GCSE (9-1)

eduqas
Part of WJEC

WJEC Eduqas GCSE (9-1) in

ELECTRONICS

ACCREDITED BY OFQUAL
DESIGNATED BY QUALIFICATIONS WALES

SPECIFICATION

Teaching from 2017
For award from 2019

Version 4 December 2024

wjec
cbac

SUMMARY OF AMENDMENTS

Version	Description	Page number
2	'Making entries' section updated to distinguish between entry codes for written assessment or on-screen assessment of Component 1.	24
3	'Making entries' section has been amended to clarify resit rules and carry forward of NEA marks.	24
4	Clarification of synoptic requirement added.	5, 6 & 13

WJEC Eduqas GCSE (9-1) in ELECTRONICS

For teaching from 2017
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GCSE ELECTRONICS

SUMMARY OF ASSESSMENT

Component 1: Discovering Electronics **Written examination: 1 hour 30 minutes** **40% of qualification**
A mix of short answer questions, structured questions and extended writing questions, with some set in a practical context
Component 2: Application of Electronics **Written examination: 1 hour 30 minutes** **40% of qualification**
A mix of short answer questions, structured questions and extended writing questions, with some set in a practical context
Component 3: Extended system design and realisation task **Non-exam assessment** **20% of qualification**
An extended system design and realisation task to assess electronics skills

This linear qualification will be available for assessment in May/June each year. It will be awarded for the first time in summer 2019.

Ofqual Qualification Number (listed on The Register): 603/0776/6

Qualifications Wales Designation Number (listed on QiW): C00/1174/1

GCSE ELECTRONICS

1 INTRODUCTION

1.1 Aims and objectives

The WJEC Eduqas GCSE in Electronics provides a broad, coherent, satisfying and worthwhile course of study. It encourages learners to develop confidence in, and a positive attitude towards, electronics and to recognise its importance in their own lives and in today's technological society.

This WJEC Eduqas GCSE in Electronics specification sets out the knowledge, understanding and skills required to ensure progression from Key Stage 3 national curriculum science and mathematics requirements and progression to AS and A level.

The specification ensures that learners have the scientific and mathematical knowledge and understanding, and the engineering skills, to tackle problems in an electronics context. GCSE Electronics is to be studied in such a way as to develop and maintain the learner's interest in engineering subjects and the appreciation of their relevance to their everyday lives. The scope and nature of the learner's study should be coherent and practical. The practical work enables learners to see the theoretical knowledge contained in the specification in action and to gain greater understanding of the knowledge in a practical context.

Studying this GCSE in Electronics enables learners to:

- develop scientific knowledge and conceptual understanding of the behaviour of analogue and digital electrical/electronic circuits including a wide range of electronic components
- develop an understanding of the nature, processes and methods of electronics as an engineering discipline to help them answer questions about practical circuits
- be aware of new and emerging technologies
- develop and learn how to apply observational, practical, problem solving and evaluative skills in the identification of needs in the world around them and to propose and test electronic solutions
- progress to level 3 qualifications in electronics and engineering

1.2 Prior learning and progression

There are no previous learning requirements for this specification. Any requirements set for entry to a course based on this specification are at the school/college's discretion.

This specification builds on subject content which is typically taught at Key Stage 3 and provides a suitable foundation for the study of electronics and engineering at either AS or A level. In addition, the specification provides a coherent, satisfying and worthwhile course of study for learners who do not progress to further study in this subject.

1.3 Equality and fair access

This specification may be followed by any learner, irrespective of gender, ethnic, religious or cultural background. It has been designed to avoid, where possible, features that could, without justification, make it more difficult for a learner to achieve because they have a particular protected characteristic.

The protected characteristics under the Equality Act 2010 are age, disability, gender reassignment, pregnancy and maternity, race, religion or belief, sex and sexual orientation.

The specification has been discussed with groups who represent the interests of a diverse range of learners, and the specification will be kept under review.

Reasonable adjustments are made for certain learners in order to enable them to access the assessments (e.g. candidates are allowed access to a Sign Language Interpreter, using British Sign Language). Information on reasonable adjustments is found in the following document from the Joint Council for Qualifications (JCQ): *Access Arrangements and Reasonable Adjustments: General and Vocational Qualifications.*

This document is available on the JCQ website (www.jcq.org.uk). As a consequence of provision for reasonable adjustments, very few learners will have a complete barrier to any part of the assessment.

2 SUBJECT CONTENT

This section outlines the knowledge, understanding and skills to be developed by learners studying WJEC Eduqas GCSE in Electronics.

Learners should be prepared to apply the knowledge, understanding and skills specified in a range of theoretical, practical, industrial and environmental contexts.

Learners' understanding of the connections between the different aspects of the subject is a requirement of all GCSE specifications. In practice, this means that synoptic questions will be set in each component. These questions will require learners to draw upon knowledge from other parts of the specification.

Practical work is an intrinsic part of this specification. It is vitally important in developing a conceptual understanding of many topics and it enhances the experience and enjoyment of electronics. The practical skills developed are also fundamentally important to learners going on to further study in electronics, engineering and related subjects, and are transferable to many careers.

The specification content is organised in sections. Each section contains the following:

Overview – summarises the content of each topic.

Electronic skills – summarises how skills may be developed in the topic.

Mathematical skills (where appropriate) – a summary of mathematical skills that should be developed in each topic. The mathematical statements in each topic are part of the assessed content. All of the mathematical skills in Appendix C are referred to at least once in one of these topics.

Calculators may be used in both written examinations and in the NEA task. Candidates are responsible for making sure that their calculators meet the relevant regulations for use in written examinations: information is found in the JCQ publication *Instructions for conducting examinations.*

Learners should be able to: – these statements clarify the breadth and depth of the content for each topic.

Six appendices provide further details about:

Appendix A – Equations in electronics
Appendix B – SI units in electronics
Appendix C – Mathematical requirements and exemplification
Appendix D – Electronic symbols
Appendix E – Independence in non-exam assessment task
Appendix F – Assessment grid for non-exam assessment

2.1 Component 1

Discovering Electronics

Written examination: 1 hour 30 minutes
40% of qualification
80 marks

This component covers the following topics:

1. Electronic systems and sub-systems
2. Circuit concepts
3. Resistive components in circuits
4. Switching circuits
5. Applications of diodes
6. Combinational logic systems

The assessment will also include synoptic questions.
These questions will require learners to draw upon knowledge from other parts of the specification.

1. ELECTRONIC SYSTEMS AND SUB-SYSTEMS

Overview

This topic explores how systems can be represented in terms of sensing, processing and output sub-systems. It investigates the types of components making up each sub-system and the need for transducer drivers.

Electronic Skills

In this topic learners will investigate electronic sensing, processing and output sub-systems and design and test systems made up of a range of components in each sub-system.

Learners should be able to:

(a) recognise that electronic systems are assembled from sensing, processing and output sub-systems, including:

- sensing units: light, temperature, magnetic field, pressure, moisture, sound, rotation
- signal processing: individual logic gates, latch, time delay, comparator
- output devices: lamp, buzzer, solenoid, LED, actuator (servo), motor, loudspeaker

(b) state the need for and use of transducer drivers

(c) design and test electronic systems.

2. CIRCUIT CONCEPTS

Overview

This topic covers the use of standard circuit symbols used to communicate electronic circuits. It investigates circuits in terms of voltage, current, resistance, energy and power and how they can be measured.

Electronic Skills

This topic develops the use of circuit symbols to communicate electronic circuits, by both drawing and analysing them. Learners will investigate circuits by measuring voltage, current and resistance and carry out calculations to predict or check these readings.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this topic. These include: recognising and using expressions in decimal and standard form; estimating results; using an appropriate number of significant figures; and changing the subject of an equation.

Learners should be able to:

(a) draw, communicate and analyse circuits using standard circuit symbols using standard convention

(b) apply current and voltage rules in series and parallel circuits

(c) use test equipment to make measurements to test electrical components and circuits including: multimeters (on voltage, current and resistance ranges), timing equipment, logic probes and oscilloscopes (or computers configured as oscilloscopes), including investigating current-voltage characteristics

(d) analyse circuits in terms of voltage, current, resistance, energy and power and use the equations:

voltage = current × resistance	$V = IR$
power = voltage × current	$P = VI$
power = (current)^2 × resistance	$P = I^2 R$
energy transfer = power × time	$E = Pt$

and select and apply $P = \frac{V^2}{R}$

3. RESISTIVE COMPONENTS IN CIRCUITS

Overview

This topic focuses on the use of resistors in series and parallel, including the E24 code for values. It investigates the use of voltage dividers in sensing circuits with a range of input components and the use of current limiting resistors for output with LEDs.

Electronic Skills

This topic provides an opportunity for learners to explore the resistance of series and parallel resistors through calculation and by carrying out tests to measure resistance of simple resistor networks. Learners will investigate the use of voltage dividers in sensing circuits for a range of input components, by carrying out calculations and taking measurements. The use of current limiting resistors for LEDs will also be investigated determining the value of resistors needed.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this topic. These include; recognising and using expressions in decimal and standard form; estimating results; using an appropriate number of significant figures; and changing the subject of an equation.

Learners should be able to:

(a) describe the effect of adding resistors in series and parallel

(b) use equations for series and parallel resistor combinations

$$R = R_1 + R_2$$ resistors in series

$$R = \frac{R_1 R_2}{R_1 + R_2}$$ resistors in parallel

(c) select resistors for use in a circuit by using the colour and E24 codes for values, tolerances and power ratings

(d) use photosensitive devices, ntc thermistors, pressure, moisture and sound sensors, switches, potentiometers and pulse generators in circuits

(e) design and test sensing circuits using these components by incorporating them into voltage dividers

(f) design and use switches and pull-up or pull-down resistors to provide correct logic level/edge-triggered signals for logic gates and timing circuits

(g) select and apply the voltage divider equation in sensing circuits

$$V_{OUT} = \frac{R_2}{R_1 + R_2} V_{IN}$$ for a voltage divider

(h) determine the value of a current-limiting resistor for LEDs in DC circuits.

4. SWITCHING CIRCUITS

Overview

This topic looks at the operation and use of n-channel enhancement mode MOSFETs, npn transistors and voltage comparator ICs in switching circuits.

Electronic Skills

This topic involves the learners investigating the use of n-channel enhancement mode MOSFETs, npn transistors and voltage comparator ICs in switching circuits through calculation, modelling and by comparing their action.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this topic. These include: recognising and using expressions in decimal and standard form; understanding and using the symbols =, <, ≤, ≥, >; estimating results; using an appropriate number of significant figures; and changing the subject of an equation.

Learners should be able to:

(a) describe and analyse the operation and use of n-channel enhancement mode MOSFETs and npn transistors in switching circuits, including those which interface to outputs

(b) select and apply the MOSFET equation

$$I_D = g_M(V_{GS} - 3)$$

(c) use the following rules for an npn transistor circuit:
for V_{IN} < 0.7 V, the transistor is off, $V_{BE} = V_{IN}$ and V_{CE} = the supply voltage
for V_{IN} ≥ 0.7 V, the transistor is on, V_{BE} = 0.7 V and V_{CE} = 0 V
and select and apply $I_C = h_{FE} I_B$ until saturation is reached

(d) describe and analyse the operation and use of voltage comparator ICs

(e) compare the action of switching circuits based on MOSFETs, npn transistors and voltage comparator ICs

(f) use data sheets to design switching circuits using MOSFETs, npn transistors and comparators.

5. APPLICATIONS OF DIODES

Overview

This topic studies the characteristics of silicon diodes and their use for component protection and as half-wave rectifiers for AC circuits. The use of zener diodes in voltage regulation circuits is also covered.

Electronic Skills

This topic provides opportunities for learners to model and simulate diode circuits, taking measurements with multimeters and oscilloscopes, and plotting results to demonstrate the operation of the diode.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this topic. These include: translating information between graphical and numerical form; plotting two variables from experimental or other data; and interpreting data presented in graphical form.

Learners should be able to:

(a) describe the I-V characteristics of a silicon diode

(b) describe the use of diodes for component protection in DC circuits and half-wave rectification of AC circuits

(c) describe the use of zener diodes in voltage regulation circuits.

6. COMBINATIONAL LOGIC SYSTEMS

Overview

This topic explores logic and the use of a range of logic gates to design systems to a given specification using truth tables and Boolean identities. Logic circuit simplification and NAND gate redundancy is also introduced.

Electronic Skills

This topic gives learners the opportunity to model and simulate logic systems from a range of logic gates, use truth tables and Boolean identities to simplify logic circuits and NAND gate redundancy. Learners also investigate the use of pull-up and pull-down resistors to provide correct logic levels at the input of gates.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this topic. These include: recognising and using truth tables and expressions in Boolean algebra; simplifying logic systems using Boolean algebra; and translating information between graphical, numerical and algebraic forms.

Learners should be able to:

(a) recognise 1/0 as two-state logic levels

(b) identify and use NOT gates and 2-input AND, OR, NAND and NOR gates, singly and in combination

(c) produce a suitable truth table from a given system specification and for a given logic circuit

(d) use truth tables to analyse a system of gates

(e) use Boolean algebra to represent the output of truth tables or logic gates and use the basic Boolean identities

$$\overline{A.B} = \overline{A} + \overline{B} \quad \text{and} \quad \overline{A + B} = \overline{A}.\overline{B}$$

(f) design processing systems consisting of logic gates to solve problems

(g) simplify logic circuits using NAND gate redundancy

(h) analyse and design systems from a given truth table to solve a given problem

(i) use data sheets to select a logic IC for given applications and to identify pin connections.

2.2 Component 2

Application of Electronics

Written examination: 1 hour 30 minutes
40% of qualification
80 marks

This component covers the following topics:

1. Operational amplifiers

2. Timing circuits

3. Sequential systems

4. Interfacing digital to analogue circuits

5. Control circuits

The assessment will also include synoptic questions.
These questions will require learners to draw upon knowledge from other parts of the specification.

1. OPERATIONAL AMPLIFIERS

Overview

This topic covers how amplifiers work and their limitations. The topic also covers the circuits for non-inverting, inverting and summing operational amplifiers (op-amps).

Electronic Skills

The topic involves the learners investigating the characteristics of amplifiers and their limitations. Learners will draw non-inverting, inverting and summing operational amplifier (op-amp) circuits and calculate values of resistors to produce given gains.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this topic. These include: recognising and using expressions in decimal and standard form; estimating results; using an appropriate number of significant figures; changing the subject of an equation; translating information between graphical and numerical form; and interpreting data presented in graphical form.

Learners should be able to:

(a) state that amplifiers increase the power or voltage of signals and select and apply the equation

$$G = \frac{V_{OUT}}{V_{IN}}$$

(b) draw a gain-frequency graph for an amplifier, measure the bandwidth from the graph and describe the trade-off between gain and bandwidth

(c) produce and interpret voltage-time graphs for the input and output signals of amplifiers

(d) draw and analyse circuits for non-inverting and inverting amplifiers based upon an op-amp

(e) show graphically and explain how clipping distortion may affect the output signal of an amplifier

(f) select and apply the equations $G = 1 + \frac{R_F}{R_1}$ and $G = -\frac{R_F}{R_{IN}}$ for op-amp circuits to select resistors to produce a given gain

(g) draw and analyse circuits for mixers based on a summing op-amp circuit and select and apply the equation for output voltage

$$V_{OUT} = -R_F\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + ...\right)$$ summing amplifier output voltage

(h) draw a block diagram of a typical amplifier system consisting of signal source, preamplifier, mixer, power amplifier and loudspeaker.

2. TIMING CIRCUITS

Overview

This topic covers the use of RC networks to create time delays and the operation of a 555 timer IC as a monostable and/or astable timer.

Electronic Skills

This topic gives the learners opportunities to explore the charging and discharging of a RC network and the operation of a 555 timer IC as a monostable and/or astable timer through calculation, modelling and simulation.

Mathematical Skills

There are a number of opportunities for the development of mathematical skills in this topic. These include: recognising and using expressions in decimal and standard form; estimating results; using an appropriate number of significant figures; making order of magnitude calculations; changing the subject of an equation; translating information between graphical and numerical form; and interpreting data presented in graphical form.

Learners should be able to:

(a) describe how a RC network can produce a time delay

(b) describe how the voltage across a charging or discharging capacitor in a RC circuit varies with time, including the interpretation of decay graphs for RC networks

(c) describe how the time delay may be changed by varying R and/or C, including interpretation of the voltage-time graph for monostable and astable timers

(d) describe the action of a 555 monostable timer and then use the equation $T = 1.1RC$, where T is the pulse duration

(e) describe the action of a 555 astable timer in terms of period and mark-space ratio

(f) use an oscilloscope, (or a computer configured as an oscilloscope) to measure the amplitude and period of the output of an astable timer

(g) select and apply equations for the frequency and mark-space ratio of a 555 astable timer

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

$$f = \frac{1.44}{(R_1 + 2R_2)C}$$ frequency of an astable

$$\frac{T_{ON}}{T_{OFF}} = \frac{R_1 + R_2}{R_2}$$ mark/space ratio of an astable

(h) draw and analyse the circuit diagrams for a monostable and/or astable timer based on a 555 IC.

3. SEQUENTIAL SYSTEMS

Overview

This topic covers the action and design of latches, BCD and decade counters, including the use of timing diagrams.

Electronic Skills

This will involve the learners designing and drawing latches, BCD and decade counters, including timing diagrams for a range of purposes.

Mathematical Skills

There are some opportunities for the development of mathematical skills in this topic. These include: converting between binary, decimal and binary-coded decimal (BCD) number systems; and drawing and interpreting timing diagrams.

Learners should be able to:

(a) draw the circuit diagram and describe the action of rising-edge-triggered D-type flip-flops used in data transfer, latches, 1- bit and 2-bit binary up-counters

(b) complete timing diagrams for D-type flip-flops used in data transfer, latches, 1-bit and 2-bit binary up- counters

(c) complete a truth table to show the signals needed to display a given character on a common cathode 7-segment display

(d) describe the action of and draw timing diagrams for dedicated binary and BCD counters

(e) recognise and analyse the block diagram and timing diagrams for a single digit decimal counting system consisting of: 4-bit BCD counter, decoder/driver and 7-segment display

(f) design and analyse systems using counters (which reset at a given value) and combinational logic to produce a given sequence

(g) design a sequencer using a 4017 decade counter and draw timing diagrams.

4. INTERFACING DIGITAL TO ANALOGUE CIRCUITS

Overview

This topic covers an introduction to the interfacing of digital to analogue circuits. It develops the use of transistors, comparators and Schmitt inverters for interfacing between digital and analogue systems.

Electronic Skills

The topic gives learners opportunities to further explore circuits using npn transistors, MOSFETs, comparators and Schmitt inverters for interfacing.

Learners should be able to:

(a) describe the action of a Schmitt inverter and its use in debouncing signals produced by mechanical switches and analogue sensors

(b) compare the properties of transistors, comparators and Schmitt inverters as interfaces between analogue and digital systems

(c) design interface circuits using npn transistors, MOSFETs and comparators to interface input sensors to outputs.

5. CONTROL CIRCUITS

Overview

This topic introduces the microcontroller as a programable integrated circuit and explores how it is interfaced and programed through flowcharts to perform tasks.

Electronic Skills

The learners will have the opportunity in this topic to work with microcontrollers, by interfacing them to inputs and outputs and by programing them to perform set tasks. The learners will also look at their application in vehicles and domestic appliances and the reason for their adoption.

Mathematical Skills

There are some opportunities for the development of mathematical skills in this topic. These include converting between binary and decimal number systems; and drawing and interpreting flowcharts.

Learners should be able to:

(a) define a microcontroller as a programable integrated circuit into which software can be loaded to carry out a range of different tasks

(b) interface sensing circuits and output devices with microcontrollers

(c) design and analyse flowchart programs to enable microcontrollers to perform tasks

(d) describe applications of microcontrollers and the reasons for their adoption as standard technology in the vehicle and domestic appliance industry.

2.3 Component 3

Extended system design and realisation task
Non-exam assessment (NEA)

20% of qualification
40 marks

The NEA is an integral part of the WJEC Eduqas GCSE in Electronics and contributes 20% to the final assessment. This component requires each learner to produce a single extended system design and realisation task independently. The task builds on the systems developed throughout the specification and the requirement to relate practical circuit design and construction to knowledge and understanding within Components 1 and 2.

This component requires learners, in the context of the knowledge and understanding in Components 1 and 2, to demonstrate their ability to:

(a) analyse a problem[1] to enable solutions to be developed

(b) develop a design specification to solve a problem

(c) propose an electronic system, composed of sub-systems, to satisfy a design specification

(d) make predictions about the way that electronic systems behave

(e) design and build an electronic system, model its performance against the design specification and modify as appropriate

(f) plan tests to make measurements, to explore a problem and select appropriate techniques and instruments

(g) evaluate practical risks in system development and application

(h) carry out tests having due regard to the correct manipulation of apparatus, accuracy of measurement and Health and Safety considerations

(i) take and record measurements on electrical circuits

(j) report results using standard scientific conventions

(k) evaluate the performance of the electronic system against the design specification

(l) suggest improvements to the electronic system following evaluation.

[1] In the context of GCSE electronics skills, 'problem' is interpreted broadly, to embrace:
- problem – difficulties in a situation e.g. a person with partial hearing cannot hear the doorbell
- context – looking at situations for possible design openings e.g. a person crossing the road
- opportunity – possibilities arising e.g. from a new improved component

Task

The task enables learners to carry out a design and realisation task based on an individually identified problem, context or opportunity. This will be researched and analysed by the learner to develop their own specification to clearly guide their system development. Learners will develop their system from a series of sub-systems which will be tested individually before assembly and testing as a complete system. Learners must evaluate the performance of their developed system against their specification and suggest improvements that could be made.

Learners should be encouraged and supported to select tasks in which they are interested and which are neither under nor over ambitious. Each learner's task is to be signed off by the teacher. The teacher should discuss the proposed focus of the task with the learner, considering the requirements of the assessment and the ability and interests of the individual learner. The teacher must be satisfied that the suggested focus has the potential for the individual learner to:

- analyse the problem and derive a design specification;
- develop and test a range of sub-systems;
- develop, realise and test a final physical system;
- evaluate the final system against the design specification and suggest improvements.

This will help ensure the task is at a suitable level for the learner concerned and will provide that individual with a level of challenge that is appropriate to their abilities, in the context of the requirements of a GCSE Electronics qualification.

For projects that include microcontrollers programed using flowcharts, a sub-routine can be considered a sub-system as long as a specification is provided for it and it can be tested and evaluated in a similar fashion to a component based sub-system.

The learner should fully document the development of the task in a report. It is the evidence contained within this report and the system produced upon which the NEA should be marked and assessed. The report should provide evidence for the following sections:

- System planning – including analysis of the problem and a design specification

- System development – including the development of the system in terms of sub-systems, annotated circuit diagrams and description of testing each sub-system and the recording of results

- System realisation – including annotated block and circuit diagrams; evidence of layout planning; description of testing of complete systems and the recording of results and user guide

- Evaluation – including a detailed evaluation of the system against the design specification and suggestions for improvement.

and

- be presented in a logical order that is clear to read and understand

- contain an acknowledgement of all sources of information and help

- include photographs of the complete physical system.

Physical circuit

Construction of the system may be on prototype board, strip board or printed circuit board. Whichever method of construction is chosen, the layout and mounting of components and wiring should be neat and logical, assist the design, testing and fault finding of the system. Pre constructed circuit boards such as PIC or Arduino development boards are not acceptable as the final circuit.

Supervision

The task must be appropriately supervised to ensure that teachers are able to confidently authenticate each learner's work. Learners are allowed supervised access to resources that may include information gathered outside supervised time.

Each learner must produce their system under 'immediate supervision'. This means the system has to be produced either:

(i) with the simultaneous physical presence of the learner and the supervisor,

or

(ii) remotely by means of simultaneous electronic communication.

In most cases supervision will be of the form described in (i), but in some circumstances, for example if the learner is carrying out a specialist process away from the centre, (ii) may be more appropriate.

Appendix E gives guidance on the level of independence in the NEA task.

Time allocation

The NEA is integral to WJEC Eduqas GCSE in Electronics and contributes 20% to the overall final assessment. Time is not prescribed for this work because the process of the learner's independent design and realisation task is iterative. It includes the design, prototyping, testing and evaluating of sub-systems and systems, alongside the writing of the task report. Learners should seek guidance from their teachers and engage as necessary in learner-led discussions.

Teachers should make time available for the following:

- to explain the requirements of the independent design and realisation task
- to guide learners to an appropriate context
- to direct learners to the assessment objectives relevant to the assessment of the component
- to analyse Health and Safety considerations and the risk assessment of practical work.

As a consequence, the overall time allocated to the independent design and realisation task both by teacher and learners should be commensurate with a **20% weighting** of the whole qualification for this component.

3 ASSESSMENT

3.1 Assessment objectives and weightings

Below are the assessment objectives for this specification. Learners must be able to:

AO1
Demonstrate knowledge and understanding of the ideas, techniques and procedures of electronics

AO2
Apply knowledge and understanding of the ideas, techniques and procedures of electronics

AO3
Analyse problems and design, build, test and evaluate electronic systems to address identified needs

The table below shows the weighting of each assessment objective for each component and for the qualification as a whole.

	AO1	AO2	AO3	Total
Component 1	17.5%	17.5%	5%	40%
Component 2	17.5%	17.5%	5%	40%
Component 3	-	-	20%	20%
Overall weighting	35%	35%	30%	100%

For each examination series, the weighting for the assessment of mathematical skills will be a minimum of 20% of the whole qualification.

Where appropriate learners will be expected to provide extended responses which are of sufficient length to allow them to demonstrate their ability to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.

3.2 Arrangements for non-exam assessment

Marking of extended system design and realisation task

Marks should be awarded for the criteria listed in the assessment grid for non-exam assessment (see Appendix F).

Exemplification statements are given in the mark grid to indicate the features which should be present in a candidate's work for full marks for that section and the level to be awarded.

A 'level of response' mark scheme is used. The relevant section(s) of the candidate's work should be read from start to finish before applying the mark scheme. Then the work should be matched to the level descriptors to decide which descriptor matches best with the candidate's work, whilst remembering to consider the overall quality of the response. Next, which mark to award within the band needs to be determined. If there is a good match with the content (and, where relevant, the communication statements for QER) then the highest mark for the band should be awarded. Lower marks within the band should be awarded for proportionately weaker matches with the content for the band.

It is the responsibility of the centre to ensure the authenticity of all work presented for assessment. All candidates are required to sign an authentication statement endorsing the originality of their work presented for assessment, and assessors must countersign that they have taken all reasonable steps to validate this. Authentication documentation must be completed by all candidates, not just those selected for moderation.

Marks should only be awarded for work that is the candidate's own. Any assistance that goes beyond general guidance must be recorded on the Electronics task form and taken into consideration when assessing the work.

Marks should only be awarded when there is supporting evidence. Supervisors must annotate each candidate's Electronics task form and/or the relevant section of the work to identify the location of relevant evidence. Annotation should also be provided to indicate to what degree the final performance meets the initial specification.

The candidate's report must contain clear photographic evidence of the completed circuit.

The centre is responsible for carrying out internal standardisation where two or more teachers have been involved in the marking of the work submitted for Component 3.

Moderation of non-exam assessment

Once the centre has marked all their candidates' work, the marks must be entered into the online system for each individual and sent electronically to the WJEC. The online system will then select and return those candidates identified for the moderation sample.

For each candidate in the sample the moderator must be sent a completed Electronics task form with the task reports and photographic evidence of the completed physical system.

4 TECHNICAL INFORMATION

4.1 Making entries

This is a linear qualification in which all assessments must be taken at the end of the course. Assessment opportunities will be available in May/June each year, until the end of the life of this specification. Summer 2019 will be the first assessment opportunity.

A qualification may be taken more than once. Candidates must resit all examination components in the same series.

Marks for NEA may be carried forward for the life of the specification. If a candidate resits an NEA component (rather than carrying forward the previous NEA mark), it is the new mark that will count towards the overall grade, even if it is lower than a previous attempt.

Where a candidate has certificated on two or more previous occasions, the most recent NEA mark is carried forward, regardless of whether that mark is higher or lower (unless that mark is absent).

The entry code appears below.

WJEC Eduqas GCSE in Electronics (written assessment): C490P1
WJEC Eduqas GCSE in Electronics (on-screen assessment): C490P2

The current edition of our *Entry Procedures and Coding Information* gives up-to-date entry procedures.

4.2 Grading, awarding and reporting

GCSE qualifications are reported on a nine point scale from 1 to 9, where 9 is the highest grade. Results not attaining the minimum strand for the award will be reported as U (unclassified).

APPENDIX A

Equations in electronics

(a) In solving quantitative problems, learners should be able to use correctly the following relationships using standard SI units, without them being provided:

voltage = current × resistance	$V = IR$
power = voltage × current	$P = VI$
power = (current)^2 × resistance	$P = I^2 R$
energy transfer = power × time	$E = Pt$

$R = R_1 + R_2$	resistors in series
$R = \frac{R_1 R_2}{R_1 + R_2}$	resistors in parallel

(b) In addition, learners should be able to select correctly from a list and apply the following relationships:

$V_{OUT} = \frac{R_2}{R_1 + R_2} V_{IN}$	voltage divider
$P = \frac{V^2}{R}$	power dissipated in a resistor
$I_D = g_M (V_{GS} - 3)$	MOSFET
$I_C = h_{FE} I_B$	current gain of a junction transistor
$f = \frac{1}{T}$	frequency, period relationship
$T = 1.1RC$	time delay of a monostable
$f = \frac{1.44}{(R_1 + 2R_2)C}$	frequency of an astable
$\frac{T_{ON}}{T_{OFF}} = \frac{R_1 + R_2}{R_2}$	mark/space ratio of an astable
$G = \frac{V_{OUT}}{V_{IN}}$	amplifier voltage gain
$G = 1 + \frac{R_F}{R_1}$	non-inverting op-amp circuit voltage gain
$G = -\frac{R_F}{R_{IN}}$	inverting op-amp circuit voltage gain
$V_{OUT} = -R_F \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + ... \right)$	summing amplifier output voltage
$\overline{A + B} = \overline{A} . \overline{B}$ $\overline{A . B} = \overline{A} + \overline{B}$	Boolean identities

APPENDIX B

SI units used in electronics

Learners should recognise, carry out calculations and be able to communicate using:

(a) The following SI units:

ampere (A), second (s), hertz (Hz), joule (J), watt (W), volt (V), ohm (Ω);

(b) The following SI multipliers:

p, n, μ, m, k, M, G, T.

APPENDIX C

Mathematical requirements and exemplification

In order to be able to develop their skills, knowledge and understanding in electronics, learners need to have been taught, and to have acquired competence in the following areas of mathematics indicated in the table below.

The table illustrates where these mathematical skills may be developed and could be assessed. The list of examples is not exhaustive. These skills could be developed in other areas of the specification content.

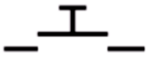
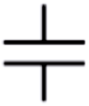
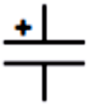
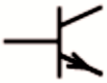
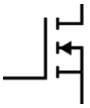
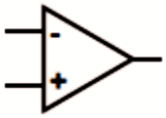
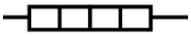
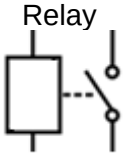
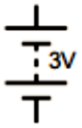
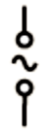
	Mathematical skill	**Exemplification of mathematical skill (assessment is not limited to the examples given below)**
1 – arithmetic and numerical computation		
a	Recognise and use expressions in decimal form	Convert between units with different prefixes, e.g. A to mA Identify the correct units for physical properties such as Hz, the unit for frequency
b	Recognise and use expressions in standard form	Use frequencies expressed in standard form such as 2.5×10^7 Hz
c	Use fractions, ratios and percentages	Calculate the fraction of the charge lost from a capacitor in a given time
d	Calculate squares and square roots	Calculate the power rating required for a resistor
2 – handling data		
a	Use an appropriate number of significant figures	Report calculations to an appropriate number of significant figures Understand that calculated results can only be reported to the limits of the least accurate measurement
b	Find arithmetic means	Calculate a mean value for repeated experimental findings
c	Make order of magnitude calculations	Evaluate equations with variables expressed in different orders of magnitude, e.g. 150 kΩ and 2.6 mA

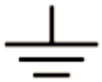
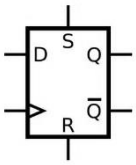
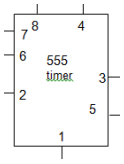
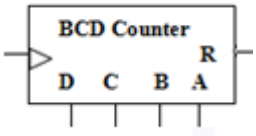
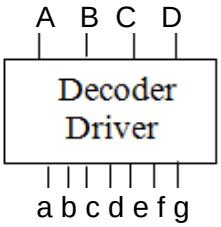
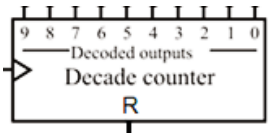
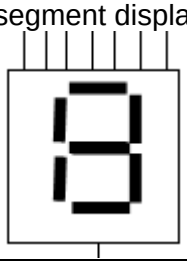
	Mathematical skill	Exemplification of mathematical skill (assessment is not limited to the examples given below)
3 – algebra		
a	Understand and use the symbols: =, <, <<, >, >>, ∝, ~	Recognise the significance of the symbols in the expression: $V_{IN} < 0.7$ V the npn transistor is off
b	Change the subject of an equation	Rearrange $P = \frac{V^2}{R}$ to make R the subject
c	Substitute numerical values into algebraic equations using appropriate units for physical quantities	Calculate the frequency of a 555 astable by substituting the values for R_1, R_2 and C into the equation: $f = \frac{1.44}{(R_1 + 2R_2)C}$
d	Solve simple algebraic equations	Find a capacitor value for a given time delay and resistance in a 555 monostable
e	Use simple Boolean identities	Simplify a logic system
4 – graphs		
a	Translate information between graphical, numerical and algebraic forms	Measure the ripple voltage from output graphs for rectified power supplies
b	Plot two variables from experimental or other data	Plot I-V characteristics of a diode
c	Draw an appropriate trend line onto plotted data	Drawing a trend line for ntc thermistors resistance against temperature
d	Interpret data presented in graphical form	Reading data from an amplifier's voltage gain graph
e	Determine the slope of a graph	Calculate a resistance value from a V-I graph
f	Calculate the rate of change from a graph showing a linear relationship	Calculate the slew rate from a V-t graph
g	Draw and use the slope of a tangent to a curve as a measure of rate of change	Calculate the gain of an amplifier from the transfer characteristic

APPENDIX D

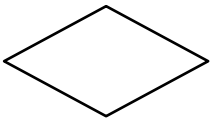
Electronic symbols

Learners should recognise and be able to use the following electronic symbols:

Switch (latching) 	Switch (non-latching) 	Light dependent resistor 	Thermistor 
Photodiode 	Microphone 	Variable resistor 	Potentiometer 
Resistor 	Capacitor 	Electrolytic capacitor 	Inductor 
NPN transistor 	N channel MOSFET 	Diode 	Zener diode 
AND gate 	OR gate 	NOT gate 	NAND gate 
NOR gate 	Op-amp 	Schmitt inverter 	Ammeter 
Voltmeter 	Buzzer 	Speaker 	Light emitting diode 
Signal lamp 	Filament lamp 	Heater 	Motor 
Relay 	Cell 	Battery 	AC supply 

Earth 	Transformer 	D type flip flop 	555 timer 
Binary counter 	Decoder driver 	Decade counter 	7 segment display 

Circles can be put on S and R inputs for D types, and on CK and R inputs for counters (or bars over the letters) when inverted.

Terminator 	Input/output 	Process 	Decision 

APPENDIX E

Independence in non-exam assessment (NEA) task

The table below gives guidance on the level of independence that a learner must follow at each stage of the NEA task.

Task stage	Level of independence	What does this level of independence mean at this stage? (The following are examples.)	What are the potential risks?	What are the controls in place to mitigate these risks?
Context for task	Independent work	Centres may give learners a free choice of focus for their task or provide learners with a theme or range of themes. However, it is not acceptable for learners to choose from a list of specific foci provided by the centre. Learners may discuss with their teacher ideas for an appropriate focus for their tasks.	The parameters that the centre provides may not allow sufficient scope for learners to independently derive their own focus. The focus a learner chooses may not provide sufficient scope to allow them to access the full range of marks available for the NEA.	The guidance that teachers provide needs to ensure that the scope is sufficient for all learners to arrive at the focus for their task independently. The viability of a learner's potential focus can be discussed with the teacher. Teacher to 'sign off' focus for project to ensure the proposed focus provides suitable scope for the learner. Any guidance that goes beyond general guidance must be recorded by the teacher on the Electronics task form and taken into account when the work is marked. For example, supplying learners with a focus for their task would be beyond general guidance.

System planning	Independent work	Learners independently carry out research and derive a specification for their task.	Learners plagiarise their work from others.	Teacher assessment of learner's work. Teacher and learner declarations state that the work is the learner's own. Any guidance that is beyond general guidance must be recorded on the Electronics task form and taken into account when the work is marked. For example, giving learners research material on a specific need for their task would be beyond general guidance. Moderators will be instructed to report any suspected instance of plagiarism or learners not working independently for further investigation.
System Development	Independent work	Learners independently plan and carry out testing of each sub-system for their system to meet their specification.	Learners plagiarise their work from others. Learners do not model their own sub-systems and test them.	There will be evidence of learners constructing and carrying out tests on sub-systems. Teacher's immediate supervision and subsequent assessment of learner's work. Teacher and learner declarations state that the work is the learner's own. Any guidance that is beyond general guidance must be recorded on the Electronics task form and taken into account when the work is marked. For example, showing learners how to interface two sub-systems for their task would be beyond general guidance. Moderators will be instructed to report any suspected instance of plagiarism or learners not working independently for further investigation.

System Realisation	Independent work	Learners independently plan and carry out the realisation and testing of their complete system to meet their specification.	Learners plagiarise their work from others. Learners do not construct their own physical system and test it.	There will be evidence of learners realising and carrying out tests on the completed system. Teacher's immediate supervision and subsequent assessment of learner's work. Teacher and learner declarations state that the work is the learner's own. Any guidance that is beyond general guidance must be recorded on the Electronics task form and taken into account when the work is marked. For example, showing learners how to test a system for their task would be beyond general guidance. Moderators will be instructed to report any suspected instance of plagiarism or learners not working independently for further investigation.
Evaluation	Independent work	Learners independently evaluate the performance of their complete system and suggest improvements.	Learners plagiarise their work from others.	Teacher assessment of learner's work. Teacher and learner declarations state that the work is the learner's own. Any guidance that is beyond general guidance must be recorded on the Electronics task form and taken into account when the work is marked. For example, supplying learners with points to discuss in the evaluation for their task would be beyond general guidance. Moderators will be instructed to report any suspected instance of plagiarism or learners not working independently for further investigation.

APPENDIX F

Assessment grid for non-exam assessment
Extended system design and realisation task

1. System planning		Band
3 - 4 marks	**The candidate has provided**: • a clear statement of a problem which includes relevant analysis • a design specification in both qualitative and quantitative terms (typically at least 3 of each), and including 2 or more detailed realistic measurable parameters	2
1 - 2 marks	**The candidate has provided:** • a statement of a problem which includes some superficial analysis • a design specification in qualitative and/or quantitative terms (typically at least 4 in total)	1
0 marks	Response not creditworthy or not attempted.	

2. System Development		Band
11- 15 marks	**The candidate has developed the system as a series of sub-systems and has:** • given a comprehensive design specification and provided most circuit details for 5 or more different sub-systems • set up and produced comprehensive tests on prototypes for 5 or more different sub-systems • presented accurate, high-quality fully labelled sub-system circuit diagrams • recorded all relevant results of testing for 5 or more different sub-systems • produced a comprehensive report of the performance of 5 or more different sub-systems	3
6 - 10 marks	**The candidate has developed the system as a series of sub-systems and has:** • given an adequate design specification and provided some circuit details for 3 or more different sub-systems • set up and produced appropriate tests on prototypes for 3 or more different sub-systems • presented accurate, good quality and mostly fully labelled sub-system circuit diagrams • recorded results with minor omissions of testing for 3 or more different sub-systems • produced an adequate report of the performance of 3 or more different sub-systems	2
1 - 5 marks	**The candidate has developed the system as a series of sub-systems and has:** • given a simple design specification, and provided limited circuit details for 2 or more different sub-systems • set up and produced simple tests on prototypes which were partially completed for 2 or more different sub-systems • presented accurate sub-system circuit diagrams which were not fully labelled or lacked clarity • recorded incomplete results of testing for 2 or more different sub-systems • produced a simplistic report of the performance of 2 or more different sub-systems	1
0 marks	Response not creditworthy or not attempted.	

3. System Realisation		**Band**
11 - 15 marks	**The candidate has:** • produced accurate, high-quality labelled block and circuit diagrams for the complete system and provided a complete component list • planned and produced a very well organised physical circuit layout with wires arranged vertically/horizontally and shown good awareness of risk assessment/safe working procedures • made wire connections and mounted components to a high standard • tested the complete hardwired system prototype and provided a detailed analysis of the results using standard scientific convention which included at least two relevant electrical measurements • produced an electronic system in which 3 or more different sub-systems worked consistently and reliably, and included a comprehensive user guide	3
6 - 10 marks	**The candidate has:** • produced accurate, good quality labelled block and circuit diagrams for the system • produced a quite well organised/planned physical circuit layout and shown some awareness of risk assessment/safe working procedures • made some wire connections and mounted some components to a good standard • tested the complete hardwired system prototype and provided an adequate analysis of the results which included at least one relevant electrical measurement • produced an electronic system in which 3 or more different sub-systems worked correctly most of the time and included a basic user guide	2
1 - 5 marks	**The candidate has:** • produced accurate block and circuit diagrams for the system which were not completely labelled or lacked clarity • produced a physical circuit layout with little evidence of organisation/planning and shown superficial awareness of risk assessment/safe working procedures • made some wire connections or mounted some components to a basic standard • tested the complete hardwired system prototype and provided a minimal analysis of the results • produced an electronic system in which 2 or more different sub-systems worked correctly at some time	1
0 marks	Response not creditworthy or not attempted	

4. Evaluation (QER)		Band
5 - 6 marks	**The candidate has:** • provided a critical and objective evaluation of how the system works in terms of the function of each block, which was well structured and made good references to the signal transfer between blocks • undertaken a critical and objective evaluation of the performance of the complete system which was valid in all respects, made comprehensive comparisons with the design specification and made at least 2 suggestions for improvement with explanations of how they improve the system *There is a sustained line of reasoning which is coherent, substantiated and logically structured. The information included in the response is relevant to the argument.*	3
3 - 4 marks	**The candidate has:** • provided an objective evaluation of how the system works in terms of the function of each block, which was quite well structured and made some reference to the signal transfer between blocks • undertaken an objective evaluation of the performance of the complete system which was valid in most respects, made some comparisons with the design specification and made at least 2 suggestions for improvement *There is a line of reasoning which is partially coherent, supported by some evidence and with some structure. Mainly relevant information is included in the response but there may be some minor errors or the inclusion of some information not relevant to the argument.*	2
1 - 2 marks	**The candidate has:** • provided a simple evaluation of how the system works in terms of the function of each block, in which some of the content may be ambiguous or disorganised • undertaken a simple evaluation of the performance of the complete system which was valid in few respects, made minimal comparison with the design specification and made at least 1 superficial suggestion for improvement *There is a basic line of reasoning which is not coherent, supported by limited evidence and with very little structure. There may be significant errors or the inclusion of information not relevant to the argument.*	1
0 marks	Response not creditworthy or not attempted	