



MINISTRY OF PORTS AND SHIPPING
MERCHANT SHIPPING SECRETARIAT - SRI LANKA
EXAMINATION FOR CERTIFICATE OF COMPETENCY
CHIEF ENGINEER OFFICER

AUTOMATION & CONTROLS

Time Allowed - Three Hours

Attempt SIX questions only as follows:

TWO (2) questions from Part A

TWO (2) questions from Part B

TWO (2) questions from Part C

Marks for each part questions are shown in brackets

All questions carry equal marks

Pass mark: 50%

Answers with clear sketches/diagrams, neat handwriting and clear expression will get full marks

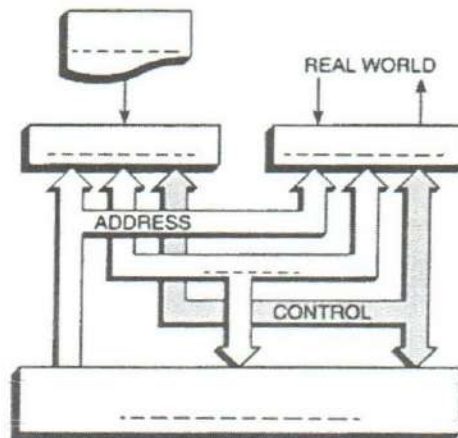
Part A

1. PID controllers require to be tuned to operate correctly, effectively, and efficiently.
 - a. What is the significance of the terms "Ultimate or Critical gain" and "Characteristic or critical period"? (02 Marks)
 - b. Explain the procedure of tuning a controller as mentioned above. (08 Marks)
 - c. State the method how values for the initial setting are computed. (04 Marks)
 - d. What is meant by the term "Damping Ratio"? (02 Marks)

2. With regards to the electronic control systems,
 - a. Explain the reason for using a feedback path in Operational amplifier circuits. (04 Marks)
 - b. Draw & explain the individual operation of following control systems,
 - i. Electronic Proportional Control (03 Marks)
 - ii. Electronic Integral Control (03 Marks)
 - iii. Electronic Derivative control (03 Marks)
 - c. Sketch & briefly describe voltage comparison circuit which consists of Zener diodes and an OP amp (03 Marks)

3. With regards to the PLC systems,

a) Identify the components in PLC architecture, as given by the following diagram (05 Marks)

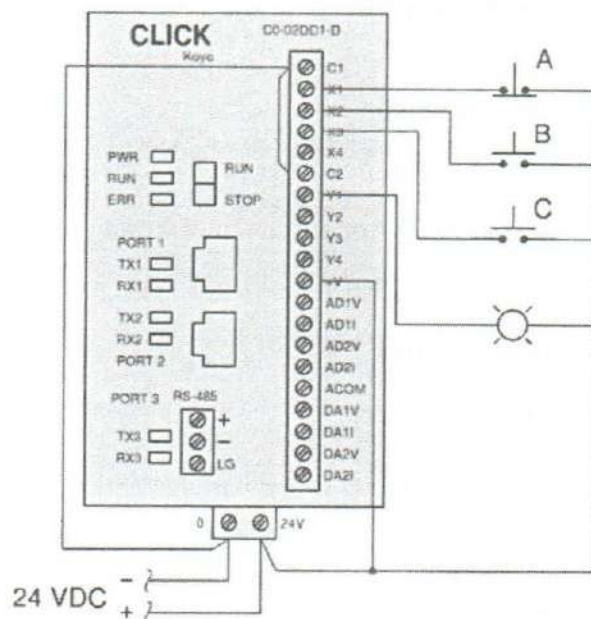


b) What do you mean by **SCADA** with related to multiple PLC applications? (04 Marks)

c) Comparing PLC systems with PC based systems, state three advantages of PC based systems over PLC systems. (03 Marks)

d) Sketch a Ladder Diagram program for this PLC to energize the lamp if the following input conditions are met: (04 Marks)

- Either switch A or switch C pressed
- Switch B unpressed



Part B

4.

- a. Sketch and describe a closed loop hydraulic system of a morning winch (08 Marks)
- b. Explain the temperature compensation arrangement of hydraulic fluid in above circuit drawn in Q4.a. (04 Marks)
- c. Briefly describe the operation of following component used in a hydraulic system and draw the symbolic representation of each component.
 - i. Flow control valve (02 Marks)
 - ii. Directional control valve (02 Marks)

5. On board a VLCC, a boiler water level, is sensed and transmitted to the controller using following pneumatic instruments.

- A DP cell
- Flapper and Nozzle with negative feed back
- Pilot valve amplifier or valve relay

- a. Sketch and describe the Level Transmitter using the above components. Indicate on your sketch the pressures commonly applied in pneumatic systems. (12 Marks)
- b. Explain what happens if the negative feedback is not used. (4 Marks)

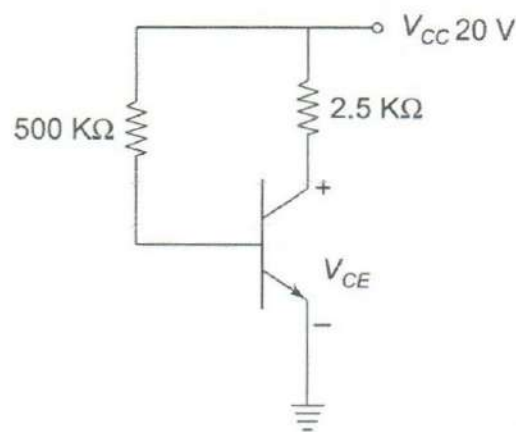
6. With regards to governors used on ships,

- a. State the requirements of governors used for a multi engine single propeller shaft arrangement. (04 Marks)
- b. State where in marine propulsion systems, "Iso Chronos governors" are used. (04 Marks)
- c. Explain how equal load sharing of KW & KVA between generators are established with governor droop and AVR droop. (04 Marks)
- d. What is meant by the "dead band" of a governor. (04 Marks)

Part C

7.

- a. Determine the operating point of a silicon transistor with base bias having parameters: $\beta = 100$; $R_B = 500 \text{ k}\Omega$; $R_C = 2.5 \text{ k}\Omega$ and $V_{CC} = 20 \text{ V}$. Show the load line and the operating point on the load line. (10 Marks)



- b. Draw and explain a Zener barrier used in hazardous area onboard a ship. (06 Marks)

8.

- a. What are the types of servo motors available in the marine industry? (04 marks)
- b. Describe the function of DC servo motor while discussing pulse width modulation used for positioning the rotor. (08 marks)
- c. How a two-phase AC servo motor is controlled for speed and direction (04 marks)

9.

- a. Draw and explain electronic force balance transmitter. (04 Marks)
- b. Sketch a basic diagram of 4- 20 mA current loop and briefly explain it. (04 Marks)
- c. What are the advantages and disadvantages of 4 to 20 mA Current loop control system? (04 Marks)
- d. Explain application of smart sensors and HART in modern control system. (04 Marks)



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PREPARATORY COURSE FOR CHIEF ENGINEER OFFICER ON SHIPS OF 3000KW PROPULSION POWER OR MORE

FINAL EXAMINATION QUESTION PAPER

Automation & Controls

- Answer **TWO** questions from **PART A**, **TWO** questions from **PART B** and **TWO** questions from **PART C**
- Time allocated: 03 Hrs
- Pass mark 50%
- Date: 2021.....

Part A

1.

- (i) Sketch and describe an Electrical Resistant type temperature measuring instrument suitable for a control system (06 Marks)
- (ii) Briefly explain **THREE** other instruments/methods available for measuring temperature (06 Marks)
- (iii) Explain the characteristics of a Thermistor (04 Marks)

2.

To transmit process parameter values as electrical signals, 4 - 20 mA current loop protocol is widely using in Automation and Control systems.

- (i) Explain with the aid of a sketch 4 -20 mA current loop in a control system (06 Marks)
- (ii) list the advantages and disadvantages of 4 -20 mA current loop (04 Marks)
- (iii) Briefly explain HART Protocol and state its advantage over conventional 4 -20 mA loop (06 Marks)

3.

With regards to the sensors and transducers,

- (i). Describe the functions of Transducer and Transmitter. (06 Marks)
- (ii). Describes the operation of the DP cell in boilers water level detection system. (06 Marks)
- (iii). In modern control systems, most of conventional pneumatic, hydraulic, and mechanical control lines are replaced by electrical lines using electrically controlled sensors, controllers, and actuators. Describe the advantages of using electrical control systems for marine applications. (04 Marks)

PART B

4.

- (i) Sketch and describe an Electro pneumatic controller in modern vessels. (08 marks)
- (ii) List the features and major parts in above controller. (04 Marks)
- (iii) What are the advantages when comparing to nozzle flapper type controller. (04 Marks)

5.

Main engine Lubricating oil temperature control system is not functioning properly. It is a pneumatic control system using PID controller. It is required to adjust the controller.

- (i) Before adjusting, what are the checks to be done in the system (04 Marks)
- (ii) Explain the method of adjusting the controller (12 Marks)

6.

The pressure in a system is sensed and transmitted to a controller using Bourdon tube, Flapper and nozzle arrangement with negative feedback and Amplifier

- (i). Sketch a system using the above-mentioned equipment and instruments of a pressure sending and transmitting system where the signal is sent to a remotely located controller. (10 Marks)
- (ii). Explain why an amplifier is required. (03 Marks)
- (iii). Explain why "negative feedback "is required. (03 Marks)

Part C

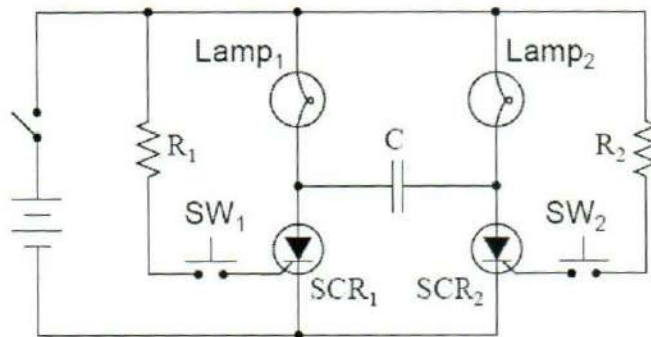
7. Identify the incorrect statement from the following. (16 Marks)
- a. Copper has high electrical conductivity, tensile strength, high ductility and corrosion resistance than aluminium.
 - b. In practice bare conductors, whether single or stranded together are called cables and conductors covered with insulation are termed as wires.
 - c. Parallel application of an inductor can be used to noise suppression in Triac control circuits.
 - d. Non-linearity of a sensor is the reciprocal of its linearity.
 - e. Aluminium conductors cost less than copper wiring, and weigh less, especially in the large sizes needed for heavy current loads.
 - f. A PLC has three modes, RUN, REMOTE and PROGRAM for different phases of its use.
 - g. A physical scenario first analyzed in to a relay ladder logic, then actual flow diagram and finally to PLC Ladder logic.

8.

2.1. Explain the following.

- a. The placement of DIAC in series with the gate of Triac to trigger. (04 Marks)
- b. Use of 4-wire resistance approach to measure the response of a RTD. (04 Marks)

2.2. The following circuit exhibits a very interesting behavior. It simply works similar as dipole switch. (The switches SW1 & SW2 can energize its lamp and de-energize other lamp). Explain how this behavior occurs, identifying the role of capacitor. (08 Marks)

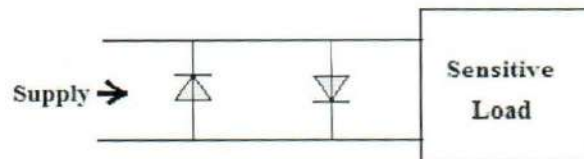


9.

9.1.

- a. Identify the two important factors, choosing a diode for rectifier circuit? (02 Marks)
- b. What is an Ideal Diode? Draw its V-I characteristics and identify the regions analogous to Switch. (02 Marks)

9.2. Roughly sketch a SCR Crowbar application using a SCR, Zener Diode and any suitable passive elements. Add modification to your model for noise cancelation. What is the advantage of above model over following simple surge protector? (04 Marks)



9.3.

- a. What are the three types of BUS topologies used in PLCs. (01 Marks)
- b. What makes a PLC Different from an Microcontroller (01 Marks)
- c. Describe three main advantages of PLCs over traditional Hard-Wired Panels. (01 Marks)
- d. What does mean by a SCAN in a PLC system. (01 Marks)

9.4 Describe how CFL lamps can be used with DC supply and its main disadvantage over the time. (04 Marks)



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- Time allocated: 03 Hrs
- Pass mark 50%
- Date: 2020.02.13

Part A

1.

To transmit process parameter values as electrical signals, 4 - 20 mA current loop protocol is widely using in Automation and Control systems.

- (i) Explain with the aid of a sketch 4 -20 mA current loop in a control system (06 Marks)
- (ii) list the advantages and disadvantages of 4 -20 mA current loop (04 Marks)
- (iii) Briefly explain HART Protocol and state its advantage over conventional 4 -20 mA loop (06 Marks)

2.

- (i) Briefly explain the principle of operation of strain gauge (06 Marks)
- (ii) Sketch and describe a shaft torque measurement device. (10 Marks)

3.

For the dynamic operation of a control system, sometimes positioners utilized to operate pneumatic diaphragm control valves.

- (i). Explain the reasons for requirement of a positioner (06 Marks)
- (ii). Briefly explain FAIL SAFE arrangements in a diaphragm controlled pneumatic valve (06 Marks)
- (iii) Sketch and describe an Electro-pneumatic positioner (04 Marks)

PART B

4.

With reference to adjusting pneumatic PID controllers,

(i) Explain four major characteristics which affect system dynamics (08 Marks)

(ii) Explain the checks to be done in the system before any adjustment made to the controller (08 Marks)

5.

(i) Define Electrical Servomotor (04 Marks)

(ii) Explain two methods available to transmit the feedback from servomotor (06 Marks)

(iii) Briefly explain the characteristics of two phase A.C. servomotor (06 Marks)

6.

To control two or more final controlling elements. Split range control systems are used on ships

(i). State two applications of split range control can be utilized on a ship. (04 Marks)

(ii). Describe "dead band" on slit control system. (04 Marks)

(iii) Sketch and describe a split control system could be use in one application of part(a). (08 Marks)

Part C

7.

a. What is the difference between wire and a cable? (04 Marks)

b. What is meant by voltage grading of the cables? (04 Marks)

c. Explain the Function of a fuse and what kind of protection offered by a fuse? (04 Marks)

d. Distinguish the Protective Earth (PE) and Functional Earth. (04 Marks)

8. Explain the following cases.

a. Diac cannot be used to make 'controlled dimmer' for an incandescent lamp. (04 Marks)

b. Some SCRs indicate continuity in both directions between the two terminals, "gate" and "cathode". (04 Marks)

c. A series Diac is applied with gate terminal, in Triac AC dimmer circuits. (04 Marks)

d. The reverse blocking capacity of a GTO is small due to the presence of anode shorts. (04 Marks)

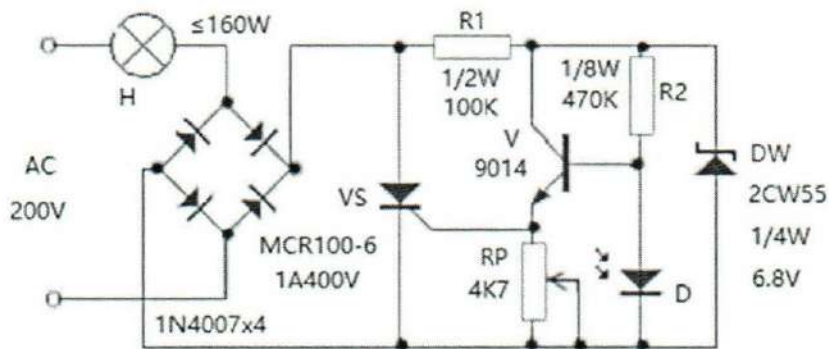
9.

9.1.

- a. Describe Stroboscopic effect and Danger of using single white light with a single phase alternating supply. (05 Marks)
- b. Explain the Working Principle of CFL lamp. (05 Marks)

9.2.

Following is light controlled electronic Switch. Explain how the circuit works analyzing the duty of elements (as pairs or sets).



(6 Marks)



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- Pass mark 50%
- Date: 2021.....

Part A

1.

- (i) Sketch and describe a measuring instrument for pressure, suitable for an automatic control system (06 Marks)
- (ii) Briefly explain **THREE** instruments/methods available for measuring Temperature (06 Marks)
- (iii) Explain the characteristics and various applications of strain gauge. (04 Marks)

2.

- (i) State the purpose of a transducer in a control system. (4 Marks)
- (ii) With reference to Variable Inductance Transducer, sketch and describe a Linear Variable Differential Transformer (LVDT) (10 Marks)
- (iii) State one application of Variable Inductance transducer (02 marks)

3.

- (i) Sketch and Describe the operation of a valve positioner. (08 Marks)
- (ii) State 3 reasons as to why a valve positioner should be fitted to a final controlling element. (04 Marks)
- (iii) What is "fail set"? (02 Marks)
- (iv) What is "fail safe"? (02 Marks)

Part B

4.

- (i) Sketch and describe an Electro pneumatic controller in modern vessels. (08 marks)
- (ii) List the features and major parts in above controller. (04 Marks)
- (iii) What are the advantages when comparing to nozzle flapper type controller. (04 Marks)

5.

For efficient and complete combustion, Fuel oil must be heated before it is burnt. For correct atomization in the cylinder, the fuel must be at the correct viscosity.

- (i) Sketch and describe a Viscosity Control System to maintain the viscosity of Fuel oil (06 Marks)
- (ii) Explain an Electronic Viscosity measuring instrument (06 marks)
- (iii) State the advantages of Electronic Viscosity measuring over the Mechanically Driven Capillary Tube Viscotherm. (04 Marks)

6.

A cascade control system can be utilized for controlling of various conditions on board a ship.

- (i) State two situations where these systems can be used. (02 Marks)
- (ii) State the advantages of this kind of system. (02 Marks)
- (iii) Sketch and Describe a two-element cascade control system for boiler water level control (12 Marks)

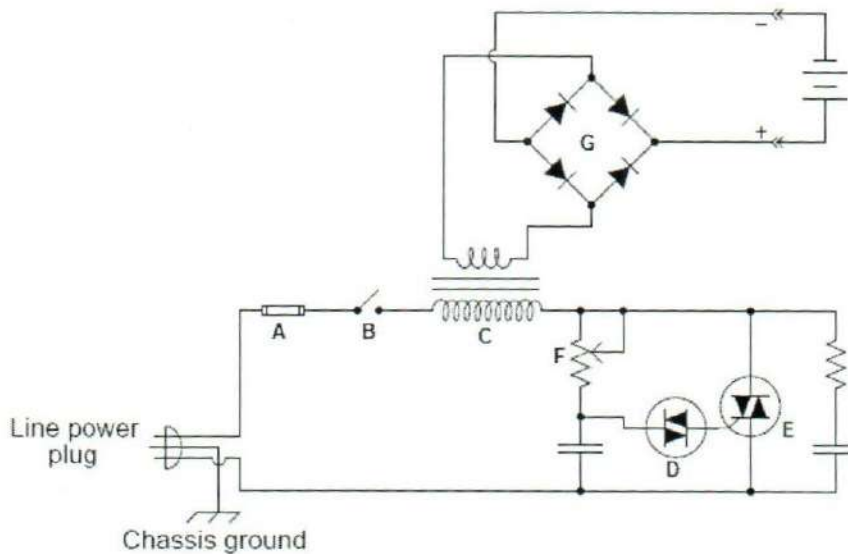
Part C

7.

7.1. Identify the correct Statements from the followings.

- a. Diac cannot be used to make 'controlled dimmer' for an incandescent lamp.
- b. Some SCRs indicate continuity in both directions between the two terminals, "gate" and "cathode".
- c. Both GTO and SCR are minority carrier devices and have four layers and three terminals.
- d. All semiconductors are Active electronic elements.
- e. A SCR may be turned on due to light, thermal and kinetic effects.
- f. None of the two terminals of an SCR will show the continuity.
- g. IGBT switching is faster than SCRs.

7.2. Following is a controlled rectifier. Whats the main difference of this circuit to SCR controlled rectifier with pulse transformers ?



(16 Marks)

8.

8.1. In a Distribution board briefly describe the advantage of each component or link.

- Isolator
- RCD
- MCB
- Earth Link

8.2. Out of ELCB and RCCB which is better to use in wiring? Motivate your answer with diagrams.

8.3. A RCCB is mentioned with 40A/ 32 mA. Explain these two pairs of value with relevant information of "let go current" across human body.

8.4. What are the types of Marine Cables with respect their usage?

8.5. What Does mean by Deep Cycling a battery. Why it is not recommending to deep -cycle Li-Po Battery.

(16 Marks)

9.

9.1. Identify the correct statements from following.

- a. In BJTs output current is current is function of current signal in to base.
- b. BJT is a High voltage High current device.
- c. In thyristors output latches on when triggered by pulse signal at the base.
- d. MOSFET is High Current Low Voltage Device.
- e. IGBT is a High Current High Voltage Device.
- f. BJTs have moderate switching speeds while IGBTs have low switching speeds.

9.2. The following is a simple Power Failure Self-locking Switch. Explain how this circuit works describing the duty of each element (or as pairs / sets).

(16 Marks)

