SG33/40/50/110CX&SG250HX&SG125HV

PID Solution

SUNGROW

Version 1.2 EN

1. Introduction

This document describes the principles of SG33/40/50/110CX&SG250HX&SG125HV PID (Potential Induced Degradation) solution.

2. PID Solution

2.1. What is the PID?

PID (Potential Induced Degradation) refers to a long-term performance loss of PV panels due to a gradual decay reaction. PID is caused by so-called stray currents or leakage currents between the PV module circuit and its metal frame. It creates polarization of the material which immobilizes the free ions that normally would be available for power generation. The PID effect is most likely to occur under humid conditions, the degree of activity is related to the degree of humidity (moisture ingression level).

2.1.1. PID in Crystalline Modules

In order to better understand the factors impacting PID the three different levels (-cell, panel and system) were separately investigated.

- Cell level: The cell was found to be the precondition for PID. Some process steps as well as the quality of the base material have been identified to significantly contribute to the extent of PID tendency on cell level.

- Panel level: Environmental factors such as humidity and temperature as well as the panel design are influencing leakage currents within the panel. Higher leakage currents can be caused by water (vapor) entering the solar panel causing the encapsulation (ENC) material becoming more conductive. Consequently, panel design and layout can impact the leakage currents and therefore play a role for the high voltage durability of panels.

- System level: On system level the potential difference between ground and cell is the most important factor for PID. The system voltage depends in first order on the number of panels serially interconnected and the irradiation and in second order on the panel temperature. The final potential of a cell relative to ground is determined by the grounding configuration. Depending on the negative, positive or no pole being grounded the resulting potential the cell is exposed to relative to ground is either fixed at a certain positive or negative value or it is not fixed – called floating potential. In the latter case one part of the string has a negative and the other a positive potential relative to ground.

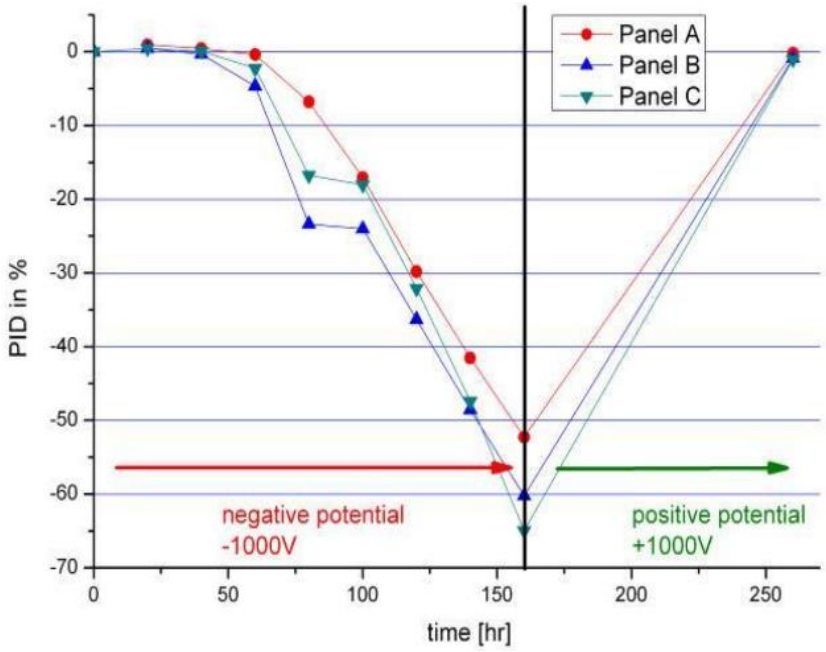
2.1.2. Detection of PID

PID can be detected in the plant through a combination of IV curves, IV data and EL images.

Since the primary cause of PID is the presence of negative bias, higher degradation in the modules towards the negative end of the strings combined with reduced fill factor in those modules is an indicator of PID in the modules.

2.1.3. Reversibility of the PID Effect

The reversibility of PID effect has been demonstrated in the lab on PID affected crystalline panels. PID reversion is possible by applying a reversed potential, as shown in the below figure. The time necessary for the recovery process depends not only on the potential but also on environmental factors such as humidity and temperature.



2.2. How to Prevent the PID?

The PID can be prevented by using the non-NA, CA glass materials to improve the glass resistance (high costs) on PV module side and Packaging materials with non-ethylene-vinyl acetate copolymer (stability unknown).

In practice, the prevention of PID effect is more from the system level prevention. Based on the reversibility of the PID effect, there will be two different PID prevention function which can be called Anti-PID function and PID recovery function. The Anti-PID function means to increase the PV- to ground potential to 0V or above, so the modules have no negative potential relative to ground during operation. The PID recovery function means to increases the PV- to ground to a high positive potential thus reversing the polarization effect that arises during operation. There are three solutions as below.

2.2.1. Solution 1: Direct or Indirect Grounding of the DC Negative Polarity

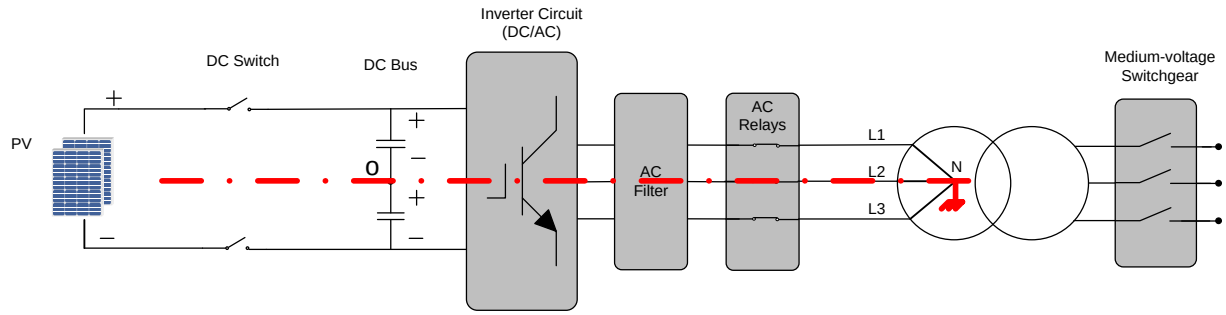
The negative pole of PV module or inverter is grounded directly through a resistor or fuse, so that the voltage of the negative pole is at the same potential as the grounded metal frame. This solution is only suitable to isolation PV system and only have Anti-PID function. Typically, this solution is used in central inverters.

2.2.2. Raise the Potential Voltage of the PV Negative Pole to the Grounding Point

1) Potential Voltage in the PV System

In the PV system like shown in the below picture, both the neutral point on the DC side and the neutral point of the grid side are hold to the same average potential (under the daytime working condition).

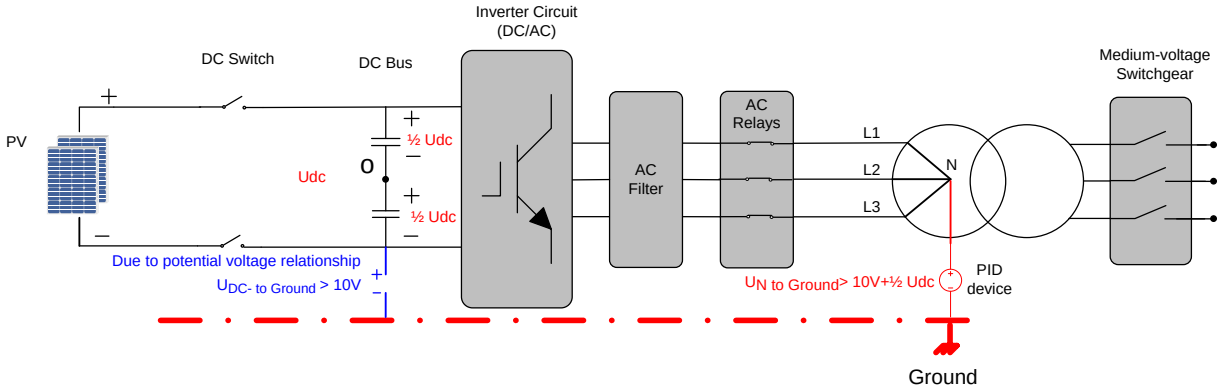
Usually the neutral point of transformer and the earth are equipotential，so the PV negative pole continues to bear negative voltage, which is the root cause of PID phenomenon.



If the DC and AC sides are designed as floating systems, a virtual DC voltage source can be added on the DC side or the AC side to freely control the potential difference of PV- to the ground. There are two solutions which called AC side PID lifting and DC side PID lifting.

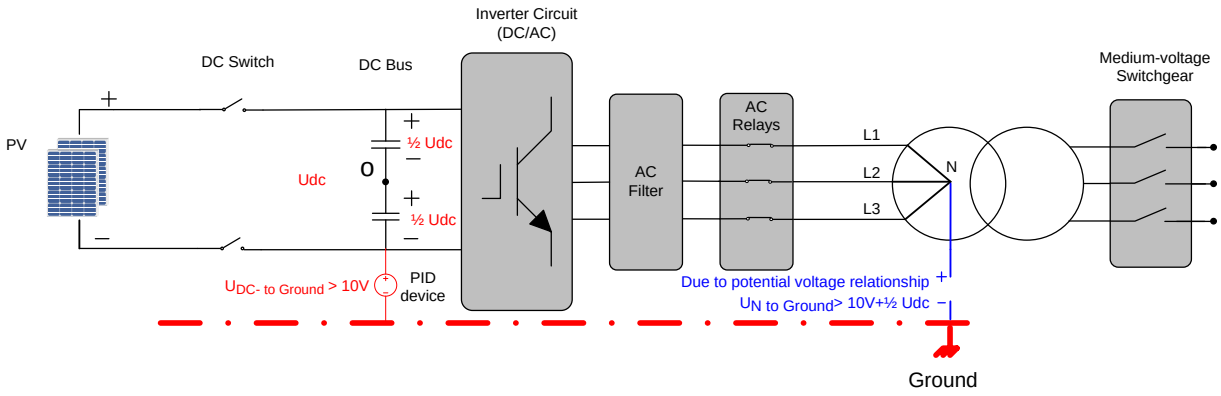
2) **Solution 2**: AC Side PID Lifting Solution

The neutral voltage $U_{N\ to\ Ground}$ of the AC side will be lifted through a PID device, so that the PV- to ground voltage of the P-type solar panel can reach above 0V, and the PV+ to ground voltage of the N-type solar panel is reduced to below 0V. The AC side PID lifting solution can supply Anti-PID function during the daytime. However, because the AC relay of the inverter will disconnect the connection between the DC side and the grid at night, so this solution cannot supply PID recovery function during the night. AC side PID lifting solution is shown in the figure as below, taking P-type solar panel as an example.



3) **Solution 3**: DC Side PID Lifting Solution

Through the PID device, the PV- to ground voltage of the P-type solar panel can reach above 0V, and the PV+ to ground voltage of the N-type solar panel is reduced to below 0V. So DC side PID lifting solution can have Anti-PID function during the daytime and PID recovery function during the night. DC side PID lifting solution is shown in the figure as below, taking P-type solar panel as an example.



2.2.3. PID Solution Summary

Solutions	Applicable conditions	PID function	
		Anti-PID function	PID recovery function
Direct or indirect grounding solution	Isolation PV system	√	×
AC side PID lifting solution	DC and AC sides are designed as floating systems	√	×
DC side PID lifting solution		√	√

3. Sungrow String Inverter PID Solution

3.1. PID Solution Description

Sungrow SG33/40/50/110CX&SG250HX&SG125HV inverters have already integrated PID module using DC side PID lifting solution. It can flexibly deal with Anti-PID function during the daytime

and PID recovery function during the night. The PID function descriptions of different type inverters are shown in Tab.1.

Tab.1 PID Function Descriptions of Different Type Inverters

Inverter	System voltage	PID function		AC phase voltage to the ground with Anti-PID function(Vrms)
		Anti-PID function	PID Recovery function	
SG125HV	1500Vdc/600Vac (L-L)	√	√	Vrms =$\sqrt{(1.1*346.4)^2+(750)^2}$=842V
SG250HX	1500Vdc/800Vac (L-L)	√	√	Vrms =$\sqrt{(1.1*462)^2+(750)^2}$=906V
SG33/40/50CX	1100Vdc/400Vac (L-L)	×*	√	/
SG110CX	1100Vdc/400Vac (L-L)	×*	√	/

Note: SG33/40/50/110CX is applied to commercial PV system and the grid is not floating systems usually, so only PID recovery function is suitable to these inverters. Because in PID recovery mode the PV side can be disconnected from the grid by AC relay.

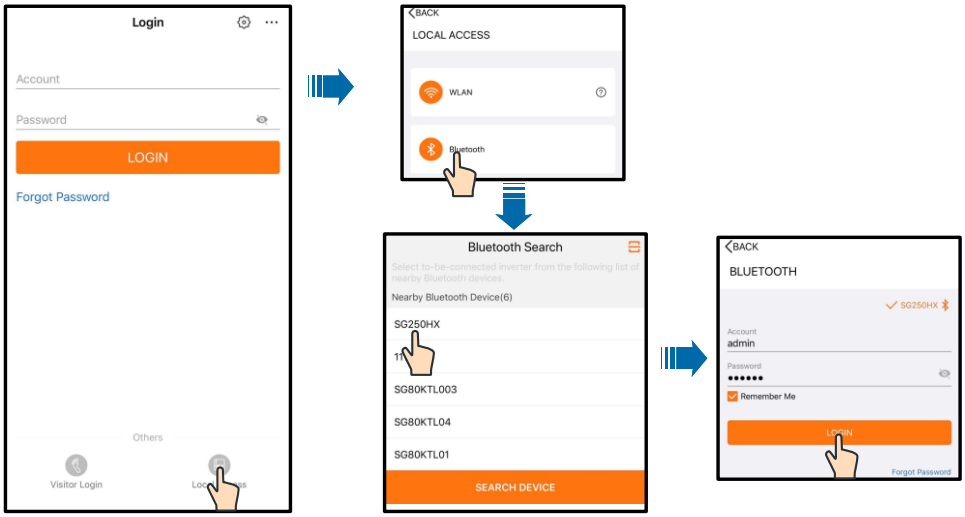
For SG250HX, Anti-PID function is to raise the PV- to ground voltage of P-type solar panel to above 0V, and the PV+ to ground voltage of N-type solar panel to below 0V during the daytime, so as to prevent PID effect. PID recovery function is to raise the PV- to ground voltage of P-type solar panel to the target voltage, and the PV+ to ground voltage of N-type solar panel to the negative value of target voltage at night, so as to suppress the PID effect. The default target voltage is 500V (which can be set through App).

For SG33/40/50/110CX, PID recovery function is to raise the PV- to ground voltage of P-type solar panel to the target voltage, so as to suppress the PID effect. The default target voltage is 500V (which can be set through App).

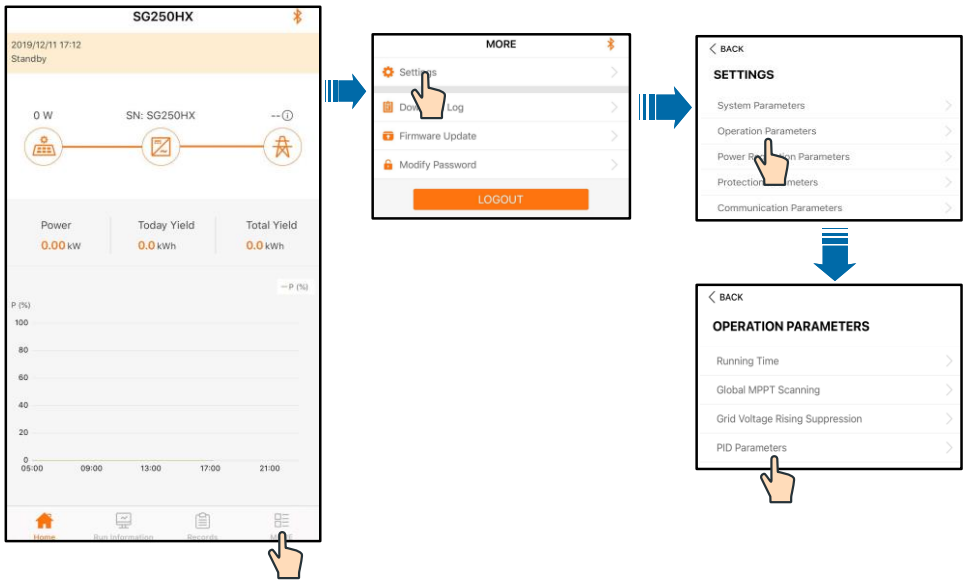
3.2. How to Choose the PID Function Mode?

Sungrow inverter PID solution has Anti-PID mode and PID recovery mode. Users can choose mode through iSolarCloud App, and setting method as below are only use for SG33/40/50/110CX and SG250HX.

Step1：Access the App via Bluetooth, enter the account name and password to enter the main page.



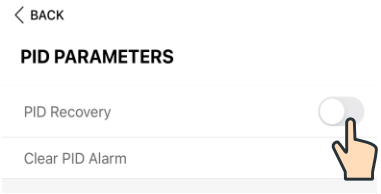
Step2：Click "More" > "Settings" > "Operation Parameters" > "PID Parameters " to enter to the PID control setting interface.



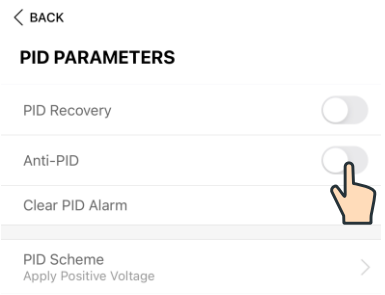
Step3：Enable PID recovery mode for SG33/40/50/110CX;

Choose PID recovery mode or Anti-PID mode for SG250HX. PID Recovery mode or Anti-PID mode can not be enabled at the same time.

SG33/40/50/110CX



SG250HX



Note: The setting method of SG125HV inverter, please see SG125HV user manual. SG125HV only supports P-type solar panel.

The starting conditions for Anti-PID and PID recovery are as follows:

SG250HX:

①Anti-PID mode:

• Turn on Anti-PID;

• Communication works normally;

• Active power greater than 5% of rated power;

• Bus voltage is less than 1350V;

• P-type solar panel: 100V(±20V) < PV+ to ground voltage < 1350V(±50V); N-type solar panel: -1350V(±50V) < PV- to ground voltage < -100V(±20V);

• The delay time is reached, and the delay time can be set from 1 ~ 3600s (default 3600s).

When the above conditions are met at the same time, the Anti-PID is started.

②PID recovery mode:

• Turn on PID recovery;

• Communication interruption;

• Perform within the allowable time period, the allowable time period is between 22:00-05:00, the allowable time period can be set;

• The voltage difference between PV+ and PV- is less than 150V;

• P-type solar panel: PV- to ground voltage < 1350V; N-type solar panel: PV+ to ground voltage > -1350V.

When the above conditions are met at the same time, the PID recovery is started.

If the neutral line at the LV side of transformer is grounded, please choose the PID recovery mode.

If the neutral line at the LV side of transformer is not grounded, the Anti-PID mode and PID recovery mode are also available. You can choose one of two modes.

SG33/40/50/110CX:

①PID recovery mode:

• Turn on PID recovery;

• Communication interruption;

• Perform within the allowable time period, the allowable time period is between 22:00-05:00, the allowable time period can be set;

• The voltage difference between PV+ and PV- is less than 150V;

• P-type solar panel: PV- to ground voltage < 1000V.

When the above conditions are met at the same time, the PID recovery is started.

3.3. Technical Requirements for the PV System Integrated with Anti-PID function

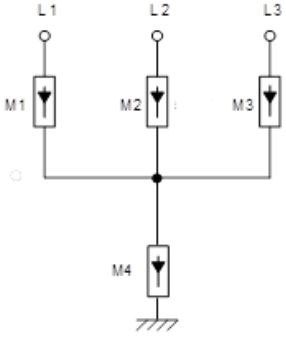
The PV plant LV side shall comply with the following requirements during the plant design and construction stage.

1) It shall only be applied to the system that neutral point of the inverter and transformer are not grounded;

2) The insulation withstand voltage on the transformer LV side shall be higher than the calculated value shown in Tab.1. SG125HV is 842V(Vrms) and SG250HX is 906V(Vrms);

3) The insulation voltage of the electrical components, such as the AC cable connected from inverter to transformer, the power supply in LV side, protective relays, energy meter and other accessories, shall be higher than the calculated value shown in Tab.1. SG125HV is 842V(Vrms) and SG250HX is 906V(Vrms);

4) The maximum continuous working voltage and action voltage of the low-voltage side lightning protection device of the grid-connected transformer must meet the requirements. The AC SPDs solutions are recommended as the below table.

Inverter	Recommended AC SPD Solution	The schematic diagram of AC SPD "3+1" method
SG125HV	The "3+1" method is recommended, the maximum continuous working voltage of M1-M3 are 500V, M4 is more than 750V	
SG250HX	The "3+1" method is recommended, the maximum continuous working voltage of M1-M4 are all 750V	

Note: In PID recovery mode the PV side is disconnected from the grid. Therefore, in this mode, the neutral line may be grounded or ungrounded. There are no specific system requirements for PV-side or grid-side.