Troubleshooting
PLC Circuits 1

“What’s in the product?”
Introduction

About this Program

This interactive, simulation based training program is designed to teach the skills necessary to troubleshoot equipment and systems that contain PLC controls.

It will help the user to understand the operation of a PLC, be able to interpret ladder diagrams which control its operation, and provides a variety of techniques for diagnosing and repairing PLC circuits. It covers how to make minor setting changes to ladder programs but does not cover how to design or make changes to the logic of these programs.

This program covers PLCs from a generic point of view. It does not cover any one make or model, however it does provide the information and skills that can be applied to any manufacturer or model of PLC.

Who Can Benefit

This program is best suited for inclusion in the later stages of an electrical training program. It is also valuable for tradespersons who need to maintain and repair circuits and systems with PLC controls.

To get the most out of this program, users should have a good knowledge of electrical theory and troubleshooting concepts for electro-mechanical circuits. This knowledge and skills can be acquired through Simutech’s Troubleshooting Skills Series.

In fact, this program builds on the concepts covered in the Skills Series programs and assumes that the user has completed these programs.

Goals and Objectives

The goal of this program is to help users develop the skills required to safely troubleshoot electrical equipment and systems containing PLC controls. In order to complete this program users must successfully troubleshoot and repair all 6 Skill Test faults on each of the three PLC Circuit Simulations.

To become a successful troubleshooter and effectively solve these faults the user will learn:

- All safety rules and safe work practices to follow while troubleshooting.
- How to determine the operation of PLC circuits by interpreting ladder diagrams, wiring diagrams, input/output schematics, and data sheets.
• How to monitor the operation of a ladder program using a laptop
• How to make minor adjustments to the ladder programs including changing timer and counter settings.
• To identify defective input, output, and CPU modules using a multimeter as well as visual and operational diagnostic tests.
• To apply a variety of troubleshooting techniques specific to diagnosing malfunctions in PLC circuits including components external to the PLC.

How it Builds Skills

Using a proven learning process as outlined below, this program will help users of all ability levels become successful troubleshooters of PLC controlled equipment by building on their troubleshooting skills with additional techniques and strategies specific to troubleshooting these types of systems.

Instructional Method

The instructional modules teach specific concepts using video demonstrations, hands-on labs, and practice exercises. Throughout these modules, simulations are used extensively to allow users to explore and experience the principles and concepts described.

Skills Application

Once users have had a chance to learn and understand the operation of PLCs and to interpret PLC ladder diagrams, they will apply their new skills by solving faults on the several PLC Circuit simulations.

In order to solve a fault it must be correctly repaired with no safety errors and the results must meet specially selected criteria for each fault, ensuring that the user employs the correct troubleshooting concepts and strategies learned in the instructional modules.

Why it Works

Hands-On Learning

The most effective way to learn a skill is with continual, monitored, hands-on practice. This program provides realistic hands-on training on simulated circuits that behave just like real equipment. This realistic troubleshooting practice gives users the experience they need to effectively transfer their skills to solve real problems on real equipment.
Privacy, Pacing, and Safety
Learning how to troubleshoot with this program offers other benefits that increase the effectiveness of the training experience. Users can explore troubleshooting concepts and proceed through the material privately and at a pace suitable to their own specific experience and learning needs. The simulations also provide a safe environment where users can learn from their mistakes without the threat of personal injury to themselves or others.

Continuous Feedback
To ensure that users understand the safety and troubleshooting concepts, the program provides feedback on an ongoing basis. It monitors every action performed in the simulations, and provides feedback messages to reinforce the strategies and techniques that should be used to troubleshoot safely and efficiently.

Performance-Based Evaluation
The processes and techniques users employ are measured and compared to baseline results that a proficient troubleshooter should be able to obtain. Each fault, and the evaluative criteria used to score that fault, is designed based on best practices. This includes time, process, and the number of meter readings. Using these targets provides users with an indication of the skill level they should strive to achieve.

The evaluation in this program is based entirely on performance. Users must be able to directly apply the skills taught in the program in order to meet the performance targets, and prove that they have achieved a certain level of proficiency in their troubleshooting abilities.
Program Overview

The program is organized into 5 main sections:

PLC Overview

This section consists of two videos and provides an overview of the basic PLC. Some of the topics covered are:

- Purpose of PLCs and why they were developed.
- The structure of a typical PLC including input, control and output modules.
- The basic operation of a PLC.
- Advantages of PLCs over electro-mechanical circuits.

PLC Components

This section delves deeper into the operation of each of the key components of the PLC:

- Input Modules
- Control Modules or CPUs
- Output Modules

It uses several videos and hands-on labs to provide a thorough understanding of the structure, operation, and behavior of each of these modules.

Input Module

This section focuses on a common type of input module called a digital or discrete module and covers the following.

- Purpose and function of an input module.
- How input devices are connected to the module.
- What values to expect when taking voltmeter or ohmmeter readings at the input module terminals of a properly functioning module.
- How to use a datasheet to determine the proper wiring for an input module as well as determining its specifications.

Control Module (CPU)

This section covers common elements and features of typical CPUs. It does not cover the specifics of any one manufacturer or type.

- Purpose and function of the CPU module.
- How it is connected and wired.
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- The meaning of typical indicator lights found on the CPU module.
- How to use a datasheet to determine the proper wiring as well as determining its specifications.
- How to perform a variety of functions regarding the software program controlling the CPU, including:
  o connecting a programmer,
  o downloading a program, and
  o monitoring the operation of the PLC through the software.

Output Module
This section focuses on a common output module called a digital or discrete module. Three different types are covered: Relay, TRIAC and Transistor, as well as loads connected in a sourcing or sinking configuration.

The following specifics are covered:
- Purpose and function of an output module.
- How output devices are connected to the module.
- What values to expect when taking voltmeter or ohmmeter readings at the output module terminals of a properly functioning module.
- How to use a datasheet to determine the proper wiring for an output module as well as determining its specifications.

Interpreting PLC Ladder diagrams

This section provides the information required to enable the user to interpret PLC ladder diagram in order to determine the operation of PLC controlled equipment. It covers the structure of ladder diagrams as well as the following common type of instructions found in them:
- Inputs and Outputs
- Relays
- Latches
- Counters
- Timers
- Clock Pulses

Videos and hands-on labs are used to provide the follow information for each type of instruction:
- Types
- Addressing
- Application
- Labels and tags
Diagnosing Malfunctions

The cornerstone strategy for solving malfunctions in any electrical circuit is Simutech's Systematic Troubleshooting Approach.

In addition to reviewing this approach, the Troubleshooting Techniques section of this module provides additional techniques and strategies specific to PLC circuits.

The Applying Troubleshooting Techniques section contains a circuit simulation of a simple PLC circuit. Included in this section are several Guided Faults where users will be able to apply the concepts learned in the troubleshooting techniques sections to actual faults on the circuit. Each fault contains a guide that walks the users, step by step, through the process of solving a variety of malfunctions.

Also included in this module are several Practice Exercises where users can practice finding additional malfunctions on this same PLC circuit simulation.

Troubleshooting PLC Circuits

This is where the user gets to troubleshoot faults on circuit simulations.

This section contains 3 core levels, Basic, Intermediate and Advanced. Each level contains a unique simulation scenario, a guided tour that describes how the simulation circuit works, 2 practice faults which are not scored, and 6 skill test faults that are evaluated and scored by the program.

When the user has completed these core levels, they will be able to print out a certificate of completion.
Maintaining Troubleshooting Skills

Once all of the Skill Test faults are complete, the Maintenance section becomes available for additional practice. This section allows users to continue to maintain their skills by troubleshooting new faults and retrying already completed faults.

Retry Faults

The Retry Faults tab allows users to retry faults from the Basic, Intermediate and Advanced levels, as well as any completed faults from the Extra or Genius fault sets. They can choose both the level from which to select the faults and whether to work through the faults randomly or in sequential order.

All retry fault attempts are scored using the same criteria as in the Skill Test section, but are evaluated on a single attempt basis, meaning users will receive a full evaluation following each retry fault attempt.

After at least one retry fault is complete, a diamond shaped indicator will appear on the Skill Rating Scale. The faults this diamond represents can be changed by selecting the appropriate option to the right of the Skill Rating Scale.

The Skill Rating Scale also shows the Overall Summary Rating from the Basic and Advanced levels with a blue triangle, letting users easily compare their results to see if their Skill Rating is improving as they retry faults.
About the Simulations

Simulations are used extensively throughout this program. They are used in the labs found in the PLC components and PLC Ladder Diagrams sections and they are also used in the troubleshooting scenarios within the Diagnosing Malfunctions and Troubleshoot the PLC Circuit sections.

Each simulation circuit contains a PLC, power supply, input devices and output devices.

You can choose which electrical design standards the simulation will use, either North American (NEMA) or European (IEC). Changing this setting will affect the equipment ratings, operating voltages as well as the prints and diagrams.

The Labs

The labs allow the user to apply the information provided in the content sections of the program.

A guide is included in each lab directing the user to perform activities and asking the user questions based on the activities.

The Practice Troubleshooting Simulation

A simple circuit is used to demonstrate the troubleshooting techniques and strategies.

With this circuit the user will be guided through the process of solving several faults.

They will then be able to practice solving additional faults on this simulation.
The Skill Test Troubleshooting Simulations

There are three different simulation scenarios used in this section. In each of these scenarios, the user will troubleshoot faults and have their results evaluated and scored.

The **Basic Level** uses a simple PLC control circuit (called Basic Circuit) where the user can control the operation of three lights through the use of one switch and three pushbuttons.

Several PLC programs are available that produce different light behaviors based on pushbutton and switch operation.

The **Intermediate Level** uses a scenario (called Sequence Circuit) where pressing pushbuttons in the correct sequence will turn on the green light and will turn off the red light. The concept is similar to the door lock scenario in Troubleshooting Control Circuits.

Several PLC programs are available that have different pushbutton sequences to turn on the green light.

The **Advanced Level** uses a scenario (called Process Circuit) where the PLC circuit will run different processes depending upon the program running in the PLC.
A process can be started by turning on the Master switch and pressing the Start button. The process can be stopped by pressing the Stop pushbutton or turning off the Master switch. S1 and S2 switches control different settings in the process.

Note that these three simulation scenarios are also used in the maintenance section of the program.

Troubleshooting Tools

Using the available tools, users can interact with the simulation just like a real system. They can:

- Monitor the operation of the PLC circuit with the PLC programmer
- Download programs to the PLC and change settings and values of PLC programs
- Take voltage and resistance measurements with a multimeter
- Repair and replace electrical components
- Disconnect and ring out wires
- Trace and replace wires

Information about each of the tools can be found in the following sections. More detailed information about the tools, and how to use them, can be found in the Help system, which is accessible in the simulations.

The PLC Programmer

This simulates the ability to connect a laptop to the PLC. The PLC Programmer uses a generic programming language to communicate with the PLC hardware in the simulations.
Using the PLC Programmer the user can:
  - View currently running programs
  - View offline programs
  - Download programs from the programmer to the PLC
  - Change the mode to Run, Test, or Program
  - Force inputs
  - Change values of counters and timers
  - Monitor the status of inputs and output using a variable table

Note, the user cannot make changes to the structure or logic of the PLC programs. Details on how to perform each of these functions is located in the help system.

The Multimeter
The multimeter is a key troubleshooting tool and is available in each simulation to diagnose malfunctions in the circuit.

A key feature of the simulations is the feedback provided when using the multimeter. With each test reading the simulator evaluates the technique being used and, when necessary, provides feedback tips to help improve testing techniques.

The Screwdriver
The screwdriver is used to disconnect and reconnect wires in the simulations.

The Wrench
The wrench is used to replace components in the simulations.

Troubleshooting Safety

Troubleshooting real equipment can be hazardous. To ensure that users learn how to troubleshoot safely, the simulator monitors all of their activities and will notify them when safety errors occur.

The program monitors for the following types of errors:
  - Personal Injury Errors
  - Live Circuit Errors
  - Safe Work Practice Errors
Resources

The Resources window is accessible by clicking the Resources button in the Main Menu of the program. This window allows users to print resource documents, manage Progress Reports, and adjust settings.

Printing Resources

From the Print Resources tab, users can print copies of the Schematic and Wiring Diagrams for all of the circuits, the Troubleshooting Flowchart, and Troubleshooting Worksheets.

It is recommended that users have paper copies of these documents printed out, to help them during the troubleshooting process.

To print a document, select the desired document from the drop down menu and then click the Print Document button. This will open the Print window, where the appropriate printer can be selected.

Progress Reports

In the Progress Reports tab, users can preview and print their Progress Report, as well as export their progress data to a .rep file.

Settings

The Settings tab allows users to set the password for their user account, select which regional settings to use in the program, and modify program settings.

The path used to find the user files on a network can also be set in this tab, by clicking the Set Data Path button. This option is only available with the Standalone Option of the software.

Users will not be able to change this path, as it requires a specific location to be chosen and the Simutech Course Manager password to be input.
Changing Program Settings

If users click the **Change Meter tips** button in the **Settings** tab, they can modify the Meter Tips they will see while in the simulations. Clicking **Change Hourly Rate** button allows the Hourly Rate used on the Work Order to be modified. The default for this rate is $100/hour.