

Blue Level Labs

- Fundamental Machine Operations Lab
- Sequence, Sensors and Actuators Lab
- Process Improvement and SCADA Lab
- System Troubleshooting Lab
- Vision Systems Lab
- Variable Frequency Drive Lab
- Servo Motion Control Lab

Fundamental Machine Operations Lab

Introduction

In these lab exercises the student begins the exploration of the automation system trainer by learning how to operate it and becoming familiar with the functions of each station in the system and the system itself. The exercises involve verifying each station has its proper PLC program installed, running each station and the entire system to gain familiarity, running 100 system cycles and troubleshooting and correcting faults as they occur. The student will be expected to document faults that occur and corrective actions taken.

Key Learning/ Performance Objectives

- Describe the operation of an automation system
- Describe the operations of the individual machines within an automation system
- Track machine and system cycle times
- Document machine faults and develop appropriate troubleshooting techniques
- Correct machine faults and document corrective actions
- Develop automation system monitoring skills and troubleshooting

Success Measures

The student will operate the automation system trainer, troubleshooting and correcting any faults that occur, and then performing 100 system cycles in a simulated "production" run with 98% uptime.

Equipment and Special Requirements

- Automation system trainer
- Starting PLC programs for each station in the system
- Troubleshooting sheets

Prerequisite Labs

- Red Level Controls Labs
- Red Level PLCs Labs

Description of Procedure

The student will verify that each station has its properly loaded PLC program, turn on and run the system, become familiar with machine and system operations, run systems cycles, troubleshoot faults and take corrective actions. Then the student will perform a "production" run of 100 cycles.



Fundamental Machine Operations Lab Procedure and Worksheet

Name	Start Time
Date	Finish Time
Instructor's Signature	

In this lab, you will be required to complete various tasks which will be used to evaluate your mastery of the requisite skills. It is your responsibility to complete these tasks accurately in a timely manner complying with all appropriate safety measures and use of all required Personal Protective Equipment (PPE).

Task - System Operation	Pass	Fail	Initials
1. The lab instructor will provide you with starting PLC programs and an overview of basic machine function.			
2. Verify that each station contains a basic starting PLC program.			
3. Load, power up and become familiar with operating each machine. Continue until full cycle (minus vision and inventory stations) is complete.			
4. Run 100 complete cycles, keeping track of the overall cycle time and failures. Use troubleshooting lab sheets for each downtime occurrence.			
5. After completing first runoff and executing corrective actions, complete second runoff.			
6. Repeat as necessary to obtain 98% uptime (or until the lab instructor signs off the lab as complete).			

Sequence, Sensors and Actuators Lab

Introduction

In these lab exercises the student continues the exploration of the automation system trainer by describing the sequence of operations of each station and identifying each type of sensor and actuator on each station and the system. The exercises involve documenting the sequence of operations for each station, recording the function of each sensor and actuator for each station and mapping them to the PLC hardware. The student will study sensor specifications and locate replacement parts.

Key Learning/ Performance Objectives

- Describe and document the sequence of machine operations for each station in the automation system
- Identify sensor and actuator types and their functions in a station of the system
- Trace sensor and actuators to their appropriate PLC inputs and outputs
- Study sensor specifications and find suitable replacement parts

Success Measures

The student will document the sequence of operations for each station in the automation system and record the function of each sensor and actuator with 90% accuracy. The student will accurately locate suitable replacements for the assigned sensors.

Equipment and Special Requirements

- Automation system trainer

Prerequisite Lab

- Fundamental Machine Operations Lab

Description of Procedure

The student will observe and document the sequence of operations for each station in the automation system, identify the sensors and actuators and their functions in each station and map the sensors and actuators to the PLC inputs and outputs. Then the student will identify suitable replacements for five sensors assigned by the instructor.



Sequence, Sensors and Actuators Lab Procedure and Worksheet

Name	Start Time
Date	Finish Time
Instructor's Signature	

In this lab, you will be required to complete various tasks which will be used to evaluate your mastery of the requisite skills. It is your responsibility to complete these tasks accurately in a timely manner complying with all appropriate safety measures and use of all required Personal Protective Equipment (PPE).

Task I - Sequence of Operations

1. Observe the machine operation and, on a separate sheet of paper, record a hand written sequence of operations for each machine action. Keep these notes for your system troubleshooting lab.

Pass

Fail

Initials

Task II - Sensors and Actuators

1. Identify each type of sensor and actuator on the entire system and, on a separate sheet of paper, record its basic function, sketch its wiring symbol and identify its input/output point on PLC.
2. Your lab instructor will choose five sensors on your list. For each of those five sensors, use Google or other search engine to identify suitable replacements for those five devices. Print specification sheets, and obtain price and delivery terms for each.

Pass

Fail

Initials

Process Improvement & SCADA Lab

Introduction

In these lab exercises the student continues the exploration of the automation system trainer by studying cycle times in the automation system and the effects of reject functions on cycle times, and by attempting to optimize cycle times for maximum system throughput. The exercises involve verifying system cycle time and machine operations, enabling reject functions using the SCADA system and observing their effects on cycle times and speeding up processes to optimize cycle times. The exercises emphasize keen observation skills.

Key Learning/ Performance Objectives

- Verify the cycle time of the automation system
- Describe a SCADA system and use it to modify the system operation
- Describe the effects of parts reject functions on system cycle time
- Optimize the system cycle time by speeding up processes

Success Measures

The student will record system cycle times and enable reject functions on each appropriate station with 90% accuracy. The student will improve the system cycle time without introducing downtime events/machine faults.

Equipment and Special Requirements

- Automation system trainer
- PC to monitor the SCADA system

Prerequisite Lab

- Sequence, Sensors and Actuators Lab

Description of Procedure

The student will observe and document the system cycle time, use the SCADA system to enable reject functions on the appropriate stations, and observe and document of the effect of the reject functions on system cycle time. Then the student will attempt to optimize the system cycle time by speeding up machine processes.



Process Improvement & SCADA Lab Procedure and Worksheet

Name	Start Time
Date	Finish Time
Instructor's Signature	

In this lab, you will be required to complete various tasks which will be used to evaluate your mastery of the requisite skills. It is your responsibility to complete these tasks accurately in a timely manner complying with all appropriate safety measures and use of all required Personal Protective Equipment (PPE).

Task I - SCADA

Task I - SCADA	Pass	Fail	Initials
1. Your lab instructor will provide you with an overview of the PLC programs and the SCADA function.			
2. Verify cycle time and machine performance with a runoff of not less than 50 pieces.			
3. Through manipulating SCADA bits, enable reject function(s) on each assembly station (not including the vision or inventory stations).			
4. After enabling reject functions, check and compare cycle times.			

Task II - Machine Process Improvement
Pass
Fail
Initials

1. Attempt to optimize (reduce) cycle time by speeding up processes without creating downtime events.

2. Repeat as necessary until the lab instructor signs off the lab as complete.

System Troubleshooting Lab

Introduction

In these lab exercises the student will troubleshoot faults on the automation system trainer. The lab instructor will put numerous “bugs” in the system and with each one, the student will identify the fault symptom, list possible causes, list steps taken to verify the cause, determine the proper corrective action, recheck for proper operation and cycle time, and record total system downtime. The exercises emphasize keen observation and troubleshooting skills.

Key Learning/ Performance Objectives

- Develop systematic troubleshooting skills
- List possible causes of system faults
- Verify causes and determine corrective actions
- Describe the effects of downtime on system throughput

Success Measures

The student will identify symptoms, list possible causes, list steps taken to verify the cause and determine the proper corrective action with 90% accuracy.

Equipment and Special Requirements

- Automation system trainer

Prerequisite Labs

- Process Improvement and SCADA Lab
- Vision Systems Lab

Description of Procedure

With each “bug” put in place by the lab instructor, the student will observe and identify the fault symptom, document possible causes, take steps to verify cause and list those steps, determine the proper corrective action, recheck the system for proper operation and cycle time, and record total system downtime.



System Troubleshooting Lab Procedure and Worksheet

Name	Start Time
Date	Finish Time
Instructor's Signature	

In this lab, you will be required to complete various tasks which will be used to evaluate your mastery of the requisite skills. It is your responsibility to complete these tasks accurately in a timely manner complying with all appropriate safety measures and use of all required Personal Protective Equipment (PPE).

Task I	Pass	Fail	Initials
1. Describe the symptom: What should be happening but is not?			
2. List possible causes:			
3. List steps taken to verify cause(s):			
4. Check machine function and cycle time.			
5. Record total downtime.			

Vision Systems Lab

Introduction

In these lab exercises the student studies vision systems used in inspection stations in automation systems to measure parts and accept or reject them according to set of measurement criteria. The exercises involve setting up and programming a vision system with a specific set of measurement criteria, then running the system and troubleshooting it accordingly to properly accept good parts and reject bad ones. The exercises emphasize PLC programming and troubleshooting skills.

Key Learning/ Performance Objectives

- Describe the function of a vision system in parts inspection
- Describe the kinds of measurement criteria employed by vision systems
- Describe the components of a vision system
- Set up a vision system and program it with measurement criteria using the inspection station PLC
- Run a vision system as part of an automated inspection process

Success Measures

The student will set up a vision system and program it with the proper measurement criteria for 95% accurate acceptance and rejection of parts in an automation system.

Equipment and Special Requirements

- Automation system trainer with vision inspection station

Prerequisite Lab

- Process Improvement and SCADA Lab

Description of Procedure

The student will study vision systems and then apply the necessary tools to set up a vision system and program it with measurement criteria using the inspection station PLC. Then the student will run the system to inspect parts and accept or reject them according to the expected criteria.



Vision Systems Lab Procedure and Worksheet

Name	Start Time
Date	Finish Time
Instructor's Signature	

In this lab, you will be required to complete various tasks which will be used to evaluate your mastery of the requisite skills. It is your responsibility to complete these tasks accurately in a timely manner complying with all appropriate safety measures and use of all required Personal Protective Equipment (PPE).

Task - Vision System Operation	Pass	Fail	Initials
1. After attending the Introduction to Vision workshop, enable the vision station on the automation system.			
2. Using vision tools and the PLC interface, set the vision system to accept good parts into inventory and reject bad parts (per the lab instructor's criteria).			
3. Verify the vision station's performance with a runoff of not less than 50 pieces.			
4. Repeat as necessary until the lab instructor signs off the lab as complete.			

Variable Frequency Drive Lab

Introduction

In these lab exercises the student studies motion control using variable frequency drives with AC motors. The exercises involve setting up the motion parameters on a VFD keypad and running the motor with the various settings, then programming the VFD motion parameters with a PLC and running the motor and changing the parameters remotely. The student will troubleshoot faults introduced into the VFD/motor combination by the lab instructor. The exercises emphasize PLC programming and troubleshooting skills.

Key Learning/ Performance Objectives

- Describe how variable frequency affects the operation of an AC motor
- Describe the basic operation and building blocks of a variable frequency drive
- Manually set up a VFD using its keypad
- Program a VFD with motion parameters using a PLC
- Troubleshoot faults in a VFD/motor combination

Success Measures

The student will set up a VFD and program it manually and with a PLC with the proper motion parameters with 100% accuracy.

Equipment and Special Requirements

- Variable frequency drive trainer
- PLC with discrete I/O and analog output cards
- Relays and other control components

Prerequisite Labs

- Vision Systems Lab
- System Troubleshooting Lab

Description of Procedure

The student will study variable frequency drives and then apply the necessary tools to set up a VFD using its keypad and then program it with motion parameters using a PLC. The student will then troubleshoot faults introduced by the lab instructor.



Variable Frequency Drive Lab Procedure and Worksheet

Name	Start Time
Date	Finish Time
Instructor's Signature	

In this lab, you will be required to complete various tasks which will be used to evaluate your mastery of the requisite skills. It is your responsibility to complete these tasks accurately in a timely manner complying with all appropriate safety measures and use of all required Personal Protective Equipment (PPE).

Task I - Manual Operation	Pass	Fail	Initials
1. The lab instructor will provide you with a variable frequency drive unit, an AC motor, a PLC with discrete I/O and analog card, and other materials.			
2. Following the user manual instructions, set up the frequency drive to operate in "Keypad" mode. Set all parameters. PRIOR TO STARTING DRIVE, HAVE THE LAB INSTRUCTOR CHECK YOUR SETTINGS!			
a. Test and troubleshoot the system until it works properly.			

Task II - PLC Operation

	Pass	Fail	Initials
1. Following the user manual instructions, set up the frequency drive to operate in 2-wire analog command mode.			
a. Connect the VFD to the PLC I/O.			
b. Write the PLC program to operate the VFD.			
c. Test and troubleshoot the system until it works properly. PRIOR TO STARTING DRIVE, HAVE THE LAB INSTRUCTOR CHECK YOUR SETTINGS!			
2. Following the user manual instructions, set up the frequency drive to operate in 3-wire analog mode.			
a. Connect the VFD to the PLC I/O.			
b. Write the PLC program to operate the VFD.			
c. Test and troubleshoot the system until it works properly. PRIOR TO STARTING DRIVE, HAVE THE LAB INSTRUCTOR CHECK YOUR SETTINGS!			
d. The lab instructor will create several fault conditions. Troubleshoot the faults and record the findings.			

Servo Motion Control Lab

Introduction

In these lab exercises the student studies motion control using servo drives and motors. The exercises involve connecting a PLC system to a servo drive unit and programming the servo motion parameters, tuning the motor/drive combination for controlled and stable operation without overshoot. The student will then write PLC and human machine interface programs to control the servo system from the HMI. The exercises emphasize PLC programming and troubleshooting skills.

Key Learning/ Performance Objectives

- Describe servo motion control
- Describe the basic operation and building blocks of a servo system
- Connect a servo drive unit to PLC system
- Program a servo drive with motion parameters using a PLC
- Tune a servo drive/motor system for controlled and stable operation
- Control a servo system from an HMI
- Troubleshoot servo motion control problems

Success Measures

The student will set up a servo system, program it with the proper motion parameters and tune the system for controlled and stable operation and zero overshoot.

Equipment and Special Requirements

- Servo drive trainer
- PLC with discrete I/O, analog output and encoder high speed counter modules
- Human machine interface unit
- Relays and other control components

Prerequisite Labs

- System Troubleshooting Lab
- Variable Frequency Drive Motion Control Lab

Description of Procedure

The student will study servo systems and then apply the necessary tools to connect a PLC system to the servo drive unit, programming it with motion parameters and tuning the system. The student will then program an HMI to control the servo system.

Servo Motion Control Lab Procedure and Worksheet

Name	Start Time
Date	Finish Time
Instructor's Signature	

In this lab, you will be required to complete various tasks which will be used to evaluate your mastery of the requisite skills. It is your responsibility to complete these tasks accurately in a timely manner complying with all appropriate safety measures and use of all required Personal Protective Equipment (PPE).

Task - Servo Motion Control	Pass	Fail	Initials
1. The lab instructor will provide you with a servo drive, a servo motor, an HMI, a PLC with discrete I/O, an analog card, an encoder (high speed counter) module, and other materials.			
2. Following the user manual instructions, connect the PLC, HMI, analog card and encoder module to the servo drive.			
a. Write the PLC program to operate and control the servo system.			
b. Test and troubleshoot the program until it works properly.			
c. Tune the servo system, demonstrating stable and controlled function without overshoot.			
3. Write PLC and HMI logic required to control the servo system from the HMI, with stop, start, forward and reverse speed commands and display made through the HMI.			



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