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INDUSTRIAL AUTOMATION



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LEARNER GUIDE

National Vocational Certificate Level 3

Version 1 - September, 2019



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Introduction

Welcome to your Learner's Guide for the Industrial Automation Program. It will help you to complete the program and to go on to complete further study or go straight into employment. The Industrial Automation program is to engage young people with a program of development that will provide them with the knowledge, skills and understanding to start this career in Pakistan. The program has been developed to address specific issues, such as the national, regional and local cultures, the manpower availability within the country, and meeting and exceeding the needs and expectations of their customers.

The main elements of your learner's guide are:

- **Introduction:**
This includes a brief description of your guide and guidelines for you to use it effectively
- **Modules:**
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The modules form the sections in your learner's guide
- **Learning Units:**
Learning Units are the main sections within each module
- **Learning outcomes:**
Learning outcomes of each learning units are taken from the curriculum document
- **Learning Elements:**
 - This is the main content of your learner's guide with detail of the knowledge and skills (practical activities, projects, assignments, practices etc.) you will require to achieve learning outcomes stated in the curriculum
 - This section will include examples, photographs and illustrations relating to each learning outcome
- **Summary of modules:**
This contains the summary of the modules that make up your learner's guide
- **Frequently asked questions:**
These have been added to provide further explanation and clarity on some of the difficult concepts and areas. This further helps you in preparing for your assessment.
- **Multiple choice questions for self-test:**
These are provided as an exercise at the end of your learner's guide to help you in preparing for your assessment.

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Module-12

LEARNER GUIDE

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Module 12 : 071400938 Perform Programmable Logic Controller(PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller(PLC) operations.

Duration: 420 hours **Theory:** 84 hours **Practical:**336hours

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1: Integrate Programmable Logic Controller	<p>The learner will be able to perform following tasks:</p> <ul style="list-style-type: none"> • Select tools and hardware as per requirement • Attach modules with PLC as per requirement • Install wiring of PLC with digital instruments • Install wiring of PLC with analogue instruments • Integrate pneumatic and hydraulic instruments with PLC as per requirement 	<p>Tools used for PLC integration:</p> <ul style="list-style-type: none"> • Understanding of tools to be used for PLC based exercises and operations. These include Electrical Tool Kits, Multimeter etc. • Using of all of above mentioned tools in different PLC integration based exercises. <p>Comparison between PLC and tradition Controllers</p> <ul style="list-style-type: none"> • Cons and pros of Relay based controller system • Cons and pros of Microcontroller • Cons and Pros of Programmable Logic Controller <p>Main parts of PLC</p> <ul style="list-style-type: none"> • Processor (Brain of PLC) • Power Supply (Heart of PLC) • Memory Unit • Programming Unit 	<ul style="list-style-type: none"> • White board • Multimedia • Computer System/Internet • Programmable Logic Controllers of Various Brands • Pneumatic & Hydraulic Trainers

		<ul style="list-style-type: none"> • Input section (Slots and Switching components) • Output section (Slots and controlling components) <p>PLC types w.r.t. Switching</p> <ul style="list-style-type: none"> • Relay type PLC (for AC/DC switching) • Transistor type of PLC (for only DC switching) • Triactype PLC (for only AC switching) <p>Discrete I/O modules</p> <ul style="list-style-type: none"> • Discrete Input module • Discrete Output module <p>Analog I/O Modules</p> <ul style="list-style-type: none"> • Analog to Digital module • Digital to Analog module • PT module (Temperature) • TC Module (Temperature) • Load Cell module <p>Addressing and Tagging of I/Os</p> <ul style="list-style-type: none"> • Identification of Slots • Identification of Inputs • Identification of Outputs • Tagging on identified I/Os 	
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		<p>Sourcing and Sinking</p> <ul style="list-style-type: none"> • Different between sourcing and sourcing type wiring • Why sourcing and why sinking? • Source in Source out • Source in Sink out • Sink in Sink out • Sink in source out <p>Pin configuration of Analog modules</p> <ul style="list-style-type: none"> • Current signal wires • Voltage signal wires • Common signal wires • Shielded wire • Earthling wire • Other signal and control wires <p>Difference between Power Signal and Control Signal</p> <ul style="list-style-type: none"> • Input Signal from sensors and transmitters • Output signal to Actuators <p>Integration of Hydraulic and pneumatic Equipment</p> <ul style="list-style-type: none"> • Integration of discrete hydraulic instruments • Integration of discrete pneumatic instruments • Integration of hydraulic analog 	
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		instruments <ul style="list-style-type: none"> Integration of pneumatic analog instruments 	
LU2: Develop logic for Programmable Logic Controller	The trainee will be able to perform the programming with PLC as detailed below: <ul style="list-style-type: none"> Select software as per requirement Program digital control operations via simulation as per application Program digital control operations with hardware as per application Program analogue control operations via simulation as per application Program analogue control operations with hardware as per application 	Different software used for PLC programming <ul style="list-style-type: none"> Various software for different manufacturers WPLSoft for Delta GX works for Mitsubishi RS Logix for Allen Bradley Winpro Ladder for FATEK TIA portal for Siemens Understanding of software <ul style="list-style-type: none"> Software installation Opening of new project Project saving Hardware configuration in software Program Compilation Write to PLC Read from PLC Simulation Data sheet of PLC built in Relays and Data Registers <ul style="list-style-type: none"> Unlatch internal relays Latch internal relays 	<ul style="list-style-type: none"> White board Multimedia Computer system/Internet Programmable Logic Controllers of Various Brands

		<ul style="list-style-type: none"> • Latch Data Register • Unlatch Data Register <p>Communication Setting</p> <ul style="list-style-type: none"> • RTU mode communication • ASCII mode communication • Communication port setting • Communication drivers • Communication cables <p>Simulation Methods</p> <ul style="list-style-type: none"> • Simulation techniques • Simulation software <p>Switching Instruction in PLC</p> <ul style="list-style-type: none"> • NO and NC contacts • Rising and Falling Edge contact • Output Coil • Logic Gates • Set and Reset Instruction • Alternating Instruction • Inverse Logic <p>Arithmetic Instructions</p> <ul style="list-style-type: none"> • Addition instruction • Subtraction instruction • Multiplication instruction • Subtraction instruction 	
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		<ul style="list-style-type: none"> • Square root instruction • Mean instruction <p>Data processing instructions</p> <ul style="list-style-type: none"> • Data movement Instructions • Data shifting instructions • Data rotation instructions • Comparison instructions • Exchange instruction • Matrix instructions • Complement instruction • Negation instruction • Display instruction <p>Timing and Counting Instructions</p> <ul style="list-style-type: none"> • Timer Instruction • Data sheet of timers • Counter Instruction • Data sheet of counters <p>Special Instructions</p> <ul style="list-style-type: none"> • Step Ladder instructions • Master Control Instruction • Encoder and Decoder Instruction • PWM instruction • Reading instructions • Writing instruction 	
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		<p>Subroutine Instructions</p> <ul style="list-style-type: none"> • Subroutine CALL • Jump instruction • Interrupt Instruction <p>Analog Programming</p> <ul style="list-style-type: none"> • Identification of analogue signals encountered with PLC (Voltage Signal, Current Signal, Pressure Signal and Temperature Signal) • Analogue configuration through software • Analogue signal processing • Thermocouple module and signal processing • PT module and signal processing. • Load cell module and signal processing. • PID Instruction and operation. • Pressure handling analogue devices. 	
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Module-13

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Module 13: 071400939 Develop Human Machine Interface (HMI)

Objective of the module: The aim of this module to get knowledge, skills and understanding to develop human machine interface (HMI)

Duration: 110 hours **Theory:**22 hours **Practical:**88 hours

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1: Configure HMI	<p>The trainee will be able to perform the following tasks:</p> <ul style="list-style-type: none"> Select HMI hardware, software and communication cables as per requirement Establish communication of HMI with other controllers 	<p>Concept of HMI</p> <ul style="list-style-type: none"> Human Machine Interface Need of HMI Area of application <p>Types of HMI</p> <ul style="list-style-type: none"> Keypad HMI Touch Screen HMI Controller embedded HMI Various brands of HMI (Wintek, Delta, Siemens, Mitsubishi etc) <p>Communication protocols</p> <ul style="list-style-type: none"> Modbus TCP/IP Profibus Profinet <p>HMI communication with different controllers</p> <ul style="list-style-type: none"> PLC 	<ul style="list-style-type: none"> White board Multimedia Computer system /Internet HMI Trainer HMI software application Communication cables PLC-HMI Interface cables Memory cards for backup Electrical Tool Kit

		<ul style="list-style-type: none"> • Variable Frequency Drive • Servo Drive • Actuator • Analyzer 	
LU2: Develop graphical User Interface	<p>The learner will be able to implement the use of HMI as follows:</p> <ul style="list-style-type: none"> • Design process diagram as per requirement • Configure tags as per requirement • Simulate GUI as per requirement • Integrate GUI with controller as per requirement 	<p>Concept of Diagram</p> <ul style="list-style-type: none"> • Process flow diagrams • Process and instrumentation diagrams <p>Basic operations of software</p> <ul style="list-style-type: none"> • Identification of software • Installation of software • Communication medium selection in software • HMI model selection in software • Opening of new project • Project saving • Project compilation • Project uploading to HMI • Project downloading from HMI <p>Simulation methods</p> <ul style="list-style-type: none"> • Simulation software • Built in simulation memories and devices in HMI • Online simulation • Offline Simulation <p>HMI Designing</p>	<ul style="list-style-type: none"> • White board • Multimedia • Computer system /Internet • HMI Trainer • HMI application software • Communication Cables • PLC-HMI Interface Cables • Memory Cards for backup • Electrical Tool Kit

		<ul style="list-style-type: none"> • Static screen development • Multiscreen management • Dynamic linking of tags • Communications with the PLC • Animation of graphic objects according to the status of the process. • Trending: viewing the X-Y plots of different parameters for analysis • Configuration of Tags • Different type of buttons drawing on HMI screen and designing • Linking of the tags of buttons • Operation and verification of buttons on simulation and hardware • Different type of indicators drawing on HMI screen and designing • Linking of the tags of indicators • Operation and verification of indicators on simulation and hardware • Different type of meters drawing on HMI screen and designing • Linking of the addresses of meters 	
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		<ul style="list-style-type: none"> • Operation and verification of meters on simulation and hardware • Different type of pipes and tanks drawing on HMI screen and designing • Linking of the addresses of pipes and tanks • Operation and verification of pipes and tanks on simulation and hardware • Different type of entries drawing on HMI screen and designing • Linking of the addresses of entries • Operation and verification of entries on simulation and hardware • Different type of display drawing on HMI screen and designing • Linking of the addresses of displays • Operation and verification of displays on simulation and hardware 	
LU3: Develop HMI Program & Recipes	The students will be able to perform the following tasks : <ul style="list-style-type: none"> • Create recipes in HMI 	Alarms and recipes <ul style="list-style-type: none"> • Alarm configuration in HMI • Operation of alarm in HMI 	<ul style="list-style-type: none"> • Multimedia • Computer system /Internet • HMI trainer • HMI software application

	<p>as per requirement</p> <ul style="list-style-type: none"> • Create alarms in HMI as per requirement • Create macros in HMI as per requirement • Set security levels in HMI 	<ul style="list-style-type: none"> • Recipe making in HMI • Operation of recipe in HMI • Report making in HMI • Report generation in HMI • History making in HMI • Bar graph drawing in HMI <p>Macros in HMI</p> <ul style="list-style-type: none"> • Need of Macros • Controller embedded HMI • Use of HMI as controller • Configuration of macros <p>Security setting in HMI</p> <ul style="list-style-type: none"> • Different level of securities • Password setting • Password reset • Limiting the number of failure for wrong password • Setting of different level passwords <p>Troubleshooting of HMI</p> <ul style="list-style-type: none"> • Testing of HMI hardware • Testing of HMI communication • Testing of HMI software • Troubleshooting of HMI hardware • Troubleshooting of HMI 	<ul style="list-style-type: none"> • Communication cables • PLC-HMI Interface cables application • Electrical tool Kit
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		<p>communication</p> <ul style="list-style-type: none"> • Troubleshooting of HMI software • Reset HMI 	
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Module Summary:

Module	Learning Units	Duration
Module 12: Perform Programmable Logic Controller (PLC) Operations	LU1: Integrate Programmable Logic Controller LU2: Develop logic for Programmable Logic Controller	420
Module 13: Develop Human Machine Interface (HMI)	LU1: Configure HMI LU2: Develop graphical User Interface LU3: Develop HMI Programs & Recipes	110

Frequently Asked Questions **(FAQs):**

Q: 1 What Is Automation?

Ans :

Automation is delegation of human control functions to technical equipment for increasing productivity, better quality, reduced cost & increased in safety working conditions.

Q : 2 What Are The Different Components Used In Automation?

Ans:

The components of automation system include

- Sensors for sensing the input parameters (RTD, Thermocouple, Pressure, Flow, Level; etc)
- Transmitters for transmitting the raw signal in electrical form
- Control system which includes PLC, DCS & PID controllers
- Output devices / actuators like drives, control valves.

Q :3 What Are The Different Control Systems Used In Automation?

Ans:

- PID Controller based control system
- PLC based control system
- DCS based Control system
- PC Based automation system

Q :4 Explain PID Based Control System?

Ans:

PID (Proportional Integral Derivative) is the algorithm widely used in closed loop control. The PID controller takes care of closed loop control in plant. A number of PID controllers with single or multiple loop can be taken on network.

PID Controllers are widely for independent loops. Although some logic can be implemented but not much of sequential logic can be implemented in PIDs.

Q : 5. What is Difference Between PLC & Relay Logic Control ?

Ans:

- PLC can be programmed whereas a relay cannot.
- PLC works for analog I/Os such as PID loops etc. whereas a relay cannot
- PLC is much more advanced as compared to relay.
- Modifications in relay base circuit is difficult compared to PLCs

Q : 6 Which Are The Leading PLC Providers ?

Ans :

The leading PLC providers include

- Rockwell Automation : Allen Bradley (Micrologix, SLC, PLC, Control Logix)
- Siemens (S7 200, S7 300 , S7 400)
- Grouper Schneider : Modicon (Nano, Micro, Premium, Quantum)
- GE Fanuc : Versa, Series 90-30, 90-70
- Mitsubishi
- Delta
- Fatek

Q : 7 What Types Of Sensors Are Used For Measuring Different Parameters?

Ans :

- Temperature sensors – RTD, Thermocouple, Thermister
- Pressure Sensor – Borden Tube, Bellows, Strain gauge
- Flow sensor – Pitot tube, Orifice, Ultrasonic+
- Level, Conductivity, Density, Ph

Q :8 What is Competency Based Training (CBT) and how is it different from currently offered trainings in institutes?

Ans:

Competency-based training (CBT) is an approach to vocational education and training that places emphasis on what a person can do in the workplace as a result of completing a program of training. Compared to conventional programs, the competency based training is not primarily content based; it rather focuses on the competence requirement of the envisaged job role. The whole qualification refers to certain industry standard criterion and is modularized in nature rather than being course oriented.

Q :9 What is the passing criterion for CBT certificate?

Ans:

The candidate will be required to be declared “Competent” in the summative assessment to attain the certificate.

Q:10 What are the entry requirements for Industrial Automation?

Ans:

The entry requirement for this course is Matric Science or equivalent.

Q :11 How can I progress in my educational career after attaining this certificate?

Ans:

You shall be eligible to take admission in the National Vocational Certificate Level-2 in Industrial Automation Technician. You shall be able to progress further to National Vocational Certificate Level-3 & Level-4.

Q:12 If one can have the experience and skills mentioned in the competency standards, does he still need to attend the course to attain this certificate?

Ans:

You may opt to take part in the Recognition of Prior Learning (RPL) program by contacting the relevant training institute and getting assessed by providing the required evidences.

Q:13 Is there any age restriction for entry in this course or Recognition of Prior Learning program (RPL)?

Ans:

There are no age restrictions to enter this course or take up the Recognition of Prior Learning program.

Q:14 What is the duration of this course?

Ans:

The duration of the course is 1,810 hrs. (2.5 Years)

Q:15 What are the class timings?

Ans:

The classes are normally offered 26 days a month from 08:00am to 01:30pm. These may vary according to the practices of certain institutes.

Q: 16 What is equivalence of this certificate with other qualifications?

Ans:

As per the national vocational qualifications framework, the level-4 certificate is equivalent to Matriculation. The criteria for equivalence and equivalence certificate can be obtained from The Inter Board Committee of Chairmen (IBCC).

Q: 17 What is the importance of this certificate in National and International job market?

Ans:

This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTTC). These standards are also recognized worldwide as all the standards are coded using international methodology and are accessible to the employers worldwide through NAVTTTC website.

Q: 18 which jobs can I get after attaining this certificate? Are there job for this certificate in public sector as well?

Ans:

You shall be able to take up jobs in the operation, maintenance, automating manufacturing, process and any kind of industry.

Q:19 What are possible career progressions in industry after attaining this certificate?

Ans:

You shall be able to progress up to the level of supervisor after attaining sufficient experience, knowledge and skills during the job. Attaining additional relevant qualifications may aid your career advancement to even higher levels.

Q: 20 Is this certificate recognized by any competent authority in Pakistan?

Ans:

This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTTC). The official certificates shall be awarded by the relevant certificate awarding body.

Q:21 Is on-the-job training mandatory for this certificate? If yes, what is the duration of on-the-job training?

Ans:

On-the-job training is not a requirement for final / summative assessment of this certificate. However, taking up on-the-job training after or during the course work may add your chances to get a job afterwards.

Q: 22 How much salary can I get on job after attaining this certificate?

Ans:

The minimum wages announced by the Government of Pakistan in 2019 are PKR 17,500. This may vary in subsequent years and different regions of the country. Progressive employers may pay more than the mentioned amount.

Q: 23 What is the teaching language of this course?

Ans:

The teaching language of this course is English/Urdu.

Q: 24 Is it possible to switch to other certificate programs during the course?

Ans:

There are some short courses offered by some training institutes on this subject. Some institutes may still be offering conventional certificate courses in the field.

Q: 25 What is the examination / assessment system in this program?

Ans:

Competency based assessments are organized by training institutes during the course which serve the purpose of assessing the progress and preparation of each student. Final / summative assessments are organized by the relevant qualification awarding bodies at the end of the certificate program. You shall be required to be declared “Competent” in the summative assessment to attain the certificate.

Q: 26 What kind of freelancer activities can be started. ?

Ans:

You can start your small business of providing services including automating the machines with the focus of PLC programming.

MLTIPL CHOICE QUESTIONS (MCQs)

MODULE: 12 PERFORM PROGRAMMABLE LOGIC CONTROLLER OPERATIONS (PLCs)

Q:1 The acronym PLC stands for:

- (A) Pressure Load Control
- (B) **Programmable Logic Controller**
- (C) Pneumatic Logic Capstan
- (D) Pressure Loss Chamber

Q:2 Ladder logic programming consists primarily of:

- (A) **Virtual relay contacts and coils**
- (B) Logic gate symbols with connecting lines
- (C) Function blocks with connecting lines

(D) Text-based code

(E) Hieroglyphics

Q:3 In PLC programming, a retentive function is one that:

(A) Defaults to the “on” state

(B) Comes last in the program

(C) Defaults to the “off” state

(D) Cannot be edited or deleted

(E) **Is not reset after a power cycle**

Q:4 What is the largest integer number that a PLC counter function can reach if it uses a 16 bit register?

(A) 32,768

(B) 65,535

(C) 65,536

(D) 65,537

(E) **32,767**

Q:5 An OR function implemented in ladder logic uses:

(A) Normally-closed contacts in series

(B) Normally-open contacts in series

(C) A single normally-closed contact

(D) **Normally-open contacts in parallel**

(E) Normally-closed contacts in parallel

Q:6 An AND function implemented in ladder logic uses:

- (A) Normally-closed contacts in series
- (B) Normally-open contacts in series**
- (C) A single normally-closed contact
- (D) Normally-open contacts in parallel
- (E) Normally-closed contacts in parallel

MODULE:13 DEVELOP HUMAN MACHINE INTERFACE (HMI)

Q:1 HMI is used for_____ in automation.

- a. Monitoring
- b. Control
- c. **Both a & b**
- d. None of these

Q:2 _____ is used HMI as Master Controller

- a. **Macros**
- b. designing
- c. Bar graphs
- d. None of these

Q:3 _____ bit data will be used in address while designing the meter on HMI screen.

- a. **16**
- b. 1
- c. 2
- d. None of these

Q:4 _____ bit data will be used in address while designing the indicator on HMI screen.

- a. 16
- b. **1**
- c. 2
- d. None of these

Q:5 How many levels of security used in HMI

- a. 1
- b. 2
- c. **7**
- d. 100

Q:6 We can design the _____ on HMI screen.

- a. Pipes
- b. Tanks
- c. Buttons
- d. **All of these**

