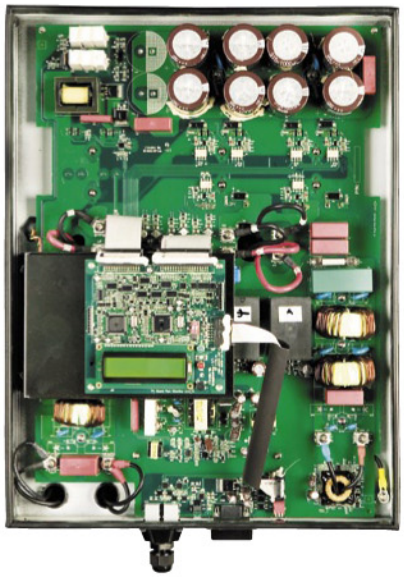


Romana Brentgens / photon-pictures.com (2)

▶ Simple design both inside and out: The results of thermographic imaging were impressive – there were only two areas where temperatures were elevated, but they were still at harmless levels.

A serious competitor

Samil Power's SolarRiver SR4K4TLA1 replaces Growatt's 5000TL as the best Asian inverter to be tested by PHOTON Lab

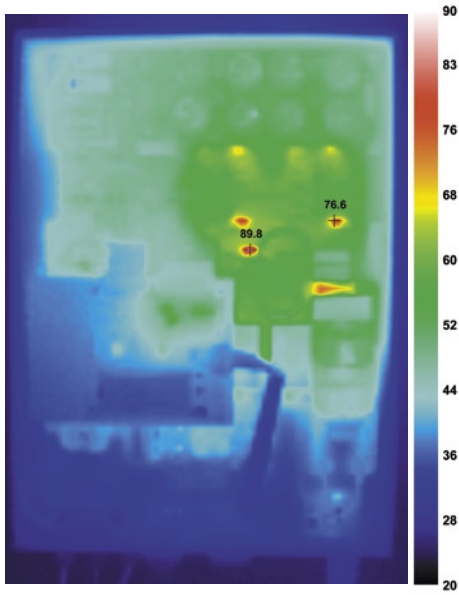
Highlights

- Samil Power's SolarRiver SR4K4TLA1 is a single-phase, transformerless inverter with a DC nominal power of 4.2 kW
- The device's MPP range streches from 200 to 450 V
- The SR4K4TLA1's conversion efficiency reaches a maximum of 97.6 percent; its European efficiency comes in at 97.1 percent, and the device's Californian efficiency is 97.3 percent
- The PHOTON efficiency at high irradiation is 96.5 percent, while the PHOTON efficiency at medium irradiation is 96.8 percent

To get a feel for the range of inverters PHOTON Laboratory has tested so far, it can help to place them into certain categories. Criteria such as the DC nominal power, MPP voltage range and perhaps the number of trackers would seem to be obvious. Another idea would be to sort the manufacturers according to their country of origin. Looking at this month's results from that angle, a new top dog emerges: the SolarRiver SR4K4TLA1 is the new champion reigning over all of the Asian inverters that PHOTON Lab has tested thus far. And it's worth keeping an eye on this title. After all, while inverters from the Far East have been readily available in the past and have come with quite attractive price tags, they had been falling short in the most important area: efficiency. But this device, with its tongue-twisting name, the SR4K4TLA1 from Chinese manufacturer Samil Power Co. Ltd., is in the same league as big shots like SMA Solar Technology AG, Kaco New Energy GmbH and Refusol GmbH. Its success can partially be attributed to the excellent job that Samil's engineers did in looking in to what was going on in the R&D departments of these top European players. The Chinese company's management has big plans: production reached 32 MW last year and in 2011 it will total 400 MW. It goes somewhat without saying that the competition should be keeping a close eye on Samil Power. PHOTON Lab received the SR4K4TLA1 after the usual test agreement was signed.

Construction

Samil Power has a spectrum of PV inverters from just over 1 kW up to the megawatt range. The inverter being tested is part of the SolarRiver series, which is made up of small, single-phase, transformerless devices with AC nominal powers between 1.5 and 4.6 kW. The inverter's design is neat and it appears to be simple to manufacture. Overall, it makes a good, compact impression. The power element circuit board covers the entire internal surface area and a great deal of hot-glue adhesive has been used to affix large components to it. The discrete power transistors and diodes are affixed to the cooling element below the power element circuit board using plastic molds, and the underside is soldered onto the circuit board. The display and control circuit boards are installed at a different angle above the power circuit board, and are connected with several flat cables. The sinusoidal filter chokes and the boost converter choke are located under the circuit board. On one side, the cooling element's function is performed by an aluminum die-cast component, while the other side serves as the inverter's back. The unit is enclosed in a sheet metal frame and the cover is also made of steel sheeting. To cool the inverter, a fan is installed on the side. In the event of a failure, the fan is difficult to replace. Since the fan is subjected to ambient conditions, the inverter should not be operated in excessively dirty locations.



An automatic grid-monitoring unit ensures safe operation, since it monitors the grid for proper voltage, frequency and impedance behavior. An insulation test is also carried out to check the resistance between the solar generator and the ground. Leakage current is monitored on the grid side.

The display and two LEDs provide information on the inverter's operating status. The electrolytic capacitors in the power element and in the control electronics have a temperature class of 105 °C, and are thus well-suited to handle ambient temperatures.

The device contains a single MPP tracker and two DC inputs, and the generator is hooked up with connectors from Amphenol-Tuchel Electronics GmbH. The inverter connects to the grid using a three-pole connector from Wieland Electric GmbH. The DC and AC connectors, including an interference filter, are located in a plastic compartment under the unit and lack an integrated DC disconnect. For communications purposes, the unit has RS232 and RS485 ports.

Operation

The device arrives at the user's home well packaged and protected. An accompanying wall bracket is used to install the inverter, which, considering its DC nominal power, is rather lightweight at 19.2 kg. Once the solar generator is properly configured and an external DC disconnect is connected, the inverter is ready for action. The device requires around 42 seconds for various tests before connecting to the grid and starting to operate. The two-row display is flush with the front cover, has yellow backlighting and is easy to read when switched on. The menu allows users to select between Chinese, English, French, German, Italian and Spanish. The display is activated once the grid and DC voltage are present. The backlighting shuts off after 30 seconds of being idle.

The settings can be altered using a single button. In addition to various status and error messages, the display shows the most important measurements.

Instruction manual

The inverter being tested came with an English instruction manual, which is also available in Chinese, French, German, Italian and Spanish. It covers safety instructions, general information about the device, getting started, the display, communications ports and installation, and other technical data. The complete menu from the LCD display is also represented in an image. The installation process is illustrated and an overview of the connections is provided. The technical data can also be downloaded from the manufacturer's website.

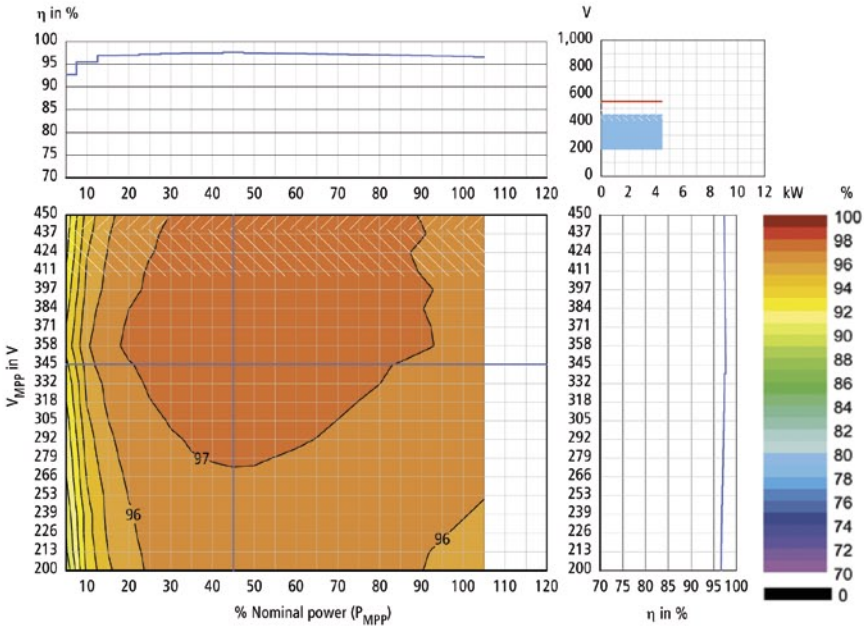
Circuit design

The inverter has a two-stage design. First energy from the PV system reaches the boost converter via an EMI filter. The boost converter increases the input voltage to the

text continues on p. 192 ▶▶

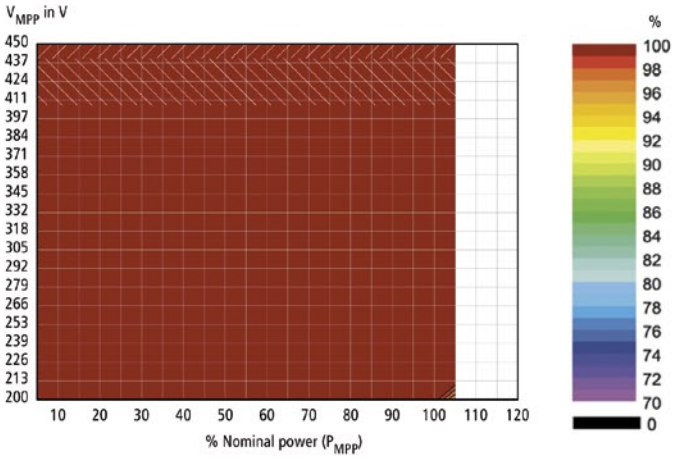
Conversion efficiency

At nominal powers of between 25 and 90 percent, a clear plateau forms above an MPP voltage of 279 V, which represents the area of maximum efficiency. The maximum efficiency is found at 45 percent of nominal power and an MPP voltage of 345 V.



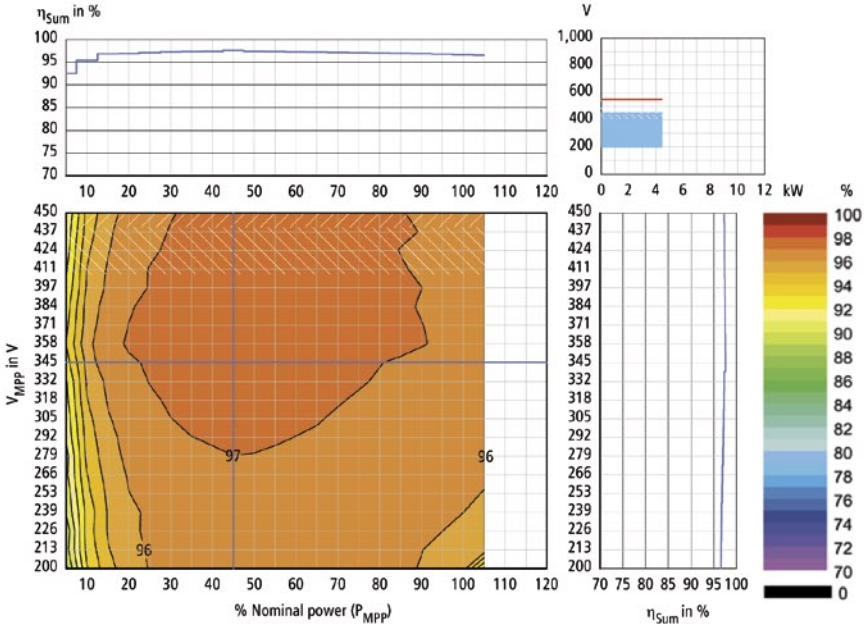
× MPPT adjustment efficiency

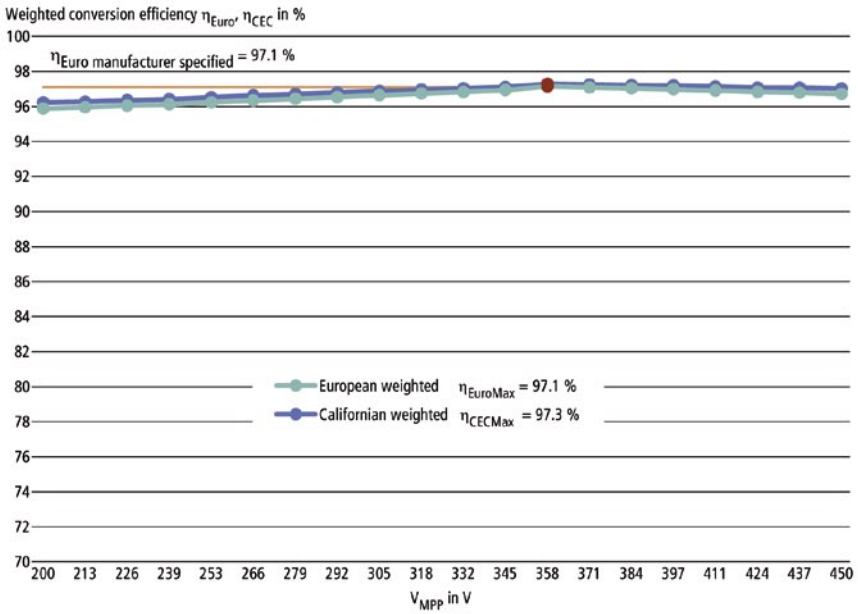
Pure textbook: The adjustment efficiency is an ideal 99 percent across the entire power range.



= Overall efficiency

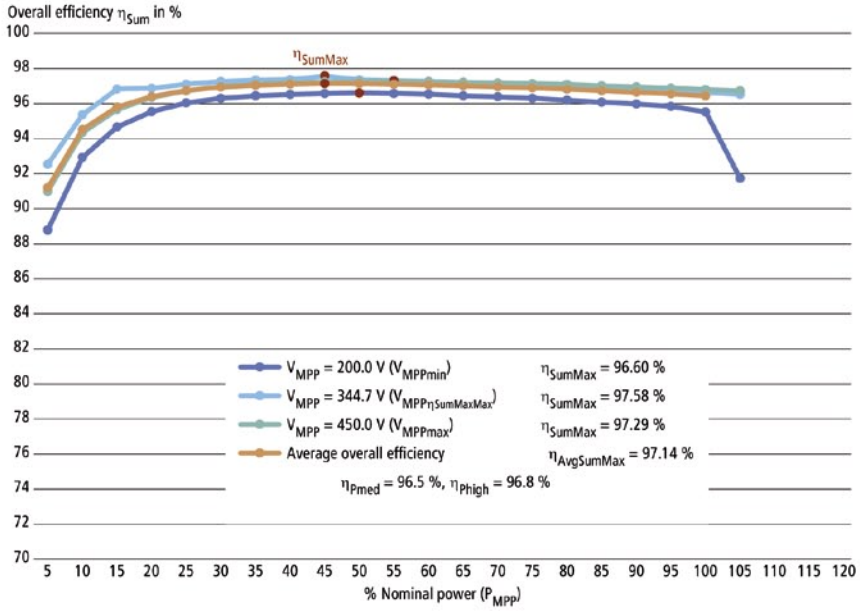
The overall efficiency is equally impressive. The inverter reaches its highest value at a nominal power of 45 percent and a medium MPP voltage of 345 V.





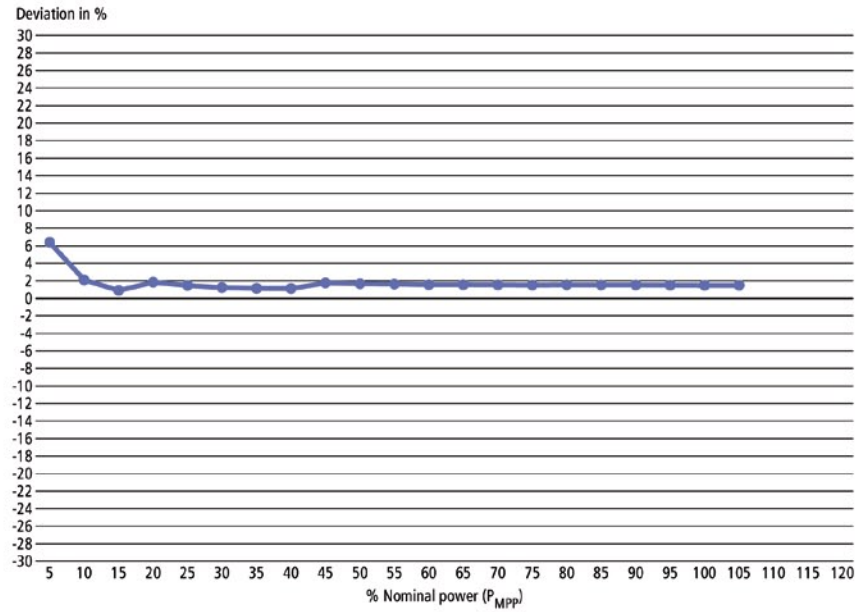
Weighted conversion efficiency

The highest efficiencies for both weightings occur at exactly the same MPP voltage of 358 V. With European weighting, the efficiency lies at 97.1 percent, while Californian efficiency comes in at 97.3 percent.



Overall efficiency at different V_{MPP} voltages

As soon as it starts to operate, the SolarRiver SR4K4TLA1 reaches a very respectable efficiency, which quickly heads for its maximum as power increases. At lower MPP voltages of 200 V, the inverter shows slight weaknesses at very low and very high powers.



Accuracy of inverter display

The display is a little inaccurate until the inverter reaches a nominal power of 10 percent, after which point the display is very precise.

internal intermediate-circuit voltage. A capacitor smoothes the input voltage, and then an output bridge hacks the input DC voltage into pulse-width modulated square voltage blocks. There are two free-wheeling arms between the output bridge and the sinusoidal chokes. These ensure that the chokes' idle current doesn't go back into the intermediate-circuit capacitor. This reduces the output bridge's switching losses as well as the output chokes' magnetic hysteresis losses, and therefore increases efficiency. By using a boost converter, the unit has an MPP voltage range of 200 to 450 V. The voltage level in the intermediate circuit is selected to ensure the inverter can always feed into the grid.

The sinusoidal filter consists of a sinusoidal choke and other capacitors and smoothes the voltage blocks into sinusoidal waves with a grid frequency of 50 Hz. A subsequent automatic disconnect separates the inverter from the grid if grid voltage or grid frequency deviate from predetermined values, or if leakage current is found on the grid side. Moreover, the unit monitors for potential ground faults. An output filter, installed immediately in front of the grid clamp, eliminates any radio interference.

Measurements

The SR4K4TLA1's maximum DC voltage is 550 V and the DC nominal power is 4,200 W. At most, the device can be connected to 4,580 W of PV power.

Locating the MPP: At a predetermined IV curve with nominal power and an MPP voltage of 342 V, the inverter needs about 42 seconds to connect to the grid, and another 10 seconds to reach its MPP. The switch from 342 V to 326 V took 12 seconds, while the switch to the next higher MPP range of 358 V took just a few seconds.

MPP range: The MPP range stretches from 200 to 450 V, which is a normal range. The maximum MPP voltage of 450 V is almost at a comfortable distance from the maximum DC voltage of 550 V.

Conversion efficiency: The inverter can operate at 105 percent of its nominal power within an MPP range of 200 to 450 V. There is a hatched area at the maximum DC voltage of 550 V that represents MPP voltage range limitations when the device is used with crystalline modules. The area with hatching in the opposite direction demarks limitations when used with thin-film modules due to the inadequate distance between the maximum MPP voltage and the maximum DC voltage. In the color diagram, there are large areas with the same color, so with identical efficiency. The area of maximum efficiency forms a large plateau at a high level. It stretches between the MPP voltages of 279 and 450 V within a nominal power range of 20 to 90 percent. The vertical line at 45 percent of nominal power and the horizontal line at an MPP voltage of 345 V meet at the maximum efficiency of 97.6 percent. At higher MPP voltages, the maximum conversion efficiency decreases by around 0.4 percentage points, while at lower voltages it drops by around 1 percentage point. The manufacturer's specification for maximum efficiency was 97.6 percent – so exactly the same as PHOTON Lab's measurements. At lower powers below 15 percent of nominal power, efficiency dropped by 5 to 7 percentage points. At nominal power, the power factor cos φ was about one.

MPPT adjustment efficiency: The MPPT adjustment efficiency is very consistent and remains at a high level over the entire operating range. It is always more than 99 percent of available power.

Overall efficiency: The area of maximum overall efficiency is located at medium voltages and powers. The vertical line at 45 percent of nominal power and the horizontal line at an MPP voltage of 345 V meet at the overall maximum efficiency of 97.6 percent.

Weighted conversion efficiency: The European efficiency reaches its peak in an MPP range of 358 V and, at 97.1 percent, it matches the manufacturer's specifications exactly. The difference between the maximum conversion efficiency and maximum European efficiency is 0.5 percentage points. The Californian efficiency is almost the same, just around 0.2 percentage points higher at 97.3 percent.

Course of overall efficiencies, average overall efficiency and PHOTON efficiency: The SolarRiver showed no considerable weaknesses when it came to its efficiency course. The PHOTON efficiency for medium irradiation is 96.5 percent and the PHOTON efficiency for high irradiation at 96.8 percent.

Feed-in at nominal power: The inverter feeds in 100 percent of nominal power over the input voltage range from 200 to 450 V at an ambient temperature of 25 °C.

Displayed output power: The inverter's measured and displayed output power deviates at low powers by up to +6.4 percent from the measurements of a power analyzer. Above 10 percent of nominal power, this error rate decreases to a range of +0.9 to 1.8 percent. Thus, the display is as accurate as a class B meter (previously known as precision class 1).

Operation at high temperatures: If the temperature increases, the inverter continues to feed 100 percent of nominal power into the grid up to an ambient temperature of around 56.5 °C. Once this temperature is reached, the device reduces its power and settles at a selected operating point of 4,200 W and an MPP voltage of 358 V. Efficiency fell by around 0.5 percentage points. Due to its very wide temperature range of -20 to 60 °C and its IP 65 protection type, this inverter can be installed both under a roof and outdoors.

Overload behavior: If the SR4K4TLA1 is offered an overload of 1.3 times its nominal input power, so 5,460 W, at an MPP voltage of 342 V

and an ambient temperature of 23 °C, the device limits power to about 4,462 W. This corresponds to an overload of 106.2 percent at a DC nominal power of 4,200 W, which means that the device has a small overload range. When power limitations take effect, the device moves the operating point on the IV curve toward higher input voltages. The DC voltage then adjusts itself to a value of around 365 V.

Own consumption and night consumption: The device's own consumption in its tested construction is around 0.1 W on the AC side; the manufacturer makes no specifications. On the DC side, consumption comes in at 4 to 6 W, while at night it draws around 0.1 W of real power from the grid. The manufacturer specifies 0 W.

Thermography: Thermographic images show the inverter from above while it is operating at nominal power at an ambient temperature of 23 °C. The component temperatures on the circuit board got up to 89.8 °C – that was recorded around the SMD resistors on the circuit board near the power transistors.

Summary

Samil Power's SolarRiver SR4K4TLA1 performed well in PHOTON Lab's tests and appears to be a good-quality product. The inverter has a very clear construction and lends itself well to simple production, while making a good, compact impression. The conversion efficiency reaches its peak at 97.6 percent in the medium MPP voltage range, whereby the difference at higher voltages is around 0.4 percentage points and around 1 percentage point at lower voltages. Therefore, the conversion efficiency's dependence on voltage and power is rather low. The development of overall efficiency is almost the same as that of conversion efficiency, due to the consistently high MPPT adjustment efficiency. The manufacturer-specified MPP voltage range is at a nearly sufficient distance from the inverter's maximum DC voltage and can almost be exploited in its entirety when used with crystalline modules. The transformerless device is not suited for use with thin-film modules.

The PHOTON efficiency for medium irradiation is very high at 96.5 percent and the difference from the maximum conversion efficiency is just 1.1 percentage points, which reflects the device's low power dependence. The PHOTON efficiency for high irradiation is somewhat higher at 96.8 percent. When choosing the MPP of a PV system, it is best to choose the middle third of this inverter's MPP voltage range.

The inverter has a small overload range at 106.2 percent, so the solar generator has to be carefully adjusted to ensure power peaks do not damage the device. The display of output power is accurate. The SolarRiver's temperature range is very broad, but if the ambient temperature increases over 56 °C, the device reduces power. The conversion efficiency's dependence on temperature is low at 0.5 percentage points.

All in all, Samil Power's SolarRiver SR4K4TLA1 earns two A grades for PHOTON efficiency. It currently ranks No. 17 in PHOTON Lab's test, based on its results for medium irradiation. That means that it is not only the best inverter produced in Asia that PHOTON Lab has tested so far, but is also one of the best products in the 5 kW power class. But in order to emerge as a true alternative to German market leaders like SMA and Kaco, Samil Power will have to prove that its products have longevity and can offer comparable service. The engineers at Samil have done their job – now it's time for management and sales to do theirs.

Text Heinz Neuenstein, Matthias B. Krause

Further information
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Manufacturer's response

PHOTON Laboratory's test results match our own measurements. We have no objections to the results.