

Engineering

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

Unit **F559**: Instrumentation and Control Engineering

Mark Scheme for January 2012

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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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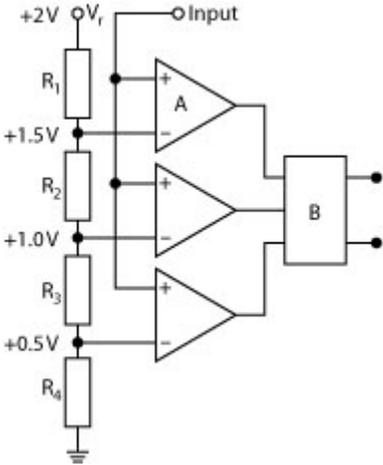
SECTION A

Question		Answer	Marks	Guidance
1		Input → control → Output →	5	Arrows (1 Mark) Boxes (1 Mark) Labels in correct order (3 Marks)
2		Central heating unit Temperature control Positional control Servo control	2	Award one mark for each valid response
3		Overall gain $G = A/(1 + \beta A)$.	1	
4		Waveguides are considerably less complicated than a two conductor cable in their manufacture and maintenance Moisture is not a severe problem as it would be with coaxial cables Does not need gas filling There are no concerns with conductor-to-conductor spacing, or of the consistency of the dielectric material, since the only dielectric in a waveguide is air. More efficient than two conductor cable Works at a higher frequency Less interference and distortion	2	
5		A logic probe is a hand-held pen-like probe used for analysing and troubleshooting the logical states 0 or 1 of a digital circuit.	2	Can also be used to inject signals into a circuit
6		Clamping work Operating a micro-switch Opening a valve Removing components from a conveyor belt Opening a sliding door	2	Accept any two valid responses Do not accept hydraulic systems
7		Analogue digital cathode ray oscilloscope dot matrix LED	2	Accept any two valid responses

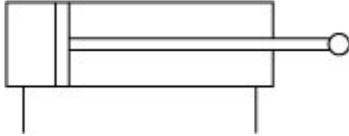
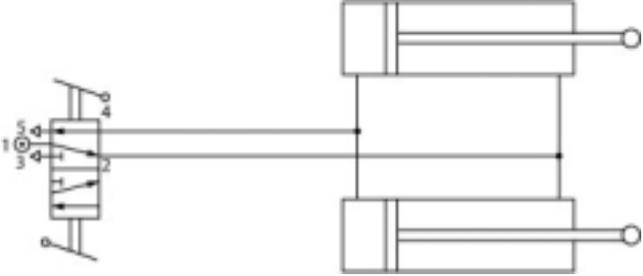
Question			Answer	Marks	Guidance
			seven segment LCD		
8			Programme memory Data memory Output devices Input devices Central Processor Unit (CPU) PIC	2	Accept any two valid responses
9			Germanium (1) Silicon (1)	2	
			Total	20	

SECTION B

Question		Answer	Marks	Guidance
1	(a)	Fire alarm Thermostat Freezers Meter compensation Monitor of oil/coolant temperatures Regulates the temperature of a battery pack Differential thermometer	2	Accept any two valid applications
	(b)	Component X - Thermistor Component Y – Signal lamp or lamp or bulb	2	Award one mark for each correct responses given
	(c)	<ul style="list-style-type: none"> • The resistance of a thermistor decreases when it gets hot. (1) • The circuit is designed to light the signal lamp on a rising temprature.(1) • Current will flow through the transistor base resistance, into the base of the first transistor, through the emitter into the left hand base of transistor two, out of the emitter and to the negative of the battery. (2) • The current has been amplified. (1) • If it is large enough, it will light the signal lamp (1) 	6	
2	(a)	Music and sound recordings TV tuner cards Microcontrollers Digital oscilloscopes Radio astronomic spectroscopy Software defined radio	2	Accept any two valid applications

Question	Answer	Marks	Guidance
(b)	 <p>A – Operational amplifier (1) B – Encoder (1)</p>	2	
(c)	<ul style="list-style-type: none"> • Three operational amplifiers are used as comparators. (1) • Threshold voltages are applied to the inverting inputs through a potential divider chain made up of resistors R_1 to R_4. (1) • The reference voltage to the chain represents the full scale level. In operation, each comparator compares the analogue input voltage with its own particular reference voltage.(1) • Each resistor is of equal value, so the voltages at each junction increase by one-quarter of the total reference voltage.(1) • The input analogue signal to go digital is then applied to all three non-inverting terminals in parallel.(1) 	6	

Question		Answer	Marks	Guidance
		<ul style="list-style-type: none"> The non binary output of each comparator will go high. An encoder takes the output and converts it into a binary signal.(1) 		
3	(a)	Transmission lines Cavity resonator Transfer of power and communication signals Antennas Microwaves for satellite communications Optoelectronic devices Ion and electron beam lithography	2	Accept any two valid applications
	(b)	Transverse Magnetic mode - Transverse Electro-Magnetic mode -	2	
	(c)	<p>When an electromagnetic wave propagates down a hollow tube, only one of the fields either electric or magnetic -- will actually be transverse to the wave's direction of travel. (1)</p> <p>The other field will "loop" longitudinally to the direction of travel, but still be perpendicular to the other field. (1)</p> <p>Whichever field remains transverse to the direction of travel determines whether the wave propagates in Transverse Electric or Transverse Magnetic mode. (1)</p> <p>Typically a waveguide is thought of as a transmission line comprising a hollow conducting tube, which may be rectangular or circular within which electromagnetic waves are propagated. Unlike coaxial cable, there is no centre conductor within the waveguide. (1)</p> <p>Signals propagate within the confines of the metallic walls that act as boundaries. (1)</p> <p>Transverse modes occur because of boundary conditions</p>	6	

Question	Answer	Marks	Guidance
	<p>imposed on the wave by the waveguide. For example, a radio wave in a hollow metal waveguide must have zero tangential electric field amplitude at the walls of the waveguide, and so the transverse pattern of the electric field of waves is restricted to those which fit between the walls. For this reason, the modes supported by a waveguide are quantized. (1)</p>		
<p>4 (a)</p>		<p>2</p>	<p>Award one mark for correctly drawn piston Award one mark for correctly drawn cylinder showing two vents</p>
<p>(b)</p>	<p>Raising and lowering a door using wires and pulleys Opening and lowering a furnace door Dipping components in and out of a degreasing bath Opening and closing a vice Opening and closing greenhouse windows Machine guard safety circuit Sequential control of a power drill</p>	<p>2</p>	<p>Accept any two valid applications</p>
<p>(c)</p>	 <p>Two T-connectors are used to divide the air supply and exhaust routes(1) With the 5-port valve in position 1, both cylinders are in the in-stroke position(1) When the 5-port valve is switched to position 2, both</p>	<p>6</p>	<p>Award three marks for the diagram One mark for a correctly drawn 5-port valve Two marks for correctly connected cylinders</p>

Question		Answer	Marks	Guidance						
		cylinders go to the outstroke(1)								
5	(a)	The return of a portion of the output of a process or system to the input, (1) especially when used to maintain performance or to control a system or process. (1)	2							
	(b)	On-Off control of a thermostat Proportional control in an under or over damped furnace Pressure switch on an air compressor Linear control – switching on an actuator such as a pump, motor or heater Speed control of a motor Temperature of a refrigerator	2	Accept any two valid applications						
	(c)	<ul style="list-style-type: none"> • Overall gain $G = A/(1 - \beta A)$ where A open loop gain (1) • Cross multiply: $G(1 - \beta A) = A$ (1) • Open bracket: $G - G\beta A = A$ (1) • Add to both sides $G\beta A$: $G = A + G\beta A$ • Take out common factor A: $G = A(1 + G\beta)$ (1) • Divide both sides by $(1 + G\beta)$: $A = G/(1 + G\beta)$ (1) • $A = 50/(1 + 50[1/40]) = 50/(1 + 1.25) = 50/2.25 = 22.2$ (1) 	6	Marks will be awarded for error carried forward						
6	(a)	Inputs are the signals or data received by the system (1) The term can also be used as part of an action; to "perform I/O" is to perform an input or output operation. I/O devices are used by a person (or other system) to communicate with a computer (1)	2							
	(b)	Input devices (1): <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>Potentiometer</td> <td>Thermistor</td> </tr> <tr> <td>Light dependent resistor</td> <td>Potential divider circuits</td> </tr> <tr> <td>Keyboard</td> <td>Mouse</td> </tr> </table>	Potentiometer	Thermistor	Light dependent resistor	Potential divider circuits	Keyboard	Mouse	2	Accept any valid responses
Potentiometer	Thermistor									
Light dependent resistor	Potential divider circuits									
Keyboard	Mouse									

Question		Answer	Marks	Guidance										
		Push to make switch Output Devices (1): <table border="1" data-bbox="349 316 1111 491"> <tr> <td>Light emitting diode</td> <td>7 segment display</td> </tr> <tr> <td>Loudspeaker</td> <td>Buzzer and bell</td> </tr> <tr> <td>Relay</td> <td>Reed switch</td> </tr> <tr> <td>Motor</td> <td>Signal and filament lamps</td> </tr> <tr> <td>Monitor</td> <td>Printer</td> </tr> </table>	Light emitting diode	7 segment display	Loudspeaker	Buzzer and bell	Relay	Reed switch	Motor	Signal and filament lamps	Monitor	Printer		
Light emitting diode	7 segment display													
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	(c)	(0 Marks) The learner did not provide a block diagram or describe a control system that was used in one of the given applications. (1-2 Marks) Limited information – award one mark for a block diagram and a further mark for describing a control system for one of the listed applications. (3-4 Marks) Adequate information – award one mark for a block diagram and up to a further three marks for describing a listed control system in depth or breadth. (5-6 Marks) Detailed information – award two marks for a labelled block diagram and up to a further four marks for describing a listed control system in depth and breadth.	6											
7	(a)	An embedded system is a computer system designed to perform one or a few dedicated functions often with real-time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts. Embedded systems control many devices in common use today (1). Embedded systems are controlled by one or more main processing cores that is typically either a microcontroller or a digital signal processor.	2											

Question		Answer	Marks	Guidance
		The key characteristic is however being dedicated to handle a particular task, which may require very powerful processors(1)		
	(b)	Radar air traffic control inertial guidance systems Various electric motors — brushless DC motors, induction motors and DC motors Automobiles, electric vehicles, and hybrid vehicles Anti-lock braking system Electronic Stability Control Traction control Automatic four-wheel drive Digital cameras Microwave ovens	2	Accept any two valid applications
	(c)	(0 Marks) The learner did not provide a description of an embedded system (1-2 Marks) Limited information – award up to two marks for describing an embedded system for a product that they had studied. (3-4 Marks) Adequate information – award up to four marks for describing an embedded system in depth or breadth for a product that they had studied. (5-6 Marks) Detailed information – award up to six marks for describing an embedded system in depth and breadth for a product that they had studied.	6	
8	(a)	<ul style="list-style-type: none"> MapleSim™ is a high-performance multi-domain modeling and simulation tool. Crocodile clips Multisim and Ultiboard 11.0 Circuit Shop allows you to design, simulate and learn about digital and analog electronic circuits. 	2	Accept any valid response

Question	Answer	Marks	Guidance
	<p>Circuit Shop is an easy to use graphical CAD tool to allow simple digital and analog electronic circuits to be constructed and simulated</p> <ul style="list-style-type: none"> • CircuitLogix website - Free electronics circuit simulator • Circuit Simulator Analyses – circuit design.info Electronic Circuit Simulation Applet • GeckoCIRCUITS website - Free power electronics circuit simulator (Java Applet) • Digiac - uses virtual test instruments, typical waveforms and digital multi-meters on the basic components used in digital circuits. • Circuit Wizard • Live Wire 		
(b)	<p>Simulation software packages 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 is not 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.</p>	2	Accept any two valid benefits
(c)	<p>(0 Marks) The learner did not provide a labelled diagram or describe how to use a simulation software package. (1-2 Marks) Limited information – award one mark for a labelled diagram and a further mark for describing how to use a simulation software package. (3-4 Marks) Adequate information – award one mark for a labelled diagram and up to a further three marks for describing how to use a simulation software package in depth or</p>	6	

Question	Answer	Marks	Guidance
	breadth. (5-6 Marks) Detailed information – award two marks for a labelled diagram and up to a further four marks for describing how to use a simulation software package in depth and breadth.		

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