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EPISODE 60

Enhancing Winter Performance: Inverter Management in Cold Weather

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Enhancing Winter Performance: Inverter Management in Cold Weather

>> Background

Navigating the challenges posed by winter conditions is crucial for photovoltaic systems, especially concerning inverters. In a recent Solis seminar, experts shared insights on optimizing inverter performance in low-temperature environments.

>> Effects of Low Temperature on Inverter Operation:

Voltage Fluctuations:

1. The resistivity of aluminum wire and copper wire are different.
2. Aluminum wire is easily oxidized by air, and a layer of oxide is formed on its surface, which will increase the contact resistance of the contact point between the aluminum wire and the copper wire. When the current passes through this contact point, the heat will be increased at the connection point and could potentially result in a fire.
3. According to safety operation regulations, aluminum wires cannot be directly connected to copper wires or copper conductor terminals.

电性能参数（STC）

组件型号	425	430	435	440	445	450	455
最大功率（Pmax/W）	425	430	435	440	445	450	455
开路电压（Voc/V）	48.7	48.9	49.1	49.2	49.4	49.6	49.8
短路电流（Isc/A）	11.22	11.30	11.36	11.45	11.52	11.58	11.65
峰值功率电压（Vmp/V）	40.4	40.6	40.8	41.0	41.2	41.4	41.6
峰值功率电流（Imp/A）	10.52	10.60	10.66	10.73	10.80	10.87	10.93
组件效率（%）	19.6	19.8	20.0	20.2	20.5	20.7	20.9

STC（标准测试环境）：辐照度1000W/m², 电池温度25℃, 光谱AM1.5

温度系数（STC测试）

短路电流（Isc）	+0.050%℃
开路电压(Voc)	−0.284%℃
峰值功率(Pmax)	−0.350%℃

逆变器参数	最大输入电压	1100V
	启动电压	195V
	最小工作电压	180V
	MPPT电压范围	180~1000V

Set PV string to 20 pieces/string

>> Voc when the ambient temperature is 25°C:
49.6×[1-0.284%×(25-25)] X 20
=992V
>> Voc when the ambient temperature is -25°C:
49.6×[1-0.284%×(-25-25)] X 20
=1132.8V

In low temperature conditions, the PV string voltage exceeds the input voltage range allowed by the inverter

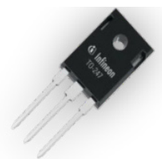
Temperature-Sensitive Components:

Internal components like IGBTs, DSPs, capacitors, etc., have specific temperature ranges for optimal performance. Operating outside these ranges may affect the lifespan and reliability of the inverter.

Rapid temperature changes, induced by low temperatures, can stress these components, negatively affecting performance.

The temperature stress caused by repeated high and low temperature changes will lead to the reduction of the physical or chemical properties of the inverter material and device, affecting the working performance or service life of the product.

Num	Key component	Temperature range
1	IGBT/MOSFET	-40°C~125°C
2	DSP	-40°C~85°C
3	filter capacitor	-40°C~45°C
4	Bus capacitor	-40°C~105°C
5	Leakage current sensor	-35°C~85°C
6	Relay	-40°C~55°C
7	.....	.....



Fan Operation:

High power inverters use external fans to dissipate heat. In low temperature conditions, external fans may freeze, compromising functionality.

>> Protective measures and operational insights

Photovoltaic inverters combat extremely cold conditions through strategic installation protection and auxiliary.

Measures:

Strategic Installation:

Positioning the inverter indoors, under eaves, beneath components, or in other shielded locations, including the use of shielding plates, to shield against direct exposure to snow and cold air. This method is particularly effective for series inverters and micro inverters, leveraging their inherent low-temperature adaptation capabilities.

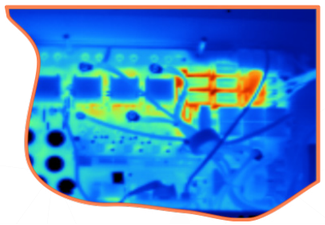
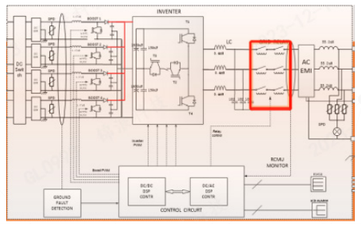
Auxiliary Cold Protection:

Implementing external or built-in heaters to initiate the heating device in low-temperature environments. This gradual warming process elevates the working temperature, facilitating the seamless operation of centralized and distributed inverters.

Type	Temperature range	Low temperature starting mode
Micro inverter	-40°C~+65°C	It starts automatically when the temperature starting condition is reached
String inverter	-30°C~+60°C	
Centralized inverter	-35°C~+60°C	Heating devices such as heating resistors or blower heaters
Distributed	-35°C~+60°C	

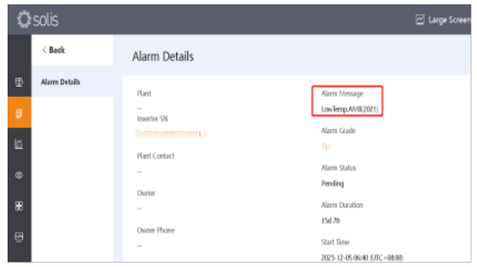
Internal Preheating and Heat Preservation:

Leveraging innovative technology and control strategies for internal preheating and heat preservation. Notably, some Solis inverters incorporate active preheating and night insulation measures, ensuring stable and reliable operation in challenging low-temperature and extremely cold conditions.

Active preheating technique	Night active heat preservation
	
When the internal ambient temperature is low, adjust the control strategy to quickly increase the internal ambient temperature. When the ambient temperature reaches the normal value, the control mode is switched again to make the inverter run efficiently.	Through the night SVG mode, the relay is still drawn when no power is generated, so that the inverter can maintain a constant internal device temperature under low power consumption, ensure its normal operation, but also avoid too drastic temperature changes of each device.

Inverters Not Starting at Low Temperature

When ambient temperatures are below -25 °C for an extended period, the inverter activates the "LowTemp. AMB" mode. Proper functionality commences when the ambient temperature reaches the under temperature threshold. Adjusting this threshold according to field requirements can enable safe lower-temperature operation. It is advised to consult with Solis technical engineers to evaluate specific field situations and confirm the feasibility of measures and thresholds.



Conclusion:

>> As temperatures decline, the importance of maintaining PV power stations and inverters becomes even more important. Low temperatures can impact the operational state of inverters, potentially triggering the "undertemperature protection" mode. Ensuring stable and reliable inverter operation in winter conditions involves implementing protective measures and adhering to essential operational and maintenance protocols. For further insights, refer to Solis Seminar [Episode 51]: "Pay attention to these common O&M problems with inverters in the wintertime."