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General Troubleshooting

Best Practices

Outline

Five parts, then the key points

1 The method

Four steps, one idea

2 Evidence

Before you touch anything

3 AC or DC

Which half, the causes, the path

4 Three cases

No code, right code, wrong code

5 Records

The fault record and closing out

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PART 1

The Method

The inverter tells you what it measured, not what is broken.

A code is a symptom. The method turns it into a cause.

The Method

Four steps

1 Symptoms

What the operator sees, what the display says. Get info before site visit

2 Information

History, data, weather, last work

3 Cause

Narrow it down, measure, confirm

4 Solution

Fix, retest, record

Steps 1 and 2 gather information before the visit. They decide whether a visit is needed and what to bring.

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The Method

Two kinds of call

Not working
No output at all. Usually a code, a trip, or a switch.

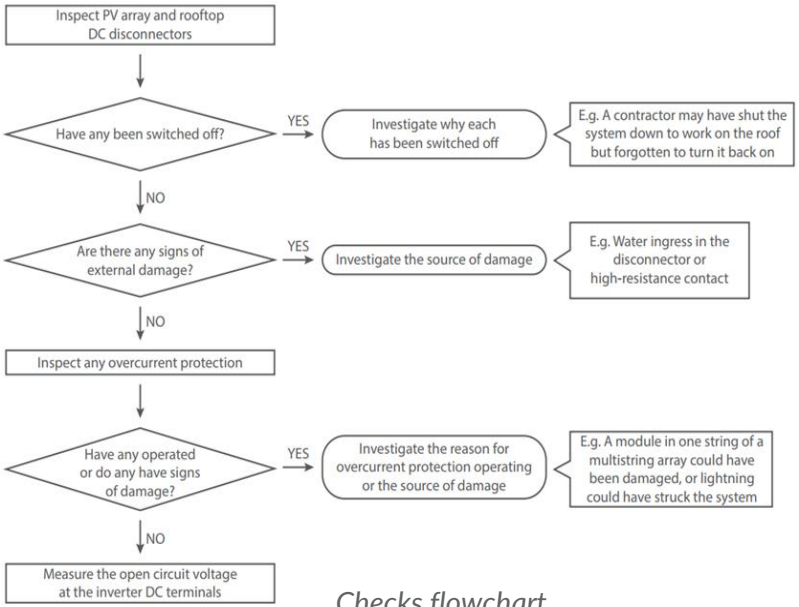
Underperforming
Making less than it should. Often no code at all.

Underperforming needs a number to compare against

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The Method

Divide and conquer



Checks flowchart

Source: GSES

Inverter first
The one place both halves meet.

Split the system
AC half or DC half? Then split again.

Cheap, safe checks first

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The Method

Field rules

1 **As designed?**

Check it was installed the way the drawing says

2 **Swap identical parts**

Swap a suspect part with its twin. If the fault moves, it's the part. If it stays, it's the position.

3 **One change at a time**

Or you cannot tell what fixed it

4 **Write it down**

Every reading, as you take it

Intermittent and multiple faults are the hardest. Be methodical.

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PART 2

Evidence

Evidence

The phone call

1 **Operator's words**

What they see, since when

2 **Monitoring**

Output history, alarms, the portal

3 **Weather**

Rain, cloud, storm since it last worked

4 **Last work**

Who was there and what they did

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Evidence

Photos and readings



Meter, terminal, reading

Source: GSES inspection photo

- Photograph everything before you touch it
- Every reading with the time and the conditions

A photo with the meter in frame is evidence

Evidence

Alarm is not fault



A portal with alerts

Source: GSES

- Gateway offline: almost always the internet
- The array may be generating perfectly well

A monitoring alarm and a generation fault are different things

PART 3

AC or DC

AC or DC?

Four signs

Points to the AC side

- A dark display: no AC to power it
- A grid, voltage or impedance code

Points to the DC side

- Display on, no power: DC or insulation
- An earth fault or a low DC voltage code

When the signs don't agree, check the maintenance records: what was worked on last, and on which side.

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Before You Open

Isolate, lock, prove

1

Licensed only

Every step from here is live electrical work

2

Isolate and lock

Grid, inverter, battery

3

Prove dead

Prove the meter on a known live source, test for zero, prove it again

Isolated is not dead. Mains stay live upstream, the array stays live in daylight. Two people, always.

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AC Side

Common causes, where to look, in order

1	2	3	4	5
Loose terminals	**Tripped breaker**	**Blown fuse**	**Grid voltage or frequency**	**Inverter**
Discolouration, distortion, a smell. Millivolt drop across the joint, compared with its neighbour.	Find out what tripped it before you reset. One that trips only under load is a hot joint.	Check the rating before replacing. The wrong rating may be why it blew.	Measure at the inverter terminals first. A long or thin AC cable can push it over, not the network.	Last, not first. Read the code, check fans and filters, re-torque the lugs, then follow the manual.

AC Side

The path: six questions, in this order

1. Is the grid there at all?
2. Has something been switched off?
3. Is there damage you can see?
4. Measure across the inverter AC isolator
5. Measure across the inverter supply main switch
6. Is the grid side dead?

DC Side

Common causes, where to look, in order

1 Low DC voltage

Divide the gap by one module's Voc. That tells you how many modules' worth of voltage is missing.

2 Shading and soiling

Measure every string within the same few minutes. Clean one section and re-measure to prove it.

3 Loose connectors

Not fully clicked together, or two different brands joined. Both make a poor contact that heats long before it fails open.

4 Fuse

Check the rating before replacing. A blown fuse is a symptom, find what blew it.

5 Miswired

Minus 500 V where plus 500 is expected means reversed.

DC Side

The path: seven steps, look first then measure

Look first

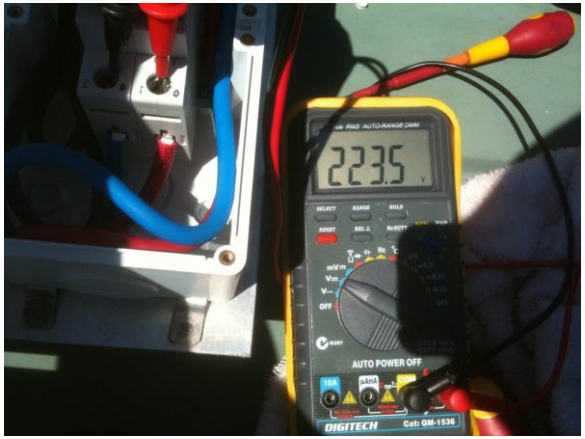
1. Are the isolators on?
2. Damage you can see?
3. Has protection operated?

Then measure

4. Voltage at the inverter
5. Across the isolators
6. Short circuit current
7. Voltage string by string

Both Paths

Measure both sides of every device



Reading across a DC isolator

Source: GSES inspection photo

Same both sides
The device is passing power. Move on to the next one.

A difference
The problem is inside that device. Stop there.

Loose Connections

The most common real cause



One scorched, one clean

Source: GSES

How you find one
Discolouration, distorted plastic, a smell. Then millivolt drop across the joint under load, compared with an identical joint beside it.

Last work
The loose joint is usually the last screw someone turned. Ask or check what was worked on, and start there.

A loose joint makes heat, not extra current. Breakers and fuses only watch current, so nothing trips. You find these by looking.

Arc Faults

Two kinds

Series arc

- A break in the current path: a loose terminal, a half-seated connector, a bad crimp. Current flows through the arc.
- Current stays normal, so no breaker or fuse can see it.

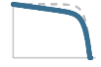
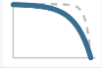
Parallel arc

- Insulation fails between two conductors and current jumps the gap. Not touching, arcing across.
- On a PV string the current is capped near Isc, so even this may not blow a fuse.

Isolate strings one at a time and inspect every connection for burning. A thermal camera finds these faster. One basic camera is shared, so look and measure first.

I-V Curves

Seven shapes

Curve shape	Likely cause
 Normal, over 90 %	Nothing to do. Record it as the baseline for next time.
 Stepped	Part of the string is bypassed and its diode is conducting: partial shade, module mismatch, a shorted bypass diode, or cracked cells.
 Low Isc	Less light is reaching the cells. Check the tracer's irradiance input first, then look for uniform soiling or shading across the whole string.
 Low Voc	Series voltage is missing. Check the tracer's temperature sensor first, then look for shorted bypass diodes, modules missing from the string, or PID.
 Sloping vertical leg, near Voc	Series resistance: a poor connection, an undersized or damaged cable, a corroded terminal.
 Sloping horizontal leg, near Isc	Shunt resistance: cell damage, PID (potential induced degradation), or a single shaded or soiled cell.
 Rounder knee	Fill factor falling (knee less square). Normal with age, but if early, check both slopes above.

Source: SEIAPI, Grid-Connected PV Operations and Maintenance Guideline, Section 4

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You used the tracer on Tuesday. On Friday you use it to diagnose.

Also: Voc and Isc per string with the meters you have, and compare strings.

PART 4

Three Cases

Worked Cases

Case 1: underperforming, no message. Eight modules at about 44 V. Expected 353 V, reading 308 V.

A	The inverter is faulty. Replace it.
B	Two modules in the string are faulted. Find them.
C	Normal. The array is just dirty.

Worked Cases

Case 1: underperforming, no message. Eight modules at about 44 V. Expected 353 V, reading 308 V.

A. The inverter is faulty. Replace it.

B. Two modules in the string are faulted. Find them.

C. Normal. The array is just dirty.

353 V is eight modules at about 44 V. 308 V is seven. One module's worth of voltage is missing, which two faulted modules can produce between them. The inverter shows no code because nothing is outside its limits. Compare the reading against what the string should give, string by string.

Worked Cases

Case 2: no output. EARTH FAULT DETECTED. Input 353 V, 0 A.

A	The array is dead. Replace modules.
B	The grid is out. Call the network.
C	Insulation fault. The array is fine. Find the leak to earth.

Worked Cases

Case 2: no output. EARTH FAULT DETECTED. Input 353 V, 0 A.

A The array is dead. Replace modules.

B The grid is out. Call the network.

C Insulation fault. The array is fine. Find the leak to earth.

353 V is present and correct, so the array is generating. The inverter measured insulation to earth and refused to connect. Insulation test each string: this one read 38 ohms to earth: a dead short, from a damaged cable under a module.

Worked Cases

Case 3: after a repair, GRID IMPEDANCE TOO HIGH. Grid is fine.

A	The utility's voltage is bad. Call them.
B	The inverter's grid sensing has failed. Replace it.
C	A loose neutral at the switchboard from the last job. Check the terminations.

Worked Cases

Case 3: after a repair, GRID IMPEDANCE TOO HIGH. Grid is fine.

A. The utility's voltage is bad. Call them.

B. The inverter's grid sensing has failed. Replace it.

C. A loose neutral at the switchboard from the last job. Check the terminations.

The inverter measured a real thing: the AC path impedance was genuinely too high. The neutral had been clamped over its insulation during the repair, so there was no metal-to-metal contact. The code says GRID. The fault is one screw in the switchboard.

Worked Cases

Clear the latch

1

Fix the cause

The cable, the terminal, the connector

2

Clear the fault

In the inverter or the portal. Some codes latch.

3

Confirm output

Watch it run. Then leave.

Fixing the cable is not the last step

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Friday on Site

Same checklist, both sites

1

Walk the checklist

Sections 1 to 7, in order, at both sites

2

If the walk finds it

String off, shading or soiling: use the matching box

3

Report

What was found, what was done, what is still needed

The checklist comes first. Faults and cleaning come out of it.

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Friday on Site

When the checklist finds something

1

String off

Ask and read, then test. It stays off until agreed

2

Shaded

Measure against a clear neighbour. Do not clear it

3

Soiled

Clean and take readings, if water is available

Nothing found? Write "none found" and carry on.

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PART 5

Records

Fault Record

What to write

Field	What goes in it
Symptom	The operator's words, the display text, the date it started
Readings	Every measurement, with time, weather and the instrument
Cause	What you found, with a photo
Fix	What you did, parts used, torque or settings changed
Retest	The readings after, and the output confirmed
Who and when	Name, date, time on site

Fault Record

Before leaving

1 **Restart in order**

DC first, then AC

2 **Confirm output**

Display, then the portal

3 **Tell the operator**

What it was, what to watch for

4 **Photo after**

The repair, the readings, the display

Leave the site with a record the next person can use

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Key takeaways

What to carry out of this session

- A code is what the inverter measured, not what is broken
- Ask what changed. Most failures follow the last visit
- Decide the half. Free checks first, then measure both sides of each device
- Loose conductors head every list. Look before you measure
- No code does not mean no fault. Compare against expected
- Fix, clear the latch, confirm output, write it down

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