Higher National Unit Specification

General information for centres

Unit title: Power Supply Circuits

Unit code: DG50 35

Unit purpose: This Unit has been designed to provide an introduction to Power Supply Circuits. It will enable candidates to know and understand the basic concepts of power supplies and allow them to apply and develop this knowledge by constructing and testing a three terminal power supply and a switched mode power supply.

On completion of the Unit the candidate should be able to:

1. Analyse the operation of unregulated power suppliers.
2. Analyse linear regulated power supplies.
3. Analyse the operation of switched mode power supplies.
4. Design, build and test regulated power supplies.

Credit value: 1 HN Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Recommended prior knowledge and skills: It is essential that the candidate has a knowledge and understanding of analogue electronic devices and operational amplifiers. This may be evidenced by the possession of the HN unit Analogue Electronic Principles or an appropriate group of NQ Units in Electronics at SCQF Level 6 or equivalent.

Core skills: There may be opportunities to gather evidence towards Core Skills in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Context for delivery: This Unit was developed for the HNC and HND Electronics awards. If the Unit is used in another group award(s) it is recommended that is should be taught and assessed with in the context of the particular group award(s) to which is contributes.

Assessment: The assessment for Outcomes 1, 2 and 3 in this Unit should be combined into one assessment paper. This paper should be taken by candidates at one single assessment event, which should last one hour and thirty minutes. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions. Outcome 4 is a practical Outcome and the candidate should be assessed using appropriate checklists. It should be noted that candidates must achieve all the minimum evidence specified for each Outcome in order to pass this Unit.

Higher National Unit specification: statement of standards

Unit title: Power Supply Circuits

Unit code: DG50 35

The sections of the Unit stating the Outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Analyse the operation of unregulated power supplies

Knowledge and/or skills

- Rectification methods
- Smoothing
- Voltage calculations
- Component calculations

Evidence requirements

Evidence for the knowledge and skills in this Outcome will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that she/he can answer correctly questions based on a sample of the items shown above. In any assessment of this Outcome three out of four items should be sampled.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- explain the operation of a full wave rectifier and sketch an annotated circuit diagram
- explain the benefit of capacitor smoothing and sketch at least two output voltage waveforms for different values of smoothing capacitor
- calculate correctly unsmoothed output voltages for peak, rms and dc values and the diode peak inverse voltage for given bridge circuit parameters
- calculate correctly the value of smoothing capacitor for a given load and ripple voltage and calculate load range for a given ripple range and smoothing capacitance

Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates will be permitted to use scientific calculators during the assessment.

Higher National Unit specification: statement of standards (cont)

Unit title: Power Supply Circuits

Assessment guidelines

Questions used to elicit candidate evidence may take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment of this Outcome should be combined with the assessments for Outcomes 2 and 3 to form a single assessment paper, details of which are given under Outcome 3.

Outcome 2

Analyse linear regulated power supplies

Knowledge and/or skills

- Load and line regulation
- Stabilisation
- Series regulator
- Over voltage protection
- Over current protection
- Three terminal regulators

Evidence requirements

Evidence for the knowledge and skills in this Outcome will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that she/he can answer correctly questions based on a sample of the items shown above. In any assessment of this Outcome five out of six items should be sampled.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- explain the need for power supply stability with reference to the power supply specification, line regulation and load regulation
- calculate correctly line regulation and load regulation for one power supply
- explain the operation of a series regulator using a block diagram
- explain the operation of SCR Crowbar circuit
- explain the operation of Current limiting circuit
- explain the operation of Foldback circuit
- explain the application of three terminal regulators

Assessment guidelines

Questions used to elicit candidate evidence may take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment of this Outcome should be combined with Outcomes 1 and 3 to form a single assessment paper, details of which are given under Outcome 3.

Higher National Unit specification: statement of standards (cont)

Unit title: Power Supply Circuits

Outcome 3

Analyse the operation of switched mode power supplies

Knowledge and/or skills

- Advantages and disadvantages over linear power supplies
- Switching frequencies
- Duty cycle
- Pulse Width Modulation
- Calculation of parameters

Evidence requirements

Evidence for the knowledge and skills in this Outcome will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that they can answer correctly questions based on a sample of the items shown above. In any assessment of this Outcome four out of five items should be sampled.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- state two advantages and two disadvantages of a Switched Mode Power Supply over a Linear Power Supply
- explain how a Switched Mode Power Supply operates with respect to variation in switching frequency and duty cycle
- explain how a Switched Mode Power Supply which incorporates Pulse Width Modulation operates
- calculate correctly the switching frequency and duty cycle for a circuit
- calculate correctly the duty cycle and output voltage for a circuit

Assessment guidelines

Questions used to elicit candidate evidence may take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment of this Outcome should be combined with Outcomes 1 and 2 to form a single assessment paper that could be taken at a single assessment event lasting one hour and thirty minutes and carried out under supervised, controlled conditions. Such a paper could be composed of an appropriate balance of short answer, restricted response and structured questions.

Higher National Unit specification: statement of standards (cont)

Unit title: Power Supply Circuits

Outcome 4

Design, build and test regulated power supplies

Knowledge and/or skills

- Design a three terminal integrated circuit d.c. – d.c. power supply
- Design a switched mode integrated circuit d.c. – d.c. or a.c. – d.c. power supply
- Build the two designed circuits
- Test the two designed circuits
- Maintain a log book

Evidence requirements

All knowledge and skills items above should be assessed for this Outcome.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- design to specification
- select the correct components
- use appropriate electronic construction techniques to produce fully operational power supplies
- test to specification
- present a completed and authenticated log book

Assessment guidelines

Centres are recommended to develop and use appropriate checklists to monitor candidate's progress. They are also recommended to monitor candidate log book entries at regular intervals.

Administrative Information

Unit code: DG50 35

Unit title: Power Supply Circuits

Superclass category: XK

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Higher National Unit specification: support notes

Unit title: Power Supply Circuits

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

This Unit has been written in order to allow candidates to develop knowledge, understanding and skills in the following areas:

1. Unregulated full wave rectification and smoothing methods and the use of equations to calculate voltage and component values.
2. Explain the need for a stable, regulated power supply with protection and how such may be achieved.
3. The basic Switched Mode Power Supply circuit operation. In particular the use of equations to calculate duty cycle and switching frequency and explain the advantages and disadvantages of switched mode power supplies.
4. The use of practical skills and knowledge to design, build and test three terminal regulated and switched mode power supplies.

This Unit has been developed as part of a group of Principles and Technology Units within the HND Electronic award.

In designing this Unit the Unit writers have identified the range of topics they would expect to be covered by lecturers. The writers have also given recommendations as to how much time should be spent on each Outcome. This has been done to help lecturers to decide what depth of treatment should be given to the topics attached to each of the Outcomes. Whilst it is not mandatory for centres to use this list of topics it is strongly recommended that they do so to ensure continuity of teaching and learning across the Electronic principles Units. In addition, the assessment exemplar pack for this Unit is based on the knowledge and/or skills and list of topics in each of the Outcomes.

A list of topics is given below. Lecturers are advised to study this list of topics in conjunction with the assessment exemplar pack so that they can get a clear indication of the standard of achievement expected of candidates in this Unit.

1. Analyse the operation of unregulated power supplies. (9 hours)

- transformation
- full wave bridge rectification
- full wave bridge rectification with positive and negative d.c. output levels
- diode volt drop
- calculation of output voltage values (Peak, rms and d.c.)
- capacitor smoothing

Higher National Unit specification: support notes (cont)

Unit title: Power Supply Circuits

- calculation of smoothing capacitance
- calculation of Ripple voltage
- calculation of smoothed rms and d.c. output voltage
- load resistance with respect to ripple
- calculation of diode Peak Inverse Voltage
- output voltage waveforms, unsmoothed, smoothed and ripple

2. Analyse linear regulated power supplies (7.5 hours)

- load regulation
- line regulation
- power supply specification and stability
- series regulator circuit
- SCR crowbar
- current limiting (also known as constant current)
- foldback limiting
- three terminal voltage regulator integrated circuit application and data sheets

3. Analyse the operation of switched mode power supplies (8 hours)

- advantages: size, efficiency, versatility
- disadvantages: Electromagnetic Compatibility, Power wastage on standby
- flyback operation
- pulse width operation
- calculation of switching frequency, duty cycle and output voltage

Assessment for Outcomes 1 – 3 Written Assessment Paper 1.5 hours

4. Design, build and test a regulated power supplies (14 hours)

- for both an integrated circuit d.c. – d.c. three terminal voltage regulator and a basic integrated circuit d.c. – d.c. or a.c. – d.c. switched mode power supply
- design: output voltage, output current for given load range, power dissipated, input voltage range, protection, line regulation and load regulation.
- build circuits
- test: output voltage across load range, protection, line and load regulation

Guidance on the delivery and assessment of this Unit

This Unit may be taught as a free standing Unit, however it also could be combined with appropriate Unit(s) to allow integration of practical assessment.

Higher National Unit specification: support notes (cont)

Unit title: Power Supply Circuits

The Unit is aimed at building on existing bridge rectifier knowledge before introducing the linear regulated power supply and the switched mode power supply. It is worth noting that both of these topics cover a wide range of circuit and device types and that the content and context of this Unit is aimed at equipping the candidate with fundamental knowledge and basic design tools

Delivery of Outcome 1 should provide candidates with the opportunity to build rectifier circuits, determine and test smoothing capacitor and output voltage values. Candidates with prior experience may prefer to simulate circuits if suitable software is available.

Delivery of Outcomes 2 and 3 should focus on the theory of linear and switched mode power supplies. Candidates should be given opportunities to calculate parameters and demonstrate understanding.

Delivery of Outcome 4 should be started as soon as convenient and combined with the delivery of Outcome two and three. It is expected that data sheets for both the linear regulator and switched mode power supply practical circuits be introduced at an early stage to allow the candidates maximum time to become familiar with these components. The practical circuits are expected to be of simple, low voltage design to allow safe working. Candidates are to be encouraged to simulate their designs using appropriate software packages prior to construction, however assessment must be based on the working practical circuits.

Assessment of this Unit falls into two parts. One written assessment paper towards the end of the Unit under controlled, supervised conditions and one practical assignment integrated into the Unit delivery.

Open learning

This Unit could be delivered on an open learning basis. The centre would have to ensure that the written assessment was carried out under controlled and supervised conditions. In addition the authenticity of any practical assignment carried out, out with the centre, would need to be provided.

For information on normal open learning arrangements, please refer to the SQA guide *Assessment and Quality of Open and Distance Learning* (SQA 2000).

Special needs

This Unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering special alternative Outcomes for Units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

General information for candidates

Unit title: Power Supply Circuits

The topic of power supply circuits is immense. As such one Unit cannot do justice to the breadth of the topic. Thus this Unit has been designed to allow a necessary introduction, an initial study into two areas within power supply circuits and practical design and build of two types of power supply.

Outcome 1 introduces the concept of converting alternating current/voltage to direct current/voltage and the means of improving the quality of the output. You will perform calculations to allow you to select correct components.

Outcome 2 builds on this by considering how to maintain specified output values given that input and output conditions will fluctuate. You will perform calculations to reinforce this. It also introduces the concept of controlling the output values by using feedback to regulate the supply to the output and the three terminal regulator power supply. Finally it introduces means of protecting the supplied circuit and the power supply circuit.

Outcome 3 introduces a different area of power supply circuits, namely Switched Mode Power Supplies, or SMPS. There are many different variations of SMPS, here you will learn about the method of converting input to output through a high frequency switching circuit which is common to the majority. You will perform calculations which link switching frequency to output voltage levels.

Outcome 4 provides an opportunity to design, select components, construct and test a three terminal regulator power supply and a SMPS. The exact circuits which you will perform calculations for in all Outcomes is at the discretion of the particular centre where you are studying. In addition you may have access to simulation software which will allow you to test some or all of your calculations and/or designs. The emphasis of this Unit is practical and it is worth noting that practical working circuits are to be produced.

Outcomes 1 to 3 will be assessed by one closed book assessment, done under controlled and supervised conditions, lasting one hour and thirty minutes. Outcome 4 is a practical assignment. You are to carry out all work in a timely fashion and on an individual basis. You will pass Outcome 4 if you successfully design, select components, construct, test and maintain a log book.

Successful achievement of this Unit will provide underpinning knowledge for further Units which make use of power supplies whether in theory or practice. You may choose to do as many have done and make power supplies your career.