Syllabus

ARM 266 Advanced Motor Control- 3 credits

Second year course for Automation, Robotics, Mechatronics A.A.S. Degree at College of Lake County

Course Description

This course covers advanced motor control as a continuation of Electrical Systems I, II, and III. The first part of the course covers general machine operation, different types of braking and loads on a motor are addressed, as well as questions of improving motor efficiency and power. Different control techniques are then discussed, including different methods of starting a motor, controlling voltage and frequency, and the role of different sensors in relation to motor operation. Troubleshooting techniques and an examination of the various causes of motor failure are discussed; preventive measures that can be taken in order to protect motors are also taught.

Learning Outcomes

1. Explain the general principles of motors and machine operation.
2. Describe the importance of motor efficiency as well as various techniques to improve efficiency.
3. Analyze motor notation symbology and control strategies, including voltage and frequency control.
4. Design motor control circuits using power electronics.
5. Demonstrate how to protect motors and prevent motor failure.
6. Use PLC programs in motor control contexts.
7. Set up sensors in order to give feedback to a control circuit.
8. Choose and install the correct safety devices for specific control circuits.
9. Troubleshoot circuit malfunctions.

Topical Outline

Section 1

Basic Motor Information and a discussion of single phase and poly phase motors are undertaken in the first Section. Students will study and understand the different starting strategies for AC motors along with other factors concerning installation related to inrush current, facility distribution systems, Service Factor, Motor Horsepower, temperature ratings, full load amperage, motor frame size and service conductor size for the motor.

Students will also learn and be able to select the proper overcurrent protection devices whether it be Fuse, Breaker, or motor overload size. Students will be able to use NEC charts to determine the proper size protection for various motor installation problems.

Students will made aware of the fact that NEC codes apply to all installations as well as some local codes in certain areas.

The students will learn and be able to identify as well as troubleshoot the different types of motor controls, including start/stop, soft start, Variable speed, Inching, and jogging.

Environmental issues with vapor, flammable liquids, dust, moisture, and ambient temperature will be discussed and how they affect motor installation.

Students will learn the difference and be able to recognize the difference between types of control systems including manual, semi-automatic, and automatic.

Students will be required to recognize and be able to describe the function of Symbols and Schematic Diagrams both NEMA and IEC, including wire colors for distribution power and cabinet wiring as per NEC and NFPA79.

Wire numbers, line numbers, cross referencing, comparison of NEMA and IEC symbols, comparison of NEMA and IEC schematic logic, IEC power and cabinet wire colors, and US DC voltage wiring color codes will be discussed and students will be able to draw diagrams as well as interpret schematics and troubleshoot them.

Control components will be discussed and students will be able to wire a circuit consisting of relays, control transformers, and motor starters.

Section 2

Students will study, draw connection diagrams and wire various motor controls using electromechanical control devices.

Using a schematic and component diagrams students will demonstrate their knowledge of these devices as well as their ability to read and interpret motor schematics. This includes start/stop circuits, three phase AC reversing starters, NEMA motor lead labels and IEC labels. Students will understand how control interlocks, and mechanical interlocks work to safeguard circuits, equipment and personnel.

Students will also gain an understanding of Jogging and inching controls as well as how they are fundamentally different. Sensors used in inching circuits will be discussed. Basic circuit control devices such as timing relays, using pushbuttons in sequencing circuits, stopping motors in a sequencing circuit.

Section 3

Students will be introduced to various sensing devices that may occur in motor control circuits. These include but are not limited to, Pressure switches, differential pressure switches, pressure sensors, float switches, liquid level sensors, flow sensors, limit switches, temperature sensing devices, electronic sensor outputs, sourcing and sinking devices, Hall Effect Devices, Proximity detectors, and photodetectors. Reading large schematic diagrams are also covered in this section. Installation of control systems is discussed, illustrated and students will demonstrate their understanding by producing control schematics.

Section 4

Students will learn full voltage, and various forms of reduced voltage starting on AC motors. Among the methods to be discussed are Full Voltage, Reduced Voltage, Wye-Delta, and Soft Starting.

DC motors are also discussed including permanent magnet, series, shunt, and compound wiring schemes. The operation, function, and importance of field loss relays will be discussed.

Starting and braking methods of single phase AC motors will be covered and students will be able to recognize the types of single phase motors on a schematic and be able to discuss how they work. Topics of dual voltage motors, consequent pole motors, multispeed motors, and shaded pole motors will be discussed.

Braking strategies including mechanical, dynamic and plugging of AC motors will be studied and braking of DC motors will be covered as well. Manual braking in the form of plugging will be discussed and troubleshooting strategies will also be covered.

Section 5

The starting and stopping of AC wound rotor, AC synchronous, and consequent pole motors will be studied and discussed in class. Wound rotor circuits will be covered as well as the sequencing of the start and stop circuits. Synchronous motor starting will discuss the DC starting circuit as well as special control components found in a control circuit for a synchronous motor.

Power factor correction may be achieved using a synchronous motor. Control of the excitation current can allow the synchronous motor to produce a leading or lagging power factor.

Consequent pole motors can be set up to have multiple speeds. This can be used as an efficiency boost or to create speed controls for application needs.

Section 6

Variable voltage, variable frequency and magnetic clutches are the main topics, in this section. Included in this will be DC motor controls, which are variable voltage. Armature power supply, field power supply, field loss, current limit, and analog tachometer circuits are discussed in this portion. Students will be able to explain their purpose and use.

Variable frequency AC motor control is discussed in this section as well as alternator frequency control, where a motor/generator is used to supply variable frequency power to induction motors to give speed control. AC Variable speed drive schematics will be discussed. The function of the rectifier, filter, chopper and regen resistor will be discussed and students will be able to identify and explain their operation. Types of semiconductors used in the inverter section will be discussed as well as their advantages and disadvantages. Special requirements for motors used with variable speed drives employing solid state switching are discussed and why special considerations need to be made.

Section 7

Motor installation is the primary point of this section along with all the things that become important when commissioning a motor in an industrial setting. The student will be able to read a motor nameplate and from that data determine wire size, fuse size, Contactor rating, mounting configuration, temperature rise, and motor efficiency. Students will be able to select the proper NEC table to make decisions about overcurrent protection, and wire size. DC motors are also included in this discussion. Termination temperatures also affect wire size to be used. Tables to be used for this are also discussed. Students will be able to determine the locked rotor current of a given motor. Conductor size for the main feeder to a motor control center for multi-motor starting is also covered. Students will be able to solve the necessary problems using nameplate data, NEC charts and determine what size components will be needed for a specific installation.

Section 8

Students will learn PLC motor control. Students will learn how to transpose a relay control into a PLC program. Students will begin by becoming acquainted with the basic components of a PLC. Students will learn the difference between the software symbols of ladder logic and their relay cousins. Students must learn to look at a PLC program and determine what potential should be at the input or output terminal or on the component. Students will program a motor control circuit.

Sensors are covered again in this section because they are important in the PLC input and output areas. Students will learn do’s and do not’s in wiring sensors for a PLC. This includes proper grounding strategies for shielded cables.

Section 9

Students will learn troubleshooting techniques in this section. They will become familiar with how to use a multimeter in troubleshooting safely as well as using other test equipment on industrial equipment. This course will add some safety instructions either not covered in the text or that are dated concerning, NFPA 70E workplace safety regulations, arc flash, and job procedures not discussed in the book but for which an employer will be looking for an applicant to be familiar with. Along with troubleshooting the circuit, we will discuss efficient means of troubleshooting factory equipment. Students will be required to troubleshoot a control circuit.

Stepping motors and switched reluctance motors

Students will become acquainted with the difference between steppers and other motors. Students will understand the term reluctance torque and how it is used in steppers. Students will be exposed to the waveform and winding configuration for steppers. The waveforms and voltages needed to step forward or backward will also be discussed. As part of the troubleshooting section, motor failures and causes will be discussed and students will be able to identify those cause and effect problems.

Course Prerequisites:

Electrical Systems I, II, III