PV String Inverter Layout with High-Power Modules – A Matter of Flexibility

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Single-MPPT inverters are proving to be the preferred choice when it comes to ease of layout and flexibility in design. It is clear that in today's inverter landscape there is no one multi-MPPT inverter which can provide a satisfactory design for all high-power modules. The KACO single-MPPT string inverter range offers a much easier and more flexible design through the use of DC combiners which is crucial when optimizing your PV module layout.

The entire solar industry has been eagerly following, and in some cases frantically playing catch-up with the trend of ever-increasing solar module power ratings. Enabled through various advances in manufacturing and the increase in wafer sizes, module manufacturers are well and truly bringing in the high-power era.

However not all high-power modules are alike.

Different manufacturers have recently invested in different wafer technologies and corresponding infrastructure. This means that the industry will be dealing with different wafer sizes and therefore different module currents for the coming years. This makes it all the more challenging for EPCs to match the right inverter with their currently available modules.

The job is made even harder by varying design software which uses different limitations for its PV park design.

This places project designers in a potentially tricky situation. Multi-MPPT inverters by nature have a limitation on the amount of PV strings that can be connected per MPPT. The majority of multi-MPPT inverters currently available on the market have a maximum input current limit somewhere between 22A and 26A per MPPT, a few go as high as 30A.

In order to prevent dangerous reverse currents from flowing, multi-MPPT inverters are designed so as to allow the connection of two PV strings per MPPT. The latest high-power modules which are now hitting the market have an I_{mpp} of 17A or higher. Connecting two such strings to a single MPPT results in a total input current which heavily exceeds the maximum input current of most multi-MPPT inverters.

This is where the conundrum begins.

When considering the maximum input current it becomes clear that two strings can no longer be connected to a single MPPT.

Inverter Simulations

Multi-MPPT Inverters

In order to analyze the exact effects these new modules could have on inverter selection we chose a selection of typical inverters with a different number of maximum power point trackers and most importantly different current ratings per tracker.

This provides us with a range from 22A up to 30A per MPPT which is typical for most available inverters. The general number of MPPTs ranges between 9 to 12 for inverters in this power range and we have also included an 1100V DC inverter for good measure.

We have also considered several module manufacturers with varying power ratings and most importantly varying current ratings. Considering the increasing role of bifacial modules we have also simulated each module with and without a 10% bifacial gain. This will allow us to observe the difference this could make to the overloading of the individual inverters.

For the calculation of the string lengths the following parameters were used:

- $MPPT_{min}$ at 60°C
- $MPPT_{max}$ at 15°C
- V_{oc} at 0°C

Legend:

- (orange) <100% oversizing
- (yellow) 100%> oversizing <120%
- (green) >120% oversizing

		185kVA Inverter 1500V DC **9 MPPT** **26A / MPPT**	250kVA Inverter 1500V DC **12 MPPT** **30A / MPPT**	175kVA Inverter 1500V DC **12 MPPT** **22A / MPPT**	110kVA Inverter 1100V DC **12 MPPT** **26A / MPPT**
Without bifacial gain	Risen Titan 605W Impp 17.30A Ibf10 19.03A Vmpp 34.98V	97% 9Str. x 33Mod.	96% 12Str. x 33Mod.	129% 12Str. x 33Mod.	145% 12Str. x 22Mod.
With 10% bifacial gain		107% 9Str. x 33Mod.	105% 12Str. x 33Mod.	142% 12Str. x 32Mod.	160% 12Str. x 22Mod.
Without bifacial gain	Trina Vertex 525W Impp 17.04A Ibf10 18.74A Vmpp 30.8V	94% 9Str. x 37Mod.	93% 12Str. x 37Mod.	126% 12Str. x 37Mod.	137% 12Str. x 24Mod.
With 10% bifacial gain		104% 9Str. x 37Mod.	102% 12Str. x 37Mod.	138% 12Str. x 37Mod.	151% 12Str. x 24Mod.
Without bifacial gain	Jinko Tiger PRO 580W Impp 13.15A Ibf10 14.47A Vmpp 44.11V	147% 18Str. X 26Mod.	145% 24Str. X 26Mod.	98% 12Str. X 26Mod.	108% 12Str. X 17Mod.
With 10% bifacial gain		161% 18Str. X 26Mod.	159% 24Str. X 26Mod.	108% 12Str. X 25Mod.	118% 12Str. X 17Mod.
Without bifacial gain	Longi HiMo5 545W Impp 13.04A Ibf10 14.34A Vmpp 41.80V	149% 18Str. X 28Mod.	146% 24Str. X 28Mod.	99% 12Str. X 28Mod.	107% 12Str. X 18Mod.
With 10% bifacial gain		163% 18Str. X 28Mod.	161% 24Str. X 28Mod.	109% 12Str. X 28Mod.	118% 12Str. X 18Mod.

The maximum number of strings was based on the maximum power point current (Impp) of the modules and the MPPT current rating of the inverters.

If the maximum input current allowed for two strings to be connected per MPPT we have calculated as such. Where the maximum input current of the inverters does not allow for the connection of two strings per MPPT we have calculated with only one string in order to stay within this limitation.

If we look at the maximum input current limitation of these multi-MPPT inverters it is difficult to come up with a design that works well with all high power and high current modules.

To enable a practical design with these new high current modules some of these inverters would need additional MPPTs or an even higher input current rating on existing MPPTs. The comparison between inverter #1 and #3 for example shows exactly the difference additional MPPTs can make, even if they have a slightly lower current rating.

It is clear that in today's inverter landscape there is no one multi-MPPT inverter which can provide a satisfactory design for all the high-power modules already available on the market and the high-power modules which are slated for release later this year and beyond.

The fact that multi-MPPT inverters have a fixed number of inputs can be a big issue when only one string can be connected per MPPT.

Using a single-MPPT inverter with a DC combiner avoids this inflexibility completely and ensures an optimal design.

KACO Single-MPPT String Inverters

This is where the blueplanet 125 - 165 TL3 string inverter range clearly shows one of its many advantages.

blueplanet 165 TL3 with and without DC-switch

Not only does this inverter range allow for a plant design based on the advantageous 'virtual central' layout but it also provides ample flexibility regardless of the type of high-power modules being used. This is because you can pair the inverter with the exact DC combiner you need for your project.

The following simulations were performed under the same conditions as the multi-MPPT inverter simulations.

		KACO blueplanet 125 TL3 1 MPPT 160A DC Input 300A $I_{DC\ SC}$	KACO blueplanet 165 TL3 1 MPPT 183A DC Input 300A $I_{DC\ SC}$
Without bifacial gain	Risen Titan 605W Impp 17.30A Ibf10 19.03A Vmpp 34.98V	>150% ≥10Str. X 33Mod.	>150% ≥13Str. X 33Mod.
With 10% bifacial gain		>150% ≥10Str. X 33Mod.	>150% ≥13Str. X 33Mod.
Without bifacial gain	Trina Vertex 525W Impp 17.04A Ibf10 18.74A Vmpp 30.8V	>150% ≥10Str. X 37Mod.	>150% ≥13Str. X 37Mod.
With 10% bifacial gain		>150% ≥10Str. X 37Mod.	>150% ≥13Str. X 37Mod.
Without bifacial gain	Jinko Tiger PRO 580W Impp 13.15A Ibf10 14.47A Vmpp 44.11V	>150% ≥13Str. X 26Mod.	>150% ≥17Str. X 26Mod.
With 10% bifacial gain		>150% ≥13Str. X 26Mod.	>150% ≥17Str. X 26Mod.
Without bifacial gain	Longi HiMo5 545W Impp 13.04A Ibf10 14.34A Vmpp 41.80V	>150% ≥13Str. X 28Mod.	>150% ≥17Str. X 28Mod.
With 10% bifacial gain		>150% ≥12Str. X 28Mod.	>150% ≥16Str. X 28Mod.

Clearly the single-MPPT topology helps not only in a favourable overall system layout but also provides an ease of DC module layout not available with all multi-MPPT inverters.

In conclusion, the topology selected by KACO offers strong freedom to select your desired high-power panel and string these panels to your KACO inverter. Combined with its high overload capability, excellent high temperature performance, industry leading efficiency and safety factors it is the perfect fit for your next project.

Our Past Ensures Our Future

As demonstrated the KACO blueplanet 125 - 165 TL3 are a perfect match for all high-power modules on the market. High-power modules are also increasingly being used for C&I projects, however. Where other manufacturers have needed to adjust their existing products, you can rest assured that our C&I inverter portfolio is already compatible with these high-power modules.

The blueplanet 87.0 - 105 TL3 inverters, which belong to the same inverter series as the blueplanet 125 - 165 TL3, are similarly prepared for use with high-power modules.

Our blueplanet 50.0 and 60.0 TL3 inverters for larger C&I applications are also based on the single-MPPT topology, have a maximum input current of 90A and 103A respectively and come in a variety of versions. These versions allow for either a direct string connection at the inverter or a virtual central design with the use of DC combiners.

Our blueplanet 15.0 and 20.0 TL3 inverters for C&I applications both allow for a maximum input current of 20A per MPPT which is more than enough to comfortably design a system layout and allows for ample oversizing.

blueplanet 60.0 TL3 and 20.0 TL3

Regardless of the possible future trends in PV module technology coming our way we are convinced that the string inverters from KACO new energy will continue to be the right choice for your future projects.

Neckarsulm, October 25, 2021.

The text and figures reflect the current state at the time of publication. Subject to changes. Errors and omissions excepted.