

# Cambridge NATIONALS LEVEL 1/2

# SYSTEMS CONTROL IN ENGINEERING

R114 Simulate, construct and test electronic circuits J833/J843

Cambridae

NATIONALS

# **Schemes of work**

Version 1

www.ocr.org.uk/subjects/engineering

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#### INTRODUCTION

This teaching resource, which we've developed with Nationals Engineering teachers, contains two types of schemes of work.

- A longer term plan which covers the whole academic year over three terms and suggests the order in which each Learning Outcome (LO) could be taught. Links to other units and LOs within Nationals Engineering are also shown.
- A **medium term** plan which also covers the whole academic year over three terms and suggests the order in which each LO could taught but also provides classroom activities and any links to other resources which might be useful. We've also included 'Have they got it?' linking to activities other LOs in this unit and/or other units and LOs within Nationals Engineering. This includes performing practical activities by which learners confirm their understanding.

#### Link to qualification

https://www.ocr.org.uk/qualifications/cambridge-nationals/systems-control-in-engineering-level-1-2-award-certificate-j833-j843/

See our range of planning and teaching resources on the link below (including delivery guides, project approaches, teaching activities, teacher guides and resources lists). <u>https://www.ocr.org.uk/qualifications/cambridge-nationals/systems-control-in-engineering-level-1-2-award-certificate-j833-j843/planning-and-teaching/</u>

See our range of assessment resources on the link below (including past paper, mark schemes, examiners' reports, candidate exemplars and set assignments). <u>https://www.ocr.org.uk/qualifications/cambridge-nationals/systems-control-in-engineering-level-1-2-award-certificate-j833-j843/assessment/</u>

## Scheme of work (longer term plan – academic year)

	Learning Outcome	Topic area/theme (from R115 specification)	Links to other Cambridge Nationals Engineering units and LOs
erm	LO1	Introduction to CAD for circuit design and simulation.	<ul> <li>R107 LO3 – Be able to use Computer Aided Design (CAD) software and techniques to produce and communicate design proposals.</li> <li>R113 LO1 – Understand basic electronic principles.</li> </ul>
	LO1	Circuit schematic diagrams using CAD – part 1.	R113 LO1 – Understand basic electronic principles.
	LO1	Circuit schematic diagrams using CAD – part 2.	R113 LO1 – Understand basic electronic principles.
L L	LO1	Circuit schematic diagrams using CAD – part 3.	R113 LO1 – Understand basic electronic principles.
tun	LO1	Circuit simulation using CAD – part 1.	R113 LO1 – Understand basic electronic principles.
Au	LO1	Circuit simulation using CAD – part 2.	R113 LO1 – Understand basic electronic principles.
	LO1	Circuit schematic entry and simulation using CAD.	R113 LO1 – Understand basic electronic principles.
	LO1	PCB layout using CAD – part 1.	R113 LO4 – Understand commercial circuit construction methods.
	LO1	PCB layout using CAD – part 2.	R113 LO4 – Understand commercial circuit construction methods.
	LO1	PCB layout using CAD – part 3.	R113 LO4 – Understand commercial circuit construction methods.

	Learning Outcome	Topic area/theme (from R114 specification)	Links to other Cambridge Nationals Engineering units and LOs
	LO2	Safe PCB manufacture – part 1.	R113 LO1 – Understand basic electronic principles.
			R113 LO4 – Understand commercial circuit construction methods.
	LO2	Safe PCB manufacture – part 2.	R113 LO1 – Understand basic electronic principles.
			R113 LO4 – Understand commercial circuit construction methods.
	LO2	Safe PCB manufacture – part 3.	R113 LO1 – Understand basic electronic principles.
			R113 LO4 – Understand commercial circuit construction methods.
	LO2	Safe PCB manufacture – part 4.	R113 LO1 – Understand basic electronic principles.
			R113 LO4 – Understand commercial circuit construction methods.
	LO2	Safe PCB construction including safe use of tools – part 1.	R113 LO1 – Understand basic electronic principles.
lerm			<b>R113 LO2</b> – Understand the operating principles of electronic components.
bui			R113 LO4 – Understand commercial circuit construction methods.
٩ م	LO2	Safe PCB construction including safe use of tools – part 2.	R113 LO1 – Understand basic electronic principles.
			R113 LO2 – Understand the operating principles of electronic components.
			<b>R113 LO4</b> – Understand commercial circuit construction methods.
	LO2	Safe PCB construction including safe use of tools – part 3.	R113 LO1 – Understand basic electronic principles.
			<b>R113 LO2</b> – Understand the operating principles of electronic components.
			<b>P113 I O</b> A - Understand commercial circuit construction methods
	LO2	Safe PCB construction including safe use of tools – part 4.	R113 LO1 – Understand basic electronic principles
			<b>R113 LO2</b> – Understand the operating principles of electronic components.
			R113 LO4 – Understand commercial circuit construction methods.

	Learning Outcome	Topic area/theme (from R114 specification)	Links to other Cambridge Nationals Engineering units and LOs
erm	LO2	Synoptic links to other units.	<ul> <li>R113 LO1 – Understand basic electronic principles.</li> <li>R113 LO2 – Understand the operating principles of electronic components.</li> </ul>
Ĕ			<b>R113 LO4</b> – Understand commercial circuit construction methods.
Spring	LO3	Introduction to testing electronic circuits.	<ul> <li>R113 LO1 – Understand basic electronic principles.</li> <li>R113 LO2 – Understand the operating principles of electronic components.</li> </ul>
			<b>R113 LO3</b> – Know test methods for electronic circuits.

	Learning Outcome	Topic area/theme (from R114 specification)	Links to other Cambridge Nationals Engineering units and LOs
	LO3	Visual inspection of PCB – part 1.	R113 LO1 – Understand basic electronic principles.
			<b>R113 LO2</b> – Understand the operating principles of electronic components.
			R113 LO3 – Know test methods for electronic circuits.
	LO3	Visual inspection of PCB – part 2.	R113 LO1 – Understand basic electronic principles.
			<b>R113 LO2</b> – Understand the operating principles of electronic components.
			R113 LO3 – Know test methods for electronic circuits.
	LO3	Using test equipment to test PCB – part 1.	R113 LO1 – Understand basic electronic principles.
er Term			<b>R113 LO2</b> – Understand the operating principles of electronic components.
			R113 LO3 – Know test methods for electronic circuits.
Ш.	LO3	Using test equipment to test PCB – part 2.	R113 LO1 – Understand basic electronic principles.
Su			<b>R113 LO2</b> – Understand the operating principles of electronic components.
			R113 LO3 – Know test methods for electronic circuits.
	LO3	Using test equipment to test PCB – part 3.	R113 LO1 – Understand basic electronic principles.
			<b>R113 LO2</b> – Understand the operating principles of electronic components.
			R113 LO3 – Know test methods for electronic circuits.
	LO3	Using test equipment to test PCB – part 4.	R113 LO1 – Understand basic electronic principles.
			<b>R113 LO2</b> – Understand the operating principles of electronic components.
			R113 LO3 – Know test methods for electronic circuits.

	Learning Outcome	Topic area/theme (from R114 specification)	Links to other Cambridge Nationals Engineering units and LOs
	LO3	Using test equipment to test PCB – part 5.	R113 LO1 – Understand basic electronic principles.
			<b>R113 LO2</b> – Understand the operating principles of electronic components.
			R113 LO3 – Know test methods for electronic circuits.
	LO3	Test and fault-finding methods – part 1.	R113 LO1 – Understand basic electronic principles.
E			<b>R113 LO2</b> – Understand the operating principles of electronic components.
er Te			R113 LO3 – Know test methods for electronic circuits.
Ĕ	LO3	Test and fault-finding methods – part 2.	R113 LO1 – Understand basic electronic principles.
Sumn			<b>R113 LO2</b> – Understand the operating principles of electronic components.
			R113 LO3 – Know test methods for electronic circuits.
	LO3	Test and fault-finding methods – part 3.	R113 LO1 – Understand basic electronic principles.
			<b>R113 LO2</b> – Understand the operating principles of electronic components.
			R113 LO3 – Know test methods for electronic circuits.

## Scheme of work (medium term plan – more detailed by academic term)

	Event	Learning Outcome	Topic area/subtopic Area (from R114 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Autumn Term	1	LO1	Introduction to CAD for circuit design and simulation.	Learners could be provided with a basic introduction and overview of how electronic CAD software is used to design and simulate electronic circuits. Teacher demonstrations could be used, along with suitable videos to show features of the software, and to explain the benefits of using CAD to design electronic circuits.		https://www.youtube.com/ watch?v=uT28P2mTfVg provides an overview of the popular Yenka circuit simulation and PCB layout software.
	2	LO1	Circuit schematic diagrams using CAD – part 1.	In this series of lessons, learners could be introduced to features of electronic CAD software including the use of component libraries, wires and interconnections, schematic entry of circuits, and preparing circuits correctly for simulation.		There are plenty of free and subscription electronic CAD software packages on the Internet. Some require download of a program, while others can be run online in a browser. Yenka (https://www.yenka. com/en/Yenka_Electronics/) is a subscription software for schematic circuit entry and simulation, and can also produce PCB layouts. Alternatives include OrCad (https://www.orcad.com/), MultiSim (https://www.multisim. com/) and Circuit Lab (https:// www.circuitlab.com/)
	3	LO1	Circuit schematic diagrams using CAD – part 2.	Learners will continue to learn how to use features of electronic CAD software and will be able to replicate electronic circuits schematically that are provided to them.		Tutorial videos from <u>www.</u> <u>youtube.com</u> could be used to explain how to use the selected CAD software.
	4	LO1	Circuit schematic diagrams using CAD – part 3.	In this final session on using CAD software for schematic entry learners could complete and confirm a circuit ready for simulation.	<b>R114 LO1</b> – Learners will be able to use electronic CAD software to schematically enter a circuit diagram.	

	Event	Learning Outcome	Topic area/subtopic Area (from R114 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Autumn Term	5	LO1	Circuit simulation using CAD – part 1.	In this first lesson on circuit simulation, learners could be provided an overview of how CAD software enables circuits to be simulated on screen. A demonstration could be shown for a simple circuit simulation, including the use of virtual power supplies and instrumentation for taking measurements.		Tutorial videos for the selected CAD/simulation software from <u>www.youtube.com</u> could be used to show how to perform circuit simulation. The following video explains the simulation of an op- amp circuit using MultiSim <u>https://www.youtube.com/</u> <u>watch?v=0Jo87alt1qM</u>
	6	LO1	Circuit simulation using CAD – part 2.	Learners could continue to develop skills in using simulation software tools to simulate the operation of electronic circuits. They could experiment with changing value of circuit components or adding extra components to circuits to examine the effects caused.		
	7	LO1	Circuit schematic entry and simulation using CAD.	In this concluding lesson learners could undertake a complete activity by schematically entering a given circuit diagram and carrying-out a circuit simulation along with circuit modifications. The step by step process involved could then be summarised in a basic presentation with annotated screenshots.	<b>R114 LO1</b> – Learners will be able to simulate a circuit using electronic CAD software, using virtual instruments to measure values. They will also be able to carry-out and investigate modifications to circuits.	
	8	LO1	PCB layout using CAD – part 1.	In this first lesson on PCB layout learners could be provided an introduction on using CAD software to produce PCB layouts. Learners could be introduced to how the technique works and be shown an example of how a circuit is taken and converted to a PCB layout.		Videos could be used to illustrate how to use CAD software to produce a PCB layout. The following video provides a complete walkthrough of how to design a PCB layout for a 555 timer circuit using Eagle PCB Design Tools https://www.youtube.com/ watch?v=JUdWgDUWqaA

	Event	Learning Outcome	Topic area/subtopic Area (from R114 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
	9	LO1	PCB layout using CAD – part 2.	Learners could continue to develop skills at using CAD software with a given circuit to produce a PCB layout including the placement of components, routing of tracks and good layout techniques.		
Autumn Term	10	LO1	PCB layout using CAD – part 3.	In this concluding lesson, learners could take a previously completed schematic circuit and produce a PCB layout. The step by step process involved could be summarised in a basic presentation with annotated screenshots, along with completed views of track and component sides of the PCB.	<b>R114 LO1</b> – Learners will be able to use CAD software to produce a PCB layout ready for manufacturing a PCB. This will include track and component views.	

	Event	Learning Outcome	Topic area/subtopic Area (from R114 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
	1	LO2	Safe PCB manufacture – part 1.	Teachers could explain the process by which learners will physically manufacture a bare PCB e.g. chemical etching or CNC milling. Practical demonstrations could be used, or videos used to explain the process.		Search www.youtube.com for 'PCB etching' or 'PCB milling' for a range of videos showing both techniques. <u>https://www.youtube.com/</u> watch?v=tWnfnt2rNO0 (PCB etching); <u>https://www.youtube.</u> <u>com/watch?v=ibZcQLIbets</u> (PCB milling)
Spring Term	2	LO2	Safe PCB manufacture – part 2.	In this series of lessons, learners will safely manufacture their own PCB. They could begin by producing a step by step plan of how the PCB will be manufactured and undertake a simple risk assessment of the activities required.		The HSE website includes comprehensive guides to risk assessment including templates: <u>https://www.hse.</u> <u>gov.uk/risk/</u>
	3	LO2	Safe PCB manufacture – part 3.	Learners will safely use equipment to manufacture a bare PCB. They could keep an annotated step by step photo diary of the manufacturing process, including how they have addressed health and safety.		
	4	LO2	Safe PCB manufacture – part 4.	In this final lesson on PCB manufacture, learners could visually inspect their completed PCB, and use other methods such as continuity checks to confirm that it satisfies the requirements of the circuit diagram.	<b>R114 LO2</b> – Learners will be able to safely manufacture a PCB and confirm that it meets the requirements of the original circuit diagram.	The following video shows how to perform a continuity test using a multimeter on a PCB <u>https://www.youtube.com/</u> <u>watch?v=5G622WDZaHg</u>
	5	LO2	Safe PCB construction including safe use of tools – part 1.	In this series of lessons, learners will populate their PCB with components ready for testing. Practical demonstrations, and videos could be used to show safe circuit construction techniques, such as soldering and use of tools and equipment e.g. side cutters, pliers, heat sinks etc.		Health and safety in engineering: <u>https://www.hse.</u> <u>gov.uk/engineering/</u> Includes a useful workshop guide booklet on health and safety in engineering workshops, including sections relevant to the manufacture of PCBs and construction of electronic circuits.

	Event	Learning Outcome	Topic area/subtopic Area (from R114 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Spring Term	6	LO2	Safe PCB construction including safe use of tools – part 2.	Learners could develop a simple plan detailing how they will construct the PCB, and the tools and equipment required. Health and safety could be addressed using simple risk assessments.		The following video provides a basic explanation of ow to solder a PCB, including safety precautions <u>https://</u> www.youtube.com/ <u>watch?v=AqvHogekDl4</u> Similar YouTube videos could be useful to show the safe and correct use of tools, such as side cutters and pliers.
	7	LO2	Safe PCB construction including safe use of tools – part 3.	Learners could construct their PCB using appropriate tools and equipment, while adhering to safe working requirements. Again, an annotated step by step photo diary could be kept showing stages of construction of the PCB.		
	8	LO2	Safe PCB construction including safe use of tools – part 4.	Learners will continue to construct their PCB, including attaching any external wires or connectors required for operation and testing. They could conclude their annotated photo diary with photographs of the completed PCB (track and component sides) and include a brief review and reflection of the construction process (i.e. what went well, and what they might improve upon).	<b>R114 LO2</b> – Learners will be able to safely use appropriate techniques to construct a completed PCB ready for testing.	

Event	Learning Outcome	Topic area/subtopic Area (from R114 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
9	LO2	Synoptic links to other units.	In this lesson, learners could review work completed in LO2 of this unit and make links to other units in the specification (especially unit R113). They could produce a simple table documenting links from content covered in LO2 to R113, and other units.	R113 LO1 and LO2 – Learners will be able to apply knowledge of basic electronic principles and the use of electronic components when schematically entering and simulating circuits using CAD software. They will also be able to draw upon knowledge of components, their applications and function when constructing and testing circuits. R113 LO4 – Learners will be able to relate to commercial PCB manufacturing processes and the use of components when manufacturing and constructing their own PCB.	
10	LO3	Introduction to testing electronic circuits.	In this series of lessons, learners will be introduced to how to test electronic circuits including the safe and correct use of test equipment. Teachers could begin with a basic overview of the reasons for testing circuits and use videos to illustrate testing taking place.		The following YouTube video provides an overview to circuit testing procedures <u>https://www.youtube.com/</u> <u>watch?v=wAc8PPw-pel</u>

	Event	Learning Outcome	Topic area/subtopic Area (from R114 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Summer Term	1	LO3	Visual inspection of PCB – part 1.	Learners could be shown physical PCB's containing faults such as dry solder joints, bridged and broken tracks, misplaced components etc. Videos could be used to explain the types of fault that can be visually identified on a PCB.		The Adafruit website provides detailed guidance on how to identify different types of poor solder joint visually <u>https://learn.</u> <u>adafruit.com/adafruit-guide-</u> <u>excellent-soldering/common-</u> <u>problems</u>
	2	LO3	Visual inspection of PCB – part 2.	Learners could physically inspect circuit boards they have constructed themselves, or which other members of their class have constructed. They could document their findings using annotated photographs, and rectify any faults identified.	<b>R114 LO3</b> – Learners will be able to perform a visual inspection of a PCB, be able to recognise faults and be able to rectify these.	
	3	LO3	Using test equipment to test PCB – part 1.	In this series of lessons learners will be introduced to different types of test equipment and its safe setup and use. Physical test equipment can be used where available to show how it is set up and used to test a PCB. Where equipment is not available, videos could be used.		www.youtube.com includes many videos showing how to safely setup and use test equipment.
	4	LO3	Using test equipment to test PCB – part 2.	Learners could be shown power supplies and how these are used to power circuits ready for testing. They could be shown how to safely setup the correct output voltage, and how to set any current limiting protection. The importance of ensuring the correct polarity when connecting a circuit could be explained.		The following video shows how to safely setup and use a bench power supply <u>https://www.youtube.com/</u> watch?v=T8Z2EFrbtpU
	5	LO3	Using test equipment to test PCB – part 3.	Learners could use a multimeter to safely measure voltage, current and resistance. This will include safe setup and operation of the multimeter, and safe connection to the circuit. Learners could be given several test circuits from which to take readings, and to produce a table of measurements taken against expected values.		The following video shows how to use a multimeter https://www.youtube.com/ watch?v=ts0EVc9vXcs

	Event	Learning Outcome	Topic area/subtopic Area (from R114 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Summer Term	6	LO3	Using test equipment to test PCB – part 4.	Learners could be shown how to use more advanced test equipment, such as a logic probe, signal generator or oscilloscope if these are available.	<b>R114 LO3</b> – Learners will be able to select, setup and safely use a range of appropriate test equipment.	Videos could be used to show how to use more complex test equipment, such as the following which shows how to use an oscilloscope https://www.youtube.com/ watch?v=CzY2abWCVTY&t=2s
	7	LO3	Using test equipment to test PCB – part 5.	Learners could select and use appropriate test equipment to test their own completed circuit construction. They could produce a basic tabulated test plan to record measured values against expected values, commenting on any differences. An annotated photo diary could be kept showing testing taking place, including safety considerations taken.		
	8	LO3	Test and fault-finding methods – part 1.	Learners could be introduced to methods for fault finding, such as testing for expected values, tracing signals from input to output of a circuit, and the half-split method where the circuit is systematically broken down into functional blocks and each tested separately.		Search the Internet for many useful sources of guidance on how to perform troubleshooting. The following provides a beginners troubleshooting guide <u>https://www.sparkfun.com/</u> <u>tutorials/226</u>
	9	LO3	Test and fault-finding methods – part 2.	Learners could undertake testing on known defective circuits, using test equipment, and expected values to identify faults. They could then suggest how the faults are rectified or rectify these themselves.		
	10	LO3	Test and fault-finding methods – part 3.	Learners could conclude by testing circuits they have constructed themselves, and confirm they are functioning correctly or require rectification. The circuits could then be rectified if they are found to be faulty. Learners could again keep a step by step annotated photo diary showing how they have performed fault-finding on their circuit.	<b>R114 LO3</b> – Learners will be able to perform testing of circuits, identifying faults and making rectification to achieve fully working circuits.	

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