CARIBBEAN EXAMINATIONS COUNCIL

Caribbean Advanced Proficiency Examination®
CAPE®

ELECTRICAL AND ELECTRONIC TECHNOLOGY SYLLABUS

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Introduction

The Caribbean Advanced Proficiency Examination (CAPE) is designed to provide certification of the academic, vocational and technical achievement of students in the Caribbean who, having completed a minimum of five years of secondary education, wish to further their studies. The examinations address the skills and knowledge acquired by students under a flexible and articulated system where subjects are organised in 1-Unit or 2-Unit courses with each Unit containing three Modules. Subjects examined under CAPE may be studied concurrently or singly.

The Caribbean Examinations Council offers three types of certification. The first is the award of a certificate showing each CAPE Unit completed. The second is the CAPE diploma, awarded to candidates who have satisfactorily completed at least six Units, including Caribbean Studies. The third is the CAPE Associate Degree, awarded for the satisfactory completion of a prescribed cluster of seven CAPE Units including Caribbean Studies and Communication Studies. For the CAPE diploma and the CAPE Associate Degree, candidates must complete the cluster of required Units within a maximum period of five years.

Recognised educational institutions presenting candidates for CAPE Associate Degree in one of the nine categories must, on registering these candidates at the start of the qualifying year, have them confirm in the required form, the Associate Degree they wish to be awarded. Candidates will not be awarded any possible alternatives for which they did not apply.

Electrical and Electronic Technology Syllabus

◆ RATIONALE

Modern civilization as we know it would not exist without electricity and the attendant technologies that have arisen out of it, for example, communications (voice, data, Internet), computer and electronic technologies. Just imagine the world without electricity and, therefore, without refrigeration, television, hi-fi stereo, computer, Internet or telephones. Electrical and electronic technology is the common thread that connects these diverse areas and those of air travel, transportation, manufacturing, mining, construction, agriculture, sports, education, medicine, entertainment, food preservation and preparation.

None of these modern marvels of the world is possible without the use of electrical and electronic technology. Therefore, it is imperative that persons, wishing to understand the rapid pace of technological advancement, have a good grasp of the fundamentals of electrical and electronic technology.

The CAPE Electrical and Electronic Technology syllabus is designed to provide the fundamental knowledge necessary for a lifelong career in the dynamic and exciting field of Electrical and Electronic Technology. More particularly, for the continued development of the Caribbean and its citizenry, it is necessary for students to be exposed to subject areas that embody current technological trends and practices of the wider world. The CAPE Electrical and Electronic Technology syllabus, therefore, seeks to address this need by offering advanced technical and vocational training that would prepare students for the world of work. It also seeks to satisfy the prerequisite for further training as technicians and engineers in specific areas.

The CAPE Electrical and Electronic Technology syllabus is expected to:

(i) facilitate articulation with this field of study provided by institutions of higher learning such as universities, community colleges, technical institutes and teachers' colleges;

(ii) provide a means whereby persons, with an interest and commitment to the field of Electrical and Electronic engineering, can upgrade their previously acquired knowledge base and skills;

(iii) encourage further development of analytical, problem-solving and experimental abilities;

(iv) equip students with fundamental knowledge for the world of work in the electrical and electronic field;

(v) provide the foundation for further career development.

The syllabus also contributes to the development of selected attributes from the CARICOM Ideal Person document as articulated by the CARICOM Heads of Government. This person is one who demonstrates emotional security with a high level of self-confidence and self-esteem, is aware of the importance of living in harmony with the environment and nurtures its development in the economic and entrepreneurial spheres in all other areas of life (CARICOM Education Strategy, 2000).

This holistic development of students aligns with selected competencies advocated in the UNESCO Pillars of learning. These are learning to be, learning to do, and learning to transform one's self and society.

◆ AIMS

This syllabus aims to:

1. develop an interest in, and an awareness of, career choices and options for further study in the field of Electrical and Electronic Engineering;

2. develop analytical, practical and experimental skills in the use of electrical and electronic technology in industry;

3. develop an awareness of practical applications of electricity and electronics within industry;

4. provide opportunities for the acquisition of advanced knowledge of the concepts and fundamentals of electricity and electronics;

5. encourage the adoption of specific safety practices;

6. inculcate an appreciation of the pivotal role of electricity in the socio-economic development of their country and the region.

◆ SKILLS AND ABILITIES TO BE ASSESSED

The Skills and Abilities which students are expected to develop on completion of the syllabus have been grouped under three headings:

(i) Knowledge;
(ii) Use of Knowledge;
(iii) Practical Ability.

Knowledge	The ability to recall and comprehend facts, principles, methods, procedures, theories and structures; interpolation and extrapolation.
Use of Knowledge	The ability to:
Application	use facts, concepts, principles and procedures in unfamiliar situations, transform data accurately and appropriately; use formulae accurately for computations;
Analysis and Interpretation	identify and recognise the component parts of a whole and interpret the relationship between those parts; identify causal factors and show how they interact with each other; infer, predict and draw conclusions; make necessary and accurate calculations and recognise the limitations and assumptions of data;
Synthesis	combine component parts to form a new meaningful whole; make predictions and solve problems;
Evaluation	make reasoned judgements and recommendations based on the value of ideas and information and their implications.
Practical Ability	The ability to use electrical and electronic equipment and tools to fabricate simple circuits, test and determine circuit parameters and gather and analyse data.

◆ PRE-REQUISITES OF THE SYLLABUS

It is expected that persons who have completed the CSEC syllabuses in Physics or Electrical and Electronic Technology or their equivalent should be able to pursue this course successfully.

CSEC Mathematics or its equivalent would be a strong asset for those who wish to undertake this course.

◆ STRUCTURE OF THE SYLLABUS

The syllabus is divided into two Units. Each Unit consists of three Modules. The Units are independent of each other. However, together they provide a comprehensive post-secondary course in the field of Electrical and Electronic Technology.

Unit 1: Electrical Theory and Communications, contains three Modules of approximately 50 hours each. The total teaching time for the syllabus is approximately 150 hours.

Module 1:	DC Circuit Theory
Module 2:	Analogue Electronics and Communications
Module 3:	Introduction to Electrical Power Systems

Unit 2: Energy Converters and Logic Circuits, contains three Modules of approximately 50 hours each. The total teaching time for the syllabus is approximately 150 hours.

Module 1:	AC Circuit Theory
Module 2:	Digital Electronics and Data Communications
Module 3:	Introduction to AC Machines

It is strongly advised that Unit 1 or an equivalent course be completed before Unit 2.

◆ UNIT 1: ELECTRICAL THEORY AND COMMUNICATIONS
MODULE 1: DC CIRCUIT THEORY

GENERAL OBJECTIVES

On completion of this Module, students should:

1. understand the basic principles of circuit analysis;

2. appreciate the use of passive components.

DC THEORY

SPECIFIC OBJECTIVES

Students should be able to:

1. explain Ohm's Law;

2. calculate the equivalent resistance of resistors in series, parallel and series-parallel;

3. derive and use the voltage and current divider principles to solve problems;

4. carry out calculations using Ohm’s law for resistors in series, parallel and series-parallel;

5. derive and apply the relationships $\mathbf{P = V^2R^{-1} = I^2R = IV}$ to calculate the power dissipated by circuit elements;

6. derive the relationship between resistance and its physical factors;

7. recall and use the temperature dependence relationship $\mathbf{R_\theta = R_0 (1 + \alpha\theta)}$ in simple calculations;

8. apply Kirchoffs' Laws for the analysis of DC networks involving two meshes;

9. use the following theorems, for a maximum of two independent sources and meshes in the solution of DC networks: Norton's, Superposition, Thevenin's, Maximum Power Transfer.

UNIT 1
MODULE 1: DC CIRCUIT THEORY (cont'd)

CONTENT

(i) Ohm's law.

(ii) Series, Parallel and Series-parallel resistor circuits.

(iii) Power calculations.

(iv) Specific resistance.

(v) Temperature coefficient of resistance.

(vi) Kirchoffs' laws.

(vii) Superposition theorem.

(viii) Thevenin's theorem and Norton's theorem.

(ix) Maximum Power Transfer theorem.

ELECTROSTATICS

SPECIFIC OBJECTIVES

Students should be able to:

1. derive formulae for capacitance in series and parallel and use these formulae to solve problems;

2. determine the relationship between capacitance and its dimensions;

3. define the terms: electric field strength, electric flux density, permittivity of free space and relative permittivity and use these terms in the solution of problems;

4. determine the capacitance for fixed and variable capacitors;

5. recall and use formulae for time constant and sketch curves for charging and discharging capacitors;

6. derive the formula for the energy stored in a capacitor and use it to solve problems.

CONTENT

(i) Capacitance in series and parallel.

(ii) Relationship between capacitance and its dimensions.

(iii) Electric field strength.

(iv) Electric flux density.

(v) Permittivity.

(vi) Construction of fixed and variable capacitors.

(vii) Charging and discharging a capacitor.

(viii) Time constant.

(ix) Energy stored in a capacitor.

INDUCTANCE

SPECIFIC OBJECTIVES

Students should be able to:

1. state the physical factors governing inductance;

2. derive the formula for inductance given its physical factors;

3. calculate the total inductance for inductors in series, parallel and combinations;

4. use Helmholtz equation for simple RL circuits;

5. derive the formula for energy stored in an inductor and use it to solve problems;

6. explain the concepts of self-inductance and mutual-inductance and their relationship;

7. explain the function of the core-material in an inductor with particular reference to the iron-core inductor or choke;

8. define the concept of the coupling coefficient with particular reference to coils inductively coupled in series;

9. explain additive and subtractive polarity.

CONTENT

(i) Physical factors governing inductance.

(ii) Inductors in series and parallel.

(iii) RL circuits.

(iv) Energy stored in an inductor.

Suggested Teaching and Learning Activities

Teachers are encouraged to engage students in activities such as those listed below as they seek to achieve the objectives of this Module.

1. Have students solve problems to enhance their understanding of the Module.

2. Encourage students to read related material to complement work done in class.

3. Use appropriate analogies to introduce the concept of current flow, as this will set the foundation for a thorough understanding of not only Ohm's Law, but also the greater part of this Module.

4. Model circuits, wherever possible, after the actual problems given in theory, so that tests can be carried out on these circuits to verify answers obtained from calculations.

UNIT 1
MODULE 1: DC CIRCUIT THEORY (cont'd)

5. Give weekly assessments to have an indication as to whether material taught was learnt, especially those related to the analysis of circuits using the theorems.

6. Use real life examples to promote discussions and illustrate the use and purpose of the theorems in the real world, for example, a talk by a practising power engineer where he discusses how he uses Thevinin's and Norton's theorems in his everyday work would be helpful.

The teacher is urged to reinforce the relevant approved codes and safety practices during the delivery of the Module. It should be made clear that safety in the handling of electricity is of paramount concern and should be the common thread connecting every topic.

RESOURCE

Hughes, Edward *Electrical and Electronic Technology,* New Jersey: Prentice Hall, 2002.

UNIT 1
MODULE 2: ANALOGUE ELECTRONICS AND COMMUNICATIONS

GENERAL OBJECTIVES

On completion of this Module, students should:

1. understand the operation of basic electronic components;

2. appreciate the various methods of modulating EM waves for communication.

SEMICONDUCTOR DIODES

SPECIFIC OBJECTIVES

Students should be able to:

1. distinguish between n-type and p-type semiconductors;

2. explain the current flow and conduction process in semiconductor materials;

3. design and construct full and halfwave rectifier circuits and explain their function;

4. solve simple problems on ripple factor;

5. describe the operation of circuit limiters and clipping circuits;

6. show quantitatively the applications of a zener diode as a voltage regulator.

CONTENT

(i) Doping: p-type and n-type semi-conductors.

(ii) Current flow and conduction process in semi-conductor materials.

(iii) The p-n-junction and depletion layer.

(iv) Junction potential difference.

(v) The p-n junction under bias.

(vi) Diode circuit models - the ideal model, the constant voltage model, the Shockley model.

(vii) Avalanche multiplication.

(viii) Zener diode.

(ix) Varactor diode.

(x) LED.

(xi) Rectification(halfwave, fullwave {two- and four-diode} circuits).

(xii) Circuit limiters.

(xiii) Clipping circuits.

(xiv) Logic circuit applications - OR and AND gates.

BIPOLAR JUNCTION TRANSISTOR

SPECIFIC OBJECTIVES

Students should be able to:

1. distinguish between PNP and NPN transistors;
2. draw typical transistor characteristics curves;
3. explain the operating regions of a transistor;
4. design and construct the biasing network of a common emitter amplifier;
5. perform load line analysis;
6. draw the small signal common emitter (CE) amplifier model using h-parametes and perform calculations to determine: input impedance, output impedance, voltage gain and current gain.

UNIT 1
MODULE 2: ANALOGUE ELECTRONICS AND COMMUNICATIONS (cont'd)

CONTENT

(i) PNP and NPN transistors.

(ii) Terminal properties of a transistor.

(iii) Operating regions of a transistor.

(iv) Transistor characteristic curves.

(v) Transistor biasing.

(vi) H-Parameter model of a transistor.

(vii) Transistor applications.

(viii) Load line analysis.

(ix) Small signal amplifier circuits.

OPERATIONAL AMPLIFIERS

SPECIFIC OBJECTIVES

Students should be able to:

1. explain the operation of an operational amplifier used as a summing amplifier, a comparator, a differentiator and an integrator (quantitative analysis is expected);

2. derive the relationship for the gain of the inverting and the non-inverting op-amp and solve problems;

3. draw circuit diagram for the Wein Bridge RC and Hartley LC oscillators and determine the frequency of oscillation.

CONTENT

(i) Definition of parameters and input/output quantities.

(ii) Single stage model.

(iii) Cascade connection.

(iv) Positive feedback.

(v) Criteria for oscillation.

(vi) Oscillators: RC and LC oscillators.

(vii) Differential amplifiers.

(viii) Inverting and non-inverting amplifiers.

(ix) Operational amplifiers, transfer characteristics, negative feedback, differentiator and integrator circuits and comparators.

ELECTROMAGNETIC (EM) WAVES

SPECIFIC OBJECTIVES

Students should be able to:

1. explain how EM waves propagate from an antenna;

2. distinguish between ground waves, sky waves and space waves;

3. list the various wavebands in use and the services utilising them.

CONTENT

(i) Propagation of EM waves.

(ii) Ground waves.

(iii) Sky waves and space waves.

(iv) Ionospheric reflections.

(v) Major wavebands and their uses.

MODULATION

SPECIFIC OBJECTIVES

Students should be able to:

1. explain the principle of amplitude and frequency modulation;
2. perform simple calculations on modulation index for AM/FM;
3. compare and contrast AM and FM systems;
4. describe operation of AM and FM modulators and demodulators;
5. draw block diagrams of AM and FM receivers and explain their operation.

CONTENT

(i) Amplitude modulation: double sideband (DSB), single (SSB) modulators and demodulators, narrowband and broadband AM.

(ii) The superheterodyne radio receiver.

(iii) Frequency modulation: FM modulator and demodulator.

Suggested Teaching and Learning Activities

Teachers are encouraged to engage students in activities such as those listed below as they seek to achieve the objectives of this Module.

1. Encourage students to research various topics and present to the class in interactive sessions.

2. Have students solve problems from the suggested texts and other reference material.

3. Demonstrate plotting of the characteristic curves of a common emitter transistor.

4. Encourage students to visit and discuss with engineers and other professionals various topics and issues relating to the subject matter.

5. Encourage students to prepare oral and written reports that make use of the technical language.

6. Organise field trips to local Telecommunications companies, IT service companies or organizations with data and communication networks.

7. Form working relationships with engineers in related fields who can advise and assist in the delivery of the subject matter.

8. Organise a mentoring program with professional organizations and relevant companies.

9. Seek sponsorship from industry for students' projects.

10. Direct students to relevant Websites that offer practical guidance in the area, for example, www.howstuffworks.com.

11. Encourage students to do the suggested laboratory exercises listed on pages 45-48. These exercises can be done either as individual or group activities.

The teacher is urged to reinforce the relevant approved codes and safety practices during the delivery of the Module. It should be made clear that safety in the handling of electricity is of paramount concern and should be the common thread connecting every topic.

UNIT 1
MODULE 2: ANALOGUE ELECTRONICS AND COMMUNICATIONS (cont'd)

RESOURCE

Hughes, Edward *Electrical and Electronic Technology,* New Jersey: Prentice Hall, 2002.

UNIT 1
MODULE 3: INTRODUCTION TO POWER SYSTEMS

GENERAL OBJECTIVES

On completion of this Module, students should:

1. understand the relationship between electricity and magnetism;

2. appreciate the importance of protection schemes in energy systems;

3. understand the operation and control of DC machines;

4. appreciate the application of communications and controls in the management of power systems.

ELECTROMAGNETISM

SPECIFIC OBJECTIVES

Student should be able to:

1. differentiate between magnetic flux and magnetic flux density;

2. describe with the aid of relevant sketches the concept of lines of magnetic flux;

3. explain the magnetic effect on a current carrying conductor;

4. recall and use the relation $F = BIL \sin \theta$ and solve problems;

5. explain Faraday's and Lenz's laws;

6. calculate the emf generated in a conductor within a magnetic field;

7. explain electromagnetic induction;

8. distinguish among the concepts of: permeability (free space, relative), magnetomotive force, magnetizing force (field intensity, field strength) and reluctance.

9. sketch and label a typical B-H curve;

10. apply B-H curve to calculate magnetic circuit characteristics for a simple toroid.

CONTENT

(i) Magnetic flux.

(ii) Flux density.

(iii) Permeability of free space.

(iv) Relative permeability.

(v) Force on a current carrying conductor in a magnetic field.

(vi) Magnetomotive force.

(vii) Reluctance, B-H Curves, magnetic circuits, Faraday's and Lenz's law.

DC ROTATING EQUIPMENT

SPECIFIC OBJECTIVES

Students should be able to:

1. describe the essential features in the construction of a conventional DC machine;

2. describe the principle of operation of a DC machine in terms of the equation $T\omega = E_r I_a$, where T = torque, ω= angular velocity, E = emf, and I_a = armature current and solve problems;

3. explain the meaning of armature reaction and commutation as applied to DC machines;

4. differentiate between the various methods of excitation with reference to the field winding connection and draw the respective circuits;

5. sketch and explain the open-circuit and no-load characteristics for various winding connections of the DC machine;

6. sketch the torque speed characteristic of series, shunt and compound wound DC machines and solve problems;

7. describe various methods of varying the speed of a DC machine using the terminal voltage and excitation current;

8. list the main uses of a DC machine.

CONTENT

(i) The emf equation.

(ii) Armature reaction.

(iii) Commutation.

(iv) The DC generator - methods of excitation.

(v) Open-circuit characteristic.

(vi) Load characteristics.

(vii) The DC motor speed/torque characteristics.

(viii) Speed control.

(ix) Losses.

(x) Conditions for maximum efficiency.

(xi) Uses.

INTRODUCTION TO POWER SUPPLY PROTECTION

SPECIFIC OBJECTIVES

Students should be able to:

1. distinguish among the concepts of continuous current, overload current and fault current;

2. explain the function and operation of a fuse and the relationship of continuous, overload and fault current to the fuse rating;

3. explain the operation of the thermal overload relay;

4. explain the operation of the inverse minimum time over-current relay;

5. sketch the inverse characteristics of the fuse, the thermal overload relay and the inverse over-current relays;

6. identify typical areas within the power supply system where fuses and circuit breakers are used;

7. explain the operation of the voltage surge protector and its uses;

8. explain the function and uses of the frequency, under-voltage and over-voltage relays.

CONTENT

(i) The relationships between continuous, overload and fault currents.

(ii) Fuses.

(iii) Over-current relays.

(iv) Frequency relays.

(v) Under-voltage and over-voltage protection.

(vi) Thermal relays.

UNIT 1
MODULE 3: INTRODUCTION TO POWER SYSTEMS (cont'd)

INTRODUCTION TO SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEMS

SPECIFIC OBJECTIVES

Students should be able to:

1. describe the basic principles of data communications (simplex and duplex);

2. list the advantages of using digital communication over analogue communication;

3. explain the need for SCADA system as applied to electricity generation, transmission and the central control room;

4. draw a simple block diagram to represent a SCADA system and explain the function of each block;

5. describe the various communications methods between the field and central control rooms;

6. explain telemetering;

7. outline the role of computers in SCADA systems.

CONTENT

(i) Communications as applied to power system.

(ii) Power line carrier.

(iii) Leased lines.

(iv) Radio waves.

(v) Telemetering.

Suggested Teaching and Learning Activities

Teachers are encouraged to engage students in activities such as those listed below as they seek to achieve the objectives of this Module.

1. Have students identify, wherever possible, equipment within the home environment that operates on the principles addressed in each section of the Module.

2. Demonstrate the Induction Laws in the laboratory.

3. Encourage students to visit a utility company to observe aspects of the Module at work in industry.

4. Have students use "free access" Websites where valuable information can be ascertained (for example, www.howstuffworks.com).

5. Encourage students to research the various topics and present to class in interactive sessions.

6. Have students share with each other (or in small groups) their understanding of various topics.

7. Encourage students to solve mathematical problems using the applicable methods available.

8. Invite technical and vocational instructors, practising engineers or specialists from industry and tertiary institutions to lecture on areas such as Power Supply Protection and SCADA Systems.

9. Visit a local motor rewind shop, where sections of DC motors can be obtained for demonstration.

10. Encourage students to attempt the suggested laboratory exercises listed on pages 45-48.

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    hese exercises can be attempted either as individual or group activities.

The teacher is urged to reinforce the relevant approved codes and safety practices during the delivery of the Module. It should be made clear that safety in the handling of electricity is of paramount concern and should be the common thread connecting every topic.

RESOURCE

Hughes, Edward *Electrical and Electronic Technology,* New Jersey: Prentice Hall, 2002.

◆ UNIT 2: ENERGY CONVERTERS AND LOGIC CIRCUITS
MODULE 1: AC CIRCUIT THEORY

GENERAL OBJECTIVES

On completion of this Module, students should:

1. understand the principles of AC theory;

2. develop the ability to apply AC theory to the analysis of RLC circuits.

AC THEORY

SPECIFIC OBJECTIVES

Students should be able to:

1. define and determine: frequency, period, amplitude, instantaneous value, rms value, average value with reference to an AC sinusoidal wave;

2. define a phasor and represent it diagrammatically;

3. add and subtract phasors;

4. draw and interpret waveforms and phasor diagrams for alternating currents and voltages in resistive, inductive and capacitive circuits;

5. define: volt-ampere, apparent active and reactive power for purely inductive and inductive resistive loads;

6. calculate volt-ampere, apparent active and reactive power for purely inductive and inductive resistive loads;

7. determine capacitor values to be applied in parallel for improving power factor.

CONTENT

(i) Definition of: period, frequency, rms value, amplitude and average value.

(ii) Power in AC circuits - non-inductive and purely inductive; apparent active and reactive power.

(iii) Power factor (lagging and leading).

(iv) Angular frequency.

IMPEDANCE AND REACTANCE

SPECIFIC OBJECTIVES

Students should be able to:

1. add, subtract, multiply and divide complex numbers;

2. determine inductive and capacitive reactance;

3. calculate and determine impedance for the following series and parallel circuits: resistance and capacitance in series and parallel, resistance and inductance in series and parallel; and resistance, inductance and capacitance in series and parallel;

4. determine resonant frequency in RLC series circuits and represent by phasor diagram;

5. determine the Q-factor for RLC series circuit.

CONTENT

(i) Complex arithmetic.

(ii) Inductive and capacitive reactance.

(iii) Impedance of RL, RC and RLC networks.

(iv) Phasor diagram for RL, RC and RLC circuits.

(v) Resonance and Q-factor for RLC series circuits.

FILTERS

SPECIFIC OBJECTIVES

Students should be able to:

1. explain the operation of the following passive filters: low pass, high pass, band pass, band stop and notch;

2. draw simple RLC circuits to implement the following filters; low pass, high pass, band pass, band stop and notch;

3. calculate the cut-off frequency and design impedance for high pass and low pass passive filters;

4. sketch and label the frequency response of the above filters.

CONTENT

(i) Passive low pass, high pass, band pass, band stop "π" and "T" sections.

(ii) Notch filters.

Suggested Teaching and Learning Activities

Teachers are encouraged to engage students in activities such as those listed below as they seek to achieve the objectives of this Module.

1. Encourage students to solve problems from the suggested text in order to become versed in the application of the concepts.

2. Have students complete all laboratory exercises so as to bridge the theory with practical.

3. Encourage students to take greater charge of their learning by reading suggested and other related texts.

4. Illustrate the concepts and terms clearly by using diagrams, real-life examples and applications.

UNIT 2
MODULE 1: AC CIRCUIT THEORY (cont'd)

5. Organise laboratory exercises, where possible, so that students can determine the results of the operation of components.

6. Invite a practising power engineer to give lectures on the application of AC theory in industry.

7. Encourage students to do the suggested laboratory exercises listed on pages 45-48. These exercises can be done either as individual or group activities.

The teacher is urged to reinforce the relevant approved codes and safety practices during the delivery of the Module. It should be made clear that safety in the handling of electricity is of paramount concern and should be the common thread connecting every topic.

RESOURCE

Hughes, Edward *Electrical and Electronic Technology,* New Jersey: Prentice Hall, 2002.

UNIT 2
MODULE 2: DIGITAL ELECTRONICS AND DATA COMMUNICATIONS

GENERAL OBJECTIVES

On completion of this Module, students should:

1. understand the operating principles of digital electronic components and switching devices;

2. develop the skill to implement step-by-step procedures for designing, building, analysing and testing simple circuits and devices using digital electronic principles, practices and components;

3. understand the basic structure and fundamental principles of modern data communications systems.

ELECTRONIC SWITCHES

SPECIFIC OBJECTIVES

Students should be able to:

1. define the characteristics of ideal and practical switches;

2. identify the major types of switching devices and relate their action to electromagnetic and electromechanical devices;

3. explain the operation of the Bipolar Junction Transistor (BJT), Metal Oxide Field Effect System (MOSFET) and thyristor as switching devices;

4. explain the behaviour of a thyristor as the voltage across it is increased in the forward biased and reversed bias mode;

5. explain the effect on the break over voltage of applying a positive potential at the gate of the thyristor;

6. explain the operation of a simple DC-DC converter using BJT devices;

7. explain the operation of a simple DC-AC converter (inverter) using BJT devices;

8. use a BJT to operate as a switch.

CONTENT

(i) Construction.

(ii) Characteristics.

(iii) Operation and applications of MOSFETs and BJTs.

COMBINATIONAL LOGIC

SPECIFIC OBJECTIVES

Students should be able to:

1. implement logic gates using SPST and SPDT switches;
2. perform mathematical operations between various number systems – binary, octal, decimal and hexadecimal;
3. minimise logic expressions using Boolean algebra and Karnaugh maps utilising a maximum of four inputs;
4. implement logic circuits from Boolean expressions;
5. design simple logic circuits from a verbal description of problem with maximum of four inputs;
6. design a simple Binary Coded Decimal (BCD) to Gray code converter.

CONTENT

(i) Revision of number systems and Boolean algebra.

(ii) Logic gate functionality: AND, OR, NOT, NAND, NOR, EX-OR, EX-NOR.

(iii) Logical operations with gates.

(iv) Minimization.

(v) Truth tables and Karnaugh maps.

(vi) Simple design problems with implementation.

(vii) Binary adders and subtracters.

(viii) Code converters.

SEQUENTIAL LOGIC

SPECIFIC OBJECTIVES

Students should be able to:

1. distinguish among SR, JK, D and T type flip flops;

2. build a simple three stage shift register;

3. build an asynchronous counter (up to mod 10);

4. design and build monostable and bistable (quantitative analysis expected) multi-vibrators using a 555 timer.

CONTENT

(i) Flip flops.

(ii) 1-bit memory.

(iii) SR, JK and D and T type.

(iv) Counters and shift registers.

(v) Applications of counters and shift registers.

(vi) Bistable multi-vibrator.

(vii) 555 timer.

(viii) Monostable multi-vibrator applications.

MEMORY CIRCUITS AND CONVERTERS

SPECIFIC OBJECTIVES

Students should be able to:

1. explain the operation of simple decoders and demultiplexers;

2. explain the operation of simple data selectors, multiplexers and encoders;

3. build simple digital electronic devices using decoders and demultiplexers;

4. build simple digital electronic devices using data selectors, multiplexers and encoders;

5. explain the operating principles of the following memory systems:

   (i) ROM;

   (ii) RAM;

   (iii) PROM;

   (iv) EPROM.

6. build D/A – 4-8 bit D/A converters driven by digital counters, D/A converter with BCD input code;

7. perform basic calculations with D/A converters using a summing op-amp;

8. build D/A converters using 2R-R resistor ladder networks;

9. explain each of the following as it relates to D/A converters:

   (i) scale error;

   (ii) offset error;

   (iii) non-linearity;

   (iv) monotonicity;

   (v) resolution;

   (vi) speed limiting errors;

   (vii) settling times;

10. explain the operations of voltage to frequency, constant slope ramp and integrating A/D converters;

11. explain the operations of the successive approximation A/D converter;

12. calculate the digital output and resolution of digital-ramp A/D converters;

13. explain the operations of sample and hold circuits.

CONTENT

(i) Binary adders.

(ii) Subtracters.

(iii) Decoders.

(iv) Demultiplexers.

(v) Data selectors.

(vi) Multiplexers.

(vii) Encoders.

(viii) ROM.

(ix) RAM.

(x) PROM.

(xi) EPROM.

(xii) D/A-conversion: D/A converters in practice, R/2R ladder D/A converters.

(xiii) A/D conversion: Simple comparators, A/D converters in action.

DATA COMMUNICATIONS

SPECIFIC OBJECTIVES

Students should be able to:

1. explain the operations of simplex and duplex data communications;

2. explain the operations of synchronous and asynchronous data communications;

3. explain the use and importance of regenerators in digital systems;

4. explain concepts of mutual information and channel capacity;

5. explain the basic operating principles of PCM and FSK, PSK and DPSK digital modulation techniques;

6. state the basic principles of error detection and correction, including CRC and Hamming Codes;

7. state the basic principles of Intercomputer Communications – UART and USART;

8. describe commonly used demodulation techniques;

9. describe Ring, Star and Bus computer networking topologies.

UNIT 2
MODULE 2: DIGITAL ELECTRONICS AND DATA COMMUNICATIONS (cont'd)

CONTENT

(i) Basic concepts: bandwidth, channel capacity, signal to noise ratio, Shannon-Hartley law and information theory.

(ii) Source coding: Huffman, Shannon-Fano.

(iii) Communication systems: simplex, duplex, synchronous and asynchronous.

(iv) Regenerators and synchronization in digital systems.

(v) Digital modulation.

(vi) Error detection and correction; CRC, Hamming Codes.

(vii) UART, USART.

(viii) Computer Networks: Ring, Star and Bus topologies.

<u>Suggested Teaching and Learning Activities</u>

Teachers are encouraged to engage students in activities such as those listed below as they seek to achieve the objectives of this Module.

1. Encourage students to research the various topics and present to the class in interactive sessions.

2. Have students solve problems from the suggested texts and other reference material.

3. Encourage students to visit related industries and organizations.

4. Encourage students to visit and discuss with engineers and other professionals various topics and issues relating to the subject matter.

5. Have students prepare oral and written reports that make use of the technical language.

6. Organise field trips to local Telecommunications companies, IT service companies or organizations with data and communication networks.

7. Use off-the-shelf digital kits to demonstrate sequential logic memory and converter circuits.

8. Form working relationships with engineers in related fields who can advise and assist in the delivery of the subject matter.

9. Organise a mentoring program with professional organizations and relevant companies.

10. Obtain sponsorship from local business and industry for students' projects.

11. Encourage students to attempt the suggested laboratory exercises listed on pages 45-48. These exercises can be attempted either as individual or group activities.

The teacher is urged to reinforce the relevant approved codes and safety practices during the delivery of the Module. It should be made clear that safety in the handling of electricity is of paramount concern and should be the common thread connecting every topic.

RESOURCES

Hughes, Edward — *Electrical and Electronic Technology*, New Jersey: Prentice Hall, 2002.

Temes, Lloyd — *Schaum's Outline of Theory and Problems of Electronic Communication*, New York: McGraw Hill, 1997.

UNIT 2
MODULE 3: INTRODUCTION TO AC MACHINES

GENERAL OBJECTIVES

On completion of this Module, students should:

1. understand the principle of operation of AC machines;

2. develop the required knowledge of the parameters related to AC machines.

TRANSFORMERS

SPECIFIC OBJECTIVES

Students should be able to:

1. identify the parts and explain the principle of operation of a single phase transformer;

2. describe (giving the equations linking the primary and secondary current, voltage and power) the operation of a single phase transformer and calculate the various parameters;

3. explain the concept and significance of eddy currents, hysteresis and leakage reactance of a transformer;

4. draw the equivalent circuit of an ideal transformer including the magnetising arm and leakage reactance;

5. calculate voltage regulation, losses and efficiency using the equivalent circuit of a transformer;

6. measure the voltage ratio and determine the turns and current ratios of a transformer.

CONTENT

(i) Principle of action.

(ii) The emf-equation.

(iii) Eddy currents.

(iv) Hysteresis.

(v) Leakage reactance.

(vi) Single phase equivalent circuit.

(vii) Voltage regulation.

(viii) Losses and efficiency.

SYNCHRONOUS ROTATING GENERATORS

SPECIFIC OBJECTIVES

Students should be able to:

1. describe the essential constructional details of a synchronous generator and distinguish between rotor types (salient and non-salient pole);

2. describe the principle of operation of the synchronous generator;

3. explain the concepts of armature reaction and synchronous impedance;

4. calculate the synchronous impedance of a synchronous generator;

5. differentiate between types of windings in a synchronous dynamo;

6. solve problems involving speed, frequency and terminal voltage of synchronous generators;

7. explain the effect of load and excitation current on voltage regulation of a synchronous generator.

CONTENT

(i) Armature reaction.

(ii) Synchronous impedance.

(iii) Voltage regulation.

(iv) Effects of load and excitation.

(v) Operating characteristics.

UNIT 2
MODULE 3: INTRODUCTION TO AC MACHINES (cont'd)

INDUCTION MOTOR

SPECIFIC OBJECTIVES

Students should be able to:

1. differentiate between the squirrel cage and wound rotor and their uses;

2. describe the principle of operation of the induction motor;

3. define rotor speed, slip, torque and losses;

4. explain the mathematical relationship between slip and torque;

5. sketch and explain the characteristics of slip and torque;

6. calculate the values of rotor speed, slip, torque and losses from given parameters;

7. list various uses of the induction motor;

8. explain methods of speed control of the induction motor.

CONTENT

(i) Principles of operation.

(ii) Slip and motor losses.

(iii) Torque and slip characteristics.

(iv) Speed control, types and uses.

<u>Suggested Teaching and Learning Activities</u>

Teachers are encouraged to engage students in activities such as those listed below as they seek to achieve the objectives of this Module.

1. Encourage students to research the various topics and present to the class in interactive sessions.

2. Have students complete all written and practical assignments and solve problems related to the topic.

UNIT 2
MODULE 3: INTRODUCTION TO AC MACHINES (cont'd)

3. Have students conduct simple experiments related to AC machines, for example, transformer action.

4. Organise field trips to the local power utility where the students can view the various power equipment contained in the Module in actual operation.

5. Visit the local motor rewind shop, where sections of motors and transformers can be obtained for demonstration.

6. Form a working relationship with a power engineer who can give guest lectures on the application aspects of the Module.

7. Encourage students to do the suggested laboratory exercises listed on pages 45-48. These exercises can be done either as individual or group activities.

The teacher is urged to reinforce for the benefit of the student the relevant approved codes and safety practices. It should be made clear that safety in the handling of electricity is of paramount concern and should be the common thread connecting every topic.

RESOURCE

Hughes, Edward *Electrical and Electronic Technology,* New Jersey: Prentice Hall, 2002.

◆ OUTLINE OF ASSESSMENT

EXTERNAL ASSESSMENT **(80%)**

Each Unit of the syllabus will be independently assessed and graded separately. The same scheme of assessment will be applied to each Module in each Unit.

The Scheme of assessment for each Unit will comprise two components, an external component and an internal component. The external component contributes 80 per cent and the internal component contributes 20 per cent towards the overall assessment for each Unit. These arrangements are detailed below.

Paper 01 (1 hour 30 minutes)	This paper will consist of 15 compulsory short answer questions covering the three Modules in the Unit.	30%
Paper 02 (2 hours 30 minutes)	This paper will consist of three sections, each corresponding to a Module in the Unit. Each section contains three essay type questions. Candidates are required to attempt two questions from each section. The first question in each section will be compulsory.	50%

INTERNAL ASSESSMENT **(20%)**

Paper 03

The Internal Assessment for each Unit requires that candidates undertake a project. For the project, candidates must construct a physical circuit of some utility which will demonstrate the practical, experimental and investigative skills they developed in the Unit. Examples of projects for Unit 1 and Unit 2 are provided on pages 45-48.

Private candidates will be required to complete all components of the examination.

MODERATION OF INTERNAL ASSESSMENT

Each year an Internal Assessment Record Sheet will be sent to schools submitting students for the examination.

All Internal Assessment Record Sheets and sample of assignments are to be submitted to the Local Registrar in time to reach CXC by May 31 of the year of the examination. A sample of assignments will be requested by CXC for moderation purposes.

These assignments will be re-assessed by CXC Examiners to inform the moderation of scores submitted by the given teacher. Teachers' marks may be adjusted as a result of moderation. An Examiner's feedback report will be sent to each teacher.

Copies of the students' assignment that are not included in the sample submitted to CXC must be retained by the school until three months after publication by CXC of the examination results.

ASSESSMENT DETAILS

Each Unit will be assessed as follows:

External Assessment by Written Papers (80% of Total Assessment)

Paper 01 (1 hour 30 minutes - 30% of Total Assessment)

1. **Number of Questions**

   All questions are compulsory. This paper will consist of 15 short answer questions. There will be five questions for each Module.

2. **Syllabus Coverage**

   (i) Coverage of the entire syllabus is required.

   (ii) The intention of this paper is to test knowledge, and use of knowledge across the breadth of the syllabus.

3. **Mark Allocation**

   Each group of 5 questions will be allocated 30 marks for a total of 90 marks**.** The marks allocated to each question will be indicated on the examination paper.

   Note:

   Full marks will be awarded for correct answers accompanied by relevant working. Where an incorrect answer is given, partial marks may be awarded for showing the appropriate method used to achieve the answer to a question.

4. **Use of Calculators**

   Candidates will be allowed to use a non-programmable calculator in the examinations. Candidates will be responsible for providing their own calculators and for ensuring that it functions throughout the examination.

Paper 02 (2 hours 30 minutes – 50% of Total Assessment)

This paper will be divided into three sections corresponding to the three Modules of the Unit.

1. **Composition of Paper**

   (i) This paper will consist of nine essay or extended response questions comprising three questions on each section.

   (ii) Candidates are required to attempt two questions from each section. The first question in each section will be compulsory.

   (iii) The total number of marks available for the paper is 150 divided evenly over each section.

   (iv) This paper contributes 50% towards the final assessment.

2. **Syllabus Coverage**

   (i) Each question requires a greater depth of understanding than the questions in Paper 01.

   (ii) The purpose of this paper is to test candidates' in-depth knowledge of the syllabus.

3. **Question Type**

   Questions require an extended response assessing knowledge, use of knowledge and practical ability.

4. **Mark Allocation**

   The compulsory question in each section will be worth 30 marks and all other questions will be worth 20 marks.

   Note

   (i) If an incorrect numerical answer in an earlier question is repeated in a later question, then marks may be awarded in the later part even though the original answer is incorrect. In this way, a candidate will not be penalised twice for the same mistake.

   (ii) A correct answer given with no indication of the method used (in the form of relevant written working) will receive no marks. Candidates are, therefore, advised to show all workings.

5. **Use of Calculators**

Candidates will be allowed to use a non-programmable calculator in the examinations. Candidates will be responsible for providing their own calculators and for ensuring that it functions throughout the examination.

INTERNAL ASSESSMENT (20% of Total Assessment)

Internal Assessment is an integral part of student assessment in the course covered by this syllabus. It is intended to assist students in acquiring certain knowledge, skills and attitudes that are associated with the subject. The activities for the Internal Assessment are linked to the syllabus and should form part of the learning activities to enable the student to achieve the objectives of the syllabus.

During the course of study for the subject, students obtain marks for the competence they develop and demonstrate in undertaking their Internal Assessment assignments. These marks contribute to the final marks and grades that are awarded to students for their performance in the examination.

The guidelines provided in this syllabus for selecting appropriate tasks are intended to assist teachers and students in selecting assignments that are valid for the purpose of Internal Assessment. The guidelines provided for the assessment of the assignments are intended to assist teachers in awarding marks that are reliable estimates of the achievement of students in the Internal Assessment component of the course. In order to ensure that the scores awarded by teachers are consistent with the CXC standards, the Council undertakes the moderation of a sample of the Internal Assessment assignments marked by each teacher. Internal Assessment provides an opportunity to individualise a part of the curriculum to meet the needs of students. It facilitates feedback to the student at various stages of the experience. This helps to build the self- confidence of students as they proceed with their studies. Internal Assessment also facilitates the development of the critical skills and abilities emphasised by this CAPE subject and enhances the validity of the examination on which candidate performance is reported. Internal Assessment, therefore, makes a significant and unique contribution to both the development of relevant skills and the testing and rewarding of students for the development of those skills.

The Caribbean Examinations Council seeks to ensure that the Internal Assessment scores are valid and reliable estimates of accomplishment. The guidelines provided in this syllabus are intended to assist in doing so.

1. **Presentation of Project**

The aims of the project are to:

(i) promote self learning;

(ii) provide opportunity for teachers to engage in the formative assessment of their students;

(iii) provide opportunity for students to demonstrate their practical, experimental and investigative skills developed in the Unit;

(iv) explore more fully, some areas of the Unit which may not be assessed adequately in an external examination.

2. **Requirements**

The reporting of results in Caribbean Advanced Proficiency Examinations is by Unit and Module and, as a result, each Project must cover the three Modules for the particular Unit. It is the responsibility of the teacher to conceptualise the Project to be done for the Unit. Using this conceptualised Project, the student is then required to develop his/her individual project-idea with the teacher acting as advisor. It is strongly advised that students complete the project definition early in the coverage of a Unit and certainly before completing 50% of the material in Module 2 of that Unit. In order to satisfy the objectives, students will be required to produce a physical circuit of some utility and to demonstrate the practical, experimental and investigative skills developed in the Unit.

Each Project to be completed must be based on a single Unit, but should encompass knowledge, topics, concepts, skills and procedures contained in all Modules within the specific Unit.

3. **Guidelines for Project Definition and Implementation**

(i) There must be one Project per Unit.

(ii) Each Project must be based solely on information delivered in that particular Unit.

(iii) The Project must use information from all three Modules of the particular Unit. The teacher must advise the students of the required Project to be done at the start of Module 1.

(iv) After discussion with the teacher the project-idea <u>must</u> be approved by the teacher for implementation by the student.

(v) The teacher is responsible for ensuring that the student's Project satisfies item (iii) above and can be implemented in the time frame with the physical resources available.

(vi) Although the Project is the responsibility of the student, it is essential that the teacher meets regularly (at least once a week) with the student so as to provide continual guidance. At the end of these student-teacher sessions, the teacher should sign the student's Project Activity Record Book after noting what guidelines have been given to the student.

4. **Project Planning and Implementation**

Students should:

(i) prepare a written statement, clearly articulating the need, problem or purpose of the experiment;

(ii) write the methodology or approach to satisfy the need, solve the problem or carry out the experiment;

(iii) develop the project scope and functional specifications;

(iv) acquire, label and maintain a **Project Activity Record Book**, which should include a record of the following:

- (a) the statement of need, problem definition or purpose of the experiment;
- (b) the approach or method statement;
- (c) sketches, diagrams and pictures;
- (d) design process, lab procedures and calculations;
- (e) resources including tools, equipment and components used;
- (f) specifications;
- (g) problems, constraints, difficulties and limitations;
- (h) test and troubleshooting procedures and results.

(v) prepare a final report of the project which should include:

- (a) the report purpose;
- (b) statement of need, problem definition or purpose of the experiment;
- (c) project scope and specifications;
- (d) methodology or approach;
- (e) design and construction details;
- (f) summary of tests and troubleshooting procedures;
- (g) testing and troubleshooting results;
- (h) verification of scope and specifications;

(i) constraints and difficulties;

(j) conclusion and recommendations.

(k) Project allocation form signed by the teacher.

5. **Mark Allocation for Project**

Marks will be awarded for the project based on the criteria listed below (see detailed mark scheme on pages 43-44).

(i)	Management of the Project	-	05
(ii)	Practical Skills	-	20
(iii)	The Written Report	-	35

MARK SCHEME FOR THE PROJECT

The mark scheme provided below is intended to assist teachers in awarding marks that are reliable assessment of the achievement of students on the project they select. **Candidates will be awarded a total of six marks for communicating information in a logical way using correct gramma**r.

	Assessment Criteria	Range of Marks	Teacher's Mark	CXC's Mark
1.	**Management of Project**	**05**		
	a) Student required little or no supervision during the project	4 - 5		
	b) Student required some supervision during the project	2 - 3		
	c) Student required major supervision during the project	0 - 1		
2.	**Practical skills**	**20**		
	a) Ability to correctly and safely use basic test instruments (for example. DMM, VOM, Oscilloscope) and other components	0 - 2		
	b) Ability to correctly identify components and component values	0 - 3		
	c) Ability to correctly and safely connect and wire basic circuits	0 - 4		
	d) Ability to meet functional specifications	0 - 8		
	e) Neatness	0 - 3		

Assessment Criteria		Range of Marks	Teacher's Mark	CXC's Mark
3.	**The Written Report**	**35**		
	i) **Technical Content – 29 marks**			
	a) Methodology	0-3		
	b) Design and construction details	0-4		
	c) Summary of tests and troubleshooting procedures	0-3		
	d) Results	0-4		
	e) Discussion and conclusion	0-8		
	f) Accuracy	0-4		
	g) Documentation	0-3		
	ii) **Communication of Information – 6 marks**			
	a) Communicates information in a logical way using correct grammar and appropriate jargon MOST of the time.	5-6		
	b) Communicates information in a logical way using correct grammar and appropriate jargon SOME of the time.	3-4		
	c) Communicates information in a logical way RARELY using correct grammar and appropriate jargon.	1-2		
Total		**60**		

◆ SUGGESTED LABORATORY EXERCISES FOR PROJECTS

The students' practical competence will be enhanced by their completing the following suggested laboratory exercises and any other similar activities.

UNIT 1

PROJECT 1: AM Receiver

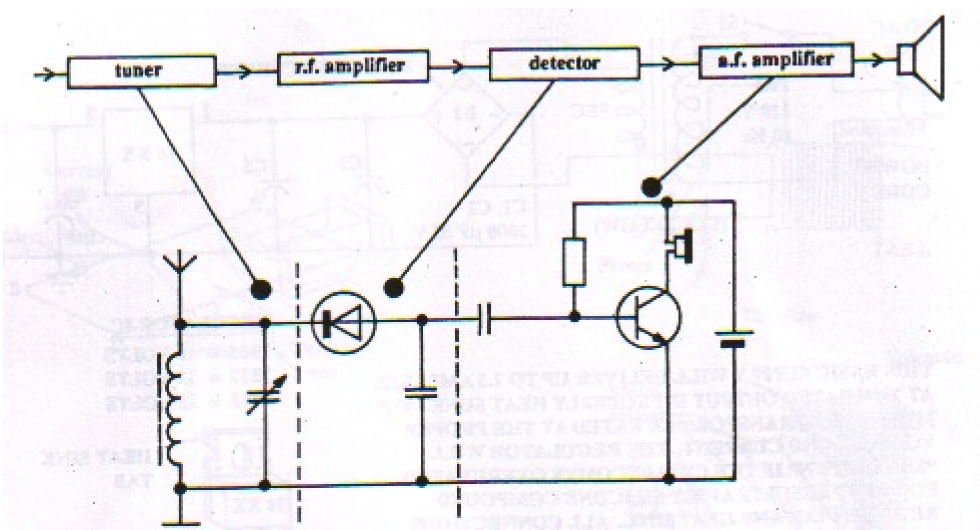


Figure I

Construct an A.M. receiver including tuning circuit, r.f. amplifier, diode detector, a.f. amplifier and speaker**. Refer to Figure I** above.

PROJECT 2: Voltage Regulator Circuits

Fixed Output Line Powered Supply

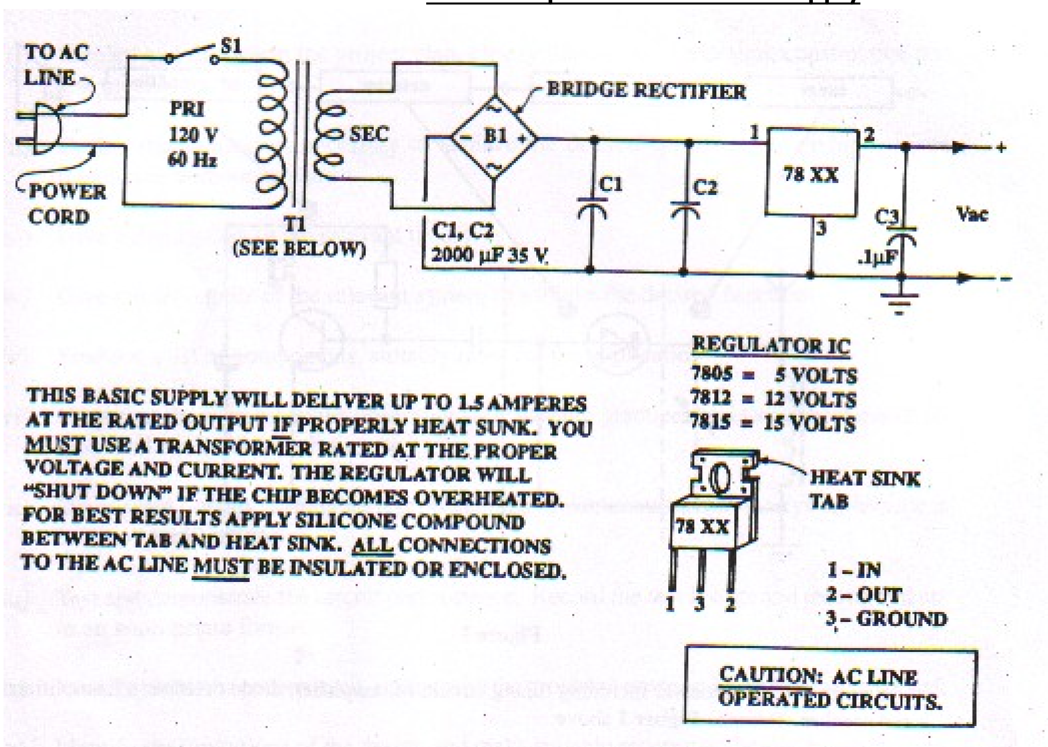


Figure II

Build your own d.c. power supply from an a.c. source. The circuit must have the following specifications (**Refer to Figure II above**):

a) Output Power = 1 Watt (maximum);

b) Output Voltage = 6 V;

c) Output Current = 1A (maximum);

d) Ripple Factor < 10%.

UNIT 1

PROJECT 3: **Current Balance**

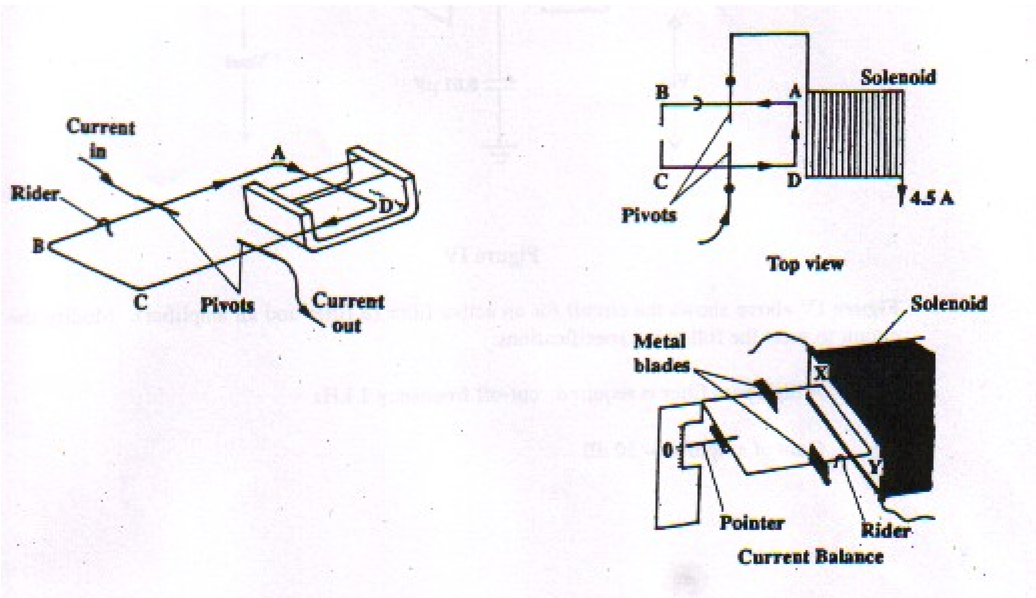


Figure III

Construct a current balance and use it to investigate the variation in magnetic flux density with distance using EITHER a bar magnet OR a current carrying wire**. Refer to Figure III** above.

PROJECT 4: **Active Filter Circuit**

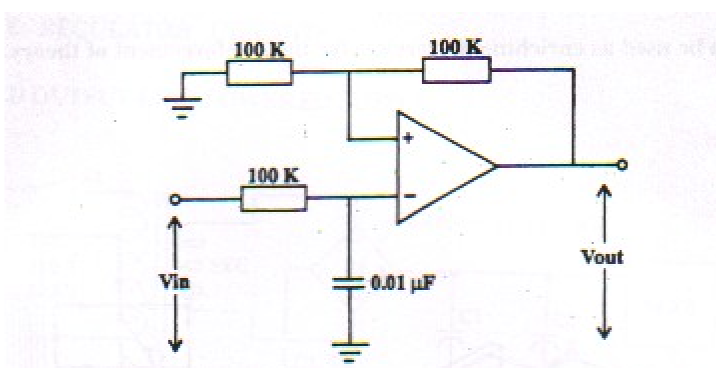


Figure IV

Figure IV above shows the circuit for an active filter (a filter and an amplifier). Modify the circuit to meet the following specifications:

(a) a high pass filter is required: cut-off frequency 1 kHz;

(b) gain of amplifier – 10 dB.

UNIT 2

PROJECT 1: 6-Digit Frequency Counter

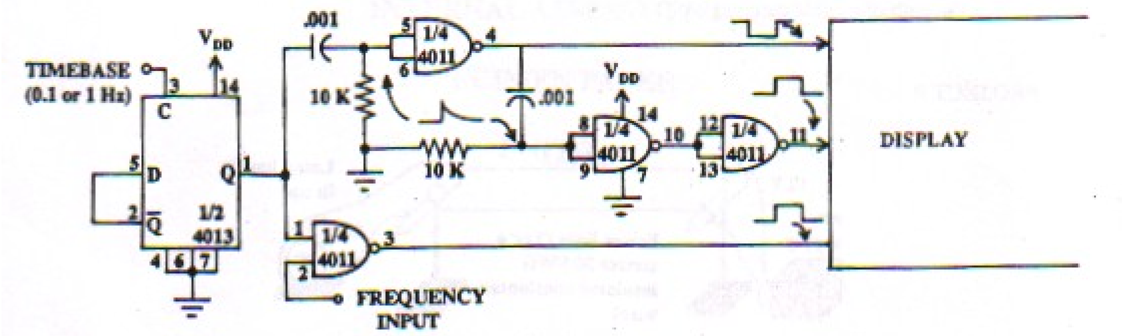


Figure I

Construct a frequency counter/meter that will measure and display frequencies up to 999 Hz. **Refer to Figure I** above.

PROJECT 2: A Model Power Line

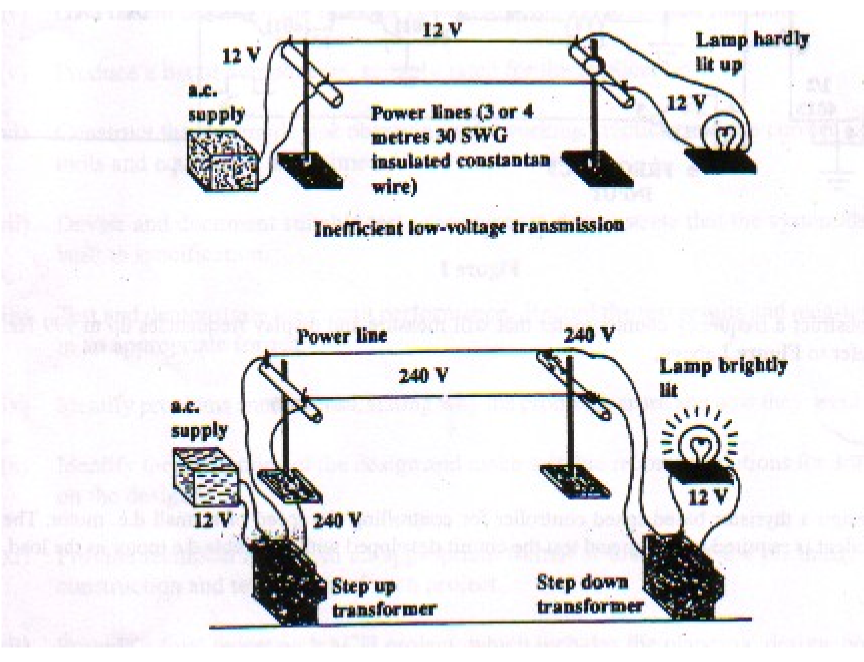


Figure II

Construct a model power line using a 12 V power supply as the 'power station' and TWO 1m length of constantan wire as the power lines and a lamp as the house. Investigate the power losses with 12 V d.c., and 12 V a.c. and then finally with TWO transformers. A lamp should be placed at the power station end and another at the house end. **Refer to Figure II.**

◆ REGULATIONS FOR PRIVATE CANDIDATES

Private candidates will be required to sit all components of the examination. Private candidates are required to write all papers.

A private candidate must identify a teacher or tutor from a registered institution (school or technical institute or community college) who will assess and approve the candidate's submissions for the Internal Assessment component of the syllabus. The name, school, and territory of the identified teacher or tutor should be submitted to the Council on registration for the subject.

◆ REGULATIONS FOR RESIT CANDIDATES

1. Resit candidates must complete Papers 01 and 02 of the examination for the year for which they re- register. Resit candidates whose moderated score is at least 50% of the maximum possible moderated Internal Assessment score may elect not to repeat this component of the examination provided they resit the examination no later than two years following the first attempt. Candidates may elect to carry forward their moderated Internal Assessment score on more than one occasion during the two years following the first sitting of the examination.

2. Resit candidates who have obtained less than 50% of the maximum possible moderated score for the Internal Assessment component must repeat the component at any subsequent sitting.

3. Resit candidates must be entered through a school, a recognised educational institution, or through the Local Registrar's Office.

◆ ASSESSMENT GRID

The Assessment Grid for each Unit provided below shows the marks assigned to each paper and to each Module, and the percentage contribution of each paper to the total scores.

Papers	Module 1	Module 2	Module 3	Total	(%)
External Assessment Paper 01 Short Answer	30	30	30	90	(30)
Paper 02 Essay/Extended Response	50	50	50	150	(50)
Internal Assessment Paper 03	20	20	20	60	(20)
Total	**100**	**100**	**100**	**300**	**(100)**

◆ GLOSSARY OF ACRONYMS/TERMS FOR ELECTRICAL AND ELECTRONIC TECHNOLOGY

ACRONYMS/TERMS	DEFINITION/MEANING
AC	Alternating Current
A/D converter	Analog to Digital converter
AM	Amplitude Modulation
AND	Logical function which is TRUE if all inputs are TRUE
CRC	Cyclic Redundancy Check
DC	Direct Current
D/A converter	Digital to Analogue converter
DPSK	Differential Phase Shift Keying
Ex-OR (XOR)	Exclusive OR. Logical function which is TRUE, if and only if, exactly one input is TRUE. Frequently called XOR
Ex-NOR	Exclusive NOR. Logical function which is TRUE, if and only if, all inputs are FALSE
EPROM	Electrically Programmable Read Only Memory
Flip-Flop	Edge-triggered element with two stable states that are toggled on different events, depending on the type, namely: D-flip-flop; JK flip- flop; T-flip-flop; and RS Flip-Flop
FM	Frequency Modulation
FSK	Frequency Shift Keying
Gate	A circuit on a chip which implements a logical function
LED	Light Emitting Diode
NAND	Logical function which is true, if and only if, all inputs are TRUE
NPN transistor	Negative Positive Negative transistor
NOR	Logical function which is TRUE, if and only if, all inputs are FALSE

ACRONYMS/TERMS	DEFINITION/MEANING
NOT	Logical function which is TRUE if the input is FALSE
PCM	Pulse Code Modulation
PNP transistor	Positive Negative Positive transistor
PROM	Programmable Read Only Memory
PSK	Phase Shift Keying
RAM	Random Access Memory
ROM	Read Only Memory
RLC circuits	Resistance Inductance Capacitance Circuits
SPDT switch	Single Pole Double Throw switch
SPST switch	Single Pole Single Throw switch
UART	Universal Asynchronous Receiver/Transmitter
USART	Universal Synchronous/Asynchronous Receiver/Transmitter

◆ MINIMUM EQUIPMENT LIST FOR EVERY FIFTEEN STUDENTS

NO.	EQUIPMENT	DESCRIPTION/SPECIFICATIONS	QUANTITY
1	Analog Multimeter	Volt/ohm/Current	3
2	Digital Multimeter	V/0/I/P/C/L	3
3	D.C. Power Supplies	5V/12V	3
4	Function Generators	Sinusoidol/square/triangular	3
5	Oscilloscope	20-100MHz Dual Trace	3
6	Bread Boards		15
7	Logic Probe	(At least TTL)	3
8	Logic Pulser	(At least TTL)	3
9	D.C. Motor	Small (0-24V); 2002-inch	1
10	Speed Encoder	Suitable for above (0-5V output)	1
11	Variac	0-240V; Single Phase	2
12	Single Phase Transformer	110/240V Primary; 15-0-15; etc centre tap	3
13	Squirrel Cage Induction Motor	1 phase cut-away view	1
14	D.C. Generator	Cut-away view	1
15	Synchronous Generator	Cut-away view	1
16	Hook-up Wire		
17	Test leads, clips, probes etc.		
18	Resistance Boxes		5
19	Capacitance Boxes		5
20	Inductance Boxes		5

Note: The above list does not include electronic and other components that may be required.

◆ SYMBOLS, ABBREVIATIONS, DEFINITIONS AND DIAGRAMATIC SYMBOLS

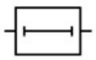
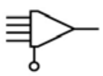
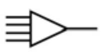
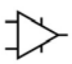
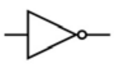
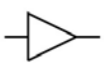
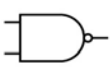
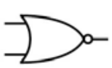
Abbreviations for Multiples and Sub-multiples		
T	tera	10^{12}
G	giga	10^{9}
M	mega or meg	10^{6}
k	kilo	10^{3}
d	deci	10-^{1}
c	centi	10-^{2}
m	milli	10^{-3}
P-	micro	10-^{6}
N	nano	10-^{9}
P	pico	10-^{12}

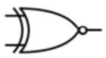
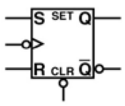
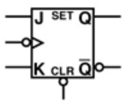
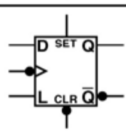
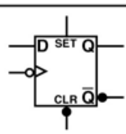
Units of length, volume, mass and time		
Quantity	**Unit**	**Symbol**
Length	Metre, kilometre	M, km
Mass	Kilogram, megagram or tonne	kg, Mg, t
Volume	cubic metre, litre	m^3, l
Time	Second, minute, hour	S, min, h

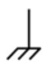
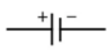
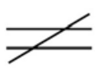
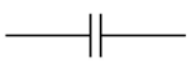
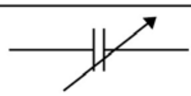
Units of length, volume, mass and time			
Quantity	**Quantity Symbol**	**Unit**	**Unit Symbol**
Admittance	Y	Siemens	*S*
Angular velocity	ω	radian per second	rad/s
Capacitance	*C*	Farad, microfarad, picofarad	F
Charge on Quantity of electricity	Q	coulomb	C
Conductance	G	Siemens	S
Conductivity	σ	Siemens per metre	S/m
Current Steady or r.m.s. value Instantaneous value Maximum value	I i I,,,	Ampere, milliampere, microampere	A, mA, μ*A*
Current density	J	ampere per square metre	A/m^2
Difference of potential Steady or r.m.s. value Instantaneous value Maximum value	v v, V.	Volt, millivolt, kilovolt	V, mV, kV
Electric field strength	E	volt per metre	V/m
Electric flux	Q	coulomb	C
Electric flux density	D	coulomb per square metre	C/m^2
Electromotive force Steady or r.m.s. value Instantaneous value Maximum value	E, e, e.m.f	volt	V
Energy	W	Joule, kilojoule, megajoule watt hour, kilowatt hour, electronvolt	J, kJ, MJ Wh, kWh eV
Force	F	newton	N
Frequency	f	Hertz, kilohertz, Megahertz	Hz, kHz, Mhz
Impedance	Z	ohm	Ω
Inductance, self	L	henry (plural, henrys)	H
Inductance, mutual	M	henry (plural, henrys)	H

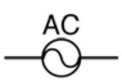
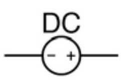
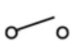
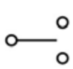
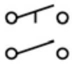
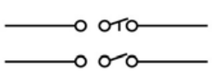
Units of length, volume, mass and time			
Quantity	**Quantity Symbol**	**Unit**	**Unit Symbol**
Magnetic field strength	H	Ampere turns per metre	At/m
Magnetic flux	Φ	Weber	Wb
Magnetic flux density	B	Tesla	T
Magnetic flux linkage	Φ	Weber	Wb
Magnetomotive force(mmf), magnetizing force, magnetic potential	NI	Ampere-turns	At
Permeability of free space or Magnetic constant	μ_o	henry per metre	H/m
Permeability, relative	μ_r		
Permeability, absolute	μ	henry per metre	H/m
Permittivity of free space or Electric constant	ε_o	farad per metre	F/m
Permittivity, relative	ε_R		
Permittivity, absolute	ε	farad per metre	F/m
Power	P	Watt, kilowatt, Megawatt	W, kW, MW
Power, apparent	s	voltampere	VA
Power, reactive	Q	var	var
Reactance	X	ohm	Ω
Reactive voltampere	Q	var	var
Reluctance	$\Re$	ampere per weber	A/Wb
Resistance	R	ohm microhm megohm	Ω, μΩ, MΩ
Resistivity	ρ	Ohm metre	Ωm
Speed, linear	u	metres per second	m/s
Speed, rotational	ω_o	radians per second	rad/s
Susceptance	B	Siemens	S
Torque	T	newton metre	Nm
Voltampere	-	Voltampere, kilovoltampere	VA, kVA
Wavelength	λ	Metre, micrometre	m ,μm

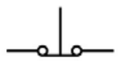
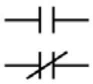
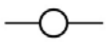
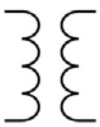
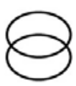
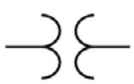
Graphical Symbols

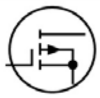
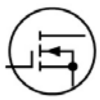
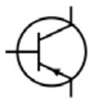
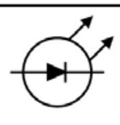
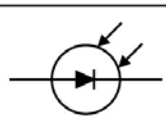
Analog and Digital Devices	
Symbol	***Devices***
	Crystal
	Delay Element
	Tri-State Buffer
	Integrator
	Summing Amplifier
	Operational Amplifier
	Inverter
	Buffer
	AND gate
	OR gate
	NAND gate
	NOR gate

Analog and Digital Devices (cont'd)	
Symbol	***Devices***
	XNOR
	RS Flip-flop
	JK Flip-flop
	Latch Flip-flop
	D Flip-flop

Fundamental Item	
Symbol	***Usage***
	Ground
	Common Ground
	Chassis
	Battery
	Resistor
	Resistor (Alternative)
	Variable Resistor
	Capacitor
	Variable Capacitor
	Circuit Breaker
	Fuse
	Inductor (Air core)
	Inductor (Magnetic core)

Fundamental Item (cont'd)	
Symbol	***Usage***
	Transducer
	Bell
	Microphone
	AC source
	DC source
	Speaker
	Lamp
	Motor
	Generator
	SPST switch
	SPDT switch
	DPST switch
	DPDT

Fundamental Item (cont'd)	
Symbol	***Usage***
	Pushbutton (break)
 N.O N.C	Normal Open Normal Close Relay contact
	Relay coils
	Transformer
	Transformer (Alternative)
	Current Transformer
	Potential Transformer

Semconductor Devices	
Symbol	***Devices***
	MOSFET (P-Type)
	MOSFET (N-Type)
	BJT (PNP)
	BJT (NPN)
	Rectifier Diode
	Zener Diode
	Thyristor (silicon Controlled Rectifier)
	Light emitting diode (LED)
	Photo-diode

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