vifalio

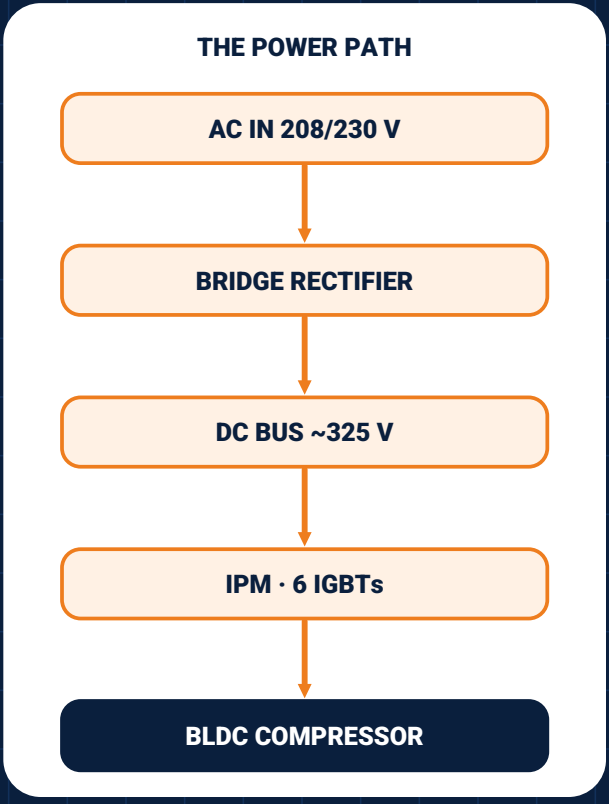
FREE PRINTABLE GUIDE · FOR HVAC TECHS

INVERTER BOARD REPAIR GUIDE

MINI-SPLIT · TEST · DIAGNOSE · FIX

How the board works, how to test every part, and when a repair is worth it.

- Block diagram: AC in to compressor
- Safe DC bus discharge
- Test fuse, MOV, bridge, caps, SMPS, IPM
- 4 diagnostic flowcharts
- Repair or replace, and what to charge



WHAT'S INSIDE

Keep it on your phone or print the pages you use on the bench.

01	How an inverter board works	3
02	Indoor board, outdoor board, communication	4
03	Tools for board work	5
04	Safety and DC bus discharge	6
05	Input stage: fuse, MOV, NTC, bridge	7
06	DC bus capacitors and relay	8
07	Switching power supply (SMPS)	9
08	IPM and compressor tests	10
09	Temperature sensors (NTC)	11
10	Flowcharts: no power · trips	12
11	Flowcharts: comm error · compressor	13
12	Error codes by fault family	14
13	Mistakes that kill boards	15
14	Repair or replace? What to charge	16
15	Bench checklist and series lamp	17
16	Next steps	18

SAFETY FIRST
Discharge the DC bus

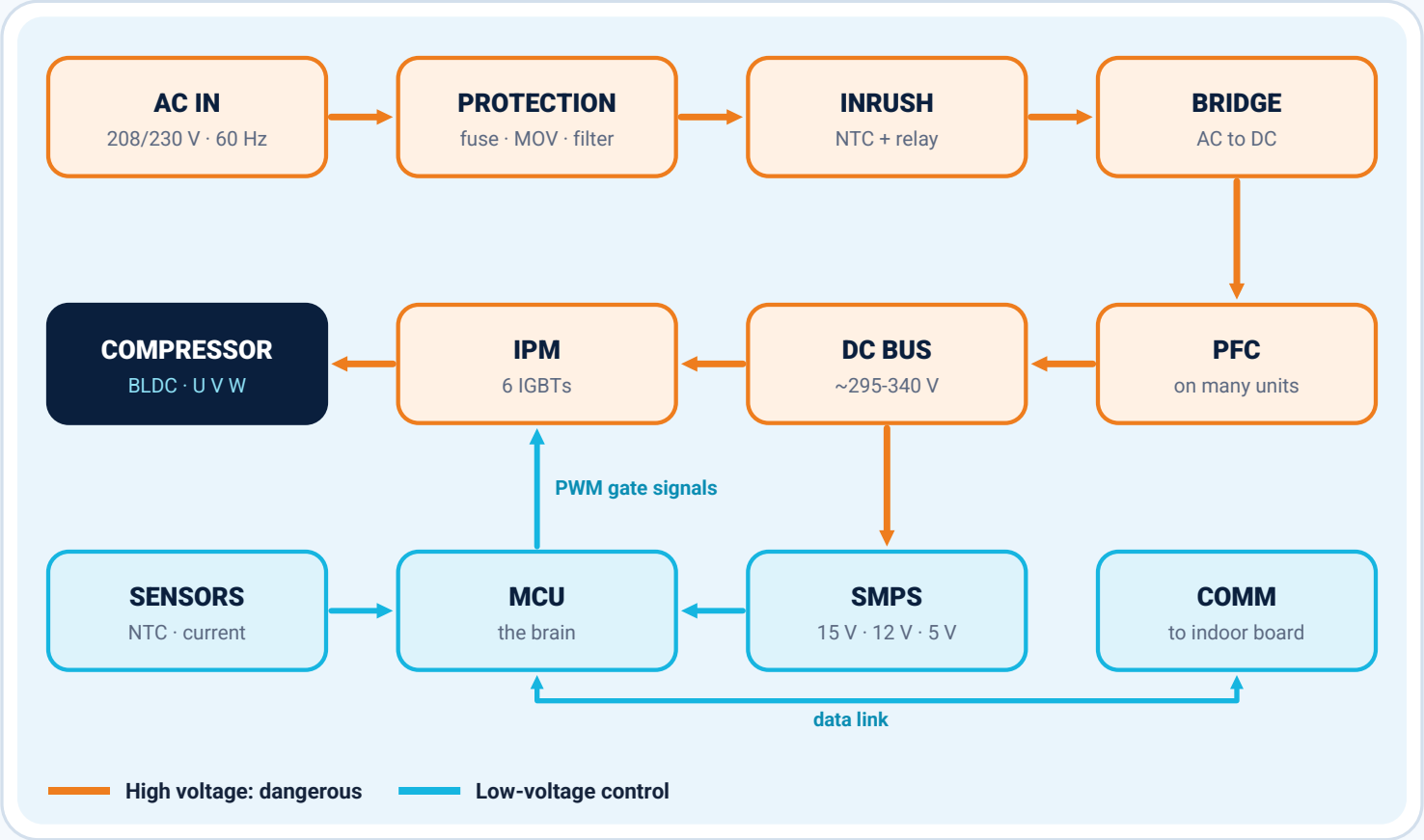
EPA 608
Refrigerant work

208/230 V · 60 Hz
US systems

vifalio.com
Free guide

HOW AN INVERTER BOARD WORKS

It turns 60 Hz AC into high-voltage DC, then chops that DC into variable-frequency power for the compressor.



POWER STAGE

Fuse, MOV and filter protect the input. The NTC limits the first rush of current into the capacitors, then a relay bypasses it. The bridge and the capacitors make the DC bus.

CONTROL STAGE

The SMPS powers the logic. The MCU reads sensors and current, talks to the indoor board and sends PWM signals that tell the IPM how fast to spin the compressor.

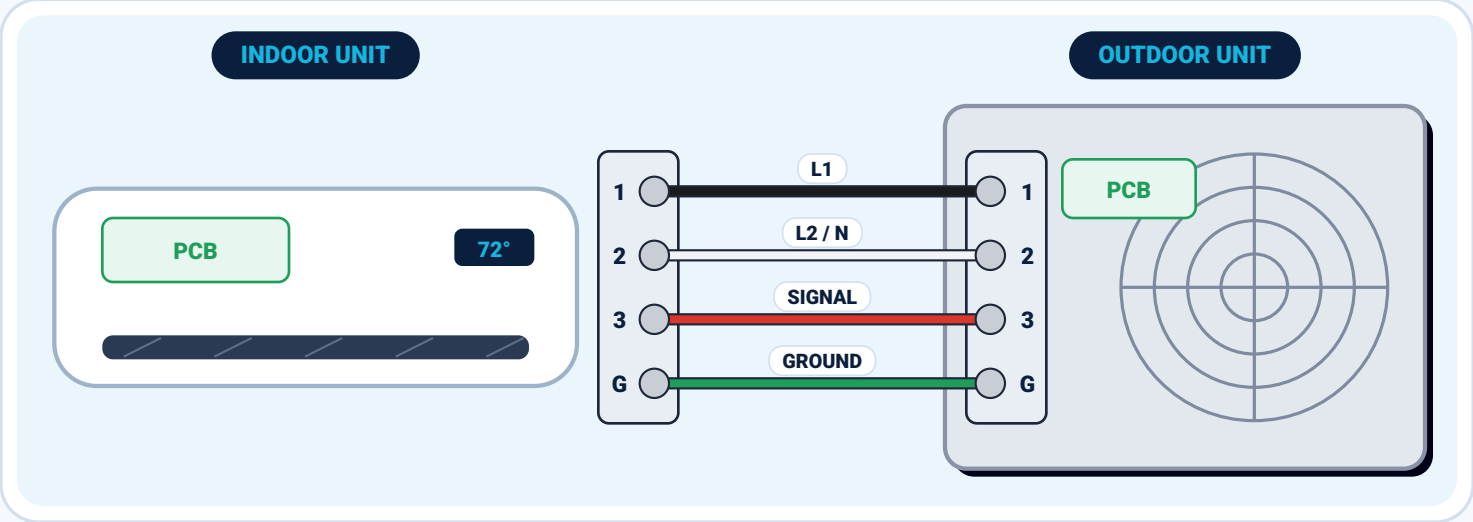
WHY IT MATTERS

Most dead boards fail in the power stage, and many 'board' codes start outside the board: sensors, wiring, fan motors, refrigerant. Test the system before you blame the board.

The DC bus stays charged after the power is off. It can hold 300+ V for minutes. Read the safety page before you touch the board.

INDOOR BOARD, OUTDOOR BOARD

Two boards share the job and talk over the interconnect cable. A wiring mistake here kills boards.



Power usually feeds the outdoor unit and reaches the indoor unit through 1 and 2. Some models are fed at the indoor unit: follow the unit's wiring diagram.

THE INDOOR BOARD

- Receives the remote (IR) or wall controller
- Reads room and indoor coil sensors
- Runs the indoor fan and louver motors
- Sends the order to the outdoor board

THE OUTDOOR BOARD

- Makes the DC bus and drives the compressor (IPM)
- Runs the outdoor fan, EEV and reversing valve
- Reads ambient, coil, discharge and IPM temps
- Stores most protection codes

CHECKING THE SIGNAL LINE

Set the meter to DC volts and measure between terminals 2 and 3 at the outdoor unit. A healthy line usually swings up and down; a steady 0 V or a value that never moves points to a dead sender or a wiring fault. The normal range changes by brand: check the service manual.

On many systems terminal 3 rides on line voltage. Never ground it, never jump it and never swap 1-2-3: putting 208/230 V on the signal terminal is one of the most common ways to burn both boards.

TOOLS FOR BOARD WORK

You do not need a lab. You need the right meters and a safe way to power up.

1

Multimeter, CAT III

DC volts on the bus, diode test, ohms, capacitance. True-RMS with LPF mode if you can.

2

Clamp meter

Compressor and fan amps, inrush current. A DC-capable clamp helps on DC fan motors.

3

ESR meter

Finds dried-out capacitors that still read OK on capacitance.

4

Discharge tool

A resistor with insulated probes to drain the DC bus. Never a screwdriver.

5

Series lamp (dim bulb)

An incandescent lamp in series with the board for the first power-up after a repair.

6

Insulation tester

Megohmmeter for compressor and fan motor windings to ground.

7

Soldering + desoldering

Temperature-controlled iron, solder sucker or desoldering gun, flux, wick.

8

Hot air + magnifier

For SMD parts and to spot cracked joints and burned traces.

9

ESD strap and mat

Static kills MCUs and drivers without leaving a mark.

10

Cleaning kit

99% isopropyl alcohol, soft brush, compressed air for dust, insects and corrosion.

Optional but useful: an inverter compressor checker (LED tester for the U-V-W outputs), a variac or isolation transformer, and a thermal camera to find hot parts.

SAFETY AND DC BUS DISCHARGE

The capacitors on the DC bus can hold a lethal charge long after the breaker is off.

1 POWER OFF, THEN WAIT

Open the disconnect, lock and tag it. Wait the time on the unit label (often several minutes) and watch the board LED go dark.

2 MEASURE THE BUS

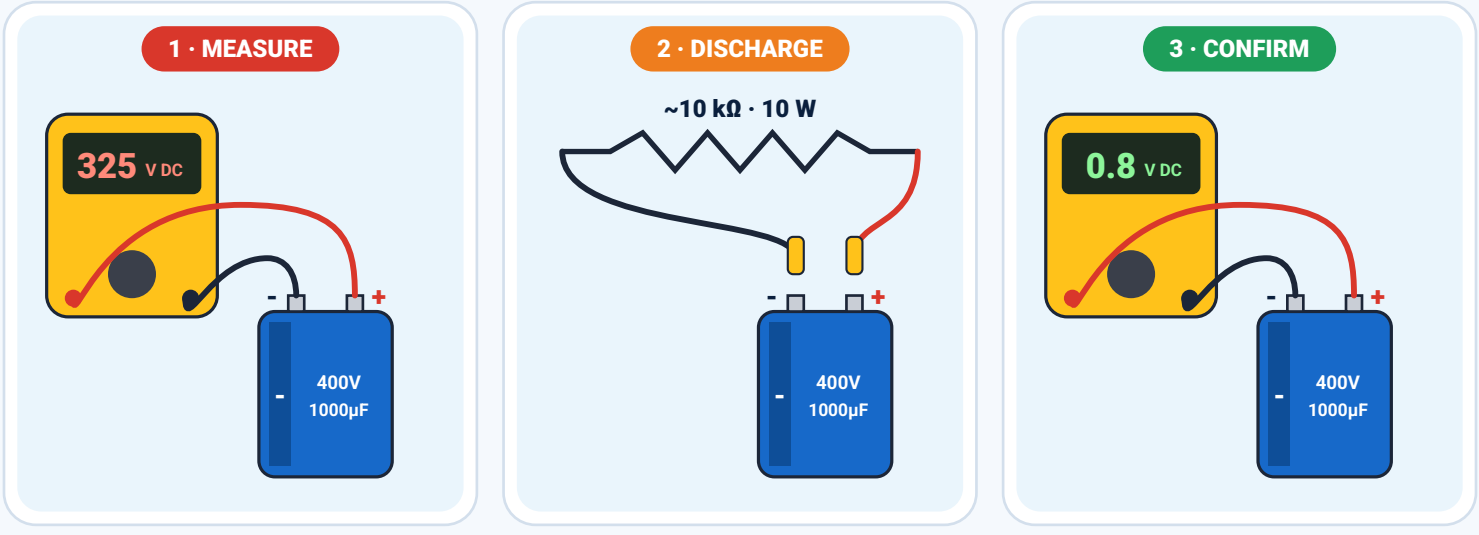
Meter on DC volts across the bus capacitor (+ and -, or P and N on the IPM). Touch nothing until it reads under 5 V DC.

3 DISCHARGE WITH A RESISTOR

Use a discharge tool: a resistor of about 10 kΩ, 10 W or bigger, with insulated probes. Hold it across + and -, then measure again.

4 STATIC, A2L AND EPA 608

Wear an ESD strap. R-32 and R-454B are mildly flammable: no soldering near a suspected leak. Opening the refrigerant circuit requires EPA 608 certification.



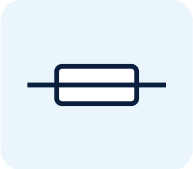
Never short the bus with a screwdriver. The arc can blow copper off the board, pit the terminals and take out the IPM or the bridge.

Study guide. The manufacturer's service manual, the NEC and local codes come first. Values shown are typical, not brand specs.

INPUT STAGE: 4 PARTS TO CHECK FIRST

Power off, bus discharged, readings taken with the board unplugged.

FUSE



JOB
Opens when something after it shorts.

TEST Ohms or continuity across the fuse.

GOOD Near 0 Ω.

BAD OL. Black or silvered glass means a hard short after it: find it before you power up.

MOV (VARISTOR)



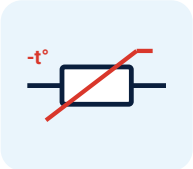
JOB
Clamps voltage spikes. Code 471 = 470 V.

TEST Look for cracks and soot. Measure ohms across it.

GOOD Very high resistance (OL).

BAD Cracked, burned or low ohms. A blown MOV often comes with a blown fuse after a surge.

INRUSH NTC



JOB
Limits the first rush into the bus caps. 5D-15 = 5 Ω cold.

TEST Ohms, cold, out of circuit or with one leg lifted.

GOOD Close to its marked value.

BAD OL (no DC bus) or cracked. A failed bypass relay makes it run hot.

BRIDGE RECTIFIER



JOB
Turns the AC into the DC bus.

TEST Diode test: ~ to + and - to ~, then reverse the leads.

GOOD About 0.4-0.7 V one way, OL the other, all 4 equal.

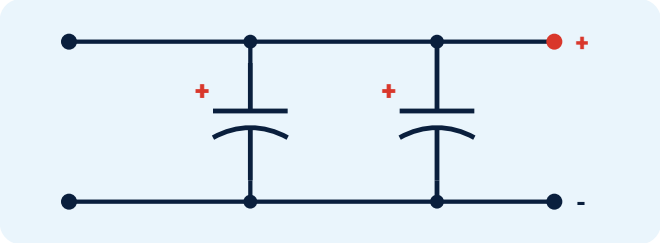
BAD Near 0 V both ways = shorted. OL both ways = open.

A blown main fuse is a symptom, not the fix. Before you replace it, check the MOV, the bridge, the IPM and the compressor windings to ground.

DC BUS CAPACITORS AND RELAY

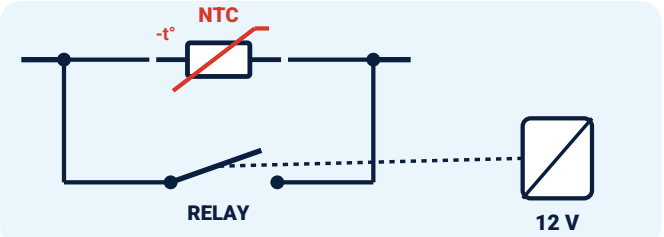
The bus capacitors smooth the DC. The relay takes the NTC out of the circuit once they are charged.

BUS CAPACITORS



- Look first: bulged top, leaks, brown residue on the board.
- Capacitance within about ±20% of the printed value (discharged, out of circuit).
- ESR: compare with a new part of the same value. High ESR = dried out.
- Replace with the same µF, same or higher voltage (usually 400-450 V), 105 °C.

INRUSH BYPASS RELAY



- Coil: usually 12 V DC, about 100-400 Ω on the meter.
- Contacts: open with the coil off, near 0 Ω when energized.
- Clicks but no bypass? Pitted contacts: the NTC runs hot and the bus sags under load.
- Bad relay signs: board resets when the compressor starts, burned NTC.

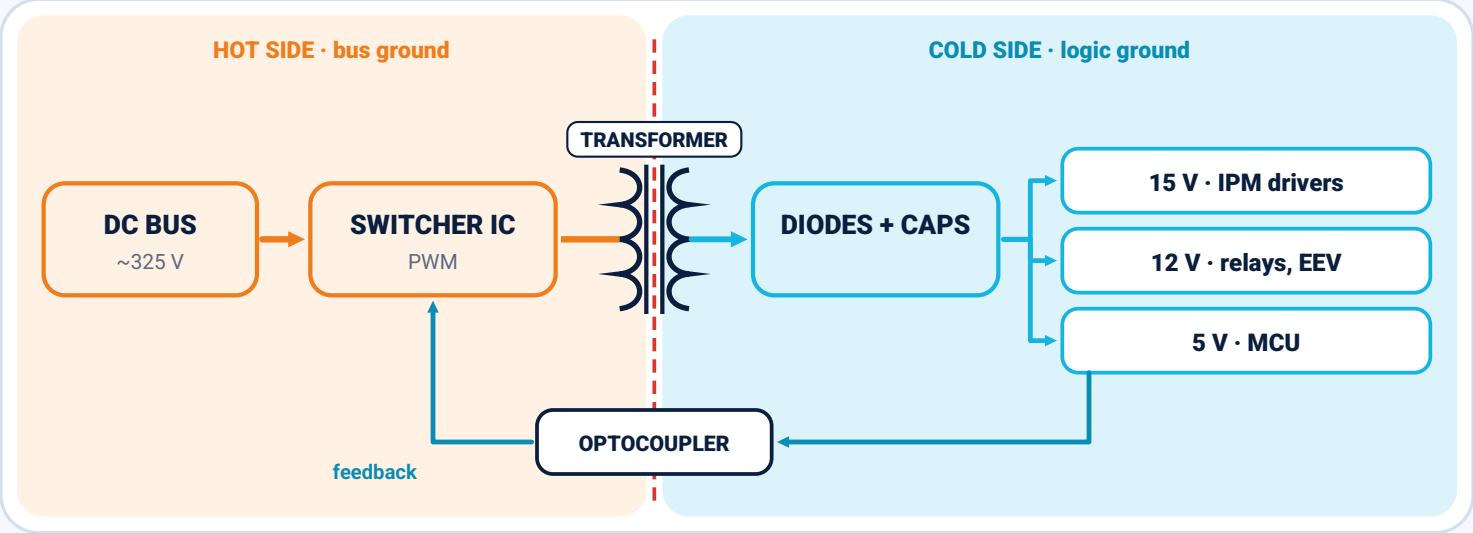
WHAT THE DC BUS SHOULD READ

SUPPLY	DC BUS (APPROX.)	NOTES
115 V unit	**~310-325 V**	Many use a voltage doubler
208 V	**~290-295 V**	About 1.41 × line voltage
230 V	**~320-325 V**	Most common US mini-split supply
240 V	**~335-340 V**	Higher if the line runs high
Active PFC running	**~360-400 V**	Boost stage on many outdoor boards

Bus low at idle: check the supply, NTC, relay and bridge. Bus fine at idle but dropping or rippling when the compressor runs: suspect the capacitors.

SWITCHING POWER SUPPLY (SMPS)

A small supply on the board turns the DC bus into the low voltages that run the logic.



HOW TO TEST IT

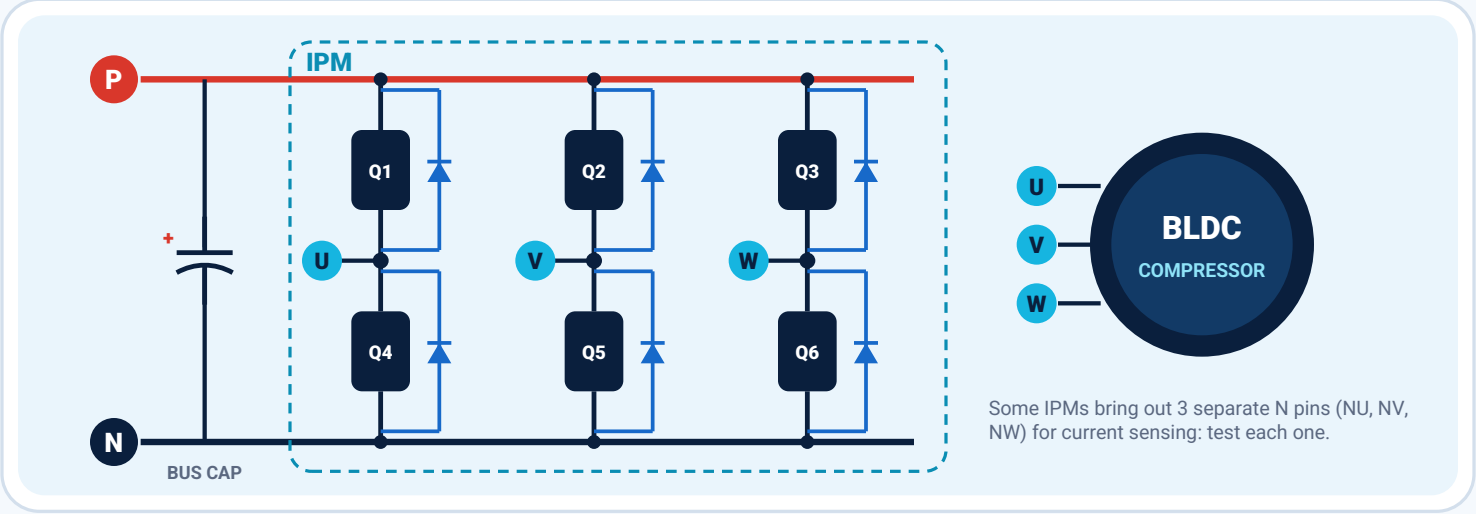
1. Bus present? If not, the problem is before the SMPS.
2. Measure each output to its own ground: hot side to bus minus, cold side to logic ground.
3. Rail at 0 V: look for a short on that rail with the power off (ohms to ground) before you blame the IC.
4. Rail low or unstable: check the ESR of the output caps and the 5 V regulator.

SYMPTOM	LIKELY CAUSE
Totally dead, bus OK	Startup resistor open, switcher IC, fusible resistor
Clicking, LED blinking, resets	Dried output caps, overloaded rail
One rail shorted	The load on that rail: driver IC, fan motor, EEV
5 V low or noisy	5 V regulator, its caps, a short on the MCU side
Rails OK, no display or comm	MCU, crystal, EEPROM, reset circuit

The hot side and the cold side have different grounds. Clip the black lead to the wrong one and the reading means nothing; on a scope it can be dangerous. Use an isolation transformer for scope work.

IPM AND COMPRESSOR TESTS

The IPM holds 6 IGBTs with diodes. A diode test tells you if it is shorted, not if it is perfect.



Some IPMs bring out 3 separate N pins (NU, NV, NW) for current sensing: test each one.

IPM DIODE TEST · unplugged, discharged, compressor leads off

RED (+)	BLACK (-)	EXPECTED
U, V, W	P	0.3-0.7 V, all 3 equal
N	U, V, W	0.3-0.7 V, all 3 equal
P	U, V, W	OL
U, V, W	N	OL
N	P	~2× one diode; may climb
P	N	OL (may climb as caps charge)

COMPRESSOR WINDINGS

Leads off the board. U-V, V-W and W-U should match each other, usually a few ohms or less. Zero the meter leads first. Megger each lead to the copper line: low megohms means a winding to ground, so fix that before any new board.

OUTPUT CHECK

With the compressor running, U-V, V-W and W-U voltages should be balanced. Use the meter's LPF mode: PWM fools normal readings. Unbalanced output with good windings points to the IPM or its drivers.

Shorted IPM? Find out why before you install a new one. A grounded compressor, no thermal paste, loose heatsink screws, a failed outdoor fan or a dirty coil will kill the next IPM too.

TEMPERATURE SENSORS (NTC)

Most mini-split sensors are NTC thermistors: resistance goes down as temperature goes up.

WHERE THEY ARE

1. **Room / return air**
   indoor unit, behind the filter
2. **Indoor coil**
   clipped to the evaporator tube
3. **Outdoor ambient**
   behind the outdoor coil
4. **Outdoor coil / defrost**
   on the condenser tubing
5. **Discharge**
   on the compressor discharge line
6. **IPM / heatsink**
   on or inside the IPM, some boards

TYPICAL RESISTANCE · example curve, B = 3950

°F	°C	10 kΩ SENSOR	5 kΩ SENSOR
32	0	**33.6 kΩ**	**16.8 kΩ**
41	5	**25.9 kΩ**	**13.0 kΩ**
50	10	**20.2 kΩ**	**10.1 kΩ**
59	15	**15.8 kΩ**	**7.9 kΩ**
68	20	**12.5 kΩ**	**6.3 kΩ**
77	25	**10.0 kΩ**	**5.0 kΩ**
86	30	**8.0 kΩ**	**4.0 kΩ**
95	35	**6.5 kΩ**	**3.3 kΩ**
104	40	**5.3 kΩ**	**2.7 kΩ**
122	50	**3.6 kΩ**	**1.8 kΩ**
140	60	**2.5 kΩ**	**1.2 kΩ**

HOW TO TEST IT

1. Unplug the sensor from the board and measure ohms at the plug.
2. Measure the real temperature at the sensor with a thermometer.
3. Compare with the chart in the service manual: within about 10% is usually fine.
4. OL = open sensor. Near 0 Ω = shorted. Both trigger a sensor code.

Curves change by brand. Discharge sensors are often 20 kΩ or 50 kΩ at 77 °F. This chart shows the shape and the order of magnitude: the service manual has the exact values.

FLOWCHARTS: NO POWER · TRIPS

Follow the boxes top to bottom. Discharge the bus every time you go to touch the board.

UNIT IS DEAD

1 208/230 V at outdoor terminals 1-2?
IF NOT: Breaker, disconnect, supply and interconnect wiring.

YES

2 Main fuse OK?
IF NOT: Find the short first: MOV, bridge, IPM, compressor to ground.

YES

3 DC bus present (~1.41 × line)?
IF NOT: Check the NTC, relay, bridge and bus capacitors.

YES

4 SMPS rails OK (15, 12, 5 V)?
IF NOT: Startup parts, switcher IC, shorted rail, output caps.

YES

5 Board LED or display alive?
IF NOT: MCU side: crystal, reset, EEPROM, connectors.

YES

ALL YES:
The board powers up: check the remote, display and control wiring.

POWERS UP, THEN TRIPS

1 Breaker holds when power is applied?
IF NOT: Hard short: bridge, MOV, IPM, or compressor or fan motor to ground.

YES

2 Windings balanced and megger OK?
IF NOT: Compressor fault: fix it before any board.

YES

3 IPM diode test OK?
IF NOT: Replace the IPM, and find out why it failed.

YES

4 Runs without shutting down?
IF NOT: Read the code and find its family on the error code page.

YES

5 Airflow, coils, fans and charge OK?
IF NOT: Overcurrent and high discharge temp often come from the system, not the board.

YES

ALL YES:
Look for loose connections and voltage drops that come and go; log the codes.

FLOWCHARTS: COMM ERROR - COMPRESSOR

Same rule: one test at a time, top to bottom, bus discharged before you touch the board.

COMMUNICATION ERROR

1 Interconnect 1-1, 2-2, 3-3, ground to ground?

IF NOT: Rewire to the diagram. Use the cable the manual asks for, no splices.

YES

2 208/230 V between 1 and 2 at the outdoor unit?

IF NOT: Power problem: breaker, disconnect, loose terminal.

YES

3 Signal swinging between 2 and 3?

IF NOT: Lift wire 3 and measure the indoor side: if it is dead, suspect the indoor board.

YES

4 Outdoor board powers up (LED, rails)?

IF NOT: Fix the outdoor power stage first: fuse, bus, SMPS.

YES

5 Talks after a full power reset (3+ min)?

IF NOT: Comm circuit on one board: optocouplers, comm fuse or resistor, or noise from a bad ground.

YES

ALL YES:

Check the cable for damage, moisture or splices; try a temporary run.

COMPRESSOR WILL NOT START

1 Calling for cool or heat, past the start delay?

IF NOT: Check mode and setpoint; wait out the 3-minute delay.

YES

2 DC bus normal and holding when it tries?

IF NOT: Bus caps, relay, supply voltage drop.

YES

3 Windings balanced and megger OK?

IF NOT: Compressor fault: replace or repair the compressor first.

YES

4 IPM diode test and outputs OK?

IF NOT: IPM or its drivers: repair or replace the board.

YES

5 Starts and keeps running?

IF NOT: Locked rotor, liquid in the compressor, EEV or refrigerant issue: EPA 608 work.

YES

ALL YES:

The compressor runs: log amps and pressures and watch for codes.

SAFETY FIRST
Discharge the DC bus

EPA 608
Refrigerant work

208/230 V · 60 Hz
US systems

vifalio.com
Free guide

ERROR CODES BY FAULT FAMILY

Every brand uses its own codes. Learn the families, then look up the exact code for that model.

FAMILY	WHAT THE BOARD IS SAYING	CHECK FIRST
Communication	Indoor and outdoor boards cannot hear each other.	Interconnect wiring, power at 1-2, signal at 2-3.
Temperature sensor	A sensor reads open or shorted.	Sensor ohms, plug, wiring, board input.
IPM / overcurrent	The IPM saw too much current or got too hot.	Compressor, fan, coil, IPM paste, IPM diode test.
Compressor drive	Start failure, lost rotor position, out of step.	Windings, outputs, DC bus, refrigerant or liquid.
DC bus voltage	Bus too high or too low.	Supply voltage, bus caps, relay, PFC stage.
Discharge / overheat	Compressor discharge is too hot.	Charge, EEV, airflow, discharge sensor.
Pressure / refrigerant	High or low pressure, low charge detected.	Fans, coils, EEV, leaks (EPA 608).
Fan motor	DC fan feedback missing or wrong speed.	Fan motor and its plug, then the fan driver.
EEPROM / memory	The board cannot read its stored data.	Chip, solder, wrong data on a new board.
Supply / current sensor	Bad input voltage or current reading.	Line voltage, connections, current sensor.

HOW TO PULL THE CODE

1. **Indoor display or LED blinks**
2. **Remote 'check' mode on many brands**
3. **Blinking LED on the outdoor board**
4. **Code history in the service menu or app**

A code tells you which protection tripped, not which part failed. Codes like E1 or P1 mean different things on each brand: the code table is in the service manual and often on a label inside the unit cover.

Write the code down before you reset power: many units clear the active code on a reset, and the code history is your best clue.

MISTAKES THAT KILL BOARDS

Most burned boards we see in the field started with one of these.

1. Interconnect miswired

1-2-3 swapped or a failing splice: line voltage on the signal circuit burns both boards. Check terminal by terminal.

2. Wrong supply voltage

208/230 V on a 115 V unit, or a lost neutral on a 115 V circuit. MOVs and fuses go first, then the rest.

3. Shorting the DC bus

A screwdriver across the caps, or a probe that slips between pins. Discharge with a resistor, use fine probes.

4. New board, bad compressor

A grounded or shorted compressor kills the new IPM in seconds. Megger and ohm the compressor first.

5. Skipping the DC fan motor

A shorted DC fan motor takes out the fan driver and sometimes the SMPS. Test the motor before the new board goes in.

6. Dry or loose IPM heatsink

No paste, old paste or loose screws: the IPM overheats and fails. Fresh paste, even torque.

7. Plugging in with power on

Hot-plugging fan, EEV or sensor connectors can destroy driver chips. Power off, discharge, then plug in.

8. Ignoring surges and water

No surge protection, ants, wasps and condensation on the outdoor board. Clean, seal and suggest a surge protector.

THE GOLDEN RULE

Before any new board goes in: compressor ohms and megger, fan motors, interconnect wiring and supply voltage. The old board died for a reason.

REPAIR OR REPLACE? WHAT TO CHARGE

Check the warranty first. Then decide by the damage, the cost and how much you trust the fix.

REPAIR THE BOARD WHEN

- The fault is clear: fuse + MOV after a surge, dried caps, relay, SMPS parts.
- No burned traces and no carbon under the IPM.
- The OEM board is discontinued, backordered or very expensive.
- You can load-test it before it goes back in the unit.

REPLACE THE BOARD WHEN

- The unit is under parts warranty: use the OEM process.
- The IPM exploded, traces are burned or the board is carbonized.
- Several sections failed, or the fault comes and goes.
- You cannot get the matching EEPROM data or settings.

PRICE RANGES · ESTIMATES (US, 2026)

JOB	TYPICAL RANGE	NOTE
Service call / diagnostic	**$90-$200**	Often credited toward the repair
Bench repair, simple parts	**$150-$350**	Fuse, MOV, NTC, relay, caps
Bench repair with IPM	**$250-$500**	IPM cost varies a lot by model
Mail-in board repair (your cost)	**$100-$300**	Plus shipping and downtime
OEM indoor board, part only	**$80-$300**	Depends on brand and model
OEM outdoor inverter board, part only	**$200-$800+**	Premium brands can go higher
Board replaced, installed	**$450-$1,500**	Part, labor, travel, warranty

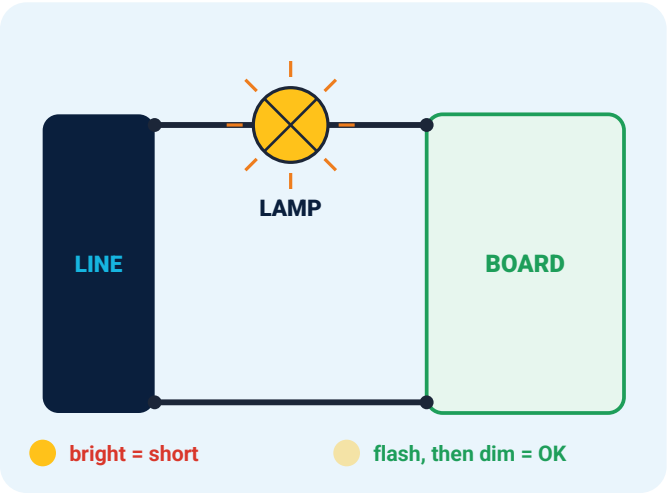
EXAMPLE QUOTE · illustration only

Parts $25 + 1.5 bench hours × $95 ($142.50) + 0.5 h load test ($47.50) = about $215 before tax. Use your own rate and market.

Estimates for planning only, not a quote. Prices change by region, brand and parts supply. Price bench work as parts + bench hours × your rate + test time, and back it with your own warranty (30 to 90 days is common).

BENCH CHECKLIST

Run it on every board, before it goes back on the wall.



FIRST POWER-UP: SERIES LAMP

Put an incandescent lamp in series with the board's supply for the first power-up after a repair. If there is a short, the lamp glows bright and stays bright, and the lamp takes the hit instead of the board. Normal: a quick flash while the caps charge, then dim.

For a 208/230 V board, use a lamp rated for that voltage, or two 120 V lamps in series. Do not try to run the compressor through the lamp.

- ☐ Bus discharged and measured before every touch.
- ☐ Every replaced part matches the original rating.
- ☐ No solder bridges, flux cleaned, joints shiny.
- ☐ Diode test on bridge and IPM after repair.
- ☐ First power-up through a series lamp.
- ☐ DC bus and all SMPS rails steady.
- ☐ Fresh thermal paste, IPM screws even and tight.
- ☐ Fan motors and compressor tested first.
- ☐ Connectors seated, interconnect checked 1-2-3.
- ☐ Full cycle run, no codes, amps logged.

SAFETY FIRST
Discharge the DC bus

EPA 608
Refrigerant work

208/230 V · 60 Hz
US systems

vifalio.com
Free guide

NEXT STEPS

1. Print the flowcharts and keep them in the van.
2. Build your discharge tool and series lamp this week.
3. Download the service manuals for the brands you see most.
4. Start a log: model, code, failed part, fix.
5. Practice on a dead board before a customer's board.

Found this guide useful? Share it with another tech.

vifalio.com

More free guides for HVAC and electrical techs