

Engineering

OCR Level 3 Principal Learning in Engineering **F559**

Unit **F559**: Instrumentation and Control Engineering

Mark Scheme for January 2013

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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.

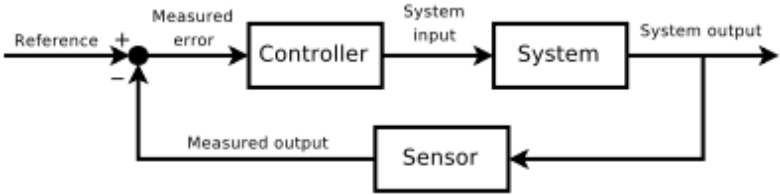
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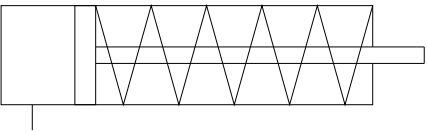
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Annotations

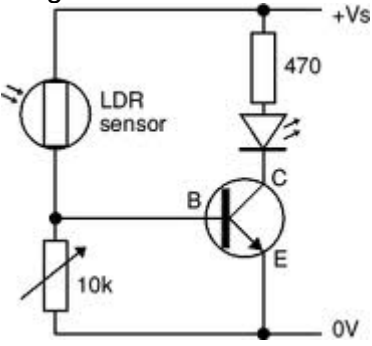
| Annotation | Meaning |
|-------------------|------------------------------------|
| Bod | Benefit of doubt |
| Ecf | Error carried forward |
| X | Incorrect |
| / | Correct |
| V | Vague – little understanding shown |
| S | Seen |

Section A

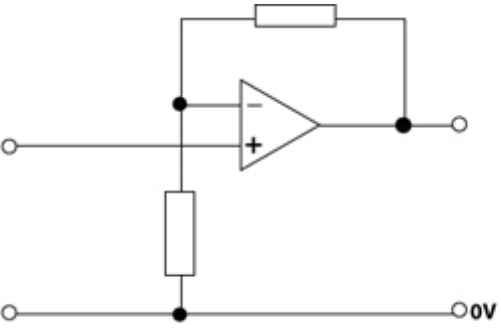
| Question | Answer | Marks | Guidance |
|----------|--|--------|---|
| 1 | <p>An example is shown.</p>  | 4 | <p>Accept any correct block diagram showing an input, control, output, and feedback.</p> <p>Award one mark for each correctly labelled block. Maximum 3 marks if no flow arrows</p> |
| 2 | Overall gain $G = A/(1 - \beta A)$. | 1 | |
| 3 | Open loop control is a linear system without any form of feedback. | 1 1 | |
| 4 | Bourdon tube Bellows gauge Diaphragm gauge. | 2 | Award one mark for each correct sensor. |
| 5 | The term actuator is used for the element of a correction unit that provides the power to carry out the control action. | 1 1 | Accept a response containing movement eg solenoid. |
| 6 | Infinite voltage gain Infinite input impedance Infinite bandwidth Zero output impedance Zero output when the differential inputs are identical | 3 | Award one mark for each correct characteristic. |

| Question | | Answer | Marks | Guidance |
|--------------|-----|--|-----------|---|
| 7 | |  | 2 | Award one mark for a correct piston and vent. Award one mark for a correct spring. |
| 8 | | <p>Electric doors Steam flow valve Factory production line electric traction units Computer disc drives Music and game systems Vehicle fuel injector control Zone valves in a control heating system</p> | 2 | Accept one mark for each correct response. Accept other correct responses. |
| 9 | (a) | Analogue to Digital Converter | 1 | |
| | (b) | Multiplexer | 1 | |
| Total | | | 20 | |

Section B

| Question | Answer | Marks | Guidance |
|--------------|--|-----------|--|
| 1 (a) | Smoke detector Automatic lighting eg Street lighting Counting Alarm systems | 2 | Accept any two correct applications. Accept other correct responses. |
| (b) | Resistance changes Resistance decreases | 2 | |
| (c) | <p>A typical circuit diagram is shown.</p>  | 6 | <p>Accept any other correct diagrams and descriptions.</p> <p>Award two marks for a labelled circuit diagram. Award up to four marks for a detailed description</p> <p>Description must include reference to:</p> <ul style="list-style-type: none"> • Potential divider • LDR • Amplifying system • Output. |
| Total | | 10 | |

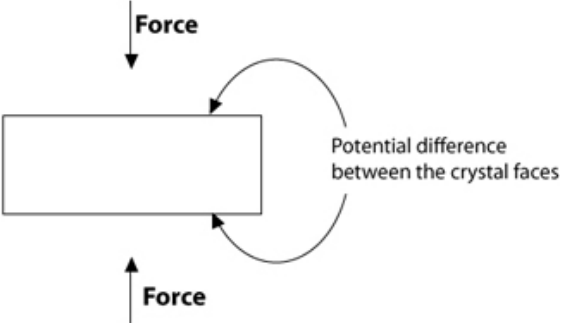
| Question | | Answer | Marks | Guidance |
|--------------|-----|---|-----------|--|
| 2 | (a) | A – Three port valve B – Double acting cylinder | 2 | |
| | (b) | Operating a micro-switch Opening a valve Removing components from a conveyor belt Opening a vehicle sliding door Vehicle suspension / brakes Down a mine ie avoidance of explosion risk Automatic vice on a production line Robotic handling unit | 2 | Award one mark for each correct application. |
| | (c) | The control valve is a double air operated five port valve. The two pilot valves are the three port valves which signal the DAO five port valve. Main point – the air which actually goes to the cylinder is separate from the air signals which move the spool. The spool which switches the connections is moved by air pressure. This has the advantage that the two three port valves can operate at different pressures. If the five port valve receives air signals at both ends at the same time, the spool will not move, provided the signals are of equal pressure. Therefore the connections to the cylinder will not change. | 6 | Description must include reference to: <ul style="list-style-type: none"> • a control valve – double air operated five port valve • the left hand three port valve • the right hand three port valve • a double acting cylinder. |
| Total | | | 10 | |

| Question | | Answer | Marks | Guidance |
|--------------|---------|--|-------------|--|
| 3 | (a) | Feedback is information being fed back from the output of a system to modify the input to the system | 1 1 | |
| | (b) |  | 2 | Operational amplifier – 1 mark. Position of feedback resistor – 1 mark. |
| | (c) (i) | 1/200 Overall gain = $A/(1 - \beta A)$ $= 100/(1 - 0.005 \times 100)$ $= 100/0.5$ $= 200$ | 1 1 1 | Award three marks for correct answer with or without working. |
| | (ii) | -1/200. Overall gain = $A/(1 - \beta A)$ $= 100/(1 - \{-0.005 \times 100\})$ $= 100/1.5$ $= 66.7$ | 1 1 1 | Award three marks for correct answer with or without working. Accept answers between 66 and 67. |
| Total | | | 10 | |

| Question | | Answer | Marks | Guidance |
|--------------|-----|---|-----------|--|
| 4 | (a) | The purpose of a monitoring system is to check that the system is functioning correctly and that no illegal activity is taking place | 1 1 | Allow marks for understanding shown. |
| | (b) | 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. ie 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. Railway automated crossings | 2 | Accept any two correct applications. Accept other correct responses. |
| | (c) | Detector – a motion sensor that detects illegal movement Panic button – pressed when persons or systems are under threat Remote keypad – for an operator to input information into the system without being on site Bell Box – rings to alert personnel to illegal activity Speaker/microphone – to communicate with persons on site Frequency Filter – the process of removing a certain band of frequencies and permitting others to be transmitted Central alarm-management unit – computer system that combines and co-ordinates all monitoring activities | 3 x 2 | Award two marks for each correct explanation For each explanation award one mark for each correct point make up to a maximum of two marks |
| Total | | | 10 | |

| Question | | Answer | Marks | Guidance |
|----------|-----|---|---------------------|---|
| 5 | (a) | Signal conditioning is used for the elements in a measurement system which convert the signal from a sensing element into a form suitable for the display unit OR Making a signal clearer and eliminating unwanted 'noise' and spurious fluctuations | 1 1 | Allow marks for understanding shown. |
| | (b) | The feedback path is used to take information from the output to modify the input into the system. | 2 | Award one mark for reference to output and one mark for reference to input. |
| | (c) | Selector (control input) – selects the desired state of the output. Usually it is a variable resistor. Control Circuit – compares the desired state (control input) with the actual state (sensor) of the controlled quantity and sends an appropriate signal to the output transducer. Output Transducer – converts the electrical signal to the controlled quantity. | 2 2 2 | Award two marks for each correct explanation For each correct explanation award one mark for each point made up to a maximum of two marks. |
| | | Total | 10 | |

| Question | | Answer | Marks | Guidance |
|--------------|-----|---|-----------|--|
| 6 | (a) | 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 | 2 | Allow marks for understanding shown. |
| | (b) | Temperature control Tension control in a belt system Humidity control Pressure control pH control Regulation of speed ie. Cruise control | 2 | Accept any two correct responses. Accept other correct responses. |
| | (c) | Relatively simple to use High performance with low maintenance costs Higher product quality at reduced costs Faster than previous controllers Easy to tune Production methods are more stable eg glass production More efficient Reduced time for product changes – minimised production losses Energy saving | 6 | Award one mark per impact. Accept other correct responses. |
| Total | | | 10 | |

| Question | Answer | Marks | Guidance |
|----------|---|------------|--|
| 7 (a) | <p>Data is represented as an <u>electromagnetic signal</u>, such as an <u>electrical voltage</u>, <u>radio-wave</u>, <u>microwave</u>, or <u>infrared</u> signal. Data signal transmission is the physical transfer of <u>data</u> (a <u>digital bit stream</u>) over a point-to-point or <u>point-to-multipoint communication</u> channel.</p> <p>Examples of such channels are <u>copper wires</u>, <u>optical fibres</u>, <u>wireless communication channels</u>, and <u>storage media</u>.</p> | 1 1 | Allow marks for understanding shown. |
| (b) | <p>Metal wire resistance thermometer/Thermistor/Strain Gauge Potentiometer/Photoconductive cell/Capacitive pressure gauge/Variable dielectric sensing element/Variable reluctance transducer/Thermocouple/Hall effect sensor/Photodiode</p> | 2 | <p>Accept any two correct responses. Accept other correct responses.</p> |
| (c) | <div style="text-align: center;">  <p>Potential difference between the crystal faces</p> </div> <p>When a crystal made up of ions is put under pressure the ions in the crystal are displaced from their normal positions. This results in a potential difference appearing across the crystal. This affect is called piezo-electricity. The input for a piezo-electric ultrasonic detector is force /pressure which squashes the crystal giving an output of potential difference</p> | 6 | <p>Accept any other correct labelled diagram</p> <p>Award one mark for a diagram and award a further mark for the labels. Description award one mark for each point made up to a maximum of four marks</p> |
| | Total | 10 | |

| Question | | Answer | Marks | Guidance | |
|--------------|-----|---|--|--------------------------------------|---|
| 8 | (a) | Simulation means to have the appearance or look like the real thing Simulated circuits are produced by computer programmers and can be observed virtually and tested on screen. | 1 1 | Allow marks for understanding shown. | |
| | (b) | 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. |
| | (c) | (i) | 1 Move lead V to A 2 Rotate switch knob from V to A 3 Remove the connection from one side of the motor and connect the multi-meter in series | 1 1 1 | |
| | | (ii) | The changes are necessary because the existing connections will measure potential difference (voltage). When the lead is connected to position A it will measure current. When the switch knob is in position A the digital readout will be in amperes. The connecting lead is removed from one side of the motor because the multi-meter must be connected in series to read a current value ie the probes are placed in series with the motor. | 1 1 1 | |
| Total | | | 10 | | |

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