

Motors: PSC, X13, Variable-Speed ECM — ID & Theory of Each

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 6 • Electrical for HVAC II (44 hr RTI) • Appendix A Comp 20 (begins) Class time: ~4 hrs (1.5 video + 2.5 bench)

1. What you'll be able to do

- Identify the four blower-motor species on sight and from the wiring: **shaded pole** (relic), **PSC** (the capacitor classic), **X13/constant-torque ECM**, **variable-speed/constant-airflow ECM** — and the condenser-fan variants.
- Explain each one's control story: PSC = speed taps + run cap; X13 = 24 V signal taps commanding programmed torque; variable ECM = serial data from the board commanding AIRFLOW.
- Predict each motor's response to duct restriction (the diagnostic gold): **PSC slows & amps drop; ECM pushes harder & amps RISE** — the "ECM hides duct problems" trap from the, now explained at the winding level.
- Know what's inside an ECM: line voltage in → rectified to DC → inverter drives a 3-phase BLDC motor — why "module + motor" are separable parts (6.2 tests them separately).
- Choose lubrication/bearing/longevity expectations per type (and why ECMs die of heat + static, not "old age").

2. Tools & materials

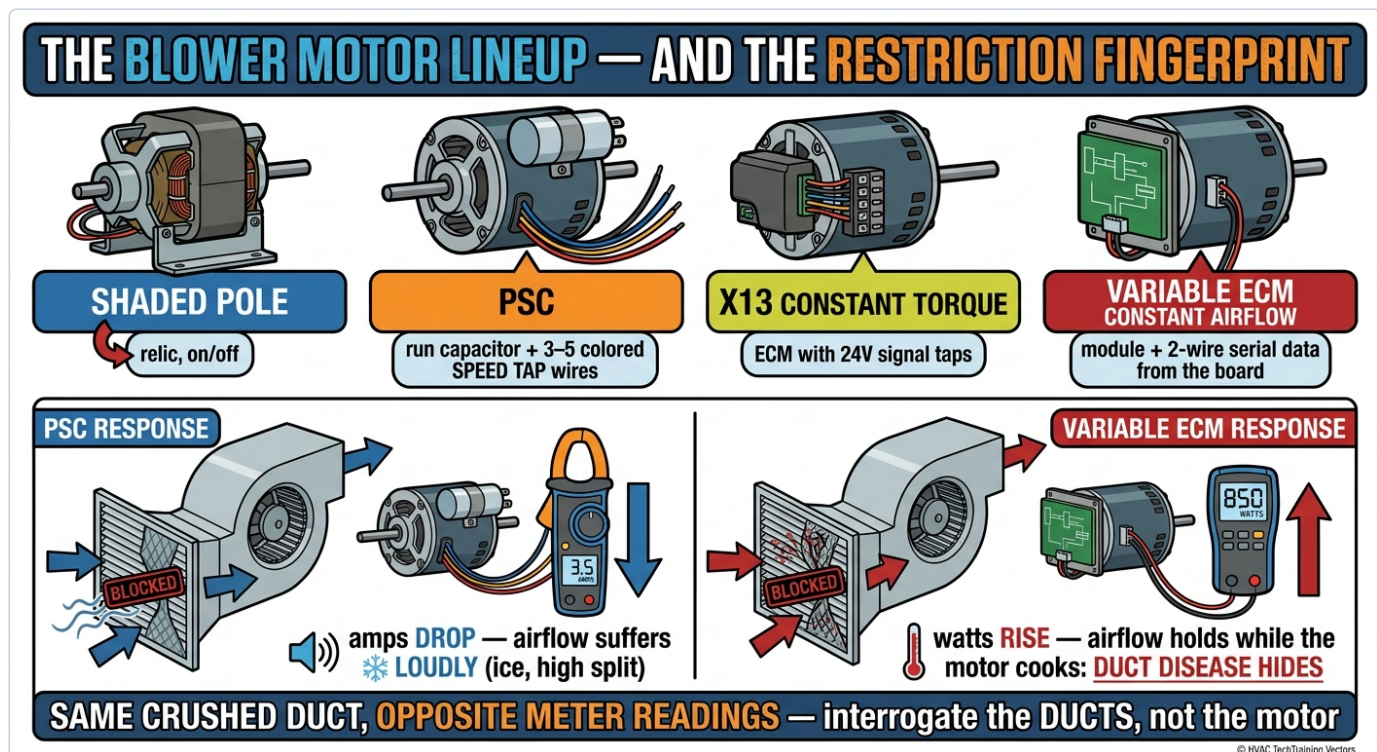
- The motor wall: shaded pole (museum), PSC blower w/ speed taps, X13, variable-speed ECM (module on/off the motor), PSC + ECM condenser fan motors
- Meters, amp clamps; the blower door rig (restriction demo)
- Manufacturer motor data plates/pinouts

3. Watch first

Order	Video	Channel	Length	Why
1	PSC, ECM, Variable Speed — Types, Troubleshooting, Longevity	HVAC School	11:14	The lineup, modern
2	Tell the Difference: Variable, PSC, Shaded Pole, X13	AC Service Tech	4:14	The 4-minute field ID
3	PSC Blower Motor Class — Speeds, Colors, Ohms, Current	AC Service Tech	9:51	The classic, mastered
4	HVAC Motor Types (RSES NATE Prep)	HVAC School	14:43	Exam-shaped review
5	X13 Troubleshooting Step by Step	AC Service Tech	7:37	Preview of 6.2
Deep dive	Variable Speed Motors & Why They Matter	HVAC School	1:05:33	Reference

4. The idea

The four species



	Shaded pole	PSC	X13 (constant torque)	Variable ECM (constant airflow)
Drive	AC, shaded coil	AC + run capacitor (3.5!)	BLDC + module, programmed torque points	BLDC + module, board-commanded CFM
Control	on/off	speed taps (3-5 colored wires; one energized at a time!)	24 V signal taps (1-5)	serial data (2-wire comm) from the IFC
Efficiency	awful	poor	good	best
Response to high static	slows	slows, amps DROP	holds torque-ish	pushes harder, amps & watts RISE
Dies of	dust	caps & bearings	heat, voltage spikes	heat, spikes, moisture down the shaft , static abuse
You'll find it in	old condenser fans	1990s–2010s everything	builder-grade 2010s+	comfort lines, modulating systems

The restriction fingerprint (the diagnostic crown jewel)

Block a return: - **PSC**: less air = less load on this motor design = RPM up slightly but moving less air, **amps DROP**. The system suffers loudly (low airflow symptoms — ice, high splits). - **ECM (variable)**: the module measures and says "I was promised 1,200 CFM" — ramps torque, **amps/ watts CLIMB**, airflow nearly holds... while the motor cooks itself and the watts bill climbs. **The duct disease hides until the motor dies of it.**

Same house, same crushed duct, opposite meter readings. This single contrast explains half of "the new system's motor failed at year 3" service history — the duct was the killer; the PSC just never confessed (, now with physics).

Inside the ECM (why module + motor)

Line AC → rectifier (DC bus ~300 V — the inverter-tech preview for Unit 9!) → microprocessor inverter → 3-phase windings on a permanent-magnet rotor. The MODULE (electronics, in the end bell) and the MOTOR (windings/bearings) fail separately and test separately (6.2): windings ohm as three equal phases; modules get the surgeon's checklist. Universal replacement modules/ motors exist (the 3.x videos) — know the species before quoting.

Condenser fans, briefly

Same evolution outdoors: PSC w/ cap (3-wire vs 4-wire — the 1.2/3.5 wiring) → ECM condenser motors on premium/inverter units. Outdoor death modes: rain down the shaft on flat-mounted "bell" motors, seized bearings from cottonwood + heat. The replace-and-set-blade-depth craft is 6.2's lab.

5. Bench procedure

1. **Species ID relay:** the motor wall, tags hidden — ID each by frame, wiring count, data plate; state its control story. 100% before moving on.
2. **PSC tap mapping:** ohm the speed taps to common (highest Ω = lowest speed — the winding tells you!), then run on each tap and clamp amps. Build the tap table by hand.
3. **The restriction fingerprint lab (the keeper):** blower rig with the adjustable restriction door: run a PSC, clamp amps, close the door — watch amps FALL. Swap the variable ECM in, same door — watch watts CLIMB. Log both curves on the worksheet. (This data card rides in your notebook forever.)
4. **ECM teardown:** module off the motor: see the bus capacitors (discharge rules echo 3.5), the 3-phase plug, the bearings. Ohm the three phases: equal = motor good (preview of 6.2's split test).
5. **The 24V-vs-data drill:** X13 taps vs variable's comm plug — identify which control wiring each accepts, and what happens if you feed an X13 a "G" signal vs the variable (nothing without data).

Checkout: four motors ID'd + control story each + the restriction fingerprint recited with BOTH meters' behavior + one PSC tap map built unaided. **Comp 20 opens.**

6. Field gotchas

- **Two PSC speed taps energized at once** (a "helpful" previous wiring) = circulating currents = dead motor soon. One tap hot, spares CAPPED (the 3.x video's lesson).
- **ECM high watts = duct interrogation, not motor blame.** A variable ECM pulling rated airflow at bloated watts is testifying about static (Unit 11 measures it).
- **Module swaps need programming context:** OEM modules ship programmed; universals get configured. A right motor with wrong programming = wrong airflow forever (and it'll "work").
- **Moisture kills ECMs from above:** the drip-loop in the harness and the shaft-down mounting rules exist for reason; attic condensate finds modules.
- **Don't ohm a module's plug expecting answers** (3.2's semiconductor warning) — module testing is 6.2's procedure, not a resistance reading.
- **Surge protection sells itself on ECM systems:** \$700 modules vs \$60 SPDs (3.x's DITEK lesson) — after the second lightning season, customers listen.

7. Competency link

- **Comp 20 begins** (completes through 6.2–6.7).
- The restriction fingerprint feeds Unit 11 (static diagnosis); the DC-bus tour feeds Unit 9 (inverters); PSC/cap ties back to 3.5.

8. Check yourself

1. Four species, one ID tell each.
 2. PSC speed taps: how does resistance map to speed, and what's the two-taps-hot sin?
 3. The restriction fingerprint: PSC amps ___, ECM watts ___ — and why each.
 4. Why does a variable ECM "hide" duct disease, and what kills it eventually?
 5. What's on the DC bus inside an ECM, and which earlier lesson's discharge rules apply?
 6. X13 vs variable: what does each accept as a command?
 7. Three equal phase resistances on an ECM motor mean what? Unequal?
 8. Why do bell-style outdoor motors die after their drain plugs are painted over / mounted wrong?
 9. A 3-year-old variable ECM failed; ducts were never checked. Write the two-line cause-of-death finding.
 10. Which costs more over 15 years: the PSC that moves 900 CFM quietly suffering, or the ECM that forces 1,200 — and what's the REAL fix either way?
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