FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE466 - POWER ELECTRONICS DEVICES, DRIVES, MACHINES & APPLICATIONS

Module Code: EE466		**Module Title:** Power Electronics Devices, Drives, Machines & Applications	
Module Registrar: Dr. Derrick Holliday			
Other Lecturers Involved: Dr Neville McNeill		**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: E		**Academic Level:** 4	

Pre-requisites: EE311 - Electronic & Electrical Principles

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
48	24	80	0	48	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

Understand the principles of common power electronic systems

Gain familiarity with the techniques required to analyse common power electronic circuits

Understand the operating principles of common DC and AC machines

Gain familiarity with the techniques required to analyse DC and AC machines

Gain familiarity with the basic principles of generalised machine theory, and the lnk betyween DC and AC machines models

Understand the operation of power electronics used to control electrical machines and drives

Gain familiarity with the combination of machines and power electronics required to achieve speed and torque control in drive systems

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

C 1: Electrical Machines: Be familiar with the basic techniques required to analyse magnetic circuits. Be familiar with the component parts of practical electrical machines. Understand the operating principles of DC and AC electrical machines. Use standard machine models to calculate key electrical quantities and to analyse machine operation. Derive two-axis models for simple AC machines.

C 2: Power Electronics: Explain the operation of common power electronics devices and circuits used in drive applications. Analyse the common rectifier, and DC-DC and DC-AC converters. Derive the equations which define the operation of a range of power converters including rectifiers, line-commutated and self-commutated systems. Calculate losses and cooling requirements for a range of power converters. Calculate current ripple produced by power converters and understand the trade-off between current ripple (switching frequency harmonics), power semiconductor losses and machine performance.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

1. Electrical Machines:
i) Revision of basic AC and DC machine behaviour (torque and back-emf production in DC machines, torque production in induction motors, and the derivation of the induction motor equivalent circuit)
ii) Design principles of rotating electrical machines
iii) Two-axis model of AC machines (origin of the two-axis model, and stationary and synchronous reference frames)
iv) Dynamic models of AC and DC machines

2. Power Electronics:
i) Introduction to power semiconductor devices
ii) Single-phase rectifier (diode and thyristor)
iii) Principles of switch mode power supplies (Buck, Boost and Fly-Back)
iv) Introduction to DC-AC converters (four switch H-bridge, fundamental switching, PWM)
v) Power semiconductor losses (calculation of power semiconductor losses, heatsinking)

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Perform calculations to analyse magnetic circuits

C 2: Perform calculations to define key electrical parameters and to analyse the performance of DC and AC machines

C 3: Develop models for common electromagnetic systems such as transformers, and DC and AC machines

C 4: Develop a two-axis model of a n AC machine

LO2

C 1: Explain the operation and characteristics of power semiconductor devices, e.g. MOSFET and IGBT

C 2: Analyse power electronic circuits, e.g. H-bridge converter

C 3: Calculate the power loss and cooling requirements for a specified power electronic circuit at a stated operating point

LO3

C 1:

LO4

C 1:

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 PRINCIPLES OF ASSESSMENT FEEDBACK

Please state briefly how these are incorporated in this module.

Students will be set 2 coursework exercises: one for each section of the module. These may consist of a selection of tutorial questions, or specific and focused technical exercises. Students will receive feedback.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

ASSESSMENT METHOD(S) INCLUDING PERCENTAGE BREAKDOWN AND DURATION OF EXAMS

To Pass the module, students need to gain a summative mark of;				**40%**		
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	LO1-3
Coursework	**Number**	2	**Weighting %**	40	**Learning Outcomes**	LO1-3
Project	**Number**	0	**Weighting %**	0	**Learning Outcomes**	

COURSEWORK / SUBMISSIONS DEADLINES:	CW1: S1 WK12, CW2: S2 WK12
RESIT ASSESSMENT PROCEDURES:	Examination of similar form to 1st diet

ADDITIONAL INFORMATION RELEVANT TO COURSE DELIVERY AND ASSESSMENT

RECOMMENDED READING

The following titles are examples of texts that may be consulted in support of the lecture series. The module does not rely on any of these texts in particular. Students are encouraged to consult any of the numerous other texts that exist on the topics of power electronics and electrical machines.

‘Power Electronics’, 3rd Ed, C W Lander (McGraw-Hill), ISBN 0-07-084162-4

‘Principles of Electric Machines and Power Electronics’, P.C. Sen (Wiley), ISBN 0-471-61717-2

‘Electrical Machines, Drives and Power Systems’, T. Wildi (Prentice-Hall), ISBN 0-13-082460-7

'Power Electronics: Converters, Applications and Design', N Mohan et.al. (Wiley), 0-471-22693-9

B.W.Williams on-line text, available at http://homepages.eee.strath.ac.uk/~bwwilliams/book.htm

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S2	**Week**	2	**Nature**	Coursework mark
Semester	S2	**Week**	14	**Nature**	Coursework mark
Semester		**Week**		**Nature**	
Further comments about feedback					

SIGNATURE (COURSE DIRECTOR):
DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE466	**Module Title:** Power Electronics Devices, Drives, Machines & Applications

Brief Description of Assessment

The assessment comprises a set of two marked coursework exercises. The coursework will be issued in parallel with the taught topics (LO's) and will be submitted for marking near the end of each taught block. Assignments will be marked and returned to students to provide feedback on performance.

There will be a single examination of three hours duration. The exam will contain six questions (2 sections each with 3 questions) covering each of the LO's. Students will be required to complete 2 questions from each section. Questions are designed to be of a length and difficulty consistent with a three hour examination.

Indicate on the table below the Start/Submission dates for each Assignment/Project and the timing of each Exam/Class Test(s).

	Semester 1	Semester 2
Week 1		
Week 2		
Week 3		
Week 4		
Week 5		
Week 6		
Week 7		
Week 8		
Week 9		
Week 10		
Week 11		
Week 12	Assignment	Assignment
Revision Week		
Exam Period		

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE467 - POWER SYSTEM DESIGN, OPERATION AND PROTECTION

Module Code: EE467	**Module Title:** POWER SYSTEM DESIGN, OPERATION AND PROTECTION	
Module Registrar: Dr Adam Dyśko		
Other Lecturers Involved: Dr Olimpo Anaya-Lara, Dr Qiteng Hong, Dr Panagiotis Papadopoulos	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: O	**Academic Level:** 4	

Pre-requisites: 3rd year UG Power Engineering Module or equivalent (e.g. EE311)

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
44	22	15	4	115	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

To enable students to appreciate the principles of analysis, design and proteciton of electrical power systems including:

1. design and operational approaches in power systems including electricity generation, transmission and distribution.
2. analysis and design of transmission and distribution networks
3. power flow, fault and stability calculations
4. power system control including load frequency control and economic dispatch
5. generation technology implications on power system design and operation
6. the main concepts related to the requirements, functions, design and operation of protection schemes for power system transmission and distribution systems
7. detailed understanding of selected protection schemes used in transmission and distribution networks.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: To derive the mathematical representations of power system equipment and the practical significance of different components in a power system

LO 2: To use these representations for power system performance analysis and design tasks

LO 3: To understand fault phenomena in power systems and the reasons why these must be protected against

LO 4: To have a broad knowledge of different means of providing power system protection and have the ability to specify and configure a number of widely-used protection schemes

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

Transmission and distribution networks: analysis of circuits with overhead lines and underground cables, ABCD parameters for long lines, voltage regulation, surge impedance loading and reactive compensation, circuit loading limits, transformers, losses and efficency, ladder iterative technique for radial circuits.

Power flow and stability: basic concepts of load flow, network equations; thermal, voltage, steady state and transient stability; equal area criterion; effects of control equipment.

Generator unit characteristics: control of power and frequency, VAr and voltage control and power quality.

Fault calculations: fault calculations and their context in power system and techniques; single- and three-phase ac and dc component calculation, thevenin equivalent circuits, sub-transient, transient and steady state fault evolution, contributions from load and generation pre-fault, effects of fault impedances. Unbalanced faults and the use of symmetrical components to calculate fault currents in systems for differetn types of faults. The impact of earthing on fault current flows.

Generation technologies, system impacts and control issues including effect on stability, control and economic operation of the power system.

Why is protection required? Types of faults and conditions to be protected against – review of faults, calculation of fault levels and the impact of faults.

Description of protection system performance characteristics: discrimination, stability, sensitivity, speed of operation.

Economics of protection systems and typical applications at various voltage levels in the UK.

Components of protection systems.

Protection philosophy, unit, non-unit, provision of backup.

Transducers: CT, VT and CVT. CT and CVT construction and equivalent circuits. Error and performance characteristics, CT saturation, ferroresonance in circuits employing CVTs.

Protection relays: electromechanical, operating principles of basic attracted armature, balanced beam and induction disc relays.

Communications for protection systems: applications, overview of physical means (and their relative merits) of communicating between relaying points.

Overcurrent relaying: characteristics, settings, grading examples of multi-relay applications.

Distance protection: characteristics, zones, residual compensation, power swing blocking, acceleration schemes.

Differential protection: circulating current and voltage balance, high impedance, transient instability, biasing, applications

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Describe, derive and manipulate models of different power system components

LO2

C 1: Use mathematical models to solve power systems problems and perform analyses

C 2: Critical thinking on the results obtained from these analysis - interpretation of results and suggestions how to correct technical problems

LO3

C 1: Critical thinking and understanding of fault phenomena, the requirements for protection and basic principles.

C 2: Ability to calculate faults levels in power systems using symmetrical components.

LO4

C 1: Ability to describe, specify and set protection schemes and to be able to comment on the suitability or otherwise of protection systems in various contexts.

C 2:	Demonstrate practical knowledge and understanding of the principles of setting protection schemes.

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 Principles of Assessment Feedback

Please state briefly how these are incorporated in this module.

Assessment will comprise of a Final Exam, a Midterm exam and one Assignment. The Midterm exam is schedule at the end of S1, so that students can assertain their progress and can improve in the S2. The Assignment will allow students to get hands-on experience in applying taught material to carry out evaluation studies or use tools typically applied in industry. Thus, students will be able to assess their progress on their own, but will also get a formal feedback with an indication where additional learning and clarification could be useful.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

Assessment Method(s) Including Percentage Breakdown and Duration of Exams

To Pass the module, students need to gain a summative mark of;					**40%**	
Examination	**Duration**	2h	**Weighting %**	70	**Learning Outcomes**	All
Coursework	**Number**	2	**Weighting %**	30	**Learning Outcomes**	All
Project	**Number**		**Weighting %**		**Learning Outcomes**	

Coursework / Submissions deadlines: End of S1 and second half of S2

Resit Assessment Procedures: Resubmission of course work

Additional Information relevant to Course Delivery and assessment

Recommended Reading

Mandatory: J. Glover, M. Sarma and T.Overbye "Power System Analysis and Design", 5th ed., Cengage Learning, (2011).

Mandatory: Network Protection and Automation Guide (NPAG), 2011 Edition, Alstom (https://electrical-engineering-portal.com/download-center/books-and-guides/electrical-engineering/automation-guide). FREE.

Additional: Paul M. Anderson: Power System Protection (IEEE Press Series on Power Engineering). Available from IEEE Xplore (http://ieeexplore.ieee.org).

Additional: Y.G. Paithankar, “Fundamentals of Power System Protection” – available on Amazon for £13.50 and provides comprehensive coverage of the subject.

Additional Student Feedback; Specify details of when additional feedback will be provided.

Semester	S2	**Week**	2	**Nature**	Results of the mid-term class test
Semester	S2	**Week**	12	**Nature**	Marked assignment report
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Further comments about feedback		The feedback is designed so to provide gudance on how to approach different types of problem solving challenges, including True/False and multiple choice questions, essay type questions, design exercises and simple numerical problems.			

Signature (Module Registrar):

DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE467	**Module Title:** POWER SYSTEM DESIGN, OPERATION AND PROTECTION
Brief Description of Assessment	
Assessment for the module is through mid-term class test (in December revision period) for 15%, assignment in second semester for 15% and final exam in May diet for 70%.	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			**Semester 2**	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**		
Week 2			**Week 2**		Test - Marked
Week 3			**Week 3**		
Week 4			**Week 4**		
Week 5			**Week 5**	Assignment Start	
Week 6			**Week 6**		
Week 7			**Week 7**		
Week 8			**Week 8**		
Week 9			**Week 9**	Assignment - Due	
Week 10			**Week 10**		
Week 11			**Week 11**		
Exam Period	Test		**Revision Week**		Assignment Marked
Review Week			**Exam Period**	Examination	

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	5	**Total # to be attempted**	3	**Compulsory Questions**	1 Question	**Sections**	Multiple
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

The exam paper is laid out to have 3 sections, section A with one compulsory question containing elements from all parts of the module, section B with two optional questions related system analysis and stability, and section C with two optional questions related to power system protection. The student needs to attempt one question from each section. This way it is not possible to avoid any part of the module in preparation for the final examination.

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; Yes

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

Students are expected to recall basic formulae, which can be inferred from fundamental electrical principles (e.g. Ohm's Law or Kirchoff's Laws). More involved equations, e.g. iterative load flow solution, are provided in the exam paper.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Final Examination

C1.

LO2 Final Examination

C1.

LO3 Final Examination

C1.

LO4 Final Examination

C1.

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE468 - ADVANCED ANALOGUE SYSTEMS

Module Code: EE468	**Module Title:** Advanced Analogue Systems	
Module Registrar: Prof James Windmill		
Other Lecturers Involved: Prof A Gachagan Dr Francesco Guarato, Dr David Paterson, Dr Andrew Reid	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: O	**Academic Level:** 4	

Pre-requisites:	Successfully passed module EE315 or equivalent analogue systems study

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
44	22	22	12	100	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

This module will provide the student with an appreciation and understanding of analogue electronic circuit design, relating to high frequency amplifiers and low noise design of electronic systems.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Have the ability to design and analyse multi-stage amplifier circuits using small signal models.

LO 2: Gain an intellectual understanding of the physical mechanisms that contribute to electrical noise in amplifier circuits, which will provide the student with the ability to implement and analyse amplifier circuits that incorporate different noise sources.

LO 3: Understand the design process for single and multi-stage amplifiers by using the knowledge gained in LO1 & LO2.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

(1) Review of analogue circuit design and simulation tools and techniques.
(2) Physics of the BJ and MOS transistors; Hybrid - Pi small signal equivalent circuits for BJ and MOS devices
(3) Analysis of single stage high frequency configurations - CE,CC,CB,CS,CD etc; Construction of high frequency amplifier building blocks
(4) High frequency design examples; Incorporation of negative feedback; Design studies of integrated circuit high frequency amplifiers
(5) Fundamental noise mechanisms - thermal, shot and 1/f noise sources; Modelling of noise sources and analysis of noisy circuits
(6) General model for a noisy amplifier system; Calculation of Noise Figure and Signal to Noise Ratio; Noise Equivalent Circuit for the BJT
(7) Examples of low noise amplifier design in instrumentation, optics and acoustic applications.

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Quality of technical report based on project assignment.
C 2: Review of progress in tutorial questions.
C 3: Performance in final examination.

LO2

C 1: Review of progress in tutorial questions.
C 2: Performance in final examination.

LO3

C 1: Quality of technical report based on project assignment.

LO4

C 1:

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 PRINCIPLES OF ASSESSMENT FEEDBACK

Please state briefly how these are incorporated in this module.

1. Course goals and assessment criteria are clearly explained in course handout, introductory lecture and MyPlace.
2. Students have significant private study time to allocate to the project based assignments.
3. Students will receive feedback on their assignment performance through MyPlace.
4. Tutorial sessions will be broken down into smaller groups to encourage learning through peer group interaction, in addition to conventional TA support.
5. MyPlace will be used to provide support materials, technical quiz, feedback on assignments to students and feedback from students on course related topics.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

ASSESSMENT METHOD(S) INCLUDING PERCENTAGE BREAKDOWN AND DURATION OF EXAMS

To Pass the module, students need to gain a summative mark of;					**40%**	
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	LO1, LO2
Coursework	**Number**	4	**Weighting %**	40	**Learning Outcomes**	LO1, LO3
Project	**Number**		**Weighting %**		**Learning Outcomes**	

COURSEWORK / SUBMISSIONS DEADLINES:	Assignment 1- S1, Wk11; Assignment 2 -S2, Wk9
RESIT ASSESSMENT PROCEDURES:	Examination

ADDITIONAL INFORMATION RELEVANT TO COURSE DELIVERY AND ASSESSMENT

Laboratory sessions will be scheduled to reinforce the taught lecture material.

RECOMMENDED READING

1. “Electronic Circuit Analysis and Design” by D.A. Neamen (McGrawHill)
2. “Low noise Electronic Design” by C.D. Motchenbacher (John Wiley)

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S1	**Week**	4	**Nature**	Online (automated) feedback on quiz
Semester	S2	**Week**	2	**Nature**	Feedback on S1 assignment
Semester	S2	**Week**	11	**Nature**	Feedback on S2 assignment
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Further comments about feedback		All feedback is delivered through MyPlace.			

SIGNATURE (MODULE REGISTRAR):
DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE468	**Module Title:** Advanced Analogue Systems
Brief Description of Assessment	
Online Quiz - Check students basic knowledge of bipolar junction transistor amplifier design. **Class Test - Formally check students understanding a BJT amplifier design and analysis.** **Assignment 1 – Simulation study of a multi-stage amplifier design. Students have to write a technical report detailing their findings regarding amplifier gains and frequency response.** **Assignment 2 – Simulation mini-project in which students will write a technical report on the behaviour and performance of an amplifier design, with particular reference to system design.** **Final Exam – 2 hour duration; Students answer 3 questions from 5.**	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			**Semester 2**	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**	Assignment Start	
Week 2			**Week 2**		Feedback Provided
Week 3			**Week 3**		
Week 4	Quiz		**Week 4**		
Week 5	Assignment Start		**Week 5**		
Week 6			**Week 6**		
Week 7	Test		**Week 7**		
Week 8		Test - Marked	**Week 8**		
Week 9			**Week 9**	Assignment - Due	
Week 10			**Week 10**		Assignment Marked
Week 11	Assignment - Due		**Week 11**		Feedback Provided
Exam Period		Assignment Marked	**Revision Week**		
Review Week			**Exam Period**	Examination	

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	5	**Total # to be attempted**	3	**Compulsory Questions**	None - free choice	**Sections**	Single
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

The 2 hour exam has 5 equally weighted questions from which the student must choose and attempt 3. It is not possible to cover the entire syllabus in the 5 questions, but the exam will cover LO1 and LO2. Other elements of the syllabus will be covered in the student coursework (with LO3).

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; Yes

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

Students are expected to recall certain formula, although a number are provided. Some questions will require students to prove/show that a certain formula is correct. The students will have to use specific mathematical formula through the majority of the examination paper.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Final Examination

C1.

LO2 Final Examination

C1.

LO3 Assignments

C1.

LO4 Final Examination

C1.

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE469 - DIGITAL SIGNAL PROCESSING PRINCIPLES

Module Code: EE469	**Module Title:** Digital Signal Processing Principles	
Module Registrar: Prof J Soraghan		
Other Lecturers Involved: Dr Carmine Clemente	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: C 0	**Academic Level:** 4	

Pre-requisites:	EE310 Signals & Systems or Equivalent Linear Systems. It will be assumed that the student has a basic understanding of the Laplace Transform and the continuous Fourier Transform and how these are used in analysing continuous LTI systems. A basic knowledge of Matlab is assumed however a full introduction to Matlab is made available.

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
33	20	24	20	103	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

Develop necessary advanced tools that will allow the student to design, analyse and simulate (Matlab) Digital Signal Processing (DSP) systems including artifical neural networks and deep learning architectures by introducing core mathematical concepts, algorithms and fundamental properties of discrete signal and systems with applications. The module also aims to provide the students with an understanding of the fundamental DSP based building blocks encountered in linear adaptive, artificial neural networks and deep learning systems.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Basics and Time Domain characteristics of DSP Systems
define the components of a basic DSP system
technically describe what the SIFTING Property of signals is and how it is useful
describe LTI discrete systems using linear difference equations with constant coefficients;
define what is meant by the impulse response, step response and frequency response of LTI discrete systems
use the 1D&2D linear convolution sum and linear correlation sum for digital filtering and signal comparison respectively and link these to the cyclic (circular) convolution/correlation and block convolution methods
understand the time domain basis of the Nyquist sampling theorem and aliasing
write periodic sinusoidal discrete signals as a finite sum of weighted, harmonically related complex exponentials (DFS) using Euler's relation

LO 2: DSP Tools and DSP System Analysis
understand the principles of and links between the ZT-DTFT, DTFT-DFT, and DFS-DFT;
understand the concept of the FFT and its computational advantage relative to direct evaluation of the DFT using the DFP Matrix method for analysing discrete signals and systems using the transform tools ;
describe aspects of a DSP system from the Pole Zero diagram including Stability, Causality, Magnitude and Phase of the Frequency Response (Sketching Rules), Minimum Phase, the typical output shapes expected from the system ;
mathematically describe DSP Rule 1 (Acquisition), DSP Rule 2 (Time Sampling : Nyquist Sampling Theorem) and DSP Rule 3 (Frequency Sampling : DFT) ; DSP Rule 4 Sub-Nyquist Sampling
understand the frequency domain basis of the Nyquist sampling Theorem and Aliasing and to define the specifications of the anti aliasing and reconstruction filters ;
describe the basic sample and hold ADC and to derive the SQNR formula explaining its significance
reconstruct continuous signals from their samples (DAC);
analytically describe multirate DSP systems from a time domain and frequency domain perspective (1D&2D decimation and interpolation);
Understand the importance and fundamental issues (Spectral Leakage, Scallop Loss, Resolution) associated with windowing in DSP;
Understand the mathematical principles of the Disrete Cosine Transform (DCT);

Using the DCT Matrix for evaluating the DCT and using th DCT for compression;

LO 3: Digital Filters, and Time Frequency Spectral Analyis with Applications
design Digital Filters using direct pole zero placement;
describe how to select between an FIR and IIR structure;
design IIR filters using the Impulse Invariant and bilinear Transformation design methods;
describe the FIR Designs method using window design method and to be able to use the inverse DTFT in this design method;
construct a canonical realisation of a Digital Filter from H(z) and from Linear Difference Equations;
understand the technical principles of the Short Time Fourier Transform (STFT) for characterising time varying discrete signals;
use Polyphase Digital filters and the Noble Identity for the design of efficient decimators and interpolators;
understand linear and non-linear adaptive filters with applications to Artifical Neural Networks and Deep Learning DSP based systems;
use the autocorrelation function and the DFT for Spectrum Estimation;
understand the principles of Speech and Radar Signal processing with applications;

LO 4: DSP Simulations & Applications
carry out simulations of DSP principles and DSP system design using Matlab;

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

Syllabus :

Part 1 :

[1] Discrete Signals & Systems and DSP

Introduction, Basic elements of a Digital Signal Processing System, Quantisation, SQNR and ADC/DAC, Basic Discrete Signals, Sampling and Aliasing (Time Domain Investigation), Sifting Property of Signals, Signal Measures, Basic Discrete Systems: Linear Time Invariant (LTI) Discrete Systems; Linear Difference Equations, LTI system Responses, 1D & 2D Convolution Sum and Correlation Sum, Cyclic (Circular) Convolution/Correlation, Overlap Add and Overlap Save methods

[2] DFS, ZT, DTFT, and System Analysis

Discrete Fourier Series (DFS), ZT of Basic Signals & Convolution using Z-transform, System Function [H(z)], Pole Zero Representation, The Discrete Time Fourier Transform (DTFT) , Frequency Response [H(Ω)], DSP Rule 1: Acquisition; DTFT of Basic Signals, Convolution and Correlation using the DTFT; Analysis of LTI Discrete Systems, Frequency Response of LTI Discrete Systems, Uses of the Pole and Zero Diagram for DSP System Analysis, Roadmap for LTI Discrete System Analysis

[3] Time Sampling (Nyquist, Aliasing) and Frequency Sampling (DFT)

DSP Rule 2: The Nyquist Sampling Theorem, Aliasing (Frequency Domain Investigation) and Anti Aliasing, and Anti Spectral Images Filters, Reconstruction of a Bandlimited Signal from its Samples, 1D & 2D Upsampling and Downsampling, Multirate Sampling; Polyphase Filters and Noble Identities, Sampling the DTFT: DFT DSP Rule 3: Frequency Domain Sampling, DFT:DFS Equivalence. DSP Rule 4: Compressive Sensing (Sub-Nyquist Sampling)

[4] The Discrete Fourier Transform and its Characteristics

The Discrete Fourier Transform (DFT), The (DFS- DFT) and (DTFT-DFT) relationships; DFT Bins, Resolution, Spectral Leakage, Scallop Loss, Windowing and Spectral Characteristics of Various Time Windows

[5] Evaluating the DFT using (i) the DFT Matrix Method and (ii) the Fast Fourier Transform (FFT)

Evaluating the DFT using the Matrix Method and the Decimation in Time radix-2 Fast Fourier Transform (FFT) Algorithm, Convolution/Correlation using the DFT/FFT, Fast Overlap Add and Overlap Save Methods,Signal interpolation using the FFT. Computing the 2D DFT.

PART 2 :

[6] The Discrete Cosine Transform (DCT) and Evaluating the DCT

DCT Basics,DCT formulation,DCT Matrix ,DCTcomputation, DCT Example [Numerical and Matlab], DCT based Compression

[7] Digital Filters : Realisation & Design

Introduction, Realisation of Digital Filters, Linear Phase FIR Digital filters, Design and Realisation of IIR filters from analog Filters using the Impulse Invariant and Bilinear Transformation Methods, Design and Realisation of FIR filters by (i) pole zero placement (ii) Comb methods (iii) Window method & (iv) Optimal Design (Parks and McClellan Design), Effects of Finite Wordlength in Real Digital Filter designs

[8] Fundamentals of Linear Adaptive, Artificial Neural Networks and Deep Neural Networks Systems

[9] Time Frequency Signal Representation

Short Time Fourier Transform with Applications to Speech and Radar Signal Processing

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Analytically describe the time domain nature of Digital Signal Processing Signals and Linear Time invariant DSP systems

LO2

C 1: Use mathematical analysis for DSP system design and analysis

LO3

C 1: Use DSP design tools for applications relevant to LO3

LO4

C 1: Use Matlab simulation tools to reinforce DSP principles

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 PRINCIPLES OF ASSESSMENT FEEDBACK

Please state briefly how these are incorporated in this module.

The students will receive feedback from their assignment submission no later that two weeks after submission. The feedback will be in the form of electronic feedback and written + face-to-face feedback. This regular feedback will help to clarify what is good performance. They also help to close the gap between current and desire performance. All the tasks leading to learning outcomes encourage time and effort on challenging tasks.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

ASSESSMENT METHOD(S) INCLUDING PERCENTAGE BREAKDOWN AND DURATION OF EXAMS

To Pass the module, students need to gain a summative mark of;					**50%**	
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	L01-L04
Coursework	**Number**	3	**Weighting %**	24	**Learning Outcomes**	L01-L04
Project	**Number**	2	**Weighting %**	16	**Learning Outcomes**	L04

COURSEWORK / SUBMISSIONS DEADLINES: 4 formal matlab tasks (2 in sem 1 and 2 in sem 2)

RESIT ASSESSMENT PROCEDURES: Examination

ADDITIONAL INFORMATION RELEVANT TO COURSE DELIVERY AND ASSESSMENT

Students will keep a detailed logbook from their laboratories. The students will complete 4 Matlab tasks during the module. Their work will be assessed using 4, 40 minute in-lcass tests and two End of Semester short reports. The best three of the in-class tests will be used in the final continuous assessment element.

RECOMMENDED READING

"Digital Signal Processing: A Practical Approach 2nd Ed' Emmanuel C. Ifeachor and Barrie W. Jervis, ISBN 0 201 59619 9

"Digital Signal Processing:- Principles, Algorithms and Applications" 3rd edition by John Proakis and Dimitris

DSP Principels Lecture Notes by Prof Soraghan

Manolakis, Prentice Hall, ISBN 0-13-394338-9

"Discrete-Time Signal Processing" 2nd edition by Alan Oppenheim and Ronald Schafer, Prentice Hall Inc, ISBN 0-13-754920-2

"Digital Signal Processing" by Monson Hayes, Schaum's Outline Series, ISBN 0-07-027389-8

"DSP First – A Multimedia Approach" by Mclellan-Schafer – Yoder, Prentice Hall, ISBN : 0-13-243171-8

Many internet sites such as:

http://www.dspguide.com/ (a free DSP book)

http://www.bores.com/index_online.htm (online DSP course)

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S1	**Week**	6	**Nature**	written face_2_face and class
Semester	S1	**Week**	10	**Nature**	written, face-2-face and class

Semester	S2	**Week**	6	**Nature**	written, face-2-face and class
Semester	S2	**Week**	9	**Nature**	written, face-2-face and class
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Further comments about feedback		The students will receive individual feedback on their end of semester reports and DSP Topic conferecne paper during the revision weeks in the respective semesters.			

SIGNATURE (MODULE REGISTRAR):
DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE469	**Module Title:** Digital Signal Processing Principles
Brief Description of Assessment	
Matlab experiments/designs for various DSP applications	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			**Semester 2**	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**		
Week 2			**Week 2**	Assignment Start	
Week 3	Assignment Start		**Week 3**		
Week 4			**Week 4**		
Week 5	Test	Test - Marked	**Week 5**	Test	Test - Marked
Week 6		Feedback Provided	**Week 6**		Feedback Provided
Week 7			**Week 7**		
Week 8			**Week 8**	Test	Test - Marked
Week 9	Test	Test - Marked	**Week 9**		Feedback Provided
Week 10		Feedback Provided	**Week 10**	Assignment - Due	
Week 11	Assignment - Due		**Week 11**	Assignment - Due	Assignment Marked
Exam Period		Assignment Marked	**Revision Week**		Feedback Provided
Review Week		Feedback Provided	**Exam Period**	Examination	Exam - Marked

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	5	**Total # to be attempted**	3	**Compulsory Questions**	1 Question	**Sections**	Multiple
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

60% for the final examination plus 40% for the continous assessment (comprising 3 best in-class tests and the 2 short end of semester reports - all equi weighted)

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; Yes

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

Students are not expected to recall the main mathematical formulae for the class.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the*

mode(s) of assessments, adding any appropriate clarification.

LO1 Final Examination

C1.

LO2 Final Examination

C1.

LO3 Final Examination

C1.

LO4 Class Test

C1.

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE470 - INFORMATION TRANSMISSION & SECURITY

Module Code: EE470	**Module Title:** Information Transmission & Security	
Module Registrar: Dr Lina Stankovic		
Other Lecturers Involved: Dr James Irvine, Dr David Crawford	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: O	**Academic Level:** 4	

Pre-requisites: EE320 (Signals and Communications Systems) or equivalent knowledge

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
44	20	45	6	85	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

Impart an understanding of the principles by which information can be transmitted with varying levels of security and the techniques by which communication systems can be analysed and designed.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Understand the concept of information as it relates to a communication system and how coding can be used to enhance transmission

LO 2: Break down a digital communications systems into its functional blocks, establish the performance of selected blocks analytically and select appropriate operational parameters to realise a required performance

LO 3: Simulate the physical layer of a communication system or subsystem given its parameters or design a communication system or subsystem to realise a required performance

LO 4: Appreciate the importance of security within communication systems, know how to design for security and how to assess security threats

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

Information theory: measures of information, entropy and source coding, source coding for memoryless sources and sources with memory, channel capacity.

Transmission principles: overview of a digital communications transceiver, review of pulse code modulation, digital transmission and noise, non-linear quantisation, optimum filtering, spread spectrum and multiple access, advanced modulation methods, spectral and power efficiency.

Channel coding: channel coding principles, linear error-correcting codes, algebraic coding theory, convolutional coding, advanced channel coding such as turbo codes.

Information security: communication security principles, symmetric and asymmetric cryptography, threat models, cryptographic protocols.

Communications systems simulation.

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Ability to make information-related calculations

C 2: Ability to design channel codes to realise a required system performance for a given channel

LO2

C 1: Ability to describe the requirements and operating principles of each functional block in a digital communications system

C 2: Ability to make analytical calculations of performance-related metrics such as signal-to-noise ratio, bit- and symbol-error rates and spectral efficiency, performance comparison between TDMA and CDMA

LO3

C 1: Ability to simulate selected functional blocks using an appropriate high-level programming language

C 2: Ability to assess the performance of a digital communications system or subsystem using simulation

LO4

C 1: Ability to assess security threats to a communication system

C 2: Ability to design security protocols for example communication scenario

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 PRINCIPLES OF ASSESSMENT FEEDBACK

Please state briefly how these are incorporated in this module.

1. Student performance will be clarified using the online assessment, assignment and laboratory and appropriate and timely feedback

2. The timetable for the assignment and laboratory is fixed/agreed at the start of the module while there will be a 7-day window for the students to complete each of their on-line assessments; such an arrangement will encourage good time management in the context of learning

3. Students will get direct and immediate feedback as to progress/understanding and performance as part of the presentation, topic assessment and laboratory exercise - both summative and formative. In additional reflective and considered feedback with regards to the assignment and laboratory activities.

4. All interim assessments are timed to provide appropriate opportunites to improve performance and reinforce understanding prior to the final examination

5. Past summative assessments will be provided to students as part of assessment preparation. Students failing the summative assessment will have the opportunity to discuss their performance in general terms with teachers.

6. Interaction and dialogue between students and teachers will be an integral part of the tutorial, and laboratory sessions and the assignment supervision

7. Self-assessment of progress will be facilitated by providing a series of tutorial problem sheets supported by numerical answers and worked examples within tutorials and lecture sessions.

8. Choice in the topic, method, criteria, weighting or timing of assessments may be provided but cannot be guaranteed. Peer review will be applied in the group assignment to allow a degree of personal reflection and grading of the presenations and submitted work.

9. Students will be invited to give feedback on the assessment methods and criteria via the staff-student committee.

10. Mutual support and group working will be encouraged in the tutorial classes.

11. The module will be delivered in a supportive, encouraging and motivational atmosphere.

12. The experience of assessing this module will be fed back to other teachers via the process of module review.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

ASSESSMENT METHOD(S) INCLUDING PERCENTAGE BREAKDOWN AND DURATION OF EXAMS

To Pass the module, students need to gain a summative mark of;					**40%**	
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	LO1, LO2, LO3
Coursework	**Number**	2	**Weighting %**	40	**Learning Outcomes**	LO3, LO4
Project	**Number**		**Weighting %**		**Learning Outcomes**	

COURSEWORK / SUBMISSIONS DEADLINES:

RESIT ASSESSMENT PROCEDURES: Examination

ADDITIONAL INFORMATION RELEVANT TO COURSE DELIVERY AND ASSESSMENT

Class test on LO4 will take place in week 6, giving students early feedback on performance. The class test (50 minutes, 2 questions from 3), is worth 15% of the overall course mark. A tutorial quiz with a marked submission not counting towards the final exam will be given in week 3. Students will have an assessed presentation on LO1, LO2 in S2 Wk4 which counts 5% towards the final mark, and an assignment on communication system simulation worth 20% in S2 Wk 10.

RECOMMENDED READING

Course Notes plus

“Data Communications & Networks: An Engineering Approach”, J.Irvine & D.Harle, (Wiley) 0-471-808725“

"Digital Communications", 3rd ed, I A Glover & P M Grant, Pearson, 2010, ISBN 978-0-71830-7

"Digial Communications: Fundamentals and Applications", 2nd ed, B. Sklar, Pearson 2014, ISBN 1292026065, 9781292026060

"Software Defined Radio using MATLAB & Simulink and the RTL-SDR", Stewart, Barlee, Atkinson, Crockett, ISBN 978-0-9929787-2-3

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S1	**Week**	7	**Nature**	Results of class test, worked solutions of questions after handing back marked papers
Semester	S2	**Week**	1	**Nature**	Assignment presentation and feedback
Semester	S2	**Week**	11	**Nature**	Lab report feedback
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	

Further comments about feedback	Understanding of each lecture topic will be assessed via on-line mechanisms (knowledge) - students will be given instant feedback as to scores with more detailed feedback given after the assignment deadline. This will all be managed via University VLE

SIGNATURE (MODULE REGISTRAR):
DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE470	**Module Title:** Information Transmission & Security
Brief Description of Assessment	
The assessment consist of 6 quizzes or online summative assessments of lecture material plus a formal assignment and presentation (the assignment is given out in week 4 and the presentation takes place in week 11) plus a lab activity which takes place in weeks 1-4 of S2 with a review of submission in week 5.	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			**Semester 2**	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**	Presentation	Feedback Provided
Week 2			**Week 2**		Quiz - Marked
Week 3	Quiz	Quiz - Marked	**Week 3**		
Week 4	Test		**Week 4**		
Week 5		Test - Marked	**Week 5**		
Week 6			**Week 6**	Assignment Start	
Week 7			**Week 7**		
Week 8			**Week 8**	Assignment - Due	
Week 9			**Week 9**		Assignment Marked
Week 10			**Week 10**		
Week 11			**Week 11**		
Exam Period			**Revision Week**		
Review Week			**Exam Period**	Examination	

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	5	**Total # to be attempted**	3	**Compulsory Questions**	None - free choice	**Sections**	Single
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

Five mainly analytical questions are provided across LO1, LO2 and LO4 (i.e. all of the course except simulation of communication systems, which is assessed through the coursework assignment. Students are free to pick any 3 questions.

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; No

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

As part of the course, a number of concepts have been proved as part of the demostration of underlying principles (i.e. Shannons Laws). Students are not expected to recite these proofs, but they are expected to understand the principles demonstrated in the proofs as they form part of the course. Formulas are not provided - the few that have to be remembered are straightforward (entropy, information, equivocation), and methodology is what is being tested. Selected values of logarithms are provided so that the solutions can be found without the use of a calculator, although use of calculators is allowed.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Final Examination

C1. Class test and final examination

C2. Final Examination

LO2 Assignments

C1. Assignment

C2. Final Examination

LO3 Assignments

C1. Design and simulation project using an SDR device

C2. Design and simulation project using an SDR device

LO4 Final Examination

C1. Final Examination

C2. Final Examination

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE471 - COMMUICATIONS NETWORKS

Module Code: EE471	**Module Title:** Commuications Networks	
Module Registrar: Dr David Harle		
Other Lecturers Involved: Dr J Irvine, Dr R. Atkinson	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: C 0	**Academic Level:** 4	

Pre-requisites: Equivalent of EE320

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
48	24	24	12	92	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

To provide an understanding of the principles and key transport technologies which underpin high-speed heterogeneous broadband communications networks and architectures while giving an insight to the technical and strategic challenges associated with the provision of a Quality of Service (QoS)-based integrated future-network platform

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Demonstrate knowledge and understanding of the principles that underpin the operation of traditional packet-based communication networks.

LO 2: Demonstrate knowledge and understanding of the issues/principles associated with designing, operating and manage future Quality of Service (QOS) based heterogeneous communication networks.

LO 3: Quantify and verify the relative merits of network protocol operation and performance using appropriate analysis techniques and practical network performance tools.

LO 4: Appreciate the role played by the standards organisations, consumers, manufacturers and network operators in the evolution and development of network standards and the implementation of future QOS based networks.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

Network Overview: taxonomy of network types, Switching Paradigms: Circuit, packet and cell switching, Datagram & Virtual Circuit, Broadcast vs. Point to Point

Network Standards & Protocols: Motivation and Principles ANSI, IEEE, ISO, ITU-T, 3GPP Introduction to Layered Architectures, Basic Concepts: Open Systems, Layering, Peer Protocols, Primitive & Services, Reference Models: telecommunications vs. computing approaches, OSI and TCP/IP.

Network Level Services: general operation and terminology.. Introduction to IP: IP packet format, fragmentation, IP addressing, (classes, subnets, CIDR), address resolution, IP control protocols, IP Routing. Introduction to IPv6. Routing Algorithms: shortest path, flooding, flow-based, distance vector (RIP), link state (OSPF), hierarchical, broad-cast and multi-cast, Border Gateway Protocols.

Data-Link Protocols - Operation and Performance: Packet Format - use of Flag, Address, Control and CRC(FCS) fields. Forward & Backward Error Control: Idle RQ, Continous RQ, Window Flow Control - Packet Sequence Numbering, Go-Back-N and Selective Re-transmission Mechanisms.

Wireless networks: Cellular operation, resource management, call control handover, GSM network operation, UMTS network operation, 3G and beyond

LANs: Motivation: attributes, benefits and pitfalls, IEEE 802 Standards: LLC and MAC functions, MAC addressing, 802 family CSMA/CD – IEEE 802.3 (High Speed Ethernet: 100Base-T types and Gigabit Ethernet), IEEE802.11 (WiFi) architecture and operation. LAN architectures and devices. ARP, DHCP principles.

Transport Layer Protocols; TCP and UDP – principles and operation. Connection management, three-way handshake, data transfer, congestion and flow management (slow start, congestion avoidance, fast re-transmit and recovery.

Quality of Service: Definition of quality of service, introduction to QoS parameters, Traffic characterisation and shaping. IP QoS support: RTP, RTP and RTCP, IntServ & RSVP, DiffServ (classification & conditioning, PHB,) GMPLS (principles). VoIP. SIP and 3GPP

Network Management: Motivation; competitive advantage, faults, billing, services, planning. Perspective; Operations Systems, Network Elements, fault management, OAM&P, Logs, Alarms, Remote Control, WAN Vs LAN. TMN; architecture, OSI Management Functions, client-server paradigm, CMIS/CMIP, Managed Objects, MIT, SNMP principles and operation, MIB

Graph Terminology and Network Representation, Introduction to graph-based algorithms, Delay Systems: General Queue Models (M/M/1, M/D/1, M/M/n & M/G/1), Priority systems. Delay analysis of packet and cell based systems. Application in system dimensioning and performance quantification. Loss Systems: Erlang B, (Engset and Bernouli); Delay and Loss Systems: M/M/m/k analysis. Application in system dimensioning and performance quantification.

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Describe (correctly and in appropriate detail) the architecture of the current internet architecture and associated packet-based protocols.

C 2: Describe the motivation and principles associated with traditional layered architectures and the functionality associated with each layer.

C 3: Describe the principles of operation of protocols associated with the Network and Data-Link layers.

C 4: Describe the principles of operation of routing protocols associated with traditional internet and be able to quantify their relative merits.

C 5: Appreciate the operation of wired and wireless networks within the local environments and be able to discuss and contrast the relative merits of the key market-dominant technologies.

C 6: Describe (correctly and in appropriate detail) the operation of the key transport layer protocols within the traditional internet architecture.

LO2

C 1: Give a clear definition of what is meant by QoS and how this impacts upon the provision of communications services within the traditional internet architecture.

C 2: Describe (correctly and in appropriate detail) appropriate architectures associated with future QoS based networks; noting the particular roles of the transport and the control planes.

C 3: Describe (correctly and in appropriate detail) the operation of the key application layer protocols within a QoS based network architecture.

C 4: Describe (correctly and in appropriate detail) the operation of the key lower-layer protocols within a QoS based network architecture.

C 5: Describe and quantify the implications to routing protocols associated with the provision of QoS based networks.

LO3

C 1: The ability to determine an appropriate class of mathematical model or technique that can be used in particular network design problem.

C 2: The ability to use mathematical models and tecniques to solve particular network design problems.

C 3: Demonstrate the ability to use a number of communication network software tools to extract protocal attributes and network/packet statistics relevant to packet-based networks and QoS related mechanisms.

C 4: Use computer-based tools to measure, record and report experimaental and numerical data relevant to communicaton network performance and operation.

LO4

C 1: Demonstrate the ability to locate the appropriate standards documents from the appropriate standards defining bodies, including IEEE, IETF, ITU, ANSI etc.

C 2: Demonstrate the ability to locate and analyse both formal and informal strategic documents produced by operators, manufactures, governments pertinent to the provision and evolution of future communications networks and services.

C 3: Demonstrate an understanding of the key techical and operational challenges associated with managing both local and enterprise networks.

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 Principles of Assessment Feedback

Please state briefly how these are incorporated in this module.

1. Student performance will be clarified using the online assessment, assignment and laboratory and appropriate and timely feedback

2. The timetable for the assignment and laboratory is fixed/agreed at the start of the module while there will be a 7-day window for the students to complete each of their on-line assessments; such an arrangement will encourage good time management in the context of learning

3. Students will get direct and immediate feedback as to progress/understanding and performance as part of the presentation, topic assessment and laboratory exercise - both summative and formative. In additional reflective and considered feedback with regards to the assignment and laboratory activities.

4. All interim assessments are timed to provide appropriate opportunites to improve performance prior to the final examination

5. Past summative assessments will be provided to students as part of assessment preparation. Students failing the summative assessment will have the opportunity to discuss their performance in general terms with teachers.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

Assessment Method(s) Including Percentage Breakdown and Duration of Exams

To Pass the module, students need to gain a summative mark of;					**40%**	
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	LO 1, 2, 3, 4
Coursework	**Number**	3	**Weighting %**	40	**Learning Outcomes**	LO 1, 2, 3, 4
Project	**Number**		**Weighting %**		**Learning Outcomes**	

COURSEWORK / SUBMISSIONS DEADLINES:	Labs S2 -wk 3, Quizzes 3 week intervals, Standards S2 Wk7
RESIT ASSESSMENT PROCEDURES:	Examination

ADDITIONAL INFORMATION RELEVANT TO COURSE DELIVERY AND ASSESSMENT

The module comprises elements of course work that contribute to the final mark.

One short written assignment - worth 10% - takes place after IEEE sponsored Standards activity

A laboratory programme that represents 10% of the final contribution - this will be assessed in terms of completed activities within three 2-hour lab sessions with a lab record - completed within the lab.

Each module topic will have an associated mini-assessment (7 topics) and the results from these tests will contribute 20% of the final marks. (The 20% will be derived from the 6 best topic)

Students will be required to complete assignment and laboratory exercises in order to to be eligible to take the final examination. Students who do not complete laboratory works will be subject to an NQ procedure and required to undertake the laboratory programme in order to sit the resits examination. Otherwise students who fail the module will be permited to sit a resit examination at the next appropriate examination diet.

The final examination will require the students to do 3 examination questions over a 2 hour duration. All aspects of the course (lectures, tutorials, laboratory exercises and assignment) will be potentially covered in the examination. A compulsory question will be set that covers the topic (or part) of the semester 1 groups assignment and presentation.

RECOMMENDED READING

Course Notes plus recommended internet sources (IEEE, IETF, ANSI, ITU)

"Data Communications & Networks: An Engineering Approach", J.Irvine & D.Harle, (Wiley) 0-471-808725"

Communication Systems: A First Course" (2nd edition), J Walrand, (McGraw-Hill) 0071229043

"Computer Networking", J. Kurose & K. Ross, (Addison Wesley) 0-201-477711-4"

Computer Networks: A Systems Approach", L Peterson & B Davie, (Morgan Kaufman) 155860832X"

Data Communications and Networking" Behrouz Forouzan, McGraw-Hill Education (ISE Editions) 0071232419

"Computer Networks", A. Tanenbaum, (PrenticeHall) 0130384887"

A Brief History of the Future: Origins of the Internet", J. Naughton, 075381093X.

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S1	**Week**	11	**Nature**	summative/formative feedback from mobile case study
Semester	S2	**Week**	5	**Nature**	Review of progress in the class laboratory work via progress sheets and logbook record
Semester	S1	**Week**		**Nature**	3 small quiz activities after tuts, wks, 3/6/9 estimated
Semester	S2	**Week**		**Nature**	4 small quiz activities after tuts, wk 3,6,9, 12 - last is revision quiz
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Further comments about feedback		Understanding of each lecture topic will be assessed via on-line mechanisms (knowledge) - students will be given instant feedback as to scores with more detailed feedback given after the assignment deadline. This will all be managed via the University VLE - myplace			

SIGNATURE (MODULE REGISTRAR):
DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE471	**Module Title:** Commuications Networks
Brief Description of Assessment	
The assessment consist of 6/7 quizzes or online summative assessments of lecture material plus a formal assignment after Standards Workshop plus a lab activity which takes place in weeks 1,2 & 3 of S2.	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			**Semester 2**	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**	Laboratory	
Week 2			**Week 2**	Laboratory	
Week 3	Quiz	Quiz - Marked	**Week 3**	Laboratory	
Week 4			**Week 4**		Quiz - Marked
Week 5			**Week 5**		Labs - Marked
Week 6	Quiz	Quiz - Marked	**Week 6**	Quiz	Quiz - Marked
Week 7			**Week 7**	Assignment Start	
Week 8			**Week 8**	Assignment - Due	
Week 9	Quiz	Quiz - Marked	**Week 9**	Quiz	Quiz - Marked
Week 10			**Week 10**		Assignment Marked
Week 11			**Week 11**		
Exam Period			**Revision Week**	Quiz	Quiz - Marked
Review Week			**Exam Period**	Examination	

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	6	**Total # to be attempted**	3	**Compulsory Questions**	1 Question	**Sections**	Multiple
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

The examination consists of a variable number of questions of which the students must attempt 3. One question is compulsory and addresses topics covered in the student labs and group assignments. The assessment of the LO listed above are addressed at some level within the 3 components of "open-book" course work (assignment, Labs and quizzes).The examination questions built upon this previous work and address fundamental issues of understanding, design and problem solving rather than simple recall of material.

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; Yes

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

Module requires numerical work but is not overtly mathematical in nature. Students are equected to know and derive the appropriate relationships when considering the performance aspects of networks. Additional complex formulae are provided if required - students are advised if there is an expectation to know/recall particular formulae or equations.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Final Examination — *Supported by in-class tests that address basic knowledge while the final examination covers understanding*

- **C1.** Final Examination and CA
- **C2.** Final Examination and CA
- **C3.** Final Examination and CA
- **C4.** Final Examination and CA
- **C5.** Final Examination and CA
- **C6.** Final Examination and CA

LO2 Final Examination — *Supported by laboratory activities and*

- **C1.** Final Examination and CA
- **C2.** Final Examination and CA
- **C3.** Final Examination and CA
- **C4.** Final Examination and CA
- **C5.** Final Examination and CA

LO3 Final Examination — *Supported by lboratory activity and investigative assignment*

- **C1.** Final Examination and CA
- **C2.** Final Examination and CA
- **C3.** Laboratory
- **C4.** Laboratory

LO4 Assignments — *Main assessment is achieved via CA activities - assignment and workshop. Topics do feature within examination*

- **C1.** Assigment
- **C2.** Assignment & Laboratory
- **C3.** Assignment & Laboratory

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

- CONTROL PRINCIPLE

Module Code:	**Module Title:** Control Principle	
Module Registrar: Reza Katebi		
Other Lecturers Involved: Hong Yue	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: O	**Academic Level:** 4	

Pre-requisites: none

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
48	12	20	15	105	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

1. To introduce the students to the basic concepts, mathematical tools and design methods of classical control theory.
2. To enable the students to use analysis and design tools used in control engineering.
3. To enable the students to analyse and design closed loop control system specifically using industrial three-term (PID) controllers.
4. To introduce the students to advanced control methods and to provide a basic understanding of a time-domain approach to control analysis and design of industrial processes.
5. To appreciate the application of control theory in industrial applications.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Appreciate and experience state-of-the-art modeling and simulation tools, represent linear dynamic systems in state space and transfer functions, create simulations using MATLAB and Simulink.

LO 2: Understand the feedback control fundamentals, use and interpret time and frequency domain performance measures, understand stability and controller tuning principles, understand the structure and effects of PID controllers, use simple PID tuning methods.

LO 3: Understand system controllability and observability, obtain awareness of functionality and design of state observers, design state feedback controllers including pole-placement design and linear quadratic optimal control. Be aware of advanced control methods, principles and applications for model predictive control and discrete-time control.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

First and second order systems, delay process, simple saturation models.

Simulation tools, GUI, SIMULINK, MATLAB.

Open loop control, feedback control, system stability definitions, simple transfer function manipulation and final value theorem.

Control system performance, transient and steady-state figures of merit, time domain step response, reference tracking and disturbance rejection in time domain.

Closed loop stability, reference tracking and disturbance rejection in frequency domain,

Bode plot, MATLAB analysis tools. Simple control principles,

proportional control, integral control and derivative control (PID control) effects,

PID controller tuning, sustained oscillation, Ziegler-Nichols rules, relay experiment, practical tuning problems of PID, definition of gain schedule, controller schedule, industrial control system case study material.

State space representation of linear systems: continuous-time state space models, relation to transfer functions,

discretisation of state space models, equivalent time-series representation.

Continuous time system fundamentals: eigen-values & eigen-vectors, stability, controllability & observability, canonical forms for systems. Discrete-time system fundamentals: eigen-values & eigen-vectors, stability, controllability & observability, canonical forms for systems.

State-space control methods: pole placement state feedback control with/without observer design, linear quadratic optimal control.

Advanced control methods: digital control systems.

Case study and project: description of application, system representation & models, system responses, control specification, controller design, performance assessment.

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Assessed through coursework and project

C 2: Ability to model simple systems with transfer function and state space representation, create simulations using MATLAB and Simulink.

C 3: Ability to analyse linear open loop system

LO2

C 1: Assessed by case study, project and examination

C 2: Ability to understand the theoretical and practical implications of feedback control systems, design contro systems using simple PID tuning methods.

C 3: Ability to assess control performance, make analytical calculations and critical evaluation of control performance -related metrics.

LO3

C 1: Assessed by case study, project and examination

C 2: Demonstrate ability to design and simulate control systems using classical and modern control theory.

C 3: Ability to apply and understand the advanced control methods, principles and applications in an industrial context.

LO4

C 1:

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 PRINCIPLES OF ASSESSMENT FEEDBACK

Please state briefly how these are incorporated in this module.

The principles of good assessment are incorporated in the design of assessment including coursework, assignment, laboratory report and final exam. This provides students with a clear view regarding their performance. Good performance will be clarified using the coursework, case study assignments and project report withappropriate and timely feedback. The timetable for the coursework and case studies is meant to encourage good time management. High quality feedback will be given in the form of one-to-few discussion of the assessed assignments and general whole-class feedback on the coursework, case study and project report. All these provide a realistic opportunity to improve performance prior to the final examination. Past summative assessments will be provided to students as part of assessment preparation. Students failing the summative assessment will have the opportunity to discuss their performance in general terms with course lecturers. Interaction and dialogue between students and lecturers will be an integral part of the tutorial sessions and the assignment supervision. Self-assessment of progress will be facilitated by providing a series of tutorial problem sheets with a mixture of answers and worked solutions being made available after an appropriate delay. Choice in the topic, method, criteria, weighting or timing of assessments may be provided but cannot be guaranteed. Students will be invited to give feedback on the assessment methods and criteria via the staff-student committee. Mutual support and group working will be encouraged in the tutorial classes. The module will be delivered in a supportive, encouraging and motivational atmosphere. The experience of assessing this module will be fed back to other lecturers via the process of module review.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

ASSESSMENT METHOD(S) INCLUDING PERCENTAGE BREAKDOWN AND DURATION OF EXAMS

To Pass the module, students need to gain a summative mark of;					**40%**	
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	LO1 LO2 LO3
Coursework	**Number**	3	**Weighting %**	25	**Learning Outcomes**	LO3
Project	**Number**	1	**Weighting %**	15	**Learning Outcomes**	LO1 LO2 LO3

COURSEWORK / SUBMISSIONS DEADLINES:

Coursework should be submitted by Week 11 in Semester 1. Project report and tutorila report should be submitted by Week 10 and Week 13, respectively, in Semester 2.

RESIT ASSESSMENT PROCEDURES: Examination

ADDITIONAL INFORMATION RELEVANT TO COURSE DELIVERY AND ASSESSMENT

RECOMMENDED READING

J. Wilkie, M. A. Johnson and M. R. Katebi, 2001, Control Engineering, Palgrave Publishers, ISBN 0-333-77129-X

G. F. Franklin, J. D. Power and A. Emami-Naeini, 1991, Feedback Control of Dynamic Systems, Addison Wesley, ISBN 0-201-50862-1

K. Ogata, Modern Control Engineering, Prentice Hall, 5 edition, 2009.

R.C. Dorf and R.H. Bishop, Modern Control Systems, Prentice Hall, 11th edition, 2008.

J. D. Apelvich, The Essentials of Linear State-space Systems, Wiley, 1999.

K. Ogata, Discrete-Time Control Systems, Prentice Hall, 1995.

Z. Gajic and M. Lelic, Modern Control systems Engineering, Prentice Hall, 1996.

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S1	**Week**	3	**Nature**	informal feedback, descriptive feedback
Semester	S1	**Week**	7	**Nature**	formal feedback
Semester	S1	**Week**	10	**Nature**	informative feedback
Semester	S2	**Week**	11	**Nature**	informal feedback, descriptive feedback
Semester	S2	**Week**	18	**Nature**	formal feedback
Semester	S2	**Week**	20	**Nature**	informative feedback
Further comments about feedback					

SIGNATURE (MODULE REGISTRAR):
DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code:	**Module Title:** **Control Principle**
Brief Description of Assessment	
The assessment is composed of 3 parts: 20% assignment in Semester 1(Coursework and Class Test), **20% Project and Tutorial Reports in Semester 2, and** **60% exam at the end of Semester 2.**	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			**Semester 2**	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**		
Week 2	Assignment Start		**Week 2**	Assignment Start	
Week 3	Assignment - Due	Assignment Marked	**Week 3**		Interim Feedback
Week 4	Assignment - Due	Assignment Marked	**Week 4**		Feedback Provided
Week 5	Assignment - Due	Assignment Marked	**Week 5**		
Week 6		Assignment Marked	**Week 6**		
Week 7	Assignment Start	Feedback Provided	**Week 7**		
Week 8			**Week 8**	Project	
Week 9			**Week 9**		
Week 10		Assignment Marked	**Week 10**		
Week 11	Test	Quiz - Marked	**Week 11**		Assignment Marked
Exam Period	Presentation		**Revision Week**	Presentation	Interim Feedback
Review Week	Presentation		**Exam Period**	Project	

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	5	**Total # to be attempted**	3	**Compulsory Questions**	1 Question	**Sections**	Multiple
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

Students are assessed for their understanding of the material, analytical ability, problem solving and analysis

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; Yes

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

Student recall only simple formula

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Final Examination

C1. class test

C2. report

C3. exam

LO2 Final Examination

C1. class test

C2. project

C3. exam

LO3 Final Examination

C1. project

C2. tutorial

C3. exam

LO4 Final Examination

C1.

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE473 - PHOTONIC SYSTEMS

Module Code: EE473	**Module Title:** Photonic Systems	
Module Registrar: Dr C Michie		
Other Lecturers Involved: Dr R Bauer, Dr G Flockhart, Dr M Lengden	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: O	**Academic Level:** 4	

Pre-requisites: Progression to year 4

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
36	20	0	6	138	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

The primary aim of this module is to enable students to develop a basic conceptual understanding and working knowledge of fibre optic communications and sensing systems, addressing basic principles of optics and waveguides, as well as understanding fibre communication and sensor engineering, design and performance limits. All of the fundamental principles of light, optics and photonic components necessary to achieve this are dealt with, giving a broad appreciation of photonics in general.

The emphasis of the course is on conceptual understanding of physical principles and system design and analysis. The course then builds upon this to develop a detailed understanding of the more common optical fibre component used in communications network architectures and fibre sensors, including long haul linear buses, wavelength division multiplexing (wdm) systems, metropolitan and wide area networks, access networks and passive optical networks (pons) and fibre Bragg gratings– from a physical perspective. Amplifier technologies are discussed in detail along with the analysis of how the use of amplifiers influences the characteristics of signals. Operation and performance characteristics of FBG sensors are also presented in detail and for a number of relevant sensing applications.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Design an optical transmission network incorporating all of the key components that would be required to deliver an end to end solution. The students will have attained a knowledge of all of the key system components, their basic operating principles and their design and performance limits.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

LO2: Design an optical transmission link and analyse its performance with respect to Bit Error Rate in accordance with typical transmitter receiver parameters and a range of system impairments – eg optically generated noise, thermal noise, extinction ratio and dispersion.

LO 3: Describe the basic operating principles of optical amplifiers and understand the key differences between fibre based amplifiers and semiconductor based amplifiers. The student will be able to analyse the impact that these amplifiers have in relation to system performance.

LO4: Explain the rationale behind different network topologies – eg DWM, CWDM, DWDM.

LO5: Understand the physical operation of fibre Bragg gratings and describe their performance characteristics for a number of sensing applications

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Have a good conceptual understanding (mental picture) of the nature and characteristics of light and its basic interactions with materials.

C 2: Understand the principles of optical waveguides and fibres and have a working knowledge of their characteristics and performance.

C 3: Be able to design optical waveguides

C 4: Have a good appreciation of the operating principles and characteristics of lasers.

C 5: Be able to design and analyse the performance of lasers

LO2

C 1: Have a good appreciation of the operating principles, design and characteristics of the major components of a fibre optic communications system i.e. the laser or LED transmitter, the optical fibre channel and the optical receiver.

C 2: Understand the structure and principles of a point to point fibre optic communications system and have a good appreciation of the performance limits imposed by the component characteristics.

C 3: Be able to design a point to point fibre optic communications system.

C 4: Be able to analyse the performance of a point to point fibre optics communications system

LO3

C 1: Understand the operating principles, the physical nature of the amplification process, the design and performance characteristics of optical amplifiers

C 2: Understand the nature of the noise sources that optical amplification introduces, be able to analyse the performance of an amplifier in terms of output signal to noise ratio (SNR) and have a good appreciation of amplified network design rules

C 3: Be able to analyse the performance of amplifier cascades and calculate output signal to noise ratios

C 4: Be able to design optical links with single and multiple optical amplifiers and analyse their performance in terms of power budgets, output signal to noise ratios and bit error rates.

LO4

C 1: Have a good working knowledge and conceptual understanding of the architectures and principles of the Photonics Networks most commonly used in the optical telecommunications industry.

C 2: Understand the applications of these networks and how they are used in the Telecomms industry.

C 3: Have a good appreciation of the structure, design, operating principles and performance characteristics off the major components used in these networks and their influence on the network performance

C 4: Understand the rationale behind, the design, characteristics and performance of WDM networks

C 5: Be able to analyse the limits on parameters that determine crosstalk and other inter channel degradation

issues in WDM networks

LO5

C 1: Have a physical understanding of the sensing principles of fibre Bragg gratings, including the performance characteristics of sensors due to temperature and strain.

C 2 : Be able to describe the various interogation schemes for precision measurements using FBGs and analyse different interferometric schemes for measurement performance

C 3 : Integrate knowledge on WDM and TDM techniques to develop multi-point, networked sensor arrays

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 Principles of Assessment Feedback

Please state briefly how these are incorporated in this module.

The course is structured to provide an understanding of the operation of the key components of an optical transmission system and how they operate to deliver end to end connectivity. At each stage the components design is analysed and quantified – tutorial questions and examples within the course illustrate the degree of understanding that is required to achieve a good level of understanding.

Tutorial questions are graded in complexity and amount of time required to complete them. They are structured such that feedback can be given immediately at a tutorial session to let students gauge where they are. Students will have undertaken a range of tutorials before any formal assessment is made.

An examination at the end of Semester 1 assesses students grasp of the fundamental concepts of optics and waveguide, as well as optical source and receiver performance. Feedback on the examination is provided in terms of the student's grade, review of test paper and discussion of model answers in class allowing students to clearly identify their strengths and weaknesses.

Laboratory excercises form part of the formal assessment process to integrate the fundamnetal understanding from S1 with more detailed communication system analysis carried out at the beginning of Semester 2. These are time tabled but students have the opportunity between laboratories to consider the questions posed and reflect on the laboratory activities.

In preparation for the assignments, tutorial related to the key concepts are delivered and students work through these collectively to explore a range of solutions and consider collectively which one (if any) would be preferable. This is deliberate to reflect that real life designs have many potential solutions and it enables students to reflect collectively and exchange ideas.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

Assessment Method(s) Including Percentage Breakdown and Duration of Exams

To Pass the module, students need to gain a summative mark of;					**40%**	
Examination	**Duration**	2h	**Weighting %**	70	**Learning Outcomes**	1-4
Coursework	**Number**	2	**Weighting %**	30	**Learning Outcomes**	1-4
Project	**Number**		**Weighting %**		**Learning Outcomes**	

Coursework / Submissions deadlines: Class test scheduled in Semester 1 Examination Diet, laboratory report due at end of second laboratory session.

Resit Assessment Procedures: Examination

Additional Information relevant to Course Delivery and assessment

The course has a class test in Semester 1 (15%), laboratory (15%) and examination (70%).

Recommended Reading

'Optical fiber Communications' G Keiser (McGraw Hill)

'Optoelectronics: An Introduction' J Wilson & J.F.B Hawkes (Prentice Hall)

‘Optics’ E Hecht and A Zajac (Addison Wesley).

Optical Networks: A Practical Perspective’(2nd Ed.) R Ramaswami & K Safarajan (Morgan Kaufmann)

Handouts provided by course registrar

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S2	**Week**	1	**Nature**	Review of examination
Semester	S2	**Week**	9	**Nature**	Overview of Laboratory Activities
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Further comments about feedback					

SIGNATURE (MODULE REGISTRAR):

DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE473	**Module Title:** Photonic Systems
Brief Description of Assessment	
The class is assessed through two pieces of coursework and a final exam. Each piece of coruse work is worth 15% and the final exm is 70%. The coursework comprises of a class test and a laboratory report.	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			**Semester 2**	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**		Feedback Provided
Week 2			**Week 2**		
Week 3			**Week 3**		
Week 4			**Week 4**		
Week 5			**Week 5**		
Week 6			**Week 6**	Laboratory	Labs - Marked
Week 7			**Week 7**		
Week 8			**Week 8**		
Week 9			**Week 9**		
Week 10			**Week 10**		
Week 11			**Week 11**		
Exam Period	Test	Test - Marked	**Revision Week**		
Review Week			**Exam Period**	Examination	Exam - Marked

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	5	**Total # to be attempted**	3	**Compulsory Questions**	None - free choice	**Sections**	Multiple
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

The final examination will consiste of two sections, in section A students choose 2 questions from a choice of 3 and in Section B choose one question from a choice of 2. Each question contains components that will examine the students physical understanding through an essay, and their ability to problem solve via mathematical calculation. Therefore, rubric describes numerical and discursive elements as required.

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; Yes

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

Students are given formulae that relate to expressions for noise sources etc. The examination process focuses on assessing understanding and methodology and the application of knowledge to specific problems rather than extensive knowledge based assessment. There is an element of knowledge based activity where students are asked to reflect on or constrast different concepts or for example describe the key components of an Erbium Doped amplifer and explain their purpose.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Final Examination

C1.

LO2 Final Examination

C1.

LO3 Final Examination

C1.

LO4 Final Examination

C1.

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE474 - ROBOTICS: SYSTEMS AND CONTROL

Module Code: EE474	**Module Title:** Robotics: Systems and Control	
Module Registrar: Dr L Petropoulakis		
Other Lecturers Involved: Dr G Dobie	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: O E	**Academic Level:** 4	

Pre-requisites: Undergraduate Hons degree in EEE or Mechanical or Comp Science

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
40	22	16	12	110	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

The objective is to provide an introduction and overview to the various core aspects of robotics which include, design, control, sensing and localisation. It provides a solid base of understanding through theory and examples. Intuition is encouraged through numerous hands-on examples.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Understand the principles of robotic engineering such as mechanics, dynamics, kinematics, path planning, control procedures, sensor technology. Carry out studies of path-planning. Assess the practical limitations due to constraints and suggest ways to circumvent or avoid them. Examine some typical cases of robot use.

LO 2: Given a robot design, sensor capability, control systems, path planing procedures, and performance specifications be able to provide detail analysis of how these meet task requirements.

LO 3: Understand the fundamentals of robotic computer vision, particularly when applied to localisation and mapping and scene identification.

LO 4: Understand critical aspects of robotic technology and control systems in general, design and control mechanisms, technology limitations, linear and non-linear concepts, statistical processes and filtering methods. Be able to make critical assessment of robot and control technology. Be able to use Matlab for a variety of control tasks, including linearisation, numerical integration, modeling and simulation techniques in robotics and other systems.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

Introduction to robotic systems; background, classification of robots based on design construction, control systems, actuation; Performance chracteristics of typical robots

Introduction and understanding of forward kinematics of robots; Denavit-Hartenberg (D-H) algorithm; Transforms; Fundamentals of inverse kinematics;

Path planning and trajectory generation methods; Generating and blending trajectory paths; Preserving continuity of motion; splines of paths; Constraints and limitations;

Introduction to sensors and their applications :- Uses and limitations

Fundamentals of robotic control ; Principles of system modelling; Matlab implementation; time and frequency domain analysis; state-space; control system analysis.

Bayesian robot localisation, including linearisation and Kalman Filtering.

Robotic computer vision, in particular when applied to mapping and localisation.

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Describe, in appropriate detail, the current types of robotic systems their dynamic and mechanical architecture and associated sensor technology.

C 2: Describe appropriate path-planning techniques taking into account ways to perform collision avoidance and speed up optimal path evaluation.

C 3: Describe some typical cases of robot use focusing on their advantages and limitations.

LO2

C 1: Describe correctly robot engineering relevance to task specification and process requirements.

C 2: Describe, in appropriate detail, how tasks or/and robot engineering approaches must be modified for successful outcomes.

LO3

C 1: Understand standard camera models

C 2: Understand common approaches to image registration

C 3: Understand how a single camera can be used for robot localisation and mapping

LO4

C 1: Use computer-based tools to evaluate designs, measure, record and report experimental and numerical data relevant to robotic and other computer control systems.

C 2: Be able to formulate models from given relevant information and design control systems to drive these models to specified positions and within required accuracy, speed and other performance related parameters..

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 PRINCIPLES OF ASSESSMENT FEEDBACK

Please state briefly how these are incorporated in this module.

1. Good performance will be clarified using assignments with appropriate and timely feedback
2. The timetable for the assignment will encourage good time management in the context learning
3. High quality feedback will be given in the form of one-to-few discussion of the assessed assignments
4. The assignments are timed to give a realistic opportunity to improve performance prior to the final examination
5. Past assessments will be provided to students as part of assessment preparation. Students failing the past assessment will have the opportunity to discuss their performance in general terms with teachers.

6. Interaction and dialogue between students and teachers will be an integral part of the assessment process
7. Students will be invited to give feedback on the assessment methods and criteria.
8. Mutual support and group working will be encouraged in the tutorial classes.
9. The module will be delivered in a supportive, encouraging and motivational atmosphere.
10. The experience of assessing this module will be fed back to other teachers via the process of module review.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

ASSESSMENT METHOD(S) INCLUDING PERCENTAGE BREAKDOWN AND DURATION OF EXAMS

To Pass the module, students need to gain a summative mark of;					**40%**	
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	LO 1,2,3,4
Coursework	**Number**	7	**Weighting %**	40	**Learning Outcomes**	LO 1,2,3,4
Project	**Number**		**Weighting %**		**Learning Outcomes**	

COURSEWORK / SUBMISSIONS DEADLINES: S1 -wk9-11 S2 -wk1-7

RESIT ASSESSMENT PROCEDURES: Examination

ADDITIONAL INFORMATION RELEVANT TO COURSE DELIVERY AND ASSESSMENT

The course contains some laboratory exercises where students will be introduced to some of the issues and designs regarding robotic engineering and control engineering in general.
Course progerss is assessed by continuous assessment (through assignments) and by examination.

RECOMMENDED READING

Typed notes of the course (supplied)
'Fundamentals of robotics', Schilling ISBN: 0-13-334376-6
'Robotic Engineering and integrated approach', Klafter et.al. ISBN: 0-13-782053-4
'Introduction to Robotics, Mechanics and Control' J.J. Craig ISBN: 0-201-10326-5
'Robotics, Vision and Control: Fundamental Algorithms in MATLAB' P Corke. ISBN: 3642201431

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S1	**Week**	12	**Nature**	Feedback on assignments and quiz
Semester	S2	**Week**	7	**Nature**	Feedback on quiz, laboratory demonstrations and reports
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Further comments about feedback		Additional feedback comments may be provided where necessary through the university VLE system			

SIGNATURE (MODULE REGISTRAR):

DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE474	**Module Title:** Robotics: Systems and Control
Brief Description of Assessment	
The assessment comprises a final examination on the topics covered during the lectures. Principles used in coursework may also be part of exam questions. The assignments consist ofa mixture of questions and laboratory work based on the lectures and the practical work carried out. There are multiple choice quizzes on week7 semester 1 and on weeks 4 and 7 in semester 2	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			Semester 2	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**		
Week 2			**Week 2**		
Week 3			**Week 3**		
Week 4			**Week 4**	Quiz	Quiz - Marked
Week 5			**Week 5**		
Week 6			**Week 6**		
Week 7	Quiz	Quiz - Marked	**Week 7**	Quiz	Quiz - Marked
Week 8			**Week 8**		
Week 9	Assignment	Exam - Marked	**Week 9**		
Week 10	Assignment	Exam - Marked	**Week 10**		
Week 11	Assignment	Exam - Marked	**Week 11**	Assignment	Assignment Marked
Exam Period			**Revision Week**		
Review Week			**Exam Period**	Examination	Exam - Marked

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	5	**Total # to be attempted**	3	**Compulsory Questions**	None - free choice	**Sections**	Multiple
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

The examination rubric consists of 5 stages i.e. improvement required, developing, sufficient, average, above average, followed by appropriate comments. The approach here is to provide students with an encouraging message to try harder and achieve more as well as rewarding good preformance where appropriate. Over time it has been shown that this approach seems to work well.

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; Yes

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

No specific mathematical formula need be recalled during examinations. Complex formulas are always provided. Occasionally derivation of simple fomrulas maybe expected from first principles outlined in the course material.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Other *Both continuous assessment and examinations are applied*

C1. Continuous assessment and examinations are used in assessment - Labs and quiz

C2. Continuous assessment and examinations are used in assessment - Labs and quiz

C3. Continuous assessment and examinations are used in assessment - Labs and quiz

LO2 Other *Both continuous assessment and examinations are applied*

C1. Continuous assessment and examinations are used in assessment - Labs and quiz

C2. Continuous assessment and examinations are used in assessment - Labs and quiz

LO3 Other *Both continuous assessment and examinations are applied*

C1. Continuous assessment and examinations are used in assessment - Labs and quiz

C2. Continuous assessment and examinations are used in assessment - Labs and quiz

C3. Continuous assessment and examinations are used in assessment - Labs and quiz

LO4 Other *Both continuous assessment and examinations are applied*

C1. Continuous assessment and examinations are used in assessment - Labs and quiz

C2. Continuous assessment and examinations are used in assessment - Labs and quiz

University of Strathclyde Engineering

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE573 - ADVANCED POWER SYSTEM ANALYSIS & PROTECTION

Module Code: EE573	**Module Title:** Advanced Power System Analysis & Protection	
Module Registrar: Panagiotis Papadopoulos		
Other Lecturers Involved: Campbell Booth, Adam Dysko, Ivana Kockar, Qiteng Hong.	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: C	**Academic Level:** 5	

Pre-requisites: EE467 or similar for Master's student from another institution

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
48	24	40	8	80	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

Allow students to understand, critically analyse and assess technical requirements for power system operation, management and planning.

To enable students to carry out advanced types of power system analysis as well as understand and use results from these analyses in power system operation and planning.

To enable students to have a detailed understanding of the main concepts related to the function, design and operation of protection schemes for distribution, transmission and generation applications.

To enable students to understand the implementation and other associated issues relating to protection of power systems.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

C 1: Describe to a detailed level temporal the hierarchy of phenomena, tasks and models in power system analysis.

C 2: Develop and use appropriate models of power systems for various power system analysis problems, and be aware of tools used for these types of analysis.

C 3: Describe and show deep understanding of various design, operation and implementation issues associated with power system protection.

C 4: Analyse power system protection applications and solve, using analytical techniques, problems relating to the setting and anticipated performance of a variety of protection systems under different conditions.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

(1) Temporal hierarchy of phenomena, tasks and models in power system analysis

(2) Models of power systems that are used in power system analysis

(3) Formulation and computational methods used for power flow analysis for complex power systems, and application of this tool for power system operation and planning

(4) Formulation and computational methods used for optimal power system operation, including economic dispatch, optimal power flow and generation scheduling problems and tools that are typically used to solve these

(5) Concept and importance of voltage stability

(6) Concepts form power system security - security analysis, reliability, at the level of a device and a network

(7) Introduction to dynamic power system phenomena & network modelling

(8) Importance and a role of a generator dynamic control -including review of swing equation, governor/AVR, modelling of generator and control as well as specific power station configurations

(9) Introduction to power system stability for multiple machines together with numerical integration techniques and eigenvalues

(10) Power Networks of the Future - Demand Side management, SmartGrids, network development scenarios

(11) Numeric protection: hardware, digital signal processing, communications, algorithms, distance and differential protection applications

(12) Advanced distance protection: schemes, communications, high resistance faults, power swing blocking, directional earth fault schemes

(13) Fault location: requirements, reactance method, travelling wave methods

(14) Distributed generation protection: generator protection, frequency, voltage, current and reverse power; loss of mains protection, ROCOF, vector shift active methods.

(15) Earthing: effects on protection, solid earthing, Petersen coils.

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Identification of critical phenomena, tasks and methods in power system operation

LO2

C 1: Identification of different power system problems- when they are used and what are major differences among these problems

C 2: Knowledge and understanding of different power system analysis problems- their formulation, computational methods and tools

C 3: Critical thinking on the results obtained from these analysis - interpretation of results and suggestions how to correct technical problems

LO3

C 1: Knowledge and understanding of components and design of protection systems

C 2: Critical thinking on protection and earthing system design

C 3: Critical thinking on issues associated with protection of systems with distributed generation

LO4

C 1: Ability to solve numerical problems relating to design and operation of various types of protection schemes

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 PRINCIPLES OF ASSESSMENT FEEDBACK

Please state briefly how these are incorporated in this module.

Assessment will comprise of a Final Exam (60%), a Midterm exam test (20%) and two Assignments/Lab exercises (20%). The Midterm exam is schedule at the end of S1, which is different from previous years due to the new 11 week semester arrangements. Assignment and Lab Exercise will allow students to get hands on experience in applying taught material to carry out evaluation studies or use tools typically applied in industry. Thus, students will be able to assess their progress on their own, but will also get a formal feedback with an indication where additional learning and clarification could be useful.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

ASSESSMENT METHOD(S) INCLUDING PERCENTAGE BREAKDOWN AND DURATION OF EXAMS

To Pass the module, students need to gain a summative mark of;				**40%**		
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	All
Coursework	**Number**	2	**Weighting %**	20	**Learning Outcomes**	C2& C3
Project	**Number**	1	**Weighting %**	20	**Learning Outcomes**	This is mid-term test - end of S1 cannot edit the word "project"

COURSEWORK / SUBMISSIONS DEADLINES: End of S1 and second half of S2

RESIT ASSESSMENT PROCEDURES: Examination of similar form to 1st diet

ADDITIONAL INFORMATION RELEVANT TO COURSE DELIVERY AND ASSESSMENT

RECOMMENDED READING

J. Glover, M. Sarma and T.Overbye " Power System Analysis and Design", 4th ed., Thomson Learning, (2007)

A.J Wood and B.F Wollenberg "Power Generation Operation and Control" 2nd ed., Wiley India Edition, (2003)

Paul M. Anderson: Power System Protection (IEEE Press Series on Power Engineering).

Y.G. Paithankar, S.R. Bhide, “Fundamentals of Power System Protection” – available for less than £10 on Amazon and provides comprehensive coverage of the subject.

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S2	**Week**	1	**Nature**	Marked Laboratory Exercise report
Semester	S2	**Week**	2	**Nature**	Results of the Midterm Exam
Semester	S2	**Week**	9	**Nature**	Marked assignment report
Further comments about feedback		The feedback is designed so to give assessment of different types of work, including a Midterm test that would be somewhat similar in structure to the final exam. It is also designed to assess different types of work and is distributed thought both semesters			

SIGNATURE (COURSE DIRECTOR):

DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE573	**Module Title:** Advanced Power System Analysis & Protection
Brief Description of Assessment	
There will be independet work based assignment, one Lab based assignment, mid term exam and the filal exam	

Indicate on the table below the Start/Submission dates for each Assignment/Project and the timing of each Exam/Class Test(s).

	Semester 1	Semester 2
Week 1		
Week 2		
Week 3		
Week 4		
Week 5		
Week 6		
Week 7		
Week 8		
Week 9		Assignment
Week 10		
Week 11	Assignment	
Week 12		
Revision Week		
Exam Period	Examination	

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE574 - HIGH VOLTAGE TECHNOLOGY AND ELECTROMAGNETIC COMPATIBILITY

Module Code: EE574	**Module Title:** High Voltage Technology and Electromagnetic Compatibility	
Module Registrar: Dr I. V. Timoshkin		
Other Lecturers Involved: Dr Mark Wilson, Dr M. J. Given	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: O	**Academic Level:** 5	

Pre-requisites:	EE467 and EE311 Fairly good understanding of electromagnetism electromagnetic wave propagation is required. In addition students should be able to analyse steady-state and transient behaviour of power systems and their protection against outages.

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
44	22	2	2	132	202

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

1. To introduce the fundamentals of high voltage electrical insulating systems
2. To provide a basic undestanding of principles, mechanisms and characteristics of high voltage discharges in gas, vacuum and condensed media.
3. To provide a basic understanding of the behaviour of dielectric materials stressed with electric fields and their use in high voltage systems
4. To understand the principles of high voltage generation and impulse testing of the high voltage systems
5. Recognise that disturbances exist within a power system substation and appreciate that these disturbances may affect electromagnetic compatibility
6. Be competent in dealing with the implications of those disturbances; in particular the effects of system switching.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: LO1 To understand and be able to discuss the basic principles and mechanisms of electrical breakdown in gases, vacuum, solids and liquids

LO 2: LO2 To be able to discuss the factors controlling and affecting the properties of electrical insulation systems with an understanding of their appropriate use in high voltage equipment.

LO 3: LO3 To be able to describe the operating principles of circuits used for the production of high voltages, and to make simple design calculations. To understand the operating principles of voltage, current, electic and magnetic field diagnostic devices.

LO 4: LO4 Understand Power Systems EMC: Understand the fundamentals of EMC; Understand the implications of disturbances in a power system environment in relation to EMC; be aware of factors that might cause potential electromagnetic interference (EMI); be aware of techniques for making a particular system more electromagnetically compatible.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

1. Breakdown in gases

i) Introduction to high voltage gischarges in gases. Basic characteristics of plasma; ionisation, recombination and attachement mechanisms. Elements of gas kinetic theory.

ii) Townsend avalanche mechanism, not-self-sustained and self-sustained discharges, Paschel law. Characteristics and mechanisms of Townsednd discharge, glow discharge, arc discharge and corona discharge. Concepts of streamers, sparks and leadres, principles of lightning strikes.

iii) Statistical nature of breakdown in gases, breakdown in coordination gaps

2. Discharges in vacuum

i) Fundamentals of discharges in vacuum: Cathode spots, mechanism of current flow, significance of electrode material.

ii) Current interruption in a vacuum discharge and the design and operation of vacuum circuit breakers

3. Breakdown and ageing in liquid insulation systems

i) Role of liquids in practical systems such as transformers and cable insulation

ii) Properties of commonly used liquid insulation

iii) Breakdown mechanisms and the role of contamination

iv) Ageing of liquids in electrical applications

4. Breakdown and ageing in solid insulation systems

i) Breakdown mechanisms: intrinsic, electrothermal, electromechanical, treeing

ii) Ageing in electrical systems including partial discharges and the methods by which they are detected

iii) Behaviour of practical solid insulation systems (cables) under DC and AC stressing

5. Principles of generation of AC, DC and impulse high voltage, basic circuit of Marx generator and Cockroft-Walton generator. Lightning impulse testing of high voltage systems. Principles of operation of transient diagnostic systems: high voltage dividers, electric and magnetic field probes, current probes.

6. Electromagnetic Compatability

i) Introduction to EMC; EMC measurements; review of electromagnetic theory with particular emphasis on high frequency aspects.

ii) Characteristics of interfering emissions ranging from continuous mode to very short transients; concept of near-field and far-field; coupling mechanisms; grounding and shielding; suppression techniques; all these as applied to lightning electromagnetic pulse (LEMP), electrostatic discharge (ESD), and power system transients arising from primary plant.

iii) Transients arising from secondary plant; arc characteristics and current chopping.

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Discuss the basic characteristics of plasma, ionisation, recombination and attachment mechanisms in plasma of gas discharges. Be able to perform calculations as necessary.

C 2: Understand the principles of breakdown and conduction in vacuum.

C 3: Understand the principles of breakdown and conduction in condensed media. Be able to calculate expected breakdown behaviour for condensed media for certain breakdown mechanisms

LO2

C 1: Discuss the factors affecting behaviour of dielectric materials stressed with high voltage

C 2: Basic calculations of electric fields in dielectric materials under DC and AC conditions

C 3: Limits of insulation systems and the effects of ageingCalculations of diagnostic values such as tan□ and partial discharge levels

LO3

C 1: Analysis of operation of AC, DC high voltage generators

C 2: Analytical design of simple impulse circuits for lightning tests

LO4

C 1: Understand basic mechanisms and princilples of EMC

C 2: Understand the nature of typical disturbances originating from outside and within power equipment and to consider appropriate mitigation techniques against these disturbances.

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 PRINCIPLES OF ASSESSMENT FEEDBACK

Please state briefly how these are incorporated in this module.

As there shall be no continual assessments, feedback will be mainly based on tutorial interactions during the teaching period.

This will be supported by feedback from the class tests

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

ASSESSMENT METHOD(S) INCLUDING PERCENTAGE BREAKDOWN AND DURATION OF EXAMS

To Pass the module, students need to gain a summative mark of;					**50%**	
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	All
Coursework	**Number**	2	**Weighting %**	40	**Learning Outcomes**	LO1 (C1-C3), LO2 (C1, C2), LO4(C1-C2)
Project	**Number**		**Weighting %**		**Learning Outcomes**	

COURSEWORK / SUBMISSIONS DEADLINES: none

RESIT ASSESSMENT PROCEDURES: Examination

ADDITIONAL INFORMATION RELEVANT TO COURSE DELIVERY AND ASSESSMENT

COURSEWORK CONSISTS OF TWO CLASS TESTS (1 HOUR EACH, in Semester 1 and Semester 2), WEIGHTING OF EACH CLASS TEST IS 20%.

RECOMMENDED READING

High voltage engineering fundamentals" E Kuffel and W S Zaengl (Pergamon) 1984 ISBN 08 024212 x

High Voltage Engineering and Testing (IEE) Hugh Ryan 2003 ISBN 0852967756

CIGRE Publication TB 535, EMC within Power Plants and Substations, CIGRE-Paris

"Electrical Transients in Power Systems", A. Greenwood, 2nd Edition, Wiley, 0471620580

"Electric Power Systems", B. Weedy, 4th Edition, John Wiley, 0471976776

"Power Systems Analysis", Guile & Paterson, Vol 1 and Vol 2, 2nd Ed, Pergamon

"Grounding and Shielding in Facilities", Morrison & Lewis, Wiley, 0-471-83807-1

"Protection of Electronic Circuits from Overvoltages", Standler, Wiley, 0-471-61121-2

"EMC-Electromagnetic Theory to Practical Design", Chatetton & Houlden, Wiley, 0-471-92878-X

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S2	**Week**	1	**Nature**	Feedback on class test 1

Semester	S2	**Week**	11	**Nature**	Feedback on class test 2
Semester		**Week**		**Nature**	
Further comments about feedback	The feedback is designed to give the results of assessment of Class tests. It may discuss problems similar to the problems in the final exam.				

SIGNATURE (COURSE DIRECTOR):
DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE574	**Module Title:** High Voltage Technology and Electromagnetic Compatibility
Brief Description of Assessment	
A TOTAL OF TWO CLASS TESTS DURING SEMESTER 1 and SEMESTER 2 (1 HOUR EACH), 2 HOURS FINAL EXAM	

Indicate on the table below the Start/Submission dates for each Assignment/Project and the timing of each Exam/Class Test(s).

	Semester 1	**Semester 2**
Week 1		
Week 2		
Week 3		
Week 4		
Week 5		
Week 6		
Week 7		
Week 8		Test
Week 9		
Week 10		
Week 11		
Week 12	Test	
Revision Week		
Exam Period		Examination

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE575 - POWER ELECTRONICS FOR ENERGY AND DRIVE CONTROL

Module Code: EE575	**Module Title:** Power Electronics For Energy And Drive Control	
Module Registrar: Prof. Lie Xu		
Other Lecturers Involved: Dr Alasdair McDonald	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: O	**Academic Level:** 5	

Pre-requisites:	EE466 or equivalent course (introduction to electrical machines and power electronics) at another institution

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
44	20	80	5	51	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

Modern energy conversion systems rely on the integration of a range of technologies including power electronics, electrical machines and system integration. This module will develop knowledge and understanding of these technologies and give the student experience in analysing their performance and selecting and designing systems for modern energy converion systems.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Comprehensively understand the scientific principles of power semiconductors, permanent magnet electrical machines and high power converter systems.

LO 2: Identify, classify and describe the performance of power converters and components through the use of analytical methods and modelling techniques.

LO 3: Use fundamental knowledge to investigate new and emerging technologies such as HVDC, FACTS and permanent magnet electrical machines.

LO 4: Apply mathematical and computer-based models for assessing and designing modern electrical machines, and able to assess the limitations of particular approaches

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

Electrical Machine Theory (Semester 1)

i) Maxwell's equations

ii) Synchronous machines (salient and cylindrical pole machines)

iii) Magnetic circuit approaches

iv) Derivation of equivalent circuits

v) Loss types and mechanisms

Electrical Machine Design (Semester 1)

i) Machine sizing considering thermal and mechanical issues

ii) Magnetic materials including soft and hard materials

iii) Use of FEA and analytical techniques to analyse machines and their performance

iv) Use of FEA and analytical techniques to design machines for an application

v) Advances in electrical machine design

Power Electronics (Semester 2)

i) Detailed description of IGBT and Thyristors and their switching behaviour. (Switching characteristics, Gate drive operation, Safe operating area, losses)

ii) Switch Mode power supplies (Buck, Boost and Flyback circuits)

iii) Two level voltage source inverters. (Revision of basic circuit, Modulation techniques)

iv) Multi-Phase Thysistor Rectifier/Line-commutated inverter circuits. (Circuit operation, Harmonic issues, Commutation effects)

v) Barriers to High Voltage/High Power Converters. (Device rating limits, Series connection

vi) Multi-level Inverter Systems

Power Systems Applications (Semester 2)

i) Thyristor based LCC HVDC

ii) Voltage Source HVDC systems

iii) FACTS Devices

iv) Generation Interface

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Describe the operation of a range of power semiconductor devices and circuits.

C 2: Apply Maxwell's equations to rotating electrical machines.

C 3: Perform calculations based on the operation of the circuits and systems presented.

LO2

C 1: Describe the relative performance of different power converter topologies

C 2: Derive torque speed behaviour for different rotating electrical machines

LO3

C 1: Discuss the operation of HVDC and FACTS systems and critically compare the merits of different converter topologies for a range of applications.

C 2: Analyse the operation of high power converter systems

C 3: Analyse the operation of permanent magnet electrical machines

LO4

C 1: Use lumped parameter methods to determine equivalent circuit parameters

C 2: Use an FEA approach to analyse designs and modify those designs

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 Principles of Assessment Feedback

Please state briefly how these are incorporated in this module.

For Semester 1, the continuous assessment component is a design, modelling and analysis project. This will involve some lab sessions where feedback will be given on the student's use of the FEA software. After the submission of the assignment, feedback will be given to the class on common issues so that the student's understanding of concepts and practice can be clarified in time for the exam. Individual feedback on the assignment hands in will be given in written form.

For Semester 2, the continous assessment component will contain two assignments covering analysis and design of power electronic converter systems. These assignments are designed to review key theory and to learn how to use the knowledge for designing converter systems. Individual feedback on the written assignment will be given in written form.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

Assessment Method(s) Including Percentage Breakdown and Duration of Exams

To Pass the module, students need to gain a summative mark of;					**50%**	
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	LO1-4
Coursework	**Number**	5	**Weighting %**	40	**Learning Outcomes**	LO1-4
Project	**Number**		**Weighting %**		**Learning Outcomes**	

Coursework / Submissions deadlines: First Semester: week 4, 8 and 13

Second Semester: week 7 and 11

Resit Assessment Procedures: Examination

Additional Information relevant to Course Delivery and assessment

The S1 Assignment is a group (2-3 members) design of PM machines for a high performance application in the energy/power and transport sectors.

Recommended Reading

Semester 1:

'Principles of Electric Machines and Power Electronics', P.C. Sen (Wiley), 0-471-61717-2

'Electrical Machines, Drives and Power Systems', T. Wildi (Prentice-Hall), 0-13-082460-7

'Electric Machinery', 6th ed., A.E. Fitzgerald et al. (McGraw-Hill), 0-07-123010-6

'Electric Motors and Drives', 4th ed., A. Hughes, B. Drury (Newnes/Elsevier), 0-08-098332-5

'Design of brushless permanent-magnet motors', J. R. Hendershot, T. J. E Miller (Clarendon), 0-19-859389-8

Semester 2:

'Power Electronics: Converters, Applications and Design', N. Mohan et al. (Wiley), 0-471-22693-9

B.W.Williams on line text http://homepages.eee.strath.ac.uk/~bwwilliams/book.htm

'Power Electronics', 3rd ed, C. W. Lander (McGraw-Hill), 0-07-084162-4

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S1	**Week**	7	**Nature**	Written feedback on first S1 assignment
Semester	S1	**Week**	11	**Nature**	Written feedback on second S1 assignment
Semester	S2	**Week**	1	**Nature**	Written feedback on third S1 assignment
Semester	S2	**Week**	9	**Nature**	Written feedback on first S2 assignment
Semester	S2	**Week**	19	**Nature**	Written feedback on second S2 assignment
Semester		**Week**		**Nature**	
Further comments about feedback					

SIGNATURE (MODULE REGISTRAR):
DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE575	**Module Title:** Power Electronics For Energy And Drive Control

Brief Description of Assessment

For Semester 1, the continuous assessment component is a design and analysis project of an electrical machine for a renewable energy/transportation device. The findings will be written up as a report and submitted along with supporting model files. There are 3 submissions throughout Semester 1 (worth 5%, 10% and 10% module mark).

For Semester 2, the continous assessment component will contain two assignments covering analysis and design of power electronic converter systems. These assignments are designed to review key theory and to learn how to use the knowledge for designing converter systems. Individual feedback on the written assignment will be given in written form.

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			Semester 2	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1	Assignment Start		**Week 1**	Assignment Start	Feedback Provided
Week 2			**Week 2**		
Week 3			**Week 3**		
Week 4	Assignment - Due		**Week 4**		
Week 5	Assignment Start		**Week 5**		
Week 6			**Week 6**		
Week 7		Feedback Provided	**Week 7**	Assignment - Due	
Week 8	Assignment - Due		**Week 8**		
Week 9	Assignment Start		**Week 9**		Feedback Provided
Week 10			**Week 10**		
Week 11		Feedback Provided	**Week 11**	Assignment - Due	
Exam Period			**Revision Week**		
Review Week	Assignment - Due		**Exam Period**		Feedback Provided

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	5	**Total # to be attempted**	3	**Compulsory Questions**	1 Question	**Sections**	Multiple
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

The paper is made up of 3 parts: Part A is compulsory and exams material from both Semesters; in Part B, the student answers 1 question from 2 on offer from Semester 1; in Part C, the student answers 1 question from 2 on offer from Semester 2 material.
The 2 hour exam allows the student to demonstrate their strengths and deep understanding (Parts B and C) while rewarding borad knowledge and understanding of the whole syllabus (Part A).

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; No

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

The student is expected to be able to recall and use key equations. Guidance will be given as to what might be expected and what might be given during exam preparation.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Final Examination *and Assignments too*

C1. Describe the operation of a range of power semiconductor devices and circuits.

C2. Apply Maxwell's equations to rotating electrical machines.

C3. Perform calculations based on the operation of the circuits and systems presented.

LO2 Final Examination *and Assignments too*

C1. Describe the relative performance of different power converter topologies

C2. Derive torque speed behaviour for different rotating electrical machines

LO3 Final Examination *and Assignments too*

C1. Discuss the operation of HVDC and FACTS systems and critically compare the merits of different converter topologies for a range of applications.

C2. Analyse the operation of high power converter systems

C3. Analyse the operation of permanent magnet electrical machines

LO4 Assignments *and Final Examination too*

C1. Use lumped parameter methods to determine equivalent circuit parameters

C2. Use an FEA approach to analyse designs and modify those designs (Assignment)

University of Strathclyde Engineering

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

-

Module Code: EE576	**Module Title:** Power system economics, markets and asset management	
Module Registrar: Brian Stewart		
Other Lecturers Involved: Keith Bell, Ivana Kockar, Brian Stewart	**Credit Weighting** 20	**Semester:** 1 & 2
Compulsory/optional/elective class: C	**Academic Level:** 5	

Pre-requisites:	Power systems principles (or equivalent introduction to power systems), in particular power system power balancing, basics of secure operation (thermal, voltage, stability and fault level limits; meaning of N-1 security), nature of demand and generation

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
44	22	11	0	123	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

1. present and give an understanding of the economics, trading and pricing of electricity supply and how it is shaped by technical, commercial and regulatory considerations;
2. give an understanding of power system economics under an environment of multiple suppliers and users;
3. present the challenges, technologies and value of asset management within an electricity supply industry context;
4. give a deep appreciation of factors affecting security of supply and how it might be quantified

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

C 1: appreciate the advantages and disadvantages of different electricity industry structures and their effects on competition, choice, prices to consumers, security of supply and need for regulation

C 2: carry out economic and electricity market analyses involving use of system prices and investment costs

C 3: understand the impact of plant failure on power systems and apply principles of reliability calculation

C 4: appreciate the scope of instrumentation and condition monitoring on power systems, describe techniques for inferring meaning from measurements and understand the main processes and value of asset management.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

Motivation for liberalisation of electricity markets

Competitive electricity market structure - single and multiple sellers and buyers

Pricing - marginal price, market clearing price, spot price; forward, future, options, swap and hedging contracts

Security and reliability - costs, Value of loss load, LOLP, system balancing

System charges - infrastructure, use of system, connections, and wheeling fees

Ancillary services

Regulatory models

Project costing and financial appraisal

Issues in development of new generation

Incentives for renewables

Optimisation in dispatch of generation

Issues on the demand side of electricity markets including smart metering

Investment in enhancing power network capacity

Classes of power system assets and their purpose and crticiality

Management: of individual assets and maintenance strategies

Decision making in management of popluations of assets

Monitoring and control systems with power and process plant;

Failure characteristics including diagnostic statistics.

Condition monitoring systems: Instrumentation and signal processing for condition monitoring; Case studies of condition monitoring systems, including rotating plant, transformers, cables.

Fault diagnosis: Approaches to fault diagnosis; Interpretation of condition monitoring data; Technologies for data interpretation, including Knowledge-Based Systems and machine learning.

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1 - *appreciate the advantages and disadvantages of different electricity industry structures and their effects on competition, choice, prices to consumers, security of supply and need for regulation*

C 1: describe and discuss different electricity supply industry structures

LO2 - *carry out economic and electricity market analyses involving use of system prices and investment costs*

C 2: set up and use mathematical models to calculate system prices for given conditions

C 3: set up and carry out financial appraisals of investments, discuss sensitivities to key factors and draw sound conclusions.

LO3 - *understand the impact of plant failure on power systems and apply principles of reliability calculation*

C 4: set up and use mathematical models of simple engineering systems to calculate system failure and repair rates

C 5: carry out an analysis of generation system loss of load probability and expected energy not supplied.

LO4 - *appreciate the scope of instrumentation and condition monitoring on power systems, describe techniques for inferring meaning from measurements and understand the main processes and value of asset management*

C 6: describe the meaning of asset management and the role of instrumentation in plant and asset management systems

C 7: discuss the issues associated with the industrial application of condition monitoring.

C 8: demonstrate an appreciation of techniques and technologies for fault diagnosis

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 PRINCIPLES OF ASSESSMENT FEEDBACK

Please state briefly how these are incorporated in this module.

Assessment will comprise of a Final Exam, a Midterm test and an Assignment. The Midterm test is scheduled at the beginning of S2, so that students can get the feedback on their progress and can improve in S2. The Assignment will enable students to research key power industry information and learn how to present it succinctly. Students will be able to assess their progress on their own, but will also get feedback with an indication where additional learning and clarification would be useful.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

ASSESSMENT METHOD(S) INCLUDING PERCENTAGE BREAKDOWN AND DURATION OF EXAMS

To Pass the module, students need to gain a summative mark of;					**50%**	
Examination	**Duration**	2h	**Weighting %**	75%	**Learning Outcomes** **Format**	All Three sections each with 2 questions; answer one question from each section
Coursework	**Number**	1	**Weighting %**	15%	**Learning Outcomes**	C1 and C3
Mid Term Exam	**Number**	1	**Weighting %**	10%	**Learning Outcomes**	All – subset of material from S1

COURSEWORK / SUBMISSIONS DEADLINES: beginning of S2 and mid-way through S2.

RESIT ASSESSMENT PROCEDURES: Examination of similar form to 1st diet

EXAMINATION RUBRIC:

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	6	**Total # to be attempted**	3	**Compulsory Questions**	3 sections, 2 questions in each; answer exactly 1 from each section. (Choice of which one in each section)	**Sections**	3
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

A mix of analysis and description is required with an emphasis on the former and complements a multiple choice test earlier in the module that tested basic concepts, and two items of coursework. The three sections are designed to ensure that students addressed of the three main parts of the course

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided;

Formulae are only provided if they would normally be difficult for students to remember precisely

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

Some basic mathematical relationships should be recalled and their use explained

ADDITIONAL INFORMATION RELEVANT TO COURSE DELIVERY AND ASSESSMENT

2nd attempt mark based solely on the resit exam mark.

Students taking the August exam as 1st attempt will have earlier coursework marks included in their final mark.

Weightings for assessment elements:

Individual research assignment: 15% (up from 10% in 2014/15)

Multiple choice test: 10% down (from 15% in 2014/15)

Exam: 75% (up from 60% in previous year)

RECOMMENDED READING

D Kirschen and G Strbac, "Fundamentals of Power System Economics", John Wiley and Sons, 2004

Barrie Murray, "Power Markets and Economics: Energy Costs, Trading, Emissions: Structure, Costs, Operation", Wiley 2009

Darryl R. Biggar & Mohammad Hesamzadeh, “The economics of electricity markets”, Wiley, 2014

Steve Stoft, "Power system economics”, IEEE Press, 2002

Wenjuan Li, "Risk Assessment of Power Systems", IEEE Press, 2005

Peter J. Tavner, "Condition monitoring of electrical machines",, WIley 1987

Keith Harker, "Power System Commissioning and Maintenance Practice", IEE 1997

Martin Heathcote, “The J&P Transformer Book”, Newnes, 2007

Walter Boyes, “The Instrumentation Reference Book”, Butterworth-Heinemann, 2000

Colin Bayliss and Brian Hardy, "Transmission and Distribution Electrical Engineering", Newnes, 2006

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S2	**Week**	1	**Nature**	Results of the Midterm Exam
Semester	S2	**Week**	3	**Nature**	Banding of performance in first assignment relative to other students; advice on how to improve
Further comments about feedback	The feedback is designed so as to give assessment of different types of work, It is also designed to assess different types of work				

SIGNATURE (COURSE DIRECTOR): DAVID HARLE
DATE OF LAST MODIFICATIONS: 27.08.2018

MODULE TIMETABLE

Module Code: EE576	**Module Title: Power system economics, markets and asset management**
Brief Description of Assessment	
Assessment will comprise a Final Exam, a Midterm test and an Assignment. The Midterm test is scheduled at the end of S1. The Assignment, for submission during the exam period at the end of S1, will enable students to research key power industry information and learn how to present it succinctly.	

Indicate on the table below the Start/Submission dates for each Assignment/Project and the timing of each Exam/Class Test(s).

	Semester 1	**Semester 2**
Week 1	Setting of individual assignment	feedback on Mid-course test
Week 2		Feedback on individual assignments
Week 3		
Week 4		
Week 5		
Week 6		
Week 7		

Week 8		
Week 9		
Week 10		
Week 11		
Week 12	Mid-course test	
Revision Week		
Exam Period	Submission of individual assignment	Exam

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE577 - WIND ENERGY & DISTRIBUTED ENERGY RESOURCES

Module Code: EE577	**Module Title:** Wind Energy & Distributed Energy Resources	
Module Registrar: Dr. David McMillan		
Other Lecturers Involved: Julian Feuchtwang, Graeme Hawker, Simon Gill	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: C	**Academic Level:** 5	

Pre-requisites:

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
44	22	18	16	100	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

This module gives an overarching understanding of the principles of wind power generation, the management of wind farms and their place in the wider power system. The course will cover the wind resource, rotor aerodynamics, wind turbine anatomy, the technologies used and their variations, power conversion and control,electrical issues within the wind farm, the impact of large capacities of wind power on the wider power system, and the connection of wind farms at both transmission and distribution levels. Students will also gain an understanding of asset management techniques applied in the wind sector and study how multiple data streams from wind assets can be used to improve decision making in the operational phase. This will provide an understanding of the lifecycle of a wind farm from site assessment to repowering and decommissioning.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Explain the nature of the wind resource and its assessment, and the design principles behind turbines which aim to capture the energy in the wind and convert it to electricity

LO 2: Describe and analysis various method for maintaining and operating a wind farm in terms of monitoring the condition of turbines, carrying out maintenance and managing faults and failures

LO 3: Understand all stages of the life-cycle of a wind farm from initial proposal through building, operating and decommissioning.

LO 4: Develop an appreciation of the electrical impact of wind generaiton and how it affects the electrical design within the wind farm through to the planning and operation of the power system as a whole, including the particular impacts of connecting wind farms at a distribution level.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

Wind Characteristics: atmospheric boundary layer, wind shear, surface roughness, log law, power law, Weibull distribution, turbulence characterisation, energy density, site characteristics, anemometry, energy yield calculation.

Rotor aerodynamics: introduction, lift and circulation, actuator disk theory, definition of CP and CT , Betz limit derivation, breakdown of momentum theory, explanation of wind turbine aerodynamic operation in terms of blade element forces, power performance curves, both ideal and realistic, power coefficient vs tip-speed ratio curves (CP-λ).

Turbine design: Danish concept, operational characteristics, structure, tower/rotor characteristics, drive-train options, size-related issues, aerodynamic control: stall/pitch regulation, constant/variable speed, offshore aspects, safety issues.

Wind turbine modelling and basic control strategies: wind turbine simulation methods; wind turbine control issues; wind turbine operational simulations; use of DNV GL Bladed wind turbine modelling software

Wind farm operations and maintenance: current methods to achieve high operational efficiency and new methods utilising multivariate data from wind assets, covering various regression and predicition methods as well as a comprehensive overview of available turbine telemetry.

Wind Farm life cycle: Site assessment, pre-construction activities, construction, lifetime operations, repowering and decomissioning

Power generation: generator options, wind farm electrical design, power electronics, electrical control systems, wind farm networks.

Power System integration: Offshore grid integraiton, HVAC or HVDC transmission schemes; Offshore and onshore substation design considerations, impact of wind on system inertia, ancillary service provision by wind

Distributed generation and distribtued energy resources: connection arrangements for distribtued generation, network constraints, Active Network Management, utilisation of local flexible demand, role of energy storage, smart gids, the future role of the Distribution Network Owner

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Understand the nature of the wind resource

C 2: Describe the Danish model of a wind turbine

C 3: Ability to differentiate operation of different wind turbine control schemes

C 4: Carry out calculations describing the aerodynamics of a wind turbine rotor

LO2

C 1: Critically assess different methods of operating and maintaining wind farms through condition monitoring

C 2: Understand the theoretical modelling of maintanence

LO3

C 1: Ability to discuss the broad range of factors that influence decisions at all stages of the wind farm life cycle

C 2: Calculate estimated energy yields for a particular site

LO4

C 1: Ability to model dynamically the interaction of a wind turbine with a wider power network

C 2: Knowledge and understanding of the key electrical components within a wind farm

C 3: Critical understanding of the pros and cons of HVAC and HVDC connection of offshore wind farms and in which circumstances one is likely to be preferable to another

C 4: Calaculate the likely Rate of Change of Frequency of a power system given information on inertia, and discuss the effect of wind penetration on this calculation

C 5: Present evidence-based arguments for decisions over connection options for distributed generation including the need for communications and control, and the ability to incorperate flexible demand and

storage

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 Principles of Assessment Feedback

Please state briefly how these are incorporated in this module.

Assessment comprises : A final exam after Semester 2, an online class test in Week 8 of Semester 2, a laboratory assessment using DNV GL Bladed to simulate operation of wind turbines (in Semeseter 1), and a case-study base exercise into active network management (at the end of Semeseter 2).

Individual feedback in the form or marks and comments will be provided on the semester 1 assignment

Marks from the class test will be returned to students shortly after the test, with the opportunity for students to contact teaching staff for individual feedback as required

The case-study excercise during Semester 2 will be partly conducted during tutorials with staff discussion of progress with students individually, examples of the calculation will be provided after the excercise to allow students to self-review their answers against a model answer

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

Assessment Method(s) Including Percentage Breakdown and Duration of Exams

To Pass the module, students need to gain a summative mark of;					**50%**	
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	all LOs
Coursework	**Number**	3	**Weighting %**	40	**Learning Outcomes**	Assignment 1: Simulating the operation of wind turbines (20%): LO1, LO4 Assignment 2: Case-study exercise on Active Network Management (5%): LO3, LO4 Class test (15%): LO1, LO2,LO3
Project	**Number**		**Weighting %**		**Learning Outcomes**	

Coursework / Submissions Deadlines:

Simulating wind turbine operation: Semester 1 Week 12 (exam week)**

Active Network Managmenet case-study exercise: Semester 2 Week 11

Class Test: Semeseter 2 Week 8

Resit Assessment Procedures: Examination

Additional Information relevant to Course Delivery and Assessment

The section on Active Network Management, distribtued generaiton, smart grids and flexible demand will be taught through a 'flipped-learning' mode. Material will be placed online via Myplace ahead of lectures with an expectation that students will review this material before attending. The second piece of coursework will form the core of this section based on the case study of the Orkney Smart Grid. This will allow students to develop the skills associated with using and analysing a large data set to reach engineering conclusions.

RECOMMENDED READING

Wind Energy Explained; J F Manwell, J G McGowan and A L Rogers, Wiley. (ISBN 0 471 49972 2)

Wind Energy Handbook; T Burton, D Sharpe, N Jenkins and E Bossanyi, Wiley. (ISBN 0 471 48997 2)

'Embedded Generation'; N. Jenkins, R. Allan, P. Crossley, D. Kirschen, G. Strbac, IET. (ISBN-10: 0852967748, ISBN-13: 978-0852967744)

Wind power plants: fundamentals, design, construction and operation;R. Gasch, J Twele;Springer, 2nd ed. 2012 (ISBN 978-3642229381)

Wind Energy Essentials: Societal, Economic, and Environmental Impacts; Richard P. Walker, Andrew Swift; Wiley, 2015 (ISBN: 978-1-118-87789-0)

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S2	**Week**	0	**Nature**	Results and feedback from wind turbine simulation coursework
Semester	S2	**Week**	9	**Nature**	Results and feedback from Class Test
Semester	S2	**Week**	12	**Nature**	Release of model calculations for class assignment and feedback from staff on overall class performance
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Semester		**Week**		**Nature**	
Further comments about feedback					

SIGNATURE (MODULE REGISTRAR):

DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE577	**Module Title:** Wind Energy & Distributed Energy Resources
Brief Description of Assessment	
There will be one lab-based assignment carried out in Semester 1 with a written report to be submitted at the start of Semester 2, one case-study based lab exercise in semester 2, one class test in Semester 2 and 1 final exam	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			**Semester 2**	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**		Assignment Marked
Week 2			**Week 2**		Feedback Provided
Week 3			**Week 3**		
Week 4			**Week 4**		
Week 5			**Week 5**		
Week 6	Assignment		**Week 6**		
Week 7	Assignment		**Week 7**		
Week 8	Assignment		**Week 8**	Test	
Week 9			**Week 9**	Assignment	Test - Marked
Week 10			**Week 10**	Assignment	
Week 11			**Week 11**	Assignment	
Exam Period	Assignment - Due		**Revision Week**		Feedback Provided
Review Week			**Exam Period**		

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	5	**Total # to be attempted**	3	**Compulsory Questions**	None - free choice	**Sections**	Single
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

The two hour exam complements the continuous assessment and will contain questions from across the course, including questions which cover one or more learning outcomes. The questions will contain a mix of detailed numerical calculations and discussion sections. This format mirrors the course content which covers multiple engineering specialties, and their interaction.

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; Yes

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

Some more advanced mathematical formulae will be given, but the student will be expected to know and/or derive the more fundamental equations.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Final Examination *and assignments*

C1. Understand the nature of the wind resource

C2. Describe the Danish model of a wind turbine

C3. Ability to differentiate operation of different wind turbine control schemes

C4. Carry out calcualtions describing the areodynamics of a wind turbine rotor

LO2 Final Examination

C1. Critically assess different methods of operating ana maintaining wind farms through condition monitoring

C2. Understand the theoretical modelling of maintanence

LO3 Final Examination *and assignments*

C1. Ability to discuss the broad range of factors that influence desions at all stages of the wind farm life cycle

C2. Calaculte estimated energy yields for particular site

LO4 Final Examination *and assignments*

C1. Ability to dynamically model the interation of a wind turbine with a wider power network

C2. Knowedge and understanding of the key electrical components within a wind farm

C3. Critical understanding of the pros and cons of HVAC and HVDC connection of offshore wind farms and in which circumstances one is likely to be preferable to another

C4. Calaculate the likely Rate of Change of frequency of a power system given information on inertia, and discuss the effect of wind penetration on this calcaulation

C5. Present evidence-based arguments for descions over connection option for distributed generation including the need for communications and control, and the ability to incorperate flexible demand and storage

University of Strathclyde Engineering

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE578 - ADVANCED DSP

Module Code: EE578	**Module Title:** Advanced DSP	
Module Registrar: Dr S Weiss		
Other Lecturers Involved: TBC	**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: C 0	**Academic Level:** 5	

Pre-requisites: EE469 DSPt

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
36	12	36	20	96	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

DEVELOP THE NECESSARY SKILLS THAT WILL ALLOW STUDENTS TO ANALYSE, DESIGN, IMPLEMENT, AND SIMULATE ADVANCED DSP TECHNIQUES AND ALGORITHMS FOR A VARIETY OF COMMUNICATIONS AND GENERAL ENGINEERING PROBLEMS.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

C 1: Understand a number of essential advanced DSP techniques.

C 2: Be able to develop and design a number of state-of-the-art applications based on these techniques.

C 3: Implement advanced DSP algorithms in a number of applications and understand which performance metrics can be used to test such a system.

C 4: Be able to pick up a new algorithm from the literature, implement it, and be able to compare its performance to a suitable benchmark.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

Review of Signal processing fundamentals:
Frequency domain analysis – LTI sustems, Fourier series, Fourier transform, discrete and fast Fourier transforms, spectral leakage, windowing. Digital filtering – representations by difference equation, flow graph, impulse and frequency response, transfer function, z-transform, poles and zeros, minimum phase, maximum phase, linear phase, group delay, stability.

Stochastic Processes:
Stochastic processes – characterisation of stochastic processes by distributions, expectations, stationarity, ergodicity, central limit theorem, interaction between stochastic signals and deterministic systems, auto-correlation and cross-correlation functions, power spectral densities, periodogram and spectrum estimation for random signals.
Binary Signalling – Quadrature amplitude modulation, complex digital baseband channel, Nyquist system, receive and transmit filtering, channel impulse response, symbol generation and detection, additive noise model, bit and symbol errors.

Adaptive Signal Processing:
Optimum adaptive filtering – generic adaptive filtering, adaptive filter archtectures and applications, mean square error cost function, covariance matrix and cross-correlation vector, Wiener solution
Training based adaptive filters – iterative gradient techniques, stochastic gradient techniques, least mean squares algorithm (LMS), LMS convergence, step size parameter, influence of correlated input on cost function and convergence, recursive least squares (RLS) adaptive filter, comparison between RLS and LMS (convergence, complexity), application to equalisation, zero-forcing and MMSE solutions.
Kalman filter – concept, state-space model, Kalman estimator, RLS and Kalman comparison, Kalman filter in information theoretic form, extended and unscented Kalman filter, Kalman filter for data fusion, particle filter.
Decision directed and blind adaptation – equalisation without explicit desired signal, maximum length pseudo-random sequences, decision directed adaptation, equation and output error adaptive filters, decision feedback equaliser. Blind adaptation and constant modulus cost function, constant modulus algorithm (CMA), effect of carrier frequency offset and carrier frequency offset recovery.
Fractionally spaced equalisation (FSE) – fractionally spaced channel model and polyphase representation of channel and equaliser, zero-forcing solution based on pseudo-inverse, MMSE solution, adaptive FSE based on LMS, RLS, and CMA.

Advanced DSP applications
Orthogonal frequency division multiplexing (OFDM) – frequency domain equalisation, cyclic prefix, circulant property and the DFT, OFDM structure, equalisation, maximum channel capacity via precoding and waterfilling, example for powerline communications channel
Mulitple input multiple output (MIMO) systems – channel model and capacity. Maximising the multiplexing gain -- equalisation or precoding via pseudo-inverse, optimum precoding and equalisation via singular value decomposition, capacity maximisation. Maximising the diversity gain – spaced-time block coding (STBC) , real and complex valued symbol constellations, extended orthogonal STBC, maximum diversity and array gain based on feedback and rotation.
Array processing and beamforming – spatial sampling, narrowband beamformer, steering vector, constraint formulation, data independent beamformer design, statistically optimum beamformer design, mimmium variance distortionless response beamformer, constrained optimisation, generalised sidelobe canceller and unconstrained optimisation. Difference between MIMO systems and beamforming, outlook on broadband beamforming.

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: level of understanding in mathematically deriving DSP algorithms

C 2: know where and how to apply DSP algorithms

C 3: be able to set important parameters of DSP algorithms dependent on specific applications

LO2

C 1: understand a number of state-of-the-art applications, such as OFDM, equalisation etc

C 2: be able to judge from DSP algorithm properties which ones are most suitable for specific applications

LO3

C 1: be able to derive workable Matlab implementations from pseudo code and literature-style descriptions

C 2: be able to embed an algorithm implementation into a specific application scenario

C 3: know which performance metrics (minimum mean square error, distance from optimum solution, constant modules, SNR, bit error ratio, etc are suitable in various scenarios

C 4: be able to derive performance parameters such as complexity or latency from an algorithm description or implementations

LO4

C 1: be able to understand important parameters of an unknown algorithm from a description or paper

C 2: be able to judge the advantages and disadvantages of an algorithm, in particular with respect to a specific application

C 3: be able to implement and unknown algorithm and develop suitable test metric or performance parameters.

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 Principles of Assessment Feedback

Please state briefly how these are incorporated in this module.

Assignments will consist of a compulsory base module and optional tasks which can gain extra marks. The submission will be on-line, and feedback will be given via on-line resources near the time of submission, no later than two weeks after submission.

For the class test, students will be able to individually view and discuss their marked test paper at the beginning of semester 2.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

Assessment Method(s) Including Percentage Breakdown and Duration of Exams

To Pass the module, students need to gain a summative mark of;				**50%**		
Examination	**Duration**	3	**Weighting %**	60	**Learning Outcomes**	LO1-LO4
Coursework	**Number**	4	**Weighting %**	40	**Learning Outcomes**	LO1-LO4
Project	**Number**		**Weighting %**		**Learning Outcomes**	

Coursework / Submissions deadlines: 4 assignments (due weeks 6 and 10 S1 and week 6 and 10 in S2).

Resit Assessment Procedures: Examination of similar form to 1st diet

Additional Information relevant to Course Delivery and assessment

Students will keep a detailed logbook from their laboratories., and their assignments. Four assignments based on lecture and laboratory material will be submitted.

There will be a mid term class test.

Recommended Reading

Todd K. Moon and Wynn C. Stirling. “Mathematical Methods and Algorithms for Signal Processing”. Prentice Hall.

John Proakis and Dimitris Manolakis. “Digital Signal Processing. Principles, Algorithms and Applications”, 4th edition. Prentice Hall.

On-line books and resources such as

http://www.dspguide.com/ (a free DSP book)

http://www.bores.com/index_online.htm (on-line DSP course)

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S1	**Week**	11	**Nature**	Post assignments feedback
Semester	S2	**Week**	2	**Nature**	Pre-mid term test feedback
Semester	S2	**Week**	11	**Nature**	Post assignment feedback
Further comments about feedback		None			

SIGNATURE (COURSE DIRECTOR):
DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE578	**Module Title:** Advanced DSP
Brief Description of Assessment	
Assessment 1 will aim be topic on filtering and statistical signal processing, aiming at the mathematical background, notation and stochastic processes component of the module. **Assignment 2 will be concerned with adaptive filtering and equalisation using trained and blind adaptive algorithms.** **Assignment 3 targets Kalman filtering and RLS problems.** **Assignment 4 deals with applications of OFDM, MIMO systems, and array processing.** **All assignments will be performed in Matlab.**	

Indicate on the table below the Start/Submission dates for each Assignment/Project and the timing of each Exam/Class Test(s).

	Semester 1	**Semester 2**
Week 1		
Week 2		
Week 3		Assignment
Week 4	Assignment	
Week 5		
Week 6		Assignment
Week 7	Assignment	Assignment
Week 8	Assignment	
Week 9		
Week 10		Assignment
Week 11	Assignment	
Week 12		
Revision Week		
Exam Period	Examination	Examination

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE579 - ADVANCED MICROCONTROLLER APPLICATIONS

Module Code:	**EE579**	**Module Title:**	**Advanced Microcontroller Applications**
Module Registrar:	**Dr James Irvine**		
Other Lecturers Involved:		**Credit Weighting** **20**	**Semester:** **1 2**
Compulsory/optional/elective class: **O**		**Academic Level:** **5**	

Pre-requisites:	EE312 or similar experience with microcontrollers/low level programming

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
20	0	70	33	77	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

Provide advanced competence in the use of industry standard microcontrollers programmed in low and high level languages in real time applications.

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Understand the trade off between high level and low level design blocks, and be able to partition design solutions accordingly, and identify appropriate problem/language partitioning in mixed level problems.

LO 2: Demonstrate competence in low level (assembly language) coding.

LO 3: Understand, design and extend simple operating systems and Real Time Operating Systems (RTOS) for microcontrollers.

LO 4: Interface peripheral hardware devices with real time critical specifications, and carry out a systematic testing programme for mixed level designs.

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

Hardware/Software Design Solutions

- Review of microcontroller architectures
- Comparison of different microcontroller types
- Low level code design
- Introduction to libraries and operating systems

Assembly Language Programming

- Arithmetic & logical instructions
- Program construct; mapping from high level constructs
- Program flow
- Use of registers
- Multiple work arithmetic

Operating Systems

- Timing critical operations
- Multi-threaded systems
- Real Time Operating Systems
- Device drivers

Advanced code design and interfacing

- Interfacing high and low level code, parameter passing
- Code translation and debugging
- Peripheral interfacing in real time applications

Advanced System Solutions

- System design for processor power constrained situations
- Design partitioning between hardware, programmable hardware, firmware, and high/low level software

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Recommend appropriate design choices for a range of different technical challenges

C 2: Design system architectures for small embedded systems, and specify appropriate components

LO2

C 1: Ability to write programs in assembly language

C 2: Ability to optimise assembler programs against defined constraints, i.e., execution time or memory use

LO3

C 1: Implement a simple operating system for a microcontroller system

C 2: Use a commercial RTOS to implement a design with time-critical requirements

LO4

C 1: Build a stand-alone embedded system capable of independent operation (specifically without a PC)

C 2: Document system construction through a technical documentation file

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 PRINCIPLES OF ASSESSMENT FEEDBACK

Please state briefly how these are incorporated in this module.

Good performance will be clarified using the 5 lab assignments, and feedback, both individually and as group discussion of good solutions, will be given on each assignment. The timetable for the assignments will encourage good time management. The assignments are timed to give a realistic opportunity to improve performance prior to the final project. Interaction and dialogue between students and teachers will be an integral part of the tutorial sessions and the project supervision. Peer learning will be an important component of the project stage, and students will have an opportunity to direct the project topic choice. Students will be invited to give feedback on the assessment methods and criteria via the staff-student committee. Mutual support and group working will be encouraged throughout, and in particular as part of the group project. The module will be delivered in a supportive, encouraging and motivational atmosphere. The experience of assessing this module will be fed back to other teachers via the process of module review.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

ASSESSMENT METHOD(S) INCLUDING PERCENTAGE BREAKDOWN AND DURATION OF EXAMS

To Pass the module, students need to gain a summative mark of;					**50%**	
Examination	**Duration**	0	**Weighting %**	0	**Learning Outcomes**	N/A
Coursework	**Number**	4	**Weighting %**	30	**Learning Outcomes**	LO1, LO2, LO3
Project	**Number**	1	**Weighting %**	70	**Learning Outcomes**	LO1, LO4

COURSEWORK / SUBMISSIONS DEADLINES: Lab challenges are due ends of week 1 (does not count towards final mark), week 4, week 6 and week 9 of the 1st semester, and week 1 of the second semester. Project must be demonstrated in week 12 of the second semester and documentation must be completed by the end of that week.

RESIT ASSESSMENT PROCEDURES: New Assignment

ADDITIONAL INFORMATION RELEVANT TO COURSE DELIVERY AND ASSESSMENT

Project is group based (groups of 3 or 4 students). 70% of the overall mark for the course comes from the project, 20% from the 4 assignments (5% each), and 10% from the student's log book for assignments and project.

RECOMMENDED READING

‘Embedded Microprocessor Systems Real World Design’ (3rd edition) Stuart Ball (Elseveir) 2002

‘Embedded Microcomputer Systems, International Edition’ Jonathan Valvano (Cengage) 2012

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S1	**Week**	3	**Nature**	Initial challenge feedback
Semester	S1	**Week**	5	**Nature**	Assignment 1 feedback
Semester	S1	**Week**	7	**Nature**	Assignment 2 feedback
Semester	S1	**Week**	9	**Nature**	Assignment 3 feedback
Semester	S1	**Week**	11	**Nature**	Assignment 4 feedback
Semester		**Week**		**Nature**	
Further comments about feedback					

SIGNATURE (MODULE REGISTRAR):

DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE579	**Module Title:** Advanced Microcontroller Applications
Brief Description of Assessment	
Individual lab assessments (5 in total, 4 counting towards final mark), and group project building a stand alone embedded system with a time critical design	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			Semester 2	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**		
Week 2	Laboratory		**Week 2**		
Week 3		Labs - Marked	**Week 3**		
Week 4	Laboratory		**Week 4**		
Week 5		Labs - Marked	**Week 5**		
Week 6	Laboratory		**Week 6**		
Week 7		Labs - Marked	**Week 7**		
Week 8	Laboratory		**Week 8**		
Week 9		Labs - Marked	**Week 9**		
Week 10	Laboratory		**Week 10**		
Week 11	Assignment Start	Labs - Marked	**Week 11**		
Exam Period			**Revision Week**		
Review Week			**Exam Period**	Assignment - Due	

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	0	**Total # to be attempted**	0	**Compulsory Questions**	1 Question	**Sections**	Single
The examination is	OPEN	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

The class is assessed by assignments and project - there is no written exam

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; Yes

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Assignments

C1. Assignment

C2. Assignment

LO2 Laboratory

C1. Lab 3

C2. Lab 3

LO3 Laboratory

C1. Lab 4

C2. Lab 4

LO4 Assignments

C1. Assignment

C2. Assignment

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE580 - DSP & FPGA BASED EMBEDDED SYSTEM DESIGN

Module Code: EE580		**Module Title:** DSP & FPGA Based Embedded System Design	
Module Registrar: Dr. L. Crockett			
Other Lecturers Involved: Dr. G. Di Caterina		**Credit Weighting** 20	**Semester:** 1 2
Compulsory/optional/elective class: O		**Academic Level:** 5	

Pre-requisites: EE469 - Digital Signal Processing, or equivalent, AND prior experience in C programming

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
22	11	40	44	83	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

Design and implementation of real time embedded systems through famiarisation with Digital Signal Processors (DSPs), Field Programmable Gate Arrays (FPGAs) and System on Chip (SoC) devices via lectures, up-to-date technical discussions and hardware programming. This course provides hands-on experience in translating Digital Signal Processing concepts into real-time embedded systems applications. .

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Demonstrate knowledge and experience of working with embedded devices, in particular DSP processors, FPGAs, and SoCs, and associated design flows.

LO 2: Translate DSP algorithms into real-time implementations capable of running on one or more of the above devices.

LO 3: Understand issues of arithmetic pertaining to DSP systems implementation, and be able to analyse and appropriately specify wordlengths.

LO 4: Solve design problems by appropriately specifying, implementing and testing / debugging DSP subsystems,

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

TOPIC 1: ALGORITHMS AND ARCHITECTURES FOR EMBEDDED SYSTEMS

Numerical representation for embedded systems, fixed point and floating point formats, cyclic buffering, computationally efficient algorithms for convolution and correlation using sectioning and overlap add and overlap save methods, computationally efficient implementation of the DFT using the FFT, Realisation and finite wordlength effects in digital filters; analog I/O interface for real time embedded systems, ADC, sampling lowpass and bandpass signals, uniform and non-uniform quantisation and encoding, oversampling in ADC conversion, DAC; constrains of real time signal processing with analog input/output signals; Overview of computer architectures for embedded systems, multicore DSP enabled embedded systems, FPGA embedded systems

TOPIC 2: DSP ENABLED EMBEDDED SYSTEM DESIGN

Texas Instruments Code Composer Studio and Matlab. TMS320C6x architecture and OMAP-L138 eXperimenter Board, with TMS320C6748 processor. Through the use of the DSP-enabled OMAP-L138 board, demonstrate and design audio processing algorithms that run in real-time on hardware. Students will be able to appreciate how to master signal processing algorithms design in CCS, code optimisation and real-time debugging on CCS and fixed-point implementation and associated issues of overflow.

TOPIC 3: FPGA BASED EMBEDDED SYSTEM DESIGN

FPGA and System on Chip (SoC) Architecture Review, FPGA Design Considerations and Case Study, Fixed Point Arithmetic on FPGAs, The CORDIC Algorithm and Architecture, Pipelining and Retiming Techniques, FIR Filter Architectures, Multirate Filtering, CIC Filters, and Digital Up/Down Conversion, Fast Fourier Transform Implementation, Numerically Controlled Oscillators, Communications System Design, Adaptive DSP Algorithms and Architectures, System on Chip Architectures and Design.

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Be able to describe the architectures of DSP, FPGA and SoC devices;

C 2: Demonstrate proficiency in using software tools and development environments for embedded system design;

C 3: Demonstrate understanding of design flows specific to embedded DSP development.

C 4: To implement complete embedded system designs;

C 5: Demonstrate understanding via reports and real-time demos with suitable test data and presentation;

C 6: Demonstrate a wider appreciation of the technology landscape and industry trends.

LO2

C 1: Demonstrate understanding of DSP algorithms and computational requirements;

C 2: Represent DSP implementation algorithms both mathematically and in signal flow graph format;

C 3: Show an appreciation of design considerations and trade-offs, e.g. computation, parallelism, optimisations;

C 4: Employ suitable methods of verifying correct operation.

LO3

C 1: Describe number formats used in DSP and FPGA / SoC devices;

C 2: Understand fixed point effects and wordlength growth, and appropriately specify wordlengths within a fixed point design;

C 3: Appreciate the numerical and hardware implications of truncation / rounding and overflow / saturation;

C 4: Make a comparison between floating point and fixed point formats in terms of dynamic range, precision, and support on embedded devices

LO4

C 1: Demonstrate the ability to specify and design embedded DSP components to meet design requirements;

C 2: Show an appreciation of practical design considerations, including timing issues and efficiency;

C 3: Demonstrate an understanding of system interfacing issues;

C 4: Logbook record keeping of algorithmic design, coded solutions, debugging steps and testing schemes;

C 5: Demonstrate an appreciation of System on Chip design.

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 Principles of Assessment Feedback

Please state briefly how these are incorporated in this module.

Help clarify what good performance is by providing worked solutions (from staff and/or peers) to selected tutorials and assignments.

Continuous assessment (summative, peer- and self) feedback throughout the course to encourage reflection and improvement.

Continuous log-book formative assessment, where students are encouraged to reflect on their strengths and weaknesses, and plan how to improve their work for future labs.

Constructive feedback on submissions, e.g. design files and reports.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

Assessment Method(s) Including Percentage Breakdown and Duration of Exams

To Pass the module, students need to gain a summative mark of;					**50%**	
Examination	**Duration**	2	**Weighting %**	50	**Learning Outcomes**	ALL
Coursework	**Number**	2	**Weighting %**	20	**Learning Outcomes**	ALL
Project	**Number**	2	**Weighting %**	30	**Learning Outcomes**	ALL

Coursework / Submissions deadlines: Major elements below (there will also be some small lab-based assessments worth 1 or 2% each).

S1 - week 7 (assignment) and S1 - end (design project);

S2 - week 5 (assignment), week 7 (class test) and S2 - end (design project).

Resit Assessment Procedures: Examination

Additional Information relevant to Course Delivery and assessment

Students will undertake an individual design project for the FPGA part of the class, which will be assessed based on their design, report, and demonstration. There will also be a contribution from (i) lab-based assessment and (ii) investigation into current/future technology landscape and applications.

Students will keep a detailed logbook from their laboratories. Students need complete an individual Assignment and three lab-based tasks for the DSP part. Students will be allocated a DSP enabled embedded design to implement during the module. The group will develop a DSP enabled embedded solution to satisfy a design brief, evaluated by a demonstration and a report in Week 11, S2.

Recommended Reading

"Digital Signal Processing: A Practical Approach 2nd Ed' Emmanuel C. Ifeachor and Barrie W. Jervis, ISBN 0 20159619 9

"Digital Signal Processors: Architectures, Implementations and Applications' Sen M Kuo and Woon-Seng Gan, ISBN 0-13-035214-4

"Digital Signal Processing and Applications with the OMAP- L138 eXperimenter", by Donald Reay, March 2011, Wiley Publishing, ISBN: 978-0-470-93686-3.

Relevant DSP and FPGA embedded design material from Texas Instruments Ltd (www.ti.com) and Xilinx, Inc.

(www.xilinx.com)

Xilinx Xcell Journal (online - see www.xilinx.com)

"The Zynq Book" and "The Zynq Book Tutorials for Zybo and ZedBoard" - both available as a free PDF download

from www.zynqbook.com.

Please note: The above are for extended reading but there are no compulsory purchases

ADDITIONAL STUDENT FEEDBACK; SPECIFY DETAILS OF WHEN ADDITIONAL FEEDBACK WILL BE PROVIDED.

Semester	S1	**Week**	9	**Nature**	Feedback on technology landscape task
Semester	S2	**Week**	2	**Nature**	Feedback on S1 design project
Semester	S2	**Week**	7	**Nature**	Feedback on S2 assignment
Semester	S2	**Week**	9	**Nature**	Feedback on S2 class test
Semester	S2	**Week**	12	**Nature**	Feedback on S2 design project
Semester		**Week**		**Nature**	
Further comments about feedback					

SIGNATURE (MODULE REGISTRAR):

DATE OF LAST MODIFICATIONS: 07/03/2019

MODULE TIMETABLE

Module Code: EE580	**Module Title:** DSP & FPGA Based Embedded System Design
Brief Description of Assessment	
FPGAs: 5% assignment (investigation), 5% small practicals, 15% design project. **DSPs: 4% assignment, 6% class test, 3% labs, 12% design project.** **50% Exam (equal weighting across FPGAs and DSPs).**	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			**Semester 2**	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**		
Week 2			**Week 2**		Assignment Marked
Week 3	Assignment Start		**Week 3**		
Week 4			**Week 4**		
Week 5			**Week 5**	Assignment - Due	
Week 6			**Week 6**		
Week 7	Assignment - Due		**Week 7**	Test	Assignment Marked
Week 8	Assignment Start		**Week 8**		
Week 9		Assignment Marked	**Week 9**		Test - Marked
Week 10			**Week 10**		
Week 11			**Week 11**	Assignment - Due	
Exam Period			**Revision Week**		Assignment Marked
Review Week	Assignment - Due		**Exam Period**		

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	5	**Total # to be attempted**	3	**Compulsory Questions**	1 Question	**Sections**	Multiple
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

There will be three sections in the exam:
A - 1 compulsory question
B - 2 questions on DSP topics
C - 2 questions on FPGA topics

Students will be required to answer 1 question from each section.
This rubric ensures an even spread of content over both parts of the class. The compulsory question will test key knowledge from both areas.

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; Yes

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Final Examination

C1. Exam

C2. Labs, assignments and projects

C3. Labs, assignments, projects and exam

C4. Labs and projects

C5. Assignments and projects

C6. Assignments and exams

LO2 Other *Combination of labs and assignments / design projects*

C1. Assignments and exam

C2. Assignments and exam

C3. Assignments, projects and exam

C4. Labs, assignments, and projects

LO3 Final Examination

C1. Exam

C2. Exam, labs, assignments, projects

C3. Exam, labs, assignments

C4. Exam

LO4 Other *Combination of labs and assignments / design projects*

C1. Assignments and projects

C2. Exam, labs, assignments and projects

C3. Projects

C4. Labs

C5. Exam, assignments.

FACULTY OF ENGINEERING

MODULE DESCRIPTION FORM

EE581 - IMAGE AND VIDEO PROCESSING

Module Code:	**EE581**	**Module Title:**	**Image and Video Processing**
Module Registrar:	**Dr V Stankovic/Dr J Ren**		
Other Lecturers Involved:	**Prof S Marshall**	**Credit Weighting** **20**	**Semester:** **1 2**
Compulsory/optional/elective class:	**O**	**Academic Level:**	**5**

Pre-requisites: EE469 Digital Signal Processing

MODULE FORMAT AND DELIVERY (HOURS):

Lectures	Tutorial	Assignments	Laboratories	Private Study	Total
33	22	22	20	103	200

EDUCATIONAL AIM *THIS MODULE AIMS TO:*

To provide an introduction to the techniques relevant to digital images and video.

This includes techniques both to process images and video and also to efficiently compress and communicate them.

The module will give the students a comprehensive understanding of various image and video processing and coding standards. The students will also study some key applications of these standards

LEARNING OUTCOMES *ON COMPLETION OF THE MODULE, THE STUDENT IS EXPECTED TO BE ABLE TO;*

LO 1: Understand components which make up a typical digital imaging system. Be able to understand and use different image and video representation methods. Analyse the problems and techniques encountered in processing and coding of digital images and videos.

LO 2: Understand the spectrum of coding standards for digital image and video with technical appreciation of some of the key compression methods used within the standards

LO 3: Appreciate the problems and techniques related to image/video communications over wireless networks

LO 4: Acquire experience of investigating an image/video processing topic within a group and reporting findings in the form of technical report and presentation

(UK SPEC suggests no more than 4 learning outcomes per module. Statements must be broad and be syllabus free and link in with the intended learning outcomes on the programme specifications.)

SYLLABUS *THE MODULE WILL TEACH THE FOLLOWING:*

Image capture and display, sampling, lighting, human visual system.

Enhancement techniques, filtering, smoothing and noise reduction.

Principles of image coding, image coding formats and standards.

Weighted filter design.

Shape coding techniques: Hough transform, Introduction to non-linear methods.

Image restoration techniques: Optimum filter design, comparison with non optimum filters, implementation in mathematical morphology and logical hardware.

The principles of feature extraction, image classification/recognition and design of such a system in real applications.

DPCM, transforms: the Discrete Cosine and Wavelet Transforms. Lossless Coding

Coding standards JPEG, JPEG2000, H264, MPEG, with particular emphasis on motion estimation and motion compensation schemes

Applications to Video Teleconferencing and Video Broadcasting.

Sources and characteristics of errors in video coding applications.

Error resilience and concealment

Problems associated with mobile video transmission and methods that may be used for combating these

ASSESSMENT OF LEARNING OUTCOMES - CRITERIA

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

[Note: Criteria break the LO down into 'teachable' elements but do not become syllabus orientated i.e. no mention of CAD package names, components etc.]

LO1

C 1: Demonstrate understanding of the main concepts of image processing.

C 2: Describe the main image enhancement methods

C 3: Demonstrate the ability to apply image processing tools in practice

C 4: Describe concepts and applications of image registration

C 5: Understand the workflow of and techniques related to image classification/recognition.

LO2

C 1: Critically analyse main image/video coding standards

C 2: Demonstrate knowledge of quantization and basics of rate-distortion theory

C 3: Describe applications of the DCT and demonstrate the ability to calculate DCT of image signals

C 4: Demonstrate ability to assess image/video quality using objective and subjective quality measures

C 5: Complete short biweekly MATLAB tasks to demonstrate concepts in L02.

LO3

C 1: Describe the main techiques used to protect image content when transmitted over packet loss networks

C 2: Describe the main principles of error resilient coding and error concealment .

C 3: Get familiar with H.264 AVC standard and software tools

LO4

C 1: Demonstrate the ability to find relevant information, process it, and present it in the coherent form

C 2: Show ability to work in a group.

C 3: Demonstrate the ability to present the findings in the form of presentation

C 4: Demonstarte the ability to discuss critically latest developments in image processing/communication field

C 5: Evaluate latest image coding standards

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

12 Principles of Assessment Feedback

Please state briefly how these are incorporated in this module.

The regular feedback can help to clarify what is good performance. They also help to close the gap between current and desired performance. All the tasks leading to learning outcomes encourage time and effort on challenging tasks. For example, L04 involves a degree of choice in the selection of topic. Also this choice reveals new concepts which can be used to shape teaching as specified in the principles.

(on Learning & Teaching web pages: *www.strath.ac.uk/learnteach/teaching/staff/assessfeedback/12principles/*)

Assessment Method(s) Including Percentage Breakdown and Duration of Exams

To Pass the module, students need to gain a summative mark of;					**40%**	
Examination	**Duration**	2	**Weighting %**	60	**Learning Outcomes**	LO1-LO4
Coursework	**Number**	2	**Weighting %**	20	**Learning Outcomes**	LO1-LO4
Project	**Number**	1	**Weighting %**	20	**Learning Outcomes**	LO4

Coursework / Submissions deadlines: Bi-weekly lab assignments, project interim report submission at the end of Semster 1, project report submission and presentations at the end of Semster 2.

Resit Assessment Procedures: Examination

Additional Information relevant to Course Delivery and assessment

Recommended Reading

Gonzalez and Woods, Digital Image Processing

Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2011

Scott E Umbaugh, Digital Image Processing and Analysis: Human and Computer Vision Applications with CVIPtools, Second Edition, CRC Press, Nov. 2010

Also Cvonline http://homepages.inf.ed.ac.uk/rbf/CVonline/

Additional Student Feedback; Specify details of when additional feedback will be provided.

Semester	S1	**Week**	6	**Nature**	Lab assignment feedback
Semester	S1	**Week**	8	**Nature**	Lab assignment feedback
Semester	S1	**Week**	12	**Nature**	Project progress feedback
Semester	S2	**Week**	5	**Nature**	Lab assignment feedback
Semester	S2	**Week**	11	**Nature**	Project presentation feedback
Semester		**Week**		**Nature**	
Further comments about feedback		Lab assignment feedback in Semester 1 Weeks 7, 9, and Semester 2 Weeks 5 and 7. Project feedback at the end of Semsters 1 and 2			

Signature (Module Registrar):

Date of Last Modifications: 07/03/2019

MODULE TIMETABLE

Module Code: EE581	**Module Title:** Image and Video Processing
Brief Description of Assessment	
Coursework (40%): Four 1-hour labs on image/video compression; one 3-hour lab on image transforms; group project assessed at the end of Semster 1 (interim report) + at the end of Semster 2 (presentations + report). Examamination in May diet (60%)	

On the table below indicate for each semester, the assessment activities experienced by a student taking this module ; start and due dates of assignment/project, lab sessions, quizzes, tests and examinations. Also indicate, under staff actions, the dates on which the assessments will be marked and feedback returned to students

	Semester 1			**Semester 2**	
	Student Action	**Staff Actions**		**Student Action**	**Staff Actions**
Week 1			**Week 1**		
Week 2			**Week 2**		
Week 3	Laboratory	Feedback Provided	**Week 3**	Laboratory	Feedback Provided
Week 4			**Week 4**		
Week 5	Laboratory	Feedback Provided	**Week 5**		
Week 6	Laboratory	Feedback Provided	**Week 6**		
Week 7			**Week 7**	Laboratory	Feedback Provided
Week 8			**Week 8**		Labs - Marked
Week 9	Laboratory	Feedback Provided	**Week 9**		
Week 10		Labs - Marked	**Week 10**		
Week 11	Project	Feedback Provided	**Week 11**	Presentation	Feedback Provided
Exam Period			**Revision Week**		
Review Week			**Exam Period**		

EXAMINATION & FINAL ASSESSMENT DETAILS

Provide details of the examination rubric used. For guidance, typically a 2-hour duration examination will require students to attempt THREE questions each representing effort approximately equivalent to 40 minutes duration while a 3-hour duration examination will require students to attempt FOUR questions of 40 minutes duration. Examination papers may be sectionalised and consist of a combination of mandatory and optional questions with the degree of choice being set by the examiner and appropriate to the Learning Objectives of the module.

Total # of questions set	5	**Total # to be attempted**	3	**Compulsory Questions**	None - free choice	**Sections**	Multiple
The examination is	CLOSED	**Book.**					

Provide a brief text description of the examination rubric adopted and explanation/justification for its use.

The examination consists of 5 questions of which the students must attempt 3. There are no compulsory questions. The assessment of the LO listed above are addressed at some level within the 3 components of "open-book" course work (assignment, Labs and project).The examination questions built upon this previous work and addresses fundemental issues of understand, design and problem solving rather than simple recall of material.

Mathematical Formula; Indicate if standard (for the module) equations or mathematical identities are provided; Yes

Please comment upon the degree to which students are required to recall, prove and use detailed specific mathematical formula within the examination.

The students are required to recall some basic mathemtical forumula. They are required to know to derive the formula for Marr Hildreth (LOG) Operator.

LEARNING OUTCOMES - CRITERIA

*For all of the LO listed previously indicate explicitly the **prime** mode of assessment. For each Criteria, indicate the mode(s) of assessments, adding any appropriate clarification.*

LO1 Final Examination *Supported by biweekly assignments and lab*

C1. Final Examination and CA

C2. Final Examination and CA

C3. Final Examination and CA

C4. Final Examination and CA

C5. Final Examination and CA

LO2 Final Examination *Supported by biweekly assignments and lab*

C1. Final Examination and CA

C2. Final Examination and CA

C3. Final Examination and CA and Lab

C4. Final Examination and CA

C5. Final Examination and CA

LO3 Final Examination *Supported by biweekly assignments*

C1. Final Examination and CA

C2. Final Examination and CA

C3. Final Examination and CA

LO4 Final Examination *Final project and presentation*

C1. Coursework/Project

C2. Coursework/Project

C3. Cousework/Project

C4. Final Examination and Project

C5. Final Examination and project

Management Science

Project Management

Academic Year 2013-14

MS418

Credit value: 20

- **Standard/level: 4**
- **Core/optional: Optional**
- **Semester: 1**
- **Pre-requisites: None**

Lecturers:
Jillian MacBryde Class Co-ordinator): jillian.macbryde@strath.ac.uk
Peter Flett: peter.flett@strath.ac.uk

1. Rationale (including Peer/External comment)

Project management and project based organisations are becoming increasingly common in industry, therefore this class assumes that every management student requires some knowledge of the tools and techniques used to manage projects within organisations. The class aims to provide the student with these. It will introduce the student with no project management background to: 1) the concept of the project lifecycle 2) project management as a strategic tool and 3) the methodologies and tools that enable efficient project execution.

2. Class Description

The class will familiarise the student with the basic concepts associated with project management. It is designed around seven main areas:

- Project Management Basics
- Setting Objectives and Defining Project Deliverables
- Work Breakdown, Structures and Milestones
- Project Planning
- Project Finance
- Risk Management
- Project Strategies

These areas will provide the student with a general understanding of project management that will complement their studies in other areas of the course, such as management finance and strategy, where the execution of company strategy may require the use of project management techniques.

3. Class Aims

- To provide the student with an understanding of the organisation as a set of projects
- To introduce the student to the activities of the project manager
- To equip the student with the basic methods used in project management
- To provide the student with an appreciation of the project environment.

4. Learning Outcomes

a. Subject specific knowledge and skills

- The basic process of project management
- The role and activities of the project manager
- A range of methods and tools used in project management
- The organisational contexts in which project management is useful
- Current debates in the field of Project Management
- Ongoing developments in theory in the field of Project Management

b. Cognitive abilities and non-subject specific skills

- Communicate effectively using the vocabulary of project management
- Work effectively in project teams
- Demonstrate presentation and management reporting skills
- Manage their time and work to deadlines
- Apply the practice of project management in a variety of contexts

5. Teaching and Learning Methods

The class will comprise classes that include a mixture of lectures, supervised class work, and assessed student presentations.
In the supervised class work, students will initially practice applying those concepts presented in lectures so that they can gain a basic understanding. In this process, learning of the concepts will be enhanced by the students examining texts on the subjects under study, both in groups and in private study, and presenting to the rest of group the essence, relevance and usefulness of those texts that they are examining.

6. Reading List

- Maylor, H (2003) Project Management, Prentice Hall.
- Schmidt, T (2009) Strategic Project Management, Wiley.

7. Indicative Structure

- **Project Management Basics**
  - Defining performance
  - The project environment
  - The project manager
- **Setting Objectives and Defining Project Deliverables**
  - Defining deliverables
  - Setting objectives
  - Project Lifecycle
- **Work Breakdown Structures and Milestones**
  - Work Breakdown Structure
  - Cost Breakdown Structure
  - Resource Breakdown Structure
- **Project Planning**
  - Defining sequences of activities
  - Using Gant Charts
  - Critical path
- **Project Finance**
  - Budgeting
  - Estimating cost
  - Controlling cost
- **Project Risk Management**
  - What is risk
  - Risk mitigation
  - Contingency funding
- **Project Strategies**
  - Aligning Projects with strategic intent
  - Linking project and operational strategy
  - Project Management as a strategic tool

8. Resources (staff/library/computing/a-v/accommodation)

The University has a fully stocked Library with access to an extensive range of books and journals on Business and Management. The current titles will be restocked in line with the requirements of this class from the departmental book note if required. The current serial provision is adequate. CIT facilities also exist within the library to allow web access to electronic journals.

9. Assessment including Reassessment

The assessment for this Project Management class comprises:
One group assignment comprising 50% of the final mark
One exam comprising 50% of the final mark

10. Matrix of Learning Outcomes/Assessment

subject specific knowledge and skills	teaching/learning method	evidence of outcome
The basic process of Project Management	l, dr, ir, rp	e, cw, gp
The role and activities of the Project manager	l, dr, ir, rp	e, cw, gp
A range of methods and tools used in project management	l, dr, ir, rp	e, cw, gp
The organisational contexts in which project management is useful	l, dr, ir, rp	e, cw, gp
Current debates in the filed of project management	l, dr, ir, rp	e, cw, gp
Ongoing developments in theory in the filed of Project Management	l, dr, ir, rp	e, cw, gp
Cognitive Abilities and Non-Subject Specific Skills		
Communicate effectively using the vocabulary of project management	cd, cw, gp	cd, cw, gp,
Work effectively in project teams	cd, cw, gp	cd, cw, gp,
Demonstrate presentation and management reporting skills	gp, cd, cw	gp, cd, cw
Manage their time and work to deadlines	gp, cd, cw	gp, cd, cw
Apply the practice of project management in a variety of contexts	gp, cd, cw	gp, cd, cw

l – lecture, c – computer lab session, dr – directed reading, ir – independent reading, rp- research papers, ep – empirical project, gp- group presentation, e – exam, cd – class discussion, cw – course work, f – feedback

8. Indicative Hours

Activity	Hours
Formal teaching sessions	24
Private study, reflection, class prep, etc	100
Independent Group work	36
Personal programme planning	2
Counseling/ mentoring	8
Assessment – preparation and execution	30
Total	**200**