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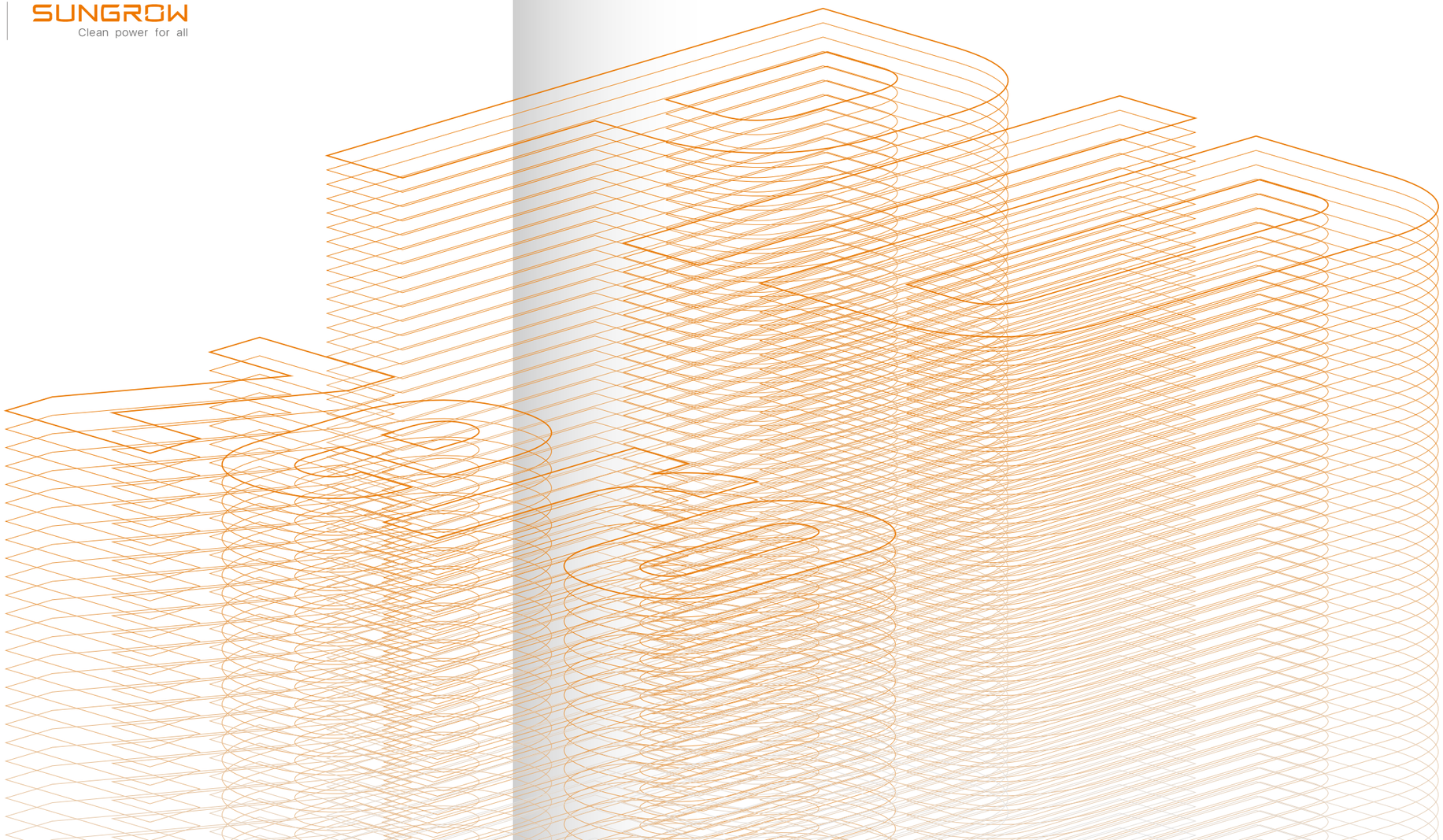
TÜV Rheinland | SUNGROW
JOINT RELEASE

PID ZERO SOLUTION

WHITE PAPER



PREFACE

Potential induced degradation (hereinafter referred to as PID) is one of the industrial pain points with huge attention, which severely affects the generating performance of PV modules. Since 2010, global research institutes and upstream and downstream enterprises have invested much in special research on PID, providing targeted Anti-PID solutions for PV systems in different scenarios.

Currently, for residential scenarios, integrated or external PID recovery modules are usually adopted to lift the PV array to ground voltage for module recovery when the PV system is disconnected from the grid at night. However, limitations of the solution are gradually exposed with the popularization of DC-coupled PV plus storage system. This kind of system runs all day long, so repairing modules when the system is disconnected from the grid at night by boosting voltage is no longer applicable.

To solve the question above, Sungrow Power Supply Co., Ltd. (hereinafter referred to as SUNGROW) innovates PID Zero, which coordinates Anti-PID during the day and PID-recovery at night through the patented mirror boost topology and intelligent control algorithm. Currently, PID-Zero has been applied on a scale in residential scenarios. The PV inverter SG2.0-10RS and PV hybrid inverter SH3.0-6.0RS equipped with this technology have been sold to many countries and regions including Europe, Asia Pacific, and Latin America.

To verify the performance of PID Zero, TÜV Rheinland (Shanghai) Co., Ltd. (Hereinafter referred to as TÜV Rheinland), appointed by SUNGROW, started a panel to perform thorough on-site verification and technical evaluation of this technology. The result shows that PV and hybrid inverters equipped with PID-Zero can suppress PID during the day and lift the voltage at night for module recovery, to ensure the long life and efficient operation of the modules. This patented technology solves the root problem of the PID effect on DC-coupled PV plus storage systems, providing new thoughts and solutions for the whole industry.

Against this backdrop, SUNGROW and TÜV Rheinland co-issued the PID Zero Anti-PID Solution for Residential PV System, which systematically describes the research background, principle, and difficulties, as well as verification scheme and review of the technology, aiming to provide superior solutions and products for customers concerned about PID and boost the upgrading of PID solutions.

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CONTENTS

01 Research Background ---- 01

02 Technology Description ---- 02
2.1 Mechanism and Reversibility of PID ---- 02
2.2 Technical Difficulties of PID Recovery ---- 03
PID Suppression during Grid-connected Power Generation ---- 03
PID Recovery at Night of PV plus Storage System ---- 03
2.3 Technical Characteristics of SUNGROW PID Zero Solution ---- 05

03 Verification and Review of PID Zero ---- 06
3.1 Verification Scheme ---- 06
Verification Items and Sample Selection ---- 06
Verification Conditions and Environment ---- 07
3.2 Verification Result ---- 08
3.3 Comprehensive Review ---- 09

01 Research Background

It has been a global consensus to build a new-energy-centered power system, as various countries put forward the climate goals of "zero carbon" or "carbon neutrality ", which has greatly promoted the development of the residential PV industry.

2000GW
2025 / Cumulative Capacity

395GW
2025 / Residential PV Cumulative Capacity

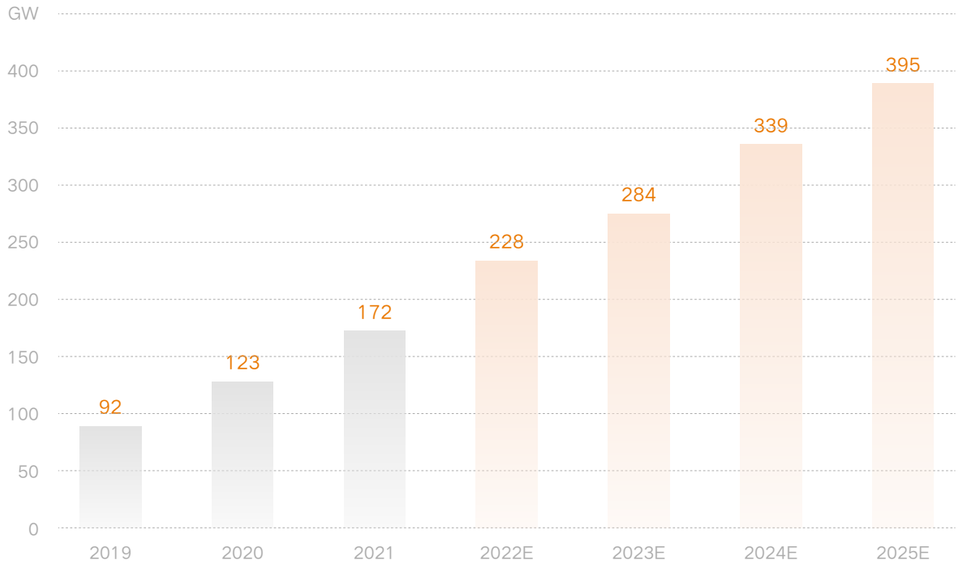


Figure 1-1 Data from BloombergNEF

Modules account for a large part, usually up to over 35%, of the cost of the residential PV system. Therefore, the long life and efficient operation of modules will directly influence the ROI of customers. Factors that lead to performance degradation of modules vary, while PID is among the most important ones. According to the experiment data of PVEL, permanent PID will lead to a generation loss of up to 30%.

02 Technology Description

2.1 Mechanism and Reversibility of PID

PID of PV modules refers to the phenomenon of degrading battery performance caused by the decrease of fill factor, short circuit current, and open-circuit voltage under negative bias voltage to ground. PID occurs more frequently under high temperature, high humidity, and high bias voltage to the ground,

High Temperature

High Humidity

High Salt

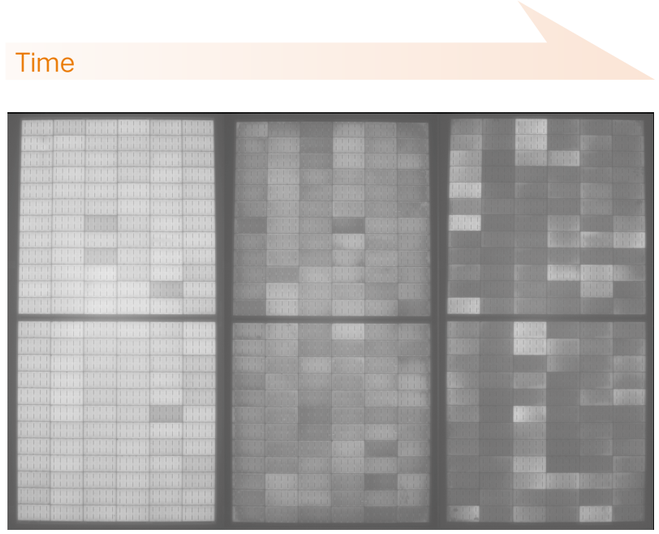


Figure 2-1-1 EL Figure of Modules affected by PID

From 2010, major research institutions and upstream and downstream enterprises around the world have invested much in special research on PID and reached a basic consensus on the mechanism of this phenomenon: sodium ions in the glass panel of PV modules pass through the packaging material and the anti-reflection coating of the battery under the traction of the potential to ground, then accumulate on the surface and enter the lattice imperfections of the battery, resulting in local short circuit of PV cells. PID can severely affect the generation performance of PV modules, but its effect can be relieved or alleviated if correct and timely measures are adopted.

For most modules, PID occurs under negative bias voltage to ground and the damage caused by PID can be repaired under positive bias voltage to ground. In this way, for most residential PV systems, PID can be prevented and relevant damage can be repaired by lifting the PV array to ground voltage.

2.2 Technical Difficulties for PID Recovery

Current solutions usually adopt an integrated or external PID recovery module, which lifts the PV array to ground voltage for module recovery when the system is disconnected from the grid at night. Considering application scenarios, characteristics, and limitations of the solution, the following two main problems remain to be resolved.

A. PID Suppression During Grid-connected Power Generation

Given the small scale of the residential PV system and PV plus storage system, the inverter needs Boost circuits to extend efficient generation time during the day. But this will break the symmetry of the PV array to ground voltage, and make it come closer to the negative electrode, increasing the risk of PID. Therefore, it is a major technical difficulty to suppress PID by boosting voltage when the system is in grid-connected operation during the day.

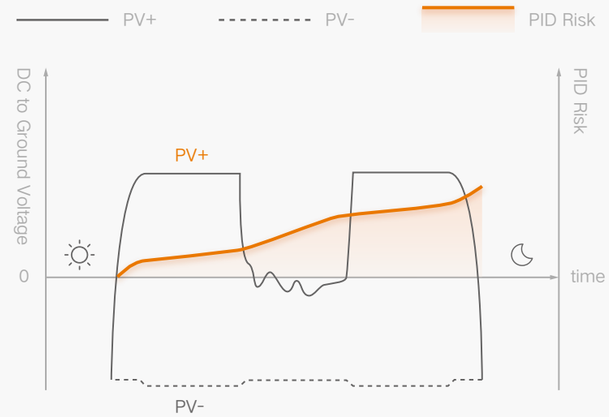


Figure 2-2-1 PID Risk of PV System

B. PID Recovery of DC-coupled PV plus Storage System

The traditional anti-PID scheme is not applicable for the DC-coupled PV plus storage system which runs all day long and stays connected to the grid even at night. Moreover, at night, the PV array to ground voltage is always limited at the lowest voltage point of the system. Compared with a PV system, the PID risk for a DC-coupled PV plus storage system is much higher.

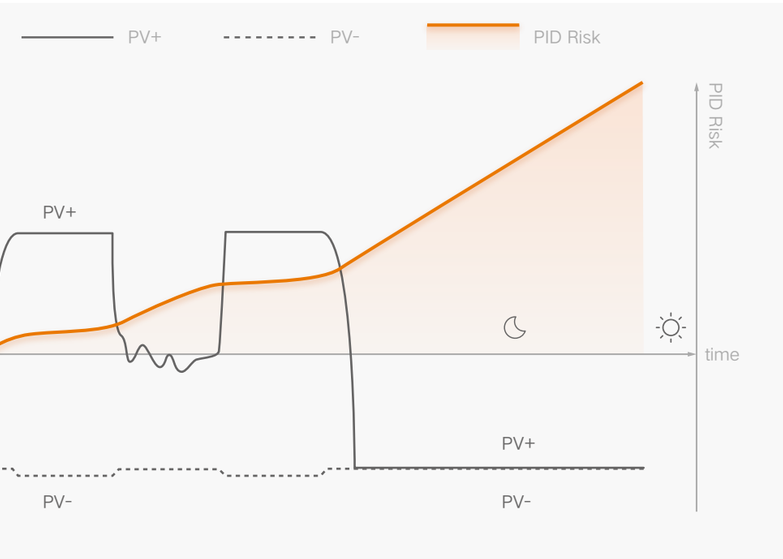


Figure 2-2-2 PID Risk of DC-coupled PV plus storage system

2.3 Technical Characteristics of SUNGROW PID Zero Solution

In view of the difficulties above, SUNGROW puts forward the PID Zero solution based on its long-term practice, R&D, and innovation.

The solution has two distinctive advantages:

- Lower Investment

Equipped with patented mirror boost topology, PID Zero saves the cost of additional recovery modules.

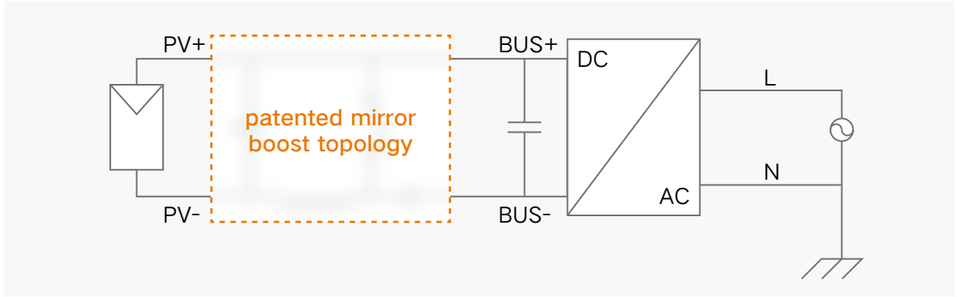


Figure 2-3-2 Patented mirror boost topology

- Broader Application Scenarios

PID Zero can lift voltage, and suppress and repair module damage caused by PID in grid-connected operation, which is applicable for both PV systems and DC-coupled PV plus storage systems.

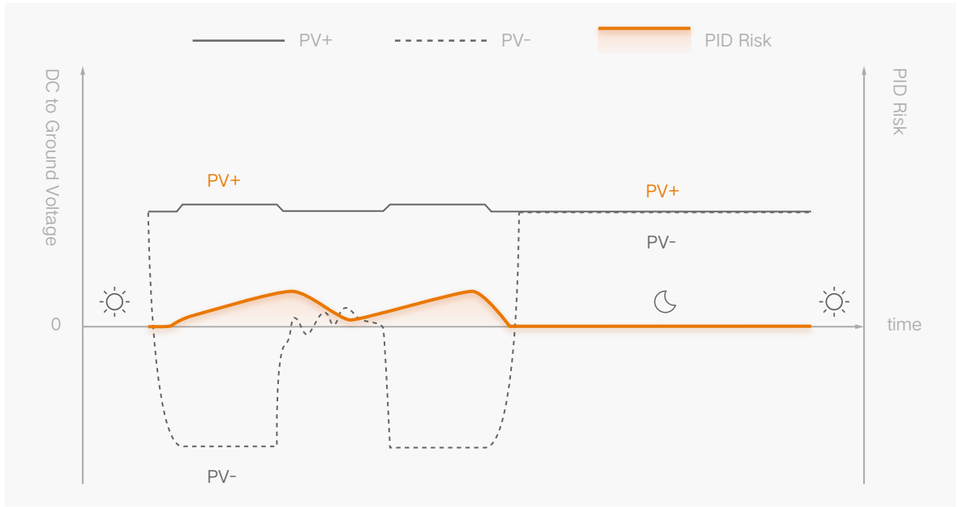


Figure 2-3-3 PID Risk of Inverters Equipped with PID Zero

03 Verification and Review of PID Zero

From April 2021 to April 2022, TÜV Rheinland, appointed by SUNGROW, started a panel to perform thorough verification and review on PV inverters and PV hybrid inverters equipped with PID Zero, to verify the real performance of this patented technology.

3.1 Verification Scheme

A. Verified Items and Sample Selection

During grid-connected operation of the inverter, PID Zero can prevent the PV array voltage from approaching PV-, for the aim of reducing the risk of PID during daily operation and repairing damages caused by PID at night.

We have quantified the above abilities of PID Zero with measurable physical quantities, and drawn our conclusion by comparing data from devices equipped with PID Zero and those without PID Zero.

Test Product	A certain type of PV inverter	SG5.0RS PV Inverter
Test Quantity	2	2
Test Item	PV- to PE voltage	PV- to PE voltage
With PID Zero	No	Yes
Test Standards and Evaluation Criteria	Shaded during the day, PV array voltage approaches PV- at dusk	Shaded during the day, PV array voltage approaches PV+ at dusk

Test Product	A certain type of PV Hybrid Inverter	SH5.0RS PV Hybrid Inverter
Test Quantity	1	1
Test Item	PV- to PE voltage	PV- to PE voltage
With PID Zero	No	Yes
Test Standards and Evaluation Criteria	Shaded during the day, PV array voltage approaches PV- at dusk	Shaded during the day, PV array voltage approaches PV+ at dusk

B. Verification Conditions and Environment

To satisfy all the function test items above, the verification work was carried out in the poverty alleviation power plant in Baibu Village, Yuexi County, Anqing City, Anhui Province with the help of SUNGROW working personnel.

100% Feed-in
Grid-connection type

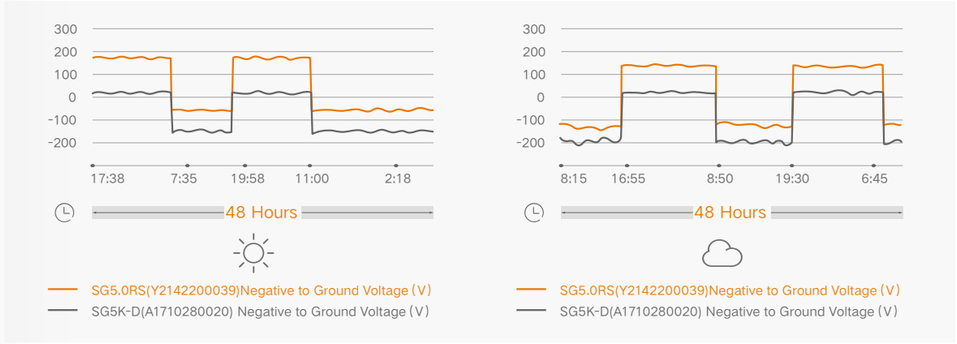
5000m²
Covering area

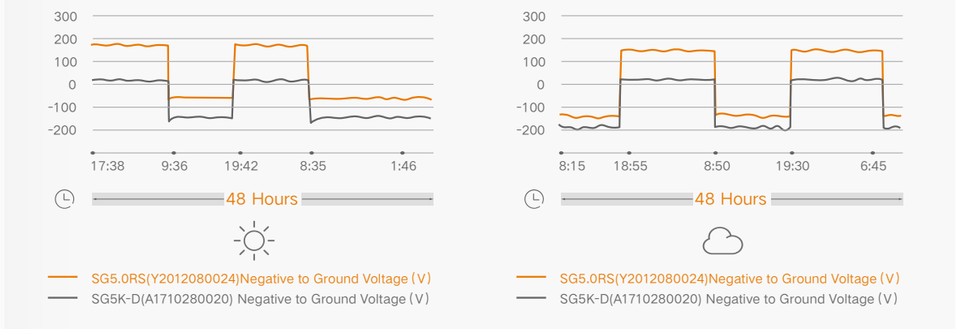
161kW
Capacity

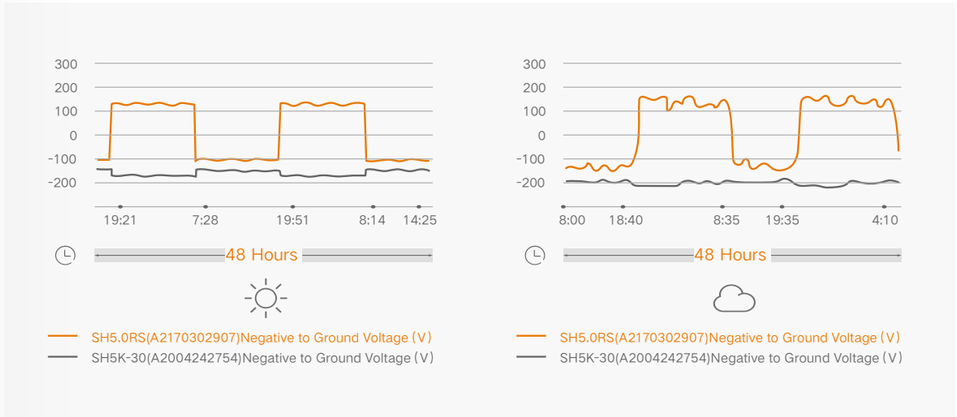
Considering that PID Zero can effectively prevent PV array voltage bias to PV- during the day (shaded) and at night, sunny and cloudy days are both chosen as operation conditions to make three rounds of comparison.

3.2 Verification Result

The verification work was started by the panel in the PV plant in accordance with the performance test items and verification environment mentioned above. After comparison of the data, it is discovered that PV and hybrid inverters equipped with PID Zero perform far greater in preventing PV array voltage bias to PV- no matter at night or on cloudy or rainy days than those without PID Zero. The result is shown below:







3.3 Comprehensive Review

In accordance with the result of technical review and performance verification, PID Zero of SUNGROW is applicable for both PV and DC-coupled PV plus storage systems. It can suppress PID during the day and intelligently repair module damage caused by PID at night, by relieving or alleviating PV array voltage bias to PV-.

Some countries where SGRS/SHRS inverters have been sold

Currently, PID Zero patented technology has been applied on a scale in residential scenarios. Equipped with PID Zero technology, the PV inverter SG2.0-10RS, and PV hybrid inverter SH3.0-6.0RS have been sold to many countries and regions including Europe, the Asian Pacific, and Latin America.