

The Multimeter: Every Function, Hands On

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 • Appendix A Competency 6 — "Measure voltage, amperage, and resistance using a multimeter" — THE competency lesson **Class time:** ~6 hrs (1.5 video + 4.5 bench; the longest single lesson so far, on purpose)

1. What you'll be able to do

- Run the **live-dead-live verification ritual** that precedes every hands-in-the-box moment for the rest of your career.
- Measure **AC voltage** across any pair (L1-L2, L-N, 24 V control), with the meter in the right mode and YOU in the right stance.
- Clamp **amperage** on one conductor and know why the clamp reads zero around a 2-wire cord.
- Measure **resistance and continuity** on a DEAD, isolated component — and know the rookie isolation mistake that lies to you.
- Use **Low-Z mode** to make ghost voltage confess.
- Translate readings into words: "240 across the contactor line side, 24 at the coil, 0 across the closed switch."

The meter is the trade's truth machine. Every component lesson after this (capacitors, contactors, motors, boards, igniters, sensors) is just "what should the meter say HERE."

2. Tools & materials

- One clamp multimeter per student (the program meter — spec'd with Low-Z, μ A for later flame work, capacitance)
- Training board + shop units; assorted dead components bin
- Lockout tags; gloves; safety glasses — PPE is part of the grade from today on

3. Watch first

Order	Video	Channel	Length	Why
1	Multimeter 101 for HVAC 3D	HVAC School	10:19	Every function, animated
2	Basic Voltage and Safety Measurements on an AC	HVAC School	7:51	The stance and the sequence
3	Multimeter Basics: Resistance vs Continuity	AC Service Tech	10:23	The two dead-circuit modes, distinguished
4	How to Use an Ohmmeter (and a SUPER rookie mistake)	HVAC School	16:31	The parallel-path lie — watch him make it
5	Low-Z Multimeter Function Fully Demonstrated	AC Service Tech	7:28	Ghost-busting mode
6	What Is Ghost Voltage?	HVAC School	19:45	Why your meter sees 60 V on a dead wire
7	3 Methods to Test Electrical Switches	AC Service Tech	8:04	Voltage-drop thinking, first taste

4. The idea

The functions, mapped to the dial

THE METER DIAL — WHICH MODE, WHICH STATE, WHERE THE PROBES GO

V~ AC VOLTS — circuit LIVE — probes ACROSS two points CARD 1

PROBES ACROSS CONTACTS

AMPS CLAMP — LIVE & RUNNING — jaw around ONE wire only

CORRECT: SINGLE CONDUCTOR

INCORRECT: MULTIPLE CONDUCTORS

CONTINUITY (beeper) — DEAD + ISOLATED — path or no path CARD 5

BEEP! CHECK CONNECTION PATH

LOW-Z — LIVE — kills ghost voltage CARD 2

GHOST VOLTAGE ELIMINATE PHANTOM VOLTS

OHMS Ω — circuit DEAD + component ISOLATED — probes across component CARD 4

TEST ISOLATED RESISTANCE

CAPACITANCE μF — DEAD + DISCHARGED CARD 6

DISCHARGE FIRST! MEASURE STORED CHARGE

LIVE-DEAD-LIVE BEFORE HANDS IN THE BOX: prove meter → lock out → verify dead → re-prove meter

Mode	Measures	Circuit state	Probes/clamp go	HVAC bread & butter
V~ (AC volts)	Pressure present	LIVE	ACROSS two points	Is 240 arriving? Is 24 leaving?
Low-Z volts	Real pressure (low input impedance)	LIVE	ACROSS	Ghost voltage executioner
A (clamp)	Flow	LIVE & running	AROUND one wire	Compressor vs RLA, element vs math
Ω (ohms)	Restriction	DEAD + isolated	ACROSS component	Windings, elements, sensors
Continuity	Path exists?	DEAD + isolated	ACROSS	Switches, fuses, broken wires
μF (capacitance)	Storage	DEAD + discharged	ACROSS cap	Lesson 3.5's whole show
μA (DC microamps)	Tiny flow	LIVE (in series)	IN the flame-sense line	Lesson 7.4 — flag it now

The ritual: live-dead-live

Before hands touch conductors:

1. **Prove your meter on a KNOWN-LIVE source** (it reads what it should — meter works).
2. **Open the disconnect / breaker. Lock/tag it.**
3. **Test the dead circuit** — every conductor pair you're about to touch reads ~0.
4. **Re-prove the meter on the known-live source** (it STILL works — your zero was real).

Four steps, thirty seconds, non-negotiable, forever. This ritual is most of the difference between old electricians and bold ones.

Voltage is measured ACROSS; the words matter

Voltage is a difference between two points. "I have 240 volts" means nothing without across what: L1-to-L2 240, L1-to-ground 120, across a CLOSED switch ~0, across an OPEN switch in a live circuit = **full source voltage** (the pressure piles up at the break!). That last one is the diagnostic gold of Unit 6: **finding source voltage ACROSS a device means THAT device is the open in the loop**. Plant it today.

The clamp: one wire, or it lies

The clamp reads the magnetic field of NET current. Both conductors through the jaw = fields cancel = zero. One conductor only. (Tiny loads: wrap 10 turns through the jaw, divide by 10 — the low-amps trick from the video.) Inrush button catches the start surge — LRA vs RLA becomes real in Unit 6.

Ohms/continuity: dead, and ISOLATED

Two commandments:

1. **Dead** — the meter's own test current can't compete with live voltage (and live ohms can kill meters).
2. **Isolated** — disconnect at least one lead of the component. Measured in-circuit, a parallel path (another winding, a coil, a board trace) gives a false "good" reading. That's the rookie mistake in the video — a "12 Ω motor" that was actually the relay coil beside it.

Continuity beeper = ohms with a soundtrack; great for switches/fuses, useless for how much resistance (a 40 Ω igniter beeps the same as a 0.5 Ω short on some meters — know your meter's beep threshold).

Ghost voltage and Low-Z

A disconnected wire lying beside live ones picks up a phantom 40-90 V through capacitive coupling — your high-impedance meter dutifully reports it, and a tech chases a circuit that isn't there. **Low-Z mode** adds a small internal load: ghosts collapse to ~ 0 , real sources stand firm. Rule: any "weird" voltage on a supposedly-dead or disconnected conductor gets a Low-Z second opinion before you believe it.

5. Bench procedure (the bulk of the day)

Station 1 — Voltage (live, supervised): 240 at the disconnect (L1-L2, each leg to ground), 120 at the furnace, 24 at the board (R-to-C), THEN the money reading: across the door switch closed (~ 0) and held open (24/120 appears!). Log every reading in "across WHAT" language.

Station 2 — The ritual: full live-dead-live on the condenser, lockout applied, instructor witnesses each student individually. This is a graded gate — no pass, no live work in any future lesson.

Station 3 — Clamp: blower amps vs nameplate FLA; both-wires-in-jaw demo (zero!); 10-wrap trick on a thermostat circuit; inrush capture on blower start.

Station 4 — Ohms/continuity (dead bin + isolation drill): fuse, door switch, strip element ($\approx 11.5 \Omega$ — Lesson 2.4 predicted it!), transformer windings; then the TRAP: ohm a relay coil in-circuit vs isolated — watch the lie, say the commandment.

Station 5 — Ghost hunt: instructor's rigged junction box: dead wire reading 60 V on normal mode. Students call it, Low-Z it, watch it collapse, explain it.

Checkout (Competency 6, formal): unaided on a unit you haven't touched: full ritual, one voltage reading in across-language, one clamp reading vs nameplate, one isolated ohm reading, one Low-Z disambiguation. Mentor signs the competency line at "correctly completed under guidance."

6. Field gotchas

- **Auto-ranging surprises:** 24.0 can be volts or millivolts — read the units glyph every time.
- **Fused amp jacks:** plugging probes into the A jacks then measuring voltage = blown meter fuse (or fireworks on some meters). Probes live in V/ Ω jacks unless you have a deliberate reason.
- **CAT ratings matter:** panel work wants CAT III+ leads. The \$12 meter special is for hobbyists.
- **One hand when possible** on live measurements; no rings; stand to the side of panels.
- **Ohming semiconductors** (boards, ECMs) tells you almost nothing — components that pass ohm tests still fail under load. The meter has limits; Unit 6 teaches what loads-under-test look like.
- **Write readings down at the unit.** "It was about 230-something" survives the walk to the truck as "fine." Numbers or it didn't happen.

7. Competency link

- **Competency 6 — COMPLETED here** (formal checkout).
- The measurement spine of: 3.5/3.6 (caps & contactors), 6.x (everything), 7.4 (μ A flame), 8.3 (strip amps), 9.8 (DC/inverter — with the DC modes).

8. Check yourself

1. Recite live-dead-live. What does step 4 protect against?
 2. Why does voltage get measured ACROSS and amps AROUND?
 3. Full source voltage appears across a device in a live circuit. What did you just find?
 4. The clamp reads 0 around an extension cord powering a running saw. Why?
 5. Two commandments of ohms — and what lie does in-circuit measurement tell?
 6. Ghost voltage: where does it come from and which mode kills it?
 7. Your meter beeps continuity on a 40 Ω igniter. Good igniter? What's the beeper actually for?
 8. Which jack/mode mistake blows meter fuses?
 9. Strip element should read $\sim 11.5 \Omega$. It reads 23. Two possible explanations (one innocent, one yours-to-fix)?
 10. What reading proves a closed switch is GOOD, and what reading convicts an open one?
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