WHITEPAPER: 1,500 V DC TECHNOLOGY

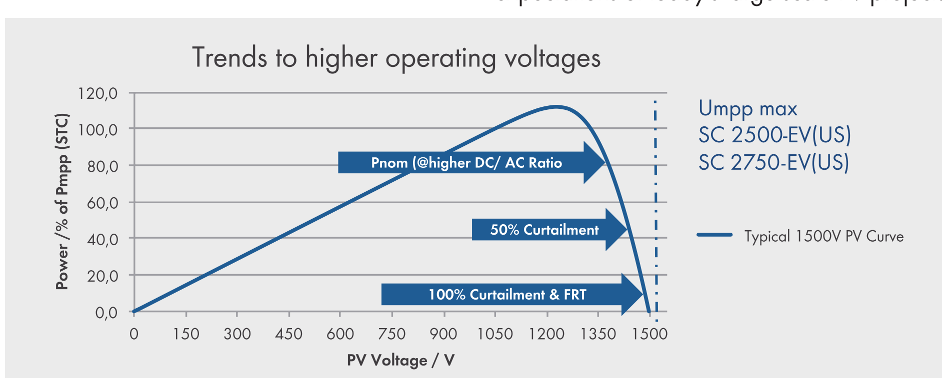
TRUE 1,500 V DC TECHNOLOGY FOR THE NEXT GENERATION OF PV POWER PLANTS

Greater annual power production and higher availability due to optimized stack design

Large PV power plants in the gigawatt range already supply entire regions with electricity in the world's sunny areas. Projects of this size are designed to last for decades. The inverters play a decisive role as a central element in the conversion of DC electricity into AC current, suitable for the grid. Only technologies specifically designed for high voltages and extreme conditions meet the most rigorous reliability and runtime requirements. Deficits in inverter technology that lead to failures and yield losses have a negative impact on the performance of a PV power plant and can severely limit profitability.

Today, PV power plants are used much more frequently at higher DC voltages, close to the open-circuit voltage (1,500 V DC). The reasons behind this are the trend towards increasingly higher nominal DC:AC power ratios, the need to quickly curtail PV power plants as well as fault ride-through events, in which the inverter must still cycle directly in open-circuit voltage. These factors can negatively affect the expected service life of an inverter stack, if not properly accounted for. A high design reserve in the stacks is absolutely essential for fault-free operation throughout the PV inverters' expected lifetime.

Keyword: Design Reserve
SMA prioritized a high DC voltage design reserve, which is quite differentiated from other competitors in this space who have instead sought to maximize efficiency at lower power levels, at the expense of uptime ad expected service life. SMA's approach results in an inverter capable of providing failure-free operation throughout the ever-increasing service life expectations of today's large scale PV projects.

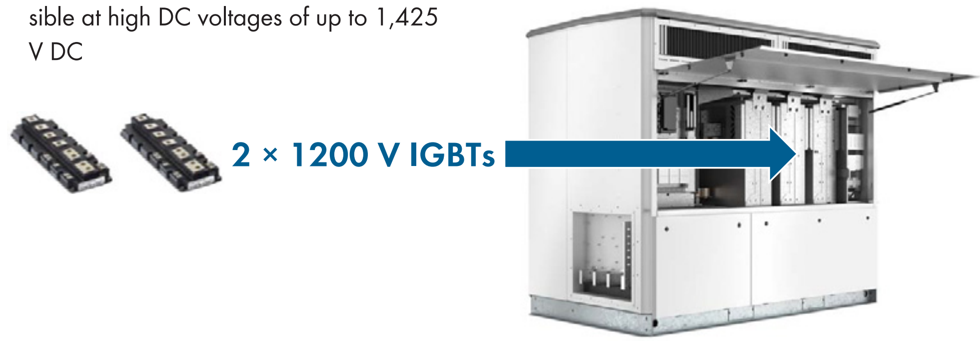


38% DESIGN RESERVE
ENSURES HIGHER AVAILABILITY AND A LONGER SERVICE LIFE

The SMA Sunny Central 2500-EV, 2750-EV, 2500-EV-US and 2750-EV-US inverters were designed specifically for 1,500 V DC PV power plants. For each stack, six IGBTs are used in three groups of two transistors connected in series. The Sunny Central 2500-EV and 2750-EV inverters therefore have 2,400 volt (2 × 1,200 V IGBTs) dielectric strength and a design reserve of 900 V, or 38%. This is in comparison to other inverters for 1,500 V DC voltages, which typically only utilize a single 1,700 V IGBT. SMA inverters thus enable plant operators to take advantage of true 1,500 V DC technology.

The advantages

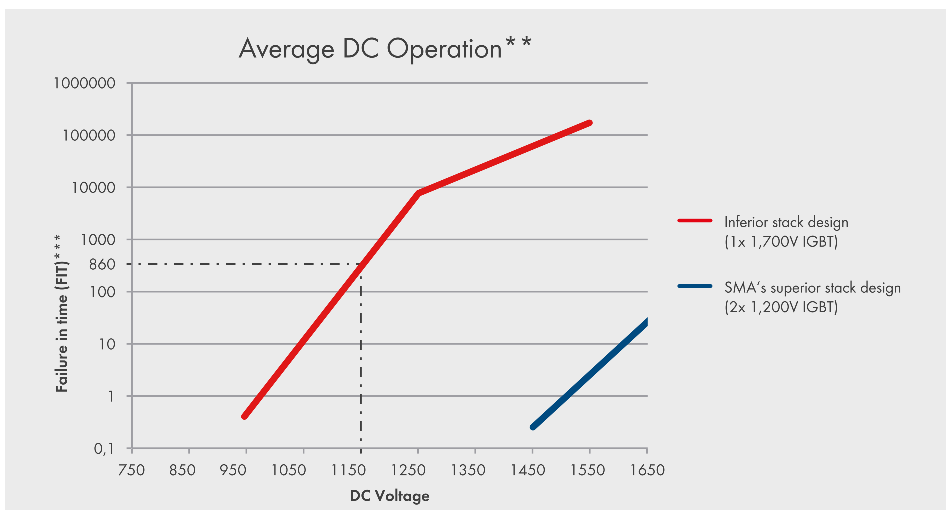
» Field-proven, robust stack topology for availabilities of more than 99% over 25 years
» Up to 100% curtailment to guarantee all operating points
» Unrestricted continuous operation is possible at high DC voltages of up to 1,425 V DC



SMA DESIGN RESERVE
REDUCES THE INVERTERS' PROBABILITY OF FAILURE TO ALMOST ZERO

Cosmic rays are high energy particles that originate from space which can periodically rain down onto earth. These showers consist of neutrons that can be hazardous to semiconductors and potentially cause failures depending on the altitude, temperature and voltage of the equipment. A sufficient dielectric strength margin is the key to protecting semiconductors from cosmic ray failures.

The SMA design reserve takes into consideration the IGBTs' resistance to cosmic rays in all of the inverter's operating areas throughout its entire lifecycle. Therefore, the probability of failure due to cosmic rays is reduced to almost zero.



Only relates to resistance to cosmic rays, resistance to cosmic rays is the effect of irradiation on components
** *Considering 150% DC:AC ratio and curtailment*
*** *1 FIT = One failure in 1 billion operating hours*

For example:

Assumed average operation at 1,150 V DC voltage (sea level, 0 m)

» 1 × 1,700 V IGBT = 1 inverter will fail 3 times in 25 years*
» 2 × 1,200 V IGBTs = 0 failures in 25 years*

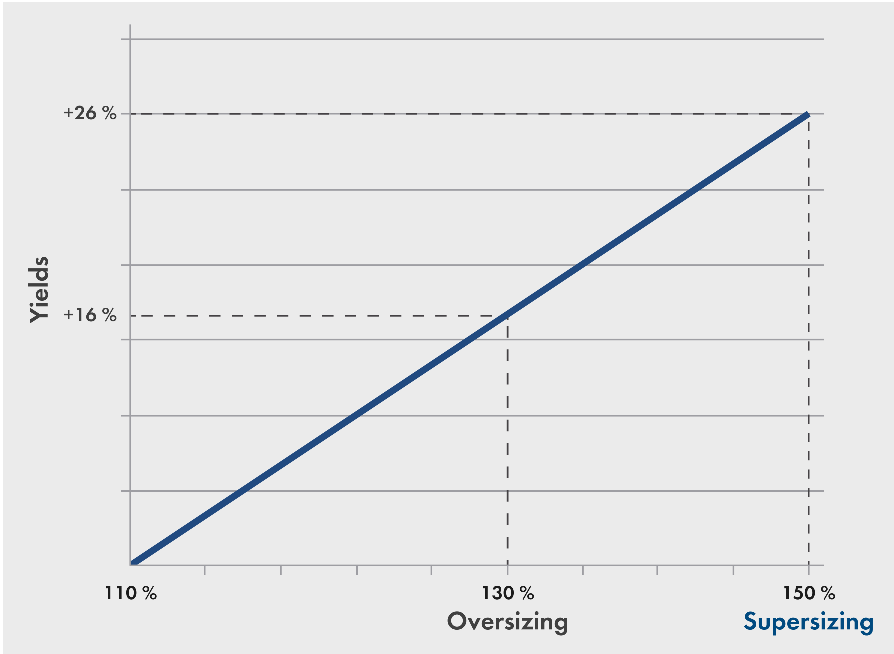
At 2,000 m (above sea level), cosmic rays rise by at least a factor of 5

» 1 × 1,700 V IGBT = 1 inverter will fail 15 times in 25 years*
» 2 × 1,200 V IGBTs = 0 failures in 25 years*

DC:AC RATIOS UP TO 150% ENABLES MORE THAN 25% HIGHER YIELDS

SMA's engineering approach with a design reserve of 38% allows significant DC:AC ratios of the PV field, up to 150% without negative effects on the stack's service life.

In this way, a consistently high energy yield throughout the entire day can be achieved. In addition, nominal power is reached more quickly and the PV power plant has constant output power, even in strong fluctuations in irradiation. Conversely, inverters with 1,700 V DC IGBTs only allow oversizing of the PV field of up to 110% without causing an extreme increase in the risk of inverter stack failures.



Higher DC:AC ratios can achieve up to 26% more energy yield.

ADDITIONAL ADVANTAGES FOR 1500 V PV PROJECTS THANKS TO MAXIMUM SYSTEM INTEGRATION

The market estimates that capital expenditure costs are reduced by up to 10% through 1,500 V DC systems thanks to balance of system (BoS) savings. Modules, module elevations and tracker systems have not been taken into consideration here.

SMA solutions also offer additional cost advantages in the planning and construction phase of PV power plants. Fully integrated components and system solutions can be transported, installed and commissioned quickly and with reduced labor. This minimizes costs and contributes greatly to accelerated project velocity during the construction of PV power plants.

- » Safe and easy transport in a standard container
- » Low shipping costs thanks to high power density
- » Turnkey solutions with ideally matched components
- » Quick commissioning with plug & play solutions (inverter and MVPS)

TURNKEY SOLUTIONS

INVERTERS AND MV STATIONS

DC SYSTEM TECHNOLOGY

HIGH POTENTIAL FOR COST SAVINGS

Insight from Andreas Tuegel, Technical Product Manager from SMA's Utility Business Unit

1. Why is 1,500 V DC technology used in PV power plants?

The main reason for using 1,500 V DC technology in PV power plants is to reduce system costs.

In particular, the advantage in using 1,500 V DC technology is that more modules can be installed per string thanks to the higher DC voltage. As a result, cost savings can be achieved in the DC home runs (DC cabling to the inverters).

We assume that this trend will continue at an even greater rate in the years to come and will thus become a new standard in the PV industry very quickly.

2. What special requirements must inverter technology meet?

The challenge in particular for 1,500 V DC capable inverters is to design and qualify the DC components such as DC fuses, DC switches and insulation monitoring units in an applicable manner.

A further aspect is designing the stack correctly for long-term operation of a PV power plant.

In the Giga PV research project, which was funded by the German Federal Ministry of Education and Research (BMBF), SMA worked closely with TÜV Rheinland and the University of Kassel to develop technological solutions with regard to costs, reliability and service life for an optimized 1,500 V DC stack. Examining the resistance to cosmic rays was essential here.

3. How do SMA customers benefit from using 1,500 V DC inverters and system technology?

PV power plants equipped with 1,500 V DC inverters and system technology from SMA offer maximum availability, uninterrupted runtimes and secure, reliable energy yields. The potential for higher DC:AC ratios and a stack topology designed for durability and fault-free operation make this the safest PV inverter investment. SMA offers a complete product portfolio for the next generation of 1,500 V DC PV power plants so that customers can obtain solutions from a single, turnkey source. As a global market leader, SMA has more than 35 years of experience and more than 24 gigawatts of Sunny Central inverters installed worldwide.

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