NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION

DEPARTMENT OF TECHNICAL AND ENGINEERING EDUCATION AND TRAINING

COMPUTER CONTROL AND MANUFACTURING SYSTEMS

PTE 6248

Second Semester Main Examination Paper

May 2019

This examination paper consists of 5 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: Laplace Transforms tables

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INSTRUCTIONS AND INFORMATION TO CANDIDATE

1. This question paper contains six (6) questions
2. Answer any four (4) questions.
3. Each question carries 25 marks.
4. Use of calculators is permissible.

Question 1

An industrial robot has a transfer function given by the following expression:

$$G(s) = \frac{1}{Js + 1}$$

A controller, which has a gain K, is connected to the robot in series (cascade).

(a) Draw the open loop representation (block diagram) of this arrangement. [3]
(b) Determine the open loop transfer function of the system. [4]
(c) The loop is then closed by a feedback loop with a transfer function H(s) = 1
  (i) Draw the closed-loop representation (block diagram) of the arrangement. [4]
  (ii) Determine the closed-loop transfer function of the system [4]
  (iii) For K = 10 find the value of θ the output (position) angle of the robot if the step input is a torque of 20 Nm for both the open loop and the closed loop after 3 seconds. Assume all initial conditions are zero and J = 5 units. [10]

Question 2

(a) Explain the benefits of implementing adaptive control strategy to NC machining. [6]
(b) Name the three categories into which adaptive control systems for machine tools can be classified. [3]
(c) Draw the diagram of software and hardware components of the system for adaptive control for maintaining a constant milling force. [10]
(d) Explain the purpose and action of each component. [6]

Question 3

(a) Most of the commercial robot controllers are of the PID type. Give reasons why the PID controller is preferred over other types of controllers. [5]
(b) Name and describe any other type of controller that may be used instead of the PID controller. [4]
(c) Write the mathematical model of the PID controller in
  (i) The time domain. [3]
  (ii) The s-domain. [3]
(d) What are the names given to the coefficients of each of the terms that comprise the PID controllers? [3]
(e) Describe the Ziegler-Nichols method of tuning PID controllers. [7]

Question 4

(a) Consider a CNC worktable driven by a closed-loop control system consisting of a servomotor, leadscrew and an optical encoder. The leadscrew has a pitch, p = 5mm and is coupled to the motor shaft with a screw to motor ratio of 1:4. The encoder generates 150 pulses per revolution of the leadscrew. If the number of pulses and the pulse rate received by the control system are 2250 and 200 Hz respectively, calculate

(i) Table speed. [3]

(ii) Motor speed in RPM. [3]

(iii) Distance travelled by the table. [3]

(b) Discuss the application Fuzzy Logic Based Models to predict surface roughness of a machined surface in a milling operation in CAPP systems. Why is there slow uptake of Fuzzy Expert systems in this area? [16]

Question 5

(a) Draw neat and annotated sketches of the following types of robot joint configurations indicating the directions of movement about and along the axes and the number of degrees of freedom in each case:

(i) Rectangular, [4]

(ii) Cylindrical, [4]

(iii) Spherical and, [3]

(iv) Articulated (Revolute). [4]

(b) Distinguish between robust control and adaptive control. [10]

Question 6

Parts have to be formed in a pneumatic press. The stamp only moves downwards if the following conditions are met:

- Protection grill is closed (B2).
- EMERGENCY-OFF not set.
- Both buttons (S2 and S3) are pressed at the same time (two-handed operation).

Figure Q6 below shows the schematic diagram of a pneumatic press and Table Q6 shows the respective input/ output assignments.

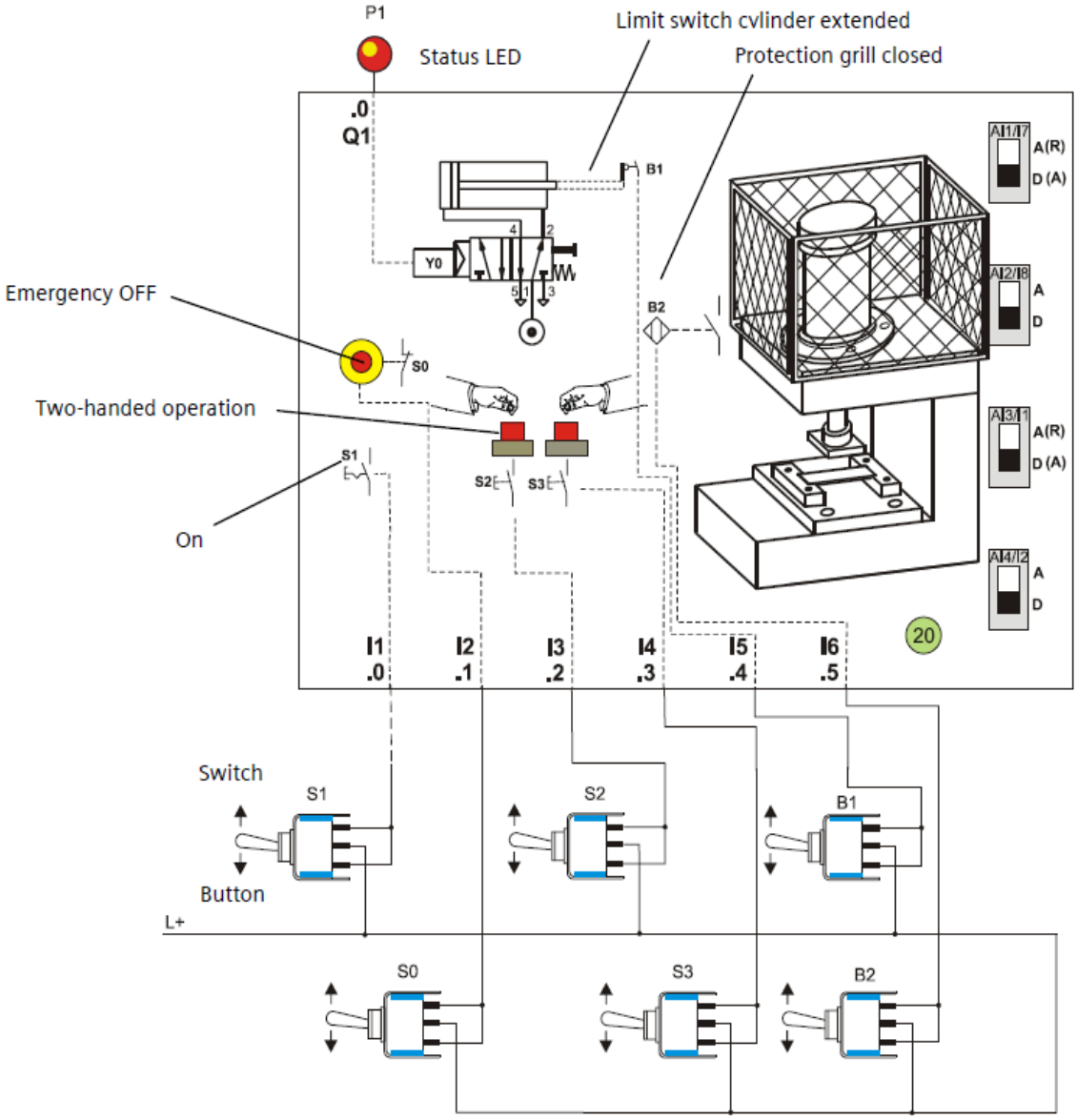

Figure Q6: Pneumatic press

Table Q6: I/O Assignments

Symbol	Absolute	Comment
S0	**E 0.1**	Emergency Off switch (normally closed)
S1	**E 0.0**	Switch On/Off
S2	**E 0.2**	Button Start
S3	**E 0.3**	Button Start
B1	**E 0.4**	Limit switch cylinder extended
B2	**E 0.5**	Protection grill closed
Y0/P1	**A 0.0**	Status LED (cylinder)

(a) Draw the flow diagram for the operation of the pneumatic press. [10]

(b) Draw the ladder logic or functional block diagram for the operation of the pneumatic press. [10]

(c) Explain how your program works. [5]

End of examination paper.