

SQA Advanced Unit Specification

General information for centres

Unit title: Switchgear and Protection of High Voltage Systems

Unit code: HV4V 48

Unit purpose: The focus of this unit is on protection utilised within the electricity supply system and associated switchgear. On completion of the unit the candidate should be able to:

1. explain the need for protection devices in high voltage systems
2. explain distribution substation feeder protection schemes
3. explain construction, operation and application of switchgear
4. explain operation and application of protection schemes

Credit points and level: 1 SQA 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 National 1 to Doctorates.*

Recommended prior knowledge and skills: Candidates should have a broad knowledge and understanding of electrical principles and the electrical distribution systems. This may be evidenced by the possession of the following SQA Advanced Units: HP46 47 DC and AC Principles, HT7K 47 Three Phase Systems, HV3L 47 Electricity Power 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
- ◆ Numeracy at SCQF level 6
- ◆ Critical Thinking at SCQF level 6

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Context for delivery: This unit has been developed for the SQA Advanced Diploma in Electrical Engineering. 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 of this unit should be combined into one assessment paper. This paper should be taken by candidates at one single assessment event, which should last two hours. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions. This assessment should be carried out at the end of the delivery of the unit, and be conducted under controlled, supervised conditions.

The assessment for Outcomes 3 and 4 of this unit should be combined into a single written assignment which requires candidates to produce a report of approximately 1,500 words plus diagrams, appendices etc. This assignment should be issued at an early stage in the delivery of the unit. Candidates should have access to relevant textbooks and notes.

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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

Explain the need for protection devices in high voltage systems

Knowledge and/or skills

- ◆ Requirements of protection
- ◆ Overcurrent and earth fault
- ◆ Protection current transformers, voltage transformers and summation transformers
- ◆ Surge protection

Outcome 2

Explain distribution substation feeder protection schemes

Knowledge and/or skills

- ◆ Operation and application of an IDMT overcurrent and earth fault protection scheme
- ◆ Operation and application a unit protection scheme
- ◆ IDMT calculations for a series circuit
- ◆ Application of digital communications within a distribution substation

Evidence requirements

Evidence for the knowledge and/or skills in Outcomes 1 and 2 will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that he/she can answer correctly questions based on a sample of the items shown under the knowledge and/or skills in both outcomes. In any assessment of the outcomes **three out of four** knowledge and/or skills items should be sampled from Outcome 1, and **three out of four** knowledge and/or skills items from Outcome 2.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of three out of four knowledge and/or skills items from Outcome 1, and three out of four knowledge and/or skills items from Outcome 2 is required each time the unit is assessed. Candidates must provide a satisfactory response to all items.

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Where sampling takes place, 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:

Outcome 1

- ◆ explain what protection is required to do in terms of fault removal, minimising disruption and discrimination
- ◆ explain overcurrent and earth faults and the consequences of such existing on an electrical system
- ◆ explain the operation and requirement for current transformers, voltage transformers and summation transformers
- ◆ explain the operation and application of surge protection

Outcome 2

- ◆ explain the operation and application of an IDMT overcurrent and earth fault protection scheme on a substation feeder
- ◆ explain the operation and application of a unit protection scheme on a substation feeder
- ◆ calculate settings for correct grading of three series circuit breakers fitted with IDMT relays with appropriate grading margin
- ◆ describe the application of SCADA, condition monitoring and remote setting and control within a distribution substation

Assessment guidelines

The assessment for Outcomes 1 and 2 should be combined together to form one assessment paper. This single assessment paper should be taken at a single assessment event lasting two hours and be carried out under supervised, controlled conditions. Such a paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

Outcome 3

Explain construction, operation and application of switchgear

Knowledge and/or skills

- ◆ Fuses
- ◆ Circuit breakers
- ◆ Switches
- ◆ Isolators

Outcome 4

Explain operation and application of protection schemes

Knowledge and/or skills

- ◆ Spur protection
- ◆ Distance protection
- ◆ Transformer protection
- ◆ Embedded generation protection

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Evidence requirements

Evidence for the knowledge and/or skills in Outcomes 3 and 4 will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that he/she can answer correctly questions based on a sample of the items shown under the knowledge and/or skills in both outcomes. In any assessment of the outcomes **three out of four** knowledge and/or skills items should be sampled from Outcome 3, and **two out of four** knowledge and/or skills items from Outcome 4.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of three out of four knowledge and/or skills items from Outcome 3, and two out of four knowledge and/or skills items from Outcome 4 is required each time the unit is assessed. Candidates must provide a satisfactory response to all items.

Where sampling takes place, 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:

Outcome 3

- ◆ explain the operation, application and main constructional features of a high voltage fuse
- ◆ explain the operation, application and main constructional features of two of the following circuit breakers: air blast, SF₆, vacuum and oil
- ◆ explain the operation, application and main constructional features of a high voltage switch
- ◆ explain the operation, application and main constructional features of a high voltage isolator

Outcome 4

- ◆ explain the operation and application of a spur protection scheme (autorecloser and sectionaliser)
- ◆ explain the operation and application of a distance protection scheme
- ◆ explain the operation and application of transformer protection (restricted earth fault, Buchholz and winding temperature)
- ◆ explain the operation and application of three items of embedded generation protection

Assessment guidelines

The assessment for Outcomes 3 and 4 of this unit should be combined into a single written assignment which requires candidates to produce a report of approximately 1,500 words plus diagrams, appendices etc. This assignment should be issued at an early stage in the delivery of the unit. Candidates should have access to relevant texts.

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Administrative information

Unit code:	HV4V 48
Unit title:	Switchgear and Protection of High Voltage Systems
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SQA Advanced Unit Specification: support notes

Unit title: Switchgear and Protection of High Voltage 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:

1. Requirement for various protection devices
2. Protection configuration of substation feeders, including application of digital technology
3. Construction and operation of switchgear and its application
4. Protection configuration of supply system schemes

This unit has been written as part of a group of optional units within the SQA Advanced Diploma in Electrical Engineering.

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. While 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 electrical units.

A list of topics is given below. Lecturers are advised to study this list of topics in conjunction with the 'Guidance on the delivery and assessment of this unit' topic below so that they can get a clear indication of the standard of achievement expected of candidates in this unit.

1. Explain the need for protection devices in high voltage systems (7 hours)

Range of different types of faults that can occur in a high voltage system

Consequences of faults

Requirement to have protection, including the concept of backup, reliability, sensitivity and selectivity.

Reasons for using, and operation of the following types of transformers: protection current transformers; voltage transformers (five limbed electromagnetic and capacitor types); and summation transformers. Safety precautions should also be covered.

Surge arrestors and arcing horns

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2. Explain distribution substation feeder protection schemes (11 hours)

Feeder protection schemes in a 33/11 kV or equivalent substation. To include: inverse definite minimum time (IDMT) overcurrent and earth fault, and unit protection on feeders.

IDMT relay operation (electromechanical type) including: plug setting multiplier, time multiplier setting and direct current supply for trip system

Grading margin

IDMT calculations for plug setting and time multiplier setting to allow grading of three circuit breakers

Introduction to and advantages of digital IDMT relays (remote setting, faster operation, condition monitoring)

Digital communications: supervisory control and data acquisition (SCADA); substation LAN for condition monitoring, remote setting and control and LAN and WAN communications (very brief introduction to LAN and WAN)

3. Explain construction, operation and application of switchgear (10 hours)

Only the main, basic features of the construction of the various types of switchgear listed below should be covered so that there is sufficient time to cover the operation and applications in more detail.

Also, the voltage and MVA ratings data for the switchgear items can be provided in tabular form.

Devices to be covered are as follows:

Air blast, SF₆, vacuum and oil circuit breakers. (Make and break load and fault current, and typical voltage and MVA ratings.)

HV isolators (not load or fault switching, typical voltage ratings)

11 kV or equivalent switches (make and break load current, fault make, typical voltage and MVA ratings)

Fuses: high rupture capacity and drop out overhead line types

4. Explain operation and application of protection schemes (10 hours)

Spur protection: autoreclose and sectionalisers. (11 kV or equivalent)

Distance protection

Transformer protection: restricted earth fault, Buchholz and winding temperature.

Embedded generation protection (under and over voltage, under and over frequency, reverse power, loss of mains, instantaneous overcurrent, phase unbalance, neutral voltage displacement, load limitation, earth fault)

Unit assessment:

Written two hour paper covering Outcomes 1 and 2

Written assignment covering Outcomes 3 and 4

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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.

The unit is designed to introduce the candidate to switchgear and protection for the electricity supply system and then to provide greater knowledge in the listed topics. These topics are pertinent for those working with the supply system or industrial installations, thus the unit should appeal to a wide range of candidates within Electrical Engineering disciplines.

Delivery of Outcome 1 should be such as to equip the candidate with knowledge of the rationale for implementing a protection scheme and some fundamental components of such a scheme. It could be taught in conjunction with Outcome 3 to allow the links between protection schemes and switchgear devices to be made as well as to introduce the assignment at an early stage within the teaching of the unit.

Delivery of Outcome 2 should focus on protection schemes utilised on standard distribution (Primary) substation feeders. This will include development of skills required to calculate IDMT settings for one such scheme.

Delivery of Outcome 4 should focus on all the protection schemes listed in the knowledge and/or skills section.

Assessment of this unit falls into two areas. One written assessment towards the end of the unit under controlled, supervised conditions and one assignment. It is recommended that the assignment is issued to the candidate at an early stage in the delivery of the unit. Details on approaches to assessment are given under evidence requirements and assessment guidelines in the SQA Advanced unit specification: statement of standards section. It is recommended that these sections be read carefully before proceeding with assessment of candidates.

Where possible an industrial visit should be carried out and linked to the assignment. If such is not possible other supplementary information should be used to support delivery (eg guest speakers, video clips). In addition, a degree of variety should be incorporated into the assignment to allow the candidates to work on individual scenarios as well as helping to avoid plagiarism. However, it is recognised that it may be inefficient to provide each candidate with a unique assignment when a large class is being taught.

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 assignment 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: Switchgear and Protection of High Voltage Systems

The aim of this unit is to cover two vital components of any electricity system; switchgear and protection. The consequences of either of these failing can be widespread and long lasting. As a direct result from this it is expected that any fault detected on an electricity supply system should be removed as rapidly as possible and with the minimum of disruption. Protection schemes and associated switchgear are the means by which such is made possible.

Many industrial sites have voltage distribution networks, running at voltages above low voltage, that incorporate protection schemes, thus study of this unit is pertinent to both those in electricity supply industry as well as other industries. In addition, study of this unit is pertinent to those who are interested in renewable energy and who wish to learn more about the connection of small scale generators to the electricity supply network.

The unit is divided into four outcomes. In Outcome 1 you will be introduced to the fundamentals of a protection scheme and relevant components that are required to accurately represent voltage and current at lower magnitudes. Outcome 2 is a detailed study of common protection found on substation feeders and will probably centre round a 33/11 kV substation. In particular you will study, in some depth, the implementation of a protection scheme that utilises inverse definite minimum time (IDMT) relays and discrimination. Note that you are not expected to be familiar with these terms prior to starting this unit. Outcome 3 covers the construction, operation and application of switchgear. For the purposes of this unit, switchgear covers: circuit breakers, switches, isolators and fuses. Lastly, Outcome 4 is a study of the operation and application of particular protection schemes within the electricity supply system.

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 during your study of this unit 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 two hours. The assignment will cover Outcomes 3 and 4 and the assessment Outcomes 1 and 2. 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.