Big ambitions

Eversolar New Energy, recently re-named ZeverSolar, has high hopes for its Eversol-TLC 17K – though some fine-tuning is still required.

No one can accuse the engineers at Suzhou, China-based ZeverSolar New Energy Co. Ltd. of lacking ambition. The company, which was previously known as Eversolar New Energy Co. Ltd., and changed its name at the end of 2011 after merging with Zof New Energy Co. Ltd., already achieved impressive results when one of its inverters was put on PHOTON Laboratory’s test bench a few months ago (see PI 9/2011, p. 132). And now, it is following that victory by putting the Eversol-TLC 17K up for testing.

The Eversol-TLC 17K has two special features: sophisticated circuitry has apparently trimmed the boost converter to achieve the highest efficiencies, and the model’s two trackers function in all three operating modes. This means that the device, given to PHOTON Lab as part of the usual test agreement, offers a great degree of flexibility. But while the device scored two A grades, there is still plenty of room for improvement.

Construction

The Eversol-TLC 17K is part of a range of three-phase transformerless inverters with AC nominal powers ranging from 10,000 to 17,000 W. The device is compact and has a clear design. The power element is positioned on a large, central circuit board. The DC- and AC-side interference filter components are housed on another circuit board in the lower part of the device. It is covered by a metal plate that holds the communication circuit board. There are three more small circuit boards on the power element circuit board with the driver units for the output bridge transistors and the inverter's control system. It has been installed somewhat higher up in the device and screens some of the power components. The boost converter's power transistors have been designed discretely and are soldered in place from the bottom of the circuit board – just like the transistors for the three output bridges, which are integrated in half-bridge modules. Both subassemblies emit their heat to a cooling tower on the rear of the device. Inside, a smaller DC fan keeps air circulating. The temperature of the cooling element itself is maintained by three DC fans on the lower right-hand side, which can only be removed or replaced with a great deal of effort. Because one fan is exposed to ambient conditions, the inverter should not be operated in very dusty conditions due to the possibility of clogging.

The display is installed on the inner side of the housing’s cover and is connected to the communications circuit board by a cable. The inverter’s housing is made up of three parts: a welded steel-plate substructure, a metal plate that supports the three fans for the cooling element, and a welded steel-plate cover. It features an IP 65 protection type and is therefore suitable for installation outdoors – avoiding excessively dusty conditions. An automatic disconnect unit ensures safe operation by monitoring the grid for the correct voltage and frequency conditions. An insulation test is carried out on the DC side, and residual current is monitored on the AC side. The display and three LEDs provide information about the operating status of the inverter. The electrolytic capacitors used in the power element as well as in the control electronics feature a temperature class of 105 °C and are therefore well-suited to handle ambient temperatures.

The solar generators are connected using six pairs of MC4 connectors made by Multi-Contact AG. A five-pin plug from Amphenol-Tuchel Electronics GmbH is used to hook the system up to the grid. The inverter features a mechanical...
DC disconnect situated by the connector plugs. RS485, RS232 and USB interfaces are also part of the standard configuration. Zeversolar also provides a wireless connection as an optional extra.

Operation

The device arrives well packaged and protected from transport damage, with a wall bracket included in the delivery. At 50 kg, the Eversol-TLC 17K is a lightweight based on its nominal DC power.

If the solar generator is properly designed and the internal DC disconnect is active, the inverter is able to start work. It requires around 62 seconds to run a series of tests before connecting to the grid and getting to work. This allows the user to access a considerable amount of information in a clearly presented form.

Instruction manual

The inverter comes with a comprehensive installation and operating manual in Chinese, English and German. Beside general explanations, it covers installation, connection, operating characteristics, the menu structure of the display, and error and status messages shown by the display and LEDs. The installation instructions can also be downloaded from the manufacturer’s website.

Circuit design

The Eversol-TLC 17K features a two-stage design and has two independent MPP trackers in the input. Energy from the PV system initially enters the inverter via an EMI filter in the power stage. The MPP trackers are made up of a zero voltage transition (ZVT) boost converter with a storage choke, free-wheeling diodes and a series-resonant circuit. Each tracker feeds into a capacitor half-bridge, the midpoint of which is connected to the individual free-wheeling diodes of the three-level half-bridges. The pulse-width modulated output voltage is formed by the three half-bridges, and the midpoint of each corresponds to one phase. A subsequent filter smooths the modulated voltage blocks into sinusoidal voltage with a grid frequency of 50 Hz. An automatic grid-monitoring unit disconnects the inverter from the grid in the event that the grid voltage or frequency deviate from specified limits, as well as if it detects residual current on the AC side or the insulation resistance on the DC side is too low. An output filter, installed directly in front of the grid clamp, eliminates any radio interference.

Measurements

All of the following measurements are based on a grid voltage of 230 V. The Eversol-TLC 17K has a maximum DC voltage of 900 V, a nominal DC output per tracker of 8,700 W and a maximum throughput of 17,400 W. An EMI filter, installed directly in front of the grid clamp, measures 800 × 480 pixels and has a black background, making it easy to read. The menu is used to select the languages. Currently, operators can choose between Chinese, English and German; the company is planning to add French, Greek and Italian to the list.

The main menu, which is navigated using five buttons, records the energy fed into the grid in the form of a diagram. Furthermore, it provides information about the status, current output, the energy fed into the grid on the current day, and the total energy fed-in. This allows the user to access a considerable amount of information in a clearly presented form.
Conversion efficiency (symmetrical)

The area of maximum conversion efficiency only forms a narrow plateau at an MPP voltage of 648 V and 45 to 55 percent of nominal power.

× MPPT adjustment efficiency (symmetrical)

The MPPT adjustment efficiency is uniformly high over a large area. However, both trackers have obvious weaknesses at low powers and high voltages.

= Overall efficiency (symmetrical)

At less than 15 percent of nominal power, the picture is dissatisfying, with the overall efficiency only really stabilizing at higher powers. Its maximum of 97.9 percent is found at an MPP voltage of 657 V and 45 percent of nominal power.
Conversion efficiency (asymmetrical)

In asymmetric operating mode, the area with consistently high conversion efficiencies starts at 25 percent of nominal power. The maximum of 97.9 percent is reached at 60 percent of nominal power and an MPP voltage of 715 V (tracker 1) and 706 V (tracker 2).

× MPPT adjustment efficiency (asymmetrical)

The poor interaction between the two trackers in asymmetrical mode is clearly indicated in the diagram by the extensive areas with low MPPT adjustment efficiencies at medium MPP voltages.

= Overall efficiency (asymmetrical)

The fact that the trackers fail to harmonize well is also reflected in the overall efficiency. The maximum of 97.7 percent is reached at high MPP voltages (715 V and 706 V) and 60 percent of nominal power.
**Conversion efficiency (parallel)**

In parallel mode, the Eversol-TLC 17K doesn't achieve the same high efficiencies as under symmetrical loads. The maximum of 97.6 percent is 0.4 percentage points lower.

![Graph showing conversion efficiency](image)

**× MPPT adjustment efficiency (parallel)**

The MPPT adjustment efficiency graph reveals that the inverter functions the same in both symmetrical and parallel operation.

![Graph showing MPPT adjustment efficiency](image)

**= Overall efficiency (parallel)**

The overall efficiency is significantly lower in parallel operation than in symmetrical mode. The maximum value of 97.5 percent is 0.4 percentage points lower.

![Graph showing overall efficiency](image)
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Interested applicants should contact:

PHOTON Europe GmbH
Sigrid Heinrichs
job@photon-international.com
www.photon-international.com
**Weighted conversion efficiency**

With symmetrical loads, the weighted conversion efficiencies are close to perfect. Even at low MPP voltages, they are high. The maximum Californian efficiency comes in at 97.8 percent, while the European efficiency is 97.6 percent.

**Overall efficiency at different V_{MPP} voltages**

The weaknesses at low voltages show up in the overall efficiency chart covering different voltages. At an MPP voltage of 720 V and a nominal power of 6 percent, the overall efficiency is a very meager 82 percent. Only at nominal powers of 15 percent or above does the picture improve.

**Accuracy of inverter display**

The power output is displayed as precisely as it should be by a precision class B meter.
The inverter's multi-tracker design, the definition of MPP voltage range is divided into several tiers:

1) If the DC power is distributed symmetrically to the MPP trackers and is given as the sum of DC nominal power, then the MPP voltage range can be defined in the same way as for single-tracker inverters. That is, the inverter can process 100 percent of its DC nominal power at any voltage level within this range.

2) If the DC power distribution can be divided asymmetrically among the number of tracker inputs, the product's datasheet must specify the DC system nominal power and the maximum power of each individual tracker. Consequently, there are two complementary definitions for the MPP voltage range: a range for the tracker or trackers operating at maximum DC power and for the other tracker or trackers operating at reduced power.

3) Another option is to connect the trackers in parallel. The test device can be operated in this manner.

To allow for comparability, the PHOTON efficiency is calculated based only on the device's performance while all MPP trackers are operating under a symmetrical load.

Locating the MPP: At a predefined IV curve with nominal power and an MPP voltage of 631 V, the inverter requires 62 seconds to connect to the grid. When measurements started, both the DC and AC sides were switched off. Both trackers reached their MPP after another 23 seconds. The two trackers needed 4 seconds to switch from 631 V to 622 V; however, when switching to the next-highest MPP range of 639 V, neither tracker could locate their MPPs.

MPP range: The MPP range stretches from 550 to 720 V, which is a narrow range. The maximum MPP voltage is 720 V, which is at a comfortable distance from the maximum input voltage of 900 V.

MPP range 1 (symmetrical power distribution): In symmetrical mode, the two trackers are each subjected to half of the nominal DC system output, which is 8,700 W. The MPP range stretches from 550 to 720 V, which is a narrow range.

MPP range 2 (fully asymmetrical power distribution): In asymmetrical operation, tracker 1 is subjected to a load of 10,000 W (100 percent of power) within a voltage range of 625 to 720 V. Tracker 2 is operated at 460 to 720 V and subjected to a load of 7,400 W (100 percent of power).

MPP range 3 (parallel power distribution): In parallel mode, the voltage range is the same as for symmetrical loads. When in parallel operation, the advantages of multi-tracker inverters, which are capable of optimally processing different string voltages, are lost.

Conversion efficiency: The inverter can operate at 100 percent of its nominal power in an MPP voltage range of 550 to 720 V. At a maximum DC voltage of 900 V, there is a hatched area that indicates the device's limitations when used with thin-film modules. This is the result of an insufficient interval between the maximum MPP voltage and maximum DC voltage. The area of maximum conversion efficiency forms a small plateau at medium power and an MPP voltage of 648 V. The vertical line at 45 percent of nominal power and the horizontal line at an MPP voltage of 648 V meet at the maximum efficiency of 98 percent, equaling the manufacturer's specs exactly. The maximum conversion efficiency drops by around 0.1 percentage points toward high MPP voltages and falls by about 0.9 percentage points toward low MPP voltages. At less than 15 percent of nominal power, the conversion efficiency falls by around 5.5 percentage points. At nominal power, the power factor cos φ was about one.

Conversion efficiency 2 (fully asymmetrical power distribution): In asymmetrical mode, both MPP voltage ranges have been plotted in the diagram; the operating points were always present simultaneously at the tracker inputs. A large area can be identified showing consistently high efficiency. It stretches over the entire MPP voltage range once power exceeds about 20 percent. The vertical line at 60 percent of nominal power and the horizontal line at an MPP voltage of 715 V for tracker 1 and 706 V for tracker 2 meet at the maximum conversion efficiency of 97.9 percent. Toward low MPP voltages, the maximum conversion efficiency drops by about 0.7 percentage points.

Conversion efficiency 3 (parallel power distribution): The area indicating the highest conversion efficiencies is somewhat smaller than was recorded in asymmetrical operation. It extends from 30 to 100 percent of nominal power and starts from an MPP voltage of 595 V. The vertical line at 75 percent of nominal power and the horizontal line at an MPP voltage of 639 V meet at the maximum conversion efficiency of 97.6 percent. Toward higher MPP voltages, the maximum conversion efficiency falls by about 0.2 percentage points and drops by about 0.7 percentage points toward lower powers.

MPPT adjustment efficiency 1 (symmetrical power distribution): The MPPT adjustment efficiency is more than 99 percent above a nominal power of 15 percent. At lower powers and higher voltages, both MPP trackers do, however, show some weaknesses.

MPPT adjustment efficiency 2 (fully asymmetrical power distribution): In this operating state, the weaknesses in locating the MPP become more evident. The diagram shows an MPP voltage range of 625 to 720 V and a maximum power of 10,000 W for tracker 1. The MPPT adjustment efficiency falls to 97 percent or less at lower powers over the entire voltage range and at medium powers in the medium voltage range. Tracker 2, with an MPP voltage range spanning 460 to 720 V and a maximum power of 7,400 W, delivers a similarly dissatisfying performance, especially in the lower power range. The diagram depicts the sum of both trackers.

MPPT adjustment efficiency 3 (parallel power distribution): The operating behavior in this mode was identical to that recorded with symmetrical loads.

Overall efficiency: There is a hatched area at the maximum DC voltage of 900 V that indicates limitations when the device is used with thin-film modules.

Overall efficiency 1 (symmetrical power distribution): In symmetrical mode, the area of maximum overall efficiency is found at medium voltages. The vertical line at 45 percent of nominal power and the horizontal line at an MPP voltage of 657 V meet at the maximum overall efficiency of 97.9 percent.

Overall efficiency 2 (fully asymmetrical power distribution): In this case, both voltage ranges have again been plotted in the diagram, with the operating points always simultaneously present at the tracker inputs. Once again, the inverter’s inconsistent performance when locating the MPP is easy to identify. The vertical line at 60 percent of nominal power and the horizontal line at an MPP voltage of 715 V (tracker 1) and 706 V (tracker 2) meet at the maximum overall efficiency of 97.7 percent. Therefore, this is 0.2 percentage points lower than under symmetrical loads.

Overall efficiency 3 (parallel power distribution): Above 15 percent of nominal power, a uniform picture is produced that resembles the diagram for conversion efficiency. The vertical line at 65 percent of nominal power and the horizontal line at an MPP voltage of 648 V meet at the maximum overall efficiency of 97.5 percent. That is 0.4 percentage points lower than under symmetrical loads.

Weighted conversion efficiency: The maximum European efficiency is found at an MPP voltage of 666 V and comes in at 97.6 percent. The manufacturer specifies a figure of 97.5 percent – albeit for a voltage of 360 V, which is outside the tested and approved MPP voltage range. The difference between the maximum conversion efficiency and maximum European efficiency amounts to 0.4 percentage points. At 97.8 percent, the maximum Californian efficiency is around 0.2 percentage points higher than European efficiency and is reached at an MPP voltage of 657 V.

Course of overall efficiencies, average overall efficiency and PHOTON efficiency: The inverter’s weaknesses at low powers are also mirrored in this category. The average overall efficiency is 97.48 percent. PHOTON efficiency at medium irradiation is 96.9 percent, while PHOTON efficiency at high irradiation is around 0.4 percentage points higher, at 97.3 percent.

Feed in at nominal power: The inverter feeds 100 percent of its nominal power into the grid over the input voltage range of 550 to 720 V at an ambient temperature of 25 °C.
Manufacturer’s response

The Eversol-TLC 17K has been compliant with the new German low-voltage directive since January 2012 and is also compliant with the feed-in management system described in the German Renewable Energy Law (EEG). Moreover, we are currently working with thin-film manufacturers to secure approval to use our inverter with these kinds of modules.

Displayed output power: The output power measured and displayed by the Eversol-TLC 17K deviates from the value measured by the power analyzer by up to 8.9 percent at the lowest possible powers. At 20 percent of nominal power, the margin of error ranged from 1 to -0.6 percent. The display is therefore equivalent to a meter in precision class B (previously class 1).

Operation at high temperatures: The inverter continued to feed 100 percent of its nominal power into the grid up to a temperature of 49.5 °C, after which point it reduced its output. The operating point selected was 2 × 8,700 W of DC power and an MPP voltage of 631 V. The efficiency fell by around 0.15 percentage points over this temperature range. Thanks to its wide temperature range of -20 to 60 °C and IP 65 protection class, the inverter can be installed under a roof or outdoors. However, the power reductions at high ambient temperatures should be taken into account.

Overload behavior: If the Eversol-TLC 17K is subjected to a load of 1.3 times its nominal input power – meaning 2 × 11,310 W – at an MPP voltage of 631 V and an ambient temperature of 24 °C, the device limits power to 8,859 W (tracker 1) and 8,728 W (tracker 2). This results in a total DC power of 17,633 W, which is equivalent to an overload of 101.3 percent. Therefore, the device does not really feature an overload range. When limiting power, the device pushes the operating point on the IV curve toward higher input voltages. The DC voltage adjusts itself to around 704 V.

Own consumption and night consumption: The power consumed by the device in its basic tested state was around 0.2 W on the AC side and 23 W on the DC side; the manufacturer specifies less than 12 W. At night, the inverter draws around 0.7 W of real power from the grid; the manufacturer’s specs were less than 0.6 W in this case.

Thermography: Thermographic images show component temperatures of up to 76.4 °C in the areas that are visible on the circuit boards. The temperatures were highest around the circuit-breaker relay, while the electrolytic capacitors in the power element were all in the safe range.

Summary

Zeversolar really came up with something special with its TLC 17K. The circuitry is sophisticated and endeavors to reduce switching losses – and it certainly succeeds, as the high conversion efficiency shows. However, even higher efficiencies were expected due to the complexity of the boost converter topology. SMA Solar Technology AG’s Tripower series achieves similar efficiencies using less complicated methods. The Eversol-TLC 17K makes a good impression on the whole, but that is tarnished by the interaction issues between the two trackers. They fail to function optimally in both asymmetric and parallel operation; even in symmetrical mode, efficiency levels drop at low powers. These issues, however, could be rectified by improving the software. Other than that, the test candidate is compact and clearly designed. Analyzing the inverter’s functions is made considerably easier by the graphics-capable display. The maximum conversion efficiency under symmetrical loads is 98 percent and is highly consistent over the entire voltage range at nominal powers of 15 percent or more. A similar impression is made by European and Californian efficiency. The European efficiency is just 0.4 percentage points lower than the maximum conversion efficiency, and the Californian efficiency trails by only 0.2 percentage points. Apart from a few minor weaknesses at low powers and high voltages, the uniform, high MPPT adjustment efficiency results in the overall efficiency being only slightly lower than the conversion efficiency. However, the MPP voltage range is narrow and includes limitations in the upper section where thin-film modules are used.

The overall efficiency fluctuates by just -0.9 percent, and by around 3 percentage points at nominal powers of 10 percent or above. However, weaknesses emerge at low powers and high voltages. PHOTON efficiency at medium irradiation comes in at 96.9 percent; at high irradiation, a figure of 97.3 percent is achieved. The comparatively large difference is indicative of the weaknesses described.

When designing a PV system, the middle third of the MPP voltage range should be chosen. The inverter does not feature an overload range. The output power is displayed accurately at 20 percent of nominal power and above. While the device’s temperature range is broad, power reductions set in at 49.5 °C. At -0.15 percent, the temperature dependency of the conversion efficiency is very low.

The flexibility offered by the Eversol-TLC 17K and its two trackers is compromised by yield issues. Despite this, the inverter is very good and has a high PHOTON efficiency. As no DC current limitations are in place in the specified voltage range, it can be fully utilized for crystalline modules up to 720 V. In a large PV system, however, the device can only be used in combination with a string box.

Further information
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