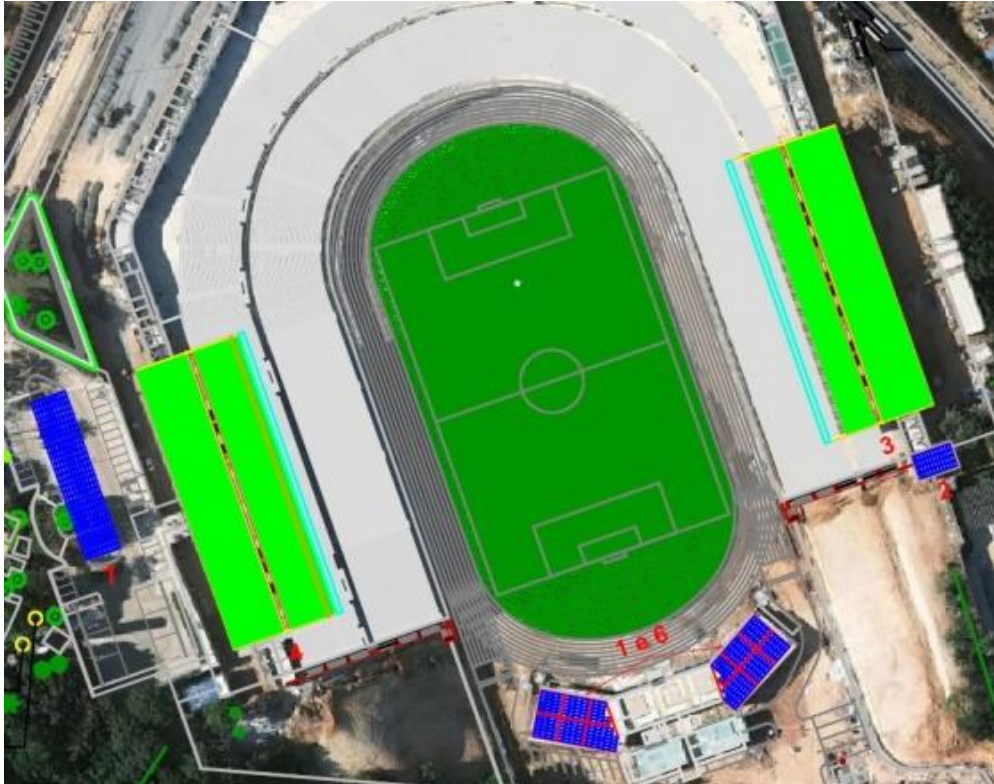


Figure 26: View of the arrangement of the system parts.



Figure 27: View of the entire stadium from the north.

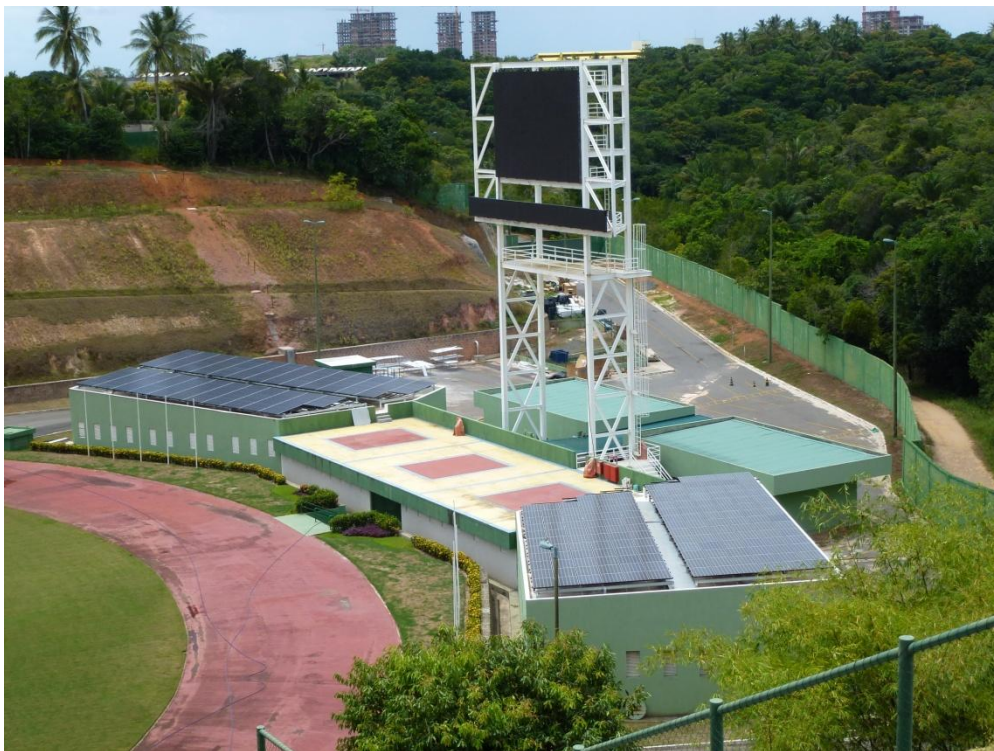


Figure 28: View of Area 1 and Area 6 with YL265C-30b modules from Yingli Solar.



Figure 29: View of Area 2 with YL265C-30b modules from Yingli Solar.



Figure 30: View of Area 7 with YL265C-30b modules from Yingli Solar.



**Figure 31: View of Area 3 with PVL-144 modules from Uni-Solar.**



**Figure 32: View of Area 3 with floodlight.**





**Figure 33: View of Area 4 with PVL-144 modules from Uni-Solar.**



**Figure 34: View of Area 4 with floodlight.**

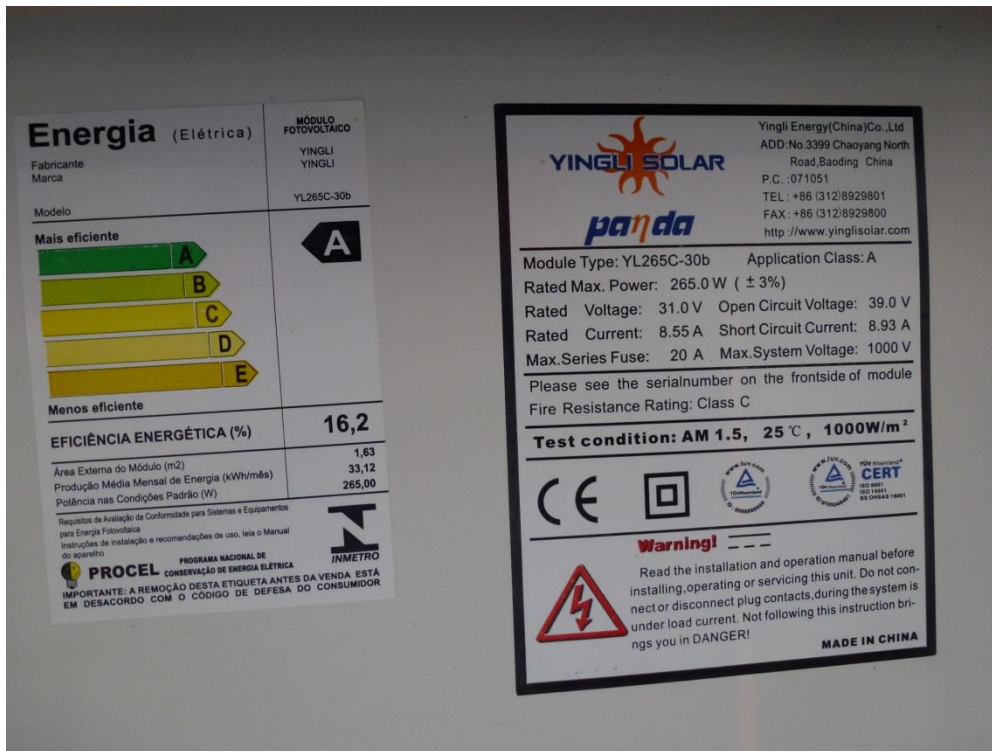


Figure 35: Label of module YL265C-30b from Yingli Solar.

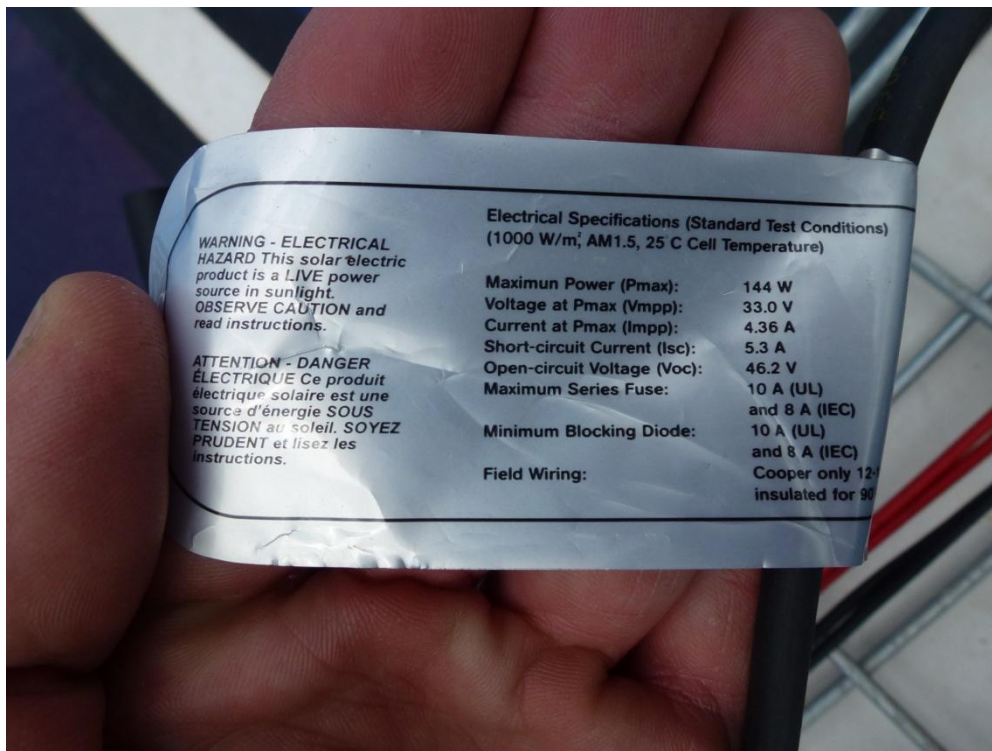


Figure 36: Label of module PVL-144 from Uni-Solar.



Figure 37: String connection by Gehrlicher Solar for PVL-144 in Area 4.



Figure 38: String fuse by Gehrlicher Solar for PVL-144 in Area 4.



Figure 39: Generator connection box.



Figure 40: Inverters installed in inverter room.

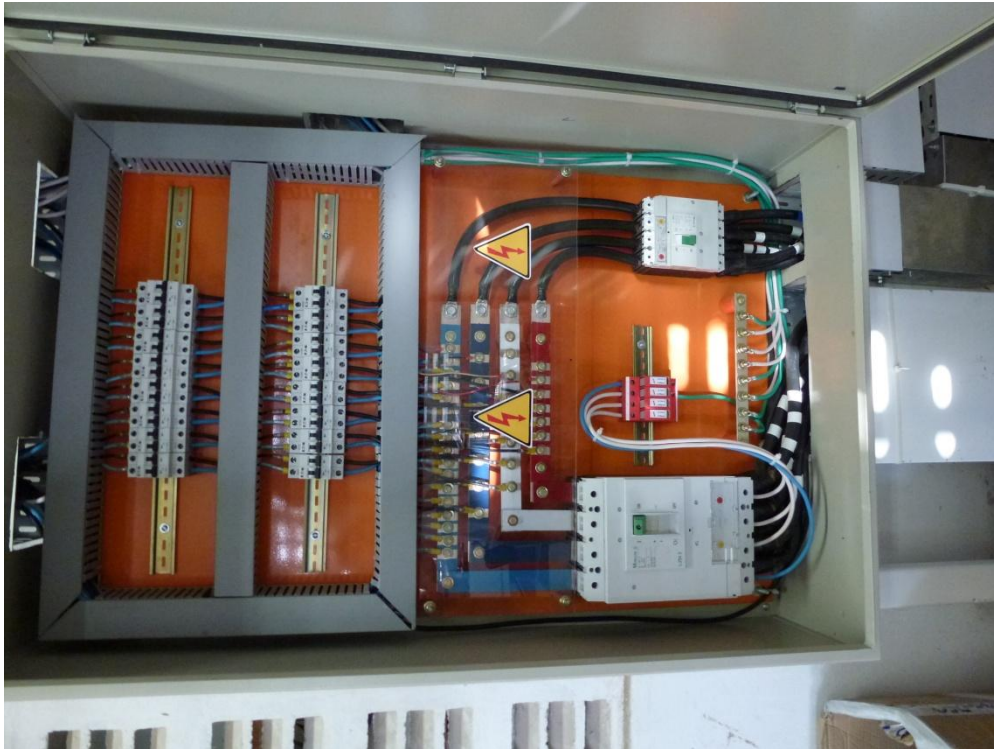


Figure 41: AC connection for the inverters.

## 5.2

### Test Report for Characteristic Curve Measurements

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Appendix  
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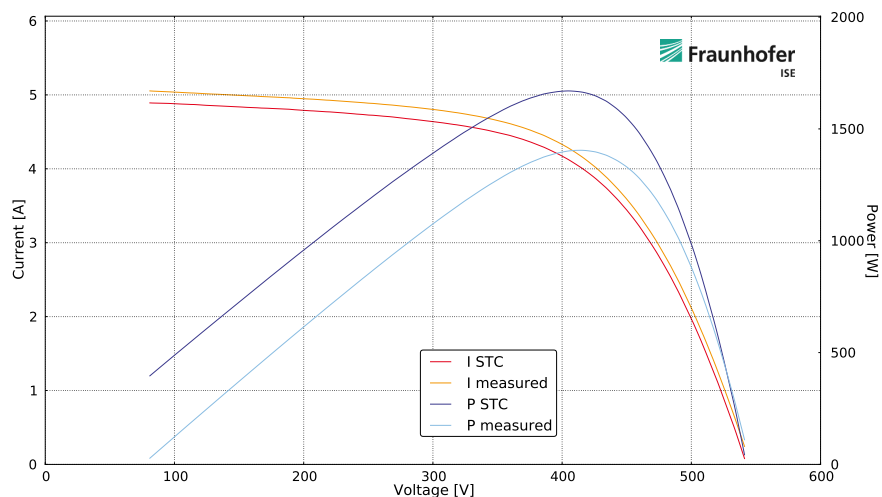
## A1 Measurement Log for Z3.1.1

Module type: PVL-144  
 Sub array: Z3.1.1  
 Date / Time: 2012-03-22 / 16:37:56  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                     | Measurement | STC    | SD   | Nominal | Dev. in % |
|---------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]       | 1407.7      | 1669.2 | 3.93 | 1728.0  | -3.4      |
| $I_{SC}$ [A]        | 5.1         | 5.0    | 0.01 | 5.3     | -6.2      |
| $U_{OC}$ [V]        | 452.6       | 544.7  | 0.12 | 554.4   | -1.8      |
| $I_{MPP}$ [A]       | 4.2         | 4.1    | 0.01 | 4.4     | -5.2      |
| $U_{MPP}$ [V]       | 336.3       | 403.7  | 0.73 | 396.0   | 1.9       |
| FF [%]              | 61.4        | 61.7   | 0.29 | 58.8    | 4.9       |
| Eta [%]             | 5.4         | 6.4    | 0.02 | 6.7     | -3.4      |
| $E$ [ $W/m^2$ ]     | 978.8       | 1000.0 | 0.00 | 1000.0  | -2.1      |
| $T$ [ $^{\circ}C$ ] | 77.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.5\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

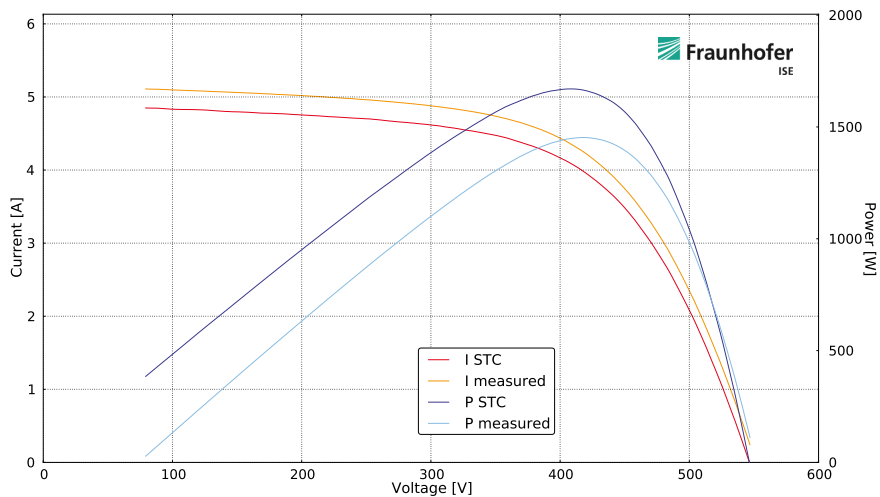
## A2 Measurement Log for Z3.1.2

Module type: PVL-144  
 Sub array: Z3.1.2  
 Date / Time: 2012-03-22 / 16:25:59  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1455.5      | 1669.3 | 2.18 | 1728.0  | -3.4      |
| $I_{SC}$ [A]      | 5.1         | 4.9    | 0.00 | 5.3     | -7.5      |
| $U_{OC}$ [V]      | 459.6       | 547.6  | 0.42 | 554.4   | -1.2      |
| $I_{MPP}$ [A]     | 4.3         | 4.1    | 0.01 | 4.4     | -5.9      |
| $U_{MPP}$ [V]     | 341.5       | 406.8  | 0.83 | 396.0   | 2.7       |
| FF [%]            | 61.8        | 62.2   | 0.07 | 58.8    | 5.8       |
| Eta [%]           | 5.6         | 6.4    | 0.01 | 6.7     | -3.4      |
| E [ $W/m^2$ ]     | 1000.9      | 1000.0 | 0.00 | 1000.0  | 0.1       |
| T [ $^{\circ}C$ ] | 76.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 5 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.4\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:



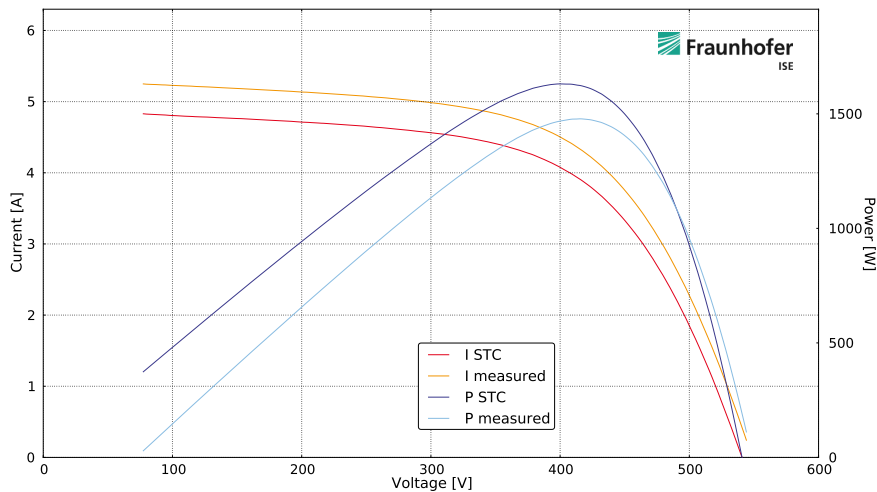
### A3 Measurement Log for Z3.1.3

Module type: PVL-144  
 Sub array: Z3.1.3  
 Date / Time: 2012-03-22 / 15:59:24  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1477.8      | 1631.5 | 1.11 | 1728.0  | -5.6      |
| $I_{SC}[A]$     | 5.2         | 4.9    | 0.01 | 5.3     | -7.5      |
| $U_{OC}[V]$     | 458.8       | 542.3  | 0.24 | 554.4   | -2.2      |
| $I_{MPP}[A]$    | 4.3         | 4.1    | 0.01 | 4.4     | -7.0      |
| $U_{MPP}[V]$    | 340.1       | 402.3  | 0.83 | 396.0   | 1.6       |
| FF [%]          | 61.4        | 61.3   | 0.20 | 58.8    | 4.3       |
| Eta [%]         | 5.7         | 6.3    | 0.00 | 6.7     | -5.6      |
| $E [W/m^2]$     | 1030.8      | 1000.0 | 0.00 | 1000.0  | 3.1       |
| $T [^{\circ}C]$ | 75.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.8\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

#### I-V-Characteristic:



#### Comments:

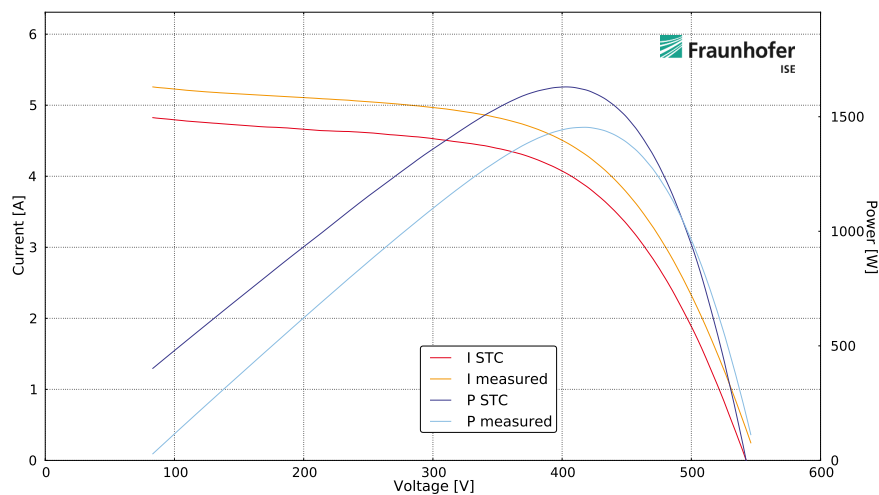
## A4 Measurement Log for Z3.1.4

Module type: PVL-144  
 Sub array: Z3.1.4  
 Date / Time: 2012-03-22 / 15:55:24  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1457.8      | 1629.3 | 2.64 | 1728.0  | -5.7      |
| $I_{SC}[A]$     | 5.3         | 5.0    | 0.01 | 5.3     | -6.5      |
| $U_{OC}[V]$     | 454.8       | 544.9  | 0.64 | 554.4   | -1.7      |
| $I_{MPP}[A]$    | 4.3         | 4.0    | 0.02 | 4.4     | -7.5      |
| $U_{MPP}[V]$    | 336.8       | 403.8  | 1.83 | 396.0   | 2.0       |
| FF [%]          | 61.0        | 60.3   | 0.22 | 58.8    | 2.6       |
| Eta [%]         | 5.6         | 6.3    | 0.01 | 6.7     | -5.7      |
| $E [W/m^2]$     | 1030.3      | 1000.0 | 0.00 | 1000.0  | 3.0       |
| $T [^{\circ}C]$ | 79.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 9.3\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

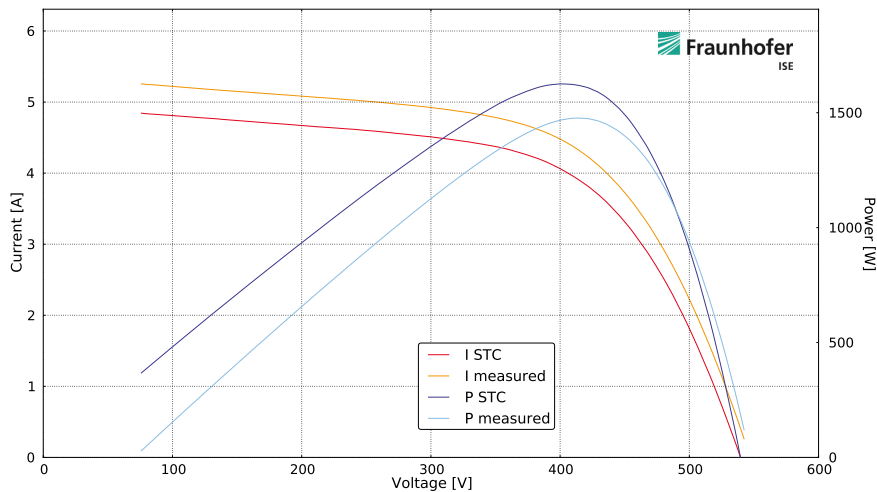
## A5 Measurement Log for Z3.2.1

Module type: PVL-144  
 Sub array: Z3.2.1  
 Date / Time: 2012-03-22 / 15:37:48  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1476.6      | 1625.3 | 1.22 | 1728.0  | -5.9      |
| $I_{SC}$ [A]      | 5.3         | 5.0    | 0.01 | 5.3     | -6.5      |
| $U_{OC}$ [V]      | 459.0       | 540.9  | 0.28 | 554.4   | -2.4      |
| $I_{MPP}$ [A]     | 4.3         | 4.0    | 0.01 | 4.4     | -7.3      |
| $U_{MPP}$ [V]     | 340.9       | 402.3  | 0.81 | 396.0   | 1.6       |
| FF [%]            | 61.2        | 60.6   | 0.16 | 58.8    | 3.1       |
| Eta [%]           | 5.7         | 6.3    | 0.00 | 6.7     | -5.9      |
| E [ $W/m^2$ ]     | 1030.8      | 1000.0 | 0.00 | 1000.0  | 3.1       |
| T [ $^{\circ}C$ ] | 74.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

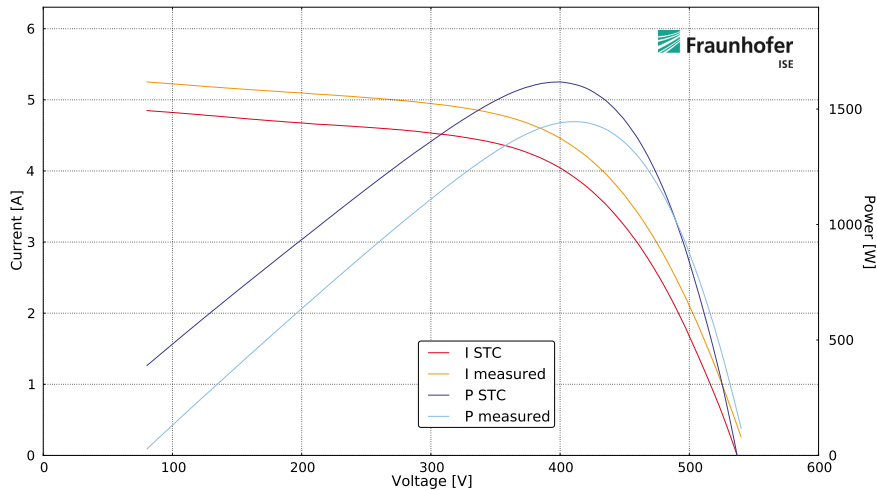
## A6 Measurement Log for Z3.2.2

Module type: PVL-144  
 Sub array: Z3.2.2  
 Date / Time: 2012-03-22 / 15:28:00  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1445.6      | 1618.4 | 2.98 | 1728.0  | -6.3      |
| $I_{SC}[A]$     | 5.3         | 5.0    | 0.01 | 5.3     | -6.5      |
| $U_{OC}[V]$     | 451.8       | 538.6  | 0.31 | 554.4   | -2.9      |
| $I_{MPP}[A]$    | 4.3         | 4.1    | 0.00 | 4.4     | -6.8      |
| $U_{MPP}[V]$    | 332.6       | 398.1  | 0.84 | 396.0   | 0.5       |
| FF [%]          | 60.9        | 60.6   | 0.15 | 58.8    | 3.1       |
| Eta [%]         | 5.6         | 6.2    | 0.01 | 6.7     | -6.3      |
| $E [W/m^2]$     | 1027.7      | 1000.0 | 0.00 | 1000.0  | 2.8       |
| $T [^{\circ}C]$ | 77.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 9.1\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

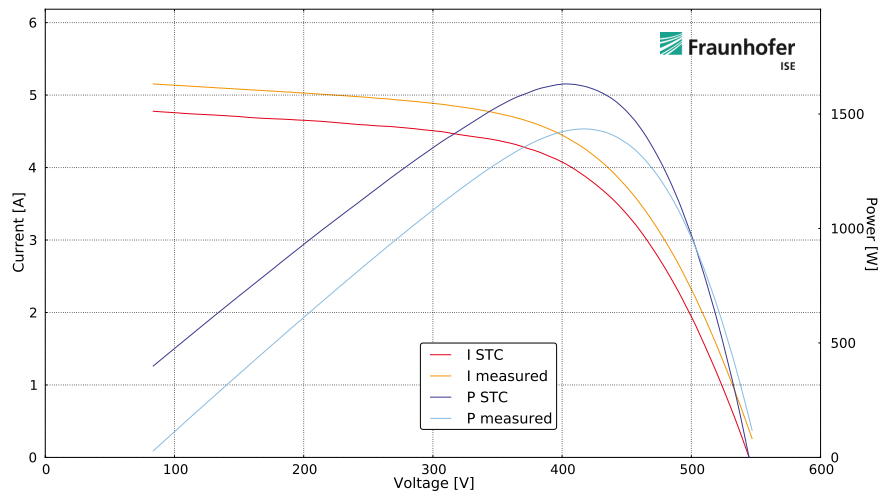
## A7 Measurement Log for Z3.2.3

Module type: PVL-144  
 Sub array: Z3.2.3  
 Date / Time: 2012-03-22 / 15:14:05  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1435.7      | 1629.0 | 1.67 | 1728.0  | -5.7      |
| $I_{SC}$ [A]      | 5.2         | 4.9    | 0.00 | 5.3     | -8.1      |
| $U_{OC}$ [V]      | 455.2       | 546.2  | 0.10 | 554.4   | -1.5      |
| $I_{MPP}$ [A]     | 4.3         | 4.0    | 0.00 | 4.4     | -7.6      |
| $U_{MPP}$ [V]     | 337.2       | 404.2  | 0.12 | 396.0   | 2.1       |
| FF [%]            | 61.2        | 61.3   | 0.06 | 58.8    | 4.2       |
| Eta [%]           | 5.5         | 6.3    | 0.01 | 6.7     | -5.7      |
| E [ $W/m^2$ ]     | 1018.6      | 1000.0 | 0.00 | 1000.0  | 1.9       |
| T [ $^{\circ}C$ ] | 79.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 9.2\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

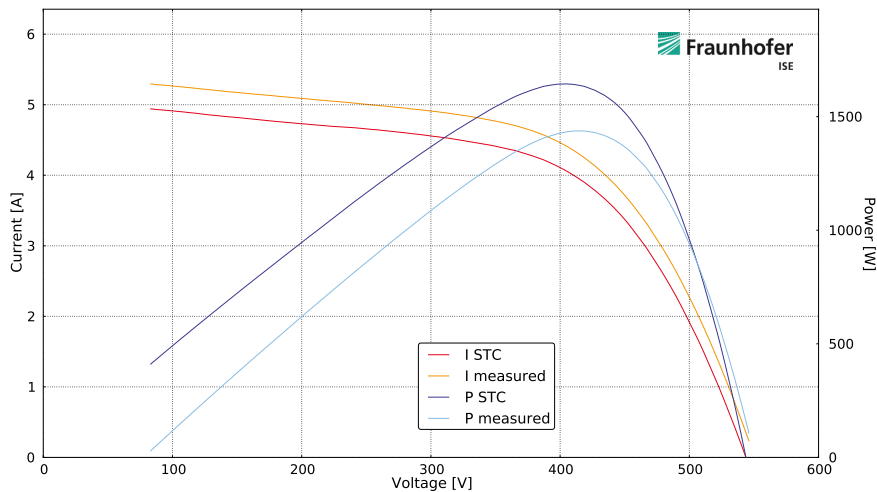
## A8 Measurement Log for Z3.2.4

Module type: PVL-144  
 Sub array: Z3.2.4  
 Date / Time: 2012-03-22 / 15:06:20  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1437.1      | 1643.8 | 1.24 | 1728.0  | -4.9      |
| $I_{SC}$ [A]      | 5.3         | 5.1    | 0.00 | 5.3     | -3.8      |
| $U_{OC}$ [V]      | 453.9       | 545.4  | 0.24 | 554.4   | -1.6      |
| $I_{MPP}$ [A]     | 4.3         | 4.1    | 0.00 | 4.4     | -6.5      |
| $U_{MPP}$ [V]     | 334.5       | 403.1  | 0.66 | 396.0   | 1.8       |
| FF [%]            | 59.8        | 59.1   | 0.05 | 58.8    | 0.6       |
| Eta [%]           | 5.5         | 6.3    | 0.00 | 6.7     | -4.9      |
| E [ $W/m^2$ ]     | 1012.7      | 1000.0 | 0.00 | 1000.0  | 1.3       |
| T [ $^{\circ}C$ ] | 79.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 9.1\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

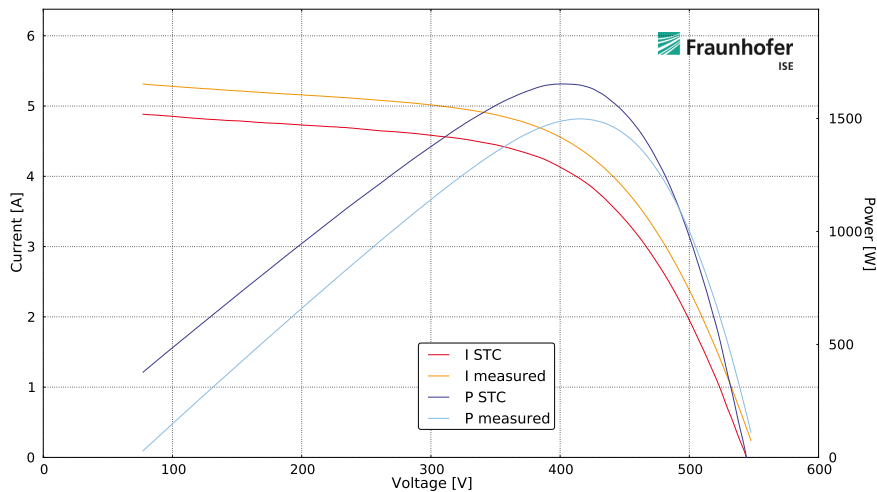
## A9 Measurement Log for Z3.3.3

Module type: PVL-144  
 Sub array: Z3.3.3  
 Date / Time: 2012-03-22 / 14:48:19  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                     | Measurement | STC    | SD   | Nominal | Dev. in % |
|---------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]       | 1493.8      | 1654.8 | 1.42 | 1728.0  | -4.2      |
| $I_{SC}$ [A]        | 5.3         | 5.0    | 0.01 | 5.3     | -5.9      |
| $U_{OC}$ [V]        | 462.4       | 545.9  | 0.35 | 554.4   | -1.5      |
| $I_{MPP}$ [A]       | 4.4         | 4.1    | 0.00 | 4.4     | -6.0      |
| $U_{MPP}$ [V]       | 341.3       | 403.7  | 0.27 | 396.0   | 2.0       |
| FF [%]              | 61.0        | 60.8   | 0.04 | 58.8    | 3.3       |
| Eta [%]             | 5.8         | 6.4    | 0.01 | 6.7     | -4.2      |
| $E$ [ $W/m^2$ ]     | 1028.8      | 1000.0 | 0.00 | 1000.0  | 2.9       |
| $T$ [ $^{\circ}C$ ] | 75.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.7\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

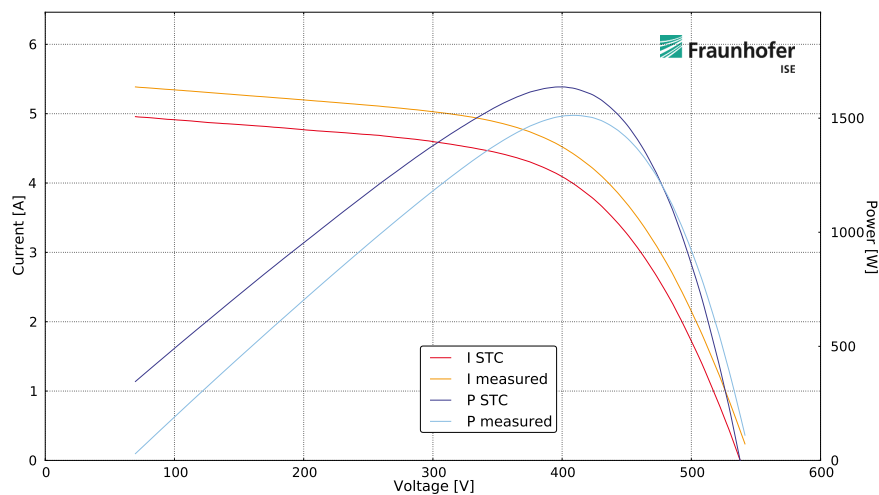
## A10 Measurement Log for Z3.3.4

Module type: PVL-144  
 Sub array: Z3.3.4  
 Date / Time: 2012-03-22 / 14:44:18  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1504.3      | 1637.6 | 1.52 | 1728.0  | -5.2      |
| $I_{SC}$ [A]      | 5.4         | 5.1    | 0.01 | 5.3     | -4.5      |
| $U_{OC}$ [V]      | 464.5       | 539.5  | 0.04 | 554.4   | -2.7      |
| $I_{MPP}$ [A]     | 4.4         | 4.1    | 0.01 | 4.4     | -5.7      |
| $U_{MPP}$ [V]     | 341.5       | 398.3  | 0.25 | 396.0   | 0.6       |
| FF [%]            | 60.4        | 59.9   | 0.10 | 58.8    | 1.9       |
| Eta [%]           | 5.8         | 6.3    | 0.01 | 6.7     | -5.2      |
| E [ $W/m^2$ ]     | 1031.7      | 1000.0 | 0.00 | 1000.0  | 3.2       |
| T [ $^{\circ}C$ ] | 70.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.1\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:



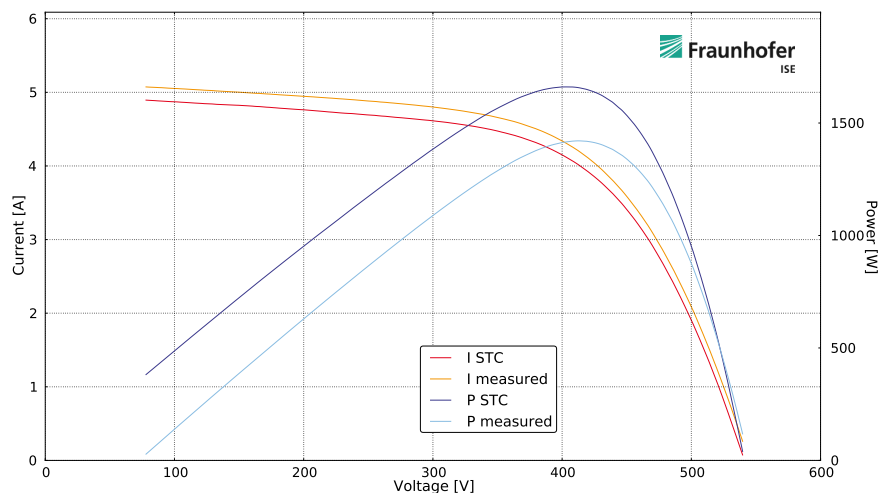
## A11 Measurement Log for Z3.4.1

Module type: PVL-144  
 Sub array: Z3.4.1  
 Date / Time: 2012-03-22 / 16:34:09  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1418.8      | 1662.2 | 2.01 | 1728.0  | -3.8      |
| $I_{SC}$ [A]      | 5.1         | 5.0    | 0.01 | 5.3     | -6.5      |
| $U_{OC}$ [V]      | 454.7       | 542.8  | 0.07 | 554.4   | -2.1      |
| $I_{MPP}$ [A]     | 4.2         | 4.1    | 0.01 | 4.4     | -5.3      |
| $U_{MPP}$ [V]     | 337.8       | 402.6  | 0.87 | 396.0   | 1.7       |
| FF [%]            | 61.6        | 61.8   | 0.20 | 58.8    | 5.1       |
| Eta [%]           | 5.5         | 6.4    | 0.01 | 6.7     | -3.8      |
| E [ $W/m^2$ ]     | 983.8       | 1000.0 | 0.00 | 1000.0  | -1.6      |
| T [ $^{\circ}C$ ] | 75.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.3\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

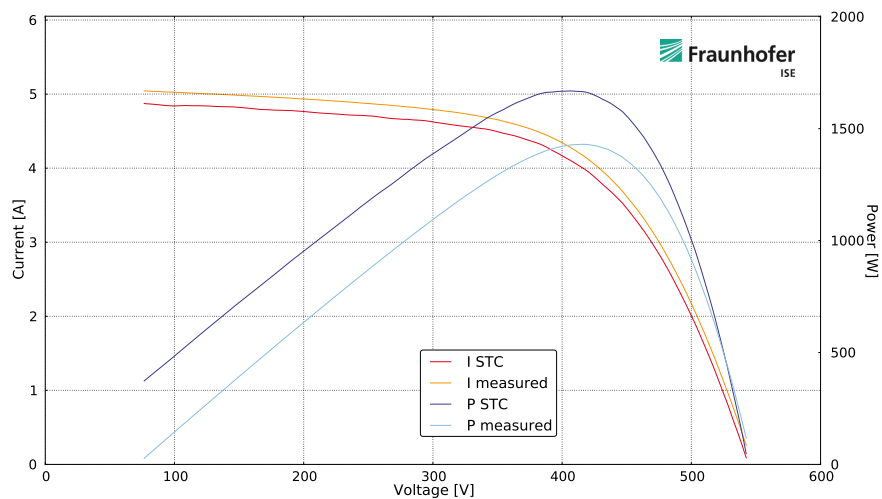
## A12 Measurement Log for Z3.4.2

Module type: PVL-144  
 Sub array: Z3.4.2  
 Date / Time: 2012-03-22 / 16:32:11  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1430.4      | 1670.0 | 2.11 | 1728.0  | -3.4      |
| $I_{SC}$ [A]      | 5.0         | 4.9    | 0.01 | 5.3     | -7.1      |
| $U_{OC}$ [V]      | 459.0       | 545.6  | 0.28 | 554.4   | -1.6      |
| $I_{MPP}$ [A]     | 4.2         | 4.1    | 0.01 | 4.4     | -5.3      |
| $U_{MPP}$ [V]     | 340.0       | 404.6  | 0.73 | 396.0   | 2.2       |
| FF [%]            | 61.7        | 62.2   | 0.13 | 58.8    | 5.8       |
| Eta [%]           | 5.5         | 6.4    | 0.01 | 6.7     | -3.4      |
| E [ $W/m^2$ ]     | 983.3       | 1000.0 | 0.00 | 1000.0  | -1.7      |
| T [ $^{\circ}C$ ] | 74.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.1\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

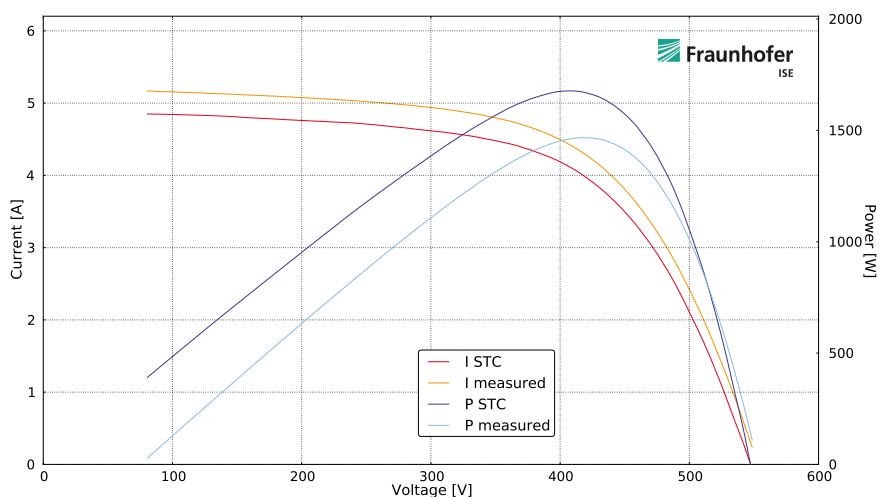
## A13 Measurement Log for Z3.4.3

Module type: PVL-144  
 Sub array: Z3.4.3  
 Date / Time: 2012-03-22 / 16:20:04  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1467.9      | 1676.5 | 1.02 | 1728.0  | -3.0      |
| $I_{SC}$ [A]      | 5.2         | 4.9    | 0.02 | 5.3     | -7.5      |
| $U_{OC}$ [V]      | 459.9       | 548.8  | 0.18 | 554.4   | -1.0      |
| $I_{MPP}$ [A]     | 4.3         | 4.1    | 0.01 | 4.4     | -5.5      |
| $U_{MPP}$ [V]     | 340.9       | 406.9  | 0.53 | 396.0   | 2.8       |
| FF [%]            | 61.7        | 62.3   | 0.27 | 58.8    | 5.9       |
| Eta [%]           | 5.7         | 6.5    | 0.00 | 6.7     | -3.0      |
| E [ $W/m^2$ ]     | 1007.4      | 1000.0 | 0.00 | 1000.0  | 0.7       |
| T [ $^{\circ}C$ ] | 77.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

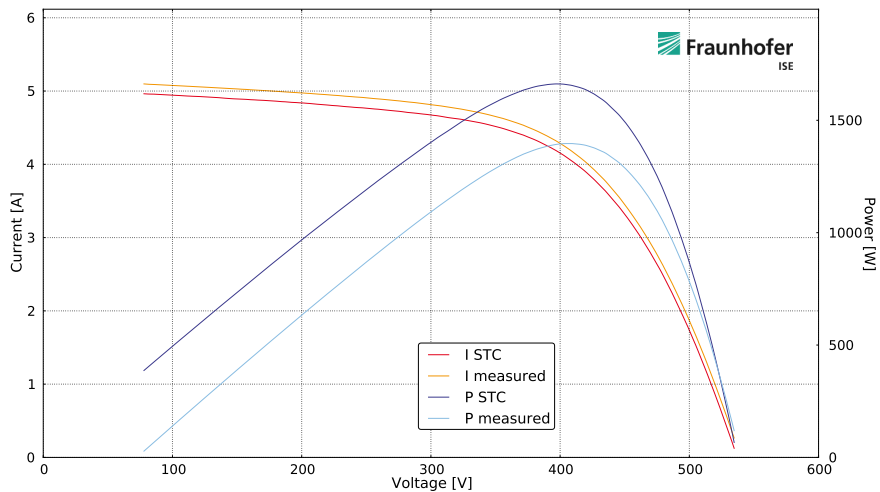
## A14 Measurement Log for Z3.4.4

Module type: PVL-144  
 Sub array: Z3.4.4  
 Date / Time: 2012-03-22 / 16:13:20  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1372.6      | 1667.2 | 5.37 | 1728.0  | -3.5      |
| $I_{SC}$ [A]      | 5.0         | 5.0    | 0.01 | 5.3     | -5.1      |
| $U_{OC}$ [V]      | 449.0       | 540.3  | 1.35 | 554.4   | -2.5      |
| $I_{MPP}$ [A]     | 4.1         | 4.2    | 0.01 | 4.4     | -3.9      |
| $U_{MPP}$ [V]     | 332.3       | 397.9  | 0.14 | 396.0   | 0.5       |
| FF [%]            | 61.0        | 61.4   | 0.13 | 58.8    | 4.4       |
| Eta [%]           | 5.3         | 6.4    | 0.02 | 6.7     | -3.5      |
| E [ $W/m^2$ ]     | 958.7       | 1000.0 | 0.00 | 1000.0  | -4.1      |
| T [ $^{\circ}C$ ] | 75.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 2 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.3\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

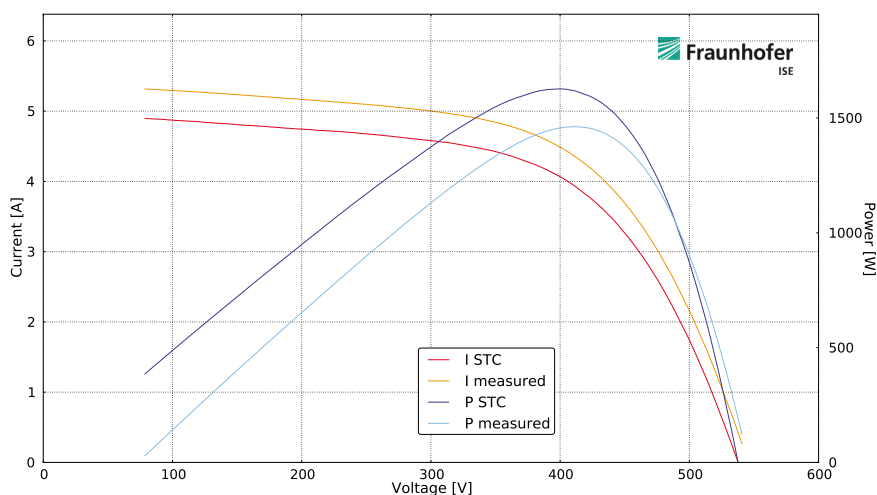
## A15 Measurement Log for Z3.5.1

Module type: PVL-144  
 Sub array: Z3.5.1  
 Date / Time: 2012-03-22 / 15:48:59  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1460.5      | 1627.4 | 2.38 | 1728.0  | -5.8      |
| $I_{SC}[A]$     | 5.3         | 5.0    | 0.01 | 5.3     | -5.9      |
| $U_{OC}[V]$     | 454.0       | 539.4  | 0.38 | 554.4   | -2.7      |
| $I_{MPP}[A]$    | 4.4         | 4.1    | 0.01 | 4.4     | -6.4      |
| $U_{MPP}[V]$    | 334.6       | 398.9  | 0.36 | 396.0   | 0.7       |
| FF [%]          | 60.6        | 60.5   | 0.14 | 58.8    | 2.9       |
| Eta [%]         | 5.6         | 6.3    | 0.01 | 6.7     | -5.8      |
| $E [W/m^2]$     | 1028.2      | 1000.0 | 0.00 | 1000.0  | 2.8       |
| $T [^{\circ}C]$ | 76.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.9\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

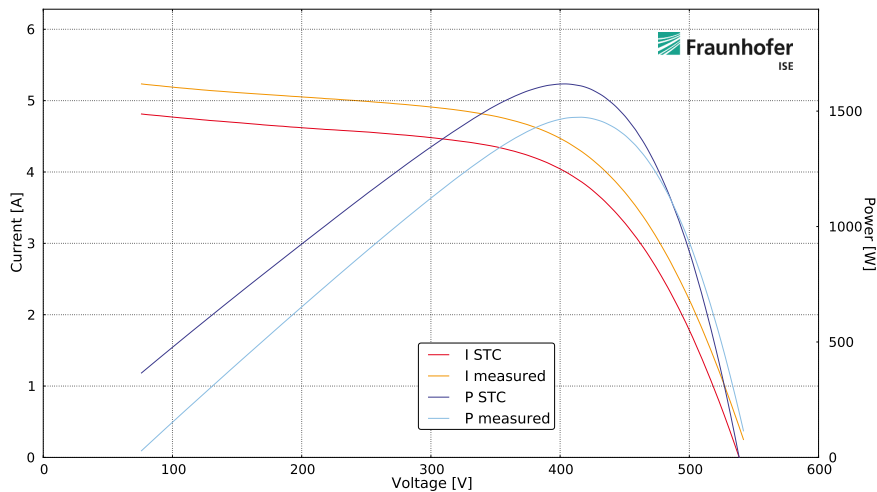
## A16 Measurement Log for Z3.5.2

Module type: PVL-144  
 Sub array: Z3.5.2  
 Date / Time: 2012-03-22 / 15:44:22  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1471.4      | 1619.2 | 1.85 | 1728.0  | -6.3      |
| $I_{SC}$ [A]      | 5.2         | 4.9    | 0.01 | 5.3     | -6.8      |
| $U_{OC}$ [V]      | 457.8       | 539.8  | 0.34 | 554.4   | -2.6      |
| $I_{MPP}$ [A]     | 4.3         | 4.0    | 0.01 | 4.4     | -7.7      |
| $U_{MPP}$ [V]     | 341.7       | 402.2  | 0.84 | 396.0   | 1.6       |
| FF [%]            | 61.4        | 60.7   | 0.05 | 58.8    | 3.2       |
| Eta [%]           | 5.7         | 6.2    | 0.01 | 6.7     | -6.3      |
| E [ $W/m^2$ ]     | 1032.1      | 1000.0 | 0.00 | 1000.0  | 3.2       |
| T [ $^{\circ}C$ ] | 74.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

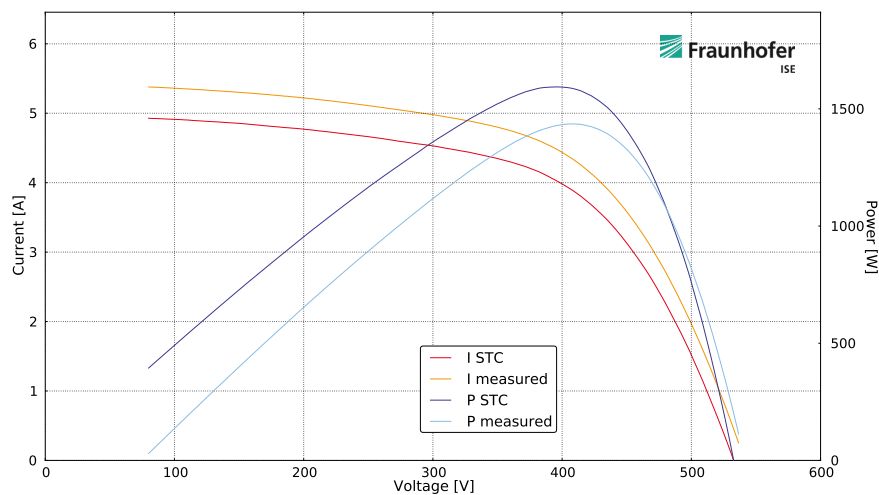
## A17 Measurement Log for Z3.5.3

Module type: PVL-144  
 Sub array: Z3.5.3  
 Date / Time: 2012-03-22 / 15:35:01  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1434.5      | 1595.0 | 0.97 | 1728.0  | -7.7      |
| $I_{SC}$ [A]      | 5.4         | 5.0    | 0.00 | 5.3     | -5.4      |
| $U_{OC}$ [V]      | 448.0       | 534.5  | 0.24 | 554.4   | -3.6      |
| $I_{MPP}$ [A]     | 4.3         | 4.0    | 0.00 | 4.4     | -7.6      |
| $U_{MPP}$ [V]     | 331.1       | 395.8  | 0.60 | 396.0   | -0.0      |
| FF [%]            | 59.6        | 59.5   | 0.02 | 58.8    | 1.2       |
| Eta [%]           | 5.5         | 6.1    | 0.00 | 6.7     | -7.7      |
| E [ $W/m^2$ ]     | 1033.0      | 1000.0 | 0.00 | 1000.0  | 3.3       |
| T [ $^{\circ}C$ ] | 77.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 9.2\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

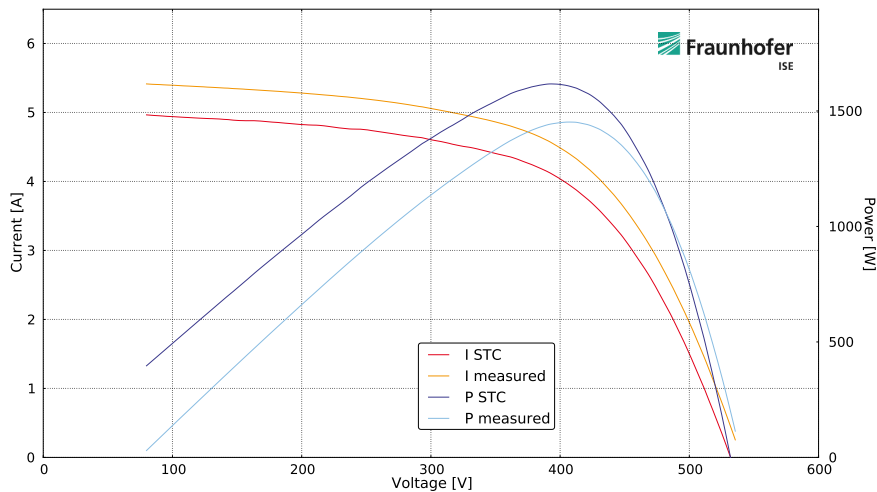
## A18 Measurement Log for Z3.5.4

Module type: PVL-144  
 Sub array: Z3.5.4  
 Date / Time: 2012-03-22 / 15:33:30  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1450.4      | 1615.5 | 2.50 | 1728.0  | -6.5      |
| $I_{SC}$ [A]      | 5.4         | 5.0    | 0.01 | 5.3     | -4.7      |
| $U_{OC}$ [V]      | 446.9       | 533.5  | 0.18 | 554.4   | -3.8      |
| $I_{MPP}$ [A]     | 4.4         | 4.1    | 0.00 | 4.4     | -6.0      |
| $U_{MPP}$ [V]     | 329.4       | 394.2  | 0.35 | 396.0   | -0.5      |
| FF [%]            | 60.0        | 60.0   | 0.17 | 58.8    | 2.0       |
| Eta [%]           | 5.6         | 6.2    | 0.01 | 6.7     | -6.5      |
| E [ $W/m^2$ ]     | 1032.8      | 1000.0 | 0.00 | 1000.0  | 3.3       |
| T [ $^{\circ}C$ ] | 77.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 9.2\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:



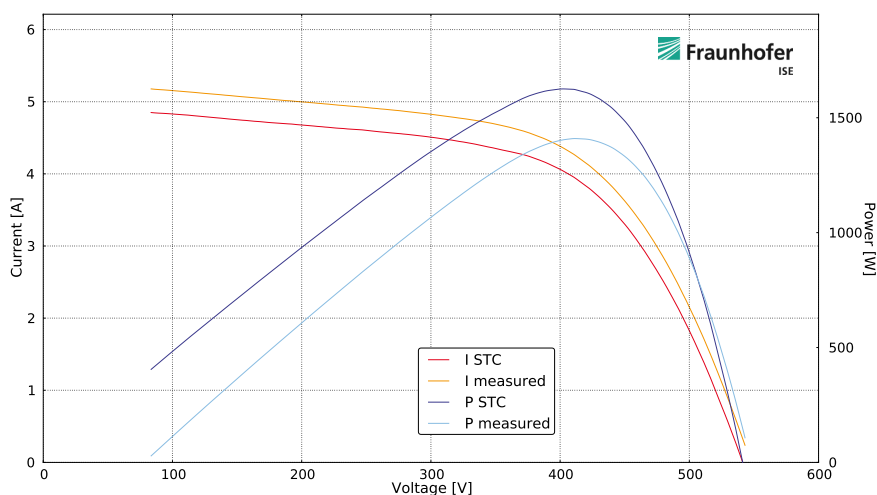
## A19 Measurement Log for Z3.6.1

Module type: PVL-144  
 Sub array: Z3.6.1  
 Date / Time: 2012-03-22 / 15:22:11  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1410.7      | 1624.8 | 1.44 | 1728.0  | -6.0      |
| $I_{SC}[A]$     | 5.2         | 5.0    | 0.02 | 5.3     | -5.8      |
| $U_{OC}[V]$     | 451.3       | 543.4  | 0.33 | 554.4   | -2.0      |
| $I_{MPP}[A]$    | 4.2         | 4.0    | 0.01 | 4.4     | -7.4      |
| $U_{MPP}[V]$    | 332.7       | 402.5  | 0.45 | 396.0   | 1.7       |
| FF [%]          | 60.4        | 59.9   | 0.28 | 58.8    | 1.8       |
| Eta [%]         | 5.4         | 6.3    | 0.01 | 6.7     | -6.0      |
| $E [W/m^2]$     | 1007.5      | 1000.0 | 0.00 | 1000.0  | 0.8       |
| $T [^{\circ}C]$ | 79.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 9.0\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

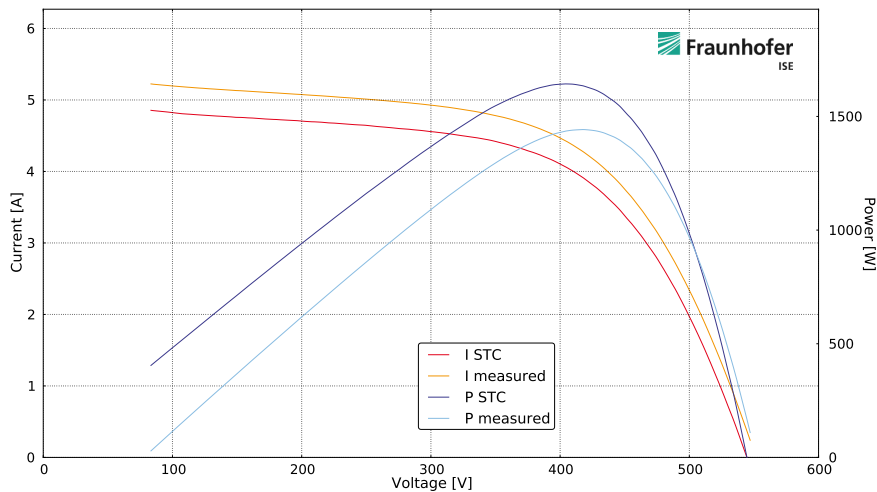
## A20 Measurement Log for Z3.6.2

Module type: PVL-144  
 Sub array: Z3.6.2  
 Date / Time: 2012-03-22 / 15:18:33  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1446.8      | 1641.2 | 2.78 | 1728.0  | -5.0      |
| $I_{SC}$ [A]      | 5.2         | 5.0    | 0.01 | 5.3     | -6.1      |
| $U_{OC}$ [V]      | 455.4       | 546.4  | 0.14 | 554.4   | -1.4      |
| $I_{MPP}$ [A]     | 4.3         | 4.1    | 0.00 | 4.4     | -6.9      |
| $U_{MPP}$ [V]     | 336.5       | 404.3  | 0.75 | 396.0   | 2.1       |
| FF [%]            | 60.7        | 60.4   | 0.17 | 58.8    | 2.7       |
| Eta [%]           | 5.6         | 6.3    | 0.01 | 6.7     | -5.0      |
| E [ $W/m^2$ ]     | 1018.2      | 1000.0 | 0.00 | 1000.0  | 1.8       |
| T [ $^{\circ}C$ ] | 79.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 9.1\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

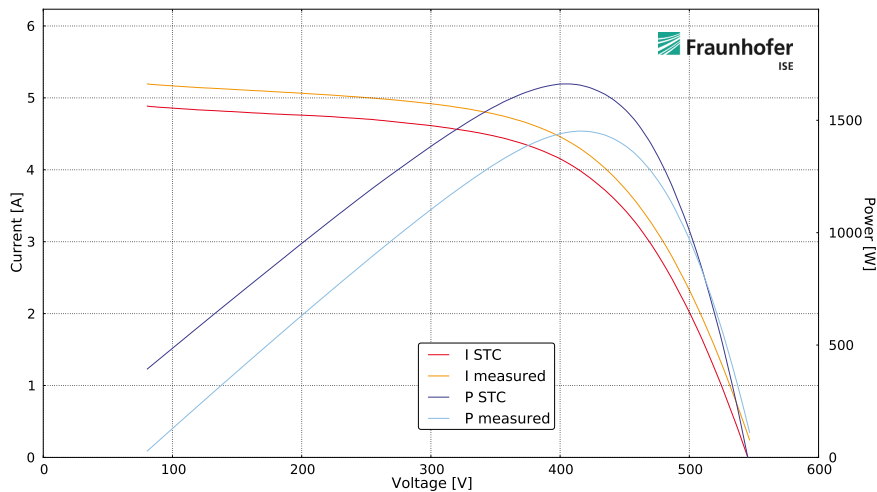
## A21 Measurement Log for Z3.6.3

Module type: PVL-144  
 Sub array: Z3.6.3  
 Date / Time: 2012-03-22 / 14:56:52  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1451.9      | 1661.3 | 3.38 | 1728.0  | -3.9      |
| $I_{SC}$ [A]      | 5.2         | 5.0    | 0.01 | 5.3     | -6.1      |
| $U_{OC}$ [V]      | 457.9       | 546.9  | 0.13 | 554.4   | -1.4      |
| $I_{MPP}$ [A]     | 4.3         | 4.1    | 0.01 | 4.4     | -5.8      |
| $U_{MPP}$ [V]     | 339.6       | 404.6  | 0.07 | 396.0   | 2.2       |
| FF [%]            | 61.0        | 61.1   | 0.05 | 58.8    | 3.8       |
| Eta [%]           | 5.6         | 6.4    | 0.01 | 6.7     | -3.9      |
| E [ $W/m^2$ ]     | 1006.8      | 1000.0 | 0.00 | 1000.0  | 0.7       |
| T [ $^{\circ}C$ ] | 77.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

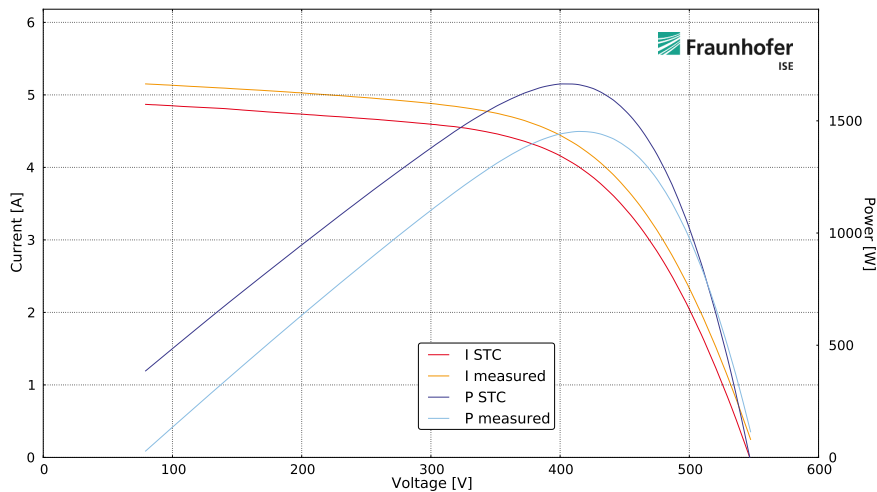
## A22 Measurement Log for Z3.6.4

Module type: PVL-144  
 Sub array: Z3.6.4  
 Date / Time: 2012-03-22 / 14:54:08  
 Interconnection: Modules in series per string: 12  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1452.7      | 1664.2 | 1.51 | 1728.0  | -3.7      |
| $I_{SC}$ [A]      | 5.2         | 4.9    | 0.01 | 5.3     | -6.9      |
| $U_{OC}$ [V]      | 460.3       | 548.1  | 0.39 | 554.4   | -1.1      |
| $I_{MPP}$ [A]     | 4.3         | 4.1    | 0.01 | 4.4     | -5.8      |
| $U_{MPP}$ [V]     | 339.7       | 405.3  | 0.16 | 396.0   | 2.4       |
| FF [%]            | 61.2        | 61.5   | 0.16 | 58.8    | 4.6       |
| Eta [%]           | 5.6         | 6.4    | 0.01 | 6.7     | -3.7      |
| E [ $W/m^2$ ]     | 1003.5      | 1000.0 | 0.00 | 1000.0  | 0.3       |
| T [ $^{\circ}C$ ] | 76.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 8.4\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

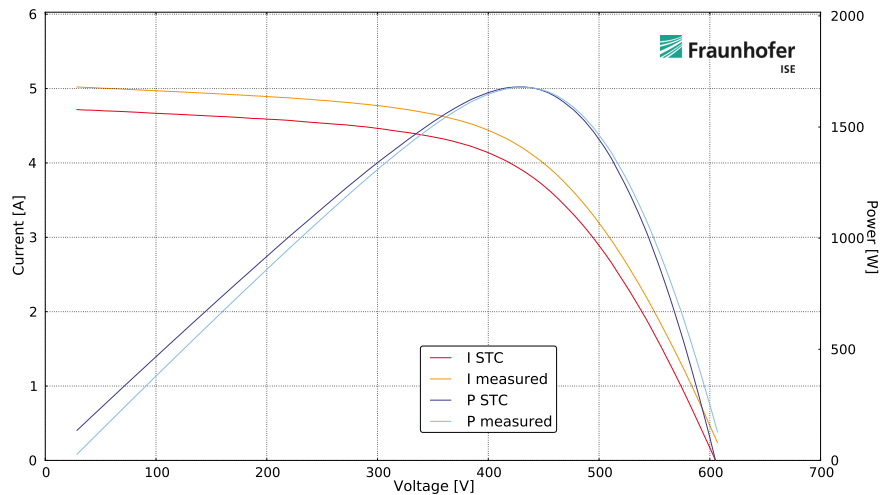
## A23 Measurement Log for Z4.11.1

Module type: PVL-144  
 Sub array: Z4.11.1  
 Date / Time: 2012-03-20 / 16:55:46  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1680.2      | 1681.3 | 3.08 | 1872.0  | -10.2     |
| $I_{SC}$ [A]      | 5.0         | 4.7    | 0.00 | 5.3     | -10.5     |
| $U_{OC}$ [V]      | 536.5       | 606.8  | 0.50 | 600.6   | 1.0       |
| $I_{MPP}$ [A]     | 4.2         | 3.9    | 0.00 | 4.4     | -9.9      |
| $U_{MPP}$ [V]     | 400.8       | 428.0  | 0.92 | 429.0   | -0.2      |
| FF [%]            | 62.3        | 58.4   | 0.05 | 58.8    | -0.7      |
| Eta [%]           | 6.0         | 6.0    | 0.01 | 6.7     | -10.2     |
| E [ $W/m^2$ ]     | 1020.1      | 1000.0 | 0.00 | 1000.0  | 2.0       |
| T [ $^{\circ}C$ ] | 63.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 6.8\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

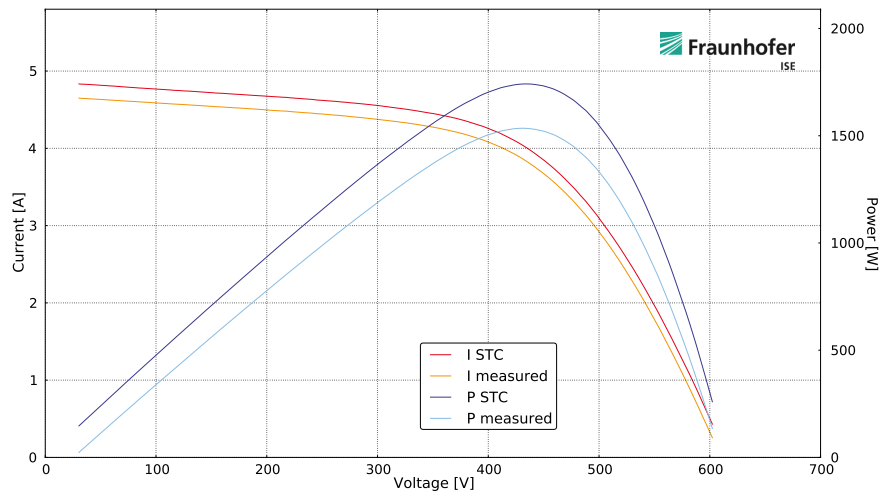
## A24 Measurement Log for Z4.11.2

Module type: PVL-144  
 Sub array: Z4.11.2  
 Date / Time: 2012-03-20 / 17:00:54  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1546.3      | 1741.4 | 2.54 | 1872.0  | -7.0      |
| $I_{SC}[A]$     | 4.7         | 4.9    | 0.01 | 5.3     | -8.1      |
| $U_{OC}[V]$     | 529.9       | 617.3  | 1.12 | 600.6   | 2.8       |
| $I_{MPP}[A]$    | 3.9         | 4.0    | 0.01 | 4.4     | -7.8      |
| $U_{MPP}[V]$    | 397.7       | 433.3  | 0.99 | 429.0   | 1.0       |
| FF [%]          | 62.2        | 57.9   | 0.13 | 58.8    | -1.5      |
| Eta [%]         | 5.5         | 6.2    | 0.01 | 6.7     | -7.0      |
| $E [W/m^2]$     | 927.4       | 1000.0 | 0.00 | 1000.0  | -7.3      |
| $T [^{\circ}C]$ | 66.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 5 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 6.9\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

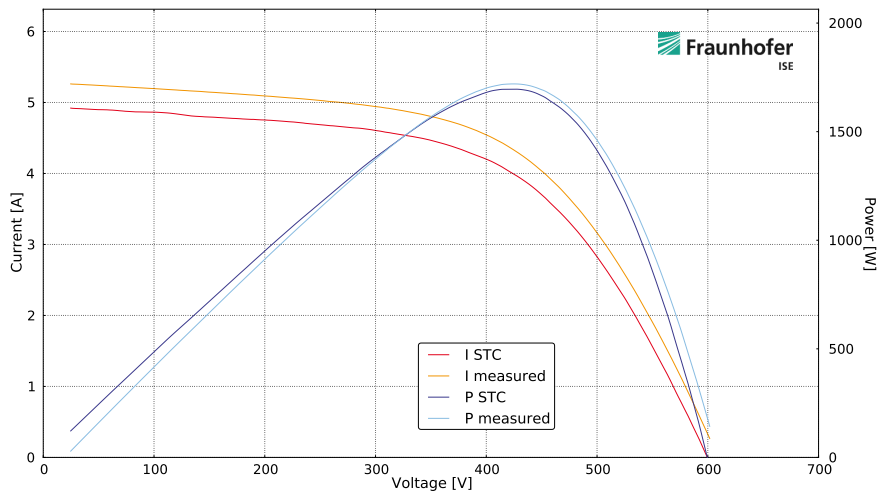
## A25 Measurement Log for Z4.11.3

Module type: PVL-144  
 Sub array: Z4.11.3  
 Date / Time: 2012-03-20 / 16:53:03  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1710.2      | 1699.4 | 3.10 | 1872.0  | -9.2      |
| $I_{SC}[A]$     | 5.2         | 4.9    | 0.00 | 5.3     | -6.6      |
| $U_{OC}[V]$     | 536.6       | 601.7  | 0.51 | 600.6   | 0.2       |
| $I_{MPP}[A]$    | 4.3         | 4.0    | 0.01 | 4.4     | -7.6      |
| $U_{MPP}[V]$    | 395.8       | 421.9  | 0.43 | 429.0   | -1.7      |
| FF [%]          | 60.9        | 57.1   | 0.07 | 58.8    | -3.0      |
| Eta [%]         | 6.1         | 6.0    | 0.01 | 6.7     | -9.2      |
| $E [W/m^2]$     | 1024.1      | 1000.0 | 0.00 | 1000.0  | 2.4       |
| $T [^{\circ}C]$ | 60.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 6.4\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

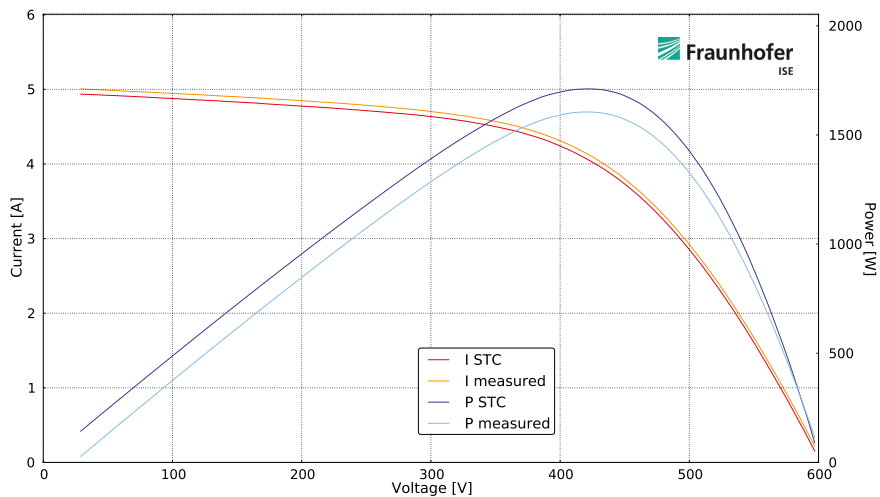
## A26 Measurement Log for Z4.11.4

Module type: PVL-144  
 Sub array: Z4.11.4  
 Date / Time: 2012-03-20 / 17:04:05  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1600.4      | 1711.4 | 2.43 | 1872.0  | -8.6      |
| $I_{SC}[A]$     | 5.0         | 5.0    | 0.00 | 5.3     | -6.4      |
| $U_{OC}[V]$     | 522.1       | 603.9  | 0.38 | 600.6   | 0.6       |
| $I_{MPP}[A]$    | 4.1         | 4.1    | 0.00 | 4.4     | -6.8      |
| $U_{MPP}[V]$    | 388.5       | 421.3  | 0.53 | 429.0   | -1.8      |
| FF [%]          | 61.4        | 57.1   | 0.01 | 58.8    | -2.9      |
| Eta [%]         | 5.7         | 6.1    | 0.01 | 6.7     | -8.6      |
| $E [W/m^2]$     | 968.7       | 1000.0 | 0.00 | 1000.0  | -3.1      |
| $T [^{\circ}C]$ | 66.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 7.0\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:



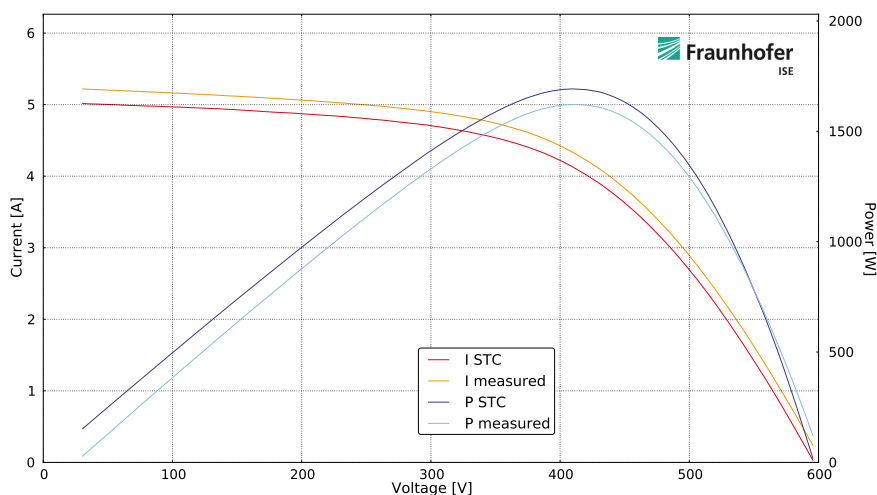
## A27 Measurement Log for Z4.12.1

Module type: PVL-144  
 Sub array: Z4.12.1  
 Date / Time: 2012-03-20 / 17:12:09  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1621.2      | 1692.8 | 2.27 | 1872.0  | -9.6      |
| $I_{SC}$ [A]      | 5.2         | 5.0    | 0.01 | 5.3     | -4.8      |
| $U_{OC}$ [V]      | 511.0       | 598.5  | 0.33 | 600.6   | -0.3      |
| $I_{MPP}$ [A]     | 4.3         | 4.1    | 0.01 | 4.4     | -5.6      |
| $U_{MPP}$ [V]     | 376.1       | 411.1  | 0.31 | 429.0   | -4.2      |
| FF [%]            | 60.8        | 56.1   | 0.05 | 58.8    | -4.7      |
| Eta [%]           | 5.8         | 6.0    | 0.01 | 6.7     | -9.6      |
| E [ $W/m^2$ ]     | 991.0       | 1000.0 | 0.00 | 1000.0  | -0.9      |
| T [ $^{\circ}C$ ] | 71.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 7.8\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

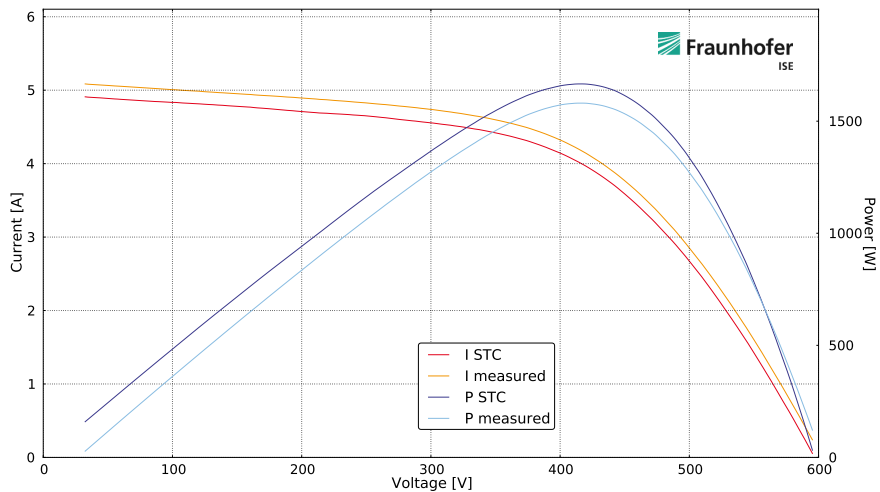
## A28 Measurement Log for Z4.12.2

Module type: PVL-144  
 Sub array: Z4.12.2  
 Date / Time: 2012-03-20 / 17:18:10  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1582.6      | 1668.0 | 4.67 | 1872.0  | -10.9     |
| $I_{SC}$ [A]      | 5.1         | 4.9    | 0.01 | 5.3     | -6.7      |
| $U_{OC}$ [V]      | 509.0       | 598.8  | 0.26 | 600.6   | -0.3      |
| $I_{MPP}$ [A]     | 4.2         | 4.0    | 0.01 | 4.4     | -7.9      |
| $U_{MPP}$ [V]     | 377.7       | 415.3  | 0.38 | 429.0   | -3.2      |
| FF [%]            | 61.1        | 56.3   | 0.02 | 58.8    | -4.3      |
| Eta [%]           | 5.6         | 5.9    | 0.02 | 6.7     | -10.9     |
| E [ $W/m^2$ ]     | 985.7       | 1000.0 | 0.00 | 1000.0  | -1.4      |
| T [ $^{\circ}C$ ] | 72.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 7.9\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

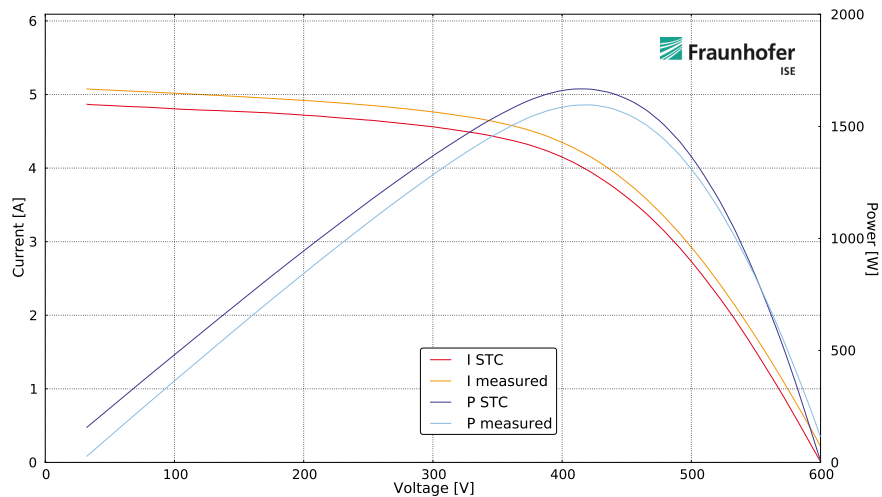
## A29 Measurement Log for Z4.12.3

Module type: PVL-144  
 Sub array: Z4.12.3  
 Date / Time: 2012-03-20 / 17:14:57  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1596.8      | 1670.7 | 4.57 | 1872.0  | -10.8     |
| $I_{SC}$ [A]      | 5.1         | 4.9    | 0.02 | 5.3     | -7.4      |
| $U_{OC}$ [V]      | 515.0       | 602.4  | 0.43 | 600.6   | 0.3       |
| $I_{MPP}$ [A]     | 4.2         | 4.0    | 0.02 | 4.4     | -8.0      |
| $U_{MPP}$ [V]     | 381.5       | 416.7  | 1.25 | 429.0   | -2.9      |
| FF [%]            | 61.1        | 56.5   | 0.10 | 58.8    | -3.9      |
| Eta [%]           | 5.7         | 5.9    | 0.02 | 6.7     | -10.8     |
| E [ $W/m^2$ ]     | 990.6       | 1000.0 | 0.00 | 1000.0  | -0.9      |
| T [ $^{\circ}C$ ] | 71.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 7.8\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

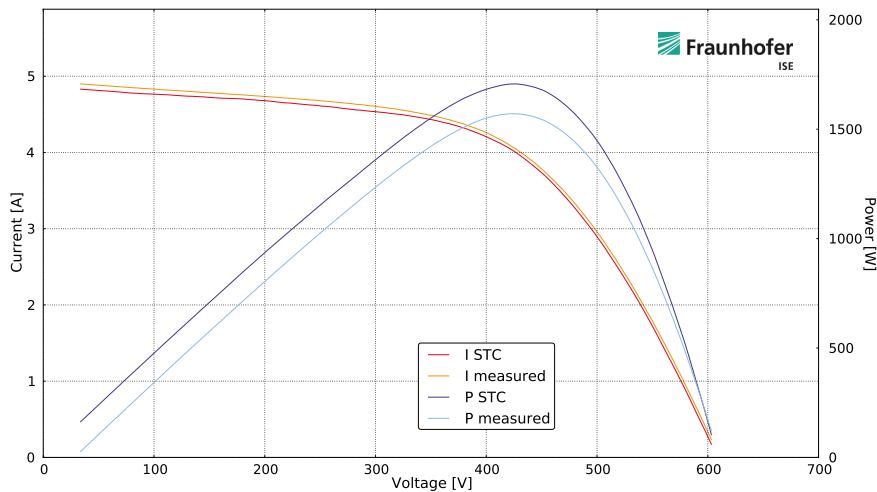
### A30 Measurement Log for Z4.12.4

Module type: PVL-144  
 Sub array: Z4.12.4  
 Date / Time: 2012-03-20 / 17:20:19  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1570.4      | 1703.6 | 3.95 | 1872.0  | -9.0      |
| $I_{SC}[A]$     | 4.9         | 4.9    | 0.01 | 5.3     | -8.2      |
| $U_{OC}[V]$     | 518.0       | 611.0  | 0.28 | 600.6   | 1.7       |
| $I_{MPP}[A]$    | 4.1         | 4.0    | 0.01 | 4.4     | -8.1      |
| $U_{MPP}[V]$    | 386.7       | 425.3  | 0.30 | 429.0   | -0.9      |
| FF [%]          | 61.9        | 57.3   | 0.14 | 58.8    | -2.5      |
| Eta [%]         | 5.6         | 6.1    | 0.01 | 6.7     | -9.0      |
| $E [W/m^2]$     | 962.4       | 1000.0 | 0.00 | 1000.0  | -3.8      |
| $T [^{\circ}C]$ | 72.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 7.8\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

#### I-V-Characteristic:



#### Comments:

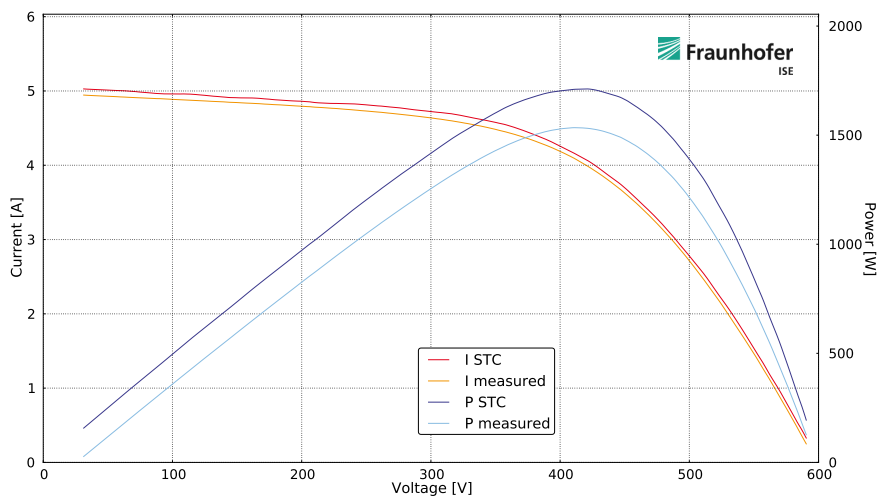
### A31 Measurement Log for Z4.13.1

Module type: PVL-144  
 Sub array: Z4.13.1  
 Date / Time: 2012-03-20 / 17:27:26  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1541.0      | 1710.3 | 0.63 | 1872.0  | -8.6      |
| $I_{SC}[A]$     | 5.0         | 5.0    | 0.02 | 5.3     | -4.8      |
| $U_{OC}[V]$     | 509.3       | 603.1  | 0.07 | 600.6   | 0.4       |
| $I_{MPP}[A]$    | 4.1         | 4.1    | 0.00 | 4.4     | -5.5      |
| $U_{MPP}[V]$    | 376.3       | 415.2  | 0.19 | 429.0   | -3.2      |
| FF [%]          | 61.0        | 56.2   | 0.18 | 58.8    | -4.4      |
| Eta [%]         | 5.5         | 6.1    | 0.00 | 6.7     | -8.6      |
| $E [W/m^2]$     | 943.7       | 1000.0 | 0.00 | 1000.0  | -5.6      |
| $T [^{\circ}C]$ | 71.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 2 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 7.7\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

#### I-V-Characteristic:



#### Comments:

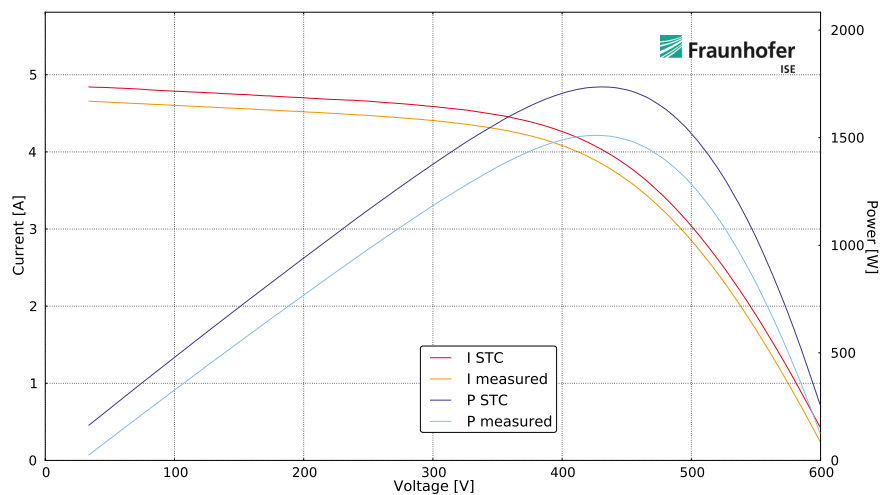
## A32 Measurement Log for Z4.13.2

Module type: PVL-144  
 Sub array: Z4.13.2  
 Date / Time: 2012-03-20 / 17:32:57  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$      | 1509.0      | 1734.4 | 4.33 | 1872.0  | -7.3      |
| $I_{SC}[A]$       | 4.7         | 4.9    | 0.01 | 5.3     | -8.2      |
| $U_{OC}[V]$       | 518.4       | 615.7  | 0.54 | 600.6   | 2.5       |
| $I_{MPP}[A]$      | 3.9         | 4.0    | 0.01 | 4.4     | -7.5      |
| $U_{MPP}[V]$      | 388.7       | 430.2  | 0.45 | 429.0   | 0.3       |
| FF [%]            | 62.6        | 57.9   | 0.06 | 58.8    | -1.6      |
| Eta [%]           | 5.4         | 6.2    | 0.02 | 6.7     | -7.3      |
| E [ $W/m^2$ ]     | 915.4       | 1000.0 | 0.00 | 1000.0  | -8.5      |
| T [ $^{\circ}C$ ] | 71.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 5 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 7.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

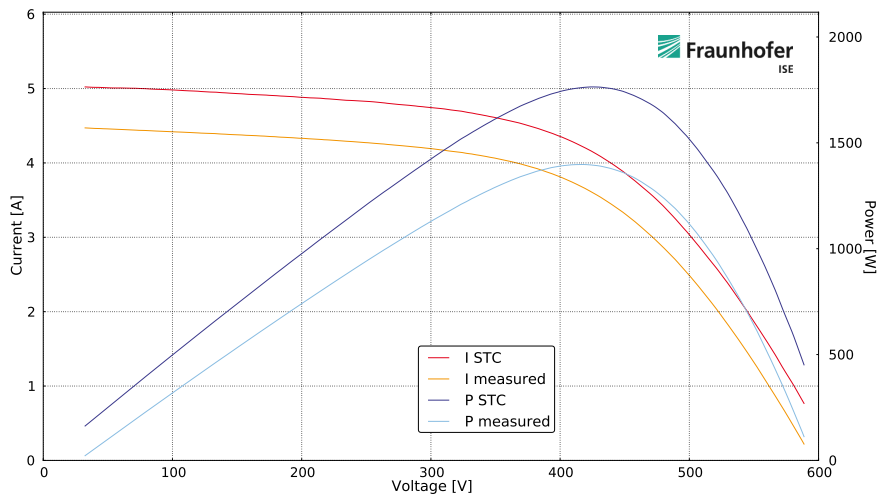
### A33 Measurement Log for Z4.13.3

Module type: PVL-144  
 Sub array: Z4.13.3  
 Date / Time: 2012-03-20 / 17:29:47  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                     | Measurement | STC    | SD   | Nominal | Dev. in % |
|---------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]       | 1406.8      | 1763.0 | 5.03 | 1872.0  | -5.8      |
| $I_{SC}$ [A]        | 4.5         | 5.0    | 0.01 | 5.3     | -4.9      |
| $U_{OC}$ [V]        | 511.6       | 618.0  | 1.42 | 600.6   | 2.9       |
| $I_{MPP}$ [A]       | 3.7         | 4.1    | 0.01 | 4.4     | -4.9      |
| $U_{MPP}$ [V]       | 379.9       | 425.2  | 0.70 | 429.0   | -0.9      |
| FF [%]              | 61.2        | 56.6   | 0.12 | 58.8    | -3.8      |
| Eta [%]             | 5.0         | 6.3    | 0.02 | 6.7     | -5.8      |
| $E$ [ $W/m^2$ ]     | 854.4       | 1000.0 | 0.00 | 1000.0  | -14.6     |
| $T$ [ $^{\circ}C$ ] | 71.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 7.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

#### I-V-Characteristic:



#### Comments:

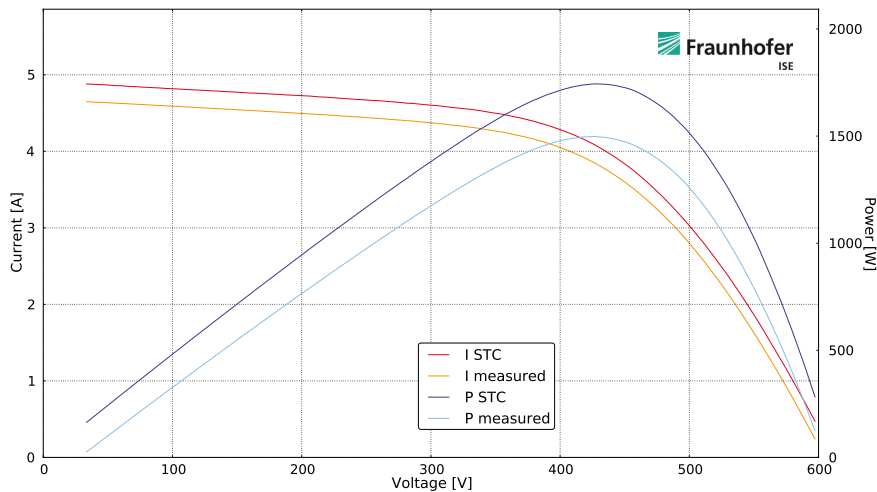
### A34 Measurement Log for Z4.13.4

Module type: PVL-144  
 Sub array: Z4.13.4  
 Date / Time: 2012-03-20 / 17:34:38  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1496.4      | 1743.3 | 0.17 | 1872.0  | -6.9      |
| $I_{SC}[A]$     | 4.6         | 4.9    | 0.00 | 5.3     | -7.4      |
| $U_{OC}[V]$     | 516.5       | 615.1  | 0.24 | 600.6   | 2.4       |
| $I_{MPP}[A]$    | 3.9         | 4.1    | 0.00 | 4.4     | -6.9      |
| $U_{MPP}[V]$    | 388.7       | 429.5  | 0.21 | 429.0   | 0.1       |
| FF [%]          | 62.4        | 57.7   | 0.04 | 58.8    | -1.8      |
| Eta [%]         | 5.3         | 6.2    | 0.00 | 6.7     | -6.9      |
| $E [W/m^2]$     | 906.4       | 1000.0 | 0.00 | 1000.0  | -9.4      |
| $T [^{\circ}C]$ | 71.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 7.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

#### I-V-Characteristic:



#### Comments:



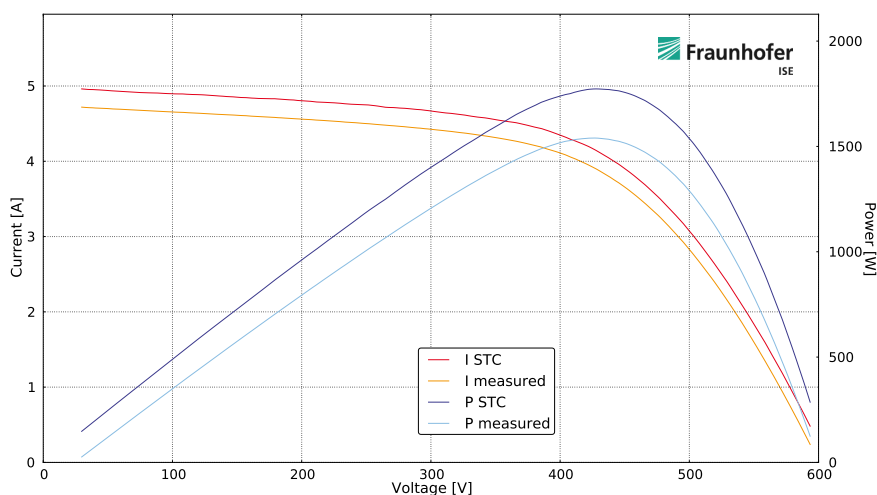
### A35 Measurement Log for Z4.14.1

Module type: PVL-144  
 Sub array: Z4.14.1  
 Date / Time: 2012-03-20 / 17:44:44  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1540.9      | 1772.1 | 1.17 | 1872.0  | -5.3      |
| $I_{SC}[A]$     | 4.7         | 5.0    | 0.00 | 5.3     | -6.0      |
| $U_{OC}[V]$     | 521.5       | 610.4  | 0.52 | 600.6   | 1.6       |
| $I_{MPP}[A]$    | 3.9         | 4.1    | 0.01 | 4.4     | -5.6      |
| $U_{MPP}[V]$    | 393.3       | 430.5  | 0.52 | 429.0   | 0.3       |
| FF [%]          | 62.6        | 58.2   | 0.04 | 58.8    | -1.0      |
| Eta [%]         | 5.5         | 6.3    | 0.00 | 6.7     | -5.3      |
| $E [W/m^2]$     | 912.0       | 1000.0 | 0.00 | 1000.0  | -8.8      |
| $T [^{\circ}C]$ | 66.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 6.9\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

#### I-V-Characteristic:



#### Comments:

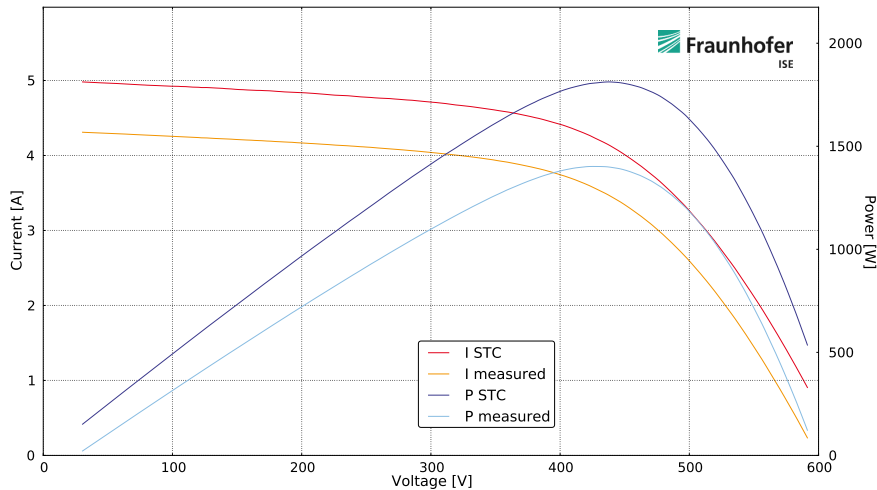
### A36 Measurement Log for Z4.14.2

Module type: PVL-144  
 Sub array: Z4.14.2  
 Date / Time: 2012-03-20 / 18:00:39  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1403.0      | 1810.8 | 1.18 | 1872.0  | -3.3      |
| $I_{SC}$ [A]      | 4.3         | 5.0    | 0.00 | 5.3     | -5.6      |
| $U_{OC}$ [V]      | 522.5       | 623.3  | 0.24 | 600.6   | 3.8       |
| $I_{MPP}$ [A]     | 3.6         | 4.1    | 0.01 | 4.4     | -5.0      |
| $U_{MPP}$ [V]     | 393.0       | 437.3  | 0.37 | 429.0   | 1.9       |
| FF [%]            | 62.3        | 58.1   | 0.01 | 58.8    | -1.3      |
| Eta [%]           | 5.0         | 6.4    | 0.00 | 6.7     | -3.3      |
| E [ $W/m^2$ ]     | 829.8       | 1000.0 | 0.00 | 1000.0  | -17.0     |
| T [ $^{\circ}C$ ] | 66.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 6.8\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

#### I-V-Characteristic:



#### Comments:

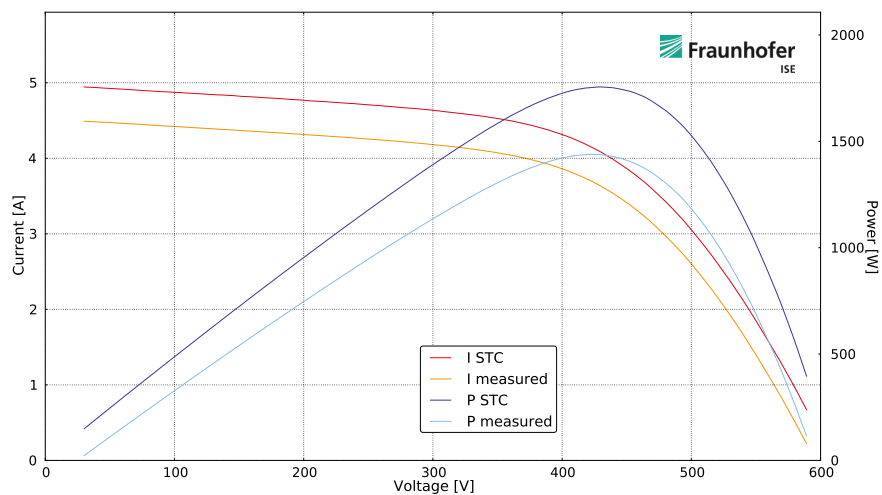
### A37 Measurement Log for Z4.14.3

Module type: PVL-144  
 Sub array: Z4.14.3  
 Date / Time: 2012-03-20 / 17:46:56  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1443.9      | 1755.1 | 2.72 | 1872.0  | -6.2      |
| $I_{SC}[A]$     | 4.5         | 5.0    | 0.01 | 5.3     | -6.1      |
| $U_{OC}[V]$     | 518.6       | 613.3  | 0.47 | 600.6   | 2.1       |
| $I_{MPP}[A]$    | 3.7         | 4.1    | 0.01 | 4.4     | -6.4      |
| $U_{MPP}[V]$    | 389.8       | 430.1  | 0.42 | 429.0   | 0.3       |
| FF [%]          | 61.8        | 57.5   | 0.08 | 58.8    | -2.2      |
| Eta [%]         | 5.1         | 6.2    | 0.01 | 6.7     | -6.2      |
| $E [W/m^2]$     | 873.1       | 1000.0 | 0.00 | 1000.0  | -12.7     |
| $T [^{\circ}C]$ | 66.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 6 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 6.9\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

#### I-V-Characteristic:



#### Comments:

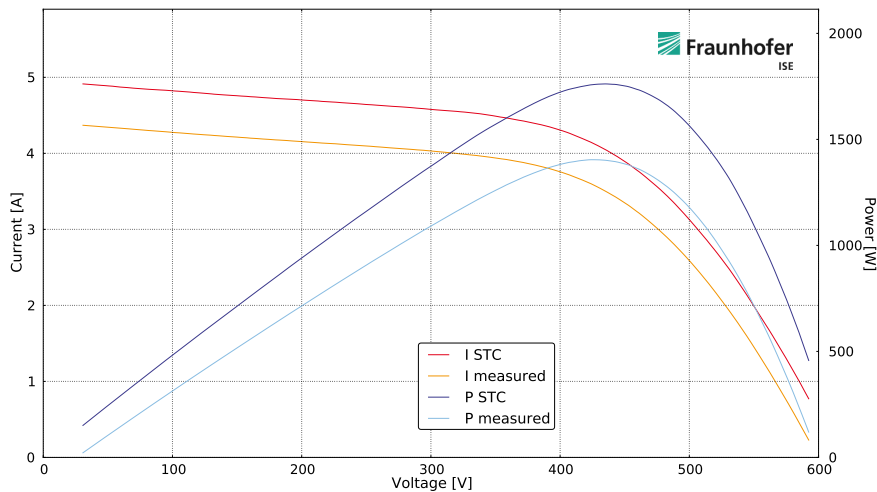
### A38 Measurement Log for Z4.14.4

Module type: PVL-144  
 Sub array: Z4.14.4  
 Date / Time: 2012-03-20 / 18:03:28  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1404.9      | 1761.3 | 0.64 | 1872.0  | -5.9      |
| $I_{SC}[A]$     | 4.4         | 5.0    | 0.00 | 5.3     | -6.6      |
| $U_{OC}[V]$     | 522.5       | 620.6  | 0.23 | 600.6   | 3.3       |
| $I_{MPP}[A]$    | 3.6         | 4.0    | 0.00 | 4.4     | -7.1      |
| $U_{MPP}[V]$    | 392.4       | 435.0  | 0.40 | 429.0   | 1.4       |
| FF [%]          | 61.5        | 57.3   | 0.04 | 58.8    | -2.6      |
| Eta [%]         | 5.0         | 6.3    | 0.00 | 6.7     | -5.9      |
| $E [W/m^2]$     | 851.8       | 1000.0 | 0.00 | 1000.0  | -14.8     |
| $T [^{\circ}C]$ | 66.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 5 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 6.9\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

#### I-V-Characteristic:



#### Comments:

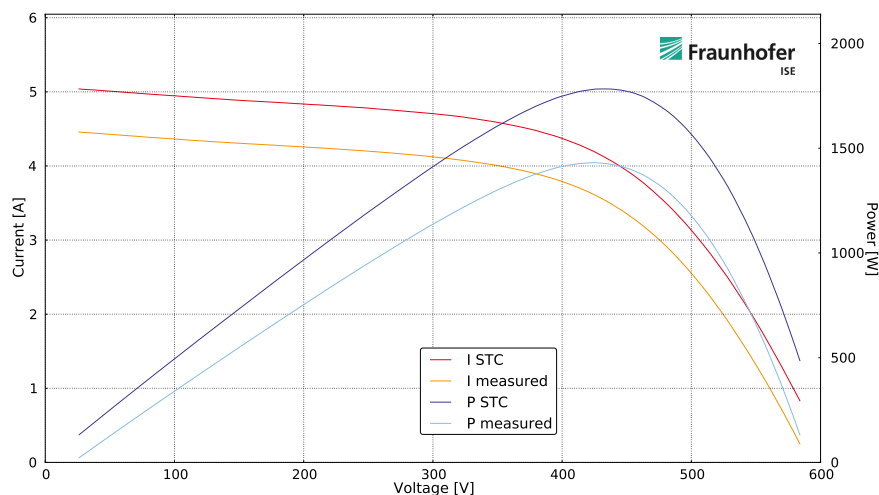
### A39 Measurement Log for Z4.15.1

Module type: PVL-144  
 Sub array: Z4.15.1  
 Date / Time: 2012-03-20 / 18:10:09  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1427.3      | 1783.6 | 0.56 | 1872.0  | -4.7      |
| $I_{SC}[A]$     | 4.5         | 5.1    | 0.00 | 5.3     | -4.3      |
| $U_{OC}[V]$     | 524.1       | 611.9  | 0.11 | 600.6   | 1.9       |
| $I_{MPP}[A]$    | 3.6         | 4.1    | 0.00 | 4.4     | -5.4      |
| $U_{MPP}[V]$    | 395.0       | 432.6  | 0.31 | 429.0   | 0.8       |
| FF [%]          | 61.2        | 57.5   | 0.02 | 58.8    | -2.3      |
| Eta [%]         | 5.1         | 6.3    | 0.00 | 6.7     | -4.7      |
| $E [W/m^2]$     | 851.9       | 1000.0 | 0.00 | 1000.0  | -14.8     |
| $T [^{\circ}C]$ | 60.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 6.0\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

#### I-V-Characteristic:



#### Comments:

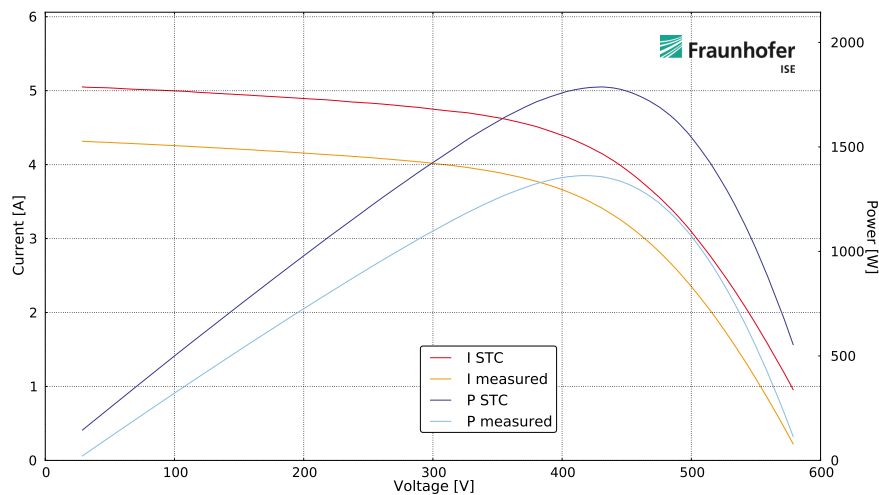
## A40 Measurement Log for Z4.15.2

Module type: PVL-144  
 Sub array: Z4.15.2  
 Date / Time: 2012-03-20 / 18:14:24  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 1362.6      | 1783.6 | 4.85 | 1872.0  | -4.7      |
| $I_{SC}$ [A]      | 4.3         | 5.1    | 0.01 | 5.3     | -4.2      |
| $U_{OC}$ [V]      | 513.0       | 611.3  | 0.78 | 600.6   | 1.8       |
| $I_{MPP}$ [A]     | 3.5         | 4.2    | 0.01 | 4.4     | -4.4      |
| $U_{MPP}$ [V]     | 384.9       | 428.1  | 0.48 | 429.0   | -0.2      |
| FF [%]            | 61.5        | 57.5   | 0.03 | 58.8    | -2.3      |
| Eta [%]           | 4.8         | 6.3    | 0.02 | 6.7     | -4.7      |
| E [ $W/m^2$ ]     | 821.7       | 1000.0 | 0.00 | 1000.0  | -17.8     |
| T [ $^{\circ}C$ ] | 64.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 6.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

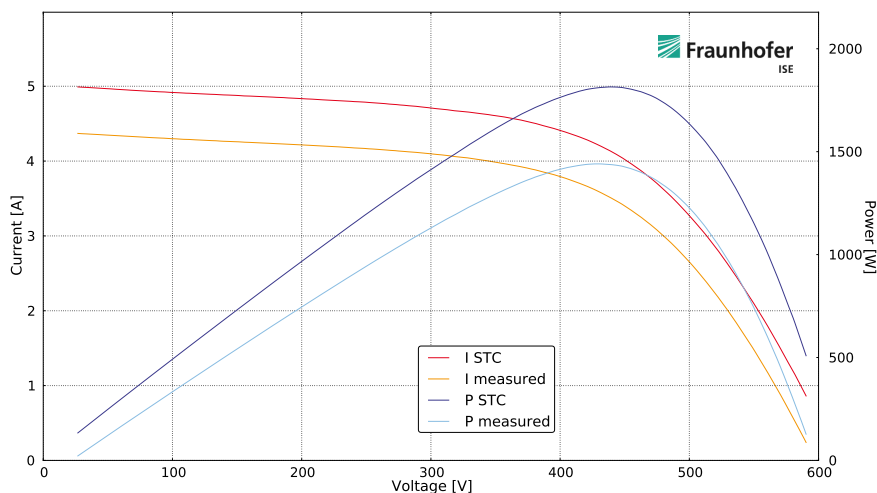
## A41 Measurement Log for Z4.15.3

Module type: PVL-144  
 Sub array: Z4.15.3  
 Date / Time: 2012-03-20 / 18:11:50  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                     | Measurement | STC    | SD   | Nominal | Dev. in % |
|---------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]       | 1443.1      | 1815.2 | 2.40 | 1872.0  | -3.0      |
| $I_{SC}$ [A]        | 4.4         | 5.0    | 0.01 | 5.3     | -5.4      |
| $U_{OC}$ [V]        | 531.4       | 619.9  | 0.23 | 600.6   | 3.2       |
| $I_{MPP}$ [A]       | 3.6         | 4.1    | 0.01 | 4.4     | -5.1      |
| $U_{MPP}$ [V]       | 400.1       | 438.8  | 0.29 | 429.0   | 2.3       |
| FF [%]              | 62.1        | 58.4   | 0.05 | 58.8    | -0.7      |
| Eta [%]             | 5.1         | 6.5    | 0.01 | 6.7     | -3.0      |
| $E$ [ $W/m^2$ ]     | 845.2       | 1000.0 | 0.00 | 1000.0  | -15.5     |
| $T$ [ $^{\circ}C$ ] | 60.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 6.0\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

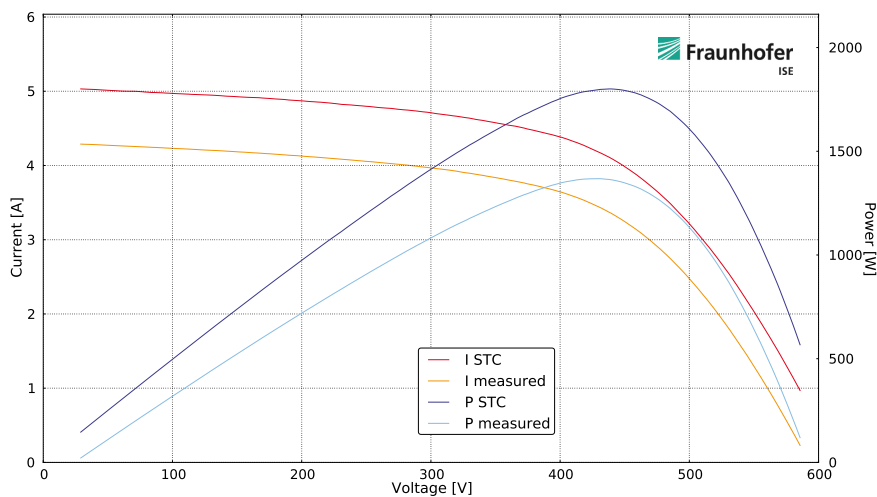
## A42 Measurement Log for Z4.15.4

Module type: PVL-144  
 Sub array: Z4.15.4  
 Date / Time: 2012-03-20 / 18:15:57  
 Interconnection: Modules in series per string: 13  
 Strings in parallel: 1

|                 | Measurement | STC    | SD   | Nominal | Dev. in % |
|-----------------|-------------|--------|------|---------|-----------|
| $P_{MPP}[W]$    | 1367.5      | 1800.1 | 1.21 | 1872.0  | -3.8      |
| $I_{SC}[A]$     | 4.3         | 5.1    | 0.00 | 5.3     | -4.6      |
| $U_{OC}[V]$     | 520.5       | 619.5  | 0.09 | 600.6   | 3.1       |
| $I_{MPP}[A]$    | 3.5         | 4.1    | 0.00 | 4.4     | -5.5      |
| $U_{MPP}[V]$    | 395.7       | 436.9  | 0.21 | 429.0   | 1.8       |
| FF [%]          | 61.3        | 57.5   | 0.02 | 58.8    | -2.3      |
| Eta [%]         | 4.9         | 6.4    | 0.00 | 6.7     | -3.8      |
| $E [W/m^2]$     | 818.6       | 1000.0 | 0.00 | 1000.0  | -18.1     |
| $T [^{\circ}C]$ | 64.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 6.5\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:



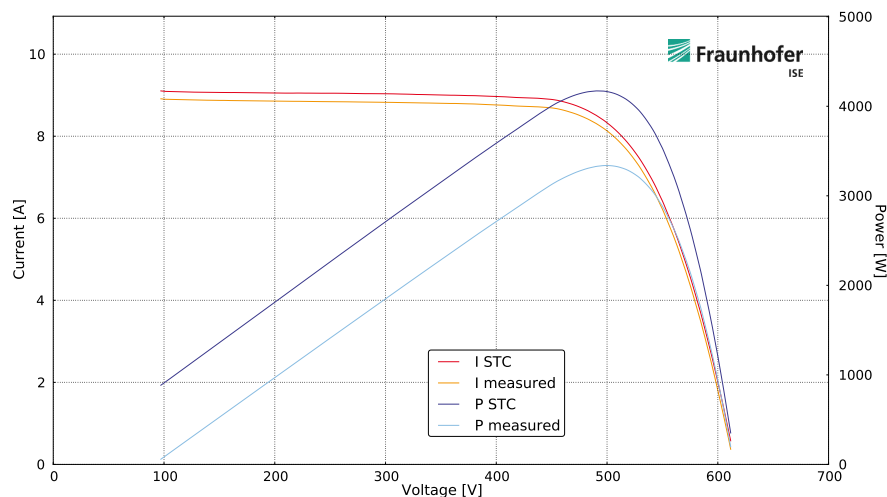
### A43 Measurement Log for Z1.1.1

Module type: YL265C-30b  
 Sub array: Z1.1.1  
 Date / Time: 2012-03-21 / 17:16:52  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3314.9      | 4171.3 | 3.25 | 4240.0  | -1.6      |
| $I_{SC}$ [A]      | 8.9         | 9.2    | 0.02 | 8.9     | 2.5       |
| $U_{OC}$ [V]      | 533.8       | 617.6  | 0.08 | 624.0   | -1.0      |
| $I_{MPP}$ [A]     | 8.1         | 8.5    | 0.01 | 8.6     | -0.9      |
| $U_{MPP}$ [V]     | 409.4       | 492.4  | 0.22 | 496.0   | -0.7      |
| FF [%]            | 70.2        | 73.8   | 0.14 | 76.1    | -3.0      |
| Eta [%]           | 12.7        | 16.0   | 0.01 | 16.2    | -1.6      |
| E [ $W/m^2$ ]     | 957.8       | 1000.0 | 0.00 | 1000.0  | -4.2      |
| T [ $^{\circ}C$ ] | 63.0        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 4.0\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

#### I-V-Characteristic:



#### Comments:

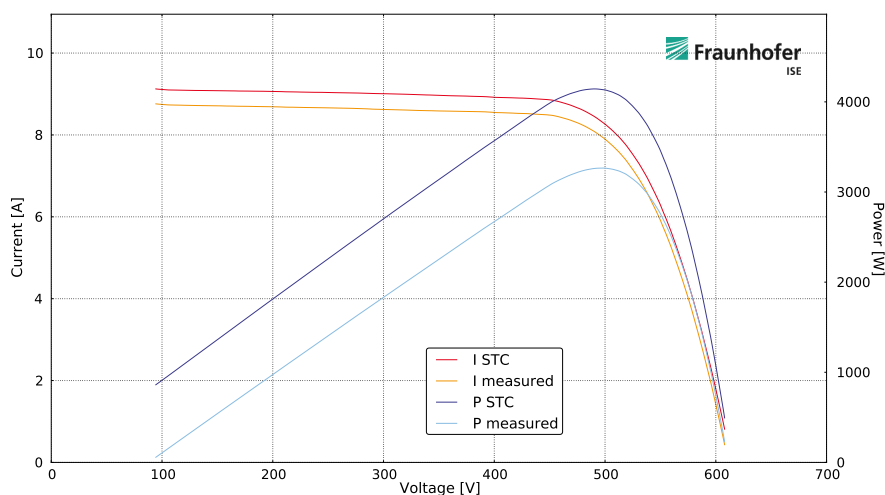
## A44 Measurement Log for Z1.1.2

Module type: YL265C-30b  
 Sub array: Z1.1.2  
 Date / Time: 2012-03-21 / 17:42:55  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3266.6      | 4143.6 | 3.69 | 4240.0  | -2.3      |
| $I_{SC}$ [A]      | 8.8         | 9.2    | 0.01 | 8.9     | 2.6       |
| $U_{OC}$ [V]      | 532.5       | 616.0  | 0.12 | 624.0   | -1.3      |
| $I_{MPP}$ [A]     | 8.0         | 8.4    | 0.01 | 8.6     | -1.2      |
| $U_{MPP}$ [V]     | 410.1       | 490.5  | 0.24 | 496.0   | -1.1      |
| FF [%]            | 70.0        | 73.4   | 0.10 | 76.1    | -3.5      |
| Eta [%]           | 12.5        | 15.9   | 0.01 | 16.2    | -2.3      |
| E [ $W/m^2$ ]     | 946.8       | 1000.0 | 0.00 | 1000.0  | -5.3      |
| T [ $^{\circ}C$ ] | 62.2        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 4.0\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

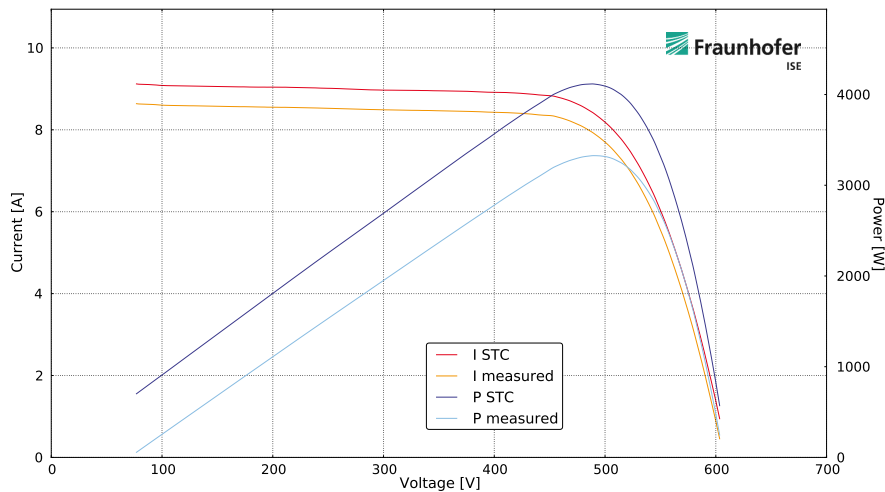
## A45 Measurement Log for Z1.2.1

Module type: YL265C-30b  
 Sub array: Z1.2.1  
 Date / Time: 2012-03-21 / 17:50:43  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3338.4      | 4118.3 | 3.30 | 4240.0  | -2.9      |
| $I_{SC}$ [A]      | 8.7         | 9.2    | 0.01 | 8.9     | 2.7       |
| $U_{OC}$ [V]      | 543.5       | 612.8  | 0.11 | 624.0   | -1.8      |
| $I_{MPP}$ [A]     | 7.9         | 8.5    | 0.01 | 8.5     | -1.1      |
| $U_{MPP}$ [V]     | 421.8       | 487.0  | 0.18 | 496.0   | -1.8      |
| FF [%]            | 70.9        | 73.3   | 0.06 | 76.1    | -3.7      |
| Eta [%]           | 12.8        | 15.8   | 0.01 | 16.2    | -2.9      |
| E [ $W/m^2$ ]     | 938.2       | 1000.0 | 0.00 | 1000.0  | -6.2      |
| T [ $^{\circ}C$ ] | 55.1        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 6 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 3.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

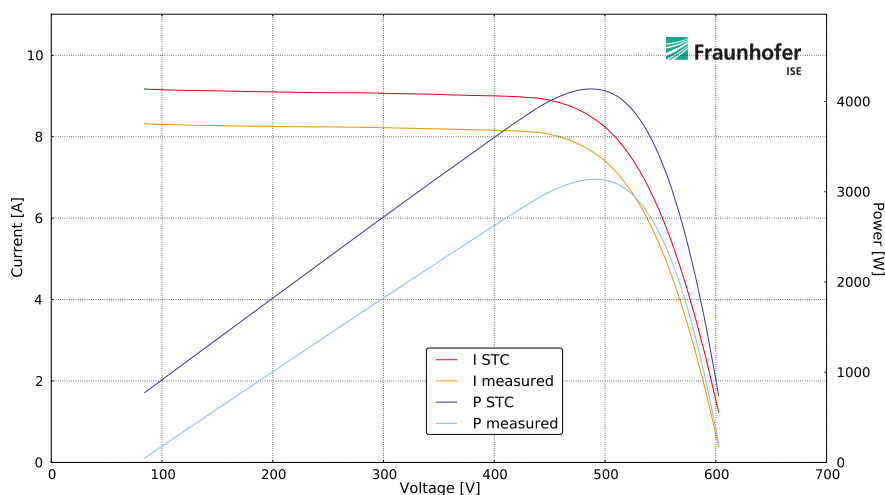
## A46 Measurement Log for Z1.2.2

Module type: YL265C-30b  
 Sub array: Z1.2.2  
 Date / Time: 2012-03-21 / 17:59:49  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3166.8      | 4137.4 | 6.36 | 4240.0  | -2.4      |
| $I_{SC}$ [A]      | 8.4         | 9.2    | 0.02 | 8.9     | 2.9       |
| $U_{OC}$ [V]      | 535.2       | 614.5  | 0.08 | 624.0   | -1.5      |
| $I_{MPP}$ [A]     | 7.7         | 8.5    | 0.01 | 8.6     | -0.7      |
| $U_{MPP}$ [V]     | 413.8       | 487.4  | 0.11 | 496.0   | -1.7      |
| FF [%]            | 70.5        | 73.2   | 0.18 | 76.1    | -3.7      |
| Eta [%]           | 12.1        | 15.8   | 0.02 | 16.2    | -2.4      |
| E [ $W/m^2$ ]     | 904.8       | 1000.0 | 0.00 | 1000.0  | -9.5      |
| T [ $^{\circ}C$ ] | 59.3        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 3 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 3.8\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

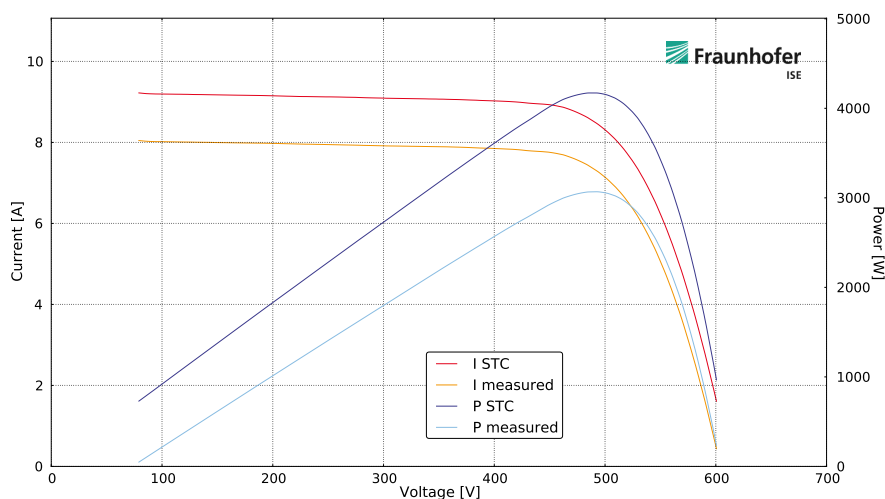
## A47 Measurement Log for Z1.3.1

Module type: YL265C-30b  
 Sub array: Z1.3.1  
 Date / Time: 2012-03-21 / 18:06:55  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3058.4      | 4175.5 | 3.40 | 4240.0  | -1.5      |
| $I_{SC}$ [A]      | 8.0         | 9.2    | 0.01 | 8.9     | 3.5       |
| $U_{OC}$ [V]      | 537.5       | 616.2  | 0.17 | 624.0   | -1.2      |
| $I_{MPP}$ [A]     | 7.3         | 8.5    | 0.01 | 8.6     | -0.1      |
| $U_{MPP}$ [V]     | 418.4       | 488.9  | 0.13 | 496.0   | -1.4      |
| FF [%]            | 70.9        | 73.3   | 0.07 | 76.1    | -3.6      |
| Eta [%]           | 11.7        | 16.0   | 0.01 | 16.2    | -1.5      |
| E [ $W/m^2$ ]     | 859.2       | 1000.0 | 0.00 | 1000.0  | -14.1     |
| T [ $^{\circ}C$ ] | 58.2        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 5 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 3.7\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

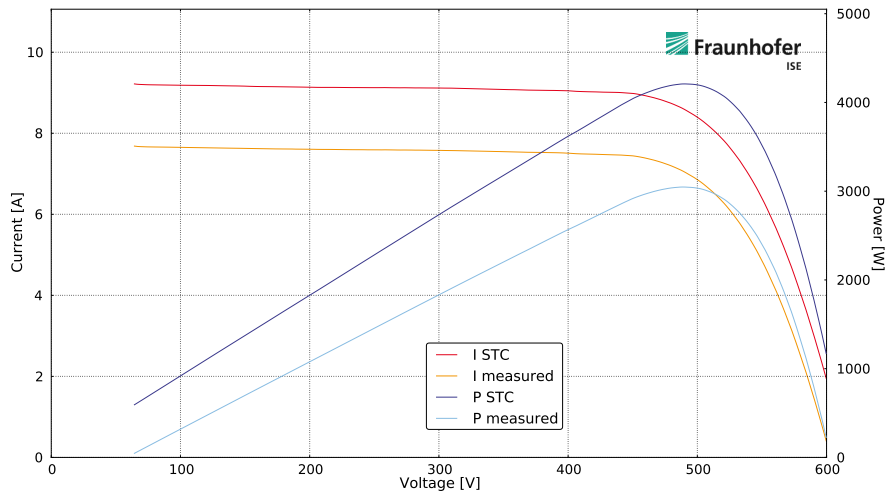
## A48 Measurement Log for Z1.3.2

Module type: YL265C-30b  
 Sub array: Z1.3.2  
 Date / Time: 2012-03-21 / 18:19:49  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3049.8      | 4210.0 | 1.58 | 4240.0  | -0.7      |
| $I_{SC}$ [A]      | 7.7         | 9.2    | 0.01 | 8.9     | 3.5       |
| $U_{OC}$ [V]      | 549.4       | 618.6  | 0.05 | 624.0   | -0.9      |
| $I_{MPP}$ [A]     | 7.0         | 8.6    | 0.01 | 8.6     | 0.3       |
| $U_{MPP}$ [V]     | 432.6       | 491.1  | 0.19 | 496.0   | -1.0      |
| FF [%]            | 72.2        | 73.6   | 0.05 | 76.1    | -3.3      |
| Eta [%]           | 11.7        | 16.1   | 0.01 | 16.2    | -0.7      |
| E [ $W/m^2$ ]     | 824.7       | 1000.0 | 0.00 | 1000.0  | -17.5     |
| T [ $^{\circ}C$ ] | 52.9        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 5 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 3.4\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

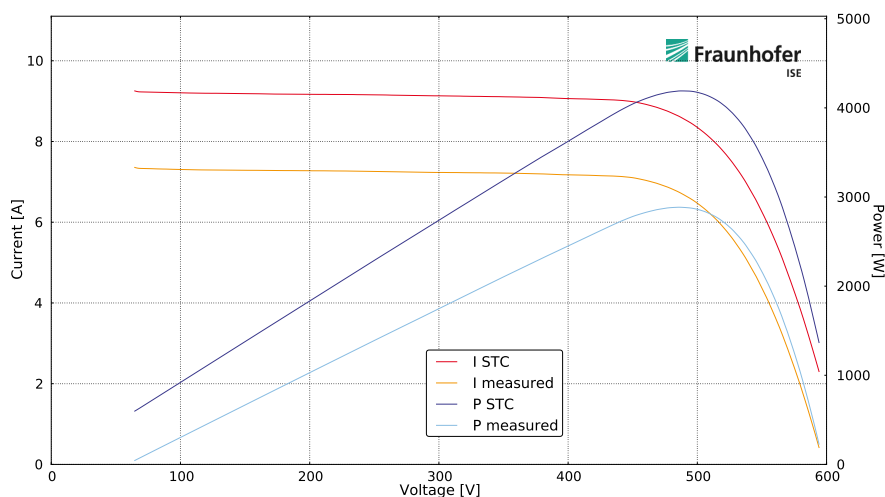
## A49 Measurement Log for Z1.4.1

Module type: YL265C-30b  
 Sub array: Z1.4.1  
 Date / Time: 2012-03-21 / 18:34:17  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 2886.0      | 4191.5 | 4.55 | 4240.0  | -1.1      |
| $I_{SC}$ [A]      | 7.4         | 9.3    | 0.01 | 8.9     | 3.7       |
| $U_{OC}$ [V]      | 543.8       | 616.1  | 0.32 | 624.0   | -1.3      |
| $I_{MPP}$ [A]     | 6.7         | 8.6    | 0.01 | 8.6     | 0.3       |
| $U_{MPP}$ [V]     | 428.6       | 488.8  | 0.23 | 496.0   | -1.5      |
| FF [%]            | 72.2        | 73.5   | 0.08 | 76.1    | -3.4      |
| Eta [%]           | 11.0        | 16.0   | 0.02 | 16.2    | -1.1      |
| E [ $W/m^2$ ]     | 786.7       | 1000.0 | 0.00 | 1000.0  | -21.3     |
| T [ $^{\circ}C$ ] | 53.6        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 3.4\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

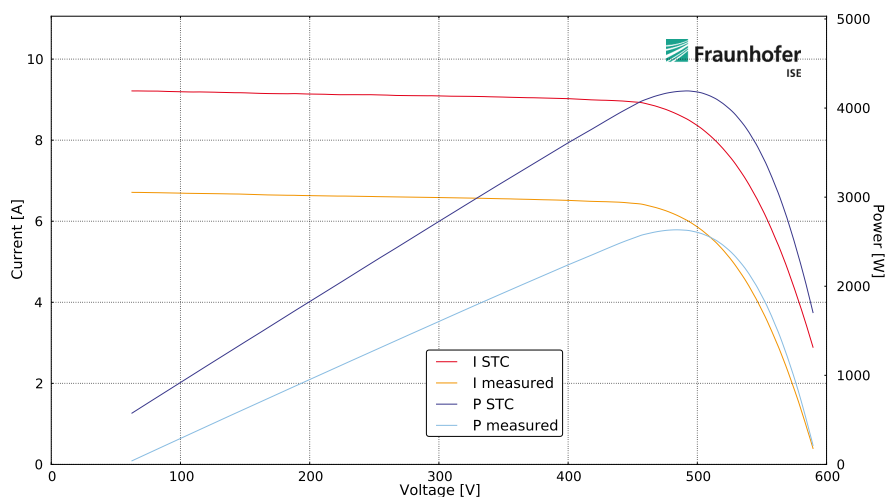
## A50 Measurement Log for Z1.4.2

Module type: YL265C-30b  
 Sub array: Z1.4.2  
 Date / Time: 2012-03-21 / 18:30:11  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 2686.8      | 4193.0 | 2.85 | 4240.0  | -1.1      |
| $I_{SC}$ [A]      | 6.8         | 9.2    | 0.01 | 8.9     | 3.6       |
| $U_{OC}$ [V]      | 540.9       | 617.5  | 0.22 | 624.0   | -1.0      |
| $I_{MPP}$ [A]     | 6.3         | 8.6    | 0.01 | 8.5     | 0.1       |
| $U_{MPP}$ [V]     | 427.6       | 490.1  | 0.23 | 496.0   | -1.2      |
| FF [%]            | 72.5        | 73.4   | 0.07 | 76.1    | -3.5      |
| Eta [%]           | 10.3        | 16.0   | 0.01 | 16.2    | -1.1      |
| E [ $W/m^2$ ]     | 734.9       | 1000.0 | 0.00 | 1000.0  | -26.5     |
| T [ $^{\circ}C$ ] | 54.4        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 6 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 3.5\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:



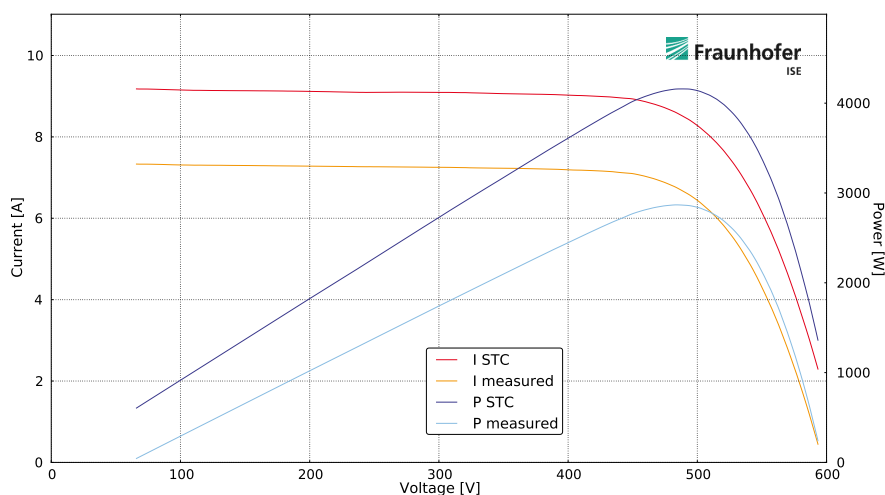
## A51 Measurement Log for Z2.1.1

Module type: YL265C-30b  
 Sub array: Z2.1.1  
 Date / Time: 2012-03-22 / 18:03:16  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 2876.9      | 4161.7 | 3.91 | 4240.0  | -1.8      |
| $I_{SC}$ [A]      | 7.4         | 9.2    | 0.01 | 8.9     | 3.1       |
| $U_{OC}$ [V]      | 541.6       | 616.0  | 0.36 | 624.0   | -1.3      |
| $I_{MPP}$ [A]     | 6.8         | 8.5    | 0.01 | 8.6     | -0.3      |
| $U_{MPP}$ [V]     | 425.0       | 488.0  | 0.26 | 496.0   | -1.6      |
| FF [%]            | 72.1        | 73.4   | 0.05 | 76.1    | -3.6      |
| Eta [%]           | 11.0        | 15.9   | 0.01 | 16.2    | -1.8      |
| E [ $W/m^2$ ]     | 794.0       | 1000.0 | 0.00 | 1000.0  | -20.6     |
| T [ $^{\circ}C$ ] | 54.5        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 5 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 3.5\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

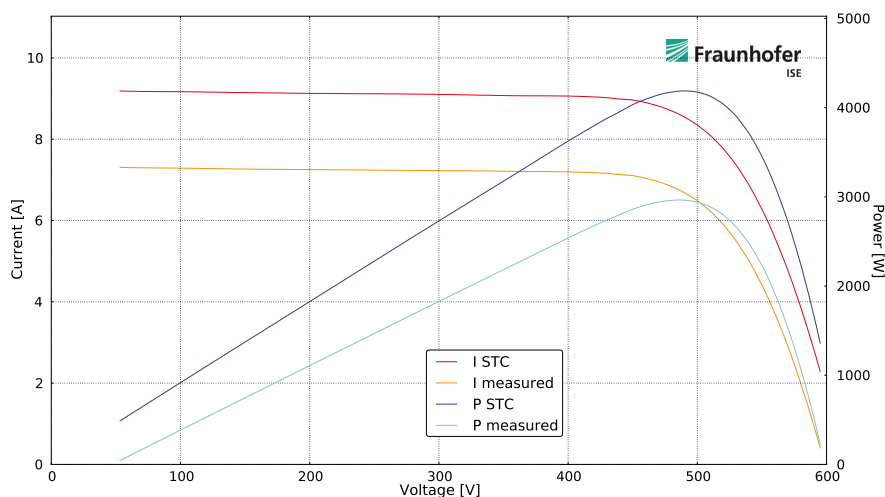
## A52 Measurement Log for Z2.1.2

Module type: YL265C-30b  
 Sub array: Z2.1.2  
 Date / Time: 2012-03-22 / 18:09:28  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 2966.6      | 4188.5 | 5.06 | 4240.0  | -1.2      |
| $I_{SC}$ [A]      | 7.3         | 9.2    | 0.01 | 8.9     | 3.0       |
| $U_{OC}$ [V]      | 554.7       | 617.6  | 0.41 | 624.0   | -1.0      |
| $I_{MPP}$ [A]     | 6.8         | 8.5    | 0.01 | 8.6     | -0.0      |
| $U_{MPP}$ [V]     | 439.3       | 489.9  | 0.35 | 496.0   | -1.2      |
| FF [%]            | 73.2        | 73.7   | 0.06 | 76.1    | -3.1      |
| Eta [%]           | 11.4        | 16.0   | 0.02 | 16.2    | -1.2      |
| E [ $W/m^2$ ]     | 789.2       | 1000.0 | 0.00 | 1000.0  | -21.1     |
| T [ $^{\circ}C$ ] | 49.1        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 5 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 3.2\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

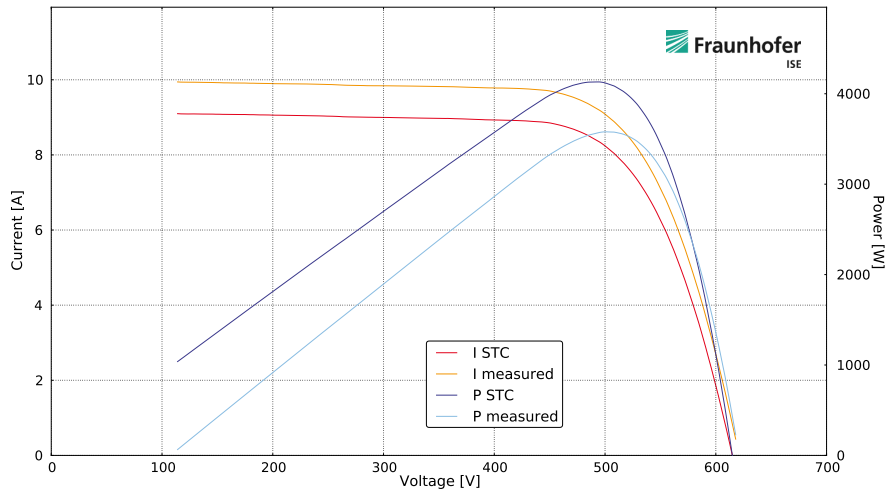
## A53 Measurement Log for Z6.1.1

Module type: YL265C-30b  
 Sub array: Z6.1.1  
 Date / Time: 2012-03-21 / 14:59:08  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3580.9      | 4133.7 | 5.39 | 4240.0  | -2.5      |
| $I_{SC}$ [A]      | 10.0        | 9.2    | 0.04 | 8.9     | 2.6       |
| $U_{OC}$ [V]      | 526.3       | 615.9  | 0.08 | 624.0   | -1.3      |
| $I_{MPP}$ [A]     | 9.0         | 8.4    | 0.01 | 8.6     | -1.3      |
| $U_{MPP}$ [V]     | 396.8       | 489.8  | 0.50 | 496.0   | -1.2      |
| FF [%]            | 68.4        | 73.3   | 0.28 | 76.1    | -3.7      |
| Eta [%]           | 13.7        | 15.8   | 0.02 | 16.2    | -2.5      |
| E [ $W/m^2$ ]     | 1075.7      | 1000.0 | 0.00 | 1000.0  | 7.6       |
| T [ $^{\circ}C$ ] | 67.3        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 4 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 5.0\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

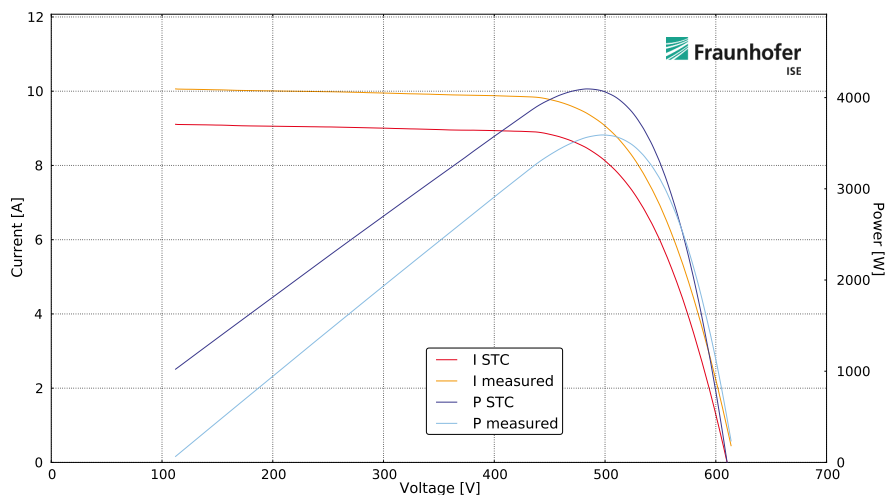
## A54 Measurement Log for Z6.1.2

Module type: YL265C-30b  
 Sub array: Z6.1.2  
 Date / Time: 2012-03-21 / 14:43:13  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD    | Nominal | Dev. in % |
|-------------------|-------------|--------|-------|---------|-----------|
| $P_{MPP}$ [W]     | 3570.3      | 4092.5 | 10.04 | 4240.0  | -3.5      |
| $I_{SC}$ [A]      | 10.0        | 9.2    | 0.03  | 8.9     | 2.8       |
| $U_{OC}$ [V]      | 524.2       | 611.0  | 0.67  | 624.0   | -2.1      |
| $I_{MPP}$ [A]     | 9.0         | 8.5    | 0.01  | 8.6     | -1.2      |
| $U_{MPP}$ [V]     | 394.8       | 484.3  | 0.54  | 496.0   | -2.4      |
| FF [%]            | 68.1        | 72.9   | 0.15  | 76.1    | -4.1      |
| Eta [%]           | 13.7        | 15.7   | 0.04  | 16.2    | -3.5      |
| E [ $W/m^2$ ]     | 1078.6      | 1000.0 | 0.00  | 1000.0  | 7.9       |
| T [ $^{\circ}C$ ] | 66.0        | 25.0   | 0.00  | 25.0    | 0.0       |

The results shown above are mean values derived from 5 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 5.0\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

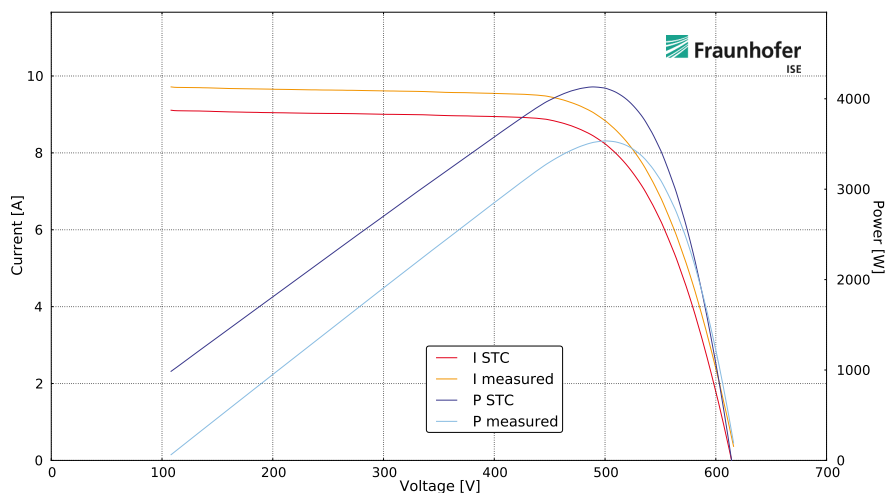
## A55 Measurement Log for Z6.2.1

Module type: YL265C-30b  
 Sub array: Z6.2.1  
 Date / Time: 2012-03-21 / 14:37:28  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3532.9      | 4132.2 | 4.22 | 4240.0  | -2.5      |
| $I_{SC}$ [A]      | 9.7         | 9.2    | 0.02 | 8.9     | 2.9       |
| $U_{OC}$ [V]      | 529.8       | 615.2  | 0.28 | 624.0   | -1.4      |
| $I_{MPP}$ [A]     | 8.8         | 8.4    | 0.01 | 8.5     | -1.2      |
| $U_{MPP}$ [V]     | 401.1       | 489.4  | 0.31 | 496.0   | -1.3      |
| FF [%]            | 68.7        | 73.1   | 0.15 | 76.1    | -4.0      |
| Eta [%]           | 13.5        | 15.8   | 0.02 | 16.2    | -2.5      |
| E [ $W/m^2$ ]     | 1048.1      | 1000.0 | 0.00 | 1000.0  | 4.8       |
| T [ $^{\circ}C$ ] | 65.1        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 9 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 4.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

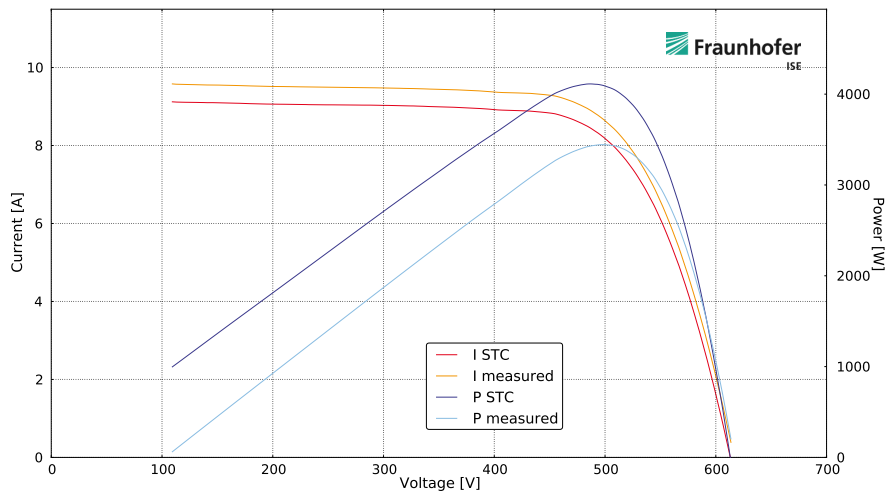
## A56 Measurement Log for Z6.2.2

Module type: YL265C-30b  
 Sub array: Z6.2.2  
 Date / Time: 2012-03-21 / 14:26:34  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3443.6      | 4112.9 | 3.37 | 4240.0  | -3.0      |
| $I_{SC}$ [A]      | 9.6         | 9.2    | 0.02 | 8.9     | 2.9       |
| $U_{OC}$ [V]      | 526.4       | 614.3  | 0.16 | 624.0   | -1.6      |
| $I_{MPP}$ [A]     | 8.7         | 8.4    | 0.01 | 8.5     | -1.3      |
| $U_{MPP}$ [V]     | 397.3       | 487.3  | 0.27 | 496.0   | -1.7      |
| FF [%]            | 68.4        | 72.9   | 0.17 | 76.1    | -4.2      |
| Eta [%]           | 13.2        | 15.7   | 0.01 | 16.2    | -3.0      |
| E [ $W/m^2$ ]     | 1032.4      | 1000.0 | 0.00 | 1000.0  | 3.2       |
| T [ $^{\circ}C$ ] | 66.2        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 8 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 4.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

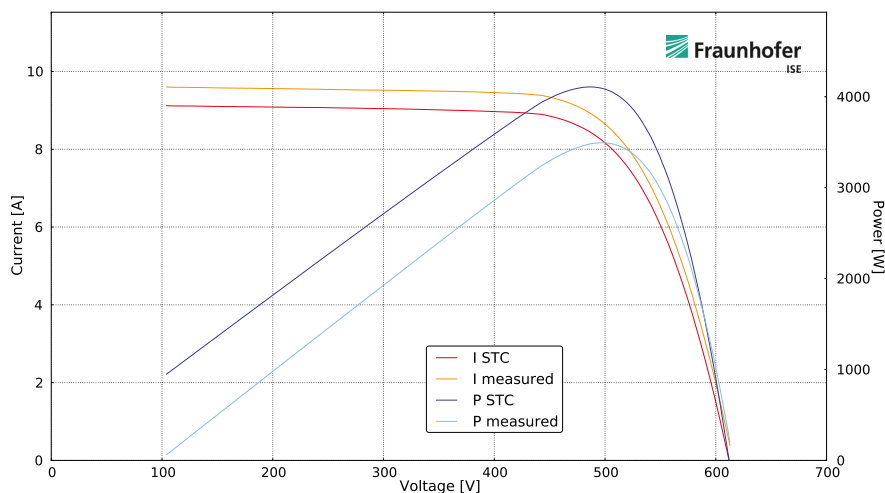
## A57 Measurement Log for Z6.3.1

Module type: YL265C-30b  
 Sub array: Z6.3.1  
 Date / Time: 2012-03-21 / 14:23:07  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3490.2      | 4109.9 | 2.41 | 4240.0  | -3.1      |
| $I_{SC}$ [A]      | 9.6         | 9.2    | 0.00 | 8.9     | 2.6       |
| $U_{OC}$ [V]      | 529.4       | 613.0  | 0.19 | 624.0   | -1.8      |
| $I_{MPP}$ [A]     | 8.7         | 8.5    | 0.01 | 8.6     | -1.1      |
| $U_{MPP}$ [V]     | 400.8       | 486.0  | 0.33 | 496.0   | -2.0      |
| FF [%]            | 68.7        | 73.2   | 0.07 | 76.1    | -3.8      |
| Eta [%]           | 13.4        | 15.7   | 0.01 | 16.2    | -3.1      |
| E [ $W/m^2$ ]     | 1035.8      | 1000.0 | 0.00 | 1000.0  | 3.6       |
| T [ $^{\circ}C$ ] | 64.1        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 5 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 4.4\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

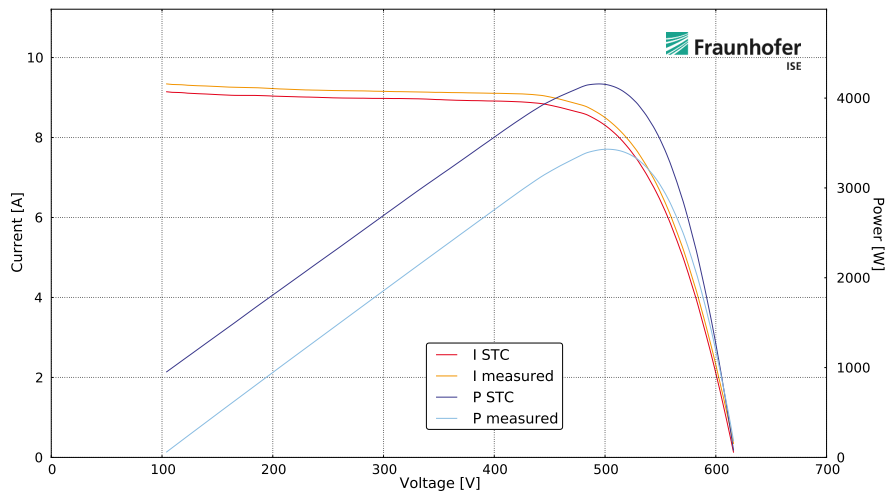
## A58 Measurement Log for Z6.3.2

Module type: YL265C-30b  
 Sub array: Z6.3.2  
 Date / Time: 2012-03-21 / 14:14:32  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3432.3      | 4154.0 | 2.60 | 4240.0  | -2.0      |
| $I_{SC}$ [A]      | 9.3         | 9.3    | 0.02 | 8.9     | 3.8       |
| $U_{OC}$ [V]      | 532.2       | 618.2  | 0.13 | 624.0   | -0.9      |
| $I_{MPP}$ [A]     | 8.5         | 8.4    | 0.01 | 8.5     | -1.8      |
| $U_{MPP}$ [V]     | 405.6       | 494.5  | 0.20 | 496.0   | -0.3      |
| FF [%]            | 69.0        | 72.5   | 0.13 | 76.1    | -4.7      |
| Eta [%]           | 13.1        | 15.9   | 0.01 | 16.2    | -2.0      |
| E [ $W/m^2$ ]     | 1006.2      | 1000.0 | 0.00 | 1000.0  | 0.6       |
| T [ $^{\circ}C$ ] | 64.8        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 6 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 4.2\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:



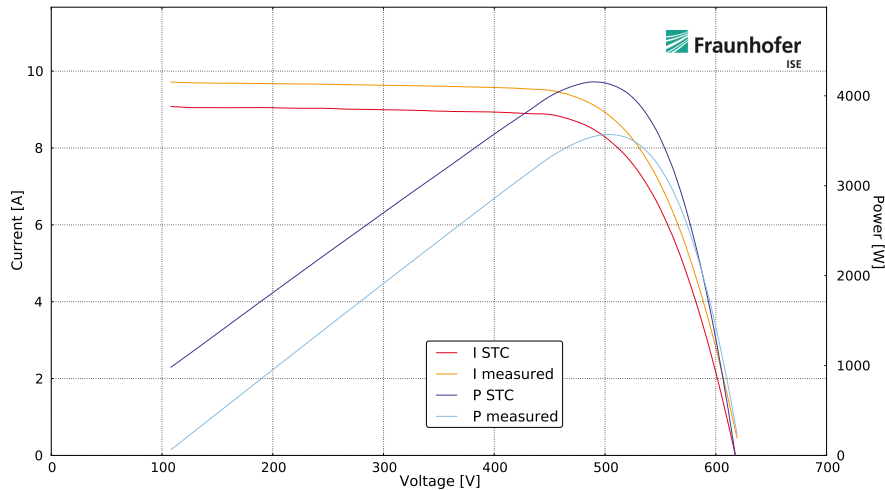
## A59 Measurement Log for Z6.4.1

Module type: YL265C-30b  
 Sub array: Z6.4.1  
 Date / Time: 2012-03-21 / 15:21:55  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3572.4      | 4154.0 | 3.87 | 4240.0  | -2.0      |
| $I_{SC}$ [A]      | 9.7         | 9.1    | 0.01 | 8.9     | 2.3       |
| $U_{OC}$ [V]      | 532.4       | 618.6  | 0.27 | 624.0   | -0.9      |
| $I_{MPP}$ [A]     | 8.9         | 8.4    | 0.01 | 8.5     | -1.2      |
| $U_{MPP}$ [V]     | 403.3       | 491.7  | 0.50 | 496.0   | -0.9      |
| FF [%]            | 69.0        | 73.5   | 0.17 | 76.1    | -3.4      |
| Eta [%]           | 13.7        | 15.9   | 0.01 | 16.2    | -2.0      |
| E [ $W/m^2$ ]     | 1054.0      | 1000.0 | 0.00 | 1000.0  | 5.4       |
| T [ $^{\circ}C$ ] | 65.2        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 6 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 4.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

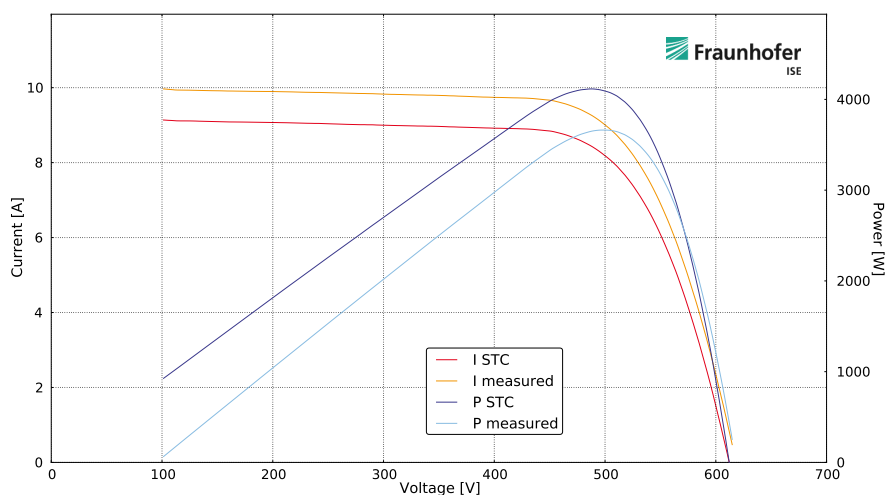
## A60 Measurement Log for Z6.4.2

Module type: YL265C-30b  
 Sub array: Z6.4.2  
 Date / Time: 2012-03-21 / 15:09:03  
 Interconnection: Modules in series per string: 16  
 Strings in parallel: 1

|                   | Measurement | STC    | SD   | Nominal | Dev. in % |
|-------------------|-------------|--------|------|---------|-----------|
| $P_{MPP}$ [W]     | 3665.0      | 4118.9 | 2.37 | 4240.0  | -2.9      |
| $I_{SC}$ [A]      | 10.0        | 9.2    | 0.00 | 8.9     | 3.1       |
| $U_{OC}$ [V]      | 534.0       | 613.7  | 0.49 | 624.0   | -1.7      |
| $I_{MPP}$ [A]     | 9.0         | 8.4    | 0.00 | 8.6     | -1.2      |
| $U_{MPP}$ [V]     | 405.0       | 487.7  | 0.33 | 496.0   | -1.7      |
| FF [%]            | 68.8        | 72.9   | 0.05 | 76.1    | -4.2      |
| Eta [%]           | 14.0        | 15.8   | 0.01 | 16.2    | -2.9      |
| E [ $W/m^2$ ]     | 1075.5      | 1000.0 | 0.00 | 1000.0  | 7.6       |
| T [ $^{\circ}C$ ] | 62.3        | 25.0   | 0.00 | 25.0    | 0.0       |

The results shown above are mean values derived from 2 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 4.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments:

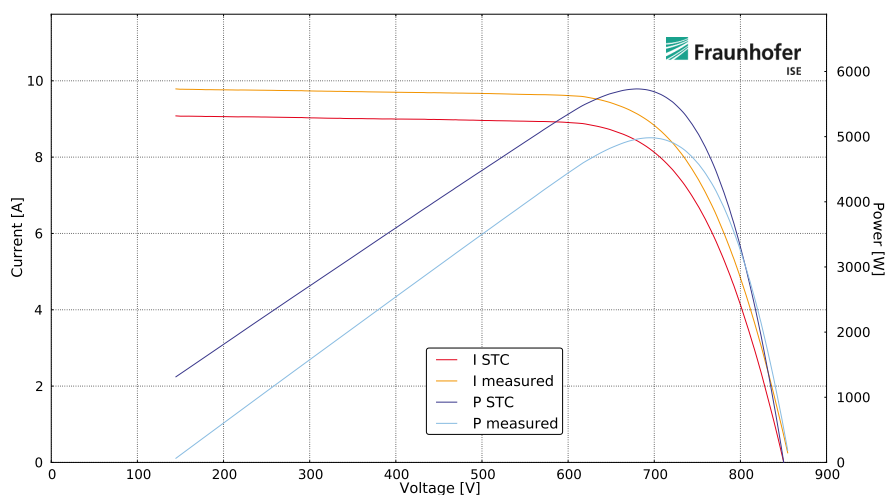
## A61 Measurement Log for Z6.5.2

Module type: YL265C-30b  
 Sub array: Z6.5.2  
 Date / Time: 2012-03-21 / 15:44:20  
 Interconnection: Modules in series per string: 22  
 Strings in parallel: 1

|                   | Measurement | STC    | SD    | Nominal | Dev. in % |
|-------------------|-------------|--------|-------|---------|-----------|
| $P_{MPP}$ [W]     | 4970.1      | 5733.9 | 10.30 | 5830.0  | -1.6      |
| $I_{SC}$ [A]      | 9.8         | 9.1    | 0.02  | 8.9     | 2.2       |
| $U_{OC}$ [V]      | 737.3       | 852.0  | 0.24  | 858.0   | -0.7      |
| $I_{MPP}$ [A]     | 8.9         | 8.4    | 0.01  | 8.5     | -1.3      |
| $U_{MPP}$ [V]     | 559.5       | 679.7  | 0.55  | 682.0   | -0.3      |
| FF [%]            | 69.1        | 73.8   | 0.22  | 76.1    | -3.1      |
| Eta [%]           | 13.8        | 16.0   | 0.03  | 16.2    | -1.6      |
| E [ $W/m^2$ ]     | 1058.8      | 1000.0 | 0.00  | 1000.0  | 5.9       |
| T [ $^{\circ}C$ ] | 64.8        | 25.0   | 0.00  | 25.0    | 0.0       |

The results shown above are mean values derived from 6 single measurements. Power losses from soiling, mismatch and electrical resistance were not considered. These are described in chapter Power Determination and included with the results of the power determination. Due to the conditions on site the measurements are clouded with an uncertainty of  $\pm 4.6\%$ . The graphic below shows the measured and the converted I-V-characteristic of a single measurement, each with power characteristic.

### I-V-Characteristic:



### Comments: