SUBJECT DESCRIPTION FORMS

Subjects offered by the

Department of Electrical Engineering

Subjects Code	**Subject Title**
EE501	Alternative Energy Technologies
EE502	Modern Protection Methods
EE505	Power System Control and Operation
EE509	High Voltage Engineering
EE510	Electrical Traction Engineering
EE512	Electric Vehicles
EE514	Real Time Computing
EE517	Fibre Optic Components
EE520	Intelligent Motion Systems
EE521	Industrial Power Electronics
EE522	Optical Fibre Systems
EE524	Open Electricity Market Operation
EE525	Energy Policy and Restructuring of Electricity Supply Industry
EE526	Power System Analysis and Dynamics
EE527	Auto-tuning for Industrial Processes
EE528	System Modelling and Optimal Control
EE529	Power Electronics for Utility Applications
EE530	Electrical Energy-saving Systems
EE533	Railway Power Supply Systems
EE535	Maintenance and Reliability Engineering
EE536	Signalling and Train Control Systems
EE537	Railway Vehicles
EE539	Aerospace Power Electronics and Actuation Systems
EE545	Modern Generation and Grid Integration Technologies
EE550	Enterprise Risk and Asset Management
EE560	Metros in Hong Kong and China
EE570	Design and Analysis of Smart Grids
EE5381	System Assurance and Safety in Railways

Subject Description Form

Subject Code	EE501
Subject Title	Alternative Energy Technologies
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Exclusion: EE545
Objectives	1. To enable students to establish a broad concept on alternative energy techniques in engineering. 2. To provide an in-depth knowledge on selected topics of alternative energy systems in engineering. 3. To enable students to understand typical alternative energy technologies, its associated issues of application and related technical considerations. 4. To enable students to understand the potential of alternative energy and characteristics & performance of various types of alternative energy systems. 5. To enable students to understand various techniques and systems for control and monitoring of alternative energy technologies, as well as the related communication protocol and interfacing requirements.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Describe the operation principle & control strategy of various alternative energy systems and topologies of these systems. b. Identify benefits & impacts of the applications of these alternative energy systems; such as their effects on environment and utility energy efficiencies. c. Describe the operation principle, characteristics and performance of various alternative energy devices/systems. d. Identify different alternative energy technologies for industrial & commercial plants and multi-storey buildings, including giving examples. e. Able to carry out literature search and report the findings in a presentation, when given a technical topic.
Subject Synopsis/ Indicative Syllabus	1. ***Energy resources and types***: Renewable and non-renewable energy resources. World potential and trends. Environmental effects. Alternative energy types and present developments. Role and importance of alternative energy. 2. ***Wind and solar energy***: Wind characteristics. Extraction characteristics. Windmill aerodynamics. Design and materials of windmills. Wind turbines. Types of wind turbines and connection. Siting and designs. Wind farms. Case study. On-shore and off-shore wind farms. Solar characteristics. Solar cells and solar thermal power. Photovoltaic conversion systems. Case study. Design and monitoring techniques. New developments. 3. ***Wave and tidal energy***: Wave and tide characteristics for energy extraction. Tidal schemes. Tidal sites. Single and multiple basin schemes. Case study. Wave energy schemes. Case study. Ocean energy conversion. 4. ***Geothermal energy and fuel cells***: Geothermal energy sources and methods. Characteristics. Hot dry rock technology. Case study. Fuel cells types and principles. Biomass energy types and case study. Future potentials. 5. ***Co-generation and combine-cycle plants***: New technologies for co-generation and CCGT. Efficiency and environmental benefits. Case study examples. Future development potentials. 6. ***Better utilization of energy resources***: Pollution reduction techniques and emission trading mechanisms and practices around the world. Clean coal technologies. Nuclear power. Environmental impacts of better utilization of energy.

Teaching/Learning Methodology	<u>Lectures and tutorials are effective teaching methods:</u> 1. To provide an overview or outline of the subject contents. 2. To introduce new concepts and knowledge to the students. 3. To explain difficult ideas and concepts of the subject. 4. To allow students to feedback on aspects related to their learning. <u>Mini-project works/Assignments are essential ingredients of this subject:</u> 1. To supplement the lecturing materials. 2. To add real experience for the students. 3. To provide deeper understanding of the subject. 4. To enable students to organise principles and challenge ideas. Seminars from industrial experts may also be arranged, this will give student up-to-date status of the development in alternative energy area, as well as market trends.

Teaching/Learning Methodology	Outcomes				
	a	b	c	d	e
Lectures	√	√	√		
Tutorials	√	√	√		
Mini-project/Assignments/Presentations				√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed				
		a	b	c	d	e
1. Class tests	18%	√	√	√		
2. Mini-project/Assignments/ Presentations	18%				√	√
3. Examination	64%	√	√	√	√	
Total	100%					

The understanding on theoretical principle and practical considerations, analytical skills and problem solving technique will be evaluated. Examination, class tests, assignments, presentations and mini-project report are an integrated approach to validly assess students' performance with respect to the intended subject learning outcomes.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	33 Hrs.
▪ Seminar/Case studies	6 Hrs.
Other student study effort:	
▪ Mini-project/Assignments	22 Hrs.
▪ Self-study	44 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Reference books:
1. *Wind power in power systems. Wiley, Thomas Ackerman*
2. Andy McCrea, Renewable Energy, Crowood Press 2013
3. L.L. Freris, Wind Energy Conversion Systems, Prentice Hall
4. Vaughn Nelson Kenneth Starcher, Introduction to Renewable Energy, CRC Press, 2016
5. W. Avery and C. Wu, Renewable Energy from the Ocean, A Guide to OTEC, Oxford University Press, 1994
6. CDM Consultancy Stage 1 Report, Study on the Potential Applications of Renewable Energy in Hong Kong, 2003 (from website of EMSD-EEO of HKSAR Government).
7. R. Messenger, Photovoltaic Systems Engineering, CRC Press, 2004
8. G.N. Tiwari, Solar Energy: Fundamental, Design, Modelling and Applications, CRC Press 2002
9. **Biofuels for Transport: An International Perspective,** International Energy Agency, 2004
10. **William E Glassley, Geothermal Energy: Renewable Energy and the Environment, CRC Press, 2010**
11. M. Stiebler, Wind Energy Systems for Electric Power Generation, Springer 2008
12. J. Cruz, Ocean Wave Energy: Current Status and Future Perspectives, Springer-Verlag 2008

Subject Description Form

Subject Code	EE502
Subject Title	Modern Protection Methods
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Student should have some prior knowledge in Power Transmission and Distribution
Objectives	1. To introduce the concept of modern power system protection to students. 2. To integrate theory and practical knowledge of power system protection. 3. To understand the design philosophy and working principle of power system protection. 4. To master the analytical techniques. 5. To apply protective relaying in power systems.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Master the concept and philosophy on power system protection. b. Apply and adapt applications of mathematics, engineering skills in the analysis, comparison, interpretation of various protection schemes in power systems. c. Integrate and justify techniques to be used in the planning and operation of power system protection. d. Solve technical problems for power system protection. e. Present technical results in the form of a technical report.
Subject Synopsis/ Indicative Syllabus	1. ***Overview of protection system and its development*****:** General considerations. Components of protection. Structure of protective relays. Unit protection and non-unit protection. Trend of protection development. 2. ***Fault and transient in power systems*****:** Fault transient behaviour in power systems. Computer simulations of the transient behaviour in power systems. 3. ***Current and voltage transducers*****:** Sources of errors. Requirements of transducers for measurement and protection. Their features and characteristics under steady state and transient conditions. 4. ***Protection systems for distribution networks*****:** Protection criteria for distribution systems. Features of directional and non-directional protection schemes for distribution systems. 5. ***Protection systems for transmission networks*****:** Distance protection system and characteristics. Differential line protection. Phase comparison line protection. Use of line carrier and communication for protection systems. 6. ***Busbar, transformer and generator protection systems*****:** High impedance and low impedance differential protection schemes. Protection schemes for busbar, transformer, and generator. 7. ***Digital protection relaying technique*****:** Features of digital protection relay. Digital relay architecture. Digital relaying algorithms. Adaptive and intelligent relays. Recent development.

Teaching/Learning Methodology	Lectures and tutorials are the primary means of conveying the basic concepts and theories. Knowledge on system analysis, design and practical applications are given through case studies, in which students are expected to integrate and justify modern techniques to be used in the planning and operation of power system protection with critical and analytical thinking. Mini-projects and experiments are designed to supplement the lecturing materials so that students are encouraged to take extra readings and to look for relevant information.

Teaching/Learning Methodology	Outcomes				
	a	b	c	d	e
Lectures	√	√		√	
Tutorials	√	√		√	
Mini-projects and experiments		√	√		√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed				
		a	b	c	d	e
1. Examination	60%	√	√	√	√	
2. Class Tests	18%	√	√	√	√	
3. Mini-project and report	12%		√	√		√
4. Laboratory and report	10%		√	√		√
Total	100%					

The examination and tests assess the technical competence of students in power system protection analysis methods and methods of protection design, planning, and operation. Mini-projects, experiments and written reports assess those on analytical skills, problem-solving techniques and practical considerations of protection design, as well as technical reporting.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	33 Hrs.
▪ Laboratory	6 Hrs.
Other student study effort:	
▪ Laboratory preparation/report	12 Hrs.
▪ Mini-projects/Self-study	54 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Reference books:
1. L. Hewitson, M. Brown and R. Balakrishnan, Practical Power System Protection, Newnes, 2005
2. Network Protection and Automation Guide, Alstom Grid, 2011
3. S.H. Horowitz and A.G. Phadke, Power System Relaying, Wiley, 2014
4. J.L. Blackburn and J. Domin, Protective Relaying: Principles and Applications, CRC Press, 2014
5. A.T. Johns and S.K. Salman, Digital Protection for Power Systems, IEE Power Series, 1995
6. Advancements in Microprocessor Based Protection and Communication – IEEE Tutorial Course, Publication No. 97TP120-0, 1997
7. Power System Protection, Vol. 1, 2, & 3, The Electricity Training Association, 1995

Subject Description Form

Subject Code	EE505
Subject Title	Power System Control and Operation
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To introduce the concept of modern power system control & operation to students; 2. To integrate theory and practical knowledge of power system control & operation; 3. To understand the working principle of power system control and operation; 4. To apply the theory in power system control & operation; and 5. To understand the industrial practice and tools used in power system control and operations
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Ability to analyse power system security control & operation; b. Ability to analyse interconnected power system interchange and economic operation. c. Ability to analyse power system computer control and applications; d. Understand the functionalities and able to use to appropriate level of competence of selected specialty software for power system control and operation purpose; e. To be aware of new technologies development trends and environmental impacts of modern power system control and operation techniques; and f. Ability to write technical reports and present the findings through individual effort as well as team work
Subject Synopsis/ Indicative Syllabus	1. ***Power system operational security and dispatch*****:** Power system security concepts. Contingency analysis. Static and dynamic security. States of operation. Prevention of blackouts. Power system state estimation concepts. Application of state estimation. 2. ***Unit commitment and economic dispatch*****:** Priority lists. Methodologies for large system economic dispatch and unit commitment. Programming methods. 3. ***Frequency and voltage control*****:** Frequency and voltage control concepts. Control loops and analysis. Automatic generation control (AGC) concepts, methodology and implementation. 4. ***Interconnected systems operation*****:** System interconnection merits and problems. Economic interchange and control. Multi-area operation. 5. ***Energy management and real-time control*****:** Energy management systems. Software systems. Computer hardware resources and configurations. Data management. Communication and distributed computing. Load forecasting. Contingency and security assessment. System restoration and emergency control concepts. **Case Study:** 1. Local system control centre arrangement. 2. Case study of past system blackout in overseas countries. 3. AGC and voltage control case studies. 4. Power system developments in HK and China as well as overseas countries. 5. Applications of computer technology in power system control and monitoring

Teaching/Learning Methodology	Lectures and tutorials are the primary means of conveying the basic concepts and theories. Experiences on real world cases and associated analysis are given through case studies, in which the students are expected to power system control and operation problems with real-life constraints and to attain pragmatic solutions with critical and analytical thinking. Guest lecture / industrial seminars will be given to provide hands-on experience and knowledge on this subject from industry practice. Mini-project is designed to supplement the lecturing materials so that the students are encouraged to take extra readings and practice specialty software tools for power system operation and control.

Teaching/Learning Methodology	Outcomes					
	a	b	c	d	e	f
Lectures	√	√	√	√		
Tutorials	√	√	√	√		
Report	√	√	√	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed					
		a	b	c	d	e	f
1. Exam	60%	√	√	√		√	
2. Class test	18%	√	√	√		√	
3. Mini-project & report	12%	√	√	√	√	√	√
4. Essay Assignment	10%	√				√	√
Total	100%						

The assessment methods include an examination, a class test, and written assignment in the form of mini-project report. The examination and class test assess the technical competence of students in power system analysis methods and methods of power system operation and control. The written reports assess the students' ability to apply the theories learned in class to practical project, and to communicate in written form.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	39 Hrs.
Other student study effort:	
▪ Mini-project preparation/report/Essay	22 Hrs.
▪ Self-study	54 Hrs.
Total student study effort	115 Hrs.

Reading List and References

Reference books:

1. W.D. Stevenson, Elements of Power System Analysis, McGraw Hill
2. Wood & Wollenberg, Power Generation, Operation and Control, J. Wiley.
3. Weedy and Cory, Electric Power Systems, 4^{th} Edition, Wiley
4. Grainger & Stevenson, Power System Analysis, McGraw Hill
5. H. Saadat, Power System Analysis, McGraw Hill
6. Antonio Gomez-Exposito, Antonio J. Conejo, and Claudio Canizares, Electric Energy Systems: Analysis and Operation, CRC Press, 2009

Subject Description Form

Subject Code	EE509
Subject Title	High Voltage Engineering
Credit Value	3
Level	5
Pre-requisite / Co-requisite / Exclusion	Nil
Collaboration Institute	HK Electric Institute
Objectives	To provide students with knowledge to understand the techniques of design and analysis pertaining to high voltage engineering, including causes and manner of insulation failure and problems encountered in practice.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Describe the insulation breakdown mechanisms so as to identify the failure phenomena of different insulation systems. b. Understand the principles and practices of high voltage equipment so as to get on to the pragmatic design and applications of high voltage equipment in industry.
Subject Synopsis / Indicative Syllabus	1. ***Introduction to Electrical Insulation*****:** Electric fields; Dielectric breakdown; Electrical insulating materials; Industrial applications of electrical insulating materials. 2. ***Breakdown of Gaseous Insulation*****:** Ionization processes; Townsend breakdown mechanism; Experimental determination of Townsend's ionization coefficients; Breakdown in electronegative gases; Streamer breakdown mechanism; Paschen's law; Corona discharges; Breakdown in non-uniform fields; Post-breakdown phenomena and applications; Vacuum insulation and breakdown. 3. ***Breakdown of Liquid Insulation*****:** Breakdown in pure liquids and commercial liquids; Purification and breakdown test; Power law for commercial liquids. 4. ***Breakdown of Solid Insulation*****:** Breakdown due to treeing, surface flashover, and surface tracking; Breakdown in composite insulation. 5. ***Partial Discharges & In-house Demonstration*****:** Classification of partial discharges by origin; Principle of partial discharge measurements; In-house demonstration of state-of-the-art measuring equipment. 6. ***High Voltage Equipment for Power System Networks*****:** Hierarchy of power system networks; Introduction to high voltage equipment and their general specifications. 7. ***Transmission Gas Insulated Switchgears*****:** Design and busbar topologies; Layout and internal construction; Environmental, health, and safety precautions in handling SF_6 gas; Type and routine tests; Inspection before installation; Commissioning test and precautions; Typical incidents around the world. 8. ***High Voltage Cables*****:** Basic high voltage cable technology; Dielectric properties; Types and constructions; Type, routine, and diagnostic tests; Health index; Water tree formation; Accessory design, operations, and maintenance considerations; Reliability reviews and failure analysis; Faulty joint dissections and lessons learnt. 9. ***Site Visit to HK Electric*****:** Site introduction; On-site demonstration of transmission gas insulated switchgears and relevant high voltage test equipment used in the electricity transmission industry.

Teaching / Learning Methodology

Lectures are the primary means of conveying the fundamental knowledge to understand the techniques of analysis and design pertaining to high voltage engineering. In-house Demonstration and Site Visit to HK Electric are aimed to provide real-life experience on the pragmatic design and applications of high voltage engineering in industry. Students are expected to solve design problems with real-life constraints and to attain pragmatic solutions with critical and analytical thinking.

Teaching/Learning Methodology	Outcomes	
	a	b
Lectures	✓	✓
In-house Demonstration	✓	
Site Visit to HK Electric		✓

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended learning outcomes to be assessed	
		a	b
1. Examination	60%	✓	✓
2. Continuous Assessment	40%	✓	✓
Assignments (Insulation breakdown)		✓	
Assignments (High voltage equipment)			✓
Log (In-house demonstration)		✓	
Log (Site visit)			✓
Total	100%		

The assessment methods include: Examination (60%) and Continuous Assessment (40%), both in alignment with intended learning outcomes 1 and 2. Examination (60%) is in form of a three-hour, closed-book, end-of-subject written examination. Continuous Assessment (40%) consists of assignments (32%) and logs (8%) which, in turn, are after-class exercises for lectures on Insulation Breakdown (16%) and High Voltage Equipment (16%) and records of practical learning for In-house Demonstration (4%) and Site Visit to HK Electric (4%), respectively.

Student Study Effort Expected

Class contact:	
▪ Lecture/In-house Demonstration/Site Visit to HK Electric	39 Hrs.
Other student study effort:	
▪ Assignments	16 Hrs.
▪ Self-study	50 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Textbooks:
NIL (Refer to Lecture Notes).

Reference books:

1. M. S. Naidu and V. Kamaraju, High-Voltage Engineering, 5th Edition, Tata McGraw-Hill, 2013.
2. F. A. M. Rizk and G. N. Trinh, High Voltage Engineering, 1st Edition, Routledge, 2017.
2. V. Y. Ushakov, Insulation of High-Voltage Equipment, Springer Verlag, 2004.
3. E. Kuffel, W. S. Zaengl and J. Kuffel, High Voltage Engineering: Fundamentals, 2nd Edition, TBS, 2000.
4. C. L. Wadhwa, High Voltage Engineering, 3rd Edition, New Age Science, 2010.
5. A. Ravindra and M. Wolfgang, High Voltage and Electrical Insulation Engineering, Wiley: IEEE Press, 2011.
6. F. H. Kreuger, Partial Discharge Detection in High-Voltage Equipment, Butterworth-Heinemann, 1990.
7. IET Digital Library, Lightning Protection, Edited by C. Vernon, Institution of Engineering and Technology, 2010.

Subject Description Form

Subject Code	EE510
Subject Title	Electrical Traction Engineering
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	
Objectives	1. To provide students with a comprehensive understanding of traction systems from an engineering viewpoint, with emphasis on the applications to railways. 2. To provide students with an appreciation of the current state-of-the-art design and applications of electric drives. 3. To enable students to understand the implications of design of traction systems for railway applications. 4. To introduce the quality indicators of railway operations and their relationships with the performance of traction drives and traction power supply systems. 5. To identify the necessary future technologies to improve the service quality in railway from the perspectives of traction drives and traction power supply systems.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Analyse the operation principles of the sub-systems in an electrified railway system with the state-of-the-art approaches and critically review their advantages and limitations with reference to operating railway lines. b. Identify the railway service quality parameters and evaluate the impact of the performance of the sub-systems to the overall system reliability, availability, safety and maintainability. c. Recognise the importance to engage in self-learning on latest technologies on railway systems at this advanced level of study.
Subject Synopsis/ Indicative Syllabus	1. ***General aspects of traction system*****:** Technical and design aspects of railway electrification. Train dynamics and speed-time characteristics. AC and DC railways, power supply systems and interference. Supply system requirements: performance under normal and emergency feeding conditions. Requirement of traction substations. Overhead and track level current collection systems. 2. ***Computer-aided design and operation of traction systems*****:** Elements of design and analysis of traction systems: cost/benefit analysis; computer simulation of AC/DC power converter drives and traction equipment; power-factor, maximum-demand and energy-efficient operation; computer simulation of train performance for optimum headway, schedule speed and energy consumption; use of expert systems for system control and train scheduling. Computer modeling of non-linear source and traction load. Power quality issues of single phase AC traction: imbalance, harmonics and voltage dip; impact to traction system and public. Corrective measures and filter design. 3. ***Traction drives*****:** Introduction of traction drives. Overview of the traction transmission systems. Tractive effort and power calculation. Overview of traction motors. Traction transformers. Single-phase drives; three-phase drives; chopper drives; inverter drives. Induction motor control for traction drives: VVVF control, PWM control and CVVF control. Principles of powering and regenerative braking; blended regenerative and rheostatic brake control. DC traction drives. 4. ***Maglev and linear drives*****:** Principle and limitations of electromagnetic techniques of suspension and levitation. Levitation using permanent magnets, superconducting magnets and eddy currents induced by mains frequency excitation. Suspension using controlled DC electromagnets. Operation of linear motors. Application of linear drives in high speed transit systems.

Case Study:

1. Traction drive systems
2. Feeding systems in AC traction
3. Signalling system installation
4. Load-flow analysis in traction power system

Teaching/Learning Methodology

Video clips together with computer animations are used to supplement conventional lectures. Case studies will be used extensively to highlight the practicality of the subject materials being covered. Practitioners are also invited to have experience sharing sessions with the class. A group project is to be carried out to demonstrate and integrate the knowledge learned.

Teaching/Learning Methodology	Outcomes		
	a	b	c
Lectures	√	√	
Tutorials		√	√
Project Work	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed		
		a	b	c
1. Mini-project (group project)	20%			√
2. Tests	20%	√	√	
3. Examination	60%	√	√	
Total	100%			

This is an advanced and yet introductory subject for students, particularly practicing engineers in the railway industry. The subject encompasses all the important elements in a typical railway and a number of case studies are used to supplement the analytical discussions. The outcomes are assessed through a mini-project (which aims to integrate the various aspects learnt), tests and written examinations.

Student Study Effort Expected

Class contact	
▪ Lecture/Tutorial	36 Hrs.
▪ Invited lecture	3 Hrs.
Other student study effort:	
▪ Assignment, mini-projects and self-studies	66 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Textbooks:

1. M.H. Rashid, Power Electronics: Circuits, Devices and Applications, 3rd Edition, Prentice Hall 2004
2. Managing railway operations & maintenance: best practices from KCRC / edited by Robin Hirsch; technical co-editors, Felix Schmid, Michael Hamlyn. A & N Harris; Birmingham: University of Birmingham Press, 2007

Reference books/journals:

1. J. Pachl, Railway Operation and Control. VTD Rail Publishing, Mountlake Terrace (USA) 2004.
2. Bonnett, Clifford F. Practical railway engineering, London: Imperial College Press, 2005.
3. Petros A. Ioannou, Intelligent Freight Transportation (Automation and Control Engineering), CRC Press, Taylor and Francis Group, 2008
4. Selected papers from IEE/IET Proceedings – Electric Power Applications

Subject Description Form

Subject Code	EE512
Subject Title	Electric Vehicles
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Exclusion: EE543
Objectives	1. To acquire a broad knowledge on modern electric vehicles (EVs). 2. To understand the development of EVs from technological, environmental, and societal perspectives.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Understand the importance of EVs for environment, energy sustainability and climate change. b. Understand various underpinning technologies for modern EVs, including electric motor drives, energy storage, batteries, charging methods, infrastructure and auxiliary systems. c. Explain the emerging technologies such as hybrid electric vehicles (HEVs), fuel cell electric vehicles (FEV) and energy storage methods.
Subject Synopsis/ Indicative Syllabus	1. ***Introduction to electric vehicles (EVs)***: Historical perspective. EV advantages and impacts. EV market and promotion: infrastructure needs, legislation and regulation, standardization. 2. ***Electric vehicle (EV) design options***: EV configurations: fixed vs. variable gearing, single- vs. multiple-motor drive, in-wheel drives. EV parameters, driving cycles and performance specifications. Choice of system voltage levels: electrical safety and protection. 3. ***Vehicle dynamics and motor drives***: Road load: Vehicle kinetics; Effect of velocity, Acceleration and grade. EV drivetrain and components. EV motor drive systems: DC drives, Induction motor drives, Permanent-magnet synchronous motor drives, Switched reluctance motor drives. Control strategies. 4. ***Batteries***: Battery parameters. Types and characteristics of EV batteries. Battery testing and maintenance; Charging schemes. Battery Management System. Open-circuit voltage and ampere-hour estimation. Battery load levelling Energy Storage. 5. ***Auxiliaries***: On-board and off-board battery chargers. Energy management units. Battery state-of-charge indicators. Temperature control units. Power steering. 6. ***Emerging EV technologies***: Hybrid electric vehicles (HEVs): types, operating modes, torque coordination and control, generator/motor requirements. Fuel cell electric vehicles (FEVs): fuel cell characteristics, hydrogen storage systems, reformers. Alternative sources of power: super- and ultra-capacitors, flywheels.

Teaching/Learning Methodology	Delivery of the subject is mainly through formal lectures, complemented by tutorials and worked examples. Self-learning on the part of students is strongly encouraged and extensive use of web resources will be made. A term paper and a related presentation enable students to develop skills in literature survey and writing. Oral presentation sessions develop students' skills in spoken communication and peer evaluation.

Teaching/Learning Methodology	Outcomes		
	a	b	c
Lectures	√	√	√
Tutorials	√	√	√
Assignment and oral presentation	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed		
		a	b	c
1. Examination	60%	√	√	√
2. Test	25%	√	√	√
3. Assignment (Term Paper/Homework)	10%	√	√	√
4. Oral presentation	5%	√	√	√
Total	100%			

It is an advanced elective on electric vehicles. The outcomes on electric vehicle technology and its impacts are assessed by the usual means of test and examination, and partly by the term paper. The outcomes on technical communication and presentation skills are evaluated by the term paper and a related oral presentation.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	30 Hrs.
▪ Presentation/Tests	9 Hrs.
Other student study effort:	
▪ Self-study and revision	48 Hrs.
▪ Report – Case Study	18 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Reference books:

1. K. T. Chau, Electric Vehicle Machines and Drives: Design, Analysis and Application, Wiley, 2015.
2. K.T.Chau, Energy Systems for Electric and Hybrid Vehicle, IET, Aug 2016
3. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, New York: RC Press, 2003.

Subject Description Form

Subject Code	EE514
Subject Title	Real Time Computing
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To understand the properties of real time programming languages, operating systems and associated hardware. 2. To apply real time system technologies and concepts in engineering applications. 3. To demonstrate and realize advantages in real time system underlying in today advanced technological evolvements.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Appreciate the important issues in real time computing systems, and their relations in engineering applications. b. Identify and understand the complications in a real time computing system. The mechanism of overcoming these obstacles is explored. c. Communicate effectively with concerned topics during discussions and presentations. d. Equip individual the ability to analyse related issues and identify the proper solution in a real-time computing design.
Subject Synopsis/ Indicative Syllabus	1. ***Real time computing systems concepts*****:** Characteristics of Real Time Computing. Properties and Speed Requirements of Real Time Systems. Synchronous Real Time Systems: Polled, Main Polled Loop with Interrupts, Cyclic Schedulers. Multi-Processors Real Time Systems: Multi-Processor Structures, Process Dispatch Latency, Inter CPU Communication, Hierarchical Approach to Real Time Systems. Process Scheduling Architecture of Cloud Computing. Example: A Real Time Control System in Coal-Fired Power Plant. 2. ***Real time systems design issues*****:** Time Handling: Representation of Time, Time constraints, Time Service and Synchronization, Real Time System Life Cycle: Requirement Specification. Real Time System Modelling Example: Cluster computing, Internet of things in power energy platform. 3. ***Real time system applications*****:** System supervision in Power System Process Operation. Implementation of IoT technology to resolve the real-time system operation issues. **Mini-Project:** Implementation of a real-time computing system based on the Real-time OS

Teaching/Learning Methodology	Lectures and tutorials are the primary means of conveying the basic concepts and theories. Experiences on design and practical applications are given through a mini-project, in which the students are expected to understand design problems with real-life constraints and to attain pragmatic solutions.

Teaching/Learning Methodology	Outcomes			
	a	b	c	d
Lectures	√	√	√	
Tutorials	√	√	√	
Experiments	√		√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed			
		a	b	c	d
1. Examination	60%	√	√		
2. Test	15%	√	√		
3. Assignment/Presentation	10%	√	√	√	
4. Mini project	15%	√	√		√
Total	100%				

The outcomes on concepts, design and applications of real-time systems are assessed by the usual means of examination and test whilst those on analytical skills, problem-solving techniques and practical considerations, as well as technical reporting and teamwork, are evaluated by a mini-project.

Student Study Effort Expected

Class contact:	
▪ Lecture/Seminar	33 Hrs.
▪ Mini-project presentation demonstration	6 Hrs.
Other student study effort:	
▪ Mini-project	30 Hrs.
▪ Self-study	41 Hrs.
Total student study effort	110 Hrs.

Reading List and References

Reference books/materials:

1 Hermann Kopetz, Real-Time Systems: Design Principles for Distributed Embedded Applications, 2nd Ed., Springer, 2013
2. C.M.Krishna, K.G.Shin, Real-Time systems, McGraw-Hill, 2015
3. J.E. Cooling, Software Design for Real-time Systems, Chapman & Hall, 1991
4. J.A. Stankovic and K. Ramamritham, Advances in Real-Time Systems, IEEE Computer & Society Press, 1993
5. Selected papers from Proceedings of Real-time Systems Symnposium (IEEE)
6. Chris Moyer, Building Applications in the Cloud, Pearson Education, 2011

Subject Description Form

Subject Code	EE517
Subject Title	Fibre Optic Components
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To enable students to understand the fundamentals of light emission, detection, amplification, and light propagation in optical fibres. 2. To learn the operation principles of key fibre components and apply the knowledge learned to design fibre components and devices. 3. To appreciate the applications of fibre components in communication and sensing systems.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Appreciate the importance of optic fibre development from a historical perspective; understand the important role of advanced fibre components in enhancing the performance of modern fibre systems. b. Understand the operating principle of various fibre components and analyze/characterize the performance of fibre components. c. Understand the same function may be achieved by using different technology (e.g., electro-optic and acoustic modulation) and understand the advantage and limitations of each technology. d. Select the most appropriate principles/techniques to design a fibre optic component with required specification, read the data sheet of various fibre optic components.
Subject Synopsis/ Indicative Syllabus	1. ***Review of optics***: Wave/quantum nature of light. Polarization, index of refraction, reflection and refraction. 2. ***Optical fibres and cables***: Propagation of light in optical fibres. Different types of fibres. Fibre attenuation and dispersion. Optical fibre measurement. 3. ***Modulation of light***: Phase modulation, frequency modulation, intensity modulation. Birefringence and polarization modulation. Electro-optic, magneto-optic and acousto-optic effects. 4. ***Optical sources***: Emission and absorption of radiation. Population inversion. Optical feedback. Threshold condition. Laser modes. Light emitting diodes, semiconductor lasers, tunable lasers. 5. ***Optical amplifiers***: Rare-earth doped fibres, optical fibre amplifiers, semiconductor amplifiers. 6. ***Photo-detectors***: Photomultipliers, photoconductive detectors, junction detectors (p-i-n diode, avalanche photodiode). 7. ***Passive devices***: Fused bi-conical taper couplers. Thin-film multilayer interference filters. Wavelength division multiplexing (DWDM) devices. Fibre Bragg gratings and their fabrication techniques. Tunable Fabry-Perot filters. Optical isolators and circulators. Integrated optic devices. **Laboratory Demonstration:** Observation of fibre modal patterns Characterization of single mode fibres: loss, dispersion, polarization dependent loss Measurement of source (LED, multi and single mode diode lasers) spectrums and power-current relations **Group-project Topics:** To choose from a list of 15 topics and write a study report and give a presentation

Teaching/Learning Methodology	Lectures are the primary means of teaching the basic concepts and theories. The understanding of basic principle is further enhanced through tutorials and laboratory demonstrations. Experiences and knowledge on design and applications of various integrated/fibre optic components, and on the use of alternative technologies to realise similar functionalities are gained through the use of examples during lectures and discussions during tutorials, and through assignments and group-study projects.

Teaching/Learning Methodology	Outcomes			
	a	b	c	d
Lectures	√	√	√	
Tutorials		√	√	√
Experiments		√		√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed			
		a	b	c	d
1. Examination	60%	√	√	√	
2. Tests and assignments	25%	√	√	√	√
3. Lab report	5%		√		
4. Group-project & report	10%		√	√	√
Total	100%				

The outcomes on concepts, design and applications are assessed by examinations, test and assignments whilst those on practical considerations of optical components and systems design, as well as team work and technical report writing abilities are evaluated by group projects and the reports.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	36 Hrs.
▪ Laboratory demo	3 Hrs.
Other student study effort:	
▪ Self-study and assignments	51 Hrs.
▪ Group project and Report	15 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Reference books:

1. E. Hecht, Optics, 4th Edition, Addison-Wesley, 2002
2. G. Keiser, Optical Fiber Communications, 3rd Edition, McGraw-Hill, 2000
3. B.E.A. Saleh and M.C. Teich, Fundamentals of Photonics, 2nd Edition, Wiley Interscience, 2007
4. D.K. Mynbaev and L.L. Scheiner, Fiber-Optic Communications Technology, Prentice Hall, 2001
5. Selected papers from relevant journals

Subject Description Form

Subject Code	EE520
Subject Title	Intelligent Motion Systems
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To describe an in depth knowledge on the design and operation of intelligent motion systems. 2. To relate and compare numerous application examples, which ranges from CD players and hard disc drives to robots and component insertion machines. 3. To enable the students to have the ability to design motion control systems for industry and domestic purposes.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Contrast and compare different motion control system configurations, and select the most appropriate one for the task. To comprehend and understand numerous motion control examples for domestic and industrial applications. b. Understand the in-depth knowledge of motion drive and sensing techniques, and the ability to use them in real engineering applications. c. Have a broad understanding of motion control platform hardware and a visionary perspective on the future developments of computing/control hardware.
Subject Synopsis/ Indicative Syllabus	1. ***Structures of intelligent motion systems***: Specifications and requirements of intelligent motion systems. Operating modes: point to point motion, trajectory path tracking, velocity path tracking, force and tension control, compliance control, vibration damping. Switching between operation modes. 2. ***Motion actuators and driving techniques***: Using Voice Coil Motors and DC brush motors in motion control. AC brushless motors, linear direct drive AC brushless motors and their driving techniques. Stepping motors and their limitations in motion tracking systems. Microstepping and electronic damping of stepping motors. 3. ***Motion sensing and estimation techniques***: Optical encoders: working principle, decoding method, and resolution enhancement through interpolation. Syncro-resolvers: working principle and interface electronics. Velocity estimation and position estimation methods for large speed range actuators. 4. ***Motion control platform***: Computer hardware requirements. Tightly coupled systems versus distributed systems. Application of DSPs in motion control. Communication methods in motion systems. Real time operating system for motion control. 5. ***Intelligent algorithms for motion control and trajectory generation***: PID controllers and their variations. Servo tuning methods. Motion control systems based on state space configuration. States observation and Kalman filters. Using Notch filters in non-rigid systems. Profile generation and motion planning algorithms. 6. ***Issues in multi-axis intelligent motion systems***: co-ordinate mapping and dynamics transformation. Multi-axis motion planning and profile generation. Motion synchronisation between axis. Decoupling inter-axis motion interference. Applying MIMO structure in tightly coupled system.

7. ***Case studies in intelligent motion systems*:**

   Three examples will be selected from the following list:
   a. Optical based position tracking in CD-ROMs and Laser discs.
   b. Magnetic head positioning in hard disk drives.
   c. Motion control system design in multi-axis robot manipulators.
   d. Gantry robot motion systems for SMT component insertion machines.
   e. Motion systems in high precision CNC tooling machines.

Case study:

Report on a high performance motion control application example

Teaching/Learning Methodology

Delivery of the subject is mainly through formal lectures, complemented by tutorials and worked examples. Self-learning on the part of students is strongly encouraged and extensive use of web resources will be made. A term paper and a related presentation enable students to develop skills in literature survey and writing. Oral presentation sessions develop students' skills in spoken communication and peer evaluation.

Teaching/Learning Methodology	Outcomes		
	a	b	c
Lectures	√	√	√
Tutorials	√	√	√
Assignment and oral presentation	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed		
		a	b	c
1. Examination	60%	√	√	√
2. Test	30%	√	√	√
3. Report	5%	√	√	√
4. Oral presentation	5%	√	√	√
Total	100%			

One end-of-semester written examination; one mid-semester-test; one end-of-semester test; a report on an assigned topic; and a power point presentation for the particular topic.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	30 Hrs.
▪ Presentation/Test	9 Hrs.
Other student study effort:	
▪ Case study	18 Hrs.
▪ Self-study	48 Hrs.
Total student study effort	105 Hrs.

Reading List and References

References books:

1. Precision Motion Control: Design and Implementation (Advances in Industrial Control) Dec 10, 2010 by Kok Kiong Tan and Tong Heng Lee, Springer
2. Motion Control Systems, Feb 21, 2011 by Asif Sabanovic and Kouhei Ohnishi, Wiley
3. S. Meshkat, Advanced Motion Control, PCIM reference series in Power Conversion and Intelligent Motion, 1988
4. M.M. Gupta, Intelligent Control Systems: Concepts and Applications, IEEE Press, 1996
5. K. Rajashekara, Sensorless Control of AC Motors, IEEE Press, 1996

Subject Description Form

Subject Code	EE521
Subject Title	Industrial Power Electronics
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To provide power electronics engineers with in-depth knowledge of the industrial power electronics. 2. To provide latest development in power supplies, industrial power electronics system and their applications in renewable energy systems. 3. To give industrial concern in power electronics design including passive components and standards 4. To introduce to students to the various topologies of the power electronics circuits. 5. To enable students to understand the power quality issues and the active and reactive power flow.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Acquire a good understanding of power supply concept and design and be able to analyse the industrial needs for static power conversion. b. Understand the international standards on power electronics design. c. Have a global view on recent development on power electronics and be aware of applications of power electronics in various industries d. Understand the various topologies and working principles of basic power converters e. Work in teams and independently when conducting power electronics design and testing.
Subject Synopsis/ Indicative Syllabus	1. ***Industrial power systems:*** Static power systems, battery systems, AC systems, DC systems, AC-DC power conversion and recent advance in renewable energy systems such as wind and solar power 2. ***Power conversion:*** Soft-switching, power factor correction, inverter configurations and static converters. 3. ***Special environment power electronics:*** Power electronics distribution system, industrial guidelines, variable speed and constant frequency systems, actuation systems, brushless drives and other applications of power electronics in industry 4. ***Industrial power supplies:*** Converter topologies, decentralized power, power modules, electro-magnetic compatibility, international standards and reliability. 5. ***Power quality improvement:*** Fourier analysis of voltage current waveforms, total harmonic distortion, rectifier, passive/active filters, power quality issues, reactive power compensation. 6. ***Magnetics and capacitors:*** High frequency inductors and transformers, winding techniques, core loss analysis, optimization of magnetics and power capacitors. **Laboratory Experiments :** Select 2 experiments from topics in computer simulation, motor drive, AC-DC and DC-DC power converters.

Teaching/Learning Methodology	Lectures and tutorials are the primary means of conveying the basic concepts and theories. Experiences on design and practical applications are given through experiments and mini-projects, in which the students are expected to solve design problems with real-life constraints and to attain pragmatic solutions with critical and analytical thinking. Interactive laboratory sessions are introduced to encourage better preparation and hence understanding of the experiments. Experiments are designed to supplement the lecturing materials so that the students are encouraged to take extra readings and to look for relevant information.

Teaching/Learning Methodology	Outcomes				
	a	b	c	d	e
Lectures	√	√	√	√	
Tutorials	√	√	√	√	
Experiments/Laboratory	√				√
Mini-project		√	√		√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed				
		a	b	c	d	e
1. Examination	60%	√	√	√	√	
2. Test and/or Assignment	20%	√	√	√	√	
3. Laboratory performance & report	10%	√			√	√
4. Mini-project & report	10%	√	√	√	√	√
Total	100%					

One end-of-semester written examination; one mid-semester-test; one end-of-semester test; laboratory performance evaluation (including punctuality, initiative, and technical reasoning); and laboratory report on a particular experiment.

Student Study Effort Expected

Class contact:	
▪ Lecture/tutorial	33 Hrs.
▪ Laboratory	6 Hrs.
Other student study effort:	
▪ Lab report/Mini-project	15 Hrs.
▪ Self-study	51 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Reference books:

1. A. M. Trzynadlowski, Introduction to Modern Power Electronics, Third Edition, Wiley, 2015.
2. M.Cirrincione, M. Pucci, G. Vitale, Power Converters and AC Electrical Drives with Linear Neural Networks, CRC Press, 2012.
3. N. Mohan, Power Electronics: Converters, Applications, and Design, John Wiley & Sons, 2012.
4. G. M. Masters, Renewable and efficient electric power systems, John Wiley & Sons, 2004
5. K.W.E. Cheng, Classical Switched Mode and Resonant Power Converters, The Hong Kong Polytechnic University, 2002

Subject Description Form

Subject Code	EE522
Subject Title	Optical Fibre Systems
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To re-introduce to students the fundamentals of light emission, modulation, detection, amplification, and light propagation in optical fibres. 2. To enable students to understand the operating principle and performance specifications of various fibre-optic components, as well as their applications in modern fibre-optic systems. 3. To equip students with the ability to analyse and design simple fibre-optic communication and sensing systems.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Appreciate recent developments in fibre optic communication systems, importance of fibre optic technology to the development of communications, engineering applications of fibre-optic technologies, and advantages of fibre optic sensors to the electrical engineering industry. b. Understand the principles of different types of optical fibres, fibre components, sensors, and communication systems. c. Know the same function may be achieved by using different technologies and understand the advantages and limitations of each technology. d. Select the most appropriate passive and active fibre-optic components to design fibre-optic sensor systems and fibre optic communication links. e. Have hands-on experience in the use of fusion splicer to make low-loss fibre joints, optical spectrum analyzer to perform spectral measurements, and fibre grating sensors for temperature and strain measurements.
Subject Synopsis/ Indicative Syllabus	1. **Overview:** Introduction to lightwave communication and sensor systems. Historical perspective. Basic concept and components. Channel capacity. 2. **Optical fibres:** Theory of optical wave-guiding. Numerical aperture. Fibre modes. Fibre fabrication. Attenuation and dispersion. Special optical fibres. 3. **Passive fibre components**: Light coupling. Splices and connectors. Couplers and splitters. Optical filters. Wavelength multiplexers/de-multiplexers. Fibre Bragg gratings. Optical isolators and circulators. 4. **Optical sources:** Light emission and absorption. Light emitting diodes. Optical feedback. Threshold condition. Laser modes. Semiconductor lasers. Tunable lasers. Modulation of light. Optical transmitters. 5. **Optical amplifiers:** Rare-earth doped fibres. Optical fibre amplifiers. Semiconductor amplifiers. 6. **Optical detectors:** PIN and avalanche photodiode. Noise and response time. Responsivity. Optical receivers. 7. **Optical fibre communication:** System architectures. Operating wavelength and system limitations. Power and rise-time budgets. Noise effects and other source of power penalty.

8. **Optical fibre sensor systems:** Intrinsic and extrinsic sensors. Intensity modulation sensors. Phase modulation sensors. Polarisation modulation sensors. Wavelength and frequency modulation sensors. Fibre grating sensors. Multiplexed and distributed sensing systems.

Laboratory Experiments/Demonstrations:
Observation of fibre modal patterns; Measurement of source spectrums and power-current relations of LED, multi and single mode diode lasers; Fibre splicing and insertion loss measurement; Fibre Bragg grating sensors.

Teaching/Learning Methodology

Lectures, quizzes, tests, laboratory experiments, mini-projects, and examination.

Teaching/Learning Methodology	Outcomes				
	a	b	c	d	e
Lectures	√	√	√	√	
Tutorials		√	√	√	
Demonstration/Experiments				√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed				
		a	b	c	d	e
1.Tests/Quizzes	18%	√	√	√	√	
2. Assignments	8%	√	√	√	√	
3. Lab and report	8%				√	√
4. Mini-project and report	6%	√	√	√		
5. Examination	60%		√	√	√	
Total	100%					

This subject introduces the theory and applications of optical fibre communication and sensor technology. The outcomes are assessed by quizzes, tests, mini-projects, laboratory experiments and examination.

Student Study Effort Expected

Class contact:	
▪ Lectures/Tutorials/Laboratory demo	39 Hrs.
Other student study effort:	
▪ Mini-project and report	20 Hrs.
▪ Self-study and assignments	46 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Reference books:

1. G. Keiser, Optical Fiber Communications, 3rd Edition, McGraw-Hill, 1999
2. J.M. Senior, Optical Fiber Communications-Principles and Practice, 3rd Edition, Prentice Hall, 2008
3. J.C. Palais, Fiber Optic Communications, 5th Edition, Prentice Hall, 2005
4. G.P. Agrawal, Fiber-optic Communication Systems, 3rd Edition, Wiley, 2002
5. J. P. Dakin and B. Culshaw, Optical Fibre Sensors, Artech House, Vols.1&2, 1989, and Vols.3&4, 1997.

Subject Description Form

Subject Code	EE524
Subject Title	Open Electricity Market Operation
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To enable students to understand the key and practical issues of restructuring electricity supply industry and to establish a broad knowledge of open electricity market operation. 2. To enable students to understand the key issues in open electricity market operation including deregulated power system operation, transmission pricing, procurement of ancillary services, congestion management, available transmission capacity so that students are provided with knowledge and techniques they need to meet the electric industry's challenges in the 21st century.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Acquire a good understanding of the rationale and key issues for restructuring electricity supply industry, practical operation and design considerations for real world electricity markets, and financial tools to hedge risks used in electricity supply industries. b. Analyse the available transmission capacity and formulate equitable transmission pricing in electricity markets. c. Assess ancillary services requirements and values based on security, economic and performance considerations. d. Present technical results in the form of technical report and verbal presentation
Subject Synopsis/ Indicative Syllabus	1. ***Restructuring of the Electricity supply industry* (*ESI*):** ESI structures; Privatisation and competition; Market structures and architectures; Regulation of Electricity Markets; Role of existing players. 2. ***Electricity market*:** Timeline coordination, design considerations and practical operation of a real-world electricity market system. Use of different financial contracts/tools including derivatives and electricity futures for risk management in electricity markets. Game theory approach for market competition analysis. Transmission congestion management in electricity market. Security considerations. 3. ***Transmission and ancillary services*:** Transmission ownership and restructuring. Measuring available transmission capacity in energy markets. Purchasing transmission capacity. Network and point to point transmission services. Fixed and firm transmission rights. Ancillary services and technical specifications, and performance based cost model. 4. ***Transmission pricing*:** The costs of transmission services. Locational prices. Embedded cost allocation methods. Stranded assets. Short-run marginal cost. Long-run marginal cost. Integrated approach of transmission pricing.

Teaching/Learning Methodology	The concept of electricity market modelling and economic analysis framework will be presented through lectures and tutorials with reference to real-life market environment. Students will be required to form groups to work through cases covering the market structure and operational aspects so as to develop ability to critically evaluate principles and operation of electricity markets. Tutorials will be structured on different sessions for better understanding on the theoretical concepts which require sufficient contributions from students. Students will also learn through active participation in the presentation of finding of their case studies.

Teaching/Learning Methodology	Outcomes			
	a	b	c	d
Lectures	√	√	√	
Case Studies & Presentation	√	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed			
		a	b	c	d
1. Examination	62%	√	√	√	
2. In-class tests	19%	√	√	√	
3. Cases study & presentation	19%	√	√	√	√
Total	100%				

The outcomes on the concepts of modelling, analysis and applications are assessed by the usual means of examination and tests whilst those on problem-solving techniques and presentation of findings, as well as technical reporting and teamwork, are evaluated by the case study exercise.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	33 Hrs.
▪ Presentation	6 Hrs.
Other student study effort:	
▪ Case study and report	15 Hrs.
▪ Self-study	51 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Reference books:

1. D. Gan, D. Feng and J. Xie, Electricity Markets and Power System Economics, CRC Press, 2013
2. D. Kirschen, G. Strbac, Fundamentals of Power System Economics, 2nd Edition, John Wiley & Sons, 2018
3. K. Bhattacharya, M.H.J. Bollen, and J.E. Daalder, Operation of Restructured Power Systems, Kluwer Academic Publishers, 2001

Subject Description Form

Subject Code	EE525
Subject Title	Energy Policy and Restructuring of Electricity Supply Industry
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To provide students with a comprehensive knowledge in formulating practical energy policies for sustainable energy utilization. 2. To develop a conceptual framework for understanding key and practical issues of restructuring electricity supply industry.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Identify, evaluate and formulate energy polices for sustainable energy utilization. b. Identify the rationale and key issues for restructuring electricity supply industry. c. Explain the market structures and regulatory framework for electricity supply industry. d. Explain and evaluate different pricing concepts and pricing contracts in restructured electricity supply industry. e. Present the results of study in the form of written technical reports and oral presentation.
Subject Synopsis/ Indicative Syllabus	1. ***Energy policy***: Scope and limit of energy policy. Policy responses: environmental control and clean energy technology, energy efficiency and alternative energy sources. Policy instruments and their evaluation. Sustainable energy concept: trade-off between energy consumption, resources availability and environment deterioration. 2. ***Energy conservation and demand side management***: Energy conservation policy: efficient utilization and transformation, recycling of materials and waste heat extraction. Load management: energy and load growth, direct and indirect load control. Integrated Resources Planning: system cost, end-use development and environment cost. 3. ***Restructuring of the ESI***: Electricity supply industry structures; Privatisation and competition; Market structures and architectures; Regulation of Electricity Markets; Key issues for China and Hong Kong. 4. ***Electricity pricing and management***: Short range marginal cost. Real time and time-of-day pricing applications. Analysis of BOT option. Transmission contracts pricing. Futures and forward markets. **Case Study:** 1. Functional analysis on energy policies 2. Practical application of sustainable energy measures 3. Analysis on key issues of ESI restructuring 4. Implementation issues on ESI restructuring

Teaching/Learning Methodology

The concept of energy policy, identifications and discussions of ways of restructuring electricity supply industry will be presented through lectures and tutorials on case studies and international experiences. Students are expected to take initiative to learn through the process of engagement and participation in lectures and tutorial sessions. Mini-Projects are used to enhance students learning experiences and practical applications. They provide students with the opportunity to develop independent evaluation, formulation and technical report writing skills pertinent to the field of energy policy and restructuring electricity supply industry.

Teaching/Learning Methodology	Outcomes				
	a	b	c	d	e
Lectures	√	√	√	√	
Tutorials	√	√	√	√	
Mini-projects	√	√	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed				
		a	b	c	d	e
1. Examination	60%	√	√	√	√	
2. Class test/Quiz	25%	√	√	√	√	
3. Mini-project & report	15%	√	√	√	√	√
Total	100%					

The subject outcomes on concepts, evaluations and formulations are assessed by means of examination, quizzes and tests. The outcomes on practical formulations, implementation and evaluations of energy polices, restructuring electricity supply industry and electricity pricing, as well as technical writing, are assessed by mini-project and reports.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	30 Hrs.
▪ Case studies/Group discussion	9 Hrs.
Other student study effort:	
▪ Mini-project discussion/report	21 Hrs.
▪ Self-study	45 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Reference books:

1. M. Chick, Electricity and Energy Policy in Britain, France and the United States since 1945, Cheltenham, Northampton, Mass: Edward Elgar, 2007
2. J. Glachant, Competition, Contracts and Electricity Markets: A New Perspective, Edward Elgar, 2011
3. A. Kerstin, Energy Policy Instruments: Perspectives on their Choice, Combinations and Evaluation, Lund University Press, 2006
4. International Energy Agency, Electricity Supply Industry, OECD/IEA, 1994
5. M. Shahidehpour, Restructured Electrical Power Systems: Operation, Trading and Volatility, Marcel Dekker, 2001
6. H. Khatib, Economic Evaluation of Projects in the Electricity Supply Industry, IEE, 2003

Subject Description Form

Subject Code	EE526
Subject Title	Power System Analysis and Dynamics
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To introduce the students to the advanced concepts and analytical skills for the stability analysis in modern power systems. 2. To understand the impact due to different system instabilities. 3. To analyse and provide solutions to the power system stability problems.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Acquire in-depth understanding of different types of power system stability problems. b. Model the dynamic behaviours of system components under disturbances. c. Apply and adapt applications of mathematics and engineering skills in the analysis of stability problems. d. Discuss the causes and effects of instabilities and recommend possible solutions. e. Acquire skills in presentation and interpretation of experimental results and communicate in written form
Subject Synopsis/ Indicative Syllabus	1. ***Power system stability***: Basic concepts and classification. Past incidents of system instability and consequences. Power system stability issues and solutions. 2. ***Reactive power compensation***: System Q-V Characteristics. Reactive support theory. Load Characteristics. Synchronous condensers, Static Var Compensators (SVS), Thyristor Switched Capacitor (TSC), Thyristor controlled Reactor (TCR). 3. ***Voltage stability***: Fundamental concepts. Singularities and multiple load flow techniques, eigenvalue methods. Load modelling, tap-changer effects, voltage controllability and voltage compensation. Proximity of collapse, Measures against collapse. Practical experience. 4. ***Dynamic stability & power system stabilisers***: Eigenvalue and modal analysis. Generator and load modelling. Power system stabiliser. Small-signal stability of multi-machine systems. Selection of input signal and installation location, parameter design and commissioning of PSS. 5. ***Application of HVDC, FACTS and ESS in improving stability***: HVDC link operation and its control for stability improvement. Flexible AC transmission devices, power angle control. Energy storage system, e.g. BESS, SOFC, FESS, and its application in stability control. **Mini-projects:** 1. Power system stability analysis using industrial power systems design and analysis software 2. Power system stabiliser design for damping of low frequency power oscillation

<table>
<tr><td>Teaching/Learning Methodology</td><td>
Lectures and tutorials are the primary means of conveying the basic concepts and theories. Experiences on system analysis, design and practical applications are given through experiments, in which the students are expected to solve the power system stability and control design problems with practical constraints and to attain pragmatic solutions with critical and analytical thinking. Students will be required to form groups to work through a mini-project for a selected topic. Mini-Projects are used to enhance students learning experiences and practical applications.

<table>
<tr><td rowspan="2">Teaching/Learning Methodology</td><td colspan="5">Outcomes</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td></tr>
<tr><td>Lectures</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>Tutorials</td><td></td><td></td><td>√</td><td></td><td></td></tr>
<tr><td>Mini-project</td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td></tr>
</table>
</td></tr>
<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td>
<table>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="5">Intended subject learning outcomes to be assessed</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td></tr>
<tr><td>1. Examination</td><td>60%</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>2. Class Test</td><td>18%</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>3. Mini-project/report</td><td>12%</td><td></td><td></td><td></td><td>√</td><td>√</td></tr>
<tr><td>4. Essay assignment</td><td>10%</td><td>√</td><td></td><td></td><td>√</td><td>√</td></tr>
<tr><td>Total</td><td>100%</td><td colspan="5"></td></tr>
</table>
The outcomes on concepts, design and applications are assessed by the usual means of examination and test Experiments and written reports assess those on analytical skills, problem-solving techniques and practical considerations of power system stability and control design as well as technical reporting.
</td></tr>
<tr><td>Student Study Effort Expected</td><td>
<table>
<tr><td>Class contact:</td><td></td></tr>
<tr><td>▪ Lecture/Tutorial</td><td>39 Hrs.</td></tr>
<tr><td>Other student study effort:</td><td></td></tr>
<tr><td>▪ Mini-project and report</td><td>15 Hrs.</td></tr>
<tr><td>▪ Essay assignment/Self-study</td><td>51 Hrs.</td></tr>
<tr><td>Total student study effort</td><td>105 Hrs.</td></tr>
</table>
</td></tr>
<tr><td>Reading List and References</td><td>
Reference Books:
1. P. Kundur, Power System Stability and Control, McGraw Hill, 1994
2. P.M. Anderson and A.A. Fouad, Power System Control and Stability, Wiley-IEEE Press, 2nd Edition, 2002
3. G. Rogers, Power System Oscillations, Springer, 1999
4. Voltage Stability of Power Systems: Concepts, Analytical Tools and Industry Experience, IEEE Publication 90th 0358-2-PWR, 1990
5. Y.H. Song, and A.T. Johns, Flexible AC Transmission Systems, IEE, 1999
6. T.V. Cutsem, and C. Vournas, Voltage Stability of Electric Power Systems, Springer, 2nd Edition, 2007
</td></tr>
</table>

Subject Description Form

Subject Code	EE527
Subject Title	Auto-tuning for Industrial Processes
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To facilitate a solid understanding of system identification. 2. To provide students with a solid knowledge of adaptive control.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Conduct parametric and non-parametric estimation for unknown processes. b. Design self-tuning and adaptive controllers. c. Design auto-tuning control systems based on relay auto-tuner. d. Use CAD package for design and simulation.
Subject Synopsis/ Indicative Syllabus	1. ***System identification***: Low-order modelling, Frequency response identification, Continuous-time and discrete-time identification, Identification by correlation, Least-squares algorithm, Recursive least-squares, Extended least-squares. Computer implementation of these algorithms. 2. ***Auto-tuning***: PID auto-tuning, Relay auto-tuning, Applications in industry. 3. ***Self-tuning control***: Self-tuning algorithms, Minimum variance and generalised minimum variance, Pole-placement algorithms, Model reference adaptive systems. **Case study:** Individual assignment related to above methods. Students will write a report and present their finding to the class.
Teaching/Learning Methodology	Lectures and tutorials are the primary means of conveying the basic concepts and theories. Case studies are designed to supplement the lecturing materials. The students are encouraged to take extra readings and to look for relevant information.

Teaching/Learning Methodology	Outcomes			
	a	b	c	d
Lectures	√	√	√	
Tutorials	√	√	√	
Case studies	√	√	√	√

<table>
<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td>
<table>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="4">Intended subject learning outcomes to be assessed</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td></tr>
<tr><td>1. Examination</td><td>60%</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>2. Case studies</td><td>40%</td><td>√</td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>Total</td><td>100%</td><td colspan="4"></td></tr>
</table>
The outcomes on concepts, analysis and design are assessed by the usual means of examination.
</td></tr>
<tr><td>Student Study Effort Expected</td><td>
<table>
<tr><td>Class contact:</td><td></td></tr>
<tr><td>▪ Lecture/Tutorial</td><td>30 Hrs.</td></tr>
<tr><td>▪ Case study</td><td>9 Hrs.</td></tr>
<tr><td>Other student study effort:</td><td></td></tr>
<tr><td>▪ Case study preparation/report</td><td>21 Hrs.</td></tr>
<tr><td>▪ Self-study</td><td>45 Hrs.</td></tr>
<tr><td>Total student study effort</td><td>105 Hrs.</td></tr>
</table>
</td></tr>
<tr><td>Reading List and References</td><td>
Reference books:
1. L. Ljung, System Identification: Theory for the User (2nd Edition), Upper Saddle River, N.J., Prentice Hall, 1999
2. C.C. Hang, T.H. Lee and W.K. Ho, Adaptive Control, Research Triangle Park, N.C. Instrument Society of America, 1993
3. Selected papers from IEEE Transactions and IEE proceeding and other relevant journals
4. P.E. Wellstead and W. Zarrop, Self-tuning Systems: Control and Signal Processing, Cichester, England: New York; Wiley, 1991
5. K. J. Astrom abd B. Wittenmark, Adaptive control (2nd Edition), Reading : Mass., Addison-Wesley, 1995.
</td></tr>
</table>

Subject Description Form

Subject Code	EE528
Subject Title	System Modelling and Optimal Control
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To provide students with a sound knowledge of system identification and modelling techniques in areas of prediction and control. 2. To introduce modern control design techniques.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Model systems using State Variable and Transfer Functions. b. Design optimal controllers for system models. c. Conduct parametric and non-parametric estimation for unknown processes. d. Apply computer packages for control system modelling and design.
Subject Synopsis/ Indicative Syllabus	1. ***System models***: functions, transformations and mapping, Laplace transformation and z-transformation, state variables and state space models of dynamic systems, relations between state space models and transfer function models, solutions of unforced linear state equations, matrix exponential, eigenvalues and eigenvectors, Jordan form, solutions of linear state equations, transition matrix. 2. ***Modelling of physical systems***: power, energy, sources, passive elements (C-, I-, R-, transformer, and Gyrator), through and across variables, linear graph, modelling examples for typical mechanical systems such as vehicle suspension, electrical motor, etc. 3. ***Stability, controllability, and observability***: stability, Lyapunov stability, Lyapunov function, controllability and observability, definition and criteria, stabilizability and detectability, feedback control. 4. ***Optimal control***: Calculus of variations, formulation of optimal control problems, Pontryagin maximum principle, Riccati equation, application to linear regulator. 5. ***System identification:*** Low-order modelling, Frequency response identification, Continuous-time and discrete-time identification, Identification by correlation, Least-squares algorithm, Recursive least-squares, Extended least-squares.
Teaching/Learning Methodology	Basic concepts and theories are taught in lectures and tutorials. Computer experiments will be assigned as part of the interactive assignments, where the students are expected to solve theoretical and practical control problems with critical and analytical thinking.

Teaching/Learning Methodology	Outcomes			
	a	b	c	d
Lectures	√	√	√	
Tutorials	√	√	√	
Assignments			√	√

<table>
<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td>
<table>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="4">Intended subject learning outcomes to be assessed</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td></tr>
<tr><td>1. Examination</td><td>60%</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>2. Assignments</td><td>40%</td><td>√</td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>Total</td><td>100%</td><td colspan="4"></td></tr>
</table>
The outcomes on concepts, analytical skills, problem-solving techniques, design and applications, and practical considerations of designing control systems are assessed by the usual means of examination and assignments, including computer-package-based assignments.
</td></tr>
<tr><td>Student Study Effort Expected</td><td>
<table>
<tr><td>Class contact:</td><td></td></tr>
<tr><td>▪ Lecture/Tutorial</td><td>39 Hrs.</td></tr>
<tr><td>Other student study effort:</td><td></td></tr>
<tr><td>▪ Reading and studying</td><td>43 Hrs.</td></tr>
<tr><td>▪ Completing assignments</td><td>23 Hrs.</td></tr>
<tr><td>Total student study effort</td><td>105 Hrs.</td></tr>
</table>
</td></tr>
<tr><td>Reading List and References</td><td>
1. L. Ljung, System Identification: Theory for the User (2nd Edition), Prentice Hall.
2. C.C. Hang, T.H. Lee and W.K. Ho, Adaptive Control, Instrument Society of America.
3. N. Nise, Control Systems Engineering, Wiley.
4. P. J. Antsaklis and A. N. Michel, Linear Systems, McGraw Hill.
</td></tr>
</table>

Subject Description Form

Subject Code	EE529
Subject Title	Power Electronics for Utility Applications
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To enable students to understand the problems faced by modern power utilities and how power electronics can overcome these problems. 2. To introduce to students to the various topologies of the power electronics circuits. 3. To provide basic understanding of the emerging power electronics technologies for power utility applications. 4. To enable students to understand the harmonics issues in power utility and means of controlling it using power electronics. 5. To enable students to design power electronics circuit that can control active and reactive power flow.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Explain why power electronics are needed in modern power system and understand of various emerging power electronics technologies for power utility applications. b. Explain the main topologies of power electronic circuits used in utility applications and how these differ from low power applications. c. Determine the harmonic filter required to satisfy the harmonic standard for a given harmonic load in a power system. d. Identify power electronics topologies for used in controlling active and reactive power in a power system. e. Communicate and work effectively on why and how power electronics can be used for power utility applications in terms of written reports and oral presentations
Subject Synopsis/ Indicative Syllabus	1. ***Power electronics revolutions in utility applications*****:** High power devices, Power Electronics and utility needs, control of power flow in the utility grid, distributed generation, improvement of electrical energy efficiencies, power quality, an overview of power electronics systems and their applications. 2. ***Inverters for high power applications*****:** Basic principles of current and voltage source inverters for high power applications, Multi-level Inverters, Analysis of their performance, AC and DC harmonics, Interaction with power grid. 3. ***Transmission systems*****:** High power issues, Source side model, Power transfer and voltage control issues, Damping of oscillation issues, Power Electronics solutions. 4. ***Power system harmonic elimination techniques*****:** Harmonics measures, Harmonic models, Harmonics standards, Propagation of Harmonics, Passive Filters, Source side issues, Active Filters. 5. ***Reactive power compensations*****:** concepts of reactive power, traditional means of controlling reactive powers, Power electronics applications for Static VAr Compensation (SVC), control of SVC, Harmonic issues, Analysis of performance and instabilities, Voltage Source Static Condensers (STATCON). 6. ***New applications of power electronics for power system controls*****:** Power Electronics for HVDC system, High Power DC-DC Converter, Topology Analysis of HVDC conversion, Flexible AC Transmission Devices, Unified Power Flow Controller (UPFC), Battery Energy Storage Systems, Analysis of performance and Control strategies.

Teaching/Learning Methodology

Lectures and tutorials are the primary means of conveying the basic concepts and theories. Mini-projects are designed to supplement the lecturing materials so that the students are given a design. They are given in the beginning of the study. Students are encouraged to form group to jointly investigate a power electronics utilization problem and they have to present the projects in front of the class.

Teaching/Learning Methodology	Outcomes				
	a	b	c	d	e
Lectures	√	√	√	√	
Tutorials	√	√	√	√	
Mini-project	√				√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed				
		a	b	c	d	e
1. Examination	60%	√	√	√	√	
2. Class Test	20%	√	√	√	√	
3. Mini-project & Report	20%	√	√	√	√	√
Total	100%					

It is a high power electronics application subject. The outcomes on concepts, design and applications are assessed by the usual means of examination and test whilst those on analytical skills, problem-solving techniques and practical considerations of power design, as well as technical reporting and teamwork, are evaluated by mini-project and the reports.

Student Study Effort Expected

Class contact:	
▪ Lecture	33 Hrs.
▪ Tutorial/Student presentation	6 Hrs.
Other student study effort:	
▪ Mini-project/report	15 Hrs.
▪ Self-study	51 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Textbooks:

1. V.K. Sood, HVDC and FACTS Controllers: Applications of Static Converters in Power Systems, Kluwer Academic Publishers, 2008.
2. Ghosh and Ledwich, Power Quality Enhancement Using Custom Power Devices, Kluwer, 2002

Reference books:

1. Zhang, Rehtanz and Pal, Flexible AC Transmission Systems: Modelling and Control, Springer, 2006
2. M.H. Rashid, Power Electronics Handbook: Devices, Circuits and Applications, Elsevier, 2005
3. K.W.E.Cheng, Classical Switched Mode and Resonant Power Converters, The Hong Kong Polytechnic University, 2002
4. E.Acha, V.Agelidis, O. Anaya-Lara, T. Miller, Power Electronic Control in Electrical Systems, Newnes, 2002.
5. Xi-Fan Wang, Yonghua Song and Malcolm Irving, Modern Power Systems Analysis (Power Electronics and Power Systems), Springer, 2008.

Subject Description Form

Subject Code	EE530
Subject Title	Electrical Energy Saving Systems
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To enable students to establish a broad concept on energy saving using techniques of electrical engineering. 2. To provide an in-depth knowledge on selected topics of energy-saving systems in electrical engineering. 3. To enable students to understand typical energy storage systems, its associated issues of grid connection and related technical considerations. 4. To enable students to understand the potential of solar energy and characteristics & performance of various kinds solar energy systems. 5. To enable students to understand various techniques and systems for control and monitoring of energy saving, as well as the related communication protocol and interfacing requirements. 6. To enable students to understand control gears for lighting systems and variable speed drives for HVAC systems & elevators.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Describe the operation principle & control strategy of various energy storage systems and topologies of these systems and identify their benefits & impacts. b. Describe the principle and characteristics of various solar energy devices, and identify the potentials of solar energy. Calculate available solar irradiation for a given location. c. Describe the operation principle and characteristics of typical control and monitoring systems for energy saving, including the communication protocols. d. Identify different energy saving control for industrial plants and multi-storey buildings, including giving examples. e. Describe the operation principle and characteristics of typical control gear for lighting and variables speed drives. f. Given a technical topic, carry out literature search and report the findings in a presentation and be able to work and communicate effectively in a team setting.
Subject Synopsis/ Indicative Syllabus	1. ***Energy storage systems*****:** Utility Load Factor, peak lopping and valley filling, energy storage systems, battery energy storage, super-capacitor, power electronics topologies, control strategy, grid connection, voltage support, power quality improvement, environmental impact, improvement of utility energy efficiencies. 2. ***Solar energy utilization*****:** Solar irradiation on earth, potentials of solar energy, solar thermal system systems, photovoltaic systems, characteristics and performance of typical BIPV systems and estimation of its energy output, distributed power generation, passive solar devices on buildings for energy saving, and case study. 3. ***Energy saving control and monitoring systems*****:** Theory of energy saving, concept of building energy efficiency, control and monitoring systems and some of its related communication protocols. Application examples.

4. ***Lighting, ballast, and variable speed drives*:** Magnetic ballast, electronic ballast, lighting design, fluorescent, LED and HID lamps, variable speed drives for HVAC systems and elevators, energy storage and regeneration for elevators, harmonics implications.

Laboratory Experiments, Seminars, Site Visits:
Demonstration on operating principles of some selected energy-saving systems.

Case study:
Selections of practical real life energy-saving systems in Hong Kong.

Teaching/Learning Methodology

Lectures and tutorials are the primary means of conveying the basic concepts and theories. Practical experiences on power electronics design, energy saving and applications are given through mini-projects. Mini-projects are given in the beginning of the study. Students are encouraged to form group to jointly investigate an industrial problem and they have to present the projects in front of the class.

Teaching/Learning Methodology	Outcomes					
	a	b	c	d	e	f
Lectures	√	√	√	√	√	
Tutorials	√	√	√	√	√	
Mini-project						√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed					
		a	b	c	d	e	f
1. Examination	60%	√	√	√	√	√	
2. Class Test and/or Assignment	30%	√	√	√	√	√	
3. Mini-project & Report	10%	√	√	√	√	√	√
Total	100%						

It is a fundamental energy saving subject. The outcomes on concepts, design and applications are assessed by the usual means of examination, assignment and test whilst those on analytical skills, problem-solving techniques and practical considerations of circuit design, as well as technical reporting and teamwork, are evaluated by experiments, mini-project and the reports.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	30 Hrs.
▪ Seminar/Case study	9 Hrs.
Other student study effort:	
▪ Mini-project/report	20 Hrs.
▪ Self-study	46 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Reference books:

<u>Battery Storage Systems</u>

1. D. Andrea, Battery Management Systems for Large Lithium Ion Battery Packs, Artech House, 2010.
2. P.W. Parfomak, Energy storage for Power Grids and Electric Transportation: A Technology Assessment, Congressional Research Service, 2012.
3. Y. Brunet, Energy storage, Wiley, 2013
4. F. S. Barnes, J.G. Levine, Large Energy Storage Systems Handbook, CRC Press, 2011

<u>Solar Energy Utilisation</u>

5. S. Yannas, Solar Energy and Housing Design, Architectural Association, 2005/2006
6. R. Messenger, Photovoltaic Systems Engineering, CRC Press, 2017 edition
7. C. Prapanavarat, Investigation of the Performance of a Photovoltaic AC Module, Generation, Transmission and Distribution, IEE Proceedings, Vol: 149, Issue 4, Jul 2002
8. Web site of Energy Efficiency and Renewable Energy from the Dept. of Energy of USA, http://www.eere.energy.gov/
9. Web site of the Key Centre of Photovoltaic Engineering in University of New South Wales, http://www.pv.unsw.edu.au/
10. S. Kouro, Grid-connected photovoltaic systems – an overview of recent research and emerging PV converter technology, IEE Industrial Electronics Magazine, 2015.

<u>Energy Saving Control and Monitoring Systems</u>

11. EMSD of HKSAR Govt, Code of Practice for Energy Efficiency of Building Services Installation, 2012
12. EMSD of HKSAR Govt, Code of Practice for Building Energy Audit, 2012
13. Anna Magrini, Building Refurbishment for Energy Performance: A Global Approach (Green Energy and Technology) Springer, 2014th Edition.
14. Bela Liptak, Instrument Engineers' Handbook, 4th Edition, Volume Two: Process Control and Optimization, CRC 2005.

<u>Lighting, Ballast, and Variable Speed Drives</u>

15. T. Q. Khanh, LED lighting: Technology and Perception, Wiley-VCH, 2015
16. J.R. Benya, D.J. Leban, Lighting Retrofit and Relighting: A Guide to Energy Efficient Lighting, John Wiley & Son, 2011
17. M.H. Rashid, Power Electronics Handbook: Devices, Circuits and Applications, Academic Press, 2010
18. Guidelines on Energy Efficiency of Lift and Escalator Installations, 2007 Edition, Electrical and Mechanical Services Department (EMSD), the Government of the HKSAR, Hong Kong
19. K.W.E.Cheng, Design and Fabrication of Electronics and Optical Systems for Advanced Automotive Lighting Systems, The Hong Kong Polytechnic University, 2007

Subject Description Form

Subject Code	EE533
Subject Title	Railway Power Supply Systems
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Collaboration Institute	MTR Academy
Objectives	1. To enable students to develop a comprehensive understanding of the modern railway power supply systems in metro and mainline systems. 2. To provide an appreciation of the specifications and design of the supply system configuration. 3. To enable students to understand the implications of supply system design on safety and service quality, as well as the practices and difficulties in implementation. 4. To provide students with the basic terminology and the practical processes of testing and commissioning. 5. To enable students to comprehend the connection of the railway supply system to the utility distribution network.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Identify the key components in a railway supply system and their functions and appreciate the relationship of the supply system to other systems in railway. b. Differentiate the requirements on power supply systems in different railway systems, metros, mainlines and light rails. c. Apply the knowledge on power supply system to comprehend the design and installation of power supply system. d. Discuss procedures of testing and commissioning of railway power system and analyse possible faults. e. Organise and present on assigned research topics. f. Recognise the importance to engage in self-learning on latest technologies on railway systems at this advanced level of study.
Subject Synopsis/ Indicative Syllabus	1. ***General aspect of railway power supply system*:** Metro system, Light rail system, electric multiple units and locomotives, functions of traction supply system, interface requirement among power and traction supply system, contact line system, permanent way, signalling, SCADA and train. 2. ***Railway power supply system – requirement and specification*:** Types of railway power supply systems, basic structure and design of standard AC distribution and DC traction substation and control system. 3. ***DC overhead line system and equipment*:** Terminology, overhead contact line types and basic characteristic; Basic design – mechanical, electrical and civil; Design for installation, testing and commissioning; failure analysis. 4. ***Traction earthing and DC stray current control system*:** Terminology, operation requirement and specification; DC current return, earthing and bonding; Design for installation, testing and commissioning; Failure analysis. 5. ***AC traction supply system and power quality issues*:** Configuration and operation of 25kV system; Power quality; Voltage dip, harmonics, imbalance, and remedial measures. Co-phase power supply and static compensators. 6. ***EMC*:** Principles of EMC, Railway-related interference problems and their solutions, booster transformer.

<table>
<tr><td></td><td>Case Study:
Site visit to MTR system
Industrial seminar</td></tr>
<tr><td>Teaching/Learning Methodology</td><td>The main lecturers are from MTRC, and their experiences/knowledge are shared with students via lectures and tutorials for conveying the concept and theories. The site visit to MTR system has reinforced the pragmatic design and application in a realistic system. Problem solving skill and team work are trained via minor project and laboratory.

<table>
<tr><td rowspan="2">Teaching/Learning Methodology</td><td colspan="6">Outcomes</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td><td>f</td></tr>
<tr><td>Lectures</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td><td>√</td></tr>
<tr><td>Tutorials</td><td></td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td></tr>
</table></td></tr>
<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td>
<table>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="6">Intended subject learning outcomes to be assessed</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td><td>f</td></tr>
<tr><td>1. Examination</td><td>60%</td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>2. Test</td><td>20%</td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>3. Presentation with Essay Submission</td><td>20%</td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>Total</td><td>100%</td><td colspan="6"></td></tr>
</table>
The outcomes on concepts, design and applications are assessed by the usual means of examination and test.

The problem solving skill is evaluated via presentation (with essay submission) and laboratory.</td></tr>
<tr><td>Student Study Effort Expected</td><td>
<table>
<tr><td>Class contact:</td><td></td></tr>
<tr><td>▪ Lecture/Tutorial</td><td>33 Hrs.</td></tr>
<tr><td>▪ Industrial/Research Presentation</td><td>6 Hrs.</td></tr>
<tr><td>Other student study effort:</td><td></td></tr>
<tr><td>▪ Presentation and Report preparation</td><td>24 Hrs.</td></tr>
<tr><td>▪ Self-study</td><td>42 Hrs.</td></tr>
<tr><td>Total student study effort</td><td>105 Hrs.</td></tr>
</table></td></tr>
<tr><td>Reading List and References</td><td>Textbooks:
1. B.S. Blanchard, Systems Engineering & Analysis, 5th Edition, John Wiley, 2011

Reference books:
1. Selected papers on IEE Proceedings on Electric Power Applications
2. Selected papers on IEE Proceedings on Power Systems</td></tr>
</table>

Subject Description Form

Subject Code	EE535
Subject Title	Maintenance and Reliability Engineering
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Collaboration Institute	MTR Academy
Objectives	1. To provide students with a comprehensive understanding on various maintenance management processes. 2. To enable students to understand the impact of maintenance management on railway objectives in safety, reliability and cost effectiveness. 3. To enable students to acquire knowledge and techniques in reliability engineering. 4. To equip students to make decisions on sound maintenance and reliability improvement. 5. To enable students to apply the techniques in reliability engineering to railway operation.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Identify the possible faults in railway systems and their impacts to the overall system reliability. b. Develop fault trees for a sub-system in railways and apply various reliability models on fault analysis. c. Discuss system data collection for reliability assessment. d. Evaluate maintenance schedules and assess the corresponding risk with appropriate techniques and tools. e. Review the advantages and limitations on condition based monitoring maintenance, alternative sourcing of inventory and maintenance outsourcing management for railway assets. f. Organise and present an assigned research topic. g. Recognise the importance to engage in self-learning on latest methodologies for system maintenance management at this advanced level of study.
Subject Synopsis/ Indicative Syllabus	**Reliability Engineering** 1. ***Reliability fundamentals*:** Reliability Mathematics. Failure distributions. Causes of failures and their treatment. Reliability apportionment and prediction. Reliability data books. Data Recording and Corrective Action System (DRACAS). 2. ***Reliability analysis and modelling methods*:** Fault tree analysis, Failure Mode Effects and Criticality Analysis (FMECA), Reliability block diagram, Reliability Growth Models – IBM and Duane Reliability Growth Modelling, Reliability testing. Monte Carlo Reliability Simulation. Weibull Analysis. **Maintenance Management** 3. ***Maintenance techniques and tools*:** Maintenance as an essential element for asset management. Reliability Centred Maintenance as a means for maintenance decision. Topics on conditioned based maintenance.

4. ***Management for business performance***: Computerized Maintenance Management System – from planning to implementation. Alternative spare sourcing. Maintenance outsourcing management for railway assets.

Case Study:

Site Visits to MTRCL Depot

Industrial/Research Seminars

Teaching/Learning Methodology

Video clips together with computer animations are used to supplement conventional lectures. Case studies will be used extensively to highlight the practicality of the subject materials being covered. Practitioners are also invited to have experience sharing sessions with the class. A group project is to be carried out to demonstrate and integrate the knowledge learned.

Teaching/Learning Methodology	Outcomes						
	a	b	c	d	e	f	g
Lectures	√	√		√			
Tutorials		√	√		√		√
Project Work	√	√	√	√	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed						
		a	b	c	d	e	f	g
1. Mini-project (group project)	20%		√		√	√	√	√
2. Tests	20%	√		√				
3. Examination	60%	√		√	√	√		
Total	100 %							

This is a specialist subject with bias on maintenance and reliability of railway assets, in particular on rolling stocks. A large number of case studies are discussed in the lectures and the outcomes are to test the understanding of the student on the underlying fundamentals through quizzes, mini-projects and written examinations.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	36 Hrs.
▪ Industrial/Research seminars	3 Hrs.
Other student study effort:	
▪ Assignment and Self-studies	66 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Textbooks:

1. V. A. Profillidis, Railway management and engineering, 3rd Edition, Burlington, Ashgate Pub. Co., 2006.
2. P. D. T. O'Connor, Practical Reliability Engineering, Wiley, 2006
3. Bury St Edmunds, Railway rolling stock, organized by the Railway Division of the Institution of Mechanical Engineers (IMechE) and the Institution of Civil Engineers (ICE) for IMechE, 2001

Subject Description Form

Subject Code	EE536
Subject Title	Signalling and Train Control Systems
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Collaboration Institute	MTR Academy
Objectives	1. To provide students with a comprehensive understanding on the basic principles and terminology of railway signalling. 2. To enable students to acquire knowledge on train control systems and their implications to safe and efficient railway operation. 3. To enable students to understand the design processes of signalling layout the control of signals. 4. To provide students with the basic concepts on the principles, means, instrumentation and commissioning of train detection and interlocking systems. 5. To appreciate the structure and components of an automatic train control system.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Identify the functions, operation principles and key components of a signalling system. b. Given track layout and signalling requirements, formulate a simple signalling layout. c. Describe the train detection methodologies and implementation considerations, and compare their advantages and limitations. d. Compare between relay interlocking and processor-based interlocking, their safety principles and commissioning plans. e. Explain the requirements and structure of an automatic train control system.
Subject Synopsis/ Indicative Syllabus	1. ***Basic signalling principles*****:** Safe operation of trains, prevention of trains collision and locking of points and routes; type of signalling, signal spacing and signalling layout; headways line capacity, headways for different types of signalling systems, factors affecting headways; control table, conditions for setting of routes, clearing of signals and locking of routes and points; aspect sequence, meaning of signal aspect and the circumstances under which signals display. 2. ***Train detection*****:** Track circuit, axle counter and advanced detection system; track circuit bonding; track circuit connections and maintenance of traction return at points and crossings. 3. ***Signalling interlocking*****:** Interlocking implementation based on relays, safety principles; processor based interlocking, interlocking implementation based on processors/computers, safety principles. 4. ***Principles of testing*****:** Competence, functional tests, scenario tests, independent test, test strategy, test plan, commissioning plan, records. 5. ***Automatic train control system*****:** Automatic train protection, automatic train operation and automatic train supervision. **Case Study:** Site visits to MTR train control centres Industrial/Research seminars

Teaching/Learning Methodology	Basic principles of signalling functions and operations are usually simple but they are always complicated by the implementation and practices in systems with unique requirements. Lectures are necessary to cover the fundamentals, supplemented by the examples and exercises from real-life applications. Site visits to the MTR Control Centres are also arranged so that the students are able to co-relate what they have learned to actual operations.

Teaching/Learning Methodology	Outcomes				
	a	b	c	d	e
Lectures	√	√	√	√	
Site visits		√		√	√
Industrial seminars					√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed				
		a	b	c	d	e
1. Examination	60%	√	√	√	√	√
2. Test	25%	√	√			
3. Assignments	15%	√	√			
Total	100%					

The examination is to evaluate the students' understanding of the underlying principles in general. Signalling involves signal layout and route setting, which requires substantial practical skills through exercises. Test and assignment provides the means to assess such practical design skills.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	33 Hrs.
▪ Industrial/Research seminars	6 Hrs.
Other student study effort:	
▪ Assignments	10 Hrs.
▪ Self-study	53 Hrs.
▪ Site visit	3 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Textbooks:

1. Edited by B. Ning, Advanced Train Control Systems, WIT, 2010

Reference books:

1. Proceedings of International Conferences on Computers in Railways, WIT Press
2. Selected papers on IRSE Proceedings
3. IRSE Green Book No. 27, Signalling the Layout
4. IRSE Green Book No. 29, Solid State Interlocking

Subject Description Form

Subject Code	EE537
Subject Title	Railway Vehicles
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Collaboration Institute	MTR Academy
Objectives	1. To provide students with a comprehensive understanding on design and applications of railway vehicles. 2. To ensure the students aware of the current state-of-the-art on design, operation and maintenance of railway vehicles in Hong Kong and overseas. 3. To enable students to understand the procurement process of railway vehicles and the necessary management. 4. To acquire knowledge on the components in railway vehicles and their modelling for analysis. 5. To appreciate the testing standards for vehicles; and the inspection and quality control measures.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Identify various types and configurations of railway vehicles. b. Discuss the design principles and system performance of railway vehicles and be aware of the latest development in the technology. c. Elaborate on the project management process for railway vehicle procurement and devise feasibility study and maintenance planning. d. Apply appropriate modelling for vehicles, body design and train dynamics in vehicle performance analysis. e. Given the acceptance standards, formulate tests and inspection for quality control purposes. f. Appreciate the role of engineers on matters other than technical issues. g. Recognise the importance to engage in self-learning on latest technologies on railway vehicle design at this advanced level of study.
Subject Synopsis/ Indicative Syllabus	1. ***Project management for procurement of railway vehicle*:** Planning and preliminary design, System selection, definition of vehicle, specification, design management, testing and commissioning, maintenance planning. 2. ***Railway vehicle design and development*:** Types and configurations of railway vehicles, design principles, system performance, Interface and environmental considerations, modern development. 3. ***System description and mechanism design*:** Carbody, bogie, coupler, door, brake, pneumatics, air-conditioning, traction and control, pantograph, and train management system. 4. ***Vehicle modelling and gauging*:** Rail vehicle components, suspension system, modelling of vehicles and analysis, kinetic envelope, load gauge. 5. ***Vehicle structures and dynamics*:** Body shell design, load cases, structural testing and analysis, fundamentals of train dynamics, wheel rail interface, track geometry effect, derailment prediction. 6. ***Vehicle acceptance and testing*:** Acceptance standards, type test, inspection and quality control, static testing, dynamic runs, trial operation and reliability monitoring.

Case Study:
Site Visits to MTRCL Depots
Industrial/Research Seminars

Teaching/Learning Methodology

The main lecturers are from MTRC, and their experiences/knowledge are shared with students via lectures and tutorials for conveying the concept and theories. The site visit to MTR system has reinforced the pragmatic design and application in a realistic system. Problem solving skill and team work are trained via minor project.

Teaching/Learning Methodology	Outcomes						
	a	b	c	d	e	f	g
Lectures	√	√	√	√	√	√	√
Tutorials		√	√	√	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed						
		a	b	c	d	e	f	g
1. Examination	60%	√	√	√	√	√	√	
2. Test	25%	√		√	√	√	√	
3. Presentation with Essay Submission	15%	√	√	√	√	√	√	√
Total	100%							

The outcomes on concepts, design and applications are assessed by the usual means of examination and test.
The problem solving skill is evaluated via presentation (with essay submission).

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	33 Hrs.
▪ Presentation seminar	3 Hrs.
▪ Site visit	3 Hrs.
Other student study effort:	
▪ Presentation preparation/report	24 Hrs.
▪ Self-study	42 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Textbooks:
1. A.H. Wickens, Fundamentals of Rail Vehicle Dynamics: Guidance and Stability, Swets & Zeitlinger Publishers, 2003

Reference books:
1. Selected papers from the Proceedings of IMechE Part F – Journal of Rail and Rapid Transit

Subject Description Form

Subject Code	EE539
Subject Title	Aerospace Power Electronics and Actuation Systems
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	1. To provide engineers with in depth knowledge of the use of power electronics and actuation systems in the aerospace industry. 2. To provide latest development and applications in power conversion, electric actuator, fly-by-wire, fly-by-light and space power engineering.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Have the ability to acquire a good understanding of aircraft actuation systems. Be able to present the understanding of the basic requirements of aircraft actuation systems. b. Understand and analyse power system needed for the aerospace applications. Be able to present the understanding of power systems for aircrafts. c. Understand the power electronics needs to military devices and space applications. Be able to present the understanding of the basic requirements of power electronics to aerospace environment.
Subject Synopsis/ Indicative Syllabus	1. ***More electric aircraft***: Basic concept of more electric aircraft, review of electric systems of aircraft, wiring and cabling, cabin lighting and utilities, electric aircraft 2. ***Aircraft power electronics***: Soft power system, rectifier units, distribution systems, and power supplies. 3. ***Actuation systems***: Review of hydraulic and electro-hydraulic control systems, hydraulic servo valve, fuel pump, landing gear, secondary flight control system, flux-reverser. 4. ***Aerospace standards***: Military standards, British standards on aerospace, and NASA standards. 5. ***Aerospace and aeronautic control:*** Reliability, fly-by-wire, fly-by-light, unmanned air vehicles, propulsion, aeronautic computing system and gyroscope. 6. ***Military power electronics and actuation***: Packaging for Military-standard, missile control and guidance system, E-bomb. 7. ***Space power engineering***: Ion-thrusters, rocket power electronics and system, power conversion and energy storage in space, space transportation, and photovoltaic system. **Laboratory Class:** Each student is required to conduct a laboratory test or attend a demonstration to understand the aerospace devices and components. **Assignment and mini-project:** Each student is required to work on a mini-project which covers the above selected areas. Written report and presentation are needed.

Teaching/Learning Methodology	Lectures and tutorials are the primary means of conveying the basic concepts and theories. Experiences on design and practical applications are given through a practical case study, in which the students are expected to understand design problems with real-life constraints and to attain pragmatic solutions.

Teaching/Learning Methodology	Outcomes		
	a	b	c
Lectures	√	√	√
Tutorials	√	√	√
Assignment/Presentation	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed		
		a	b	c
1. Examination	60%	√	√	√
2. Tests	20%	√	√	√
3. Report/Presentation/ Assignment	20%	√	√	√
Total	100%			

One end-of-semester written examination; test(s); a laboratory report; a power point presentation and report for the particular topic.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	30 Hrs
▪ Laboratory	6 Hrs
▪ Test/Presentation	3 Hrs
Other student study effort:	
▪ Case Study	18 Hrs
▪ Self-study	48 Hrs
Total student study effort	105 Hrs

Reading List and References

Reference books:

1. Selected articles from Military and Aerospace Electronics, PennWell Publishing Company
2. Selected articles from Defense & Aerospace Electronics, Pasha Publications, Inc.
3. A.M. Cruise, J.A. Bowles, T.J. Patrick, C.V. Goodall, Principles of Space Instrument Design, Cambridge University Press, 2006
4. Noah D. Manring, Fluid Power Pumps and Motors: Analysis, Design and Control McGraw-Hill Education, 2013
5. M. Jelali, A. Kroll, Hydraulic Servo-systems: Modelling, Identification and Control, Springer, 2013
6. R.P.G. Collinson, Introduction to Avionics Systems, Kluwer Academic, 2011.
7. I. Moir, A. Seabridge, Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, Wiley, 2012.
8. P.Thalin, Fundamentals of Electric Aircraft, SAE International, 2018.

Subject Description Form

Subject Code	EE545
Subject Title	Modern Generation and Grid Integration Technologies
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Students are expected to have substantial knowledge about electrical power systems. Exclusion: EE501
Collaboration Institute	HK Electric Institute
Objectives	1. To enable students to establish a broad concept on modern power generation technologies, including local relevant renewable energy and gas turbines. 2. To enable students to understand typical renewable energy technologies and related energy storage systems, its associated characteristics, performance, issues of application and related technical considerations. 3. To provide an in-depth knowledge on gas turbine power plants, combined cycle systems, cogeneration and trigeneration systems. 4. To enable students to understand how to integrate renewable energy into power grid, its related issues, concept of micro grid, smart grid, distributed generation and distribution automation.
Intended Learning Outcomes	Upon Completion of the subjects, student will be able to: a. Identify suitable renewable energy source and fuel-mix for electricity generation in Hong Kong under current situations b. Explain the principle of operation for the generation technologies, including their integration into the modern power grid or micro grids. c. Design the overall architecture for the power generation systems and the interfacing parts, and analysis their performance.
Subject Synopsis/ Indicative Syllabus	1. Energy resources and types (1.5 weeks): Renewable and non-renewable energy resources. World potential and trends. Environmental effects. Local relevant renewable energy types and present developments. Role and importance of renewable energy. 2. Wind and solar energy (2 weeks): Overview of wind energy, wind turbine technology, onshore and offshore wind farms, planning considerations for offshore wind farm, wind resource assessment, wind farm siting and optimization, case study. PV technology, PV panel comparison (performance, cost) and criteria for PV module selection, photovoltaic conversion systems, feasibility study and site selection, design and monitoring techniques, new development in PV technology, case study. 3. Energy storage technology (2 weeks): Types of utility scale energy storage systems and the associated power electronic systems and energy management: pumped water storage, hydroelectric dams, batteries, supercapacitors, superconducting magnetic energy and hydrogen storage. Concept of vehicles-to-grid. 4. Gas turbine and cogeneration technology (1 week): comparison of its emission with other fossil fuel plants. Types of gas turbines and its characteristics and operation features. Combined cycle, cogeneration and trigeneration. Major equipment of a Combined Cycle Generation Unit, Thermal cycle and performance indices of combined cycle generation unit.

	5. Electrical System in a Power Generation Plant (1 week): Theory of Electricity Generation, Major Electrical Equipment and Machines of a Generation Unit, Power Distribution Systems in a Power Plant, Case study. 6. Grid integration (3 weeks): Integrating renewable energy sources into the power grid, the issues, the associated power electronic systems and its design, load levelling, energy demand response & management, related power dispatching issues. Complementary characteristics among RE sources and energy storages. Case studies: possible example is Longyangxia Dam Solar Park and Alto Rabagao Solar Dam. Applications of smart grids in this area. Concept of micro-grid and distributed generation & distributed automation. 7. Application examples, demonstration and trends (1.5 weeks): Demonstration projects or case study on micro-grid, smart meters, distributed automation, co-generation, trigeneration and vehicle-to-grid concept. Future trends. **Note:** 1 week is reserved for test(s) and revision. **Site Visit in a weekend:** Lamma Power Station and Lamma Winds 1. L9 Combined-Cycle Generation Unit 2. Gas Receiving Station 3. PV Solar Panel System 4. Wind Turbine
Teaching/Learning Methodology	Delivery of the subject is mainly through formal lectures, complemented by tutorials, work examples/case studies and a visit/ demonstration. Self-learning on the part of students is strongly encouraged and extensive use of web resources will be made. Assignments, in-class assignments, tests and final examination will be the assessment tools.

Teaching/Learning Methodology	Outcomes		
	a	b	c
Lectures	√	√	√
Work examples/ case studies	√	√	√
Visit/demonstration		√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed		
		a	b	c
1. Examination	60%	√	√	√
2. Tests	15%	√	√	√
3. Assignments	15%	√	√	√
4. In-class assignments	10%	√	√	
Total	100%			

This is an advanced and yet appreciation subject for students who are interested in power and energy systems. The outcomes are assessed by usual means of examination, tests and assignments.

Student Study Effort Expected	Class contact:	
	▪ Lecture/Tutorial	39 Hrs.
	Other student study effort:	
	▪ Assignment and Self-study	66 Hrs.
	Total student study effort	105 Hrs.
Reading List and References	1. Ibrahim Dincer and Calin Zamfirescu, "Advanced power generation systems", Elsevier Science, 2014 2. Nicu Bizon, "Advances in energy research : distributed generations systems integrating renewable energy resources", Nova Science Publishers, 2011 3. IEA, "The power of transformation : wind, sun and the economics of flexible power systems", PECD Publishing 2014 4. Mukund R Patel, "Wind and solar power systems : design, analysis, and operation", CRC Press 2006 5. Rolf Kehihofer, "Combined-cycle gas & steam turbine power plants", PennWell, 2009 6. Masoos Ebrahimi and Ali Keshavarz, "Combined cooling, heating and power : decision-making, design and optimization", Elsevier, 2015 7. Ashok D Rao, "Combined cycle systems for near-zero emission power generation", Oxford England : Woodhead Pub., 2012 8. Q Zhong and T Hornik, "Control of power inverters in renewable energy and smart grid integration", John Wiley & Sons, 2013 9. Antonio Moreno-Munoz, "Large scale grid integration of renewable energy sources", IET 2017 10. Ali Keyhani, "Design of smart power grid renewable energy systems", Wiley, 2011 11. Fereidon P Sioshansi, "Smart grid integrating renewable, distributed & efficient energy", Elsevier/Academic Press, 2011 12. K. Salman, "Introduction to the Smart Grid: concepts, technologies and evolution", IET 2017	

Subject Description Form

Subject Code	EE550
Subject Title	Enterprise Risk and Asset Management
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Collaboration Institute	MTR Academy
Objectives	1. To allow students to appreciate how enterprise risk management and asset management contribute to business sustainability of railway operation and the required organisation. 2. To provide students with basic understanding of Enterprise Risk Management in railway industry. 3. To provide students with comprehensive understanding on asset management for railways and the concept and principles of which are also applicable to other industry sectors. 4. To enable students to acquire knowledge on the key asset management processes and techniques adopted. 5. To enable students to apply international standard and practices on asset management.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Understand the key elements of asset management and ERM framework, international standards and critical success factors for system implementation. b. Appreciate the asset management and enterprise risk management techniques. c. Recognise the importance to engage in self-learning on latest industry best practices on asset management at this advanced level of study.
Subject Synopsis/ Indicative Syllabus	1. ***Enterprise Risk Management*** • Enterprise Risk Management (ERM) framework • Risk management organisation for ERM • Risk aggregation and reporting, risk categorization and measurement, risk identification and assessment, risk control and responses, review and audit • Critical success factors for ERM • Application of ERM in typical railway system 2. ***Asset Management*** **Asset Management Framework** • Introduction to ISO55000:2014 • Alignment with corporate asset management direction • Asset management organizations • Asset management and business sustainability **Enabling Processes for Asset Management** • Establishment and measurement for levels of service • Demand forecasting and management • Risk management for asset management • Condition assessment and performance monitoring • Reliability Centred Maintenance • Asset criticality • Maintenance management planning

	• Asset investment and reinvestment decision making • Value engineering, life cycle costing & Internal Rate of Return • Audit and management review for asset management **Asset Management Information Systems and Data Management** • Asset management information system • Data structure and numbering • Data collection and management • Data analytics and machine learning for asset management **Case Study:** Case studies of asset management and ERM techniques and practices Industrial/Research seminars
Teaching/Learning Methodology	The concept of risk and asset management, reliability analysis and system assurance analysis will be presented through lectures and tutorials with reference to real-life applications on railway and related systems. Students will be required to form groups to work through cases covering practices on the real-life cases. Guest lectures are structured on appropriate sessions for relating the theoretical concepts real-life to practices. Students are required to share, present and defense their finding on their case studies.

Teaching/Learning Methodology	Outcomes		
	a	b	c
Lectures	√	√	√
Case Studies	√	√	√
Discussion Forum and Presentation	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed		
		a	b	c
1. Examination	60%	√	√	√
2. Class Test	20%	√	√	
3. Case study report	20%	√	√	√
Total	100%			

The outcomes on the concepts of analysis are assessed by the usual means of examination and test whilst those on practical application, problem-solving techniques and presentation of findings, as well as technical reporting and teamwork, are evaluated by the case study exercise.

Student Study Effort Expected

Class contact:	
▪ Lecture	33 Hrs.
▪ Guest Lecture	6 Hrs.
Other student study effort:	
▪ Case study preparation/report	18 Hrs.
▪ Self-study	48 Hrs.
Total student study effort	105 Hrs.

Reading List and References

Reference books/journals:
1. ISO55000 : 2014 and ISO55001 :2014
2. ISO 31000: 2009 Risk management – Principles and guidelines
3. BS 31100: 2008 Risk management – Code of practice

Subject Description Form

Subject Code	EE560
Subject Title	Metros in Hong Kong and China
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Collaboration Institute	MTR Academy
Objectives	To provide students through lectures, site visits and exchanges with Metro personnel; an overview knowledge and an appreciation of Metro operations, business and projects, using systems in Hong Kong and China as illustrations.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. demonstrate an understanding of the fundamentals of metro operations and management b. acquire a comprehensive knowledge of key engineering systems in metros to pave the way for more advanced studies c. appreciate the key issues in the planning and implementation of metro projects.
Subject Synopsis/ Indicative Syllabus	1. Introduction a. Objectives and key attributes of Metros b. Major components of a Metro c. Role of Metros in public transport d. A survey of operating Metros in Hong Kong and China. e. Future development of Metros in Hong Kong and China. 2. Key systems in Metro a. Trains b. Trackwork and civil infrastructure c. Signalling, control and communication systems d. Power supply system e. Station facilities f. System integration and system assurance 3. Metro Operation a. Train operation b. Station operation c. Depot operation d. Asset maintenance e. Key performance indicators f. Safety and risk management 4. Metro business a. Customer services b. Non-fare business c. Fare policy and strategy 5. Metro Project a. Project planning b. Project implementation c. Funding of projects

<table>
<tr><td>Teaching/Learning Methodology</td><td>a) Lectures – 30 hours
b) Site visits
c) Tutorial/Discussion with Metro personnel – 9 hours

Core subject knowledge will be delivered in the lectures, site visits will enhance the students' understanding on the subject contents, while tutorials and discussion with Metro personnel will give more details on the real world practices.

<table>
<tr><td rowspan="2">Teaching/Learning Methodology</td><td colspan="3">Outcomes</td></tr>
<tr><td>a</td><td>b</td><td>c</td></tr>
<tr><td>Lectures</td><td>√</td><td>√</td><td></td></tr>
<tr><td>Tutorials</td><td>√</td><td></td><td>√</td></tr>
</table></td></tr>
<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td><table>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="3">Intended subject learning outcomes to be assessed</td></tr>
<tr><td>a</td><td>b</td><td>c</td></tr>
<tr><td>1. Mini project/assignments</td><td>40%</td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>2. Examination</td><td>60%</td><td></td><td>√</td><td>√</td></tr>
<tr><td>Total</td><td>100%</td><td colspan="3"></td></tr>
</table>
Candidates are expected to select a mini-project from the wealth of case studies to demonstrate their understanding of the metro systems. The examination covers both practical and theoretical aspects of the major issues to be considered in the design and planning of metro systems in both Hong Kong and Mainland.</td></tr>
<tr><td>Student Study Effort Expected</td><td><table>
<tr><td>Class contact:</td><td></td></tr>
<tr><td>▪ Lectures</td><td>30 Hrs.</td></tr>
<tr><td>▪ Tutorials</td><td>9 Hrs.</td></tr>
<tr><td>Other student study effort:</td><td></td></tr>
<tr><td>▪ Site Visits</td><td>9 Hrs.</td></tr>
<tr><td>▪ Self-study</td><td>57 Hrs.</td></tr>
<tr><td>Total student study effort</td><td>105 Hrs.</td></tr>
</table></td></tr>
<tr><td>Reading List and References</td><td>1. Hirsch, R. (Ed), (2007), 'Managing Railway Operations and Maintenance: Best Practices from KCRC', University of Birmingham Press
2. Industry specific codes of practice, procedures, standards and manuals</td></tr>
</table>

Subject Description Form

Subject Code	EE570
Subject Title	Design and Analysis of Smart Grids
Credit Value	3
Level	5
Pre-requisite / Co-requisite/ Exclusion	Nil
Objectives	1. To provide students with a comprehensive understanding on design and analysis of smart grids; 2. To ensure the students aware of the current state-of-the-art on design, operation and control of smart grid; 3. To acquire knowledge on the components in smart grids and their functions; and 4. To enable students to apply advanced analysis tools in planning and operation of smart grids.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Acquire in-depth understanding on recent development of power grids, i.e. smart grid; b. Apply advanced analysis tools in planning and operation of smart grids; and c. Acquire skills in presentation and interpretation of results in written form.
Subject Synopsis/ Indicative Syllabus	1. ***Introduction to smart grid (1.5 week)*****:** Overview of power system operation; Comparison between existing grid and smart grid; Objectives; Benefits; Challenges; Basic structure and functions of components. 2. ***Communications and measurement (1.5 weeks*****):** Latest technologies; Wide Area Monitoring Systems (WAMS), Phasor Measurement Units (PMU), Smart Meters, Smart Appliances, and Advanced Metering Infrastructure (AMI); GIS and Google Mapping Tools; Multiagent Systems Technology. 3. ***Micro-grid (2 weeks)*****:** Concept of micro-grid; design and analysis; distributed generation; distributed automation. 4. ***Renewable energy and storage (2 weeks)*****:** Renewable energy resources and options for smart grid including solar energy, wind energy, fuel cell, biomass etc.; Penetration and variability; Demand Response; Electric vehicles and plug-in hybrid; Battery energy storage systems. 5. ***Interoperability, standards and cyber security (2 week):*** State-of-the-art, Benefits, Challenges, Risks. 6. ***Analysis tools (3 weeks)*****:** Power/load flow studies; Static security assessment; State estimation and stability assessment; Reliability assessment; Decision support tools; Advanced optimization and control; Environmental impacts; Pathway for designing smart grid. 7. ***Application examples and its trends (1 week)*****:** Demonstration projects; Testbeds and benchmark systems; Future trends; Research, education and training.

Teaching/Learning Methodology	Lectures and tutorials are the primary means of conveying the concepts and theories. Mini-projects are designed to supplement the lecturing materials so that the students are encouraged to take extra readings and the latest development of the smart grids.

Teaching/Learning Methodology	Outcome		
	a	b	c
Lectures	√	√	
Tutorials		√	√
Mini-project		√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed		
		a	b	c
1. Examination	63%	√	√	
2. Class test	18%	√	√	
3. Mini-project	19%		√	√
Total	100%			

Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

The outcomes on understanding on development of smart grid and application of advanced analysis tools are assessed by the usual means of examination and tests. Mini-projects and written reports assess those on analytical skills, problem-solving techniques and technical reporting.

Student Study Effort Expected

Class contact:	
▪ Lectures	36 Hrs.
▪ Tutorial	3 Hrs.
Other student study effort:	
▪ Self-study	50 Hrs.
▪ Mini-project	16 Hrs.
Total student study effort	105 Hrs.

Reading List and References

1. P. Sioshansi, "Smart Grid: Integrating Renewable, Distributed & Efficient Energy," Elsevier Inc., 2012.
2. J.A. Momoh, "Smart Grid: Fundamentals of Design and Analysis," 2012 IEEE, John Wiley & Sons, Inc., 2012.
3. Peter Fox-Penner, "Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities," Island Press, 2010.

Subject Description Form

Subject Code	EE5381
Subject Title	System Assurance and Safety in Railways
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Exclusion: EE538
Collaboration Institute	MTR Academy
Objectives	1. To allow students to appreciate the importance of safety in railway operation and the required organisation for hazard management. 2. To provide students with a comprehensive understanding on the relationship between railway safety and service performance objectives and application of methodologies of system assurance and safety risk. 3. To enable students to acquire knowledge on the key management processes and analysis techniques adopted in various project phases. 4. To enable students to apply international standards on railway system assurance and safety risk. 5. To enable students to acquire hand-on experience from railway operators on system assurance and safety risk practices.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Identify safety performance indicators and the safety risk principles to produce such indicators. b. Given a railway sub-system, devise the simple safety risk ranking and matrices; and carry out hazard operability study. c. Conduct various system assurance analyses with different techniques to ensure fulfillment of international standards for different purposes. d. Organise safety committees, formulate system assurance programme planning and develop safety cases. e. Analyse the collected safety statistics and plan the hazard registration system. f. Appreciate the safety management skills required in engineering systems g. Recognise the importance to engage in self-learning on latest technologies on railway systems at this advanced level of study.
Subject Synopsis/ Indicative Syllabus	1. ***Safety Risk Assessment***: Railway safety performance, lifecycle safety management process, ALARP (As Low AS Reasonably Practicable) principle, societal perception of risk, risk ranking and matrices, closed-loop risk management process, tolerability of risk and formulation of risk criteria, value of preventing a fatality, equivalent fatality, risk mitigation principle 2. ***System Assurance Analysis Techniques & Standards***: Hazard & operability study, use of guidewords in identification of hazards, fault tree analysis, event tree analysis, cause-consequence analysis, preliminary hazard analysis, operation & support hazard analysis, cost-benefit analysis, qualitative and quantitative risk analyses, system safety modelling, classification of safety critical items, human error & system safety, safety integrity level & software, MIL STD 882D, IEC 61508, EN50126, BS 5760 3. ***Organisation & Programme Management***: Safety committees, system assurance programme planning, structure of system safety report/safety Case, in-service safety risk monitoring programme, collection and use of safety statistics, hazard registration system, hazard management organisation.

Case Study:

MTRCL System assurance practices

Industrial/Research seminars

Teaching/Learning Methodology

<u>Lectures and tutorials are effective teaching methods:</u>

1. To provide an overview or outline of the subject contents.
2. To introduce new concepts and knowledge to the students.
3. To explain difficult ideas and concepts of the subject.
4. To allow students to feedback on aspects related to their learning.

<u>Mini-project works/Assignments are essential ingredients of this subject:</u>

1. To supplement the lecturing materials.
2. To add real experience for the students.
3. To provide deeper understanding of the subject.
4. To enable students to organise principles and challenge ideas.

<u>Case studies:</u>

1. To give real examples for some of the concept presented in the lectures.
2. To explain some practical considerations when applying technologies in real projects
3. To motivate and stimulate students interest

Teaching/Learning Methodology	Outcomes						
	a	b	c	d	e	f	g
Lectures	√	√	√	√	√		
Tutorials			√	√	√		
Mini-project works/Assignments					√	√	√
Case studies						√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed						
		a	b	c	d	e	f	g
1. Examination	60%	√	√	√	√	√		
2. Class Test	20%	√	√	√	√	√		
3. Assignments/Mini-project works	20%			√		√	√	√
Total	100%							

The understanding on theoretical principle and practical considerations, analytical skills and problem-solving technique will be evaluated. Examination, class tests, assignments, presentations and mini-project report are an integrated approach to validly assess students' performance with respect to the intended subject learning outcomes.

Student Study Effort Expected	Class contact:	
	▪ Lecture/Tutorial	39 Hrs.
	Other student study effort:	
	▪ Assignment/Mini Project	21 Hrs.
	▪ Self-study	45 Hrs.
	Total student study effort	105 Hrs.
Reading List and References	**Textbooks:** 1. D.J. Smith, Reliability, Maintainability and Risk, 5th Edition, Butterworth-Heinemann, 1997 2. J.D. Andrews and T.R. Moss, Reliability and Risk Assessment, Longman, 1993 3. F. Redmill, M. Chudleigh and J. Catmur, System Safety: HAZOP and Software HAZOP, Wiley, 1999 **Reference books/journals:** 1. EN50126:1999 "Railway Applications – The specification and Demonstration of Reliability, Availability, Maintainability and Safety" 2. MIL -STD-882D "Standard Practice for System Safety", Department of Defence, USA	

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