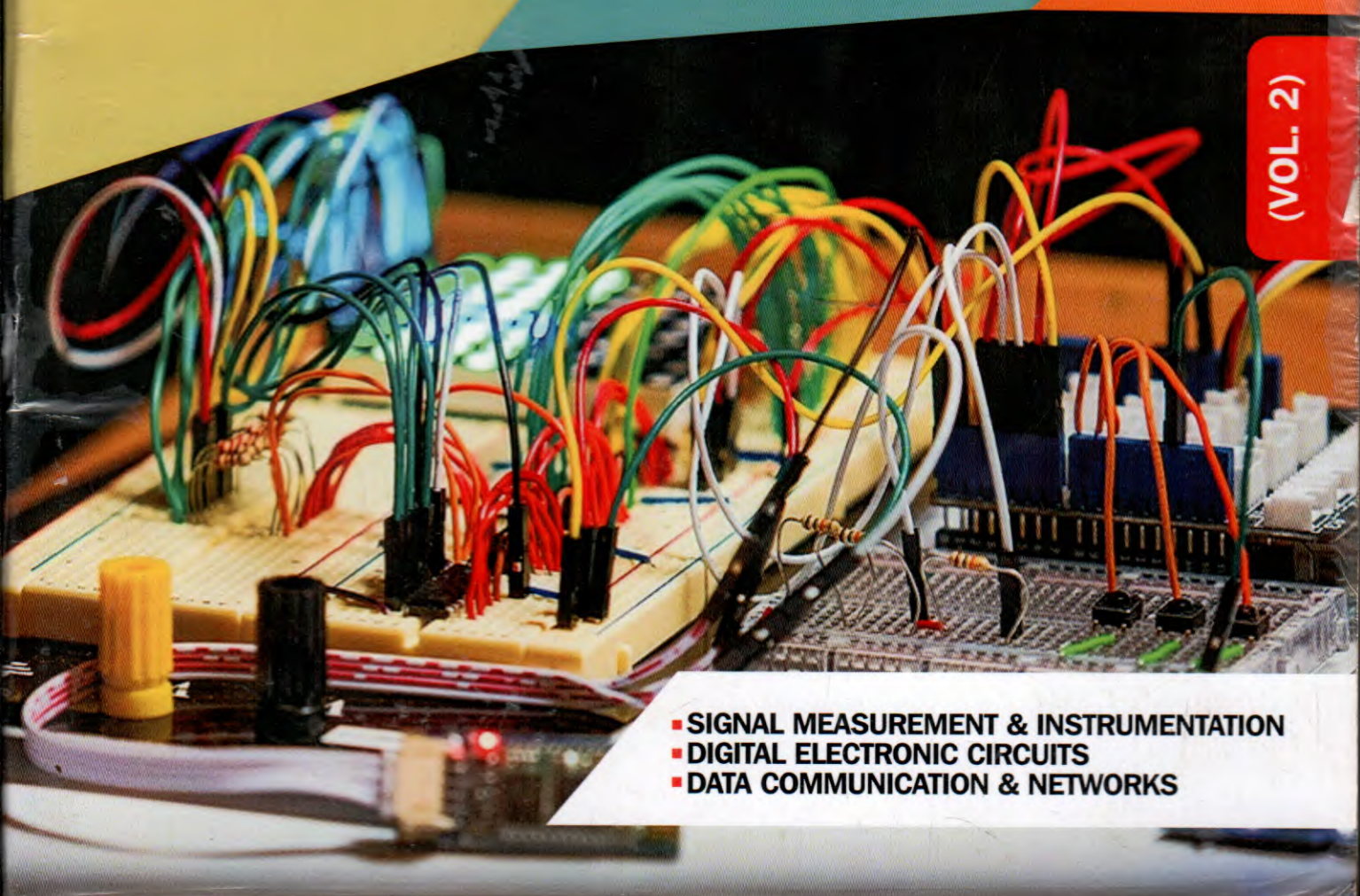




UNDERGRADUATE
COMPUTER
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LABORATORY MANUAL

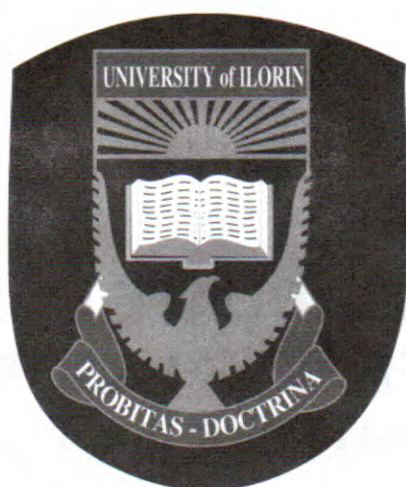
(VOL. 2)

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- SIGNAL MEASUREMENT & INSTRUMENTATION
 - DIGITAL ELECTRONIC CIRCUITS
 - DATA COMMUNICATION & NETWORKS

UNDERGRADUATE COMPUTER ENGINEERING LABORATORY MANUAL (VOL. 2)

Signal Measurement & Instrumentation
Digital Electronic Circuits
Data Communication & Networks





UNDERGRADUATE COMPUTER ENGINEERING LABORATORY MANUAL (VOL. 2)

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Foreword

This instruction manual is the second in the series of the undergraduate Computer Engineering laboratory manuals designed to facilitate a practical-oriented approach to learning by students of Computer Engineering in Nigerian Universities. In developing this manual, requirements in the Basic Minimum Academic Standard (BMAS) as defined by both the National Universities Commission (NUC) and the Council for the Regulation of Engineering in Nigeria (COREN) for courses to be audited by Computer Engineering undergraduates were considered.

This volume focuses on experiments in Signal Measurement and Instrumentation, Digital Electronic Circuits and Data Communication and Computer Networks. A total of six laboratory sessions are to be performed by students in each of these areas.

At the end of each laboratory session, each student is expected to write a report on the experiments conducted in the workbook provided and submit to laboratory instructors for assessment.

It is our desire that the use of this manual in undergraduate Computer Engineering laboratories will achieve our goal of imparting students with the necessary hands-on experience that will make them productive Computer Engineers in the future.

J.F. Opadiji, Dr.Eng, R.Eng.

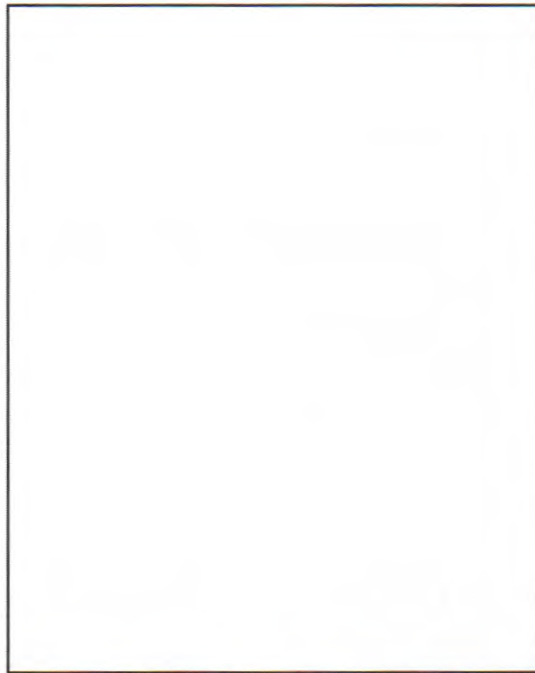


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STUDENT INFORMATION PAGE



Student Passport Photograph

SURNAME:

FIRST NAME:

OTHER NAME:

MATRICULATION NUMBER:

ACADEMIC SESSION:

CURRENT LEVEL:



ATTENDANCE PAGE

DATE	EXPERIMENT NUMBER	EXPERIMENT TITLE	SIGNATURE (Technologist- in-Charge)
	UILCPE/SMI 1	Measurement Error	
	UILCPE/SMI 2	Signal Sensing and Transducing	
	UILCPE/SMI 3	Signal Conditioning	
	UILCPE/SMI 4	Calibration	
	UILCPE/SMI 5	Signal Display	
	UILCPE/SMI 6	Mini Projects	
	UILCPE/DEC 1	Digital Logic Gate and Truth table	
	UILCPE/DEC 2	Combinational Logic Circuits	
	UILCPE/DEC 3	A/D and D/C Converter	
	UILCPE/DEC 4	Circuit Minimization	
	UILCPE/DEC 5	Transistor Transistor logic	
	UILCPE/DEC 6	Flip Flop	
	UILCPE/DCN 1	Transmission Media & LAN Topologies	
	UILCPE/DCN 2	Communication Devices & Cable Interconnection	
	UILCPE/DCN 3	IP Addressing & Wireless Configuration	
	UILCPE/DCN 4	Configuration of Network Devices	
	UILCPE/DCN 5	Static and Dynamic Routing Configuration	
	UILCPE/DCN 6	VLAN, Trunking, VLAN Trunking Protocol and Port Security	



LABORATORY SAFETY RULES AND OPERATING PROCEDURES

1. Note the location of the Circuit Breaker to shut off power in an emergency. Note the location of the nearest exit to your location.
2. Students are allowed in the laboratory only when the laboratory instructor (Technologist) is present.
3. Food and drinks are strictly prohibited in the laboratory. In the case where it becomes necessary to drink water, keep open drinks away from the laboratory benches.
4. Report any broken equipment or defective parts to the laboratory instructor. Do not open, remove the cover, or attempt to repair any equipment.
5. When the laboratory exercise is over, all equipment must be turned off and returned to the designated location.
6. All equipment, tool and instruments are the property of the University and must not be taken out of the laboratory.
7. Do not move instruments from one laboratory station to another laboratory station.
8. Do not tamper with or remove security straps, locks, or other security devices.
9. When touching the FPGA development boards or any other circuit boards, please do not touch the solid-state parts on the board but handle the board from its edge.
10. Lateness to laboratory sessions will not be condoned. Students who arrive later than thirty (30) minutes into the session will not be allowed into the laboratory.

I have read and understood these rules and procedures. I agree to abide by the rules and procedures at all times while in the laboratory, failure to follow these rules and procedures will result in my immediate dismissal from the laboratory and additional disciplinary action may be taken.

SIGNATURE

DATE



GENERAL LABORATORY SAFETY INFORMATION

Introduction

The danger of injury or death from electrical shock, fire, or explosion is present while conducting experiments in this laboratory. To work safely, it is important that you understand the prudent practices necessary to minimize the risks and what to do if there is an accident.

Electrical Shock

Avoid contact with conductors in energized electrical circuits. The typical *cannot let-go* (the current in which a person cannot let go) current is about 30mA (OSHA). Muscle contractions can prevent the person from moving away from the energized circuit. Possible death can occur as low as 50mA. For a person that is wet the body resistance can be as low as 1000 ohms. A voltage of 50V can result in death.

Do not touch someone who is being shocked while still in contact with the electrical conductor or you may also be electrocuted. Instead, shut down the power source or switch off the electric circuit breaker if the power source is inaccessible.

Make sure your hands are dry. The resistance of dry, unbroken skin is relatively high and thus reduces the risk of shock. Skin that is broken, wet, or damp with sweat has a low resistance.

When working with an energized circuit, work with only your right hand, keeping your left hand away from all conductive material. This reduces the likelihood of an accident that results in current passing through your heart.

Be cautious of rings, watches, and necklaces. Skin beneath a ring or watch is damp, lowering the skin resistance. Shoes covering the feet are much safer than sandals.

Fire

Some electronic components can become extremely hot and cause severe burns if touched. In case of fire outbreak, turn off the power supply and notify the laboratory instructor. Avoid using fire extinguishers on electronic equipment.

Explosions

When using electrolytic/tantalum capacitors, be careful to observe proper polarity and do not exceed the voltage rating. Electrolytic and tantalum capacitors can explode and cause injury.

First Aid

A first aid kit is always available in the laboratory. Consult the laboratory instructor if you need to make use of the first aid kit and proceed to University Clinic if needed.



TROUBLESHOOTING HINTS

1. Be sure that the power is turned on.
2. Be sure that the supply voltages are correct and the ground connections are common. For some power supplies, the 'ON' button needs to be clicked in order to turn on the output channel.
3. Be sure the circuit you built is identical to that in the diagram. Do a node-by-node check if needed.
4. Be sure the resistors, capacitors and inductors used in your circuit all have the correct values. You can get that information using a digital multimeter, color code or the nominal value printed on the component.
5. Be sure that the experiment is set up correctly and you are measuring the correct parameter

GUIDELINES FOR LABORATORY REPORT NOTEBOOK

The laboratory workbook contains the record of all works pertaining to the experiment. This record should be sufficiently complete so that anyone of similar technical background can perform the experiment by simply following your experimental procedures. Record everything directly into the workbook during the experiment.

Organization in your workbook is important. Descriptive headings should be used to separate and identify the various parts of the experiment. Record the data in chronological order. A neat, organized and complete record of an experiment is just as important as the experimental work.

1. **Heading:** The experiment number should be at the top of each page. Your name and date should be at the top of the first page of each day's experimental work.
2. **Title:** The experiment title should be clearly stated.
3. **Objective(s):** A brief but complete statement of what you intend to find out or verify in the experiment should be at the beginning of each experiment
4. **Diagram(s):** A circuit diagram should be drawn and labeled so that the actual experiment circuitry could be easily duplicated at any time in the future. Be especially careful to record all circuit changes made during the experiment.
5. **Equipment List:** List those items of equipment which have a direct effect on the accuracy of the data. It may be necessary later to locate specific items of equipment for rechecks if discrepancies develop in the results.
6. **Procedure(s):** In general, lengthy explanations of procedures are unnecessary. Short commentaries alongside the corresponding data may be used. Keep in mind the fact that the experiment must be reproducible from the information given in your notebook.
7. **Data:** Think carefully about what data is required and prepare suitable data tables. Record instrument readings directly. Do not use calculated results in place of direct data; however, calculated results may be recorded in the same table with the direct data. Data tables should be clearly identified and each data column labeled and headed by the proper units of measure.
8. **Calculations:** Not always necessary but equations and sample calculations are often given to illustrate the treatment of the experimental data in obtaining the results.
9. **Graphs:** Graphs are used to present large amounts of data in a concise visual form. Though not required for every practical session, they are often an efficient analytical tool. Data to be presented in graphical form should be plotted in the laboratory so that any questionable data points can be checked while the experiment is still set up. The grid lines in the notebook can be used for most graphs. If special graph paper is required, affix the graph permanently into the notebook. Give all graphs a short descriptive title. Label and scale the axes. Use units of measure. Label each curve if more than one on a graph.



10. **Results:** The results should be presented in a form which makes the interpretation easy. Large amounts of numerical results are generally presented in graphical form. Tables are generally used for small amounts of results. Theoretical and experimental results should be on the same graph or arranged in the same table in a way for easy correlation of these results.
11. **Answers to Questions:** Some laboratory sessions will ask questions based on the experiments you just performed. The answer to the questions are usually gotten using the data acquired during the experiment. These questions will be graded so take time to answer them carefully. Be sure that you use only the acquired data to answer the questions
12. **Conclusion:** This is your interpretation of the results of the experiment as an engineer. Be brief and specific. Give reasons for important discrepancies.

LABORATORY GRADING POLICY

1. Students must follow the Guidelines for Laboratory Report Notebook for submission of the laboratory report.
2. Each student must submit one **REPORT** per laboratory experiment.
3. The **EXACT DURATION** of a laboratory session will be decided by the laboratory instructor prior to **the laboratory experiment**.
4. Students **should not** skip the laboratory periods. **SPECIAL PERMISSION** must be obtained from the **LABORATORY INSTRUCTOR** to do so. Otherwise, grade points will be **DEDUCTED** from the student's total grade earned for the scheduled laboratory experiment.
5. Each laboratory session will be graded out of 100 points. The average of all the scores attained for all sessions in a semester will be the scores for the student in the course for that semester.
6. Students who arrive for a laboratory session more than thirty (30) minutes after commencement of session will not be allowed in and will be given a zero (0) grade for that session
7. All laboratory report **MUST** be submitted before the deadline as decided by the laboratory instructor.

If required, Lab policy may be modified at the discretion of the lab Instructor



EXPERIMENT #:
EXPERIMENT TITLE:

UILCPE/SMI 1
Measurement Error

OBJECTIVES:

- To study the major types and sources of measurement errors
- To understand how errors can be measured and recorded
- To take measurement of quantities such as current, voltage and calculate the errors in the expected value of readings

BACKGROUND:

Error in measurements occurs when there is a deviation in the readings of a measured quantity from its true value. Therefore, it is of utmost importance that errors be reduced to the possible minimal level in any measurement system. Three major sources of error have been identified. They are:

- (1) **Systematic Error:** These are errors due to a particular measuring instrument or experimental technique e.g. the use of non-calibrated instruments, taking measurement in the presence of noise and errors due to environmental changes.
- (2) **Gross Errors:** These errors occur due to human mistakes. For example, Mistakes in recording measured data and in calculating derived values.
- (3) **Random Error:** This is also called the mean deviation that results due to lack of precision in taking measurements i.e. unpredictable variations in the measurement system. They are either above or below the actual value. In this case, the mean of repeated readings can be taken to get the best estimate value.

The following error statistics have been found useful in error analysis.

$$\text{Absolute Error} = \text{Measured value} - \text{Expected value} \quad (1.1)$$

$$\text{Relative Error} = \frac{\text{Measured Value} - \text{Expected Value}}{\text{Expected Value}} \quad (1.2)$$

$$\text{Or Relative error} = \frac{\text{Absolute Error}}{\text{Expected Value}} \quad (1.3)$$

$$\text{Relative uncertainty} = \left| \frac{\text{uncertainty}}{\text{Measured quantity}} \right| \quad (1.4)$$

$$\text{Mean (Average)} \bar{x} = \frac{X_1 + X_2 + \dots + X_N}{N} \quad (1.5)$$

Where: $X_1 + X_2 + \dots + X_N$ = the sum of all readings taken.

N = the total number of readings

The variation in the measurements is usually reported by the standard deviation σ of the measurements. This is given as:

$$\text{Standard deviation } \sigma = \sqrt{\frac{d_1^2 + d_2^2 + \dots + d_N^2}{N-1}} \quad (1.6)$$

PREPARATION

1. In Figure 1.1, calculate the expected value of the voltmeter reading.

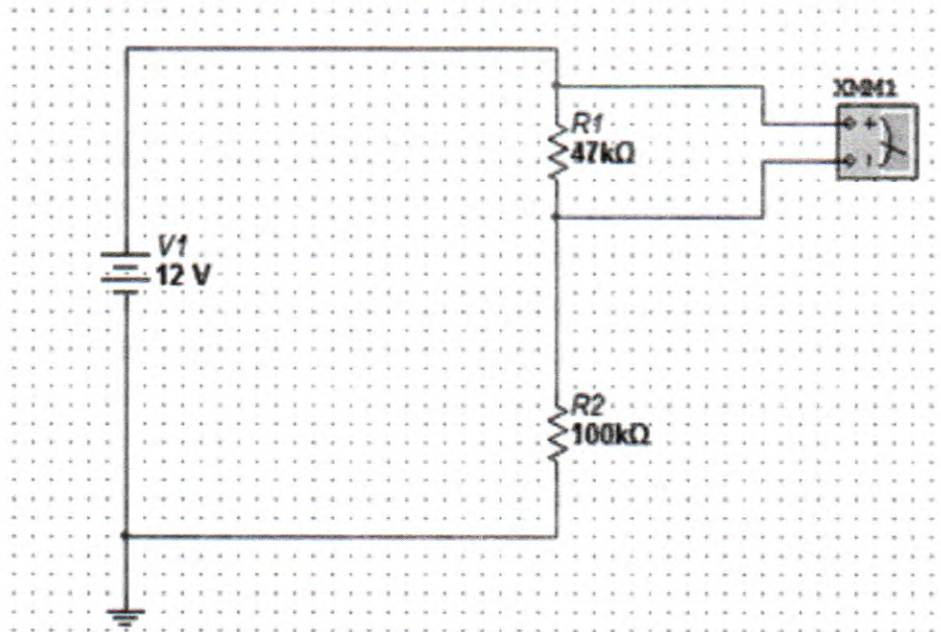


Figure 1.1: Voltage Measurement Circuit

2. If the fourth bands of your resistors are plated with gold, calculate the errors in the expected reading due to the error of the given resistors.
3. In Figure 1.2, calculate the expected value of the ammeter reading.

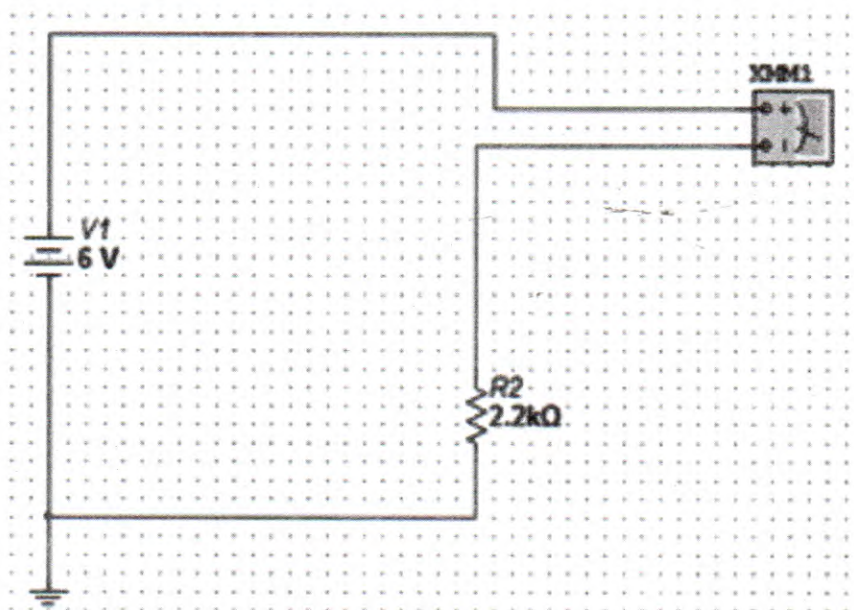


Figure 1.2: Current Measurement Circuit

4. If the fourth band of your resistor is plated with gold, calculate the error in the expected reading due to the error of the given resistor.

EXPERIMENT

- i. You are provided with three resistors with nominal value of $2.2\text{K}\Omega$, $47\text{K}\Omega$, and $100\text{K}\Omega$ to be used in this exercise. Measure and record the value of each resistor in turn using the Digital Multimeter.
- ii. Connect the circuit shown in Figure 1.1 on the breadboard, measure and record the voltage drop across the $47\text{K}\Omega$ resistor using the digital multimeter set to the range that will allow you to obtain the maximum digits after the decimal point.
- iii. Connect the circuit shown in Figure 1.2 on the breadboard, measure and record the current in the circuit using the digital multimeter set to the range that will allow you to obtain the maximum digits after the decimal point.
- iv. Carry out the simulation of the experiment in step ii and iii.
- v. You will be given a set of N number resistor of the same colour code, note the value of the resistor by its colour code.
 - a) Pick ten resistors out of the set, measure and record the resistance value of each resistor making sure all resistors of the sample are measure and a resistor is not measure twice (Record your reading under Sample A),
 - b) Repeat step v(a) taking fifteen and twenty resistors for Sample B and C respectively,
 - c) Compute and record the mean value

EXPERIMENT #: UILCPE/SMI2
EXPERIMENT TITLE: Signal Sensing and Transducing

OBJECTIVES:

- To obtain measurement for sample physical quantities
- To study resistance measurement technique using a Wheatstone bridge circuit
- To understand how a temperature transducer (thermistor) works; measure thermistor temperatures at varied resistance values

BACKGROUND

Measuring systems typically consists of three elements: a transducing, signal conditioner and the display. This can be represented as shown in the diagram below.

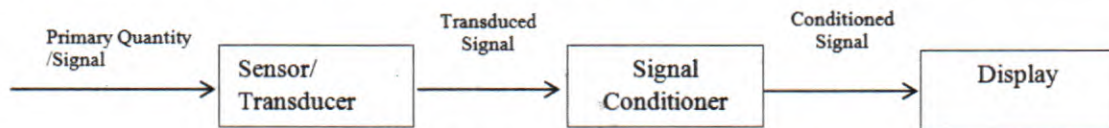


Figure 2.1: Block Diagram of a typical Measuring System

A transducer has two main components: the sensing element and the transducing element. Sensors detect or measure a signal or stimulus; they acquire information from the real world e.g. piezoelectric sensors, pressure sensors etc while the element which receives the physical/electrical quantity and converts or modifies it into other useful forms of physical variables that can be measured is the transducer. For example, speed can be converted to voltage. Primary transducer converts real world parameters into electrical signals while secondary transducer converts electrical signal into analog or digital usable values. Examples are: Potentiometer, photodiode/phototransistor, Wheatstone Bridge etc.

The Wheatstone bridge can be employed together with sensors such as thermistors to make measurements and to find the resistance of a resistor. Figure 2.2 is a typical arrangement of a Wheatstone bridge circuit.

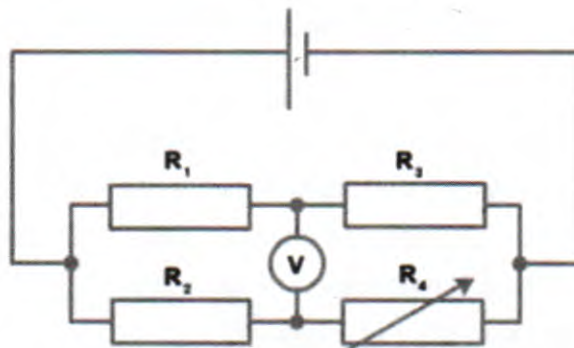


Figure 2.2: Wheatstone Bridge

The variable resistor R_4 is adjusted until the voltmeter reads 0V in order to ensure the bridge is balanced. When a Wheatstone bridge is balanced:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad (2.1)$$

When the bridge is unbalanced by altering the resistance of one of the resistors, a reading proportional to the change in the resistance of the resistor will be obtained.

PREPARATION

1. In Figure 2.3, calculate V_{R1} that will ensure null deflection of the galvanometer. Derive a mathematical expression to balance the bridge.
2. Replace R_3 with the following resistors and repeat step 1 with each resistor: 5K Ω , 10K Ω , and 20K Ω .
3. Replace R_1 and R_2 with 1K Ω resistor, and repeat step 1 and 2.

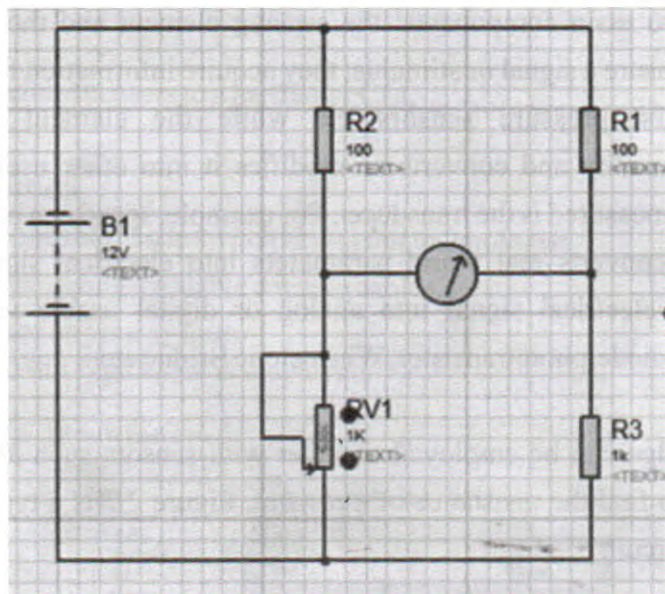


Figure 2.3: Measurement of an Unknown Resistance

EXPERIMENT

- i. Carefully connect the circuit in Fig. 2.3 on your breadboard.
- ii. Connect the DC power supply and gradually adjust the knob to 12V.
- iii. Adjust V_{R1} to achieve zero deflection on the galvanometer and measure the resistance of V_{R1} from the center of the port with respect to the ground.
- iv. Replace R_3 with the following resistors and repeat step (iii) with each resistor: 5K Ω , 10K Ω , and 20K Ω .
- v. Replace R_1 and R_2 with 1K Ω resistor, and repeat steps (iii) and (iv).
- vi. Carry out the simulation of the entire experiment.
- vii. Compare your result of the preparation, simulation and experiment.

EXPERIMENT #: UILCPE/SMI3
EXPERIMENT TITLE: Signal Conditioning

OBJECTIVE:

- To understand the operation of instrumentation amplifier

BACKGROUND

Transduced signals need to be modified or increased in magnitude before they are ready as output, this process is referred to as signal conditioning. One of the important functions of signal conditioning devices is signal amplification. An amplifier increases the magnitude of the weak signal received from a transducer. The amount by which the signal is increased is termed gain.

The Operational Amplifier (Op Amp) consists of two input terminals, one of which inverts the phase of the signal (the inverting input terminal), the other preserves the phase (non-inverting input terminal), and an output terminal as shown in Figure 3.1.

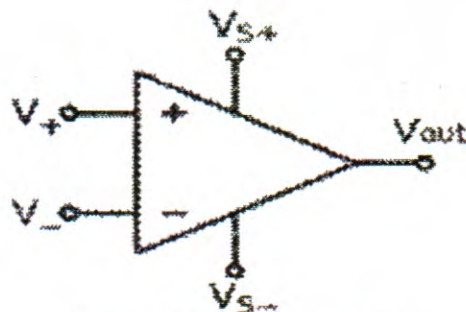


Figure 3.1: Operational Amplifier

Where:

V_+ = the non-inverting input

V_- = the inverting input

V_{out} = the output

An **Instrumentation Amplifier** is one of the most widely used Op-Amp in measurement systems. It is an extension of the difference amplifier in that, the difference between its input signals is amplified. The amplifier is made up of three op amps and seven resistors of equal values except the external gain resistor used in adjusting its gain and this is usually connected in between the gain setting terminals. The instrumentation amplifier amplifies small signal voltages. Figure 3.2 shows a typical instrumentation amplifier circuit.

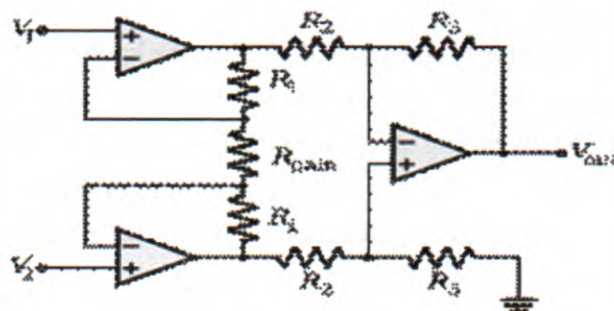


Figure 3.2: Typical arrangement of an instrumentation amplifier



The output voltage of an instrumentation amplifier is given by

$$v_0 = A_v(v_2 - v_1) \quad (3.1)$$

And the voltage gain,

$$A_v = 1 + \frac{2R}{R_G} \quad (3.2)$$

Where:

R_G = the external gain resistor,

R = the value of the equal resistors

This implies that the output voltage v_0 depends on the resulting difference between the two input signals v_1 and v_2

PREPARATION

1. Carefully study the circuit diagram of Fig. 3.3 and explain with the aid of a block diagram the stages of the signal processing of the amplifier.
2. With the aid of an equation, express the voltage gain at the output of IC₁, IC₂ and IC₃.

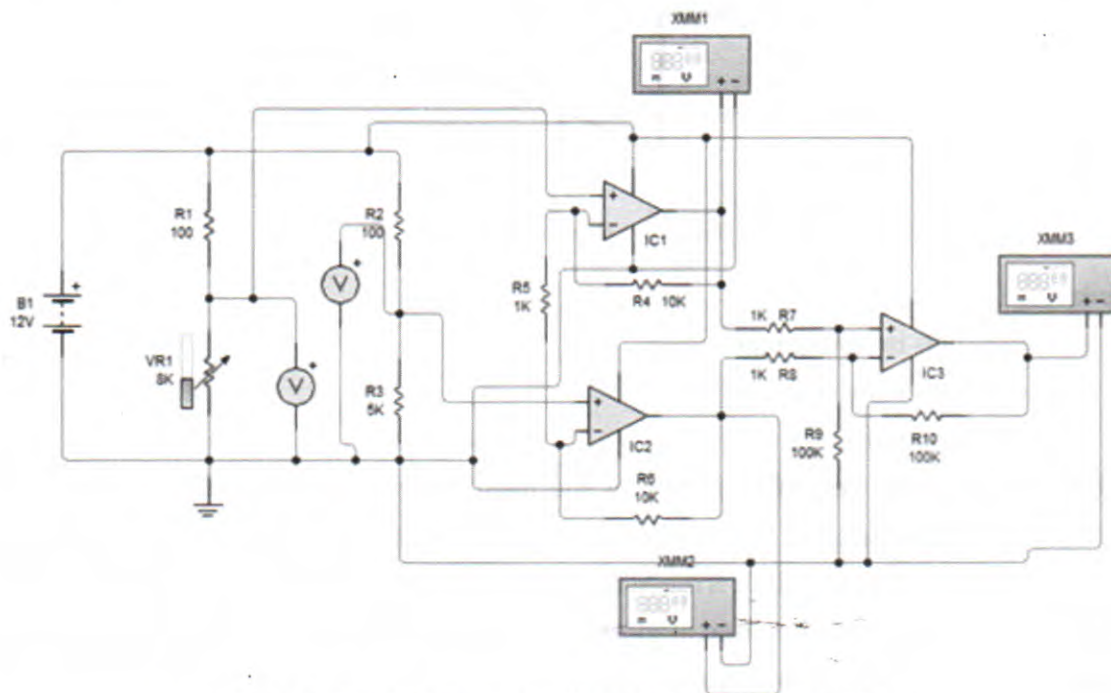


Figure 3.3: Circuit Diagram to simulate an Instrumentation Amplifier

EXPERIMENT

- i. Build and simulate the circuit in Fig. 3.3.
- ii. Connect the DC power supply and gradually adjust the knob to 12V.
- iii. Adjust V_{R1} and monitor the voltage at the output of each IC with your multimeter. Measure and record five different reading of V_{R1} including the resistance at which the bridge circuit is balanced and the corresponding voltage reading at the output of each IC.
- iv. Replace V_{R1} with Temperature Dependable Resistor (TDR) and then with Light Dependable Resistor (LDR) and repeat step iii above.
- v. Replace R_7 , R_8 , R_9 , and R_{10} with $10k\Omega$ resistor and repeat step iv above
- vi. Compare and contrast your results of steps iii and iv.

EXPERIMENT #: UILCPE/SMI 4

EXPERIMENT TITLE: Calibration

OBJECTIVES:

- To understand the importance of calibration
- To establish the characteristic relationship between temperature and output voltage
- To establish the characteristic relationship between temperature and resistance

BACKGROUND

Calibration forms a major part of error reduction approaches in measurement systems. Errors due to the environmental conditions in which instruments are used and the rate of usage of instruments can be corrected using calibration approach. Instrument Calibration helps in defining the degree of accuracy of the instrument under consideration. The calibration process can be described as making comparison between the output of an instrument under consideration and the output of an instrument whose accuracy is known (i.e. the calibrator or working standard) when the same input is passed to both. This process is repeated for a range of inputs to cover the whole range of measurement of the instrument. It is important to note that calibration instruments must be kept strictly for calibration purposes so that their accuracy can be maintained for an acceptable period of time.

Thermistors are temperature measuring devices made of ceramics or polymer used in various temperature measurement systems, hence, the need for a proper calibration procedure to ensure accuracy in its measurements. The resistance of a thermistor changes with its temperature in a nonlinear manner. The relationship is given by the Steinhart-Hart Equation 4.1.

$$T = \frac{1}{C_1 + C_2 \ln(R) + C_3 (\ln(R))^3} \quad 4.1$$

Where: T = the absolute temperature of the thermistor (in K)

R = Resistance of the thermistor at Temperature T (in Ω)

C_1 , C_2 and C_3 are constants known as the Steinhart parameters for a given thermistor.



PREPARATION

Consider the circuit in Figure 4.1; derive an equation to calculate the resistance of thermistor T_1 assuming all other parameters are known.

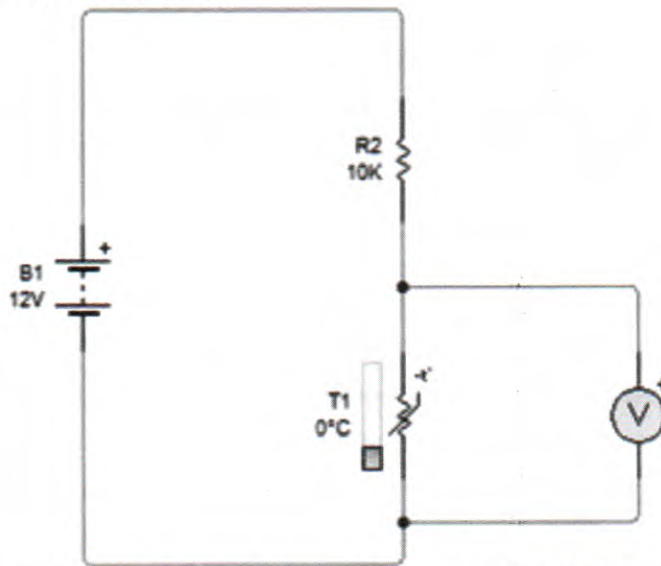


Figure 4.1: Circuit diagram to measure the Voltage across a Thermistor

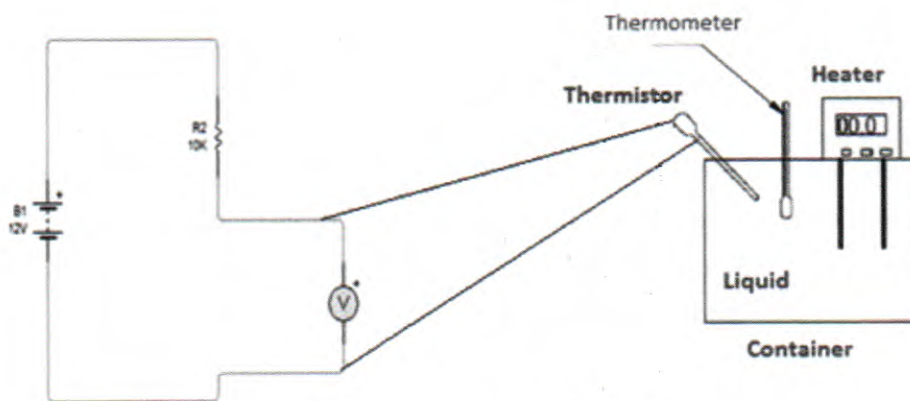


Figure 4.2: Illustration of Calibration Process

EXPERIMENT

- i. Set up the circuit diagram on the breadboard as shown in Fig.4.2 with a wire wrapping to extend the lids of the thermistor.
- ii. Fill the beaker/container with crushed ice from the refrigerator and add water from the lab sink.
- iii. Insert the thermistor head (ensure the lids is not in water), thermometer, and the electric heater into the ice water.
- iv. Mix the crushed ice and water thoroughly and wait for a minute or two to let the temperature in the beaker to become uniform. You can do the stirring with the boiling ring but be careful not to spill the water.
- v. Do not connect the heater to the supply until you are ready to take your reading and with the instructor approved.
- vi. Start your reading from 0°C , 5°C , or 10°C ; take not less than ten readings at a step of five. Plot the graph of Temperature ($^{\circ}\text{C}$) against Voltage (V). Calculate the thermistor resistance at each Voltage.

EXPERIMENT #: UILCPE/SMI 5**EXPERIMENT TITLE:** Signal Display**OBJECTIVES:**

- To understand how measured variables are displayed
- To study the mode of operation of the seven segment display module
- To carry out simulation using seven segment display module

BACKGROUND

Measured data needs to be presented in a form that can be readily used and analyzed. Various display techniques are available. For example, the oscilloscope, electrical meters which are used in measuring varying electrical voltage. Signals converted to digital forms can be displayed using electronic output displays. This form of display allows a parameter to be read immediately and any other response if required can be taken immediately as well. An example is the seven-segment display.

The seven-segment display is a common character format used for display purposes. It can display both numeric and alphabetic information but limited to the display of nine-letter subset of the full alphabet. It consists of seven rectangular LEDs usually labeled a, b, c, d, e, f, g; each LED is called a segment. It displays the required number by illuminating the individual segments in various combinations.

The seven-segment display is of two types: the common anode and common cathode. A common anode seven-segment display has all of the anodes of the LEDs tied together and each of the segments is illuminated by connecting to a LOW voltage while a common cathode seven-segment display has all the cathodes of the LEDs tied together and the individual segments are illuminated by connecting to a HIGH voltage.

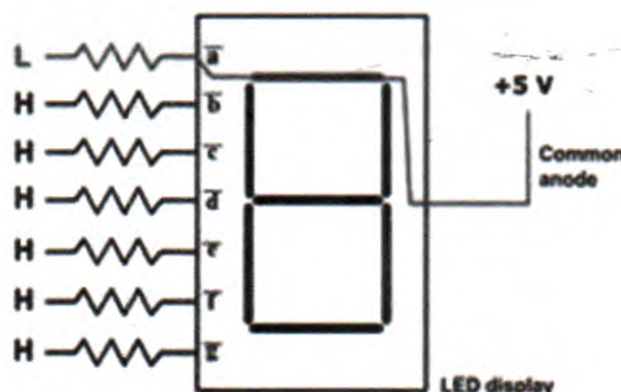


Figure 5.1: Common Anode Seven Segment Display

PREPARATION

- I. Describe the ICL7107 architecture for the Seven Segment Display as shown in Fig. 5.2.

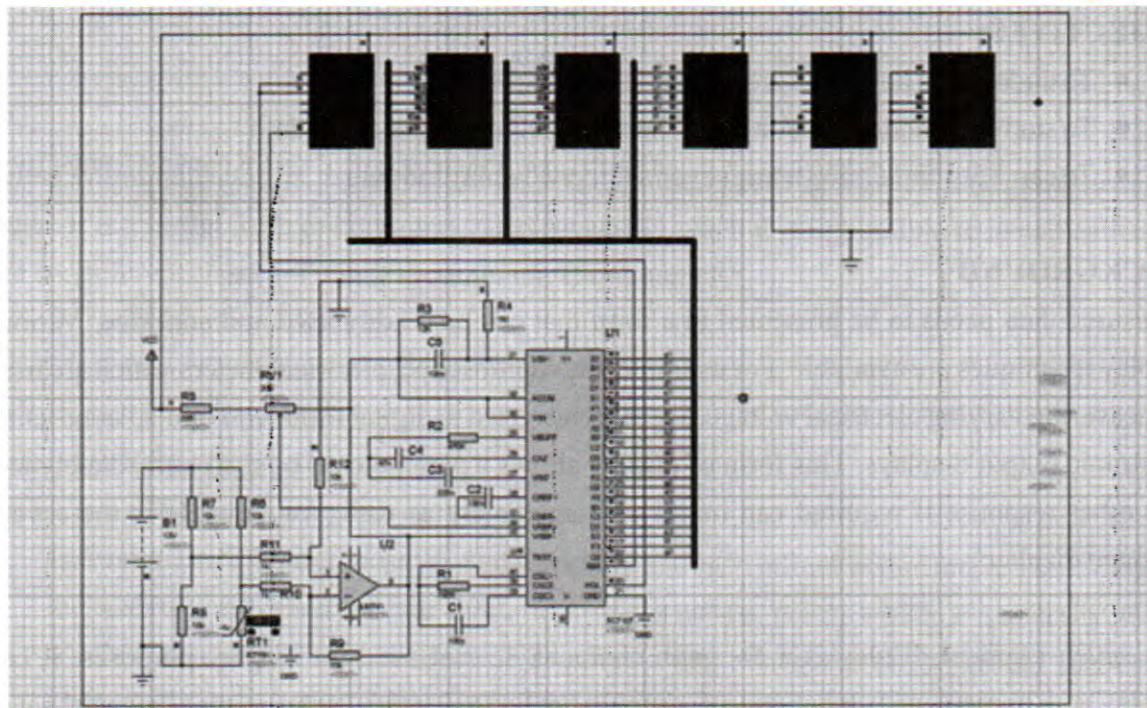


Figure 5.2: Circuit Diagram to display Measured Variable

EXPERIMENT

- i. Carry out the simulation of the circuit in Fig. 5.1 on Proteus simulating software.
- ii. When your simulation is successful, assemble your components on the breadboard.
- iii. Connect the power supply.
- iv. With your voltmeter across RT1, vary the temperature using soldering iron and observe the output temperature on the Seven Segment Display module.
- v. Record eight readings of five steps for temperature and corresponding voltages from your voltmeter.
- vi. Plot a graph of Temperature in ($^{\circ}\text{C}$) and voltage (V).

EXPERIMENT #:

UILCPE/SMI 6

Mini Projects:

1. Implement an amplifier(s) that can output +9VDC and -9VDC from the output of a strain gauge whose voltage varies from 0.3V to 1.4V as it is been subjected to various loads while connected to a supply of 12V.
2. Implement an automatic switching system to ensure all the flood lighting in a school premises automatic come ON during the night or when the weather is too cloudy and go OFF automatically when the day is bright enough. (Specifications: The switch should be able to control 5 lamps of 100Watts, 240V each).
3. Power a 30V, 1.5A cooling fan depending on the internal temperature of a compartment with a dual supply of $\pm 10V$. Using a Wheatstone bridge, implement a circuit that converts changes in resistance to voltage.
4. In a locally fabricated plastic molding machine, there is need to protect some of its electrical components such as the motor(s) from getting spoilt. As an instrumentation engineer, implement a circuit to monitor, display the molding machine temperature and automatically shut it down when it exceed its maximum rating temperature during molding process (max. temp. = $120^{\circ}C$).
5. Implement a system that can amplify the output from a mobile phone and microphone.

EXPERIMENT #: UILCPE/DEC 1
EXPERIMENT TITLE: Digital Logic Gate and Truth Table

OBJECTIVES

- To understand the behavior of various Logic Gate
- To verify truth table

EQUIPMENT AND COMPONENTS REQUIRED

1. Oscilloscope
2. Breadboard
3. DC power supply
4. Digital millimeter (DMM)
5. Resistors
6. Switch
7. LED
8. Logic gates

BACKGROUND

Logic gate is an electronic circuit that possess one or more input signals (0 or 1) with single logic output which is also 0 or 1 depending on the logic decision of the input signal. The logic signal 1 represents 5V, HIGH and TRUE while the logic signal 0 represents 0V, LOW and FALSE. Logic gate can have one or more inputs but always have one output. The truth table is used to depict the behaviour of logic gates. A typical example of logic gate (NAND) with three inputs and a single output is as shown in Figure 1.1 with equation 1.1 expressing the characteristics.

$$X = \overline{A \times B \times C} \quad (1.1)$$

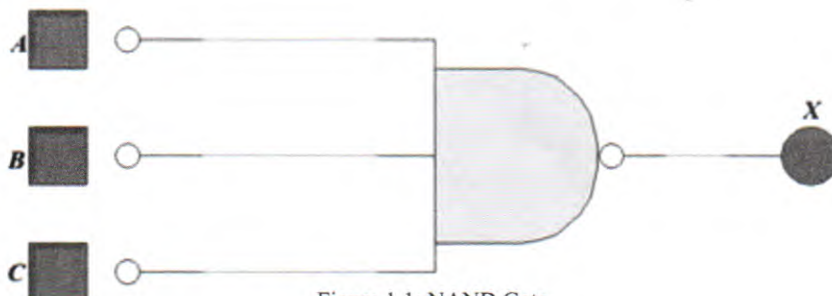


Figure 1.1: NAND Gate

Table 1.1: NAND Gate Truth Table

A	B	C	X
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

PREPARATION

1. A NAND gate with two inputs are connected with the outputs of another two NAND gates with two inputs. Identify the gate, show the layout of the statement in logical symbols and write its truth table.
2. A NOR gate with two inputs are connected with the outputs of another two NOR gates with two inputs. Identify the gate, show the layout of the statement in logical symbols and write its truth table.
3. Draw the symbols and truth table for various logic gates. Show the mathematical relationship between the inputs and output.
4. Mention five areas of application of digital Logic gates.

EXPERIMENT

1. Connect the circuits shown in Figures 1.2 – 1.8 using the logic gate provided.
2. Using a digital millimeter and Oscilloscope measure the voltage at the input terminal of various gates and the output terminal. Show the input and output waveform. Any discrepancies? Explain your observation.
3. Show the truth table for Figures 1.2 – 1.8. Observe the input and output of various logic gates used through the LED.
4. Compare the results from 3 with the one obtained in preparation 4. State your observations.

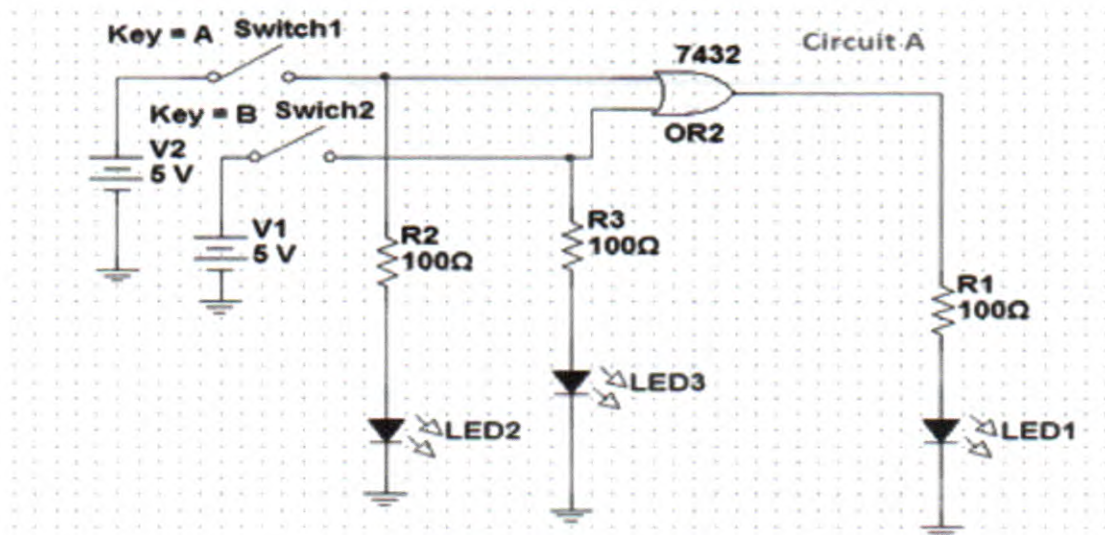


Figure 1.2: Demonstration of OR-gate operation

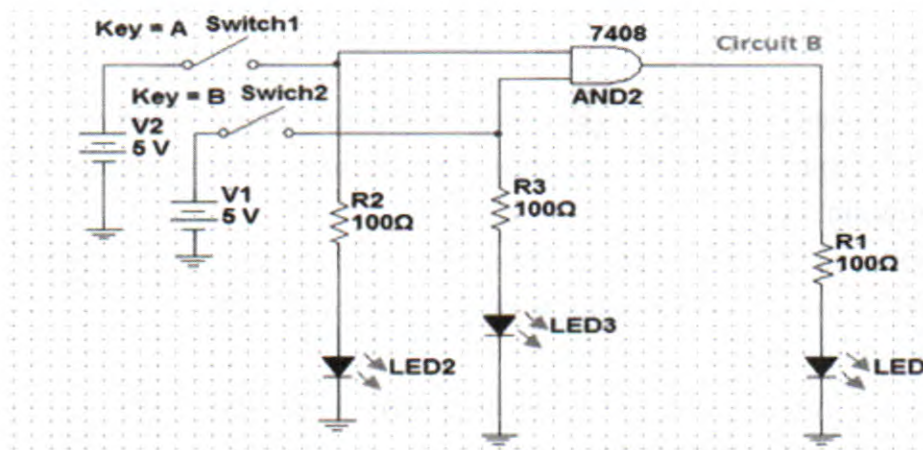


Figure 1.3: Demonstration of AND-gate operation

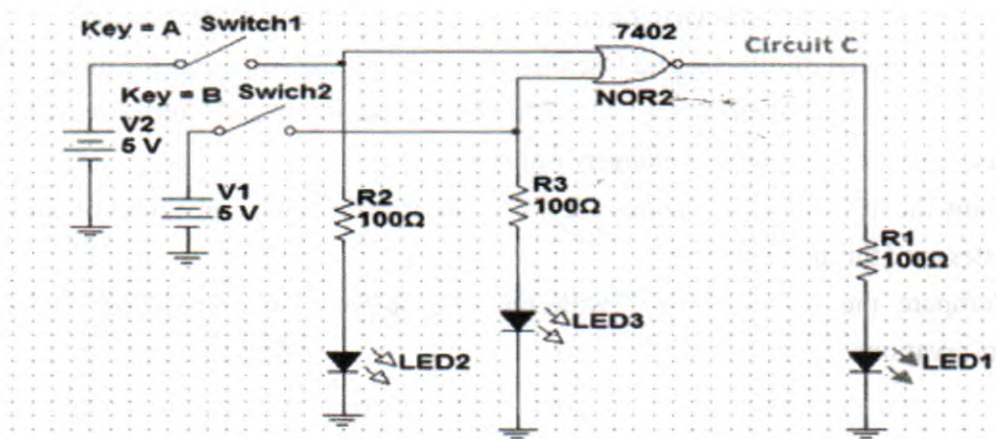


Figure 1.4: Demonstration of NOR-gate operation

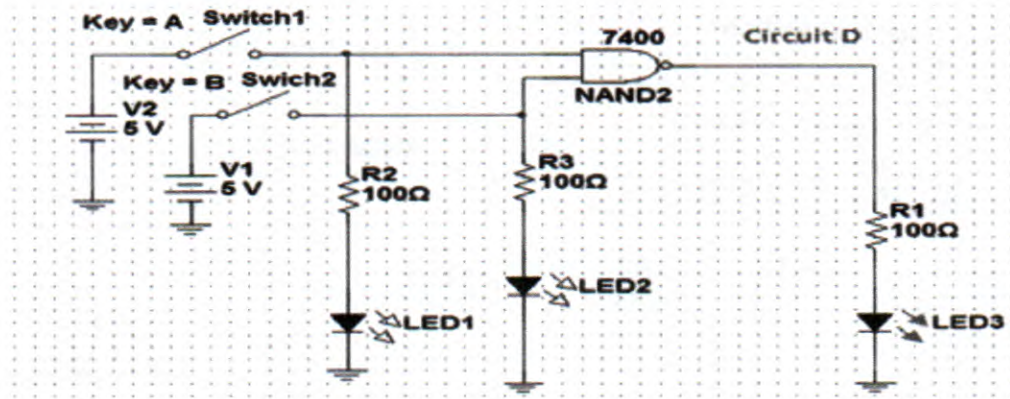


Figure 1.5: Demonstration of NAND-gate operation

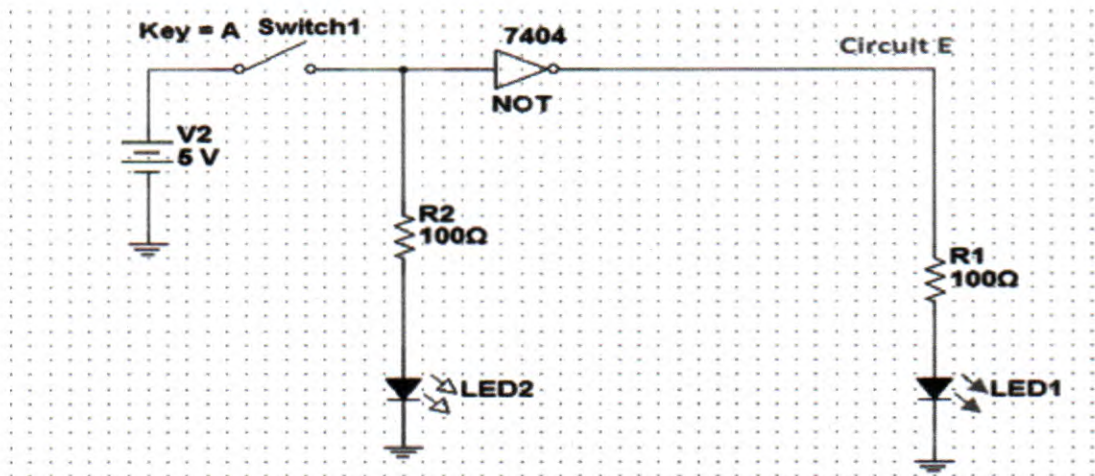


Figure 1.6: Demonstration of NOT-gate operation

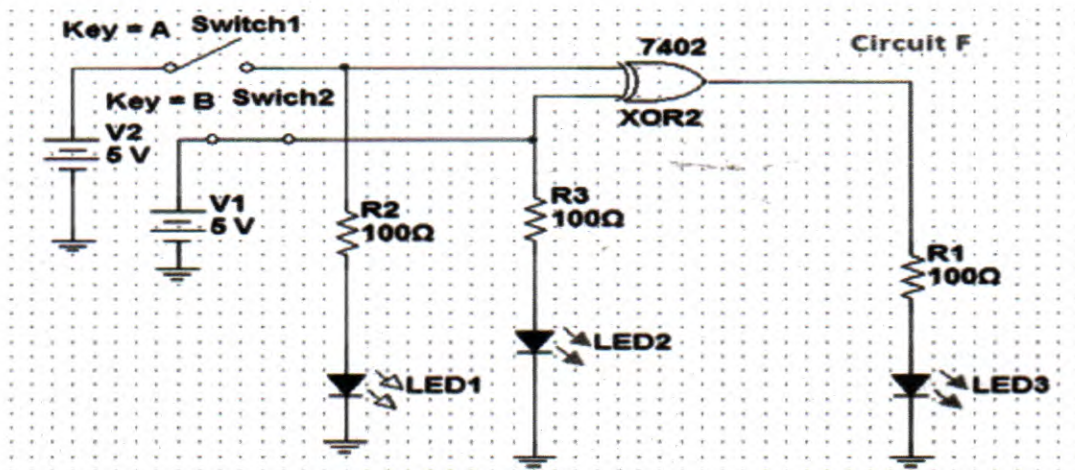


Figure 1.7: Demonstration of XOR-gate operation

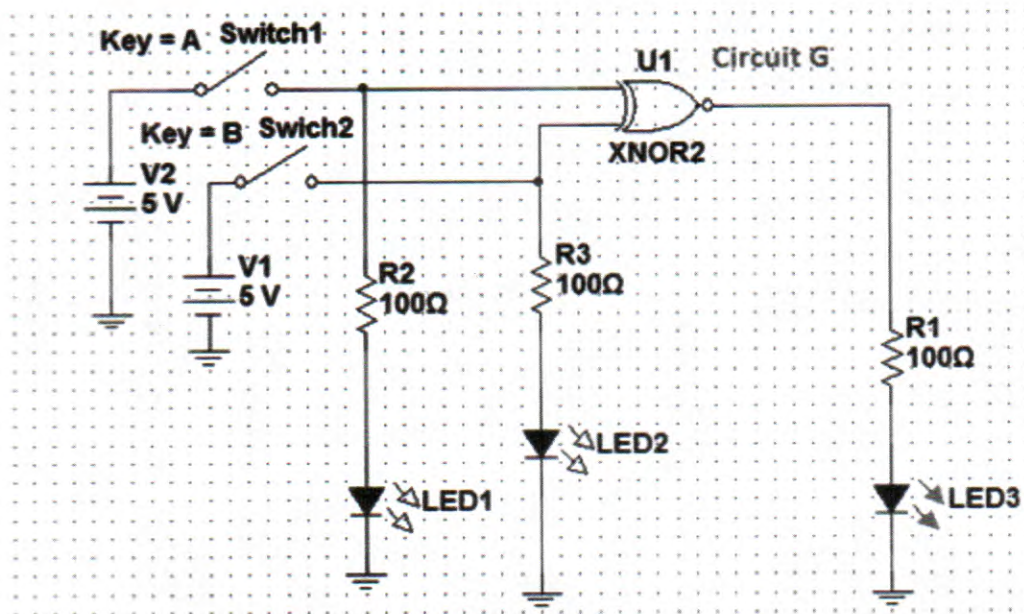


Figure 1.8: Demonstration of XNOR-gate operation

EXPERIMENT #: UILCPE/DEC 2**EXPERIMENT TITLE: Combinational Logic Circuits****OBJECTIVES:**

- To implement Half-adder and Full adder
- To implement Half-subtractor and Full- subtractor

EQUIPMENT AND COMPONENTS REQUIRED

1. DC power supply
2. Digital Multimeter (DMM)
3. Logic gates
4. Oscilloscope

BACKGROUND

Combinational Circuit is the arrangement or assembly of two or more logic gates, devices or circuit to attain a logic function or operation. Combinational circuits are dependent solely on the logic levels of the input signal at that particular period of time, there output signal is independent of the past logic levels of their input signal. However, they are memoryless logic gates i.e they don't possess any memory due to the fact that there output is not prior to the previous input logic levels. Information cannot be stored when using combinational circuit unlike flip flop systems which possess memory function due to the output signal depending on the previous input logic signal. They possess one or more input signals with one or multiple output signals which is basically used to make logic decision to governor the operation of digital devices. There are several examples of combinational logic circuits namely: Adders, Subtractors, Multiplexers, Demultiplexers, Encoders and Decoders e.t.c.

Adders: - It is a logic operation used to perform arithmetic function of summing up of two or more binary bits together. This binary operation is used in digital electronics to sum up binary bits together in order to control compound circuit. Adders can be classified into:

- **Half Adder:** - It is a logic operation that sum binary bit using two logic gate i.e the XOR and the AND logic gate. The two logic gates are combined together to sum the current state of two input signals to give two output signals i.e the SUM and the CARRY.
- **Full Adder:** It is a logic operation that is used to perform extensive addition of more binary bits. The half adder has a limitation of performing just only two bits addition operation from the input signals. It cannot accommodate carry-in from previous additions. In order to execute addition operation from previous computations there is need to have another input from the previous addition with the present two input signals to sum up, making the total of three input signal to compute.

Subtractor: - It is a combinational circuit that computes the difference between two binary digits at a time. It operates just like adders by applying the complement approach. There are different categories of subtractor, namely:

- **Half Subtractor:** The half subtractor operates with two logic gates, i.e. XOR gate, NOT gate and AND gate. These three logic gates are combined all together to form the half subtractor.
- **Full Subtractor:** It is a combinational logic circuit that performs extensive arithmetic operation of many bits at a time. It is the combination of two half subtractors and one OR gate; also, it works exactly like a full adder and increases the number of bits it can compute with full advancement compared to half subtractor.

PREPARATION

1. Mention the advantage of Full adder over half adder
2. State the difference between Sequential and Combinational Circuits

EXPERIMENT

1. Connect the circuit diagrams of Figures 2.1 to 2.5.
2. Using a digital Multimeter, measure the outputs of the final gates. State your observations.
3. Use an oscilloscope to monitor the output waveform.
4. Based on the input and output of the logic gate combination in Figures 2.1 – 2.5, represent the combinations with a truth table for Half-adder, Full adder, half-subtractor and full-Subtractor.

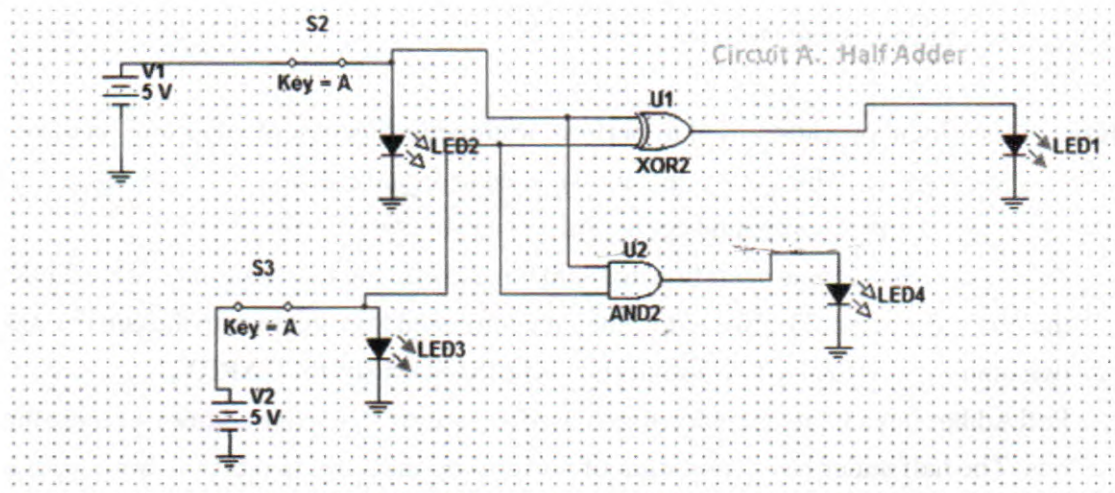


Figure 2.1: Demonstration of Half Adder operation

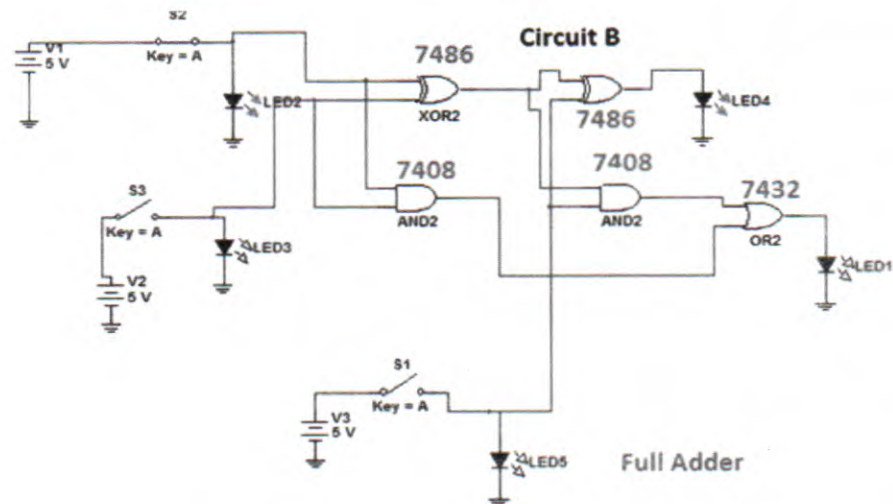


Figure 2.2: Demonstration of Full Adder operation

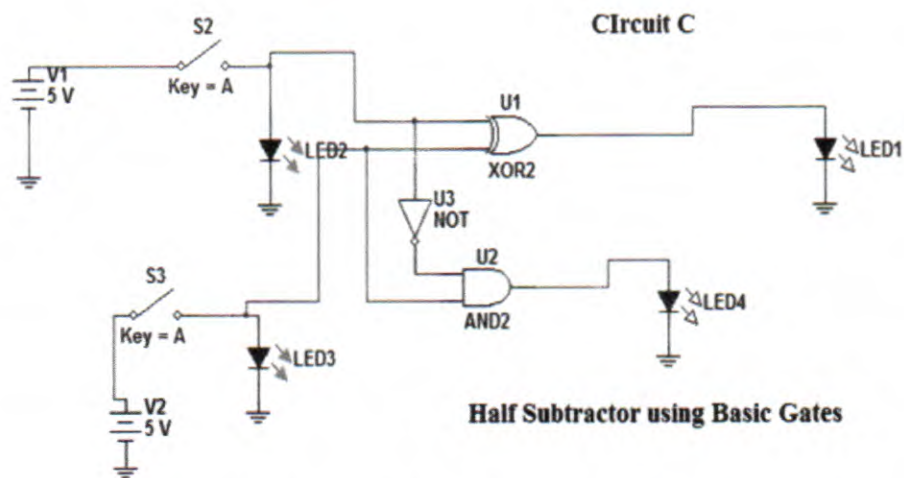


Figure 2.3: Demonstration of Half Subtractor operation

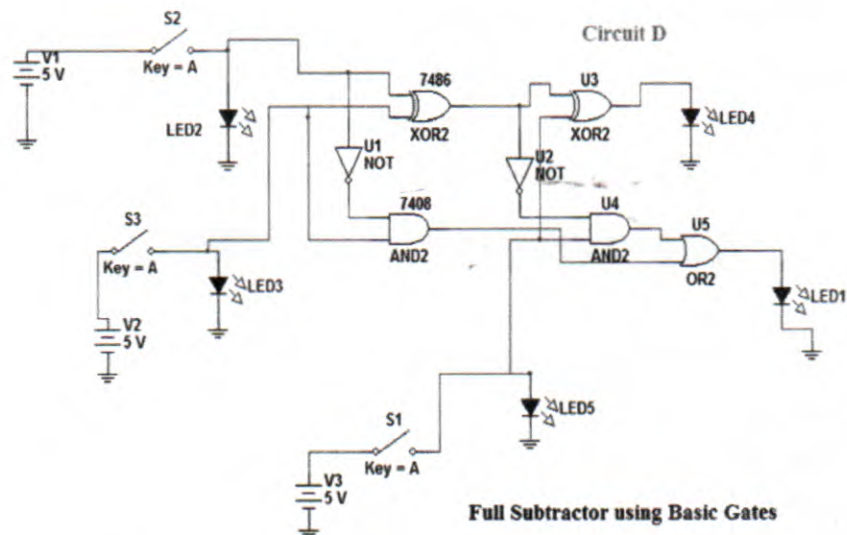


Figure 2.4: Demonstration of Full Subtractor operation

EXPERIMENT #: UILCPE/DEC 3
EXPERIMENT TITLE: A/D and D/C Converter

OBJECTIVES:

- To construct and study the output of a 4-bit R-2R ladder type of digital to analog converter
- To construct and study the output of a Flash type of analogue to digital

EQUIPMENT AND COMPONENTS REQUIRED

1. DC power supply
2. Digital Multimeter
3. Op Amp
4. Potentiometer
5. Resistors
6. Oscilloscope

BACKGROUND

Analog signals are continuous variable at different time interval, there values changes with respect to the physical quantity or parameter attached to it. Analog signal is a function of physical entity related to it. They are always inconsistent and need to be sampled before the signal can be used to perform a specific function. The digital signal is a discrete value which is either 1 or 0 bit. Most digital electronics uses discrete values for it normal logic operation and also to perform advanced control.

- ❖ **Analog to Digital Conversion:** It is the conversion of analog signals which is a continuous variable into discrete component or binary bits (0 or 1). Most sensors or transducers signal are always in physical quantities which relate with the parameter that they vary with, these signals cannot be used for logical operation or analysis, and therefore there is need for them to be sampled and converted to logic. The calculation for the ADC in digital electronics can be deduced in equation 3.1.

$$\text{Digital Value / Decimal Equivalent} = \frac{\text{Voltage Input} \times 2^n}{V_{ref}} \quad (3.1)$$

Where: Digital value is the binary equivalent

Voltage Input is the analog signal

V_{ref} is the reference voltage

n = no of bits

- ❖ **Digital to Analog Conversion:** - It is the conversion of digital signal (0 or 1) into analog signals and it is also known as DAC. The discrete numbers or binary numbers is converted to analog signal for further electronic operation to be carried out on it. This is mostly used in telecommunication field, where the signal bit or digital component has to be converted to analog signal or continuous variable with respect to the digital component before the signal can be



transmitted from one point to another via a designated medium like air or copper cable. The calculation for the DAC can also be deduced in equation 3.2.

$$V_{out} = \left(\frac{(V_{ref} \times \text{Decimal equivalent})}{2^n} \right) \quad (3.2)$$

Where Digital value is the binary equivalent

Voltage Input is the analog signal

Vref is the reference voltage

n = number of bits

$$\text{Resolution for Digital to analogue} = \left(\frac{V_{ref}}{2^n - 1} \right) \quad (3.3)$$

PREPARATION

1. Calculate the equivalent analogue output for all possible combination for 4 bits digital input.
2. Why is R2R method of conversion in Digital to analogue preferred to other methods
3. Why is Flash method of conversion in analogue to Digital preferred to other methods
4. Calculate the resolution for a 4 bit digital input with 10V input voltage and compare the result with the difference in voltage from one digital state to another.
5. Show that the maximum number of output voltage is $\left(\frac{15}{16} \times V_{ref} \right)$

EXPERIMENTS

(A) Digital to Analogue

1. Connect the circuit diagram in Fig. 3.1 using any simulation software.
2. Set up the circuit on your project board.
3. Apply 4 bit in various combinations and observe the corresponding analogue output.
4. Based on your circuit analysis, construct a table giving the output voltage for each DAC binary value 0000 to 1111.
5. Compare this with the result in PREPARATION 1.
6. Subtract the difference in voltage to switch from one digital state to another and record the value. State your observation.

(B) Analogue to Digital

1. Connect the circuit diagram in Figure 3.2 using any simulation software.
2. Set up the circuit on your breadboard.
3. Set the input voltage to 5V and set the reference voltage to 10V. Observe the corresponding digital output.
4. Record the values of the input voltage when each LED at the output is HIGH.

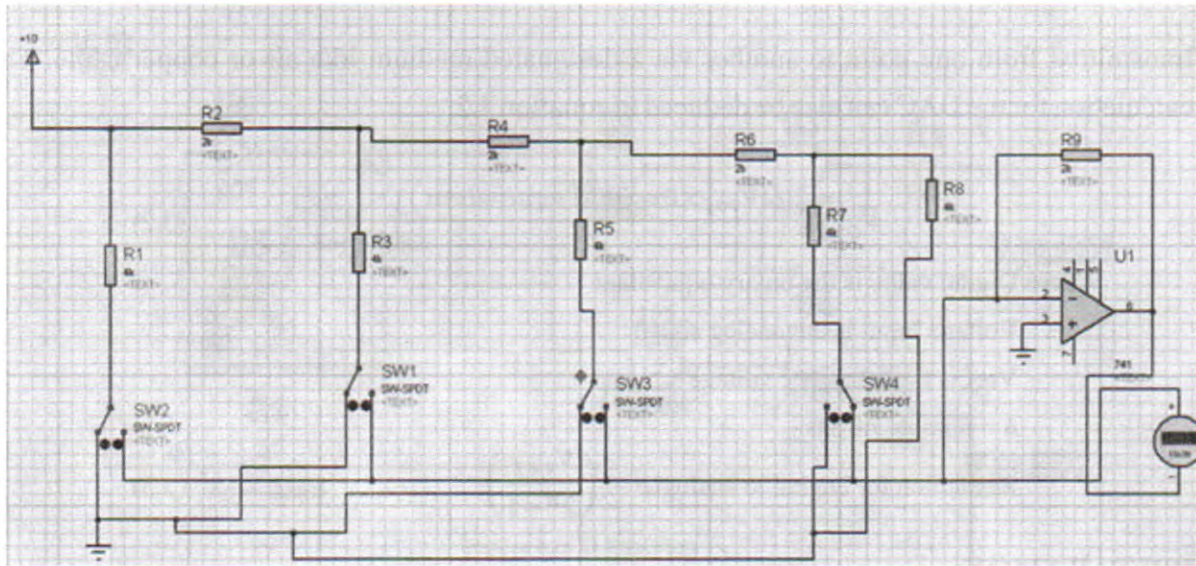


Figure 3.1: Digital to Analog Converter circuit diagram

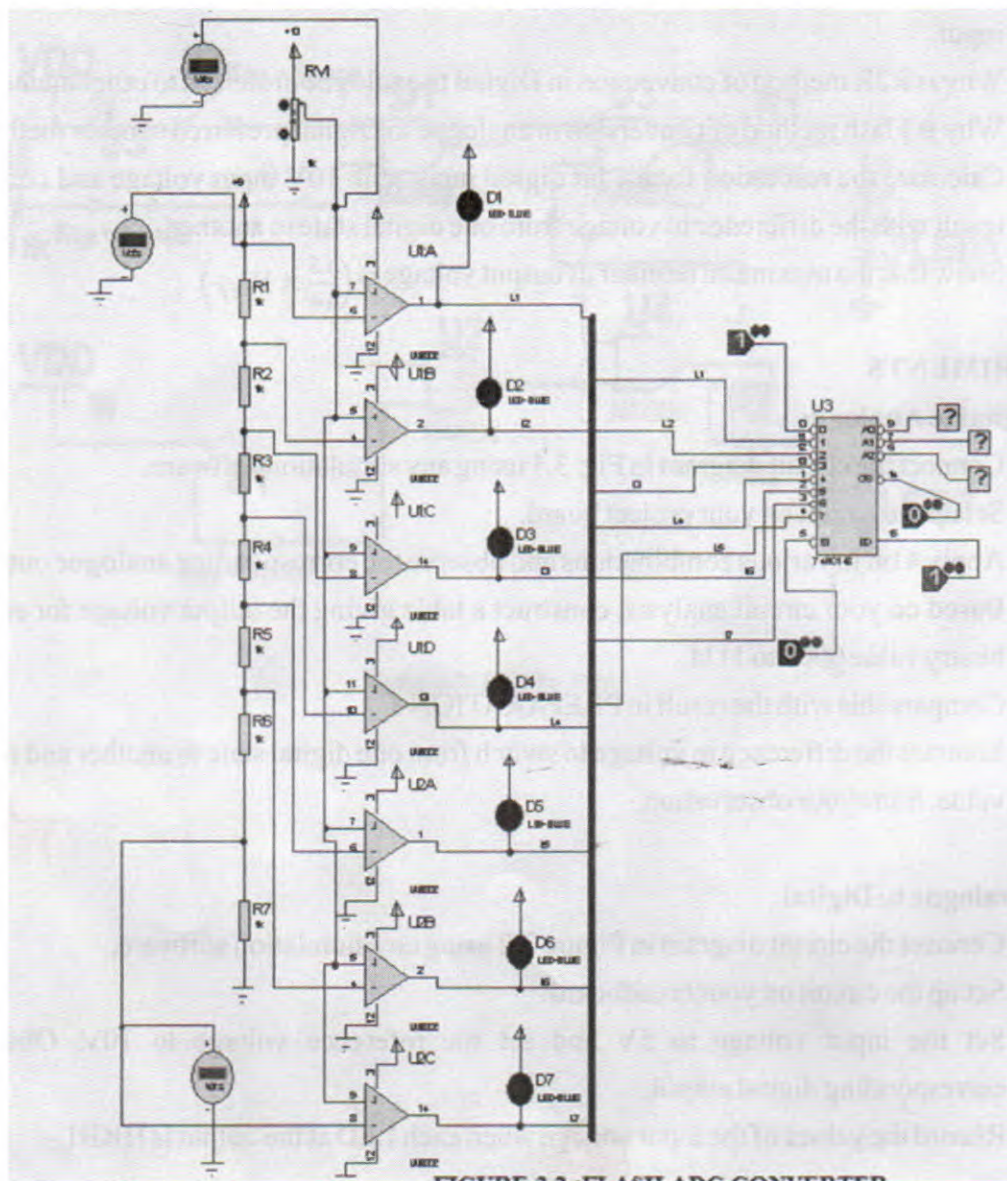


Figure 3.2: Analog to Digital Converter

EXPERIMENT #: UILCPE/DEC 4

EXPERIMENT TITLE: Circuit Minimization

OBJECTIVES:

- To reduce complex logic function
- To Draw K-map of any given complex function based and show the implementation with logic gates

EQUIPMENT AND COMPONENTS REQUIRED

1. DC power supply
2. Digital Multimeter (DMM)
3. Logic gates
4. Switch
5. Resistor
6. LED

BACKGROUND

Circuit Minimization involves the reduction of any given complex circuit into smaller entities with the retention of its similar operation and functionality. It is basically used to reduce space, power consumption, resistance in the circuit and decreasing the components failure which can affect the reliability of the system. The common approaches of minimizing logic circuits are Boolean Algebra, De Morgan's Theorem and Karnaugh Map. The complex logic circuit with each bit in either HIGH or LOW state is represented in Boolean Algebra and solve with different law in order to establish the output. There are several conservative law of Boolean Algebra ranging from AND Law, OR Law, Associative Law, Commutative Law, Complementation Law, Associative Law, Absorptive Law, Distributive law and so on. De Morgan's Theorem is also used in logic analysis to solve complex logic circuit into simpler forms with the approach of Sum of Product (SOP) and Product of Sum (POS) in solving Boolean Algebra. The process of using De Morgan's theory to resolve a complex logic circuit is known as demorganization while the Karnaugh Map also known as K - Map works like the truth table in analyzing logic circuit and also in reducing their forms too. It is also an effective way of reducing the circuit.

PREPARATION

1. Minimize the following Boolean expression using Karnaugh map
 - A. $F = W'X'Y'Z' + W'X'YZ + W'XYZ' + W'XYZ + WX'Y'Z' + WX'YZ' + WXYZ' + WXYZ$
 - B. $F = X'Y'Z' + X'Y'Z + X'YZ + X'YZ' + XY'Z' + XYZ'$
2. Reduce the following expressions using DeMorgan's theorem
 - A. $(X' + (YZ)')'$
 - B. $((AB) + (CD))''$

EXPERIMENT

1. Consider Figure 4.1 with four switches namely WXYZ. LED is connected to the output which is to be powered on when the following conditions are satisfied. You only have an output when these three conditions are satisfied:
 - i. The switches 1 and 4 are closed or switches 2 and 3 are closed
 - ii. The four switches are closed
 - iii. Any three of the four switches are closed
2. Draw the truth table of circuit shown in Figure 4.1
3. Draw the K- Map to represent the truth table
4. Use the K- Map to minimize the function
5. Circuit in Figure 4.2 is a minimized logical circuit of Figure 4.1. Connect both circuits using any simulation software and also implement this on your project board. State your observation.

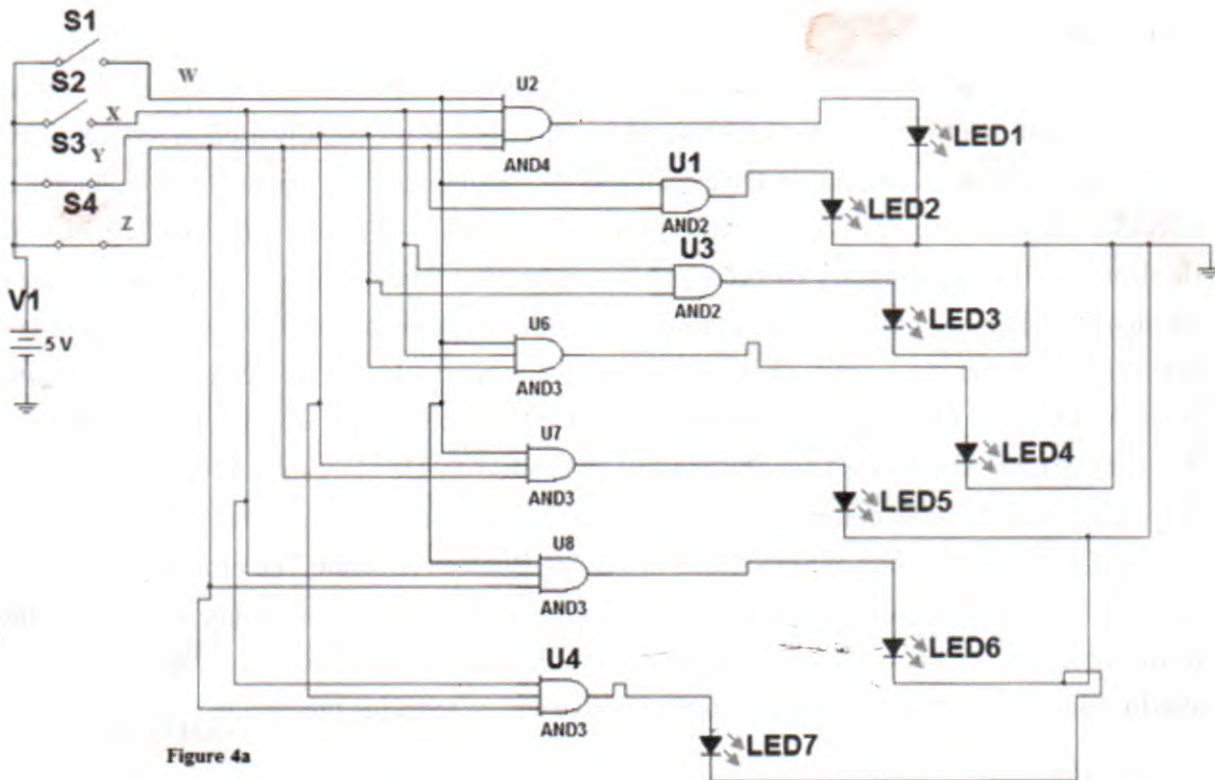


Figure 4.1: Complex Logic Gates arrangement

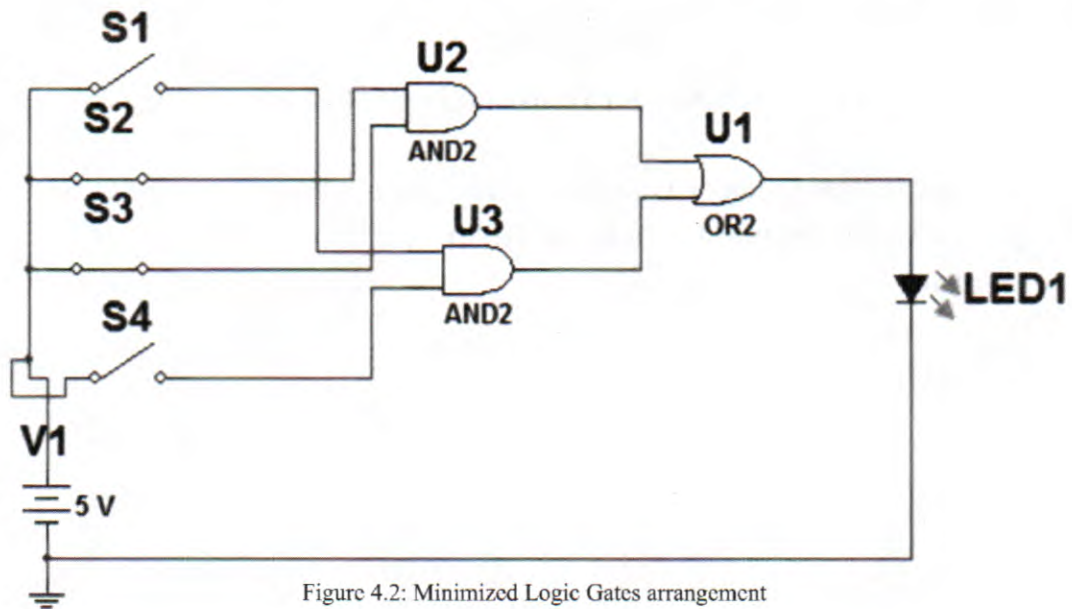


Figure 4.2: Minimized Logic Gates arrangement

EXPERIMENT #: UILCPE/DEC 5**EXPERIMENT TITLE: Transistor Transistor Logic (TTL)****OBJECTIVE:**

- To study the operation of Transistor Transistor Logic

EQUIPMENT AND COMPONENTS REQUIRED

1. Breadboard
2. DC power supply
3. Digital Multimeter (DMM)
4. Resistors
5. Transistors
6. Diodes
6. Oscilloscope

BACKGROUND

Transistor – Transistor Logic (TTL), is a logic device or Integrated Circuit (IC) module used to attain logic functions such as AND, OR, NOT, XOR, XNOR. They contain multiple logic gates internally in which the input or output is connected via the pin outlet. They are powered by +5V DC externally. The input logic signal 1 (or High) is active when the voltage supply to the logic function is between 2V and 5V denoted by V_{IH} , while the input logic signal 0 (or LOW) is active based on supply of 0V to 0.8V. The range between 0.8V to 2V is known as indeterminate which illustrates that if voltage is supplied within this range it can be interpreted as Logic HIGH or LOW, thus making the system not reliable at that particular instance. However, for the Logic Output, the output voltage signal which represents Logic State 1 (or HIGH) ranges from 2.4V to 5V denoted by V_{OH} while the Logic State 0 (or LOW) ranges from 0V to 0.4V which is also represented as V_{OL} . The logic state which is represented by the voltage range in between 0.4V to 2.4V is indeterminate and be referred to as Logic HIGH or LOW, any Logic circuit with this voltage output is not reliable. Considering the Bipolar Logic Family the most widely used is Transistor-Transistor Logic and and this evolved directly from Diode –Transistor Logic. It has strong drive capability and can be used as a complimenting switch or inverter. TTL NAND gate with Totem pole Output circuit is suitable when Low power dissipation, Low output impedance and Improved Propagation time delay is desired. This can be achieved by replacing the output collector resistor with combination of two transistors and a diode to form an output stage called a totem pole.

1. The General Transistor Transistor Logic Inverter

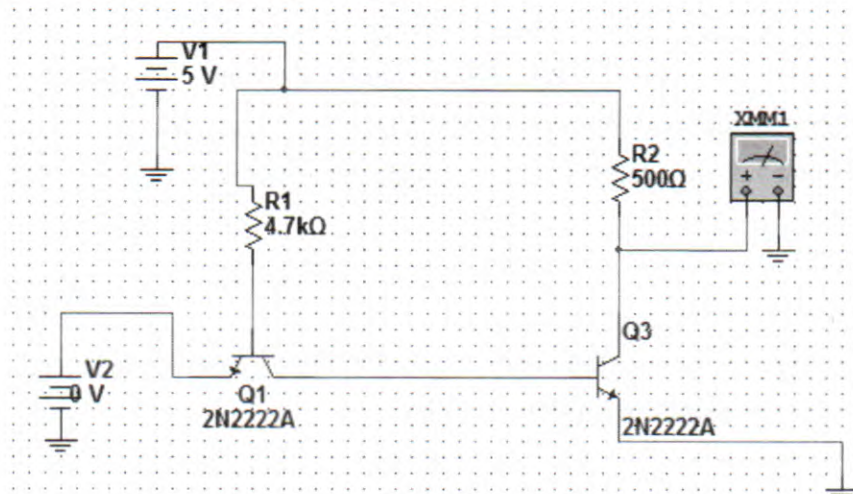


Figure 5.1: Basic TTL Inverter Circuit

2. Two input TTL NAND gate

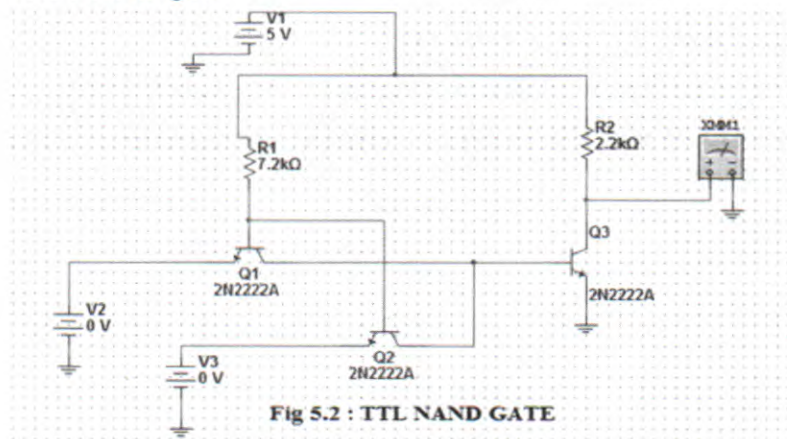


Fig 5.2 : TTL NAND GATE

Figure 5.2: TTL NAND Gate

3. Two input TTL NAND gate with Totem pole Output

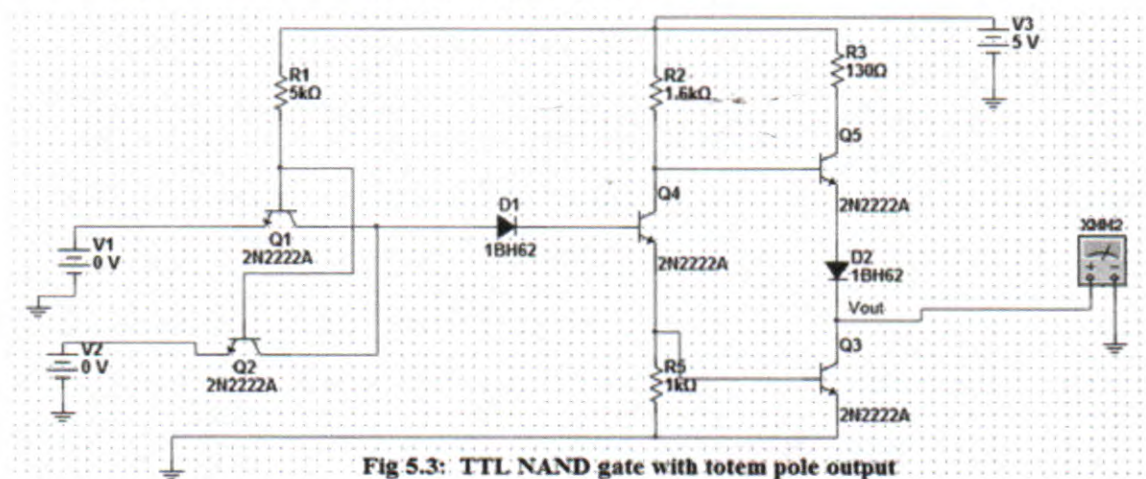


Fig 5.3: TTL NAND gate with totem pole output

Figure 5.3: TTL NAND Gate with Totem pole output

PREPARATION

1. Draw the diode equivalent circuit of Figures 5.1 and 5.2.
2. Explain briefly three bipolar logic families and the advantages of TTL over them.
3. Explain briefly the working principle of TTL NAND gate with totem pole.
4. Using Figure 5.3, calculate the output voltage when V_1 and V_2 are in LOW and also HIGH states.

EXPERIMENT

1. Build and simulate the circuit shown in Figure 5.1. Measure the output voltages V_{OH} and V_{OL} .
2. Build and simulate the circuit shown in Figure 5.2. Set;
Case 1: $V_2=0, V_3=0$; Case 2: $V_2=0, V_3=5$; Case 3: $V_2=5, V_3=0$ and Case 4: $V_2=5, V_3=5$.
3. Draw the truth table for case 1 to 4.
4. Using the following parameters, measure the output voltage and draw a typical voltage transfer curve of TTL circuit. Let $V_2=V_3=V_{input}$, for $0 \leq 0.9$ increase V_{input} in step of 0.1 and for $1 \leq 5$ increase V_{input} in step of 1
5. What are the values of V_{OH}, V_{OL}, V_{IH} and V_{IL}
6. Build and simulate the circuit shown in Figure 5.3. Measure the output voltage when the two inputs are LOW and HIGH respectively. Also compare measured values to calculated values.

EXPERIMENT #: UILCPE/DEC 6**EXPERIMENT TITLE:** Flip Flop**OBJECTIVES:**

- To understand Flip Flop (FF) and latch as memory devices
- To understand behavior of different types of Flip Flop

EQUIPMENT AND COMPONENTS REQUIRED

1. Oscilloscope
2. Breadboard
3. DC power supply
4. Digital millimeter (DMM)
5. Function Generator
6. Logic Gates
7. Switches

BACKGROUND

Flip Flop (FF) is the combination or arrangement of different logic gates to form a memory cell. They depend on the past and present logic levels to give their outputs. These logic gates are arranged like combinational circuit but they possess the feature to store information hence, they are referred to as memory logic gate. Flip flop gates consist of one or multiple logic input with just only two different outputs known as Normal Output (Q) and Inverted Output ($\bar{Q}$) is called RESETTING or CLEARING. Flip Flop is a family name used generally to classify latch, bistable multivibrator and other forms of logic memory.

- ❖ **Latch:** It is the most common form of logic memory gates and it can be designed using either NAND gate or NOR gate. Latch is more sensitive to input change compared to flip flop. Figures 6.1 and 6.2 show the circuit diagrams of NAND gate and NOR gate Latches.

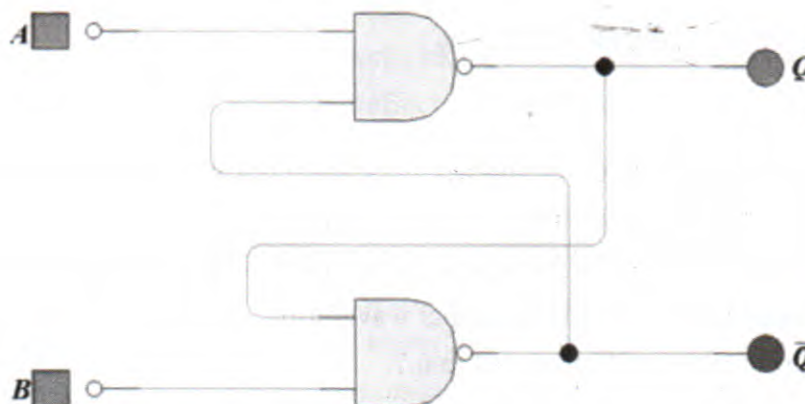


Fig 6.1: Diagram of NAND gate Latch

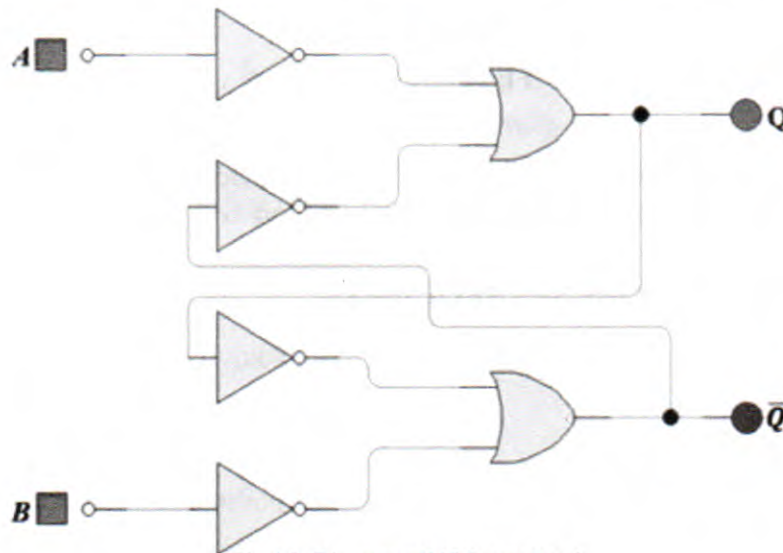


Fig 6.2: Diagram of NOR-gate Latch

- ❖ **SR Flip Flop:** It is also known as SET RESET flip flop which is constructed using two cross-coupled NOR logic gates. The Set and Reset is the input logic signal of the SR flip flop while the output signal is Q and ($\bar{Q}$). Q and ($\bar{Q}$) are in hold state when the set(S) and reset(R) inputs are LOW ($S = R = 0$).
- ❖ **J K Flip Flop:** The output doesn't alter (i.e change) when the input signals are low (i.e $J = 0, K = 0$), the output is in SET mode only when J is in high state and K is in low state (i.e $J = 1, K = 0$), while the output is in RESET mode when K is in high state and J is in low state (i.e $J = 0, K = 1$).
- ❖ **D Flip Flop:** It is also a memory logic circuit known as delay flip flop or data Flip Flop. At each instant of clock signal like rising edge of the clock, it notes the value of the D-input signal which is the normal output (Q) of the D Flip flop. In most of the application the normal output (Q) does not change but when the clock is at non – rising edge the D-input signal is at don't care condition. The D input and clock input is neglected if the logic circuit is forced to set or reset. The D flip flop is mostly used in shift registering, memory cell and delay line in digital electronics.

PREPARATION

1. The waveform in Figure 6.3 is applied to a typical NAND SR latch. Assuming the initial value of Q is 0. Sketch the output waveform.
2. The waveform in Fig 6.3 is also applied to a typical NOR SR latch. Assuming the initial value of Q is 0. Sketch the output waveform.
3. Draw the truth tables of Figures 6.4 to 6.7.
4. Use the result from 3 to explain the difference between Latch and Flip flop

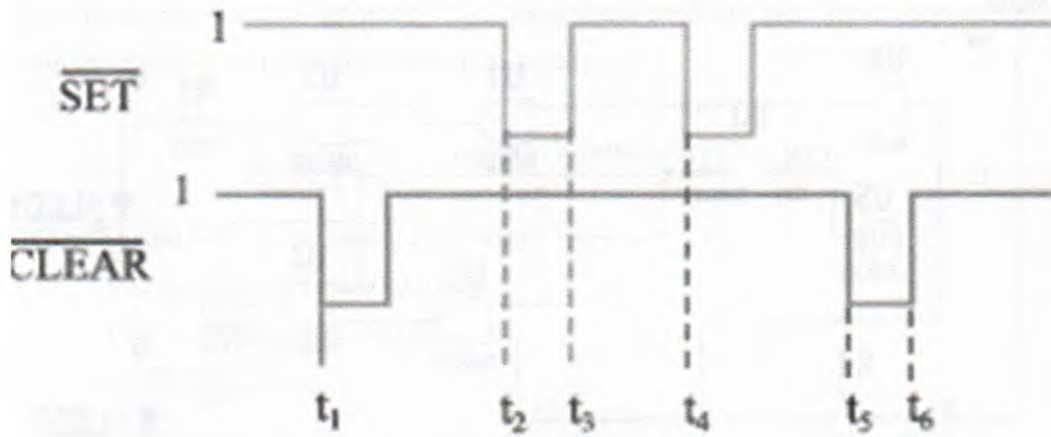


Figure 6.3: Flip Flop Waveform

EXPERIMENT

1. Connect the circuits shown in Figures 6.4 to 6.7.
2. Show the truth table for the circuits connected.
3. Compare the results from 2 to the result gotten from task 3 in PREPARATION. State your observations.
4. Which of the three types of Flip flop connected do you consider the best memory device?

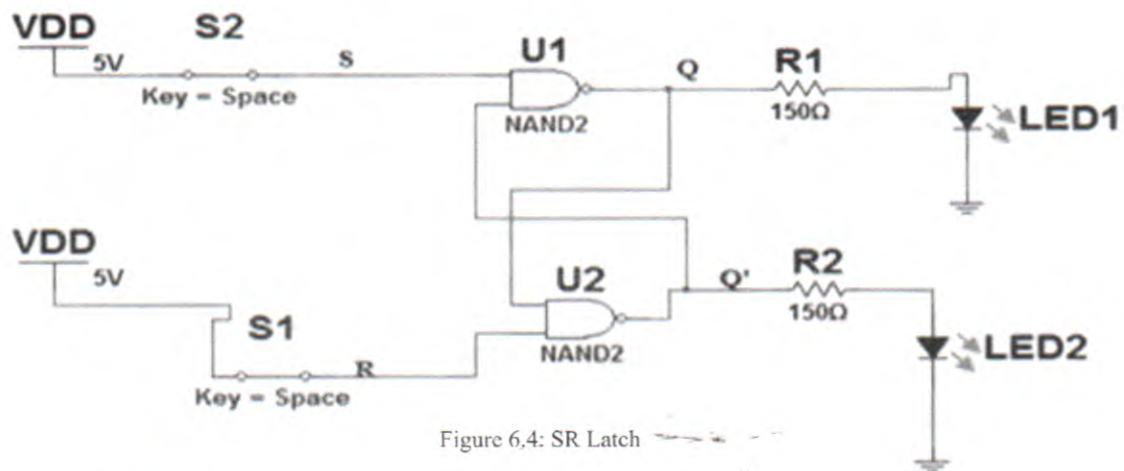


Figure 6.4: SR Latch

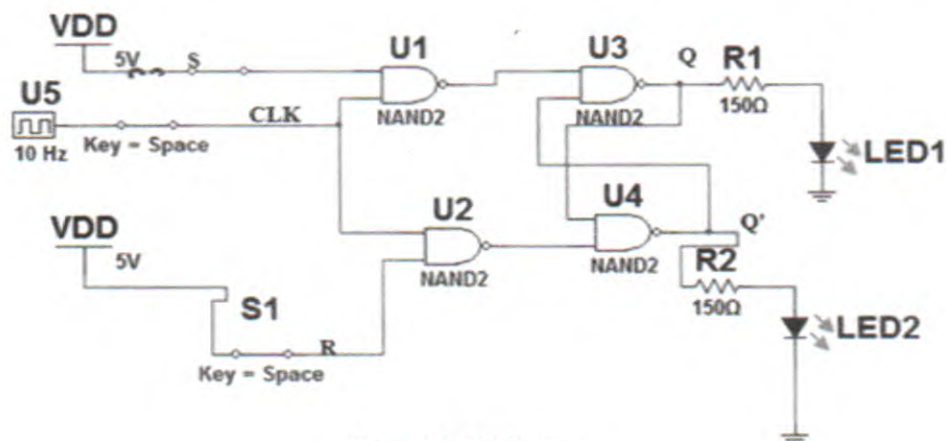
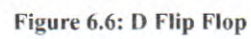


Figure 6.5: SR Flip Flop



EXPERIMENT #:**UILCPE/DCN 1****EXPERIMENT TITLE:****Transmission Media and LAN Topologies****OBJECTIVES:**

- To familiarize the students with the types of transmission media available for data communication and their properties
- To understand the types of LAN topologies and their uses

COMPONENTS AND EQUIPMENT REQUIRED

1. 8-Port Network Switch
2. 8-Port Network Hub
3. Network Cables
4. Host (Computer)

BACKGROUND

A data network consists of two or more autonomous devices that are linked (connected) together in order to share data, resources and allow electronic communication. In a data transmission system, the transmission medium is the physical path between transmitter and receiver. Devices on a network are linked together by a transmission media. There are two (2) basic categories of transmission media for data communication.

Guided Transmission Media: This type of media is also known as bounded media and uses a "cabling" system that guides the data signals along a specific path. The data signals are bound by the cabling system. There are three (3) basic types of guided media:

- Twisted Pair:** The least expensive and most widely used guided transmission medium is twisted pair which consists of two insulated copper wires arranged in a regular spiral pattern as shown in Figure 1.1. A wire pair acts as a single communication link.



Figure 1.1: Twisted pair cable

- Coaxial Cable:** It consists of a hollow outer cylindrical conductor that surrounds a single inner wire conductor. A single coaxial cable has a diameter of from 1 to 2.5 cm as shown in Figure 1.2. Coaxial cable can be used over longer distances and support more stations on a shared line than twisted pair.

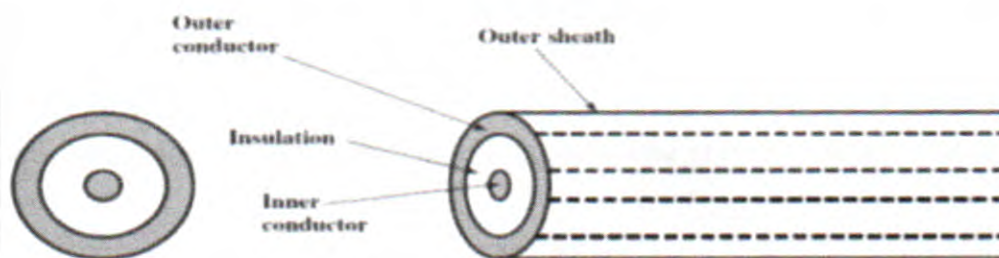


Figure 1.2: Coaxial Cable

Optical Fiber: An optical fiber is a thin flexible medium capable of guiding an optical ray. An optical fiber cable has a cylindrical shape and consists of three concentric sections: the core, the cladding, and the jacket as shown in Figure 1.3.

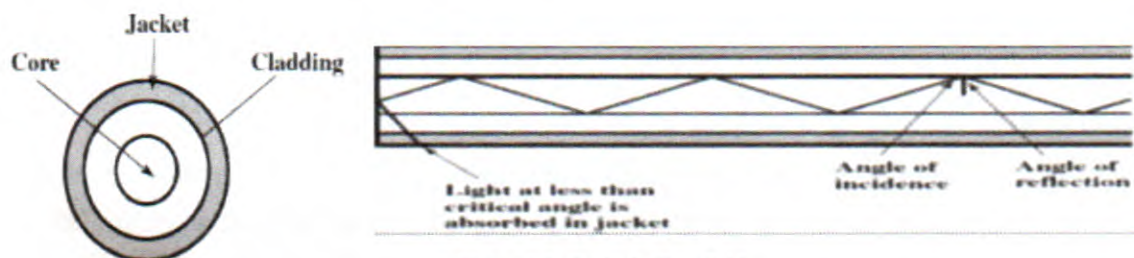


Figure 1.3: Optical Fiber Cable

Unguided Transmission Media: This type of media is also known as unbounded media and it consists of a means for the data signals to travel but nothing to guide them along a specific path. They are called unbounded because the signals are not bound to a cabling media. Unguided media employ an antenna for transmitting through air, vacuum, or water.

Local Area Network (LAN) is the connection of two or more network devices that spans a relatively small area.

Protocol is set of rules which are used by network devices to interact or communicate.

Topology is the arrangement of network devices systems in a network. The major types of network topologies are:

- i. **Bus Topology:** All devices are connected to a central cable, called the bus or backbone.
- ii. **Ring Topology:** All devices are connected to one another to form a closed loop.
- iii. **Star Topology:** All network devices are connected to a central hub or switch.
- iv. **Mesh Topology:** All Devices are connected with many redundant interconnections between network nodes.
- v. **Cellular Topology:** it divides the area being serviced into cells and each cell communicates through a central hub.
- vi. **Tree Topology:** Only one route exists between any two nodes on the network. It is similar to the star topology but the nodes are connected to the secondary hub, which in turn is connected to the central hub.

EXPERIMENT

- i. The students should connect types of guided transmission media.
- ii. The students should connect four (4) hosts using bus and star topology
- iii. Label the bus and star topology **B1, B2, B3, B4** and **S1, S2, S3, S4** respectively.
- iv. Each hosts has been configured with IP Address as shown in Table 1.1.



Table 1.1: Hosts and IP Addresses

SYSTEM NAME	IP ADDRESS
B1	192.168.1.1
B2	192.168.1.2
B3	192.168.1.3
B3	192.168.1.4
S1	192.168.2.1
S2	192.168.2.2
S3	192.168.2.3
S4	192.168.2.4

- v. On the host labeled B1, start the command prompt (DOS prompt) application. You should see a screen with a prompt awaiting command as shown in Figure 1.4.

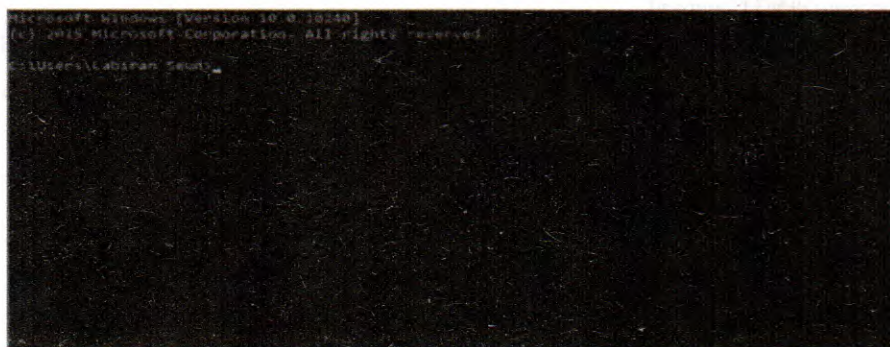


Figure 1.4: Command Prompt Interface

- vi. Type in the command **“ping 192.168.1.2 -t”**. The PING (Packet Internet Gopher) command is a protocol that is used to test connectivity between two systems. When you execute the above PING command on host B1, it sends a message to the IP address 192.168.1.2 (The address for host B2) and then gets a reply from B2. The reply messages are as shown in Figure 1.5.

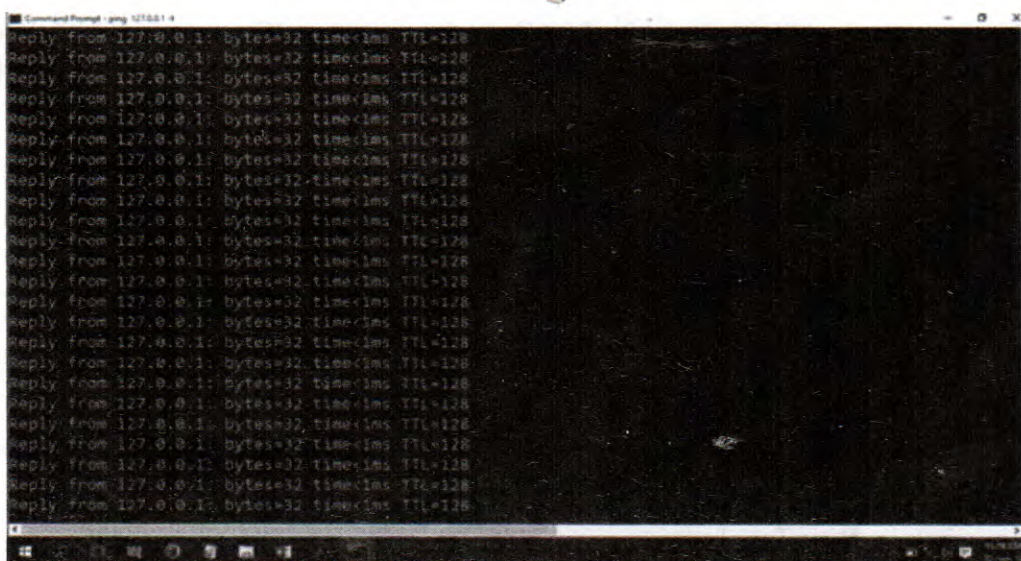


Figure 1.5: Reply Command from B2



- i. Record the time it takes for the reply to get back to system B1 from System B2 (Your instructor will show you how to do this).
- ii. Following the same procedure, execute a PING command from system B3 to system B4 and record the response time.
- iii. Check for any changes to the response time on system B1 and record it.
- iv. Execute a PING command from host B2 to B3, record the response time and check and record any change in the response time on host B1 and B3.
- v. Execute a PING from host B4 to B1, record the response time and check and record any change in the response time on system B1, B2 and B3.
- vi. Tabulate your readings as shown in Table 1.2. (Hint: Record a dash (-) in every irrelevant column for instance the columns under Response Time for B2, B3, and B4 in the first PING command.

Table 1.2: Bus Topology PING Command

	Response time on B1 (ms)	Response time on B2 (ms)	Response time on B3 (ms)	Response time on B4 (ms)
1 st PING command				
2 nd PING command				
3 rd PING command				
4 th PING command				

- xiii. Repeat the procedures in steps v to xii using a star topology.

REVIEW QUESTIONS

1. Suppose that data are stored on 1.4-Mbyte floppy diskettes that weigh 30 g each. Suppose that an airliner carries 10^4 Kg of these floppies at a speed of 1000 km/hr. over a distance of 5000 km. What is the data transmission rate in bits per second of this system?
2. You are required to connect two buildings that are over 27km apart together for high speed and high volume data communication. It is important that there be very minim data loss. What kind of guided media transmission media would you use and why?
3. Are the values in the table for the star topology arrangement the same as the values in the table for the bus topology arrangement? If no, can you explain the difference in values obtained?
4. Using Squares to represent hosts and straight lines to represent cable connection, draw a schematic diagram of a network consisting of six (6) hosts using the following topologies
 - i. Bus Topology
 - ii. Star Topology
 - iii. Mesh Topology
 - iv. Ring Topology
 - v. Tree Topology

5. Which topology do you think will require the least amount of cabling and why?
6. Which topology has the most redundancy and why?
7. Suppose we are required to add new computers to the network, which is the best suited topology and why?
8. Which is the most expensive topology to implement and why?
9. Which topology is most likely to become unusable due to collision on the network as the number of nodes (computers) increase? Explain your choice
10. Write out three advantages and three disadvantages of each of the topologies discussed in this experiment.

EXPERIMENT #: UILCPE/DCN 2

EXPERIMENT TITLE: Communication Devices and Cable Interconnection

OBJECTIVES:

- To understand the types and properties of network communication devices
- To learn the different types of Ethernet cables and their configurations

COMPONENTS AND EQUIPMENT REQUIRED

1. Cat5e cables
2. RJ-45 Connectors
3. RJ-45 Module
4. Crimping Tool
5. Punch-Down Tool
6. Wire Stripper
7. Cutter
8. LAN tester

BACKGROUND:

Communicating devices are central hubs where cables coming from different devices can converge. This way, only one network port is needed on each device. These communicating devices aggregate media segments relaying signals from one segment to the other while organizing the cables. We will consider the major devices in this laboratory but there are two terms we need to understand to throw better light on the operation of these devices and their evolution,

Collision Domain: This is an Ethernet term used to describe a network scenario in which one device sends data out on a network segment and every other device on that same segment receives the packet no matter what. This means that if a different device tries to transmit at the same time, a collision will occur. It is basically a domain where collision can occur between two devices if they transmit data at the same time.

Broadcast Domain: This is a network segment where any broadcast message sent by one system within that broadcast domain will be received by all other systems within that domain. Systems outside the broadcast domain cannot receive the broadcast. In a manner of speaking, a collision domain is a subset of the broadcast domain as there can be several collision domains in a single broadcast domain. A connection of several devices in a single broadcast domain is referred to as a network.

Network Communication Devices

i. **Hubs:** A hub is a multiport repeater used for connecting hosts in a physical star topology. A hub creates a single collision and broadcast domain. This makes it a very inefficient device and is hardly seen anymore

ii. **Bridges:** Bridges were invented to create more collision domains on the network. Each port on a bridge is its own collision domain. Bridges therefore have several collision domains but a single broadcast domain. Bridges were used to reduced collision and signal loss on a network by combining them with hubs

iii. **Switches:** At the most elementary level, a switch is simply a multiport bridge with more brainpower. While switches do provide a bridging function, but they do that with greatly enhanced management ability and features. Modern switches have the ability to create more than one broadcast domain. This is referred to as layer 3 switching.

iv. **Routers:** These are the internetwork connecting devices. Each port on a router is a separate broadcast domain. Routers are really intelligent devices that understand which group of systems (network) a broadcast is meant for and ensure that only those systems get the broadcast.

v. **Gateways:** A gateway is used to connect together networks that are using completely different protocols. A gateway is an intelligent device that can translate in between protocols. It is the border guard between networks with different protocols. In modern networks, a gateway can be a router or even a layer 3 switch.

Ethernet is the prevalent LAN protocol while the Unshielded Twisted Pair (UTP) cable is the media of choice in Ethernet based LAN installation. In the context of 100-ohm UTP cables used for Ethernet wiring, the only categories of interest are Cat3, Cat4, Cat5, Cat5e, Cat6 and Cat7. Cat3 and Cat4 were used for quite a limited time since the emergence 100Base-Tx networks meant a quick shift to Cat5. By the year 2000, moves to 1000Base-TX (Gigabit Ethernet) networks created a need for another specification (Cat5e). Cat5e is now being superseded by Cat6 cable and there is a developing standard for Cat7.

UTP Patch Cables

There are basically two types of UTP patch cables.

- i. **Straight-Through Network Cable** - This is popularly known as the straight cable and it acts as an extension enabling a device (e.g. a computer, printer, etc.) with a network interface card (network port) to be attached to a network communication device such as a switch, hub or router.
- ii. **Crossover-Over Cables:** This type of network cable is most commonly used to connect two hosts directly. Examples would be connecting a computer directly to another computer, connecting a switch directly to another switch, etc.

EXPERIMENTS

- i. Students should connect network devices together using the appropriate transmission media.

A. Making Straight Cables

- ii. Using your wire strippers, remove the outer sheath of your UTP Cat5e cable. Some crimping tools have wire strippers incorporated. BE CAREFUL NOT TO DAMAGE THE INNER WIRES (twisted pairs) as you remove the



sheath. Expose about 40mm of the twisted pair wires

- iii. Untwist the pairs, straighten and arrange them side by side using the 568-B standard.
- iv. Trim the wires to 13mm using the crimping tool. Make sure the edges of the wires are arranged side by side to form a perfect straight line.
- v. With the RJ-45 connector pins facing up, carefully slide the wires into the connector. Note that the pin count starts from the left.
- vi. Insert the connector inside the appropriate slot on the crimping tool and gently compress the handle to crimp it.
- vii. Do exactly the same thing to the other end of the cable and you have a straight cable
- viii. Using the LAN tester, check that your straight cable was properly made.

B. Making Cross-Over Cables

- ix. Follow procedure ii to vii under making a straight cable with one little exception. Use 568-A on one end of the cable and 568-B on the other end. If done properly, you should have a cross-over cable once you are done.
- x. Using the LAN tester, check that your cross over cable was properly made.

REVIEW QUESTIONS

1. The diagram in Figure 2.1 depicts an example of an actual internetwork with hubs, bridges, switches, routers and hosts. How many broadcast domains exist there?

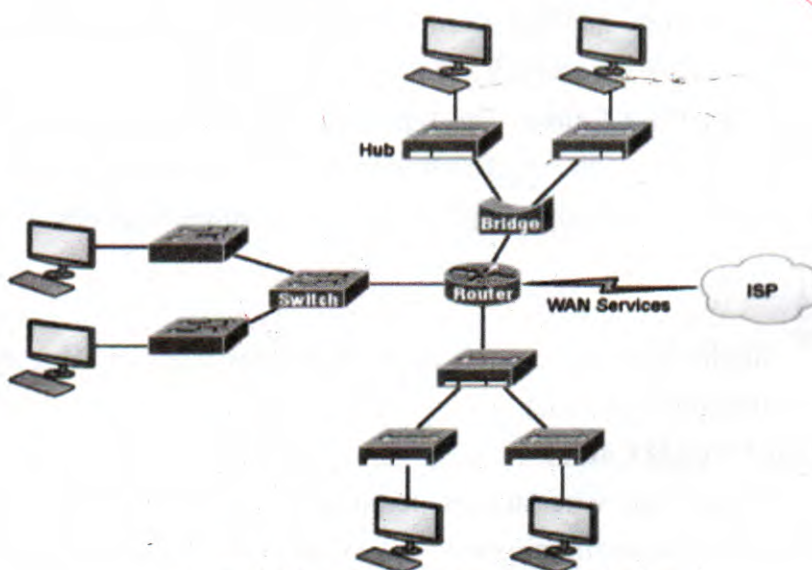


Figure 2.1: Internetwork of Communication Devices



1. How many collision domains exist in the network shown in Figure 2.1?
2. If any of the hosts in the network were to send a broadcast, how many host will receive the broadcast
3. Assuming you are the administrator of a network with one hundred (100) hosts all connected to three (3) interconnected hubs. Two of the hubs have 48-ports while the last one has 8-ports.
 - i. Represent this information diagrammatically
 - ii. How many collision and broadcast domains exist in this network?
4. The management is complaining that communication is slow on the network and there are many of data that never get to the destination (lost packets). You are given a budget of N100 to improve the network. At the only available network store in town, you find ONLY the following devices at the following price
 - Routers with 5 interfaces @ N90
 - Routers with 4 interfaces @ N70
 - Routers with 3 Interfaces @ N50
 - Switches with 24 ports at N40
 - Switches with 12 ports @ N30
 - Switches with 8 ports @ N20
 - Bridges with 4 ports @ N15
 - Bridges with 2 ports @ N9
 - Hubs with 8 ports @ N6
 - Hubs with 16 ports @ N10
 - Hubs with 24 ports @ N15

Assuming that the organization has three departments called **A**, **B** and **C** with 30 hosts in department **A**, 40 hosts in department **B** and 30 hosts in department **C** and every member of each department has to receive any broadcast sent within the department.

How would you utilize the money at your disposal to improve the network performance?

Your design should include a network diagram and an explanation of why you think that is the best utilization of the money available to you. Please not that there is no single correct answer and the question is meant to test your creativity and analytical planning. Remember that the more collision domains and broadcast domains the better the network.

5. How would you make a working straight through and cross-over cable using the two unused pair (Brown and Blue) instead of the normally used pair (Orange and Green)?
6. You are called in by a company to troubleshoot why their newly installed network is not functional. The complaint is that not all users can reach themselves across the network. On inspection you find that the network consists of consist of 65 computers connected to three 24-port switches which are looped together. You also discover



that all connecting cables (patch cables connecting the computers to the switches and also the switches to each other) are straight through cables. Why do you think that some users cannot communicate with themselves? What would you do to rectify the problem?

EXPERIMENT #:**UILCPE/DCN 3:****EXPERIMENT TITLE: Internet Protocol (IP) Addressing and Wireless Configuration****OBJECTIVES:**

- To understand IP addressing and configuration
- To understand wireless configuration

COMPONENTS AND EQUIPMENT REQUIRED

1. Hosts (PCs)
2. Network Switch
3. Straight Through Cables
4. Computer Systems with Wireless NIC
5. Wireless Access Point (WAP) or Wireless Router

BACKGROUND

An Internet Protocol (IP) address is a numeric identifier assigned to each machine on a network. It designates the specific location of a device on the network. IP addressing was designed to allow hosts on one network to communicate with a host on a different network. An IP address consists of 32 bits of information. These bits are divided into four sections, referred to as octets or bytes, with each containing 1 byte (8 bits).

There are several classes of networks based on network size namely: Class A, B, C, D and E as shown in Figure 3.1

	8 bits	8 bits	8 bits	8 bits
Class A:	Network	Host	Host	Host
Class B:	Network	Network	Host	Host
Class C:	Network	Network	Network	Host
Class D:	Multicast			
Class E:	Research			

Figure 3.1: Network Classes

Subnet Masks

A subnet mask is a 32-bit value that allows the device that's receiving IP packets to distinguish the network ID portion of the IP address from the host ID portion of the IP address. This 32-bit subnet mask is composed of 1s and 0s, where the 1s represent the positions that refer to the network subnet addresses. The default subnet mask for Classes A, B and C are shown in Table 3.1.



Table 3.1: Default Subnet Mask

	N N H	SS ZSS ZSS 0
	N H H	SS ZSS 0 0
	H H H	SS . 0 0

Wireless communication is the technique of sending and receiving signals through air using antenna. It is a useful form of communication especially when it is impossible to install cables. There are different classes of wireless communications namely:

- i. Infra-Red Communication
- ii. Microwave Communication.
- iii. Radio Communication

Wireless LAN Operating Mode

There are two options for the operating mode:

- i. **Infrastructure Mode:** Most Wi-Fi networks function in infrastructure mode. Devices on the network all communicate through a single access point, which is generally the wireless router. Infrastructure mode requires a central access point that all devices connect to and there is no direct communication between nodes.
- ii. **Ad-hoc mode:** This is also known as “peer-to-peer” mode. Ad-hoc networks don't require a centralized access point. Instead, devices on the wireless network connect directly to each other. The new Wi-Fi Direct standard also builds on ad-hoc mode, allowing devices to communicate directly over Wi-Fi signals.

EXPERIMENT

A. IP Addressing

1. Using straight cables, connect four hosts to the network switch and label them as A, B, C and D.
2. Power up the network switch and the hosts.
3. On A, start the “**Network and Sharing Center**” application. Click on change adapter settings. It should bring you a screen showing all the network adapters on the computer.
4. Right click on your Ethernet adapter and select properties from the dropdown options. It will pop up the Ethernet Properties page.
5. Left click (once) on the option “**Internet Protocol Version 4 (TCP/IPv4)**” Then click on the properties tab beneath it. This should bring you the Internet Protocol Version 4 (TCP/IPv4) properties page. Alternatively, you can double click (click twice very quickly) on the option “**Internet Protocol Version 4 (TCP/IPv4)**” and it will still bring the same properties page.
6. Select the radio button titled “Use the following IP address”. This should make the greyed out boxes accessible. Now type in the following in the appropriate boxes.

IP Address: **192.168.5.1**



Subnet Mask: 255.255.255.0

Default Gateway: 192.168.5.254

7. Close the “Ethernet Properties” page and other settings pages to return to the desktop.
8. Repeat procedure 3 to 7 on systems B, C and D respectively using the information below.

System B

IP Address: 192.168.5.2

Subnet Mask: 255.255.255.0

Default Gateway: 192.168.5.254

System C

IP Address: 192.168.7.1

Subnet Mask: 255.255.255.0

Default Gateway: 192.168.7.254

System D

IP Address: 192.168.7.2

Subnet Mask: 255.255.255.0

Default Gateway: 192.168.7.254

9. On host A, start the command prompt application and type in the following command: “ping 192.168.5.1” then press the enter button. Observe and make a note of the message returned on the command prompt screen..
10. Send a PING request to system B by typing the same command but replacing the IP address with that of system B. (i.e. “ping 192.168.5.2”). Observe the results carefully.
11. Send out a PING request to systems C and system D. Observe and record the result.
12. From each of hosts B, C and D, carry out the same sequence of commands as in A. Observe and record the result. First send a PING request to the host and then to all the other hosts in turn.
13. Type the following command into the command prompt on host A: “ping 192.168.5.2 -t” and observe the result. Note the difference between the results observed and that observed with the command typed in step 10. Remove the straight cable connecting host A to the switch and observe the changes in the response on the screen. Reconnect the cable to the switch and again observe the change in response.

B. Setting up a Wireless LAN in Ad-hoc Mode

1. Check the version of your operating system. If your host is running windows XP or lower, proceed to step 2. If you are running windows 7, proceed to step 8. If you are running windows 8 or higher, proceed to step 12.
2. Go to **Control Panel**, click on **Network Connections** and find **Wireless Network Connection**. Right click Wireless Network Connection and select **Properties**.
3. Select the **Wireless Networks** tab, click the **Add** button. It opens the Wireless network properties page.

4. Click on **Association** tab and type in the name (SSID) for your ad-hoc network. Tick **This is a computer-to-computer [ad hoc] network; wireless access points are not used.** Then click OK. It should take you back to the **Wireless network connection properties** page.
5. Check under the referred Networks section to confirm that your ad-hoc network has been included in the list then click OK to save all the settings.
6. Configure an IP address manually on the wireless NIC using the following Class C IP address: **192.168.0.1**.
7. Your ad-hoc network is set up and you can now scan for wireless network using another computer, a mobile phone, a tablet, etc. and you should see your ad-hoc network on the list of available networks. **YOU HAVE TO MANUALLY CONFIGURE THE IP ADDRESS ON THE SYSTEM THAT WANTS TO CONNECT TO THE AD-HOC NETWORK.** Use the class C IP address 192.168.0.2.
8. Start the "Network and Sharing Center" application and click Set up a new connection or network.
9. Select **Set up a wireless ad hoc (computer-to-computer) network** from the options presented and click next.
10. Keep Clicking Next till you get to the screen where it requests for the Network name (SSID). Type in the name of your ad-hoc network, select your Security Type (use No authentication) and tick save this network if you want windows to save all the parameters you have entered for a future date then click next.
11. It will bring a window showing you the details of your ad-hoc network. Click on close. Now you can scan for wireless networks using another computer or a wireless enabled device and you should see your network. It should automatically issue an IP address to your host or device when you connect otherwise manually configure the IP on both the host and the connecting system to ensure they are on the same network.
12. Right click on the start button and launch the Command Prompt (Admin) application.
13. Type the following command at the prompt: **netsh wlan set hostednetwork mode=allow ssid=MyNetwork key=MyPassword.** Change the "MyNetwork" (in red) to the name of your ad-hoc network and "MyPassword" to the security password of the network then press enter.
14. To start the configured network, type the following command: **netsh wlan start hostednetwork**
15. Scan for wireless networks using another computer or a wireless enabled device. It should automatically issue an IP address to your system or device when you connect otherwise manually configure the IP on both the host and the connecting system to ensure they are in the same network.
16. To stop the network, type the following command: **netsh wlan stop hostednetwork.**

C. Setting up a Wireless LAN in Infrastructure Mode



1. Connect your wireless router with a straight cable to the host to be used for the configuration.
2. To log in to the administrator interface, configure your system Ethernet NIC IP address to be on the same network as the access point so they can communicate.
3. From your system command prompt, execute a PING command to the access point to ensure that they can communicate.
4. Open a web browser and type in the IP address of your access point in the URL bar. If the PING on step 3 was successful, it should show you the configuration interface of the access point. It will ask for a username and password to grant access. Consult your device manual for the default login credentials but change it once you are logged in as your first administrative task.
5. Once login credentials are changed (and sometimes the device reboots after major configuration changes), go to the IP address configuration page and give the access point whatever IP address you have designed beforehand for your network. Use the address **192.168.27.1**
6. If your device is a wireless router, it is standard to configure the device to automatically assign IP addresses (DHCP) to all connecting devices. Go to the DHCP setting and configure the following parameters
 - IP range: 192.168.27.5 – 192.168.27.10
 - Subnet Mask: 255.255.255.0
 - Default Gateway: 192.168.27.1
 - DNS: 192.168.27.1

Your instructor will help you through this process if you are having issues carrying out this configuration.

7. Go to the wireless property page and configure the following settings
 - SSID
 - Encryption Type (Security)
 - Network Password (if required)
 - Wireless standard (802.11a,b,g,a,ac) if required
8. Once all these are configured, the wireless network should be up. Scan for available wireless networks with your computer or mobile devices and connect.

REVIEW QUESTIONS

1. Are all the four systems in the above experiment on the same network? Explain your answer in detail.
2. Differentiate between the physical network and the logical network.
3. What do you think is the function of the “Default Gateway” IP address in the configuration?
4. What are the classes of the IP addresses of systems A, B, C and D?
5. What adjustment can be made to the IP address configuration to ensure that all the



systems can communicate with themselves? Write out an IP address configuration for the four systems that you think might work and enable all the systems communicate.

EXPERIMENT #: UILCPE/DCN 4
EXPERIMENT TITLE: Configuration of Network Devices
OBJECTIVES:

- To familiarize students with hardware connection of network devices
- To understand how to connect network device to a computer using terminal emulator
- To understand basic router configurations

BACKGROUND

Newly purchased managed devices needs to be configured to suit the need of the network designer and as to this, most Cisco devices uses Command Line Interface (CLI) to configure the network device. Command line interface is an interface where you type in configuration commands and you can use show commands to get the desired output from network device. There are some instances where you can use Graphical User Interface for network devices firewalls but most of the work is done on the command line interface. There are so many commands that are available to use this gives the Command line interface an advantage than any graphical interfaces. Before we can enter any commands we need access to the CLI and this can be done in three ways namely:

- Console
- Telnet
- SSH

The console port is located at the back of every configurable devices and this is what allow access to the CLI. This is normally used the first time we are configuring network devices.

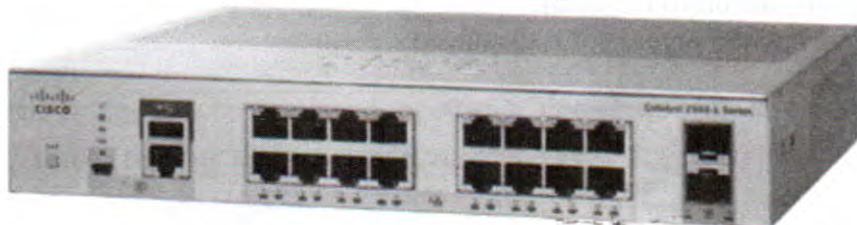


Figure 4.1: Typical Manageable Switch

Figure 4.1 is a typical Cisco catalyst switch where you have the RJ-45 port and a micro USB port highlighted in blue where we can plug in Cisco console serial cable. Modern computer without serial ports can use serial to USB cable.



Figure 4.2: Console Serial Cable



Figure 4.3: Serial to USB Cable

After all the connections have been done we need to install any of the terminal emulators on our system to have access to CLI. Over the years a lot of terminal emulator has been developed and few of these are mentioned below some can work on windows while some can work on Mac, Linux and some other Operating system

- Putty
- Teraterm
- Win32console
- VonEmu
- Qodem

Putty will be used to connect users to a particular CLI.

EXPERIMENTS

A. Hardware connection

1. Get a network manageable Cisco switch from your technologist
 2. Connect the hardware using available console cables.
 3. Install putty software on your system.
- Run the program and the Figure 4.4 is displayed.

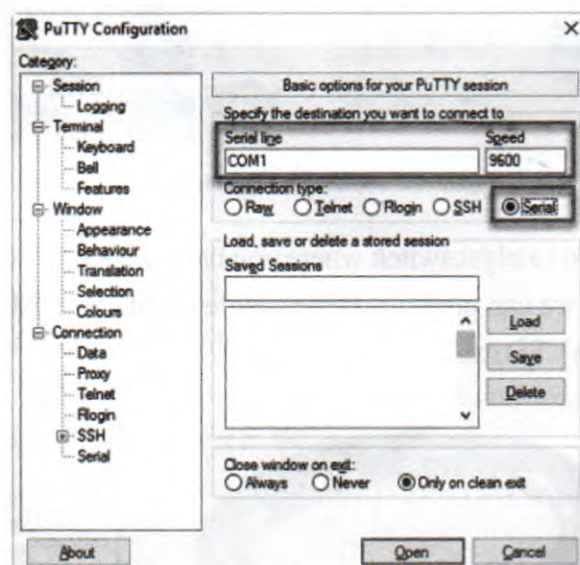


Figure 4.4 : Putty Interface

1. Select serial port and pick the com port that you find on the device manager.
2. Power on the device and when the switch boots, you will see a lot of information on the console. Wait for this initialization to complete and also some information about the device will be displayed and finally **Press RETURN to get started!**

B. Initial Configuration of a Router on Packet Tracer

1. Connect the topology shown in Figure 4.5.
2. Click on the router and on CLI, you will see continue with configuration dialog?
[yes/no]:click on **No** and continue with your command
3. Router>enable (User Execution mode)
Router# (Privilege mode)
4. To view router IOS and Hardware information
Router# show version
5. To view Flash information
Router# show flash
6. To view router Start up config
Router# show startup-config
7. To navigate into Global Configuration mode
Router# Config terminal
Router(config)#
8. Configure Hostname and Interface IP address
Router(config)# hostname student
Student(config)#
9. To configure IP address on Ethernet interface(LAN Interface)
Student(config)# interface fastethernet 0/0
Student(config-if)# ip address 192.168.10.3 255.255.255.0
Student(config-if)# clockrate 6400
Student(config-if)# no shutdown
Student(config-if)# exit
10. Configure a warning message to display before login
Student(config)# banner motd #Please note that Unauthorized access is not allowed!#
Configure telnet Passwords
Student(config)# line vty 0 4
Student(config-line)# password student
Student(config-line)# login
Student(config-line)# exit
11. To Configure console Passwords
Student(config)# line console 0
Student(config-line)#password student
Student(config-line)# login
Student(config-line)# exit



12. Configure privilege Password
 Student (config)#enable password network
 Student (config-line) #enable secret student
13. To view Router current configuration
 Student# show running-config
14. Saving Configuration to the router
 Student# copy running-config startup-config
15. Go back to user execution mode and from there move to privilege mode .What do you observe.
16. To erase configuration on the router
 Student#reload
17. To erase configuration on the router completely
 Student#erase start
 Student#reload

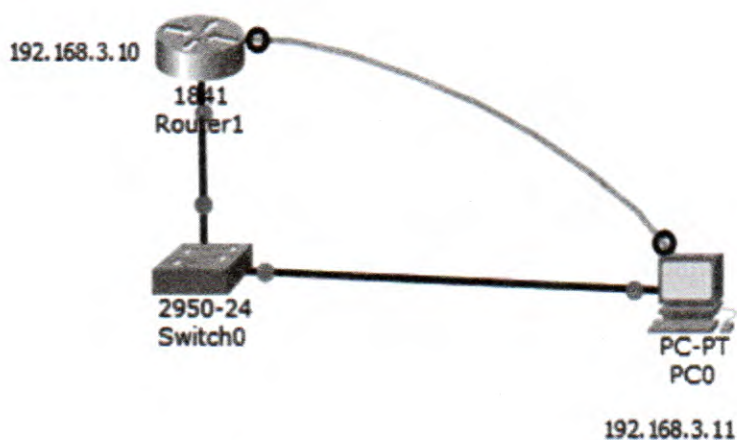


Fig 4.5: Topology for basic router configuration

EXPERIMENT #: UILCPE/DCN 5

EXPERIMENT TITLE: Static and Dynamic Routing Configuration

OBJECTIVE:

- To configure Static and Dynamic routing

BACKGROUND

Static routing is the process in which routers are manually configured with all the necessary information for successful packet forwarding. The routing table is constructed in every router by inserting the network addresses for every network. Static routes to network destinations are unchangeable.

Routing Information Protocol (RIP) is a dynamic protocol used to find the best route or path from end-to-end (source to destination) over a network by using a routing metric/hop count algorithm. This algorithm is used to determine the shortest path from the source to destination, which allows the data to be delivered at high speed in the shortest time. When routers are connected together they build up their routing table but only routers that are directly connected together are recognized. RIP uses hop count as its metric which is nothing more than counting the number of routers (hops) you have to pass to get to your destination.

Routers learn about remote networks either dynamically, using routing protocols, or manually, or using static route. Static routes are very common and do not require the same amount of processing and overhead as dynamic routing protocols

PREPARATION

Read extensively on static and dynamic Routing

EXPERIMENT

A. Static Routing

1. Draw the network topology shown in Figure 5.1 using Packet Tracer
2. Assign the IP address as shown in Table 5.1.
3. To Assign IP address to Serial ports and Fastethernet ports, use the following commands

```
Router (config)# interface sa0/0/0
Router (config-if)# ip address 192.168.10.2 255.255.255.0
Router (config-if)# no shutdown
```

 Use these commands to assign IP address in Table 5.1 to all the ports on the network
4. Check Experiment 3 on how to assign IP address to end device
5. Try and ping system in faculty of Engineering from science and art respective and state your observations
6. Configure Static Routing between the three routers Using the following commands

```
Ip route(destination prefix)(destination prefix subnet mask)(interface of forwarding router IP address)
```



From engineering type the following commands

engineering#show ip route (what do you observe)

engineering#config terminal

engineering(config)#ip route 172.17.0.0 255.255.0.0 192.168.10.2

engineering(config)#ip route 172.18.0.0 255.255.0.0 192.168.10.2

engineering(config)#sh ip route

7. Repeat this for router in art and science
8. Now ping systems in Faculty of Engineering from science and art respective and state your observations.

B. Dynamic Routing

1. Arrange the network topology shown in Figure 5.2 on your packet tracer
2. Assign the IP address as shown in Table 5.2
3. Check Experiment 3 on how to assign IP address to end device
4. Ping the system in COMSIT from NOC, Material, Agric and vise-versa.
5. Now configure RIP on the two routers and try step 4 again
6. Use the following commands to configure RIP

Router>en

Router# config t

Router (config)#router rip

Router (config-router)#network 192.168.3.0

Router (config-router)#network 192.168.4.0

Router (config-router)#network 192.168.5.0

Router (config-router)#exit

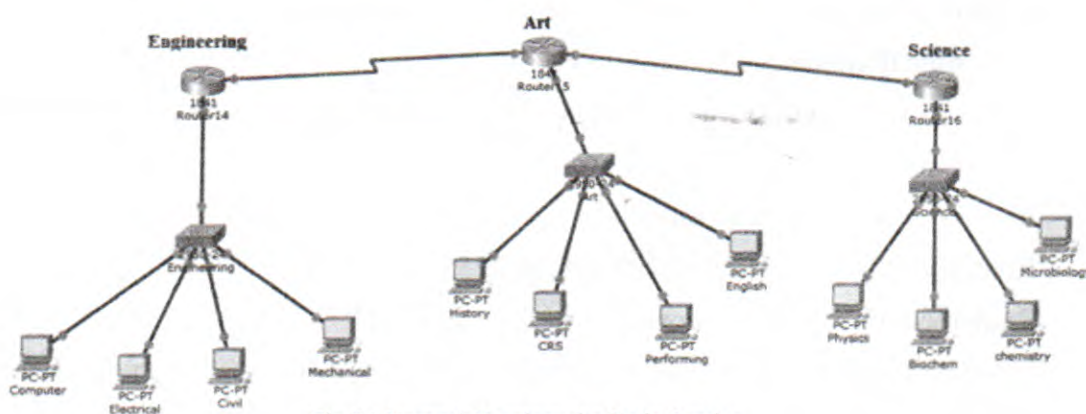


Fig 5.1 Network Topology for Static Routing

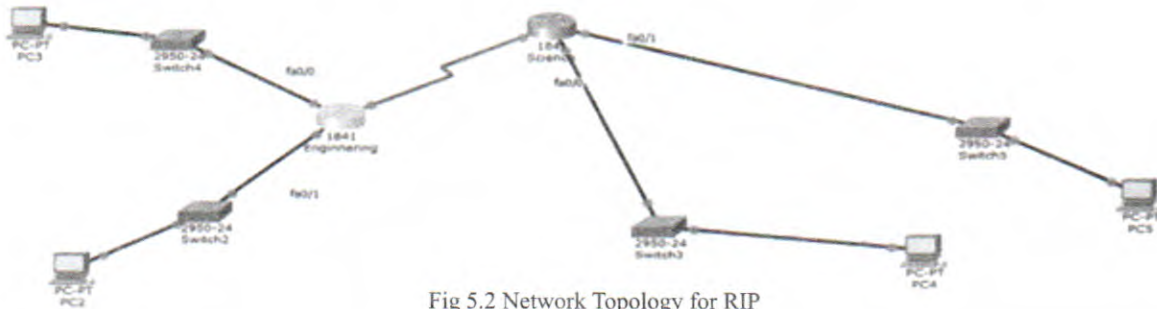


Fig 5.2 Network Topology for RIP

Table 5.1: IP Addresses for Devices in Figure 5.1

Device	Interface	IP address	Subnet Mask	Default Gateway
Engineering(R1841)	Sa0/0/0	192.168.10.1	255.255.255.0	192.168.10.1
Engineering(R1841)	Fa0/01	172.16.10.1	255.255.0.0	172.16.10.1
Computer(PC)	Fa0/0	172.16.10.2	255.255.0.0	172.16.10.1
Civil (PC)	Fa0/0	172.16.10.3	255.255.0.0	172.16.10.1
Electrical(PC)	Fa0/0	172.16.10.4	255.255.0.0	172.16.10.1
Mechanical (PC)	Fa0/0	172.16.10.5	255.255.0.0	172.16.10.1
Art(R1841)	Sa0/0/0	192.168.10.2	255.255.255.0	192.168.10.2
Art (R1841)	Fa0/01	172.17.10.1	255.255.0.0	172.17.10.1
Art(R1841)	Sa0/0/1	192.168.20.1	255.255.255.0	192.168.20.1
English(PC)	Fa0/0	172.17.10.2	255.255.0.0	172.17.10.1
CRS (PC)	Fa0/0	172.17.10.3	255.255.0.0	172.17.10.1
Performing(PC)	Fa0/0	172.17.10.4	255.255.0.0	172.17.10.1
History (PC)	Fa0/0	172.17.10.5	255.255.255.0	172.17.10.1
Science(R1841)	Sa0/0/0	192.168.20.2	255.255.255.0	192.168.20.2
Science (R1841)	Fa0/01	172.18.10.1	255.255.0.0	172.18.10.1
Biochem PC)	Fa0/0	172.18.10.2	255.255.0.0	172.18.10.1
physics (PC)	Fa0/0	172.18.10.3	255.255.0.0	172.18.10.1
Chemistry(PC)	Fa0/0	172.18.10.4	255.255.0.0	172.18.10.1
Microbiology (PC)	Fa0/0	172.17.10.5	255.255.255.0	172.18.10.1

Table 5.2 IP Addresses for Devices in Figure 5.2

Device	Interface	IP address	Subnet Mask	Default Gateway
Switch(Senate)	(VLAN1)	192.168.3.2	255.255.255.0	
Switch(CBT)	(VLAN1)	192.168.6.2	255.255.255.0	
Switch(NOC)	(VLAN1)	192.168.4.2	255.255.255.0	
Switch(COMSIT)	(VLAN1)	192.168.6.2	255.255.255.0	
Router(Engineering)	Sa0/0/0	192.168.2.1	255.255.255.0	
	Fa0/0	192.168.4.1	255.255.255.0	
	Fa0/1	192.168.3.1	255.255.255.0	
Router(Science)	Sa0/0/0	192.168.2.2	255.255.255.0	
	Fa0/0	192.168.6.1	255.255.255.0	
	Fa0/1	192.168.5.1	255.255.255.0	
PC(Food)	Fa0/0	192.168.3.3	255.255.255.0	192.168.3.1
PC(Biomedical)	Fa0/0	192.168.4.3	255.255.255.0	192.168.4.1
PC(Agric)	Fa0/0	192.168.6.3	255.255.255.0	192.168.6.1
PC(Material)	Fa0/0	192.168.5.3	255.255.255.0	192.168.5.1

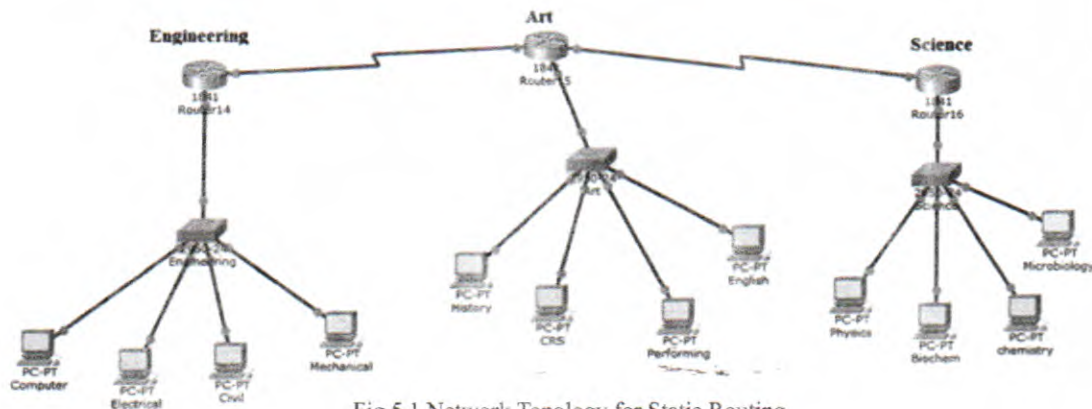


Fig 5.1 Network Topology for Static Routing

EXPERIMENT #:**UILCPE/DCN 6****EXPERIMENT TITLE: VLAN, Trunking, VLAN Trunking Protocol and Port Security****OBJECTIVES:**

- To configure VLANs and Trunking in a switch Network
- To implement VTP on switches across the Network
- To implement port Security on switches across the network
- To implement Spanning Tree Protocol

BACKGROUND:

VLAN: The role of providing access into a LAN is normally reserved for an access layer switch. A Virtual Local Area Network (VLAN) can be created on a Layer 2 switch to reduce the size of broadcast domains, similar to a Layer 3 device. A VLAN allows a network of computers and users to communicate in a simulated environment as if they exist in a single LAN and are sharing a single broadcast and multicast domain. VLANs are implemented to achieve scalability, security and ease of network management. It can quickly adapt to changes in network requirements and relocation of workstations and server nodes. Higher-end switches allow the functionality and implementation of VLANs. The purpose of implementing a VLAN is to improve the performance of a network or apply appropriate security features.

VLAN Trunking Protocol (VTP): VTP is used to create VLANs on one switch and all the other switches will automatically synchronize. The VTP server is the switch used to create, modify or delete VLANs while the other switches are VTP clients.

Port Security: The number of MAC addresses a switch can learn on an interface has no limit and all MAC addresses are allowed. Port-security is used to alter this behaviour, to stop any unauthorized individual from gaining access to the network.

PREPARATION

Read extensively on VLAN, VTP, Port Security.

EXPERIMENT**A. VLAN**

1. Arrange the topology shown in Figure 6.1
2. Assign IP address in Table 6.1 to the devices.
3. Ping the system within staff Switch and student Switch.
4. Ping the system from staff Switch to student Switch.
5. Configure two VLANs on staff Switch namely Agric and Computer as shown in Fig 6.1
6. Configure VLAN on Students Switch namely Agric and Computer as shown in Fig 6.1
7. Ping the system on Computer VLAN and Agric on Staff Switch
8. Ping the system on VLAN Computer and Agric on Students Switch



9. Ping the system on VLAN Computer on staff Switch and Computer on Students Switch
10. Ping the system on VLAN Agric on staff switch and Agric on Students switch
11. Write your observation in 8,9,10 and 11 above

Sample configuration of VLAN and Trunking

Switch>en

Switch#enable

Switch#config t

Enter configuration commands, one per line. End with CNTL/Z.

Switch(config)#vlan 10

Switch(config-vlan)#name sales

Switch(config-vlan)#exit

Switch(config)#vlan 20

Switch(config-vlan)#name account

Switch(config-vlan)#exit

Switch(config)#exit

Switch#

Switch#config t

Enter configuration commands, one per line. End with CNTL/Z.

Switch(config)#interface range FastEthernet 0/1-2

Switch(config-if-range)#switchport mode access

Switch(config-if-range)#switchport Access

Switch(config-if-range)#switchport access vlan 10

Switch(config-if-range)#exit

Switch(config)#

Switch#

Switch#config t

Enter configuration commands, one per line. End with CNTL/Z.

Switch(config)#interface range FastEthernet 0/3-4

Switch(config-if-range)#switchport mode access

Switch(config-if-range)#switchport access vlan 20

Switch(config-if-range)#exit

Switch(config)#show vlan

Trunking

Switch>en

Switch#config t

Enter configuration commands, one per line. End with CNTL/Z.

Switch(config)#interface fa0/5

Switch(config-if)#switchport mode trunk



```
Switch(config-if)#
```

```
Switch(config-if)#exit
```

B. VTP

1. Arrange the topology shown in Figure 6.1
2. Configure Staff as the VTP server and Student as VTP client
3. Create VLAN 100 for Agric and 200 for Computer
4. Assign Addresses to the VLANs
5. Configure Trunking for Fa0/7
6. From Students switch types this command and observe the display
Show VLAN brief
7. Also assign Addresses to the VLANs
8. Repeat step 8,9,10,11 and 12 of 6.1

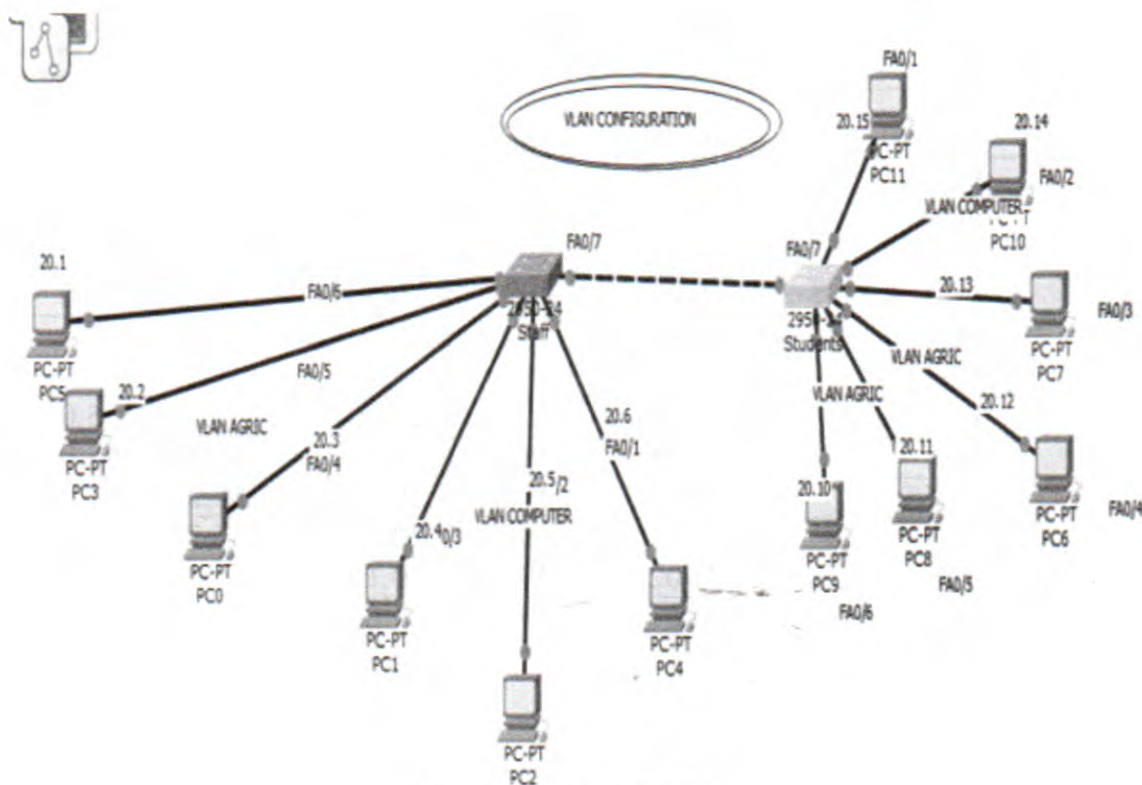


Figure 6.1: Topology for VLAN

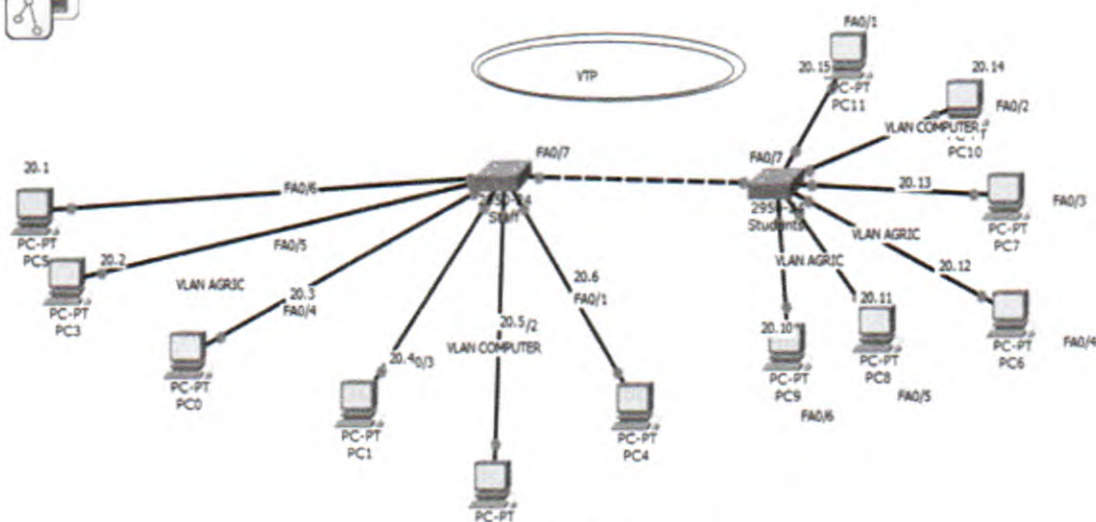


Figure 6.2: VTP Topology

Table 6.1: VLAN IP address

Device	Interface	IP address	Subnet Mask
Staff			
PC5	Fa0/06	192.168.20.1	255.255.255.0
PC3	Fa0/05	192.168.20.2	255.255.255.0
PC0	Fa0/04	192.168.20.3	255.255.255.0
PC1	Fa0/03	192.168.20.4	255.255.255.0
PC2	Fa0/02	192.168.20.5	255.255.255.0
PC4	Fa0/01	192.168.20.6	255.255.255.0
Students			
PC9	Fa0/06	192.168.20.10	255.255.255.0
PC8	Fa0/05	192.168.20.11	255.255.255.0
PC6	Fa0/04	192.168.20.12	255.255.255.0
PC7	Fa0/03	192.168.20.13	255.255.255.0
PC10	Fa0/02	192.168.20.14	255.255.255.0
PC11	Fa0/01	192.168.20.15	255.255.255.0

A. Port Security

1. Connect the topology shown in Figure 6.3
2. Set the VLAN 1 address to 192.168.50.2
3. Check the Mac-address of system Engineering
4. Open the CLI and configure port security using following commands

Switch>

Switch>en

Switch#config t

Enter configuration commands, one per line. End with CNTL/Z.



```
Switch(config)#interface FastEthernet 0/3
```

```
Switch(config-if)#switchport mode access
```

```
Switch(config-if)#switchport port-Security maximum 1
```

```
Switch(config-if)#switchport port-Security mac-address sticky or system mac-address.
```

```
Switch(config-if)#switchport port-Security violation shutdown
```

```
Switch(config-if)#exit
```

5. Note that MAC address is unique to every system or host
6. Ping the switch from the system connected
7. Disconnect the system and connect another system as shown in Figure 6.4
8. Ping the Switch again. State your observation.
9. Change violation to restrict and denied and verify the output.
10. Change maximum to 2 and connect system 2 back.
11. Ping the Switch again and verify your output

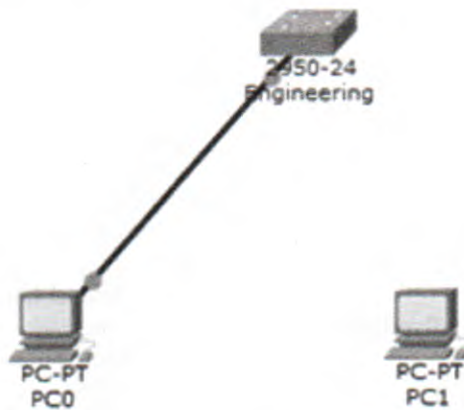


Figure 6.3: Topology to Demonstrate Port-Security

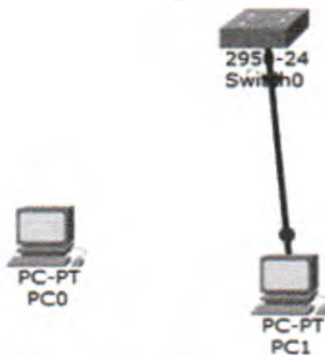


Figure 6.4: Topology to Demonstrate Port-Security

Table 6.2: Configuration Modes

Mode	Purpose	Prompt	Command to enter	Command to exit
User EXEC	Allow you to connect with remote devices, perform basic tests, temporary change terminal setting and list system information	Router >	Default mode after booting. Login with password, if configured.	Use <i>exit</i> command
Privileged EXEC	Allow you to set operating parameters. It also includes high level testing and list commands like show, copy and debug.	Router #	Use <i>enable</i> command from user exec mode	Use <i>exit</i> command
Global Configuration	Contain commands those affect the entire system	Router(config)#	Use <i>configure terminal</i> command from privileged exec mode	Use <i>exit</i> command
Interface Configuration	Contain commands those modify the operation of an interface	Router(config-if)#	Use <i>interface type number</i> command from global configuration mode	Use <i>exit</i> command to return in global configuration mode
Sub-Interface Configuration	Configure or modify the virtual interface created from physical interface	Router(config-subif)	Use <i>interface type sub interface number</i> command from global configuration mode or interface configure mode	Use <i>exit</i> to return in previous mode. Use <i>end</i> command to return in privileged exec mode.
Setup	Used by router to create initial configuration, if running configuration is not present	Parameter[Parameter value]:	Router will automatically insert in this mode if running configuration is not present	Press CTRL+C to abort. Type yes to save configuration, or no to exit without saving when asked in the end of setup.
ROMMON	If router automatically enters in this mode, then it indicates that it fails to locate a valid IOS image. Manual entrance in this mode Allow you to perform low-level diagnostics.	ROMMON>	Enter reload command from privileged exec mode. Press CTRL + C key combination during the first 60 seconds of booting process	Use <i>exit</i> command.

APPENDIX A: STANDARD RESISTOR COLOR CODE

The color code for the resistor value utilizes two digits and a multiplier digit in that order, as shown in Figure A1. A fourth band designates the tolerance.

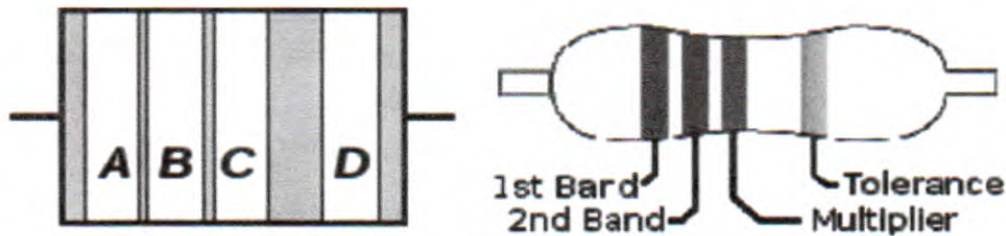


Figure A1: Resistor with Four Color Bands.

The resistance of a resistor with the four bands of color may be written as

$$R = (A \times 10 + B) \times C \pm D$$

Where A and B are the values of the first and second bands, respectively, C is a multiplier and D is the tolerance. The color code together with multipliers and tolerances are listed in Table A1.

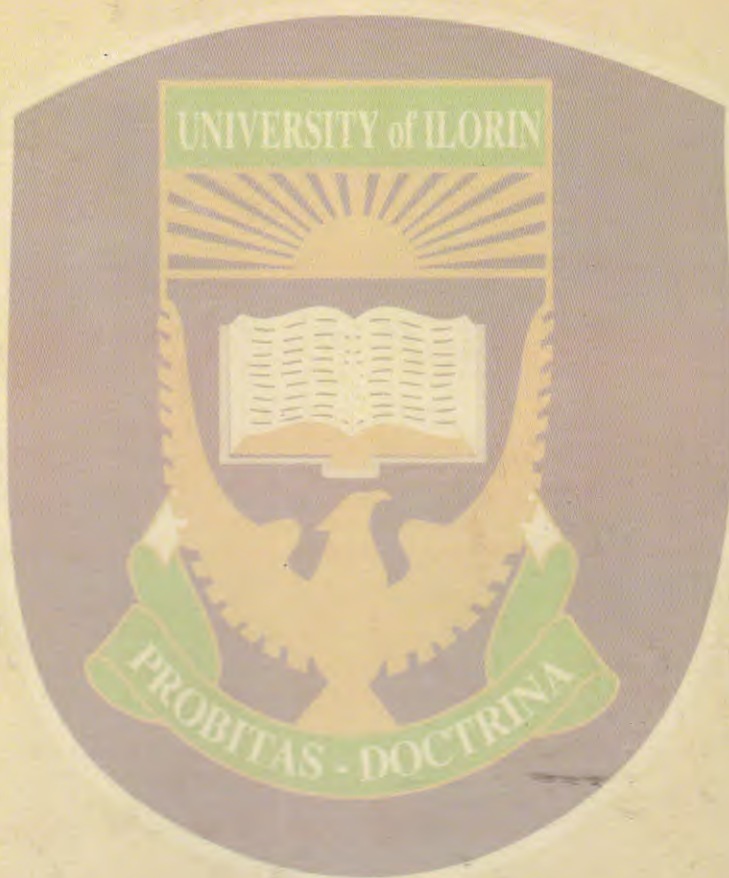
Table A1: Resistor Color Code

Color	Significant figures	Multiplier	Tolerance
Black	0	$\times 10^0$	--
Brown	1	$\times 10^1$	--
Red	2	$\times 10^2$	$\pm 2\%$
Orange	3	$\times 10^3$	--
Yellow	4	$\times 10^4$	--
Green	5	$\times 10^5$	--
Blue	6	$\times 10^6$	--
Violet	7	$\times 10^7$	--
Gray	8	$\times 10^8$	--
White	9	--	--
Gold	--	$\times 10^{-1}$	$\pm 5\%$
Silver	--	$\times 10^{-2}$	$\pm 10\%$
None	--	--	$\pm 20\%$









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