An exploration of inverter environmental adaptability

Environmental Adaptability is product's ability to cope with unexpected disturbance of the environment in its lifespan, it is an import quality feature.

There are two factors of visible environmental adaptabilities: one is product, the other is environment, environmental adaptability is the connection between product and environment. Same products will have different adaptability for different environment, different products will have different adaptability for same environment as well. Environmental adaptability is one of the key features of product quality, once the product design is finished, its materials, components, topologies and manufacturing methods will be decided also, then the environmental adaptability is fixed. The environmental adaptability is a quality feature determined by design and manufacturing, ensured by experimentation and management, generally the product environmental adaptability can be effected by following factors:

a) Environmental adaptability of materials and components.

b) Structural design ability including thermal design, anti-shock and vibration design, anti-corrosion design and PCB layout design.

c) Manufacturing ability including: Structure quality, components quality, PCBA and protection quality.

Solar system normally was exposed at outdoor environment, may frequently work at high and low temperature, high humidity, windy, sandy, rainy and salty environments. As the key component of the whole solar system, it is responsible for current transfer, system communication, error diagnosis and safety protection. Inverter must adapt different operation environments, especially the harsh environments.

The main temperature challenge is from day-night temperature difference, seasonal temperature difference, climate difference and self heat-induced temperature difference. In the cold areas the winter temperature can reach -20℃, in summer temperature can go up to 40℃. Huge day-night temperature difference, high seasonal temperature difference, the inner and outer temperature difference may lead to a great challenge for inverter. moreover, inverters working at coastal area need to deal with corrosion issue.

Let us unveil how we build MAX series inverters'environmental adaptability.

MAX series on-grid inverters

1 Mechanical design

Our inverters adopt multiple methods including compact PCBA, anti-corrosion painting, fan cooling to ensure temperature balance inside the inverter, reduce risk of temperature difference and condensing caused. during design period, simulate heat performance of inverter to analyze heat-sink, power transistor, capacitor etc., optimize the layout, utilize inner air route to eliminate high temperature risk of far end components.

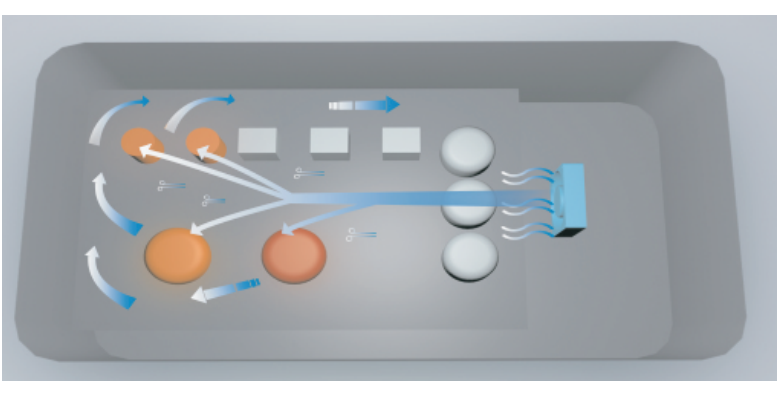

Figure1-1 MAX series internal cooling

2 Components selection

Both low and high temperature may damage the solar inverters, so high-quality components with excellent thermal performance are extremely important for a reliable inverter.

Components	Brands	Working temperature
DC input terminal	Amphenol	−40℃ to 85℃
DC switch	Santon	-40℃ to 70℃
IGBT	Wolter Kluwer	-40℃ to 175℃
	ON Semiconductor	-40℃ to 150℃
DSP	TI	-40℃ to 85℃
PV input film capacitor	Vishay	-55℃ to 105℃
DC-Link film capacitor	Vishay	-55℃ to 105℃
	Kemet	-55℃ to 110℃
AC sensor	VAC	-40℃ to 80℃
Relay	Panasonic	-50℃ to 85℃
DC sensor	LEM	-40℃ to 105℃
	Sinomag	-40℃ to 125℃

Table 2-1 MAX series key components and working temperature

3 Climate and environment verification test

Discover and eliminate the weakness of inverter by using temperature test, humid heat test, high-low temperature working test and salt spray test. When solar inverter works in high-temperature and high-humidity environment, designers should take into consideration the influence of the insulation reduction and internal condensation. By putting the inverter into constant hot and humid environment to test its adaptability to high humidity environment, and anti-condensation ability by adjusting humidity and temperature alternatively. During the test the inverter will be exposed to constant temperature and humidity chamber, set the temperature to 50℃ and humidity to 95%, the inverter will work at full load for 48hours, after 48hours the inverter should be still 100% functional and communicate normally.

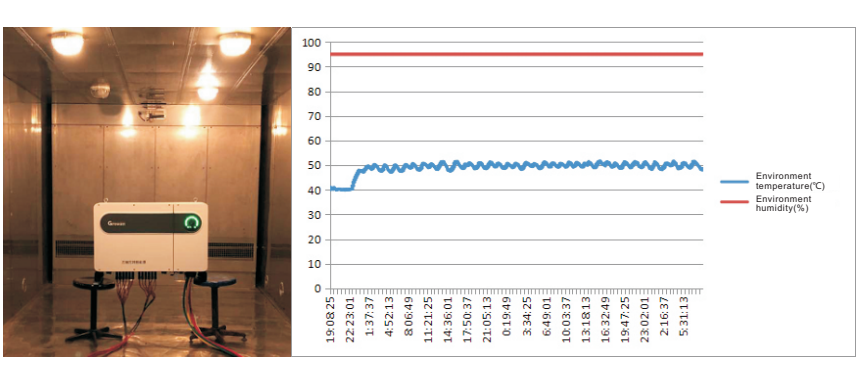

Figure3-1 MAX series constant high-temperature and high humidity test

Solar inverter would work at cold temperature, cold temperature will change the physical factor of the materials and may cause temporary or permanent damage, so aside from selecting components which can endure low temperature, a fully assembled inverter must pass low temperature working and storage test as well.

During the low temperature storage test, the inverter will be put into test lab, set temperature to -40℃, after storing for at least 24 hours the inverter should start normally. During the low temperature working test set temperature of chamber to -40℃, inverter should work normally.

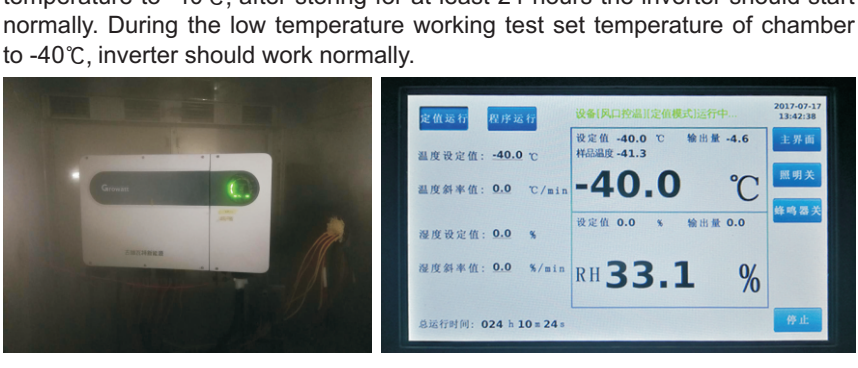

Figure 3-2 MAX series pass the low temperature storage and working test

For some coastal areas with high salt density and high humidity environments inverter will have corrosion issues that may seriously affect the solar plant's safety and reliability. So there should be strict salt spray test in the inverter testing process. There will be neutral salt spray test and variable salt spray test. After the test there should be no damage of the surface painting and finishing, no corrosion for other metal parts, the inverter can be started normally.

Figure 3-3 MAX series salt-spray test

To simulate real environment, it is necessary to put inverter into a real solar plant for long-term observation and test. The tested inverter was installed at a coastal factory rooftop, summer temperature is 38℃, the inverter surface can reach 60℃, when there is a sudden rain the surface temperature can decrease to 30℃, this kind of sudden temperature change can test the reliability of the inverter.

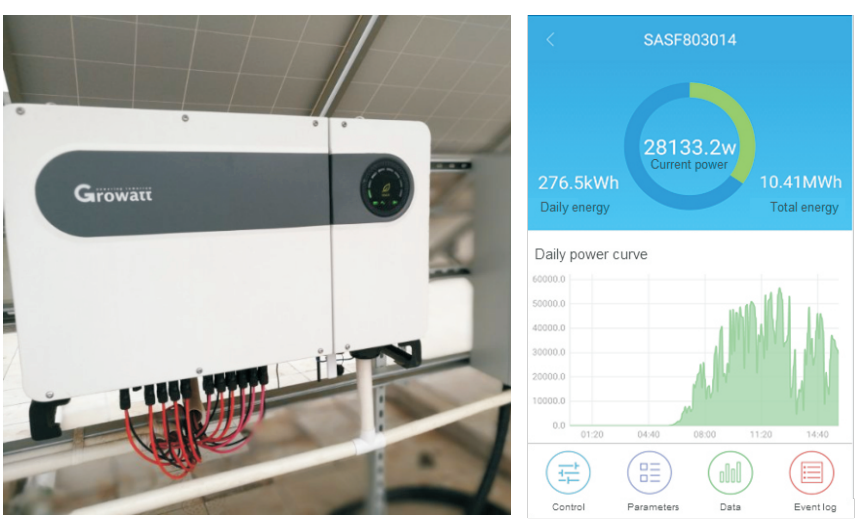

Figure 3-4 MAX series long-term simulation test

Except for environmental adaptability, there are other product quality factors like reliability, indemnificatory, testability, safety and maintainability. Environmental adaptability is the most fundamental quality factor. If the product cannot guarantee the normal operation in its lifespan under harsh environment it is not possible to fulfill other quality factors. The higher environmental adaptability is, the lower failure rates, which brings lower maintenance requirement.