Electronics Maintenance

Basic Test Equipment

Objectives:

- Identify the schematic symbols used to represent various devices
- Define the terms voltage, current, and resistance, and explain their relationship in a circuit
- Discuss how voltage, current, and resistance are measured with a multimeter
- Describe the major features of analog and digital VOMs
- Explain how to use both analog and digital VOMs to measure voltage, resistance, and current in a circuit
- Discuss some of the important safety precautions you must take when using a multimeter

Troubleshooting with Volt-Ohm-Milliamp Meters

Objectives:

- List the safe practices you should use when troubleshooting with a VOM
- Describe the purpose of a continuity test
- Perform tests for short circuits
- Perform resistance tests on resistors, fuses, solenoids, relays, switches, transformers, motors, and semiconductors
- Identify insulation and continuity problems by using a megger
- Measure current by using a direct series connection or by using a clamp-type ammeter
- Measure the output voltage of a DC power supply and the voltage of an AC feeder line
- Measure voltage at disconnect switches, circuit breakers, contactors, and transformers
- Perform voltage tests on circuit boards, PLC systems, and motor circuits

Using Basic Oscilloscopes

Objectives:

- Explain how an oscilloscope operates and describe its component parts
- Describe how to perform low-voltage measurements on electrical components
- Explain how to measure the voltage output of a power supply and measure AC ripple
- Describe how to perform measurements in SCR and TRIAC circuits
- Test both DC and AC servo motor controller circuits, as well as heater controller circuits
- Perform basic scope measurements on digital circuits

Basic Semiconductor Components: Diodes

Objectives:

- Describe how diodes work and how to determine if they're working properly
- Explain how different types of diodes function
- List a variety of diode uses in electronic systems
- List the characteristics that make a particular diode useful in a given situation
- Know how a diode works with other components in an electronic circuit
- Select a proper diode for replacement in a circuit

Basic Semiconductor Components: Transistors

Objectives:

- Describe the construction of bipolar transistors, and explain how their operation resembles that of the diode
- Explain how bipolar transistors can control and amplify current in a circuit
- Describe the construction and operation of JFETs and MOSFETs
- Use an ohmmeter to perform basic tests on bipolar transistors
- Perform some basic troubleshooting measurements and calculations on circuits that contain amplifying devices

Switching Devices

Objectives:

- List the advantages and disadvantages of various switch types
- Analyze basic relay ladder diagrams
- Explain how a diode can be used as a switch
- List some of the problems of diode switching
- Describe how very rapid electronic switching is accomplished
- Explain the circumstances in which a mechanical switch may be preferable to a rapid electronic switch

Electronic Sensors

Objectives:

- Describe some important thermoelectric effects
- Explain the importance of a bridge circuit in certain types of electronic instrumentation
- Describe how certain nonlinear resistors are used in circuits
- Explain how certain components can be used as protection devices for circuits
- Define the scientific terms stress and strain

Special Rectifiers: Electron Tubes

Objectives:

- List four different methods of obtaining electron emission
- Explain how vacuum tubes and gas-filled tubes operate
- Describe how a triode uses a control grid to control electron flow
- Explain why a screen grid is used in a tetrode
- Describe the function of a suppressor grid in a pentode
- Describe how electron beams are controlled in a cathode ray tube (CRT)
- Troubleshoot a half-wave rectifier power supply

Optoelectronic and Fiber-Optic Components

Objectives:

- Explain why electronics and optics are natural partners in the field of optoelectronics
- Identify the modern theories of light and how they help you to understand optoelectronic applications
- Describe the basic theory of light communications
- Explain the basic theory and applications of bar codes
- Identify the advantage of using infrared light instead of visual light with intrusion alarms and television remote controls
- Describe the basic operation of electron microscopes and their advantages over optical microscopes
- Explain how fluorescent light and other light sources operate

Electronics Hardware

Objectives:

- Identify various connector and terminal types and their specific applications
- Identify many types of wire and cables and specify the applications for each type
- Determine the expected resistance of a wire
- Estimate the change in wire resistance with changing wire characteristics
- Select the proper soldering equipment and material for electronic component soldering jobs
- Outline the proper procedures for soldering components in both PC board and SMT applications
- Explain the special handling procedures required when working with SMT components

Amplifiers

Objectives:

- Indicate the advantages of the various classes of transistor amplifier operations
- Calculate the dB gain of an amplifier
- Identify several types of transistor amplifier circuits
- Explain the methods that are used for biasing amplifiers
- Explain how to perform simple troubleshooting operations on amplifiers
- Understand the various types of distortion that are introduced by amplifiers

Audio and RF Circuits

Objectives:

- Describe how sound intensity is measured
- Compare the advantages of AM and FM transmission
- Describe how narrow-band FM is used in industrial communications
- Explain the advantages of coaxial cable over copper wire as a transmission medium
- Discuss the tone frequencies that are used in control systems, including subaudible and ultrasonic tones
- Describe how pushbutton dialing can be used in industrial systems
- Explain the different methods used to assemble common emitter amplifiers
- Identify different common-emitter amplifiers on a schematic drawing

Oscillators, Feedback, and Waveforms

Objectives:

- Explain how an oscillator works
- Identify several basic oscillator circuits
- Discuss how feedback is obtained in an oscillator
- Recognize several different waveforms, and explain how they're created
- Understand how a phase-locked loop works as a frequency synthesizer
- Explain how a 555 integrated circuit timer/oscillator produces a square wave

Electronic Power Supply Systems

Objectives:

- Explain the basic function of rectifiers
- Describe how half-wave and full-wave rectifier circuits operate
- Determine the output voltage from various rectifier circuits
- Calculate the percent of voltage regulation in a power supply
- Explain the operation of filters and bleeder resistors in power supplies
- Describe the purpose of a voltage-divider network in a power supply
- Explain the operation of electronic voltage regulators
- Describe the operation of several commonly used industrial power supplies

Industrial Amplification Systems

Objectives:

- Explain how a power amplifier is different from a voltage amplifier
- Calculate dB gain by using input and output resistances, impedances, and phase angles
- Describe the advantages and disadvantages of VMOS, BiFET, Darlington, push-pull, and complementary amplifiers
- Explain how to use amplifiers to obtain the proper phase angles needed to operate a twophase induction motor
- Analyze an operational amplifier on the basis of the virtual ground or the summing point
- Describe how an amplifier introduces distortion and noise in an amplified signal

Servo and Control Systems

Objectives:

- Explain the functions of the various components of a servo system
- Discuss the overall operation of servo systems
- Describe the common applications of servo systems
- Discuss the use of various electronic circuits in servo applications
- Calculate the gain of servo systems

Pulse and Logic Circuits

Objectives:

- Explain the differences between digital and analog circuits
- Define how slow-speed circuits compare to fastspeed digital circuits
- Tell how logic zeroes and ones-also called lows and highs-are used
- Compare the different kinds of logic gates
- Identify latch or flip-flop circuits
- Explain the difference between serial and parallel inputs and outputs

Programmable Controllers and Microprocessors

Objectives:

- Identify the inputs and outputs used in a PC, and describe their functions
- State the functions of the various blocks of a microprocessor system
- Cite the advantages and disadvantages of different kinds of memory devices
- Indicate the different ways that PCs may be programmed
- Identify the language, jargon, and mnemonics associated with microprocessors and programmable controllers

Industrial Electronic Troubleshooting

Objectives:

- Explain why a safety inspection is the first inspection that should be made on a failed piece of equipment
- Discuss how to make safety a part of all troubleshooting and repair procedures
- Understand how to collect accurate data on trouble clues
- Describe how to use system indicators to help you troubleshoot an electronic system problem
- List the steps for proper basic troubleshooting, such as identifying failure trends, seeking obvious causes, and circuit board swapping
- Describe how to perform advanced troubleshooting, such as using binary divide techniques and focusing on one of many failure possibilities
- List the aptitude and attitude qualities needed to be a good industrial troubleshooter

Electronic Troubleshooting of Industrial Motor Controllers

Objectives:

- Describe various methods of controlling the speed and direction of a DC motor
- Explain the proper steps for troubleshooting a DC motor controller
- List the various types of stepper motor drives and explain how to troubleshoot these systems
- Define how DC servo systems operate and explain the normal test points for locating faults in these systems
- List the types of adjustable frequency drives and explain how to troubleshoot their circuits
- Describe how brushless servo systems operate and how to troubleshoot various problems with these systems

Troubleshooting Sensing Devices and Systems

Objectives:

- Identify the components of a typical limit switch and describe how to test these devices
- Describe the operation of pressure switches
- Identify the components of and troubleshooting procedures for temperature-sensing devices and level detectors
- Describe the operation of and troubleshooting methods for proximity, ultrasonic, photoelectric, fiber optic, and laser sensors
- Define the proper troubleshooting methods for sensors that are connected to input modules

Troubleshooting Industrial Control Systems and Output Devices

Objectives:

- Describe the operation of relays and solenoids and procedures for troubleshooting them
- Explain how to troubleshoot across-the-line starters and contactors, including solid-state controlled contactors
- Explain the importance of arc-suppression diodes and resistor/capacitor networks in output-device circuits
- Define the operation of and repair methods for simple numeric readouts
- Explain how DC and AC output modules operate and how to troubleshoot them
- Identify different types of closed-loop control systems and methods to troubleshoot and repair them
- Explain how to troubleshoot and repair human/machine interface systems

Troubleshooting Industrial Computer Systems and Software

Objectives:

- Discuss the principal parts and types of memory found on a computer motherboard
- Identify power supply components and ratings
- Locate the main power supply fuse and identify the type of power supply by its connectors
- Identify the various types of computer drive systems and their cables
- List the repair and troubleshooting procedures for computer hardware and software problems
- Describe the operation of and troubleshooting procedures for optical and RF identification systems
- Explain the purpose of vision system hardware and software and the troubleshooting procedures for them

Industrial Computer Networks

Objectives:

- Describe the methods of communication within networks
- Explain the configurations of various types of industrial network systems
- Identify and describe different types of network cables
- Discuss various network protocols
- Describe troubleshooting methods for networks

Introduction to Troubleshooting

Objectives:

- Locate the causes of trouble in basic electronic circuits by the logical process of eliminating various alternatives
- Read electronics schematics and recognize component symbols
- Recognize actual components and circuits by comparison with a schematic
- Discuss safety measures and first-aid care

Basic Troubleshooting Methods

Objectives:

- Recognize symptoms; know what they are, how to use them, and how to refine them
- List the methods of quickly isolating trouble areas by separating what's right from what "ain't"
- Describe the various troubleshooting techniques
- Explain where and how to use different troubleshooting methods, either separately or in tandem, to speed up the resolution of your troubleshooting assignments

Selecting Instruments for Troubleshooting

Objectives:

- Discuss the different kinds of basic meters and oscilloscopes
- Select the right instrument for a given job
- Explain instrument response, circuit loading, accuracy, and other data
- Demonstrate how to use a meter to make both out-of-circuit and in-circuit tests on several basic components
- Read and explain both analog and digital readouts
- Describe instrument specifications, and explain how to interpret them
- Define common oscilloscope and meter controls and their uses

Measuring Techniques in Troubleshooting

Objectives:

- Measure test voltages and currents
- Understand how loading can affect tests, and how to minimize loading effects
- Make high-voltage measurements safely
- Measure alternating current without opening the circuit
- Set up and make a-c (alternating-current), d-c (direct current), frequency, and time measurements with an oscilloscope
- Use wattmeters, frequency counters; capacitor meters, insulation testers, and other special instruments found in industry
- Test digital circuits using digital probes and pulse injectors

Support Services for Troubleshooting

Objectives:

- Demonstrate good soldering techniques
- Select and maintain solder tips
- Describe the various desoldering methods
- Care for desoldering irons and systems
- Discuss troubleshooting aids
- Explain troubleshooting strategies

Practical Troubleshooting Problems

Objectives:

- Recognize the various kinds of power supplies, and the troubles to be expected from each
- Explain how ohmmeters, voltmeters, and oscilloscopes are used to locate power-supply troubles
- Describe how regulators work, including what symptoms they develop and how to read them
- Define how to test electrolytics, transistors, diodes, and other parts, within as well as outside the circuit
- Explain the testing of digital circuits, including how it differs from and compares with other kinds of troubleshooting
- Recognize microprocessors, and be able to find troubles in them and in digital systems

Approach to Troubleshooting

Objectives:

- Lay out a schedule for preventive maintenance of digital and microprocessor equipment
- Name the “levels” of advanced digital/MPU troubleshooting
- Explain the significance of system block diagrams to speedy troubleshooting
- Select appropriate test nodes for various kinds of industrial electronic systems
- Describe advanced concepts of symptom analysis in digital and microprocessor systems

Analysis of Systems

Objectives:

- Explain system thinking
- Utilize diagnostic thinking
- Isolate faults in digital, analog, and microprocessor subsystems
- Analyze activity on bus systems that are common to industrial electronic systems
- Describe several popular bus, standards

Test Equipment Applications

Objectives:

- List testing equipment you’re likely to need to troubleshoot systems in your company
- Describe functions of various modern test instruments
- Utilize delayed sweep in modern oscilloscopes
- Set up operating controls of advanced instruments for industrial troubleshooting
- Choose the instrument most appropriate to a given set of symptoms displayed in a particular type of system

Safe Troubleshooting Practices

Objectives:

- List the factors involved in troubleshooting industrial electronic systems safely
- Describe or demonstrate the correct use of hand tools most frequently used for servicing
- Practice safe techniques while working around heavy electric power
- Recognize the need for cardiopulmonary resuscitation (CPR), and administer CPR effectively

Troubleshooting Industrial Systems Part 1

Objectives:

- Make and use troubleshooting flowcharts
- Use symptom clue tables to speed troubleshooting
- Approach heavy-duty a-c control as readily as you tackle servicing in any other subsystem
- Analyze failure rates and apply your analysis to regular maintenance and troubleshooting
- Test and evaluate individual linear and digital devices

Troubleshooting Industrial Systems Part 2

Objectives:

- Apply a digital oscilloscope where and when it seems indicated
- Attach a logic analyzer to multiple nodes as well as to buses
- Capture signatures in equipment that has been prepared for this technique, and analyze what you find
- Establish useful signatures in systems not so prepared by the manufacturer

Reactance and Impedance

Objectives:

- Explain how resistors, capacitors, and inductors work in DC (direct current) circuits
- Calculate time relationships in circuits
- Determine the reactance of a capacitor or inductor in an AC (alternating current) circuit
- Calculate the impedance of series RLC (resistive-inductive-capacitive) circuits
- Find the phase angle between the voltage and current in parallel RC (resistive-capacitive), RL (resistive-inductive), and series RLC circuits
- Work with j operators

Resonant Circuits

Objectives:

- Understand the difference between time domain and frequency domain displays
- List all the conditions necessary for series and parallel resonance
- Calculate the resonant frequency of an LC (inductive-capacitive) circuit
- Calculate the value of the quality factor Q
- Describe the relationship between Q and bandwidth
- Describe some of the uses of tuned circuits in a radio
- Understand the results of distributed components

Applications and Troubleshooting of Resonant Circuits

Objectives:

- Estimate voltages for troubleshooting both DC and AC circuits
- Explain the importance of impedance matching
- Identify the circuits for low-pass, high-pass, band-pass, and band-reject filters
- Identify two important power-supply filter designs
- Describe the relation between the band-pass and the 3 dB (decibel) points on a filter's characteristic curve
- Explain how transmission lines are related to resonant circuits and waveguides
- Explain how transmission lines can be used as components or tuned circuits

Rectifiers and Power Supplies

Objectives:

- Identify the basic types of electronic rectifiers
- List the advantages of different rectifier connections
- Determine the current through and the voltage across nonlinear components, such as diodes
- Discuss the operation of power supply filters
- Explain how voltage dividers are used in power supplies
- Calculate the values of voltage divider components
- Describe how voltage-regulating devices and circuits operate
- Explain how current and voltage are regulated in power supplies

Amplifiers

Objectives:

- Indicate the advantages of the various classes of transistor amplifier operations
- Calculate the dB gain of an amplifier
- Identify several types of transistor amplifier circuits
- Explain the methods that are used for biasing amplifiers
- Explain how to perform simple troubleshooting operations on amplifiers
- Understand the various types of distortion that are introduced by amplifiers

Oscillators

Objectives:

- Explain the principal differences between several types of oscillator circuits
- Describe the flywheel effect and how it's produced
- Calculate the resonant frequency of a basic oscillator circuit
- Explain the operation of complex RLC tuned circuits
- Explain the operation of oscillators that have LC feedback circuits
- Explain the operation of oscillators that have RC feedback circuits
- Discuss the basic applications of oscillator circuits
- Describe how a frequency synthesizer works

Modulation and Detection Circuits

Objectives:

- Explain the various forms of modulation
- Determine the degree of amplitude and frequency modulation
- Describe the frequencies that result from combining or mixing two signals
- Calculate the bandwidth of AM and FM signals
- Describe the advantages and disadvantages of pulse-code modulation
- Explain the theory and applications of phase-locked loops
- Describe the various types of demodulation circuits, and the functions of the various circuit components
- Discuss the advantages and disadvantages of different types of pulse modulation, such as PAM, PWM, and PPM

Switching Circuits

Objectives:

- Identify the output conditions for various gate circuits
- Show how transistors are used as logic gates
- Discuss the operation of multivibrators and flip-flops
- Discuss the advantages and disadvantages of various logic families
- Show the application of Boolean algebra to logic circuitry

Logic Circuits

Objectives:

- Convert binary numbers to other number systems, and vice versa
- Develop and use truth tables
- Describe and explain the use of some of the more common encoders, decoders, and converter circuits
- Explain how adders, subtracters, and comparators are used

Gating and Counting Circuits

Objectives:

- Describe the working of arithmetic-logic gates
- Work with half-adder and full-adder circuits
- Discuss the use of subtracter circuits
- Identify applications for both decade and binary counters
- Determine the modulus of a counter

Pulse and Digital Circuits

Objectives:

- Sketch several types of pulses, and point out those dimensions or characteristics of pulses that are of particular interest in electronic circuits and systems
- Explain the relationship of time constants to pulse-forming circuits
- Identify the different types of output waveforms obtained from integrating circuits and differentiating circuits when pulses are applied to their inputs
- Draw schematics for basic integrating and differentiating circuits
- Identify basic limiter and clamper circuits, and describe how they improve the operation of pulse circuits and digital systems
- Discuss the use of pulses to trigger other circuits
- Explain how pulses can represent binary numbers

Pulse Techniques

Objectives:

- Calculate the rise time of a pulse or square wave from an oscilloscope display
- Identify a glitch, and understand its effect on digital circuits
- Measure pulse width and settling time
- Determine pulse repetition rate from the period of a pulse waveform
- Explain the difference between frequency and time domains
- Understand how Fourier analysis is used to explain the makeup of various waveforms

Pulse Generators

Objectives:

- Determine the voltage across a charging or discharging capacitor at any instant of time
- Calculate the current through an RL circuit for any instant of time
- Explain the importance of five time constants
- Explain the relationship between time-constant and integrating or differentiating circuits
- Explain the operation of multivibrators
- Tell why a Schmitt trigger is important in the study of pulse circuits

Wave-Shaping Circuits

Objectives:

- Distinguish between a clipper and a limiter
- Recognize a baseline stabilizer capable of stabilizing to zero volts
- Limit a waveform to some value other than zero volts
- Explain how a waveform can be clamped to a positive or negative voltage
- Discuss why a d-c (direct-current) restorer circuit is sometimes needed
- Compare an ideal clamping circuit with those that exist in the real world
- Identify a sawmaker circuit
- Explain how amplifiers change the characteristics of a pulse

Timing

Objectives:

- Describe how timers are used in spot welders and list other applications of timers
- Explain the purpose of each internal part of the 555 IC (integrated-circuit) timer
- Tell how counters are used for timing
- Explain how a one-shot multivibrator can be used to obtain a fixed time interval and how a 555 IC timer can be used as a monostable multivibrator
- Compare the 555 and 3905 IC timers

Pulse Circuit Applications

Objectives:

- Determine the on period for a 555 monostable multivibrator circuit
- Describe how a 555 timer can be used in an astable multivibrator circuit
- Determine the free-running frequency of a 555 astable multivibrator
- Discuss the use of synchronization for astable multivibrators, and for astable 555 timer freerunning circuits
- Describe how pulses are used for measuring both voltage and capacity, and how switching regulators work in power-supply systems

Troubleshooting Pulse Circuits

Objectives:

- List the characteristics of pulses to be tested
- Compare the troubleshooting of pulse circuits with that of other systems
- Determine which part of digital and pulse circuits to test first in quick troubleshooting procedures
- Explain the use of logic analyzers and the purpose of single-step testing
- Understand the troubleshooting techniques for a microprocessor system

Logic Circuit Fundamentals

Objectives:

- Define terms commonly used in electronic logic
- Identify the symbols of electronic logic in system diagrams
- Explain those simple logic circuits used in industrial machinery
- Draw simple logic diagrams, and interpret those that others have drafted
- Name and recognize the logic circuits that use discrete components
- Discuss basic integrated-circuit logic devices
- List the symbols and notation conventions of Boolean logic
- Write simple Boolean algebra equations

Introduction to Number Systems

Objectives:

- Explain the binary numbering used by computers and digital electronics equipment
- Understand hexadecimal notation as is used in machine-language programs
- Recognize octal numbers, and know how they're used
- Count in binary, octal, and hexadecimal numbers
- Convert values from one number system to another
- Perform simple calculations in all four number systems
- Explain the main advantage of the binary-coded decimal (BCD) system as compared with the ordinary binary number system

Logic Devices and Diagrams

Objectives:

- Draw logic diagrams that conform to a desired logic function
- Define Boolean variables, terms, and expressions
- Trace logic circuitry through gates, whether they're discrete or parts of ICs
- Figure out the logic equivalents for complex logic circuits
- Simplify logic circuitry through Karnaugh mapping
- Recognize those binary patterns that produce a particular result in logic circuitry
- Compile truth tables for complex logic functions

Logic Families

Objectives:

- Define the major families of digital logic ICs (integrated circuits)
- Identify a logic family from its operating parameters
- Define such terms as SSI, MSI, LSI, and VLSI
- Describe IC packaging for logic components
- Understand such logic-device qualities as noise immunity and noise margin
- Explain the meaning of fan-in and fan-out
- Interpret specification sheets for logic ICs

Applications of Logic Circuits

Objectives:

- Explain the functions of digital circuits composed of simple logic gates
- Design a simple binary ladder for digital-to-analog conversion
- Compile truth tables for sequential logic devices
- Recognize the diagram symbols for various types of flip-flops
- Read timing diagrams for flip-flops and counters
- Explain registers, counters, decoders, and multiplexers
- Understand just how logic registers perform arithmetic operations

Troubleshooting Logic Controllers

Objectives:

- Identify expected logic levels by measuring d-c (direct-current) supply voltages
- List key specifications for logic circuit test equipment
- Trace logic functions with a logic probe, and identify errors
- Use an oscilloscope as a logic tracer
- Describe the fundamental operations of a logic analyzer
- Explain what a signature analyzer does
- Wire up a logic probe of your own
- Calculate approximate frequency of a digital signal from oscilloscope readings
- Replace MOS (metal-oxide semiconductor) devices without damage to them or to the system equipment

Linear and Digital Circuit Principles

Objectives:

- Draw transfer curves for functions of both linear and digital devices
- Explain the nature of analog operation, as compared to digital
- List the advantages of digital operation, and those of analog (linear)
- Describe the operation and uses of Hall-effect devices
- Identify circuits wired up from linear or digital ICs
- Discuss voltage and power parameters for digital and linear devices
- Draw diagrams of common linear and digital circuit hookups
- Recognize applications for the popular SSI (small-scale integration) and MSI (medium-scale integration) digital ICs

Integrated-Circuit Techniques

Objectives:

- Name the materials and processes used in IC fabrication, and list their purposes
- Locate the data you need in order to use ICs properly
- Understand and use manufacturers' numbering systems
- Explain the key parameters for most linear and digital IC devices
- Discuss typical applications for digital and linear technologies
- Describe the technologies incorporated in hybrid ICs
- Place ICs safely into industrial operating environments
- Keep IC voltages and currents within safe operating limits

Linear Integrated Circuits

Objectives:

- Diagram the concepts of sensing and process control with linear ICs
- Recognize diagrams for common linear devices and functions
- Define the words analog' and linear as they apply to industrial electronics
- List several kinds of analog IC amplifiers
- Describe the operation of a general-purpose op amp (operational amplifier)
- Explain how an active filter works
- Follow the operation of a phase-locked-loop IC

Digital Integrated Circuits

Objectives:

- Read logic diagrams for digital IC (integrated-circuit) devices and functions
- Explain the inputs and outputs of several digital ICs
- Distinguish which kinds of latches or flip-flops an advanced IC uses
- Differentiate between a shift register and a port register
- Explain the difference between asynchronous and synchronous counters
- Discuss the difference between bus drivers and display drivers

Integrated-Circuit Logic Systems

Objectives:

- Interpret full-scale schematic diagrams for industrial equipment
- Interchange digital devices in designs without destroying performance
- Explain the kinds of buses used for industrial digital systems
- List uses for logic gates in systems that perform industrial tasks
- Relate digital systems to specific operations

Troubleshooting Linear and Digital IC Systems

Objectives:

- Approach troubleshooting with a systems outlook
- Verify inputs to linear and digital sections and subsystems
- Use a digital multimeter appropriately in IC systems
- Choose a proper instrument for each troubleshooting test
- Identify IC and connector socket pins for troubleshooting
- Interpret indications from a clip-on logic tester
- Wire up test jigs that save troubleshooting time
- Analyze oscilloscope waveforms in linear IC stages

Industrial Computer Fundamentals

Objectives:

- Describe some of the limitations of early industrial computers
- Tell how analog computers evolved, and why their popularity has waned
- Explain the differences in the ways analog and digital computers are used
- Understand why digital computers have largely supplanted analog types
- Describe what goes on inside an industrial computer
- Draw block diagrams showing typical industrial computer applications
- Name the different ‘types of industrial computer displays
- List some important manufacturing tasks undertaken by modern computers
- Describe what it takes to write software programs for industrial computers

Digital and Analog Systems

Objectives:

- Explain the fundamental principles involved in analog computer systems
- Recognize commonly used analog computer diagram symbols, and explain their meanings
- Explain the fundamental principles of digital computing systems
- Describe the functioning of open and closed loops
- Explain the difference between switched and proportional-control schemes
- Name several types of proportional-control arrangements

Software and Programming

Objectives:

- Define the term software
- Describe those industrial systems that need software
- List some of the sources of industrial software
- Recognize the standard symbols used in industrial control diagrams
- Explain how to use ladder logic, machine and assembly language, and BASIC
- Lay out simple control problems in terms of Boolean algebra
- Write control algorithms in ladder logic
- Use fundamental logic simplification techniques

Computer-Aided Control Systems

Objectives:

- Draw a block diagram of a CAD/CAM system
- Describe the equipment needed for computer-aided graphics
- Recognize CAD/CAM software
- List some requirements for selecting a CAD or CAM system
- Explain the benefits of computer aid in industrial operations
- Cite applications for computer-aided design and drafting (CADD)

Interfacing Principles

Objectives:

- List the services that interface devices perform
- Describe the nature of serial and parallel data movements
- Discuss methods for converting analog data to digital data
- Explain signal conditioning
- Draw an ordinary analog/digital control loop and identify its components
- Describe the parity method of checking data transfers for errors

Introduction to Computer

Objectives:

- List the most important factors on which the selection of a computer is based
- Name some of the skilled jobs and positions related to computer work
- Describe what is meant by the term “multiplexing”
- Tell what is meant by “bugs” as the term relates to computers
- Point out the main sections of a computer
- Identify some of the peripheral items in a computer system
- Define some of the important terms used in computing work such as “ROM,” “RAM,” “subroutine,” “video monitor,” and others
- Tell how a microprocessor plays a part in a computer system

Introduction to Microprocessor Applications

Objectives:

- Explain how bytes are comprised of bits
- Describe how a microprocessor acts only on the receipt of codes from its instruction set and explain two examples
- Tell how a microprocessor uses a feedback loop to control machinery
- Compare the history of the MPU with the advancement of electronics from the vacuum tube through to very large scale integration (VLSI)
- Explain how an MPU system is used for maintenance diagnosis
- Tell what is meant by “scratchpad” memory and “handshaking”
- Translate bit patterns to binary 1 and 0 patterns
- Explain MPU firmware, including who prepare it and what they do with it

Microprocessor Basics, Part 1: Underlying Principles and Concepts

Objectives:

- Draw the logic symbols of the buffer and noninverting buffer, and the NOT, AND, OR, NAND, NOR, XOR, and XNOR logic gates; and understand their use in logic circuits
- Show how logic gates are applied in security and safety applications
- Explain how analog and digital signals differ
- Identify pulse characteristics, including pulse width, pulse repetition, rate, pulse recurrence time, duty cycle, rising edge, and falling edge
- Set up and explain truth tables for logic gates
- Draw the logic diagrams for two R-S flip-flops, the D flip-flop, and for the J-K flip-flop, and explain their operations and truth tables for all possible input and clock-pulse conditions
- Determine the equivalent binary number for a decimal number (and vice versa)
- Count in binary numbers

Microprocessors Basics, Part 2: How a Microprocessor Works

Objectives:

- List the registers and work centers in a typical microprocessor
- Tell how a microprocessor brings data into its registers
- Describe how data enters and leaves a microprocessor
- Explain how a microprocessor sends data into memory, and later finds it
- Explain the purpose of the instruction register and decoder
- Point out the position of an ALU (arithmetic-logic unit) in a microprocessor
- Describe the function of accumulators
- Detail how condition codes or status flags keep track of ALU activities
- Follow a program counter as it steps through program execution
- Define a stack, and name the duties of the stack pointer
- Tell why the MPU has an index register, and how it can be used
- Name the control inputs and outputs of an MPU, and tell what each one does

Motor Control Fundamentals

Objectives:

- Explain the operation of a motor starter
- Differentiate between NEMA and IEC starters
- Interpret control circuits using control diagrams
- Determine the proper size of a starter for a given motor
- Describe the operations of reversing and multi-speed starters
- Identify automatic and manual signaling devices
- Explain the operation of capacitive and inductive switches
- Determine the type of enclosure appropriate for a given environment

Industrial Motor Controls Part 1

Objectives:

- Define the function of the central processing unit (CPU)
- Describe the CPU scan
- Identify analog and discrete signals
- Describe different types of PLC memory
- Explain the function of input and output systems
- Identify the elements of a relay ladder logic program
- Describe the operation of timers and counters

Industrial Motor Controls Part 2

Objectives:

- Describe typical PLC elements such as contacts and coils
- Explain how PLCs scan or solve ladder logic programs
- Explain typical ladder logic terminology and symbology
- Describe the operation of a PLC-controlled pick-and-place robot and how to troubleshoot the robot using the PLC system
- Explain how the programming console for a PLC will highlight power flow as a troubleshooting aid
- List the steps to the development of ladder logic for a mixing vat and describe how to troubleshoot the vat
- Explain how the use of internal coils makes ladder logic development easier for a multidirection motor system as used in a roll stand machine

Working with an Uncomplicated Microprocessor, MC6802 Part 1

Objectives:

- Explain the effect of a d-c voltage regulator, and apply it to the proper MPU pins
- Measure a-c (alternating current), and ripple voltages in an MPU power supply
- Trace and test VCC and VSS connections, and check out other chip connections
- Send instruction into a microprocessor
- Explain which MPU logic will cause read and write operations
- Bring data into a microprocessor from direct or extended addresses in memory
- Name the main addressing modes of the MC6802 microprocessor instruction set
- Set a flag in the CCR (condition codes register) to force a program branch
- Decode an address and use the memory-mapping concept of in/out control
- Direct data to a particular register inside an MPU
- Address either on-chip or external RAM (random-access memory)

Software-Microprocessor Programming Principles

Objectives:

- Quickly convert among the decimal, hexadecimal, and octal number systems
- Follow and develop simple programs written in hexadecimal notation
- Store a program in the read-write memory of your ICS XK-300 Microprocessor Trainer
- List the nine varieties of instructions for the MC6802
- Run a program the you have written which subtracts hexadecimal numbers
- Use two's-complement math to find the decimal value of a negative-signed binary number

Working with an Uncomplicated Microprocessor, MC6802 Part 2

Objectives:

- Find the entry vectors for the four major types of interrupt, including Reset
- Arrange either a 1-bit or a whole-byte prompt
- Locate display or other output addresses in a memory-mapped MPU system
- Display contents of memory chips in RAM and ROM, and map the memory
- Examine registers of the MC6802 microprocessor
- Use single-step execution as a software-debugging tool

Software-Microprocessor Programming Principles Part 2

Objectives:

- Think through a programming task, and break it into component parts
- List the procedures necessary for an MPU to perform each part of the job
- Draw a flowchart that illustrates the most efficient sequence for a give MPU undertaking
- Streamline a program, both to save memory space and to make it run more efficiently
- Utilize mnemonics in writing source code for a program
- Document your program plan with appropriate comments on a Programming Sheet
- Differentiate between an effective address and the object code for that address
- Demonstrate that you can choose wisely from among the several op codes available for some MPU commands
- Assemble object code for a program you've written
- Manipulate data inside and outside the MPU by the use of software
- Program the MPU to do advanced arithmetic
- Build your own reference book of useful routines and subroutines that you've devised
- Use conditional branches for decision-making
- Control program execution by careful use of jumps and branches

Interfacing through Serial and Parallel Ports

Objectives:

- Explain the difference between serial- and parallel-data transfer
- Address output ports without the use of peripheral adapters
- Memory-map a peripheral interface adapter (PIA)
- Use interrupts to bring an outside task to the attention of the MPU
- Discuss the concept of parity and how it keeps data transfer accurate
- Direct the MPU to input or output data in the pulse and handshake modes
- Save data on magnetics tape, using a cassette interface
- Discuss the basics of a disk controller
- Manage the protocol between MPU and line printer
- Tell how an MPU makes characters on a video terminal

Troubleshooting Microprocessor Equipment Part 1

Objectives:

- Diagram the main modules of a microprocessor system from its operation
- Arrange trial runs of the equipment so that you can judge its performance
- Analyze equipment operation (or nonoperation) and decide where a fault may lie
- List the four main steps in tracing down the breakdown of a specific part
- Go directly to key test points that will tell you most about system operation
- Check out software associated with a system, and eliminate bugs that develop
- Design diagnostic routines that exercise various portions of a system
- Read monitor listings and identify any built-in diagnostic possibilities
- Assess system operation by use of breakpoints place in the software
- Eliminate software bugs that cause unwanted loops or break up proper loops
- Describe what assemblers, compliers, and interpreters do

Troubleshooting Microprocessor Equipment Part 2

Objectives:

- Use a digital multimeter to trace VCC problems
- Trace logic through gates and decoders with a logic probe
- Build your own logic tracer and assess its readings
- Apply a logic pulser properly, and evaluate its circuit effects
- Interpret what a triggered oscilloscope tells you about digital operations
- Understand the application of a logic analyzer
- Explain the concepts behind signature analysis used as a troubleshooting tool
- Verify the grounding integrity of a microprocessor system installation
- Hunt down cable and connector problems that disable a system
- Check out all the sections of a computer or MPU-controller mainframe
- “Ring” three-state buses for shorts and opens
- Maintain peripheral equipment, including keyboards, video monitors, line printers, and disk drives

Other families of Microprocessors

Objectives:

- Find and use specification sheets on microprocessors and support chips
- Recognize the architecture of several popular microprocessors
- Employ many different addressing modes in software
- Recognize the meaning and use of the those instructions peculiar to advanced MPUs
- Define the characteristics and applications of microprocessors with 16-bit data buses
- Explain the 24-bit addressing system used in at least one modern microprocessor
- Understand the directions being taken in current microprocessor development

Physical Properties and Their Measurement Part 1

Objectives:

- Determine the slope of a line and the direction of acceleration vectors
- Calculate centripetal force and angular acceleration
- Solve problems involving power, work, efficiency, and mechanical advantage

Physical Properties and Their Measurement Part 2

Objectives:

- Describe how the properties of a liquid determine the liquid’s viscosity
- Convert temperature readings from the English system of measure to the SI system
- Solve problems involving heat, light, and sound

Measuring Instruments and Signal Processing

Objectives:

- Given a particular schematic, identify the correct circuit function
- Identify the principle upon which a permanent-magnet meter movement works
- Distinguish between indicating, recording, and integrating instruments
- Correlate the proper logic gate with a typical logic statement
- Select certain working parts, given a particular meter movement construction

Transducers

Objectives:

- Identify basic types of transducers and similar sensing devices
- Explain the operating principles of transducers
- Discuss the characteristics and applications of various types of transducers
- Select the proper transducer for any particular industrial application

Introduction to Control Systems

Objectives:

- Discuss the types of components in a closed-loop system, and their functions
- Recognize the effect of deviation and duration on control response
- Explain the functions of the various types of synchro systems
- Calculate signal responses from scaling transducers
- Cite the function of the various microprocessor parts

Controllers

Objectives:

- Relate the role of the controller in a process-control system
- Identify the various terms and response characteristics of controller systems
- Recognize the symbols and nomenclature used to describe controller circuits
- Select the correct module symbol for a desired controller action

Control System Methods

Objectives:

- Select the proper logic gate to obtain the desired output for any given input
- Write the logic statement for a logic circuit
- Determine the binary word output of a memory unit
- Describe the functions of registers in a microprocessor unit

Data Logging, Transmission, and Display

Objectives:

- Discuss various data-input methods, codes, and devices
- Feel at home with the various special terms used in the computer field
- Understand the different methods of communication between computers and related equipment
- Write a simple computer program

Control System Applications, Maintenance, and Troubleshooting

Objectives:

- Explain the meaning of reliability and performance as they relate to control systems
- Calculate simple probabilities
- Discuss the methods of increasing system reliability
- Explain how people fit into control system operation and management
- Outline how to troubleshoot a controller
- Discuss how digital computers impact controller reliability

Voltage and Frequency Controllers

Objectives:

- Identify the four methods of converting power from one form to another
- Understand a plant distribution system for power
- Point out the effects of fluorescent lamps, heating equipment, and electronic equipment on the line voltage
- Understand the methods of preventing voltage fluctuations in the power system
- Describe how power factor affects the operation of the plant power system
- Describe a crowbar circuit
- Know how a ferroresonant transformer works
- Understand how the output of an inverter can be adjusted to have any desired frequency

Nondestructive Test Equipment

Objectives:

- Describe the advantages and disadvantages of each major NDT method
- Describe the equipment and procedures for each widely used NDT method
- Relate the basic concepts behind each NDT method
- Describe the use of electronics in NDT methods
- Draw a simple diagram of an X-ray machine
- Cite the equipment components used for ultrasonic testing

Resistance Welding Equipment

Objectives:

- Describe two types of electric welding
- Identify the steps in making a resistance weld
- Explain how capacitor discharge welders operate
- Discuss the use of ignitrons in resistance welders
- Calculate the form factor of a waveform
- Calculate the percent duty cycle of an electronic device

Induction and Dielectric Heating

Objectives:

- Explain the spin theory of magnetism
- Discuss how induction heating works
- Define the three ways of transferring heat
- Describe source applications of induction heating
- Explain how dielectric heating works
- Describe some applications of dielectric heating
- Discuss the advantages of induction and dielectric heating
- List the disadvantages of induction and dielectric heating

Cranes, Scales, and Materials Handling

Objectives:

- Describe the types of cranes and where they're used in industry
- Tell about important factors concerned with wiring cranes, and controlling, braking, and stopping crane motors
- List four kinds of crane controls and describe their special features
- Identify the types of remote radio-control systems and be familiar with the special rules concerning them
- Describe the kinds of instruments designed for crane work
- Describe how strain gages are used in load cells as a part of electronic weighing systems
- List the methods of calibrating heavy-duty weighing systems and the main features of each type