SQA Advanced Unit Specification

General information for centres

Unit title: Electricity Power Systems

Unit code: HV3L 47

Unit purpose: This Unit is designed to provide candidates with knowledge and understanding of electrical power supply systems and the concept of power quality. Candidates will also be provided with the opportunity to analyse power system faults and explain methods of improving power system efficiency.

On completion of the Unit the candidate should be abl ne to:

1. Demonstrate knowledge of Electricity Supply Systems.
2. Explain power quality.
3. Analyse power system faults.
4. Solve power factor improvement problems.

Credit points and level: 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*)

**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 National 1 to Doctorates.*

Recommended prior knowledge and skills: Candidates should have a broad knowledge and understanding of the electrical distribution system. This may be evidenced by the possession of the following SQA Advanced Unit: HT7K 47 Three Phase Systems. However, entry requirements are at the discretion of the centre.

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

- Written Communication (reading) at SCQF level 6
- Written Communication (writing) at SCQF level 6
- Using Number at SCQF level 6
- Using Graphical Information at SCQF level 6
- Using Information Technology at SCQF level 6
- Critical Thinking at SCQF level 6

Context for delivery: This Unit has been developed for the SQA Advanced Certificate and SQA Advanced Diploma in Electrical Engineering awards. If this Unit is delivered as part of another

group award, it is recommended that it should be taught and assessed within the subject area of the group award to which it contributes.

Assessment: The assessment for Outcomes 1 and 2 for this Unit should be combined into a single assignment. Where possible this should be linked to an industrial visit. The assessment for Outcomes 3 and 4 should be combined into a single assessment paper. This paper should be taken by candidates at one single assessment event, which should last one and a half hours. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions.

SQA Advanced Unit specification: statement of standards

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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

Demonstrate knowledge of Electricity Supply Systems

Knowledge and/or skills

- Single line schematic
- Function of main items of apparatus
- Types of low voltage earthing systems
- Energy sources
- Load matching
- Substation single line schematic
- Maximum demand, load and diversity factors
- Energy monitoring

Outcome 2

Explain power quality

Knowledge and/or skills

- Harmonic sources
- Harmonic impact
- Harmonic reduction

Evidence Requirements

Evidence requirements for Outcomes 1 and 2 require that each candidate will need to demonstrate that they can answer correctly questions based on all of the knowledge and skills items. The evidence may be presented in responses to specific questions.

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

Outcome 1

- Draw a single line schematic of the electricity supply system which includes the following apparatus: interconnected generators, transmission system, distribution system, industrial and low voltage loads, relevant transformers and small scale generation. The schematic should show at least two feeders in all systems to allow for duality of supply and one spur feeder and should be annotated with relevant voltage levels.
- Explain the function of each item of apparatus in the electricity supply system and the requirement of alternative feed routes
- State earthing points within the electricity supply system and state three types of Low Voltage earthing systems
- State and describe at least four energy sources and list typical ratings for each
- Explain load matching
- Draw a single line schematic of a Primary substation with at least two infeeds.
- Explain maximum demand, load and diversity factors and state their importance.
- Explain the need for energy monitoring

Outcome 2

- List common harmonic sources
- Explain how harmonics can affect the electricity supply system
- Explain how harmonics may be reduced with the application of filters

Assessment guidelines

The assessment for Outcomes 1 and 2 knowledge and/or skills items listed should be combined to form a single assignment. This assignment should be presented by the candidate in report format and should be approximately 1,500 words, plus diagrams, appendices etc. The candidate should have access to suitable texts. Where possible the assignment should be linked to a relevant industrial visit.

Outcome 3

Analyse power system faults

Knowledge and/or skills

- Fault types
- Fault level calculation assumptions
- Fault level calculations

Outcome 4

Solve power factor improvement problems

Knowledge and/or skills

- Power factor improvement
- Calculation of power factor capacitor ratings: Star connected load
- Calculation of power factor capacitor ratings: Delta connected load
- Economical power factor

Evidence Requirements

Evidence requirements for Outcome 3 require that each candidate will need to demonstrate that they can answer correctly questions based on **all** of the knowledge and skills items. Evidence requirements for Outcome 4 will be provided on a sample basis. All evidence may be presented in responses to specific questions. In any assessment of Outcome 4, each candidate will need to demonstrate that they can answer correctly questions based on a sample of **three out of four** of the knowledge and skills items listed.

In order to ensure that candidates will not be able to foresee what items they will be questioned on a different sample of the three knowledge and skills items listed should be selected from Outcome 4 each time the Unit is assessed. In addition all numerical calculations should differ each time the Unit is assessed.

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

Outcome 3

- List at least four types of fault that may occur in a three phase system
- List three assumptions that allow ease of fault level calculation
- Calculate the fault level at a three phase short circuit fed at least by two transformers, cables and a local generator. Only reactance to be used and calculations to be in per unit.

Outcome 4

- Explain the effect of the use of capacitors or synchronous machines to aid power factor improvement.
- Determine the size and rating of power factor improvement capacitors for a star connected three phase inductive load.
- Determine the size and rating of power factor improvement capacitors for a delta connected three phase inductive load.
- Calculate economical power factor for given scenario

Assessment guidelines

The assessment of Outcomes 3 and 4 knowledge and/or skills listed should be combined to form a single assessment paper that should be taken at a single assessment event lasting one and a half hours 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.

Administrative Information

Unit code: HV3L 47

Unit title: Electricity Power Systems

Superclass category: XK

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SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

SQA Advanced Unit specification: support notes

Unit title: Electricity Power Systems

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:

- The apparatus of and its connection to the electricity supply system, including some advantages and disadvantages, required to allow continual provision of electrical power. The connection of a 33/11kV, or equivalent, substation, the concepts of maximum demand, load and diversity factors and energy monitoring.
- Harmonics and their suppression.
- Typical fault types and per unit fault level calculations for a three phase system.
- Power factor improvement, including the calculation of power factor capacitor ratings, relating to improvement of system efficiency.

This Unit has been developed as a Unit within the Mandatory section of the SQA Advanced Certificate and SQA Advanced Diploma in Electrical Engineering awards.

In designing this Unit the Unit writer has identified the range of topics expected to be covered by lecturers. The writer has 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 Electrical 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 obtain a clear indication of the standard of achievement expected of candidates who undertake study of this Unit.

1. Demonstrate knowledge of Electricity Supply Systems (15 hours)

- Interconnection and duality of supply system to provide security of supply
- Simple single line schematic for electricity supply system
- Function of each section of the supply system (Generators, Transformers, Transmission system, Distribution system, Low voltage)
- Earthing connections:
  - Transformer star points
  - Low voltage earthing: TT, TN, TNCS
- Types of energy source, listing advantages, disadvantages, voltage range and MVA range:
  - Steam turbine (Nuclear, coal)
  - Gas turbine
  - Water turbine
  - Wind

  - Wave
  - Solar
  - Combined heat and power
- Load matching
- Single line schematic for 33/11 kV substation, or equivalent, with:
  - Two infeed transformers
  - Infeed circuit breakers
  - Bus section circuit breaker
  - Three feeder circuit breakers, two forming either end of a loop and one feeding a spur.
- Maximum demand
- Load factor
- Diversity factor, include standard After Diversity Maximum Demand for domestic premises.
- Mention availability of commercial software packages to aid load calculations

2. Explain power quality (5 hours)

- Harmonics as frequency multiplies of fundamental
- Harmonic sources: non linear loads (Rectifiers, electronic motor control circuits), computers, filament lamps, unbalanced loads.
- Possible effects of harmonics: mechanical vibration, machines running hotter, interference with electronic and /or communications equipment, Radio Frequency Interference
- The use of capacitors and inductors (Series resonance) as one method of harmonic filtration

3. Analyse power system faults (12 hours)

- List standard fault types
  - Line to earth
  - Line to line
  - Double or triple line to earth
  - Broken conductor
  - Three phase short circuit (line to line to line)
- List three assumptions to allow ease of calculation:
  - System stable
  - System on no load immediately prior to fault
  - System inductive reactance >> than resistance thus resistance assumed negligible
- List standard fault levels for local distribution voltages (250 MVA at 11kV, 100 MVA at 33kV in the UK)
- Per unit calculations
- Concept of ‘infinite busbar’ provided by grid system
- Working with three phase short circuit (worst case scenario) calculate fault level for a fault on an 11kV feeder from a busbar. It is expected that the circuit used will be similar to infinite system feeding twin 33kV lines with inductive reactance and one transformer per line. In addition it is expected that at least one generator should be connected to the 11 kV busbars.

4. Solve power factor improvement problems (8 hours)

- Capacitors for power factor improvement
- Synchronous machines for power factor improvement
- P, Q and S power diagram pre and post power factor improvement
- Connection of power factor capacitors and filters to match load (star to star, delta to delta)
- Calculation of capacitor size and rating for three phase power factor improvement, both star and delta.

Guidance on the delivery and assessment of this Unit

This Unit may be taught as a freestanding Unit, however it also could be combined with appropriate Unit(s) to allow integration of related topics.

It is designed to introduce the candidate to a general electricity supply system and then to provide greater knowledge in; distribution, faults and system efficiency. These are pertinent topics for those working with the supply system or industrial installations. Thus the Unit should appeal to a wide range of candidates.

Delivery of Outcome 1 should be such as to equip the candidate with knowledge of the fundamental components of the electricity supply system.

Delivery of Outcome 2 should focus on harmonics and the need to reduce their influence by filtering. Where possible an industrial visit could be carried out and linked to the assignment that covers Outcomes 1 and 2. If such is not possible other supplementary information could be used to support delivery. (eg guest speakers, video clips) While it is not possible to provide every candidate with a unique assignment, where possible a degree of variety should be introduced to help avoid plagiarism.

Outcome 3 is devoted to faults and calculation of fault levels. Delivery could be centred around 11kV, or equivalent, voltages to allow relevance to as wide a range of candidates as possible, however individual centres may wish to focus on fault level calculations based on other voltage levels.

Delivery of Outcome 4 should focus power factor improvement as a means of improving power system efficiency. Where possible small scale practical work could be implemented.

Assessment of this Unit falls into two areas. One written assessment towards the end of the Unit sat under controlled, supervised conditions and one assignment. It is recommended that the assignment is presented to the candidates during delivery of Outcome 1 and that it could be submitted approximately half way through the delivery of the Unit to allow for an even spread of assessment.

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 assignments carried out, out with the centre, would need to be proved.

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.

General information for candidates

Unit title: Electricity Power Systems

The electricity power system of Europe and parts of Asia is arguably one of the largest, if not the largest, industrial system and infrastructure in the world. Similar systems exist in most other continents. This Unit has been designed to introduce you to such a system. While it has been written with the UK supply system in mind, there is built in flexibility to allow your tutor to use the regional supply system wherever you are. In addition it is recognised that aspects of the electricity supply are equally relevant to engineers working in industries that have high electrical power consumption. Thus, after the introduction, this Unit focuses on some aspects of electricity power systems that are equally valid to industrial engineers as well as electricity supply engineers.

The Unit is divided into four Outcomes. In Outcome 1 you are introduced to the function of each of the main items of plant found in a supply system as well as how to represent the complex system by means of a single line schematic diagram. You are then taken further with a more detailed study of the electrical distribution system and the loads connected to it. The UK standard voltages are 11 kV and 33 kV on this system. Outcome 2 looks at the increasingly important area of harmonics and filtering in order to reduce their pollution. Outcome 3 provides a detailed look, by means of calculation, at the maximum fault level at points within the electrical system. Fault level is usually expressed in MVA and is set at a maximum of 250 MVA for 11 kV and 100 MVA for 33 kV in the UK. Or in other words, for the 11 kV system, the maximum fault current permitted is approximately 13 kA. Note that your tutor may prefer to focus fault level calculations on the transmission system. The final Outcome focuses on the means of improving the efficiency of the supply system by power factor improvement to reduce the system I^2R losses.

Assessment is at the discretion of the centre at which you are studying. However, it is envisaged that you will have two opportunities to prove your knowledge and abilities. Firstly your tutor should provide you with an assignment early on in your study and secondly you will be required to sit a closed book assessment, which will be carried out under controlled and supervised conditions and will last one and a half hours. You are to carry out all work in a timely fashion and on an individual basis.

Successful achievement of this Unit will provide underpinning knowledge for the study of further Units that cover other aspects of the electricity supply system.