CONTENTS

ELECTRICAL ENGINEERING

Electrical Engineering - Volume 1
No. of Pages: 538
ISBN: 978-1-905839-77-3 (eBook)
ISBN: 978-1-84826-977-4 (Print Volume)

Electrical Engineering - Volume 2
No. of Pages: 506
ISBN: 978-1-905839-78-0 (eBook)
ISBN: 978-1-84826-978-1 (Print Volume)

Electrical Engineering - Volume 3
No. of Pages: 466
ISBN: 978-1-905839-79-7 (eBook)
ISBN: 978-1-84826-979-8 (Print Volume)

For more information on e-book(s) and Print Volume(s) order, please click here

Or contact: eolssunesco@gmail.com
CONTENTS

Preface xxv

VOLUME I

Electrical Engineering 1
Kit Po Wong, School of Electrical and Electronic Engineering, University of Western Australia, Perth, Australia and Department of Electrical Engineering, Hong Kong Polytechnic University, Hong Kong, China

1. Introduction: Live Power
2. Pre-1800: Charged Times
3. Electricity as a Science: Electromagnetism and Circuit Theory
4. Engineering Electricity: Important Direct Current Devices
   4.1. DC Generators
   4.2. The Telegraph System
   4.3. Arc Lamps
   4.4. DC Motors
5. Selling Electricity: Asphyxiating Gas
6. Centralized Power: Battle of the Currents
7. A Material World: Conducting Materials
8. Sending the Right Signals: Communications, Control, and Measurements
   8.1. Signal Processing
   8.2. Industrial Control
   8.3. Measurement and Instrumentation
   9.1. Traditional Electricity Utility Structures
   9.2. Grounds for a Competitive Electricity Market
   9.3. Deregulation and Privatization
   9.4. The Development of Electricity Markets
   9.5. Basics of Electricity Market Structure
   9.6. New Technologies

Electric and Magnetic Circuits and Fields 34
Loi Lei Lai, Head, Energy Systems Group, City University, London, UK

1. Introduction
2. Electric and Magnetic Circuits and Fields
   2.1. Electric Circuits
   2.2. Magnetic Circuits
   2.3. Electric Field
   2.4. Magnetic Field
3. Integration of Circuit and Field Theories
   3.1. Current Distribution and Losses
4. Introduction to Amplifiers
   4.1. Operational Amplifiers
   4.2. Differential Amplifier
   4.3. Negative Feedback -Non-inverting Amplifiers
   4.4. Frequency Response of Operational Amplifier Circuit
   4.5. Active Filters using Operational Amplifiers
5. Active Filters for Power Quality Improvement
   5.1. Active Filter Classification
      5.1.1. Classification by Purposes
      5.1.2. Classification by System Configuration
5.1.2.1. Shunt Active Filters and Series Active Filters
5.1.2.2. Hybrid Active/Passive Filters
5.1.3. Classification by Control Strategy
  5.1.3.1. Time-domain and Frequency-domain Approach
  5.1.3.2. Harmonic Detection Approach
6. Biological Effects of Electromagnetic Fields
  6.1. Time-varying Electric and Magnetic Fields with Frequencies less than 100 kHz
  6.2. Radio-frequency Radiation at Frequencies between 100 kHz and 300 GHz
  6.3. Guidelines
  6.4. Reports and Views from Scientific Organizations
7. Conclusions

Electric and Magnetic Fields
Kwang Y. Lee, Department of Electrical Engineering, The Pennsylvania State University, University Park, PA 16802, U.S.A.

1. Introduction
2. Electrostatic Fields
   2.1. Electric Charge
   2.2. Electric Field
   2.3. Gauss’ Law
   2.4. Electrostatic Potential
   2.5. Capacitance
      2.5.1. Conductors in Electrostatic Fields
      2.5.2. Insulating Materials in Electric Field
      2.5.3. Capacitance
      2.5.4. Calculation of Capacitance
      2.5.5. Energy Stored in a Capacitor
   2.6. Electric Currents
3. Magnetic Fields
   3.1. Lorentz Force
   3.2. Force on a Wire
   3.3. Hall Effect
   3.4. Biot-Savart Law
   3.5. Electromagnetic Induction
   3.6. Maxwell’s Equations
4. Conclusions

Electromagnetic Devices and Magnetic Circuits
W. L. Chan, Department of Electrical Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, P R China
K. K. Li, Department of Electrical Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, P R China

1. Introduction
2. Magnetic Materials
   2.1. Ferromagnetic Materials
   2.2. Iron-core Losses
3. Magnetic Circuit
4. Energy and Co-energy Calculation
   4.1. Electromechanical Energy Conversion
   4.2. Forces in Magnetic Structures
   4.3. Moving Iron Transducers
5. Electromagnetic Devices
   5.1. Magnetic Levitation and Propulsion
   5.2. Relay
ELECTRICAL ENGINEERING

5.3. Solenoids  
5.4. Magnetic Resonance Imaging  
5.5. Loudspeakers  
5.6. Microphones

**Direct Current and Alternating Current Systems**

Naganathy Rajkumar, *Research Fellow, Energy Systems Group, City University Northampton Square, London EC1V 0HB, UK*

1. Introduction  
   1.1. History of Electricity Distribution

2. Theory of Electric Circuits  
   2.1. Circuit Elements  
       2.1.1. Resistance  
       2.1.2. Inductance  
       2.1.3. Capacitance  
       2.1.4. Reactance  
       2.1.5. Impedance

   2.2. Electric Power

3. Three-phase systems  
   3.1. Power in Three-phase Systems  
       3.1.1. Star-connection  
       3.1.2. Delta-connection

4. The Electric Power System  
   4.1. Constraints on Transmission Networks  
       4.1.1. Voltage Constraints  
       4.1.2. Current Constraints  
       4.1.3. Operating Constraints

   4.2. Methods to Improve Transmission Capability  
       4.2.1. Voltage Constraints  
       4.2.2. Current Constraints  
       4.2.3. System Operating Conditions  
       4.2.4. Stability Control

5. High Voltage Direct Current (HVDC) Transmission  
   5.1. HVDC System  
   5.2. Types of HVDC Systems  
       5.2.1. Back-to-back System  
       5.2.2. Two-terminal System  
       5.2.3. Multi-terminal System

   5.3. Comparison of Power Transmission Capacity of HVDC and AC  
   5.4. Major Advantages of DC Transmission

   5.5. Major Disadvantages of DC Transmission

6. Flexible AC Transmission System (FACTS)  
   6.1. FACTS devices  
       6.1.1. Static VAr Compensator (SVC) and Static Synchronous Compensator (STATCOM)  
       6.1.2. Thyristor-Controlled Series Compensator (TCSC) and Static Synchronous Series Compensator (SSSC)  
       6.1.3. Phase Shifting Transformer (PST)  
       6.1.4. Interphase Power Controller (IPC)  
       6.1.5. Unified Power Flow Controller (UPFC)

   6.2. Location of FACTS  
   6.3. Benefits of FACTS

   6.4. FACTS Applications  
       6.4.1. SVC  
       6.4.2. STATCOM  
       6.4.3. TCSC  
       6.4.4. UPFC
7. Power Quality
   7.1. Harmonics
      7.1.1. Harmonic Resonance
      7.1.2. Magnitudes of Harmonic Components
      7.1.3. Methods of Harmonics Reduction
   7.2. Future of Power Quality

Network Analysis
Albert Ting Pat So and Wai L. Tse, Department of Building and Construction, City University of Hong Kong, Hong Kong, China

1. Introduction
2. Passive Components
   2.1. Resistors
   2.2. Capacitors
   2.3. Inductors
3. Voltage and Current Sources
4. Circuits
   4.1. Single-phase Circuits
   4.2. Three-phase Circuits
5. Ohm’s Law, Kirchhoff’s Voltage Law and Kirchhoff’s Current Law
   5.1. Ohm’s Law
   5.2. Kirchhoff’s Voltage Law
   5.3. Kirchhoff’s Current Law
6. Node and Mesh Analysis
   6.1. Node Analysis
   6.2. Mesh Analysis
7. Network Theorems
   7.1. Linearity
   7.2. Superposition Theorem
   7.3. Thevenin’s Theorem
   7.4. Norton’s Theorem
   7.5. Tellegen’s Theorem
   7.6. Reciprocity Theorem
   7.7. Substitution Theorem
   7.8. Compensation Theorem
   7.9. Maximum Power Transfer Theorem
8. Two-Port Networks
   8.1. Introduction
   8.2. Open-circuit Impedance Parameters
   8.3. Short-circuit Admittance Parameters
   8.4. Equivalent Relationship between T and “Π” Networks
9. Advanced Circuit Analysis techniques
   9.1. Fourier Analysis
   9.2. Wavelet Analysis

Electric Power Conversion System Synthesis - Theory and Practice
Patrick Chi-Kwong Luk, Cranfield University, Department of Aerospace, Power and Sensors, UK
Kahalil El Khamlichi Drissi, LASMEA, Université Blaise Pascal, Aubiere Cedex, FRANCE.

1. Introduction
2. Rapid Increase in Electronically Powered Applications
   3.1. Primitive DC-DC Converter
   3.2. Unified Model
4. Resonant Converters
4.1. Elementary Resonant Switch
4.2. Systematic Synthesis of Quasi-Resonant Converters
   4.2.1. Development of Energy State Equation
   4.2.2. Identification of Different Circuit States
   4.2.3. Insertion of Switches
   4.2.4. Regulation Process
5. Applications
6. Conclusion and Trends in the 21st Century

Active Networks
Davor Vujatovic, Engineering Manager, EDF Energy Services Ltd., UK

1. Types of Electric Networks
   1.1. Definitions for Active and Passive Components
   1.2. Alternative Definitions
       1.2.1. Modeling a Capacitor
       1.2.2. Modeling an Inductor
       1.2.3. Alternative Definition of Active Circuits
   1.3. Active Circuits in Power Electronics
2. Active Filters
   2.1. Voltage Source Inverter (VSI) as Active Filter
3. Power in Three Phase Systems
   3.1. Alternative Expressions
   3.2. Active Filter Compensation Strategy Based on p-q theory
4. Simulation
   4.1. Implementation of the Active Filter
   4.2. Simulations Results
5. Conclusion

Signals and Systems
Yee Hong Leung, Curtin University of Technology, Australia
Buon Kiong Lau, Lund University, Sweden

1. Introduction
2. The Elements of Signals and Systems
3. The Mathematical Approach to Signals and Systems
4. Signal Representation
   4.1. Continuous-Time and Discrete-Time Signals
   4.2. Continuous-Amplitude and Discrete-Amplitude Signals
   4.3. Time Domain and Frequency Domain Representation of Signals
   4.4. Representation of Signals in the Complex Frequency Domain
   4.5. Bandpass and Baseband Signals
   4.6. Multi-Dimensional Signals
   4.7. Random and Non-Random Signals
   4.8. Wavelets
5. Systems Theory
   5.1. Linear Time invariant Systems
   5.2. Impulse Response, Convolution and Transfer Functions
   5.3. Linear Constant Coefficient Differential and Difference Equations
   5.4. State-Space Representation
   5.5. Stability
6. Applications
   6.1. Control Systems
   6.2. Signal Processing
Signal Theory
Alexander M. Lowe, Department of Applied Chemistry, Curtin University of Technology, Australia

1. Introduction
2. Properties of Signals
   2.1. Periodic / Aperiodic
   2.2. Symmetric / Asymmetric
   2.3. Discrete/Continuous Time
   2.4. Discrete/Continuous Valued
   2.5. Signal Energy and Power
   2.6. Signal to Noise Ratio
3. Elementary Signals
   3.1. Unit Impulse
   3.2. Unit Step
   3.3. Complex Exponentials
4. Linear Time Invariant Systems
   4.1. Classification of Systems
      4.1.1. Memory / Memoryless
      4.1.2. Invertibility
      4.1.3. Causality
      4.1.4. Stability
      4.1.5. Time Invariance
      4.1.6. Linearity
   4.2. The Convolution Sum
   4.3. The Convolution Integral
   4.4. Properties of Linear Time Invariant Systems
      4.4.1. Associative Property
      4.4.2. Commutative Property
      4.4.3. Distributive Property
      4.4.4. Causality
5. Fourier Analysis
   5.1. The Fourier Series
   5.2. The Fourier Transform
6. Discrete-Time Signals
   6.1. Sampling Theorem
   6.2. Aliasing
   6.3. Discrete-Time Fourier Transform
   6.4. Discrete Fourier Transform (DFT)
   6.5. Quantization
7. Random Processes
   7.1. The Ensemble
   7.2. Ergodicity
   7.3. Specification of a Random Process
   7.4. Stationarity
   7.5. Power Spectral Density
   7.6. Convolution and Random Processes

Analog Signal Processing
Abdesselam Bouzerdoum, School of Electrical, Computer & Telecommunications Engineering, University of Wollongong, Australia
Douglas Chai, School of Engineering and Mathematics, Edith Cowan University, Perth, Australia
Farid Boussaid, School of Electrical, Electronic & Computer Engineering, The University of Western Australia, Perth, Australia

1. Introduction
2. Analog Signals and Systems
2.1. Analog Signals
2.2. Analog Systems

3. Linear Time Invariant Systems
3.1. Time Domain Analysis
   3.1.1. Impulse Response
   3.1.2. Differential Equation Representation
3.2. Transform Domain Analysis
   3.2.1. Laplace Transform
   3.2.2. Fourier Transform
   3.2.3. Frequency Response

4. Theory of Filters
4.1. Frequency-Selective Filters
4.2. Gain and Loss Functions
4.3. Ideal and Practical Filters
4.4. Approximations
   4.4.1. Butterworth Approximation
   4.4.2. Chebyshev Approximation
   4.4.3. Elliptic Approximation
   4.4.4. Bessel-Thompson Approximation
4.5. Frequency Transformations
   4.5.1. Lowpass Transformation
   4.5.2. Highpass Transformation
   4.5.3. Bandpass Transformation
   4.5.4. Bandstop Transformation

5. Analog Signal Processing Circuits and Hardware Implementation
5.1. Basic Circuit Components
5.2. Basic Analog Signal Processing Circuits
   5.2.1. Amplifiers
   5.2.2. Adders
   5.2.3. Multipliers
   5.2.4. Integrators
   5.2.5. Differentiators
   5.2.6. Current-to-Voltage and Voltage-to-Current Converters
5.3. Modulators and Demodulators
5.4. Passive RLC Filter Realization
   5.4.1. Prototype Lowpass Realization
   5.4.2. General Filter Realization
5.5. Active RC Filter Realization
   5.5.1. First Order Analog Circuits
   5.5.2. Biquads
5.6. IC Active Filters
   5.6.1. MOSFET-C Filters
   5.6.2. GmC Filters
   5.6.3. Switched-Capacitor Filters
   5.6.4. Characteristics of IC Active Filters

6. Conclusion
4. Digital Signal Processing Systems
   4.1. Linear Time-Invariant Systems
   4.2. Difference Equation
5. Transfer Functions and Structures
   5.1. FIR Filters
   5.2. IIR Filters
   5.3. Digital Filter Realizations
      5.3.1. FIR Filter Structures
      5.3.2. IIR Filter Realizations
6. Discrete Fourier Transform
   6.1. Some Properties of the DFT
   6.2. Linear Filtering via DFT
7. Random Signal Representation
   7.1. Random Signals
   7.2. Autoregressive Moving Average Process
   7.3. Power Spectral Density

Image Processing
Douglas G. Myers, Department of Computer Systems Engineering, School of Electrical and Computer Engineering, Curtin University of Technology, Perth, Western Australia

1. Introduction
2. Some Comments on Vision
3. What Is An Image?
4. The Relationship between Digital And Analogue Images
5. The Concept of An Image Processing System
6. The Process of Image Formation
7. The Image as a Representation
8. The Image Processing Hierarchy
9. The Pre-Processing Level
10. Low Level Image Processing
11. Medium Level Image Processing
12. Image Interpretation
13. Interpolation in Image Processing
14. The Edge Detection Problem
15. Applications of Image Processing
16. Some Image Processing Packages

Modulation and Detection
Sven Erik Nordholm, Western Australian Telecommunications Research Institute, Nedlands, Australia
Hans-Jürgen Zepernick, Blekinge Institute of Technology, Ronneby, Sweden

1. Introduction
2. Principles of Modulation
   2.1. Continuous Wave Modulation
      2.1.1. Linear Modulation
      2.1.2. Frequency and Phase Modulation
   2.2. Pulse Modulation
      2.2.1. Pulse Amplitude Modulation
      2.2.2. Pulse Position Modulation
      2.2.3. Pulse Code Modulation
   2.3. Digital Modulation
      2.3.1. Geometric Representations of Digital Modulation Signals
      2.3.2. Phase Shift Keying
      2.3.3. Frequency Shift Keying
2.3.4. Amplitude Shift Keying
2.3.5. Amplitude Phase Keying
2.3.6. Continuous Phase Modulation

3. Detection and Receiver Structures
   3.1. Coherent Detection
   3.2. Non-coherent Detection

4. Future Development, Economic and Environmental Implications

Index

About EOLSS

VOLUME II

Materials and Components in Electrical Engineering
Brett D. Nener, The University of Western Australia, Australia.

1. Introduction
2. Conductive Materials, Wires and Cables
3. Dielectric Materials and Devices
4. Semiconductor Materials and Devices
5. Magnetic Materials and Devices
6. Superconducting Materials and Devices
7. Fiber Optic devices and Systems
8. The Future

Conductive Materials, Wires, and Cables
Goran Matijasevic, University of California - Irvine, USA
Lutz Brandt, Ormet Corporation, USA

1. Basic Concepts of Electrical Conduction
2. Electronic Band Model
3. Conductive Materials
   3.1. Conduction in Pure Metals
   3.2. Common Elemental Conductors
   3.3. Conductivity of Dilute and Concentrated Metal Alloys
   3.4. Conductive Alloys
   3.5. Special Electric and Electronic Applications for Metals and Alloys
      3.5.1. Metals and Alloys for Electrical Contacts
      3.5.2. Metals and Alloys for Thin Film Applications
      3.5.3. Metals and Alloys for Fuses
      3.5.4. Metals and Alloys for Thermocouples
      3.5.5. Transparent Conductors
   3.6. Synthetic and Composite Conductors
      3.6.1. Intrinsically Conducting Polymers
      3.6.2. Conductive Composite Materials
      3.6.3. Conductor Loaded Polymers
      3.6.4. Transient-liquid-phase-sintering Polymer Composites
      3.6.5. Conductor Loaded Ceramics
      3.6.6. Molecular Scale Materials
4. Electrical Wires
5. Wire Sizes
6. Current Carrying Capacity
7. Skin Effect

©Encyclopedia of Life Support Systems (EOLSS)
8. Types of Electrical Wire
9. Cables Components
   9.1. Protective Covering
   9.2. Conductor Material
   9.3. Insulation Material
   9.4. Fillers
   9.5. Jacketing Materials
   9.6. Metallic Barriers and Shields
10. Cable Performance in Fire
11. Environmental Issues
12. Conclusion: Sustainable Use of Metal Resources

Dielectric Materials and Devices
Steven A. Boggs, *Electrical Insulation Research Center, Departments of Physics and Electrical Engineering, University of Connecticut, Storrs, CT, USA.*

1. Dielectric Materials
   1.1. Dielectric Gases
      1.1.1. Air
      1.1.2. SF₆
      1.1.3. Vacuum
   1.2. Liquids
   1.3. Solids
      1.3.1. Polymers
      1.3.2. Ceramics
   1.4. Fiber Reinforced Composites
2. Dielectric Devices
   2.1. Circuit Breakers
   2.2. Vacuum Tubes
   2.3. Copiers and Laser Printers
   2.4. Electret Transducers
   2.5. Piezo- and Pyroelectric Materials and Transducers
   2.6. Ferroelectric Liquid Crystals and Devices Based Thereon
   2.7. Capacitors

Magnetic Materials and Magnetic Techniques
Andrew Nafalski, *University of South Australia, Adelaide, Australia*

1. Introduction
2. Basics of Magnetism
3. Magnetic Behaviour of Materials
   3.1. Paramagnetism
   3.2. Diamagnetism
   3.3. Ferromagnetism
   3.4. Antiferromagnetism
   3.5. Ferrimagnetism
   3.6. Anisotropy
   3.7. Magnetostriction
4. Types of Magnetic Materials
   4.1. Crystalline Materials
   4.2. Ferrites
   4.3. Metallic Glasses
   4.4. Permanent Magnets
5. Applications of Magnetism
   5.1. Electrical Machines and Transformers
   5.2. Magnetic Techniques and the Environment
5.3. Using the Magnetic Field of the Earth

6. Promising Developments

Superconducting Materials and Devices
Catherine Patricia Foley, CSIRO Telecommunications and Industrial Physics, Lindfield, NSW, Australia

1. Introduction
   1.1. Some History

2. Superconducting Properties
   2.1. Zero Resistance and Exclusion of Magnetic Flux
      2.1.1. Background
      2.1.2. The Basic Quantities of \( T_c, H_c, \) and \( I_c \)
      2.1.3. Type I and Type II Superconductors
      2.1.4. Microscopic Theory of Superconductivity
   2.2. Quantum Coherence

3. LTS Materials

4. HTS Materials

5. Devices
   5.1. Josephson Junctions
      5.1.1. A Model of a Josephson Junction
      5.1.2. Practical Josephson Junctions
   5.2. SQUIDs
      5.2.1. Low \( T_c \) SQUIDs
      5.2.2. HTS SQUIDs
      5.2.3. Applications of SQUIDs
   5.3. Amplifiers
   5.4. Microwave Devices
      5.4.1. Filters
      5.4.2. Delay Lines

6. Conclusions

Fiber Optic Devices and Systems
Pak Lim Chu, Optoelectronics Research Centre, City University of Hong Kong, China

1. Introduction

2. Basic Construction of Optical Fiber

3. Multimode and Single mode Fibers

4. Types of Non-communication Fiber
   4.1. Pure Silica Fiber
      4.1.1. UV-Silica Fiber
      4.1.2. Near Infrared (NIR) Silica Fiber
      4.1.3. Metal-Coated Silica (MCS) Fiber
      4.1.4. Plastic Clad Silica (PCS) Fiber
   4.2. Polycrystalline Fiber
   4.3. Polymer Optical Fiber

5. Medical Applications of Optical Fibers
   5.1. Image Transmission and Endoscopy
   5.2. Fiber Optic Sensors for Medical Applications
      5.2.1. Medical Intensity Sensors
      5.2.2. Microbending Sensor
   5.3. Fiber Optic Confocal Scanning Microscope
   5.4. Fiber Bundle for DNA Identification
   5.5. Fiber Surgery
      5.5.1. Laser Thrombolysis
      5.5.2. Laser Soldering

6. Conclusion
1. Introduction
2. Characteristics and Response
   2.1. Static Response
   2.2. Dynamic Response
3. Errors and Error Control
   3.1. Systematic Errors
   3.2. Random and Gross Errors
   3.3. Error Reduction Techniques
4. Standards
5. Analog and Digital Instruments
   5.1. Analog Instruments
   5.2. Digital Instruments
   5.3. Virtual Instruments (VIs)
6. Control of Instruments
7. Design, Testing, and Calibration
   7.1. Testing and Use of Instruments
   7.2. Calibration
8. Applications of Instruments

Galvanometers, Electromechanical Voltmeters and Ammeters

1. Introduction
2. Measurement Fundamentals
   2.1. Information Retrieval
   2.2. Measurement Uncertainty
   2.3. Standards
      2.3.1. Voltage Standards
      2.3.2. Resistance Standards
3. Electromechanical Voltmeters and Ammeters
   3.1. The Moving-Coil Electromagnetic Ammeter and Voltmeter
      3.1.1. The D’Arsonval Galvanometer
      3.1.2. The Permanent Magnet Moving-coil Ammeter and Voltmeter
   3.2. The Moving-Iron Ammeter and Voltmeter
   3.3. The Electrodynamic Ammeter and Voltmeter
   3.4. The Electrostatic Voltmeter
   3.5. Analog Multimeters
4. Thermal-Type Instruments
5. Potentiometers
   5.1. The Slide-Wire DC Potentiometer
   5.2. The AC Potentiometer
      5.2.1. The DrysdaleTinsley AC Potentiometer
      5.2.2. The Gall–Tinsley AC Potentiometer

Electronic Voltmeters and Ammeters

1. Introduction
2. Analog Meters
2.1. DC Analog Voltmeters and Ammeters
2.2. AC Analog Voltmeters and Ammeters
2.3. True rms Analog Voltmeters

3. Digital Meters
3.1. Dual-Slope DVMs
3.2. Successive-Approximation ADCs
3.3. AC Digital Voltmeters and Ammeters
3.4. Frequency Response of AC Meters

4. Radio-Frequency Microvoltmeters

5. Vacuum-Tube Voltmeters and Oscilloscopes
5.1. Analog Oscilloscopes
5.2. Digital Storage Oscilloscopes (DSOs)
5.3. Portable Oscilloscopes
5.4. High-Voltage Oscilloscopes

High Voltage Measurements
Rastko Zivanovic, Technikon Pretoria, South Africa

1. Introduction
2. Requirements for High-Voltage Measurements
3. Voltage and Current Transducers
   3.1. Current Transducers
      3.1.1. Current Transformers (CTs)
      3.1.2. Optical Current Transducers (OCTs)
   3.2. Voltage Transducers
      3.2.1. The Electromagnetic Voltage Transformer
      3.2.2. The Capacitive Voltage Transformer (CVT)
      3.2.3. The Cascade Voltage Transformer
4. Measurement Techniques and Algorithms
   4.1. Digital Technology for High-Voltage Measurements
      4.1.1. Signal Conditioning and Data Transmission
      4.1.2. Digital Signal Processing
   4.2. Measurements of Primary Electrical Quantities
      4.2.1. Electrical Voltage, Current, and Power
      4.2.2. Electric Energy
      4.2.3. Fundamental Frequency
   4.3. Power-Quality Measurements
5. Integrated High-Voltage Measurement Systems
   5.1. State Estimation
   5.2. Disturbance Recorders
   5.3. Synchronized Phasor Measurements

Magnetic Measurements
Steven A. Macintyre, MEDA, Inc., Dulles, VA, USA

1. Introduction
2. Magnetic-Field Fundamentals
3. Vector Instruments
   3.1. Induction Coils
   3.2. Fluxgate
   3.3. Hall Effect
   3.4. Magnetoresistance
   3.5. SQUID
   3.6. Fiber Optic
4. Scalar Instruments
   4.1. Nuclear
4.2. Optically Pumped

5. Characterizing Magnetometer Performance
   5.1. Solenoid
   5.2. Helmholtz Coil
   5.3. Magnetic Shields
   5.4. Measurement Accuracy

Power and Energy Measurements  299
Arnaldo Brandolini, Politecnico di Milano, Italy
Alessandro Gandelli, Politecnico di Milano, Italy

1. Introduction
2. Electric Power Measurements
   2.1. DC Electric Circuits
   2.2. Single-Phase AC Electric Circuits
   2.3. Power Measurement in Three-Phase Systems
      2.3.1. Triple Single-Phase Circuits and Three-Phase Circuits
      2.3.2. The General Three-Phase System
      2.3.3. Phase Voltage and Power and Total Power of a Three-Phase System
      2.3.4. Aron Theorem
   2.4. Three-Wire Three-Phase Systems: Dependence and Independence of Measurements
      2.4.1. General Theorems on the Power Measurements in Three-Phase Systems
      2.4.2. Consequences of the Power Theorems

3. Power and Energy-Measuring Instruments
   3.1. General Remarks
   3.2. Induction Wattmeters
      3.2.1. Principles of the Induction System
      3.2.2. Single-Phase Wattmeter Indicators
      3.2.3. Induction Instruments: Integrating Wattmeters
      3.2.4. Mechanical Counter for Energy Meter
   3.3. Electrodynamical Wattmeters
   3.4. Static Wattmeters and Energy Meters

Digital Instruments  319
Javier García, University of Oviedo, Spain
Daniel F. García, University of Oviedo, Spain

1. Introduction
2. AD and DA Signal Conversions
   2.1. DA (Digital-to-Analog) Converters
   2.2. AD (Analog-to-Digital) Converters
3. Theory of Signal Acquisition
   3.1. Sampling
   3.2. Quantization
   3.3. Coding
4. Data-Acquisition Systems
   4.1. Single-Channel Systems
      4.1.1. Signal Conditioning
      4.1.2. Sample-and-Hold Circuits
   4.2. Multichannel Systems
      4.2.1. Analog Multiplexing
      4.2.2. Digital Multiplexing
5. Instrument Communication
   5.1. The RS-232
   5.2. GPIB (IEEE-488)
   5.3. The Fieldbuses
6. Examples of Digital Instruments
   6.1. The Oscilloscope
       6.1.1. Digital versus Analog Oscilloscope
       6.1.2. Structure and Operation of a Digital Oscilloscope
   6.2. Power Recorders

7. Virtual Instruments
   7.1. Data-Acquisition Boards
   7.2. Software Development Systems for Virtual Instrumentation
   7.3. VXIbus

8. Concluding Remarks and Future Directions

---

**Sensors and Transducers**

Salvatore Graziani, *Università degli Studi di Catania, Italy*

1. Introduction
2. Motion Sensors
   2.1. Resistive Potentiometers
   2.2. Linear Variable Differential Transformers (LVDT)
   2.3. Capacitive Sensors
   2.4. Strain Gages
   2.5. Acoustic and Optic Sensors
   2.6. Encoders
3. Velocity Sensors
   3.1. Moving-Coil Pickup
   3.2. DC and AC Tachometers
4. Force Transducers
   4.1. Piezoelectric Transducers
   4.2. Strain-Gage Load Cells
5. Temperature Sensors
   5.1. Resistance Thermometers
   5.2. Thermoelectric Devices
   5.3. Radiation Devices
6. Magnetic-field Sensors
   6.1. MOS Magnetic-Field Sensors
7. Chemical Sensors
   7.1. Chemosensors
   7.2. Luminescent Sensors
   7.3. Radioactive Sensors
   7.4. Gas Sensors
8. New Research Trends
   8.1. Smart and Soft Sensors
   8.2. Micro Electro-Mechanical Systems (MEMS)

---

**Instrumentation Systems**

Halit Eren, *Curtin University of Technology, Perth, Western Australia*
Chun Che Fung, *Curtin University of Technology, Perth, Western Australia*

1. Introduction
2. Instruments and Instrumentation Systems
   2.1. Instruments
   2.2. Instrumentation of Large Systems
   2.3. Automation
3. Digital Systems, Microprocessors, and Computers
   3.1. Embedded Controllers
   3.2. Dedicated Computers
4. Networks and Communications in Instrumentation Systems
2.3.4. Energy Storage Systems
   2.3.4.1. Battery Energy Storage systems (BESS)
   2.3.4.1.1. Utilizing spare batteries of the Electric Vehicles
   2.3.4.2. Flywheel Storage
   2.3.4.3. Compressed Air Energy Storage
   2.3.4.4. Super-conducting Magnetic Energy Storage
   2.3.4.5. Pumped Energy Storage
   2.3.4.6. Super-capacitors

2.4. Electricity Power Transmission and Distribution
   2.4.1. AC Power Transmission
   2.4.2. Transformers
   2.4.3. HVDC Transmission
   2.4.4. Distributed Generations
   2.4.5. Energy Storage within transmission and distribution Network
      2.4.5.1. Curtailing Peak Demands
      2.4.5.2. Improving Security
      2.4.5.3. Improving Reliability
      2.4.5.4. Impact on Generation
      2.4.5.5. Electricity Forecasting
      2.4.5.6. Additional Facets

3. Electro-technologies for end-uses of electricity
   3.1. Conventional Electric Machines
      3.1.1. DC Machines
         3.1.1.1. Basic Description of DC Machines
         3.1.2. Permanent Magnet Brushless DC machines
      3.1.3. Induction Motors
   3.2. Finite Element Analysis of Machines
   3.3. Energy Efficiency Improvements in Electric Motors and Drives
      3.3.1. Variable Speed Drives
         3.3.1.1. Variable speed drives with DC motors
         3.3.1.2. Variable speed drives with induction motors
         3.3.1.3. Switched Reluctance Motor Drives
         3.3.1.4. Intelligent Control of Motors
   3.4. Demand-side Technologies
   3.5. Energy Efficiency Improvements of Residential Appliances
   3.6. Plasma Technologies

4. Electric Vehicles
   4.1. Electric Vehicle Basics
   4.2. Speed and Distance of an EV
   4.3. Energy Usage
   4.4. Batteries and Chargers
   4.5. Regenerative Braking
   4.6. Hybrid electric vehicles
   4.7. Fuel Cell Vehicles

5. Conclusion

Direct Current Machines
Edward D. Spooner, The University Of New South Wales, Australia.

1. Introduction
2. Magnetism and Electromagnetic principles
   2.1. Permanent Magnets
   2.2. Magnetic Field around Conductors
   2.3. Magnetic Field around a Coil
   2.4. Electromagnets
   2.5. Magnetic Strength of Electromagnets
   2.6. Electromagnetic Induction
3. Current Carrying Wires and Coils
   3.1. Force on a Wire in a Magnetic Field
   3.2. Force and Torque on a Coil in a Magnetic Field
4. Basic Motor Principles
   4.1. The Commutator and Motor Action
   4.2. Simplified Version of the dc Motor
   4.3. Sizes of Machines (related to Torque)
   4.4. Construction of Motors
   4.5. The Stator of a dc Machine
   4.6. Rotor
   4.7. The Commutator
   4.8. Electromotive Force (EMF) in dc Machines
5. Machine Equations and Circuits
   5.1. Basic Equivalent Circuit of a dc Motor
   5.2. Direct current Motor Operation & Torque generation
   5.3. DC Machine Torque Equations
   5.4. DC Machine Equations and Speed Regulation
   5.5. Machine Power and Losses
6. Types of dc Machine
   6.1. Permanent Magnet
   6.2. Shunt Wound
   6.3. Separately Excited
   6.4. Series Connected
   6.5. Compound Connected Motor
7. Stepper Motors
   7.1. General
   7.2. Permanent Magnet Stepper Motors
   7.3. Reluctance Stepper Motors
   7.4. Torque – Step Rate
8. Conclusions
3.1. Synchronous Generator Supplying an Isolated Load
   3.1.1. Principle
   3.1.2. Voltage Regulation
3.2. Synchronous Generator Connected to the Grid
   3.2.1. Synchronizing Procedure
   3.2.2. Operating Conditions of Synchronous Generator
   3.2.3. Power/Load Angle Relationship
   3.2.4. Synchronizing Power and Torque
   3.2.5. Hunting
4. Synchronous Motors
   4.1. Operating Principle
   4.2. Effect of Field Excitation: V-curves
   4.3. Effect of Mechanical Load
   4.4. Starting Synchronous Motors
   4.5. Applications of Synchronous Motors
5. Excitation System

**Induction Motor and Self-Excited Induction Generator**
Tze-Fun Chan, *The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China*

1. Introduction
2. Basic Construction
   2.1. Stator
   2.2. Rotor
      2.2.1. Wound-Rotor Type
      2.2.2. Cage-Rotor Type
      2.2.3. Comparison between Cage-Rotor and Wound-Rotor Induction Motors
   2.3. Air Gap
   2.4. Auxiliaries
3. Principle of Action
4. Power Relationship and Torque-Slip Characteristics
5. Motor Starting
6. Speed Control
7. Motoring, Generating, and Plug-Braking Modes of Operation
   7.1. Motoring Mode
   7.2. Generating Mode
   7.3. Plug-Braking Mode
8. High-Torque Induction Motors
9. Single-Phase Induction Motors
   9.1. Principle of Operation
   9.2. Types of Single-Phase Induction Motors
      9.2.1. Split-Phase Motors
      9.2.2. Capacitor Motors
      9.2.3. Shaded-Pole Motors
10. Self-Excited Induction Generators

**Finite Element Analysis of Machines**
Siu-Lau Ho, *Hong Kong Polytechnic University, China*

1. Introduction
   1.1. Brief Review of FEM
2. 2-D Magnetostatic Model
3. 2-D Complex Eddy-Current Model
4. Rotating Model
   4.1. Pseudo-Stationary Approximation
   4.2. Stator Co-Ordinate System
4.3. Time-Stepping Method
4.4. Air-Gap Macro-Element Method
5. Coupled Model
5.1. Current Iteration Method
5.2. FEM Coupled with Circuit Equations
6. Representation of Skewed Slots
7. Sinusoidal Pulse-Width Modulation
8. 3-D Model
9. Conclusions

Switched Reluctance Machines and Permanent Magnet DC Brushless Machines
Eric Cheng, The Hong Kong Polytechnic University, China
Norbert Cheung, The Hong Kong Polytechnic University, China

1. Introduction
2. Rotationary Switched Reluctance Motor
   2.1. Basic Information
   2.2. Principle of Operation
   2.3. Power Electronic Circuit of SRM
      2.3.1. Unipolar Electronic Drive
      2.3.2. Drive with Shared Components
   2.4. Operation
3. Rotationary Permanent Magnet Brushless DC Machines
   3.1. Basic Information
   3.2. Principles of Operation
   3.3. Equation and Model of the Motor
   3.4. Operating Characteristics
   3.5. Control of the PMDCBM
4. The Linear Permanent Magnet Brushless Synchronous Motor (LPMSM)
5. The Variable Reluctance Linear Motor

Intelligent Control of Motors
Eric Cheng, The Hong Kong Polytechnic University, China

1. Introduction
2. Control Methods for Motors
   2.1. High Dynamic Performance
   2.2. DC Drives
   2.3. Modulation
      2.3.1. DC Drives
      2.3.2. Basic Concept of Pulse-Width Modulation for AC Drives
      2.3.3. Space-Vector Modulation (SVM)
      2.3.4. Motor Drives
   2.4. Constant V/F Control
   2.5. Stator Resistance Compensation Techniques
   2.6. Vector Control Drives
   2.7. Direct Torque Control
   2.8. Adaptive Control
   2.9. Artificial Intelligence Control
      2.9.1. Fuzzy Logic Control (FLC)
      2.9.2. Neural Network Control (NNC)
      2.9.3. Genetic Algorithm (GA)
3. Sensor and Estimation
   3.1. Speed and Flux Sensing
   3.2. Intelligent Sensors
   3.3. Sensorless Motor Control
3.3.1. Flux Estimation
3.3.2. Model Reference Adaptive Method (MRAM)

4. Intelligent Motors
4.1. Power Circuit
4.2. Intelligent Motors
5. The Challenges of Intelligent Control

Electric Vehicles
C.C. Chan, University of Hong Kong, Hong Kong, China

1. Introduction
2. Why Electric Vehicles?
3. Past, Present and Future of EVs
   3.1. Past Years Development
   3.2. Present Major Issues
   3.3. Development Trends
4. Present Status
5. Engineering Philosophy of EV Development
   5.1. EV concept
   5.2. EV Engineering Philosophy
   5.3. Key EV Technology
      5.3.1. Body design
      5.3.2. Energy management
      5.3.3. System Optimization
6. EV and HEV Configurations
   6.1. EV Configurations
   6.2. HEV Configurations
7. Electric Propulsion
   7.1. General Consideration
   7.2. Vector Controlled Induction Motor Drives
   7.3. PM Brushless Motor Drives
   7.4. SR Motor Drives
8. Energy Sources
   8.1. General Consideration
   8.2. Batteries
   8.3. Fuel Cells
   8.4. Ultracapacitors
9. EV Infrastructure
   9.1. General Consideration
   9.2. Charging Infrastructure
   9.3. Impacts on Power System
      9.3.1. Harmonic Compensation
      9.3.2. Current Demand Minimization
10. Conclusion
11. Acknowledgements

Electric Power Assisted Steering System for Automobiles
M.Faz Rahman, School of Electrical Engineering & Telecommunications, University of New South Wales, Sydney, Australia

1. Introduction
2. Essential components of an EPAS system
3. Torque sensors for EPAS
   3.1. Strain Gauge Sensors
   3.2. Optical Torque Sensors
   3.3. Capacitive Torque Sensors
3.4. Surface Acoustic Wave Torque Sensor
3.5. Magnetostrictive and Magnetic Torque Sensors
3.6. Piezoelectric Torque Sensor

4. Other Sensors
4.1. Current Sensor
4.2. Angular Position and Speed Sensors

5. Actuators for Electric Power Steering
5.1. PM Brushed DC Motor
5.2. PM AC Synchronous Motor

6. Operating Conditions and Specifications
7. EPAS System Controller
7.1. Torque Control Loop
7.2. Torque Assist Map
7.3. Damping Control
7.4. Reverse Sliding Load and Return to Neutral position

8. From EPAS to Steer by Wire
9. Conclusion

Energy Storage Systems 251
Paulo F. Ribeiro, Calvin College, Grand Rapids, Michigan, USA
Brian Keith Johnson, University of Idaho, Moscow Idaho, USA
Mariesa Crow, University of Missouri-Rolla, Rolla, Missouri, USA
A. Arsoy, Kocaeli University, Turkey
Michael Steurer, Florida Sate University, Tallahassee, Florida, USA
Yilu Liu, Virginia Tech, Blacksburg, Virginia, USA

1. Introduction
2. Energy Storage Systems
   2.1. Superconducing Magnetic Energy Storage (SMES)
   2.2. Battery Energy Storage (BESS)
   2.3. Advanced Capacitors
   2.4. Flywheel Energy Storage (FES)
3. Power Electronic Interface
   3.1. Semiconductor Devices
   3.2. Basic Configurations and Topologies
   3.3. Design Decision Tree
5. FACTS Plus Energy storage: Utility Application Performance
   5.1. STATCOM with SMES
   5.2. FACTS Device with BESS
   6.1. Maintain Acceptable Voltage during a Fault
   6.2. Restore Voltage during Hot Load Pick-up after Clearing the Fault
7. Summary of Performance Consideration
8. Cost Consideration
9. Conclusions

Plasma Science and Technology 278
J. Leon Shohet, The University of Wisconsin-Madison, USA

1. Introduction
2. Basic Plasma Properties
   2.1. Density, Temperature, Composition
   2.2. Plasma Production
3. Plasma Physics
   3.1. Plasma Dynamics

©Encyclopedia of Life Support Systems (EOLSS)
3.1.1. Particle Diffusion
3.1.2. Heat Transport
3.1.3. Effects of AC Electric and Magnetic Fields

4. Types of Plasma
4.1. Glow Charge
4.2. Arc Discharge
4.3. RF Discharge
4.4. Breakdown
4.5. Effects of DC Magnetic Fields
4.6. Plasma Potential
4.7. Debye Length

5. Plasma Diagnostics
5.1. Probes
   5.1.1. Radiation Probes
   5.1.2. Radiation Spectroscopy
5.2. Plasma Models
   5.2.1. The LTE Model
5.3. Particle Analysis

6. Plasma Surface Interactions
6.1. Plasma-Assisted Chemical Vapor Deposition (PACVD)
6.2. Etching
   6.2.1. Physical Aspects
   6.2.2. Chemical Aspects
6.3. Plasma Polymerization

7. Biomaterials
8. Biomicroelectromechanical Systems (bioMEMs)

Electric power distribution systems
F.C. Chan, General Manager, CLP Engineering Ltd., Hong Kong SAR, China

1. Introduction
2. Distribution System Planning
   2.1. Basic Design Criteria
   2.2. Network Configuration
   2.3. Reliability Considerations
   2.4. Load Characteristics and Types of Customer
   2.5. Equipment Specification
3. Distribution Lines and Substations
   3.1. Subtransmission Lines
   3.2. Distribution Lines
   3.3. Distribution Substations
   3.4. LV Network
   3.5. Primary and Secondary Systems
4. Distribution System Operation
   4.1. System Protection
   4.2. SCADA
   4.3. Distribution Automation
   4.4. Geographical Information System
   4.5. System Performance

Electric Power System Analysis, Operation And Control
Xiao-Ping Zhang, Institute for Energy Research and Policy, University of Birmingham, UK

1. Introduction
2. Modeling of Power System Components
   2.1. Transmission Lines
2.2. Transformers
2.3. Loads
2.4. Synchronous Generators
2.5. HVDC Systems and Flexible AC Transmission Systems (FACTS)

3. Load Flow Analysis
3.1. Classifications of Buses for Load Flow Analysis
3.2. Formulation of Load Flow Problem
3.3. Load Flow Solution by Newton-Raphson Method
3.4. Fast Decoupled Load Flow Method

4. Power System Dynamic Simulations
4.1. Modeling of Power Systems Components for Dynamic Simulations
   4.1.1. Dynamic Modeling of Power System Components
   4.1.2. Load Model
   4.1.3. Transmission Network
4.2. Methods for Power System Dynamic Simulations
4.3. Integration Methods for Differential Equations
   4.3.1. Explicit Integration Methods
   4.3.2. Implicit Integration Methods
4.4. The Explicit-Partitioned (EP) Method
4.5. The Implicit-Simultaneous (IS) Method

5. Automatic Generation Control
5.1. Generator Model
5.2. Turbine Model
5.3. Generator Governor Model
5.4. Turbine-Generator-Governor System Model
5.5. AGC for a Single Generator System
5.6. AGC for Two Area Systems

6. Power System Stability and Control
6.1. The Basic Concept of Power System Angle Stability Control
6.2. Power System Angle Stability Control Methods
6.3. Dynamic Security Assessment and Control of Angle Stability

7. Power Electronics and its Applications to Power System Control
7.1. Flexible AC Transmission Systems (FACTS)
7.2. Power System Control by FACTS

8. Voltage Control and VAR Management
8.1. Objectives of Voltage Control and VAR Management
8.2. Reactive Power Characteristics of Power Systems Components
8.3. Devices for Voltage Control and VAR Management
8.4. Voltage Control and VAR Management by Optimal Power Flow

9. Sub-synchronous Resonance
9.1. Physical Mechanisms of SSR
   9.1.1. Electrical Resonance Frequency
   9.1.2. Induction Generator Effect
   9.1.3. Torsional Interactions and SSR
9.2. Modeling and Analysis of SSR
9.3. Countermeasures of SSR

10. State Estimation
10.1. Power System State Estimation Problems
10.2. Generalized State Estimation

Index

About EOLSS

©Encyclopedia of Life Support Systems (EOLSS)