NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Master of Engineering Degree in Manufacturing Engineering and Operations Management

COMPUTER CONTROL OF MANUFACTURING SYSTEMS

COURSE CODE -TIE 6120

Second Semester Main Examination Paper
May, 2015

This examination paper consists of 4 pages

Time Allowed	**:**	**3 hours**
Total Marks	**:**	**100**
Special Requirements	**:**	**Calculator**
Examiner's Name	**:**	**Dr Z. B. Dlodlo**

INSTRUCTIONS TO CANDIDATE

1. Answer any four (4) questions.
2. Each question carries 25 marks.

QUESTION 1

(a) What are the major differences between the classical or frequency-domain technique and the state space or time-domain approach used for the design and analysis of feedback control systems? [5]

(b) Name and describe the advantages and disadvantages of each approach. [5]

(c) Represent the electrical network shown in Fig Q1 in state space, where $v_o(t)$ is the output. [15]

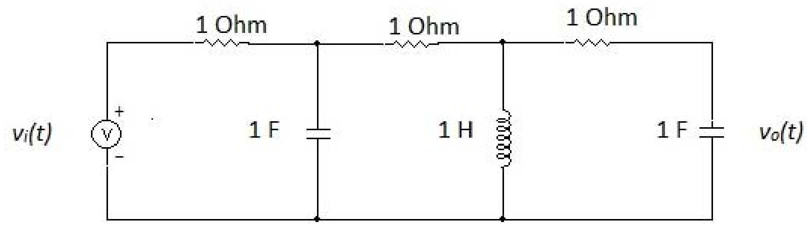

Fig Q1

QUESTION 2

The International Standard for Programmable Controllers (the IEC 1131-3) specifies three graphical languages and two text-based languages for programming PLCs.

(a) Explain, why it became necessary to develop this standard. [5]

(b) Name and describe the languages indicating to which category the language belongs and one application for which it is suited. [10]

(c) Discuss how personal computers (PCs) and PLCs are converging in industrial applications. [10]

QUESTION 3

(a) Name the basic hardware components of a servo. [4]

(b) Explain the information flow in numerical control and the individual basic blocks of the system. [6]

(c) Figure Q3 shows a block diagram of a positional servomechanism.
Given $\tau_{CL} = 0.01$ sec, $K_p = 100$ V/mm, K_{CL} = (rad/sec/V) = 5, $r = 0.2$ (mm/rad).

Determine

(i) The natural frequency ω_n (rad/sec) and damping ratio ς of the positional servo. [5]

(ii) The initial acceleration $\ddot{x}$ (mm/sec^2) at the start of a step command $x_{com} = 2$ mm. [5]

(iii) The steady-state error $er_{p,ss}$ (mm) at velocity of $\dot{x} = 20$ mm/sec. [5]

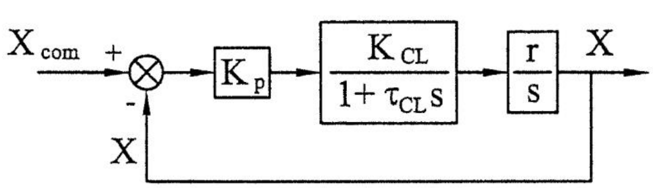

Fig Q3

QUESTION 4

(a) State the Final Value Theorem. [2]

(b) Using the Final Value Theorem, derive an expression for the steady-state error *E(s)* to a system whose transfer function is *G(s)*. [3]

(c) Verify that if the position loop in Fig Q4 is closed with unity gain and K_p is placed in the forward path (e.g. between the position and velocity summing points), the final value of the position to a step command of magnitude θ_d will be θ_d. Assume that the friction ($T_f(s)$) and gravitational ($T_{gr}(s)$) torques are zero. [20]

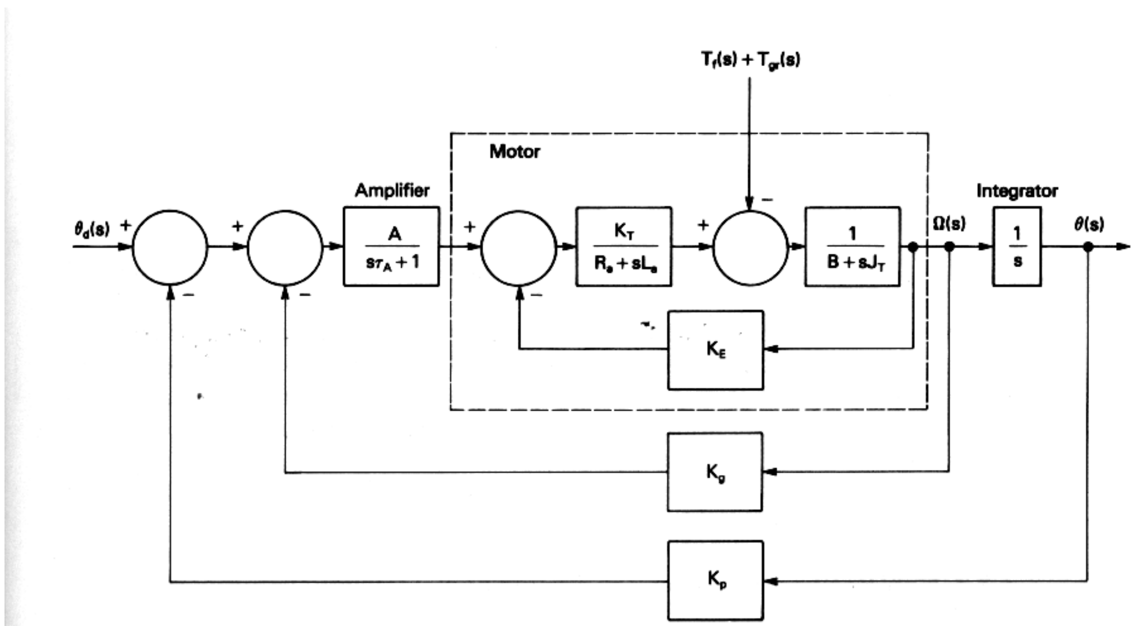

Fig Q 4

QUESTION 5

(a) Explain why it is necessary to implement an adaptive control strategy to NC machining. [5]

(b) Name the three categories into which adaptive control systems for machine tools can be classified. [3]

(c) Draw the diagram of the software and hardware components of the system for adaptive control for constant milling force. [10]

(d) Explain, briefly, the purpose and action of each component. [7].

QUESTION 6

(a) About 80% of commercial robot controllers are of the PID type. Give reasons for this huge preference of the PID controller over other types of controllers. [5]

(b) Name and briefly 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 controller. [3]

(e) In practice, how are the constants mentioned in (d) above determined? [7]

END OF EXAMINATION