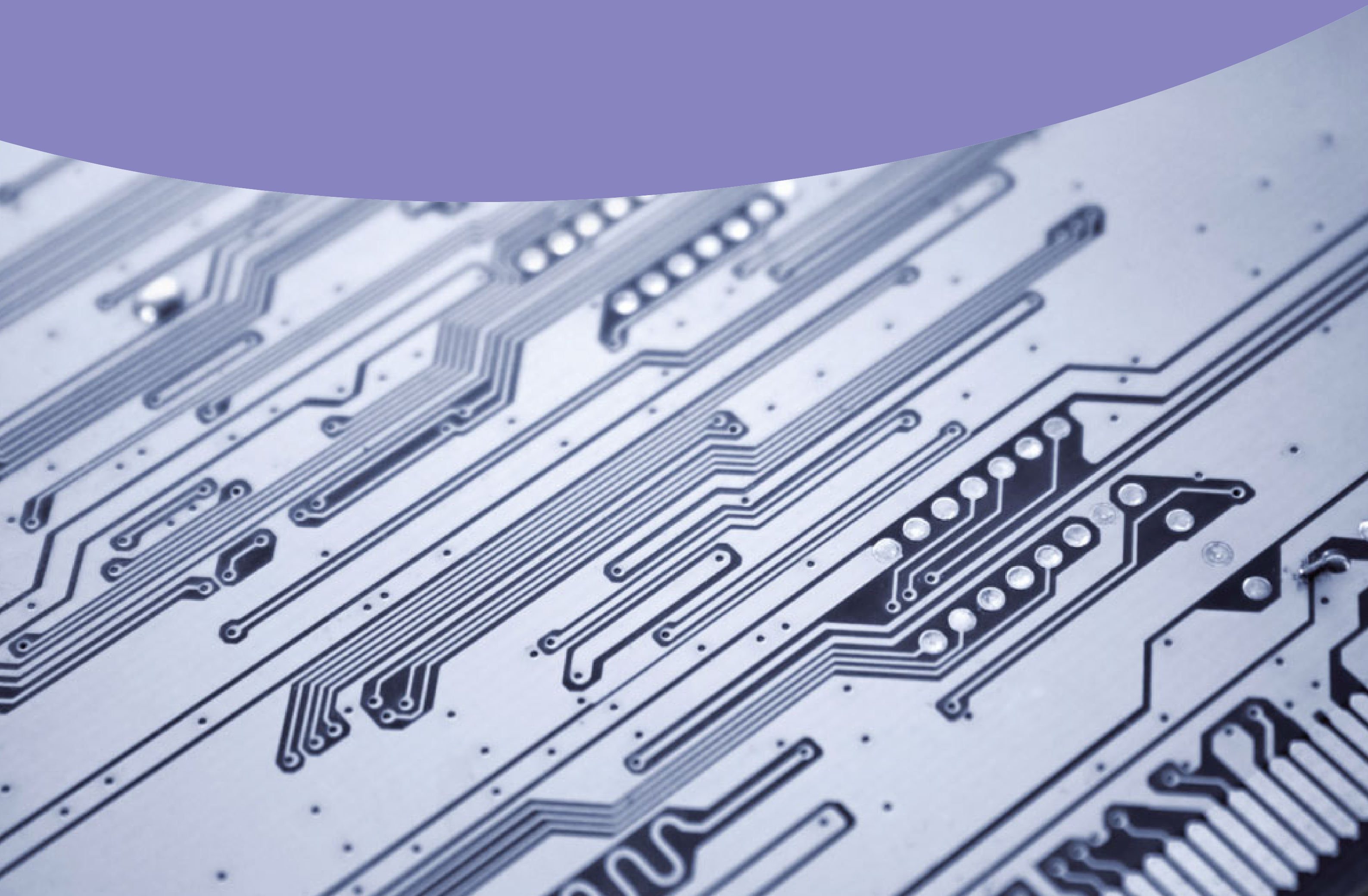
# GCE

## AS and A Level Specification

# Electronics

**For exams from June 2014 onwards**
**For certification from June 2014 onwards**



# Contents



Vertical black lines indicate a significant change or addition to the previous version of this specification.

# 1 Introduction



## 1.1 Why choose AQA?

It's a fact that AQA is the UK's favourite exam board and more students receive their academic qualifications from AQA than from any other board. But why does AQA continue to be so popular?

- **Specifications**

  Ours are designed to the highest standards, so teachers, students and their parents can be confident that an AQA award provides an accurate measure of a student's achievements. And the assessment structures have been designed to achieve a balance between rigour, reliability and demands on candidates.

- **Support**

  AQA runs the most extensive programme of support meetings; free of charge in the first years of a new specification and at a very reasonable cost thereafter. These support meetings explain the specification and suggest practical teaching strategies and approaches that really work.

- **Service**

  We are committed to providing an efficient and effective service and we are at the end of the phone when you need to speak to a person about an important issue. We will always try to resolve issues the first time you contact us but, should that not be possible, we will always come back to you (by telephone, email or letter) and keep working with you to find the solution.

- **Ethics**

  AQA is a registered charity. We have no shareholders to pay. We exist solely for the good of education in the UK. Any surplus income is ploughed back into educational research and our service to you, our customers. We don't profit from education, you do.

If you are an existing customer then we thank you for your support. If you are thinking of moving to AQA then we look forward to welcoming you.

## 1.2 Why choose Electronics?

The AQA GCE Electronics specification aims to attract students to the subject by offering a stimulating and rewarding programme of study.

The knowledge and skills acquired through the study of Electronics form a sound base, not only for taking the subject further, but also for employment in the scientific and technological professions. In addition, in studying this subject students will encounter techniques and disciplines of value in many other subject areas.

The specification applies basic electronic principles and a systems approach in order to lift the lid on many modern electronic systems encountered in everyday life. It reflects up-to-date practice, encourages a safe approach to using electronic systems, and promotes an awareness of the social, economic and cultural impact of Electronics.

Ability and confidence in the subject are developed by having an emphasis on learning through doing, with straightforward practical work. Practical skills are internally assessed at both AS and A2 through a practical project. At AS, students are required to identify a problem, devise a specification for a solution and then build and test it; at A2, students follow the same process with the added requirement to produce a full evaluation of the system.

The specification also provides ample opportunities for students to develop the six Key Skills.

Delivery of the specification requires a minimal amount of specialist equipment. By emphasising skills and processes in the teaching of the specification, teachers will ensure that students have the opportunity to develop constructional and communication capabilities of a high order. These capabilities will be of value beyond the confines of the students' work in Electronics.

Key features of this specification include:

- a simple assessment structure
- based on a systems approach
- equally weighted external examinations
- coursework elements at both AS and A Level
- practical problem solving is encouraged
- modern developments in electronics and its applications are considered
- previous experience of the study of electronics is not a pre-requisite.

This specification provides continuity from the existing AQA GCSE Electronics specification and offers a coherent progression route into Higher Education.

This new specification and the one it replaces have many core elements common to both, and teachers will find the transition between them straightforward.

## 1.3 How do I start using this specification?

### Already using the existing AQA Electronics specification?

- Register to receive further information, such as mark schemes, past question papers, details of teacher support meetings, etc, at **http://www.aqa.org.uk/rn/askaqa.php** Information will be available electronically or in print, for your convenience.
- Tell us that you intend to enter candidates. Then we can make sure that you receive all the material you need for the examinations. This is particularly important where examination material is issued before the final entry deadline. You can let us know by completing the appropriate Intention to Enter and Estimated Entry forms. We will send copies to your Exams Officer and they are also available on our website **http://www.aqa.org.uk/admin/p_entries.html**

### Not using the AQA specification currently?

- Almost all centres in England and Wales use AQA or have used AQA in the past and are approved AQA centres. A small minority are not. If your centre is new to AQA, please contact our centre approval team at **centreapproval@aqa.org.uk**

## 1.4 How can I find out more?

### Ask AQA

You have 24-hour access to useful information and answers to the most commonly-asked questions at **http://www.aqa.org.uk/rn/askaqa.php**

If the answer to your question is not available, you can submit a query for our team. Our target response time is one day.

### Teacher Support

Details of the full range of current Teacher Support meetings are available on our website at **http://www.aqa.org.uk/support/teachers.html**

There is also a link to our fast and convenient online booking system for Teacher Support meetings at **http://events.aqa.org.uk/ebooking**

If you need to contact the Teacher Support team, you can call us on 01483 477860 or email us at **teachersupport@aqa.org.uk**

# 2 Specification at a Glance



## AS Examinations

**Unit 1 – ELEC1 Introductory Electronics**

Written Examination – 67 marks, 6 or 7 compulsory questions of varying length.

1 hour
35% of the total AS marks
17½% of the total A Level marks

Available in June only

**Unit 2 – ELEC2 Further Electronics**

Written Examination – 67 marks, 6 or 7 compulsory questions of varying length.

1 hour
35% of the total AS marks
17½% of the total A Level marks

Available in June only

**Unit 3 – ELEC3 Practical System Development**

Coursework – 50 marks
Focused on the content of AS units 1 and 2

30% of the total AS marks
15% of the total A Level marks

Available in June only

AS Award 1431

## A2 Examinations

**Unit 4 – ELEC4 Programmable Control Systems**

Written Examination – 80 marks, 7 or 8 compulsory questions of varying length.

1½ hours
17½% of the total A Level marks

Available in June only

**Unit 5 – ELEC5 Communications Systems**

Written Examination – 80 marks, 7 or 8 compulsory questions of varying length.

1½ hours
17½% of the total A Level marks

Available in June only

**Unit 6 – ELEC6 Practical System Synthesis**

Coursework – 50 marks
Focused on the content of A2 units 4 and 5

15% of the total A Level marks

Available in June only

A Level Award 2431

AS + A2 = A Level

# 3 Subject Content

## 3.1 Unit 1 ELEC1 Introductory Electronics

### System synthesis

Candidates should be able to:

- recognise and understand that simple systems consist of an input, a process, an output and possibly feedback;
- analyse and design system diagrams where the lines between subsystems represent the flow of information;
- represent complex systems in terms of subsystems;
- recognise that signals may be analogue or digital in nature, and differentiate between them;
- describe and explain the operation of modern electronic systems which may make use of several sensors.

### Voltage (*V*), current (*I*), resistance (*R*), power (*P*)

Candidates should be able to:

- understand the need for identifying a zero volt point in a circuit;
- define and apply the fact that resistance, *R*, is the ratio of the voltage across a conductor, *V*, to the current, *I*, flowing through it,

$$R = \frac{V}{I}$$

- calculate the combined resistance of resistors connected in series using $R_T = R_1 + R_2 + R_3 + \ldots$.
- calculate the combined resistance of resistors connected in parallel using

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots\ldots$$

- select appropriate preferred values for resistors from the E24 series;
- identify the value of resistors using the colour code and BS 1852 code;
- define and apply the fact that power dissipated in a component is the product of *V* , the voltage across a component in a circuit, and *I* , the current through that component;
- apply the formula $VI$, or $I^2R$, or $V^2/R$ to calculate the power dissipation in a circuit or component.

### Diodes

Candidates should be able to:

- describe the use of light-emitting diodes (LEDs), silicon diodes and Zener diodes and carry out relevant calculations;
- calculate the value of the series resistor for dc circuits;
- sketch $I - V$ characteristics for silicon diodes and Zener diodes;
- select appropriate silicon diodes and Zener diodes from given data sheets;
- describe how a Zener diode can be used with a current limiting resistor to form a simple regulated voltage supply;
- calculate the value and power rating of a suitable current limiting resistor.

### Resistive input transducers

Candidates should be able to:

- interpret and use characteristic curves (which may use logarithmic scales) of resistive input transducers;
- describe and explain the use of LDRs, negative temperature coefficient thermistors, variable resistors and switches in a voltage divider circuit to provide analogue signals;
- calculate suitable values for series resistors for use with and for protection of LDRs and thermistors;
- carry out calculations on voltage dividers consisting of resistors and resistive input transducers.

### Transistors and MOSFETs

Candidates should be able to:

- describe the use of an npn junction transistor as a switch;
- describe the use of an n-channel (enhancement mode) MOSFET as a switch;
- compare the advantages and disadvantages of a MOSFET and a junction transistor when they are both used as switches.

### Output Devices

Candidates should be able to:

- describe the use of electromagnetic relays, solenoids, buzzers, motors, and seven-segment displays in a system and understand and explain circuit protection provided by a diode in parallel with a relay, solenoid or motor;
- understand and use COM, NO and NC notation.

### Operational amplifiers (op-amps)

Candidates should be able to:

- recall the characteristics of an ideal op-amp and be aware how these may be different for a typical op-amp;

- know, understand and use the difference between inverting and non-inverting inputs;
- understand the power supply requirements and output voltage swing limitations of real op-amps leading to saturation;
- describe, understand and explain the use of an op-amp in a comparator circuit.

## Logic gates and Boolean algebra

Candidates should be able to:

- identify and use NOT, AND, OR, NAND, NOR and EX-OR gates in circuits;
- construct, recognise and use truth tables for NOT, AND, OR, NAND, NOR and EX-OR gates and simple combinations of them;
- understand the operation of, and use combinations of, NOT, AND, OR, NAND, NOR and EX-OR gates to form other logic functions;
- generate the Boolean expression from a truth table or logic diagram.

## Design and simplification of combinational logic systems

Candidates should be able to:

- design a logic system from a truth table, written description or Boolean algebra expression using combinations of gates;
- simplify a logic system using either Boolean algebra or Karnaugh maps;
- convert logic systems comprising mixed gates into either NOR or NAND gates only;
- describe and explain the operation of combinational logic systems.

# 3.2 Unit 2 ELEC2 Further Electronics

## Capacitors

Candidates should be able to:

- recall that a capacitor is capable of storing electrical charge and electrical energy;
- recall that a capacitor will block a direct current but will allow the passage of an alternating current;
- recall that the unit of capacitance is the farad and that practical capacitors are usually measured in pF, nF and μF;
- calculate the combined capacitance of capacitors connected in series and parallel combinations;
- select appropriate capacitors given data on maximum working voltage, polarisation and leakage current.

## dc RC networks

Candidates should be able to:

- explain the meaning of and calculate the value of the time constant for RC circuits;
- recall that after one time constant:

  for a charging capacitor, $V = 0.63V_s$

  for a discharging capacitor, $V = 0.37V_s$,

  where $V_s$ is the supply voltage and $V$ is the voltage across the capacitor;
- recall that:

  after $0.69RC$, $V = 0.5V_s$

  after $5RC$ for a charging capacitor, $V \approx V_s$

  after $5RC$ for a discharging capacitor, $V \approx 0$
- sketch graphs of voltage against time for a capacitor charging and discharging.

## Timing subsystems

Candidates should be able to:

- recall that a monostable circuit has one stable output state and one unstable output state;
- recognise, draw and use the circuit diagram of a monostable based on a 555 timer circuit;
- describe the operation of a monostable based on a 555 timer;
- calculate the time period of such a monostable using $T = 1.1RC$
- recall that an astable circuit has no stable output states but continually changes;
- recognise, draw and use the circuit diagram of an astable based on a 555 timer circuit;
- describe the operation of an astable based on a 555 timer;
- calculate the time, $t_L$, that the output is low using

  $$t_L = 0.7R_BC$$
- calculate the time, $t_H$, that the output is high using

  $$t_H = 0.7(R_A+R_B)C$$
- calculate the output frequency using

  $$f = \frac{1.44}{(R_A+2R_B)C}.$$

## Sequential logic subsystems

Candidates should be able to:

- recall the circuit diagram of a bistable latch based on NAND gates and describe its operation and function;
- recall the symbol for a rising edge triggered D-type flip-flop and describe its operation and function;
- recall that in a shift register information is passed along from one element to the next on each clock pulse;
- recall how rising edge triggered D-type flip-flops can be used to form a shift register and describe its operation and applications.

## Counter subsystems

Candidates should be able to:

- describe the use of feedback to make a rising edge triggered D-type flip-flop divide by 2;
- design 4-bit up or down counters based on rising edge triggered D-type flip-flops, and draw timing diagrams for these counters;
- design 4-bit modulo-N counters based on rising edge triggered D-type flip-flops, and draw timing diagrams for these counters;
- convert a 4-bit binary number to decimal or hexadecimal notation;
- describe the use of a BCD or hexadecimal decoder with a seven segment display.

## The Operational Amplifier

Candidates should be able to:

- recall the properties of an ideal op-amp;
- recall that for a real op-amp, the product of voltage gain and bandwidth is a constant;
- recall that negative feedback is used to reduce the overall voltage gain of an op-amp amplifier subsystem.

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## Amplifier subsystems

Candidates should be able to:

- use the formula voltage gain = $\frac{V_{out}}{V_{in}}$
- recall and use the definition of bandwidth of an amplifier as the frequency range over which the voltage gain is within 70% of the maximum;
- draw and recognise the inverting op-amp amplifier circuit and describe its applications;
- use the formula $\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$
- recall that the input resistance is equal to the value of the input resistor, and that the circuit has a virtual earth point;
- draw and recognise a summing op-amp amplifier circuit and describe its applications;
- use the formula $V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$
- recall that the input resistance of each input is equal to the value of its input resistor, and that the circuit has a virtual earth point;
- draw and recognise the single op-amp difference amplifier circuit and describe its applications;
- use the formula $V_{out} = (V_{+}–V_{-})\,\frac{R_f}{R_1}$
- recall that the input resistance of each input is different and comparatively low;
- draw and recognise the non-inverting op-amp amplifier circuit and describe its applications;
- use the formula $\frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_{in}}$
- recall that the input resistance is equal to that of the op-amp;
- draw and recognise the voltage follower op-amp amplifier circuit and describe its applications;
- recall that the voltage gain of a voltage follower is 1, but that the current and power gain can be very large;
- recall that the input resistance is equal to the resistance of the op-amp.

## Power amplifier subsystems

Candidates should be able to:

- use the formula power gain = $\frac{P_{out}}{P_{in}}$
- recall and use the definition of bandwidth of an amplifier as the frequency range over which the power gain is within 50% of the maximum;
- draw and recognise the enhancement mode MOSFET (both n- and p-channel) source follower amplifier circuits and describe their applications;
- estimate the power dissipated in a source follower and describe methods for removing the excess heat generated;
- draw and recognise the push-pull amplifier circuit using p- and n-channel enhancement mode MOSFETs and describe its operation and applications;
- describe the common types of distortion associated with push-pull amplifier subsystems (cross-over and saturation/clipping) and how they can be reduced;
- describe the advantages of push-pull amplifier subsystems over single ended output subsystems;
- estimate the maximum power output from a push-pull amplifier subsystem.

## 3.3 Unit 3 ELEC3 Practical System Development

### Nature of Coursework

A brief outline of the coursework requirements are given below.

Candidates should:

- identify a specific problem to be solved;
- consider alternative solutions and give reasons for selecting the solution they have chosen;
- conduct research so that a list of performance parameters can be provided;
- using **at least three** active devices, devise appropriate circuit diagrams calculating appropriate component values;
- construct the system;
- test the system and make suitable modifications;
- produce a report which details all stages of the development.



### Coursework Overview

For many candidates, this will be their first encounter with electronic systems and the demands of the coursework should reflect this. The coursework will require candidates to design, construct and assess an electronic system to solve a specific electronics problem. Candidates should be encouraged to select a problem to solve in which they are interested and which is considered achievable by their supervisor. The expected outcome is a working electronic system, a written report detailing the work undertaken and an assessment of the success of the work in solving the initial problem. The coursework is expected to be carried out alongside the theoretical work of AS Unit 1 and Unit 2 and should be such that it can be completed in 30 hours (with a suggestion of 20 hours laboratory/workshop time and 10 hours private study) and must contain **at least three** active devices. There should be sufficient detail in the report to enable someone else to carry out the same work and know what to expect in terms of the system's function and performance. Supervisors must ensure that the work undertaken is that of the candidate and is of an appropriate standard for AS, and is not largely software based.

Coursework guidance can be found in Section 3.8.

# Assessment Criteria – Commentary on the AS Marking Criteria

There are 25 marking criteria. For each criterion, Supervisors can award 0, 1 or 2 marks as appropriate.

## A Problem Analysis and Solution Design

The candidate:

(a) – clearly defined the problem to be solved with minimal guidance.
Marks:
0 the supervisor has to help the candidate to choose a problem to solve and the candidate provides an inadequate description.
1 the candidate makes an independent choice but gives an inadequate description OR receives assistance with the choice but gives a clear description.
2 the candidate makes an independent choice and provides an adequate description.

(b) – carried out relevant research from at least two named sources.
Marks:
0 there is inadequate evidence that research has been carried out from two separate named sources.
1 there is inadequate evidence documented OR when inadequate details are given of the two named sources.
2 well-documented information from at least two separate sources whose full details are recorded.

(c) – carried out practical investigations into at least two relevant factors.
Marks:
0 there is inadequate evidence that two practical investigations have been conducted.
1 there is well-documented evidence for one practical investigation OR when inadequate details are given of the two practical investigations.
2 well-documented information from at least two practical investigations.

(d) – gave a detailed description of the requirements of the system.
Marks:
0 an inadequate description.
1 a description of the intended system which lacks detail.
2 a detailed description of the intended system.

(e) – specified at least three **numerical** and **realistic** parameters.
Marks:
0 an inadequate specification containing fewer than two parameters.
1 a specification, where inadequate details are given OR when only two parameters are specified in detail.
2 a detailed specification containing at least three numerical and realistic parameters.

(f) – considered two or more alternative solutions.
Marks:
0 inadequate details given of alternative solutions.
1 a description, where the advantages and disadvantages of the alternatives are not fully given.
2 a detailed description of the advantages and disadvantages of at least two alternatives.

(g) – justified the choice of solution from the others considered.
Marks:
0 inadequate details given for the choice.
1 a weak justification for the choice made.
2 a detailed justification for the choice made.

## B System Development

Items (a), (b) and (c) should **not** be awarded if fewer than three active devices are used.

The candidate:

(a) – devised circuit details of at least one subsystem with minimal guidance.
Marks:
0 no significant details of a subsystem OR fewer than three active devices within the whole system.
1 incomplete details of any subsystem.
2 full details of at least one subsystem.

(b) – correctly calculated a component value for a subsystem.
Marks:
0 inadequate details of how the component value was determined OR fewer than three active devices within the whole system.
1 incomplete details of how any component value was determined OR a calculation justifying a component choice.
2 full details of how at least one component value was determined.

(c) – assessed the performance of at least one subsystem, using measurements.
Marks:
0 no significant details of any subsystem measurements OR fewer than three active devices within the whole system.
1 incomplete details of any subsystem measurements.
2 full details of at least one subsystem measurements.

(d) – explained in detail how the whole system works.
Marks:
0 inadequate details of how the system works AND/OR there is little evidence of any form to the writing.
1 incomplete details of how the system works AND/OR the form of writing is inappropriate.
2 full details of how the system works and the form and style of writing are appropriate.

(e) – converted circuit diagrams into a well-organised circuit board layout with minimal guidance.
Marks:
0 a disorganised layout even with guidance.
1 a disorganised layout achieved with minimal guidance OR a well-organised layout with guidance.
2 a well-organised layout achieved with minimal guidance.

(f) – safely constructed two or more subsystems of the complete electronic system.
Marks:
0 an inadequate risk assessment and fewer than two subsystems constructed.
1 an inadequate risk assessment but at least two subsystems constructed OR an adequate risk assessment and fewer than two subsystems constructed.
2 an adequate risk assessment and at least two subsystems constructed.

(g) – produced a neatly constructed electronic system.
Marks:
0 a system with unnecessarily long wires covering components, so making any modifications difficult.
1 a system which has been constructed without sufficient care, some wires too long and components not always secured to the circuit board.
2 a neatly constructed and carefully organised system.

(h) – made most of the system function.
Marks:
0 little of the system works (one or no subsystem) despite significant supervisor assistance.
1 a system in which two or more of the subsystems work with or without some supervisor assistance.
2 a system in which most, if not all, of the subsystems function to some extent, with or without significant supervisor guidance.

(i) – made all of the system function with minimal guidance.
Marks:
0 a system in which most, if not all, of the system functions to some extent, with or without significant supervisor guidance.
1 a system which has some minor faults but the candidate received only minimal guidance OR when the system works fully and the candidate received some guidance.
2 a system which works fully and the candidate received only minimal guidance.

## C Making Measurements

Two marks must be gained for item (b) before any are awarded for item (c).

The candidate:

(a) – devised a test procedure for the complete system prior to making any system measurements.
Marks:
0 there is little or no evidence of any planning prior to testing.
1 there is some evidence of planning of the testing procedures and some of the relevant equipment has been identified.
2 there is clear evidence of detailed planning of the testing procedures and the relevant equipment has been identified.

(b) – made and recorded basic numerical measurements on the complete system parameters.
Marks:
0 there is little or no evidence of any testing.
1 measurements made and recorded are trivial or incomplete.
2 basic numerical measurements have been made and carefully recorded.

(c) – made and recorded detailed numerical measurements on the complete system parameters.
Marks:
0 there is little or no evidence of anything other than basic testing.
1 most relevant numerical measurements on the system parameters have been made and recorded.
2 all relevant numerical measurements on the system parameters have been made and carefully recorded.

(d) – assessed the working parts of the complete system and referred to the measurements made.
Marks:
0 there is little or no evidence of any assessment of the performance of the complete system.
1 an assessment is made but there is little reference to the measurements of the system parameters.
2 a detailed assessment is made of the final system and reference is made to the measurement of the system parameters.

(e) – identified some limitations in the performance of the complete system and suggested modifications to overcome these limitations.
Marks:
0 there is little or no evidence of any attempt to identify limitations in the performance of the complete system.
1 limitations are identified but no suggestions are made as to how to overcome these limitations.
2 limitations are identified along with suggestions of how to overcome them OR there are no limitations of the system and full marks have been gained for A(e), C(b) and C(c).

(f) – carried out the modifications and re-assessed the system.
Marks:
0 when there is little or no evidence of any modification of the complete system to enhance its performance.
1 when modifications are made, but a re-assessment is not made.
2 when modifications and a detailed re-assessment are made of the final system OR there are no limitations and full marks have been gained for A(e), C(b), C(c) and C(e).

## D Report

The report:

(a) – details all the stages of the development of the project.
Marks:
0 the form and style of writing in the report are inappropriate such that significant details are omitted AND/OR the meaning of the report is unclear. Correct terminology is seldom used and spelling, punctuation and grammar are poor.
1 the report has a form and style of writing which has small omissions. The meaning of the report is generally clear but it is neither succinct nor free from repetition. Correct terminology is occasionally used and spelling, punctuation and grammar are generally accurate.
2 the report has an appropriate form and style of writing in that, it is coherent, complete, succinct and free from repetition. Correct terminology is used throughout and spelling, punctuation and grammar are accurate.

(b) – contains clear photographic evidence and a complete circuit diagram.
Marks:
0 no clear photographic evidence is supplied.
1 the report contains clear photographic evidence, but does not have a complete circuit diagram.
2 the report contains clear photographic evidence and a complete circuit diagram.

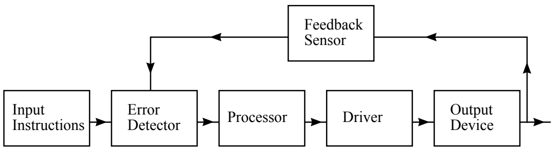
(c) – contains an acknowledgement of **all** sources of information and help, including a bibliography.
Marks:
0 there is an attempt to give a summary of the sources of information and help received presentation of this information is not appropriate to this type of report.
1 there are some details of the sources of information and help received but it is incomplete and not presented in an appropriate style and format for this type of report.
2 the summary of sources of information and help received is complete and presented in an appropriate style and format for this type of report.

# 3.4 Unit 4 ELEC4 Programmable Control Systems

## Control Systems

Candidates should be able to:

- describe the features of the generalised control system shown below;




- distinguish between open and closed loop control systems and describe their characteristics;
- describe what is meant by feedback in a control system and give examples of systems with feedback;
- distinguish between positive and negative feedback in control systems and describe the characteristics of each.

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## Microprocessor subsystems

Candidates should be able to:

- describe the relative merits of hardwired systems and software controlled systems;
- describe the architecture of a generalised microprocessor control system consisting of microprocessor, clock, memory (ROM and RAM) and input/output ports, connected by a bus structure;
- describe the architecture of a generic single chip microcontroller;
- describe the social and economic benefits and implications of the use of microcontrollers.

## Programming

Candidates should be able to:

- analyse a process into a sequence of fundamental operations;
- convert a sequence of fundamental operations into a flow chart;
- interpret flow charts and convert them into a generic microcontroller program;
- recognise and use a limited range of assembler language microcontroller instructions (see Data Sheet, *Appendix E*);
- write subroutines to:
  - configure the input and output pins
  - read data from a sensor
  - write data to an output device
  - give a specified time delay
  - give a specified sequence of control signals
  - perform simple arithmetic and logic operations
  - detect events using polling and hardware interrupts;
- compare the use of hardware interrupts and polling to trigger events;
- interpret programs written with a limited range of assembler instructions.

## Input subsystems

Candidates should be able to:

- draw a block diagram for an 8-bit digital ramp Analogue to Digital Converter, ADC, and explain its operation;
- describe uses of an ADC;
- describe the limitations of this type of ADC;
- describe the circuit for a Flash ADC and explain its operation;
- calculate component values for a Flash ADC;
- compare the relative merits of flash ADCs and digital ramp ADCs;
- describe the use and operation of reflective and slotted optical switches;
- describe the use and operation of a slotted disk shaft encoder;
- describe the use and operation of a binary coded shaft encoder;
- explain why a Gray coded shaft encoder is preferred in practice to a binary coded encoder.

## Output subsystems

Candidates should be able to:

- describe the circuit for an 8-bit Digital to Analogue Converter, DAC, based on a summing amplifier and explain its operation;
- describe uses of a DAC;
- calculate component values for a DAC;
- calculate the output voltage from a DAC;
- describe the use and operation of multiplexed seven segment displays (LCD and LED);
- describe the use and operation of multiplexed dot matrix displays;
- describe the different types of stepper motor;
- describe the use and operation of stepper motors;
- describe the essential differences in operation between conventional motors and stepper motors.

## Interfacing subsystems

Candidates should be able to:

- describe the use of tri-state buffers;
- describe the use of data latches;
- describe how data latches can be constructed from D-type flip-flops;
- recall the circuits for inverting Schmitt triggers and describe their operation;
- calculate the switching levels for inverting Schmitt triggers;
- explain how a Schmitt trigger can be used to regenerate a noisy input signal;
- describe the circuits needed to drive multiplexed displays (LCD and LED);
- recall the circuit for an H-bridge driver and describe its use and operation;
- describe the circuits needed to drive both conventional and stepper motors.

## Robotic systems

Candidates should be able to:

- describe the essential components of robotic systems sensors, actuators and control architectures;
- describe the merits and suitability of different power sources;
- design control algorithms for a robotic system to achieve a given objective;
- describe the ability of such systems to sustain artificially intelligent behaviour through the use of artificial neural networks;
- discuss the applications of robotic systems;
- describe the social and economic impact of robotic systems;
- describe possible future developments of robotic systems.

# 3.5 Unit 5 ELEC5 Communications Systems



## General principles

Candidates should be able to:

- know and understand that communication is the transfer of meaningful information from one location to another;
- draw a block diagram, understand and explain the operation of a generalised communication system, consisting of input transducer, carrier generator, modulator/encoder, transmitter, transmission link (medium), receiver, demodulator/decoder, output transducer;
- compare, in qualitative terms, the transmission of electromagnetic signals along a twisted pair, coaxial cable, optical fibre, and in free space;
- understand and apply the relationship between bandwidth and capacity to carry information;
- understand the need to multiplex a number of signals onto one transmission medium;
- describe and understand the principles of frequency division multiplexing and time division multiplexing;
- recall and describe the difference between noise, distortion and crosstalk;
- calculate, and appreciate the significance of, signal-to-noise ratio (in dB).

## Audio systems

Candidates should be able to:

- calculate the reactance of a capacitor using the formula

$$X_c = \frac{1}{2\pi fC}$$

- draw, analyse and explain passive high pass and low pass filters using RC circuits;
- calculate the breakpoint frequency of passive filter circuits;
- draw, analyse and explain first order active filters based on an inverting op-amp, including treble cut, treble boost, bass cut and bass boost;
- calculate the breakpoint frequency of active filter circuits;
- calculate the values of components in an active filter circuit for a given breakpoint frequency;
- describe and explain the use of common audio power IC amplifiers.

## Radio communication – General Principles

Candidates should be able to:

- describe the transfer of data by different types of carriers and media;
- explain the need for a carrier wave;
- explain how the signal amplitude and frequency are encoded on the carrier using amplitude modulation (AM);
- draw time waveforms to illustrate the nature of AM including the effect of depth of modulation on the envelope;
- draw and label a frequency spectrum for a sinusoidal carrier wave amplitude modulated by:
  - a single frequency signal, showing the carrier and side frequencies
  - a signal consisting of a range of frequencies, showing the carrier and sidebands
- explain and calculate the bandwidth requirements of AM signals;
- explain how a signal's amplitude and frequency are encoded on the carrier using frequency modulation (FM);
- draw time waveforms to illustrate the nature of FM;
- describe and calculate the practical bandwidth requirements of FM signals;
- know that radio stations broadcasting in LF and MF bands use AM;
- describe channel allocation within LF and MF broadcasting;
- know that FM is used for entertainment broadcasting in the 88 MHz – 108 MHz VHF band;
- understand and explain the relationship between channel spacing and signal bandwidth;
- know that DAB broadcasting is used in the 217.5 MHz – 230 MHz VHF band, and that channels are grouped in multiplexes on different frequencies;
- explain why different DAB channels are transmitted at different data rates, depending on the programme content.

## Radio receivers

Candidates should be able to:

- describe and explain the function of the systems within a simple radio receiver, consisting of an aerial, tuned circuit, detector/demodulator and earphone;

- calculate the optimum length for a half-wave dipole for a given wavelength/frequency;
- know that the impedance of the antenna should match that of the feed;
- describe in qualitative terms, how voltage and current vary in a parallel LC circuit near resonance;
- know that resonance occurs when $X_L = X_c$ and hence calculate the resonant frequency;
- draw a resonance curve for a parallel LC circuit;
- explain the use of an LC network to select a particular frequency;
- explain the significance of the quality factor of a tuned circuit and its relationship to the selectivity of the receiver;
- use the resonant frequency formula

$$f = \frac{1}{2\pi\sqrt{LC}}$$

  to calculate suitable values of $L$ and $C$;
- explain how an rf amplifier can be used to improve sensitivity;
- draw a block diagram for a superhet receiver consisting of an aerial, rf amplifier, local oscillator, mixer, if amplifier and filter, demodulator, AGC, af amplifier and loudspeaker;
- describe the principle of operation of the superhet;
- describe the frequency spectrum at the output of the mixer, limited to the main mixer products of the two input frequencies and the sum and difference frequencies;
- describe the advantages and disadvantages of the superhet receiver over a simple receiver.

## Digital communication

Candidates should be able to:

- compare the relative merits of analogue and digital communication;
- describe and illustrate the following pulse modulation techniques and describe the subsystems required to produce them from an analogue signal:
  - pulse amplitude modulation (PAM)
  - pulse width modulation (PWM)
  - pulse position modulation (PPM)
  - pulse code modulation (PCM)
- explain how the sampling rate and resolution affect the bit rate and perform appropriate calculations;
- discuss the relative merits of half and full duplex communication links;
- discuss the relative merits of serial and parallel data transmission;
- discuss the relative merits of synchronous and asynchronous transmission;
- describe the use of start and stop bits, and a parity bit;
- calculate bit and baud rate;
- describe the ideas of packet switching;
- explain the operation and use of serial and parallel shift registers and draw their respective timing diagrams;
- explain the action of a multiplexer;
- describe the use of multiplexers for serial data transmission;
- design and describe logic diagrams, truth tables and Boolean algebra relating to 2 to 1 and 4 to 1 multiplexers;
- explain how a Schmitt trigger can be used to regenerate a digital signal qualitatively.

## Mobile communication

Candidates should be able to:

- understand that mobile telephones are connected to the main telephone network via a radio link to a nearby base station;
- understand how a large number of mobile telephones can be used within a restricted frequency allocation;
- calculate the maximum number of mobile telephones that can be supported on one cell given the size of the cell and the available bandwidth;
- understand the meaning of the following terms: repeater, regenerator, cellular, frequency reuse;
- describe situations in which mobile communications can affect everyday life.

## Optelectronics

Candidates should be able to:

- describe how optical fibres are constructed and work;
- understand the use of total internal reflection in optical fibre systems;
- describe the effect of attenuation, dispersion and radiation on an optical digital signal;
- describe the use of a laser diode as a light source and the use of PIN diodes as detectors (detailed knowledge of devices not required).

# 3.6 Unit 6 ELEC6 Practical System Synthesis

## Nature of Coursework

While the process for conducting the A2 coursework is similar to that for the AS coursework, the additional experience of the candidates at A2 means that the assessment of the work can focus on higher level skills than could be expected from AS candidates. Those assessment skills which do overlap provide synopticity. The coursework undertaken by the candidates will be to design, construct and assess an electronic system to solve a problem, but for A2 the problem identified will be focused on the theoretical work of A2 Unit 4 and Unit 5. In addition to the coursework requirements outlined in Section 3.3, candidates will also be required to provide a full evaluation of their system.

A summary of the higher level skills required from A2 candidates is given below:

**Section A: Problem Analysis and Solution Design**
It is expected that candidates will give a detailed description of the requirements of their system and so more emphasis is placed on the performance parameters specified and the justification for the values selected.



**Section B: System Development**
When candidates are constructing their systems, they will be experienced in constructing circuits and calculating component values. However, the interfacing of subsystems, particularly those involving complex ICs and modules is important for assessment.

**Section C: Making Measurements**
It is expected that candidates will be able to measure the system performance in terms of the system parameters, and so emphasis is placed on the accuracy of these measurements in terms of the suitability of the measuring instruments used and their calibrated accuracy.

**Section D: Evaluation and Report**
The report will contain clear photographic evidence and a complete circuit diagram. It is therefore appropriate to concentrate on the evaluation of the final performance figures for the electronic system with the performance parameters in the specification. Differences need to be justified as part of the evaluation. However, evaluation can only take place for a system that has been fully specified and it is only possible to know if the performance matches the initial specification if comprehensive testing and measurements have been made.

## Coursework Overview

Those candidates continuing to A2 will have gained significant experience from their successful AS course and so demands of the A2 coursework should be commensurate with this, as well as providing opportunities to revisit some of the skills gained during AS level work. In this way the A2 coursework provides synopticity throughout the course.

This work is expected to be carried out alongside the candidates’ theoretical studies. The expected outcome is a working Electronic system and a written report detailing the work undertaken and an assessment of the success of the work in solving the initial problem.

The A2 coursework undertaken for Unit 6 should be such that it can be completed in 30 hours (with a suggestion of 20 hours’ laboratory/workshop time and 10 hours’ private study) and must contain **at least three** active devices. Candidates should be encouraged to select a problem to solve in which they are interested and which is considered achievable by their supervisor. Supervisors must ensure that the work undertaken is that of the candidate and is of an appropriate standard for an A2 Level Electronics course, and is not largely software based.

Coursework guidance can be found in Section 3.8.

# Assessment Criteria – Commentary on the A2 Marking Criteria

There are 25 marking criteria. For each criterion, Supervisors can award 0, 1 or 2 marks as appropriate.

## A Problem Analysis and Solution Design

The candidate:

(a) - clearly defined the problem to be solved with minimal guidance.
Marks:
0 the supervisor has to help the candidate to choose a problem to solve and the candidate provides an inadequate description.
1 the candidate makes an independent choice but gives an inadequate description OR receives assistance with the choice but gives a clear description.
2 the candidate makes an independent choice and provides an adequate description.

(b) – carried out relevant research from at least two named sources.
Marks:
0 there is inadequate evidence that research has been carried out from two separate named sources.
1 there is inadequate evidence documented OR when inadequate details are given of the two named sources.
2 well-documented information from at least two separate sources whose full details are recorded.



(c) – carried out practical investigations into at least two relevant factors.
Marks:
0 there is inadequate evidence that two practical investigations have been conducted.
1 there is well-documented evidence for one practical investigation OR when inadequate details are given of the two practical investigations.
2 there is well-documented information from at least two practical investigations.

(d) – specified at least three **numerical** and **realistic** parameters.
Marks:
0 an inadequate specification containing fewer than two parameters.
1 a specification, where inadequate details are given OR when only two parameters are specified in detail.
2 a detailed specification containing at least three numerical and realistic parameters.

(e) – justified the values of the three numerical parameters.
Marks:
0 there is little or no attempt made to justify the specification parameters.
1 there is some justification for at least two of the specification parameters.
2 a detailed justification for at least three of the parameters specified.

(f) – considered two or more alternative solutions.
Marks:
0 inadequate details given of alternative solutions.
1 a description of two alternative solutions, where the advantages and disadvantages are not fully given.
2 a detailed description of the advantages and disadvantages of at least two alternatives.

(g) – justified the choice of solution from the others considered.
Marks:
0 inadequate details given for the choice.
1 a weak justification for the choice made.
2 a detailed justification for the choice made.

## B System Development

Items (a), (b) and (c) can only be awarded if three active devices are used.

The candidate:

(a) – devised circuit details of at least one subsystem with minimal guidance.
Marks:
0 no significant details of a subsystem OR fewer than three active devices within the whole system.
1 incomplete details of one subsystem.
2 full details of any subsystem.

(b) – made and recorded two or more measurements on at least one subsystem.
Marks:
0 no significant details of any subsystem measurements OR fewer than three active devices within the whole system.
1 incomplete details of any subsystem measurements.
2 full details of at least two subsystem measurements.

(c) – explained how two or more different subsystems were interfaced together.
Marks:
0 inadequate details of any interfacing issues.
1 incomplete details of an interfacing issue and how it was solved.
2 full details of an interfacing issue and how it was solved.

(d) – explained in detail how the system works.
Marks:
0 inadequate details of how the system works AND/OR there is little evidence of any form or style to the writing.
1 incomplete details of how the system works AND/OR the form and style of writing are inappropriate.
2 full details of how the system works and the form and style of writing are appropriate.

(e) – converted circuit diagrams into a well-organised circuit board layout with minimal guidance.
Marks:
0 a disorganised layout even with guidance.
1 a disorganised layout achieved with minimal guidance OR a well-organised layout with guidance.
2 a well-organised layout achieved with minimal guidance.

(f) – safely constructed two or more subsystems of the complete electronic system.
Marks:
0 an inadequate risk assessment and fewer than two subsystems constructed.
1 an inadequate risk assessment but at least two subsystems constructed OR an adequate risk assessment and fewer than two subsystems constructed.
2 an adequate risk assessment and at least two subsystems constructed.

(g) – produced a neatly constructed electronic system.
Marks:
0 a system with unnecessarily long wires covering components, so making any modifications difficult.
1 a system which has been constructed without sufficient care, some wires too long and components not always secured to the circuit board.
2 a neatly constructed and carefully organised system.

(h) – made all of the system function with minimal guidance.
Marks:
0 a system which does not work fully OR where the candidate received significant guidance.
1 a system which has some minor faults but the candidate received only minimal guidance OR when the system works fully and the candidate received some guidance.
2 a system which works fully and the candidate received only minimal guidance.

## C Making Measurements

The candidate:

(a) – devised a test procedure for the complete system prior to making any system measurements.
Marks:
0 there is little or no evidence of any planning prior to testing.
1 there is some evidence of planning of the testing procedures and some of the relevant equipment has been identified.
2 there is clear evidence of detailed planning of the testing procedures and the relevant equipment has been identified.

(b) – made and recorded detailed numerical measurements on the complete system parameters.
Marks:
0 there is little or no evidence of anything other than basic testing.
1 most relevant numerical measurements on the system parameters have been made and recorded.
2 all relevant numerical measurements on the system parameters have been made and carefully recorded.

(c) – justified the accuracy of these measurements.
Marks:
0 there is little or no evidence of any justification for the accuracy of the measurements made.
1 there is some justification for the accuracy of the measurements made, with one discussed in detail.
2 there is detailed justification for most of the measurements made on the system parameters.

(d) – assessed the working parts of the complete system and referred to the measurements made.
Marks:
0 there is little or no evidence of any assessment of the performance of the complete system.
1 an assessment is made but there is little reference to the measurements made of the system parameters.
2 a detailed assessment is made of the final system and reference is made to the measurement of the system parameters.

(e) – suggested modifications to overcome the limitations in the performance of the complete system.
Marks:
0 there is little or no evidence of any attempt to identify limitations in the performance of the complete system.
1 limitations are identified but no suggestions are made as to how to overcome these limitations.
2 limitations are identified along with suggestions of how to overcome them OR there are no limitations of the system and full marks have been gained for A(d) and C(b).

(f) – carried out the modifications and re-assessed the system.
Marks:
0 there is little or no evidence of any modification of the complete system to enhance its performance.
1 modifications are made, but a re-assessment is not made.
2 modifications and a detailed re-assessment are made of the final system OR there are no limitations and full marks have been gained for A(d), C(b) and C(e).

## D Evaluation and Report

Items A(d) and A(e) must have scored 2 marks each if D(a) is to be awarded 2 marks. Items C(b) and C(c) must have scored 2 marks each if D(b) is to be awarded 2 marks.

The report:

(a) – evaluates the performance of the final system against the initial specification.
Marks:
0 there is little or no evaluation of the complete system against the initial specification parameters.
1 an evaluation of the complete system is made against the initial specification parameters.
2 a full evaluation of the complete system is made against the initial specification parameters including its fitness for purpose in solving the initial problem.

(b) – compares the initial specifications and final performance.
Marks:
0 there is little or no attempt to demonstrate that the final system's performance figures match the initial design specification OR the system does not match the initial design specification.
1 the candidate demonstrates that the system falls just short of matching the initial design specification.
2 the candidate demonstrates that the system matches or exceeds the initial design specification.

(c) – details all stages of the development of the project.
Marks:
0 significant details are omitted from the report AND/OR the meaning of the report is unclear. The candidate will be awarded 0 for this criteria if no photographic evidence is supplied. Correct terminology is seldom used and spelling, punctuation and grammar are poor.
1 the report has small omissions, is not succinct, occasionally uses correct terminology and has inaccurate spelling, punctuation and grammar.
2 the report is coherent, complete, succinct with correct terminology used throughout and accurate spelling, punctuation and grammar.

(d) – contains an acknowledgement of **all** sources of information and help, including a bibliography.
Marks:
0 there is an attempt to give a summary of the sources of information and help received, presentation of this information is not appropriate to this type of report.
1 there are some details of the sources of information and help received but it is incomplete and not presented in an appropriate style and format for this type of report.
2 the summary of sources of information and help received is complete and presented in an appropriate style and format for this type of report.

## 3.7 How Science Works

*How Science Works* is an underpinning set of concepts and is the means whereby students come to understand how scientists investigate scientific phenomena in their attempts to explain the world about us. Moreover, *How Science Works* recognises the contribution scientists have made to their own disciplines and to the wider world.

Further, it recognises that scientists may be influenced by their own beliefs and that these can affect the way in which they approach their work. Also, it acknowledges that scientists can and must contribute to debates about the uses to which their work is put and how their work influences decision-making in society.

In general terms, it can be used to promote students' skills in solving scientific problems by developing an understanding of:

- the concepts, principles and theories that form the subject content
- the procedures associated with the valid testing of ideas and, in particular, the collection, interpretation and validation of evidence
- the role of the scientific community in validating evidence and also in resolving conflicting evidence.

As students become proficient in these aspects of *How Science Works*, they can also engage with the place and contribution of science in the wider world. In particular, students will begin to recognise:

- the contribution that scientists can make to decision-making and the formulation of policy
- the need for regulation of scientific enquiry and how this can be achieved
- how scientists can contribute legitimately in debates about those claims which are made in the name of science.

An understanding of *How Science Works* is a requirement for this specification and is set out in the following bullet points which are taken from the *GCE AS and A Level subject criteria for science subjects*. Each bullet point is expanded in the context of Electronics. The specification references given illustrate where the example is relevant and could be incorporated.

| | |
|---|---|
| **A** | **Use theories, models and ideas to develop and modify scientific explanations** |
| | Scientists use theories and models to attempt to explain observations. These theories or models can form the basis for scientific experimental work.<br>Scientific progress is made when validated evidence is found that supports a new theory or model.<br>Candidates should use examples of scientific theories and models that have been developed and apply them to real world situations. |
| | *Examples in this specification include:*<br>• Unit 1, Introductory Electronics, System synthesis: represent complex systems in terms of subsystems.<br>• Unit 5, Communications Systems, Mobile Communications: understand how a large number of mobile telephones can be used within a restricted frequency allocation. |

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| **B** | **Use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas** |
| | Scientists use their knowledge and understanding when observing objects and events, in defining a scientific problem and when questioning the explanations of themselves or of other scientists.<br>Scientific progress is made when scientists contribute to the development of new ideas, materials and theories.<br>As part of their coursework project, candidates will learn to:<br>• define an electronics problem;<br>• draw up a suitable specification which enables the problem to be solved;<br>• build and test the solution and review it in the light of findings. |
| | *Examples in this specification include:*<br>• Unit 1, Introductory Electronics, Design and simplification of combinational logic systems: describe and explain the operation of combinational logic systems.<br>• Unit 6, Practical System Synthesis, Section A, Problem Analysis and Solution design:<br>(a) clearly defined the problem to be solved with minimal guidance;<br>(b) carried out relevant research from at least two named sources;<br>(c) carried out practical investigations into at least two relevant factors;<br>(d) specified at least three numerical and realistic parameters;<br>(e) justified the values of the three numerical parameters;<br>(f) considered two or more alternative solutions;<br>(g) justified the choice of solution from the others considered. |

<table>
<tr><td rowspan="3">C</td><td>Use appropriate methodology, including ICT, to answer scientific questions and solve scientific problems</td></tr>
<tr><td>Observations ultimately lead to explanations in the form of hypotheses. In turn, these hypotheses lead to predictions that can be tested experimentally. Observations are one of the key links between the ‘real world’ and the abstract ideas of science.<br><br>Once an experimental method has been validated, it becomes a protocol that is used by other scientists.<br><br>ICT can be used to speed up, collect, record and analyse experimental data.<br><br>Candidates will know how to:<br>• plan, or follow a given plan, to carry out an investigation on topics relevant to the specification;<br>• identify the variables in the investigation and the control;<br>• select appropriate apparatus and methodology, including where necessary ICT, to carry out reliable experiments relevant to topics in the specification;<br>• choose measuring instruments according to their sensitivity and precision.<br><br>There are many opportunities which permeate the practical work. However, teachers should endeavour to incorporate these into their teaching.</td></tr>
<tr><td>Examples in this specification include:<br>• Unit 2, Further Electronics, Amplifier subsystems:<br>use the formula $V_{out} = -R_f\left(\frac{V_1}{R_1}+\frac{V_2}{R_2}+\frac{V_3}{R_3}\right)$.<br>• Unit 4, Programmable Control Systems, Programming:<br>convert a sequence of fundamental operations into a flow chart.</td></tr>
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| **D** | **Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts** |
| | Scientists perform a range of experimental skills that include manual and data skills (tabulation, graphical skills etc).<br>Scientists should select and use equipment that is appropriate when making accurate measurements and should record these measurements methodically.<br>Scientists carry out experimental work in such a way as to minimise the risk to themselves, to others and to the materials, including organisms, used.<br>Candidates will be able to:<br>• follow appropriate experimental procedures in a logical order;<br>• use appropriate apparatus and methods to make accurate and reliable measurements;<br>• identify and minimise significant sources of experimental error;<br>• identify and take account of risks in carrying out practical work. |
| | *Examples in this specification include:*<br>• Unit 3, Practical System Development, Section B, System Development, and Section C, Making Measurements:<br>B(c) assessed the performance of at least one subsystem, using measurements;<br>C(c) made and recorded detailed numerical measurements on the complete system parameters.<br>• Unit 6, Practical System Synthesis, Section B, System Development, and Section C, Making Measurements:<br>B(b) made and recorded two or more measurements on at least one subsystem;<br>C(b) made and recorded detailed numerical measurements on the complete system parameters;<br>C(c) justified the accuracy of these measurements. |

<table>
<tr>
<td rowspan="3">E</td>
<td>Analyse and interpret data to provide evidence, recognising correlations and causal relationships</td>
</tr>
<tr>
<td>Scientists look for patterns and trends in data as a first step in providing explanations of phenomena. The degree of uncertainty in any data will affect whether alternative explanations can be given for the data.<br><br>Anomalous data are those measurements that fall outside the normal, or expected, range of measured values. Decisions on how to treat anomalous data should be made only after examination of the event.<br><br>In searching for causal links between factors, scientists propose predictive theoretical models that can be tested experimentally.  When experimental data confirm predictions from these theoretical models, scientists become confident that a causal relationship exists.<br><br>Candidates will know how to:<br>• tabulate and process data;<br>• identify data that is outside the expected range of values;<br>• plot and use appropriate graphs to establish or verify relationships between variables and system performance;<br>• use equations and carry out appropriate calculations.</td>
</tr>
<tr>
<td>Examples in this specification include:<br><br>• Unit 3, Practical System Development, Section C, Making Measurements:<br>(d) assessed the working parts of the complete system and referred to the measurements made;<br>(e) identified some limitations in the performance of the complete system and suggested modifications to overcome these limitations.<br>• Unit 6, Practical System Synthesis, Section C, Making Measurements:<br>(c) justified the accuracy of these measurements;<br>(d) assessed the working parts of the complete system and referred to the measurements made;<br>(e) suggested modifications to overcome the limitations in the performance of the complete system.</td>
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| F | **Evaluate methodology, evidence and data, and resolve conflicting evidence** |
| | The validity of new evidence, and the robustness of conclusions that stem from them, is constantly questioned by scientists.<br>Experimental methods must be designed adequately to test predictions.<br>Solutions to scientific problems are often developed when different research teams produce conflicting evidence. Such evidence is a stimulus for further scientific investigation, which involves refinements of experimental technique or development of new hypotheses.<br>Candidates will know how to:<br>• Identify the limitations of both the components and methodology used;<br>• modify their system;<br>• re-assess their system in the light of findings. |
| | *Examples in this specification include:*<br>• Unit 3, Practical System Development, Section C, Making Measurements:<br>(e) identified some limitations in the performance of the complete system and suggested modifications to overcome these limitations;<br>(f) carried out the modifications and re-assessed the system.<br>• Unit 6, Practical System Synthesis, Section D, Evaluation and Report:<br>(a) the candidate evaluated the performance of the final system against the initial specification;<br>(c) the report details all stages of the development of the project. |

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| G | **Appreciate the tentative nature of scientific knowledge** |
| | Scientific explanations are those that are based on experimental evidence which is supported by the scientific community.<br>Scientific knowledge changes when new evidence provides a better explanation of scientific observations.<br>Candidates will understand that system performance is founded on experimental evidence and that such evidence must be shown to be reliable and reproducible. If such evidence does not support system performance then the system must be modified or replaced. |
| | *Examples in this specification include:*<br>• Unit 3, Practical System Development, Section C, Making Measurements:<br>(b) made and recorded basic numerical measurements on the complete system parameters;<br>(c) made and recorded detailed numerical measurements on the complete system parameters;<br>(d) assessed the working parts of the complete system and referred to the measurements made;<br>(e) identified some limitations in the performance of the complete system and suggested modifications to overcome these limitations.<br>• Unit 4, Programmable Control Systems, Robotic Systems:<br>describe the ability of robotic systems to sustain artificially intelligent behaviour through the use of artificial neural networks. |

<table>
<tr><td rowspan="3">H</td><td>Communicate information and ideas in appropriate ways using appropriate terminology</td></tr>
<tr><td>By sharing the findings of their research, scientists provide the scientific community with opportunities to replicate and further test their work, thus either confirming new explanations or refuting them.<br><br>Scientific terminology avoids confusion amongst the scientific community, enabling better understanding and testing of scientific explanations.<br><br>Candidates will be able to provide explanations using correct scientific terms, and support arguments with equations, diagrams, and where appropriate clear graphs. The need for answers to be expressed in such a way pervades all of the written papers and the coursework.</td></tr>
<tr><td>Examples in this specification include:<br><br>• Unit 3, Practical System Development, Section D, The report:<br>(a) details all stages of the development of the project;<br>(b) contains clear photographic evidence and a complete circuit diagram;<br>(c) contains an acknowledgement of all sources of information and help, including a bibliography.<br>• Unit 6, Practical System Synthesis, Section D, Evaluation and Report:<br>(a) the candidate evaluated the performance of the final system against the initial specification;<br>(b) the initial specification and final performance agree very closely.</td></tr>
</table>

<table>
<tr><td rowspan="3">I</td><td>Consider applications and implications of science and appreciate their associated benefits and risks</td></tr>
<tr><td>Scientific advances have greatly improved the quality of life for the majority of people. Developments in technology, medicine and materials continue to further these improvements at an increasing rate.<br><br>Scientists can predict and report on some of the beneficial applications of their experimental findings.<br><br>Scientists evaluate, and report on, the risks associated with the techniques they develop and applications of their findings.<br><br>Candidates will study how science has been applied to develop technologies that improve our lives and will also appreciate that the technologies themselves pose risks that have to be balanced against the benefits.</td></tr>
<tr><td>Examples in this specification include:<br><br>• Unit 2, Further Electronics, Power amplifier subsystems:<br>describe the common types of distortion associated with push-pull amplifier subsystems (cross-over and saturation/clipping) and how they can be reduced.<br>• Unit 4, Programmable Control Systems, Robotic Systems:<br>discuss the applications of robotic systems.</td></tr>
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| J | **Consider ethical issues in the treatment of humans, other organisms and the environment** |
| | Scientific research is funded by society, either through public funding or through private companies that obtain their income from commercial activities. Scientists have a duty to consider ethical issues associated with their findings.<br>Individual scientists have ethical codes that are often based on humanistic, moral and religious beliefs.<br>Scientists are self-regulating and contribute to decision making about what investigations and methodologies should be permitted.<br>Candidates will appreciate how science and society interact. They should examine how science has provided solutions to problems but that the solutions require society to form judgements as to whether the solution is acceptable in view of moral issues that result. Issues such as the effects on the planet, and the economic and physical well being of the living things on it will also be considered. |
| | *Examples in this specification include:*<br>• Unit 3, Practical System Development, Section B, System Development:<br>(f) safely constructed two or more subsystems of the complete electronic system.<br>• Unit 4, Programmable Control Systems, Robotic Systems:<br>describe the social and economic impact of robotic systems. |

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| K | **Appreciate the role of the scientific community in validating new knowledge and ensuring integrity** |
| | The findings of scientists are subject to peer review before being accepted for publication in a reputable scientific journal.<br>The interests of the organisations that fund scientific research can influence the direction of research. In some cases the validity of those claims may also be influenced.<br>Candidates will understand that scientists need a common set of values and responsibilities. They should know that scientists undertake a peer-review of the work of others. They should know that scientists and engineers work with a common aim to progress scientific knowledge and understanding in a valid way and that accurate reporting of findings takes precedence over recognition of success of an individual. Similarly, the value of findings should be based on their intrinsic value and the credibility of the research. |
| | *Examples in this specification include:*<br>• Unit 3, Practical System Development, Section D, The report:<br>(a) details all stages of the development of the project<br>(b) contains clear photographic evidence and a complete circuit diagram<br>(c) contains an acknowledgement of **all** sources of information and help, including a bibliography.<br>• Unit 4, Programmable Control Systems, Robotic Systems:<br>discuss the applications of robotic systems. |

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| | **Appreciate the ways in which society uses science to inform decision-making** |
| L | Scientific findings and technologies enable advances to be made that have potential benefit for humans.<br>In practice, the scientific evidence available to decision makers may be incomplete.<br>Decision makers are influenced in many ways, including their prior beliefs, their vested interests, special interest groups, public opinion and the media, as well as by expert scientific evidence<br>Candidates will be able to appreciate that scientific evidence should be considered as a whole. They will realise that new scientific developments inform new technology. They will realise the media and pressure groups often select parts of scientific evidence that support a particular viewpoint and that this can influence public opinion which in turn may influence decision makers. Consequently, decision makers may make socially and politically acceptable decisions based on incomplete evidence. |
| | *Examples in this specification include:*<br>• Unit 1, Introductory Electronics, Transistors and MOSFETs: compare the advantages and disadvantages of a MOSFET and a junction transistor when they are both used as switches.<br>• Unit 4, Programmable Control Systems, Microprocessor Subsystems: describe the social and economic benefits and implications of the use of microcontrollers. |

## 3.8 Coursework Guidance

Having decided upon the aim of the project, candidates should undertake appropriate research so that a list of performance parameters (specification) can be given. It is expected that the specification will contain realistic numerical values against which the final performance of the work can be judged. Candidates are expected to consider alternatives and give reasons for selecting the chosen solution.

The overall system should be developed as subsystems which should be tested and assessed in isolation before being incorporated into the complete system. This will ensure that the complete system grows by a gradual and incremental process, having been tested at each stage of its development. Candidates will be expected to develop their coursework systems on protoboard and may use computer simulations to help them. The systems should be left in protoboard form; there is no requirement for candidates to transfer their work to strip board or printed circuit board. For all modes of circuit assembly, the layout and mounting of components and wiring should be neat and logical in order to assist in the design, testing and fault finding processes. Candidates will be expected to undertake risk assessments during their coursework in order to ensure the safety of themselves, associated workers, the components and test equipment.

When completed, a plan for testing the complete system should be drawn up prior to any testing of the system. Full testing should take place but only for the conditions likely to be encountered in normal operation; testing should not be to destruction. Testing should cover the important operating parameters of the system as detailed in the specification. It is neither necessary nor appropriate to measure and record every possible voltage or current. The testing should be fully documented with results being displayed in tables and graphs, as appropriate. These tests will enable the candidate to assess the system and identify faults and limitations. The candidate should aim to modify the final system to correct for any limitations and then re-assess its final performance.

Throughout the project, candidates are expected to keep a record of consultations with their supervisor. This can be used to provide supplementary evidence for the award of marks. A copy of the Record of Supervision form is provided in *Appendix F*.

The candidates are expected to fully document the development of their project in the report. It should be remembered that it is the evidence in this report upon which the coursework is marked and assessed. It is recommended that the report is written at the same time as the project is being carried out; it should not be left until the practical work is complete.

The report must contain clear photographic evidence. Supervisors must annotate reports to justify the award of marks (see Section 6.5). Credit cannot be given unless there is sufficient evidence to support the award of marks. The report should be presented in a logical order that is easy to read and understand. It should be free from repetition and must contain an acknowledgement of all sources of information and help.

The assessment scheme for the coursework is criterion-referenced and so it would be acceptable for all the candidates in a centre to gain high marks. Supervisors should note that coursework should be such that access to all of the marks for all of the skills should be available to all candidates.

The role of the supervisor is crucial. It is the supervisor's task to ensure that appropriate project work is undertaken by the candidate and to provide appropriate guidance. The supervisor should also provide additional guidance and assistance if requested, but this must be taken into account when the work is assessed.

Attention is drawn to the distinction between guidance and assistance given to candidates. Guidance is advice given to the candidate by the supervisor but where the supervisor does not become involved in doing the work. All candidates are entitled to guidance from their supervisor. Assistance is help given to the candidate by the supervisor where the supervisor becomes involved in doing the work, eg fault finding.

It should be noted that there are no marking criteria which relate to the complexity of the electronic systems produced. Candidates are required to use a minimum of three active devices and will be penalised within Section B of the coursework marking criteria if they fail to comply with this. Additional complexity should be used where necessary to complete the electronic system and maintain the motivation of the candidate. However, it is essential that the candidate has a realistic prospect of achieving a working system and it should not be so complex that this cannot be achieved.

Physical hardware must be produced. If there is no hardware then a mark of 0 must be awarded, even if the system has been computer modelled. The absolute minimum requirement for a report is a signed cover sheet and a clear photograph of the hardware and these must be included with all submitted reports.

## 3.9 Mathematical Requirements

In order to be able to develop their skills, knowledge and understanding in electronics, students need to have been taught, and to have acquired competence in, the appropriate areas of mathematics relevant to electronics as indicated below.

### Arithmetic and numerical computation

(a) recognise and use expressions in decimal and standard form

(b) make estimates of the results of calculations (without using a calculator)

(c) use ratios, fractions and percentages

(d) use calculators to find and use $x^n$, $\frac{1}{x}$, $\sqrt{x}$, $\log_{10} x$, $e^x$, $\ln_e x$ functions

(e) use calculators to handle sin $x$, cos $x$, tan $x$ when $x$ is expressed in degrees or radians

(f) use hexadecimal and binary systems

### Handling data

(a) use an appropriate number of significant figures

(b) use prefix and power of ten notation for large and small quantities

(c) be aware that electronic components operate within a tolerance and use this data accordingly

(d) use negative notation index for units

(e) use logarithms in relation to quantities which range over several orders of magnitude

### Algebra

(a) understand and use the symbols: $=$, $<$, $\ll$, $\gg$, $>$, $\propto$, $\sim$

(b) change the subject of an equation

(c) substitute numerical values into algebraic equations using appropriate units for physical quantities

(d) solve simple algebraic equations

### Graphs

(a) translate information between graphical, numerical and algebraic forms

(b) plot two variables from experimental or other data

(c) understand that $y = mx + c$ represents a linear relationship

(d) use a variety of scales on axes, such as logarithmic and semi-logarithmic

(e) determine the slope and intercept of a linear graph

(f) draw and use the slope of a tangent to a curve as a measure of rate of change

(g) recognise and interpret sine and cosine waves, including amplitude, frequency, period and phase

It is assumed that candidates will have the use of calculators which have at least the functions of addition (+), subtraction (–), multiplication (×), division (÷), square root (√), sine, cosine, tangent, natural logarithms and their inverses, logarithms to base 10 and their inverses and a memory.

3

# 4 Scheme of Assessment

## 4.1 Aims

AS and A Level courses based on this specification should encourage candidates to:

a) develop their interest in, and enthusiasm for Electronics, including developing an interest in further study and careers in the subject;

b) appreciate how society makes decisions about scientific issues and how the sciences contribute to the success of the economy and society;

c) develop and demonstrate a deeper appreciation of the skills, knowledge and understanding of *How Science Works*;

d) develop essential knowledge and understanding of different areas of the subject and how they relate to each other.

## 4.2 Assessment Objectives (AOs)

The Assessment Objectives are common to AS and A Level. The assessment units will assess the following assessment objectives in the context of the content and skills set out in Section 3 (Subject Content).

Specifications require, in all assessment units, that candidates demonstrate these assessment objectives in the context of the skills, knowledge and understanding prescribed, including using extended prose. Each assessment unit addresses one, or more, aspects of each of the assessment objectives. In the context of these assessment objectives, the following definitions apply:

- knowledge: includes facts, specialist vocabulary, principles, concepts, theories, models, practical techniques, studies and methods
- issues: include ethical, social, economic, environmental, cultural, political and technological
- processes: include collecting evidence, explaining, theorising, modelling, validating, interpreting, planning to test an idea, peer reviewing.

### AO1: Knowledge and understanding of science and of *How Science Works*

Candidates should be able to:

a) recognise, recall and show understanding of scientific knowledge

b) select, organise and communicate relevant information in a variety of forms.

### AO2: Application of knowledge and understanding of science and of *How Science Works*

Candidates should be able to:

a) analyse and evaluate scientific knowledge and processes

b) apply scientific knowledge and processes to unfamiliar situations including those related to issues

c) assess the validity, reliability and credibility of scientific information.

### AO3: *How Science Works*

Candidates should be able to:

a) demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods

b) make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy

c) analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.

### Quality of Written Communication (QWC)

In GCE specifications which require candidates to produce written material in English, candidates must:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary where appropriate.

In this specification, QWC will be assessed in both Unit 3 and Unit 6 by means of the written coursework report. The report provides opportunity for the assessment of the Quality of Written Communication (QWC). This is undertaken within the two marking criteria relating to the description of how the whole system works, (AS)Bd and (A2)Bd and (AS)Da and (A2)Dc.

### Weighting of Assessment Objectives for AS

The table below shows the approximate weighting of each of the Assessment Objectives in the AS units.

| Assessment Objectives | Unit Weightings (%) | | | Overall Weighting of AOs (%) |
|---|---|---|---|---|
| | Unit 1 | Unit 2 | Unit 3 | |
| AO1 Knowledge and understanding | 16 | 16 | 3 | 35 |
| AO2 Application of knowledge and understanding | 16 | 16 | 3 | 35 |
| AO3 How science works | 3 | 3 | 24 | 30 |
| Overall weighting of units (%) | 35 | 35 | 30 | 100 |

### Weighting of Assessment Objectives for A Level

The table below shows the approximate weighting of each of the Assessment Objectives in the AS and A2 units.

| Assessment Objectives | Unit Weightings (%) | | | | | | Overall Weighting of AOs (%) |
|---|---|---|---|---|---|---|---|
| | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | |
| AO1 Knowledge and understanding | 8 | 8 | 1½ | 7 | 7 | 2 | 33½ |
| AO2 Application of knowledge and understanding | 8 | 8 | 1½ | 9 | 9 | 1 | 36½ |
| AO3 How science works | 1½ | 1½ | 12 | 1½ | 1½ | 12 | 30 |
| Overall weighting of units (%) | 17½ | 17½ | 15 | 17½ | 17½ | 15 | 100 |



## 4.3 National Criteria

This specification complies with the following.

- The Subject Criteria for Science
- The Code of Practice for GCE
- The GCE AS and A Level Qualification Criteria
- The Arrangements for the Statutory Regulation of External Qualifications in England, Wales and Northern Ireland: Common Criteria

## 4.4 Prior Learning

There are no prior learning requirements.

We recommend that candidates should have acquired the skills and knowledge associated with a GCSE Electronics course or equivalent. Any requirements set for entry to a course following this specification are at the discretion of centres.

## 4.5 Synoptic Assessment and Stretch and Challenge

The definition of synoptic assessment in the context of science is:

Synoptic assessment requires candidates to make and use connections within and between different areas of science, for example, by:

- applying knowledge and understanding of more than one area to a particular situation or context;
- using knowledge and understanding of principles and concepts in planning experimental and investigative work and in the analysis and evaluation of data;
- bringing together scientific knowledge and understanding from different areas of the subject and applying them.

There is a requirement to formally assess synopticity at A2. Synoptic assessment in Electronics is assessed in the A2 units through both the written papers (Unit 4 and Unit 5) and the coursework project (Unit 6).

The requirement that Stretch and Challenge is included at A2 will be met in the externally assessed units by:

- using a variety of stems in questions to avoid a formulaic approach through the use of such words as: analyse, evaluate, compare, discuss;
- avoiding assessments being too atomistic, connections between areas of content being used where possible and appropriate;
- having some requirement for extended writing;
- using a range of question types to address different skills, ie not just short answer/structured questions;
- asking candidates to bring to bear knowledge and the other prescribed skills in answering questions rather than simply demonstrating a range of content coverage.

## 4.6 Access to Assessment for Disabled Students

AS/A Levels often require assessment of a broader range of competences. This is because they are general qualifications and, as such, prepare candidates for a wide range of occupations and higher level courses.

The revised AS/A Level qualification and subject criteria were reviewed to identify whether any of the competences required by the subject presented a potential barrier to any disabled candidates. If this were the case, the situation was reviewed again to ensure that such competences were included only where essential to the subject. The findings of this process were discussed with disability groups and with disabled people.

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments. For this reason, very few candidates will have a complete barrier to any part of the assessment.

Candidates who are still unable to access a significant part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award. They would be given a grade on the parts of the assessment they had taken and there would be an indication on their certificate that not all the competences had been addressed. This will be kept under review and may be amended in the future.

# 5 Administration

## 5.1 Availability of Assessment Units and Certification

After June 2013, examinations and certification for this specification are available in June only.

## 5.2 Entries

Please refer to the current version of *Entry Procedures and Codes* for up to date entry procedures. You should use the following entry codes for the units and for certification.

Unit 1 - ELEC1

Unit 2 - ELEC2

Unit 3 - ELEC3

Unit 4 - ELEC4

Unit 5 - ELEC5

Unit 6 - ELEC6

AS certification - 1431

A Level certification - 2431

## 5.3 Private Candidates

This specification is available to private candidates. As we are no longer producing supplementary guidance in hard copy, see our website for guidance and information on taking exams and assessments as a private candidate:

www.aqa.org.uk/exams-administration/entries/private-candidates



## 5.4 Access Arrangements and Special Consideration

We have taken note of equality and discrimination legislation and the interests of minority groups in developing and administering this specification.

We follow the guidelines in the Joint Council for Qualifications (JCQ) document: *Access Arrangements, Reasonable Adjustments and Special Consideration: General and Vocational Qualifications.* This is published on the JCQ website (**http://www.jcq.org.uk**) or you can follow the link from our website (**http://www.aqa.org.uk**).

Section 8.4 of the document states that "a practical assistant is not permitted to carry out tasks which are the focus of the assessment". Accordingly, only candidates who can carry out the tasks themselves can access marks for the Practical Skills Assessment (PSA) in Unit 3 and Unit 6. However, so that candidates may obtain reliable experimental results, practical assistants may be used to carry out manipulation under the candidate's instructions. In these circumstances, as stated in Section 2.4 of the document, marks cannot be gained for demonstrating techniques. The candidates will be able to access the marks available for the other skills, for example handling and evaluating data collected, and drawing conclusions in AO3.

### Access Arrangements

We can make arrangements so that candidates with disabilities can access the assessment. These arrangements must be made **before** the examination. For example, we can produce a Braille paper for a candidate with a visual impairment.

### Special Consideration

We can give special consideration to candidates who have had a temporary illness, injury or indisposition at the time of the examination. Where we do this, it is given **after** the examination.

Applications for access arrangements and special consideration should be submitted to AQA by the Examinations Officer at the centre.

## 5.5 Language of Examinations

We will provide units in English only.

## 5.6 Qualification Titles

Qualifications based on this specification are:

- AQA Advanced Subsidiary GCE in Electronics, and
- AQA Advanced Level GCE in Electronics.

## 5.7 Awarding Grades and Reporting Results

The AS qualification will be graded on a five-point scale: A, B, C, D and E. The full A Level qualification will be graded on a six-point scale: A*, A, B, C, D and E. To be awarded an A*, candidates will need to achieve a grade A on the full A Level qualification and an A* on the aggregate of the A2 units.

For AS and A Level, candidates who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate. Individual assessment unit results will be certificated.

## 5.8 Re-sits and Shelf-life of Unit Results

Unit results remain available to count towards certification, whether or not they have already been used, as long as the specification is still valid.

Each unit is available in June only. Candidates may re-sit a unit any number of times within the shelf-life of the specification. The best result for each unit will count towards the final qualification. Candidates who wish to repeat a qualification may do so by retaking one or more units. The appropriate subject award entry, as well as the unit entry/entries, must be submitted in order to be awarded a new subject grade.

Candidates will be graded on the basis of the work submitted for assessment.

# 6 Coursework Administration

The Head of Centre is responsible to AQA for ensuring that coursework/portfolio work is conducted in accordance with AQA's instructions and JCQ instructions.

## 6.1 Supervision and Authentication of Coursework

In order to meet the regulators' Code of Practice for GCE, AQA requires:

- **candidates** to sign the Candidate Record Form (CRF) to confirm that the work submitted is their own, and
- **teachers/assessors** to confirm on the CRF that the work assessed is solely that of the candidate concerned and was conducted under the conditions laid down by the specification.

The completed CRF for each candidate must be attached to his/her work. All teachers who have assessed the work of any candidate entered for each component must sign the declaration of authentication. Failure to sign the authentication statement may delay the processing of the candidates' results.

The teacher should be sufficiently aware of the candidate's standard and level of work to appreciate if the coursework submitted is beyond the talents of the candidate.

In most centres teachers are familiar with candidates' work through class and homework assignments. Where this is not the case, teachers should make sure that **all** coursework is completed under direct supervision.

In all cases, some direct supervision is necessary to ensure that the coursework submitted can be confidently authenticated as the candidate's own.

- If it is believed that a candidate has received additional assistance and this is acceptable within the guidelines for the relevant specification, the teacher/assessor should award a mark which represents the candidate's unaided achievement. The authentication statement should be signed and information given on the relevant form.
- If the teacher/assessor is unable to sign the authentication statement for a particular candidate, then the candidate's work cannot be accepted for assessment.

## 6.2 Malpractice

Teachers should inform candidates of the AQA Regulations concerning malpractice.

Candidates must **not**:

- submit work which is not their own;
- lend work to other candidates;
- allow other candidates access to, or the use of, their own independently-sourced source material (this does not mean that candidates may not lend their books to another candidate, but candidates should be prevented from plagiarising other candidates' research);
- include work copied directly from books, the internet or other sources without acknowledgement or an attribution;
- submit work typed or word-processed by a third person without acknowledgement.

These actions constitute malpractice, for which a penalty (eg disqualification from the examination) will be applied.

If malpractice is suspected, the Examinations Officer should be consulted about the procedure to be followed.

Where suspected malpractice in coursework/portfolios is identified by a centre after the candidate has signed the declaration of authentication, the Head of Centre must submit full details of the case to AQA at the earliest opportunity. The form JCQ/M1 should be used. Copies of the form can be found on the JCQ website (**http://www.jcq.org.uk/**).

Malpractice in coursework/portfolios discovered prior to the candidate signing the declaration of authentication need not be reported to AQA, but should be dealt with in accordance with the centre's internal procedures. AQA would expect centres to treat such cases very seriously. Details of any work which is not the candidate's own must be recorded on the coursework/portfolio cover sheet or other appropriate place.

## 6.3 Teacher Standardisation

We will hold annual standardising meetings for teachers, usually in the autumn term, for the coursework units. At these meetings we will provide support in developing appropriate coursework tasks and using the marking criteria.

If your centre is new to this specification, you must send a representative to one of the meetings. If you have told us you are a new centre, either by submitting an estimate of entry or by contacting the subject team, we will contact you to invite you to a meeting.

We will also contact centres if

- the moderation of coursework from the previous year has identified a serious misinterpretation of the coursework requirements,
- inappropriate tasks have been set, or
- a significant adjustment has been made to a centre's marks.

In these cases, centres will be expected to send a representative to one of the meetings. For all other centres, attendance is optional. If you are unable to attend and would like a copy of the materials used at the meeting, please contact the subject team at **electronics@aqa.org.uk**.

## 6.4 Internal Standardisation of Marking

Centres must standardise marking within the centre to make sure that all candidates at the centre have been marked to the same standard. One person must be responsible for internal standardisation. This person should sign the Centre Declaration Sheet to confirm that internal standardisation has taken place.

Internal standardisation may involve:

- all teachers marking some trial pieces of work and identifying differences in marking standards;
- discussing any differences in marking at a training meeting for all teachers involved in the assessment;
- referring to reference and archive material such as previous work or examples from AQA's teacher standardising meetings;

but other valid approaches are permissible.

## 6.5 Annotation of Coursework



The Code of Practice for GCE states that the awarding body must require internal assessors to show clearly how the marks have been awarded in relation to the marking criteria defined in the specification and that the awarding body must provide guidance on how this is to be done.

The annotation will help the moderator to see as precisely as possible where the teacher considers that the candidates have met the criteria in the specification.

Work must be annotated by the following method:

- noting in the margin of the coursework report, at the place where the evidence is to be found, the code corresponding to the criterion; eg A(c), D(c) etc. There are two marks available for each criterion, and the supervisor should allocate a mark of 0, 1 or 2 depending upon how far the candidate has succeeded in satisfying the marking criteria. The mark should be added to the annotation on the report eg A(c)1, D(c)2.

In addition the following methods of annotation can be used:

- key pieces of evidence flagged throughout the work by annotation either in the margin or in the text;
- summative comments on the work, referencing precise sections in the work.

## 6.6 Submitting Marks and Sample Work for Moderation

The total mark for each candidate must be submitted to AQA and the moderator on the mark forms provided or by Electronic Data Interchange (EDI) by the specified date. Centres will be informed which candidates' work is required in the samples to be submitted to the moderator.

## 6.7 Factors Affecting Individual Candidates

Teachers should be able to accommodate the occasional absence of candidates by ensuring that the opportunity is given for them to make up missed assessments.

If work is lost, AQA should be notified immediately of the date of the loss, how it occurred, and who was responsible for the loss. Centres should use the JCQ form JCQ/LCW to inform AQA Candidate Services of the circumstances. Where special help which goes beyond normal learning support is given, AQA must be informed through comments on the CRF so that such help can be taken into account when moderation takes place (see Section 6.1).

Candidates who move from one centre to another during the course sometimes present a problem for a scheme of internal assessment. Possible courses of action depend on the stage at which the move takes place. If the move occurs early in the course, the new centre should take responsibility for assessment. If it occurs late in the course, it may be possible to arrange for the moderator to assess the work through the 'Educated Elsewhere' procedure. Centres should contact AQA at the earliest possible stage for advice about appropriate arrangements in individual cases.

## 6.8 Retaining Evidence and Re-using Marks

The centre must retain the work of all candidates, with CRFs attached, under secure conditions, from the time it is assessed, to allow for the possibility of an enquiry about results. The work may be returned to candidates after the deadline for enquiries about results. If an enquiry about a result has been made, the work must remain under secure conditions in case it is required by AQA.

# 7 Moderation

## 7.1 Moderation Procedures

Moderation of the coursework is by inspection of a sample of candidates' work, sent by post from the centre to a moderator appointed by AQA. The centre marks must be submitted to AQA and to the moderator by the specified deadline (see **http://www.aqa.org.uk/deadlines.php**). We will let centres know which candidates' work will be required in the sample to be submitted for moderation.

Following the re-marking of the sample work, the moderator's marks are compared with the centre marks to determine whether any adjustment is needed in order to bring the centre's assessments into line with standards generally. In some cases, it may be necessary for the moderator to call for the work of other candidates in the centre. In order to meet this possible request, centres must retain under secure conditions and have available the coursework and the CRF of every candidate entered for the examination and be prepared to submit it on demand. Mark adjustments will normally preserve the centre's order of merit, but where major discrepancies are found, we reserve the right to alter the order of merit.

## 7.2 Post-moderation Procedures

On publication of the AS/A Level results, we will provide centres with details of the final marks for the coursework unit.

The candidates' work will be returned to the centre after moderation has taken place. The centre will receive a report with, or soon after, the despatch of published results giving feedback on the appropriateness of the tasks set, the accuracy of the assessments made, and the reasons for any adjustments to the marks.

We reserve the right to retain some candidates' work for archiving or standardising purposes.

# Appendices

## A Performance Descriptions

These performance descriptions show the level of attainment characteristic of the grade boundaries at A Level. They give a general indication of the required learning outcomes at the A/B and E/U boundaries at AS and A2. The descriptions should be interpreted in relation to the content outlined in the specification; they are not designed to define that content.

The grade awarded will depend in practice upon the extent to which the candidate has met the Assessment Objectives (see Section 4) overall. Shortcomings in some aspects of the examination may be balanced by better performances in others.

A

## AS performance descriptions for Electronics

| | Assessment Objective 1 | Assessment Objective 2 | Assessment Objective 3 |
|---|---|---|---|
| **Assessment Objectives** | **Knowledge and understanding of science and of *How Science Works***<br>Candidates should be able to:<br>• recognise, recall and show understanding of scientific knowledge<br>• select, organise and communicate relevant information in a variety of forms. | **Application of knowledge and understanding of science and of *How Science Works***<br>Candidates should be able to:<br>• analyse and evaluate scientific knowledge and processes<br>• apply scientific knowledge and processes to unfamiliar situations including those related to issues<br>• assess the validity, reliability and credibility of scientific information. | ***How Science Works***<br>Candidates should be able to:<br>• demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods<br>• make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy<br>• analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways. |
| **A/B boundary performance descriptions** | Candidates characteristically:<br>a demonstrate knowledge and understanding of most principles, concepts and facts from the AS specification<br>b select relevant information from the AS specification<br>c organise and present information clearly in appropriate forms using scientific terminology. | Candidates characteristically:<br>a apply principles and concepts in familiar and new contexts involving only a few steps in the argument<br>b describe significant trends and patterns shown by data presented in tabular or graphical form<br>c interpret and explain phenomena with few errors and present arguments and evaluations clearly<br>d carry out structured calculations with few errors<br>e design a system to perform a stated function for most situations within the context of the AS specification. | Candidates characteristically:<br>a devise and plan experimental and investigative activities, selecting appropriate techniques<br>b demonstrate safe and skilful practical techniques<br>c make observations and measurements with appropriate precision and record these methodically<br>d interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts |

| | | | |
|---|---|---|---|
| **E/U boundary performance descriptions** | Candidates characteristically:<br>a demonstrate knowledge and understanding of some principles and facts from the AS specification<br>b select some relevant information from the AS specification<br>c present information using basic terminology from the AS specification. | Candidates characteristically:<br>a apply a given principle to material presented in familiar or closely related contexts involving only a few steps in the argument<br>b describe some trends or patterns shown by data presented in tabular or graphical form<br>c provide basic explanations and interpretations of some phenomena, presenting very limited evaluations<br>d carry out some steps within calculations<br>e design a simple system to perform a stated function for some situations within the context of the AS specification. | Candidates characteristically:<br>a devise and plan some aspects of experimental and investigative activities<br>b demonstrate safe practical techniques<br>c make observations and measurements and record them<br>d interpret, explain and communicate some of the results of their own and others' experimental and investigative activities, in appropriate contexts. |

## A2 performance descriptions for Electronics

| | Assessment Objective 1 | Assessment Objective 2 | Assessment Objective 3 |
|---|---|---|---|
| **Assessment Objectives** | **Knowledge and understanding of science and of *How Science Works***<br>Candidates should be able to:<br>• recognise, recall and show understanding of scientific knowledge<br>• select, organise and communicate relevant information in a variety of forms. | **Application of knowledge and understanding of science and of *How Science Works***<br>Candidates should be able to:<br>• analyse and evaluate scientific knowledge and processes<br>• apply scientific knowledge and processes to unfamiliar situations including those related to issues<br>• assess the validity, reliability and credibility of scientific information. | ***How Science Works***<br>Candidates should be able to:<br>• demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods<br>• make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy<br>• analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways. |

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| | | | |
|---|---|---|---|
| **A/B boundary performance descriptions** | Candidates characteristically:<br>a demonstrate detailed knowledge and understanding of most principles, concepts and facts from the A2 specification<br>b select relevant information from the A2 specification<br>c organise and present information clearly in appropriate forms using scientific terminology | Candidates characteristically:<br>a apply principles and concepts in familiar and new contexts involving several steps in the argument<br>b describe significant trends and patterns shown by complex data presented in tabular or graphical form<br>c interpret and explain phenomena effectively, presenting arguments and evaluations clearly and logically<br>d carry out extended calculations, with little or no guidance<br>e design a system to perform a stated function for most situations in the context of the A2 specification<br>f select a wide range of facts, principles and concepts from both AS and A2 specifications<br>g link together appropriate facts, principles and concepts from different areas of the specification. | Candidates characteristically:<br>a devise and plan experimental and investigative activities, selecting appropriate techniques<br>b demonstrate safe and skilful practical techniques<br>c make observations and measurements with appropriate precision and record these methodically<br>d interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts. |
| **E/U boundary performance descriptions** | Candidates characteristically:<br>a demonstrate knowledge and understanding of some principles and facts from the A2 specification<br>b select some relevant information from the A2 specification<br>c present information using basic terminology from the A2 specification | Candidates characteristically:<br>a apply given principles or concepts in familiar and new contexts involving a few steps in the argument<br>b describe, and provide a limited explanation of, trends or patterns shown by complex data presented in tabular or graphical form<br>c provide basic explanations and interpretations of some phenomena, presenting very limited arguments and evaluations<br>d carry out routine calculations, with guidance<br>e design a simple system to perform a stated function for some situations within the context of the A2 specification<br>f select some facts, principles and concepts from both AS and A2 specifications<br>g put together some facts, principles and concepts from different areas of the specification | Candidates characteristically:<br>a devise and plan some aspects of experimental and investigative activities<br>b demonstrate safe practical techniques<br>c make observations and measurements and record them<br>d interpret, explain and communicate some of the results of their own and others' experimental and investigative activities, in appropriate contexts |

# B Spiritual, Moral, Ethical, Social and other Issues

## Moral, Ethical, Social and Cultural Issues

It is clear that Electronics plays a major part in modern world development whether this be in the form of the domestic personal computer or the impact of global communication. This specification is keenly aware of the implications of this development. The general philosophy of the subject is rooted in an ethical approach. In particular, there are references in the specification to the social, economic, moral and cultural effects of electronic aspects of technological advance.

The following sections of the specification may be particularly apposite for analysis and discussion of moral and cultural issues:

- describe and explain the operation of modern electronics systems which may make use of several sensors (AS Unit 1 – Introductory Electronics).
- describe the social and economic benefits and implications of the use of microcontrollers (A2 Unit 4 – Programmable Control Systems).
- discuss the applications of robotic systems (A2 Unit 4 – Programmable Control Systems).
- describe the social and economic impact of robotic systems (A2 Unit 4 – Programmable Control Systems).
- describe possible future developments of robotic systems (A2 Unit 4 – Programmable Control Systems).
- state and describe situations in which mobile communications can affect everyday life (A2 Unit 5 – Communications Systems).

## European Dimension

AQA has taken account of the 1988 Resolution of the Council of the European Community in preparing this specification and associated specimen units.

## Environmental Education

AQA has taken account of the 1988 Resolution of the Council of the European Community and the Report “Environmental Responsibility: An Agenda for Further and Higher Education” 1993 in preparing this specification and associated specimen units.

## Avoidance of Bias

AQA has taken great care in the preparation of this specification and specimen units to avoid bias of any kind.

## Health and Safety

AQA recognises the need for safe practice in laboratories and tries to ensure that experimental work required for this specification and associated coursework complies with up-to-date safety recommendations.

Nevertheless, centres are primarily responsible for the safety of candidates and teachers should carry out their own risk assessment.

Candidates should make every effort to make themselves aware of any safety hazards involved in their work. As part of their coursework they will be expected to undertake risk assessments to ensure their own safety and that of associated workers, the components and test equipment.

# C Overlaps with other Qualifications

The AQA GCE Electronics Specification overlaps peripherally with AQA GCE Physics (Specification A). There is marginal overlap with AQA GCE Design and Technology (Systems and Control).

# D Key Skills

Key Skills qualifications have been phased out and replaced by Functional Skills qualifications in English, Mathematics and ICT from September 2010.

# E Data Sheet

**Resistors**

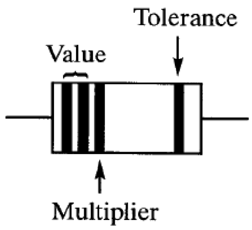
Preferred values for resistors (E24) series:
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 ohms etc.

**Resistor Printed Code (BS 1852)**

This code consists of letters and numbers:
R means $\times$ 1
K means $\times$ 1000 (ie $10^3$)
M means $\times$ 1 000 000 (ie $10^6$)
Position of the letter gives the decimal point
Tolerances are given by the letter at the end of the code,
F = ± 1%, G = ± 2%, J = ± 5%, K = ± 10%, M = ± 20%.

**Resistor Colour Code**

| Number | Colour |
|---|---|
| 0 | Black |
| 1 | Brown |
| 2 | Red |
| 3 | Orange |
| 4 | Yellow |
| 5 | Green |
| 6 | Blue |
| 7 | Violet |
| 8 | Grey |
| 9 | White |




Tolerance, gold = ±5%, silver = ±10%, no band = ±20%

**Silicon diode**

$V_F = 0.7$ V

**Silicon transistor**

$V_{be} \approx 0.7$ V in the on state, $V_{ce} \approx 0.2$ V when saturated

**Resistance**

$R_T = R_1 + R_2 + R_3 + \ldots$ series

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$ parallel

**Capacitance**

$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$ series

$C_T = C_1 + C_2 + C_3 + \ldots$ parallel

**Time constant ac theory**

$T = CR$, $T_{½} = 0.69\,CR$

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$X_C = \frac{1}{2\pi fC}$ reactance

$X_L = 2\pi fL$ reactance

$f = \frac{1}{T}$ frequency, period

$f_0 = \frac{1}{2\pi\sqrt{LC}}$ resonant frequency

| | | |
|---|---|---|
| **Operational amplifier** | $G_V = \dfrac{V_{out}}{V_{in}}$ | voltage gain |
| | $G_V = -\dfrac{R_f}{R_1}$ | inverting |
| | $G_V = 1 + \dfrac{R_f}{R_1}$ | non-inverting |
| | $V_{out} = -R_f\left(\dfrac{V_1}{R_1} + \dfrac{V_2}{R_2} + \dfrac{V_3}{R_3}\right)$ | summing |
| | $V_{out} = (V_+ - V_-)\ \dfrac{R_f}{R_1}$ | difference |
| **555 Astable and Monostable** | $T = 1.1RC$ | monostable |
| | $t_H = 0.7\ (R_A + R_B)C$<br>$t_L = 0.7\ R_BC$ | astable |
| | $f = \dfrac{1.44}{(R_A + 2R_B)C}$ | astable frequency |
| **Electromagnetic waves** | $c = 3 \times 10^8\ \text{m s}^{-1}$ | speed in vacuo |

## Assembler language microcontroller instructions

| Mnemonic | Operands | Description | Operation | Flags | Clock cycles |
|---|---|---|---|---|---|
| NOP | none | No operation | none | none | 1 |
| CALL | K | Call subroutine | stack <=PC<br>PC <=K | none | 2 |
| RET | none | Return from subroutine | PC <= stack | none | 2 |
| INC | R | Increments the contents of R | (R) <= (R) + 1 | Z | 1 |
| DEC | R | Decrements the contents of R | (R) <= (R) – 1 | Z | 1 |
| ADDW | K | Add K to W | W <= W + K | Z, C | 1 |
| ANDW | K | AND K with W | W <= W • K | Z, C | 1 |
| SUBW | K | Subtract K from W | W <= W – K | Z, C | 1 |
| ORW | K | OR K and W | W <= W + K | Z, C | 1 |
| XORW | K | XOR K and W | W <= W ⊕ K | Z, C | 1 |
| JMP | K | Jump to K (GOTO) | PC <= K | none | 2 |
| JPZ | K | Jump to K on zero | PC <= K if Z = 1 | Z = 1 | 2 |
| JPC | K | Jump to K on carry | PC <= K if C = 1 | C = 1 | 2 |
| MOVWR | R | Move W to the contents of R | (R) <= W | Z | 1 |
| MOVW | K | Move K to W | W <= K | Z | 1 |
| MOVRW | R | Move the contents of R to W | W <= (R) | Z | 1 |

GCE Electronics (2430) For exams from June 2014 onwards

Qualification Accreditation Number: AS 500/2355/X - A Level 500/2341/X

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Every specification is assigned a discounting code indicating the subject area to which it belongs for performance measure purposes.
The discount codes for this specification are:
AS RC52
A Level 1730

The definitive version of our specification will always be the one on our website, this may differ from printed versions.