

HVACR Electrical Systems

Crosswalk to HVAC Excellence Competencies

The following HVAC Excellence competencies (rev. 2007) are covered in this publication. Only the covered competencies are listed. The first column identifies the competency by name. The second column identifies the exact location in this MAVCC publication where that competency is covered.

HVAC Excellence Competencies	MAVCC Objectives and Tasks
Electrical Core Exam	
Electrical Theory	
Describe and identify conductors.	Unit 1, Objective 7—Insulators, semiconductors, and conductors Unit 2, Objective 3—Electrical wiring
Describe and identify insulators.	Unit 1, Objective 7—Insulators, semiconductors, and conductors
Describe and identify semi-conductors.	Unit 1, Objective 7—Insulators, semiconductors, and conductors
Describe Ohm's Law.	Unit 1, Objective 18—The three equations for using Ohm's Law Unit 1, Objective 19—Using Ohm's Law to find unknown values Unit 1, Objective 20—Using Ohm's Law to determine values in a series circuit Unit 1, Objective 21—Using Ohm's Law to determine values in a parallel circuit Unit 1, Objective 22—Using Ohm's Law to determine values in series-parallel circuits
Solve problems applying Ohm's Law.	Unit 1, Assignment Sheet 2—Use Ohm's Law to determine unknown values in resistive circuits
Demonstrate proficiency is calculating the total resistance in multiple resistors in a series circuit.	Unit 1, Assignment Sheet 2—Use Ohm's Law to determine unknown values in resistive circuits
Demonstrate proficiency is calculating the total resistance in multiple resistors in a parallel circuit.	Unit 1, Assignment Sheet 2—Use Ohm's Law to determine unknown values in resistive circuits
Describe and demonstrate the effects of voltage drop in a series circuit.	Unit 1, Assignment Sheet 2—Use Ohm's Law to determine unknown values in resistive circuits
Calculate and measure the voltage output of a transformer using the number of turns on the primary vs. the secondary sides.	Unit 6, Objective 2—How a transformer works Unit 6, Objective 3—Control transformer specifications

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Interpreting Electrical Diagrams	
Describe the differences between a “Pictorial”, a “Ladder Diagram”, and a “Schematic”.	Unit 4, Objective 5—Sources and applications of wiring diagrams Unit 4, Objective 6—Pictorial wiring diagrams Unit 4, Objective 7—Schematic wiring diagrams Unit 4, Objective 8—Electronic wiring diagrams Unit 4, Objective 9—Draw a pictorial diagram Unit 4, Objective 10—Building a ladder schematic diagram Unit 4, Objective 11—Using symbols
Identify standard electrical symbols used in schematics.	Located throughout this publication
Identify inoperative/defective component using schematic wiring diagrams.	Unit 15, Assignment Sheet 1—Identify components on HVACR system electrical diagrams Unit 15, Assignment Sheet 2—Identify component operations from HVACR system electrical diagrams Unit 15, Assignment Sheet 3—Select test instruments or procedures for specific HVACR system troubleshooting Unit 15, Assignment Sheet 4—Solve HVACR electrical troubleshooting problems Unit 15, Job Sheet 1—Troubleshoot series electrical circuits on selected HVACR equipment Unit 15, Job Sheet 2—Troubleshoot parallel electrical circuits on selected HVACR equipment Unit 15, Job Sheet 3—Troubleshoot series-parallel electrical circuits on selected HVACR equipment
Identify voltage between two points using schematic wiring diagrams.	Unit 3, Assignment Sheet 1—Use Watt’s Law to determine power Unit 4, Job Sheet 1—Draw pictorials, fabricate working models, and draw ladder schematics for basic series and parallel circuits Unit 4, Job Sheet 2—Draw pictorials, fabricate working models, and draw ladder schematics for series-parallel circuits Unit 4, Job Sheet 3—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with varied loads and switching

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	<p>Unit 5, Job Sheet 1—Draw pictorials, fabricate working models, and draw ladder schematics for shunt circuits with one SPST switch</p> <p>Unit 5, Job Sheet 2—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with 3-way switches</p> <p>Unit 5, Job Sheet 3—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with 3-way and 4-way switches</p> <p>Unit 5, Job Sheet 4—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with safety switches</p> <p>Unit 5, Job Sheet 5—Draw pictorials, fabricate working models, and draw ladder schematics for a basic small refrigeration unit circuit</p> <p>Unit 6, Job Sheet 1—Check current relays with an ohmmeter</p> <p>Unit 6, Job Sheet 2—Check potential relays with an ohmmeter</p> <p>Unit 6, Job Sheet 3—Check current relays with an ammeter and a voltmeter</p> <p>Unit 6, Job Sheet 4—Check a potential relay with an ammeter and a voltmeter</p> <p>Unit 6, Job Sheet 5—Install a solid-state, time-delay relay</p> <p>Unit 6, Job Sheet 6—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with basic relays</p> <p>Unit 6, Job Sheet 7—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with dual relays</p> <p>Unit 6, Job Sheet 8—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with special applications</p> <p>Unit 6, Job Sheet 9—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with multiple relays</p> <p>Unit 15, Assignment Sheet 4—Solve HVACR electrical troubleshooting problems</p>
<p>Determine sequence of operation using schematic wiring diagrams.</p>	<p>Unit 15, Assignment Sheet 1—Identify components on HVACR system electrical diagrams</p> <p>Unit 15, Assignment Sheet 2—Identify component operations from HVACR system electrical diagrams</p> <p>Unit 15, Assignment Sheet 3—Select test instruments or procedures for specific HVACR system troubleshooting</p> <p>Unit 15, Assignment Sheet 4—Solve HVACR electrical troubleshooting problems</p>

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	Unit 15, Job Sheet 1—Troubleshoot series electrical circuits on selected HVACR equipment Unit 15, Job Sheet 2—Troubleshoot parallel electrical circuits on selected HVACR equipment Unit 15, Job Sheet 3—Troubleshoot series-parallel electrical circuits on selected HVACR equipment
Knowledge of Electrical Components	
Identify the types and describe the proper application and use of “Circuit Protectors.”	Unit 5, Objective 10—Protection devices Unit 5, Objective 11—Overcurrent protection devices
Identify, describe, and explain the function and application of thermostats.	Unit 7, Objective 2—Thermostat types and their applications Unit 7, Objective 3—Temperature sensors Unit 7, Objective 4—Electrical contacts Unit 7, Objective 5—Major components of a heating/cooling thermostat Unit 7, Objective 6—Heating thermostat anticipation Unit 7, Objective 7—Cooling thermostat anticipation Unit 7, Objective 8—Installing heating/cooling thermostats Unit 7, Objective 9—Multistage thermostats Unit 7, Objective 10—Subbase applications Unit 7, Objective 11—Basic internal thermostat switching Unit 7, Objective 12—Programmable thermostat applications Unit 7, Objective 13—Electronic thermostat characteristics Unit 7, Objective 14—Additional benefits of solid-state thermostats Unit 7, Objective 15—Special applications of line voltage thermostats
Identify, describe, and explain the function and application of transformers.	Unit 3, Objective 3—Transformers Unit 3, Objective 5—Types of power supplies Unit 6, Objective 2—How a transformer works Unit 6, Objective 3—Control transformer specifications Unit 6, Objective 4—Providing DC power

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Identify, describe, and explain the function and applications of relays.	Unit 6, Objective 5—Relay components and uses Unit 6, Objective 6—Using relay symbols in electrical drawings Unit 6, Objective 7—Control relays and contactors Unit 6, Objective 8—Control relay and contactor switching arrangements Unit 6, Objective 9—Types of motor starting relays and their uses Unit 6, Objective 10—Motor starting current relay operations Unit 6, Objective 11—Motor starting current relay specifications Unit 6, Objective 12—Motor starting voltage relay operations Unit 6, Objective 13—Potential relay specifications Unit 6, Objective 14—Time delay relays
Identify, describe, and explain the function and application of switches.	Unit 5, Objective 2—Controls and their applications Unit 5, Objective 3—Types of controls Unit 5, Objective 4—Control systems Unit 5, Objective 5—Switch configurations and symbols Unit 5, Objective 6—Identifying switch symbols Unit 5, Objective 7—Three- and four-way switches and their applications
Evaluate and replace thermostats.	Unit 7, Job Sheet 1—Install a wall thermostat and determine heat anticipation Unit 7, Job Sheet 2—Replace a standard thermostat with an electronic programmable thermostat Unit 7, Job Sheet 3—Program a programmable thermostat
Evaluate and replace relays.	Unit 6, Job Sheet 1—Check current relays with an ohmmeter Unit 6, Job Sheet 2—Check potential relays with an ohmmeter Unit 6, Job Sheet 3—Check current relays with an ammeter and a voltmeter Unit 6, Job Sheet 4—Check a potential relay with an ammeter and a voltmeter Unit 6, Job Sheet 5—Install a solid-state, time-delay relay

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	Unit 6, Job Sheet 6—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with basic relays Unit 6, Job Sheet 7—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with dual relays Unit 6, Job Sheet 8—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with special applications Unit 6, Job Sheet 9—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with multiple relays
Evaluate and replace switches.	Unit 5, Job Sheet 1—Draw pictorials, fabricate working models, and draw ladder schematics for shunt circuits with one SPST switch Unit 5, Job Sheet 2—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with 3-way switches Unit 5, Job Sheet 3—Draw pictorials, fabricate working models, and draw ladder schematics for circuits with safety switches Unit 5, Job Sheet 4—Draw pictorials, fabricate working models, and draw ladder schematics for a basic refrigeration circuit
Fundamentals of Motors/Capacitors	
Describe how capacitors are rated and tested.	Unit 11, Objective 6—Guidelines for capacitor replacement Unit 11, Objective 7—Grouping capacitors
Describe the function of the parts of an induction motor.	Unit 8, Objective 5—Basic AC motor operation Unit 8, Objective 6—Single-phase AC motor starting Unit 8, Objective 7—Basic AC electric motor parts and their functions Unit 8, Objective 8—Types of motor construction Unit 8, Objective 9—Types of motor mounts and typical applications
Disassemble and assemble an induction motor.	Unit 9, Job Sheet 2—Disassemble, inspect, clean, reassemble, and check operation of a shaded-pole motor Unit 10, Job Sheet 4—Disassemble, inspect, clean, reassemble, and check operation of a split-phase motor

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Measure locked rotor amps, and full load amps.	Unit 2, Job Sheet 7—Use digital and analog ammeters to read start and run amperage of a motor Unit 9, Job Sheet 2—Disassemble, inspect, clean, reassemble, and check operation of a shaded-pole motor Unit 10, Job Sheet 4—Disassemble, inspect, clean, reassemble, and check operation of a split-phase motor Unit 12, Job Sheet 4—Disassemble, inspect, clean, reassemble, and check operation of a PSC fan motor
Describe how overload protectors function.	Unit 5, Objective 10—Protection devices Unit 5, Objective 11—Overcurrent protection devices Unit 5, Objective 12—Pressure-actuated protection devices Unit 5, Objective 13—Motor protection devices Unit 5, Objective 14—Bimetal protection devices Unit 5, Objective 15—Protecting electronic circuits Unit 8, Objective 7—Basic AC electric motor parts and their functions
Describe the function, application, and wiring of a start capacitor.	Unit 11, Objective 5—Types of capacitors Unit 12, Objective 3—CS motor characteristics and applications Unit 12, Objective 4—PSC motor characteristics and applications Unit 12, Objective 6—Troubleshooting capacitor motors
Evaluate and replace a start capacitor.	Unit 11, Objective 6—Guidelines for capacitor replacement Unit 11, Job Sheet 1—Check capacitors with an analog ohmmeter Unit 11, Job Sheet 2—Check capacitors with a capacitor analyzer Unit 12, Job Sheet 6—Install a hard start kit Unit 12, Job Sheet 7—Troubleshoot a CSR compressor with an ammeter
Describe the function, application, and wiring of a run capacitor.	Unit 11, Objective 5—Types of capacitors Unit 11, Objective 6—Guidelines for capacitor replacement Unit 12, Objective 3—CS motor characteristics and applications

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HVAC Excellence Competencies	MAVCC Objectives and Tasks
	Unit 12, Objective 5—CSR motor characteristics and applications Unit 12, Objective 6—Troubleshooting capacitor motors
Evaluate and replace a run capacitor.	Unit 11, Job Sheet 1—Check capacitors with an analog ohmmeter Unit 11, Job Sheet 2—Check capacitors with a capacitor analyzer Unit 12, Job Sheet 7—Troubleshoot a CSR compressor with an ammeter
Describe and explain motor speed.	Unit 8, Objective 12—Pulley selection Unit 9, Objective 3—Shaded-pole motor construction Unit 9, Objective 4—Controlling shaded-pole speed
Explain and change the direction of rotation in a single phase motor	Unit 9, Objective 5—Shaded-pole motor rotation Unit 10, Objective 5—Wiring connections for split-phase motors
Describe the method used in change rotation direction in a three-phase motor.	Unit 14, Objective 4—Wiring connections for three-phase motors
Demonstrate the method used in change rotation direction in a three-phase motor.	Unit 14, Job Sheet 1—Wire a dual-voltage, three-phase motor, reverse rotation, and check operation
Describe a three-phase motor.	Unit 14, Objective 2—Characteristics and applications of three-phase motors Unit 14, Objective 3—Three-phase motor construction Unit 14, Objective 4—Wiring connections for three-phase motors
Explain the difference between a Wye and Delta three-phase motor.	Unit 14, Objective 3—Three-phase motor construction
Describe a dual voltage three-phase motor.	Unit 14, Objective 4—Wiring connections for three-phase motors
Demonstrate the wiring configurations of a dual voltage three-phase motor.	Unit 14, Job Sheet 1—Wire a dual-voltage, three-phase motor, reverse rotation, and check operation
Describe a permanent split capacitor motor.	Unit 12, Objective 2—Applications of capacitors to motors Unit 12, Objective 3—CS motor characteristics and applications Unit 12, Objective 4—PSC motor characteristics and applications

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Describe a capacitor start induction run motor.	Unit 12, Objective 3—CS motor characteristics and applications
Describe a multi-speed motor.	Unit 9, Objective 4—Controlling shaded-pole motor speed Unit 12, Objective 4—PSC motor characteristics and applications
Electrical Troubleshooting and Problem Solving	
Troubleshooting and problem solving questions involve diagnostic procedures requiring the use of test instruments, data plate information, and wiring diagrams.	Unit 15, Objective 1—Terms and definitions Unit 15, Objective 2—Guidelines for troubleshooting HVACR system electrical circuits Unit 15, Objective 3—Identifying circuit components and their operations Unit 15, Objective 4—Guidelines for test meter selection Unit 15, Objective 5—Using a voltmeter Unit 15, Objective 6—Applying the hopscotch method for troubleshooting Unit 15, Objective 7—Using an ammeter Unit 15, Objective 8—Using an ohmmeter Unit 15, Objective 9—Check for shorts and grounds Unit 15, Objective 10—Using jumpers to troubleshoot Unit 15, Objective 11—Troubleshooting techniques Unit 15, Assignment Sheet 1—Identify components on HVACR system electrical diagrams Unit 15, Assignment Sheet 2—Identify component operation from HVACR system electrical diagrams Unit 15, Assignment Sheet 3—Select test instruments or procedures for specific HVACR system troubleshooting Unit 15, Assignment Sheet 4—Solve HVACR electrical troubleshooting problems Unit 15, Job Sheet 1—Troubleshoot series electrical circuits on selected HVACR equipment Unit 15, Job Sheet 2—Troubleshoot parallel electrical circuits on selected HVACR equipment Unit 15, Job Sheet 3—Troubleshoot series-parallel electrical circuits on selected HVACR equipment

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Knowledge of the following test instruments	
Ohmmeter	Unit 2, Objective 7—Test instrument characteristics Unit 2, Objective 8—Reading test instruments Unit 2, Objective 10—Using ohmmeters Unit 2, Objective 11—Using an ohmmeter to check motors Unit 2, Objective 12—Checking a hermetic compressor motor with an ohmmeter
Ammeter	Unit 2, Objective 7—Test instrument characteristics Unit 2, Objective 8—Reading test instruments Unit 2, Objective 13—Using ammeters
Voltmeter	Unit 2, Objective 7—Test instrument characteristics Unit 2, Objective 8—Reading test instruments Unit 2, Student Supplement 2—Multimeters
Multimeter	Unit 2, Objective 7—Test instrument characteristics Unit 2, Objective 8—Reading test instruments Unit 2, Student Supplement 2—Multimeters
Electric Heat	
Thermostat	
Identify the proper location for and install a conventional thermostat.	Unit 7, Objective 8—Installing heating/cooling thermostats Unit 7, Job Sheet 1—Install a wall thermostat and determine heat anticipation
Explain the detailed wiring and operation of a set back programmable thermostat.	Unit 7, Objective 12—Programmable thermostat applications Unit 7, Objective 13—Electronic thermostat characteristics Unit 7, Objective 14—Additional benefits of solid-state thermostats Unit 7, Job Sheet 2—Replace a standard thermostat with an electronic programmable thermostat Unit 7, Job Sheet 3—Program a programmable thermostat