Final Examination
Semester 1 / Year 2013

COURSE : PROGRAMMABLE LOGIC CONTROLLERS
COURSE CODE : ELEG 3243
TIME : 2 1/2 HOURS
DEPARTMENT : ELECTRICAL & ELECTRONIC ENGINEERING
LECTURER : ENG PEI CHEE

Student's ID :
Batch No. :
18 MAR 2013

Notes to candidates:
1) The question paper consists of 8 pages and 22 questions.
2) Section A: 10 questions, Section B: 9 questions and Section C: 3 question.
3) Answer ALL questions in Section A and Section B.
4) Choose ANY TWO questions from Section C to answer.
5) Begin each section on a new page.
6) Return the question paper with your answer booklet.
PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

Section A: (10 marks)
Section A contains TEN questions. Circle the correct answer. Candidates should answer ALL the questions. (1 mark for each question)

1. [ True ] The retentive timer must be intentionally reset with a separate signal.

2. [ True ] The OR function, implemented using contacts, requires contacts connected in series.

3. [ True ] The timing diagram shown is that of an ON-delay timer.

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Input
_________________________
Output
_________10 s_________
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4. [ True ] If the preset time of a timer is 150 and the time base is 100 ms, the time-delay period would be 1500 seconds.

5. [ True ] A PLC up-counter normally counts true-to-false transitions.

6. The main advantage of PLCs with fixed I/O is
   a. lower cost
   b. increased flexibility
   c. greater selection of modules
   d. faster replacement of I/O modules

7. A typical PLC system consists of the following blocks:
   a. CPU and Memory, I/O, Recovery Unit
   b. CPU, Memory, I/O, Power Supply, Programming Device
   c. Data, Control, Memory, CPT, Input/output
   d. Flex I/O, Opto-isolators, limit switches, power supply

8. A programmable logic controller (PLC) is a specialized _________ used to control machines and process.
   a. relay
   b. computer
   c. disk
   d. monitor
PROGRESSIVE CONTROL POINTERS (PLCs)

9. An opto-isolator is used to:
   a. rectify AC inputs
   b. control AC outputs
   c. electrically isolate the processor circuitry from the inputs and outputs
   d. electrically isolate the inputs from the outputs

10. For the hardwired relay circuit shown below, when PB1 is momentarily pressed
    a. R will de-energize
    b. G will energize
    c. M will energize
    d. All of the above.
PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

Section B: (50 marks)
Section B contains 9 questions. Candidates should answer ALL the questions.

1. Briefly explain the **PLC scanning process.**

2. What are the **five main components** of a PLC system? Briefly describe the **functionality** for each component.

3. Construct a **ladder logic diagram** to implement the following Boolean expression. 

   \[ Z = [(P+Q+R)(U+V)W.X] + (S+T).Y \]

4. The PLC ladder logic shown below is incorrect. Correct the ladder logic with proper ladder construction techniques.

5. Sketch the internal design of the 5/2 way double acting pneumatic cylinder valve in the extending process.
PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

6. Below figure shows the sketch of a drilling process that requires the drill press to turn on only if there is a part present and the operator has one hand on each of the start switches. This precaution will ensure that the operator's hands are not in the way of the drill.

Draw the ladder logic diagram for the above operation. [5m]

7. Design a PLC program and prepare a typical I/O connection diagram and ladder logic program that will correctly execute the hardwired control circuit in Figure 6-71. [5m]
8. Explain the differences of on-delay and off-delay timer. [5m]

9. Write a program (ladder diagram) that will increment a counter's accumulated value 1 count every 60 s after a switch is closed. A second counter's accumulated value will increment 1 count every time the first counter's accumulated value reaches 60. Turn on and latch a pilot light when the second counter accumulated value reaches 12. The first counter will reset when its accumulated value reaches 60, and the second counter will reset when its accumulated value reaches 12.

How long the switch has to be closed in order to turn on the pilot light? [5m]
PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

Section C: Control Problem (40 marks)
Section C contains THREE questions. Candidates should choose ANY TWO questions to answer. (20 marks for each question)

1. A machine is being designed to wrap boxes of chocolate. The boxes arrive at the machine on a conveyor belt. The list below shows the process steps in sequence.

i. The box is manually inserted on a conveyor by the operator.
ii. The push button START is pressed by the operator and the conveyor (C) starts moving.
iii. Process stops operating when the STOP button is momentarily pressed
iv. The box arrives and is detected by an optical sensor (P). After this the conveyor (C) is stopped and the box is clamped in place (H).
v. A wrapping mechanism (W) is turned on for 2 seconds.
vi. A sticker cylinder (S) is turned on for 1 second to put consumer labelling on the box.
vii. The clamp (H) is turned off and the conveyor (C) is turned on.

a) Construct an IO table.
b) Develop a ladder diagram for the system.

Note: Don’t forget to include the regular start and stop inputs.
2. The sequence of operation to implement the process illustrated in Figure C2 is to be as follows:
   - Normally open start and normally closed stop pushbuttons are used to start and stop the process.
   - When the start button is pressed, solenoid A energizes to start filling the tank.
   - As the tank fills, the empty level sensor switch closes.
   - When the tank is full, the full level sensor switch closes.
   - Solenoid A is de-energized.
   - Agitate motor starts automatically and runs for 3 min to mix the liquid.
   - When the agitate motor stops, solenoid B is energized to empty the tank.
   - When the tank is completely empty, the empty sensor switch opens to de-energize solenoid B.
   - The start button is pressed to repeat the sequence.

![Diagram of tank with solenoids and sensors](image_url)

Figure C2

c) Construct an IO table.
d) Construct a flowchart for the operation.
e) Construct the PLC ladder diagram based on your flowchart in b).
3. Figure C3 illustrates a paint-spraying system where boxes fed by gravity through a feeder magazine are delivered one at a time onto a moving conveyor belt. Boxes are pushed towards the conveyor by the cylinder A which extend and retract operation is controlled by switch S1 and S2. A spraying nozzle paints each box as it passed by and a detector D1 counts each box being sprayed. When 20 boxes have been painted the valve V2 shuts off and cylinder A stops operating.

Eight seconds later the conveyor stops moving and the hopper with its load now moves to the B+ position where it is emptied. Thirty seconds later the hopper returns to the original B- position. End of cycle of operation.

![Diagram of paint-spraying system](image)

**PLC INPUTS**
1. SWITCH S1 (operates at A=)
2. SWITCH S2 (operates at A+)
3. DETECTOR D1 (ON)
4. START SIGNAL (ON)

**PLC OUTPUTS**
1. Valve V1 (ON: A--; OFF: A+)
2. Valve V2 SOL
3. Motor M
4. Valve V3 (ON: B+; OFF: B−)

**Note:** Assume switch S1–S4 are normally 'open' when not actuated.

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a) Construct a sequence listing and  
b) Design a suitable PLC program for the above sequence of operation.

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