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INDUSTRIAL AUTOMATION

LEARNER GUIDE

National Vocational Certificate Level 2

Version 1 - September, 2019

NAVTTC

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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 Automationprogram 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 sthe 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:**
- 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**:
  Thiscontains the summary of the modules that make up your learner's guide
- **Frequently asked questions**:
  These have beenadded 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-5

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Module 5: 071400935 Apply Electric Circuit Concepts

Objective of the module: The aim of this module to get knowledge, skills and understanding to apply electric circuit concepts

Duration: 112 hours **Theory:** 28 hours **Practical:** 112 hours

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1: Perform measurement of electrical quantities using meters	**The student will be able to:** • Test electrical components as per requirement. • Test electrical quantities as per requirement.	**Basic Electrical Quantities :** Understand basic Concepts of Electrical quantities such as Voltage &Current &understand theirunits. Learner should be able to define these quantities and have clear physical understanding of these quantities, their units and mathematical relations. **Active & Passive Components :** Familiarize with the active and passive components including resistors, capacitors, inductors, diodes & transistors. • Their types, values ranges, color coding and package types. • Differentiating between working and faulty electrical components **Electrical Energy Sources:** Should be able to understand different electrical energy sources and their measurement principles while adhering to standard earthing and grounding practice.	• White board/Multimedia • Computer system/Internet • Variable Power Supply • Digital Multimeter • Assorted electrical components (Active & Passive) • Jumper Wires • Project Boards • Energy Sources

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
		Operation of Digital Multimeter (DMM) Be able to use different modes of digital multi-meter (Clamp meter, DMM) along with their corresponding levels/grades. • Recording the measured quantities by connecting the components of multimeter. • Measurement of current & voltage for a single loop circuit. .	
LU2: Perform calculations of electrical quantities	**The learner will be able to:** • Calculate current, voltage, resistance and power of a circuit as per requirement • Solve Series & Parallel Circuits as per requirement	**Ohm's Law** : Study the basics of Ohm's Law. • Basic concept of series and parallel circuits with calculations and through Ohm's Law. **Energy & Power Calculations for Basic Circuits:** • Understand & Practice power and energy calculations for basic circuits. • Power calculations for selecting AC& DC sources.	• White board/Multimedia • Computer system/Internet • Variable Power Supply • Digital Multimeter (DMM) • Assorted electrical components (Active & Passive) • Jumper Wires • Project Boards • Energy Sources • Watt Meter
LU3: Use electric diagrams and symbols	**The student will be able to:** • Identify electrical and control symbols for components as per	**Symbols for Electrical & Control Components:** • Study standard symbols for electrical and control	• Pencils /Erasers /Sharpener • White board /Multimedia • Internet / • Computer system • Drawing sheets & tools

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
	requirement • Draw electrical single line diagrams manually as per requirement.	components and practice manual or computer-based drawing. • Reading and understanding given standard drawing for power and control circuits. • Draw single line diagrams for power and control circuits while understanding the basic working knowledge.	• Electrical components stencil
LU4: Terminate cables and circuit accessories	**The trainee will be able to:** • Select tools and accessories as per requirement • Lay down cables as per requirement	**Wire & Cable** : Should be able to differentiate between cable and wire. **Types of AC Cables** : Familiar with different types of AC cables for single phase and three phase (with details of color coding, core specifications, wire gauges, and material, shielding and insulation specifications). **Types of DC Cables** : Understand different type of DC cables (with details of rating, wire sizing and material, shielding and insulation specifications). **Selection of Cables :** Knowledge of cable-selection tables as per international standards.	• White board/Multimedia • Computer system/Internet • Variable Power Supply • Digital Multimeter (DMM) • Different types of wires & cable • Project Boards
LU5: Install DC Circuits wiring	**The student will be able to:** • Select wiring tools,	**Tools & Accessories for DC Wiring:** Introduction to tools and accessories	• White board/Multimedia • Computer system/Internet

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
	components, accessories and cables as per requirement. • Connect DC components as per requirement.	for DCWiring. • Connecting different components of DC circuits according to terminal tags and labels as per standard diagrams. • Compare the observed results with the desired results of implemented DC circuits. **DC Relays & Switches :** • Study of DC relays and switches. • Understand Latching and Unlatching circuit with DC wiring. • Implement different types of Logic Gates using relays.	• Variable Power Supply • Digital Multimeter (DMM) • Different types of wires & cable • Project Boards • Energy Sources • Electrical tool kit. • DC Relays (24 VDC) • Switches • Push Buttons • DC indicator (24 VDC) • Terminal Blocks
LU6: Install AC circuit wiring	**The student will be able to:** • Select wiring tools, accessories and cables as per requirement • Connect AC components as per requirement	**Tools & Accessories for DC Wiring:** Introduction to tools and accessories for AC wiring. **Types of Cables.** Be familiar with different types of AC Cables. **AC Circuits Installation :** • Connecting different components of AC circuits according to terminal tags and labels as per standard diagrams. • Compare the observed results with the desired results of implemented AC circuits. • Study of AC relays contactors and switches. **Single Phase & Three Phase Wiring:**	• Multimedia/Internet /Computer system • Electrical Tool kit. • AC relays (220 VAC) • Switches • Push buttons • AC indicator (220 VAC) • Terminal blocks • Magnetic Contactor (220 VAC) • Timer relay (220 VAC) • Overload Relays • Circuit Breaker • Under voltage relay • Three phase AC Motor • Single phase AC Motor

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
		• Differentiate the single phase and three phase electrical wiring. • Understand reverse-forward, star-delta and DOL (Direct Online) operations for motors using relay logic.	

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Module-6

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Module 6: 071400936 Install Automation Instruments

Objective of the Module: The aim of this module to get knowledge, skills and understanding to install automation instruments

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

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1: Install Digital Instruments	**The trainee will be able to:** • Select tools and accessories as per requirement • Identify digital instruments as per requirement • Install digital instruments as per requirement • Operate digital instruments as per requirement	**Basic terms of digital electronics:** • Normally open • Normally close • NPN switching • PNP switching • Transmitter & Receiver **Operation of digital multimeter in following modes;** • Voltage measurement • Current measurement • Resistance measurement • Temperature measurement **Digital Instruments used for industrial automation** • Photo Sensors • Capacitive Sensors • Inductive Sensors • Solenoids • Micro Switches • Pressure Switches etc. **Connectionsof Digital**	• White board • Multimedia • Internet • Computer system • Digital Trainer • Jumper wires • Variable power supply • Seven segment display • Gate ICs • 555 Timer ICs • LCD • Indicators • Memory devices

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
		instruments/sensors • Two wires • Three wires **Technical Manuals/Sheets Reading** • Wiring Diagram of Sensors • Parameters/Baud rate setting of sensors in Controller • Installation procedure of sensors **Digital Instruments Troubleshooting** • Open Circuit • Short Circuit • Aging Effect • Sensors Testing with meter	
LU2: Install Analogue Instruments	**The trainee will be able to perform following duties :** • Select tools and accessories as per requirement • Identify Instruments for different output signals as per requirement • Install Analogue Instruments as per requirement	**Basic terms related to analogue electronics;** • Signal Conversions i. ADC-Analog to Digital Conversion ii. DAC-Digital to analog Conversion • Amplification • Signal Conditioning • Strain Gauge • Analogue Signal types & levels **Analogue Instruments/Sensors used**	• White board • Multimedia • Computer system/Internet • Analogue/meter Trainer • Jumper wires • Variable power supply • Indicators • Ammeter • Voltmeter • Galvanometer • Analog multimeter • Analog sensor module

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
		for industrial automation • Temperature sensor • Pressure sensor • Flow sensor • Level sensor • Load cell **Connections of Sensors** • Two wires • Three wires • Four wires **Technical Manuals/Sheets Reading** • Wiring Diagram of Sensors • Parameters/Baud rate setting of analogue sensors in Controller • Installation procedure of sensors **Digital Instruments Troubleshooting** • Open Circuit • Short Circuit • Analogue Sensors Testing with digital / analogue meter	
LU3: Install Hydraulic and Pneumatic	**The learner will be able to perform the following tasks :**	**Hydraulic and Pneumatic Valves** • DCV(directional control valve)	• Multimedia Projector • Computer system /Internet • Hydraulic Boards

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
Equipment	• Select tools as per requirement • Identify hydraulic and pneumatic symbols • Draw hydraulic and pneumatic systems diagrams manually • Identify different hydraulic components and instruments as per requirement • Install hydraulic components and instruments as per requirement • Operate hydraulic equipment as per requirement • Identify different Pneumatic components and instruments as per requirement • Install pneumatic components and instruments as per requirement • Operate pneumatic	○ Shuttle valve ○ Check valve ○ 2/2-way valve ○ 3/2-way valve ○ 5/2-way valve ○ 5/3-way valve • PCV (pressure control valve) ○ Pressure limiting ▪ Pressure reducing valve ▪ Pressure relief valve ○ Pressure regulator ○ Pressure sequencing valve • Limit switches • Pressure Gauges • Rotary actuators • Types of cylinder (single acting;	• Pneumatic Boards • Compressor • Oil /Oil tank • Motor /Pump • Different DCV (Directional control valves) • Different PCV (Pressure control valves) • Single and Double acting Cylinders for both Hydraulic and Pneumatic systems • Limit switches • Rotary Actuators • Filter/Pressure Regulator • Pressure relief Valve • Connecting Pipes

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
	equipment as per requirement/teacher guidance. • Troubleshoot Hydraulic and Pneumatic system	double acting) **Valves Actuation Methods** • Lever Operated • Pilot Operated • Solenoid operated • Symbols of levers and valves **Operational knowledge hydraulic/pneumatic system** • cascade control • cylinder sequencing **Troubleshooting Techniques** • Safety practices during Pneumatics and Hydraulic operations • Pump troubleshooting • Flow and pressure • System overheating • Actuators • Valves	

Module Summary:

Module	Learning Units	Duration
Module 5: Apply Electric Circuit Concepts	**LU1:** Perform measurement of electrical quantities using meters **LU2:** Perform calculations of electrical quantities **LU3:** Use electric diagrams and symbols **LU4:** Install DC Circuits wiring **LU5:** Install AC circuit wiring **LU6:** Terminate cables and circuit accessories	140
Module 6: Install Automation Instruments	**LU1:** Install Digital Instruments **LU2:** Install Analogue Instruments **LU3:** Install Hydraulic and Pneumatic Equipment	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)
- Grouppe 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 (NAVTTC). These standards are also recognized worldwide as all the standards are coded using international methodology and are accessible to the employers worldwide through NAVTTC 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 (NAVTTC). 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 leaching 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.

MLTIPLE CHOICE QUESTIONS (MCQs)

MODULE: 5 APPLY ELECTRIC CIRCUIT CONCEPTS

Q.1 The flow of electrons is called ----------

(a) Voltage (b) Resistance (c) **Current**(d) Impedance

Q.2 The unit of Current is _____.

(a) Ohm (b) **Ampere** (c) Volt (d) Watt

Q.3 A quantity which determines the flow of charge is _____.

(a)**Voltage difference** (b) Resistance difference

(c) Power difference (d) Level Difference

Q. 4 P.D stands for _____.

(a) Power Display (b) Power driven

(c) **Potential difference** (d) Proportional difference

Q. 5 In series circuits the voltage _____.

(a)Increases (b) Decreases (c) **Drops** (d) Constant

Q. 6 Current remains _____ in series circuits.

(a)Increasing (b) decreasing (c) **Constant** (d) Oscillating

Q. 7 Voltage remains _____ in parallel circuits.

(a) Increasing (b) decreasing (c) Divides (d) **constant**

Q. 8 Current _____ in parallel circuits

(a) Increases (b) Decreases (c) **Divides** (d) Constant

Q: 9 An analog ammeter has

a. Digits b. **Needle** c. Roman numbers d. Arabic digits

Q:10 Ammeter can be connected

a. before the cell or battery b. before the bulb c. after the bulb d.**any where**

Q:11 Opposition to the flow of current is ----------

a. Current b. **Resistance** c. Impedance d. Voltage

Q:12 A multi meter is used to measure

a. Resistance b. Current c. Voltage d. **All of the Above**

Q13. Two multi meters A and B have sensitivities of 10 kΩ/V and 30 kΩ/V respectively. Then ……..

a. Multimeter A is more sensitive

b. Multimeter B is more sensitive

c. Both are equally sensitive

d. None of the above

Q:14 An ideal ammeter has …… resistance

a. **Low** b. Infinitec. Zero d. High

Q:15 The resistance of an ideal voltmeter is ……

(a) Low (b). **Infinite** (c) Zero (d). High

Q.16 _____ cell cannot be recharged.

(a) **Primary** (b) Secondary (c) Variable (d) Constant

Q.17 Every cell has a certain _____ resistance denoted as r_i.

(a) External (b) **Internal** (c) Extrinsic (d) Intrinsic

Q.18 The combination of cells is called _____.

(a)**Battery** (b) Adapter (c) Voltage level (d) Current level

Q.19 In series combination cells voltage level _____.

(a)**Increases** (b) Decreases (c) Constant (d) No change

Q.20 In order to provide higher currents, cells are connected in _____.

(a) Series (b) **Parallel** (c) Cascaded (d) Any of above

MODULE: 6 INSTALL AUTOMATION INSTRUMENTS:

Q:1 Which of the following is correct for tactile sensors?

a) **Touch sensitive**

b) Pressure sensitive

c) Input voltage sensitive

d) Humidity sensitive

Q: 2. Change in output of sensor with change in input is _____

a) Threshold

b) Slew rate

c) **Sensitivity**

d) None of the mentioned

Q: 3 Smallest change which a sensor can detect is _____

a) **Resolution**

b) Accuracy

c) Precision

d) Scale

Q:4 Thermocouple generate output voltage according to _____

a) Circuit parameters

b) Humidity

c) **Temperature**

d) Voltage

Q:5 . Sensor is a type of transducer.

a) **True**

b) False

Q:6 Which of the following is not an analog sensor?

a) Potentiometer

b) Force-sensing resistors

c) Accelerometers

d) None

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