

**A STUDY OF COMPUTER ASSISTED TEACHING AND
EVALUATION TECHNIQUES FOR ELECTRICAL AND
ELECTRONICS ENGINEERING LABORATORIES**

Thesis

Submitted in partial fulfillment
of the requirement for the degree of

DOCTOR OF PHILOSOPHY

By

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Under the supervision of

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2003

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PILANI, RAJASTHAN**

CERTIFICATE

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ACKNOWLEDGEMENT

I am deeply grateful to **Dr.R.Srinivasan**, Supervisor for his invaluable guidance and suggestions provided through out, with out which I would not have completed this thesis.

I wish to express my deep sense of gratitude to **Dr.Vedam Subramaniam**, Head & **Dr.A.A.Natarajan**, Professor, Department of Electrical & Electronics Engineering for their encouragement and valuable guidance.

I wish to express my gratitude to **Mr.Sriram**, Managing Director and **Mr.K.Siva Ramakrishna Sastry**, Technical Director of Kuruganti Computers Pvt. Ltd., and their staff for helping me in developing the software.

I wish to express my sincere thanks to **DAC Members & Staffs of Birla Institute of Science and Technology, Pilani** for their invaluable guidance, strong support, enlightening suggestions, reviews and involvement in this research work.

My sincere thanks are due to library staff of IIT(M) for helping me to obtain the relevant journal, reports and books in time and to my daughters **Ms.Yathu Sree** and **Ms. Usha Sree** who supported me through out this project.

I record with deep sense of gratitude my sincere thanks to teachers and students of various Engineering colleges and polytechnics who helped me in getting the necessary data pertaining to the research.

R.Thirumalai

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LIST OF ABBREVIATION

ITI	-	Industrial Training Institute
EEE	-	Electrical and Electronics Engineering
E & I	-	Electronics and Instrumentation Engineering
I & C	-	Instrumentation and Control Engineering
BJT	-	Bijunction Transistor
JFET	-	Junction Field Effect Transistor
UJT	-	Uni Junction Transistor
SCR	-	Silicon Control Rectifier
CE	-	Common Emitter
UG	-	Under Graduate
VI	-	Virtual Instruments
OC	-	Open Circuit
SC	-	Short Circuit
LED	-	Light Emitting Diode
VB	-	Visual Basic
CD	-	Compact Disc
Op. amp.	-	Operational amplifier
ROM	-	Read only memory
CATES	-	Computer Assisted Teaching and Evaluation System
CAT	-	Computer Assisted Teaching
SQL	-	Structured Quarry Language
Param	-	Parameter
DBMS	-	Database Management
HMML	-	Hypertext Mark up Language
HTTP	-	Hypertext transfer Protocol
URL	-	Uniform Resource Locator

ABSTRACT

Laboratory Education plays an important role in Teaching & Learning of basic engineering concepts. The Engineering Educational Institutions are classified as Industrial Training Institutes, the polytechnic colleges and Institutes/colleges offering engineering at their undergraduate level. Currently the strength of typical engineering class in Tamil Nadu is around 70 students (60 plus 10% for lateral entry of Diploma students plus "lapsed" seats that could not be filled up in First year but got filled up in the second year). Many Institution^s divide their strength to two sections for laboratory classes. Each laboratory class will have a strength of 30 or 35 students divided into six batches. Each batch will have five to six students. Under these circumstances, the laboratory activities are group activities handled by a couple of teachers and are teacher oriented. There is little scope for adaptive learning for students. Further there is a wide variation in marking scheme.

The thesis is an attempt to over come the above problems with respect to Electrical Engineering and Electronics Engineering Laboratories. List of experiments have been identified for both the laboratories. The various software that are available to do electrical engineering laboratory and electronics engineering laboratory are studied. Software packages are developed to perform these laboratory activities by Virtual Instrumentation Technique. The software comprises relevant theory, connection diagram, the procedure, connection by simulation, tabulation and graph for each experiment. The software has been designed to be used by the students well ahead of doing actual experiments inside the laboratory. A self-test is built-in to give the feedback to the student user. The relevant Instruments like voltmeter / Ammeter / Wattmeter /

CRO / Signal Generator / Multimeter are provided virtually on the computer for making measurements during the experiment.

These suggested software packages have been demonstrated to the teachers and students in polytechnic colleges and Engineering Colleges and their feedbacks are obtained. The software has been modified to suit to the needs of ultimate users students/ teachers and Institutions.

In order to find the effectiveness of computer aided teaching (CAT), field – tests were done. Institutions were selected such as Self-financing Institutions, Government, Aided Autonomous Colleges and Polytechnics. Samples were taken from all the above institutions. Two sets of students under each category having the same entry behaviour were chosen. One set of students were taught with CAT and the other with traditional techniques. Rank correlation has also been determined among various institutions. It has been shown that the hypothesis that learning outcome is better when CAT is used. For this the statistical tool – students 't' test has been adopted.

A time study was conducted in the Laboratory teaching and learning process with and without computer aided teaching for different sets of students for different experiments. It has been seen that there is a general reduction of time consumed for actual connection and conducting experiment in the case of CAT students as compared to non CAT students. So time gained can be profitably utilized for interaction with teachers and getting further in-depth training – a case of adaptive learning.

The CAT will assist the learner to accelerate and strengthen the learning process in the laboratory. It is an enhancement of the teaching learning process and is not intended to replace the conventional laboratory activity with the proposed scheme.

A computer evaluation technique (CATES) been designed for laboratory teaching and learning. The student can take the test in level-I and obtain his grade. If the student obtains mastery, he can take level-II and present his score to the teacher who gives his final evaluation and grade. Ample opportunities are given for adaptive learning. Certain minimum standard is maintained for all students of varying capabilities. Thus an attempt has been made to maintain certain minimum standards while providing flexibility to meet the requirements of students of varying capabilities with this individual learning and self - evaluation has been made possible.

This research has identified the problems in the present day Electrical Engineering and Electronics Engineering Laboratory teaching and learning process. The developed software package (CATES) is tested in real situations for teaching & learning. The CAT overcomes the problems to a large extent and helps each student to learn at his own pace and through CATES. This research will pay way for a drastic change in education system by setting up Virtual University concept in the Engineering Education Field.

CHAPTER - I

INTRODUCTION

1.1 Historical Review

Generally the engineering education is professionally oriented. The laboratories of various disciplines in the engineering field form an integral part of institutions imparting such education. With the same limited time in which theory is imparted to the students, experience should be given on practicals also. Because of this the theoretical concepts which the students learn, are well grasped by them after doing suitable experiments in the laboratory. After they pass out (1), the students feel confident in handling various equipments in the engineering field.

The laboratories are set up in the engineering colleges, polytechnic colleges and industrial training institutes based on certain standards (2) viz the experiments are conducted based on the syllabus as recommended by the appropriate authority, the knowledge level of experiments, the purpose and an add-on insight during the experiment to promote his theoretical knowledge, facility to easily handle the experiment repeatedly and independently by the students etc.

There should be periodical updates and refinement which gives a healthy practice in the maintenance of laboratory system, since a number of varying factors progressively creep like group of students per experiment may increase, time availability per experiment may get reduced due to constraints beyond control occasionally for the institutions, modern updating concepts regarding the experiments themselves etc.

Electrical and Electronics engineering laboratories are surveyed. The labs are checked whether they have the facility to carry out the experiments successfully. Subsequently, these can be improved as 'what is easily desirable and affordable' for betterment of their aim in providing practical knowledge to engineering students.

A study is conducted by taking samples from Industrial Training Institutes (ITI) which are teaching Electrical and Electronics Engineering Laboratory Courses to the level of crafts man as Electrician, Instrument Mechanic and Electronics Technician. It reveals that more emphasis was laid on machine/component identification, brief working and in reading circuit diagrams, checking / replacing components. This corresponds to about 80% of knowledge and psychomotor skills and 20% for actual experiment.

A typical example is given in the laboratory where an individual experiment is conducted with motor characteristics which involves connecting the motor, changing the direction of rotation, measurement of powers and calculation of efficiency. The Instructor has full freedom in fixing up the educational objectives and assures practical knowledge on the students. Generally, Teachers/ Instructors have slightly different scales in fixing up the difficulty level in evaluating the individual performance. It is also observed that always individual attention is given to each student in the laboratory by the Instructors. The duration of each laboratory session is about 6 hours, and sometimes it is extended to 8 hours. The Instructor also helps in crating faults in the circuits / system and training the students in identifying the faults and shows the students how to rectify them.

Many times the same experiment conducted with different students / batches and in different institutions. Some institutions have slip-ring motors; some have universal motors and some other has repulsion motor depending on the availability.

The passing of end examinations conducted as per statutory requirements has less uniformity and the instructors were given freedom to change the questions to suit the local environment. The study concluded that there is no identical situation or standardization. In addition, the weightage given to the documentation of student's record in laboratories is also varying. The difference in evaluation is due to infrastructure, availability of workspace, size of lab class, the consumables available, the quality and quantity of supporting staff, quality of the Instructor and his experience in the particular institution for a proper interaction with student. There is a wide variation between Government run institutions, the Institution sponsored by Industrial houses and the private (Self – Financing) institutions with respect to the quality. But the actual casualties are the students and the engineering education.

In the case of tertiary education, namely the education which is provided in polytechnic colleges, the situation is completely different. These colleges admit the students to undergo institutional study for 3 year duration and they offer engineering diploma to them. In their curriculum the laboratory activities form 40 to 50 percent of total performance depending upon each state and their syllabus (3). During the laboratory classes the students were given an instruction sheet which covers the aim, equipments required, procedure, safety precautions and conclusions with model graph. Students may perform the experiment many times without knowing the relevant theory (The theory portions are yet to be taught to the students due to time constraints). The role of instructors in such laboratories is immense and they transform and guide the students from the start till the end. The laboratory coaching thus is a teacher centric (Fig 1). More time is needed for the student to understand and assimilate; in addition to that, more involvement of supporting staffs is also necessary in the laboratory. The reports on laboratory activity is brought out by the student in the form of laboratory records which are mostly similar in nature with certain standard test results of any particular experiment in that laboratory based on

the environment conditions. The evaluation process is also not uniform. Consequently there is a wide variation in relative assessment of outcomes. Many electronics laboratories are in possession of ready made kits, with 'switch on-observe effect' concept (Fig 2). Here less opportunity is given to the student to study the concept in detail. The Electrical Machines laboratory has minimum instruments and equipments. Lack of proper maintenance and qualified trained staff reflects on the quality of laboratory education imparted to the students.

In the case of undergraduate education, the study was conducted in four types of colleges namely the Government, Aided, Autonomous and Self-financing. A wide variation of infrastructure is noticed in all the four types in terms of provision of machines, instruments, components and laboratory area. The laboratory activity conducted is mainly focused on previous year students/ teacher experience. Mostly the same laboratory working sheets are repeated. Some colleges have typical laboratory manuals (4) provided for many years. The lists of experiments vary widely among the four types of colleges for a particular laboratory. Some colleges perform 8, other 10 and some other 15 experiments for the same course curriculum, which is mainly based on the infrastructure availability. For example in Devices and Circuits laboratory there is less uniformity in the list of experiments and in the analysis of results (outcome).

Few engineering institutions give good scope for self-learning of students. Here results depend on entry behavior and self motivation of the students. In general, the laboratory instructor decides the depth of knowledge he desires to impart to students in the experiment taking into consideration, the infrastructure, supporting staff, level of incoming students, the students' interest, and their encouragement from management (5). The question paper for end examination is set by the instructor himself. Usually there is wide variation in standard and depth of knowledge and time

for performing the experiment. As per syllabus, set of experiments are to be performed, but it varies widely from one college to another, among batches, and among teachers. For conducting laboratory sessions the time allotted as per syllabus is 6 hours in two sessions. But always the time spent on lab session ranges from One and half hours to Two and half hours only. The students are not engaged or given enough opportunity to utilize full three hours in the laboratory.

Many experiments, especially in electronics lab the questions are stereotype, and they do not even change the components. As a result, all the batches are expected to get same inference. This leads to lack of enthusiasm and interest in students to perform experiments. Hence the lab activity is shifted from individual to group. Mostly experiments are conducted by a batch of students. The batch of students will get same set of readings and conclusions. As per university norms, the students are evaluated individually, exposure is given only in the form of group effort, so the system of Teaching – Learning – Evaluation becomes less satisfactory.

To elucidate, let us take an example of an experiment in the Electrical Engineering Laboratory which is popular, the determination of efficiency and regulation of single phase transformer by conducting open circuit and short circuit tests. A college uses Digital Wattmeter and Digital Ammeter mounted on the work table, the batch of students are allowed to do 'end-connections' and after due verification switch 'on' and take readings. For the same experiment, for another set of student, they are asked to use CT and LPF Wattmeter. In this context the instructor feels that, the students were given an opportunity to understand and learn 'in-depth' in the laboratory situations. Though in the laboratory, exposure is to reading circuit diagram, making actual connections, procedure, precaution, observation, analysis and conclusion, all these things vary widely among the laboratories for the same course. A datum to fix the understanding and knowledge-transfer is not seriously thought of.

The assessment scheme adopted for laboratory activity is also found to have wide variations (6). Under the continuous assessment scheme, the students are given an experiment in batches to perform and tabulate the readings in a standard format indicating the result and conclusion. About 20% of the marks are allotted as internal assessment. During end examination, 80% of marks are awarded. Many colleges offer 50% to 60% of the marks for connection diagram, actual connections and procedure. For viva voce about 5% to 10% of the marks are allotted. Some experiments are knowledge based, some of them are skill oriented and some others are design and analysis oriented. There is no distinct grade of awarding marks; it is left to the teacher on the scene, mostly influenced by his/her environment. The universities appoint an external examiner for the final examination. Depending on the circumstances, he, in consultation with the internal examiner adopts a marking scheme for each experiment or for group of experiments. This results in wide variations.

Finally, the responsibility lies in the viva voce answered by the students, determine, in fixing the final grade. In particular the allotment of 5% - 10% for viva reflects poorly on the over-all grade of the student passing out. Since it is a professional course, certain amount of in-depth-knowledge is expected from the pass outs. Here too, there is no uniformity among various institutions in the allotment of marks.

A detailed study is under $\hat{\text{t}}$ aken in the teaching of electrical engineering and electronics engineering laboratory courses in polytechnic colleges (Diploma) and Engineering colleges / Institutions (UG). The outcome of the study is depicted in the following chapters.

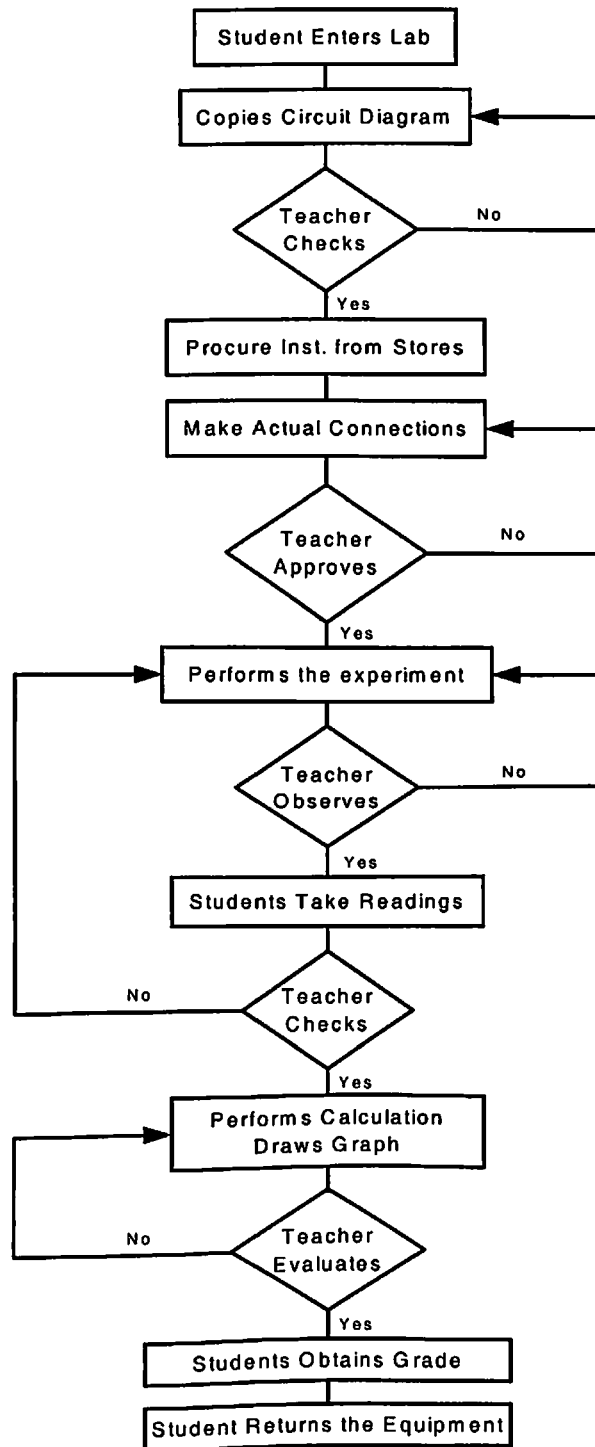


Fig (1)

**The sequence of activities in the Electrical Machines Lab
at Polytechnic Colleges**

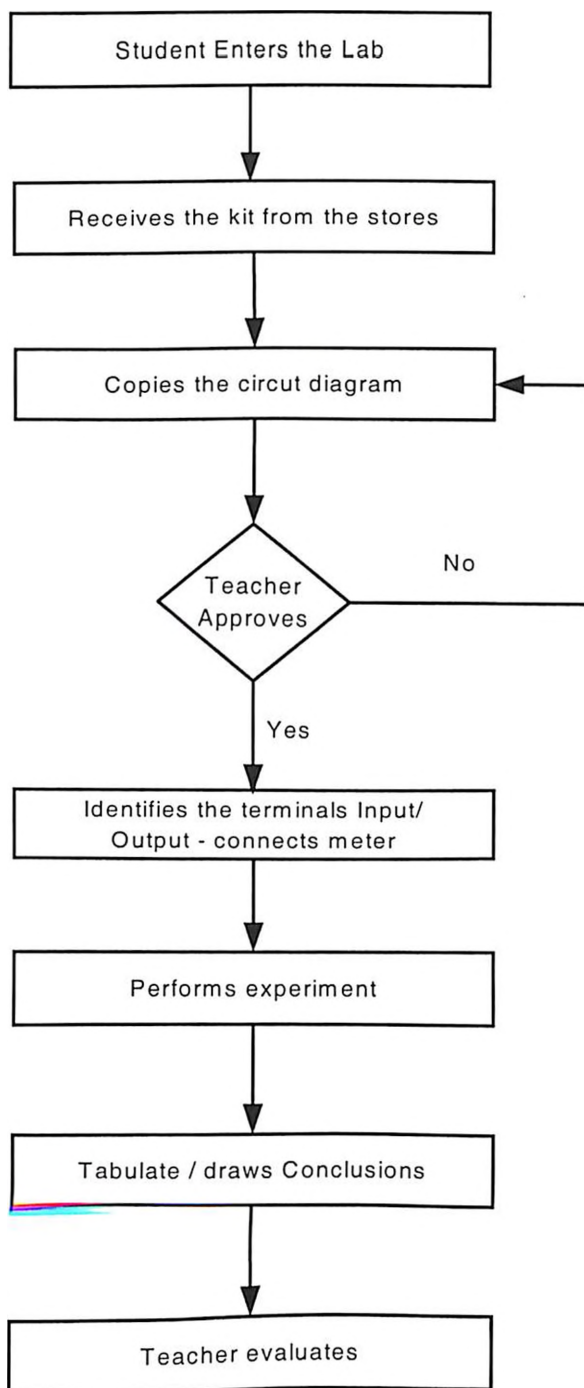


Fig (2)

The sequence of activities in the Electronics Engineering Laboratories at Polytechnic Colleges

1.2. Teaching Electrical and Electronics Laboratory in Tertiary Education

1.2.1. Overview

The polytechnic colleges are offering three year Diploma courses in Electrical & Electronics Engineering (EEE) and Electronics & Communication Engineering (ECE), Computer science and Engineering (CSE), Mechanical Engineering (ME) in addition to minor courses (minor in nature with respect to intake of students). These courses will have Electrical laboratory and Electronics laboratories in their curriculum. The Electrical Engineering laboratory consists of three independent, sections covered over three semesters namely Electrical Circuits laboratory having experiments on verification of KCL, KVL, Thevenins' theorem, power measurements, series and parallel resonance, maximum power transfer theorem. The syllabus for this laboratory is prescribed by the competent authority (3). The content varies from state to state like experiments on Measurement of resistance using Megger, Measurement of earth resistance using earth testing megger (7).

Electrical Machines laboratory having 2 sections: The Electrical Machines Lab-I for experiments on DC Motor and generator and the Electrical Machines Lab-II for AC Machines containing static and dynamic Machines. This includes transformer, Asynchronous motors and synchronous generators and motors. In some situations (8) the transformers topic is included in the Machine-I laboratory and the Machine-II lab will have Alternators & Synchronous motors in addition to the Induction machines.

The Electrical Engineering laboratories are equipped with machines and the associated measuring Instruments as per the AICTE norms (9). The Government run institutions will have enough machines, equipments and instruments. During the last decade the laboratories of polytechnic colleges run by the Government and Government Aided, are all sufficiently updated and equipped by 'World Bank Aid Project' (10) and by direct central assistance from Government and AICTE grants. Of late the private

institutions have also recently built laboratories which are adequate to meet the objectives of Teaching-Learning. Many institutions have prepared laboratory manuals for their students use and some in association with certain service organizations (11) also.

Now in the case of Electronics Laboratory, the polytechnic colleges have two laboratories section spread to two semesters, the Electronics Lab-I for odd semester and Electronics Lab-II for even semester. In some colleges the division is Electron Devices Laboratory and Electronics Circuits Laboratory. On scrutiny the Electronics Lab-I will have characteristics experiments for various devices like BJT, FET, and SCR etc. with certain diode experiments as rectifiers, voltage regulators and on filters. The Electronics Lab-II will have experiments on various amplifiers (using transistors and operational amplifiers) and oscillators (12) (including relaxation oscillators). In certain syllabus this laboratory includes logic gates, ADC & DAC experiments (13).

The syllabus and its content have considerable variation in different states (14). The individual Institutions fix additional experiments apart from the standard experiments. The experiment contents of laboratory is environment oriented (teaching faculty, infrastructure, Input student level). The syllabus gives only a broad out-line of what is intended. For example, when the students are expected to verify Circuit theorems and circuit laws, the polytechnic instructor selects a circuit and asks the student to verify by conducting the experiment. The circuit components are decided by the faculty and the results are also a known value. Minimum information is imparted in terms of tolerance or specification of components. It is mostly a repeated experiment. As a group activity, the student shows inadequate interest. Some institutions have eliminated these experiments considering them as simple and waste of time. In the case of Electrical Machines Laboratory even though there is scope of conducting many experiments, the institutions/instructor is confined to perform only select basic experiments. While evaluating the student's performance in the laboratory activities, 50-50 is given to knowledge and skill (conducting experiment and taking reading) and no weightage is given for analysis of results or application in the field.

1.2.2 Teaching-Electrical Engineering Laboratory

In the polytechnic college, the Electrical Engineering Laboratory is used to verify the concepts taught in the class room and to build the confidence of the students in learning their subjects. The present scenario of teaching the Electrical Engineering laboratory is shown with details of experiments Fig (3). The Instructor usually conducts a couple of classes in explaining the experiments for one cycle viz., 5 to 8 experiments; During the lecture, circuit diagram, procedures, safety precaution, tabulation, calculation including model graph are explained to the students. Usually this activity is supplemented by issuing laboratory manual, (15) which contains all these relevant particulars. The student is expected to draw the circuit diagram before the start of the experiment in the lab and obtain the Instructors concurrence. He also lists the equipments-instruments according to their range and gets it from the stores. After he sets up the experiment the connections are verified (for correctness and for the safety of the equipments used by him) by the supporting staff.

The student will perform the experiment by taking readings as required under the supervision of the instructor. After the completion of the experiment, he perform calculations (like determination of torque, slip or efficiency in case of a motor) needed for the experiment and obtains the result get the approval of the Instructor. The students are satisfied if they obtain the desired characteristic curve as per the model graph supplied to them. The students are assessed awarded the marks suitably for the experiment. The sequence of activities in the electrical machines laboratory is in Fig (1).

In one cycle, different experiments with different concepts are involved. In some experiments the students would not have got the subjects taught in the class, the theory pertaining to the experiment yet. Still he has to go to his lab class and arrive at the desired results of the experiment in the laboratory classes. In the final examination the student of course perform the experiment on an individual basis fully conversant with the relevant theory portion. The change to individual performance makes the student enhance his learning outcome and experience.

ELECTRICAL ENGINEERING LABORATORY
--

ELECTRICAL MACHINE LAB – I	ELECTRICAL MACHINE LAB - II
1. Verification of KCL, KVL	1. Alternator regulation 2. Alternator - Load test
2. DC Generator OC Test 3. DC Generator - shunt - Ext. Cha	3. 3 Phase SQIM - Load test 4. Single phase motor Load test 5. Circle diagram
4. DC Motor - Starting & Speed Control 5. DC Motor - Load Test – Calculation of efficiency	6. V and Inverted V curves 7. Synchronizing
6. Swinburns test	
7. Transformer OC & SC Test	

Major experiments performed in the Polytechnic Colleges

Fig (3)

In the semester time table is framed to work for 16 weeks including revision and Model examination. In a class strength of 60 students, at a time 30 students will attend the laboratory practical classes. These thirty students are divided in to six batches. Each batch contains five students designed to perform an experiment. The Instructor will have

to see all the six experiments in each class. The supporting staffs will issue the necessary meters for all the experiments and take it back. In the first half an hour the students will draw the diagram of connections. They have to copy it from the instruction sheet/Laboratory Manual given. In the next half an hour they will receive the relevant instruments from the stores. In the next half an hour the students will make actual connections. The instructor will verify the actual connections. The experiment is switched on and the student takes half an hour to perform the experiment. All the students are actively involved while doing the experiment. The readings of various meters are tabulated. The remaining time is left at the disposal of the students to perform the calculations and draw the graph. The batch mate will disconnect the meters and hand it over to the stores. As many of the institutions follow the continuous assessment system each student will do the calculations and obtain the initial of the Instructor, in each of the laboratory class. There will be enough time to conduct 10 experiments in the laboratories in a semester. The various time elements are shown in (Fig.5) for a duration of 3 Hrs. inside the laboratory.

The polytechnic college will conduct a model practical examination prior to the end examination to give opportunity to the students to perform the experiment individually. The Allocation of marks to the lab activity is for 100 marks (Fig.6). In this 20 marks is for internal assessment and 80 marks for the end examination. Invariably the laboratory marks will be higher than the theory marks of the students. The supporting staff plays a major role in conducting the lab sessions. They are always with the students while conducting the experiment in order to take care of the instruments and equipments. The whole laboratory activity is teacher oriented (Fig.7).

1.2.3 Teaching – Electronics Engineering Laboratory

In Polytechnic curriculum the subject of Electronics was introduced in the early seventies as an elective, in 1980 syllabus revision, as a core subject with laboratory activity. Initially vacuum tubes were taught and in 1985 syllabus revision an elective namely Industrial Electronics course was introduced. The Technical Teachers Training Institute (TTTI) has organized many short-term courses for the polytechnic teachers in Electronics in addition to their Diploma in Technical Teaching and B.Tech - Education Programs. Orientation courses were also conducted by selecting a model college and bringing staff members together and laboratory manuals are prepared.

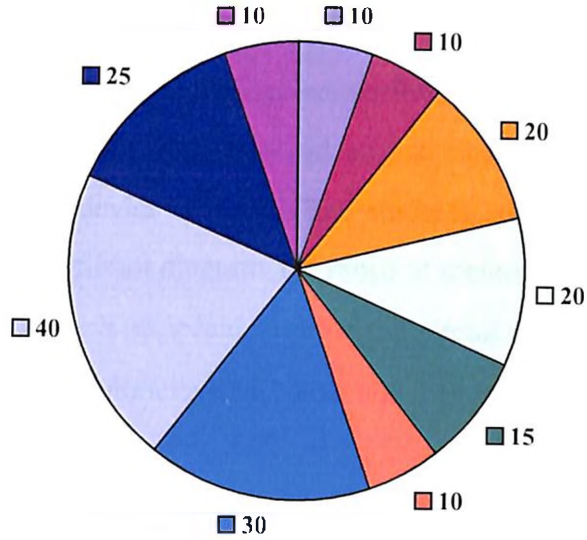
ELECTRONICS ENGINEERING LABORATORY

ELECTRONICS LAB - I	ELECTRONICS LAB - II
1. Characteristics of Junction diode	1. RC Coupled amplifier
2. Characteristics of Zener diode	2. Transformer Coupled Amplifier
	3. Differential Amplifier
3. Characteristics of BJTS	4. Hartley Oscillator
4. Characteristics of FETS	5. Colpits Oscillator
5. Characteristics of SCR	
6. Characteristics of CE,CB	6. Multivibrators
7. Characteristics of UJTS	7. Logic Gates
	8. Counters
8. Characteristics of DIAC	
9. Characteristics of TRIAC	9. ADC / DAC

Major experiments performed in the Polytechnic Colleges

Fig (4)

TIME MANAGEMENT - TLP



- Induction-Enters the Laboratory
- Draw the circuit diagram and reads the procedures
- Checks the exp. with Teacher-waits in Q
- Receives equipment & material from stores
- Make actual connections
- Wait for the circuit checkup by lab staff
- Energises the circuit perform the experiement
- Performs Tabulation, Calculation, graph
- Correction with Teacher offers grad-Q
- Equipments disconnected Return to stores

Fig (5)

Details of time elements in the Laboratory activities.

As per syllabus (3) 6 Hrs are allotted for Electronics Engineering Laboratory work per week. The Electronics Engineering laboratory is spread over to two semesters during the latter half of second year and first half of third year (IVth & Vth semester) (Fig.4). The Electronics lab is christened as Electronics Lab I and Electronics Lab II. In the lab I the characteristics of the devices are performed. For example; semi conductor diode, static characteristic in the forward and reverse bias is performed. Usually a kit is available with the given device mounted. The students are given an instruction sheet. Invariably it contains the circuit diagram, the range of meters, procedure conclusions and model graph. The student is expected to draw the circuit diagram, obtain the relevant meters like mill ammeter, voltmeter multimeter and then rig up the circuit.

The laboratory staffs will usually be interested in the safety of the components and the equipment like power supply, CRO and multimeter. They check up the connection and energies the circuit. The students take up the readings at various intervals of the given variable and note it down in a tabular column. The role of the teacher is an observer and imparts knowledge while reasoning out the variations and enables the students to plot the graph which is ultimately the performance characteristics of the devices. The devices are junction diode, zener diode, transistors like BJT, UJT and SCR, Diac and Triac. In this laboratory certain rectifier experiments and filters are also included. In Government polytechnic 12 to 14 experiments and in private and aided polytechnic 16 to 18 experiments are performed. These experiments will take about an hour to complete. The student group will have wide range from two to 6 students (Fig.8). Only certain components are available/ given to the students suiting to the range of meters available in the particular institutions.

In the electronics circuits laboratory experiments like RC coupled amplifier, transformer coupled amplifier, differential amplifier, multivibrators, oscillators and logic

circuits are usually performed. Almost for all experiments kits are available. The students are expected to connect oscillator, power supply and AC milli voltmeter. The students are made to obtain the Gain Band Width product/ Frequency response. The teacher spends very less time and the students are also very comfortable while conducting the experiment. The evaluation (Fig 6) is also simple as there are no deviations in the result. The students are only verifying the characteristics. This laboratory has 'switch-on', take readings' concept. In many kits, that are available in various institutions have built in instruments and power supply which gives less opportunity for student to identify the terminal and make circuit connections as per the diagram.

MARKING SCHEME – LABORATORY ACTIVITIES – POLYTECHNIC

CONNECTION DIAGRAM	:	20
ACTUAL CONNECTIONS	:	15
PROCEDURE/ TABULATION	:	20
CALCULATION / RESULT	:	20
VIVA VOCE	:	05
INTERNAL ASSESSMENT	:	20

The marks allocated has ^{ve} not reveal^{ed} the students ability by testing, either the knowledge or Psychomotor skill for an experiment.

Fig (6)

Observations

The electronics laboratory activity in different polytechnic colleges varies widely. The knowledge transfer and the requisite skill imparted to the students in the laboratory situation depend on the infrastructure and the teachers. The importance is not given to the component specification and circuit analysis. There is little opportunity for the students/faculty in understanding the working of the circuit. They are addicted to 'Electronics laboratory kit' manufacturer's manuals. The laboratory activities are teacher oriented (Fig.7), the equipments availability are minimum with majority of them are 'in service'. The time allotted for conducting the laboratory activity in the present scenario with the in-depth level of experiments is high and are not given opportunity to change the value of passive components and study the circuit.

Some Polytechnic Colleges started giving group board and components enabling the students to rig up the circuit for select experiments. As it is a group activity, the objective is not achieved. Many times the laboratory staff rig up the circuit and the students observe it. The evaluation of the students by the teachers is mostly by observation and viva questions. The students are maintaining a record book with observation and conclusions and submit them for evaluation is of almost stereotype.

BATCH SIZE OF ELECTRONICS ENGINEERING LABORATORY (POLY TECHNICS)

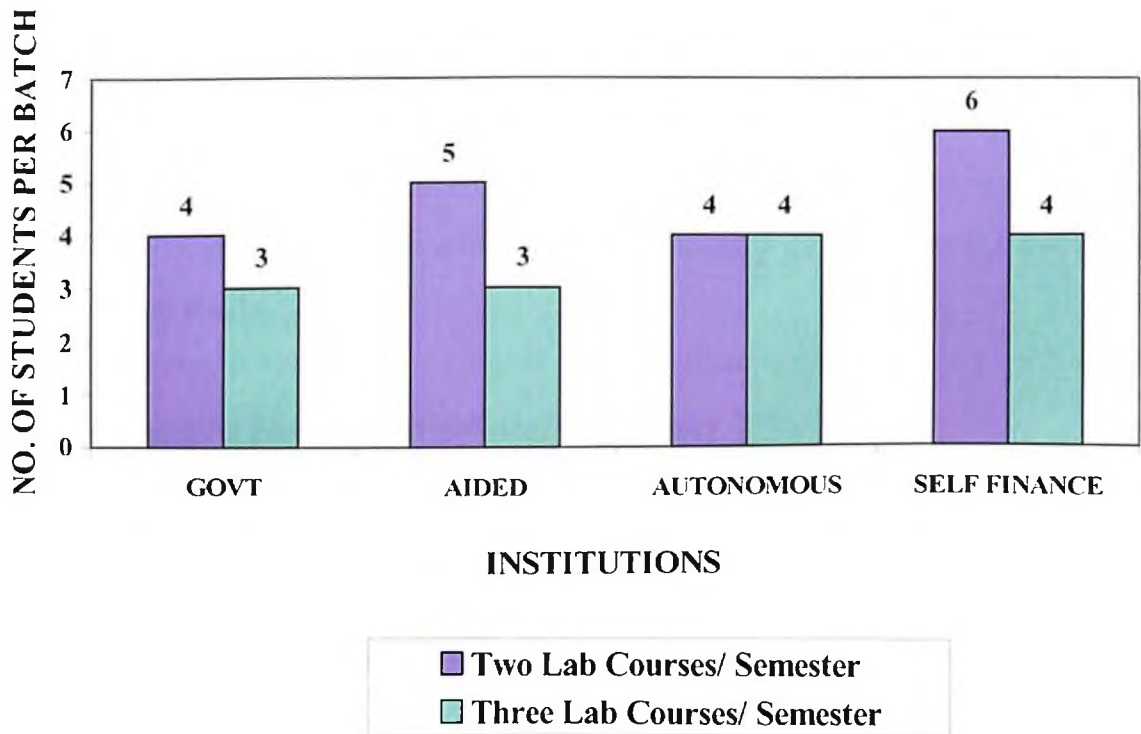


Fig (7)

The number of students per batch engaged simultaneously for performing an Experiments in the Electronics Engineering Laboratory for offering two lab courses for semester and three lab courses for semester (Lateral Entry is not taken into account).

1.3 Teaching Electrical and Electronics Laboratory in UG Courses

1.3.1 Introduction

Teaching Electrical Engineering is always an interesting experience to the teachers as it involves mostly an abstract concept. Teachers can develop the subject from the effect to the cause. To increase the knowledge (Remembering previously learned information) and in understanding the basic concepts, many learning techniques may not give fruit full result like verification of concepts by the learners in a laboratory situation (18). This is an indispensable task. This has developed the confidence between the teachers and taught.

1.3.2 Teaching Electrical Engineering Laboratory

A study is undertaken in the Electrical Engineering laboratory teaching by TLP (Traditional Laboratory Practices) at Southern Universities and Colleges (Fig.9). Electrical Engineering Laboratory needs good investment and proper maintenance. At present certain commissioned institutions have high capacity machines and newly established laboratories have smaller capacity of machines (Investment constraints). The students were given instruction sheets or laboratory manual which will contain the circuit diagram, the procedure and the model graph. The students are expected to list the components/meters required, then receive them from the stores and make necessary connections. The Technical staff will check the circuit (for the safety of equipments/meters) and switches ON the supply. The students then conduct the experiments and tabulate the readings under the supervision and vigil of the Laboratory Staff. As per the requirements/Instructions they perform the calculations and plot the required graph, which will be checked by the teacher.

List of Technical Institutions / Universities imparting UG Courses taken for study

Electrical and Electronics Engineering Laboratory courses syllabus were studied for the Research

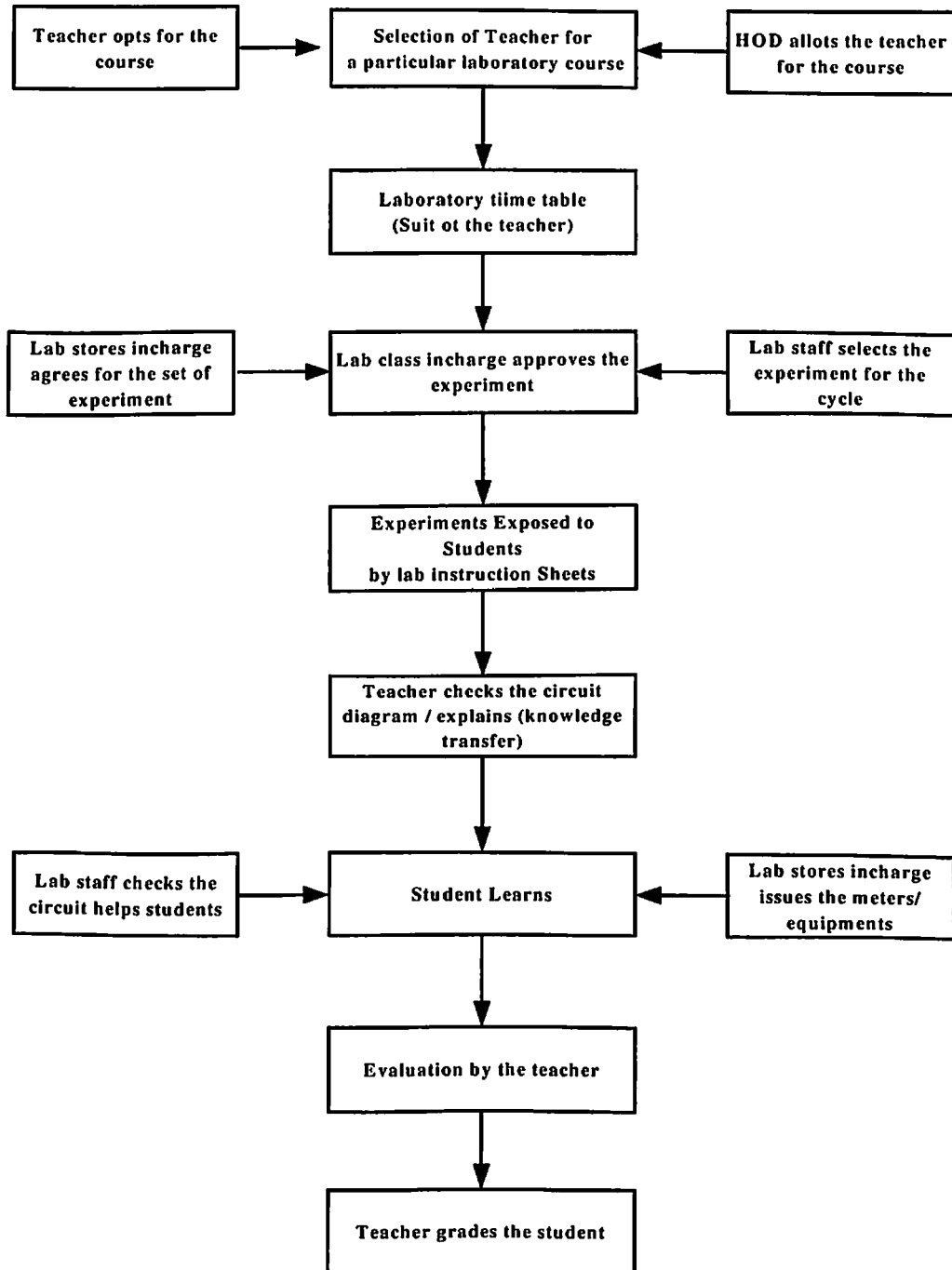
1.	Anna University	Chennai
2.	Bharathidasan University	Trichy
3.	Bharathiyar University	Coimbatore
4.	Madurai Kamaraj University	Madurai
5.	PSG Institution of Tech	Coimbatore
6.	Vellore Institution of Tech	Vellore
7.	SSVMS University	Kancheepuram
8.	Sathyababa Institute of Tech (Deemed University)	Chennai
9.	REC (Now NIT)	Trichy

The syllabus of the universities is considered for the preparation of simulation Lab Experiments.

Fig (8)

TRADITIONAL LABORATORY TEACHING

UG COURSES



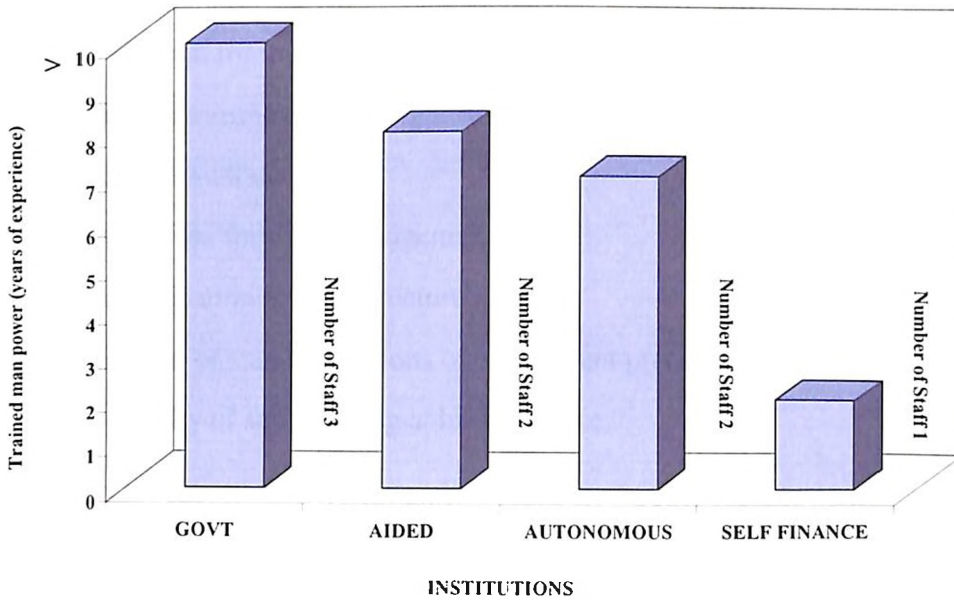
Laboratory activities are Teacher Oriented

Fig (9)

Very little knowledge is imparted to the students to the concept 'why' while doing the Laboratory experiments. In majority of the colleges, at the UG level, in the Electrical Laboratory, individual performance (conducting of experiments individually) are not adopted. Minimum with two students to maximum of six students (in some class-mass education – Teaching by demonstration) are given opportunity to conduct the experiment (Fig 8). The students are invariably not utilizing the 3 hours allotted time inside the laboratory. The actual performance of experiment takes 20 to 40 minutes (Fig 5). The students have taken the laboratory activity to verify certain principles and concepts experimentally. Less emphasis is given to comprehension, analysis, application or reasoning. No serious thought is given for the evaluation. Normally a norm-referenced test is conducted (used to ascertain an individual status with respect to the performance of other individuals on that test). For better teaching-learning in a laboratory situation, effort should be on mastery level of learning, preference should be given to a criterion-reference test (ascertain an individual status with respect to a defined behavioral domain).

It is observed that the institutions/colleges which are having a team of experienced staff as supporting staff, the students were given enough opportunity to achieve the desired learning outcome (Fig 10). Even though the syllabus of various universities stipulates certain minimum experiments, at present, the colleges, teachers and the students are taking only the minimum (six to eight) number of experiments. The allocation of budget for Electrical Maintenance/up gradation or modernization of Electrical Laboratory is minimum. For the past five years (More allocation of funds for computer/Communication Engineering departments as it is felt that new technological input requirements) Teachers are also migrating to other departments (or concentrate in other fields) like Bioengineering or Mecc^otronics or Embedded Systems. Hence during the last decade the staff strength or development in the Electrical Laboratory activity is decreasing.

TRAINED MANPOWER (SUPPORTING STAFF)



Availability of trained manpower to conduct laboratory classes in Engineering Colleges.

Fig (10)

1.3.3 Literature Survey and Problem Identification

The review of existing system of Teaching Electrical Engineering and Electronics Engineering laboratories both the Polytechnic Colleges and Engineering colleges reveals the following

- The batch size is more and it is increasing.
- Wide variation of human resources (Trained and experienced man power).
- No built in mechanism for ascertaining the entry behaviour before conducting an experiment.
- Laboratory activities are teacher oriented.

- No scope for students to go for adaptive leasing.
- Lack of uniformity in evaluation.
- No attempt for individual learning
- Little opportunity for change of circuit components or circuit configuration in electronics laboratory.
- Little scope for time management.
- Wide variation in infrastructure.
- Variation of standardizations of experiment procedure.
- No facility of self learning at his own pace.

The constraints:

The time allowed for the lab session is only three hours. The laboratory activity cannot be eliminated as per the university norms and it should be done in the college by each student. The teacher is indispensable.

The objectives have to be fulfilled to the maximum extent in the teaching and learning process of electrical and electronic engineering laboratory and hence, the Computer Assisted Teaching is designed. At present, all the colleges are having computers and the departments too have computers in enough numbers. The students are no more novices to the computers. Hence, the Computer Assisted Teaching is contemplated.

Before attempting to develop suitable software for Computer Aided Teaching, a detailed study is made on various available software products. For example, VPLab Power Conversion Using Virtual Power Laboratory, package has experiments on DC Motor, Three Phase AC Induction Motor, Single Phase AC Induction Motor, Three Phase AC Synchronous Machine, Single Phase Transformer, Three Phase Transformer, Solid State Controlled Rectifier, and Triac Controller. These experiments are very

elaborate. To perform experiments from start to finish, the student are forced to go through various steps given in the software which are not essential for verifying a particular concept. Normal time taken to complete an experiment including the tabulation, calculations and answering the end questions takes more than two and half hours. This product focuses towards replacing the conventional laboratory activity which is not the objective.

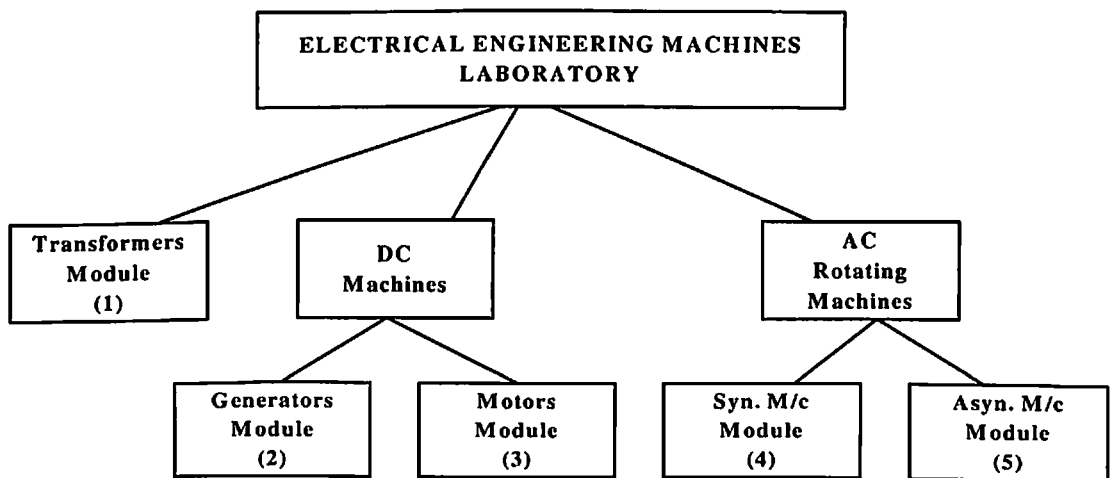
Certain software like LABVIEW developed by National Instruments can be used to simulate various lab activities but it needs a software programming skill and it has its own scripting language through which the students are expected to interact with the software, which is beyond the scope of the students learning electrical and electronics laboratory fundamentals during their third and fourth semester of their study. This could be used for project work application in higher classes. Moreover, the educational institutions have to invest on this software for Teaching Learning Process.

There are various virtual laboratory (98) for technology developed (99) by different universities (100) (available as free downloaded version) is developed by Professors with different learning objectives and outcomes (97). For example, DC Motor Speed Control is to be taught to our student by introducing resistance either in armature circuit or in the field circuit. But the software has built-in thyristor control for speed variation which is not for our level of students. It is not possible to alter the software to suite our students.

NASA Learning Technologies (96) developed software for web based education. Though it is not free, is does not suite for syllabus. It is attempting to do experiments in simulation to augment a laboratory environment. These packages can be used by student for adaptive learning. This will supplement the laboratory activity and not assist the student to do basic experiments (94).

Previous
reference
9

Hence a software package which does not involve huge investment, which has basic electrical and electronic laboratory coverage suiting our syllabus and environment, which does not replace conventional laboratory, which enhances Teaching Learning Process is developed.



Major Grouping of Electrical Engineering Laboratory experiments for the development of software

Fig (11)

1.3.4 The Concept of Virtual Electrical Machines Laboratory

To overcome the deficiency, a study was conducted to develop software to simulate the Electrical Engineering Laboratory activities. The students were given an opportunity to learn the experiment virtually (fully ~~on~~ ^{on} the computer screen) before they take up a real laboratory activity (19).

This will not replace the conventional Electrical Laboratory. It will interface the classroom and laboratory teaching which will supplement the learning process. The software is developed with the following tools VB and VC++ Photo shop, Coral draw, Photo flash, sound forge to work in Multimedia work station (20).

For the purpose of development of software, the Electrical Engineering Machines Laboratory activity is grouped into three sections (Fig 11). The first section deals with transformers. The second being DC Machines comprises of motors and generators and the third being the AC Rotating Machines. This section will include the synchronous motor/generator and asynchronous motors. First section will have four experiments; the second with six experiments and the third will have nine experiments. The software is developed for the user in the Electrical Laboratory having the syllabus for one credit course. The use of the software assumes certain entry behaviour in terms of knowledge and skill in the operation of computers. It is found that while implementation the desired input is available with samples taken during the study.

The software is loaded as five Modules. Each module is in a CD ROM. The five CDs are independent and the user can operate in their 'stand alone' PC having minimum configuration of P-II, 32MB, 16BIT, High Colour Monitor, 800x600 pixel.

Module 1

Transformer

In this module the theory is started with principle of transformer, types and the working. The voltage ratio, turns ratio, current ratio is defined and the manner of finding them are explained. The following experiments are included.

1. The open circuit test - To determine the no load current and its power factor. The power input on no load. The separation of hysteresis and eddy current losses and drawing of the phasor diagram on no load (61, 52).
2. The short circuit test – To determine the copper loss at a particular load and at various loads. Variation of copper loss at various load currents (53, 56).
3. Predetermination of efficiency of transformer at various loads and at various power factors from the open circuit and short circuit test results (52, 59).
4. Load test on single phase transformer – Loading the transformer with loading rheostat. The input and output are measured using wattmeter. Efficiency calculation and efficiency curve at various loads are obtained and plotted. The condition for maximum efficiency is verified (60, 61).
5. Determination of equivalent circuit – From the open circuit and short circuit test results the equivalent circuit is drawn. The determination of regulation at various loads and power factor (50).
6. Three phase transformer – Polarity test, Vector grouping of transformers, Three phase to Two phase conversion, Scott connection, Voltage measurement (51).

This module is designed with experimental simulation, theory and self test. Each experimental simulation will have connection diagram, virtual measuring instruments, transformers; loading rheostat and connections for inter connection of instruments and

equipments by prompt and drag technique. Sample readings, calculations and graphs are available on the computer screen,

Module 2

DC Generator

This module gives the requisite theory portions on basic principle of DC generator, constructional details and its working. The emf equation is also explained. The experiments that are included in this module are given below

1. **Open circuit test** – This experiment is performed on the generator coupled to the DC motor. Initially the procedure to start the prime mover (dc motor) is explained. The generator is made to run at rated speed and then the field current is increased to obtain open circuit characteristics (Magnetisation curve). The concepts like residual magnetism, condition for self excitation are explained (55).
2. **Load test on separately excited generator** – This simulated experiment gives details of obtaining and plotting of both external and internal characteristics. The effect of armature reaction is explained. Experiments can be simulated up to 125% of the full load (51, 52).
3. **Load test on shunt generator** – This experiment deals with the determination of external and internal load characteristics. The conditions for self excitation are explained. Regulation characteristic is introduced (58).
4. **Load characteristics of cumulatively compounded generator** – This experiment explains the method of obtaining both internal and external characteristics of a cumulatively compounded generator (54).

5. Load characteristics of differentially compounded generator – The variation of terminal voltage and emf generated at various load currents are obtained and plotted (56).
6. Load characteristics of series generator – In this experiment the series generator is coupled to the prime mover. As the load current increased the emf generated also increased and hence the terminal voltage also increases. The variation of terminal voltage with various load current are obtained and plotted virtually (51, 52).

In all the experiments the prime mover is the DC motor. As the generator is loaded the motor is also loaded and its speed will decrease. In the simulation the speed is assumed constant but in practice it is not so. The error is exposed to the user and the necessary precautions while conducting the experiment is also explained.

Module 3

DC Motor

In this module, the principle of motor action is explained in the theory. Various types of DC motor connections are briefed. The various experiments that are included in this module are listed below.

1. Swinburn test – The motor is run on load. The no load current, voltage and input power is measured. Shunt motor is taken for experiment. Calculation of losses and efficiency at various loads are determined. A performance curve is predicted and plotted in this experiment (52).
2. Speed control of DC shunt motor – In this experiment, armature control and field control are provided. In the armature control, the rheostat is introduced in the

armature circuit keeping the field current constant. As the armature voltage increases the speed increases. This characteristic curve is plotted. In the case of field control, the field current is increased and decreased and the variation of speed is noted and plotted virtually. The effect of hysteresis of the field circuit is briefed (53, 58).

3. Load test on shunt motor – In this experiment, the DC shunt motor is started using three point starters. Using the field regulator, the motor speed is adjusted to revolve at the rated speed. Using the field regulator, the motor speed is adjusted to revolve at the rated speed virtually. The spring balances provided with the brake drum are adjusted to load the motor. A detailed procedure is incorporated to conduct the experiment. The performance curve can be plotted to know the variation of efficiency, load current, torque, speed with respect to variation of output (60).
4. Load test on series motor Load test on series motor – Series motor is started only on load. A built in precaution is provided in this module. Series motor is started with series resistance starter. The load is adjusted with the brake drum attached springs. The performance characteristics like variation of speed, torque, efficiency, load current with respect to output were obtained and plotted virtually (54, 55).
5. Load characteristics of compound motor – In this module the determination of series field connection to run either as cumulative or as differential is explained. The motor is started with four point starter. The field regulator is adjusted to bring the speed to its rated value. The motor is loaded in stages and the changes in various parameters are noted for both cumulative and differential connections. The performance characteristics are obtained and plotted virtually (52).
6. Level compounded motor – A compound motor will have same speed as that of no load speed when it is loaded to $7/8^{\text{th}}$ full load is used to conduct the performance characteristics virtually (53).

Module 4

Synchronous Generators and synchronous Motors

In this module, brief explanation is given on construction, principle of working of synchronous generators and motors. The synchronous generator is coupled to DC Motor. The starting of the prime move is by three point starter and field control is provided for speed adjustments. The following experiments are included in this module.

1. Open circuit test on alternator – The alternator DC motor set is used for this experiment. The motor is started and brought to rated speed. The field (excitation) current is increased to obtain the magnetization characteristics of the field system. The open circuit characteristics give the relationship between the field current and the induced emf – This curve can be obtained and plotted by simulation technique (52).
2. Short circuit test – When the prime mover is at its rated speed the alternator output terminals are short circuited with ammeter. The excitation is increased in stages to obtain the armature current. The relationship between the exciting current (DC) and the armature current (AC) gives the short circuit characteristics (57).
3. Predetermination of regulation of alternator – In this experiment both the synchronous impedance method and amper turn method of determining regulation is explained. This experiment uses the data from open circuit test and short circuit test results (52, 57).
4. Alternator load test – In this experiment, the three phase alternator is directly connected to the resistive load bank. The output power is measured by two wattmeters. The regulation curve of the alternator is obtained and plotted virtually (62).

5. Synchronising of alternator – The various terminal markings of the standard synchronizing panel is simulated and explained. The connections to prime mover, alternator are performed virtually synchronizing can be done with either dark lamp method, bright lamp method or synchroscope option is provided. All the safety precautions and procedure are explained. A systematic procedure for synchronizing is given. After virtually synchronising, the prime mover is disconnected which enable the alternator to receive power from bus – bar and run as synchronous motor (61, 62).
6. Load sharing of alternator – In this experiment two wattmeters are interfaced between bus-bar and alternator in the synchronizing panel. After synchronizing the alternator the prime mover speed is increased to share load. Experiments can be performed by varying the excitation to know the effect of reactive power supply. The readings and tabulations are done virtually (64).
7. Synchronous motor field characteristics – In this experiment the synchronous motor is provided with damper winding. The starting is through a three phase auto transformer. After starting the motor the field current is varied by the rheostat. The power factor variation for different excitation is obtained and plotted which gives inverted V curve. The variation of load current (armature current) for various field current is obtained and plotted giving V curve. All the readings are obtained and graph is plotted virtually (65).
8. Synchronous motor load characteristics – In this simulated experiment the synchronous motor, the input is measured by two wattmeters. The output is varied by the spring balance and loading arrangement. The variation of efficiency, for a various outputs are obtained and plotted. The field excitation is varied to study the operation of motor as synchronous phase modifier (63).

Module 5

Induction Motor

In this module, the principle of rotating magnetic field is explained in the theory. The construction and principle of operation of three phase squirrel cage and slip ring motor is briefed. The following experiments are included in this module.

1. No load test on three phase squirrel cage induction motor – The connection diagram to conduct no load test is provided. The motor is started into star delta starter. The electrical power input is measured using two wattmeters. No load phasor diagram is drawn with the readings obtained in this test.
2. Blocked rotor test – In this experiment the rotor is blocked by spring balance arrangement. The voltage is applied to the stator through a three phase auto transformer. The readings of the meters are noted when full load current is circulated. In this test the losses are calculated.
3. Load test on squirrel cage induction motor – In this experiment the motor is loaded by spring balance and brakedrum set up. The input parameters are measured by the ammeter, voltmeter and two wattmeters. Tachometer is used to measure the speed. All the instruments can be connected virtually. The motor is started and loaded in stages. Various parameters like line current speed / slip. Input power, power factor are noted for the corresponding output variation. The characteristic curves are noted.
4. Circle diagram – From the test results of no load and blocked rotor test, procedure is explained to draw the circle diagram and to determine the

magnitude of parameters at various loads. Provision is given to find the maximum quantities like power factor, line current, torque and output.

5. Load test on single phase motor – In this experiment plain split phase motor is considered. Digital wattmeter, digital voltmeter and digital clip-on ammeter is used to measure the input parameters. Brake drum and spring balances are provided virtually to perform load test. The performance curve is plotted for various loads.

For all the modules the simulation package is designed by taking the actual readings. When the user performs the experiment in real situation, the readings will be almost same. The meters and the equipments are also simulated with standard size, shape and scale markings which are available generally in all electrical engineering laboratories (57, 63).

1.3.5 The Working of Virtual Electrical Machines Laboratory

The software developed for each module uses multi media. It gives circuit diagram with the relevant meters and their ranges. The objectives of the experiment are clearly defined to the user. The student is to list the equipments/instruments needed to conduct the experiment. After verification of the relevance and the ranges with specification of various instruments, the computer allows to proceed to the next step. The instruments will be available on the screen virtually. A proper layout of instruments and equipments are made on the work table. The student can connect the meters, with the motor, starter and so on to the mains. The connections are performed by 'drag' technique using the mouse. Only if the connections are correct the student can switch on. The readings will be displayed on the individual meter dial.

To familiarize the student, various measuring Instruments like analog meters, digital meters, multi-range meters, clip-on meters are adopted. Mechanical or Electrical loading can be done by the prompter using the mouse on the computer screen. The changed readings are tabulated. The relevant graphs are available to enable the student to know and understand the significance and outcome of the experiment.

The student can run the program, on the computer which is interactive before actually doing the experiment. This activity will supplement and enhance the learning, he operates the motor/ generator by simulation technique. The relevant safety precautions are inculcated by pop-up screen. The laboratory activity is preceded and succeeded by a set of questions. The feedback (by answers) is built in at both the stages. After learning the module content the student is asked to go to the laboratory and perform the experiments to have 'hand-on' experience, which is indispensable. It is observed that the student performs the experiment with necessary input individually (21). The strain on the teachers is considerably reduced so that he concentrates on the quality. The student performs the experiment quickly and positively. It is not just learning by doing but it is learning, understanding and verifying by doing which enhances the retentively and his ability to apply to different situations. This has increased the knowledge and understanding of the experiment which is measured by the viva questions.

The Electrical Machines laboratory of different college will have different machines of capacity and specifications hence the simulation package is designed in such a way that the teacher/college can feed the data of their equipment specifications and the sample readings so that when the students performs the experiment almost same readings will be obtained / observed by him. The student gets convinced and the confidence is built up. It is found that average time taken by the student ranges from 20 to 30 minutes for an experiment, which is very much smaller than the traditional technique in which he spends more time for connection and approval from the laboratory instructor.

Another advantage is that if a college is not in possession of certain equipment say for example; differentially compounded DC generator, the student learns by simulation technique in the virtual Electrical Machines Laboratory the operational characteristics; he accepts it as with the other experimental characteristics, which he performs with the available machine. An attempt is made to transfer the knowledge from textbook to the laboratory situation, which enhances the student ability, which is revealed by the post-test results.

Electrical Engineering Laboratory is not replaced by simulation but a new interface between classroom teaching and laboratory teaching is designed, implemented and evaluated. This interface bridges the gap of inadequacy in laboratories and narrows down discrepancies in learners abilities and enhances the teaching learning process, not only in terms of content but also in quality. It leads to standardization of laboratory activity. The evaluation is not only subjective but also objective. The extra effort taken by the students will give better dividend. A detailed case study-I on Virtual Electrical Machines Laboratory is given in Chapter – V.

MARKING SCHEME – UG COURSES

ELECTRICAL ENGINEERING LABORATORY		ELECTRONICS ENGINEERING LABORATORY	
CONNECTION DIAGRAM	: 20	CONNECTION DIAGRAM	: 20
LISTING OF APPARATUS, EQUIPMENTS WITH THEIR SPECIFICATION	: 10	DESIGN LISTING OF COMPONENT	: 10
ACTUAL CONNECTIONS	: 15	ACTUAL CONNECTION	: 15
PROCEDURE / TABULATION	: 20	PROCEDURE / TABULATION	: 20
CALCULATION / GRAPH / RESULT	: 10	CALCULATION / GRAPH / RESULT	: 10
VIVA VOCE	: 10	VIVA VOCE	: 10
LABORATORY RECORD	: 10	LABORATORY RECORD	: 10

The marks allocated are in general, no variations are adapted for different experiments

Fig (12)

1.3.6 Teaching Electronics Engineering laboratory

The basic Electronics Engineering Laboratory Teaching in UG courses varies depending on the course content. Many nomenclature is used namely Devices Lab, Circuits Lab, Electrical & Electronics fundamentals lab, Digital Labs, Analog Labs and so on in different Colleges. A study is undertaken to analyse the syllabus for the electronics laboratory in the first and second year course of Engineering in various southern universities and autonomous institutions (Fig.9). Some courses are offered as one credit for Electronics laboratory and some courses are offered as two credits. Broadly, the Electronics Engineering Laboratory course will have four sub assemblies. The circuits and devices lab, consist of verification of KCL, KVL and certain network theorems. This lab will include determination of the characteristics of semi conductor devices and rectifiers also. The second sub assembly is based on transistor circuits including amplifiers and oscillators. The third sub assembly involves basic logic circuits, counters, shift registers and ALU. The fourth sub assembly involves op.amp. applications and multivibrators. Each laboratory activity for a semester will involve ten to twelve experiments.

Traditionally in an Electronics Engineering laboratory an instruction sheet will be given to the students for each experiment containing the circuit diagram, the component list, the procedure and the expected outcome. The student group normally uses a group board and fixes the components and rig up the circuit. Time is spent on the assembly and checking the circuit. This is unsuited for group activity as one will assemble the circuit and others will observe. The electronics laboratory will have group activity due to environment constraints. The student connects the power supply, oscillator and CRO to study the behavior of the circuit. The evaluation is mostly on the observation and report writing. In some situations a record book will be maintained with the observations and inferences. The marking scheme is not suiting to the experiment

(Fig 12). Very little opportunity is available to the student to design and understand, develop, the working of the circuit as he spends more time on connecting and getting result. For some experiments the time taken by the student to perform that experiment is about 30% of the time allotted (3 Hrs). In many Institutions and situations, the non availability of good electronic measuring instruments in working condition play a major role in conducting the experiment (Fig 5). There is no minimum standardized procedure for evaluation. It is left to the laboratory staff and the environment. The availability of good condition of measuring instrument plays a major role (22).

Many experiments suggested by the University in the Electronics Engineering Laboratory are not able to be executed by the affiliated colleges. The reason attributed by them are lack of infra structure (Non availability of components, equipments) Untrained man power, lack of service facility for equipments and dearth of motivation. Above all the teacher sets the standard. The whole laboratory activity is teacher centered rather than student centered.

A detailed methodology is suggested for conducting the Electronics Engineering Laboratory for the UG courses in the following chapter.

CHAPTER - II

COMPUTER ASSISTED LABORATORY TEACHING IN UG COURSES

2.1 Over View

It is an accepted fact that laboratory activities are indispensable in engineering curriculum. The researcher has done a variety of studies in different institutions imparting engineering and technology and identified the need for bringing in certain inbuilt quality and transfer the laboratory teaching from teacher/institution centered to student/learner centered. Even though many universities stipulate certain minimum number of experiments, the quality of laboratory activities lies with the teachers and the environment (infrastructure). It is extremely difficult to bring uniformity in laboratory practices. The evaluation and awarding grades are different. The faculty plays 100% role in this. Mostly the marks are awarded by observation, for adopting safety precautions and to certain extent for the skills. Even though 'learning is learners responsibility', certain guide lines and assistance is provided to the student through Computer Assisted Laboratory Teacher (CAT). Two major laboratory activities namely the electrical engineering laboratory and electronics engineering laboratory are taken for consideration.

2.1.1. Introduction to Software

Majority of the colleges, at the UG level, in Electrical Engineering Laboratory, individual performance (conducting experiments individually) is not adopted. Minimum with two students to maximum of six students (in some cases mass education -

Laboratory activity by demonstration) were given training to conduct the experiment. The actual performance of experiment takes between 20 to 40 minutes. The students are not utilizing the 3 hours of allotted time inside the laboratory effectively. Many students have taken the laboratory activity to verify certain principles and concepts experimentally. Less emphasis is given to comprehension, analysis, application or reasoning.

The syllabus for various Electrical & Electronics laboratories offered by different southern universities was studied (Fig. 9). The experiments were grouped in to twenty modules for Electronics Engineering Laboratory and five modules for Electrical Engineering laboratory. Each module is provided with list of experiments that could be performed, related theory in brief, the circuit diagram/ connection diagram, a step by step procedure, the important precautions, the manner of taking readings, the process of tabulation, the method of obtaining and plotting graph and the expected conclusions. At the end, selected questions are included as a means for self assessment for the student (23), knowledge is imparted.

The study reveals that the students were given enough opportunity to achieve the desired learning outcome when the institutions are having a team of experienced supporting staff. Even though the syllabus of various universities stipulates experiments, at present, the college, teachers and the student are taking certain important experiments for which enough infrastructures is available. The allocation of budget for Electrical Maintenance/up gradation or modernization of Electrical Laboratory is less.

Software is designed for facilitating Instruction - LEO - Teaching Concept and as such teachers can use this software for explaining the concepts effectively (24). The software developed will have multimedia effect. The tools that are used for the development of software are VB, VC++, Photoshop, Corel Draw, Photo Flash, and sound Forge and to work on Multimedia work station.

These software is designed to be operated by stand-alone personal Computers (PC) but if required it can be connected in Network also. The minimum configuration needed to run the software is Processor P-II, RAM-32MB 16 BIT High colour monitor 800 x 600 pixel. Almost all the educational institutions imparting engineering courses are having computers with this configuration and many, more than the above specifications. It has been identified that the instruments like cathode ray oscilloscope, (CRO), function generator, multimeter, power supply and certain hardware like switches and indicators (LED) are often used in the Electronics laboratories. These instruments are simulated in the screen so that the student can work with these instruments constituting virtual electronics laboratory. It is quite different from standard packages that are available like 'Electronic work bench', Simulation 'circuit maker', 'P-Spice' etc. The software is developed only for learning - teaching process. The teachers can alter the coding to suit their laboratory equipment available virtually in the computer. The students access is denied for the software coding. The software is self driven. The students can use it easily to perform the experiment (25).

2.2 Computer Assisted Electronics Engineering Laboratory

Each software module is divided into four parts. The first part is about the program how to use the CD. This is designed for the first time user. This explains the manner of installation and running the program for different modules. It is provided with a unique password. The user uses the password to open the files. This program will list the major components like theory, experiment simulation, and the self test. When the user clicks the theory, it will open a page which will contain an Index with the list of experiments for which related theoretical information are available. Each module will have nine to ten experiments. Most of them related to single concept, for example, 'oscillators'. It means various types of oscillators. The user clicks to select the experiment. The corresponding file is opened containing the theory. It will be

programmed to have five to eight frames. The word document gives related theory portions for understanding the experiment. It will have built in sub modules containing circuit diagram, block diagram, related graph and explanations about working of the circuit depending on the experiment.

The user can read two or three times if need arises. It is suitably designed in such a way that it will not take more than five minutes to read the theory portion for each experiment for an average student. It may contain one or two open ended concepts enabling the student to obtain the answer from the teacher, peer or from text book. It will not give complete theory portions but will give a lead to understand the experiment. It is adequate. The theory portion in every module is designed such that, it will enable the student to have enough motivation and basic knowledge to conduct the experiment. While passing through this phase of activity the student gets individual experience about the need of the experiment, its significance and the expected outcome.

The next file is performance of experiment by simulation. This program contains an index page. It has nine to ten experiments listed down. Enough theoretical inputs for understanding the experiment is explained earlier. The screen will have options as EXIT, PROCEDURE, THEORY, and CALCULATOR in addition to NEXT. If a student wants to discontinue the process of learning through the software, he can click the EXIT and go to starting frame of the experiment. While doing experiment by simulation, if THEORY option is clicked, the relevant theory portion is displayed on the screen. The complete theory portion or a particular frame can be brought in by the user. When PROCEDURE button is pressed a completed step by step procedure will come up on the screen to perform the experiment with an option of audio. At any point of time the whole process can be brought back to initial frame to proceed with the experiment. This built in flexibility is to enhance 'Just in time' learning. This is found in practice, enhances the retentivity of the concept learnt among the students. Certain simulation

experiments will have options for selecting the graphs to view the variation of parameters at different situations on the screen. In the case of Electronics laboratory each experimental circuit is tested. The components are selected in such a way that it will be available in the user institutions. The measuring instruments like milli ammeter, milli voltmeter, Multimeter, Function generator, cathode ray oscilloscope are thoroughly planned and the program is written to simulate these equipments which the student can see and use in his normal laboratory activities.

One of the main draw back in the Traditional Electronics laboratory practices is the matching of components to a particular circuit operation and its availability in the laboratory. This aspect is taken care of in this program. All the circuits are designed and tested. The working of circuits is with learning objectives. The procedure is such that the students have to get the circuit on the computer screen on the rigged up condition with the meters, signal sources. The hardware like switches and indicators (LED) are also simulated at appropriate places. The user clicks and studies the working of the circuit. Enough opportunity is given to change the voltage or frequency and study the response of the circuit. For click and learn technique, boxes are created, such that the user can click appropriate box and obtain additional information at that stage itself. This module will have sub assemblies like procedure, tabulation, and conclusion. When 'procedure' is clicked, a detailed step-by step activity sequence is provided to conduct the experiment. It will have not only word document but also have Audio (Sound Forge) such that the procedure is taught to the user by audio and video combination which is found very effective in the process of knowledge transfer.

The software has built in design steps for certain electronics experiments like for schemitt trigger, how to select UTP (Upper Trip Point) LTP and (Lower trip point). Its related formula is given. While performing the experiment, the user can change the values of R & C and simulate the circuit to under stand the 'cause and effect' in the

behaviour of that particular circuit. Each experiment can be performed in about half an hour. As there is no risk of damaging any equipment the user performs with built in confidence quickly. As the procedure is given in four or five frames, the user can click backwards to check the activity sequence while proceeding with the experiment. Individual skill is enhanced. The program guides the user to know what values are to be noted and the manner of tabulation. The conclusion of the experiment is given in such a way that the user obtains the desired result.

2.3 Computer Assisted Electrical Engineering Laboratory

In the case of Electrical Engineering laboratory the user has to select the experiment say Induction Motor. This module includes three phase Squirrel cage Induction, and single phase Induction motor. The user can click to do 'load test' or 'no load and blocked rotor test' experiment. If he clicks 'load test', then the module has software with sub programs like theory, experimental simulation and the self test. In the theory, details of three phases Induction motor is explained briefly, the construction, principle of operation and characteristics and the application. It is provided in five frames. The theory content is sufficient to understand the load test on three phase Squirrel cage induction motor. It will give pre-view or Introduction and enough motivation for the user to do the experiment. It will not take more than five minutes to read the content information.

In the simulation module the user clicks appropriate box like 'next'. A connection diagram will be available. From the connection diagram the student has to list the requirement of meters with their ranges. The specification of the machine under test is also given. The user has to list the components and meter with specification, then 'next' is clicked. The software checks the correctness and then the items will be simulated on the screen. The power source, the mains switch, the starter, the ammeter,

the two watt meters the voltmeter, the Tachometer; the loading arrangements are all available on the screen. The user has to connect various meters with the equipment under test virtually. To enable the user for inter connection of various instruments the procedure is standardized. A prompt will appear on the screen. Mouse can be moved to click over the 'prompt' and the connections were executed. Then next prompt will come.

This method is used to inculcate on the student mind that ammeters are in series and the voltmeters are in parallel. Similarly the current coil of the watt meters are to be connected in series with the load and the pressure coil are to be connected across the load. Certain special equipments like low power factor watt meter clip-on ammeters, use of CT (Current Transformer), PT (Potential Transformer) are also used in the simulated experiment.

The user is required to connect all the meters to the equipment as appeared in the circuit diagram. By the use of mouse the main switch can be closed. The starter handle can be operated by the 'prompt'. The motor is made to rotate on the screen virtually. The direction of rotation of the motor can be observed. If is to be reversed, by changing the supply sequence, it can be altered.

On simulation the instruments in the screen will show the actual value of the parameters. The ammeter will show the no load current. The watt meter W_1 will read backwards (as the power factor of the Induction Motor on no load is less than 0.5) the watt meter W_2 will read forward showing the power input on no load. The voltmeter will read the supply voltage. The tachometer will show the speed on No load. The motor is provided with spring balance and loading arrangement. The user can move the mouse and increase the tightness of the belt for loading. The spring balance will read the load in kilogram and the user can see the effect by noting down the readings in various meters. He can load the motor up to the full load or up the maximum range available in the

meters. The loading can be increased in steps. In the similar way the loading can be decreased. The supply can be switched off by clicking the main switch handle.

The next frame gives the tabulation of various readings taken. The relevant graphs are provided to enable the user to understand the experiment. The user is expected to comment on the shape of the curve. This will ultimately enable the student to understand the experiment.

When the user clicks the procedure, a step by step activity sequence is programmed not only word document but also Audio. The user reads the document in the same speed as in the audio. As the student glance through the frame the Audio gives not only the activity but also the safely precaution for example when the main switch is ON the supply indicators R,Y,B lamp must be 'ON' indicating that three phase supply is available in the panel for conducting the experiment. The starter handle (Star-Delta) cannot be switched directly to run position but it must be put down so that the motor is connected in star and it is allowed to run at reduced voltage. When switched to Delta the starter handle has to move quickly to Delta position by moving the mouse. If time is lapsed the motor will come to the off position. Similarly while conducting the experiment if current exceeds the range of connected meter it is not possible to increase the loading on the motor. The procedure will give the activity sequence till the user completes the experiments and helps in the conclusion such as when load increases the speed decreases and the slip increases. As the load increases the power factor also increases. As the load increases the torque increases. As the load increases the efficiency increases and beyond a particular load it decreases and so on. The model graph enables the student to accept the conclusions. The verification of conclusions is done by simulation experiment.

2.4 Self Test

Each module is provided with a self test questions. Each experiment is having a set of dedicated questions. The questions are arranged in 15 to 20 numbers. The questions are objective type either multiple choices or fill up the blanks variety. The student after completing the experiment by simulation technique has to take up the self test. The maximum time taken will be 15 to 20 minutes. The user has to click the correct answer. At the end of the test the student knows his performance. The user has to obtain at least 90% in the self test. Each question is provided with built in answer. If he wants to know the correct answer he has to click and the answers which are provided with justification (of course only after completing the test in a prescribed time). The user completes the activity with certain confidence. The self test is provided with audio so that he gets the audio response 'correct' or incorrect. It finally gives the student the grade sheet with congratulations.

2.5 Observations

After completing the experiment with simulation the student has complete knowledge about the experiment, the connection diagram, the need for the experiment, the specification of various components/ machines and the related theory portion. He understands the actual connections of the various equipments meters, their ranges, manner of reading, interpretation of scale of the Instrument (multiplication factor). The user actually conducts the experiment virtually, he starts the motor, and load the motor observes the decrease of speed, notes the increase of torque, increase of input and so on. The user understands the procedure and safety precautions. The user takes up a self test at the end of the experiment, which shows where he stands. The user lists the questions or identifies the area where he finds difficulty. He is conducting the experiment again if the need be, in his own pace and finds himself comfortable while learning (from teacher centered to student centered). The user now discusses freely with his peers and with the teacher. The teacher clarifies and also identifies the learning outcome by his own method

of questioning. A rapport is forced to bridge the teacher and the taught. This feed back enhances the laboratory teaching and learning. The whole activity in the beginning takes about 1½ Hrs but as he gets familiar with the computer operation and loading of CD and connecting the circuit, the speed is considerably decreased resulting the time taken for completing this activity becomes less than an hour. As it is an individual activity for the student, the Instructors' time is better utilized.

The feed back session actually increases the knowledge and skill among the groups. The level of learning is also uniform. The user is attempting mastery over the experiment. The teacher has ample opportunity to enhance the standard or lower by skipping certain concepts, like propagation delay, effect of distributed capacitance, the significance of rise time of triggering pulse, the bouncing effect of the switch/hardware, the operating time of Electro magnetic relay and so on. By this a built in flexibility is provided to the teacher. The teacher enhances the quality only if the student is ripped enough to receive the instruction and exhibit his learning outcome by way of answering the questions. A good discussion with the teacher and a free exchange of ideas with their fellow students (peers) enhances the teaching learning process yielding better results.

So far the student understands either electronic laboratory experiment or Electrical laboratory experiment with out entering the laboratory. The student sees on the computer screen itself the actual instruments/components the hardware, the equipments etc with 3D effect. The software using VB fulfills this task. After learning through simulation the students in group enters the laboratory for actual performance of laboratory activity.

Limitations

Certain concepts like increase of temperature when current flows through the conductors in Electrical Machines or the cause of Thermal run away in Electronic components, a feel of components, their size, their leads, the manner of handling etc

cannot be taught to the students by simulation. Hence the use of Electronics Engineering laboratory and Electrical Engineering laboratory in real situation cannot be eliminated.

All experiments prescribed by the university at different levels are to be done actually by the students in the laboratory situation and they are to be evaluated in the end examination. Similarly the teacher/ laboratory instructor is an essential ingredient in the lab activity in engineering education. Hence the students are allowed to perform the same experiment what they did in simulation, actually in real situation with real component and equipment. As individual experiments by individual students are not possible in the present scenario, group activity is preferred. The group may have two or three students. It has got its own advantages. The group enters the laboratory with the correct circuit diagram. Since the components & circuits are already tested. The student directly goes to be stores obtain the relevant components/meters and connect them as per the circuit diagram. Regarding connection also the procedure is standardized which the student understands when he did the connections by drawing the mouse/prompt in the computer screen. The students complete the circuit connections in a very short time. The teacher/lab instructor verifies the circuit connections and energies the circuit. The students perform the test/experiment in a systematic way. In this group activity the experiments are conducted with all safety precautions in a very short time. The teacher observes the manner of conducting the experiment. The teacher evaluates the individual students. The teacher asks questions, gives a design problem, and asks to extrapolate certain result, infer certain conclusions, and bring out limitations etc will make the student to learn better.

Documentation

The laboratory activity is not complete if it is not provided with documentation of experimental result individually. As the student is exposed with correct circuit diagram and he conducts the experiment, takes relevant appropriate readings from the

instruments, draws graph and writes down in his own words the procedure he has adopted and the safety precautions he has encountered with his own conclusions. This document becomes the observation and laboratory record. It may be computer generated also. This record is presented to the teacher for final evaluation and the student obtains suitable 'grade' for the record of work done for that particular experiment in that particular laboratory.

The laboratory teaching-learning is not stopped here. The student is allowed to register with CATES (Computer Assisted teaching and evaluation software packages). He takes the test for level-I. If he scores more than 90% he is permitted to level - II and so on. The learning is continuous and which is most desirable in engineering education. The student is left free to learn when once he is evaluated by the teacher of his lab class. The student takes CATES as an option. The student is evaluating himself how much mastery over the subject has been achieved. In the subsequent chapters a detailed description is provided for CATES.

CHAPTER - III

Virtual Electronics Laboratory

3.1 Introduction

The conventional Electronics Laboratory has many electronic components like Diode, Transistors, (BJTS, FETS, UJTS) Integrated circuits and varieties of passive components like resistors, capacitors, Inductors and certain hard wares like relays, switches, indicators and so on. The study reveals finds that majority of the engineering colleges have sufficient quantity of these items. Many institutions are augmenting these items under 'projects'. In addition to the components various measuring instruments and signal sources and power supplies are available in assorted ranges and many in numbers. Many instruments are not used for Teaching-learning and quite good equipments are not in service. In order to enhance the quality in imparting laboratory education a Virtual Electronics Laboratory has been developed.

This laboratory contains almost all the passive and active components and measuring instruments including the hardware items. The software is developed to perform Electronic lab experiments virtually using computer (17). Each experiment is self contained that is how to use the CD and its 'password', the related theory, experimental simulation and the questions and answers for the self test.

It is found in practice that people will remember and recall about 20% of what they hear and 40% of what they see and hear but 70% of what they see, hear and do (26). Hence the complete electronics laboratory normally used in engineering colleges has been created as Virtual Laboratory through software in a series of CD/ROMS. The inter activity of these CDs gives real laboratory experience (minus the nervousness and embarrassment from poor performance or mistakes). These CDs can be operated in the

personal computers; need not be in the college environment or on a particular time. This software educates the student with theory, guides him through the experiment and helps him to perform efficiently but in a non judgmental and non threatening way. These CDs will also evolve the performance of students instantaneously.

The virtual laboratory experiments are created with multimedia making it attractive, interesting and user friendly, instant score of performance of the learner. This actually saves time and self-paced. The teacher time is saved by about 30% compared to the traditional method in imparting knowledge in the laboratory situation.

This laboratory activity can be done at any time and the students' retentivity is enhanced (about 50%). These CDs actually bridges the gap between theory and practice (27). The components and instruments are real looking. No damage is caused as they are virtual one. These experiments can be run on the computer before going through the real lab situation. The circuits used are practical workable circuits with components that are available in the laboratories abundantly as of to day. Virtual Laboratory learning through trial and error test is possible and this is liked by the student community. A type of freedom is given to the learners to test ideas and investigate alternatives. Opportunity is provided to learn hardware through software simulation (28).

The Basic Electronics laboratory syllabus is grouped to 20 Modules (CDROMS) and each module contains eight to ten experiments which fall on the same group dealing similar concepts. The details of each module are briefed below.

3.2 Electronics Laboratory Modules

Module 1: Basic op.amp circuit.

This module contains nine experiments which are all related to basic amplifiers. The theoretical input to perform the experiments consists of introduction of basic op.amp. block diagram with terminal (741) specifications and summing point restraints. The working of inverting and non inverting DC amplifiers and AC amplifiers are given

for study. The DC and AC voltage follower, the inverting and non inverting summing amplifier and differential amplifier are explained.

The experiments that are included are listed below:

1. Inverting DC amplifier
2. Inverting AC amplifier
3. Non inverting DC amplifiers
4. Inverting summing amplifier
5. Non inverting AC amplifiers
6. DC voltage follower
7. AC voltage follower
8. Non inverting summing amplifier
9. Differential amplifier

The Instruments like Dual trace CRO, power supply signal Generator and Digital multi-meter are available virtually. The circuit is rigged up with passive components whose values can be varied. The relevant test points are brought out to know the voltage or signal conditions in the circuit (90, 86).

Module 2: Op.amp. application circuit.

This modules deal with some of the basic applications of operational amplifier. Sufficient theoretical back ground is provided. It deals with working of op.amp as a comparator, Integrator, constant current source, and Differentiator. How an op.amp. can be used as current to voltage converter and voltage to current converter is also added. The behavior of op.amp to act as precision half wave and precision full wave rectifier is explained.

The experiments that are included in this module are listed below

1. Differentiator
2. Integrator
3. Constant current source
4. Current to voltage converter
5. Inverting voltage to current converter
6. Non inverting voltage to current converter
7. Simple Non-inverting comparator
8. Window comparator
9. Precision half wave rectifier
10. Precision full wave rectifier.

The Electronics Instruments and power supply are provided. The circuits are tested and set points are brought out on the screen (82, 85, 86).

Module 3: Basic filters

This deals with theoretical aspects on classification of filters and filter networks. The relevant equations of filter networks are explained. The classification and characteristic impedance of pass and stop band filter, constant K low and high pass filter and m-derived T section filter, and band pass and band elimination filter are covered.

The experiments that are included in this module are listed below

1. Active low pass filter
2. Active wide band pass filter
3. Active high pass filter
4. Active wide band reject filter
5. Passive low pass filter
6. Passive wide band pass filter
7. Passive high pass filter
8. Passive wide band reject filter.

A Dual Trace CRO, Audio signal generator with facility to vary resistor & capacitor is provided. Bode Plot can be obtained for the circuit (71, 72, 77).

Module 4: Advanced Filters

In this module the theory part of Basic filter definitions with advantages and limitations of filters are described. Poles and transition response is explained. Most popular filters like Butter worth filter, chebyshev filter, Bessel filter and their responses are included.

Design, implementation and characteristics of the following important filter are listed below:

1. Butterworth first order low pass filter
2. Butterworth second order low pass filter
3. Butterworth first order high pass filter
4. Butterworth second order high pass filter
5. Chebyshev low pass filter
6. Chebyshev high pass filter
7. Bessel low pass filter
8. Bessel high pass filter

The 741 op.amp. is used in association with variable resistors and capacitors. Test points are provided in every circuit. Audio generator and Dual trace oscilloscopes are created virtually on the computer monitor to see Bode plot for various filters (68, 70, 75).

Module 5: Signal sources and Log circuits

In this module theory is covered for logarithmic and Antilog amplifiers, Multiplying and divider circuits, Wein bridge oscillator circuit. The working of square and Triangular wave generator is also added. Explanation about the working of linear ramp generator and voltage controlled oscillator is provided.

The experiments that can be simulated and studied are listed below

1. Logarithmic Amplifier
2. Antilog amplifier
3. Multiplying circuit
4. Divider circuit
5. Wein bridge oscillator
6. Square-wave generator
7. Triangle – wave generator
8. Linear ramp generator
9. Voltage controlled oscillator

All the circuits are rigged with 741 analog linear Integrated circuit. Power supply, multi meter, CRO is also added to use with the circuit (66, 72, 73).

Module 6: Basic electrical circuits.

In the theory, part basic concepts about the behavior of voltage sources (DC) in series, parallel and series and parallel is explained. Resistances in series and in parallel with the explanation of ohms law KCL and KVL, Star-Delta & Delta – Star conversion are provided. This module is exclusively designed for entry level students containing basic circuit experiments.

The experiments included are very basic.

1. DC voltages in series, parallel, series and parallel
2. Star – Delta conversion
3. Delta – Star conversion experiments
4. Experiments on resistances on series, parallel
5. kirchoffs voltage law verification
6. kirchoffs current law verification

The circuits are simulated with switches and sources. The switch can be ON or OFF by moving the mouse of the computer suitably. Multi meter is generated virtually to make the measurement in the simulation circuit. The module is designed to become familiar with the basic principles (64, 84, 87).

Module 7: Network theorems

In this module the experiments are arranged in such a way that the network theorems are verified using an electrical circuit by simulation.

The various theorems that could be learnt by this module are listed below

1. Voltage divider circuit
2. Power and its measurement
3. Reciprocity theorem
4. Thevenins theorem
5. Maximum power transfer theorem
6. superposition theorem
7. Millmans theorem
8. Nortons theorem
9. Maxwell's loop current

The experiments are designed for easy understanding using DC sources and passive components. A Digital multi meter and DC power supply is simulated. For all the network theorems the relevant definition and explanation is given in the theoretical portion of the module. The values of Resistors can be altered to find the effectiveness in the circuit behavior while verifying the network theorems (69, 82).

Module 8: rectifiers and its application

This module deals with theory section of the basic phenomenon of rectification. The working of Transformer interfaced full wave rectifier and bridge rectifier. It explains voltage multiplier circuits. The behavior of various clipper circuits like series clipper, parallel and biased clipper in addition to the positive and negative clamper circuits are explained.

The various experiments that could be performed are listed below

1. Half wave rectifier
2. Full wave rectifier
3. Bridge rectifier
4. Voltage multiplies
5. Parallel clipper
6. Series clipper
7. Biased positive and negative clipper
8. Positive clamper
9. Negative clamper

This module has the necessary measuring instruments like CRO and multi meter and the power supply and hardware like transformer, fuse and switches (73, 74, 76).

Module 9: RLC characteristics

In this module the theoretical explanations are provided about capacitor charge and RC time constant. The behavior of inductance and resistance and the concept of impedance in RL and RC circuit and RLC circuit are added . The significance of resonance frequency in parallel resonant circuit and its impedance is explained. The measurement of AC power, the phase relationship of V and I in RC and RL circuit are included.

There are nine experiments that could be performed with this module namely

1. Charging of capacitor
2. Phase relationship of RC series circuit
3. Phase relationship in RL series circuit
4. Impedance of a series RC circuit
5. Impedance of a series RL series circuit
6. Frequency response and impedance of parallel resonant circuit
7. Frequency response and impedance of series resonant circuit
8. Calculation and measurement of power in AC circuits
9. Testing & determination of inductor characteristics using Function Generator

This module includes CRO, milli ammeter power supply, Audio Oscillator, Digital multi meter and various components like step down transformer assorted resistors and capacitors (79, 80).

Module 10: Basic Transistor characteristics

In this module explanations are given on basic principle of transistor action, familiarization of transistor terminals and testing confined to Bijunction transistor. The

biasing arrangements for PNP and NPN transistors are explained. The characteristics of transistor in the three configurations like CE, CC and CB are explained. The significance of input impedance and amplifier gain in CE mode are explained with an introduction to common Trouble shooting techniques in this amplifier.

There are ten experiments that would be performed with the module namely

1. Transistor familiarization and testing (PNP)
2. Transistor familiarization and testing (NPN)
3. PNP transistor biasing
4. NPN transistor biasing
5. Common emitter characteristics
6. Common collector characteristics
7. Common base characteristics
8. CE current gain
9. CE impedance, power and phase relationship
10. Trouble shooting in CE amplifiers

Multi meter, power source CRO, transistor and passive components are provided virtually to conduct the experiments (70, 71, 81).

Module 11: Advanced Transistor circuits

In this module theoretical explanations are provided on how a transistor can be made to act as a switch and the need and working of a cascaded transistor amplifier. The characteristics of emitter follower and pull – pull amplifier with single supply are explained. The working of complementary symmetry push pull amplifier with single and dual supply is explained. The class A, power amplifier working with loud speaker as load and its frequency response as an Audio amplifier is explained. An introduction is provided for Instrumentation amplifier.

The following experiments can be performed using this module are given below

1. Transistor as a switch
2. Cascaded transistor amplifier
3. Emitter follower
4. Push-Pull amplifier
5. Dual supply complementary Push-pull amplifier
6. Single supply complementary symmetry push pull amplifier
7. The loud speaker and class A power amplifier
8. Frequency response of an audio amplifier
9. The instrumentation amplifier

The equipments namely the Audio oscillators, power supply, CRO, multi meter are provided in addition to various components and transistor to do the relevant experiments (70, 78, 86).

Module 12: Transistor Devices

This module gives the explanation of basic differential amplifier with common mode input and single ended input. It introduces the JFET, its terminal identification and its characteristics. The working of JFET common source amplifier is explained. The explanations are given regarding the working of unijunction transistor and SCR and its static characteristics. This module also includes the characteristics of Zener diode and junction diode and its behavior in forward and reverse bias action and explanations are provided.

The experiments that could be performed by this module are listed below

1. Differential amplifier with differential mode input
2. Differential amplifier with common mode input
3. Differential amplifier with single ended input
4. JFET familiarization and characteristics
5. JFET common source amplifier
6. Uni junction transistor characteristics
7. SCR characteristics
8. Junction diode characteristics
9. Zener diode characteristics.

All the circuits are tested with available components. The measuring instruments like CRO and signal generators power supply are provided. Facilities are included to alter the magnitude of passive components and study the behavior of the circuit (83, 84, 85).

Module 13: Oscillators

The workings of oscillator circuits are provided in the theory section of this module. The important oscillator circuits namely the UJT relaxation oscillator using 2N2646 is explained. The Hartley oscillator, phase shift oscillator, colpitts oscillator, clap oscillator, crystal oscillator, wien's bridge oscillator circuits are explained. The characteristics of negative resistance element Thermistor is included. The basic function generator IC, its terminal markings and the output, wave form selection are explained in this module.

The various experiments that could be performed

1. UJT relaxation oscillator
2. Hartley oscillator
3. Phase shift oscillator
4. Colpitts oscillator
5. Clapp oscillator
6. Crystal oscillator
7. Wien bridge oscillator
8. Characteristics of thermistor
9. IC function generator

The equipments like power supply, Inductor, capacitor, resistor of assorted values are available to perform the circuits. All the circuits are workable and tested. CRO is used to see and measure the output of various oscillators (87, 88, 89)

Module 14: Basic Timer (555) and Opto Electronics

In this module the working of Integrated circuit chip NE555 working as a stable Multi vibrator, Mono stable multi vibrator, as a voltage controlled oscillator, schmitt trigger, ramp generator are explained. This module also contains certain opto electronic devices like LED, LDR, Opto couplers, Photo transistor; their principle of working is explained in the theory. In addition a complete power supply circuit including step down transformer and filters are explained.

The following experiments can be conducted through this module, namely

1. Astable Multivibrator using 555 timer
2. Mono stable Multivibrator using 555 timer
3. VCO using 555 timer
4. Schmitt trigger using 555 timer
5. Light dependent resistor

6. Opto electronic device (LED)
7. Opto couplers
8. Photo transistor
9. Transformer power supply and filter

This module has power source, CRO, multi meter and switches and passive components needed to conduct the experiments (66, 67, 70).

Module 15: Bridges

The theoretical input is given in the working of DC and AC bridges. The circuit diagram, the phasor diagram and its working of wheat stone bridge, Kelvins bridge, capacitance comparison bridge, Anderson bridge Maxwells bridge, Heys bridge, Schering bridge owens bridge and wien bridge are explained.

The various experiments that could be performed by this module are

1. Wheat stone ridge
2. Kelvins bridge
3. Capacitance comparison bridge
4. Anderson bridge
5. Maxwells bridge
6. Heys bridge
7. Schering bridge
8. Owens bridge
9. Wien bridge

The power supply and null detector are provided. Facility is given to alter the component values to make the bridge unbalance, the formula and calculations are provided to under stand the concept and working of each bridge (72, 77, 81).

Module 16: Basic logic gates

This module gives introduction to digital electronics in the theory. It explains the concepts of basic logic gates. Explanation is provided for the operation of Diode logic, Transistor logic gates Manipulation of logic gates, Binary information concept is explained. Theoretical explanations are provided for Integrated circuit gates. The applications of logic gates are explained. The Basic theorems of Boolean algebra are described.

The experiments that could be performed are verification of truth table for the following

1. AND gate
2. OR gate
3. NOT gate
4. NAND gate
5. NOR gate
6. Ex-OR gate
7. EX-NOR gate
8. AND – NOR gate
9. Applications as signal selector gate, Binary decoder and Equality detector

Necessary binary switches, output LED indicator and relevant IC gate are provided to conduct various experiments (83, 87, 88).

Module 17: Advanced Logic Gates

In the theory part of this module contains the working of bi stable switch using transistors is explained. The working of Binary Memory circuit, explanation is provided for a simple 'T' Binary. An introduction is given to the Basic memory and Gated

memory. The working of clocked RS flip flop, 'T' flip flop, RS master – slave flip flop, JK master slave flip flop, D flip flop, Edge triggered flip flop. Description is provided for series entry and parallel entry of data to the logic gate circuit.

The experiments that could be performed with this module are listed below

1. Verification of truth table for R-S flip flop using NAND gates
2. Verification of Truth table for R-S flip flop using NOR gates
3. Clocked R-S flip flop 4. J-K flip flop
4. D flip flop
5. T flip flop
6. Serial in and Serial out
7. Serial in and parallel out
8. Parallel in serial out
9. Parallel in parallel out

The logic circuit with input binary switches and output LED logic indicators are provided to verify the truth table. A graphic symbol for each gate and provision of needed clock pulses by clicking with the mouse is available for conducting the experiment (75, 76, 78).

Module 18: Counters

In the theory an introduction is provided for need and application of electronic counter. The types of counters in this module are Johnson counter, Modulo-M counter, Ripple counter, Down counter, Ring counter and Fixed – Modulo counters. The working of each counter with their timing diagram and output sequence for each clock/Trigger input pulse is described.

The experiments that could be performed with this module are given below

1. Four bit Ripple counter
2. Four bit down counter
3. Ring counter
4. Johnson counter
5. Modulo – 3 counter
6. Modulo – 5 counter
7. Modulo-7 counter
8. Modulo-9 counter
9. Modulo -11 counter

The logic condition can be checked with LED. Provision is given to know the timing diagram using CRO. Logic input pulses are provided using logic input generator (81, 86, 88).

Module 19: Binary Arithmetic

In the theory an introduction is given to binary arithmetic. How half adder and full adder circuit is functioning is explained. The principle of 2-bit binary addition, working of multiplexer and demultiplexer is explained. A description is given on 2 bit full adder and 4 bit full adder. The significance of basic D/A converter and explanation is provided for typical ladder D/A converter and binary adder and sub tractor circuits.

The experiments that can be performed with this module are listed below

1. Half adder
2. Full adder
3. Adding two 2-bit binary numbers
4. Multiplexer
5. Demultiplexer
6. Two-bit full adder
7. Four bit full adder

8. Digital to Analog converter with ladder resistor network
9. Digital to Analog converter (weighted resistor network)
10. Sign magnitude and binary subtraction.

The experiments will have input logic through binary switches and the output through LED's the Input/Output relation is provided in a tabular form for easy understanding and verification by the user (82, 83).

Module 20: Digital Electronic Applications

In this module theoretical explanations are provided for Analog to Digital converter. How a Decimal digit display is working for various binary inputs is explained. The working of Schmitt trigger and an introduction to random access memory and read only memory is added. The working of Mono stable multi vibrator using 74121 and Tristate buffer using 74125 are explained. The pin configuration and block diagram explanation of ALU (Arithmetic logic unit) 74181 and description about Data Transmission and parity.

The experiments that could be performed using this module are given below

1. Analog to Digital converter
2. Decimal digit display
3. Schmitt trigger
4. Random access memory (RAM)
5. Read only memory (ROM)
6. Monostable multi vibrator using (74125)
7. Tristate buffer using 74125
8. Arithmetic logic unit ALU (74181)
9. Data transmission and parity

The necessary binary switches and LED indicators are provided to understand the experiments (71, 85, 88).

3.3 Observations

The virtual Electronics laboratory is designed for UG courses having one credit. It can be used for various engineering discipline students like computer science, EEE, E&I, I&C including Mechanical Production and Chemical engineering students. These twenty modules are provided in twenty CD's. Each CD can be operated independently. All the modules have theory, experimental simulation with all relevant components and measuring instruments it has built in self test. The list of experiments that each module is arbitrary fixed. The student can perform one or two and skip to the desired experiments.

While designing the modules, the Electronics laboratory has 4 parts namely Analog laboratory having module nos.1,2,3,4 and 5, Digital electronics laboratory having module nos.16,17,18,19 and 20, Electrical circuits laboratory having module nos.6,7,8 and 9, Devices and circuits laboratory having module nos.10,11,12,13,14 and 15. One or two modules may be redundant for a particular course. The student can go through the module but credit need not be offered to that. All the modules are provided with 'procedure' file which can be accessed independently or can be revoked while performing the experiment. This will enhance inquisitiveness while learning. Each module is having built in self test which will enable the student to have proper entry behavior both in knowledge, skill in performing the experiment and the idea of specification of component and the expected result or out come of each experiment before entering the Traditional electronics laboratory to perform the experiment actually. These modules are 'self – paced' inter activity with immediate feed back and integrate multimedia. The whole software coding is available with the teacher (given in the appendix). The teacher can alter the experiment if need be suiting to his environment.

The important limitation for these CD ROMs are that they are designed to show the 'causes and effects' for a particular circuit and the user can not change the circuit diagram but the passive component values can be changed which will cause a response in the output. Similarly the parameters of the sources can be changed with in the specific range for which the circuit is designed. Certain modules are designed to explain the concept only it is not possible to change the active components in the circuit. The virtual laboratory modules will act as a bridge between class room teaching and the conventional laboratory activity.

CHAPTER - IV

COMPUTER ASSISTED TEACHING & EVALUATION SYSTEM (CATES)

4.1 Introduction

The emergence of continued growth of computer network technologies are changing the way people around the world work and learn. Computer networks offer new alternatives for creating, storing, accessing, distributing and sharing learning materials. Computer networks provide new channels for interactions between “teachers and students”, “teachers and teachers” and between “students and students”.

Assessment is an essential aspect of all instructions. Teachers need to know what and how well students have learned and so do students themselves. Assessment can take the form of a quiz or examination to test students learning achievements, or of a questionnaire to investigate students` attitudes and reactions to new instructional courseware.

The main focus of this chapter is to identify how computer ~~is~~ plays a major role in testing and evaluation of the knowledge of the engineering students. This describes the Computer – Assisted Testing and Evaluation Systems as an innovative application software to electrical and electronics laboratory education using computer technology.

The use of computers for testing purposes has a history spanning more than 20 years. Many studies were conducted to ascertain computer based tests were

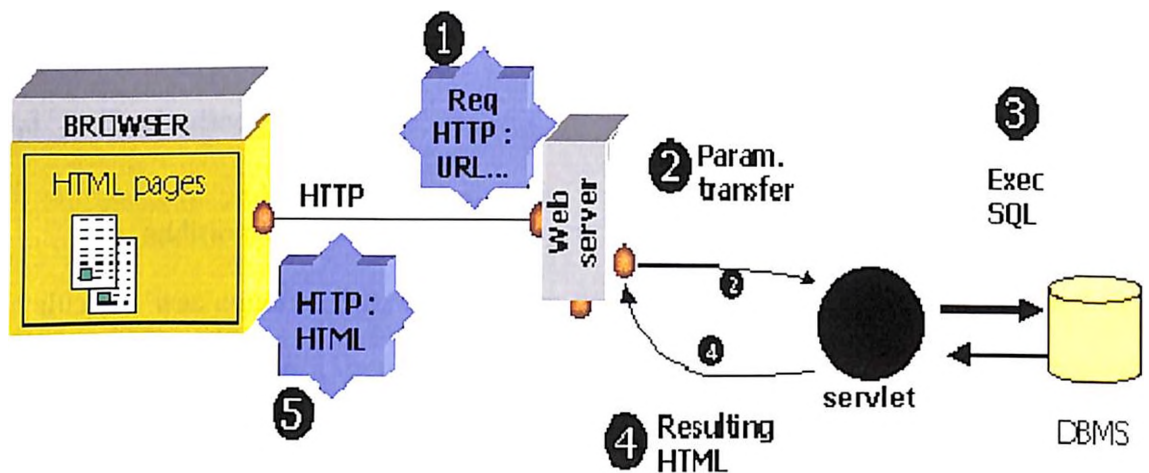
equivalent to paper pencil tests. Bugbee (29) included that the use of computers indeed affects testing. However some factors such as design, development, administration and user characteristics must be taken into consideration when computers are used for testing. Alessi and Trollip (30) in their classic book on computer based instruction devoted a chapter to the design, development and use of computer based testing. They pointed out that the two main ways of incorporating computer into the testing process are test construction and test administration. When constructing tests, test developers use computer's word processing abilities to write test items and use their storage capabilities to bank and later retrieve test items. Jacob and chase (31) pointed out that computers can present test materials paper – and – pencil cannot, for example 3D diagrams in computer graphics, and motion affects rotating geometric forms and animation. When administering tests, computer can be used to provide individualized test environment that facilitates the students to take the test. More over, test contents can be customized for students by providing difficulty levels and emphases. Computer based testing can also be designed to provide the test takers with immediate feed back and scoring.

Advancement in computer technology has allowed stand-alone computers to be equipped with powerful communication abilities. Student communities distributed geographically can be easily evaluated as computers are networked and thanks to the internet technology. This provides an alternative for assessing student's learning achievements and attitudes towards subject.

4.2 Design

CATES is an online testing web tool built for internet. By using HTML, courseware-authors and test-developers can create hyper text modes incorporating multimedia content and forward them to other nodes through links. In order to put

HTML test items on web servers and collect responses, standard Java programming is used. Web test takers can employ browsing software such as Netscape or internet Explorer to access and take test.



Architecture of CATES

Above figure shows the architectural design for the CATES software. The interaction with the end user is done using web browsers. The end user may be students or data administrators or question administrators or test administrators or portal managers. Requests sent by the end users are received by the servlet programs written in java available in web server. For validations and for storage purpose, the servlet programs connect with the database and generate the results which in turn displayed to the end users again HTML pages. Thus the dynamic effect is felt.

The system design for CATES can be viewed as the User interface layer consisting of students taking the test, teachers can construct test items, test

administrators can select existing test items from an item bank and teachers/evaluators access and analyse the student's test results. The development of CATES involves programming the specifications to fulfill the production requirements identified in the analysis and design phase. The test items, student information and test results were stored in any RDBMS. In CATES, we use Microsoft access for testing purpose.

4.3 Evaluation

In addition to the system developers self – testing (Alpha test), a formative evaluation was conducted to examine the usability of the CATES functions and the presentation of the test items. Two major evaluation approaches were adopted. Expert based and user based. One experienced test developer checked the way the test items were presented on the computer screen. The system, interface and test – item presentation were then debugged and revised according to the evaluation results. The purpose of the user – based evaluation was to explore the usability of the system, the presentation of the test and student's experience using computers but not to examine students learning achievement. Therefore the difficulty, discrimination ability and validity of the test itself can be determined.

Software Needed

The following are the software needed for the 'CATES' to work

1. Web Browser like Internet explorer or Netscape to browse HTML pages
2. Web server like Java Web Server which supports java class files
3. Database like Microsoft Access

Modules

There are five major functional modules in the software.

1. Portal Administration
2. Data Administration
3. Question Administration
4. Test Administration
5. Student Module

The role of portal administration is referred as “super admin” in the software. His role is to maintain the portal and facilitate the other end users to access the software. He is responsible for creating new accounts for the end user to access the portal namely data admin or question admin or test admin. When ever a new account is created, he is the person responsible for allocating the login ids and password to the users. He has unrestricted access with in the software. Normally this role will be performed by the Head of the Department in the Collegiate Education.

The role of data administration is referred as “data admin” in the software. His role is to collect the questions from the experts and feed the questions to the question-bank database maintained by the super admin. When he receives a question from an expert, he will have details such as Topic and sub-topic to which that question is categorized, whether that question is a theory or practical oriented, which level it belongs namely simple, medium, and complex. The questions added by him are objective type with alternatives. Each question is provided with justification with correct response.

The role of question administration is referred as “question admin” in the software. Normally experts in that subject play the role of the question admin. Actually he can validate a question or modify a question available in the question bank. If the expert feels that a question can be removed from the question bank he has rights to do so. Question admin has rights to create new subjects and new sub-topics such that data admin can always feed questions under them when ever new questions are collected by them.

The role of test administration is referred as “test admin” in the software. He is responsible to administer tests to the students. He is responsible to maintain the results of the students who have taken up various tests. The test admin registers the candidate details and authenticate him to take the test. He is responsible to generate various analysis reports such as department-wise performance analysis, Time-wise performance analysis, Candidate wise performance analysis, Question wise performance analysis.

The student on registration is allowed to take up the test. Student can start the test on successful authentication by specifying his correct user id and password. Online timer is maintained for entire test. On successful completion of the test, students can view the scores. A special features is incorporated in the software, the candidate himself can view the correct answers with justification.

Thus CATES is user friendly. The salient screen shots are in the appendix.

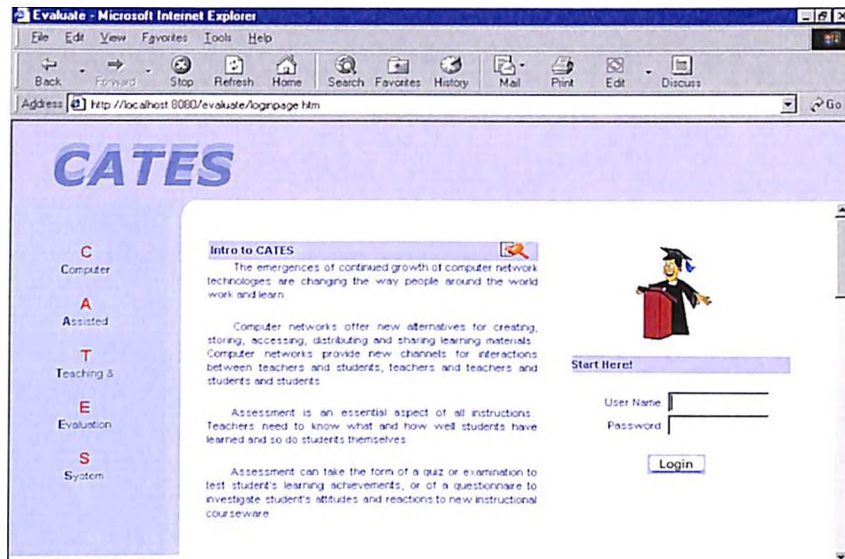
4.4 Observations

The CATES system is a collective and collaborative effort of faculty and student to interactive testing system. To study the effectiveness of the computer aided testing and evaluation, lot of data were collected. Feedback obtained from the

education society was used to enhance the software. As student community can obtain their performance then and there when they take up an examination, the teacher community is benefited by continuous assessment of the students, subject and validity of the question in the question bank by which they can modify their teaching strategies and enhance knowledge.

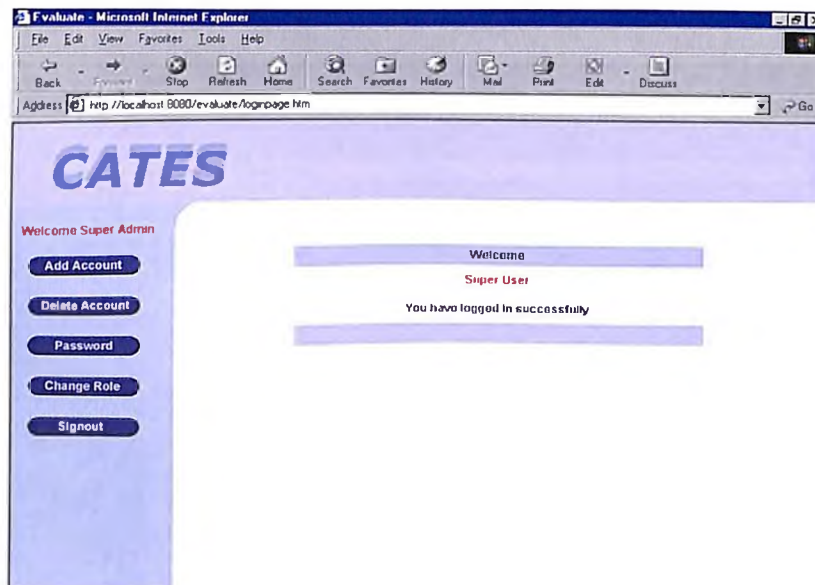
Computer aided assessments cannot totally replace the paper-and pencil assessment. The world has approved the online examination and assessment pattern because of user-friendly approach and maintenance. From the personal experience, the researcher has used CATES and found that it is a major testing alternative in teaching and evaluation for electrical and electronic engineering laboratory activities. It is expected that more research will be conducted on interactive method of testing and evaluation system in engineering environment and software like CATES will benefit the students and teachers.

CATES Home Page



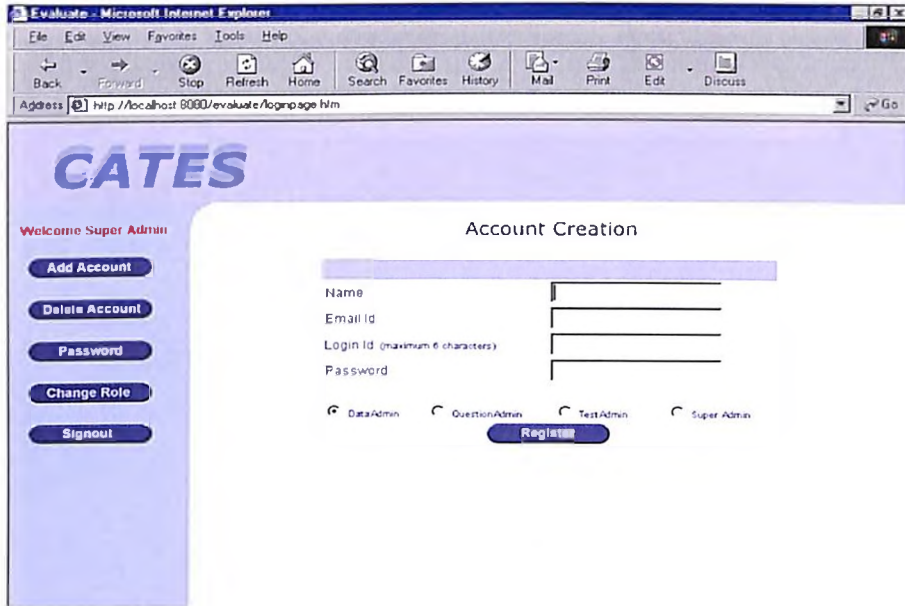
Screen Shot : 1

CATES Super User Home Page



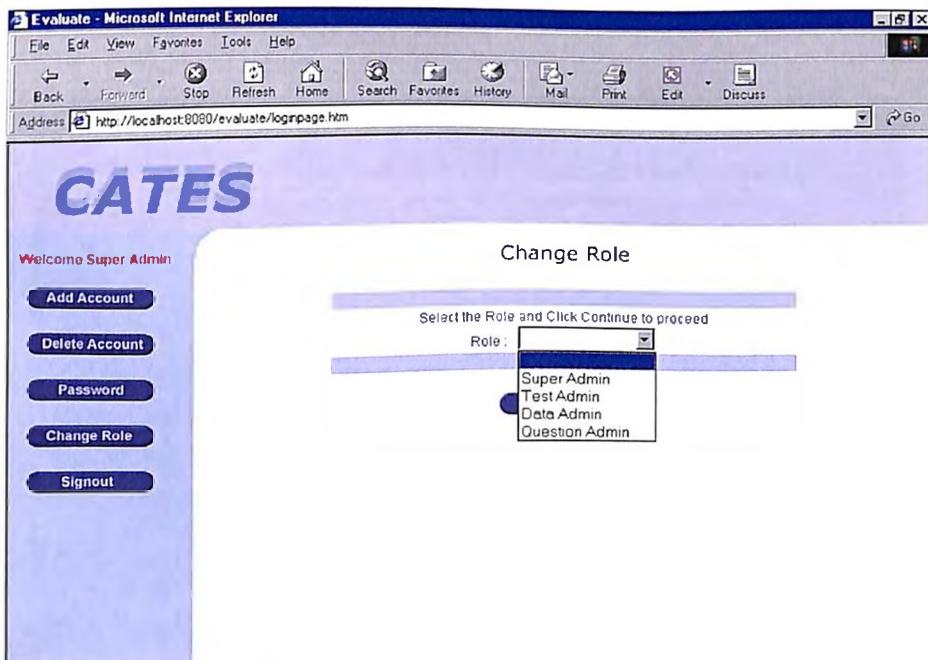
Screen Shot : 2

On Clicking Add Account



Screen Shot : 3

On clicking Change Role Super Admin can change his role



Screen Shot : 4

Data Admin updates the Question Bank

Question Generation

Subject: INSTRUMENTATION
 Chapter: Digital
 Question Type: Theory Practical
 Level: Medium

Question: _____
 Option1: _____
 Option2: _____
 Option3: _____
 Option4: _____

Answer: _____
 Justification: _____

Option1 Option2 Option3 Option4

Submit **Reset**

Screen Shot : 5

Question Admin as an expert or Faculty in that area can check the validity of the question, capable of adding new subject or sub topic under it, changing the level of the question or removing the question from QB

Q-Bank Verification

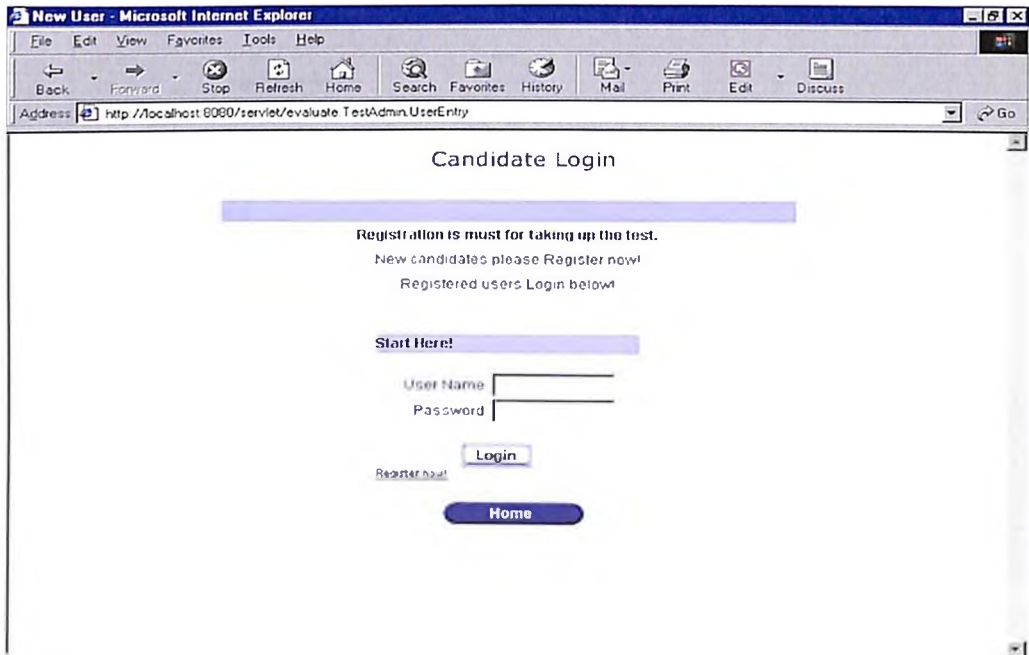
Question Details

S.No	Question ID	Topic	Description	Delete
1	QB0720	Digital	A Instrument with 1	☒
2	QB0721	induction	INDUCTION INSTRUMENT	☒
3	QB0722	induction	INDUCTION ENERGY MET	☒
4	QB0723	induction	INDUCTION ENERGY MET	☒
5	QB0724	induction	INDUCTION ENERGY MET	☒
6	QB0725	induction	THE DIFFECTING TORQU	☒
7	QB0726	induction	METER CONSTENT IN AH	☒

Back

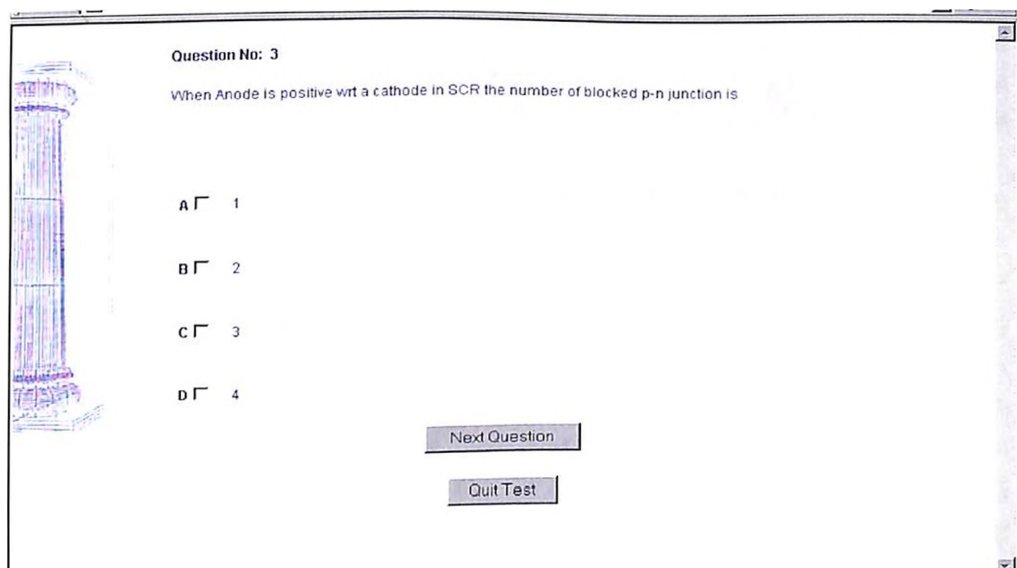
Screen Shot : 6

**If a Candidate is registered he can use
this Login Page**



Screen Shot : 9

Question Display



Screen Shot : 10

At the end of the test results are shown to the students

Test Results Now!

Name: usha
Registration Number: TR000018
Date: 18-Dec-2002
Topic : Machines
Department : ICE

Overall Performance

Number of Question in the Test	15
Marks Secured	12
Class Score	13.5
Time Taken	12

Incharge : Prof. R.R.

[To know the justification click here](#)

[Click to Print This Page](#) [Back](#)

Screen Shot : 11

Various Type of reports are available for analysis for Experts

Internet Explorer

File Edit View Favorites Tools Help

Stop Refresh Home Search Favorites History Mail Print Edit Discuss

http://8080/evaluate/loginpage.htm

ES

Admin Page

Test Details

You can click on the link below to get test details

No. Of Candidates Today	1
-------------------------	---

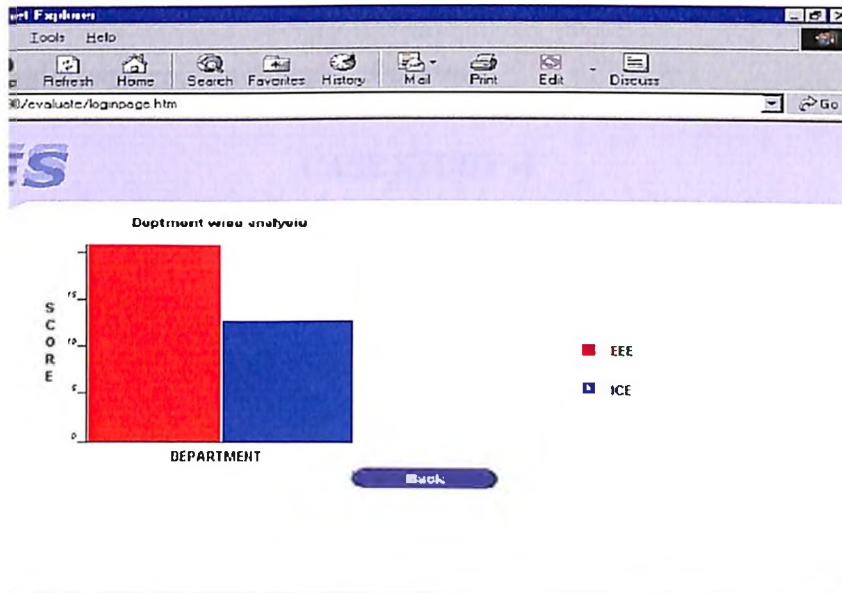
Analysis

You can get analysis reports here!

Department- wise	Click Here
Time- wise	Click Here
Candidate- wise	Click Here

Screen Shot : 12

Department wise Performance Analysis Two Department students have taken up the test, shown in two colors here



Screen Shot : 13

Student's Performance Analysis

Student's Performance Analysis

Test: 100001
Department: EEE
Test Code: 100001
Roll No. HI No.

Roll No.	Name	Score
300010	Geetha S.	12
300012	Ramesh K.	12
300017	John Ebenezer J.	13
300018	Vinod S.	12
300019	Govindaraj C.	15
300021	Prasanna	14
300022	Aravind H.	14
300023	Pranav K.	12
300026	Rajesh G.	15
310012	Vivek T.	15
310014	Uma S.	13
310015	Gayatri	14
310017	Ravi T.	13

Class Score: 12

continue

Screen Shot : 14

CHAPTER - V

CASE STUDIES

5.1 Virtual Electrical Machines Laboratory

CASE STUDY - I LOAD TEST ON SQIM

Introduction

The course ware is studied to teach Electrical Engineering Laboratory and Electronics Engineering laboratory for the undergraduate and polytechnic courses. The simulated Electrical Laboratory has five modules in the form of five CDs and Electronics laboratory contains twenty modules in twenty CDs. Each module contains a set of experiments. Each experiment in the modules, were administered to different set of students by different teachers and at different institutions. The data were collected and compiled and the conclusions were drawn. There are certain common experiments in the modules which other discipline (branch of engineering) students have to perform as per their course ware. The depth of knowledge and skill requirements is different for different set of students. A case study method is taken for one experiment in Electrical Engineering Laboratory course.

The different branches of engineering apart from EEE namely ECE, ICE, CSE, Chemical, Mechanical Production, Marine, Plastics, Leather etc., are having Electrical Engineering Laboratory course in their course curriculum. This is true for both for Under - graduate courses and for Polytechnic courses one of the experiment which is common for all courses is 'Load test on Squirrel Cage Induction Motor'. Every Elec. Eng. laboratory will have suitable infrastructure to conduct this experiment. Even though the size of the machine and the loading arrangements are different in different institutions,

all will conduct the experiment to obtain the performance characteristics of the SQIM. Hence this experiment is taken for case study.

The experiment 'Load test on Squirrel Cage Induction Motor' is performed in different institution. The polytechnic student will have objective of determining the efficiency for chemical/mechanical branch for a particular load but will have the behaviour of variation of efficiency at different loads for an UG student. The EEE students will study the variation of power factor, Torque and slip etc., with respect to variation of load. The student has to interpret the results and designs his own conclusions regarding the behaviour of the given machine at the given situation.

The computer aided teaching and learning module' is prepared to learn the experiment, the load test on 'Squirrel Cage Induction Motor' It is expected that the following learning out comes are achieved by the laboratory activity.

- Identifies the terminals of the mains
- Identifies the terminals of the starter
- Identifies the terminals of motor and meters with their ranges
- Forms layout of meters on the work table
- Selects the wires for connections
- Checks the actual connections
- Knows the precautions and start the motor
- Takes the no load readings
- Loads the motor by tightening the break drum
- Pours water to cool the break drum.
- Takes various readings of the meters
- Completed the experiment after taking the required readings
- Switches off the supply
- Perform calculations
- Interpret the results with graph.

The above outcomes of the learner are desirable for different levels of the students who are undertaking the experiment. The polytechnic colleges, one from Govt., Aided, Autonomous and Self finance are selected. Similarly from Engineering colleges are one from Govt., Aided, Autonomous and Self finance is selected. First a demonstration is given to the teachers and the supporting staff explaining the method of using the module individually. All the feedback questions from the faculty were answered. The colleges were requested to spare a batch which is expected to do this experiment as a part of laboratory activity in their time table and curriculum. Different Colleges/ Institutions will undergo this experiment at different time schedule. The Teachers were entrusted with the responsibility of implementing Computer – Assisted teaching. A preliminary planning is undertaken with respect to requirement of computer facilities such as Installation of software, password implementation, making use of the software, plotting of graph, method of taking self test and obtaining grade. The fullest co-operation of teacher / supporting staff in every institution is obtained.

Implementation

A set of forty students each was divided into two groups each contains twenty students. All the forty students were trained to have almost same entry behaviour. The students for each group are selected by the process random number technique. The entry behavior is ascertained by Viva-Voce questions and certain fundamentals were revised. Concepts like three phase power measurement, speed measurement loading technique, voltage – current, measurement type of motor, type of starter etc., were explained only five minutes time duration were spent to brief the student.

One group of students was asked to perform the 'Load test on Squirrel Cage Induction Motor' in the conventional or Traditional Laboratory technique. A detailed instructional sheet is given to the batch of student. Each laboratory session will contain five different experiments. One of the experiments in that cycle will be the 'Load test on Squirrel Cage Induction Motor'. Usually four students will form the batch. These four

students will act as the 'sample' for the study. This batch will take the instructions from the information sheet. This sheet will have connection diagram, apparatus required, procedure, tabulation model graph and expected conclusion. The students will copy the circuit diagram from the Instruction sheet in an observation note book and draw the tabulation also. This will be scrutinised by the teacher and he will initial it. This activity takes about thirty minutes. The student group will list the equipments/meters in a prescribed format and submit it to the Electrical Laboratory stores. The students in turn will receive the required meters.

The student groups will make connections as per the circuit diagram. The Technical staff verifies the actual connections and permits the student to start the motor. He may ask some questions to ascertain that the group is aware of the safety precautions and the procedure. The group starts performing the experiment one student will note the speed using the tachometer another student will load the motor by lightening the break drum belt as per their peer's advice, another will note the readings of the meters for various sets while another will note down the observations in the note book.

After loading the motor up to the desired value, usually full load current and noting down all the meter readings, the load is removed and the supply is switched off. As friction is created in the break drum, while loading, water is poured to cool and dissipate the heat. All the students will copy the readings and start calculating. It is observed that one or two in the batch will start doing the calculations and all the batch mates will copy the values in the diagram. The readings and calculations were shown to the teacher for approval. The students will draw the performance curve and obtain the grade.

All the documentation works are repeated in the record supplied and submitted for final evaluation and grade is given to individual students. The difference in the grade is usually through the observation and viva questions in the laboratory by the teacher and the supporting staff. The mode of assessment will be shown in fig (12). This mark is

taken for the internal assessment mark. The students were allotted three hours time to completing the experiment. In the study, the students were able to finish their calculations and plot the two graphs namely the output Vs efficiency and output Vs Torque and some times output Vs speed or slip is also plotted. In the last fifteen minutes a test is conducted to measure the learning outcome of the students. The question paper will have fifteen questions. The questions are objective test items with multiple choices fill in blank or one or two sentence answer. The individual scoring of the students were recorded. The same procedure is carried out in all the four different institutions and to all the twenty students.

After satisfying the entry behaviour the other set of twenty students were taken to the computer centre. Each student is made to sit in front of a computer and using the password he is asked to open the file and select the experiment 'Load test on Squirrel Cage Induction Motor'. The student clicks the theory and reads the content information which is available in seven frames. As it is provided with audio built-in, the student reads in the same speed as the audio and complete in five minutes.

To start the experiment he clicks the experiment simulation file. The first frame will be the connection diagram as shown in Fig (13). The student will see the diagram for one or two minutes. If need be, he copies the diagram in a paper. The student observes the connection of motor namely star run or delta run, the type of starter used, the manner of wattmeter connections the voltmeter connection, the line ammeter, the connection to starter and motor. The student clicks the list of instruments and its ranges on seeing the diagram. Only if he supplies the valid input, the student is allowed to proceed to the next frame. The listing must be complete including the technometer and the loading arrangement with spring balance. Then clicks the next, which will show on the screen all the meters, starter, motor as shown in fig (14). This will give the layout of various instruments in the work table.

In this frame there will be a promptor. The student has to move the mouse to connect 'R' phase to current coil M of wattmeter 'one' the mouse is clicked, the connections are made virtually. Then next prompt will appear at L and it should be connected to L1, of starter when he moves mouse of the computer and clicks at L which automatically connect the starter. Like this all the prompt must be connected. A systematic connection is made and all connections are made to perform the experiment. Then he clicks the procedure. Step - I, Step-II etc., to explain the function of switch on the main, and then mouse is made to move to the handle of the main switch and when clicked, the main switch is 'ON' immediately. These are indicated by lamp glow. The next step is to start the starter handle to move the handle down to connect the motor in star. After a pre set time the handle is moved to delta by the mouse the motor will start rotating. The voltmeter will read the supply voltage; the tachometer will read the no load speed. The wattmeter W_1 will read backwards and wattmeter W_2 will read forwards. The ammeter will read the load current. All the set up in working condition is as shown in fig (15). The mouse is moved to tighten the belt in the break drum. The spring balance reading is seen by clicking the prompt that is provided. When the motor is loaded the changes in all the meters are noted. As the load increases there will be a change in the wattmeter readings and the decrease in the speed and increase the line current which are all seen on the computer screen as shown in fig (16). The experiment is performed up to the rated load. This will be observed when the student clicks to over load as it will not increase the current and the readings of wattmeter or the spring balance can not be increased.

The readings are tabulated and efficiency calculations are shown and the graph between the output and efficiency is available when Graph - I is clicked as shown in Fig (17). Another performance characteristic is namely output Vs powerfactor is available by clicking the mouse Graph-II as shown in Fig (18). Similarly output Vs slip as shown in Fig (19) and Toque Vs slip as shown in Fig (20).

The whole experiment is performed on the computer screen virtually in about thirty minutes. It is found that the variation of time for different students is from twenty minutes to thirty five minutes. As it is an individual activity and the whole process is software driven, it is customer friendly and an average every student performs the experiment in thirty minutes. After completing the experiment in the computer virtually, the students enter the lab in a group of four.

The four students will obtain the necessary meters from the stores and started connecting the motor, starter and meters to the mains. This activity is very fast and there won't be any flaw or mistakes. The teacher checks the actual connections and energises the supply. The student performs the experiment systematically he takes readings of all the meters and tabulate them. He plots the graph and shows the teacher for evaluation. The software package has inbuilt question with justification of answers. The student can take up the test and he knows his score. In this study all the twenty students were asked to take up the test. Few students have wrong response for few questions and they are allowed to see the answer and know the correct response with justification.

The two set of students from four colleges who have done this experiment were given the same question paper. One set with traditional teaching and learning which is mostly teacher oriented and the other set, with compute Assisted teaching and learning which is mostly student oriented. The questions are of the form.

- Why 'R' phase wattmeter reverse on no load?
- Why 'negative' reading reduces as the load on the motor increases?
- What precautions are to be taken while using the STAR/DELTA starter to start the motor?
- The input to the motor is found varying when and why?
- What technique is used to load the motor?
- Why speed decreases as load increases?
- When is the efficiency maximum?

- Why p.f. increases as load increases?
- Why Torque increases as load increases?
- Why Squirrel Cage Induction Motor is called Asynchronous motor?
- Why Torque increases as slip increases?
- Why voltage decreases slightly as load increases?
- How will you reverse the pr-coil terminals with out switching off of supply?
- How will you reverse the motor direction?

Analysis of out come

The case study one data sheet shows the statistical data available for twenty students with fifteen questions. The scores of individual students are predominantly higher with computer aided teaching. Hence it can be concluded that the learning out come is successful with CAT. The samples are collected from Govt. aided, autonomous and self finance colleges. In all the samples the individual students have scored more than the traditionally learned students. Irrespective of the learning ability, the CAT enhances the scoring of the students.

The time allotted in both the cases is three hours. The same set of teachers was involved. Almost same entry behaviour or standard is assumed. The number of students giving correct response to every question is more in case of CAT students while the correct response is low in case of traditionally learned students. Since all the questions are attempted by the students which mean the question are to their standard. More difficult questions can be asked by the teacher which helps the student to go for adoptive learning.

The number of students who are completing the question paper in about 85% of the time is more when compared to that of conventional method. Majority of students have taken the allotted time (100%) when they take up conventional method of learning. It is found that the higher ability students (quick learners) have completed the question paper in answering correctly and quickly when they take up CAT.

The study involves different institutions. Since the same experiment is tried with almost same level of students a rank correlation among students of various institutions are carried out. The self financing college students were having average score with CAT is almost equal to the average scores of Aided government college students with out CAT. This study also reveals that the students of Govt., college are having highest coefficient of learning having 12.5/15 next comes the autonomous institutions with 11.9/15, the Aided institution with 11.6/15 and the self financing institutional with 10.5/15.

Hence it is concluded that the computer Aided teaching of Electrical Engineering Laboratory Experiment on Load test on Squirrel Cage Induction Motor enhances the learning out come of the students. Mastery level of learning is achieved, as all students are aware of the answers to all the questions. Standardization is attempted. Quality is enhanced. The student / learner correct himself the deficiencies existing in the present system are over come to the large extent.

CASE STUDY - I

DATA SHEET

SUBJECT : MODULE : 3 EXPERIMENT NO : 2 TOPIC : 'Induction Motor Load Test' - 3Q SQIM

Number of Questions : 15

Number of Students : 20

Engineering Colleges

	Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Govt.	CAT	19	20	19	20	20	19	20	18	20	20	20	19	19	19	19
	TLP	17	16	15	17	17	16	15	15	14	16	15	15	17	18	19
Aided	CAT	20	19	18	19	18	20	20	19	18	20	19	18	16	18	19
	TLP	16	16	14	17	16	16	16	15	15	17	14	15	16	17	18
Autonomous	CAT	19	20	20	18	19	20	20	18	17	18	17	20	16	17	18
	TLP	16	17	15	16	16	17	16	16	17	16	15	15	15	16	18
SF	CAT	18	18	17	18	17	18	18	16	15	17	17	14	15	14	15
	TLP	15	14	13	15	12	14	13	14	13	15	15	12	14	12	12
Coff 0.91 Effectiveness	CAT	0.95	0.962	0.925	0.937	0.925	0.925	0.975	0.8875	0.875	0.4375	0.9125	0.8875	0.825	0.85	0.8875
Coff .7699	TLP	0.8	0.787	0.7125	0.125	0.7625	0.7875	0.75	0.75	0.7375	0.8	0.7375	0.7125	0.775	0.7875	0.837

CASE STUDY - I
SCORES OF STUDENTS

Students No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Av:12.5	CAT	12	14	11	14	12	13	15	11	12	13	12	14	15	08	10	12	13	14	14	12
Govt:	TLP	11	12	10	12	13	12	12	13	11	12	12	11	13	10	09	11	12	13	13	11
Avt.11.65	CAT	12	14	10	12	13	14	12	15	08	09	10	11	12	13	09	14	12	13	10	10
Aided Av:10.7	TLP	09	11	10	09	08	12	11	13	15	10	12	11	10	10	11	12	13	13	10	11
Av:11.9	CAT	13	15	11	12	14	10	12	13	15	10	12	11	10	10	11	12	13	13	10	11
Autonomous Av:11.1	TLP	12	13	12	11	13	09	11	12	13	11	13	10	09	09	09	13	12	12	09	09
Av:10.5	CAT	10	12	10	12	09	08	06	09	08	10	12	13	12	15	14	10	12	12	08	08
SF Av:9.15	TLP	09	11	08	10	08	06	05	08	07	10	11	12	11	14	15	09	09	08	06	06

The scores of students are higher with CAT

SCREEN SHOTS

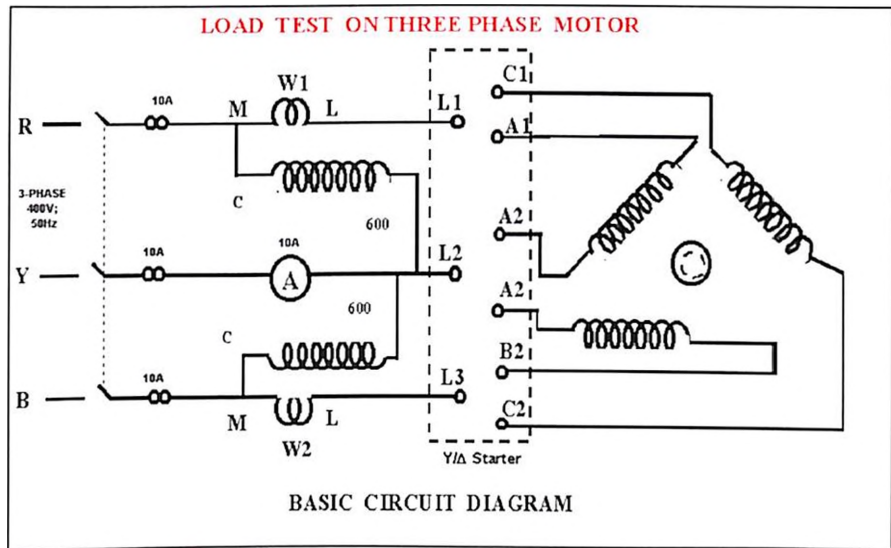


Fig (13)

The circuit diagram for conducting load test with meters and starter

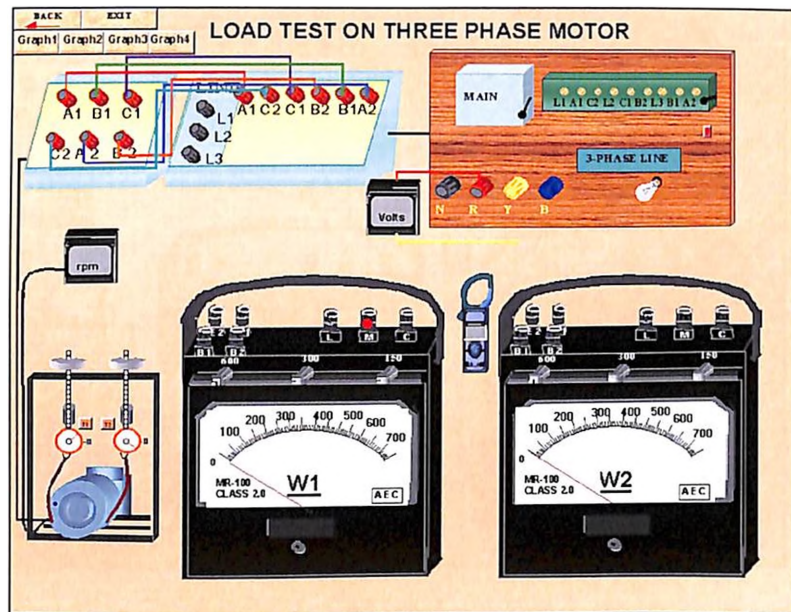


Fig (14)

The layout of meters with motor and starter in the virtual Laboratory

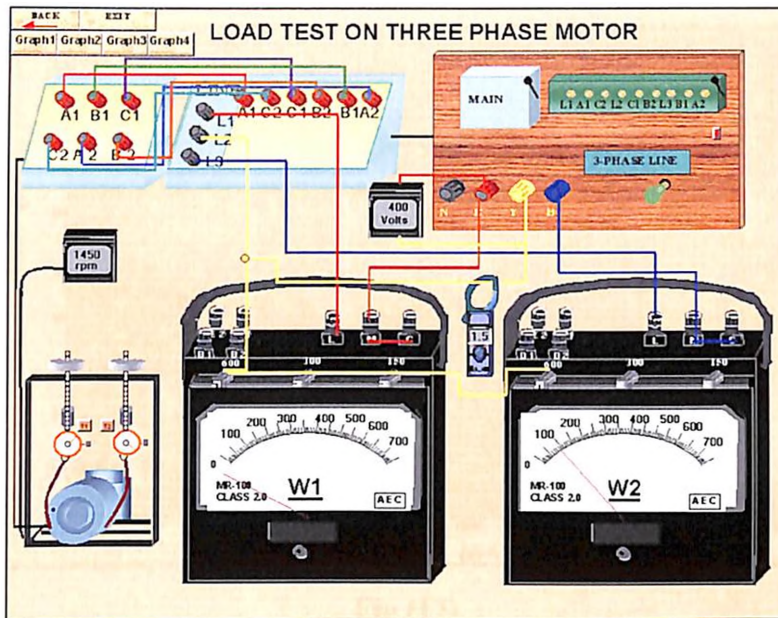


Fig (15)

The virtual laboratory in working condition when the Induction motor runs on No load

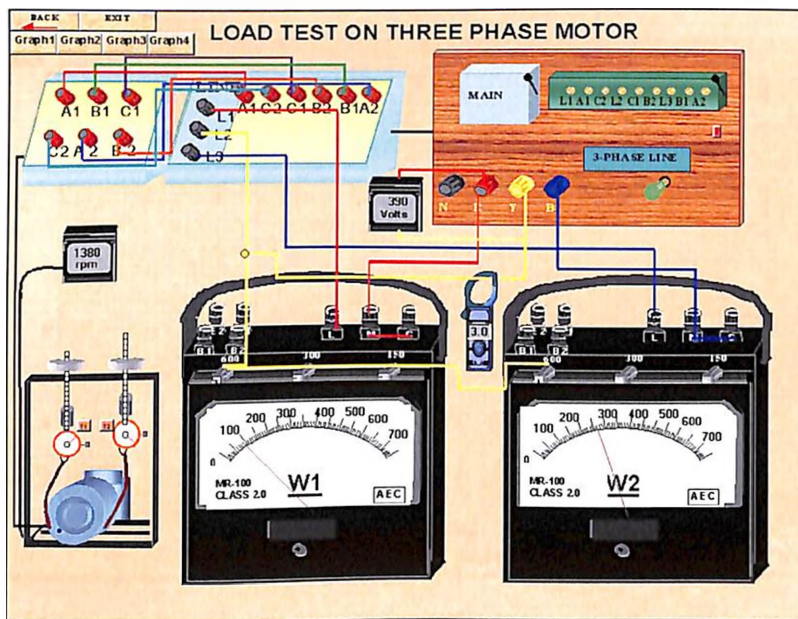


Fig (16)

The virtual laboratory when the Induction Motor on load showing the readings on all the meters

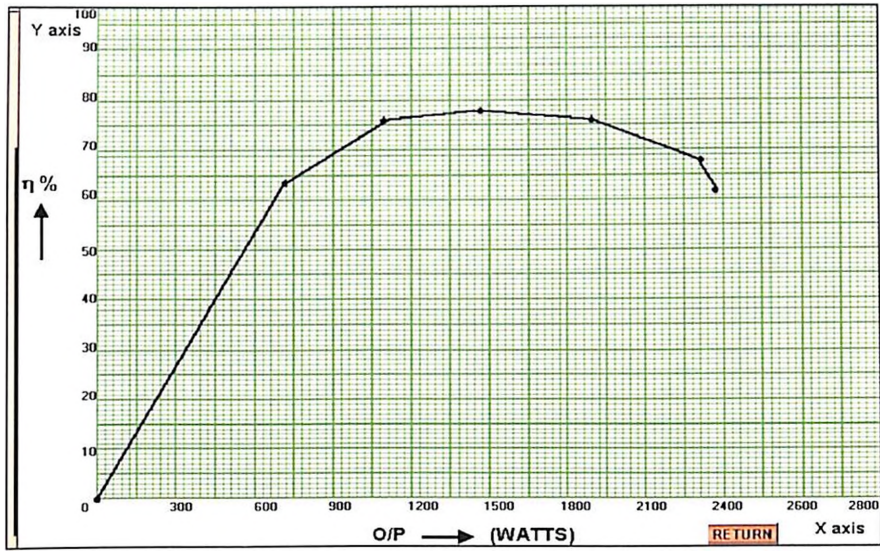


Fig (17)

Performance curve
Output Vs efficiency

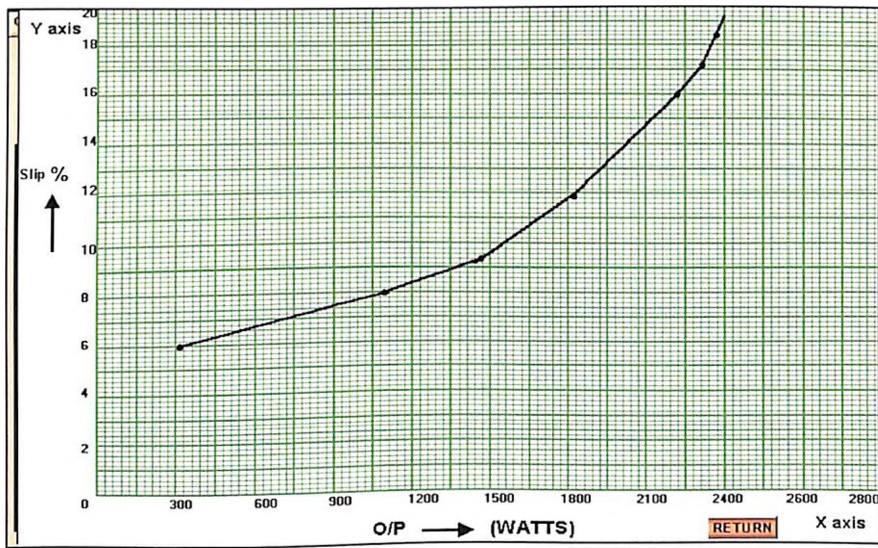


Fig (18)

Performance curve
Output Vs slip

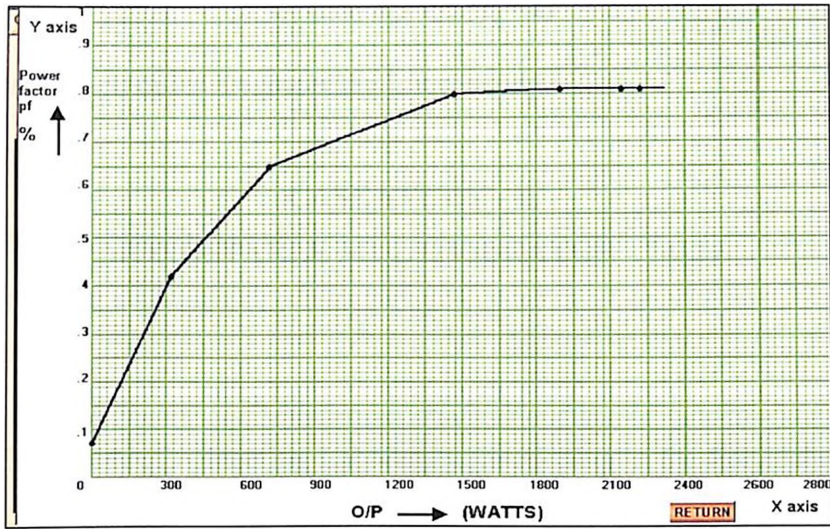


Fig (19)

Performance curve
Output Vs Power factor

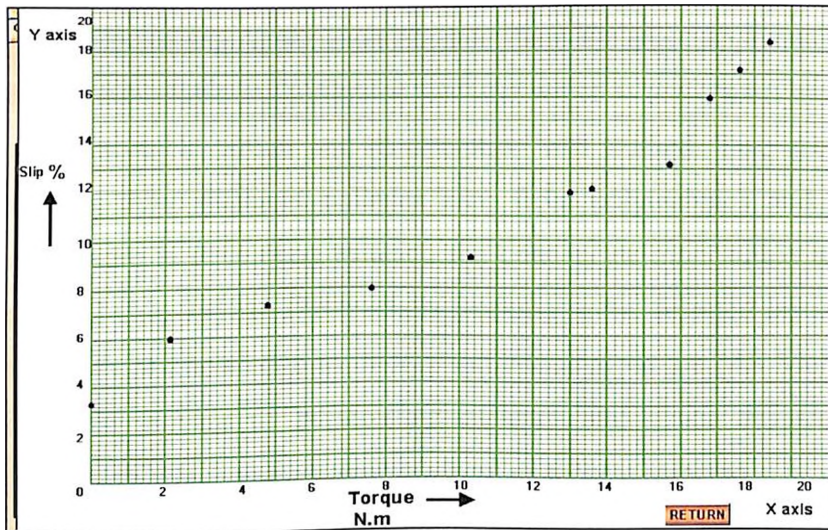


Fig (20)

Performance curve
TORQUE Vs slip

CASE STUDY - II

5.2 Virtual Electronics Engineering Laboratory

CASE STUDY - II

MONOSTABLE MULTIVIBRATOR - 74121

Introduction

The Electronics Engineering Laboratory functioning in the Polytechnic Colleges and Engineering Colleges will comprise of two or three laboratories. The different types of experiments are conducted to support various levels of students. Usually Electronics Engineering Laboratory activities include circuit laboratory and devices laboratory. In the circuit laboratory various linear and digital circuit experiments are performed. From the simulation module, Digital Electronics Applications is taken for the case study.

In Digital Electronics Application Module there are eight applications. A study was conducted on monostable multivibrator teaching which is performed by 555 IC chip connected as a monostable circuit and its operation was studied. Two set of students were selected from three different colleges each from polytechnics and engineering colleges. The software is developed to teach the concept of monostable multivibrator using monolithic IC chip 74121. The teachers working in the selected institutions were consulted. The depth of knowledge to understand and analyse the MS Multivibrator is not found favorable in case of polytechnic colleges and hence the study favored engineering colleges of which three engineering colleges were selected.

Two set of students were asked to Rig up a monostable circuit using 74121. The set of students were briefed about the need of monostable circuit and its application. A set of 4 students were asked to Rig up the circuit using 'Digital Trainer' available in their lab. The students were asked to design the circuit for a given time delay, implementation and check the input-output relationship using Truth Table. Then feed an input signal from signal source and see the wave frame at the output.

The next set of students was given Computer Assisted learning. The students are provided with individual computers and the software is installed. After opening the file with the given password the student will see the 'Index' as shown in Fig.(21). The student selects the monostable multivibrator using 74121 in the index by clicking on the prompt. It will open a window to select theory, simulation of experiment, or self test.

The student clicks theory then the file will open and it will give information about all the experiments with an Index in that CD. From the screen the student clicks the monostable multivibrator, as shown in Fig.(22). The theory will spread to 7 to 8 frames with audio back-up. This will include certain pop-up screen. The circuit diagrams are also shown while reading the theory portion as shown in Fig. (24). Actually 555 connection as monostable is provided as pop-up window. This will enhance the students understanding ability. If the students know, he can skip that particular concept and so on. After completing the reading of the relevant theory portion the student can press 'Back' so that the menu frame can be reached.

By clicking the simulation experiment option the circuit diagram with external connections are viewed. The logic input switches and the output indicators are available as shown in Fig. (23). The function table available on the screen will enable the student to understand the logic input and expected logic output conditions. In the same frame the student can have the option of going to theory or procedure or to back (after completing the experiment) when the student clicks the procedure Fig. (25). Step by step activity is also available with audio back up.

In the simulated screen the integrated circuit internal block diagram, the supply terminals for the IC, the logic input switch conditions (0 or 1) and the output LED giving the condition for output logic one or zero by its illumination are all shown. The

students verify the function table and understand the working of monostable multivibrator. The R.C. constants can be varied by click up the required value available in the window and study the behaviour of I/O relationship.

After completing the experiment the student can take up self test Fig. (26), by clicking the prompt. The questions will be displayed in the screen with four options as they are designed only for objective test and hence items are shown as in Fig. (25). The student clicks the correct response and obtains the final score in the self test. If need be, he can click the answer and know the correct answer with justification.

Now both set of students were given a post-test by the teacher. Their scores were tabulated as follows:

Question No.	1	2	3	4	5	6	7	8	9	10
No of Students response (CAT)	4	5	5	4	5	5	5	4	5	3
No of Students response (TLP)	4	2	3	1	4	4	5	3	2	1

It is found that the students with CAT are able to answer more questions correctly and the scores are better when compared to students without simulation and hence it is concluded that the learning outcome is high with CAT. This is the result observed in all the three set of samples taken from all the three type of colleges.

SCREEN SHOTS

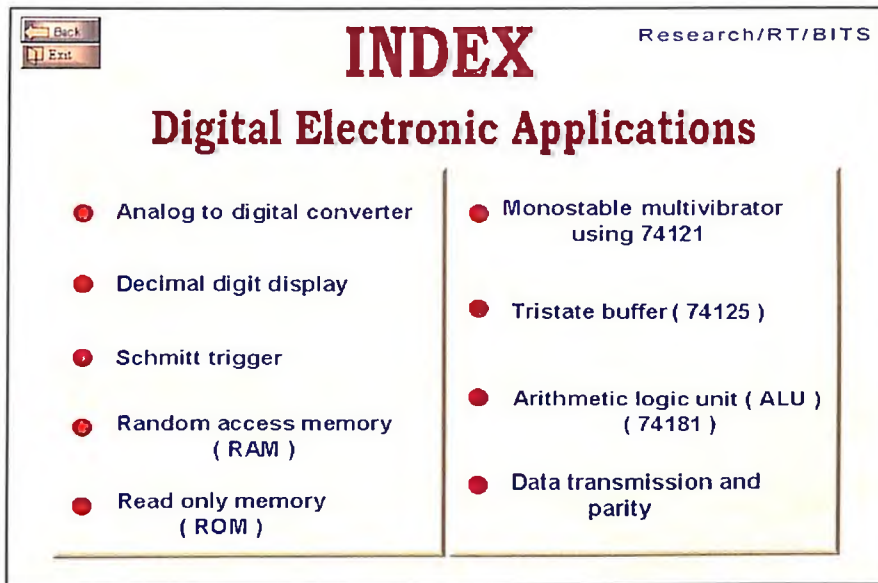


Fig (21)

Digital Electronic Applications Module (Index)

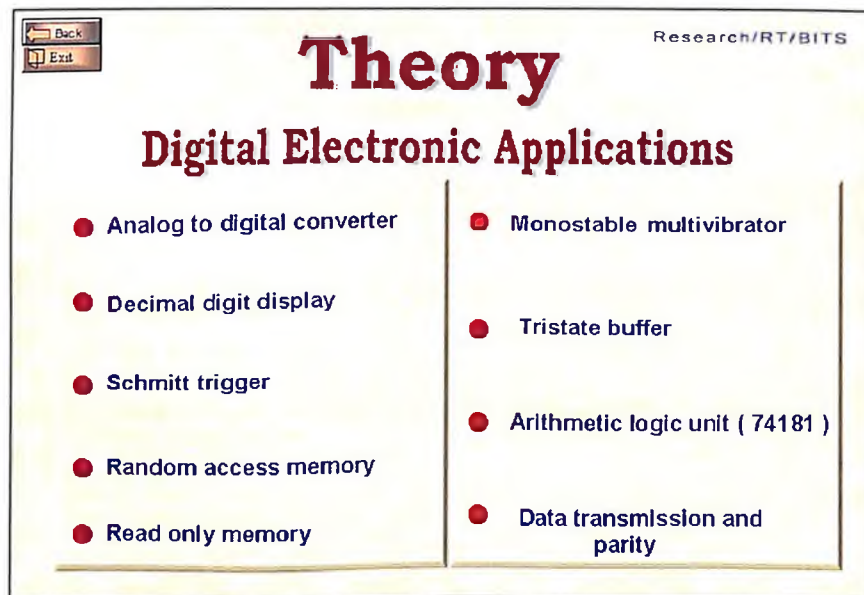


Fig (22)

Digital Electronic Applications Theory (Index)

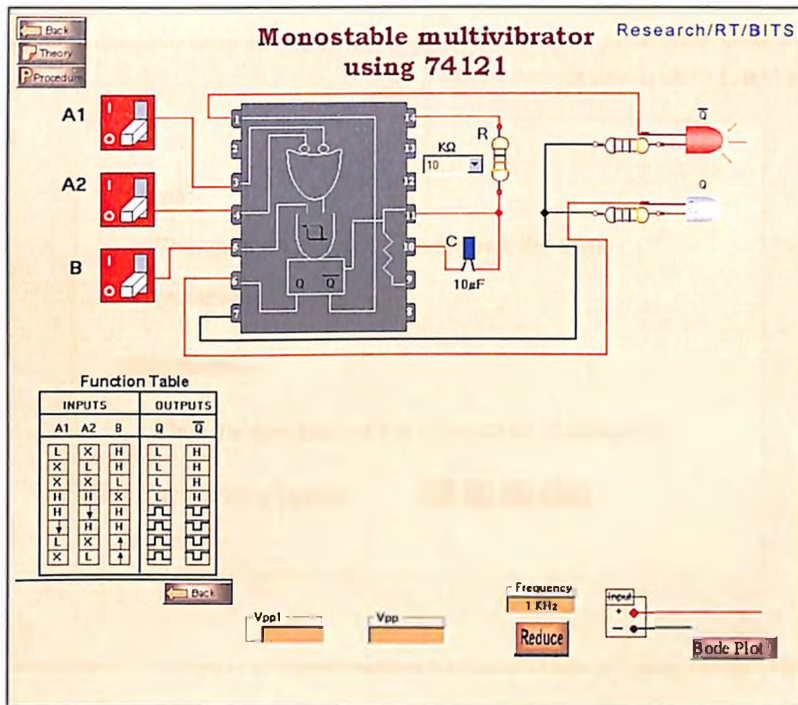


Fig (23)

Pin Diagram of 74123 with function table

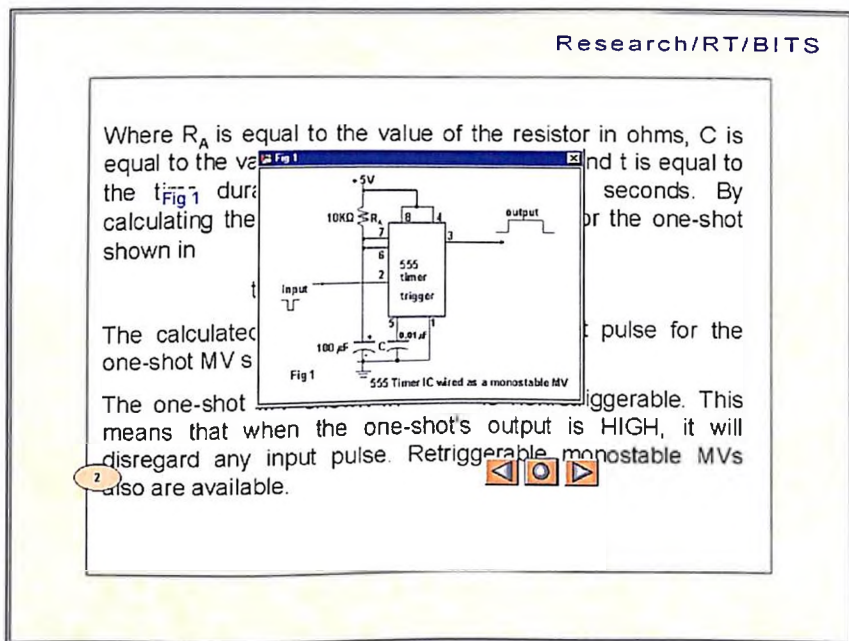


Fig (24)

Content Information with Pop-up window


Research/RT/BITS

Step3:-

Change the values of R and repeat the same procedure.

Conclusion:-

Thus the operation of the monostable multivibrator

3 IC 74121 is studied. 

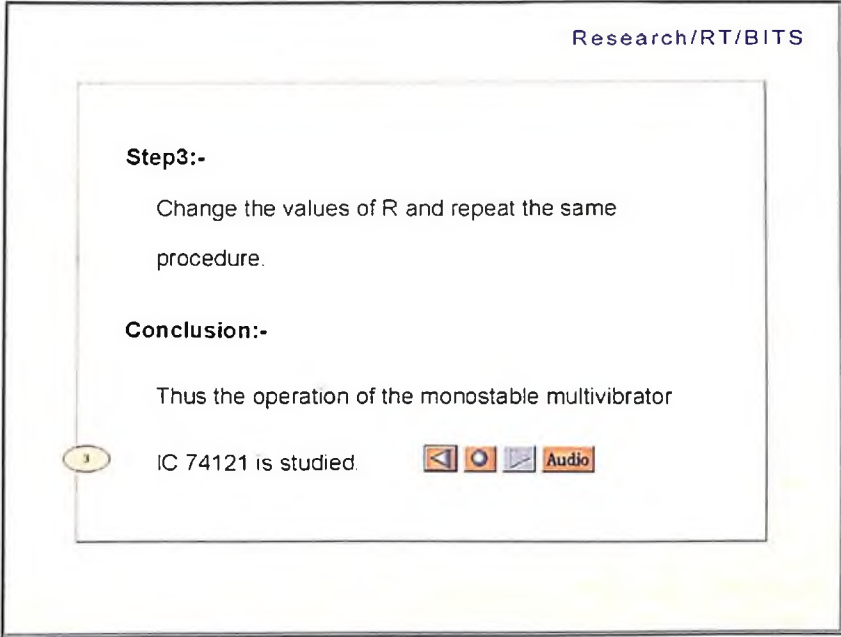


Fig (25)



Procedure – document frame

Research/RT/BITS

Choose the correct answer from A to D by clicking on the following buttons given below

16. Monostable multivibrator has

- A. One stable state.
- B. One quasistable state.
- C. Two quasistable state.
- D. Both A and B.

A **B** **C** **D** **Score** **0** **Answer**  

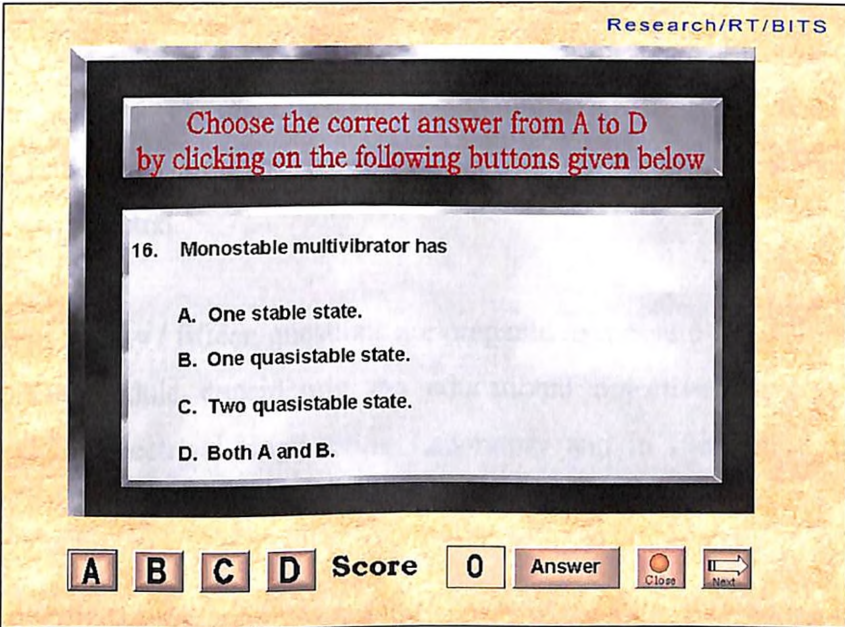


Fig (26)

Self test – document frame

CHAPTER - VI

VERIFICATION OF HYPOTHESIS

6.1 METHODOLOGY

The software developed for conducting the laboratory activities in Electrical Engineering Laboratory and Electronics Engineering Laboratory were initially exposed to teachers of various colleges and polytechnics. Initially, the simulation package was adopted as a teaching aid rather than students learning tool. Efforts were taken to identify the colleges and teachers to motivate the students to study the laboratory activity by simulation technique. During the Ph.D. seminar by the researcher at various colleges the feedbacks were impressive and demonstrations were made at length. By patience and perseverance the learning packages was accepted by teachers and students. A methodology was developed to evaluate usefulness of the software package.

The colleges are selected with a dedicated team of teachers to use CATS. The students are selected at random. The laboratories are selected (i.e.) Electrical Engineering Laboratory or Electronics Engineering Laboratory. The module to be evaluated is also selected.

A set of twenty / fifteen questions are prepared to measure the learning outcome for a particular module considering the educational objectives. Every module is evaluated both in Electrical Engineering Laboratory and in Electronics Engineering Laboratory.

The questions were administered to two sets of students. One set of students did the experiment in a traditional way (TLP). Another set of students did the experiment after going through Computer Assisted Learning (CAL). The same the end sets of questions were administered. The marks secured by each student are found. Analysis is

made how each question was answered by each set of students. The time taken to complete the test is also recorded. Out of twenty questions, how many correct responses the student has given in the final score of the students. Invariably for almost all the modules the students' scores were high if they are through computer assisted learning. In one of the sample the variation in outcome for the two methods as regards to score are not much but the time taken for completing the test varies considerably. The CAT enables the student to give response quickly. It increases the confidence among students. It enables the student for further learning, as the Interaction time available is more.

Before administrating the computer assisted learning, a norm reference test (NRT) is administered. This test is performed by simple objective test items, quiz questions, and peer discussion. The main objective being that all the students will have equal knowledge level pertaining to the performance of the test. As an example before administrating the lab experiment 'Load test on three phase Induction motor', the NRT contains questions like

What instrument is used to measure power in AC circuit?

What instrument is used to measure speed?

How many wattmeters are used to measure input power to 3 phase motor?

What is the normal supply voltage?

What is the frequency of the AC supply?

What type of 3 phase Induction Motor namely Squirrel cage or slip ring?

What is the capacity of the motor under test?

A brief discussion was done with the group of students carefully avoiding the questions and its answer, which may appear on the post-test to be administered at the end of the activity. All the students (fifteen in number) were prepared to have almost equal entry behaviour.

The selected fifteen students were briefed about the computer-assisted learning. A demonstration was conducted for ten to fifteen minutes. This activity mainly concentrates how to open the file and interact with the computer. As the program is self-driven the students can perform the whole experiment virtually. The student was also motivated to answer the questions given at the end of the session. Since answers were also given, the students after obtaining the score, the questions for which he did wrong response, immediately tries to know the correct response. By this technique all the students have taught the subject; a mastery level of learning is attempted. In the Traditional method, various constraints are met by the students and the teacher.

The students who are taking the lab experiments without CAT are also given the briefing by the concerned teacher. It is to ensure that both the set of students one with simulation and the other with traditional technique will have the same entry behaviour. In the Traditional method it is observed that the student is making little preparation before entering the lab.

At the end of the experiment the question paper was exposed to both batches of students. The responses were collected and analysed statistically and conclusions were drawn as CAT improves the learning outcome of students. In the subsequent chapter a statistical tool is used to justify the statement.

6.2 Statistical Analysis

An interface between the classroom and the laboratory is developed during the course of research. A very handy versatile tool namely the computer is used in the process. Software is developed suiting to the needs. Normally available PC with PII configuration is sufficient to run the software. No special training is needed to run the software. As the virtual laboratory software is 'custom built' it takes minimum time to install and run by the individual.

The Researcher has taken two major groups of institutions to study the effectiveness of the concept of Computer Assisted Teaching Laboratory Courses. They are polytechnic colleges conducting Diploma courses in Engineering awarding Diploma certificates, the other engineering colleges offering engineering courses at under graduate level.

In the case of polytechnics three different kinds of institutions are selected to obtain samples. Namely, the Government Institutions (The CN Polytechnic), the Autonomous Institutions, where the standard is better (The Murugappa Polytechnic) and the third variety of institution namely the self-financing polytechnics (The Ramakrishna Polytechnic). In these institutions the input level of the students are vastly varying. Samples of twenty students were taken. In order to ascertain the uniformity in the entry behaviour a norm reference test (NRT) is conducted. This is done by questioning, peer discussion, an objective test for ten minutes, or a briefing session and a demonstration depending on the situation. Complete satisfaction is obtained before administering CAT.

In the case of under graduate courses the samples are taken from Govt. Engineering College (REC Trichy) a self financing college (Dr.MGR Engg. College) an Autonomous Institution (Sathyabama University) SSVSMS Institute, (Deemed University), the Al Ghurair University (Dubai), the Sharja Engineering College (Sharja UAR) and a group of students from IIT Madras. The test scores and other data were collected.

Each module is tested with different set of students and at different time. In our present laboratory curriculum simultaneously five or six batches are made to learn and perform the laboratory activities doing different experiment namely only batch will be doing load characteristics of DC shunt generator. The other batches will perform load test on DC compound generator, Load test on DC shunt motor, shunt generator on no load (determination of critical resistance and critical speed) and so on.

Each batch doing a particular experiment will consists of four to six students. Four such batches are selected for analysis. The Electrical Engineering Laboratory is offered as 'one credit' course to one set of students and the same curriculum (syllabus) was offered as 'two credit' course to another set of students. In all these cases care is taken to ascertain the entry behaviour is almost same before administrating the test.

While selecting the samples the students are taken as a group. The group invariably consists of twenty (4x5) students. These twenty students is almost a heterogeneous group. Some students are very good (from the past record) some are intelligent (as commented by their teachers) some of them are slow learners and average. But before administrating the test the students are motivated sufficiently so that the outcome is not varying very widely. The teacher before administering the test takes enough caution by knowing the objective of the test and the significance of the research.

Each module defines a particular set of experiment. Each student in the sample has to perform the experiment in the conventional way. It takes about three hours. In an environment as per the curriculum the students are expected to perform the experiment only once in their study. It is difficult to find time for repeating experiment both for the student and for the laboratories. The experiment will be repeated or the machine under test is to be used once in a year or in a semester by a batch of students. Hence it is a time consuming exercise for the researcher. It is possible to take samples once in a year or twice in a year. Hence elaborate planning is done to administer the test and obtain the response from different set of students.

Each module will have fifteen or twenty questions. These questions are framed to measure his learning outcome. These questions are designed to give quick response (objective type). The questions are framed not only to test the knowledge and understanding but also appreciate the significance and applications. Certain amount of

psychomotor skill is also tested. Certain safety precautions and sequence of operations, elegant standard engineering practices are also incorporated.

Computer is used for evaluation. No paper-pencil technique is used (a software package for Computer Assisted Teaching and Evaluation System). 'CATES' is used to obtain the response. Initially the students and the teachers were taught to use CATES package. Many times the different set of students was used for evaluating each module. After overcoming the initial difficulties, the students and the teachers are more comfortable in using the computer and the CATES package.

An educational tour was undertaken by the researcher (UAE) to implement the concept and to obtain the feedback in an environment widely different from present set up. The electrical laboratory experiments were conducted by using 'lab-volt kits' (Tiny motors of different varieties with multiple set of experiment using common loading arrangement). All the students were made to conduct the same experiment at a time. The number of students taking up the lab course is less and the availability of the 'lab-volt' kits, numbers is high. After the teacher completes a concept in the classroom the students were allowed to perform the relevant experiment say for example after teaching the DC Generator the students were asked to verify the characteristics of the generator, critical resistance, ON load performances etc.

In the Indian context the laboratories are not equipped with many numbers of same varieties enabling all the students to perform simultaneously. We give a set of experiments in a cycle as explained earlier. It may have five or six experiments. Each experiment has to be performed by a group of students on a particular day and session. On a particular day and session the students will know what experiments he will have to perform and he will be given an experimental instruction sheet sometimes. The related

subject is not yet covered by the teacher in the classroom but the student has to perform the experiment with the help of instruction sheets given. The teacher will supplement with necessary input. The advantage is that student learns twice.

Al Ghurair University and Sharja College were selected (United Arab Emirates) for the research because it is the first time they are offering the Electronics and Electrical Laboratory Courses for their new set of students. Initially to know the effectiveness, the subject was taught on Transformers, principle, construction, emf-equation, regulation, losses and efficiency. The students were asked to conduct OC and SC test on the transformer and derive the conclusions on efficiency and the equivalent circuit. Since the subject is taught, two sets of samples of 15 students were taken as usual. It is ascertained that entry behaviour for two samples is same.

One set of sample of students were asked to conduct the experiment in the conventional way and the other set will be with computer assisted learning. At the end of the laboratory activity both the samples were administered with the same set of questions. Their responses were collected. The student's scores were available immediately after the test. Detailed analysis was made and conclusions were derived with student 't' test (testing difference between means of two samples). The questions remains same only the marks secured differs. The scores obtained by various students are tabulated. The outcome of the CAT students compared with traditionally learnt students is shown Fig.27.

The following Tables gives the sample data collected and presented with the conclusions for selected modules.

COMPARISON OF LEARNING OUTCOME (POLYTECHNICS)

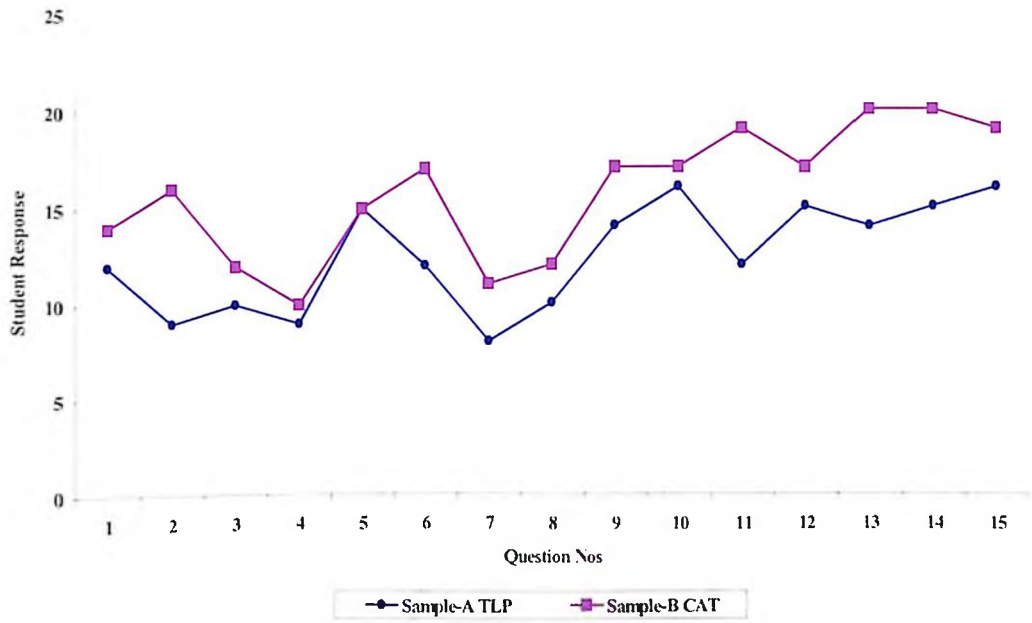


Fig (27)

COMPARISON OF LEARNING OUTCOME (UG COURSES)

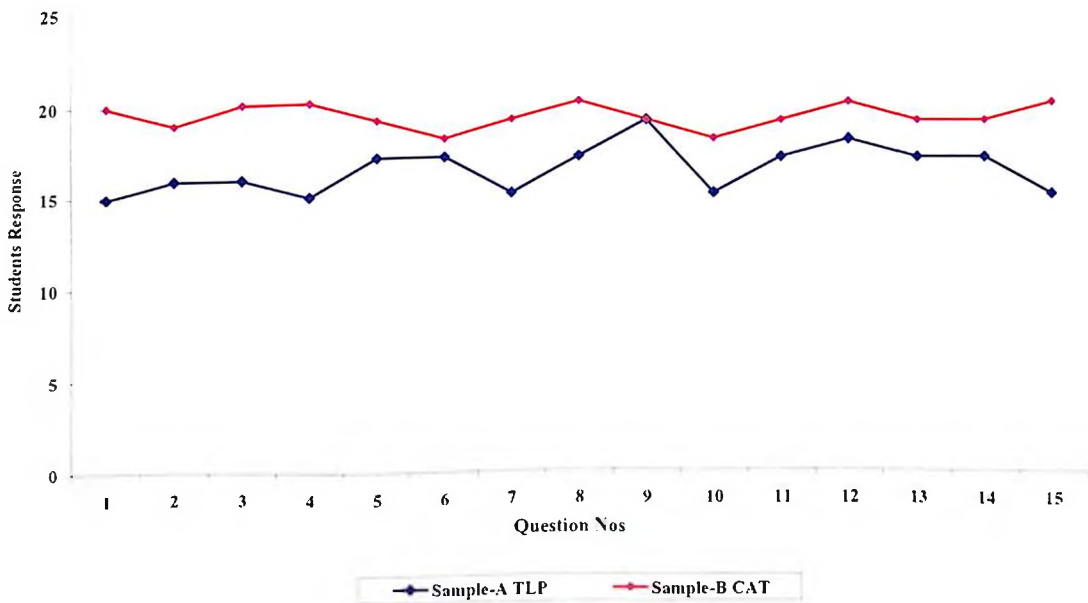


Fig (28)

EFFECTIVENESS OF CAT - ENGINEERING COLLEGES

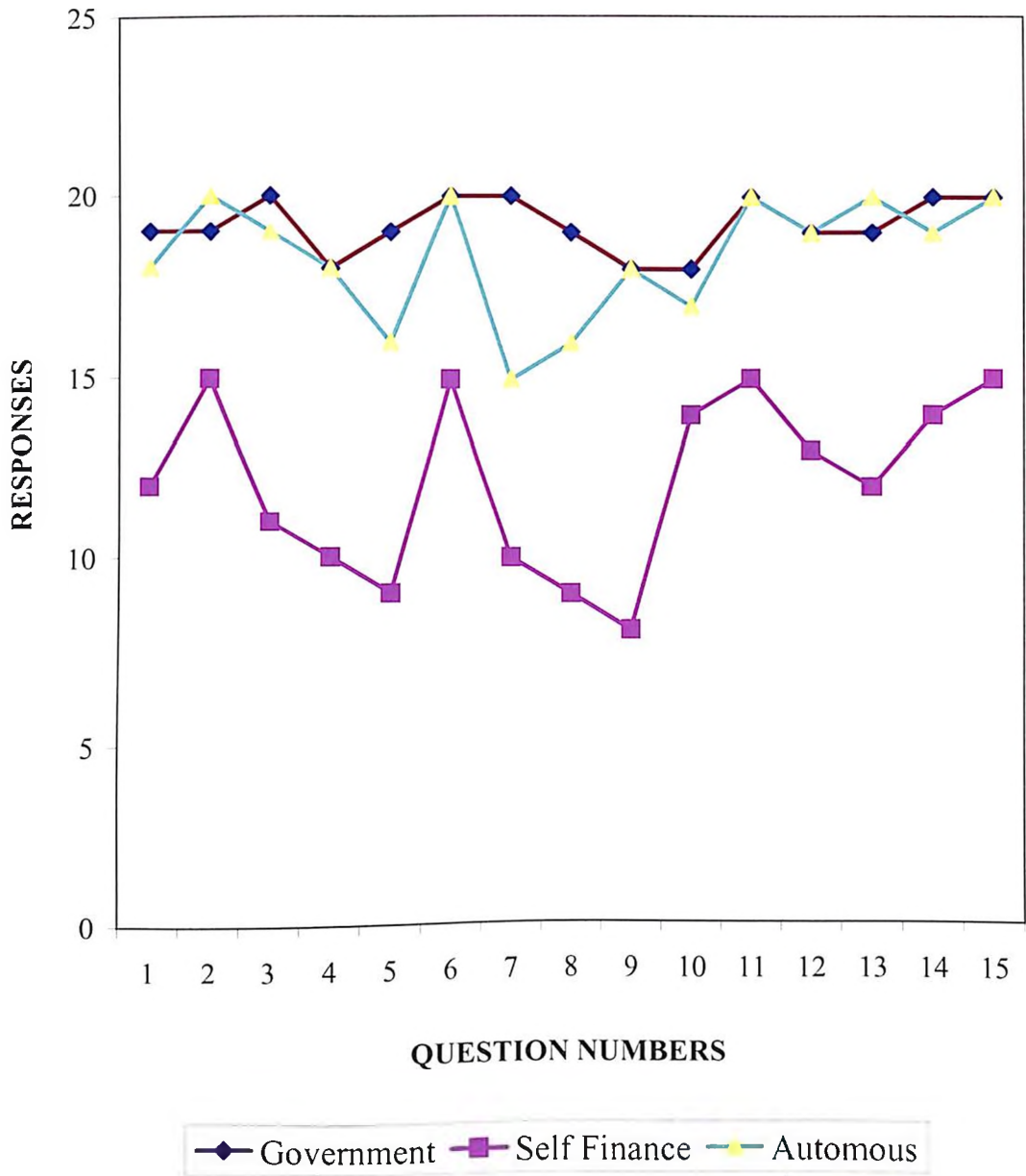
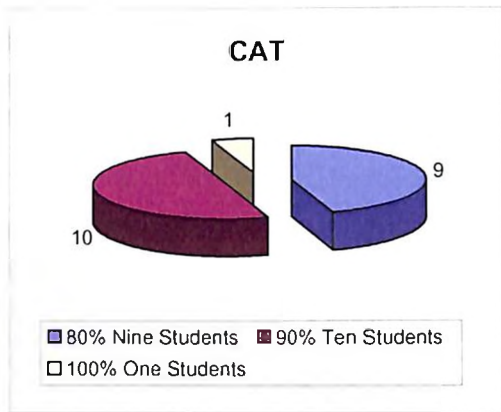
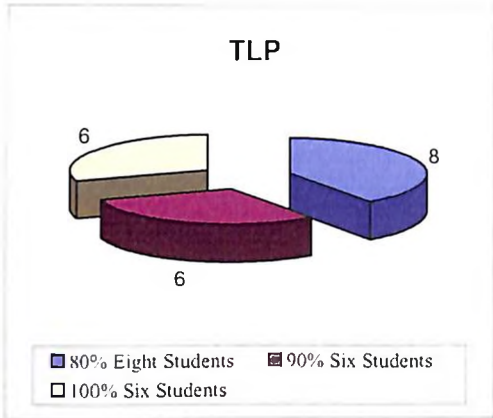


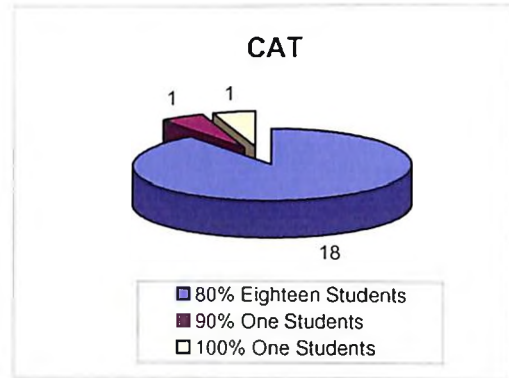
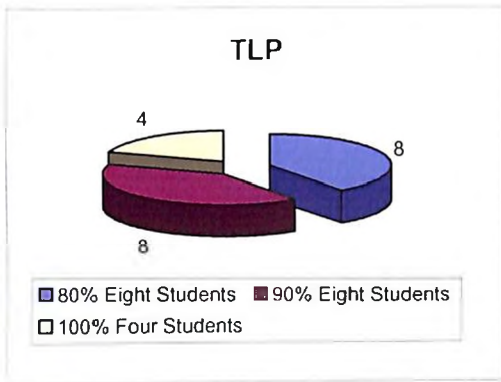
Fig (29)

TIME RESPONSE

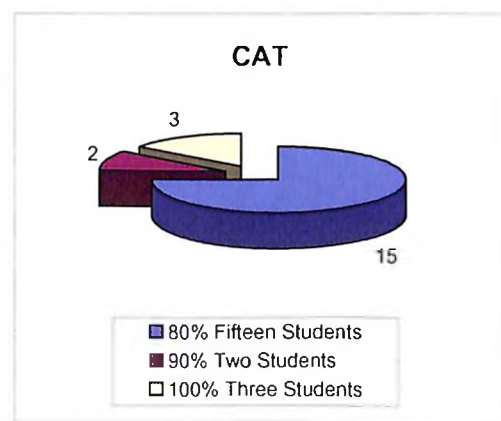
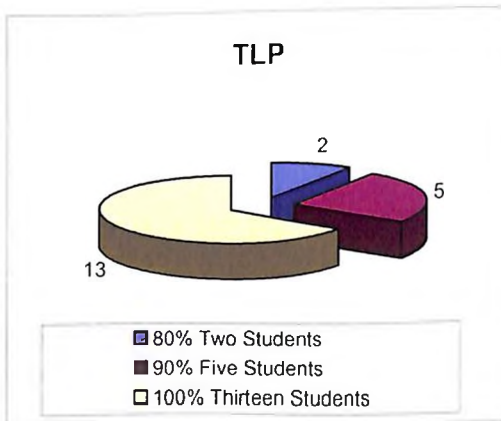
SAMPLE 1 : SELF FINANCE COLLEGES



SAMPLE 2 : AIDED ENGINEERING COLLEGES



SAMPLE 3 : GOVERNMENT ENGINEERING COLLEGES



EFFECTIVENESS OF CAT
 More Students Complete test in less time

Fig (30)

Sample Analysis

Table - I
Electrical Engineering Laboratory
Topic : DC Generator load Tests

Module 2

Null Hypothesis : There is no difference in the performance of the students

Alternative Hypothesis: There is a significant improvement by CAT

Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TLD	13	13	15	10	11	10	13	13	14	12	11	10	11	9	8	8	9	10	12	12
CAT	13	13	15	12	13	9	14	13	15	15	14	14	12	11	14	12	10	11	14	15

$$d = \begin{matrix} 0 & 0 & 0 & 2 & 2 & -1 & 1 & 0 & 1 & 3 & 3 & 4 & 1 & 2 & 6 & 4 & 1 & 1 & 2 & 3 \end{matrix} = \sum d = 35$$

$$d^2 = \begin{matrix} 0 & 0 & 0 & 4 & 4 & 1 & 1 & 0 & 1 & 9 & 9 & 16 & 1 & 4 & 36 & 16 & 1 & 1 & 4 & 9 \end{matrix} = \sum d^2 = 117$$

$$t = \frac{\bar{d}}{S} \quad \text{where } \bar{d} = \text{the mean of the difference}$$

S = Standard deviation of the differences

$$\text{The value of } S = \sqrt{\frac{\sum d^2 - n(\bar{d})^2}{n-1}}$$

The degrees of freedom (dof) $\gamma = n - 1$ where $n = 20$

$$\text{Substituting for } S = \sqrt{\frac{\sum d^2 - n(\bar{d})^2}{n-1}} = \sqrt{\frac{117 - 20(1.8)^2}{20-1}}$$

$$\text{Substituting } t = \frac{1.8 \times 4.472}{1.6733 \times 1.712} = 4.81$$

For $\gamma = 19$; $t_{0.05} = 2.093$ (from table) for 5% level of significance. Since the calculated value is greater than the table value the null hypothesis is rejected and the alternate hypothesis is accepted.

Conclusion

The performance of the students with Computer Assisted Teaching is effective when compared to that of the students with Traditional learning practices.

Sample Analysis

Table - II
Electrical Engineering Laboratory
Topic : Swinburns Tests

Module 3

Null Hypothesis : There is no difference in the performance of the students

Alternative Hypothesis: There is a significant improvement by CAT

Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TLP	12	13	15	10	11	10	13	13	14	12	11	10	11	9	8	8	9	10	12	12
CAT	13	13	15	12	13	9	14	13	15	15	14	14	12	11	14	12	10	11	14	15
d = (CAT - TLP)	1	0	0	2	2	-1	1	0	1	3	3	4	1	2	6	4	1	1	2	3
$\Sigma d = 36$ $\bar{d} = \Sigma d/n = 36/20 = 1.8$ Where $n = 20$ $\sqrt{n} = 4.472$																				
d ²	1	0	0	4	4	1	1	0	1	9	9	16	1	4	36	16	1	1	4	9
d ² = 118																				

$$t = \frac{\bar{d} \sqrt{n}}{S}$$

where \bar{d} = the mean of the difference

S = Standard deviation of the differences

$$\text{The value of } S = \sqrt{\frac{\Sigma d^2 - n(\bar{d})^2}{n - 1}}$$

The degrees of freedom (dof) $\gamma = n - 1$ where $n = 20$

For $\gamma = 19$; $t_{0.05} = 2.093$ ($t = 4.81$) (from table) for 5% level of significance. Since the calculated value is greater than the table value the null hypothesis is rejected and the alternate hypothesis is accepted.

Conclusion

The performance of students with computer assisted teaching is effective when compared to the students with traditional learning technique.

Sample Analysis

Table - III
Electrical Engineering Laboratory
Topic : Transformer Tests

Module 1

Null Hypothesis : There is no difference in the performance of the students

Alternative Hypothesis: There is a significant improvement by CAT

Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TLP (X ₁)	10	11	10	12	11	9	12	13	15	14	11	12	9	8	9	11	12	13	11	12
CAT (X ₂)	12	12	13	12	15	8	13	12	15	15	13	14	13	14	12	15	15	14	13	12
Mean of TLP = $\bar{X}_1 = 11.25$ say 11 = A ₁											Mean of CAT = $\bar{X} = 13.1$ say 13 = A ₂									
$\bar{X}_1 - A_1$	-1	0	-1	1	0	-2	1	2	4	3	0	1	-2	-3	-2	0	1	2	0	1
$\Sigma \bar{X}_1 - A_1$	5																			
$\bar{X}_2 - A_2$	-1	-1	0	-1	2	-5	0	-1	2	2	0	1	0	1	-1	3	2	1	0	-1
$\Sigma (\bar{X}_1 - A_1)^2$	1	0	1	1	0	4	1	4	16	9	0	1	4	9	4	0	1	4	0	1
	61																			
$\Sigma (X_2 - A_2)^2$	1	1	0	1	4	25	0	1	4	4	0	1	0	1	1	4	4	1	0	1
	54																			

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S} \sqrt{\frac{n_1 n_2}{n_1 + n_2}}$$

n₁ = No. of questions for TLP
 n₂ = No. of questions for CAT
 A₁ = Assumed mean of TLP
 A₂ = Assumed mean of CAT
 γ = (n₁ + n₂ - 2) = 38

Where \bar{X}_1 and \bar{X}_2 are the means
 S = Combined Standard deviation

The value of S =
$$\sqrt{\frac{\Sigma (X_1 - A_1)^2 + \Sigma (X_2 - A_2)^2 - n_1 (\bar{X}_1 - A_1)^2 - n_2 (\bar{X}_2 - A_2)^2}{n_1 + n_2 - 2}}$$

t_c = 3.2
 For γ = 38; t_{0.05} = 1.96 (from table)

with other formula
 t = 4.489

Influence

The calculated value of 't' is greater than t_{0.05} value for 5% level of significance the alternative hypothesis is accepted.

Conclusion

The mean of marks scored by the students with Computer Assisted Teaching is effective when compared to students by traditional learning practice.

Sample Analysis

Table - IV
Electrical Engineering Laboratory
Topic : Load test on DC Motor

Module 2

Null Hypothesis : There is no significant difference in the mean of the marks secured by the students of the two groups.

Alternative Hypothesis: There is a significant difference in the mean of marks secured by the students of the two groups

Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TLP	10	11	10	12	11	9	12	13	15	14	11	12	9	8	9	11	12	13	11	12
CAT	12	12	13	12	15	8	13	12	15	15	13	14	13	14	12	15	15	14	13	12

Applying 't' test:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S} \sqrt{\frac{n_1 n_2}{n_1 + n_2}}$$

Where x_1 and x_2 are the mean of the difference
 S = Standard deviation of the differences

$$S = \sqrt{\frac{\sum (X_1 - A_1)^2 + \sum (X_2 - A_2)^2 - n_1 (\bar{X}_1 - A_1)^2 - n_2 (\bar{X}_2 - A_2)^2}{n_1 + n_2 - 2}}$$

where $t \sim (n_1 + n_2 - 2)$ degrees of freedom

Students $t_c = 3.2014$

Students $t_t = 1.960$ at 5% level of significance

$\gamma = n_1 + n_2 - 2 = 38$

$t_{0.05} = 1.96$ from Table

Inference

The calculated value of 't' is greater than the table value. Hence the null hypothesis is rejected and the alternative hypothesis is accepted..

Conclusion

The mean of the marks scored by the students with Computer Assisted Teaching is effective when compared to that of the students with Traditional learning practices.

Sample Analysis

Table - V

Electrical Engineering Laboratory

Topic : Load test on single phase Induction Motor

Module 5

Null Hypothesis : There is no difference in the performance of the students

Alternative Hypothesis: There is a significant improvement by CAT

Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TLP	11	9	11	14	12	12	12	11	10	11	15	11	12	10	12	11	12	13	15	11
CAT	14	13	13	15	14	11	13	13	15	14	15	14	14	12	13	13	14	15	15	15

Applying 't' test: (difference formula)

$$\text{Students 't'} = \frac{\bar{d} \sqrt{n}}{S} \quad \text{where } \bar{d} = \text{the mean of the difference}$$

$$S = \text{Standard deviation of the differences}$$

The value of 'S' is calculated as follows:

$$\text{The value of } S = \sqrt{\frac{\sum d^2 - n(\bar{d})^2}{n - 1}}$$

where t ~ (n-1) degrees of freedom

$$\text{Students } t_c = 6.245$$

$$\text{Students } t_t = 2.093 \text{ at } 5\% \text{ level of significance}$$

Inference

The calculated value of 't' is greater than the table value. Hence the null hypothesis is rejected and alternative hypothesis is accepted.

Conclusion

The performance of the students with Computer Assisted Teaching is effective when compared to that of the students with Traditional learning technique.

Sample Analysis

Table - VI

Electronics Engineering Laboratory

Topic: Passive wide band pass filter

Module 3

Null Hypothesis : There is no difference in the performance of the students

Alternative Hypothesis: There is a significant improvement by CAT

Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TLP	10	7	8	7	6	8	9	8	7	9	8	7	9	11	11	10	9	8	8	7
CAT	14	12	12	13	12	11	13	12	13	12	13	7	13	11	12	13	12	13	15	15

Applying 't' test: (difference formula)

$$\text{Students 't'} = \frac{\bar{d} \sqrt{n}}{S} \quad \text{where } \bar{d} = \text{the mean of the difference}$$

$$S = \text{Standard deviation of the differences}$$

The value of 'S' is calculated as follows:

$$\text{The value of } S = \sqrt{\frac{\sum d^2 - n(\bar{d})^2}{n - 1}}$$

where $t \sim (n-1)$ degrees of freedom

$$\text{Students } t_c = 8.565$$

$$\text{Students } t_t = 2.093 \text{ at } 5\% \text{ level of significance}$$

Inference

The calculated value of 't' is greater than the table value. Hence the null hypothesis is rejected and alternative hypothesis is accepted.

Conclusion

The performance of the students with Computer Assisted Teaching is effective when compared to that of the students with Traditional learning technique.

Sample Analysis**Table - VII**

Electronics Engineering Laboratory
Topic : Ramp Generator using 555 times

Module 5

Null Hypothesis : There is no difference in the performance of the students

Alternative Hypothesis: There is a significant improvement by CAT

Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TLP	10	7	8	7	6	8	9	8	7	9	8	7	9	11	11	10	9	8	8	7
CAT	14	12	12	13	12	11	13	12	13	12	13	7	13	11	12	13	12	13	15	15

Applying 't' test: (difference formula)

$$\text{Students 't'} = \frac{\bar{d} \sqrt{n}}{S} \quad \text{where } \bar{d} = \text{the mean of the difference}$$

S = Standard deviation of the differences

The value of 'S' is calculated as follows:

$$\text{The value of } S = \sqrt{\frac{\sum d^2 - n(\bar{d})^2}{n - 1}}$$

where t ~ (n-1) degrees of freedom

$$\text{Students } t_c = 3.238$$

$$\text{Students } t_t = 2.093 \text{ at } 5\% \text{ level of significance}$$

Inference

The calculated value of 't' is greater than the table value. Hence the hypothesis is rejected and alternative hypothesis is accepted.

Conclusion

The performance of the students with Computer Assisted Teaching is effective when compared to that of the students with Traditional Learning practices.

Sample Analysis

Table - VIII
Electronics Engineering Laboratory
Topic : Current to voltage converter and voltage to current converter

Module 2

Null Hypothesis : There is no difference in the performance of the students

Alternative Hypothesis: There is a significant improvement by CAT

Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TLP	12	14	12	9	11	12	9	12	8	9	10	11	10	11	12	13	13	12	11	15
CAT	13	15	15	14	15	15	14	15	13	14	15	15	14	15	14	14	13	15	11	15

Applying 't' test: (difference formula)

$$\text{Students 't'} = \frac{\bar{d} \sqrt{n}}{S} \quad \text{where } \bar{d} = \text{the mean of the difference}$$

$$S = \text{Standard deviation of the differences}$$

The value of 'S' is calculated as follows:

$$\text{The value of } S = \sqrt{\frac{\sum d^2 - n(\bar{d})^2}{n - 1}}$$

where $t \sim (n-1)$ degrees of freedom

$$\text{Students } t_c = 7.086$$

$$\text{Students } t_t = 2.093 \text{ at } 5\% \text{ level of significance}$$

Inference

The calculated value of 't' is greater than the table value. Hence the null hypothesis is rejected and the alternative hypothesis is accepted.

Conclusion

The performance of the students with Computer Assisted Teaching is effective when compared to that of the students with Traditional learning practices.

Sample Analysis

Table - IX
Electrical Engineering Laboratory
Topic : Load test on Alternator

Module 4

Null Hypothesis : There is no difference in the performance of the students

Alternative Hypothesis: There is a significant improvement by CAT

Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TLP	10	9	11	12	12	11	12	13	15	12	15	9	8	11	12	13	14	15	11	12
CAT	15	13	14	10	12	10	10	13	15	14	15	13	7	13	14	15	14	15	12	14

Applying 't' test: (difference formula)

$$\text{Students 't'} = \frac{\bar{d} \sqrt{n}}{S} \quad \text{where } \bar{d} = \text{the mean of the difference}$$

$$S = \text{Standard deviation of the differences}$$

The value of 'S' is calculated as follows:

$$\text{The value of } S = \sqrt{\frac{\sum d^2 - n(\bar{d})^2}{n - 1}}$$

where $t \sim (n-1)$ degrees of freedom

$$\text{Students } t_c = 2.339$$

$$\text{Students } t_t = 2.093 \text{ at } 5\% \text{ level of significance}$$

Inference

The calculated value of 't' is greater than the table value. Hence the null hypothesis is rejected and the alternative hypothesis is accepted.

Conclusion

The performance of the students with Computer Assisted Teaching is effective when compared to that of the students with Traditional Learning practices.

Sample Analysis

Table - IX
Electrical Engineering Laboratory
Topic : Load test on Alternator

Module 4

Null Hypothesis : There is no difference in the performance of the students

Alternative Hypothesis: There is a significant improvement by CAT

Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TLP	10	9	11	12	12	11	12	13	15	12	15	9	8	11	12	13	14	15	11	12
CAT	15	13	14	10	12	10	10	13	15	14	15	13	7	13	14	15	14	15	12	14

Applying 't' test: (difference formula)

$$\text{Students 't'} = \frac{\bar{d} \sqrt{n}}{S} \quad \text{where } \bar{d} = \text{the mean of the difference}$$

$$S = \text{Standard deviation of the differences}$$

The value of 'S' is calculated as follows:

$$\text{The value of } S = \sqrt{\frac{\sum d^2 - n(\bar{d})^2}{n - 1}}$$

where t ~ (n-1) degrees of freedom

$$\text{Students } t_c = 2.339$$

$$\text{Students } t_t = 2.093 \text{ at } 5\% \text{ level of significance}$$

Inference

The calculated value of 't' is greater than the table value. Hence the null hypothesis is rejected and the alternative hypothesis is accepted.

Conclusion

The performance of the students with Computer Assisted Teaching is effective when compared to that of the students with Traditional Learning practices.

Sample Analysis

Table - X
Electrical Engineering Laboratory
Topic : Common Emitter Characteristics

Module 10

Null Hypothesis : There is no difference in the performance of the students

Alternative Hypothesis: There is a significant improvement by CAT

Q.Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TLP	11	12	9	11	10	10	12	13	15	12	11	12	12	11	12	11	13	12	13	12
CAT	15	15	14	15	15	14	14	15	15	14	15	13	12	13	14	14	15	12	13	11

Applying 't' test: (difference formula)

$$\text{Students 't'} = \frac{\bar{d} \sqrt{n}}{S} \quad \text{where } \bar{d} = \text{the mean of the difference}$$

$$S = \text{Standard deviation of the differences}$$

The value of 'S' is calculated as follows:

$$\text{The value of } S = \sqrt{\frac{\sum d^2 - n(\bar{d})^2}{n - 1}}$$

where $t \sim (n-1)$ degrees of freedom

$$\text{Students } t_c = 5.5716$$

$$\text{Students } t_t = 2.093 \text{ at } 5\% \text{ level of significance}$$

Inference

The calculated value of 't' is greater than the table value. Hence the null hypothesis is rejected and the alternative hypothesis is accepted.

Conclusion

The performance of the students with computer assisted teaching is effective when compared to that of the students with Traditional learning practices.

RANK CORRELATION

Type II Analysis - Effectiveness of CAT

Hypothesis: The performance level of the students in all the colleges remains the same.

Table - XI

Sample - I (Private College) :

Correct response	18	20	19	18	16	20	15	16	18	17	20	19	20	19	20
Question No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Sample - II (Aided College) :

Correct response	12	15	11	10	9	15	10	9	8	14	15	13	12	14	15
Question No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Sample - III (Government College) :

Correct response	19	19	20	18	19	20	20	19	18	18	20	19	19	20	20
Question No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Applying Rank Correlation formula:

$$R = 1 - \frac{6 \sum D^2}{N^3 - N}$$

Rank correlation between 1st sample and 2nd sample = 0.7669643

Rank correlation between 2nd sample and 3rd sample = 0.49642

Rank correlation between 1st sample and 3rd sample = 0.4348

Inference

The hypothesis is rejected as the rank correlation differs between all the three samples.

Conclusion

The third sample is highly ranked when compared to the second and first. So the performance level of the students in the government colleges is high when compared to that of the aided colleges or the private colleges.

The Government Colleges admit the students having higher input ability. The computer Assisted Learning (CAT) enhances the learning outcome of even higher ability students.

6.3 Observations

The sample data presented in the thesis are selected in a random manner. For evaluating effectiveness of CAT in Electrical Engineering Laboratory important modules such as transformer tests, load test on DC shunt motor and load test on single phase motor are presented. In the case of Electronics Engineering Laboratory the passive wide band filter experiment, a ramp generator design circuit using 555 IC timer and an experiment on linear IC 741 with current to voltage converter and voltage to current converter. The data collected were tabulated.

Since the sample chosen of small value (twenty students) student 't' test is used to prove the hypothesis. The mean difference (\bar{d}) and the standard deviation(s) are determined. The degree of freedom is 19(γ). The calculated value is higher than the table value for 5% of significance level the alternate hypothesis is accepted. The learning outcome is high with CAT. The students have scored better. This was revealed by the teachers who have conducted this evaluation. Irrespective of the college/course/module/laboratory, it is uniformly concluded that the student's scores are higher with CAT.

As the software package is tested with Government, Aided and Self financing colleges a rank correlation is made. Even though the input is assumed same with norm reference test the scores obtained by the students with the post test reveals that the students in Govt. colleges are ranked higher than aided and private colleges. Hence it can be concluded that Computer Assisted Laboratory learning enhances the learning outcome of even higher ability students.

6.4 Effects of Simulation in Teaching / Learning

Error Analysis

The simulation package for various experiments are developed taking into account the actual readings that are obtained while conducting the experiment. In order to meet the time constraints while the student performs the simulated experiments a set of five readings are taken for consideration covering the whole set of variables. For examples while conducting the load test on 'shunt motor' the readings on No load, $\frac{1}{4}$ load, $\frac{1}{2}$ load, $\frac{3}{4}$ load, full load is taken. Some times 10% of over load is taken for certain other experiments. The tabulation, calculation and the graphs are given only for this set of readings. While taking readings certain parameters like supply voltage, error in the measuring instruments, observation in spring balance readings the error in noting down the speed are taken into account. Ideal situation is not assumed. The readings are taken for a particular environment.

While conducting experiment for load test on 3 phase Squirrel Cage Induction Motor the supply voltage at the start of the experiment is 400v and at full load it was observed to be 398 volts. But in realities the supply voltage varies from 400v to 387 volts from no load to full load in one situation 400v to 390 volts in another situation. Similarly one motor on no load runs at 1495 and the other may run at 1480. This may be due to error in the Technometer also. The same motor when the supply voltage is less the speed will be loss but how much it will decrease for the given reduction in speed is also not predictable in practice as it is not steady. (i.e.) the variation of supply voltage takes place while measuring the speed.

Another important factor contributing to the variation from simulation to actual readings is temperature. The temperature also is not steady as it depends on the current and the coiling which is greatly affected by the environment.

Similarly in the case of Electronics Engineering Laboratory while Electronic Circuits are formed near ideal components are selected. The component behaviour will vary depending on the environment. For example, Diode 4001 is taken for forward bias characteristic. Two similar diodes will have exactly similar characteristics. The error if it is within the permissible limit it is accepted in the quality control of the manufacture but while performing the individual device characteristic it will be having deviation.

In the simulation the components like resistors inductors capacitors values are taken as static and the values are absolute values. But in realities it will have tolerance hence the result will vary from the simulated value of the circuit and the actual values while doing the experiment in the laboratory.

Hence it is concluded that the student has to conduct the experiments with actual components and equipments in the electronics engineering laboratory and with actual machines equipments and meters in the electrical engineering laboratory and the results obtained is to be documented. The teacher will be able to assist the students in reasoning out the variations. During the study many samples were taken and the comparison is made. It is found that the variation is not more than 5%. In many situations the different batches obtain the same set of readings.

LOAD TEST ON 3-PHASE INDUCTION MOTOR

Actual Reading

TABULATION - A

Sl. No.	VL volts	IL Amps	N rpm	Spring Balance Reading		Wattmeter Reading I m = 4		Wattmeter Reading II m = 4		Torque N.m	Power factor	I/P watts	O/P watts	$\eta\%$	Slip%
				T1 kg	T2 kg	Div	Actual watts	Div	Actual Watts						
1.	400	1.65	1450	0	0	-70	-280	90	360	0	0.077	80	0	0	3.3
2.	395	2	1410	3	1	-5	-20	150	600	2.17	0.4239	580	320.24	55.24	6
3.	395	2.5	1390	6	1.5	50	200	230	920	4.88	0.6548	1120	710.34	63.42	7.33
4.	390	3	1380	8.5	1.5	90	360	270	1080	7.59	0.7088	1440	1096.86	76.17	8.0
5.	390	3.5	1360	11.0	1.5	130	520	340	1360	10.31	0.7952	1880	1468.34	78.1	9.33
6.	390	4	1340	14	2	160	640	375	1500	13.02	0.792	2140	1827.62	85.34	11.94
7.	390	4.5	1320	16.5	3.5	190	760	425	1700	13.56	0.809	2460	1894.39	76.19	12.0
8.	388	5	1300	18	3.5	220	880	470	1880	15.73	0.8214	2760	2141.41	77.59	13.33
9.	387	5.5	1260	21	5.5	235	940	505	2020	16.82	0.8029	2960	2219.35	74.48	16.0
10.	385	6	1240	24.5	8	260	1040	590	2360	17.9	0.8498	3400	2324.36	68.36	17.33
11.	385	6.5	1220	26.5	9.5	300	1200	650	2600	18.44	0.8767	3800	2355.86	61.99	18.67

LOAD TEST ON 3-PHASE INDUCTION MOTOR

Reading Used For Simulation

TABULATION - B

Sl. No.	VL volts	IL Amps	N rpm	Spring Balance Reading		Wattmeter Reading I m = 4		Wattmeter Reading II m = 4		Torque N.m	Power factor	I/P watts	O/P watts	$\eta\%$	Slip%
				T1 kg	T2 kg	Div	Actual watts	Div	Actual watts						
1.	400	1.65	1450	0	0	-70	-280	90	360	0	0.077	80	0	0	3.3
2.	398	2.25	1400	6	1.5	0	0	230	920	4.98	0.5	920	550	0.61	6.6
3.	395	3.50	1380	11	1.5	130	520	340	1360	10.31	0.79	1880	1468	74	8
4.	390	4.50	1320	16.5	3.5	190	760	425	1700	13.56	0.8	2460	1894	76.19	12
5.	387	5.50	1280	21	5.5	235	940	505	2020	16.82	0.82	2960	2220	74.5	14.6
6.	385	6.00	1260	24.5	8.0	260	1040	590	2360	17.9	0.84	3400	2324	68.3	16

CHAPTER - VII

THESIS CONCLUSIONS

The laboratory education plays an indispensable role in Engineering curriculum. It is only in the laboratories the students are made to understand by verifying the principles and the concepts of what they learn in the class rooms. The rapid growth in technology over the recent years reflects on the performances of educational system. The developments in information technology and computers and their advantages are utilised in the teaching - learning process.

The Electrical Engineering and Electronics Engineering laboratories form the core subjects for all branches of engineering. The curriculum offered by various universities (Fig.9) are studied and sets of experiments that the students are expected to perform are listed in both the laboratories. The expected learning outcome of individual user in each experiment is framed by objectives. The necessary infrastructure and hardware needed for conducting each experiment like Ammeter, Voltmeter, Signal generators, CRO are selected. The design level of circuit and its expected performance are identified. For performing each experiment the required theoretical input for the user is decided in consultation with teacher fraternity.

The present system of mass education is changed to individual education by CAT (computer aided teaching). The Electrical Engineering laboratory activities are grouped into five modules. The five modules are as : (1) Transformers (2) DC Motors (3) DC Generators (4) Synchronous Motors & Generators and (5) Induction Motors. *Software packages has been developed* for each module (using VB, VC++, PhotoShop, CorelDraw, Photo Flash, Sound forge) to work in multimedia work station. To run the software a stand alone PC (with minimum P.II 32 MB, 16 Bit, High Colour Monitor (800 x 600 pixel which are normally available in all the colleges and polytechnics) is used.

The software is menu driven and user friendly. Each module has an introduction to the user explaining the method of log in and the password. The software has three sections. Each section will have an Index to identify the experiment. The first section will have theory portion for each experiment in 8 to 9 frames. It is provided with multimedia input to enable the student to understand the basic concepts before going in for laboratory activity. The second section will have the experiment with connection diagram, the related equipments and meters. The connections can be performed and experiment can be conducted by simulation. The values of speed, current, voltage, power, frequency and wave forms are simulated. Each set of readings are actual readings and implemented in the coding so that the user can do the experiment through simulated real values. This section will also explain the procedure and safety precaution. The third section will have a self test with 10 to 15 questions with answers pertaining to each experiment, which will enable the students for self evaluation. The time taken by an average student to perform the experiment by simulation technique using the software is about 15 minutes.

The Electronics engineering laboratory is divided into five major sections. (1) Digital (2) Analog (3) Transistors (4) Basic Circuits (5) Electronic Circuits. Each major section will have four sub sections. For example in case of Analog it is sub divided into (1) Basic op. amp. (2) Op. amp. application (3) Basic and Advanced filters (4) Signal sources and log circuit. Each sub section will have different experiments; For example: op. amp. application, experiments such as (1) Differentiator (2) Integrator (3) Constant current source (4) Constant voltage source (5) Inverting V-I converter (6) Non-inverting V-I converter (7) Simple non inverting comparator (8) Window comparator (9) Precision half wave rectifier (10) Precision full wave rectifier. The software for this has first a section to log in and three other sections namely theoretical input, the experiment simulation and the self test.

All the experiments and circuits were tested on real situations and then the component values were selected and implemented in the simulation package.

The software packages were demonstrated to the teachers of Govt. colleges, Aided colleges, Autonomous colleges and Self Financing colleges initially. After that feedbacks were obtained from the teachers. The availability of meters, equipments and their ranges and the method of conducting the experiment in real situation were taken into account to modify the software.

The modified software was tested with different sets of students and in different colleges and polytechnics. The data collected were analysed Fig (28). The statistical tool, student 't' tests, was used to prove that the learning outcome of the student was better with CAT. Rank correlation was performed among various colleges to identify them self Fig (29). It was found that students scored high and then learning ability was better. They learnt the experiments more quickly which is revealed by the time analysis Fig (30).

Software is developed for evaluation of the performance of the students using computers called CATES (Computer Assisted teaching and evaluation system). This package is designed for theory as well as for practicals.

The CATES package has facility to hold question bank for each experiment. The teacher can up date the question bank as and when required. The experts will decide the standard of questions. The CATES package will have three levels of questions; simple, medium and complex. The test administrator who is the teacher can set the number of questions as desired having 60% simple, 30% medium and 10% complex for level I. The data administrator will prepare the question paper accordingly and keep it ready for the students use. The question paper will have stop clock timer attached. The question paper will be exposed only for a particular time. As soon as the students complete the task it

will record the time. It will not allow the students to take more than the prescribed time for completing the question paper. The software has provision for obtaining the individual students score, the class score and the ranking of students towards questions. The result is available in the form of test score in addition bar or pie chart. If the student wants to know the correct answer for a particular question which he does not know, at the end of the test, he can click the `answer' which will give the correct answer along with the justification. This activity has helped, to learn quickly. It is observed that the retentively is higher as the students doubt is cleared immediately.

The CATES can be used to set up different question paper labeled as level-I, level-II depending on the difficulty level. The level II may have 50% of complex level questions, 40% of medium level question and 10% of simple ones. By this the higher ability students can do level-II which leads to adaptive learning method.

Scope for further research

The software package is developed for performing experiments virtually by simulation technique for certain experiments mostly used by the UG students in the Electrical Engineering Laboratory and Electronics Engineering Laboratory. The software can be expanded suitably to accommodate more experiments.

The simulation technique can be adopted for other laboratories such as the Micro Processor laboratory, Process controls laboratory Transducer laboratory, Industrial Instrumentation laboratory.

CATES is tested in the intra net environment with network facility. Though it is designed to work in World Wide Web, it can be up graded suitably with suitable security mechanism, enabling the student to take up the test at his desired place and time with his computer. The question bank can be up dated with experts and the software can be

tailored to meet the user needs of not only learning and teaching of laboratory courses but also other theory subjects.

With the combination of virtual Electrical and Electronics Laboratory software and e-learning material and CATES, attempt can be made to set up and develop virtual university. This will bring in distance Education in Engineering disciplines for practising engineers.

In a nutshell the computer Assisted teaching and evaluation system enhances interactivity, integrates different media, facilitates standardization, reduces learning and teaching duration and helps in self-paced adaptive learning and availability on demand and can reach wider audience.

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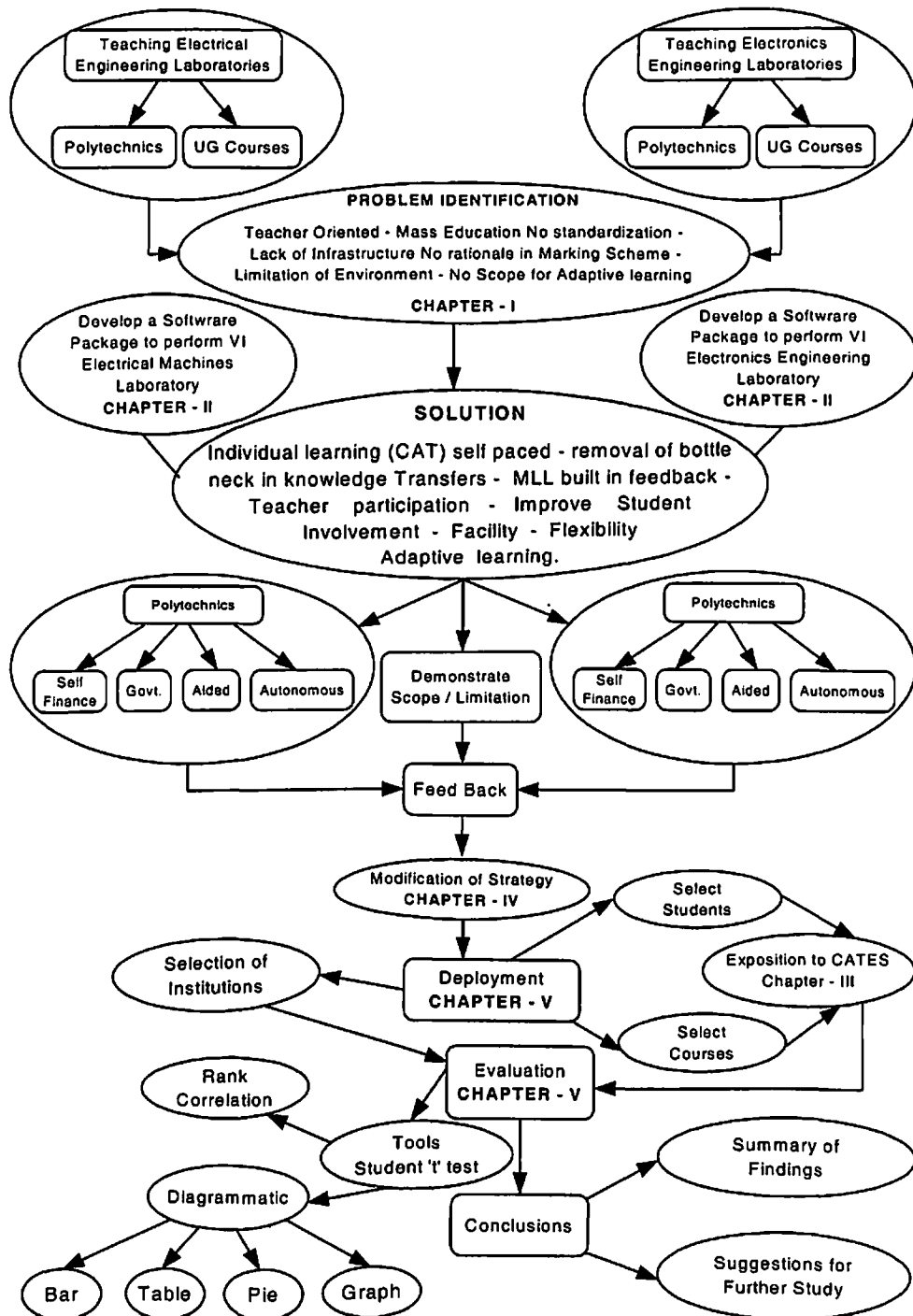
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APPENDIX - I

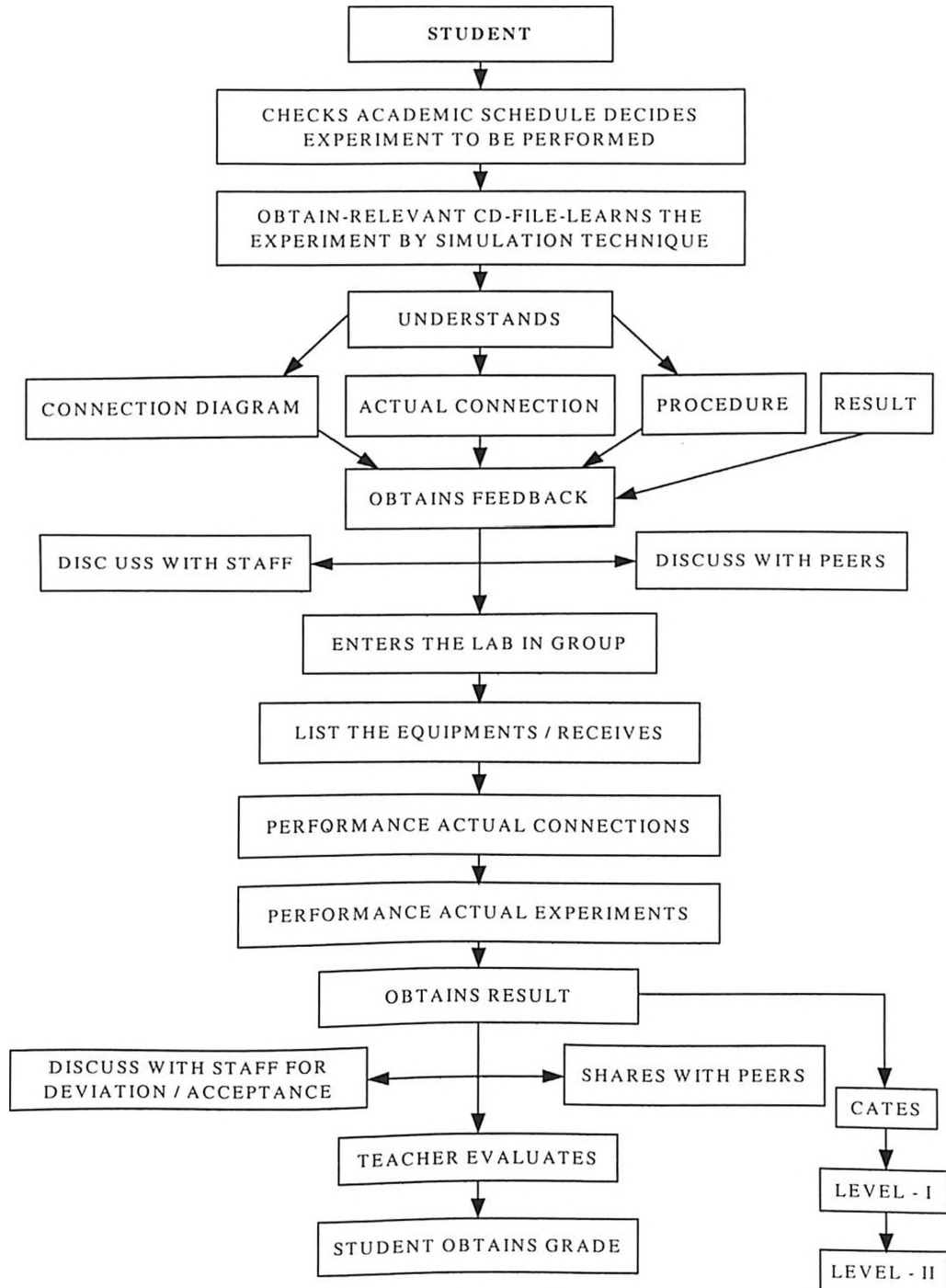
COMPUTER ASSISTED TEACHING AND EVALUATION TECHNIQUES FOR ELECTRICAL & ELECTRONICS ENGINEERING LABORATORIES



RESEARCH TREE

APPENDIX – II

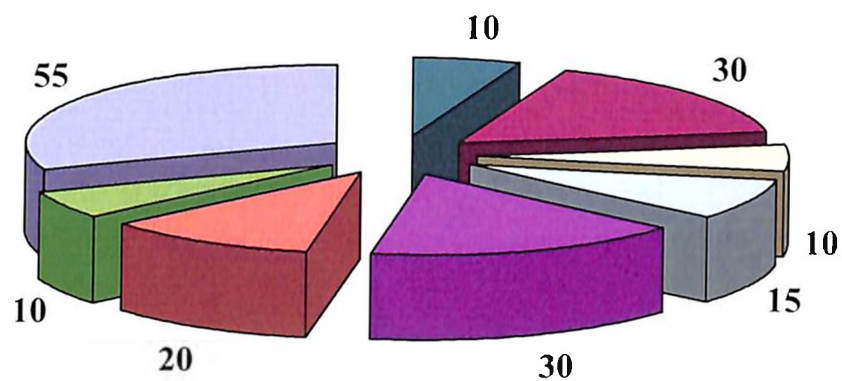
CAT - (COMPUTER ASSISTED TEACHING) ELECTRICAL & ELECTRONICS ENGINEERING LABORATORY TEACHING / LEARNING



STUDENT CENTRIC

APPENDIX – III

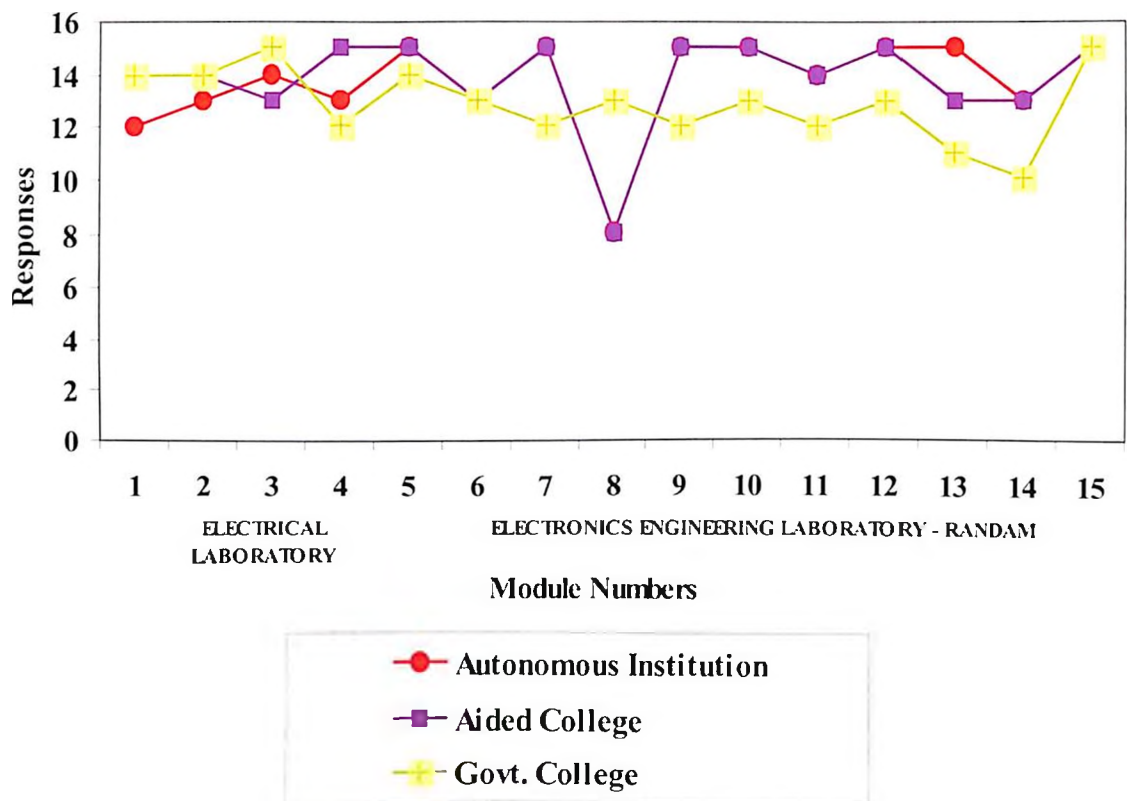
TIME MANAGEMENT - CAT



- Induction
- Understand and performance experiment by CAT
- Receive Material from Stroes
- Actual Connections
- Perform Experiment - Tabulation
- Verification Result - Teacher
- Meters Disconnective - Retd to Stores
- Time for adaptive learning CATES

APPENDIX – IV

COMPARISION OF LEARNING OUTCOME IN DIFFERENT COLLEGES



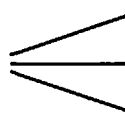
The higher ability students will learn the experiment quickly and give the results satisfactorily by CAT.

APPENDIX - V

Rank Correlation

Nodel
College

**Effectiveness of CAT
Electrical Engineering Laboratory
Random Selection:**

Participating Colleges  **NIT - G
PSG - A
Dr.MGR - P**

Question No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
No. of Correct Res :	G	19	19	20	18	19	20	20	19	18	18	20	19	19	20	20
	A	12	15	11	10	9	15	10	9	8	14	15	13	12	14	15
	P	18	20	19	18	16	20	15	16	18	17	20	19	20	19	20
Ranks	R ₃	6	13	9	6	2.5	13	1	2.5	6	4	13	9	13	9	13
	R ₂	7.5	13.5	6	4.5	2.5	13.5	4.5	2.5	1	10.5	13.5	9	7.5	10.5	13.5
	R ₁	2.25	0.25	9	6.25	0	0.25	12.25	0	25	42.25	0.25	0	30.25	2.25	0.25
R ₃ -R ₂ = D ; (R ₃ - R ₂) ² =	D ²	2.25	0.25	9	6.25	0	0.25	12.25	0	25	42.25	0.25	0	30.25	2.25	0.25
	Σ D ²	130.5														
R ₂ -R ₁ = D ; (R ₂ - R ₁) ² =	D ²	1	49	42.25	6.25	16	1	64	16	1	72.25	1	6.25	1	4	1
	Σ D ²	282														
R ₁ -R ₃ = D ; (R ₁ - R ₃) ² =	D ²	0.25	42.25	12.25	16	16	0.25	132.25	16	16	4	0.25	6.25	42.25	12.25	0.25
	Σ D ²	316.3														

$$\text{IIIrd and Second} = R = 1 - \frac{6 \Sigma D^2}{N^3 - N} = 1 - \frac{6 \times 130.5}{3360} = 0.76696$$

$$\text{IInd and First} = R = 1 - \frac{6 \Sigma D^2}{N^3 - N} = 1 - \frac{6 \times 282}{3360} = 0.40642$$

$$\text{Ist and Third} = R = 1 - \frac{6 \Sigma D^2}{N^3 - N} = 1 - \frac{6 \times 316.5}{3360} = 0.4348$$

The first sample is highly ranked when compared to second and third so the performance level of the students in the Govt. Colleges and high when compared to that of the aided colleges and private colleges.

APPENDIX - VI

TRANSFORMER TESTING

Aim : The aim of the experiment is to perform tests on single phase transformer and determine its turns ratio, voltage ratio current ratio and percentage regulation.

Materials used

1. Single phase portable type variac.
2. Single phase double wound transformer primary 230V secondary 115V.
3. Single phase loading Rehostat 1.5 kw
4. Digital AC Volt meter 500V - 2 nos.
5. Digital AC Ammeter 5A - 2 nos.
6. Portable analog ammeter.
7. Connecting wires.

Procedure :

Step I : 1. Switch ON the Ac supply.

2. Set the variac voltage to 230 V

Step II : 1. Note down the current and voltage on HV side of transformer under no load condition.

Step III : 1. Switch ON the loading rehostat and apply the load one by one.

2. Repeat step 1 and step 2.

Step IV: Calculate the turns ratio, current ratio and % regulation.

$$\text{Voltage ratio} = \text{Turn Ratio} = \frac{\text{Voltage on HV side}}{\text{Voltage on LV side}}$$

$$\text{Current ratio} = \frac{1}{\text{Turn Ratio}}$$

$$\% \text{ Regulation} = \frac{\text{Change in voltage}}{\text{No load voltage}} \times 100$$

Conclusion : Thus the turn ratio, current ratio, voltage ratio and % regulation is determined.

Transformer

Principle

The transformer is basically a static electrical machine which works on the principle of electromagnetic induction.

In this case, the conductors are stationary and the magnetic flux is varying with respect to time. Thus, the induced emf is called as statically induced emf.

1



The transformer is a static piece of apparatus used to transfer electrical energy from one circuit to another. The two circuits are magnetically coupled.

One of the circuits is energized by connecting it to a supply at specific voltage magnitude, frequency and

2

waveform referred to as prim



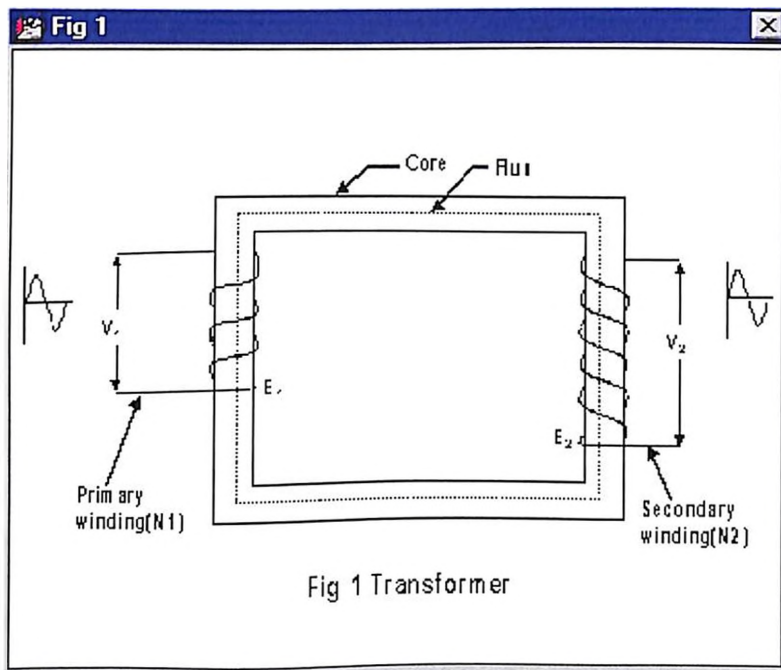
A mutually induced voltage will be available across the other circuit referred to as secondary, at the same frequency and waveform but with a change in voltage magnitude. These aspects are indicated in Fig. 11.

Construction

The following are the essential requirements of a transformer:



(a) A good magnetic core



(b) Two windings - Primary and Secondary.

(c) A time varying magnetic flux

The transformer core is generally laminated and is made up of a good magnetic material such as transformer steel or silicon steel. The material used should possess high relative permeability and low hysteresis loss. One type of transformer, is called as the core type which is constructed using L-shaped laminations or stampings.

4

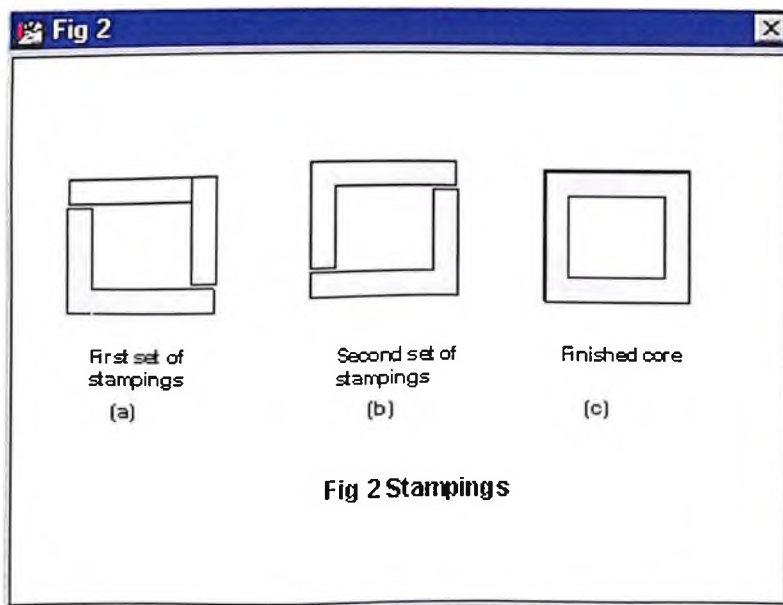


Fig 2

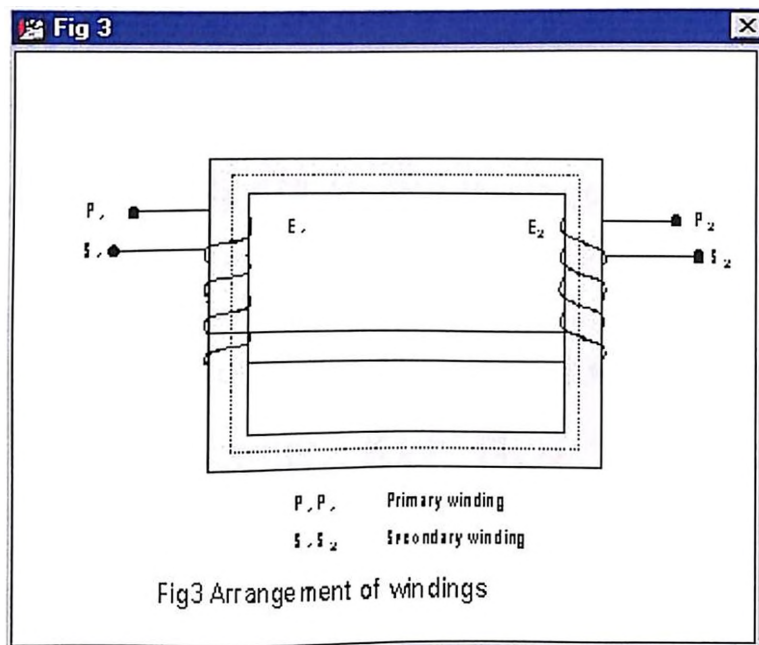
Fig.12a - c indicate the stacking arrangement of the stampings and the finished core.

There are two windings in a transformer. They are called primary and secondary windings. Generally, the windings are made of copper. The arrangement of windings on the transformer core is shown in Fig.13.

Working

Let us say that in the primary winding has N_1 turns and the secondary winding has N_2 turns.

5



The primary winding is supplied with a sinusoidal voltage of magnitude V_1 at a frequency 'f' hertz. A working flux of ϕ webers is set up in the magnetic core. This working flux is alternating and sinusoidal in nature similar to that of the applied voltage. When this flux links the primary and the secondary winding, emfs are induced in them. The emf induced in the primary is the self induced emf and that induced in the secondary is the mutually induced emf. Let the induced voltages in the primary and the secondary be E_1 and E_2 volts respectively.


6

These voltages will have sinusoidal waveform and the same frequency as that of the applied voltage. The currents, which flow in the closed primary and the secondary circuits, are respectively I_1 and I_2

In any transformer, $K = N_2 / N_1$, defines the transformation ratio.

Three categories of transformer action are possible.

$E_2 < E_1$ (i.e $V_2 < V_1$) -- Step down transformer

$E_2 = E_1$ (i.e $V_2 = V_1$) -- 1:1 or  transformer

$E_2 > E_1$ (i.e $V_2 > V_1$) -- Step up transformer

7

The induced emfs are proportional to the number of turns. In any transformer, the primary ampere-turns equal the secondary ampere turns.

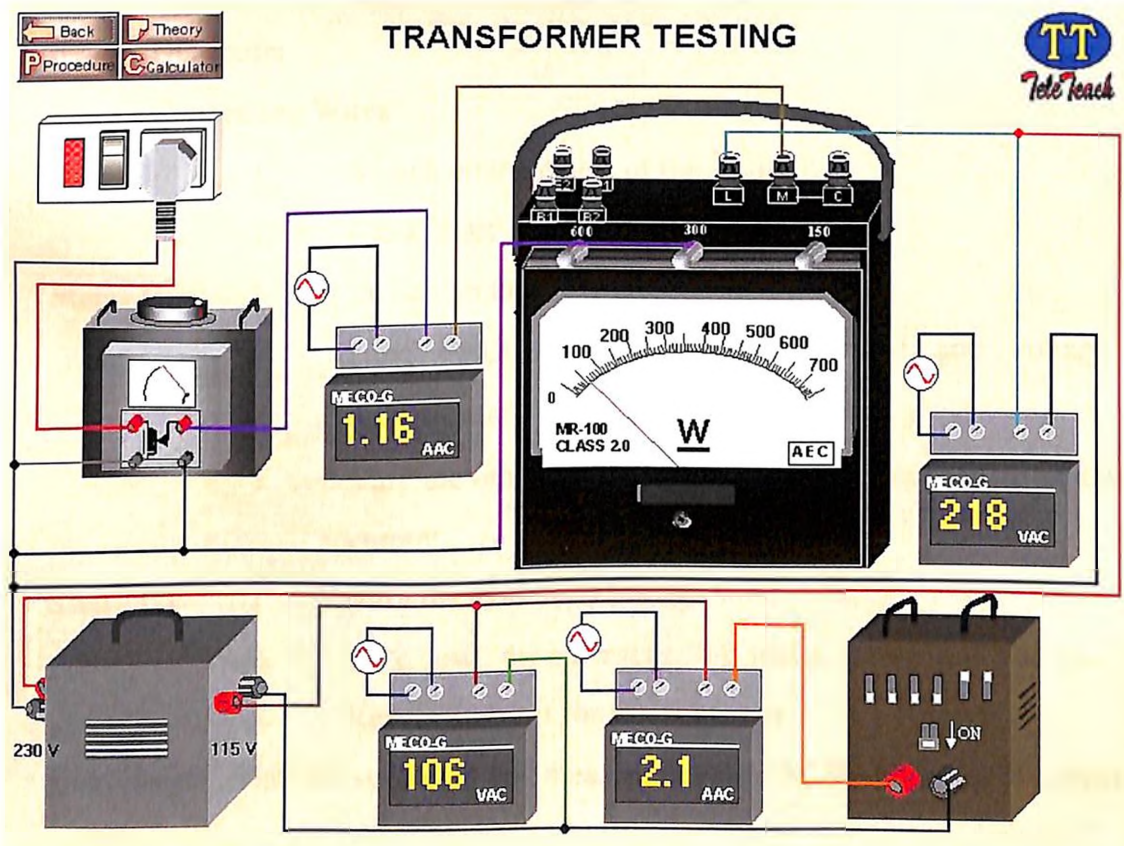
$$\text{i.e. } N_1 I_1 = N_2 I_2$$

Thus, we have $I_1 / I_2 = E_2 / E_1 = V_2 / V_1 = N_2 / N_1 = K$

Whenever the transformer is loaded the primary of the transformer draws the required amount of current in order to keep the working flux constant.

8

Thus, the transformer works in perfect static balance.



DC Motor

Principle

Whenever a current carrying conductor is placed in a stationary magnetic field an electromagnetic force is produced. This force is exerted on the conductor and hence the conductor is moved away from the field. This is the principle used in DC motors.


Construction

1 The construction of DC motor is directly similar to DC generator.

The salient parts of the DC motor are yoke or frame, main field system, brushes, armatures and commutator

Working

2 In DC motor, both the armature and field windings are connected to a DC supply. In motor, the current carrying armature conductors are placed in a stationary magnetic field produced by the field winding. Due to the electromagnetic torque exerted on the armature conductors, the armature starts revolving.

This results in conversion of electrical energy to mechanical energy in the armature. When the armature is in motion, we have revolving conductors in a stationary magnetic field. As per Faraday's Law of electromagnetic induction, an emf is induced in the armature conductors. As per Lenz's law, this induced emf will oppose the voltage applied to the armature. Hence, it is called the counter or back emf. There also occurs  drop in the armature circuit due to its resistance.

Thus, the applied voltage has to overcome the back emf in addition to supplying the armature circuit drop and producing the necessary torque for the continuous rotation of the armature.

Fig 1 illustrates the circuit symbols for the armature, the shunt field and the series field of a DC machine irrespective of whether the DC machine is generating or motoring.

4

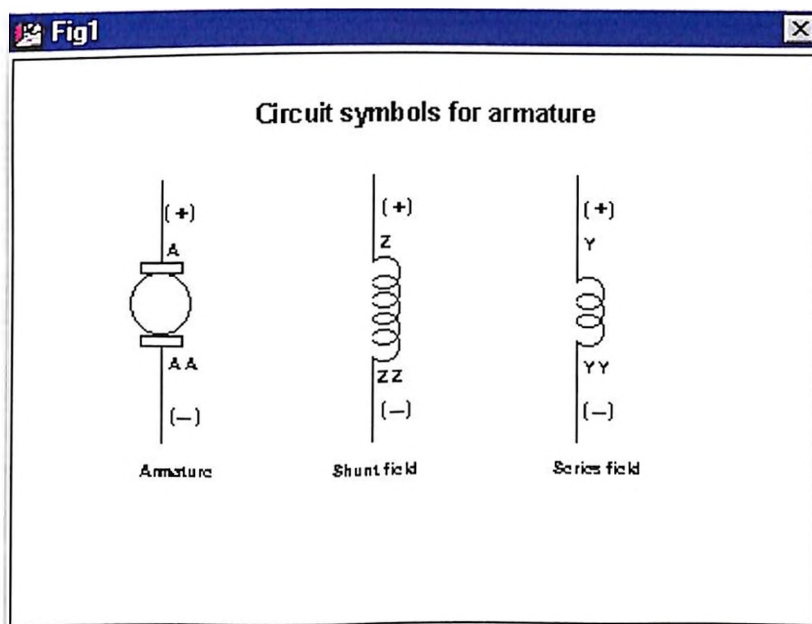


Fig 2 gives the electrical equivalent circuits of a DC shunt motor where

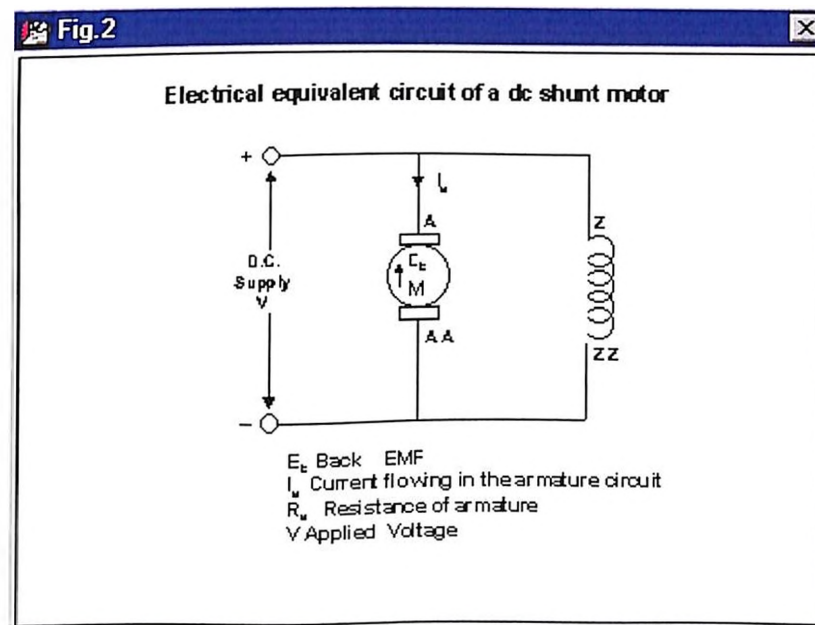
E_b = back emf in volts

I_a = current flowing in the armature circuit in amperes

R_a = resistance of armature circuit in ohms

V = applied voltage in volts.

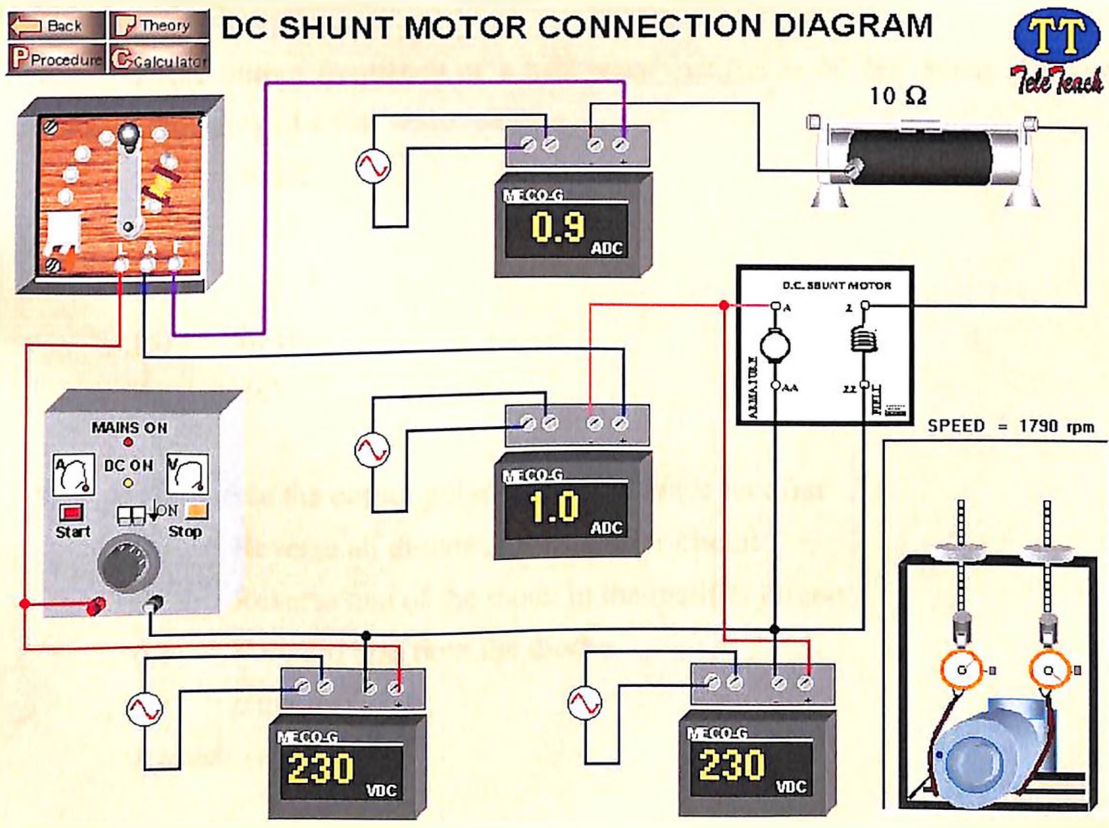
5



Thus, the characteristic equation of a DC motor is

$V = E_b + I_a R_a$ Where $I_a R_a$ represents the potential drop in the armature circuit.

6



APPENDIX - VIII**SELF TEST****Topic : Rectifiers and its Application**

1. The diode is often referred to as ...
 - (a) SCR
 - (b) Rectifier
 - (c) Either (a) or (b)
 - (d) None of the aboveAnswer : (b)

2. If the output frequency of a half wave rectifier is 60 Hz. What is the output frequency of a full wave rectifier
 - (a) 30 Hz
 - (b) 60 Hz
 - (c) 120 Hz
 - (d) 90 HzAnswer (c)

3. To reverse the output polarity of a full wave rectifier
 - (a) Reverse all diodes in the rectifier circuit
 - (b) Reverse one of the diode in the rectifier circuit
 - (c) Forward bias both the diodes
 - (d) either (a) or (b)Answer (a)

4. An Alternating current will become a direct current if
- (a) One half of the ac power is reduced
 - (b) It is switched and made to flow in the same direction as the other half wave
 - (c) both (a) and (b)
 - (d) None of the above

Answer (c)

5. The _____ can be used as an input device for any type of rectifier circuit
- (a) Transformer
 - (b) Transducer
 - (c) Diode
 - (d) Battery

Answer (a)

6. The full wave signal has _____ as many positive cycles as the half wave signal
- (a) Twice
 - (b) Half
 - (c) Same
 - (d) Thrice

Answer (a)

7. The dc or average value of full wave signal is $V_{dc} =$ _____
- (a) $V_p / 3.14$
 - (b) $2V_p / 3.14$
 - (c) $3.14 / 2V_p$
 - (d) $3.14 / V_p$

Answer (b)

8. The period of full wave signal is _____
- (a) Twice the input period
 - (b) Half the input period
 - (c) Same as the input period
 - (d) None of the above

Answer (b)

9. The output frequency of half wave rectifier is
- (a) Half the input frequency
 - (b) Twice the input frequency
 - (c) Same as the input frequency
 - (d) 3/4th of the input frequency

Answer (c)

10. The rms value of a sine wave equals $V_{\text{rms}} =$ _____
- (a) $0.707 V_{\text{dc}}$
 - (b) $0.707 V_{\text{p}}$
 - (c) $70.7 V_{\text{dc}}$
 - (d) Either (b) or (c)

Answer (b)

11. Calculate the peak voltage if $V_{\text{rms}} = 10\text{V}$
- (a) $V_{\text{p}} = 1.41 \text{ V}$
 - (b) $V_{\text{p}} = 4.27 \text{ V}$
 - (c) $V_{\text{p}} = 4.49 \text{ V}$
 - (d) $V_{\text{p}} = 14.1 \text{ V}$

Answer (d)

12. Full wave rectifier is also referred to as _____
- (a) Conventional full-wave rectifier
 - (b) Two diode full wave rectifier
 - (c) Centre Tapped full wave rectifier
 - (d) All the above

Answer (a)

13. Bridge rectifier produces
- (a) Half wave output
 - (b) Full wave output
 - (c) Either (a) or (b)
 - (d) Sine wave output

Answer (b)

14. Diodes used in low frequency power supplies are called _____
- (a) Low frequency diodes
 - (b) SCR
 - (c) Small signal diodes
 - (d) Rectifier diodes

Answer (d)

15. _____ is a circuit that removes either positive or negative part of a wave form
- (a) Half wave rectifier
 - (b) Clamper
 - (c) Full wave rectifier
 - (d) Clipper

Answer (d)

16. If R_S , R_L , R_b are the source resistance, load resistance and bulk resistance then, what is the condition for a stiff clipper to work properly
- (a) $100 R_p > R_S > 0.01 R_L$
 - (b) $R_b < 100 R_S < 0.01 R_L$
 - (c) $100 R_b < R_S < 0.01 R_L$
 - (d) $R_L < R_b < 0.01 R_S$

Answer (c)

17. If sine wave is given as input to the clamper then its output is _____
- (a) Shifted upto DC
 - (b) An added dc voltage to the sine wave
 - (c) Either (a) or (b)
 - (d) None of the above

Answer (c)

18. _____ shapes the signals

- (a) Clipper
- (b) Clamper
- (c) Rectifier
- (d) Either (a) or (b)

Answer (a)

19. Any clamper that satisfies the _____ condition is called a stiff clamper

- (a) $1 / R_L C = 100 T$
- (b) $1 / R_L C > 100 T$
- (c) $R_L C = 100 T$
- (d) $R_L C > 100 T$

Answer (d)

20. The dc voltage of a bridge rectifier is _____

- (a) $V_{dc} = 2V_p/\pi$
- (b) $V_{dc} = \pi/2V_p$
- (c) $V_{dc} = V_p/\pi$
- (d) $V_{dc} = 2V_p\pi$

APPENDIX - IX

SINGLE PHASE INDUCTION MOTOR

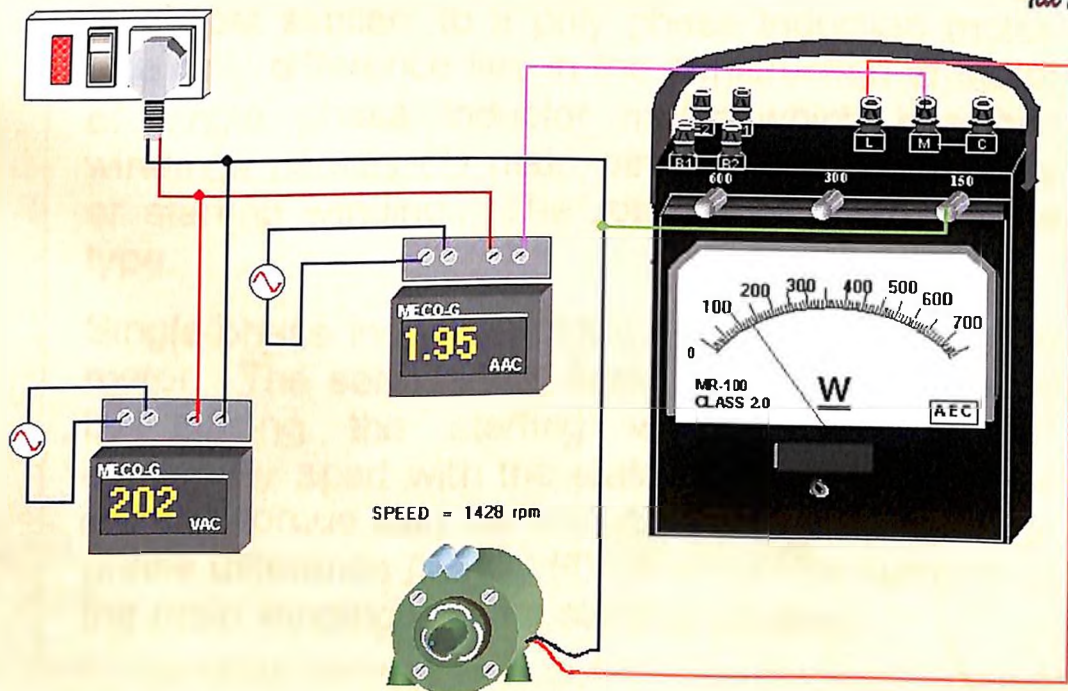
1. Basic Electrical Lab - Screen Shot
2. Virtual Lab with meters and motor connected.
3. Single phase motor theory.
4. Procedure

Topics

Basic Electrical Lab

- Experiment simulation
- Theory
- Self test

SINGLE PHASE INDUCTION MOTOR CONNECTION DIAGRAM



Single Phase Induction Motor

Single phase induction motors will operate on single phase supply. They find wide variety of applications in industries, workshops, offices, and space vehicles as well as for domestic purposes. Depending on the method of starting, the classification of single phase induction motors is done as following:

- (1) Split - phase induction motor.
- (2) Capacitor - start, capacitor - start - and - run and two - value capacitor motors.
- (3) Shaded pole motors.



1

The construction of a single phase induction motor is almost similar to a poly phase induction motor. The only difference lies in the construction of stator of single phase inductor motor which has two windings namely (1) main winding and (2) auxiliary or starting winding. The rotor is of squirrel cage type.

Single phase induction motor is not a self - starting motor. The self starting feature can be introduced by placing the starting winding spaced 90° electrically apart with the stator main winding. The starting torque can be increased by keeping large phase difference (ideally 90°) between the currents in the main winding and the starting winding.



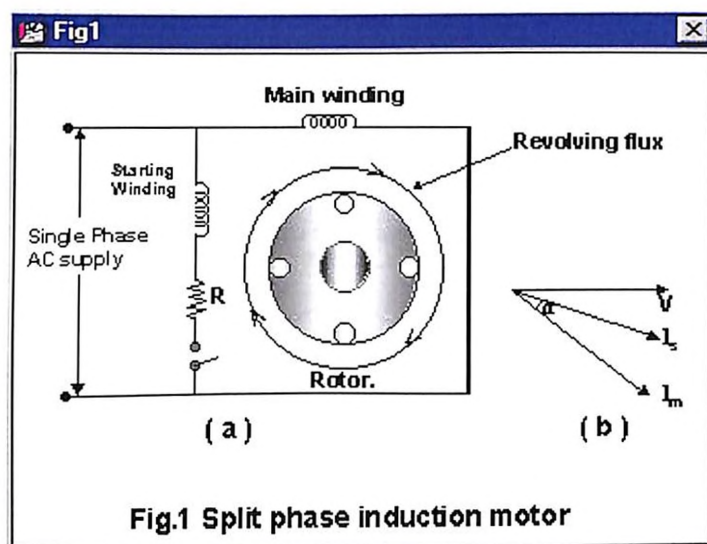
2

(1) Split - Phase Induction motor:

Fig 1(a)

The split - phase induction motor is shown in Fig.18(a). Its stator has two windings, namely (1) Main winding with low resistance and high reactance and (2) Auxiliary or starting winding with high resistance and low reactance. The windings are so chosen to achieve time displacement of the currents flowing through the two windings. Since the starting torque is proportional to $\sin \alpha$ [where α is the angle between main winding current (I_m) and starting winding current (I_s),] the phase angle

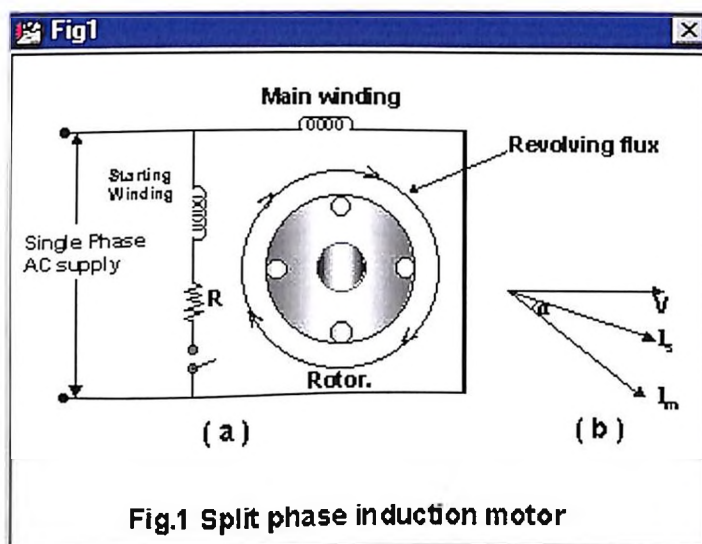
3



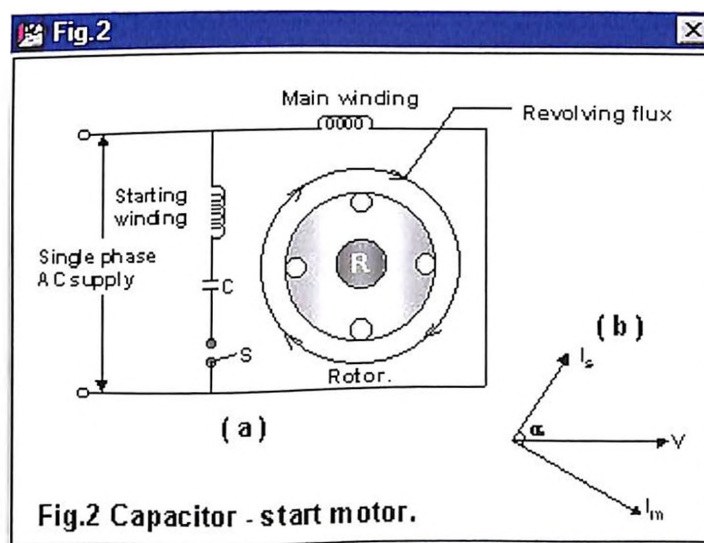
Between I_s and I_m is made as large as possible which is represented in the Fig 1(b) The centrifugal switch 's' connected in series with the starting winding from the supply is made to open, once the motor reaches 80 percent of its rated speed. Split-phase motors are used in washing machines, domestic refrigerators, duplicating machines, fans, blowers and centrifugal pumps.

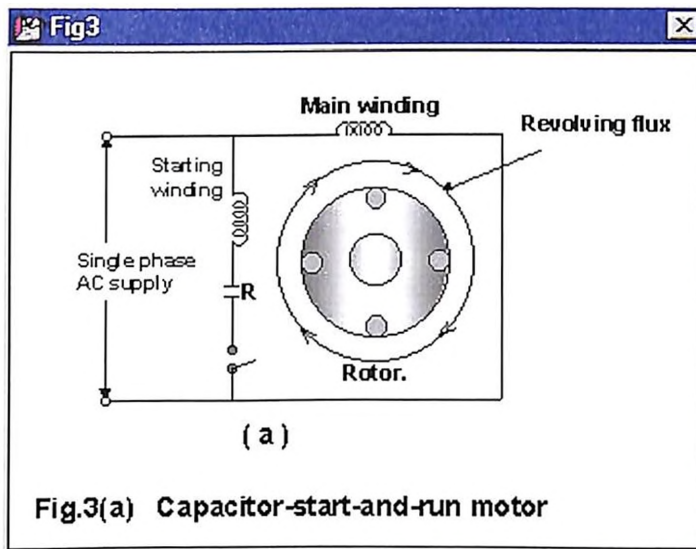
Capacitor - start motor

The torque developed by a split - phase motor is less (α is around 30° , $\sin \alpha$ is small and hence the torque.

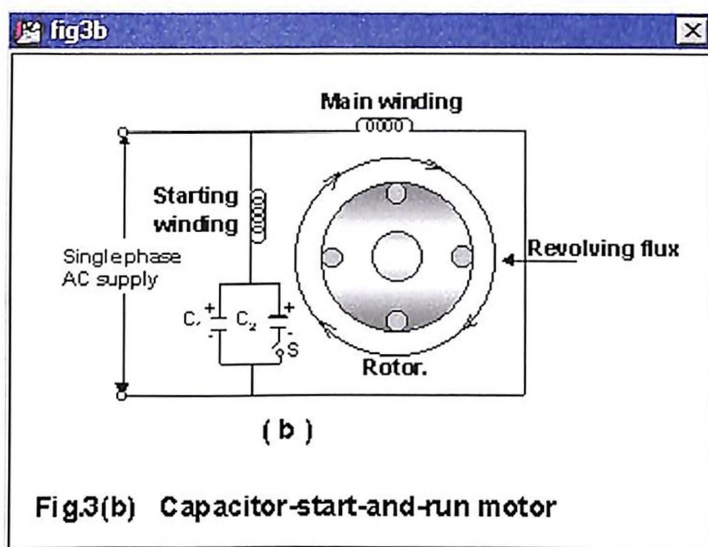



This condition could be overcome by replacing the resistor with a capacitor in the starting winding as shown in the Fig 2(a). The capacitor used for this purpose is of electrolytic type and is generally mounted on the surface of the motor. The phase angle α between current in the starting winding (I_s) and the main winding (I_m) is around 80° as shown in the Fig 2(b) and hence the starting torque developed is nearly double that of the torque developed by a split - phase motor. The centrifugal switch serves the same purpose as in a split phase motor.

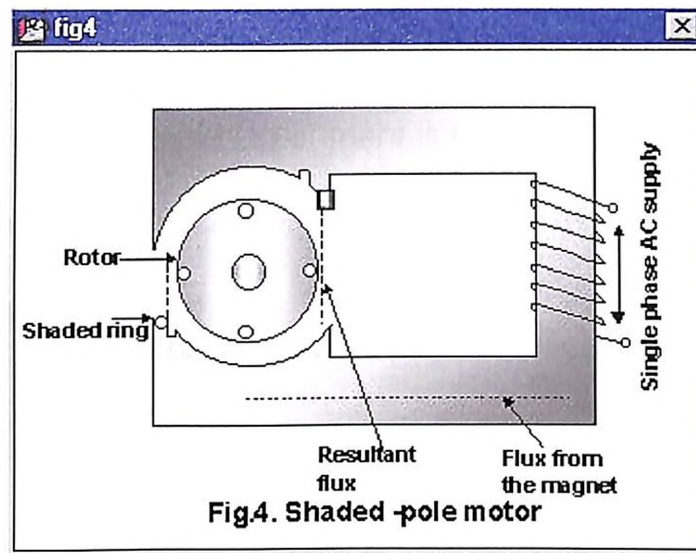




have high starting torque as well as high power factor, which increases the cost of the capacitor. This could be avoided by using a two - value capacitor motor. In this type of motor, a high value capacitor is used in series with the starting winding during starting and a low value capacitor is substituted by means of centrifugal switch (S) during running as shown in Fig.20(b). The two - value capacitor motor has following salient features (I) - very quiet operation (ii) higher efficiency and power factor (iii) ability to start at heavy loads. These motors find applications in compressors and fire strokes.



In a shaded pole motor, the phase - split is obtained by the phenomenon of inductio Fig 4 short - circuited copper coil known as 'shading ring' is placed around the small portion of the poles as shown in Fig.21. The rotor is of squirrel cage type. The portion of the pole where the shaded ring is placed is known as shaded portion and the remaining portion of the pole is known as shaded portion and the remaining portion of the pole is known as 'unshaded portion'. Whenever the field winding is excited with alternating current, the magnetic axis of the pole, shifts from the unshaded  the shaded portion.



This shifting of magnetic axis is equivalent to physical movement of the pole. Thus the rotor starts rotating in the direction of the shift of the magnetic pole.

Shaded pole motors are simple in construction but extremely rugged. It is cheap and reliable. The disadvantages are (i) low overload capacity (ii) poor efficiency and (iii) low starting torque. These motors are generally used in hair driers, ventilators, toys, small fans and circulators.

SINGLE PHASE INDUCTION MOTOR

Aim: The aim of this experiment is to perform operation and measurements on single phase induction motor.

Materials required:

1. Capacitor start single phase induction motor.
2. Digital AC voltmeter - 500 V
3. Digital AC Ammeter - 2.5 / 5A.
4. Wattmeter 250 V / 5A.
5. Connecting wires.



1

Procedure:

Step1:

Switch on AC supply.

Step2:

Note the current, voltage and power.



2

Step 3:

Note the speed of the motor.

Conclusion: Thus the operation and measurement on single phase induction motor is performed.



APPENDIX - X

INTRODUCTION

TO

VP Lab Software

&

LabVIEW Software

Power Conversion Using the Virtual Power Laboratory VPLab[®]

By

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Edited 2/6/2001

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Preface

Power Conversion Using the Virtual Power Laboratory VPLab[®] is a text with an accompanying software package, **VPLab[®]**. The laboratory exercises are in the form of 14 experiments, illustrating the essential theory of power conversion.

We believe that laboratory experiences are essential to learning in all areas of engineering. In our careers in electrical engineering we have seen the benefits of laboratory courses supplementing lecture courses in electric circuits, semi-conductor devices, electro-optics, microwaves, control systems and power conversion. We have come to believe that most of the benefits of the traditional laboratory course can be captured in a virtual laboratory course. Moreover, we find that the virtual laboratory course has some educational advantages not available in the traditional laboratory course.

This book was written to offer a virtual laboratory experience to students in the area of power conversion. Power conversion is a standard course in the electrical engineering curricula of most colleges of engineering. It deals with the conversion of electrical to mechanical power (motors); electrical power at one voltage level to electrical power at another voltage level (transformers); ac (alternating current) power to dc (direct current) power (rectifiers); and ac power to ac power (solid state ac controllers). A theoretical and practical background in this subject is essential to electrical as well as mechanical engineers.

Conceived as a computer based inter-active means for offering a laboratory course in power conversion, **VPLab[®]**, a computer simulation, can be utilized by students who have available a modest PC configuration. Within the **VPLab[®]** are dc motors, ac motors, and single-phase and three-phase transformers, rectifier and converter. These devices are all modeled by the **VPLab[®]** computer program to provide realistic operating characteristics. All of the device models have been designed to accurately produce the same results as actual equipment, which have been extensively tested in the laboratory. **VPLab[®]** contains a set of electrical instruments, (voltmeters, ammeters, wattmeters and oscilloscopes) and a set of mechanical instruments, (dynamometer and tachometer). The **VPLab[®]** text describes 14 experiments (laboratory exercises) utilizing the power conversion devices and instruments in a completely realistic way; each one designed using an actual laboratory experiment as a guide. Each experiment directs the student to exercise the device under study; collect and record data; and construct graphs and answer questions concerning the device, as illuminated by the experiment. A laboratory report may be submitted, as in a traditional laboratory, based on the experiment. We have provided a suggested format for such a laboratory report in Appendix II.

The success of a virtual laboratory is based on how closely the experimental and concomitant learning matches that of the traditional laboratory. We have used our long experience in teaching laboratory courses at the university level to design **VPLab[®]** to provide a high degree of match. We have been diligent in modeling **VPLab[®]** devices (motors, transformers and power electronic devices) to produce simulated operating characteristics that agree with the characteristics of actual devices. In addition, the student is directed by the text to follow procedures that parallel

the experimental procedures necessary in a real laboratory. In the event that a student makes an experimental error, such as overloading the device under test, the effect is apparent; however, no real damage is done (a big advantage of the virtual laboratory).

Power Conversion Using the Virtual Power Laboratory VPLab[®] (text and accompanying diskette or CD) provides each student of power conversion with an inter-active virtual power laboratory (VPLab[®]). The laboratory experiments may be keyed to a concurrent lecture course to provide virtually the same laboratory experience as was found in a traditional power laboratory. Accordingly, the experiments in the virtual laboratory supplement the lecture courses, intensifying the learning experience.

Power Conversion Using the Virtual Power Laboratory VPLab[®] can be used as the basis for a laboratory course in power conversion, in a number of different scenarios. For example, it can be used for a one-quarter unit or one-semester unit laboratory to accompany a lecture course in power conversion. Typically, this would include completing seven experiments in a quarter or perhaps as many as 10 in a semester.

A machine-oriented laboratory course might include experiments 3.1, 3.2, 3.4, 4.1, 4.2, 5.1, 6.1, 7.1, 7.2, in a quarter, plus 3.3, 8.1, in a semester. In order to accommodate some exposure to power electronics we might include experiments 9.1 and 10.1 and remove 3.2 and 4.2. Actual laboratory course design is, of course, up to the instructor and dependent on a number of factors, including the type of lecture course being offered.

Alternatively, this courseware can be used as the basis for a lecture/laboratory course in power conversion using one of the standard texts as a reference (as cited on page 10).

About the Authors

Dr. Saul Goldberg and Dr. William F. Horton are professors in the Electrical Engineering Department, College of Engineering, California Polytechnic State University, San Luis Obispo, California. They have published more than 40 technical papers and a book in the subject area of electric power systems. Both are senior members of the Institute of Electrical and Electronics Engineers (IEEE). As principals of the consulting company Power Systems Consultants, located in San Luis Obispo, they have served as consultants to a variety of clients in the power industry.

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Saul Goldberg received the Bachelor of Science Degree (Electrical Engineering) from Fairleigh Dickinson University and the Master of Engineering and Doctor of Philosophy (Engineering) from the University of Florida at Gainesville. His industrial experience includes assignments at Bendix-Eclipse Pioneer Division, Mount Sinai Hospital (Department of Radiology, Miami Beach, Florida), Southern California Edison Company and Pacific Gas and Electric Company.

Introduction to LabVIEW

Refer to Appendix A, *System Requirements* for more information about system configuration requirements. Refer to the *LabVIEW Release Notes* for installation instructions.

What Is LabVIEW?

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where data determine execution.

In LabVIEW, you build a user interface by using a set of tools and objects. The user interface is known as the front panel. You then add code using graphical representations of functions to control the front panel objects. The block diagram contains this code. If organized properly, the block diagram resembles a flowchart.

You can purchase several add-on software toolsets for developing specialized applications. All the toolsets integrate seamlessly in LabVIEW. Refer to the National Instruments Web site at ni.com/labview for more information about these toolsets.

LabVIEW is integrated fully for communication with hardware such as GPIB, VXI, PXI, RS-232, RS-485, and plug-in data acquisition devices. LabVIEW also has built-in features for connecting your application to the Internet using the LabVIEW web server and software standards such as TCP/IP networking and ActiveX.

Using LabVIEW, you can create 32-bit compiled applications that give you the fast execution speeds needed for custom data acquisition, test, measurement, and control solutions. You also can create stand-alone executables and shared libraries, like DLLs, because LabVIEW is a true 32-bit compiler.

LabVIEW contains comprehensive libraries for data collection, analysis, presentation, and storage. LabVIEW also includes traditional program development tools. You can set breakpoints, animate program execution,

and single-step through the program to make debugging and development easier.

LabVIEW also provides numerous mechanisms for connecting to external code or software through DLLs, shared libraries, ActiveX, and more. In addition, numerous add-on tools are available for a variety of application needs.

Why Should I Use LabVIEW?

LabVIEW empowers you to build your own solutions for scientific and engineering systems. LabVIEW gives you the flexibility and performance of a powerful programming language without the associated difficulty and complexity.

LabVIEW gives thousands of successful users a faster way to program instrumentation, data acquisition, and control systems. By using LabVIEW to prototype, design, test, and implement your instrument systems, you can reduce system development time and increase productivity by a factor of 4 to 10.

LabVIEW also gives you the benefits of a large installed user base, years of product feedback, and powerful add-on tools. Finally, National Instruments technical support and Developer Zone ensure successful development of your solutions.

How Does LabVIEW Work?

LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. Every VI uses functions that manipulate input from the user interface or other sources and display that information or move it to other files or other computers.

A VI contains the following three components:

- **Front panel**—Serves as the user interface.
- **Block diagram**—Contains the graphical source code of the VI that defines its functionality.
- **Icon and connector pane**—Identifies the VI so that you can use the VI in another VI. A VI within another VI is called a subVI. A subVI corresponds to a subroutine in text-based programming languages.

Front Panel

The front panel is the user interface of the VI. You build the front panel with controls and indicators, which are the interactive input and output terminals of the VI, respectively. Controls are knobs, push buttons, dials, and other input devices. Indicators are graphs, LEDs, and other displays. Controls simulate instrument input devices and supply data to the block diagram of the VI. Indicators simulate instrument output devices and display data the block diagram acquires or generates.

Block Diagram

After you build the front panel, you add code using graphical representations of functions to control the front panel objects. The block diagram contains this graphical source code. Front panel objects appear as terminals on the block diagram. You cannot delete a terminal from the block diagram. The terminal disappears only after you delete its corresponding object on the front panel.

Every control or indicator on the front panel has a corresponding terminal on the block diagram. Additionally, the block diagram contains functions and structures from built-in LabVIEW VI libraries. Wires connect each of the nodes on the block diagram, including control and indicator terminals, functions, and structures.

Palettes

LabVIEW palettes give you the options you need to create and edit the front panel and block diagram.

Tools Palette

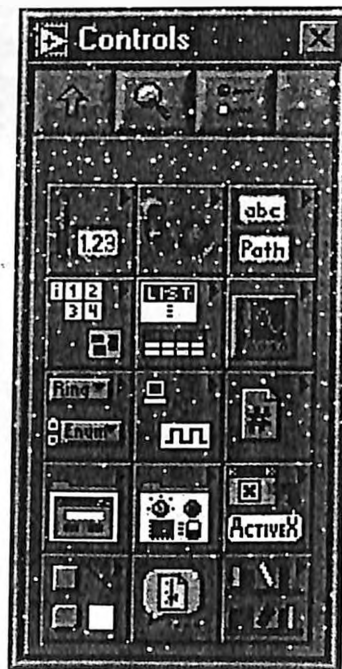
The **Tools** palette is available on the front panel and the block diagram. A tool is a special operating mode of the mouse cursor. When you select a tool, the cursor icon changes to the tool icon. Use the tools to operate and modify front panel and block diagram objects.

Select **Window»Show Tools Palette** to display the **Tools** palette. You can place the **Tools** palette anywhere on the screen.



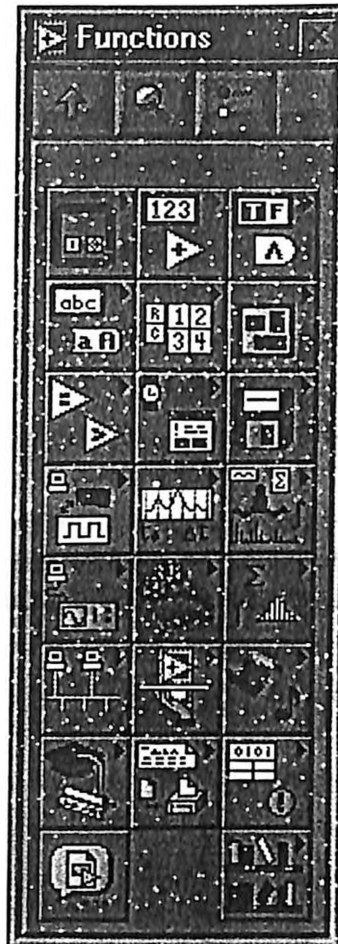
Controls Palette

The **Controls** palette is available only on the front panel. The **Controls** palette contains the front panel controls and indicators you use to create the user interface. Select **Window»Show Controls Palette** or right-click the front panel workspace to display the **Controls** palette. You can place the **Controls** palette anywhere on the screen.



Functions Palette

The **Functions** palette is available only on the block diagram. The **Functions** palette contains the objects you use to program your VI, such as arithmetic, instrument I/O, file I/O, and data acquisition operations. Select **Window»Show Functions Palette** or right-click the block diagram workspace to display the **Functions** palette. You can place the **Functions** palette anywhere on the screen.



Navigating the Controls and Functions Palettes

Use the navigation buttons on the **Controls** and **Functions** palettes to navigate and search for controls, VIs, and functions. When you click a subpalette icon, the entire palette changes to the subpalette you selected. You also can right-click a VI icon on the palette and select **Open VI** from the shortcut menu to open the VI.

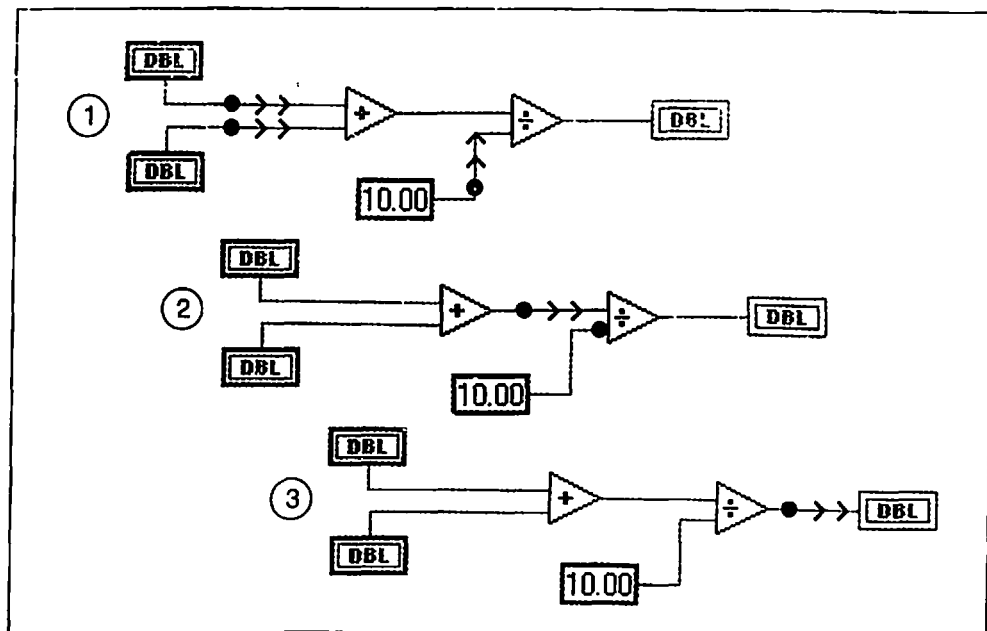
The **Controls** and **Functions** palettes contain the following navigation buttons:



- **Up**—Takes you up one level in the palette hierarchy.
- **Search**—Changes the palette to search mode. In search mode, you can perform text-based searches to locate controls, VIs, or functions in the palettes.
- **Options**—Opens the **Function Browser Options** dialog box, from which you can configure the appearance of the palettes.

Data Flow

LabVIEW follows a dataflow model for running VIs. A block diagram node executes when all its inputs are available. When a node completes execution, it supplies data to its output terminals and passes the output data to the next node in the dataflow path.



Where Do I Start?

If you are new to LabVIEW, use this *Getting Started with LabVIEW* manual and the *LabVIEW Tutorial* to help you get started quickly. The *LabVIEW Tutorial* introduces you to the LabVIEW environment. *Getting Started with LabVIEW* teaches you how to build VIs for data acquisition and instrument control and how to debug them. It also teaches you how to use the Search Examples feature and the DAQ Solution Wizard.



You can complete the activities in this book in approximately 90 minutes.

LabVIEW Tutorial

Use this tutorial to learn basic LabVIEW concepts. The tutorial guides you through several activities to familiarize you with graphical programming. Access the *LabVIEW Tutorial* by selecting **Help»Contents and Index** or by clicking the **LabVIEW Tutorial** button in the **LabVIEW** dialog box, shown in the following illustration.



You can complete the *LabVIEW Tutorial* in approximately 15 minutes.



If you are already running LabVIEW, either launch LabVIEW or close all open VIs including the Demo VI to access the **LabVIEW** dialog box.

After you finish the *LabVIEW Tutorial*, continue with the activities in this manual to learn how to build LabVIEW programs for instrument I/O, data acquisition, and control.

You should complete the activities in this book in the order in which they appear because subsequent activities build on the sample programs you create. Approximate completion times are given for each activity and each section within an activity.

Virtual Instruments

This chapter teaches you step by step how to create an application in LabVIEW. It also guides you through the Search Examples feature to help you find examples in LabVIEW.

You will learn to do the following:

- Create a new program in LabVIEW. The VI you build generates data, analyzes it, then writes it to a file.
- Use the Search Examples feature to find and run an example.

Search for Examples

After completing the *LabVIEW Tutorial*, you are ready to run some examples in LabVIEW.



You can complete this activity in approximately 5 minutes.

1. In the **LabVIEW** dialog box, click the **Search Examples** button to open the *Search Examples* online help, which lists LabVIEW examples.

If you are already running LabVIEW, either launch LabVIEW or close all open VIs including the Demo VI to access the **LabVIEW** dialog box.

2. Select **Analysis** in the **Demonstrations** category.
3. Click **Temperature System Demo** to open this demonstration VI.
4. Click the **Run** button on the front panel toolbar to see how the VI runs.
5. Click the sliders, knobs, and other controls to see how they affect the data.
6. Stop the program by clicking the **Acquisition** switch to the **off** position.



Build a Virtual Instrument

This activity demonstrates how you can plot, analyze, and save data in LabVIEW.

 You can complete this activity in approximately 30 minutes.

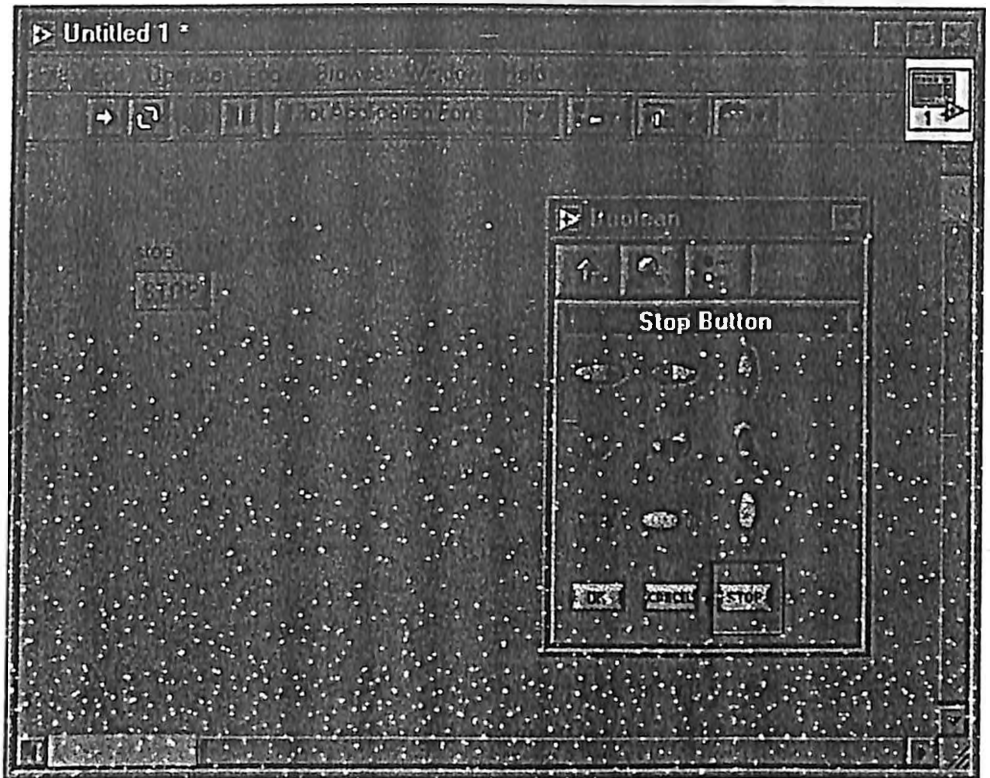
Create a User Interface

You can create a graphical user interface on the front panel using controls and indicators on the **Controls** palette.

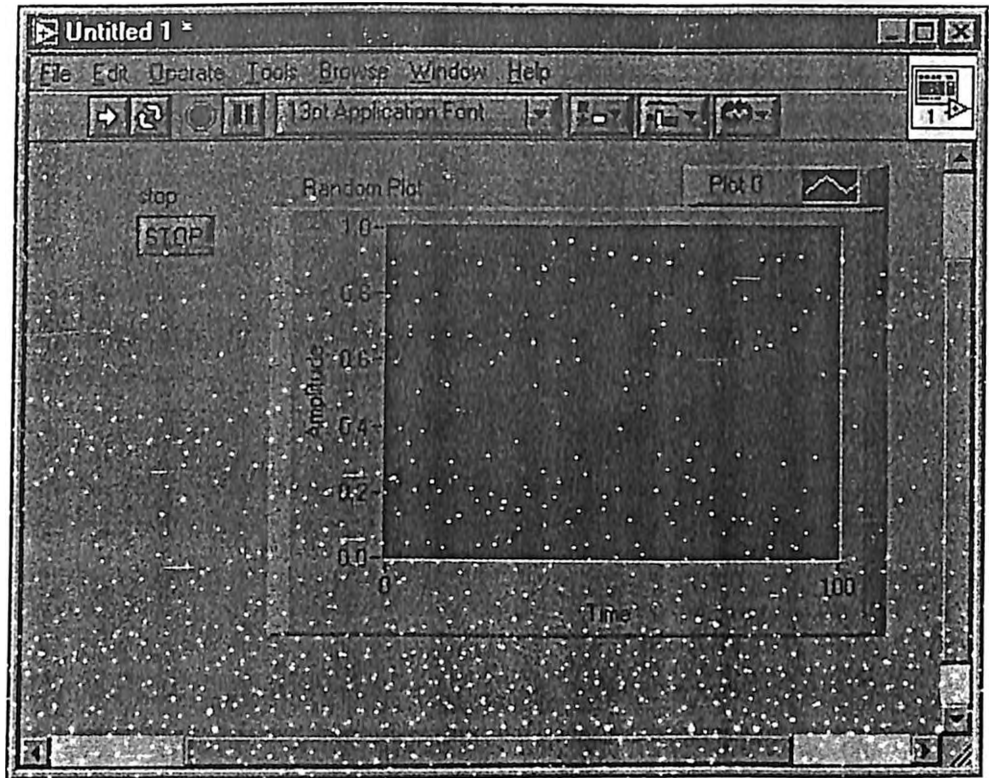
 You can complete this section in approximately 5 minutes.

1. Create a new VI by selecting **New VI** in the **LabVIEW** dialog box.
If you are already running LabVIEW, either launch LabVIEW or close all open VIs including the Demo VI to access the **LabVIEW** dialog box.
2. Create a stop button by selecting **Controls»Boolean»Stop Button** on the **Controls** palette, as shown in the following illustration.
3. Right-click the object and select **Visible Items»Label** from the shortcut menu to show or hide the text label for an object.
4. Use the Positioning tool on the **Tools** palette to rearrange or resize objects. Select **Window»Show Tools Palette** to show the **Tools** palette.





5. Use the **Up** navigation button on the **Controls** palette to navigate back to the main **Controls** palette. Create a waveform chart by selecting **Controls»Graph»Waveform Chart**. This chart plots data one point at a time. Use the Labeling tool on the **Tools** palette to label the waveform chart **Random Plot**.
6. Select **Window»Show Tools Palette** to show the **Tools** palette. Use the Operating tool on the **Tools** palette to change the scale of the waveform chart. Double-click **-10.0** on the Y axis of the Random Plot indicator and type **0.0** to change the scale. Double-click **10.0** on the Y axis of the Random Plot indicator and type **1.0** to change the scale. The front panel should now match the following illustration.



Build the Block Diagram

So far, you have defined how the user interface will look. Now you can create the source code on the block diagram. For this VI, you generate random numbers ranging from zero to one and plot them on a chart.



You can complete this section in approximately 5 minutes.

1. View the block diagram by selecting **Window»Show Diagram** or clicking the block diagram window.

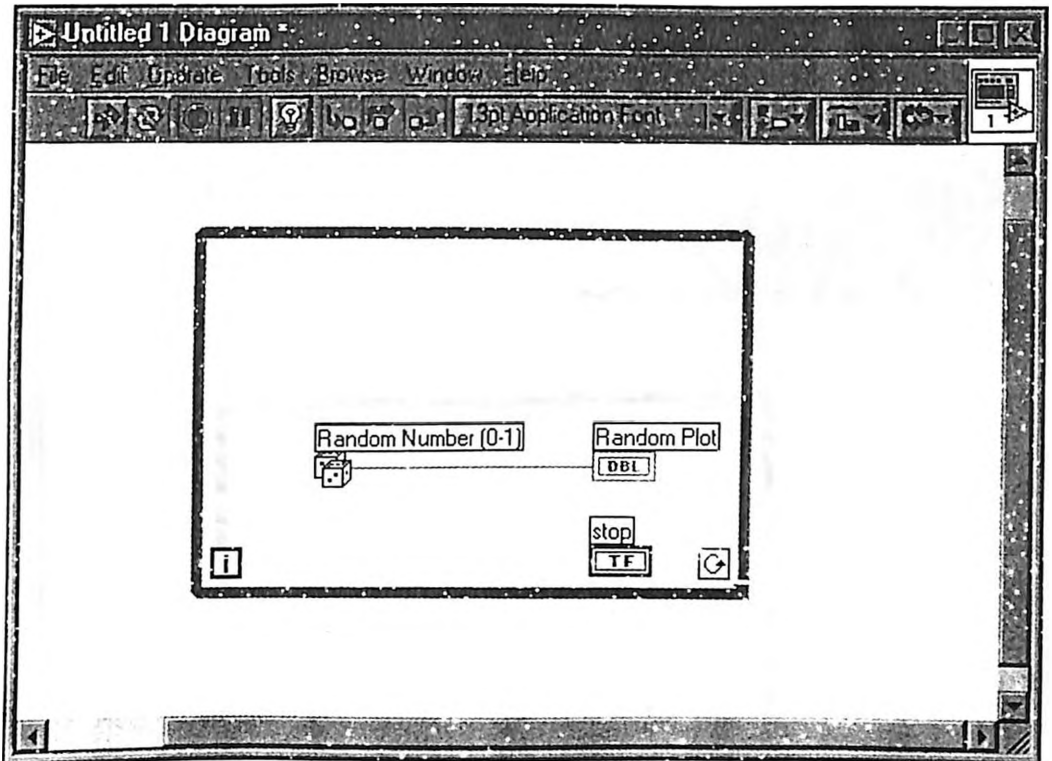


Tip Use the keyboard shortcut <Ctrl-E> to switch between the front panel and block diagram.

2. The two terminals on the block diagram correspond to the **Stop** button and the Random Plot waveform chart on the front panel. Select **Window»Show Functions Palette** to show the **Functions** palette.
3. Select **Functions»Numeric»Random Number (0–1)**. As you drag the Random Number (0–1) function close to the Random Plot terminal, LabVIEW automatically draws a wire. When you release the mouse button to place the function, LabVIEW automatically connects the function to the terminal with a wire.



4. Use the **Up** navigation button on the **Functions** palette to navigate back to the main **Functions** palette. Create a **While Loop** by selecting **Functions»Structures»While Loop**. The **While Loop** runs all code within its boundaries until the conditional terminal receives a **TRUE** or **FALSE** value. The default behavior is **Continue if True**.
5. Place the mouse cursor in the position on the block diagram where you want to anchor the top-left corner of the **While Loop**. Drag the dotted rectangle diagonally to enclose the **Random Number** function, the **Random Plot** chart, and the **Stop** button terminal. The block diagram should now match the following illustration.



re and Run the VI

You transfer data between block diagram objects through wires. Wires are different colors, styles, and thicknesses, depending on their data types. A broken wire appears as a dashed black line. When you finish wiring this VI, you can run it from the front panel to see it plot data to the chart.

) You can complete this section in approximately 5 minutes.



1. Select **Window»Show Tools Palette** to show the **Tools** palette. Select the **Wiring** tool on the **Tools** palette.

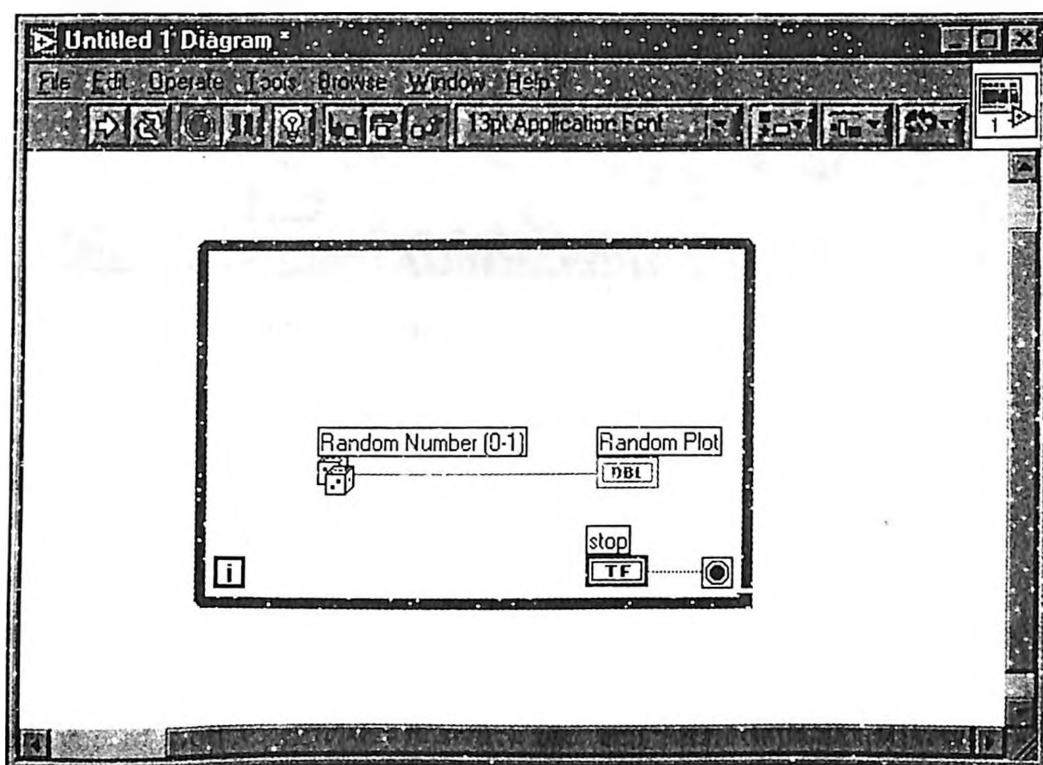


2. Wire the **Stop** button terminal to the While Loop conditional terminal. To do this, click the **Stop** button terminal, move the mouse cursor to the conditional terminal to create a wire and click again to connect the wire.

Tip When you position the Wiring tool over a terminal, the terminal blinks, and a tip strip with the name of the terminal appears.



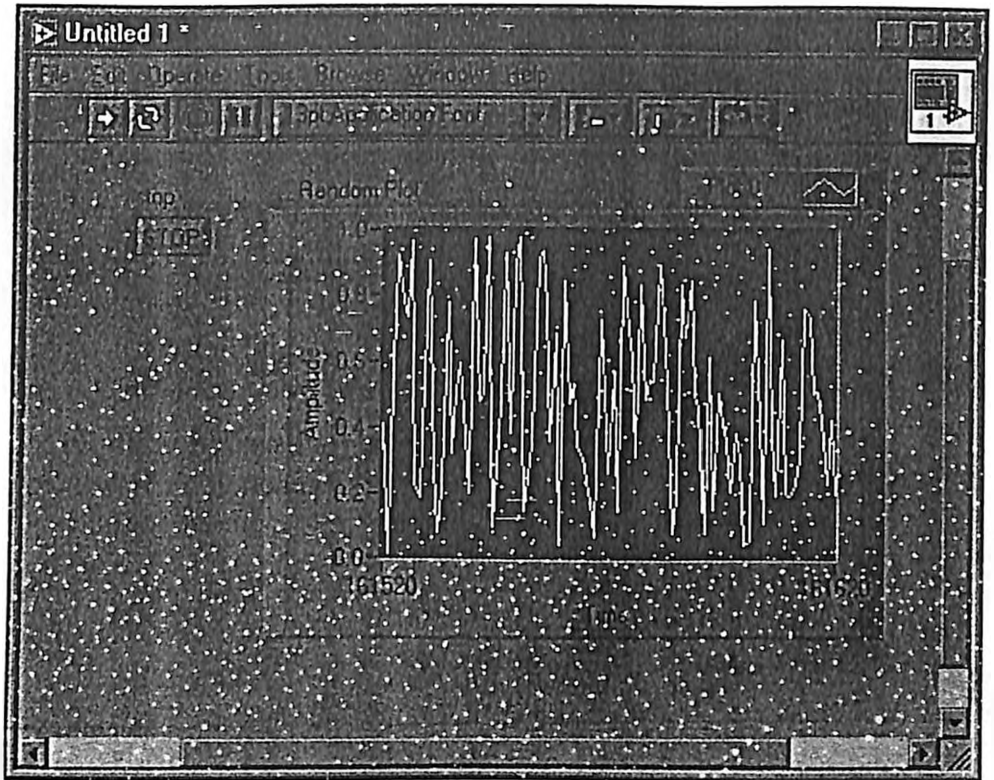
3. Because this VI uses a **Stop** button, you must change the behavior of the While Loop conditional terminal to **Stop if True**. Right-click the conditional terminal or the border of the While Loop and select **Stop if True**. The appearance of the conditional terminal changes as shown at left. The block diagram should now match the following illustration.



4. View the front panel by pressing <Ctrl-E>. Select **Window>Show Tools Palette** to show the **Tools** palette. Select the **Operating** tool on the **Tools** palette.



5. Click the **Run** button on the toolbar to run the VI. The front panel should now resemble the following illustration.



6. Click the **Stop** button to stop the VI.