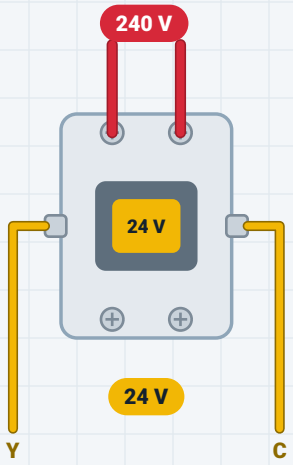
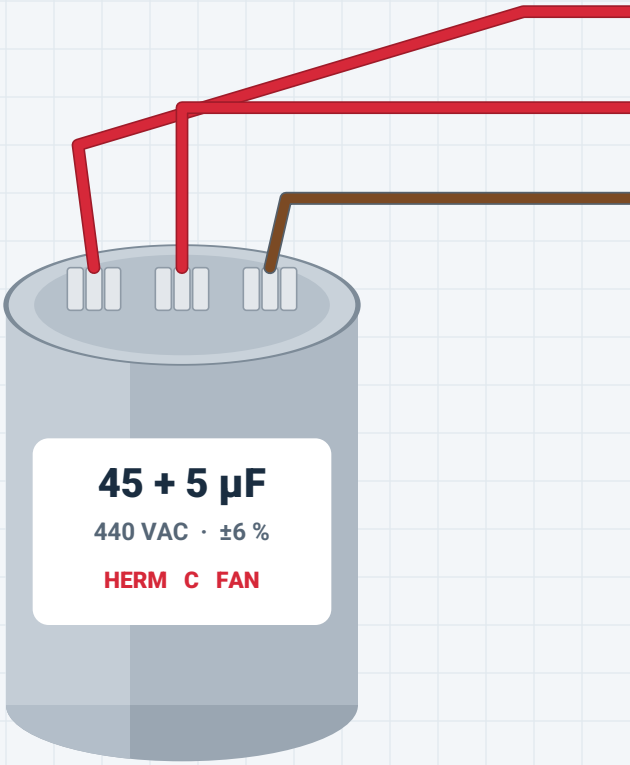
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FREE GUIDE FOR HVAC TECHS & HELPERS

AC DEAD? DON'T GUESS. MEASURE IT.





HVAC ELECTRICAL MAP & TROUBLESHOOTING

Find the electrical fault in a split AC, a gas furnace with AC or a heat pump: what to measure, where, and what the reading means.

- 240 V vs 24 V map, drawn in color
- Capacitor, contactor, compressor tests
- Furnace board, defrost, safety switches
- 15 symptoms + 2 flowcharts
- Checklist + printable reading sheet



HOW TO USE + SAFETY FIRST

Red is line voltage (120/240 V). Yellow is 24 V control. Green is ground. Same colors on every page.

1 LEARN THE MAP

Page 3: where the power comes in and where the 24 V goes. Symbols on page 4.

2 TEST PART BY PART

Pages 5 to 13: what to measure on each part and the reading you should see.

3 FOLLOW THE ROUTE

Symptoms (p. 14), flowcharts (p. 15), checklist (p. 17) and reading sheet (p. 18).

LOCK OUT, TAG OUT, TEST, DISCHARGE

1 SHUT OFF

Breaker off AND outdoor disconnect pulled. Indoor and outdoor units have separate circuits.

2 LOCK + TAG

Your lock and tag on the breaker or disconnect, so nobody turns it back on while you work.

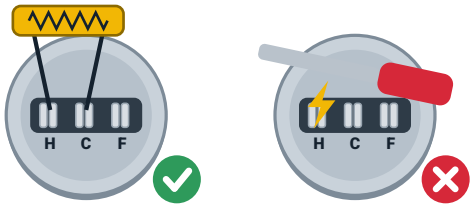
3 TEST DEAD

Check the meter on a live source, then L1-L2, L1-ground, L2-ground. Read 0 V before touching.

4 DISCHARGE

Capacitors hold a charge. Use a resistor tool on insulated leads, never a screwdriver.

DISCHARGING A CAPACITOR



RESISTOR TOOL — NEVER A DEAD SHORT

Hold the resistor across HERM-C and FAN-C, then confirm 0 V. Follow the maker: Goodman calls for a 20-30 Ω resistor.

WHAT'S INSIDE

3 The map: 240 V power, 24 V control
4 20 HVAC diagram symbols
5 24 V transformer and board fuse
6 Contactor: coil and contacts
7 Dual run capacitor: C, HERM, FAN
8 Compressor: C, S, R and ohms
9 Condenser fan motor: PSC vs ECM
10 Blower motor and fan relay
11 Furnace / air handler board
12 Heat pump: valve and defrost
13 Pressure switches and float switch
14 15 symptoms: where to measure
15 Flowcharts: no start, no cooling
16 10 mistakes that waste parts
17 Electrical service checklist
18 Printable reading sheet
19 Final word and sources

240 V + 24 V — Two circuits, two colors

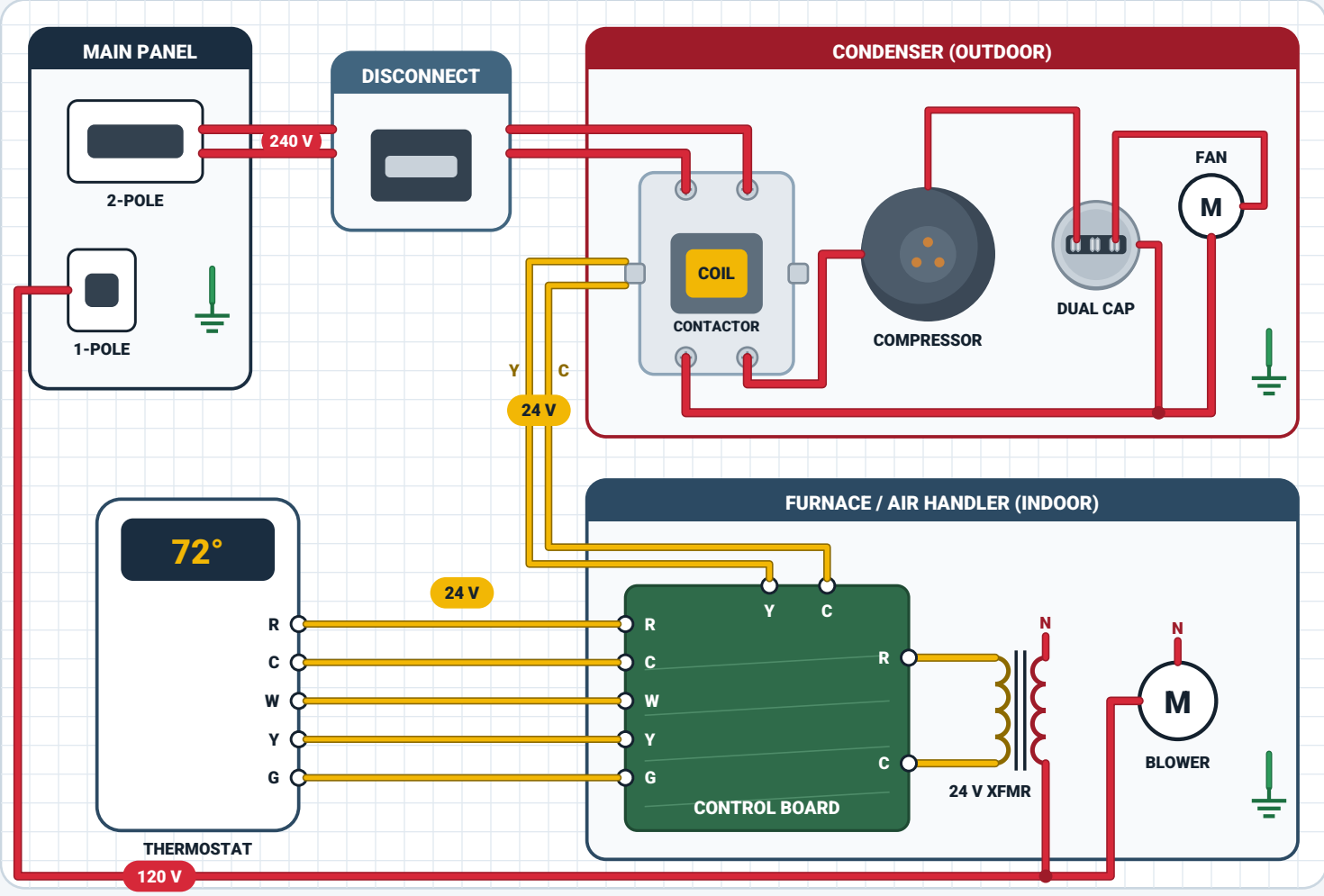
20 SYMBOLS — Drawn and explained

REAL VALUES — µF, ohms, psig, volts

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THE MAP: 240 V POWER, 24 V CONTROL

Every system has two circuits. The 24 V side gives the orders; the 240 V side does the work.



THE POWER PATH

Panel breaker, outdoor disconnect, contactor, then compressor and fan. Indoors, a separate 120 V (gas furnace) or 240 V (air handler) circuit feeds the transformer and blower.

THE CONTROL PATH

The transformer makes 24 V for R and C on the board. The thermostat closes R to Y, G or W. Y and C run outside to the contactor coil.

THE GOLDEN RULE

24 V pulls in the contactor; the contactor closes the 240 V. No 24 V at the coil? The fault is on the control side, not in the compressor.

Thermostat terminals (R, C, W, Y, G, O/B) are covered in the Vifalio thermostat wiring guide. Mini-splits with inverter boards: see the Vifalio inverter board guide.

240 V + 24 V
Two circuits, two colors

20 SYMBOLS
Drawn and explained

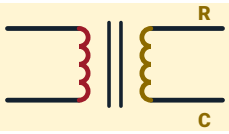
REAL VALUES
µF, ohms, psig, volts

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20 HVAC WIRING DIAGRAM SYMBOLS

The unit's diagram is glued inside the panel cover. Brands draw them a little differently; the idea is the same.

01



Transformer

Line voltage in, 24 V out (R and C).

02



Contactor coil

24 V coil (CC). Pulls the contacts closed.

03



Contact, normally open

Open at rest. Closes when its coil is on.

04



Contact, normally closed

Closed at rest. Opens when its coil is on.

05



Fuse

Opens on a short. Board fuse: 3 A or 5 A.

06



Breaker

Opens on overload. Reset only after testing.

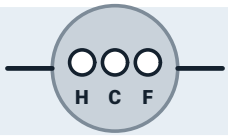
07



Capacitor

Run or start capacitor, rated in µF and volts.

08



Dual capacitor

One can, two capacitors: C, HERM, FAN.

09



Compressor

Three terminals: C, S and R.

10



Motor

Condenser fan or blower, PSC or ECM.

11



Heater element

Electric heat strip in the air handler.

12



Thermistor

Sensor: resistance changes with temperature.

13



Pressure switch

Opens on high or low refrigerant pressure.

14



Temperature switch

Limit, rollout or defrost thermostat.

15



Float switch

Opens when condensate water rises.

16



Relay

Small coil switches a separate contact.

17



Solenoid coil

Reversing valve or gas valve coil.

18



Ground

Bonded to the cabinet and the panel ground.

19

Factory vs field wiring

Solid = factory. Dashed = installer.

20



Splice vs crossing

Dot = joined. No dot = only crossing.

240 V + 24 V
Two circuits, two colors

20 SYMBOLS
Drawn and explained

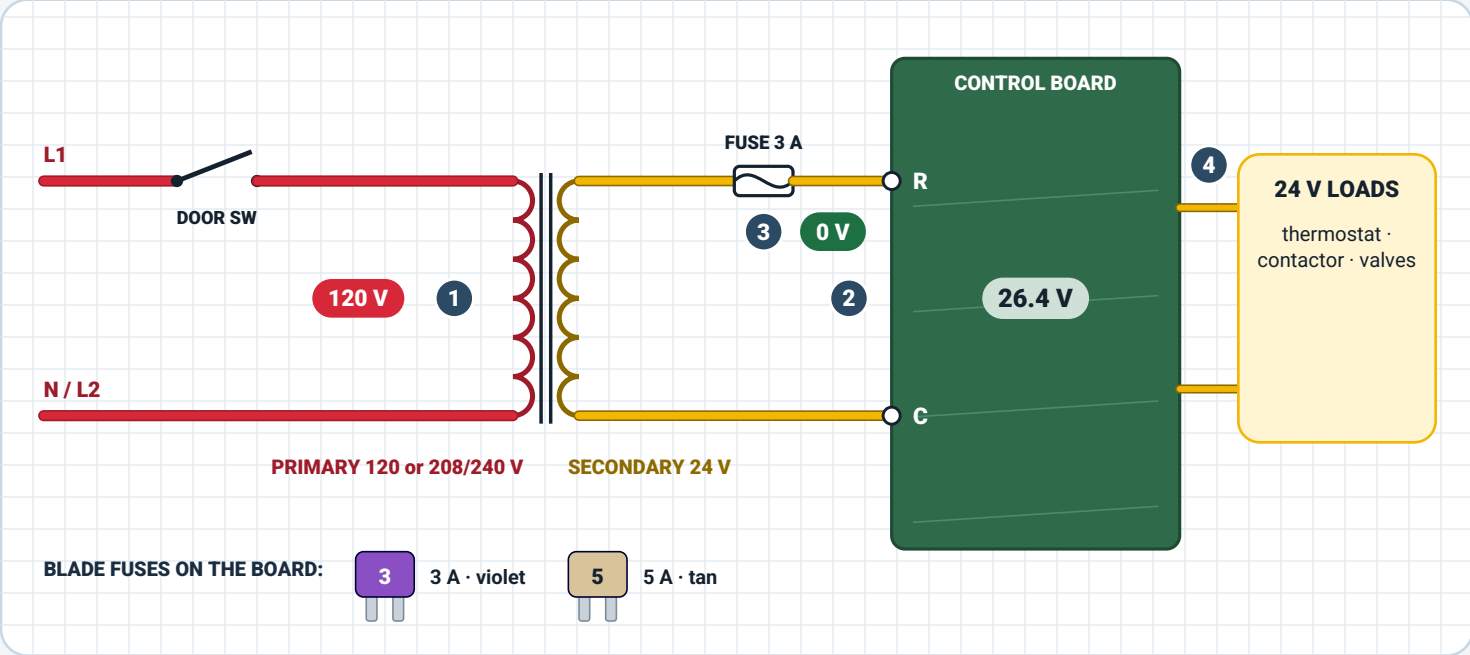
REAL VALUES
µF, ohms, psig, volts

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Training guide with typical values. Follow the unit's wiring diagram, the manufacturer's instructions, the NEC and local code. Lock out power first.

24 V TRANSFORMER + BOARD FUSE

No 24 V means no thermostat, no contactor, no nothing. Start here when the whole system is dead.



HOW IT WORKS

- The transformer steps line voltage down to 24 VAC. A common size is 40 VA: 40 ÷ 24 = about 1.67 A of 24 V current.
- The blade fuse on the board (3 A violet or 5 A tan) protects the transformer and the board from a short in the 24 V wiring.
- Gas furnaces have a door switch in the 120 V feed. Panel off = board dead. Hold it in only while you test.

TEST POINTS

1. Primary: 120 V on a gas furnace, 208/240 V on an air handler. No volts: breaker, service switch or door switch.
2. Secondary R to C: about 24 to 28 V. Under about 20 V with the loads on = overloaded or failing transformer.
3. Across the fuse, power on: 0 V = good fuse. 24 V across it = the fuse is open.
4. Fuse blown? Find the short first: Y or R rubbing on C or on metal, often at the outdoor unit.

TRANSFORMER MATH

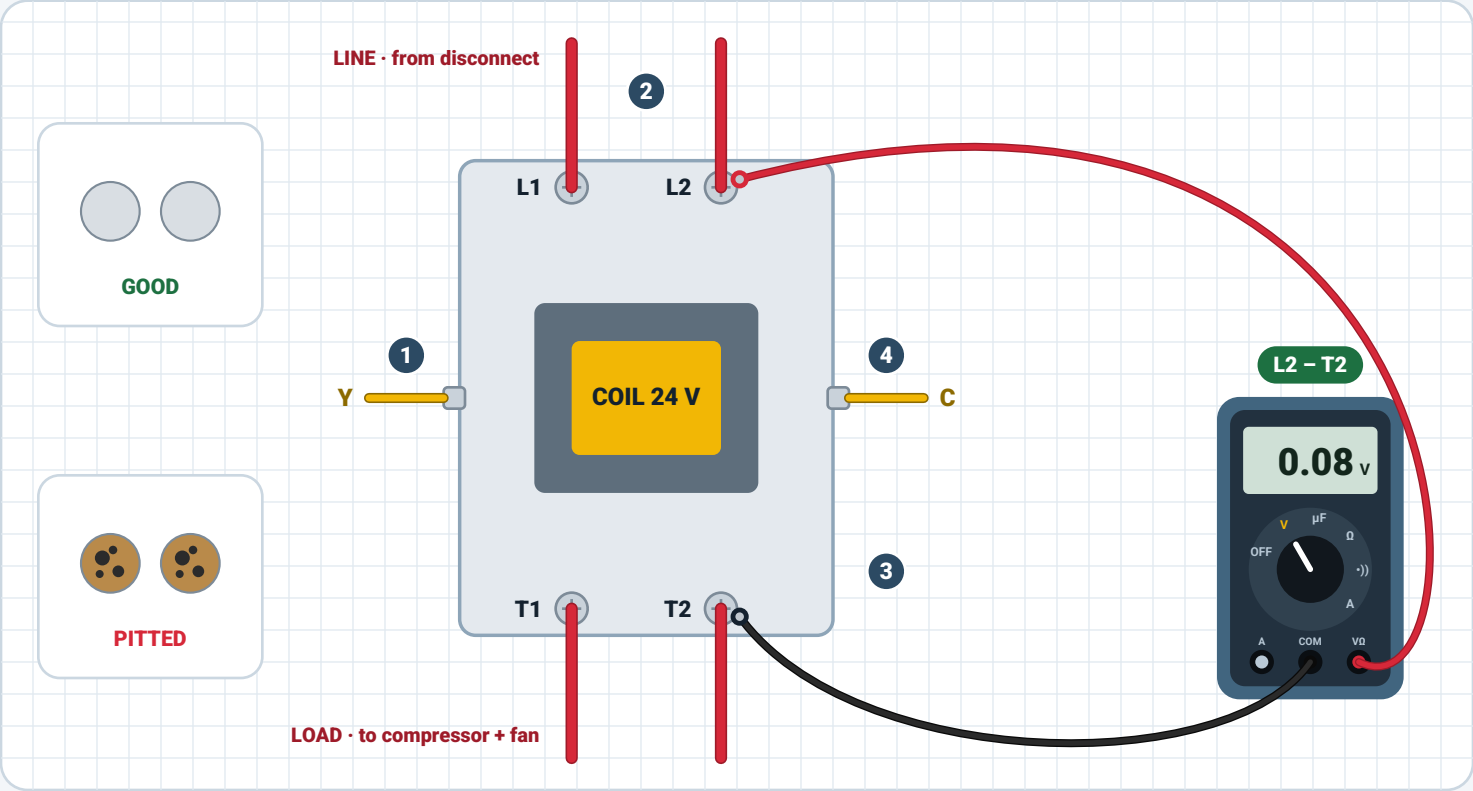
40 VA ÷ 24 V ≈ 1.67 A

That is the most the 24 V side can feed. Add up the loads: contactor, gas valve, relays, thermostat. Near the limit = weak 24 V and blown fuses. Replace with the same or higher VA.

Never install a bigger fuse and never jumper it. A fuse that blows again is pointing at the short.

CONTACTOR: 24 V COIL, 240 V CONTACTS

The thermostat's Y call reaches the coil, the coil pulls the contacts closed, and the compressor and fan get 240 V.



WHAT TO MEASURE

1. Coil: 24 to 28 V across its two terminals when the thermostat calls. No volts = the problem is upstream (board, wire, switches).
2. Line side L1 to L2: 208 to 240 V. Load side T1 to T2 must read the same with the contactor pulled in.
3. Across one pole under load (L1 to T1, or L2 to T2): close to 0 V. A volt or more = burned contacts.
4. Coil ohms, wires off: low ohms (a few to a few dozen). OL = open coil. 0 Ω = shorted coil.

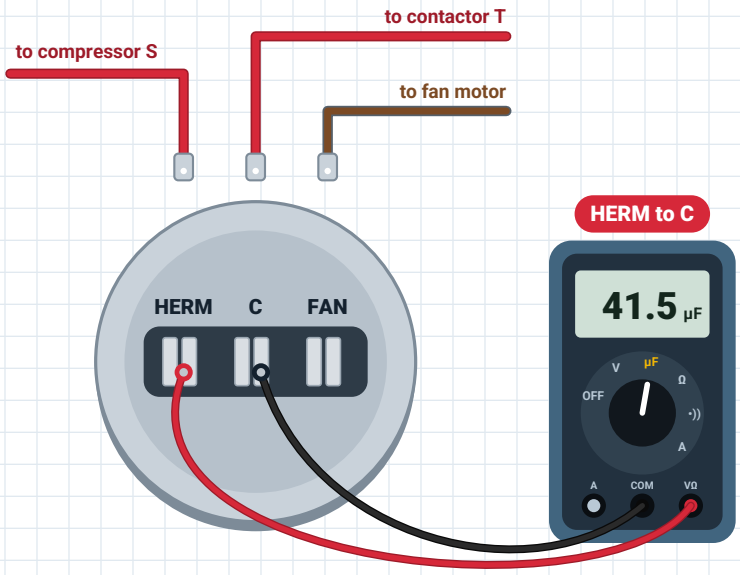
REPLACE IT WHEN

- Contacts are pitted, burned or welded shut (the compressor won't stop).
- The coil is open, buzzes loud or chatters with good 24 V.
- The plunger sticks, or ants and dirt keep it from closing.
- Volts across a closed pole under load. Replace it; don't file the contacts.

Live test: with the access panel off, 240 V is exposed on L1, L2, T1 and T2. Use a CAT III meter, insulated probes and gloves, and keep your other hand off the cabinet.

DUAL RUN CAPACITOR: C, HERM, FAN

The most replaced part on a residential AC. Test it with a meter, not with your eyes.



UNDER-LOAD TEST (running)

µF = start amps × 2,652 ÷ volts across the cap

6.4 A × 2,652 ÷ 377 V = 45.0 µF

Clamp the start wire (HERM to S). The volts across HERM-C read higher than the line, here 377 V on a 240 V line: that is normal.

BENCH TEST (power off)

1. Lock out, discharge, take a photo and pull the wires.
2. Meter on µF: HERM to C, then FAN to C.
3. Compare each reading with the label and its tolerance (often ±5 % or ±6 %).
4. Replace any can that is bulged on top or leaking oil.

EXAMPLE: 45/5 µF CAPACITOR, ±6 %

Section	Label	Allowed range	Reading	Result
HERM-C	45 µF	42.3 – 47.7 µF	41.5 µF	REPLACE
FAN-C	5 µF	4.7 – 5.3 µF	4.9 µF	OK

REPLACEMENT RULES

- Same µF on each section. Never 'close enough'.
- Same or higher voltage: 440 V can replace 370 V, never the other way.
- Two single caps can replace a dual: both C terminals go to the same line.
- No under-load test on blower caps: spinning wheel, loose leads.

START CAP / HARD-START KIT

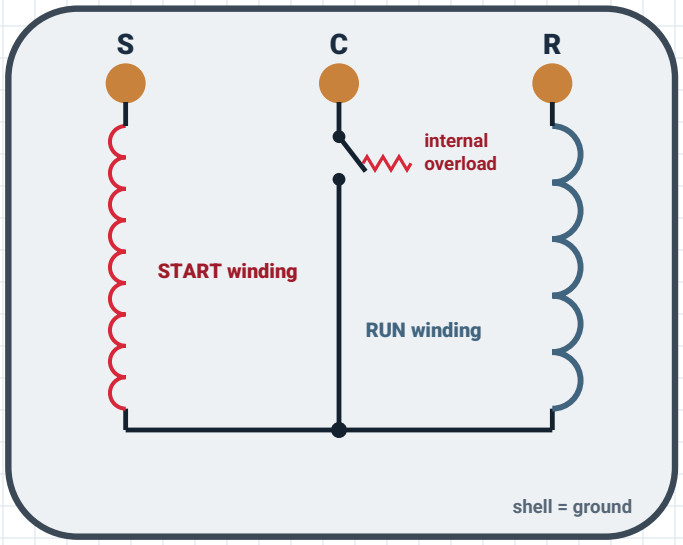
Rated as a range, for example 108-130 µF. It helps only for a second at startup. Same µF test: the reading must fall inside the range.

BLEED RESISTOR

Some capacitors carry a resistor across the terminals (Goodman lists 15,000 Ω, 2 W) that drains them. Burned or missing? Discharge it yourself before you touch it.

COMPRESSOR: C, S, R AND THE OHMS RULE

Three resistance readings tell you if the motor is good. The two small ones always add up to the big one.



EXAMPLE · wires off, compressor cool



0.8 + 2.1 = 2.9 Ω · C-R + C-S = S-R

Reading	What it means
C-R and C-S open, S-R reads normal	Internal overload open (hot). Let it cool 3 to 4 hours and retest before you condemn it.
One winding open, compressor cool	Open winding: the compressor is bad.
Any terminal to ground reads ohms	Grounded winding. Don't restart it. Confirm with a megohmmeter.
A winding far below the others or 0 Ω	Shorted winding. Compare with the manufacturer's published values.
Windings OK, but it hums and trips	Check the capacitor, the contactor and the voltage at startup first.

NO LABEL ON THE TERMINALS?

1. Measure all three pairs.
2. The highest pair is S and R; the one left over is C.
3. From C, the lower reading goes to R, the higher to S.

Never run a compressor with the terminal cover off. A shorted terminal can blow out hot oil and fire (terminal venting). Reset a breaker only after electrical testing.

GROUND TEST

Each terminal to the shell or the copper line: OL is good. Any ohms reading = grounded winding, and the compressor is done. Many techs confirm with a megohmmeter.

VOLTS AT STARTUP

Measure L1-L2 at the contactor while it starts. It must stay inside the nameplate range (often 187-253 V on 208/230 V units).

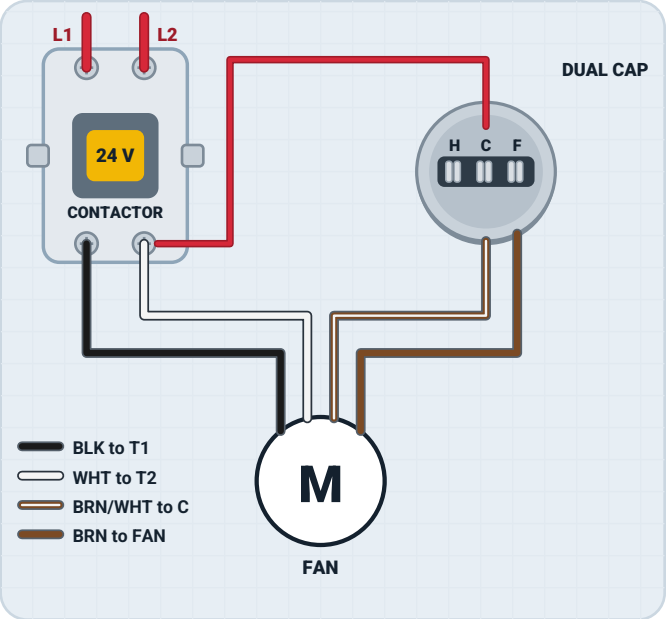
AMPS vs RLA / LRA

Running amps at or under RLA. Amps near LRA and no start = locked compressor or a weak capacitor or start boost.

CONDENSER FAN MOTOR: PSC vs ECM

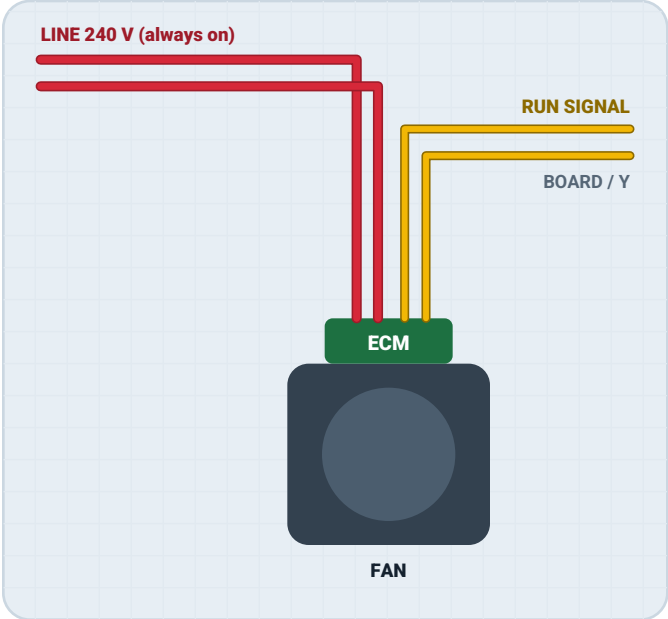
If the fan stops, head pressure climbs and the compressor trips on its overload or on the high-pressure switch.

PSC MOTOR · most common



- Gets 240 V from the contactor and uses the FAN section of the run capacitor.
- Typical leads: one to each line (T1, T2) and two to the capacitor (FAN and C). Colors vary: follow the motor label.
- Test: capacitor µF, amps vs nameplate FLA, ohms between leads, shaft spins freely with power off.
- Hums, won't start, or starts after a push = test the FAN capacitor first.

ECM MOTOR · high-efficiency units



- Brushless DC motor with its own electronics. No run capacitor.
- Line voltage is there all the time; a separate signal (24 V or from a board) tells it to run.
- Line voltage + signal present + motor stopped = bad motor or module.
- Signal missing = look upstream: board, wiring, thermostat call.

REPLACING A CONDENSER FAN MOTOR? MATCH ALL SIX

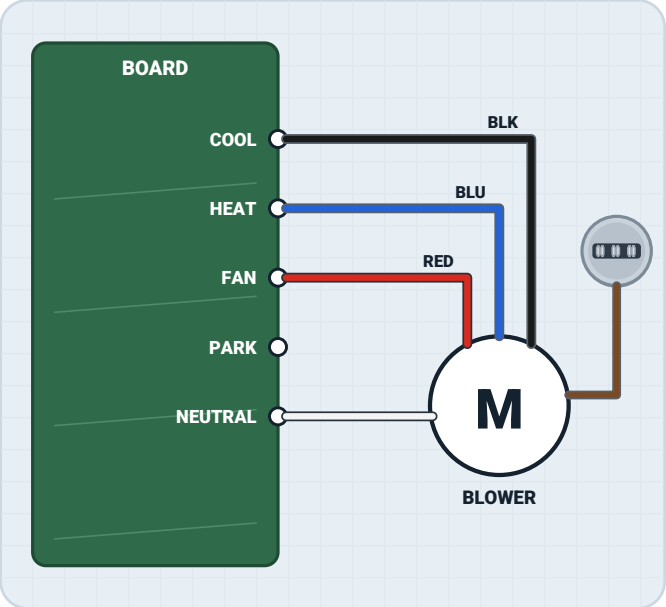
- HP
- RPM
- Rotation
- Voltage
- Cap µF
- Frame + shaft

The fan should start every time the compressor does. Watch both at startup: a fan that lags, runs slow or turns backward is a clue.

BLOWER MOTOR + FAN RELAY

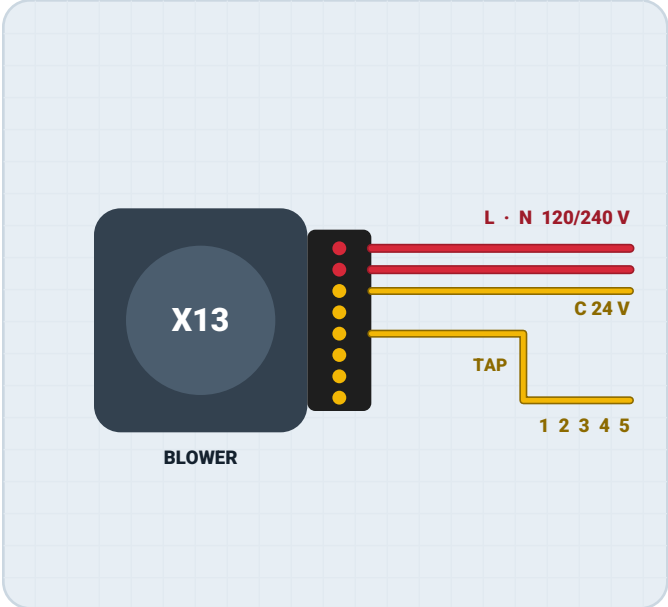
Indoor airflow. Without it the coil freezes in cooling and the furnace trips its high limit in heating.

PSC BLOWER WITH SPEED TAPS

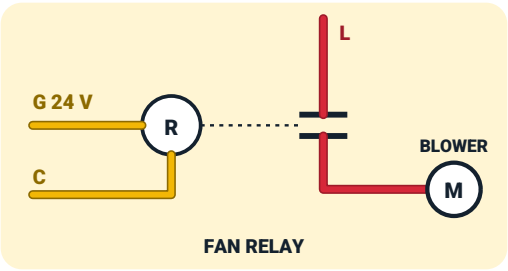


- One speed wire is powered at a time: the board picks the COOL, HEAT or FAN tap. Unused taps sit on PARK (dead) terminals.
- Common tap colors: black high, blue medium, red low, white neutral. Always check the motor label.
- Run capacitor usually 5 to 10 µF, 370 V. A weak cap = slow, hot motor.
- Test: volts from the active tap to neutral, amps vs FLA, capacitor µF.

ECM / X13 · constant torque



- Line voltage (120 or 240 V) on L and N all the time.
- 24 V from C to one tap (1 to 5) picks the speed.
- Line voltage on L-N and 24 V on a tap, but no run = bad motor.
- Variable-speed ECMs use a 16-pin plug: follow the brand's chart.



THE FAN RELAY ON THE BOARD

Thermostat G powers the fan relay coil (24 V). Its contact sends line voltage to the blower tap. G at the board and no blower? Measure the relay output before you buy a motor.

240 V + 24 V
Two circuits, two colors

20 SYMBOLS
Drawn and explained

REAL VALUES
µF, ohms, psig, volts

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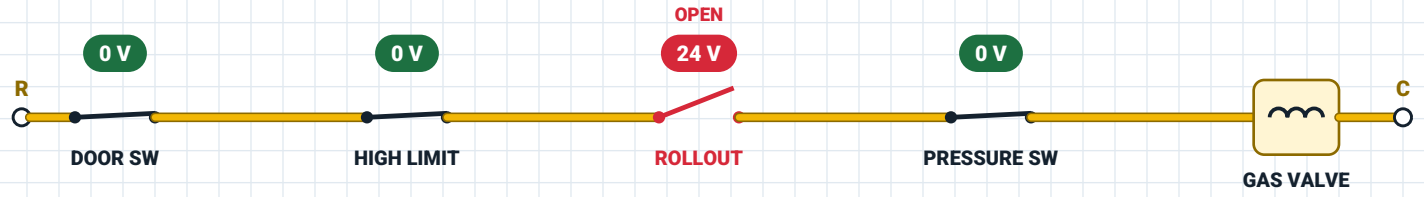
FURNACE / AIR HANDLER BOARD

The board runs a fixed sequence. Know it and you know which step failed.

CALL	INDUCER	PRESSURE SW	IGNITER	GAS VALVE	FLAME	BLOWER
1	2	3	4	5	6	7
R closes to W	draft fan starts	proves draft	warm-up, ~15-20 s	24 V opens it	proved in seconds	on after a delay

THE 24 V SAFETY CHAIN

Switches in series. Power on: the OPEN one reads 24 V across its terminals; the closed ones read 0 V.



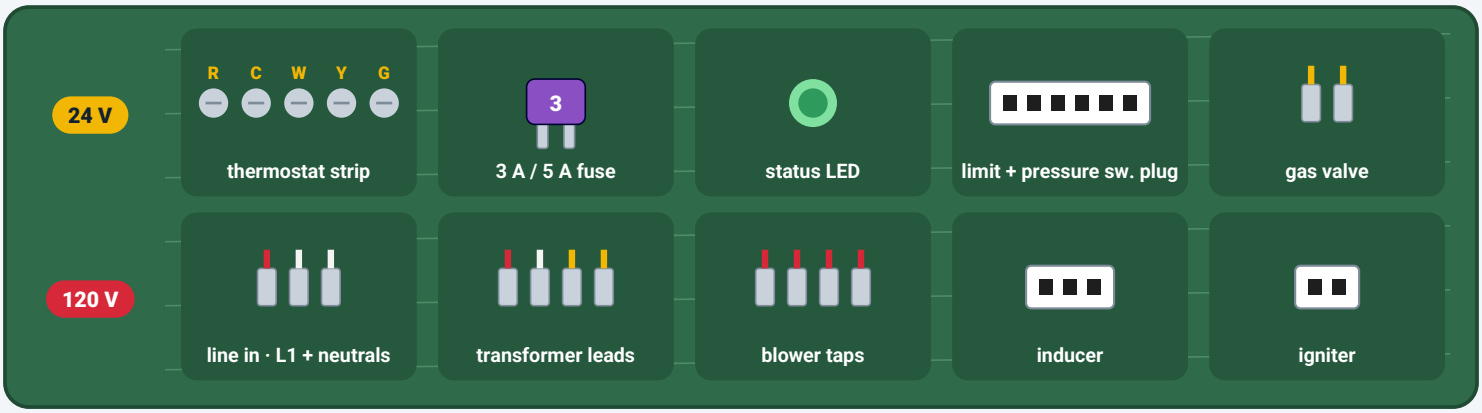
LED DIAGNOSTIC (generic)

- **Steady or slow blink**
  Normal standby on most boards.
- **Off**
  No 24 V: fuse, transformer, door switch, breaker.
- **Flash code**
  Count the flashes, read the door label. Codes differ by brand.

LIMIT, ROLLOUT, FLAME SENSOR

- High limit opens on overheating (dirty filter, weak blower) and resets by itself.
- Rollout opens when flame rolls out of the burner area. Most are manual reset: find the cause (blocked flue, cracked heat exchanger) first.
- Flame sense reads in µA DC. Check the minimum on the board data (one Bryant board: 0.5 µA). Low: clean the rod, check the ground.

WHAT YOU FIND ON A TYPICAL FURNACE BOARD



240 V + 24 V
Two circuits, two colors

20 SYMBOLS
Drawn and explained

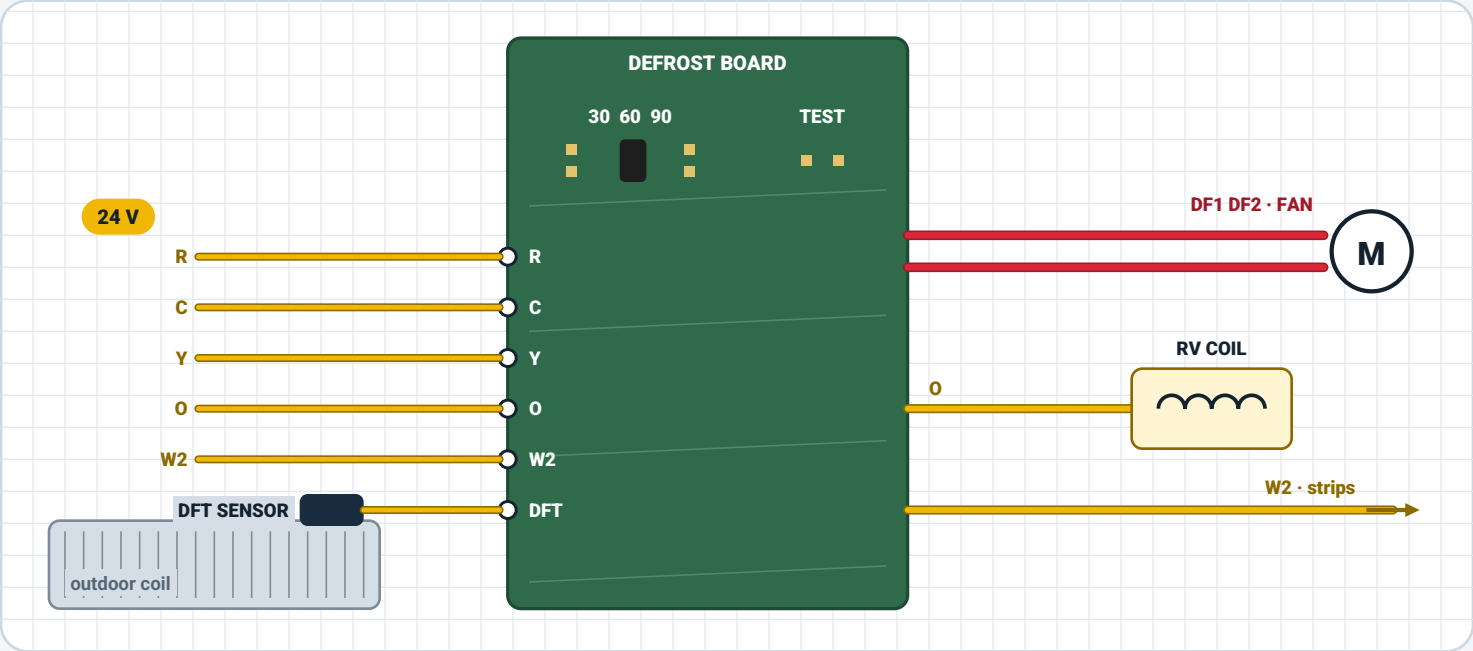
REAL VALUES
µF, ohms, psig, volts

vifalio.com
Free guide

Training guide with typical values. Follow the unit's wiring diagram, the manufacturer's instructions, the NEC and local code. Lock out power first.

HEAT PUMP: REVERSING VALVE + DEFROST

The same compressor heats and cools. A 24 V coil on the reversing valve decides which way the refrigerant flows.



O OR B?

O energizes the valve in cooling (most brands). B energizes it in heating (Rheem/Ruud). Wrong setting = cold air in heat mode. Thermostat setup: see the Vifalio thermostat guide.

REVERSING VALVE COIL

- In the energized mode: 24 V at the coil. No volts = O/B setting, wiring or defrost board.
- 24 V present, coil OK, valve won't shift = stuck valve (refrigeration repair).
- Coil reads OL = replace the coil only.

DEFROST BOARD (time + temperature)

- Interval pins: 30, 60 or 90 min of compressor run time.
- The coil sensor closes when cold (one brand: 34 ± 5 °F) and opens when warm (60 ± 5 °F).
- In defrost: valve shifts to cooling, outdoor fan stops, W2 turns on the strips to temper the air.
- Defrost ends when the sensor opens or a maximum time runs out (often about 10 to 14 min).

QUICK DEFROST TEST

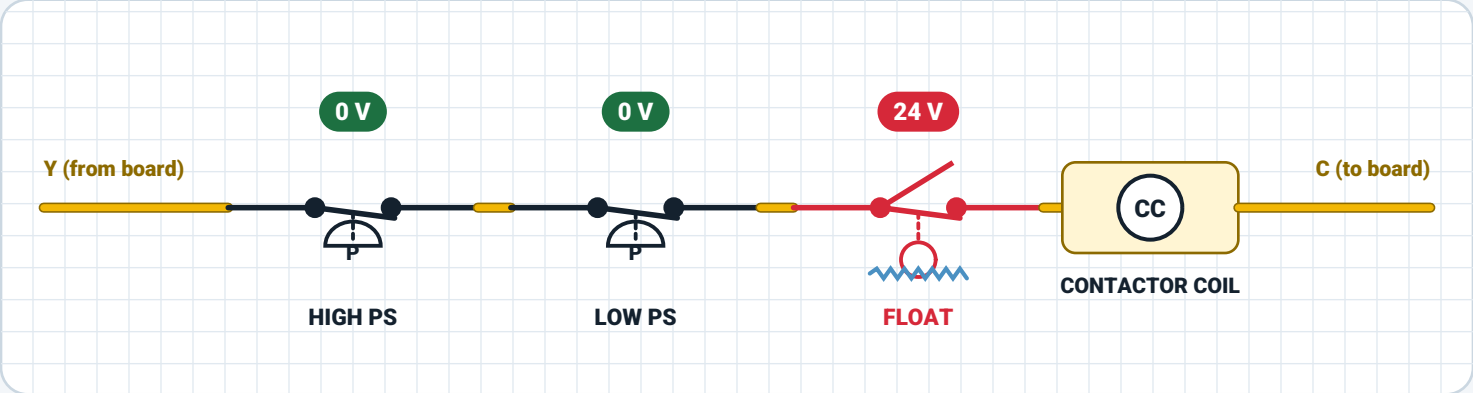
Heat calling, sensor jumpered as cold (DFT to R on many boards), then short the TEST pins. Within seconds: 24 V on O, fan off, 24 V on W2. Pull the test jumper right away. Steps vary by brand.

AUX HEAT STRIPS

Each element has a limit (one brand: opens about 150-160 °F, closes about 110 °F). Measure amps per element; ohms with power off. Never wire around a limit.

PRESSURE SWITCHES + FLOAT SWITCH

Safety switches sit in series with the 24 V that feeds the contactor coil. One opens, the compressor stops.



Switch	Opens (example values)	Resets	Common causes
High pressure (R-410A)	About 610 ± 10 psig (Goodman). Max cut-out 650 psig (one Copeland family).	Auto or manual	Dirty condenser coil, dead fan motor, overcharge, air in the system
Low pressure / loss of charge	About 50 psig, closes ~95 psig (Goodman HP). Copeland: AC cut-out not below 55 psig.	Auto; some boards lock out	Low charge, frozen coil, low airflow, restriction
Float switch (condensate)	Opens when water rises in the pan or the trap.	Auto, when the water drains	Clogged drain line or trap, failed condensate pump

HOW TO TEST

1. Power on, Y calling: measure across each switch. 0 V = closed. 24 V = that one is open.
2. Power off, wires off: continuity across the switch at normal pressure = closed.
3. Switch open? Find the cause (gauges, coil, drain) before you replace the switch.
4. Never jumper a safety switch and leave it like that.

WHERE YOU FIND THEM

HIGH PRESSURE

Outdoor unit, on the discharge or liquid line. Usually two wires in series with Y or with the contactor coil.

LOW PRESSURE / LOSS OF CHARGE

On the suction line, the large one. It opens when the charge or the airflow is low.

FLOAT SWITCH

In the secondary pan, the main pan or the drain trap. It usually opens R or Y so the system stops before water overflows.

Some outdoor boards count trips and lock out after several in a row. Cycle power only after fixing the cause.

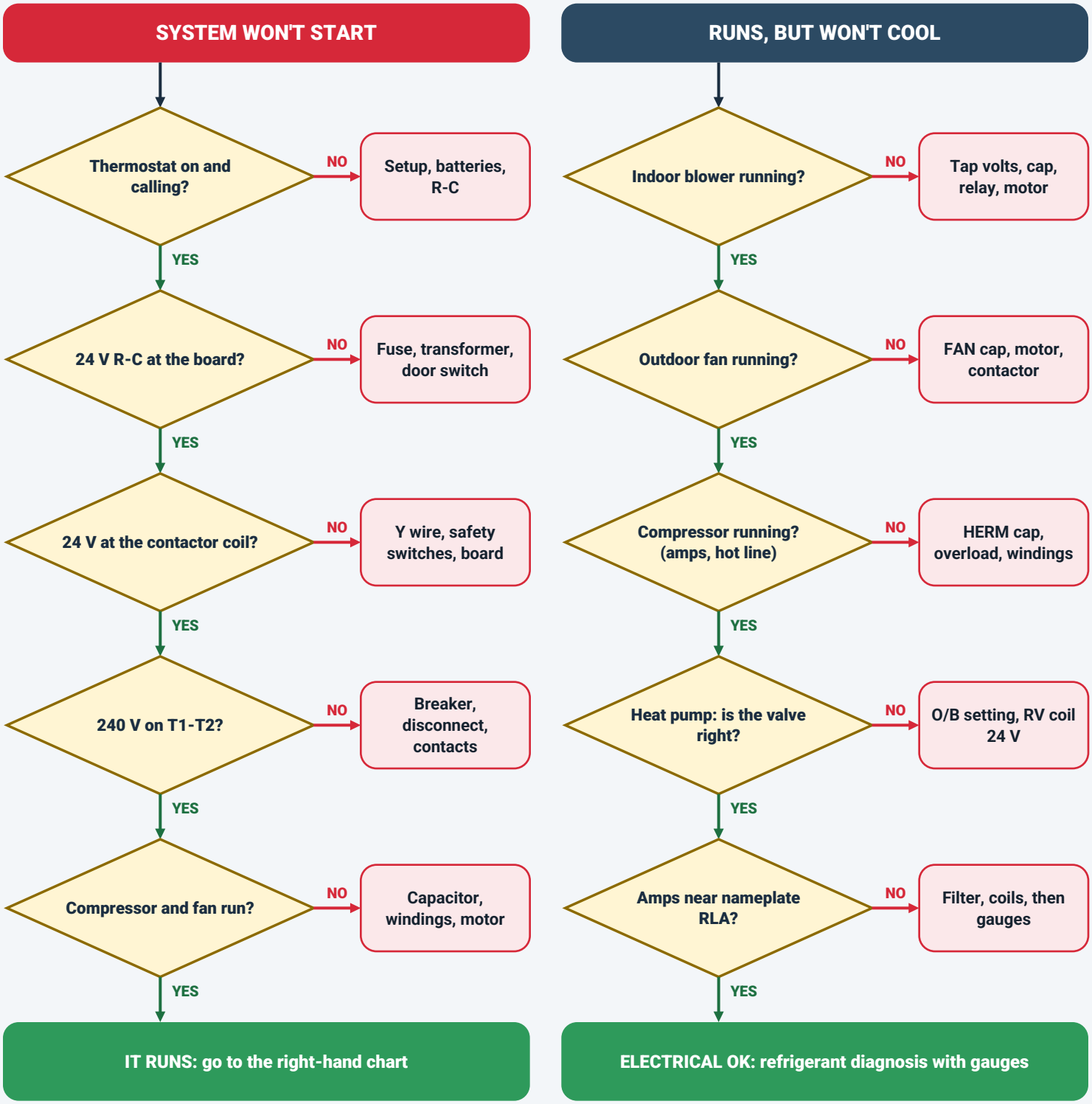
15 SYMPTOMS: WHERE TO MEASURE

Start at the left, measure in the middle, read the meaning at the right.

Symptom	Where to measure	What it usually means
Thermostat blank, nothing runs	R-C at the board, board fuse, transformer primary	No 24 V: fuse, transformer, door switch or breaker
Board fuse blows again	Y-C and R-C ohms, wires off; outdoor cable	Short in the 24 V wiring, often at the outdoor unit
Indoor runs, outdoor dead	24 V at the contactor coil; 240 V at L1-L2	No 24 V: wire, switch or board. No 240 V: breaker or disconnect
Contactor in, nothing runs	T1-T2 volts vs L1-L2	Line OK but T1-T2 low or 0 = burned contacts
Compressor hums, trips	HERM-C µF; volts at startup	Weak capacitor, low voltage or locked compressor
Fan runs, compressor off	C-R, C-S, S-R; amps	Overload open (hot), open winding or bad HERM section
Compressor runs, fan off	FAN-C µF; volts at motor; shaft	Bad FAN section or motor. Shut it off before it trips
Contactor out, 24 V at board Y	Volts across each safety switch	High, low or float switch open
Contactor chatters	24 V at the coil while it chatters	Low 24 V, power-stealing thermostat or bad coil
Compressor won't stop	Contacts with power off; Y at the coil	Welded contacts or Y shorted to R
Outdoor runs, blower dead	Volts on the blower tap; cap µF; G at board	Bad fan relay, capacitor, motor or ECM module
Inducer runs, no ignition	24 V across the pressure switch	Pressure switch not closing: vent, hose, drain
Burners light, then go out	Flame sense µA; ground	Dirty flame sensor or poor ground
Heat pump blows cold on heat	24 V at the RV coil; O/B setting	Wrong O/B, bad coil or stuck valve
Outdoor coil iced solid	Defrost test; sensor	Bad defrost board, sensor or valve

FLOWCHARTS: NO START - NO COOLING

Go from top to bottom. Every NO sends you to the part to test.



240 V + 24 V
Two circuits, two colors

20 SYMBOLS
Drawn and explained

REAL VALUES
µF, ohms, psig, volts

vifalio.com
Free guide

Training guide with typical values. Follow the unit's wiring diagram, the manufacturer's instructions, the NEC and local code. Lock out power first.

10 MISTAKES THAT WASTE PARTS

Each one sends a good part to the trash and brings a callback.

1 Replacing the compressor first

Most 'dead' compressors are a bad capacitor, a bad contactor or a hot overload.

2 Judging a capacitor by its looks

A flat top can still read 20 % low. Measure µF on every call.

3 Wrong µF or lower voltage

Same µF on each section, equal or higher voltage. 370 V can't replace 440 V.

4 Condemning a hot compressor

An open overload reads like an open winding. Let it cool 3 to 4 hours and retest.

5 New fuse, short not found

The board fuse is doing its job. Find the Y-C or R-C short first.

6 Meter on the wrong range

Check the meter on a live source first, and use the right jacks.

7 No voltage check at startup

Low voltage at startup cooks compressors. Measure while it starts.

8 Jumpering a safety switch

An open pressure, limit or float switch is reporting a real fault.

9 Ignoring the ground

No ground = shock risk and flame sense problems. Check every bond.

10 Forgetting the 24 V side

No 24 V at the coil = the fault is upstream, not in the outdoor unit.

ELECTRICAL SERVICE CHECKLIST

Run it on every call, in this order. Write the readings on the sheet on the next page.

- [ ] **1. Lock out and test dead**
  Breaker and disconnect off, lock and tag, 0 V on L1-L2, L1-ground and L2-ground.
- [ ] **2. Read the nameplates**
  Write down volts, RLA, LRA, FLA and the capacitor µF from both units.
- [ ] **3. Look and smell**
  Burned or melted wires, ants, rust, loose lugs, signs of water.
- [ ] **4. Discharge and test capacitors**
  HERM-C and FAN-C µF against the label and its tolerance.
- [ ] **5. Inspect the contactor**
  Contact faces, coil ohms, the plunger moves freely.
- [ ] **6. Compressor windings**
  C-R, C-S and S-R; then each terminal to ground.
- [ ] **7. 24 V side**
  R-C at the board, the fuse, and the thermostat calls for Y, G and W.
- [ ] **8. Power up and measure**
  Line volts at rest and at startup; T1-T2 matches L1-L2.
- [ ] **9. Amps**
  Compressor, condenser fan and blower against the nameplate.
- [ ] **10. Safety switches**
  Across high, low and float switches: 0 V when closed.
- [ ] **11. Heat mode**
  Furnace sequence, or heat pump defrost test and aux heat amps.
- [ ] **12. Tighten and close**
  Tighten the lugs, close the covers, explain what you found.

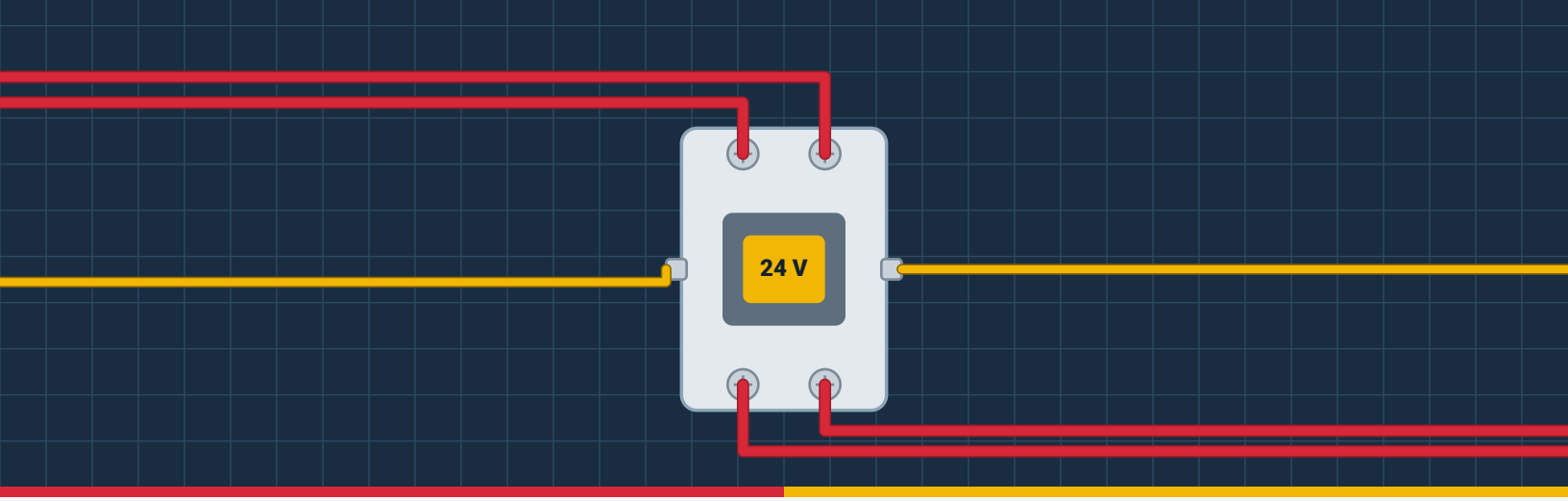
READING SHEET - PRINT AND FILL

Write every reading. On the next visit you compare, and the change tells you what is failing.

Customer / address	Date

Outdoor model / serial	Indoor model / serial

Measurement	Expected	Reading	OK?
Line volts L1-L2: at rest / at startup	208-240 V		☐
Volts T1-T2, contactor pulled in	= L1-L2		☐
24 V, R-C at the board	24-28 V		☐
24 V at the contactor coil	24-28 V		☐
Capacitor HERM-C	label µF ± tol.		☐
Capacitor FAN-C	label µF ± tol.		☐
Compressor C-R / C-S / S-R	C-R + C-S = S-R		☐
Compressor terminals to ground	OL		☐
Compressor amps	≤ RLA		☐
Condenser fan amps	≤ FLA		☐
Blower amps	≤ FLA		☐
Flame sense (furnace)	≥ board minimum		☐
Defrost test (heat pump)	O on, fan off, W2 on		☐
Notes			



MEASURE FIRST.
REPLACE SECOND.

Every part on this map can be proven good or bad with a meter in a few minutes. Do that before you sell a part.

More free guides at vifalio.com: thermostat wiring, inverter board repair, HVAC career + EPA 608.

SOURCES WE READ

Copeland Application Engineering bulletins AE4-1365 R6 and AE4-1311 R9; Goodman R-410A Service Instructions (transformer, contactor, capacitor, compressor, X13, defrost and limit tests); HVAC School (capacitor testing and replacement, run capacitor under-load test, start winding article, contactor article); Bryant 355MAV furnace troubleshooting guide SM05-2; Open Exam Prep (control transformers and board fuses).

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