Digital Logic Circuits
Annotated Instructor's Guide

Module 12401-03

MODULE OVERVIEW

This module explains basic digital logic elements, flip-flops, shift registers, and counters.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following:

Core Curriculum; Instrumentation Levels One through Three

OBJECTIVES

When you have completed this module, you will be able to do the following:

1. Identify the different gates and circuits in digital logic.
2. Describe the truth tables and timing diagrams for various digital gates.
3. Describe the operation of different digital flip-flops.
4. Describe the operation of shift registers.
5. Describe the operation of counters.
6. State the purpose of the American National Standards Institute (ANSI) Q90–Q93 standards.

PERFORMANCE TASKS

There are no performance tasks for this module.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Module Examinations*

*Located in the Test Booklet.

SAFETY CONSIDERATIONS

There are no required safety considerations for this module.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

Bebop to the Boolean Boogie, 1995. Clive Maxfield. Solana Beach, CA: High Text Publications, Inc.
Digital Fundamentals, 1995. Thomas L. Floyd. Englewood Cliffs, NJ: Prentice Hall, Inc.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *Digital Logic Circuits*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction	
A. AND Gates	_____
B. OR Gates	_____
C. Amplifiers	_____
D. Inverters	_____
E. NAND Gates	_____
F. NOR Gates	_____
G. Exclusive OR Gates	_____
H. Combination Logic	_____
Session II. Basic Flip-Flops, Latches, and Shift Registers	
A. Basic Flip-Flops and Latches	_____
1. RS NOR Latch and RS NAND Latch	_____
2. Clocked RS Latch	_____
3. Data (D) Latch and D Flip-Flop	_____
4. JK Master-Slave Flip-Flop and Toggle (T) Flip-Flop	_____
B. Shift Registers	_____
1. Basic	_____
2. Serial In–Serial Out	_____
3. Serial In–Parallel Out	_____
4. Parallel In–Serial Out	_____
5. Parallel In–Parallel Out	_____
6. Universal	_____
Session III. Counters	
A. Four-Bit Binary	_____
B. Up	_____
C. Down	_____
D. Up/Down	_____
E. Synchronous	_____
F. Ripple Carry	_____
G. Binary Coded Decimal	_____
H. Ring and Johnson	_____
I. Programmable	_____

Session IV. Arithmetic Elements, Decoders, Standards, Review, and Module Examination

A. Arithmetic Elements _____
   1. Half Adder _____
   2. Full Adder _____

B. Decoders _____

C. ANSI/ASQC Standards _____

D. Review _____

E. Module Examination _____
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

Instrument Calibration and Configuration
Annotated Instructor's Guide

Module 12402-03

MODULE OVERVIEW

This module covers instrument calibration and configuration for pneumatic, analog, and smart transmitters and presents some generic calibration procedures that can be applied to most instruments. It also introduces the basic principles of the HART® protocol, discusses calibrating HART® transmitters, and describes control valve positioners.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following:

Core Curriculum; Instrumentation Levels One through Three; Instrumentation Level Four Module 12401-03

OBJECTIVES

When you have completed this module, you will be able to do the following:

1. Define calibration.
2. Discuss the three-point and five-point methods of calibration.
3. Calibrate the following pneumatic instruments using the proper equipment:
   - Differential pressure transmitters
   - Temperature transmitters
4. Calibrate the following 4–20mA instruments using the proper calibration equipment:
   - Differential pressure transmitters
   - Temperature transmitters
5. Define smart instruments.
6. Identify a HART® communicator.
7. Calibrate a smart transmitter using a HART® communicator.
8. Calibrate a transducer.
9. Calibrate the following valve positioners:
   - Pneumatic positioner
   - Electro-pneumatic positioner
   - Smart positioner (digital valve controller)

PERFORMANCE TASKS

Under the supervision of the instructor, you should be able to do the following:

1. Calibrate a pneumatic differential pressure transmitter using the proper equipment.
2. Calibrate a pneumatic temperature transmitter using the proper equipment.
3. Calibrate a 4–20mA differential pressure transmitter using the proper calibration equipment.
4. Calibrate a 4–20mA temperature transmitter using the proper calibration equipment.
5. Calibrate a smart transmitter using a HART® communicator.
6. Calibrate a transducer.
7. Calibrate the following valve positioners:
   - Pneumatic positioner
   - Electro-pneumatic positioner
   - Smart positioner (digital valve controller)

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Wallace & Tiernan pneumatic calibrator (Wally Box®) or similar instrument
Pneumatic DP transmitter
Compressor
Pneumatic temperature transmitter (Foxboro® 12A or similar model)
Multifunction loop calibrator (Fluke® Model 725 or similar model)
Analog differential pressure transmitter (Rosemount 1151DP Alphaline® or similar model)
Analog temperature calibrator (Fluke® Model 724 or similar equipment)
HART® communicator
Sample pneumatic or electro-pneumatic positioners
Module Examinations*
Performance Profile Sheets*

*Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize good laboratory practices.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

Applied Instrumentation in the Process Industries, Volume 1, Second Edition. W.G. Andrew, H.B. Williams. Houston, TX: Gulf Publishing Company.

Measurement and Control Basics, Third Edition. T.A. Hughes. Research Triangle Park, NC: Instrumentation, Systems, and Automation Society (ISA).

Maintenance and Calibration of HART® Field Instrumentation. R. Pirret, P.E., Marketing Manager-Process Tools. Everett, WA: Fluke Corporation.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 65 hours are suggested to cover *Instrument Calibration and Configuration*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic	**Planned Time**
Sessions I–VIII. Introduction to Calibration	
A. Introduction	_____
B. Defining Calibration	_____
1. Measured Variables (Input Energies)	_____
2. Signals (Output Energies)	_____
3. Five-Point Method of Calibration	_____
C. Pneumatic Calibration Equipment and Calibrating Procedures	_____

1. Calibrating Pneumatic Differential Pressure Transmitters _____
2. Electro-Pneumatic and Electro-Mechanical Temperature Transmitters _____

D. Laboratory – Trainees practice calibrating pneumatic differential pressure transmitters and pneumatic temperature transmitters using the proper equipment. This laboratory corresponds to Performance Tasks 1 and 2. _____

Sessions IX–XVII. Calibration Part Two and Smart Transmitters

A. Analog Calibration Equipment and Calibrating Procedures _____
1. Analog Differential Pressure Transmitters _____
2. Temperature Transmitters with Analog Output _____

B. Smart Transmitters _____
1. HART® Communication and Communicator _____
2. HART® Device Calibration _____

C. Laboratory – Trainees practice the following tasks. This laboratory corresponds to Performance Tasks 3 through 5. _____
- Calibrate a 4–20mA differential pressure transmitter using the proper calibration equipment. _____
- Calibrate a 4–20mA temperature transmitter using the proper calibration equipment. _____
- Calibrate a smart transmitter using a HART® communicator. _____

Session XVIII–XXV. Transducers and Control Valve Positioners

A. Transducers _____
B. Control Valve Positioners _____
1. Pneumatic and Electro-Pneumatic Positioners _____
2. Smart Positioners (Digital Valve Controllers) _____

C. Laboratory – Trainees practice calibrating transducers and control valve positioners. This laboratory corresponds to Performance Tasks 6 and 7. _____

Session XXVI. Review, Module Examination, and Performance Testing

A. Review _____
B. Module Examination _____
1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing _____
1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

Performing Loop Checks
Annotated Instructor's Guide

Module 12403-03

MODULE OVERVIEW

This module explains how to inspect a loop, check the continuity of a loop, prove a loop, and calibrate a loop. The complete process is known as commissioning a loop.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following:

Core Curriculum; Instrumentation Levels One through Three; Instrumentation Level Four Modules 12401-03 and 12402-03

OBJECTIVES

When you have completed this module, you will be able to do the following:

1. Verify mechanical installation.
2. Verify correct tag numbers according to loop sheets.
3. Perform continuity checks on both electrical and pneumatic loops.
4. Prove a loop.

PERFORMANCE TASKS

Under the supervision of the instructor, you should be able to do the following:

1. Perform a continuity check on a pneumatic system.
2. Perform a continuity check on an electrical system.
3. Prove a loop.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Fluke® ProcessMeter™ or similar instrument

Wallace & Tiernan® Model 65-2000 pneumatic tester (Wally Box®) or similar instrument

Fluke® Model 725 multifunction process calibrator or similar instrument

HART® communicator or similar instrument

Module Examinations*

Performance Profile Sheets*

*Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize good laboratory practices.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

www.hartcomm.org. The website of the HART Communication Foundation, an independent, non-profit organization that provides support for application of the HART Protocol.

www.isa.org. The website of the Instrument Society of America.

www.thehartbook.com. A website providing information on HART Communications products, services, and suppliers.

Instrumentation for Process Measurement and Control, 1997. 3rd ed. Norman A. Anderson. Boca Raton, FL: CRC Press.

Maintenance and Calibration of HART Field Instrumentation. R. Pirret, P.E., Marketing Manager, Process Tools. Everett, WA: Fluke Corporation.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 7½ hours are suggested to cover *Performing Loop Checks*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic	**Planned Time**
Session I. Introduction, Verification, and Tag Numbers	
A. Introduction	_____
B. Verifying Mechanical Installation through Visual Inspection	_____
1. Primary Element	_____
2. Field Transmitter	_____
3. Field Wiring, Conduit, Fiber-Optic Cable, and Tubing	_____
4. Control Room Components	_____
C. Tag Numbers and Loop Sheets	_____
Session II. Loop Continuity Tests and Proving a Loop	
A. Loop Continuity Tests	_____
1. Electrical	_____
2. Pneumatic	_____
3. Fiber-Optic	_____
B. Proving a Loop	_____
1. Simulation	_____
2. Required Test Equipment	_____
C. Laboratory – Trainees practice loop continuity tests and proving a loop. This laboratory corresponds to Performance Tasks 1, 2, and 3.	_____
Session III. Calibrating a Loop, Review, Module Examination, and Performance Testing	
A. Calibrating a Loop	_____
1. Conventional 4–20mA Instrument Loops	_____
2. HART® Instruments	_____

B. Review _____

C. Module Examination _____

1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

D. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

Troubleshooting and Commissioning a Loop
Annotated Instructor's Guide

Module 12404-03

MODULE OVERVIEW

This module explains how to troubleshoot, prove, and commission a loop.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following:

Core Curriculum; Instrumentation Levels One through Three; Instrumentation Level Four Modules 12401-03 through 12403-03

OBJECTIVES

When you have completed this module, you will be able to do the following:

1. Practice universal and methodical troubleshooting techniques in loop tuning.
2. Troubleshoot an oscillating process.
3. Troubleshoot a newly installed control loop.
4. Practice safety procedures when troubleshooting a loop.
5. Commission a loop.

PERFORMANCE TASKS

Under the supervision of the instructor, you should be able to do the following:

1. Troubleshoot an oscillating process.
2. Troubleshoot a newly installed control loop.
3. Commission a loop.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Controller

Strip chart recorder

Computer simulator may be used for controller and recorder

Module Examinations*

Performance Profile Sheets*

*Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize good laboratory practices.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

www.automationtechies.com. An online resource for automation, process control and instrumentation professionals.

www.isa.org. The website of the Instrument Society of America.

Process Control Instrumentation Technology, 2002. Curtis D. Johnson. New York: Prentice Hall.

Process Control Systems, 1996. F. Greg Shinskey. New York, NY: McGraw-Hill Professional Publishing.

Troubleshooting: A Technician's Guide, 2000. William A. Mostia. Research Triangle Park, NC: Instrument Society of America.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *Troubleshooting and Commissioning a Loop*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic	**Planned Time**
Session I. Introduction and Troubleshooting	
A. Introduction	_____
B. Fundamentals of Troubleshooting	_____
1. Analyzing the Loop	_____
2. Identifying the Problem	_____
3. Understanding the Loop and Its Function	_____
C. Troubleshooting an Oscillating Process	_____
1. Verifying That a Problem Exists	_____
2. Gathering Information	_____
3. Identifying Possible Causes of the Problem	_____
4. Locating the Problem	_____
5. Using a Troubleshooting Flowchart	_____
Session II. Proving a Loop	
A. Proving a Loop	_____
1. Interpreting a Loop Sheet	_____
2. Applying Logical Steps in Troubleshooting a New Loop	_____
B. Laboratory – Given a control loop to troubleshoot or a diagram with a simulated problem, trainees practice troubleshooting an oscillating process and troubleshooting a newly installed control loop. This laboratory corresponds to Performance Tasks 1 and 2.	_____
Session III. Commissioning a Loop	
A. Commissioning a Loop	_____
1. Drawings and Documents	_____
2. Commissioning Procedure	_____
B. Laboratory – Trainees practice commissioning a loop. This laboratory corresponds to Performance Task 3.	_____

Session IV. Laboratory, Review, Module Examination, and Performance Testing

A. Laboratory – Trainees practice troubleshooting and commissioning oscillating and newly installed loops. This laboratory corresponds to Performance Tasks 1, 2, and 3. _____

B. Review _____

C. Module Examination _____

1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

D. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

Tuning Loops
Annotated Instructor's Guide

Module 12405-03

MODULE OVERVIEW

This module explains the functions and applications of various PID controllers and how to perform closed, open, and visual loop tuning.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following:

Core Curriculum; Instrumentation Levels One through Three; Instrumentation Level Four Modules 12401-03 through 12404-03

OBJECTIVES

When you have completed this module, you will be able to do the following:

1. Describe the function and applications of various PID controllers.
2. Apply the appropriate equations and perform closed loop tuning.
3. Perform open loop tuning.
4. Perform visual loop tuning.

PERFORMANCE TASKS

Under the supervision of the instructor, you should be able to do the following:

1. Perform closed loop tuning.
2. Perform open loop tuning.
3. Perform visual loop tuning.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Controller
Strip chart recorder
Computer simulator may be used for controller and recorder
Safety goggles
Heat-resistant gloves
Safety shoes
Module Examinations*
Performance Profile Sheets*

*Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize good laboratory practices.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

www.isa.org. The website for the Instrument Society of America.

Good Tuning: A Pocket Guide, 2000. G.K. McMillan. Research Triangle Park, NC: Instrument Society of America.

Standards and Practices for Instrumentation and Control: Instrument Loop Design, 1989. Research Triangle Park, NC: Instrument Society of America.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 15 hours are suggested to cover *Tuning Loops*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic	**Planned Time**
Session I. Introduction, Review of Proportional Control, and Terms	
A. Introduction	_____
B. Review of Proportional Control	_____
1. Proportional/Integral (PI) Control	_____
2. Proportional/Integral/Derivative (PID) Control	_____
C. Terms and Definitions Associated with Loop Tuning	_____
Session II. Basic Equations	
A. Energy Balance	_____
B. Time Constant	_____
C. Complete Response	_____
D. Process Gain	_____
E. Proportional Gain	_____
F. Integral Time	_____
G. Derivative Time	_____
D. PID Loop	_____
Session III. Loop Tuning Methods	
A. Loop Tuning Methods	_____
1. Ultimate Period/Ziegler-Nichols Closed Loop	_____
2. Dampened-Oscillation	_____
B. Laboratory – Use the control loop or the computer simulator and the methods described to tune the loop. This laboratory corresponds to Performance Task 1.	_____
Session IV. Open Loop Methods	
A. Open Loop Methods	_____
1. Time Constant	_____
2. Reaction Rate	_____
B. Laboratory – Use the control loop or the computer simulator and the methods described to tune the loop. This laboratory corresponds to Performance Task 2.	_____

Session V. Visual Loop Tuning

A. Introduction _____

1. Incremental Changes _____
2. Apparent Instability _____
3. Sluggish Response _____

B. Laboratory – Use the control loop or the computer simulator and the methods described to tune the loop. This laboratory corresponds to Performance Task 3. _____

Session VI. Review, Module Examination, and Performance Testing

A. Review _____

B. Module Examination _____

1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

MODULE OVERVIEW

This module explains the function and purpose of programmable logic controllers (PLC), different numbering systems used in PLCs, and the hardware and software used in PLCs.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following:

Core Curriculum; Instrumentation Levels One through Three; Instrumentation Level Four Modules 12401-03 through 12405-03

OBJECTIVES

When you have completed this module, you will be able to do the following:

1. Describe the function and purpose of a programmable logic controller (PLC).
2. Compare hardwired and PLC systems.
3. Count and convert between number systems.
4. Explain the purpose of binary codes.
5. Describe the purpose of the various power supplies used within a PLC.
6. Explain the general function of an input/output (I/O) module, including the following types:
   - Discrete
   - Numerical data
   - Special
   - Remote
7. Explain the power supply and ground connections to I/O modules.
8. State the function of the PLC processor module.
9. Explain the interrelations between the various microprocessor components.
10. State the characteristics of various types of memory.
11. Describe the characteristics and features of a PLC processor module.
12. Explain the purpose of PLC software and firmware.
13. Describe the features and the differences between PLC programming languages.
14. Describe the features of relay ladder logic instruction categories.
15. Explain the principles used to correlate PLC hardware components to software instructions.
16. Program and install a PLC.

PERFORMANCE TASKS

Under the supervision of the instructor, you should be able to do the following:

1. Given a PLC diagram, identify the basic components in a PLC system.
2. Given a ladder logic diagram, point out commonly used symbols and their meaning.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
PLC
Programmable device
Ladder logic printout
Module Examinations*
Performance Profile Sheets*

*Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

Instrumentation, 1975. F.W. Kirk and N.R. Rimboi. New York, NY: American Technical Society.

Basic Instrumentation, 1966. New York, NY: McGraw-Hill.

Process Control Instrumentation Technology, 1977. John Wiley and Sons. New York: NY.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *Programmable Logic Controllers*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction, Overview, and Number Systems Review	
A. Introduction	_____
B. Overview	_____
1. Hardwired and PLC Systems	_____
2. Hardwired/PLC Systems Comparison	_____
C. Number Systems Review	_____
1. Binary	_____
2. Octal	_____
3. Hexadecimal	_____
4. Codes (Binary)	_____
Session II. Hardware, Processors, and Performance Testing	
A. Hardware	_____
1. Power Supply	_____
2. Input/Output Modules	_____
B. Processors	_____
1. Scanning	_____
2. Memory	_____
C. Performance Testing – Use a PLC diagram to identify the basic components in a PLC system (Task 1).	_____
Session III. Software, Hardware to Program Correlation, and Performance Testing	
A. Software	_____
1. Languages	_____
2. Ladder Diagram Instructions	_____
B. Hardware to Program Correlation	_____
C. Performance Testing – Use a ladder logic diagram to identify the basic components in a PLC system (Task 2).	_____

Session IV. Guidelines for Programming and Installation, Review, and Module Examination

A. Guidelines for Programming and Installation _____
   1. Programming _____
   2. Installation _____
   3. I/O Wiring _____
   4. Dynamic System Checkout _____

B. Review _____

C. Module Examination _____
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

MODULE OVERVIEW

This module introduces the instrument trainee to distributed control systems (DCS). It explains the evolution of DCS, the DCS/human interface, and the maintenance of a DCS.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following:

Core Curriculum; Instrumentation Levels One through Three; Instrumentation Level Four Modules 12401-03 through 12406-03

OBJECTIVES

When you have completed this module, you will be able to do the following:

1. Define a distributed control system (DCS).
2. Identify the typical components associated with a DCS.
3. Identify the various network configurations used with a DCS.
4. Describe uses for a DCS.
5. Explain how an instrument technician interfaces with a DCS.

PERFORMANCE TASKS

There are no performance tasks for this module.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Operational DCS or simulator
Module Examinations*

*Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

Instrumentation, 1975. F.W. Kirk and N.R. Rimboi. New York, NY: American Technical Society.

Basic Instrumentation, 1966. New York, NY: McGraw-Hill.

Process Control Instrumentation Technology, 1977. John Wiley and Sons. New York: NY.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *Distributed Control Systems*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction, Manufacturing, Definition, and Evolution	
A. Introduction	_____
B. Manufacturing	_____
1. Wet and Dry Processes	_____
2. Plant Management	_____
C. Definition	_____
D. Evolution	_____
1. Traditional Control Loop	_____
2. Central Monitoring	_____
3. Central Control	_____
4. Programmable Logic Controllers	_____
5. Distributed Control	_____
Session II. Human Interface	
A. Data Highway	_____
B. Topology	_____
C. Protocols	_____
D. Workstations	_____
E. Local Area Network	_____
F. Remote Communications	_____
Session III. Maintenance	
A. Instruments	_____
B. Calibration	_____
C. Methods	_____
D. Acquiring Expertise	_____
Session IV. Review and Module Examination	
A. Review	_____
B. Module Examination	_____

1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

MODULE OVERVIEW

This module defines the key properties of chemicals involved in instrumentation and identifies types of analyzers used at most industrial facilities to measure them. It includes chromatography and ultraviolet and infrared analyzers.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following:

Core Curriculum; Instrumentation Levels One through Three; Instrumentation Level Four Modules 12401-03 through 12407-03

OBJECTIVES

When you have completed this module, you will be able to do the following:

1. Define the following properties in a process or environment, and identify methods used to analyze them:
   - Density
   - Specific gravity
   - Viscosity
   - Turbidity
   - Flash point
   - Oxidation-reduction potential (ORP)
   - pH
   - Conductivity of a liquid
   - Oxygen (O_2)
   - Carbon monoxide (CO)
   - Carbon dioxide (CO_2)
   - Hydrogen sulfide (H_2S)
   - Total hydrocarbon content
   - Particulates in a clean room
2. Describe chromatography and its uses.
3. Describe ultraviolet analyzers and their uses.
4. Describe infrared analyzers and their uses.

PERFORMANCE TASKS

There are no performance tasks for this module.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Safety equipment
Viscosity test equipment
Fluids of various viscosities
Flash tester
Fluids with different flash points
pH probe
Oxidation-reduction potential (ORP) probe
Material safety data sheets (MSDSs)

Carbon monoxide detector
Hydrogen sulfide indicator
Analyzers
Sample gases
Hand tools
Module Examinations*

*Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize good laboratory practices and proper disposal of waste.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

www.isa.org. The website of the Instrument Society of America.

The Condensed Handbook of Measurement and Control, 1997. N.E. Battikha. Research Triangle Park, NC: Instrument Society of America.

Industrial Pressure, Level & Density Measurement, 1995. Bela G. Liptak. Boca Raton, FL: CRC Press.

Instrumentation Reference Book, 2002. Walter Boyes. 3rd ed. Research Triangle Park, NC: Instrument Society of America.

Measurement & Instrumentation Principles, 2001. Alan S. Morris. Boston: Butterworth-Heinemann.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 20 hours are suggested to cover *Analyzers*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction, Density, Specific Gravity, and Viscosity	
A. Introduction	_____
1. Classification	_____
2. Calibration	_____
B. Density and Specific Gravity	_____
1. Air Bubble Measurement	_____
2. Displacement Measurement	_____
3. Densitometer	_____
4. Nuclear Detectors	_____
C. Viscosity and Viscometers	_____
Session II. Turbidity and Flash Point	
A. Turbidity	_____
1. Jackson Turbidimeter	_____
2. Transmission Analyzer	_____
3. Reflection Analyzer	_____
4. Ratio Analyzer	_____
B. Flash Point	_____
1. Standardized Systems	_____
2. *OSHA 1910.106(a)*	_____

Session III. Oxidation-Reduction Potential and pH

A. Oxidation-Reduction Potential _____
   1. Probe Calibration _____
   2. Probe Maintenance _____
B. pH _____
   1. pH-Sensitive Electrodes _____
   2. Reference Electrodes _____

Session IV. Conductivity (of a Liquid) and Oxygen

A. Conductivity of a Liquid _____
   1. Electrodes _____
   2. Inductive Probes _____
B. Oxygen _____
   1. High-Temperature Electrochemical Sensors _____
   2. Paramagnetic Analyzers _____
   3. Galvanic Sensors _____

Session V. Carbon Monoxide, Carbon Dioxide, and Hydrogen Sulfide

A. Carbon Monoxide _____
B. Carbon Dioxide _____
   1. Emissions _____
   2. Monitoring _____
C. Hydrogen Sulfide _____
   1. Personnel Protection Indicators _____
   2. Semiconductor Sensors _____
   3. Electrochemical Sensors _____

Session VI. Total Hydrocarbon, Particulates, and Chemical Components

A. Total Hydrocarbon _____
B. Particulates _____
   1. Optical Microscopy _____
   2. Discrete Particle Counters _____
C. Chemical Components _____

Session VII. Infrared Radiation

A. Basic Theory _____
B. Affecting Factors _____
C. Sensing Equipment _____
D. Spectrometry _____

Session VIII. Ultraviolet Light Wave Absorption, Review, and Module Examination

A. Ultraviolet Light Wave Absorption _____
   1. Analysis _____
   2. Flame Detectors _____
B. Review _____
C. Module Examination _____
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.