UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
SEPTEMBER 2023 SEMESTER

COURSE : MEB4062 - MECHATRONICS

DATE : 29 NOVEMBER 2023 (WEDNESDAY)

TIME : 9.00 AM - 11.00 AM (2 HOURS)

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.
6. **Attached APPENDIX - I together with the Answer Booklet.**

Note :

i. There are **SEVEN (7)** pages in this Question Booklet including the cover page and appendices.

ii. **DOUBLE-SIDED** Question Booklet.

1. A simplified block diagram of an Analog to Digital Converter (ADC) is shown in **FIGURE Q1**. It uses a Successive Approximation Register (SAR) with eight output lines D_0-D_7 to produce different voltages. The SAR will produce output voltages if 12-volt reference voltage (V_{REF}) is supplied to the reference input line. The SAR requires eight clock pulses to perform the entire process.

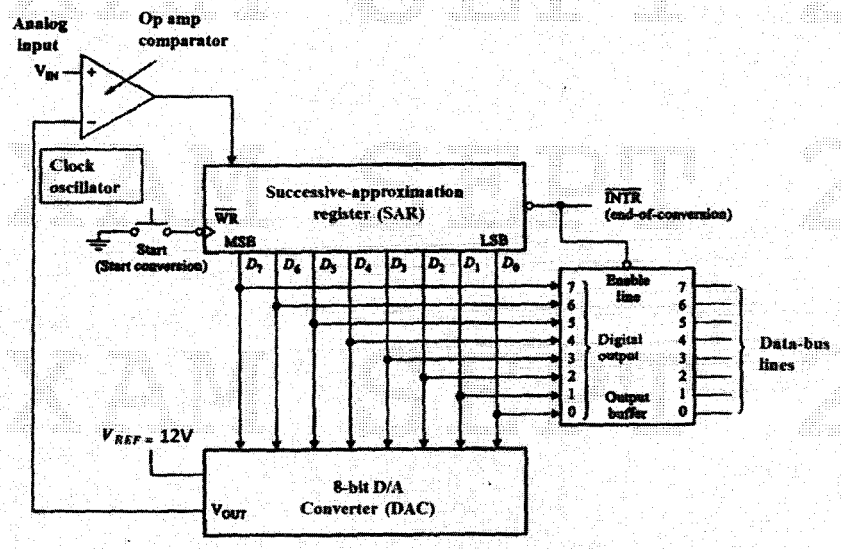


FIGURE Q1

a. Describe is the function of the Analog to Digital Converter (ADC) and explain its operation.

[6 marks]

b. Derive the voltage levels produced by each output line of the SAR assuming that one output line is ON at one time.

[8 marks]

c. The SAR-ADC is used to convert a 5.67-volt analog voltage to an equivalent 8-bit digital output. Using timing diagram provided in **Appendix 1,** develop the output waveform of the SAR for a duration of eight clock pulses.

[8 marks]

d. Referring to **part (c)**, estimate the digital to Analog Converter (DAC) output voltage (V_{out}) curve. Label all the voltage level for each curve.

[8 marks]

2. A manufacturing plant utilises a hydraulic system shown in **FIGURE Q2** for its automatic clamping and drilling machine operation. The system consists of two cylinders which are cylinder A and cylinder B, one sequential valve and one pressure limiting valve.

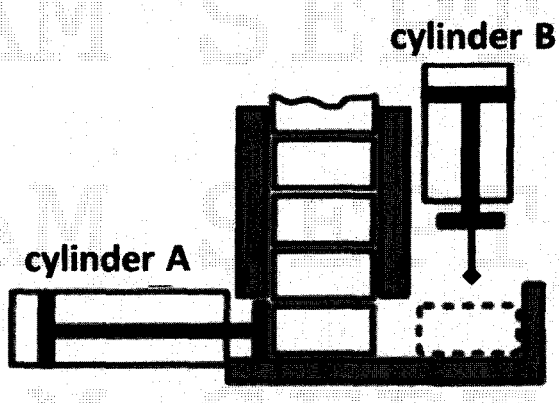


FIGURE Q2

a. When the sequential valve is activated, Cylinder A will extend to clamp the material. Subsequently, when the inlet pressure reaches a specific threshold, Cylinder B will extend to initiate the drilling process. Finally, both Cylinder A and Cylinder B should automatically retract at the end of the operation. With the aid of an appropriate diagram, propose a way to achieve the sequence.

[15 marks]

b. The hydraulic cylinder is to be used to move a work piece through a distance of 50 mm in 10 s. A force of 10 kN is required to move the work piece. Evaluate the required working pressure and hydraulic liquid flow if a cylinder with a piston diameter of 100 mm is available.

[5 marks]

c. A potential problem with the system is that the hydraulic fluid can become trapped in the pressure line to control the valve and so preventing the valve from switching. Propose an alternative way in realising the above sequence.

[5 marks]

d. As an improvement, the company will be using a programmable logic controller (PLC). When pushbutton 1 are pressed, cylinder A will extend followed by cylinder B. The extension of cylinder B will be held for a duration of 15 s to ensure the drilling quality. Next, cylinder B and cylinder A will retract simultaneously. Assuming limit switches are used in the system, design the PLC diagram, and explain the operations.

[15 marks]

3. Design and schematic drawing of a ladder diagram for pumping system to transfer water from storage tank into a pressure tank is shown in **Figure Q3a**. The manual circuits shown in **Figure Q3b** turns on the pump only while the push button is pressed.

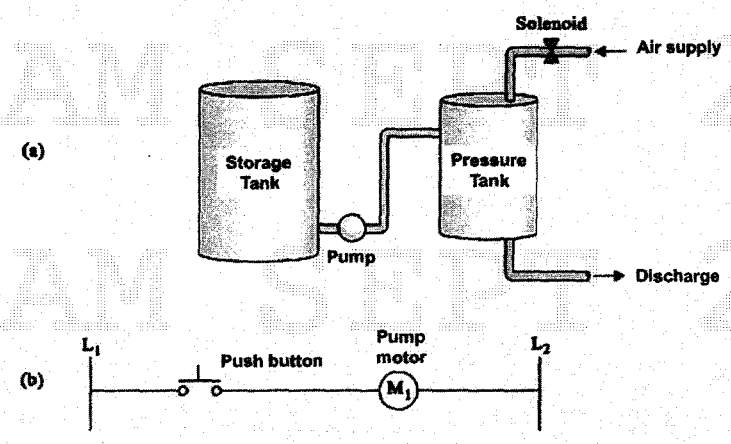


FIGURE Q3

With the aid of diagram produce and describe the ladder circuit that automates the water pumping system given the following conditions:

a. Pump to continue operate even the push button is released.

[6 marks]

b. Eliminate the needs for operator to manually stop the pump.

[8 marks]

c. The pump should start automatically when the water level become too low in pressure tank.

[8 marks]

d. A fail-safe measure to protect the pump from damages.

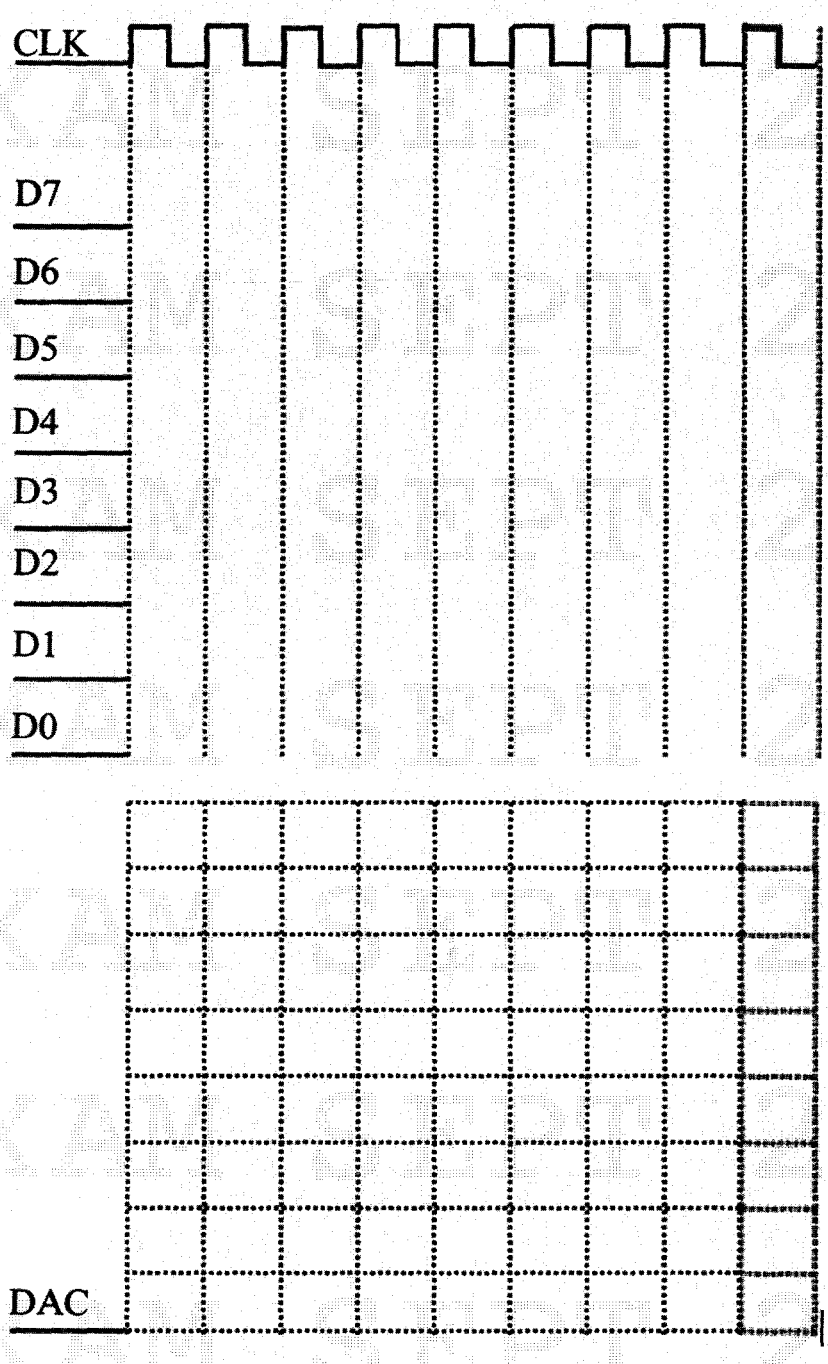
[8 marks]

- END OF PAPER -

APPENDIX - I

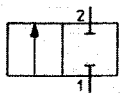
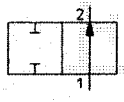
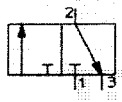
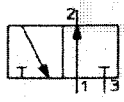
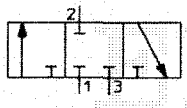
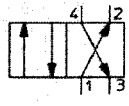
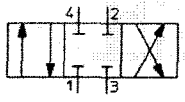
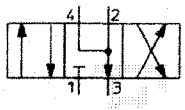
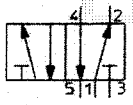
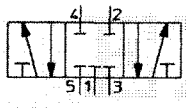
(To be submitted together with answer script)

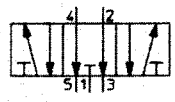
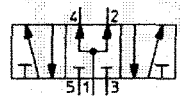
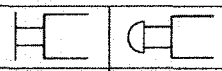
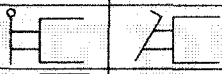
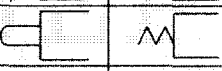
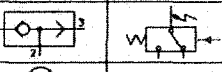
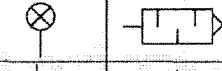
Question 1	Exam ID	Table No.
1		



APPENDIX - II

Pneumatic Symbols

Symbol	Description
	Directional control valve 2/2-way valve, closed normal position
	Directional control valve 2/2-way valve, open normal position
	Directional control valve 3/2-way valve, closed normal position
	Directional control valve 3/2-way valve, open normal position
	Directional control valve 3/3-way valve, closed neutral position
	Directional control valve 4/2-way valve
	Directional control valve 4/3-way valve, closed neutral position
	Directional control valve 4/3-way valve, exhaust neutral position
	Directional control valve 5/2-way valve
	Directional control valve 5/3-way valve, closed neutral position

Symbol	Description
	Directional control valve 5/3-way valve, exhaust neutral position
	Directional control valve 5/3-way valve, open neutral position
	Manual Control General / Manual Control Button
	Manual Control Lever / Manual Control Pedal
	Mechanical Control Plunger / Mechanical Control Spring
	Mechanical Control Roller / Mechanical Control Roller with idle return
	Solenoid with one effective winding / Solenoid with two windings acting in opposition
	Combined Control by solenoid and pilot valve / Pressure Control
	Shuttle valve / Pneumatic-Electric-Relay
	Pneumatic indicator / Silencer
	Pressure Control Valve Air operated / Mechanical Component Detent