INVERTER
POCKET GUIDE 2022

A handy reference for solar installers

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PV Inverter Supplier Globally in Shipment Terms in 2021

Source: IHS Markit now part of S&P Global

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WHAT IS AN **INVERTER?**

Welcome to *EcoGeneration*'s 2022 Inverter Pocket Guide, a reference guide for solar installers.

This pocket guide contains essential information that every solar system designer and installer needs to have on hand when working with different types of inverters.

An inverter, or power conversion equipment (PCE), simply converts direct current (DC) from the solar array, batteries or other DC source into AC, which is suitable to export to the grid or run appliances. Its output must be pure sine wave.

All inverters must comply with the AS/NZS4777.2: 2020 edition and be listed on the Clean Energy Council approved inverter list (cleanenergycouncil.org.au/industry/products/inverters) if you want to create small-scale technology certificates (STCs). If an inverter isn't on the list, don't install it.

All inverters must be installed in accordance with Australian Standards and under Clean Energy Council guidelines.

INVERTER CATEGORIES AND SUB-CATEGORIES

Grid-connected (GC) inverters

- String
- Central
- Micro
- DC optimisers

Hybrid (with battery storage)

Multi-mode inverters

- Back-up mode
- UPS mode

Standalone inverters

WHAT IS A GRID-CONNECTED INVERTER?

A grid-connected (GC) inverter is connected to the grid with the capability to export power into the grid or supply loads parallel to the grid. A grid-connected inverter must synchronise to the grid – or other AC source – to operate. When the grid is interrupted or goes outside its pre-set frequency or voltage limits, the grid-connected inverter must shut down (anti-islanding function).

String inverters This is the most popular type of inverter used in small-scale solar systems. PV modules connected in series are joined to a string inverter with a DC cable. In residential solar systems, only one is typically required, usually mounted close to the electrical switchboard.

The number and configuration of the solar modules connected to a string inverter must not exceed the input voltage and current specifications of the inverter.

String inverters may have one or more multiple power point tracker (MPPT) connections.

Central inverters A central inverter is usually only used on solar installations above 1MW. All the solar strings are wired back to a central point, which may make monitoring and maintenance easier, however it presents a single point of failure.

Microinverters A microinverter is a very small inverter sized for each PV module. Micros are mounted under the panel and convert the DC current from the PV module into an AC current. They are connected from the PV module to the switchboard with an AC cable. Each microinverter acts as an individual MPPT for the connected PV module.

DC optimisers These are technically not inverters because they need to be connected to a special string-inverter near the switchboard. The main difference between a DC optimiser and microinverter is the DC from the PV module is connected to the inverter with DC cable.

Hybrid inverter The PV array is directly connected to the hybrid inverter as well as the grid. The hybrid inverter will charge the battery storage and converts the DC current from the battery storage into AC current for the attached loads. Hybrid inverters do not supply AC current when the grid is disconnected.

WHAT IS A MULTI-MODE INVERTER?

A multi-mode inverter operates in more than one mode – it operates from the grid when available and in off-grid mode when the grid is disconnected. A multimode inverter requires battery storage to be connected to operate in off-grid mode.

Back-up mode Multi-mode inverters with back-up or off-grid functionality operate from the grid when available. When the grid is interrupted, the multi-mode inverter shuts down then restarts in the back-up or off-grid mode. There is a time lapse of about five seconds between the grid and off-grid mode, which will shut down all connected appliances in that time.

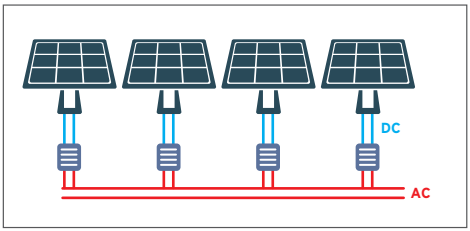
UPS mode A multi-mode inverter with UPS functionality operates from the grid when available. However, when the grid is interrupted, the changeover from grid to off-grid is instantaneous (less than 30 milliseconds) and connected appliances will not shut down.

WHAT IS A STANDALONE INVERTER?

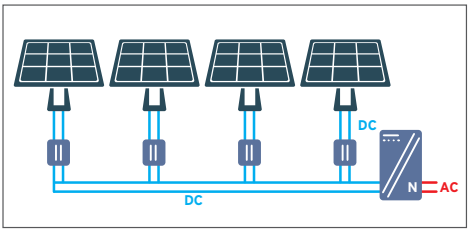
A standalone inverter does not need the grid to be connected to supply AC power to the loads. A standalone inverter is connected to battery storage that is recharged by PV or another renewable source. A genset may also be connected.

The standalone inverter can be the same as a multi-mode inverter, but cannot have a connection to the grid.

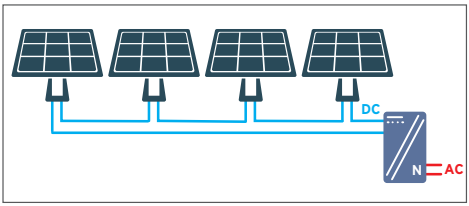
MICROINVERTERS



OPTIMISERS



STRING INVERTERS



COVER IMAGE: PETRMALINAK

THE LATEST AS/NZS 4777.2: 2020 IMPACTS ALL **SOLAR DESIGNERS** AND **INSTALLERS**

The latest edition of the Australian Standard AS/NZS4777.2: 2020 Grid Connection of Energy Systems Via Inverters, Part 2: Inverter Requirements is now mandatory so it is time for solar designers and installers to get up to speed.

Designers and installers should ensure they check the Clean Energy Council-approved inverter list – don't just take a salesperson's word for it.

CHANGES AND ADDITIONS

The preface in AS/NZS4777.2: 2020 lists nine significant changes and additions. Here, we address three that designers and installers must know:

1. Inverter set points In response to addressing the many problems solar owners are experiencing with grid security and power quality in recent years, distributed network service providers (DNSP) have implemented local inverter set points. These are designed to respond to grid fluctuations and keep inverter systems connected to the grid for longer. It is an installer's responsibility to select the correct region during the initial commissioning phase and to ensure the inverter set points match the local DNSP's requirements.

This has now been formalised in AS/NZS4777.2: 2020 to make the installer's job easier, although larger projects may have different set points so check with the DNSP. AS/NZS 4777.2: 2020 Table 3.6 lists the Volt-watt response default set-point values and Table 3.7 lists the Volt-var default set-point values

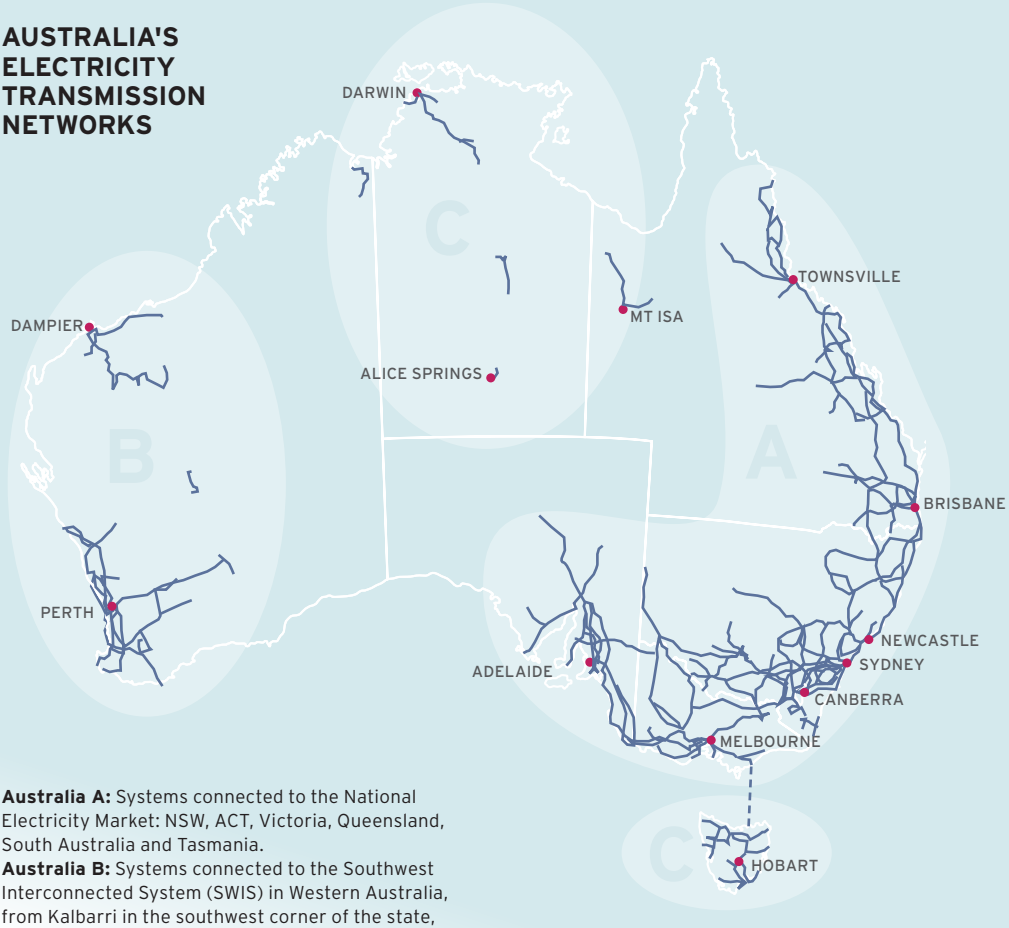
Australia's electrical distribution network has been divided into three regions and set points are defined for each region. Inverter manufacturers will include these in their initial configuration process of the inverter so for the installer it will be as simple as A, B, C or NZ.

2. Export and generation limits DNSP regularly puts export and generation limits on inverter generation to protect their networks. AS/NZS4777.2 clauses 6.2 and 6.3 formalise both soft and hard limits for generation and export limit control.

3. Standalone power systems (SAPS) In SAPS systems, there are new requirements for earth fault/earth leakage detection.

AS/NZS 4777.2: 2020 clause 2.4.2 states: "Where an inverter has a port for connecting a battery system installation that requires an alarm for monitoring of earth faults in conformance to AS/NZS 5139, the inverter should provide an alarm. Where no alarm is provided in the inverter, the inverter documentation shall require the addition

AUSTRALIA'S ELECTRICITY TRANSMISSION NETWORKS



Australia A: Systems connected to the National Electricity Market: NSW, ACT, Victoria, Queensland, South Australia and Tasmania.
Australia B: Systems connected to the Southwest Interconnected System (SWIS) in Western Australia, from Kalbarri in the southwest corner of the state, to Kalgoorlie in the east.
Australia C: For isolated or remote power systems.
New Zealand: All systems in New Zealand.

of an external alarm and monitoring device."

If AC coupling your SAPS, the GC PV inverter will most likely have inbuilt earth fault/earth leakage detection. In DC coupled SAPS systems, the charge controller may not have inbuilt earth fault/earth leakage detection so an additional monitoring device may be required. Whatever the scenario, it is the installer's responsibility to comply.

KEEPING COMPLIANT

This information is a guide only. Solar designers and installers should familiarise themselves with all the changes and new requirements of AS/NZS4777.2: 2020.

Remember, if you sign off the job, you are legally responsible for it being compliant so don't risk your livelihood by not knowing the new requirements.

SHADING AND ORIENTATION ISSUES

ORIENTATION

On many residential jobs, the hardest part of the PV installation is finding enough roof area free of shading so all panels are facing the same direction.

AS/NZS 5033: 2021 Clause 2.1.6 states: "PV modules that are electrically in the same string shall be all in the same orientation within +/- five degrees azimuth and +/- five degrees tilt angle." This is where microinverters or DC optimisers come into their own. Each PV module has a micro or optimiser, meaning different performing modules do not affect the other modules.

SHADING

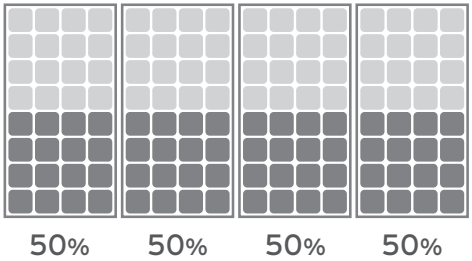
PV modules have bypass diodes to help solve the problem of faulty cells or partial shading. However, when shading occurs across the whole PV module, the output of that module can be close to zero and it affects the whole string output.

String-connected PV modules are only as good as their least performing module (remember your series/parallel circuit theory from the first year of your apprenticeship?).

Microinverters are effective when connected in parallel so one does not affect the performance of another, making microinverter arrays resilient to shading.

STRING INVERTER SYSTEM

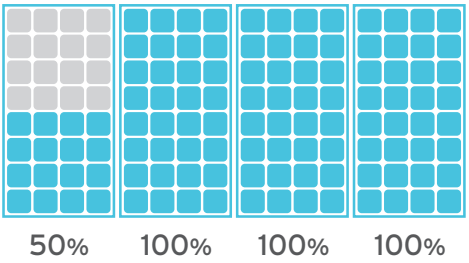
Performance



- Entire system affected by one module.
- Susceptible to soiling, shading and module defects.

MICROINVERTER SYSTEM

Performance



- All modules controlled independently.
- Resilient to environmental factors.

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PRODUCT GUIDE

The following table shows some of the main Clean Energy Council approved inverter manufacturers in Australia, their key products and where to find them. Note that some manufacturers sell modules and microinverters as a single integrated unit. Before installing any inverter, check the model is current

BRAND	PRODUCTS	
APsystems	Single phase dual microinverters: DS3-S (625 W), DS3-L (750W), DS3 (880W); Native three phase QUAD microinverter: QT2 (2000 W); Communication gateways: ECU-R , ECU-C; Monitoring: EMA portal	
Enphase Energy	IQ7, IQ7+, IQ7X, IQ7A Product name communication gateway: Envoy-S Metered	
FIMER	Single phase: UNO-DM-PLUS-Q (1.2-6.0kW). Three-phase: PVS-10/12.5/15, PVS-20/30/33, PVS-100/120, PVS-175, PVS-350. Free Monitoring: Aurora Vision and Energy Viewer (coming in 2023): Single-phase hybrid: PowerUNO (2-6.0KW). Three-phase hybrid: PowerTRIO (4-8.5kW). Energy Storage solution: PowerX (9.6-48 KWh)	
GoodWe	XS Series: 1.5/2/2.5/3kW, Single Phase, Single MPPT; DNS Series: 3/ 4.2 / 5kW, Single Phase, Dual MPPT; TDS Series: 3/4.2/5kW, Single Phase, Dual MPPT; MS Series: 5/6/8.5/10kW, Single Phase, Three MPPT; EH Series: 3.6/5/6kW, Single Phase, Hybrid Ready Inverter; EH Series: 3.6/5/6kW, Single Phase, Hybrid Inverter (HV); ES Series: 5kW, Single Phase, Hybrid (LV); EM Series: 3/3.7/5kW Hybrid Inverter; SDT G2 Series: 5/6/8/10/15/20kW, Three Phase, Dual MPPT; SMT: 25/29.9/36, Three Phase, Three MPPT; MT Series: 50/60/80kW, Three Phase, Four MPPT; HT Series; 100/110/120kW, Three Phase, 9/12/12 MPPT; ET Series: 5/6/8/10kW, Three Phase, Hybrid Inverter (HV); Lynx Home Series U: 5.4kW Low Voltage Battery	
Growatt	Hybrid inverter: SPH 2.5-6KTL BL-UP. Battery-ready inverter: 2.5-6KTL-XH Inverter. AC coupled inverter: 2.5-6KTL-XA Inverter	
LuxPower	Spectrum AC-coupled inverter, 3600VA; Spectrum 5K Hybrid inverter, 8kW	
Selectronic	SP Pro Bidirectional Inverter, Battery Charger, Synchronised transfer switch system all in one: 24V, 48V and 120V, 3.0-240kW (made in Australia). Selectronic Certified Solar inverters Fronius PRIMO: Single Phase 3.0–8.2kW; Fronius SYMO: 3 Phase 8.2-20kW; Fronius ECO: 3 Phase 25.0-27.6kW; ABB/FIMER UNO: Single phase 4.6- 6.0kW; Monitoring: Select.live	
Solis Australasia Ginlong	Solis S5; 5-GR1P(3-6); S5-GR1P(0.7-3.6)K-M; 5-GR1P(3-6)K; Solis-1P(7-8)K-5G; S5-GR1P(7-10) K with 3 MPPT; S5-GR3P(5-20)K; S5-GC(25-40)K; S5-GC(50-60)K; S5-GC(60-70)K-HV; S5-GC(80-125)K-HV; S5-EH1P(3-6)K-L	
Solplanet (AISWEI)	Single phase: ASW S-G2 Series (3-6kW); ASW S-Series (3-6kW); ASW S-Series (5-10kW) Three Phase: ASW LT-G2-A Series (3-6kW); ASW LT-G2-A Series (8-20kW); ASW LT-G3 Series (25-40kW); Single phase hybrid: ASW H-S2 Series (3-6kW)	
Sungrow Australia	Crystal inverter series: Single MPPT Range: 2kW Inverter (SG2.0RS-S); 3kW Inverter (SG3.0RS); 5kW Inverter (SG5.0RS); 5kW Inverter (SG5.0RS-ADA); 8kW Inverter (SG8.0RS-ADA); 10kW Inverter (SG10RS-ADA). Sungrow Residential Energy Storage Battery (SBR096/128/160/192/224/256). Sungrow Residential Hybrid Inverter (SH5.0/6.0RS, SH5.0/10RT)	

on the Clean Energy Council approved inverter list. This ensures it complies with AS/NZS 4777.2: 2020 and you will be able to create small-scale technology certificates (STCs).

	AUSTRALIAN DISTRIBUTORS
	Raystech, RFI, Prosun Solar, Sol Distribution, Krannich
	AC Solar Warehouse, Flex, One Stop Warehouse, RF Industries, Solar+Solutions
	Tradezone, Supply Partners, One Stop Warehouse, Greentech, Raystech, Prosun Solar
	Solar Plus Solutions, One Stop Warehouse, MMEM, Krannich, Supply Partners, Tradezone
	Go Solar Group, Austra Energy, Blue Sun Group, Tradezone
	SPB
	National Distributors, Supply Partners, Krannich, AC Solar Warehouse, Regional Distributors, DPA Solar, Solar Charge
	MMEM–Greentech, One Stop Warehouse, Sol Distribution
	One Stop Warehouse
	Solar Juice, One Stop Warehouse, AC Solar Warehouse, Raystech Group

Solis S5-GR1P(7-10)K with 3 MPPT

Fronius PRIMO

Goodwe DNS Series

Solplanet ASW S Series 6-10kW

Growatt inverter

APsystems DS3 range

PROS AND CONS OF **INVERTERS**

INVERTERS	PROS	CONS
GC string Inverter	• Low cost per watt, usually the cheapest of all options. • Location of inverter (near the switchboard, easy for servicing). • Easy to install. • More efficient when there are no shading issues.	• PV arrays must be same orientation otherwise a GC inverter must have multiple MPPT (different to string connections). • Single point of failure. • PV modules in shade will affect the output of the whole string. • One faulty PV module will lower the output from all the PV modules in the string. • Standard string inverter not battery-ready.
GC central inverter	• Ideal for 1MW-plus systems. • Engineered for reliability. • Less points of failure on large installations.	• Big and bulky, and needs plenty of room. • More expensive than individual string inverters.
Micro-inverters	• Ideal for PV modules facing different orientations. • System monitoring provides individual PV module data. • Ideal for PV arrays with shading issues. • Easy to expand the PV array as all PV modules don't need to be the same.	• More expensive than a string inverter. • One micro for each PV module required. • Servicing is harder as each micro is under the PV module. • Mounted with the PV module makes micros more susceptible to extreme weather conditions.
DC optimisers	• Ideal for PV modules facing different orientations. • Ideal for PV arrays with shading issues. • System monitoring provides individual PV module data. • Safe DC voltages when not connected to inverter.	• Still requires an inverter, mounted near the switchboard.
Hybrid	• Inverter charges battery storage. • Cheaper and easier to install than separate inverters.	• Generally less efficient than dedicated solar-only or battery-only inverters.
Multi-mode with back-up mode	• Battery storage can be attached at a later date.	• Changeover between grid and back-up takes five seconds so appliances shut down. • Must have battery storage installed to work in back-up mode.
Multi-mode with UPS mode	• Battery storage can be attached at a later date. • Instantaneous changeover between grid and UPS mode so does not shut down appliances.	• Must have battery storage installed to work in back-up mode.
Stand-alone inverters	• Does not need a grid connection. • May be a cheaper solution than extending the grid. • Uses battery storage for 24/7 AC energy. • Uses renewable sources (PV, wind, hydro) to charge the battery storage.	• Complexity of system. • Quite expensive. • Requires ongoing maintenance. • May need a genset to cover when renewable sources are low.

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TROUBLESHOOTING WHEN INSTALLING INVERTERS

Here are the primary mistakes made when installing inverters:

- Voltage rise: Cable between inverter and switchboard is too small.
- Inverter PV plugs and sockets where fitted: Ensure only mated with those of same type from same manufacturer.
- Inverter voltage and volt watt settings not enabled and configured to local DNSP values.
- PV module voltages and current not matched to attached inverter.
- Inverter clipping caused by connecting too many modules in a string.
- Too many microinverters on a branch.
- Not following manufacturer's instructions, especially in relation to clearances and ventilation.
- Location: Inverter installed in direct sunlight or open to weather (check the IP rating).
- When mounting an inverter, think switchboard and apply the same mounting conditions (AS/NZS 3000).
- System not tested in accordance with AS/NZS 3000 Section 8: Verification, AS/NZS 4777 and AS/NZS 5033.

WHO IS RESPONSIBLE?

As a licensed electrician and accredited Clean Energy Council designer/installer, when you sign-off on the electrical, solar design and/or solar installation you take legal responsibility that the design/installation is correct and that it meets all the standards and Clean Energy Council Guidelines.

If you are working as a subcontractor to a solar retailer and the retailer requires you to sign off on their design aspects, you are taking on the retailer's design liabilities, often for little or no extra reward.

Be careful, if it is not right, don't sign off on it. In the worst case scenario, it can cost you your livelihood and even your home.

TESTING AND COMMISSIONING YOUR INVERTER

AS/NZS 4777.1: 2016 Section 7, System Documentation and Commissioning spells out your legal obligations.

At the completion of the installation of an inverter, documentation should ensure key system information is readily available to customers, inspectors, maintenance personnel and emergency service personnel (AS/NZS 4777.1: 2016 Cl 7.1).

Verification of the inverter shall be carried out in accordance with the requirements of AS/NZS 3000 prior to energising and placing the installation into service (AS/NZS 4777.1: 2016 Cl 7.3).

After inspection and testing has been completed, the system is to be commissioned by energising the inverter in accordance with the manufacturer's instructions.

The following specific tests shall be performed, and the results documented on the commission sheet (AS/NZS 4777.1: 2016 Cl 7.6).

- Operate the main switch (inverter supply) and verify the connection time is greater than 60 seconds.
- Isolate the main switch (mains supply) under load and verify the inverter disconnection time is less than two seconds.
- Program/verify the inverter set point region setting is correct for the inverter location.
- Record all settings.
- Check the shutdown procedure is correct and results in a safe shutdown of the inverter.
- Set export limit settings if specified by DNSP.

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EcoGeneration **thanks David Tolliday from Holmesglen TAFE for his generous contribution to the 2022 Inverter Pocket Guide.**

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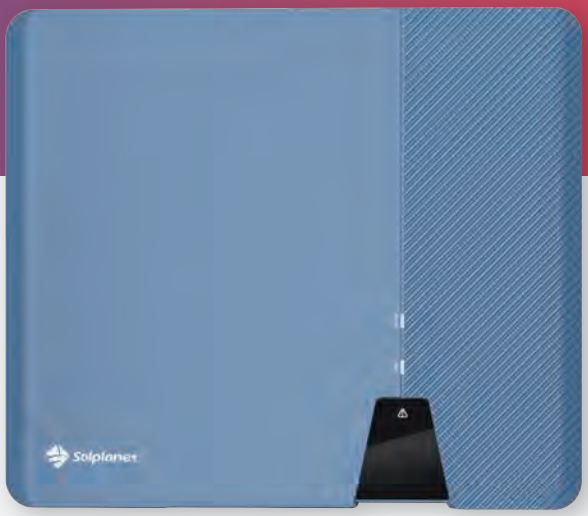

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