SQA Advanced Unit Specification

General information for centres

Unit title: Transmission of Measurement Signals

Unit code: HV6J 48

Unit purpose: This Unit is designed to enable candidates to gain knowledge and understanding of different methods and techniques of transmitting measurement signals. The Unit will cover pneumatic, instrument electrical and digital signals transmission and it will also cover modulation techniques.

On completion of the Unit candidates should be able to:

1 Analyse elements of pneumatic transmission systems.
2 Analyse elements of instrument electrical transmission systems.
3 Analyse modulation system components.
4 Explain elements of digital transmission systems.

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: Access to this Unit will be at the discretion of the centre and the following recommendations are for guidance only. Candidates should have a wide knowledge of Measurement and Control Engineering. This could be evidenced by the possession of the SQA Advanced Units: HV63 47 Distributed Control Systems and HV67 47 Measurement Systems 1.

Core Skills: There are opportunities to develop the Core Skills of Written Communication (Writing), Written Communication (Reading) and Problem Solving (Critical Thinking) at SCQF level 5 and Using Graphical Information at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Context for delivery: If this Unit is delivered as part of a 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: It is recommended that Outcomes 1, 2 and 4 in this Unit should each be assessed by separate assessment papers. The papers should be taken by candidates as three separate assessments that should each last approximately one and a half hours. The assessment papers should be composed of a suitable balance of short answer, restricted response and structured questions. These assessments should be conducted under controlled, supervised conditions.

It is recommended that Outcome 3 is assessed by a practical exercise and a paper composed of a suitable balance of short answer, restricted response and structured questions. The practical exercise should normally be completed in approximately two hours. The question paper part of the assessment should last approximately one and half hours and be conducted under controlled supervised conditions.

The assessments for the four Outcomes should be carried out at the end of the delivery of each Outcome.

It should be noted that candidates must achieve all the minimum evidence specified for each Outcome in order to pass the Unit.

Unit specification: statement of standards

Unit title: Transmission of Measurement Signals

Unit code: HV6J 48

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 elements of pneumatic transmission systems

Knowledge and/or skills

- Principle of operation of a pneumatic instrument relay
- Principle of operation of a volume booster
- Principle of operation of a pneumatic force balance transmitter
- Graphical representation of the relationship between the input force and the resultant output pressure in a pneumatic transmitter
- Closed loop gain of a pneumatic force balance transmitter

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this Outcome four out of five knowledge and/or skills items should be included with the knowledge and/or skills item on analysing the closed loop gain of a pneumatic force balance transmitter always being included.

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

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, with the aid of a sketch, the principle of operation of one type of pneumatic instrument relay
- explain, with the aid of a sketch, the principle of operation of a volume booster
- explain, with the aid of a sketch, the principle of operation of a pneumatic force balance transmitter
- calculate the points to plot and then produce a graph which shows the relationship between the input force and the resultant output pressure in a pneumatic force balance transmitter
- analyse the closed loop gain of a pneumatic force balance transmitter

Evidence should be generated through assessment undertaken in controlled, supervised conditions.

Assessment guidelines

Assessment should be conducted under closed-book conditions and as such candidates must not be allowed to bring handouts, notes or textbooks to the assessment but they should be allowed to bring a non-programmable calculator.

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

Outcome 2

Analyse elements of instrument electrical transmission systems

- K Variable capacitance sensing element
- I to P converter
- P to I converter
- Operational amplifier
- Screened amplifier
- Common mode rejection ratio (CMR)
- Differential amplifier circuit that is used to remove common mode signals

Evidence Requirements

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

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

- explain and analyse the principle of operation of a variable capacitance sensing element
- explain, with the aid of a sketch, the principle of operation of an I to P converter
- explain, with the aid of a sketch, the principle of operation of a P to I converter
- explain, with the aid of a sketch of the standard symbol, the principle of operation of an operational amplifier
- explain, with the aid of a sketch, the principle of operation of a screened amplifier circuit
- explain the terms effective CMR, true CMR and average CMR and also produce an approximate graph of effective CMR when provided with graphs of average CMR and true CMR
- calculate and analyse the circulating currents and the voltage applied to the amplifier in a differential amplifier circuit

Evidence should be generated through assessment undertaken in controlled, supervised conditions.

Assessment guidelines

Assessment should be conducted under closed-book conditions and as such candidates must not be allowed to bring handouts, notes or textbooks to the assessment but they should be allowed to bring a non-programmable calculator.

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

Outcome 3

Analyse modulation system components

Knowledge and/or skills

- Asymptotic response graph of gain against frequency for a simple high pass filter
- Asymptotic response graph of gain against frequency for a simple low pass filter
- Amplitude modulation of a measurement signal
- Amplitude modulation calculations that include depth of modulation, modulation index and bandwidth
- Frequency modulation of a measurement signal
- Frequency modulation calculations that include sensitivity of the voltage controlled oscillator, modulation index and bandwidth
- Time division multiplexing (TDM)
- Frequency division multiplexing (FDM)
- Advantages and disadvantages of TDM and FDM

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this Outcome six out of nine knowledge and/or skills items should be included. At least one of the two knowledge and/or skills items on analysing the response of a simple high pass filter and on analysing the response of a simple low pass filter should always be included.

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

- analyse the response of a simple high pass filter
- analyse the response of a simple low pass filter
- explain the principle of operation of amplitude modulation
- perform calculations on amplitude modulation that will incorporate depth of modulation, modulation index and bandwidth
- explain the principle of operation of frequency modulation
- perform calculations on frequency modulation that will incorporate sensitivity of the voltage controlled oscillator, modulation index and bandwidth
- explain the principle of operation of time division multiplexing
- explain the principle of operation of frequency division multiplexing

- explain two advantages and two disadvantages of time division multiplexing and frequency division multiplexing

Evidence should be generated through a practical exercise and a question paper. The question paper should be conducted under controlled, supervised conditions.

Assessment guidelines

The question paper part of the assessment should be conducted under closed-book conditions and as such candidates must not be allowed to bring handouts, notes or textbooks to the assessment but they should be allowed to bring a non-programmable calculator. The practical exercise part of the assessment should involve the candidate being supplied with a high and/or low pass filter circuit and associated electronic test equipment or alternatively electronic simulation software. The candidate must determine the response of the filter(s), plot the graph of the response(s) and explain their findings.

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

Outcome 4

Explain elements of digital transmission systems

Knowledge and/or skills

- Sampling theorem
- Pulse code modulation
- Digital shaft encoder used to measure angular displacement
- Analogue-to-digital converter
- Ladder type of digital-to-analogue converter
- Double parity error detection technique
- Chain code error detection technique

Evidence Requirements

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

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

- explain the sampling theorem and the effects of aliasing that can occur in a signal that has not been sampled sufficiently
- explain the process of pulse code modulation and the features of quantisation and companding
- explain, with the aid of a sketch, the principle of operation of a digital shaft encoder
- explain, with the aid of a sketch, the principle of operation of one type of analogue-to-digital converter

- calculate the output voltage that is generated by a 4-bit ladder type of digital-to-analogue converter when a digital signal is applied to the input of the converter
- determine the error in a code that has been transmitted using the double parity error detection technique
- generate the chain code for a four bit binary number

Evidence should be generated through assessment undertaken in controlled, supervised conditions.

Assessment guidelines

Assessment should be conducted under closed-book conditions and as such candidates must not be allowed to bring handouts, notes or textbooks to the assessment but they should be allowed to bring a non-programmable calculator.

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

Administrative information

Unit code: HV6J 48

Unit title: Transmission of Measurement Signals

Superclass category: VE

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History of Changes:

Version	Description of change	Date

Source: SQA

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.

Unit specification: support notes

Unit title: Transmission of Measurement Signals

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 Analyse elements of pneumatic transmission systems.
2 Analyse elements of instrument electrical transmission systems.
3 Analyse modulation system components.
4 Explain elements of digital transmission systems.

This Unit is at SCQF level 8 and has been devised as a mandatory Unit within the new SQA Advanced Diploma in Measurement and Control Engineering award. However this does not preclude the use of this Unit in other awards where award designers feel this to be appropriate.

In designing this Unit, the Unit writer has identified the range of topics that they would expect 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 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 recommended that they cover them.

A list of topics for each Outcome is given below.

Outcome 1

Analyse elements of pneumatic transmission systems (10 hours inc. assessment)

- flapper and nozzle assembly
- direct acting instrument relay
- reverse acting instrument relay
- continuous bleed instrument relay
- non-bleed instrument relay
- volume booster
- high pass instrument relay
- low pass instrument relay
- computer relay
- input coil on a transmitter
- feedback bellows
- single beam dp transmitter
- double beam dp transmitter
- mathematical and graphical relationship between the input force and the resultant output pressure in a pneumatic force balance transmitter

- closed loop gain of a pneumatic force balance transmitter which includes the following parameters:
  - bellows area
  - feedback pressure
  - differential pressure
  - input pressure
  - output pressure
  - range
  - input force
  - linkage constant
  - spring constant

Outcome 2

Analyse elements of instrument electrical transmission systems (10 hours inc. assessment)

- variable capacitance sensing element
- electronic dp cell
- P to I converter
- I to P converter
- operational amplifier
- screened amplifier
- common mode rejection ratio (CMR) including:
  - definition and graphical representation of effective CMR
  - definition and graphical representation of true CMR
  - definition and graphical representation of average CMR
- differential amplifier circuit to remove common mode signals which will include the following parameters
  - earth differential voltage
  - source resistance
  - noise
  - circulating current
  - line to earth impedance
  - amplifier gain

Outcome 3

Analyse modulation system components (10 hours inc. assessment)

- standard symbols for high pass, low pass, band pass and band stop filters
- characteristics of high pass, low pass, band pass and band stop filters
- electronic circuits for simple high pass and low pass filters
- use of software packages to demonstrate the operating characteristics of simple high pass and low pass filters
- use of signal generators and oscilloscopes to demonstrate the operating characteristics of simple high pass and low pass filters
- asymptotic gain/frequency response graphs for simple high pass and low pass filters
- amplitude modulation including:
  - principle of amplitude modulation
  - depth of modulation
  - modulation index
  - bandwidth

- frequency modulation including:
  - principle of frequency modulation
  - sensitivity of voltage controlled oscillator (VCO)
  - modulation index
  - bandwidth
- time division multiplexing (TDM)
- frequency division multiplexing (FDM)
- advantages and disadvantages of TDM and FDM

Outcome 4

Explain elements of digital transmission systems (10 hours inc. assessment)

- sampling and the sample theorem
- aliasing
- pulse code modulation
- quantisation
- companding
- digital shaft encoder
- analogue-to-digital converter including:
  - comparator type
  - counter ramp type
  - successive approximation type
- ladder type of digital-to-analogue converter
- error detection codes including:
  - single parity error detection
  - double parity error detection
  - Hamming code
  - chain code

Unit Assessment

Question paper for Outcome 1	1 hour 30 minutes
Question paper for Outcome 2	1 hour 30 minutes
Question paper for Outcome 3	1 hour 30 minutes
Practical exercise for Outcome 3	2 hours
Question paper for Outcome 4	1 hour 30 minutes

Guidance on the delivery and assessment of this unit

This Unit has been designed to incorporate sufficient time to allow the lecturer to teach, in a student centred way, different methods and techniques of transmitting measurement signals. It will cover pneumatic, instrument electrical and digital signal transmission and it will also cover modulation techniques.

The content of the four Outcomes means that they are not a direct follow on to each other and hence they could be delivered in any order. Due to the range of topics covered in each Outcome it is recommended that each Outcome is assessed, with a separate paper, at the end of the delivery for that Outcome.

The knowledge and skills of each Outcome could be supported by practical exercises.

Details on approaches to assessment are given under Evidence Requirements and Assessment guidelines under each Outcome 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.

Opportunities for developing Core Skills

There are opportunities to develop the Core Skills of Written Communication (Writing), Written Communication (Reading) and Problem Solving (Critical Thinking) at SCQF level 5 and Using Graphical Information at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line support. With regard to assessment, planning would be required of the Centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that written assessments were conducted under controlled, supervised conditions. Arrangements would need to be made to ensure that the candidate could perform practical work on filter circuits. This could involve the candidate attending the Centre or utilising video conferencing. Alternatively, special arrangements could be made for the candidate to demonstrate the practical work to a designated, responsible person local to the candidate.

For information on open learning, please refer to *SQA guide assessment and quality assurance of open and distance learning (A1030, Feb 2001).*

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: Transmission of Measurement Signals

This Unit has been designed to provide you with the knowledge and skills that will enable you to understand different methods and techniques of transmitting measurement signals.

In Outcome 1 you will learn about different methods and techniques of transmitting pneumatic signals.

In Outcome 2 you will learn about different methods and techniques of transmitting instrument electrical signals.

In Outcome 3 you will learn about modulation techniques that are used when transmitting measurement signals.

In Outcome 4 you will learn about different methods and techniques of transmitting digital signals.

The formal assessment for this Unit will consist of four separate assessments. The assessment papers for Outcomes 1, 2 and 4 will each last 1 hour 30 minutes. The assessment for Outcome 3 will consist of a practical exercise that will last 2 hours and a question paper that will last 1 hour 30 minutes.

The question paper assessments will be carried out under closed-book conditions in which you will not be allowed to take notes, handouts, textbooks, etc into the assessment although you will be allowed to use a non-programmable calculator.

The assessments for each of the four Outcomes will be taken at the end of the delivery for each Outcome.