UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: December 2020

Module Number: ME5213 **Module Name: Industrial Automation**

[Three Hours]

[Answer **all questions**, each question carries **12** marks]

Clearly state all assumptions that you may make. Refer to Annex-A and Annex-B for standard symbols. Use a separate answer book for each question.

Q1. i) Define and briefly describe "repeatability" and "reproducibility" related to a measurement.

[2 Marks]

ii) Briefly explain the function of a "measurement system" and its configuration using a suitable sketch.

[2 Marks]

iii) Automated systems have to interact and measure things in the real world. Proper selection of sensors with relevant specifications is one of the key factors that will determine how well a system functions.

(a) Define sensors and list various specifications that need to be carefully studied before purchasing a Thermocouple for reading the temperature of a furnace.

(b) Differentiate between "Nonlinearity" and "Hysteresis" errors of a sensor.

[4 Marks]

iv) The Internet of Things (IoT) is a fast-moving technology that makes everything smart.

(a) Briefly explain the term "Internet of Things". You may use a sketch to describe your answer.

(b) Name four(4) different industries that can benefit from IoT.

[4 Marks]

Q2. i) Pneumatics has become one of the main requirements for most of the automated industrial applications in manufacturing. State the main four(4) distinct stages of a pneumatic system.

[2 Marks]

ii) In a pneumatic system, it is not recommended to use the air leaving the compressor without going through the process of "compressed air preparation". Briefly describe the necessity of the above operation in pneumatic systems.

[2 Marks]

Q2 continues to the next page

iii) The positional sketch of a feeding device is shown in **Figure Q2(iii)**. The initial positions of the two-cylinder drive 1A and 2A are detected by the two magnetic reed switches 1B1 and 2B1.

The system starts to operate when the operator presses the "START" pushbutton. The sequence compromises the following steps,

Step 1: The piston rod of cylinder 1A advances, the workpiece pushes out from the magazine.
Step 2: The piston rod of cylinder 2A advances, the workpiece feeds to the machine station.
Step 3: The piston rod of cylinder 1A retracts.
Step 4: The piston rod of cylinder 2A retracts.

Once the operator presses the "START" push button, the system should operate continuously until the "STOP" push button is pressed.

(a) Create an Actuation Chart for the above operation.

(b) Draw the Displacement-Step Diagram for two cylinders.

(c) Design the complete Electro-Pneumatic circuit of the feeding device including both **Pneumatic** and **Electrical** circuit diagrams.

[8 Marks]

Q3. i) A Programmable Logic Controller, or PLC, is a ruggedized computer that is used for automating industrial applications. These controllers can automate a specific manual process, machine function, or even an entire production line.

List four(4) main advantages of employing PLCs for modern applications over conventional control panels with relays.

[2 Marks]

ii) Suppose you are an engineer who has been assigned to automate a part of an incoming inspection process of metal pieces before forwarding them into a CNC machine. Configuration of the process layout is shown in **Figure Q3(ii)**. You are required to measure the height of the input metal pieces transferred through the conveyor and reject items that do not fall within the permitted dimension range. The rejection process should contain two separate stages to eject "high height" and "low height" items from the conveyer before they enter the CNC machine.

The approved height of the workpiece is 10 ± 1 cm.

(a) Decide the type of sensor(s) you would use to identify the presence of the items and to differentiate items based on their height.
Describe how the height differentiation is done.

(b) Design the ejection system using electro-pneumatic actuators and Describe the operation. You may use appropriate sketches to describe your design.

(c) Sketch the design of an operator control panel for this application including all the necessary functions such as manual operations and safety options.

(d) Draw the PLC wiring diagram and the ladder logic program.

[10 Marks]

Q4. i) SCADA (Supervisory Control and Data Acquisition) is a type of industrial control system that is used to monitor and remotely control critical industrial processes. Briefly describe the function of the following main components of a typical SCADA system.

(a) Central site

(b) Master station

(c) Remote Terminal Unit (RTU)

(d) Communications System

[2 Marks]

ii) Assume you as an automation engineer of a soap production factory. You are asked to apply a SCADA system to the existing semi-automated production lines.

(a) Some argue that HMI and SCADA are the same systems. State whether you agree with this argument? Explain your answer with reasons.

(b) List the main issues that you have to consider when selecting a proper remote terminal unit?

(c) Prepare a list of specifications (four(4) specifications per issue) to address issues that you listed in (ii)(b) above?

[6 Marks]

iii) Most of the industrial motor controls are accomplished by a programmable logic controller that connect either with a VFD (Variable Frequency Drives) or a Soft Starter.

(a) Explain the purpose and function of a soft starter.

(b) Compare the motor controlling by a VFD and soft starters.

[4 Marks]

Q5. Assume you are an automation engineer and you are assigned a task to design and instrument a packaging and labeling system for tomatoes that are exported as closed one side visible small cartoons. There are two sizes: 10 tomatoes per packet and 20 tomatoes per packet. In your project design reports, you have to describe the steps of establishing the design/performance specifications for the system, selecting and sizing sensors, actuators, drive systems, controllers, signal conditioning and interface hardware, and software for the full or semi-automation of the system. Keeping this in mind, answer the following. You may make any assumptions and use suitable sketches.

i) Describe the system indicating

- the purpose of the system for high-quality packaging and labeling,
- how the system operates,
- the important inputs, response, or output variables to be measured to have open-loop or closed-loop control appropriate for the system operation.

[4 Marks]

Q5 continues to the next page

ii) Propose a suitable controller(s) and indicate the operation of the controller(s) in the system. List five specifications required to select a suitable controller modal/ brand.

[2 Marks]

iii) List the sensors required to automate the system, indicate the type, and prepare four specifications for each sensor.

[2 Marks]

iv) List actuators and drive systems present in such systems and indicate the type and which of these actuators have to be controlled. Prepare four specifications for each actuator that you have proposed.

[2 Marks]

v) Describe how the users or the operators interact with the system, and the user interface requirements.

[2 Marks]

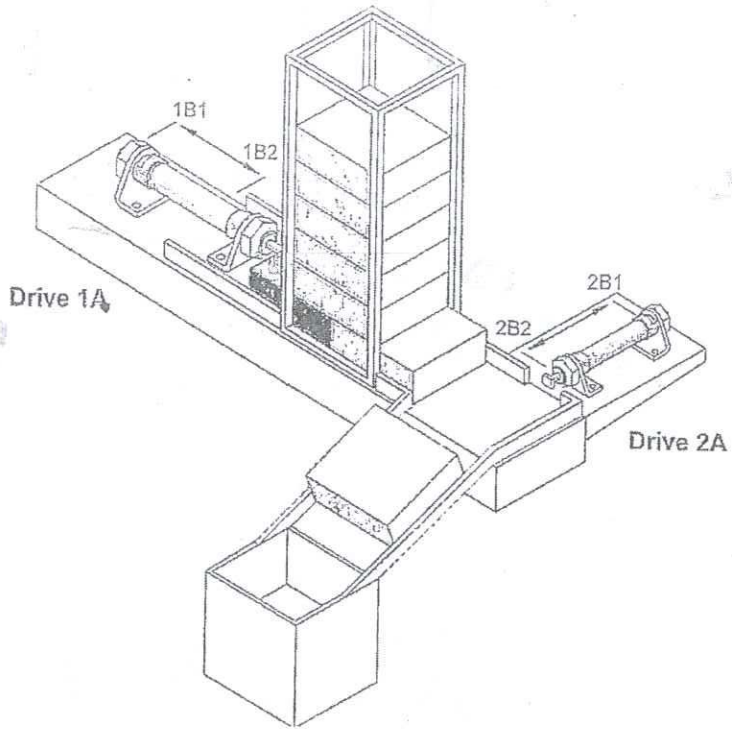


Figure Q2(iii) : Positional sketch of the feeding device

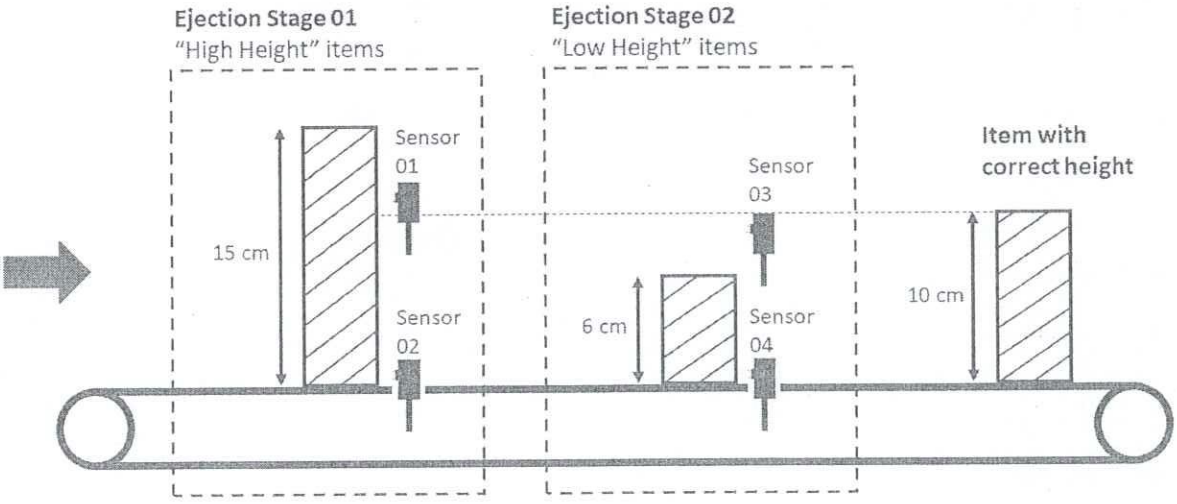
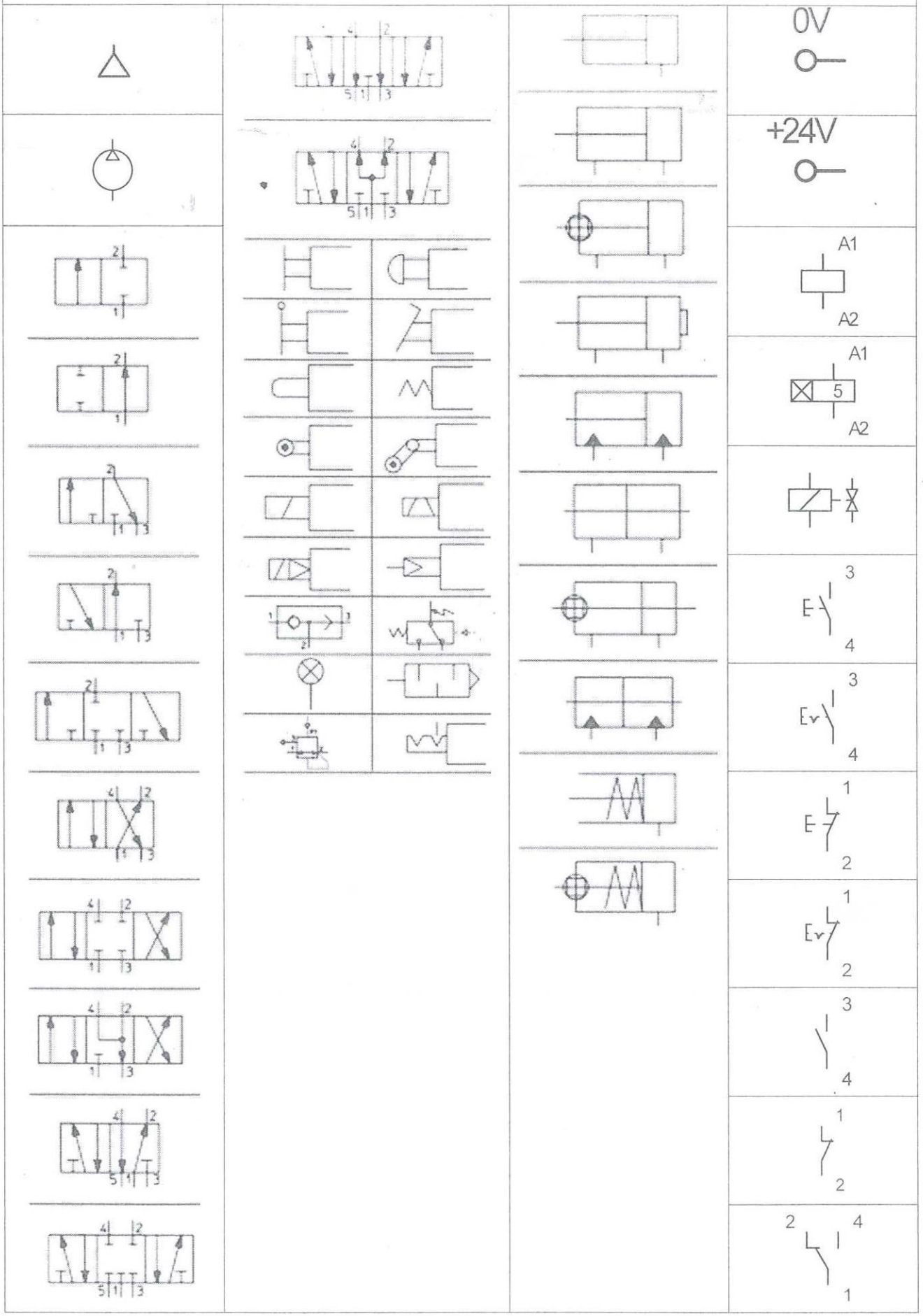


Figure Q3(ii) : Process layout of the height inspection stage

Annex - A: Pneumatic and Electro-Pneumatic Symbols



Annex - B: PLC Ladder Logic Programming Symbols	
X	Input
Y	Output
M	Memory bit
S	Set
R	Reset
T	Timer
C	Counter