ecogeneration

INVERTER POCKET GUIDE
A handy reference for solar installers
Enphase Microinverters

What's underneath the panels makes all the difference.

Backed by one million hours of testing, Enphase’s seventh generation microinverters are easier to install, more powerful and smarter than ever. With no single point of failure and unique software-defined architecture, the Enphase system provides better value for both installer and customer on any rooftop.

Find out more at enphase.com/au
WHAT IS AN INVERTER?

Welcome to the Inverter Pocket Guide, a handy reference guide for solar installers. The 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 PCE (power conversion equipment) simply converts direct current (DC) from the solar array, batteries or other DC source into AC, which is suitable to export into the grid or run appliances. Its output must be pure sine wave. All inverters must comply with AS/NZS4777.2:2015 and be listed on the CEC approved inverter list (https://www.solaraccreditation.com.au/products/inverters.html) if you want to create STCs (small technology certificates). If it isn’t on the list then it’s simple – 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

Stand-alone Inverters

WHAT IS A GRID-CONNECTED INVERTER?

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

STRING-INVERTERS

The most popular type of inverter used in small-scale solar systems. PV modules connected in series are connected to a string-inverter with a DC cable. In residential, there is typically only one 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 MPPT (multiple power point trackers) connections.

CENTRAL INVERTERS

A central inverter is usually only used on solar installations over 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 simply 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 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.

www.ecogeneration.com.au
DC OPTIMISERS
Technically not an inverter, as DC optimisers 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
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 is an inverter which operates in more than one mode; that is, it operates from the grid when available and off-grid mode when the grid is disconnected. A multimode inverter requires battery storage to be connected to operate in the off-grid mode.

BACK-UP MODE
Multimode inverters with back-up or off-grid functionality operate from the grid when available. When the grid is interrupted, the multimode inverter will shut down then re-start 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 the appliances connected.

UPS MODE
A multimode 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 STAND-ALONE INVERTER?
A stand-alone inverter does not need the grid to be connected to supply AC power to the loads. A stand-alone inverter is connected to battery storage that is recharged by PV or other renewable source. A genset may also be connected.

The stand-alone inverter can be the same as a multimode inverter but cannot have a connection to the grid.
MOST UP-TO-DATE RESIDENTIAL SOLUTION

—What you must know about Growatt's new residential Inverter, MIN 2500-6000TLX.

- NEAT | Compact design with OLED display
- LIGHT | 35% lighter than other similar inverters
- DURABLE | Touch button, lasts over three million clicks
- SAFE | Type II SPD on DC side, optional AFCI
- SMART | USB/RS485 and optional WiFi/GPRS/4G

Growatt New Energy Technology Co., Ltd.
1800 476 928(GROWAT) | www.ginverter.com.au | auservice@growatt.com
SHADING & ORIENTATION

ORIENTATION
On many residential jobs, the hardest part of the installation is finding enough roof area, free of shading and all facing the same direction to install the PV modules.

AS/NZS 5033 Clause 2.1.6 states “PV modules that are electrically in the same string shall be all in the same orientation within ±5 (azimuth and tilt angle).

This is where microinverters or DC optimisers come into their own. Each PV module has its own 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 affect the whole string output.

String-connected PV modules are only as good as its 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.

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**STRING INVERTER SYSTEM**

**Performance**

| 50% | 50% | 50% | 50% |

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

**MICROINVERTER SYSTEM**

**Performance**

| 50% | 100% | 100% | 100% |

- All modules controlled independently
- Resilient to environmental factors
New residential solar inverter series UNO-DM-PLUS-Q

With the new line of residential inverters, UNO-DM-PLUS-Q, the energy of the sun becomes everything you need at home, every day and without losses. Easy to install, simple to maintain and always connected, the UNO-DM-PLUS-Q inverters, available in power ratings from 2.0 to 6.0 kW, are a new energy that becomes true.

www.abb.com/solarinverters
## PROS & CONS OF INVERTERS

<table>
<thead>
<tr>
<th>INVERTERS</th>
<th>PROS</th>
<th>CONS</th>
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| **GC string-Inverter** | Low cost per watt, usually the cheapest of all options  
                         | Location of inverter (near the switchboard, easier for servicing)  
                         | Easy to install  
                         | More efficient when 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** | More expensive than individual string-inverters  
                         | Ideal for 1MW-plus systems  
                         | Engineered for reliability not price point  
                         | Less points of failure on large installations | Big and bulky, needs plenty of room  
<pre><code>                     | Expensive |
</code></pre>
<table>
<thead>
<tr>
<th>INVERTERS</th>
<th>PROS</th>
<th>CONS</th>
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</thead>
</table>
| **Microinverters** | Ideal for PV modules facing different orientations<br>
|                  | System monitoring, provides individual PV module data<br>
|                  | Ideal for PV arrays with shading issues<br>
|                  | Easy to expand the PV array, as all PV modules don't need to be the same | More expensive than a string-inverter<br>
|                  |                                                                       | One micro for each PV module required<br>
|                  |                                                                       | Servicing is harder as each micro is under the PV module<br>
|                  |                                                                       | Mounted with the PV module makes micros more susceptible to extreme weather conditions |
| **DC optimisers** | Ideal for PV modules facing different orientations<br>
|                  | Ideal for PV arrays with shading issues<br>
|                  | System monitoring, provides individual PV module data<br>
|                  | Safe DC voltages when not connected to inverter<br>                  | Still requires an inverter, mounted near the switchboard<br>
| **Hybrid**        | Inverter charges battery storage<br>
|                  | Cheaper and easier to install than separate inverters<br>            | Generally less efficient than dedicated solar-only or battery-only inverters<br>
| **Multi-mode with back-up mode** | Battery storage can be attached at a later date<br>                  | Changeover between grid and back-up takes five seconds, so appliances shut down<br>
|                  |                                                                       | Must have battery storage installed to work in back-up mode<br>
| **Multi-mode with UPS mode** | Battery storage can be attached at a later date<br>
|                  | Instantaneous changeover between grid and UPS mode, so does not shut down appliances | Must have battery storage installed to work in back-up mode<br>
| **Stand-alone inverters** | Does not need a grid connection.<br>
|                  | May be a cheaper solution than extending the grid<br>
|                  | Uses battery storage for 24/7 AC energy<br>
|                  | Uses renewable sources (PV, wind, hydro) to charge the battery storage | Cost<br>
|                  |                                                                       | Complexity of system<br>
|                  |                                                                       | Must have ongoing maintenance<br>
|                  |                                                                       | May need a genset to cover when renewable sources are low
COMMON MISTAKES WHEN INSTALLING INVERTERS

- Voltage rise: too-small cable between inverter and switchboard
- PV module voltages and current not matched to attached inverter
- Inverter clipping caused by connecting too many modules in a string
- Too many micros on a branch
- Not following manufacturer's instructions, especially in relation to clearances and ventilation
- Location – not installing 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)

WHO IS RESPONSIBLE?
As a licensed electrician and accredited CEC designer/installer, when you sign-off on the electrical, solar design and/or solar install you will be taking legal responsibility that the design/install is correct and that it meets all the Standards and CEC Guidelines.

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

Be careful – if it is not right, then don’t sign off. In the worst case it can cost you a lot more, even your home and your livelihood.
REPLACING A FAULTY INVERTER

In a developing industry like grid-connected PV, many manufacturers have come and gone. This makes it nearly impossible to get a warranty or replace some brands of inverters. If you find yourself in this situation, you need to make some decisions.

• Replace like for like if the inverter is still available
• If no longer available, replace with the equivalent inverter as recommended by the original manufacturer
• Select an equivalent inverter, matching the power, voltage, current and whether it is transformer/transformerless technology. You may be required to upgrade the whole system to current Standards & CEC guidelines, so check with your local electricity regulator. It may be better and cheaper to scrap the old system and install a new system.

Take advice from the suppliers but ultimately the person signing the replacement off will be legally responsible if something goes wrong.

REMEMBER to isolate, test and lock off before removing and replacing the inverter or working on the system.
The following table shows some of the main Clean Energy Council (CEC) approved microinverter manufacturers in Australia, their key products and where to find them. Note that some manufacturers sell modules and microinverters as a single integrated unit.

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<th>MANUFACTURER</th>
<th>PRODUCTS</th>
<th>AUSTRALIAN DISTRIBUTORS</th>
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<tbody>
<tr>
<td>ABB</td>
<td>UNO-DM PLUS 1.2-6kW</td>
<td>Contact ABB on 1800 769 663</td>
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<tr>
<td>Enphase Energy</td>
<td>IQ7, IQ7+, IQ7X Product name communication gateway: Envoy-S Metered</td>
<td>AC Solar Warehouse Flex One Stop Warehouse RF Industries Solar+Solutions</td>
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<tr>
<td>Goodwe</td>
<td>Residential: ES Series 3.7/5kW Hybrid Inverter</td>
<td>Solar Plus Solutions One Stop Warehouse</td>
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<td>ET Series 5/8/10kW Three Phase Energy Storage Inverter</td>
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<td></td>
<td>EM Series 3/3.7/5kW Hybrid Inverter</td>
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<td>NS Series 1-3kW Single-MPPT Single Phase</td>
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<td></td>
<td>DSN Series 3-5kW Dual MPPT Single Phase</td>
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<td></td>
<td>DSS Series 4.2/5kW Dual MPPT Single Phase</td>
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<td><strong>Small to medium sized commercial rooftop applications:</strong></td>
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<td></td>
<td>Smart DT Series 4-20kW Dual-MPPT Three Phase</td>
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<td>SMT Series 25/30/36kW Three-MPPT Three Phase</td>
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<td><strong>Large commercial ground-mounted:</strong></td>
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<tr>
<td></td>
<td>MT Series 50/60/70kW Four MPPT Three Phase</td>
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<td><strong>On-grid retrofitting storage solutions utilizing:</strong></td>
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<tr>
<td></td>
<td>SBP Series AC-Coupled Retrofit Solution</td>
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## Products

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<thead>
<tr>
<th>Manufacturer</th>
<th>Products</th>
<th>Australian Distributors</th>
</tr>
</thead>
</table>
| Seletronic   | SP Pro - Multi-Mode Inverters  
               24V, 48V and 120V, 3.0kW - 60kW  
               Fronius Primo – Seletronic Certified Single Phase Inverter  
               3.0 - 8.2kW  
               ABB Uno – Seletronic Certified Single Phase Inverter  
               3.3kW - 6.0kW  
               SelectSun - Seletronic Certified Three Phase Inverter  
               20.0kW - 40.0kW  
               Select.live - Remote Monitoring System | MPower  
                                                                    Supply Partners  
                                                                    Krannich |
| SMA          | MLPE: TS4-R-Monitoring, TS4-R-Safety,  
               TS4-R-Optimisation  
               **MLPE communications:** Gateway, Cloud Connect  
               Advanced  
               **Solar inverters:**  
               Sunny Boy 1.5, 2.5 VL-40  
               Sunny Boy 3.0, 4.0, 5.0 AV-40  
               Sunny Tripower 5000, 6000, 7000, 8000, 9000, 10000, 12000 TL-20  
               Sunny Tripower 3.0, 4.0, 5.0, 6.0, 8.0, 10.0 AV-40  
               Sunny Tripower 15000, 20000, 25000 TL-30  
               Sunny Tripower 50-40  
               Sunny Tripower 60, 75-10  
               **Battery inverters:**  
               Sunny Boy Storage 2.5 VL-10  
               Sunny Boy Storage 5.0-10  
               **Communication:** SMA Energy Meter-20, Sunny Home Manager 2.0, Data Manager M, Inverter Manager | BayWa r.e.  
                                                                                                                                                             Flextronics  
                                                                                                                                                             Krannich Solar  
                                                                                                                                                             Solar + Solutions;  
                                                                                                                                                             RFI Technology Solutions  
                                                                                                                                                             Sol Distribution  
                                                                                                                                                             Solar Juice |
| Sungrow Australia | **Crystal inverter series**  
               Single MPPT Range: 2kW Inverter (SG2K-S), 2.5kW Inverter (SG2K5-S), 3kW Inverter (SG3K-S)  
               Dual MPPT Range: 3kW Inverter (SG3K-D), 5kW Inverter (SG5K-D)  
               Sungrow PowCube Residential Energy Storage System  
               Sungrow Residential Energy Storage Battery (SBP4K8)  
               Sungrow Residential Hybrid Inverter (SH5K-20) | Blue Sun Group  
                                                                                                                                                             One Stop Warehouse  
                                                                                                                                                             Powerark Solar Supply Partners |
INDUSTRY STANDARDS

ACCREDITATION GUIDELINES

To ensure the high quality of solar installations by accredited installers, the Clean Energy Council produces both design guidelines and install and supervise guidelines for grid-connect systems.

While the guidelines set requirements that must be followed, they do not constitute a fully definitive set of rules and are to be read in conjunction with all relevant Australian Standards.

Where these guidelines have additional requirements above that stated in the Australian Standards, these guidelines should be followed:

- Battery Installation Guidelines for Accredited Installers (PDF) – Mandatory from 1 November 2017
- Grid-Connected Solar PV Systems: Install and Supervise Guidelines for Accredited Installers Version 13 (PDF) – Mandatory from 1 July 2019
- Grid-Connected Solar PV Systems: No Battery Storage, Design Guidelines for Accredited Installers – February 2013 (PDF)
- 30-100kW Grid-Connected Solar PV Systems: No Battery Storage, Design Guidelines for Accredited Installers (PDF) – Mandatory from 1 July 2016

Data tables are provided by the CEC in addition to the grid-connect design guidelines. They contain information on the annual daily irradiation on an inclined plane expressed as percentage of the horizontal value. For further information go the CEC’s website www.cleanenergycouncil.org.au.

Microinverters must adhere to standards to ensure safety, compliance and ultimately peace of mind for those who purchase and install them.

Disclaimer: The publisher has made every effort to ensure that the information in this guide was correct at the time of publication. The publisher does not assume, and hereby disclaims, any liability to any party for any loss, damage or disruption caused by errors or omissions, whether such errors or omissions result from negligence, accident or any other cause.

Ecogeneration would like to thank David Tolliday from Holmesglen for his generous contribution to the Inverter Pocket Guide book.
SECONDARY INJECTION AND POWER QUALITY TESTING

Our testing and commissioning team offers comprehensive testing services to the commercial and industrial solar installers. With the changes to AS/NZS 4777:2015 the grid connected solar systems above 30kW must install grid protection relays and requires secondary injection testing to prove that the correct operation of the protection relay as per the parameters set by the DSNP.

Some DNSP's also require power quality readings with the solar system connected and disconnected as part of their requirements to approve solar systems.

We offer the most COMPETITIVE testing service to the Solar Installers FAST
Book your next test with Dara, Email Now
Sales@dara-switchboards.com.au

Dara Custom Switchboards
Production Plant and Head Office

5 Faigh Street, Mulgrave, VIC 3170
Tel - 1300 DARASW/0478 398 344
www.testsolar.com.au
www.electricalswitchboards.com.au
Did You Know...
Huawei is the World’s Leading Solar Inverter Manufacturer?

- **NO.1** Global Shipments in Total
- **90GW+**
- **NO.1** Patents Application Globally In 2017
- **NO.72** Fortune Global 500

- Integrating DCPV2 Switches in full Compliance with Standard AS60947 and AS5033 on Safety
- AI Powered Arc Fault Circuit Interrupter (AFCI) to Proactively Mitigate Fire Risk
- 98.3% Industry-leading Efficiency Converts More Solar Energy for Your House

**FusionSolar Smart PV Solution**
Huawei Technologies(Australia) Pty Ltd
Tower B, 799 Pacific Highway, Chatswood NSW 2067

**SUN2000-3-20KTL-M0**