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الجامعة الإسلامية العالمية ماليزيا

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

ENGINEERING LAB II
ECE 1201
ELECTRONICS LAB MANUAL

SEMESTER _________

YEARS _____________

NAME:

MATRIC NO:

INDEX

Dress codes and ethics

وَقُل لِّلۡمُؤۡمِنَٰتِ يَغۡضُضۡنَ مِنۡ أَبۡصَٰرِهِنَّ وَيَحۡفَظۡنَ فُرُوجَهُنَّ وَلَا
يُبۡدِينَ زِينَتَهُنَّ إِلَّا مَا ظَهَرَ مِنۡهَاۖ وَلۡيَضۡرِبۡنَ بِخُمُرِهِنَّ عَلَىٰ جُيُوبِهِنَّۖ
وَلَا يُبۡدِينَ زِينَتَهُنَّ إِلَّا لِبُعُولَتِهِنَّ أَوۡ ءَابَآئِهِنَّ أَوۡ ءَابَآءِ بُعُولَتِهِنَّ أَوۡ
أَبۡنَآئِهِنَّ أَوۡ أَبۡنَآءِ بُعُولَتِهِنَّ أَوۡ إِخۡوَٰنِهِنَّ أَوۡ بَنِيٓ إِخۡوَٰنِهِنَّ أَوۡ بَنِيٓ
أَخَوَٰتِهِنَّ أَوۡ نِسَآئِهِنَّ أَوۡ مَا مَلَكَتۡ أَيۡمَٰنُهُنَّ أَوِ ٱلتَّٰبِعِينَ غَيۡرِ أُوْلِي
ٱلۡإِرۡبَةِ مِنَ ٱلرِّجَالِ أَوِ ٱلطِّفۡلِ ٱلَّذِينَ لَمۡ يَظۡهَرُواْ عَلَىٰ عَوۡرَٰتِ ٱلنِّسَآءِۖ
وَلَا يَضۡرِبۡنَ بِأَرۡجُلِهِنَّ لِيُعۡلَمَ مَا يُخۡفِينَ مِن زِينَتِهِنَّۚ وَتُوبُوٓاْ إِلَى
ٱللَّهِ جَمِيعًا أَيُّهَ ٱلۡمُؤۡمِنُونَ لَعَلَّكُمۡ تُفۡلِحُونَ ٣١

24:31 And say to the believing women that they should lower their gaze and guard their modesty; that they should not display their beauty and ornaments except what (must ordinarily) appear thereof; that they should draw their veils over their bosoms and not display their beauty except to their husbands, their fathers, their husband's fathers, their sons, their husbands' sons, their brothers or their brothers' sons, or their sisters' sons, or their women, or the slaves whom their right hands possess, or male servants free of physical needs, or small children who have no sense of the shame of sex; and that they should not strike their feet in order to draw attention to their hidden ornaments. And O ye Believers! turn ye all together towards Allah, that ye may attain Bliss.

Safety

Safety in the electrical laboratory, as everywhere else, is a matter of the knowledge of potential hazards, following safety precautions, and common sense. Observing safety precautions is important due to pronounced hazards in any electrical/computer engineering laboratory. Death is usually certain when 0.1 ampere or more flows through the head or upper thorax and have been fatal to persons with coronary conditions. The current depends on body resistance, the resistance between body and ground, and the voltage source. If the skin is wet, the heart is weak, the body contact with ground is large and direct, then 40 volts could be fatal. Therefore, never take a chance on "low" voltage. When working in a laboratory, injuries such as burns, broken bones, sprains, or damage to eyes are possible and precautions must be taken to avoid these as well as the much less common fatal electrical shock. Make sure that you have handy emergency phone numbers to call for assistance if necessary. If any safety questions arise, consult the lab demonstrator or technical assistant/technician for guidance and instructions. Observing proper safety precautions is important when working in the laboratory to prevent harm to yourself or others. The most common hazard is the electric shock which can be fatal if one is not careful.

Acquaint yourself with the location of the following safety items within the lab.

a. fire extinguisher
b. first aid kit
c. telephone and emergency numbers

ECE Department	03-6196 4530
Kulliyyah of Engineering Deputy Dean's Student Affairs	03-6196 4410
IIUM Security	03-6196 5555
IIUM Clinic	03-6196 4444

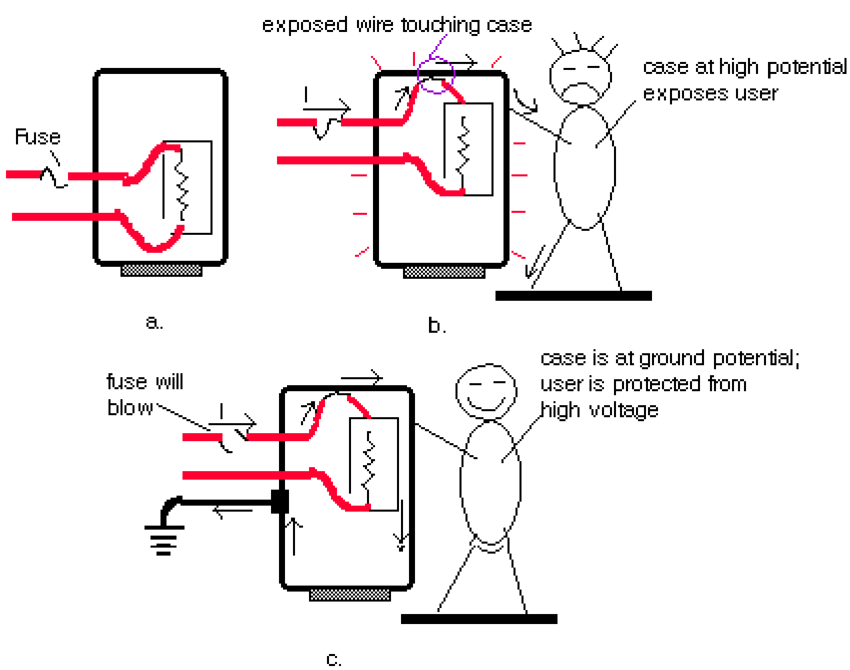
Electric shock

Shock is caused by passing an electric current through the human body. The severity depends mainly on the amount of current and is less function of the applied voltage. The threshold of electric shock is about 1 mA which usually gives an unpleasant tingling. For currents above 10 mA, severe muscle pain occurs and the victim can't let go of the conductor due to muscle spasm. Current between 100 mA and 200 mA (50 Hz AC) causes ventricular fibrillation of the heart and is most likely to be lethal.

What is the voltage required for a fatal current to flow? This depends on the skin resistance. Wet skin can have a resistance as low as 150 Ohm and dry skin may have a resistance of 15 kOhm. Arms and legs have a resistance of about 100 Ohm and the trunk 200 Ohm. This implies that 240 V can cause about 500 mA to flow in the body if the skin is wet and thus be fatal. In addition skin resistance falls quickly at the point of contact, so it is important to break the contact as quickly as possible to prevent the current from rising to lethal levels.

Equipment grounding

Grounding is very important. Improper grounding can be the source of errors, noise and a lot of trouble. Here we will focus on equipment grounding as a protection against electrical shocks. Electric instruments and appliances have equipments casings that are electrically insulated from the wires that carry the power. The isolation is provided by the insulation of the wires as shown in the figure a below. However, if the wire insulation gets damaged and makes contact to the casing, the casing will be at the high voltage supplied by the wires. If the user touches the instrument he or she will feel the high voltage. If, while standing on a wet floor, a user simultaneously comes in contact with the instrument case and a pipe or faucet connected to ground, a sizable current can flow through him or her, as shown in Figure b. However, if the case is connected to the ground by use of a third (ground) wire, the current will flow from the hot wire directly to the ground and bypass the user as illustrated in figure c.



Equipments with a three wire cord is thus much safer to use. The ground wire (3rd wire) which is connected to metal case, is also connected to the earth ground (usually a pipe or bar in the ground) through the wall plug outlet.

Always observe the following safety precautions when working in the laboratory:

1. Do not work alone while working with high voltages or on energized electrical equipment or electrically operated machinery like a drill.

2. Power must be switched off whenever an experiment or project is being assembled, disassembled, or modified. **Discharge any high voltage points to grounds with a well insulated jumper. Remember that capacitors can store dangerous quantities of energy.**

3. Make measurements on live circuits or discharge capacitors with well insulated probes keeping one hand behind your back or in your pocket. Do not allow any part of your body to contact any part of the circuit or equipment connected to the circuit.

4. After switching power off, discharge any capacitors that were in the circuit. Do not trust supposedly discharged capacitors. Certain types of capacitors can build up a residual charge after being discharged. Use a shorting bar across the capacitor, and keep it connected until ready for use. If you use electrolytic capacitors, do not :
    - put excessive voltage across them
    - put ac across them
    - connect them in reverse polarity

5. Take extreme care when using tools that can cause short circuits if accidental contact is made to other circuit elements. Only tools with insulated handles should be used.

6. If a person comes in contact with a high voltage, immediately shut off power. Do not attempt to remove a person in contact with a high voltage unless you are insulated from them. If the victim is not breathing, apply CPR immediately continuing until he/she is revived, and have someone dial emergency numbers for assistance.

7. Check wire current carrying capacity if you will be using high currents. Also make sure your leads are rated to withstand the voltages you are using. This includes instrument leads.

8. Avoid simultaneous touching of any metal chassis used as an enclosure for your circuits and any pipes in the laboratory that may make contact with the earth, such as a water pipe. Use a floating voltmeter to measure the voltage from ground to the chassis to see if a hazardous potential difference exists.

9. Make sure that the lab instruments are at ground potential by using the ground terminal supplied on the instrument. Never handle wet, damp, or ungrounded electrical equipment.

10. Never touch electrical equipment while standing on a damp or metal floor.

11. Wearing a ring or watch can be hazardous in an electrical lab since such items make good electrodes for the human body.

12. When using rotating machinery, place neckties or necklaces inside your shirt or, better yet, remove them.

13. Never open field circuits of D-C motors because the resulting dangerously high speeds may cause a "mechanical explosion".

14. Keep your eyes away from arcing points. High intensity arcs may seriously impair your vision or a shower of molten copper may cause permanent eye injury.

15. Never operate the black circuit breakers on the main and branch circuit panels.

16. **In an emergency all power in the laboratory can be switched off by depressing the large red button on the main breaker panel. Locate it. It is to be used for emergencies only.**

17. **Chairs and stools should be kept under benches when not in use. Sit upright on chairs or stools keeping the feet on the floor. Be alert for wet floors near the stools.**

18. Horseplay, running, or practical jokes must not occur in the laboratory.

19. **Never use water on an electrical fire. If possible switch power off, then use CO_2 or a dry type fire extinguisher. Locate extinguishers and read operating instructions before an emergency occurs.**

20. Never plunge for a falling part of a live circuit such as leads or measuring equipment.

21. Never touch even one wire of a circuit; it may be hot.

22. Avoid heat dissipating surfaces of high wattage resistors and loads because they can cause severe burns.

23. Keep clear of rotating machinery.

Precautionary Steps before Starting an Experiment

a) Read materials related to experiment beforehand as preparation for pre-lab quiz and experimental calculation.

b) Make sure that apparatus to be used are in good condition. Seek help from technicians or the lab demonstrator in charge should any problem arises.
   - Power supply is working properly ie I_{max} (maximum current) LED indicator is disable. Maximum current will retard the dial movement and eventually damage the equipment. Two factors that will light up the LED indicator are short circuit and insufficient supply of current by the equipment itself. To monitor and maintain a constant power supply, the equipment must be connected to circuit during voltage measurement. DMM are not to be used simultaneously with oscilloscope to avert wrong results.
   - Digital multimeter (DMM) with low battery indicated is not to be used. By proper connection, check fuses functionality (especially important for current measurement). Comprehend the use of DMM for various functions. Verify

measurements obtained with theoretical values calculated as it is quite often where 2 decimal point reading and 3 decimal point reading are very much deviated.

- The functionality of voltage waveform generators are to be understood. Make sure that frequency desired is displayed by selecting appropriate multiplier knob. Improper settings (ie selected knob is not set at minimum (in direction of CAL – calibrate) at the bottom of knob) might result in misleading values and hence incorrect results. Avoid connecting oscilloscope together with DMM as this will lead to erroneous result.
- Make sure both analog and digital oscilloscopes are properly calibrated by positioning sweep variables for VOLT / DIV in direction of CAL. Calibration can also be achieved by stand alone operation where coaxial cable connects CH1 to bottom left hand terminal of oscilloscope. This procedure also verifies coaxial cable continuity.

c) Internal circuitry configuration of breadboard or Vero board should be at students' fingertips (ie holes are connected horizontally not vertically for the main part with engravings disconnecting in-line holes).

d) Students should be rest assured that measured values (theoretical values) of discrete components retrieved ie resistor, capacitor and inductor are in accordance the required ones.

e) Continuity check of connecter or wire using DMM should be performed prior to proceeding an experiment. Minimize wires usage to avert mistakes.

f) It is unethical and unislamic for students to falsify results as to make them appear exactly consistent with theoretical calculations.

INTRODUCTION TO ENGINEERING LAB II (ECE 1201) - ELECTRONICS

1. Basic Guidelines
2. Lab Instructions
3. Grading
4. Lab Reports
5. Schedule and Experiment No. (Title)

1. Basic Guidelines

All experiments in this manual have been tried and proven and should give you little trouble in normal laboratory circumstances. However, a few guidelines will help you conduct the experiments quickly and successfully.

1. Each experiment has been written so that you follow a structured logical sequence meant to lead you to a specific set of conclusions. Be sure to follow the procedural steps in the order which they are written.
2. Read the entire experiment and research any required theory beforehand. Many times an experiment takes longer that one class period simply because a student is not well prepared.
3. Once the circuit is connected, if it appears "dead'' spend few moments checking for obvious faults. Some common simple errors are: power not applied, switch off, faulty components, lose connection, etc. Generally the problems are with the operator and not the equipment.
4. When making measurements, check for their sensibility.
5. **It's unethical to "fiddle" or alter your results to make them appear exactly consistent with theoretical calculations.**

2. Lab Instructions

1. Each student group consists of a maximum of two students. Each group is responsible in submitting 1 lab report upon completion of each experiment.
2. Students are to wear proper attire i.e shoe or sandal instead of slipper. Excessive jewelleries are not advisable as they might cause electrical shock.
3. Personal belongings i.e bags, etc are to be put at the racks provided. Student groups are required to wire up their circuits in accordance with the diagram given in each experiment.
4. A permanent record in ink of observations as well as results should be maintained by each student and enclosed with the report.
5. The **recorded data** and **observations** from the lab manual need to be **approved** and **signed** by the **lab instructor** upon completion of each experiment.
6. Before beginning connecting up, it is essential to check that all sources of supply at the bench are switched off.
7. Start connecting up the experiment circuit by wiring up the main circuit path, then add the parallel branches as indicated in the circuit diagram.
8. After the circuit has been connected correctly, remove all unused leads from the experiment area, set the voltage supplies at the minimum value, and check the meters are set for the intended mode of operation.

9. The students may ask the lab instructor to check the correctness of their circuit before switching on.
10. When the experiment has been satisfactory completed and the results approved by the instructor, the students may disconnect the circuit and return the components and instruments to the locker tidily. Chairs are to be slid in properly.

3. Grading

The work in the Electronics related lab carries 55% of total marks for the ECE 1201 subject (ENGINEERING LAB II). The distribution of marks for Electronics Lab is as follows:

Prelab	10%
Lab Report	45%
Quiz (2 Quizzes)	15%
Final Test	30%
Total	**100%**

Note: Final mark distribution

Pre-Lab = 10 %

Quiz = 15 %

Final Test = 30 %

Lab Report = 45%

4. Lab Reports

a. Report format and Evaluation:

The following format should be adhered to by the students in all their laboratory reports:

No.	Evaluation Items	Marks 20%	Marks obtain
1	Objectives	1	
2	Brief Theory	2	
3	Equipment list	2	
4	Experiment Set-up	2	
5	Results/Observations	5	
6	PSPICE	4	
7	Discussion and Conclusion	4	
	TOTAL	**20**	

Evaluation Criteria

Range of scores		Grade	
0	6.5	F	Poor
7	7.5	E	
8	8.5	D-	
9	9.5	D	
10	10.5	C	Fair
11	11.5	C+	
12	12.5	B-	Good
13	13.5	B	
14	14.5	B+	
15	16.5	A-	Very Good
17	20	A	Excellent

Of those listed above each section included in a report should be clearly nominated with the appropriate heading. The information to be given in each section is set out below:

(i) Objective

This should state clearly the objective of the experiment. It may be the verification of law, a theory or the observation of particular phenomena. Writing out the objective of the experiment is important to the student as it emphasizes the purpose for which the experiment is conducted.

(ii) Brief Theory

In this section, the related theory of the experiment must be discussed **briefly**. This section is important to assist student in making conclusion by comparing the experimental results to the theory.

(iii) Results

All experimental results which have been approved by the lab instructor (including graphs) must be attached in the report.

(iv) PSPICE

PSPICE output (as instructed in the lab manual) must be attached in the report to show the comparison of simulation results and experimental results.

(vi) Discussion & Conclusion

Once the analysis of the results is complete, the student must forms some deductions on the results of his analysis. Usually this involves deducing whether the final results show that the aim of the experiment has been achieved or not, and if they verify some law or theory presented to the student during the lectures. **Comments and comparison asked in the lab manual must be discussed in this section**. In making a decision on the former point, the student should reread the aim; and on the latter, the text book should be referred to, to ascertain whether there is theoretical agreement or not.

The student should give considerable thought to the material that he intends to submit in this section. It is here that he is able to express his own ideas on the experiment results and how they were obtained. It is the best indication to his teacher of whether he has understood the experiment and of how well he has been able to analyze the results and make deductions from them.

It is recommended that the conclusion should be taken up by the student's clear and concise explanation of his reasoning, based on the experimental results, that led to the deductions from which he was able to make the two statements with which he began the conclusion.

It is very rare for an experiment to have results which are entirely without some discrepancy. The student should explain what factors, in his opinion, may be the possible causes of these discrepancies. Similarly, results of an unexpected nature should form the basis for a discussion of their possible nature and cause.
The student should not be reluctant to give his opinions even though they may not be correct. He should regard his discussion as an opportunity to demonstrate his reasoning ability.

Should the results obtained be incompatible with the aim or with the theory underlying the experiment, then an acceptable report may be written suggesting reasons for the unsatisfactory results. It is expected that the student should make some suggestions as to how similar erroneous results for this experiment might be avoided in the future. The student must not form the opinion that an unsatisfactory set of results makes a report unacceptable.

b. Presentation of Lab Reports:

All students are required to present their reports in accordance with the following instructions.

(i) Reports have to be **handwritten** for submission.

(ii) Writing should appear on one side of each sheet only.

(iii) The students' name & matric number, section number, lab session and the lecturer's name must be printed in block letters at the top left-hand corner of the first sheet of the report. This must be followed in the middle of the sheet by:

- The course code
- The experiment number
- The title of the experiment
- The date on which the student carried out the experiment.

(iv) All sections such as objective, brief theory and so on, should be titled on the left hand side of the working space of the page.

(v)

- Each type of calculation pertaining to the experiment should be preceded by a brief statement indicating its objective.
- All calculations are to be shown in sufficient details to enable the reader to follow their procedure.
- All formulas used are to be written in correct symbols prior to the substitution of the known quantities.

(vi) All graphs are to be drawn on graph paper in blue or black ink. Other colors may be used for identification. The abscissa and ordinate are to be drawn in all times and scaled with the value clearly indicated at each major division. The quantity at each axis represents and the unit in which it is calibrated should be clearly indicated. Each graph is to be titled so as to indicate clearly what it represents.

(vii) The report submitted by each student should contain a conclusion and discussion of more than 300 words.

(viii) The cover of the report **must be** as follows:

REPORTS ON

ECE 1201: ENGINEERING LAB - II

"EXPERIMENT NO. :"
"TITLE OF THE EXPERIMENT"

No.	Evaluation Items	Marks 20%	Marks obtain
1	Objectives	1	
2	Brief Theory	2	
3	Equipment list	2	
4	Experiment Set-up	2	
5	Results/Observations	5	
6	PSPICE	4	
6	Discussion and Conclusion	4	
	TOTAL	**20**	

Date of Experiment: ___________________ Date of Submission:___________________

Group No. :

Matric No: ___________ Name : ____

Matric No: ___________ Name : ____

Matric No: ___________ Name : ____

5. Schedule & Experiment No. (Title)

Tentative Week	Experiment No. (Title)	Lab Report Submission
1	Introductory class – Briefing on the organization of the course	-
2	Introduction to PSPICE – Tutorial 1	-
3	PSPICE - Tutorial 2	-
4	**Experiment No. 1 & 2** (Diode Characteristics & Zener Diode Characteristics)	-
5 & 6	**Experiment No. 3** (Wave Rectifier & Clipper Circuit)	**Week 5**: Submission of Lab Report for Experiment 1 & 2
7&8	**Experiment No. 4** (BJT Characteristics & Common-Emitter Transistor Amplifier)	**Week 7:** Submission of Lab Report for Experiment 3
9	**Experiment No. 5** (BJT Biasing Circuits)	**Week 9:** Submission of Lab Report for Experiment 4
10	**Experiment No. 6** (MOSFET - Common Source Amplifier)	**Week 10:** Submission of Lab Report for Experiment 5
11	**Experiment no. 7** (Inverting and Non-Inverting OP Amp)	**Week 11:** Submission of Lab Report for Experiment 6
12	-	**Week 12:** Submission of Lab Report for Experiment 7
13 & 14	Final Exam	

All lab report should be submitted **upon starting the lab session** of the following week to the lecturer/demonstrators on duty for your section. Late submission of the lab report will not be entertained and will be given **Nil** for the report. Strictly **no make up lab due to absenteeism is allowed** without sound reason.

Pre-Lab Questions for Experiment 1 & 2

1. What is the need for doping?

2. How depletion region is formed in the PN junction?

3. Sketch the expected I_D versus V_D for :
   i. PN Junction Diode
   ii. Zener Diode.

EXPERIMENT 1: Diode Characteristics

Objective:

- To study the characteristics of silicon and germanium diodes.

Equipment:

Instruments
DC power supply
Function Generator
Digital Multimeter (DMM)

Components
Diodes : Silicon (D1N4002), Germanium (D1N4148)
Resistors: 1kΩ, 1MΩ

Procedure:

Part A : Forward-bias Diode Characteristics

1. Construct the circuit of *Fig. 1.1* with the supply (E) is set at 0 V. Record the measured value of the resistor.

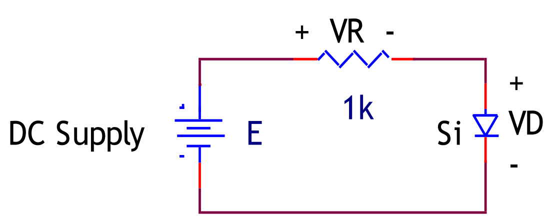


Fig. 1.1

2. Increase the supply voltage until V_D reads 0.1 V. Then measure current I_D and record the results in Table 1.1
3. Repeat step 2 for the remaining settings of V_D shown in the Table 1.1.
4. Replace the silicon diode by a germanium diode and complete Table 1.2.
5. Plot on a graph paper I_D versus V_D for the silicon and germanium diodes. Complete the curves by extending the lower region of each curve to the intersection of the axis at $I_D = 0$ mA and $V_D = 0$ V.
6. How the two curves differ? What are their similarities?

Part B : Reverse-bias Diode Characteristics

1. Construct the circuit of *Fig. 1.2* with E is set at 20V. Record the measured value of the resistor.

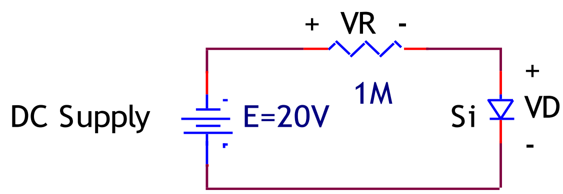


Fig. 1.2

2. Measure the voltage V_D. Measure the reverse saturation current, I_s.
3. Repeat the above step for germanium diode.
4. How do the results of Step 2 compare to Step 3? What are the similarities?

PSPICE Instructions:

1. Construct the circuit in *Fig. 1.1* using PSPICE.
2. From PSPICE simulation, obtain the forward bias characteristics for both Silicon and Germanium diodes.

Results and Calculations:

Part A (Forward Bias)

1. R (measured) = ________________

2. I_D (measured). Fill in Table 1.1 and Table 1.2

V_D (V)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.75
I_D (mA)								

Table 1.1(Silicon Diode)

V_D (V)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.75
I_D (mA)								

Table 1.2 (Germanium Diode)

Part B (Reverse Bias)

1. R (measured) = ___________

2. <u>Silicon Diode</u>

   V_D (measured) = ___________

   I_S (measured) = ___________

3. <u>Germanium Diode</u>

   V_D (measured) = ___________

   I_S (measured) = ___________

EXPERIMENT 2: Zener Diode Characteristics

Objectives:

- To study the characteristics of Zener diode.
- To study the voltage regulation in Zener diode regulation circuit.

Equipment:

Instruments
DC power supply
Digital Multimeter (DMM)

Components
Diode : Zener (10-V)
Resistors: 0.1kΩ, 1kΩ (2 pcs), 3.3kΩ

Procedure:

Part A : Zener Diode Characteristics

1. Construct the circuit of *Fig. 2.1*. Set the DC supply to 0 V and record the measured value of R.

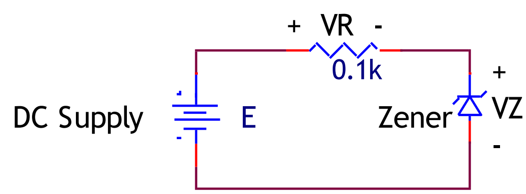


Fig. 2.1

2. Set the DC supply (E) to the values appearing in Table 2.1 and measure both V_Z and V_R. Calculate the Zener current, I_Z using the Ohm's law given in the table and complete the table.

3. Plot I_Z versus V_Z using the data in Table 2.1 on a graph paper.

Part B : Zener Diode Regulation

1. Construct the circuit of *Fig. 2.2*. Record the measured value of each resistor.

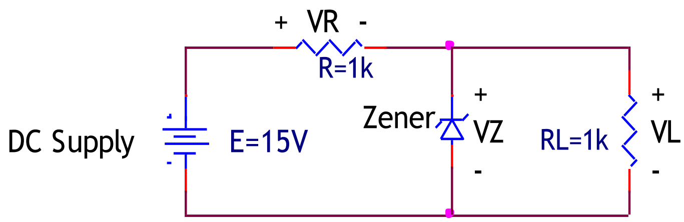


Fig. 2.2

2. Measure the value of V_L and V_R. Using the measured values, calculate the value for current across R, I_R, current across R_L, I_L, and current across the zener diode, I_Z.

3. Change R_L to 3.3 kΩ and repeat Step 2.

4. Comment on the results obtained in Steps 2 and 3.

PSPICE Instructions:

1. Construct the circuit in *Fig. 2.2* using PSPICE.

2. Find the values of V_L, V_R, I_Z, I_L and I_R when R_L=1 kΩ.

3. Change R_L to 3.3 kΩ, find the same values as Step 2.

Results and Calculations:

Part A

1. R (measured) = ___________

2.

E (V)	0	1	3	5	7	9	11	13	15
V_Z (V)									
V_R (V)									
$I_Z = V_R / R_{meas}$ (mA)									

Table 2.1

Part B

1. R (measured) = _____________, R_L (measured) = ____________

2. V_R (measured) = ____________, V_L (measured) = ____________

   $I_R = V_R / R$ = ____________, $I_L = V_L / R_L$ = ____________,

   $I_Z = I_R – I_L$ = ____________

3. Change R_L to 3.3kΩ;

   R_L (measured) = ____________,
   V_R (measured) = ____________, V_L (measured) = ____________

   $I_R = V_R / R$ = ____________, $I_L = V_L / R_L$ = ____________,

   $I_Z = I_R – I_L$ = ____________

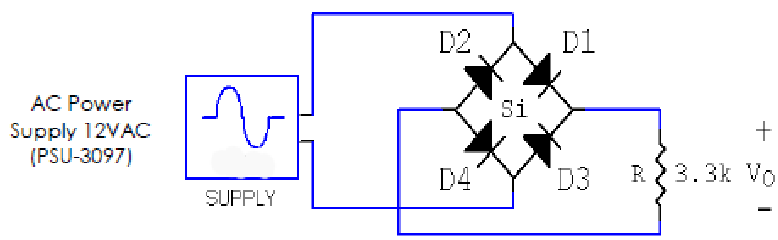
Pre-Lab Questions for Experiment 3

1. What is the difference between half wave and full wave rectifiers?

2. Name two types of full-wave rectifier.

3. What is a function of a clipper circuit?

4. Provide an equation of V_o for the full wave rectifier circuit below. Assume the diode has a value of $V\gamma$ when it is forward biased and the AC supply, $V_i = V_p \sin \omega t$ (V)



EXPERIMENT 3: Wave Rectifier and Clipper Circuits

Objectives:

- To calculate and draw the DC output voltages of half-wave and full-wave rectifiers.
- To calculate and measure the output voltages of clipper circuits.

Equipment:

Instruments
DC power supply
AC power supply - (Model : PSU-3097 ,12VAC ~0~ 12VAC).
Digital Multimeter (DMM)
Function Generator
Oscilloscope

Components
Diode : Silicon (D1N4002)
Resistors: 2.2kΩ, 3.3kΩ

Procedure:

Part A : Half Wave Rectification

1. Construct the circuit of *Fig. 3.1*. Set the supply to 9 V p-p sinusoidal wave with the frequency of 1000 Hz. Put the oscilloscope probes at function generator and sketch the input waveform obtained.
2. Put the oscilloscope probes across the resistor and sketch the output waveform obtained. Measure and record the DC level of the output voltage using the DMM.

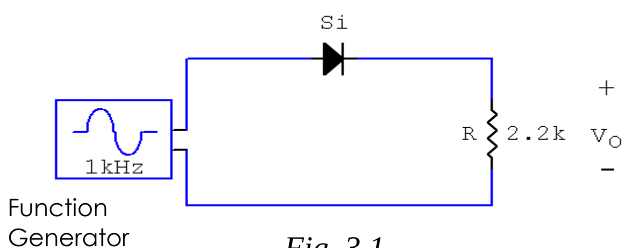


Fig. 3.1

3. Reverse the diode of circuit of *Fig. 3.1*. Sketch the output waveform across the resistor. Measure and record the DC level of the output voltage.
4. Comment on the results obtained from step 2 and 3.

Part B : Full-Wave Rectification

1. Construct the circuit of *Fig. 3.2* with 12 VAC, AC Power Supply. (Model : PSU-3097 ,12VAC ~0~ 12VAC).

2. Put the oscilloscope probes across the resistor and sketch the output waveform obtained. Measure and record the DC level of the output voltage using the DMM.

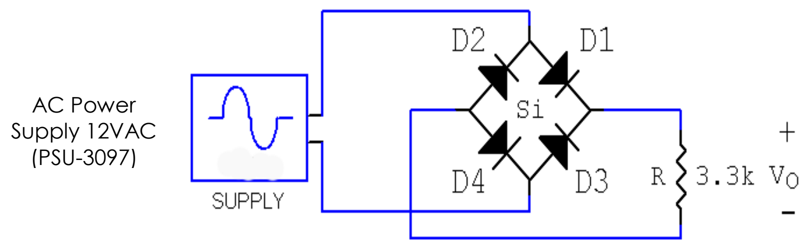


Fig. 3.2

Part C : Parallel Clippers

1. Construct the circuit in *Fig. 3.3*. The input signal is an 8 V p-p square wave at frequency of 1000 Hz. Record the measured resistance value.
2. Set the oscilloscope in DC mode.
3. Put the oscilloscope probes at function generator and sketch the input waveform obtained.

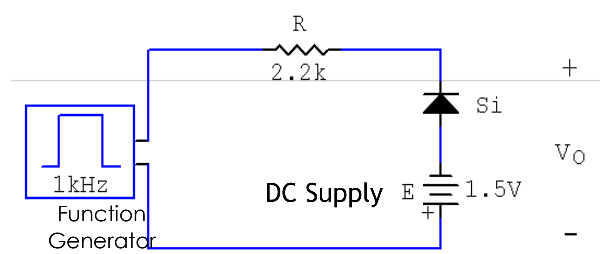


Fig. 3.3

4. Sketch the output waveform obtained from the oscilloscope.
5. Reverse the battery of the circuit and sketch the output waveform.
6. How do the waveforms differ? What is the function of the battery in the circuit?
7. Change the input signal of the circuit of *Fig. 3.3* to an 8 V p-p sinusoidal signal with the same frequency of 1000 Hz. Repeat step 3 and 4 for this circuit.

Part D : Series Clippers

1. Construct the circuit in *Fig. 3.4*. The input signal is an 8 V p-p square wave at frequency of 1000 Hz. Record the measured resistance value.
2. Set the oscilloscope in DC mode.
3. Put the oscilloscope probes at function generator and sketch the input waveform obtained.

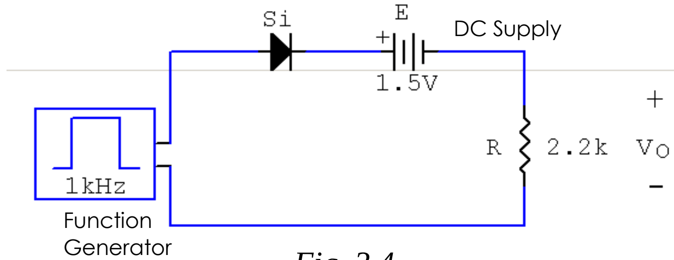


Fig. 3.4

4. Sketch the output waveform obtained from the oscilloscope.
5. Reverse the battery of the circuit and sketch the output waveform.
6. Change the input signal of the circuit of *Fig. 3.4* to an 8 V p-p sinusoidal signal with the same frequency of 1000 Hz. Repeat step 3 and 4 for this circuit.
7. How does the series clipper differ from the parallel clipper?

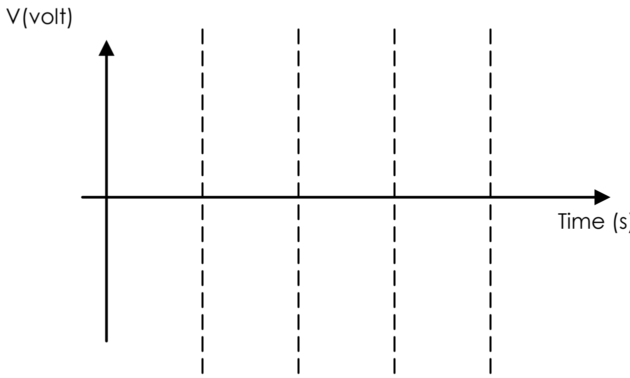
PSPICE Instructions:

Get the expected output waveform for circuits in *Fig. 3.1* (Part A) & *Fig. 3.3* (Part C) using PSPICE Simulation.

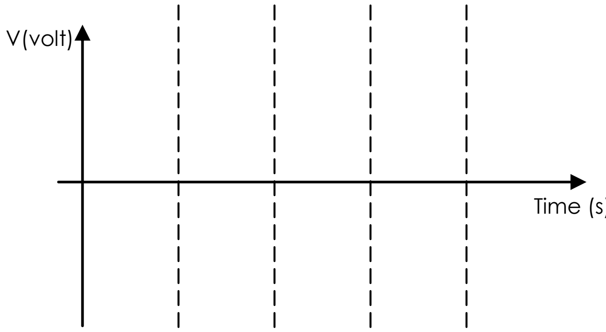
Results and Calculations:

Part A

1. Input waveform, V_i :



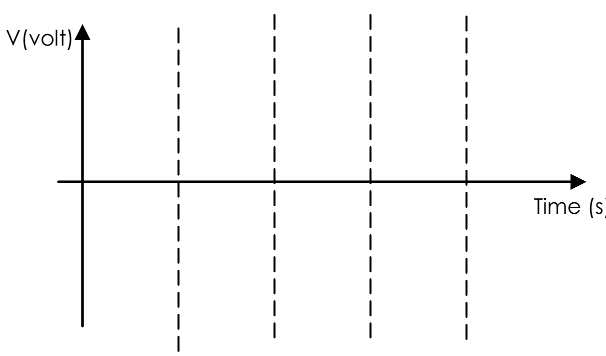
2. Output waveform, V_o :



DC level of V_o (measured) = __________

Part A (reversed diode)

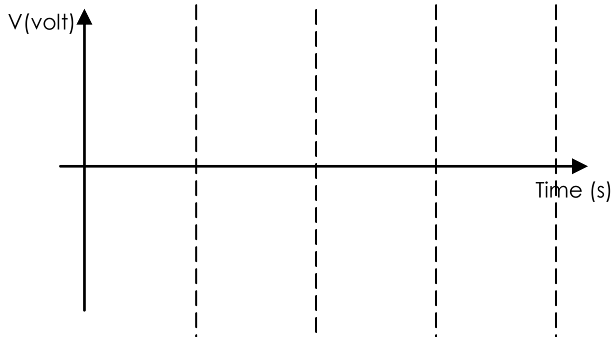
3. Output waveform, V_o :



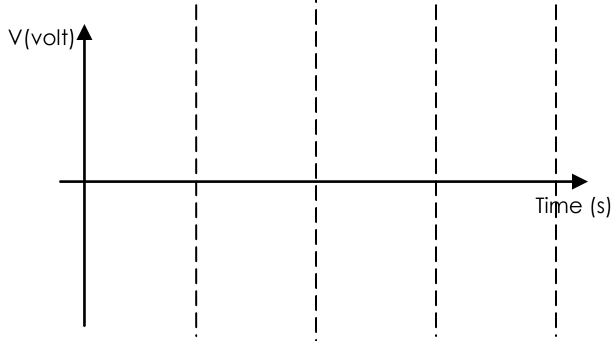
DC level of V_o (measured) = __________

Part B

1. Input waveform, V_i :



2. Output waveform, V_o :

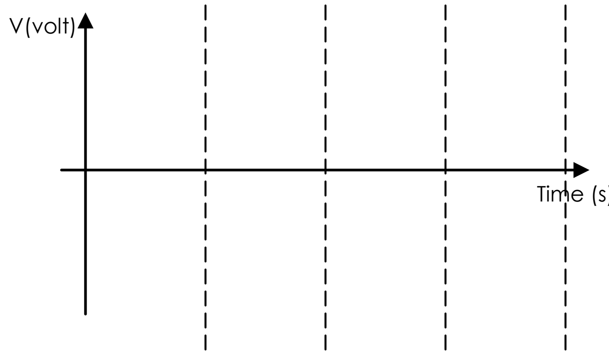


DC level of V_o (measured) = ___________

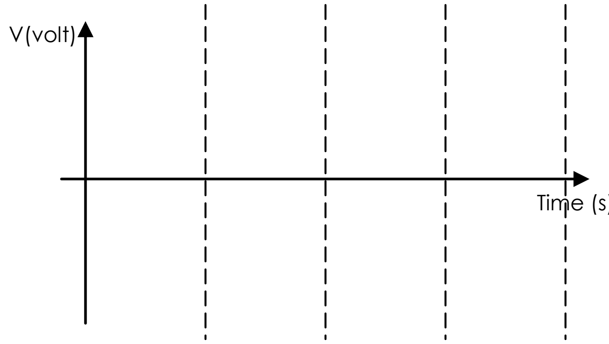
Part C (v_{in} square-wave)

1. R (measured) = ________________

2. Input waveform :

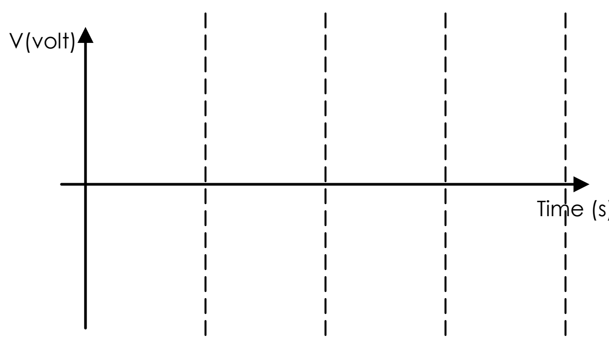


3. Output waveform :



Part C (v_{in} square-wave, battery reversed)

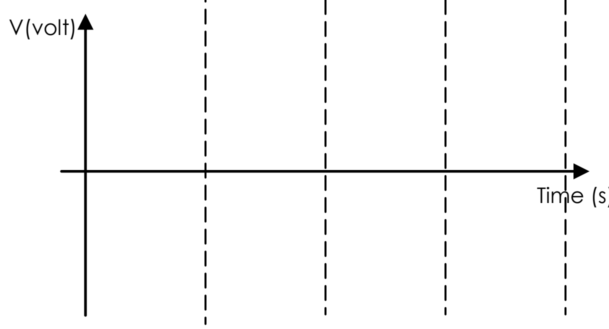
4. Output waveform :



Part C (v_{in} sine-wave)

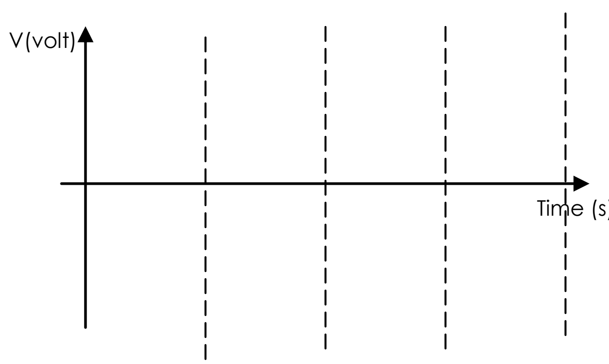
5. Input waveform :

6. Output waveform :



Part C (v_{in} sine-wave, battery reversed)

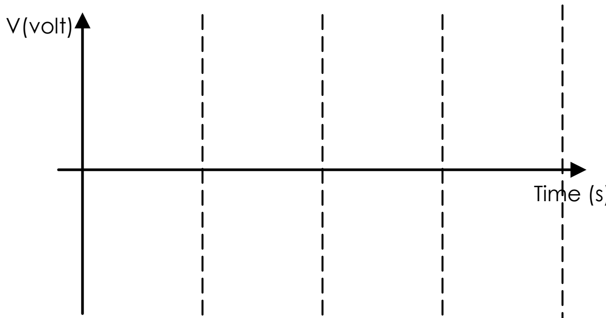
7. Output waveform :



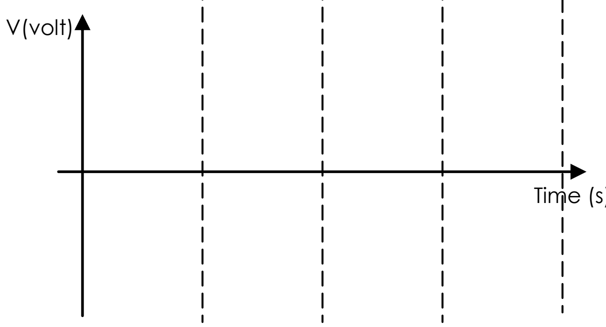
Part D (v_{in} square-wave)

1. R (measured) = _______________

2. Input waveform :

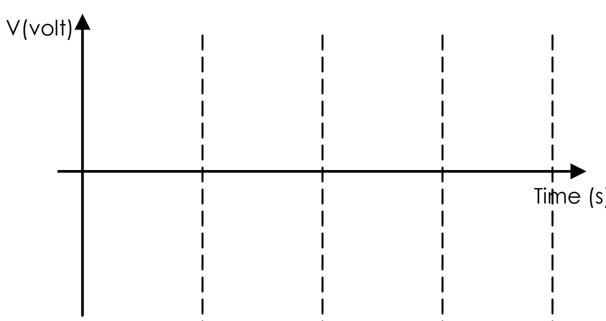


3. Output waveform :



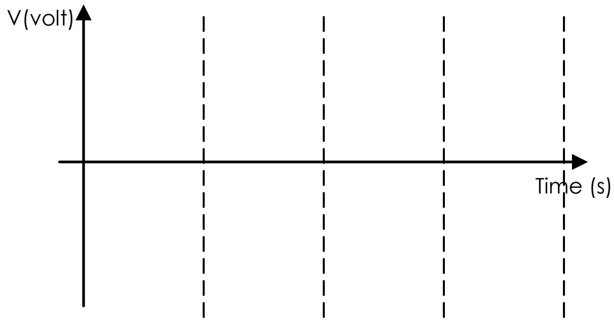
Part D (v_{in} square-wave, battery reversed)

4. Output waveform :

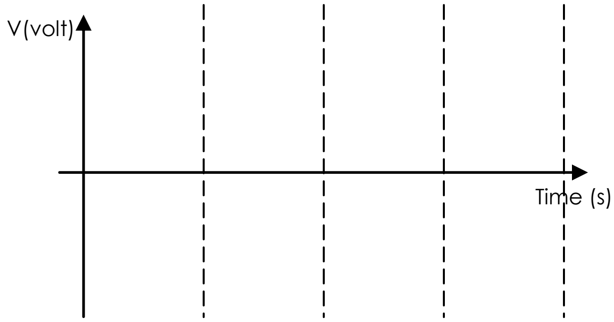


Part D (v_{in} sine-wave)

5. Input waveform :

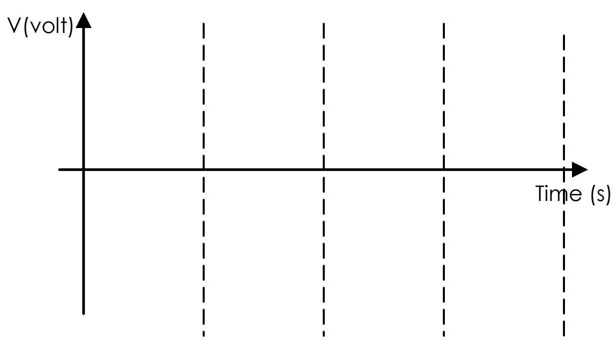


6. Output waveform :



Part D (v_{in} sine-wave, battery reversed)

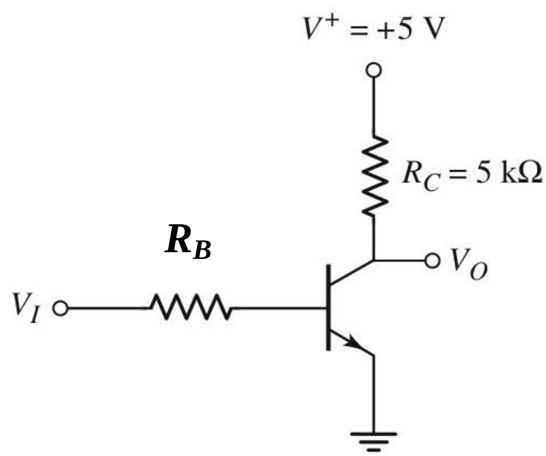
7. Output waveform :



Pre-lab Questions for Experiment 4

1. Sketch the IV characteristic (i_C versus v_{CE}) for an npn transistor.

2. A BJT circuitry is shown below. Given that R_B = 150 kΩ, R_C = 5 kΩ, V_I = 1.5 V and β = 120. Calculate the DC values for V_B, V_E, V_C, I_E. and V_O



EXPERIMENT 4: BJT Characteristics & Common-Emitter Transistor Amplifier

Objectives:

- To graph the collector characteristics of a transistor using experimental methods.
- To measure AC and DC voltages in a common-emitter amplifier.

Equipment:

Instruments
1 DC Power Supply
3 Digital Multimeter (DMM)
1 Function Generator
1 Oscilloscope

Components
Capacitors: 15 µF, 10 µF
Resistors: 1 kΩ, 3 kΩ, 10 kΩ, 33 kΩ, 330 kΩ, 10 kΩ potentiometer, 1MΩ potentiometer
Transistors: 2N3904

Procedure:

Part A : The Collector Characteristics (BJT)***Using two potentiometers***

1. Construct the circuit of *Fig. 4.1*. Vary the 1MΩ potentiometer to set I_B = 10 µA as in Table 4.1.

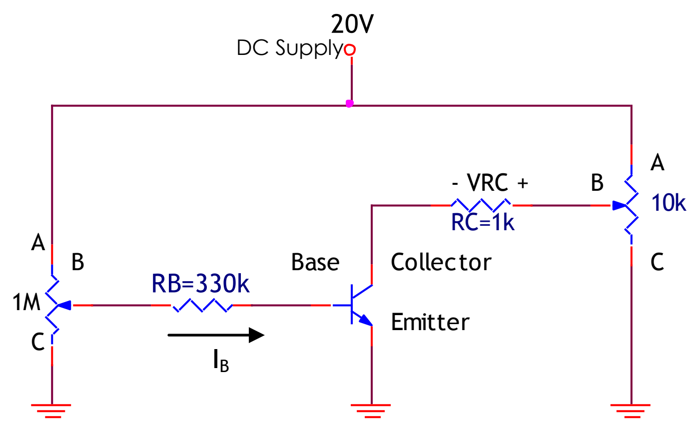


Fig. 4.1

2. Set the V_{CE} to 2V by varying the 10kΩ potentiometer as required by the first line of Table 4.1.
3. Record the V_{RC} and V_{BE} values in Table 4.1.

4. Vary the 10 kΩ potentiometer to increase V_{CE} from 2V to the values appearing in Table 4.1. (Note: I_B should be maintained at 10 µA for the range of V_{CE} levels.)

5. Record V_{RC} and V_{BE} values for each of the measured V_{CE} values. Use the mV range for V_{BE}.
6. Repeat step 2 through 5 for all values of I_B indicated in Table 4.1.
7. Compute the values of I_C (from $I_C = V_{RC}/R_C$) and I_E (from $I_E = I_B+I_C$). Use measured resistor value for R_C.
8. Using the data of Table 4.1, plot the collector characteristics of the transistor on a graph paper. (Plot I_C versus V_{CE} for the various values of I_B. Choose an appropriate scale for I_C and label each I_B curve).

<u>Part B : Common-Emitter DC Bias</u>

1. Measure all resistor values (R_1, R_2, R_C and R_E) from circuit in *Fig. 4.2* using DMM.
2. Calculate DC Bias values (V_B, V_E, V_C and I_E) and record them.
3. Calculate AC dynamic resistance, r_e.
4. Construct circuit as of *Fig. 4.2* and set V_{CC} = 10 V.
5. Measure the DC bias values (V_B, V_E, V_C and I_E) and record them.
6. Calculate I_E using values obtained in Step 5.
7. Calculate r_e using the value of I_E from Step 6.
8. Compare value of r_e obtained both from Step 3 & 7.

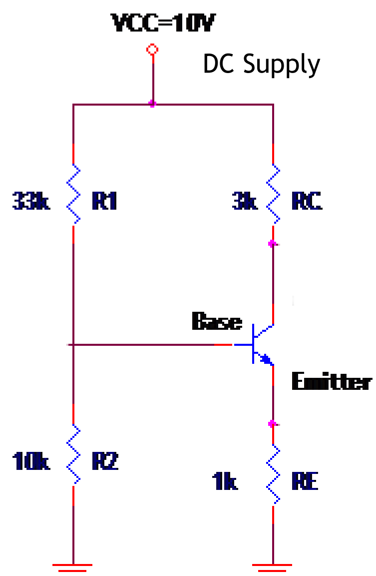


Fig. 4.2

PSPICE Instructions:

Using PSPICE Simulation, find the DC Bias values (V_B, V_E, V_C and I_E) for the circuit in *Fig. 4.2*. Compare the values obtained from PSPICE with the experimental ones.

Results and Calculations:

Part A – Step 3

I_B (μA)	V_{CE} (V) meas	V_{RC} (V) meas	I_C (mA) (calc)	V_{BE} (V) meas	I_E (mA) (calc)
	2				
	4				
10	6				
	8				
	2				
	4				
30	6				
	8				
	2				
50	4				
	6				
	8				

Table 4.1

Part B

1. R_1 (measured) = _____________, R_2 (measured) = ____________,
   R_C (measured) = ____________, R_E (measured) = ____________

2. V_B (calculated) = ____________, V_E (calculated) = ____________
   V_C (calculated) = ____________, I_E (calculated) = ____________

3. r_e (calculated) = ____________

$$r_e = \frac{26(mV)}{I_E \ (mA)}$$

5. V_B (measured) = ____________, V_E (measured) = ____________
   V_C (measured) = ____________,

6. I_E (calculated) using measured values of V_E and R_E = ___________

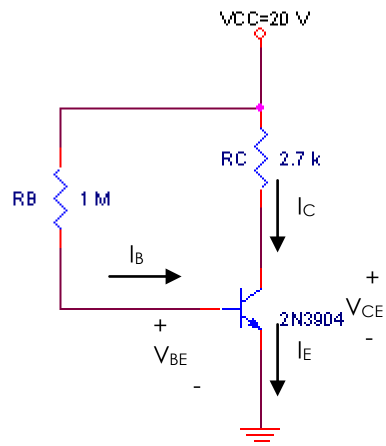
$$I_E = V_E / R_E$$

7. r_e (measured) = _____________, using measured I_E from Step 6.

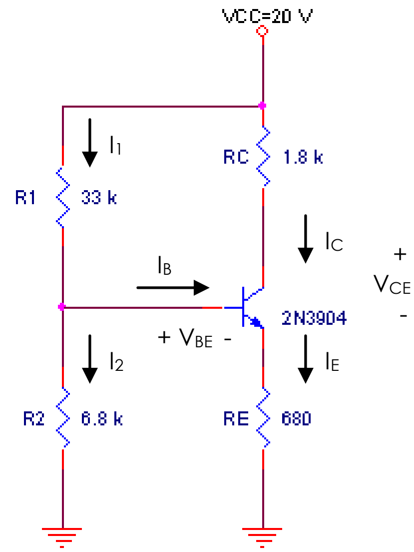
8. Graph I_C versus V_{CE} for each value of I_B (use graph paper).

Pre-lab Questions for Experiment 5

1. Refer to the figure below. Assume $V_{BE(on)} = 0.7$ V and $\beta = 100$. Calculate I_B, I_C, I_E.



2. Using β =100, calculate the theoretical values of I_E, I_C, I_B and V_{CE} . From the values of the currents, calculate the values of V_B, V_E and V_C.



EXPERIMENT 5: BJT Biasing Circuits

Objectives:

To determine the quiescent operating conditions of the fixed- and voltage-divider-bias BJT configurations.

Equipment:

Instruments
1 DC Power Supply
3 Digital Multimeter (DMM)

Components
Resistors: 680 Ω, 1.8 kΩ, 2.7 kΩ, 6.8 kΩ, 33 kΩ, 1 MΩ
Transistors: 2N3904, 2N4401

Procedure:
Part A : Fixed-Bias Configuration

1. Measure all resistor values (R_B and R_C) from circuit in *Fig. 5.1* using DMM. Record them.
2. Construct circuit as of *Fig. 5.1* using 2N3904 transistor and set V_{CC} = 20 V.
3. Measure the voltages V_{BE} and V_{RC}. Record them.
4. Calculate the resulting base current, I_B and collector current, I_C. Using the values obtained, find β.
5. Using the values obtained in Step 4, calculate the values of V_B, V_C, V_E and V_{CE}.
6. Measure V_B, V_C, V_E and V_{CE}.
7. How do the measured values (Step 6) compare to the calculated values (Step 5)?
8. Simply remove the 2N3904 transistor and replace with 2N4401 transistor.
9. Then, measure the voltages V_{BE} and V_{RC}. Using the same equations, calculate the values of I_B and I_C. From the values obtained, determine the β value for 2N4401 transistor.
10. Compile all the data needed for both transistors in Table 5.1.

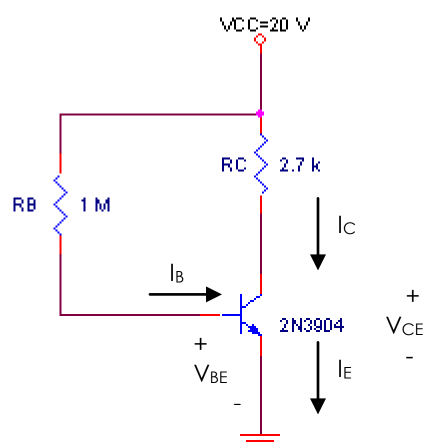


Fig. 5.1

11. Calculate the magnitude (ignore the sign) of the percent change in each quantity due to a change in transistors.
12. Place the results of your calculations in Table 5.2.

Part B : Voltage-Divider-Bias Configuration

1. Measure all resistor values (R_1, R_2, R_B and R_C) from circuit in *Fig. 5.2* using DMM. Record them.
2. Using the β determined for 2N3904 transistor in Part B, calculate the theoretical values of V_B, V_E, I_E, I_C, V_C, V_{CE} and I_B for the network shown in *Fig. 5.2*. Record them in Table 5.3.
3. Construct the network of *Fig. 5.2* and measure V_B, V_E, V_C and $V_{CE.}$ Record them in Table 5.3.

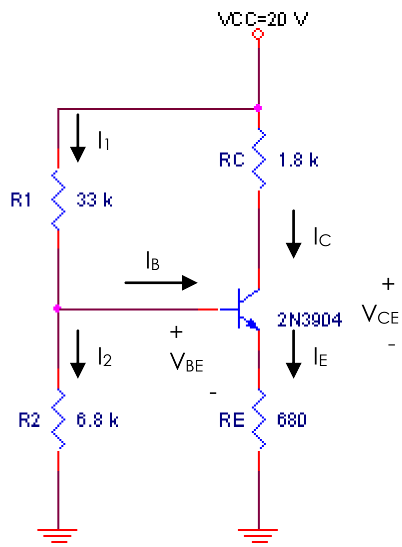


Fig. 5.2

4. Measure the voltages V_{R1} and V_{R2} (take readings to the hundredth or thousandth place). Calculate the currents I_E and I_C and the currents I_1 and I_2. Using Kirchoff's current law, calculate the current I_B. Record I_E, I_C and I_B values in Table 5.3.
5. How do the calculated and measured values of Table 5.3 compare?
6. Compile the measured values of V_{CE} (Step 3), I_C and I_B (Step 4) along with the magnitude of β in Table 5.4.
7. Simply remove the 2N3904 transistor and replace with 2N4401 transistor.
8. Then, measure the voltages V_{CE} , Also, measure the voltages V_{R1} and V_{R2} (take readings to the hundredth or thousandth place). Calculate the current I_C and the currents I_1 and I_2. Using Kirchoff's current law, calculate the current I_B.
9. Complete Table 5.4 with the values of V_{CE}, I_C, I_B and β.
10. Calculate the magnitude (ignore the sign) of the percent change in each quantity due to a change in transistors.
11. Place the results of your calculations in Table 5.5.

PSPICE Instructions:

Using PSPICE Simulation, find the values of V_B, V_E, V_C, V_{CE}, I_C, I_B and I_E for the circuit in *Fig. 5.2*. Compare the values obtained from PSPICE with the experimental ones.

Results and Calculations:

Part A

1. R_B (measured) = ______________, R_C (measured) = _______________

3. V_{BE} (measured) = ______________, V_{RC} (measured) = ______________

4. I_B = __________________, I_C = _________________, β = _____________

$$I_B = \frac{V_{RB}}{R_B} = \frac{V_{CC} - V_{BE}}{R_B} =$$

$$I_C = \frac{V_{RC}}{R_C} =$$

$$\beta = \frac{I_C}{I_B} =$$

5. V_B (calculated) = _____________, V_C (calculated) = _______________

   V_E (calculated) = _____________, V_{CE} (calculated) = ______________

   Show your workings!

6. V_B (measured) = _____________, V_C (measured) = _______________

   V_E (measured) = _____________, V_{CE} (measured) = ______________

7. Comparison of results from Step 5 & Step 6 :

9. V_{BE} (measured) = _______________, V_{RC} (measured) = _______________

I_B = ____________________, I_C = ___________________, β = ______________

$$I_B = \frac{V_{RB}}{R_B} = \frac{V_{CC} - V_{BE}}{R_B} =$$

$$I_C = \frac{V_{RC}}{R_C} =$$

$$\beta = \frac{I_C}{I_B} =$$

10.

Trans. Type	V_{CE} (V)	I_C (mA)	I_B (μA)	β
2N3904				
2N4401				

Table 5.1

11.

$$\%\Delta\beta = \frac{\left|\beta_{(4401)} - \beta_{(3904)}\right|}{\left|\beta_{(3904)}\right|} x100\% =$$

$$\%\Delta I_C = \frac{\left|I_{C(4401)} - I_{C(3904)}\right|}{\left|I_{C(3904)}\right|} x100\% =$$

$$\%\Delta V_{CE} = \frac{\left|V_{CE(4401)} - V_{CE(3904)}\right|}{\left|V_{CE(3904)}\right|} x100\% =$$

$$\%\Delta I_B = \frac{\left|I_{B(4401)} - I_{B(3904)}\right|}{\left|I_{B(3904)}\right|} x100\% =$$

12.

%Δβ	$\%\Delta I_C$	$\%\Delta V_{CE}$	$\%\Delta I_B$

Table 5.2

<u>Part B</u>

1. R_1 (measured) = ______________, R_2 (measured) = _____________,

   R_C (measured) = _____________, R_E (measured) = _____________

2. V_B (calculated) = _____________, V_E (calculated) = _____________

   I_E (calculated) = _____________, I_C (calculated) = _____________

   V_C (calculated) = _____________, V_{CE} (calculated) = ____________

   I_B (calculated) = ______________

Show your workings!

2N3904	V_B(V)	V_E(V)	V_C(V)	V_{CE}(V)	I_E(mA)	I_C(mA)	I_B(μA)
Calculated (Step 2)							
Measured (Step 3&4)							

Table 5.3

4. Show your works for calculating I_E and I_C (using measured values recorded in Table 5.3).

I_1 = ________________, I_2 = _________________

$$I_1 = \frac{V_{R1}}{R_1} =$$

$$I_2 = \frac{V_{R2}}{R_2} =$$

Using KCL, I_B = ________________

(Currents calculated from measured values; considered as measured I_E, I_C & I_B)

5. Comparison of calculated and measured values of Table 5.3:

6.

Trans. Type	V_{CE} (V)	I_C (mA)	I_B (μA)	β
2N3904				
2N4401				

Table 5.4

8. V_{CE} (measured) = ________________

$$I_C = \frac{V_{CC} - V_{CE}}{R_C + R_E} =$$

I_1 = ________________, I_2 = _________________

$$I_1 = \frac{V_{R1}}{R_1} =$$

$$I_2 = \frac{V_{R2}}{R_2} =$$

Using KCL, I_B = ________________

9. Complete Table 5.4 (Step 6) with the values obtained in Step 8 and β value obtained for 2N4401 transistor.

10.

$$\%\Delta\beta = \frac{|\beta_{(4401)} - \beta_{(3904)}|}{|\beta_{(3904)}|} x100\% =$$

$$\%\Delta I_C = \frac{|I_{C(4401)} - I_{C(3904)}|}{|I_{C(3904)}|} x100\% =$$

$$\%\Delta V_{CE} = \frac{|V_{CE(4401)} - V_{CE(3904)}|}{|V_{CE(3904)}|} x100\% =$$

$$\%\Delta I_B = \frac{|I_{B(4401)} - I_{B(3904)}|}{|I_{B(3904)}|} x100\% =$$

11.

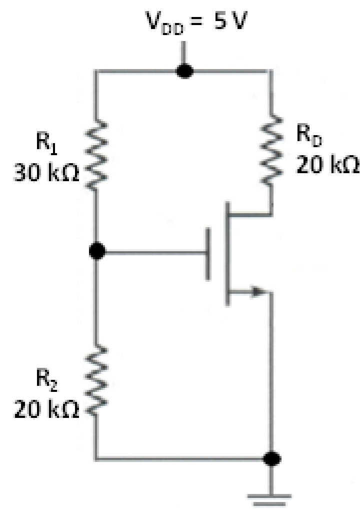
%Δβ	$\%\Delta I_C$	$\%\Delta V_{CE}$	$\%\Delta I_B$

Table 5.4

Pre-lab Questions for Experiment 6

1. Sketch the typical *I-V* characteristics and indicate the non-saturation and saturation regions for an n-channel MOSFET at various values of V_{GS} (V_{GS3} > V_{GS2} > V_{GS1}). Also show the pinch-off points on the plotted curves.

1. For the common source amplifier circuit below: V_{TN} = 1V, K_n = 0.1 mA/V^2 and $\lambda = 0$



a) Find the value of the drain current, I_D . Confirm your assumption whether the FET is in saturation or non-saturation mode.
b) Calculate the values of V_{GS}, V_{DS} and the drain voltage V_D

EXPERIMENT 6: MOSFET - Common Source Amplifier

Objective:

- To perform the DC and AC analyses of a common source amplifier using an n-channel MOSFET.

Equipment:

Instruments
DC power supply
Function Generator
Digital Multimeter (DMM)
Oscilloscope

Components
NMOS: 2N 7000
Resistors: 15kΩ, 33kΩ
Capacitors: 1µF (2)

Procedure:

Part A : MOSFET DC Analysis

1. Construct the circuit of *Fig. 6.1*. Record the measured values of the resistors.

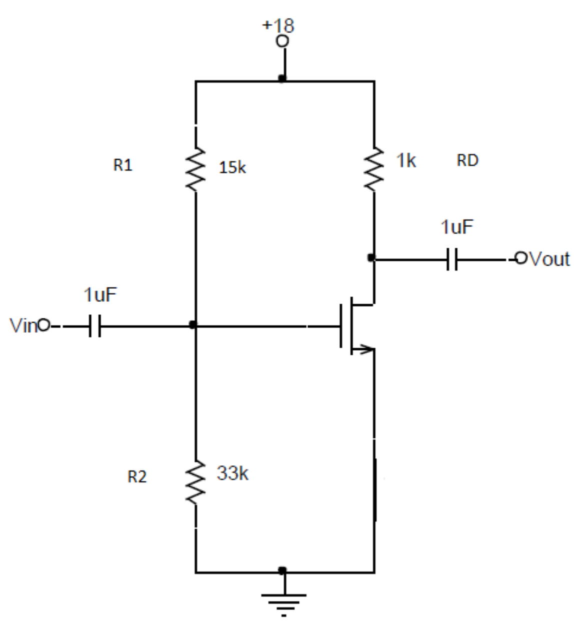


Fig. 6.1

2. Calculate the values of V_{GS}, V_{DS} and I_D. Use a gate threshold voltage, $V_{TN} = 2$ V and $K_n = 75$ mA/V^2.

3. Assume V_{in} = 0 V. Measure the values of V_{GS}, V_{DS} and $I_{D.}$
4. Compare the calculated and measured values.

Part B : Common Source Amplifier (AC Analysis)

5. Use the same circuit configuration
6. Set the function generator for a 200 mVpp, 20 kHz sine wave. Connect it to V_{in}.
7. Connect a 1 kΩ load resistor from V_{out} to ground
8. Connect Channel 1 of the oscilloscope to V_{in} and Channel 2 of the oscilloscope to V_{out}.
9. Measure the peak-to-peak output voltage on Channel 2 of the oscilloscope.
10. Now set the DC power supply to 2.9V.
11. Measure the peak-to-peak output voltage on Channel 2 of the oscilloscope
12. Comment on the observations from step 5 to step 11.

PSPICE Instructions:

1. Construct the circuit in *Fig. 6.1* using PSPICE.
2. From PSPICE simulation, obtain the DC voltages at all terminals of MOSFET, V_{GS}, V_G and V_{DS}.

NOTE:
Unfortunately, this transistor model is not in the default library. Hence, you have to add the 2N7000 model if you would like to use it in PSPICE.

Go to the Breakout Library → Choose MBreakN3 → Placed it in your circuit
Select the transistor → Go to Edit → PSpice Model
A Model Editor window will appear. Paste the TEXT file below and click Save.

The Text File (can be downloaded from E-Learning)
.MODEL 2N7000 NMOS (LEVEL=3 RS=0.205 NSUB=1.0E15 DELTA=0.1
+KAPPA=0.0506 TPG=1 CGDO=3.1716E-9 RD=0.239 VTO=1.900 VMAX=1.0E7
+ETA=0.0223089 NFS=6.6E10 TOX=1.0E-7 LD=1.698E-9 UO=862.425
+XJ=6.4666E-7 THETA=1.0E-5 CGSO=9.09E-9 L=2.5E-6 W=0.8E-2)

Results and Calculations:

Part A (MOSFET - DC Analysis)

1. R_1 (measured) = ________________, R_2 (measured) =_______________,
   R_D (measured) =__________________

2. V_{GS}, V_{DS} and I_D (calculated). Show your workings!

3. V_{GS} (measured) = ________________, V_{DS} (measured) = _______________ and

   I_D (measured) = _________________

Part B (MOSFET-AC Analysis)

9. For DC Power Supply = 18V, with V_{in} = 200 mVpp, 20 kHz sine wave

V_{out} peak-to peak = ___________

11. For DC Power Supply = 2.9 V, with V_{in} = 200 mVpp, 20 kHz sine wave

V_{out} peak-to peak = ___________

12. Comment on the observations from step 5 to step 11

Pre-lab Questions for Experiment 7

1. Identify each of the op-amp configurations

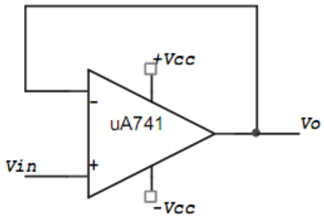


Fig. 1(a)

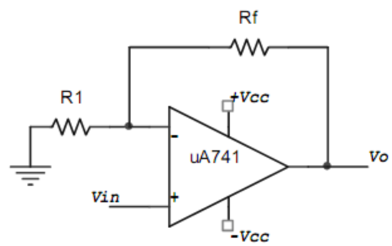


Fig. 1(b)

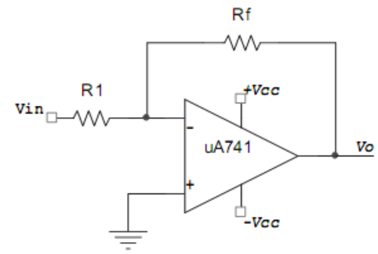
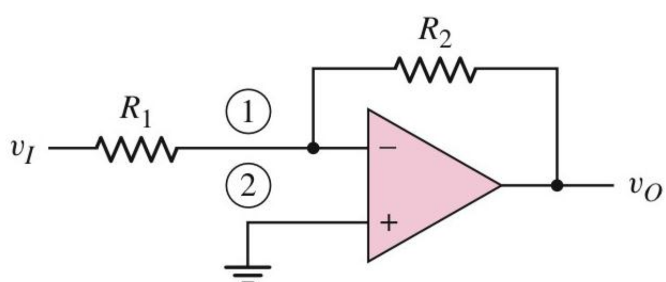


Fig. 1(c)

2. For the inverting amplifier below, determine the values of R_1 and R_2, if the gain A_v = -8, the current in the feedback resistor is 10 μA and the output voltage is -5.0 V.



3. Find the value of R_f that will produce closed-loop gain of 300 in each amplifier in fig. 3(a) & 3(b).

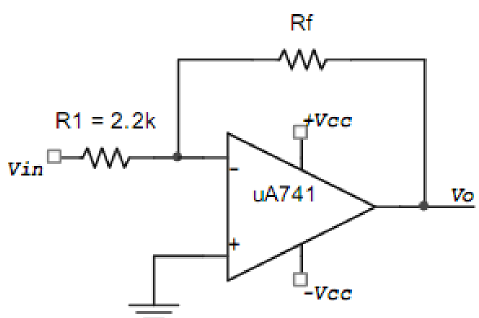


Fig. 3(a)

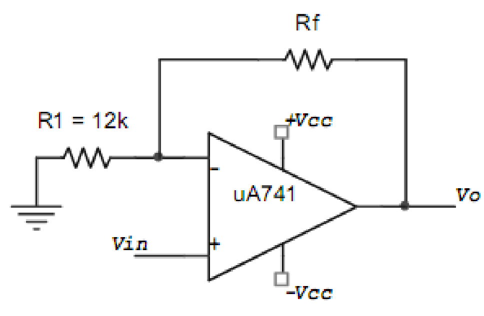


Fig. 3(b)

EXPERIMENT 7: Inverting and Non-inverting OP Amp

Objectives:

- To theoretically analyze the basic op-amp circuits.
- To build and test typical op-amp application circuits, such as inverting and non-inverting amplifier

Equipment:

Instruments

DC power supply – You need two power supplies. One for 15V and another one for the -15V

Digital Multimeter (DMM)

Function Generator

Oscilloscope

Components

Op Amp : LM 741

Resistors: 1 kΩ, 10 kΩ (4), 22 kΩ, 100 kΩ (2)

Procedure:

Part A: Inverting Amp

1. Set up the oscilloscope to show a dual trace, one for the input of the op-amp and one for the output. Use DC input coupling. Set up the function generator to produce a sine wave with an amplitude >0.5 V and frequency 1 kHz. Make sure that the grounds of the function generator, oscilloscope, and prototyping board are somehow connected.
2. Measure the values of your resistors, then using the prototyping board, wire up the inverting amplifier shown in Figure 8.1.
3. Measure the gain A_V for R_f = 1 kΩ, 10 kΩ and 100 kΩ. Using measured values of R_f and R_1= 22 kΩ, compare to $A_V = - R_{ref} / R_1$ and verify that the amplifier inverts.
4. For the circuit with R_f =100 kΩ, increase the input voltage until distortion occurs at the output. Record the input voltage and draw the distorted output waveform. Report the input at which this occurs.

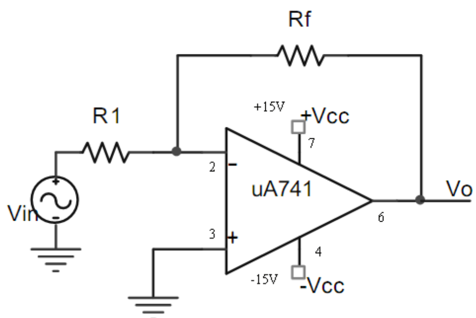


Fig. 7.1

5. For the circuit with R_f = 100 kΩ, measure the gain A_V at the logarithmically-spaced frequencies of 100 Hz, 300 Hz, 10 kHz, ..., 1 MHz, 3 MHz. Repeat for R_f = 10 k. Plot your results on log-log graph paper. (You will need 5 cycles for the log paper on the frequency axis.) Also show on this graph the theoretical gain $|A_V| = R_{ref} / R_1$.

Part B: Non-Inverting Amp

1. Construct the non-inverting amplifier as shown in Figure 7.2. Use R_f = 10 kΩ and R_1= 1 kΩ
2. Apply a 1V amplitude, 1kHz sinusoidal input signal to the amplifier. Display V_{in} and V_o at the same time. (They need to be displayed simultaneously so that you can see the phase shift between them.) Draw the image. The phase measurement and peak-peak measurements must be turned on.
3. Report the phase shift as well as gain.
4. Increase the input voltage by 0.1 V each time until distortion occurs at the output. Record the input voltage and capture the distorted output waveform. Report the voltage at which this distortion occurs.

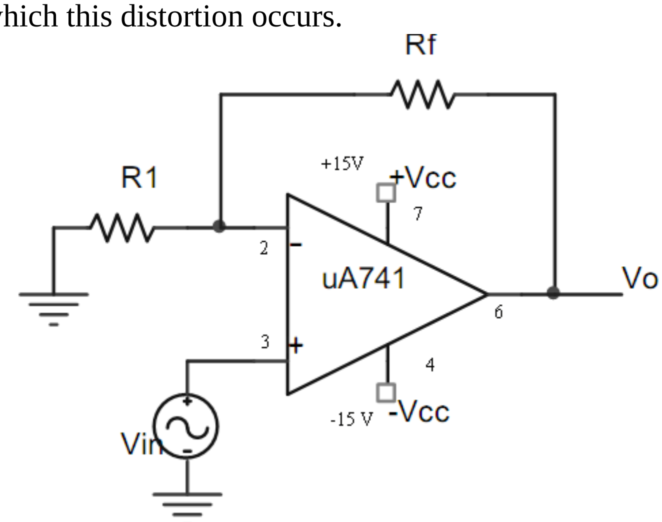


Fig. 7.2

PSPICE instruction:

- Construct the circuit and obtain the input-output waveform for both of the inverting and non-inverting op-amp.

Part A :

1. $V_{in(peak\text{-}to\text{-}peak)}$ (measured) = ___________________

2. R_1 (measured) = : ________________ , R_f (measured) =________________

3. Measure different values of R_{ref} , to calculate A_v , using A_v = : - R_f / R_1

   R_f =____________________, A_v =__________________

   R_f =____________________, A_v =__________________

   R_f =____________________, A_v =__________________

4. $V_{in(peak\text{-}to\text{-}peak)}$ (measured) =______________________

   Draw the distorted output waveform.

5. Fill up the table measure gain A_v ($A_v = V_{out(peak\text{-}to\text{-}peak)} / V_{in(peak\text{-}to\text{-}peak)}$).

	100Hz	300Hz	10kHz	100kHz	1MHz	3MHz
R_f =100k						
R_f =10k						

   Plot your results on the graph paper.

   The theoretical gain $|A_v| = R_f / R_1$ =_______________ (calculated).

Part B :

1. R_1 (measured) = ________________ R_f (measured)=______________

2. Draw the input and output signal at the same graph.

3. The output signal's phase ,Φ (measured)=______________

   A_v (measured)= $V_{out(peak\text{-}to\text{-}peak)}$ / $V_{in(peak\text{-}to\text{-}peak)}$ = _________________

4. $V_{in(peak\text{-}to\text{-}peak)}$ (measured) = _________________

   $V_{out(peak\text{-}to\text{-}peak)}$ (measured) = ________________(the voltage at which this distortion occurs.)

   Draw the distorted output waveform.