

Electricity for the HVAC Tech: Volts, Amps, Ohms, Watts — and the Two Systems in Every Unit

YES Electric • Arc Workforce Academy HVAC Apprenticeship

Draft 1 (October 2026). This lesson is under review. Videos are made by other companies, not YES Electric; follow this lesson and your journeyman where they differ. Boxes marked "Shop photo coming" will get real photos from our shop in a later version.

Unit 3 • Electrical for HVAC I (36 hr RTI) • Appendix A Competency 6 Class time: ~4 hrs
(1.5 video/classroom + 2.5 bench walk-through)

1. What you'll be able to do

- Speak the four electrical quantities (V, A, Ω , W) with the right intuition attached (Lesson 2.4's math now gets hands).
- Map the **two electrical systems living in every residential HVAC unit**: line voltage (120/240 V power) and low voltage (24 V control) — and never confuse which one you're touching.
- Trace the power path on the shop unit: panel → breaker → disconnect → contactor → loads; and the control path: transformer → thermostat → contactor coil.
- State the three identities of residential power: 120 V leg-to-neutral, 240 V leg-to-leg, one phase — and what "single phase" means at the unit.
- Hold the safety frame this whole unit lives in: **voltage is always treated as present until YOUR meter proves otherwise** (the meter ritual itself is 3.2).

2. Tools & materials

- Shop split system + gas furnace, panels off, POWER LOCKED OUT (instructor-controlled demo power only)
- The training board (relays, transformer, stat — the ACST-style board we build/bought)
- Flashlights, wiring diagram printouts of the shop units

3. Watch first

Order	Video	Channel	Length	Why
1	Electrical Basics, How and Why Electrons Move	HVAC School	30:11	The mental model, properly built
2	Basic Electrical Circuit Terms	HVAC School	16:50	Vocabulary: line, load, hot, neutral, ground
3	Electrical Basics — The Circuit	HVAC School	3:22	The loop, in 3 minutes
4	Teaching HVAC Electrical to Students Using a Training Board	AC Service Tech	21:55	Exactly what our bench will do
Reference	Electrical Basics Class · Basic Electrical Theory	HVAC School	1:14 / 1:01	The long-form versions for review week

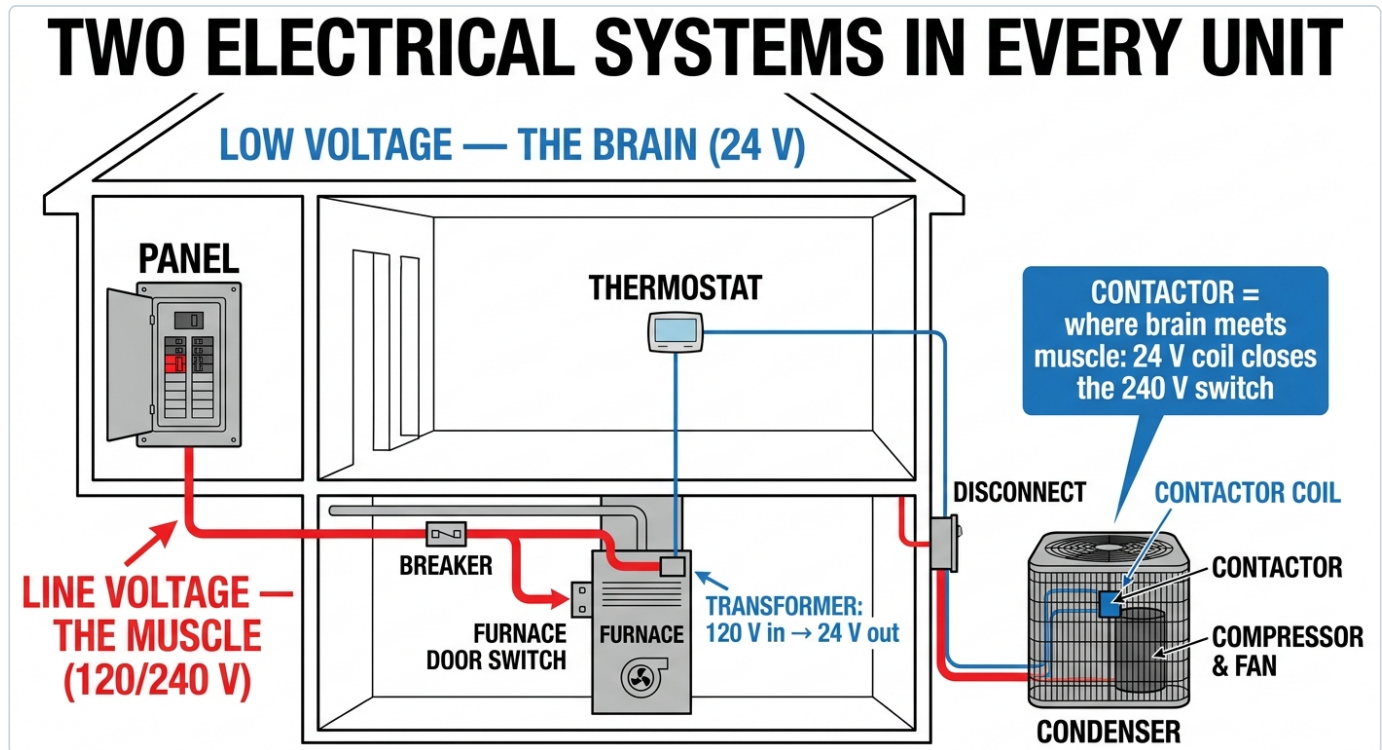
4. The idea

The quantities, with hands attached

Quantity	Is	Field intuition	You'll measure with
Volts (V)	Electrical pressure	Pushes; present even when nothing flows (a charged hose, nozzle closed)	Meter probes ACROSS
Amps (A)	Flow	Only flows when a path closes; what does work AND what kills	Clamp AROUND one wire
Ohms (Ω)	Restriction	Loads are designed restriction; corrosion is unplanned restriction	Meter on a DEAD circuit
Watts (W)	Work rate	$V \times A$ — heat made, air moved	Computed (or wattmeter)

The loop rule that solves half of all no-run calls: **electricity only works in a complete loop** — source → switch(es) → load → back to source. No loop, no flow. Every switch in the loop is a place the loop can be open ON PURPOSE (thermostat, safety) or BY FAILURE (broken wire, burnt contact). Diagnosis (Unit 6) is finding WHERE the loop opened — today is seeing the loops.

The two systems in every unit



LINE VOLTAGE (the muscle): 240 V from the panel through a breaker, through the outdoor **disconnect**, to the **contactor** — and through it (when closed) to compressor and fan. Indoors: 120 V to the furnace through the **door switch** (the "no power" trick every tech learns day one).

LOW VOLTAGE (the brain): the furnace **transformer** steps 120 → **24 V**. That 24 V goes up to the thermostat and back down as commands: Y closes the contactor's coil, G runs the blower relay, W fires the heat sequence (the full letter code is Lesson 6.3 — you met it in the wiring scratchpad table). The contactor is where brain meets muscle: a 24 V coil closing a 240 V switch.

Why split systems? Safety (24 V in the wall to your stat, not 240), control finesse, and diagnosis: **half your no-cool calls are 24 V problems wearing a 240 V costume**. A unit that's "dead" with a perfect breaker usually lost its brain, not its muscle.

Single phase, two legs

Residential power is **one phase, center-tapped**: two 120 V "legs" that are mirror images. Leg-to-neutral = 120 V (furnace, lights). Leg-to-leg = **240 V** (condenser, strips). That's why a 240 V condenser has TWO hot wires and no neutral — and why losing ONE leg makes things half-work in strange ways (the "hums but won't start" overture — Unit 6). Three-phase exists in commercial (12.2); recognize the third wire, leave it for later.

The cast of characters (meet them today, test them in 3.5-3.6)

- **Breaker** (panel): overcurrent guard for the WIRE, sized by MOP (Lesson 1.2's plate).
- **Disconnect** (at the condenser): the service switch — your physical lockout point.

- **Door switch** (furnace): kills line power with the panel off — and the 24 V brain with it.
- **Transformer:** 120/240 in → 24 out; the fuse on the board (3 A or 5 A) protects it — the "blown low-voltage fuse" is a top-5 service finding.
- **Contactor / relays:** small-voltage coils closing big-voltage switches.
- **Capacitors:** stored energy EVEN WITH POWER OFF — the one component that can bite on a dead unit. Look, don't touch, until 3.5 teaches the discharge ritual.

5. Bench procedure (locked out; instructor energizes for demos only)

1. **Path walk, line voltage:** start at the panel. Student fingers trace (on the DEAD unit): breaker → wire size → disconnect → contactor line side → compressor & fan. Name each stop and its job.
2. **Path walk, low voltage:** transformer → board → stat wire bundle → thermostat → back to contactor coil. Find where 24 V leaves the furnace and re-enters the condenser (the 2-wire pair to the contactor coil).
3. **The loop game (training board):** instructor opens one hidden switch at a time (door switch, stat, breaker, coil wire) — class states which SYSTEM died (brain vs muscle) from the symptom alone, then traces to confirm.
4. **Two-legs demo (instructor, live, students observe):** meter shows $120 + 120 = 240$ leg-to-leg at the disconnect; then one leg opened — watch what still runs. Write down three symptoms of a lost leg.
5. **Cast scavenger hunt:** photograph and label all six characters on two different units.
Bonus: find the low-voltage fuse on the furnace board.

Checkout: trace both complete loops unaided on a unit the student hasn't worked on, naming every component and its system; answer "the breaker's on but nothing runs — which system do you suspect first and what's the cheapest check?" (Brain; is there 24 V — which 3.2 teaches you to measure.)

6. Field gotchas

- **The door-switch classic:** panel off = furnace brain-dead = condenser dead too (its 24 V comes from the furnace). Techs have condemned transformers with the door open. Check the obvious loop-openers first.
- **Two sources, one unit:** lockout at the disconnect kills the condenser's 240 — but the 24 V control may still arrive from the furnace. And capacitors hold charge regardless. "Off" has layers; 3.2/3.5 give you the verification ritual.
- **Float switches, door switches, rollouts — safeties open the BRAIN on purpose.** A "dead" system is often a safety doing its job; find out WHY before bypassing anything (and never leave a bypass behind — Unit 7).

- **Low-voltage fuse blows for a reason** (usually a shorted stat wire or a stuck contactor coil). Replacing it without finding the short = repeat call (the hunt is 6.5).
- **Never trust wire colors.** Red can be common, white can be hot; previous techs improvise. The diagram and your meter are truth (3.7, 3.2).

7. Competency link

- **Competency 6** begins (meter mastery completes it in 3.2).
- Frames every electrical lesson after: capacitors/contactors (3.5/3.6), diagrams (3.7), safety/sizing (3.8), motors & boards (Unit 6).

8. Check yourself

1. Four quantities, one field intuition each.
 2. State the loop rule and use it to explain a unit that's "completely dead."
 3. Which two components convert between the brain and muscle systems? (Transformer down, contactor coil up.)
 4. Where does the condenser's 24 V come from? So what does the furnace door switch do to the AC?
 5. 120 vs 240 at the panel — how do the legs make each?
 6. Three symptoms of a lost leg?
 7. What does the 3 A fuse on the furnace board protect, and what usually kills it?
 8. Which component is dangerous with all power off, and what's the rule until 3.5?
 9. Breaker ON, stat calling, nothing runs anywhere. Brain or muscle first, and why?
 10. Why is "the red wire" not a diagnosis?
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Arc Workforce Academy · YES Electric LLC Apprenticeship 2026-AL-141731 · Lesson 3.1 v1.0 (2026-06-10)