Principal Learning

Engineering

Unit **F559:** Instrumentation and Control Engineering

OCR Level 3 Principal Learning

Mark Scheme for June 2014

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

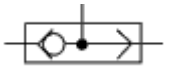
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.

[The following questions should be annotated with ticks to show where marks have been awarded in the body of the text: (QM to add)**]**

Please send a brief report on the performance of candidates to your Team Leader (Supervisor) by the end of the marking period. The Assistant Examiner's Report Form (AERF) can be found on the RM Cambridge Assessment Support Portal.

Your report should contain notes on particular strength displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

Question			Expected Answer	Mark	Rationale/Additional Guidance
1	(a)		**State which letter is identifying the input.** A	[1]	
	(b)		**State which letter is identifying the output.** C	[1]	
	(c)		**State which block is feedback.** D	[1]	
2			**State the formula for overall gain in a system using negative feedback.** Overall gain G = A/(1+ βA).	[1]	
3			**Explain what is meant by the term 'closed loop control' as compared to 'open loop control'.** Closed loop control has three blocks in series comprising of input control/process - output and a feedback system. Open loop control does not have feedback.	[1] [1]	
4			**Name an input and output signal for the following signal conditioners:** **(a) Strain gauge** Input/Output – Change of resistance/Potential Difference (**b) Potential divider circuit using a potentiometer** Input/Output – Rotation/e.m.f. or change in voltage	[2] [2]	

Question			Expected Answer	Mark	Rationale/Additional Guidance
5			**State three benefits of using electronic instruments to take measurements.** Accurate measurements Reliable measurements Can record measurements Sensors can record measurements in hazardous circumstances Storage of results	**[3]**	Award one mark for each correct benefit Accept other correct responses
6			**Name an input transducer and the state which it reacts to.** Light Dependent Resistor/Light Intensity Thermistor/Temperature Microphone/Sound Bimetalic strip/Temperature	**[2]**	Award one mark for an input transducer and one mark for a state Accept other correct responses
7			**Draw, in the space provided the symbol for a shuttle valve.** 	**[1]**	Accept minor differences
8			**A pneumatic cylinder has a piston of cross-sectional area 0.02 m^2. Calculate the working pressure applied to the cylinder when the force exerted by the out-stroking piston is 40 kN.** Pressure = force/cross-sectional area = 40/0.02 = 2000 kN m^{-2}	**[1]** **[1]** **[1]**	Award three marks for correct answer with or without working Accept as correct 2000 with or without the unit
				[1]	

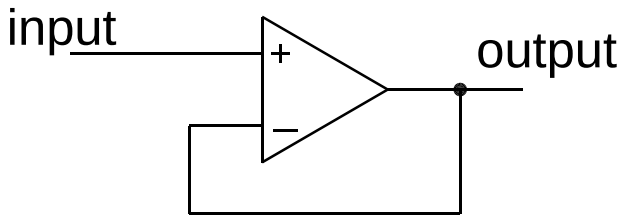
Question			Expected Answer	Mark	Rationale/Additional Guidance
9			**State the type of signal processing element used to select one from of a number of analogue signals for further processing.** Multiplexer		
			Section A Total	**[20]**	

SECTION B

Question			Expected Answer	Mark	Rationale/Additional Guidance
1	(a)		**State two practical applications of a Thermistor.** Temperature control sensor Resistance thermometer Digital thermostat Meter compensation Fire alarm Commercial freezer.	**[2]**	Accept any two correct applications Accept other correct responses
1	(b)	(i)	**Determine the thermistor resistance for a temperature of 0 ^{o}C.** 32 kΩ	**[1]**	Accept answers between 30 and 34 kΩ with or without units
		(ii)	**Determine temperature when the thermistor resistance is 10 kΩ** 25 ^{o}C	**[1]**	Accept answers between 23 and 27 ^{o}C with or without units
1	(c)		**Describe in detail, how the circuit operates.** During warm or hot conditions the resistance of the thermistor will drop. By design the value of resistor R will be high. Current will flow through resistor R_b into the base of the first transistor, through the emitter into the base of transistor two, out of the emitter and to the negative of the battery. The current has been amplified, so if it is large enough the signal lamp will light.	**[6]**	Award one mark for each point made up to a maximum of six Description must include reference to: • Thermistor • Potential divider • Resistor R_b • Transistor T1 • Transistor T2 • Signal lamp Output.
				[10]	

Question			Expected Answer	Mark	Rationale/Additional Guidance
2	(a)		**Give two practical applications of a pneumatic system.** Operating a micro-switch Opening a valve Removing components from a conveyor belt Opening a vehicle sliding door Down a mine i.e. avoidance of explosion risk.	**[2]**	Award one mark for each correct application Accept other correct responses
2	(b)		**Give two other methods of operating a 3-port valve.** Manual control: Lever/foot pedal Mechanical control: spring/roller/plunger Electrical: solenoid Control by application or release of pressure i.e. pilot actuation	**[2]**	Award one mark for each correct method Accept other correct responses
2	(c)		**Explain the operation of the pneumatic circuit shown in Fig. 4.** The 3-port valve A is operated by a foot pedal. The SAC 1 is controlled by the 3-port valve A. When the foot pedal is pressed compressed air flows through the valve into the SAC 1. The piston rod moves out going positive or outstroke. The guard moves into position. When the foot pedal is released the force of the spring in SAC 1 returns the piston and moves the guard – goes positive or in-stroke.	**[6]**	Award one mark for each point made up to a maximum of six Explanation must include reference to: • SA cylinder • DA cylinder • 3-port valves • 5-port valves • Flow control valve • Guard.
			Total	**[10]**	

3	(a)		**Name one component that can provide a feedback signal in a control system.** Pressure senor/transducer: Resistive, strain gauge, inductive, capacitive, semiconductor, ceramic, piezoelectric and linear variable differential transformer Level sensor/transducer: Conductivity, capacitive, ultrasonic, radar, nucleonic, load cells, radiometric, microwave, hydrostatic and sonar Flow sensor/transducer: Ultrasonic, coriolis, vortex, magnetic and differential pressure Temperature sensor/transducer: Thermistor, resistance, thermocouple, radiation pyrometer Displacement sensor/transducer: Diffraction grating, lasers and variable resistance signal conditioning Other sensors are encoders, tachometers, accelerometers , comparators and rate gyroscopes	**[1]**	Award one mark for a correct name Accept other correct responses
3	(b)		**In a negative feedback amplifier the gain is 600. Calculate the overall gain when the feedback fraction 1/200.** Overall gain = A/(1 + βA) = 600/(1 + [1/200] x600) = 600/(1 + 3) = 600/4 = 150	**[1]** **[1]** **[1]**	Award three marks for correct answer with or without working

	(c)	(i)	**Draw a circuit diagram of an operational amplifier being use as a buffer amplifier.**  	**[1]** **[1]** **[1]** **[1]**	Award two marks for a correct op amp Award one mark for feedback line Award one mark for feedback connecting to inverting input .
		(ii)	**Draw an input and output signal for a buffer amplifier.**   	**[1]** **[1]**	
			Total	**[10]**	

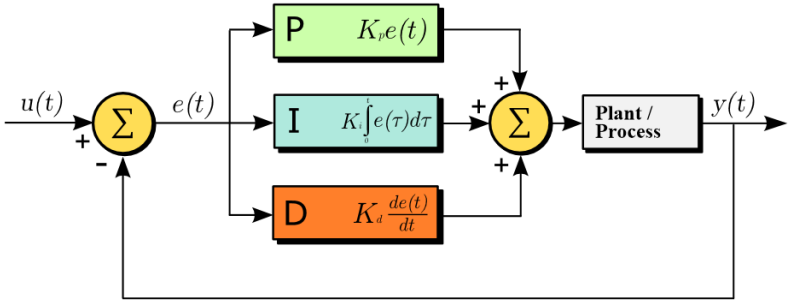
Question			Expected Answer	Mark	Rationale/Additional Guidance
4	(a)		**Explain why it is necessary to have a control system monitored.** The purpose of monitoring a control system is: to check that the system is functioning correctly and records irregularities and fault location.	 **[1]** **[1]**	Allow marks for understanding shown
4	(b)		**Give two practical applications of a monitored control system.** Monitoring, recording and logging of plant status and process parameters. Provision of operator information regarding the plant status and process parameters. Provision of operator controls to affect changes to the plant status. Automatic process control and batch/sequence control during start-up, normal operation, shutdown, and disturbance. i.e. control within normal operating limits. Detection of onset of hazard and automatic hazard termination. Prevention of automatic or manual control actions which might initiate a hazard.	 **[2]**	Accept any two correct applications Accept other correct responses

Question			Expected Answer	Mark	Rationale/Additional Guidance
4	(c)		**The following are examples of characteristics of embedded systems within monitoring equipment: Reliability Maintainability Availability Security Dedicated** **Choose three of these examples and explain in detail, what is meant by each term.** Reliability **-** the probability that the system will operate to an agreed level of performance, for a specified period, subject to specified environmental conditions. Maintainability - the probability of system working correctly, effectively and efficiently over a period of time after an error has occurred and been corrected. Availability - the probability of a system working at all times without any form of disruption. Security – the system must provide confidential and authentic communication because even perfectly designed systems can fail if the assumptions concerning the workload and possible errors turn out to be wrong. Dedicated – a system that is given entirely towards a certain application which includes details of design that can be used to minimize resources and maximize robustness.	**3 x [2]**	Allow marks for understanding shown Accept any three examples of characteristics Accept other correct responses
			Total	**[10]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
5	(a)		**Give two transducers that could be used for measuring light level in this system.** Light dependent resistor (LDR)/photo resistor/photodiode/ phototransistor/photoelectric cell/photoconductive cell.	**[2]**	Accept any two correct transducers Accept other correct responses
5	(b)		**Explain the difference between analogue and digital signals.** Analogue signals are electrical representations of physical quantities which vary continuously over a range of values. The information they carry is in the amplitude and shape of their waveforms. Digital signals have two states. Their outputs and inputs involve only two levels of voltage, referred to as high or low. High is near the supply voltage and low is near 0 volts. In logic, high is 1 and low is 0.	**[1]** **[1]**	
5	(c)	(i)	**Explain the reason for having the (PLC) Programmable Logic Controller shown in Fig. 6.** The PLC is an interface between the sensor and the computer. The interface is a tool and concept that refers to a point of interaction between components, and is applicable at the level of both hardware and software. This allows a component, to function independently while using interfaces to communicate with other components via	**[1]** **[1]** **[1]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
		(ii)	an input/output system and an associated protocol. In addition to hardware and software interfaces, a computing interface may refer to the means of communication between the computer and the user by means of peripheral devices such as a monitor or a keyboard, an interface with the Internet via Internet Protocol, and any other point of communication involving a computer. **Explain the function of the computer in this system.** The main and basic function of the computer in this system is to write and modify programmes to the PLC. In addition data can be saved and stored in the computer's ROM.	**[1]** **[1]** **[1]**	Allow marks for understanding the function of a computer
			Total	**[10]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
6	(a)		**Give one benefit of using a PID (proportional-integral-derivative) mode control system as compared to any other type of control system.** The classical PID controllers are versatile and robust Greater number of options given to designer Integral controller gives zero Steady State Error for a step input A derivative control terms often produces faster response Dynamics of the system are easily changed PID control allows for much better adjustments to be made in the system If process conditions change, re-tuning the controller usually produces satisfactory response	**[1]**	Allow marks for understanding shown
6	(b)		**Give three industrial applications of a PID controller.** Temperature control Tension control in a belt system Humidity control Pressure control pH control Regulation of speed.	**[3]**	Accept any three correct applications Accept other correct responses

Question			Expected Answer	Mark	Rationale/Additional Guidance
6	(c)		**Describe, with the aid of a labelled diagram, the operation of a PID controller.**	[2]	
					Award one mark for the blocks and lines Award one mark for filling in the blocks
			The PID produces a control action which is composed of three modes: one which is proportional to the error one which is proportional to the integral of the error one which is proportional to the rate at which the error is changing.	[4]	
			A PID controller is a generic control loop feedback mechanism. A PID controller calculates an "error" value as the difference between a measured process variable and a desired set-point. The controller attempts to minimize the error by adjusting the process control inputs.		Award one mark for each point made up to a maximum of four
			The PID controller calculation (algorithm) involves three separate constant parameters.: the proportional, the integral and derivative values, denoted P, I, and D. The PID values can be interpreted in terms of time: Proportional P depends on the present error I on the accumulation of past errors		Description must include reference to: • Proportional block • Integral block • Derivative block • Overall operation of controller

Question			Expected Answer	Mark	Rationale/Additional Guidance
			D is a prediction of future errors, based on current rate of change. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, or the power supplied to a heating element. By tuning the three parameters in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set-point and the degree of system oscillation. Note that the use of the PID algorithm for control does not guarantee optimal control of the system or system stability. .		
			Total	**[10]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
7	(a)		**Explain what is meant by the term 'signal' in the context of a liquid level indicator.** The signal ie. change in liquid level, conveys orders or information to another part of a system, to remedy this situation.	**[2]**	Allow marks for understanding shown Accept signal meaning the result of varying the resistance
7	(b)		**Give two ways, other than the system shown in Fig. 7, in which the level of liquid in a tank can be measured using electronic instrumentation.** Float switch with optoelectronic liquid level switch Level sensor with reed switch chain technology Optoelectronic liquid level limit switch Pressure operated switch Loop powered level indicator Ultrasonic indicator Load cell Capacitance/resistance change system.	**[2]**	Accept any two correct methods Accept other correct responses .
7	(c)		**Explain how mechanical movement is converted into an electrical signal that can be measured.** When the level of the liquid goes down: the float moves the pointer moves i.e. mechanical movement, on the potentiometer which decreases the resistance in the circuit the supply voltage remains the same Using I = V/R The current rises which is recorded on the ammeter i.e. electrical signal Liquid is added to the tank to restore its original level	**[6]**	Award one mark for each correct point made up to a maximum of six Explanation must include reference to: • Original/Final level of liquid • Float • Potentiometer • Change in resistance • Electric current • Ammeter
			Total	**[10]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
8	(a)		**State two other benefits of using simulation software.** Computerised simulation software can be used to test circuits without the need to physically build them. The computer simulation can be saved. Physical components are not required, so money isn't wasted on expensive parts. Can speed up production processes. The circuit can be edited, which makes it easier and cheaper to modify your design as you go along.	**[2]**	Accept any two correct benefits Accept other correct responses Accept benefits originating from specific types of software
8	(b)		**Name two instruments other than a virtual ammeter and virtual voltmeter that can be used in a simulated test.** Logic probe Digital Multi-meter Digital Signal Generator Function Generator Signal Analyser Logic Analyser CRO	**[2]**	Award one mark for each correctly named instrument Accept other correct responses

Question			Expected Answer	Mark	Rationale/Additional Guidance
8	(c)		**Explain how a virtual ammeter and a virtual voltmeter can be used to test simulated electronic circuits.** The point of a simulation is to study a circuit before building it. Construct your simulated circuit diagram. Place the simulated voltmeter across the component that you need a voltage measurement from. Check that the voltmeter is in parallel with your chosen component. Place the simulated ammeter between components that you need to take a measurement from. Check that the ammeter is connected in series within the circuit. Before switching on, check that both instruments are set to a suitable scale. Switch on and take the readings. Analyse the information. Make any changes to the circuit that are necessary to achieve your objectives	**[6]**	Award one mark for each correct point made up to a maximum of six Explanation must include reference to: • Purpose of virtual ammeter • Ammeter must be connected in series • Purpose of voltmeter • Voltmeter must be connected in parallel • Suitable scales for both instruments have been selected • Test principles
			Total	**[10]**	

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