ELECTRONIC CIRCUIT ANALYSIS - II
LABORATORY MANUAL (ECE - 227)
II/IV ECE SEM – II

By
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DEPARTMENT OF ELECTRONICS AND COMMUNICATON ENGINEERING

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (A)
(Affiliated to AU, Approved by AICTE & Accredited by NBA) Sangivalasa-
531 162, Visakhapatnam District, Phone: 08933-225083/84/87

Vision of the Institute

ANITS envisions to emerge as a world-class technical institution whose products represent a good blend of technological excellence and the best of human values.

Mission of the Institute

To train young men and women into competent and confident engineers with excellent communication skills, to face the challenges of future technology changes, by imparting holistic technical education using the best of infrastructure, outstanding technical and teaching expertise and an exemplary work culture, besides molding them into good citizens

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Vision of the Department

To become a center of excellence in Education, research and produce high quality engineers in the field of Electronics and Communication Engineering to face the challenges of future technological changes.

Mission of the Department

To achieve vision department will

Transform students into valuable resources for industry and society by imparting contemporary technical education.

Develop interpersonal skills and leadership qualities among students by creating an ambience of academic integrity to participate in various professional activities

Create a suitable academic environment to promote research attitude among students.

Program Educational Objectives (PEOs):

PEO1 : Graduates excel in their career in the domains of Electronics, Communication and Information Technology.

PEO2 : Graduates will practice professional ethics and excel in professional career through interpersonal skills and leadership qualities.

PEO3 : Graduates demonstrate passion for competence in higher education, research and participate in various professional activities.

Program Outcomes (POs):

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1 : Implement Signal & Image Processing techniques using modern tools.

PSO2 : Design and analyze Communication systems using emerging techniques.

PSO3 : Solve real time problems with expertise in Embedded Systems.

ELECTRONIC CIRCUITS AND ANALYSIS-II LABORATORY	
ECE 227	**Credits:2**
Instruction: 3 Practicals /Week	Sessional Marks:50
End Exam: 3 Hours	End Exam Marks:50

Prerequisites: ECA-I

Course Objectives:

The objective of this lab is to correlate the theoretical concepts of different analog electronic circuits with practical feasibility thereby giving them a scope to learn basic electronic circuits and their different electrical characteristics in a better way.

Course outcomes:

By the end of the course student should be able to:	
1	Analyze and Design feedback amplifiers and sinusoidal oscillator circuits.
2	Analyze and Design various power amplifiers and tuned voltage amplifiers.
3	Calculate the parameters of differential amplifier using BJTs or Op-amp
4	Analyze and Design amplifier circuits using op-amps.
5	Analyze and Design various application circuits using op-amp such as summing amplifier, integrator, differentiator etc

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes:

		PO												PSO			Performance Indicators
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO	1	2	2	2	2				1	1	1					2	1.1.2, 1.4.1 , 2.1.2, 2.1.3, 2.3.1, 2.3.2, 2.4.4, 3.2.2, 3.2.3, 3.4.1, 3.4.2 , 4.1.1, 4.1.2, 4.1.4, 8.1.1, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3
	2	2	2	2	2				1	1	1					2	1.1.2, 1.4.1 ,2.1.2, 2.1.3, 2.3.1, 2.3.2, 2.4.4, 3.2.2, 3.2.3, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.4, 8.1.1, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3
	3	2	2	2	2				1	1	1					2	1.1.2, 1.4.1 ,2.1.2, 2.1.3, 2.3.1, 2.3.2, 2.4.4, 3.2.2, 3.4.1, 3.4.2, 4.1.2, 4.1.4, 8.1.1, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3
	4	2	2	2	2				1	1	1					2	1.1.2, 1.4.1,2.1.2, 2.1.3, 2.4.4, 3.2.2, 3.4.1, 3.4.2, 4.1.2, 4.1.4, 8.1.1, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3
	5	2	2	2	2				1	1	1					2	1.1.2, 1.4.1 ,2.1.2, 2.1.3, 2.3.1, 2.3.2, 2.4.4, 3.2.2, 3.4.1, 3.4.2, 4.1.2, 4.1.4, 8.1.1, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3

For PO1 – PO5	
If percentage of PIs related to CO >40%	Level 3
If percentage of PIs related to CO 21% to 40%	Level 2
If percentage of PIs related to CO ≤20%	Level 1
For PO6 – PO12	
If percentage of PIs related to CO >51%	Level 2

If percentage of PIs related to CO ≤50%	Level 1

PIs percentage for the Cos:

CO	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
CO1	40%	38%	30%	30%				33%	28%	43%		
CO2	40%	38%	30%	30%				33%	28%	43%		
CO3	40%	38%	23%	20%				33%	28%	43%		
CO4	40%	23%	23%	20%				33%	28%	43%		
CO5	40%	38%	23%	20%				33%	28%	43%		

Competency	Indicators
1.1 Demonstrate competence in mathematical modelling	1.1.2 Apply advanced mathematical techniques to model and solve Electronics and Communication engineering problems.
1.4 Demonstrate competence in specialized engineering knowledge to the program	1.4.1 Apply Electronics and Communication engineering concepts to solve engineering problems.
2.1 Demonstrate an ability to identify and formulate complex engineering problem	2.1.2 Identify engineering systems, variables, and parameters to solve the problems 2.1.3 Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.3 Demonstrate an ability to formulate and interpret a model	2.3.1 Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy. 2.3.2 Identify assumptions (mathematical and physical) necessary to allow modeling of a system at the level of accuracy required.
2.4 Demonstrate an ability to execute a solution process and analyze results	2.4.4 Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
3.2 Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.2 Build models/prototypes to develop a diverse set of design solutions 3.2.3 Identify suitable criteria for the evaluation of alternate design solution
3.4 Demonstrate an ability to advance an engineering design to defined end state	3.4.1 Refine a conceptual design into a detailed design within the existing constraints (of the resources) 3.4.2 Generate information through appropriate tests to improve or revise the design
4.1 Demonstrate an ability to conduct investigations of technical issues consistent with their level of knowledge and understanding	4.1.2 Examine the relevant methods, tools and techniques of experiment design, system calibration, data acquisition, analysis and presentation 4.1.4 Establish a relationship between measured data and underlying physical principles.
8.1 Demonstrate an ability to recognize ethical dilemmas	8.1.1 Identify situations of unethical professional conduct and propose ethical alternatives
9.1 Demonstrate an ability to form a team and define a role for each member	9.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team 9.1.2 Implement the norms of practice (e.g., rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
10.1 Demonstrate an ability to comprehend technical literature and document project work	10.1.1 Read, understand and interpret technical and non-technical information. 10.1.2 Produce clear, well-constructed, and well-supported written engineering documents. 10.1.3 Create flow in a document or presentation- a logical progression of ideas so that the main point is clear.

LIST OF EXPERIMENTS

1. Obtain the input and output impedance of a trans-conductance amplifier with and withoutfeedback.
2. Obtain the frequency response of a voltage shunt negative feedback amplifier with andwithout feedback.
3. Generate a sinusoidal signal using Colpitts oscillator at a desired frequency.
4. Generate a sinusoidal signal using Wein bridge circuit.
5. Generate a sinusoidal signal using RC phase shift oscillator and observe the Lissajous patterns at different phase shifts.
6. Plot the frequency response of a tuned voltage amplifier and find the resonant frequency.
7. Obtain the output waveforms of a class-B push pull power amplifier and calculate theefficiency and distortion.
8. Obtain the output waveforms of a class-A transformer coupled power amplifier and calculatethe power conversion efficiency.
9. Determine the gain and CMRR for the BJT differential amplifier.
10. Obtain the signals at the output junctions of multistage BJT differential pair.
11. Verify different applications of an Operational amplifier.
12. Verify different parameters of an operational amplifier.
13. Observe the working of an operational amplifier in inverting, non inverting and differentialmodes.
14. Plot the V-I characteristics of an n-channel enhancement MOSFET and verify its operationas an inverter.
15. Verify the working of a CMOS source follower amplifier.

Text books:

1. Jacob Millman, Christos Halkias, Chetan Parikh, "Integrated Electronics", 2nd Edition,McGraw Hill Publication, 2009.
2. Donald A. Neamon, “Electronic Circuit Analysis and Design”, 2nd Edition. TMGpublications.

References:

1. Ramakanth A Gayakwad, “Op-Amps and Linear Integrated Circuits”- 4th Edition.

Justification of CO-PO mapping:

CO1:	The students are expected to **Apply** the knowledge of fundamentals of mathematics and electronic engineering in designing the feedback amplifiers and sinusoidal oscillators **[PO1]** **Analyze** the feedback amplifiers and sinusoidal oscillators to evaluate the performance by measuring parameters. **[PO2]** **Design** solutions for feedback amplifiers and sinusoidal oscillators **[PO3]** **Conduct investigations of** designed feedback amplifiers and sinusoidal oscillators **[PO4]** **Practice Ethics** in the laboratory by exhibiting punctuality, dress code, decent behavior, careful handling of the equipment and sincere towards observation/record writing. **[PO8]** **Individual and team work** must be exhibited by the students by maintaining harmony with the batch mates, for the cooperative way of learning. **[PO9]** **Communication** skills must be exhibited by the students during viva (oral) and record submission (written) **[PO10]**

CO2:	The students are expected to **Apply** the knowledge of basics of mathematics in deriving the frequency response power amplifiers and tuned voltage amplifiers. [PO1]. **Analyze** the performance of given tuned voltage amplifier in different frequency bands and find efficiency percentage of power amplifiers. [PO2]. **Design** solutions for power amplifiers and tuned voltage amplifiers **[PO3]** **Conduct investigations of** designed power amplifiers and tuned voltage amplifiers **[PO4]** **Practice Ethics** in the laboratory by exhibiting punctuality, dress code, decent behavior, careful handling of the equipment and sincere towards observation/record writing. **[PO8]** **Individual and team work** must be exhibited by the students by maintaining harmony with the batch mates, for the cooperative way of learning. **[PO9]** **Communication** skills must be exhibited by the students during viva (oral) and record submission (written) **[PO10]**
CO3:	The students are expected to **Apply** the knowledge of engineering basics to solve the parameters of differential amplifier using BJTs **[PO1]** **Analyze** the parameters of differential amplifier using BJTs.**[PO2]** **Design** solutions for the differential amplifier using BJTs **[PO3]** **Conduct investigations of** designed differential amplifier using BJTs **[PO4]** **Practice Ethics** in the laboratory by exhibiting punctuality, dress code, decent behavior, careful handling of the equipment and sincere towards observation/record writing. **[PO8]** **Individual and team work** must be exhibited by the students by maintaining harmony with the batch mates, for the cooperative way of learning. **[PO9]** **Communication** skills must be exhibited by the students during viva (oral) and record submission (written) **[PO10]**
CO4:	The students are expected to **Apply** the knowledge of engineering fundamentals, to design & analyze the amplifier circuits using op-amps. **[PO1]** **Analyze** the response of the amplifier circuits using op-amps. **[PO2]** **Design** solutions for the amplifier circuits using op-amps **[PO3]** **Conduct investigations of** designed the amplifier circuits using op-amps **[PO4]** **Practice Ethics** in the laboratory by exhibiting punctuality, dress code, decent behavior, careful handling of the equipment and sincere towards observation/record writing. **[PO8]** **Individual and team work** must be exhibited by the students by maintaining harmony with the batch mates, for the cooperative way of learning. **[PO9]** **Communication** skills must be exhibited by the students during viva (oral) and record submission (written) **[PO10]**
CO5:	The students are expected to **Apply** the knowledge of electric network circuits fundamentals in designing the applications circuits using op-amp.[**PO1]** **Analyze** the application circuits using op-amp to evaluate the circuit parameters, and to **design** the applications circuits using op-amp.**[PO2]** **Design** solutions for the applications circuits using op-amp **[PO3]** **Conduct investigations of** designed application circuits using op-amp **[PO4]** **Practice Ethics** in the laboratory by exhibiting punctuality, dress code, decent behavior, careful handling of the equipment and sincere towards observation/record writing. **[PO8]** **Individual and team work** must be exhibited by the students by maintaining harmony with the batch mates, for the cooperative way of learning. **[PO9]** **Communication** skills must be exhibited by the students during viva (oral) and record submission (written) **[PO10]**

Justification of Mapping of Course Outcomes with Program Specific Outcomes:	
CO1-CO2	Students are expected to exhibit the skill to analyze negative feedback amplifiers, sinusoidal oscillators, power amplifiers and tuned voltage amplifiers.
CO3-CO5	Students are expected to analyze the response of differential amplifier using BJTs, amplifier circuits using op-amps and the applications circuits using op-amp.

SCHEME OF EVALUATION

Total marks for each student to evaluate in lab: 100 marks
Out of 100 marks:

a. **External exam Evaluation: 50 marks**
b. **Internal Evaluation: 50 marks**
   Internal exam: 25 marks
   Evaluation in Lab: 25 marks

EXTERNAL EXAMS (50 Marks)			
S.No.	**Lab exam assessment**	**Marks allotted**	
1.	Write Up-Aim, apparatus, Circuit diagram	**05**	
2.	Procedure	**05**	
3.	Tabular columns , Theoretical calculations(if any),Formulas	**05**	
4.	Model graphs & precautions	**05**	
5.	Performance	**10**	
6.	Results & graph	**10**	
7.	Viva	**10**	
	TOTAL MARKS	**50**	
INTERNAL EVALUATION (50 Marks)			
1.	**Internal Exam at the end of semester(Marks division same as above)**		**25**
2.	**Evaluation in lab**		
	Observation(write up for every experiment)	**5**	**25**
	Viva (viva in every lab)	**5**	
	Record Aim & apparatus-1mark Circuit diagram and procedure-3 marks Theory-3 marks Calculations and tables-2 marks Result-1marks	**10**	
	Attendance >90% - 5 marks >80% - 90% - 4 marks >75% - 80% - 3 marks >=66% - 75% -2 marks <66% - No Marks	**5**	
	Total marks:		**50**

RUBRICS

(ECA-II Laboratory)

S.No	Performance Indicator	Excellent >80% to ≤100%	Good >60% to ≤80%	Average >40% to ≤60%	Poor performance ≤40%
1.	An ability to identify, formulate and **solve** Electronic Circuit analysis **problems** with basic **electronics knowledge** and to **design/analyse** and conduct experiments as well as interpret **data** as an **individual or with a team.(Based on Observation)(5M) (PO1, PO2, PO3, PO4, PO9)**	Able to apply the concepts of electronic circuits to solve given problem statement. Able to Develop a design Strategy, analyze the circuit as an individual or with a team. Able to relate theoretical concepts with practical problem solving. Able to use modern tool and/or discrete components effectively to produce desired output.	Shows nearly complete understanding of concepts of electronics in problem solving. Developed a design Strategy, analyzed the circuit with some guidance. Must be assisted in integrating Previous knowledge and relating theoretical concepts to problem solving. Ability to use the modern tool and/or discrete components is less and/or need guidance to know the usage of components and equipment.	Unable to apply the concept of electronic circuits in solving problems effectively. Developed the design strategy with Guidance and unable to analyze the circuit properly. More Guidance is need to integrating previous knowledge. Incorrect use of computer tool software and/or incorrect usage of components and equipment to generate desired output.	Poor knowledge on electronics concept. Developed design contains many errors. Unable to recollect the theoretical knowledge with practical problem solving. Unable to use the modern tool/or components.
2.	An ability to communicate effectively when employing **oral communications**. **(Based on viva) (5M). (PO10)**	Able to listen carefully and able to describe the purpose of the experiments and its scope. Able to plan and deliver a well-organized oral presentation on purpose of doing experiment and its scope.	Able to listen carefully and presents key elements of oral presentation on purpose of doing experiment and its scope. And few desired information is missing.	Able to listen carefully and less knowledge on purpose of doing experiments and its scope.	Unable to listen carefully and unable to describe the purpose of doing experiment and relevant theoretical information clearly.
3.	Graduates to acquire the ability to communicate effectively when employing **written Communications** by following the **ethical principle** of report writing. **(10M)** **(PO8,PO10)**	Report is presented very neatly and used very good professional writing style with the professional code of ethics. Used graphs, tables and diagrams to support points, interpret and assess information.	Report is presented good and used good professional writing style with the professional code of ethics. Used graphs, tables and diagrams to support points, interpret and assess information. Few desired information is missing in the report.	Report is presented with poor organization of the content.	Report contains many errors and having inadequate information.

ABOUT THE LAB

In ECA-I Lab students will be able to study and analyses the basic electronic devices like diodes, BJTs, JFETs, Half-wave & full-wave rectifiers. Rectifiers are introduced and their performances with different types of filters are observed and basic amplifiers. With this knowledge students will be able to do mini-projects with the help of diodes and transistors

In ECA-II lab students will be able to analyze and design different linear and non-linear waveforms with different time constants and different types of inputs. Design, analysis and voltage regulators circuits will be done and understand the principles and parameters of different amplifiers, oscillators and to study the characteristics of OP-AMP by measuring various parameters. With this knowledge students will be able to do mini-projects with the help of amplifiers and Oscillators.

LIST OF MAJOR EQUIPMENT IN EDC-I LABORATORY

SL.NO	NAME OF THE EQUIPMENT	MAKE	QUANTITY
1.	20 MHz, 25MHz & 30MHz DUAL TRACE OSCILLOSCOPE	SCIENTECH/SCIENTIFIC/ CADDO/FALCON	16
2.	1 MHz FUNCTION GENERATOR WITH DIGITAL DISPLAY	SCIENTECH/SCIENTIFIC/ SYSTRONICS/ FUTURE TECH/ METRAVI/APLAB	18
3.	TRPS 0-30V, 2A DUAL CHANNEL	ITL HYD/FALCON	26
4.	TRPS 0-30V, 2A SINGLE CHANNEL	ITL HYD	10
5.	AC MICRO VOLTMETER	SYSTRONICS	10
6.	5KVA SERVO CONTROLLED STABILIZER	ITL	01
7.	BENCH TOP DIGITAL MULTIMETER	METRAVI/APLAB	23

TOTAL EXPENDITURE OF THE LABORATORY (including consumables):Rs. 17,19,646/-

EDC-I LABORATORY

Do's

1. Be punctual and regular to the laboratory.
2. Maintain Discipline all the time and obey the instructions.
3. Check the connections properly before turning ON the circuit.
4. Turn OFF the circuit immediately if you see any component heating.
5. Dismount all the components and wires before returning the kit.
6. Any failure / break-down of equipment must be reported to the faculty

Don'ts

1. Don't touch live electric wires.
2. Don't turn ON the circuit unless it is completed.
3. Avoid making loose connections.
4. Don't leave the lab without permission.
5. Do not handle any equipment without reading the instructions/Instruction manuals

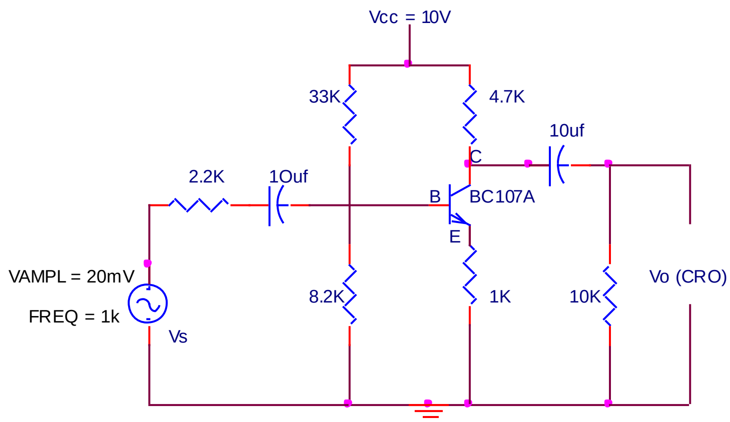
1. CURRENT SERIES AMPLIFIER

AIM:
To obtain the frequency response characteristics of a Current Series amplifier with and without feedback and Obtain the bandwidth.

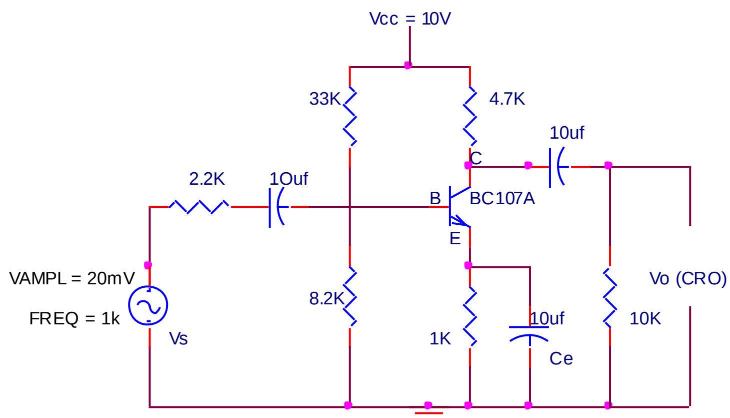
APPARATUS :

Power supply	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No
Resistors	1kΩ,4.7k,8.2k	1 No
Resistors	2.2k,33k,10K	1 No
Capacitors	10µF	3 No ,
Transistors	BC107	1 No
Bread board		
CRO Probes		

CIRCUIT DIAGRAMS :-



CURRENT SERIES AMPLIFIER WITH FEEDBACK



CURRENT SERIES AMPLIFIER WITHOUT FEEDBACK

PROCEDURE :

1. Connections are made as per the circuit diagram.
2. A 10V supply is given to the circuit.
3. The circuit is connected for with feedback, i.e., without bypass capacitor.
4. A certain amplitude of input signal is kept constant using signal generator and for different frequencies, the output voltage from CRO are noted.
5. Now, the circuit is connected for without feedback i.e., with bypass capacitor C_E and R_E in the circuit.
6. By keeping the input signal constant, the output voltage for different frequencies are noted.
7. Gain for with and without feedback is calculated using

Gain = 20 log Vo / Vi (dB)

Where V_o is output voltage, V_i is input voltage.

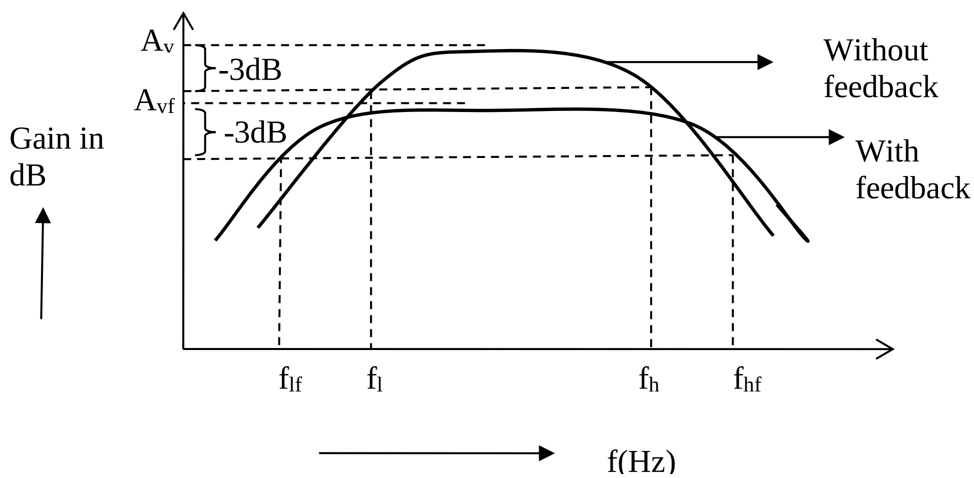
TABULAR FORM : **WITH FEEDBACK** **V_i =**

INPUT FREQUENCY (Hz)	O/P Voltage(Vo) (V)	Voltage gain AV=Vo/Vi	Gain in dB = 20 log AV
100			
200			
300			
500			
700			
1k			
2k			
3k			
5k			
7k			
10k			
20k			
30k			
50k			
70k			
100k			
200k			
300k			
500k			
700k			
1M			

WITHOUT FEEDBACK: **V_i =**

INPUT FREQUENCY (Hz)	O/P VOLTAGE (Vo)	Voltage gain A_V=Vo/Vi	Gain in dB = 20 log AV
100			
200			
300			
500			
700			
1k			
2k			
3k			
5k			
7k			
10k			
20k			
30k			
50k			
70k			
100k			
200k			
300k			
500k			
700k			
1M			

MODEL GRAPH :



Bandwidth= f_l-f_h

GRAPH:
A graph is plotted between gain (dB) and frequency (Hz) for both with and without feedback.

PRECAUTIONS:

1. Connections must be made with proper polarity.
2. Avoid loose and wrong connections.

QUESTIONS:

1. What is the relationship between the transfer gain with feedback A_f and that without feedback A.

A. $A_f = A/(1+A\beta)$

2. Define negative feedback.

A. The amout of feedback applied is subtracted from the input to get negative feedback.

3. What are the advantages of negative feedback.

A. High BW,less noise,less distortion,gain stability

4. How is the i/p impedance and o/p impedance of a current shunt feedback amplifier

A. $R_{if} = R_i/(1+A\beta)$, $R_{of} = Ro(1+A\beta)$

RESULT:

The frequency response characteristics of current series amplifier with & with out feed back and bandwidth are obtained.

2. PARAMETERS CALCULATION OF A CURRENT SERIES FEEDBACK AMPLIFIER

AIM:

To calculate the input impedance, output impedance and voltage gain of current series feedback amplifier with and without feedback

APPARATUS :

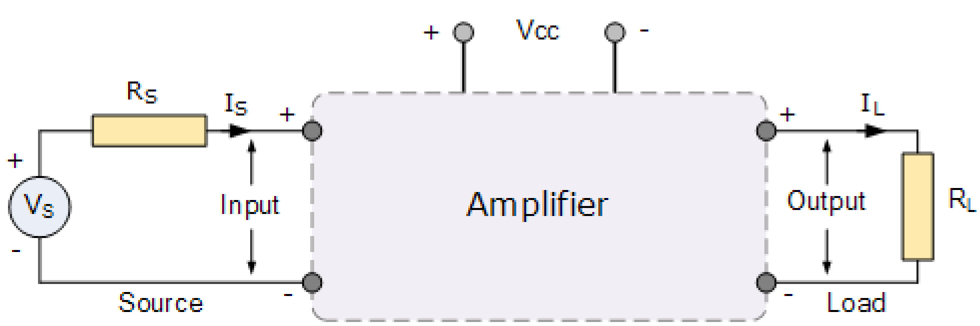
Power supply	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No
Resistors	1kΩ,4.7k,8.2k	1 No
Resistors	2.2k,33k,10K	1 No
Capacitors	10µF	3 No ,
Transistors	BC107	1 No
Bread board		
CRO Probes		

Theory:

An amplifiers impedance value is particularly important for analysis especially when cascading individual amplifier stages together one after another to minimise distortion of the signal.

The *input impedance of an amplifier* is the input impedance "seen" by the source driving the input of the amplifier. If it is too low, it can have an adverse loading effect on the previous stage and possibly affecting the frequency response and output signal level of that stage. But in most applications, common emitter and common collector amplifier circuits generally have high input impedances.

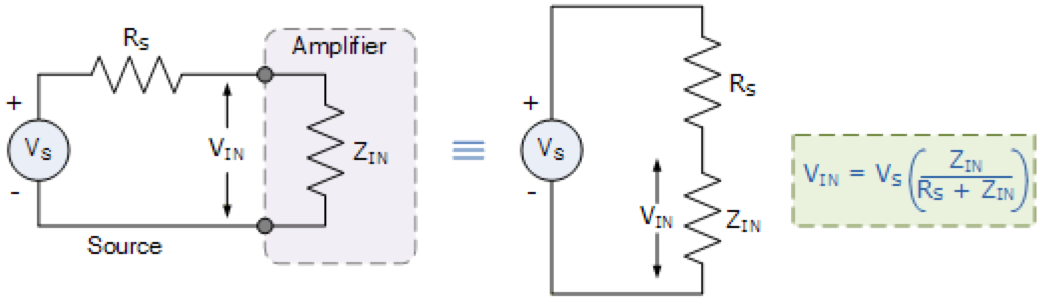
Output and Input Impedance Model



Where, V_S is the signal voltage, R_S is the internal resistance of the signal source, and $R_L$is the load resistance connected across the output. We can expand this idea further by looking at how the amplifier is connected to the source and load.

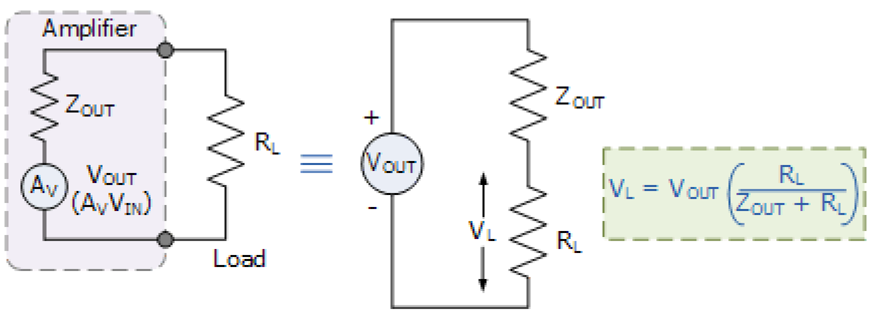
When an amplifier is connected to a signal source, the source "sees" the input impedance, Zin of the amplifier as a load. Likewise, the input voltage, Vin is what the amplifier sees across the input impedance, Zin. Then the amplifiers input can be modelled as a simple voltage divider circuit as shown.

Amplifier Input Circuit Model



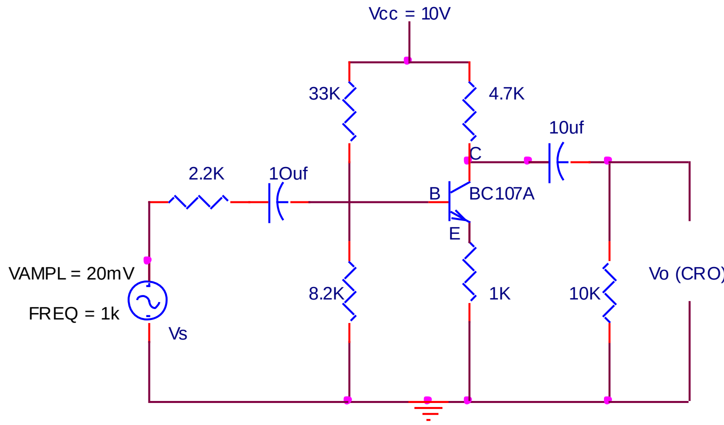
The same idea applies for the output impedance of the amplifier. When a load resistance, R_L is connected to the output of the amplifier, the amplifier becomes the source feeding the load. Therefore, the output voltage and impedance automatically becomes the source voltage and source impedance for the load as shown.

Amplifier Output Circuit Model

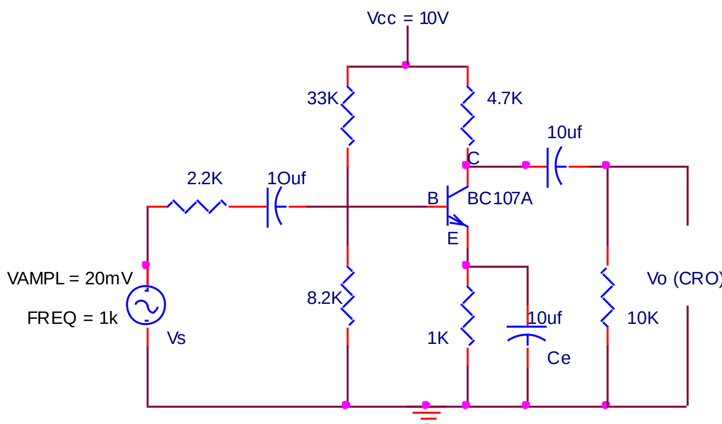


Then we can see that the input and output characteristics of an amplifier can both be modelled as a simple voltage divider network. The amplifier itself can be connected in*Common Emitter* (emitter grounded), *Common Collector* (emitter follower) or in*Common Base* configurations. In this tutorial we will look at the bipolar transistor connected in a common emitter configuration seen previously.

CIRCUIT DIAGRAMS :-



CURRENT SERIES AMPLIFIER WITH FEEDBACK



CURRENT SERIES AMPLIFIER WITHOUT FEEDBACK

Theoretical Calculations:

Calculation of $h_{ie}= h_{fe} x\ r_e$

h_{fe}= using multimeter calculate hfe value for the given transistor

r_e= 26mV/I_E

$I_E=V_E/R_E$(calculate drop across R_E using multimeter for DC bias circuit)

Input impedancae without Feedback:

$$Z_{IN} = R_1 \ // \ R_2 \ // \ h_{ie}$$

Output impedancae without Feedback:

$Z_O = R_C \,//\, R_L$

Voltage gain without feedback:

$$A_V = -hfe\frac{Z_O}{Z_{IN}}$$

Input impedancae with Feedback:

$$Z_{IN} = R_1 \,//\, R_2 \,//\, (h_{ie} + (1 + hfe)R_e)$$

Output impedancae with Feedback:

$$Z_O = R_C \,//\, R_L$$

Voltage gain with feedback:

$$A_V = -hfe\frac{Z_O}{Z_{IN}}$$

Practical Observations(with and without feedback):

V_{IN}= ___V(using CRO)

$$\boldsymbol{Z_{IN} = Rs\left[\frac{V_{IN}}{V_S - V_{IN}}\right]}$$

V_L= ___V(using CRO)

V_{NL}= ___V(using CRO)

$$\boldsymbol{Z_O = R_L\left[\frac{V_{NL} - V_L}{V_L}\right]}$$

$$\boldsymbol{A_V = \frac{V_L}{V_{IN}}}$$

PROCEDURE:

1. Connections are made as per the circuit diagram. With out input source, Ce and load i.e in DC bias
2. A 10V DC supply is given to the circuit for biasing
3. Calculate emitter voltage across Re and find emitter current Ie
4. Circuit is connected as per circuit diagram without feedback i.e., without Ce.
5. A certain amplitude of input signal (say 20mV) is kept constant using the function at a constant frequency of 1KHz

6. Note down the V_{IN} ,V_L , V_{NL} using CRO
7. Now the Circuit is connected as per circuit diagram with feedback i.e keeping Ce
8. Note down the V_{IN} ,V_L , V_{NL} using CRO
9. Calculate input impedance Z_{IN} ,output impedance Z_O ,and voltage gain A_V and compare with theoretical values.

PRECAUTIONS :

1. Avoid loose and wrong connections.
2. Avoid parallax error while taking readings.

VIVA QUESTIONS:

1. What is the relationship between the transfer gain with feedback A_f and that without feedback

A. $A_f=A/(1+A\beta)$

2. What are the advantages of negative feedback.

A. High BW, less noise, less distortion, gain stability

2. How is the i/p impedance and o/p impedance of a Current series feedback amplifier

A. $R_{if} = R_i (1+A\beta)$, $R_{of} = Ro (1+A\beta)$

3. What are the types of feedback amplifiers.

A. Voltage shunt, current shunt, current series, voltage series feedback amplifiers.

RESULT:

The input impedance Z_{IN} ,output impedance Z_O ,and voltage gain A_V with & with out feedback are calculated and compared theoretically.

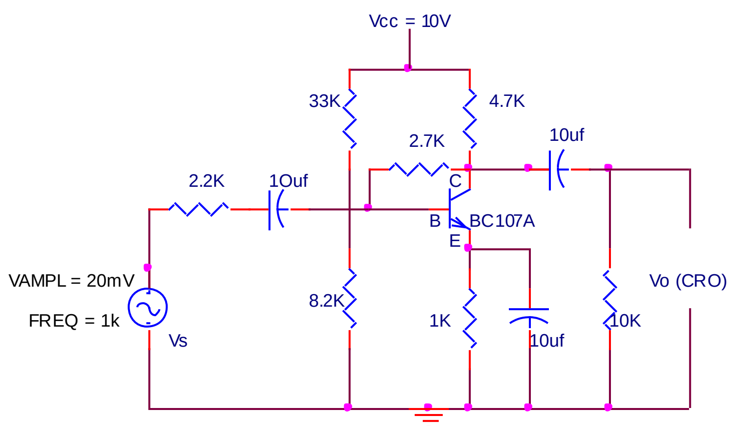
3. VOLTAGE SHUNT AMPLIFIER

AIM:
To obtain the frequency response of a voltage shunt feedback(with and without) amplifier and obtain the bandwidth

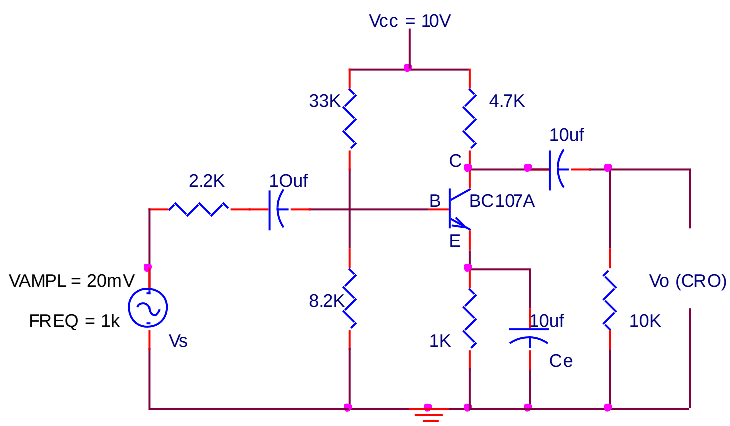
APPARATUS :

Power supply	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No
Resistors	1kΩ,4.7k,8.2k	1 No
Resistors	2.2k,33k,10K,2.7K	1 No
Capacitors	10µF	3 No ,
Transistors	BC107	1 No
Bread board		
CRO Probes		

CIRCUIT DIAGRAMS :



VOLTAGE SHUNT AMPLIFIER WITH FEEDBACK



VOLTAGE SHUNT AMPLIFIER WITHOUT FEEDBACK

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. A 10V DC supply is given to the circuit for biasing.
3. The circuit is connected without feedback i.e., without R_F
4. A certain amplitude of input signal (say 20mV) is kept constant using the function generator and for different frequencies the output voltage from CRO are noted.
5. Now, the circuit is connected with feedback i.e., with R_F.
6. By keeping the input signal constant the output voltages for different frequencies are noted from CRO.
7. Gain with and without feedback is calculated from the formula

Gain = 20 log Vo / Vi (dB)

Where V_o is output voltage, V_i is input voltage.

TABULAR FORM :

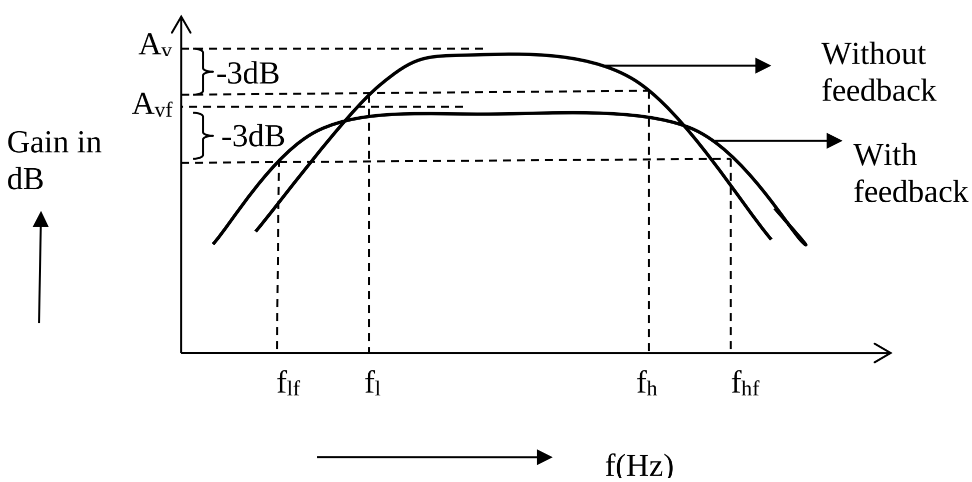
WITH FEEDBACK: **I/P VOLTAGE V_i =**

FREQUENCY (Hz)	O/P VOLTAGE (Vo)	Gain in dB = 20 log Vo / Vi
100		
200		
300		
500		
700		
1k		
2k		
3k		
5k		
7k		
10k		
20k		
30k		
50k		
70k		
100k		
200k		
300k		
500k		
700k		
1M		

WITHOUT FEEDBACK: **I/P VOLTAGE V_i =**

FREQUENCY (Hz)	O/P VOLTAGE (Vo)	Gain in dB = 20 log Vo / Vi
100		
200		
300		
500		
700		
1k		
2k		
3k		
5k		
7k		
10k		
20k		
30k		
50k		
70k		
100k		
200k		
300k		
500k		
700k		
1M		

MODEL GRAPH :



Bandwidth= f_l-f_h

GRAPH : A graph is plotted between gain (dB) and frequency(Hz) which is frequency response of voltage shunt feedback amplifier for without feedback and with feedback.

PRECAUTIONS :

3. Avoid loose and wrong connections.
4. Avoid parallax error while taking readings.

QUESTIONS:

1. What is the relationship between the transfer gain with feedback A_f and that without feedback A.

A. $A_f=A/(1+A\beta)$

2. What are the advantages of negative feedback.

A. High BW, less noise, less distortion, gain stability

3. How is the i/p impedance and o/p impedance of a voltage shunt feedback amplifier

A. $R_{if} = R_i/(1+A\beta)$, $R_{of} = Ro/(1+A\beta)$

4. What are the types of feedback amplifiers.

A. Voltage shunt, current shunt, current series, voltage series feedback amplifiers.

RESULT:

The frequency response of the given voltage shunt amplifier with & with out feedback are obtained .

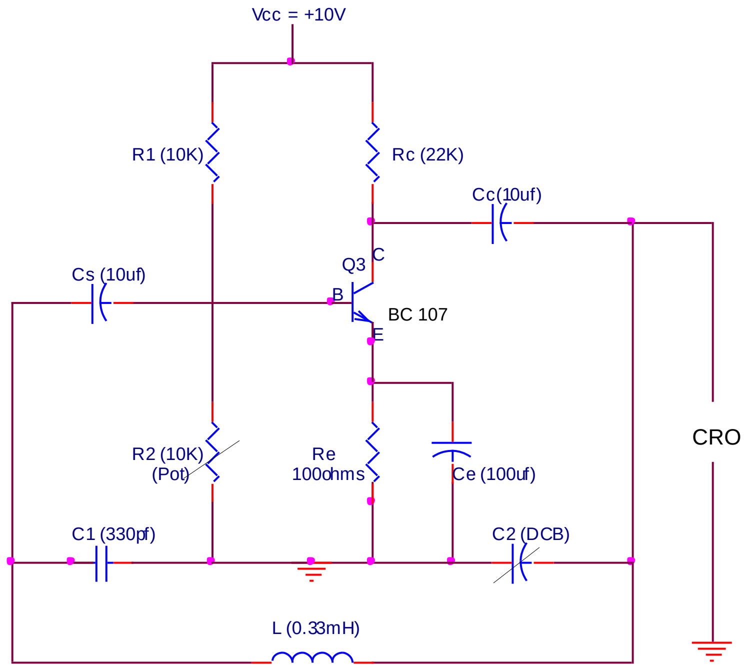
4. COLPITTS OSCILATOR

AIM:
To determine the frequency of oscillations of the Colpitts Oscillator.

APPARATUS :

Power supply	0-30V	1No.
CRO	20MHz	1No.
Inductor	0.33mH	1 No
Resistors	10kΩ, 22kΩ, 100kΩ	1 No
Capacitors	100µF, 330pF	1 No
Capacitors	10µF	2 No,
Transistors	BC107	1 No.
Potentiometer	10K	1 No
DCB		1 No
Bread board		
CRO Probes		

CIRCUIT DIAGRAM:



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COLPITTS OSCILLATOR

PROCEDURE :

1. The circuit is connected as shown in figure.
2. The capacitor C_1 is kept constant and C_2 is up to some value.
3. The resistor R_2 is adjusted until sinusoidal waveform is observed on the CRO.
4. Then the time period and hence the frequency are Calculated which is nearly equal to the theoretical frequency.
5. The theoretical and practical values of frequency are verified using the formula.

$$f_o = 1 / 2\Pi \sqrt{LC_{eq}} \text{ where } C_{eq} = \frac{C_1C_2}{C_1+C_2}$$

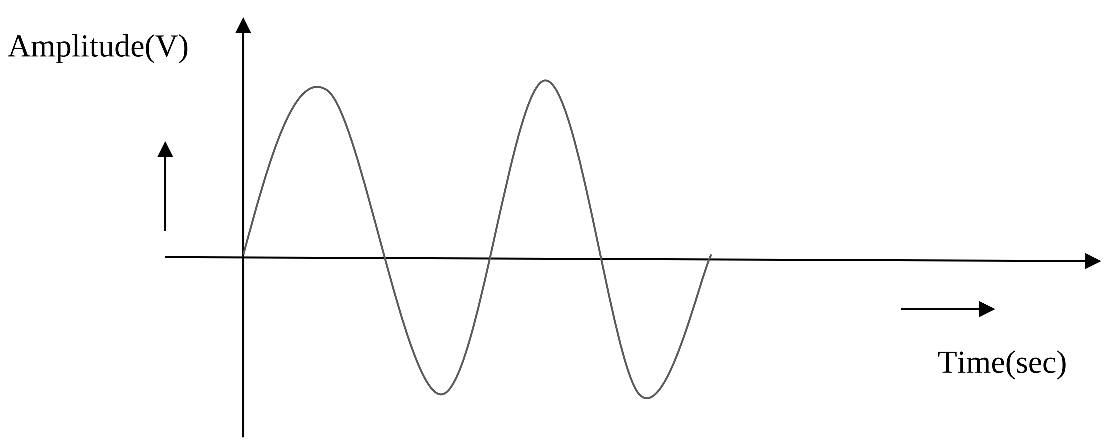
$$f_o \text{ practical} = 1/T \text{ (Hz) } T = \text{Time period.}$$

6. The experiment is repeated for different values of C_2 and each time the time period is noted.

TABULARFORM :

S.NO.	INDUCTANCE (L)	CAPACITANCE			Theoretical $f_o=1/2\Pi \sqrt{LC_{eq}}$ (kHz)	T (Sec)	f=1/T (Hz)	Amplitude (V)
		C_1	C_2	C_{eq}				
1.	0.33mH	330pf	330pf					
2.	0.33mH	330pf	470pf					
3.	0.33mH	330pf	570pf					

MODEL GRAPH :



PRECAUTIONS :

1. Avoid loose and wrong connections.
2. The sinusoidal waveform obtained must be distortion.
3. Readings should be taken without parallax error.

QUESTIONS:

1. What type of feedback is used in oscillators.

A. Positive feedback

2. Define tank circuit.

A. It is the circuit which generates oscillations in the oscillator using tank circuit components.

3. What is barkhausen condition.

A. i. loop gain $|A\beta|=1$ ii. Total phase shift = 360° or 0°

4. Why LC oscillators cannot be used as a audio frequency oscillators.

A. At audio frequency range 1.e at low frequency the inductor size becomes bulky.

RESULT: The frequency of the oscillations of colpitts oscillator is determined .

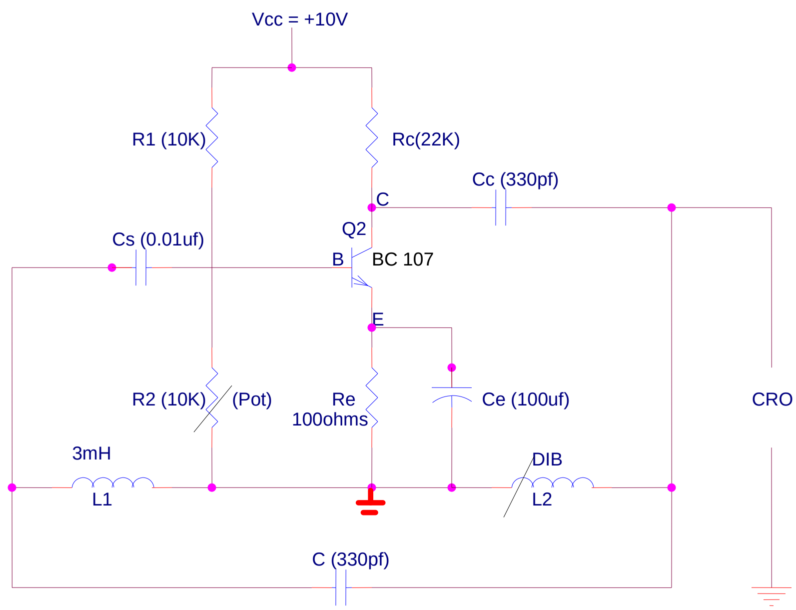
5. HARTLEY OSCILLATOR

AIM:
To determine the frequency of oscillations of Hartley oscillator.

APPARATUS:

Power supply	0-30V	1No.
CRO	20MHz	1No.
Inductor	100µH	1 No
Resistors	10kΩ, 22kΩ, 100kΩ	1 No
Capacitors	100µF, 0.01µF	1 No
Capacitors	330pF	2 No,
Transistors	BC107	1 No.
Potentiometer	10K	1 No
DIB		2 No
Bread board		
CRO Probes		

CIRCUIT DIAGRAM :



HARTLEY OSCILLATOR

PROCEDURE:

1. Connections are made as shown in circuit diagram.
2. The inductor 'L_2' is up to some value, keeping inductor 'L_1' constant
3. The potentiometer 'R_2' is adjusted until sinusoidal waveform is observed on CRO.
4. The time period and hence the frequency are calculated for the wave obtained which is nearly equal to the theoretical frequency.
5. The theoretical and practical values of frequency are verified using the formula.

$$f_o = 1 / 2\Pi \sqrt{L_{eq}C} \text{ where } L_{eq} = L_1+L_2$$

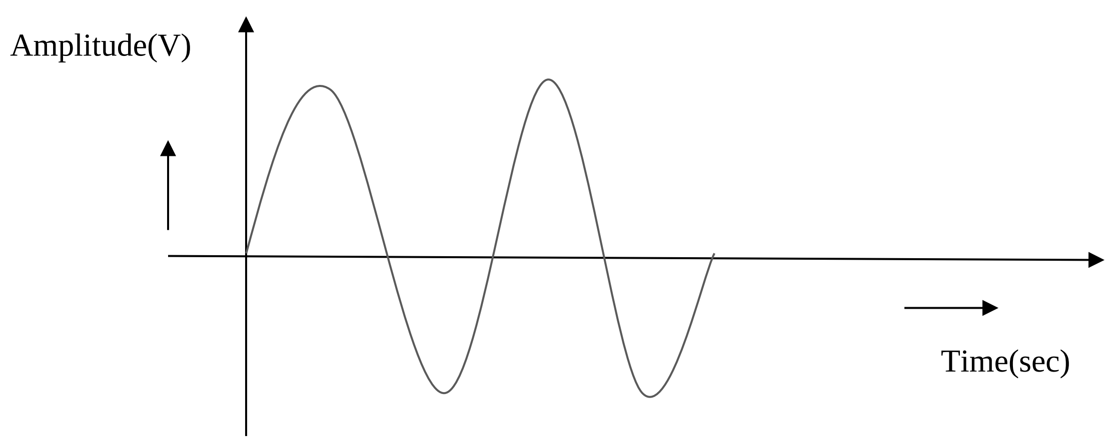
$$f_o \text{ practical} = 1 / T \text{ (Hz) } T = \text{Time period}$$

6. The experiment is repeated for different values of 'L_2' and each time the time period is noted .

TABULAR FORM :

C	Inductance			Theoretical $f = 1 / 2\Pi\sqrt{L_{eq} C}$	Time T (Sec)	PRACTICAL f = 1 /T (Hz)	Amplitude (V)
	L_1	L_2	$L_{eq} = L_1 + L_2$				
470pf	3mH	3mH					
470pf	3mH	4mH					
470pf	3mH	5mH					

MODEL GRAPH:



GRAPH :

A graph is plotted between time period on x-axis and amplitude on y-axis to obtained a sinusoidal waveform at a particular value of L_2.

PRECAUTIONS :

1. Avoid loose contacts.
2. Avoid wrong connections.

QUESTIONS:

1. What type of feedback is used in oscillators.

A. Positive feedback

2. What are the types of oscillator.

A. Sinusoidal oscillators and relaxation oscillators

3. What is barkhausen condition.

A. i. loop gain $|A\beta|=1$ ii. Total phase shift = 360° or 0°

4. Why LC oscillators cannot be used as a audio frequency oscillators.

A. At audio frequency range 1.e at low frequency the inductor size becomes bulky.

5. What is the other name for LC and RC oscillators and its ranges of frequency.

A. LC are also called as Radio frequency oscillators(range= 20KHz to 100MHz)

RC are also called as audio frequency oscillators (range=20Hz to 20 KHz)

RESULT:

The frequency of oscillations of Hartley oscillator is determined.

6. RC PHASE SHIFT OSCILLATOR

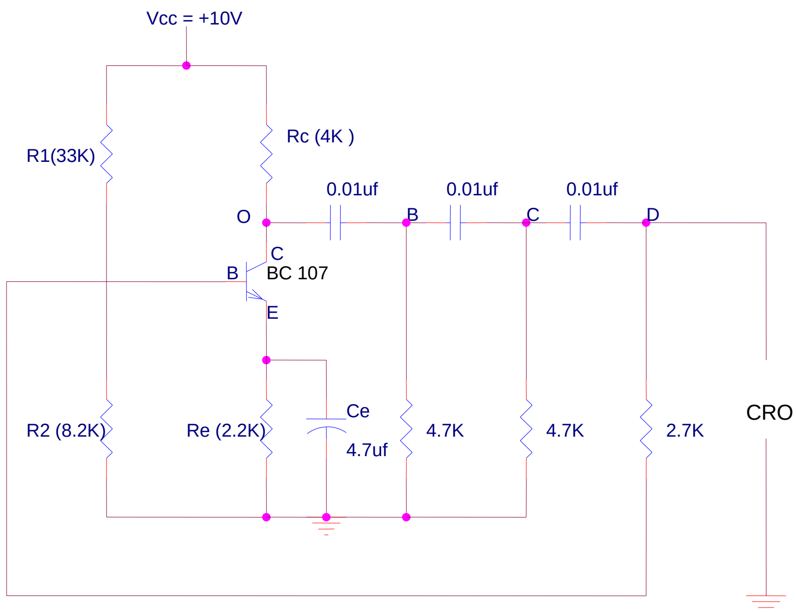
AIM:

To find the frequency of oscillations of the RC phase shift oscillator and to measure the phase shift of each section of the RC network.

APPARATUS:

Power supply	0-30V	1No.
CRO	20MHz	1No.
Resistors	33kΩ,8.2kΩ,4kΩ	1 No
Resistors	2.2kΩ, 2.7kΩ,10KΩ	1 No
Resistors	4.7kΩ	2 No
Capacitors	0.01μF	3 No
Capacitors	4.7μF	1 No
Transistors	BC107	1 No
Bread board		
CRO Probes		

CIRCUIT DIAGRAM :



RC PHASE SHIFT OSCILLATOR

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. observe the output waveform at '0' on CRO which is sinusoidal.
3. Now, the CRO probe is changed to position 'B' such that the output waveform at B is observed on CRO, which is shifted by 60^o w.r.t. '0'
4. The output waveform at 'C' is observed on CRO, which is shifted by 120^o w.r.t. '0'.
5. The output waveform at 'D' is observed on CRO,which is shifted by 180^o w.r.t. '0'.
6. Theoretically the frequency of oscillations is calculated by the formula,

   $$f=1/2\pi RC\sqrt{6+4K}, \qquad K = R_C / R$$

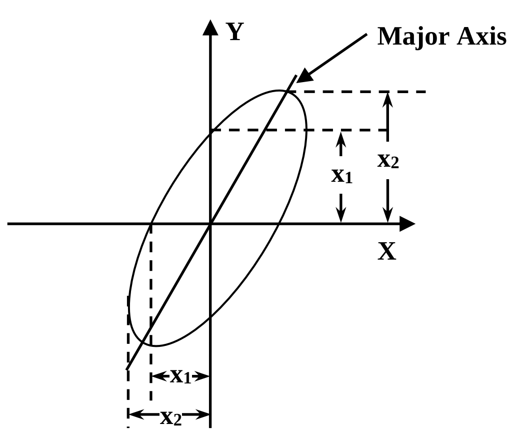
   Practically the time period 'T' on CRO is noted and frequency **f = 1/T** is calculated.

7. A graph is plot for phase and amplitude locating the phase shift observed on CRO at different positions of (B,C,D).

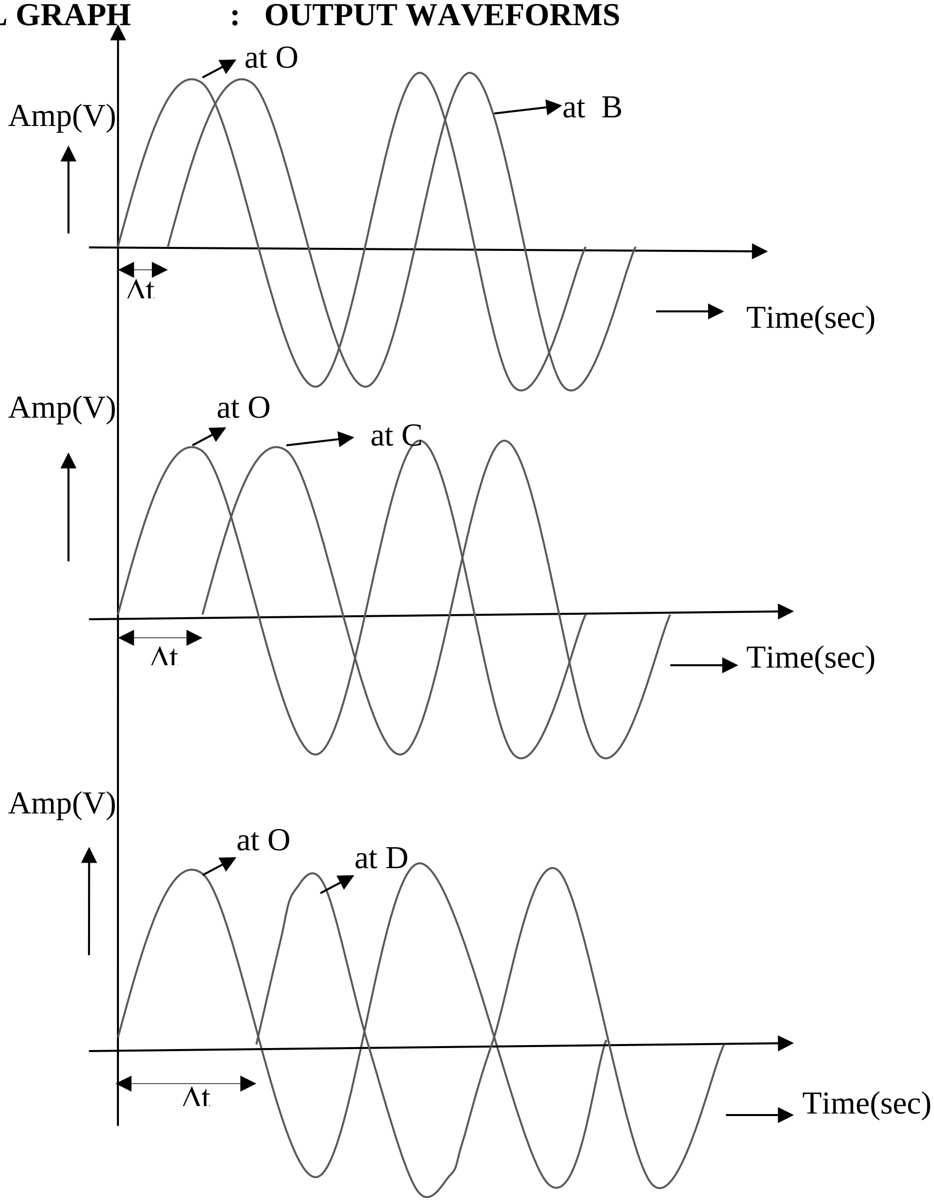
TABULAR FORM :

R_C (KΩ)	Position w.r.t Collector	Lissajous Pattern	x_1	x_2	$\theta=\sin^{-1}(x_1/x_2)$	T (Sec)	f_0 (Hz) Theoretical	Amplitude (V)	Δt (sec)
4K	B								
	C								
	D								

LISSAZEOUS PATTERN:



MODEL GRAPH : OUTPUT WAVEFORMS



PRECAUTIONS :

1. The readings are to be noted down without parallax error.
2. Wrong connections should be avoided.

QUESTIONS:

1. How the Barkhausen Criteria is satisfied in the RC phase-shift oscillator?

A. To satisfy total phase shift 360°,each RC section gives 60° i.e 60°x 3=360°

2. How do you vary the frequency of the RC phase-shift oscillator?

A. By changing R and C components and again designing the circuit with changed components to get the new frequency.

3. What is the maximum phase-shift that can be obtained by a single RC section?

A. 60°

4. What is the frequency range that can be obtained by the RC phase shift oscillator?

A. Audio range=20Hz to 20KHz

5. What is the need of lissazeous pattern**.**

A. To find the phase angle of each RC section

RESULT: The frequency of oscillations of a phase shift oscillator is found and phase shift of each section of the RC network(in Lissazeous pattern) is measured.

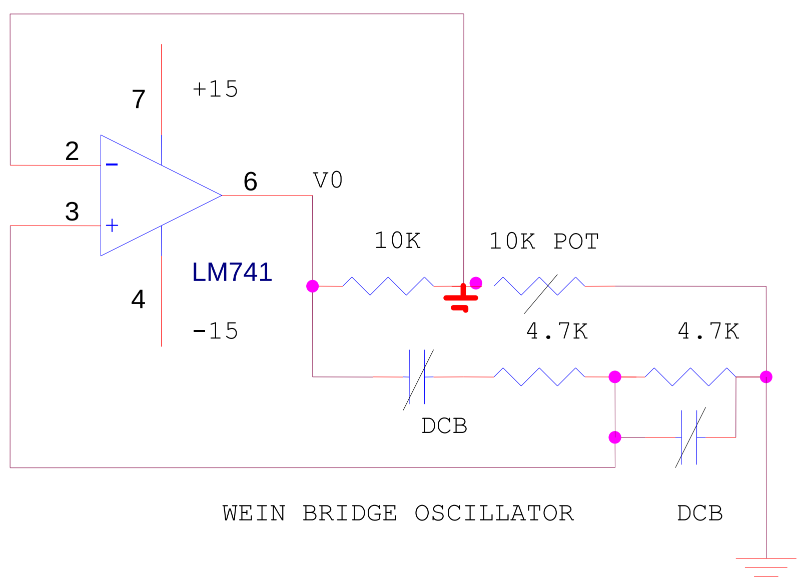
7. WEIN BRIDGE OSCILLATOR

AIM: To obtain the frequency of oscillations of a Wein Bridge oscillator.

APPARATUS:

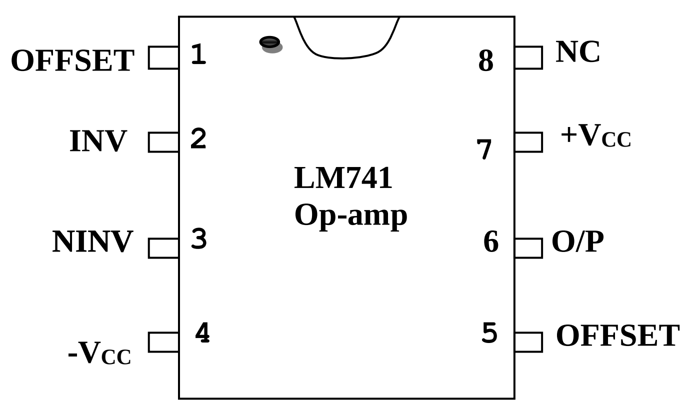
Power supply(2 channel)	0-30V	1No.
CRO	20MHz	1No.
Resistors	10KΩ	1 No
Resistors	4.7kΩ	2 No
DCB		2 No
potentiometer	10KΩ	1 No
Op-amp	LM 741 IC	1 No
Bread board		
CRO Probes		

CIRCUIT DIAGRAM :



WEIN BRIDGE OSCILLATOR

PIN DIAGRAM :



PROCEDURE :

1. Connections are made as per the circuit diagram.
2. The two capacitances are varied by using variable capacitance box.
3. The output wave is observed on the CRO.
4. The time period of the wave for each value of capacitor is noted.
5. The frequency of the wave is calculated from the time period using the formula **f = 1/T**
6. Theoretical frequency is calculated by using the formula

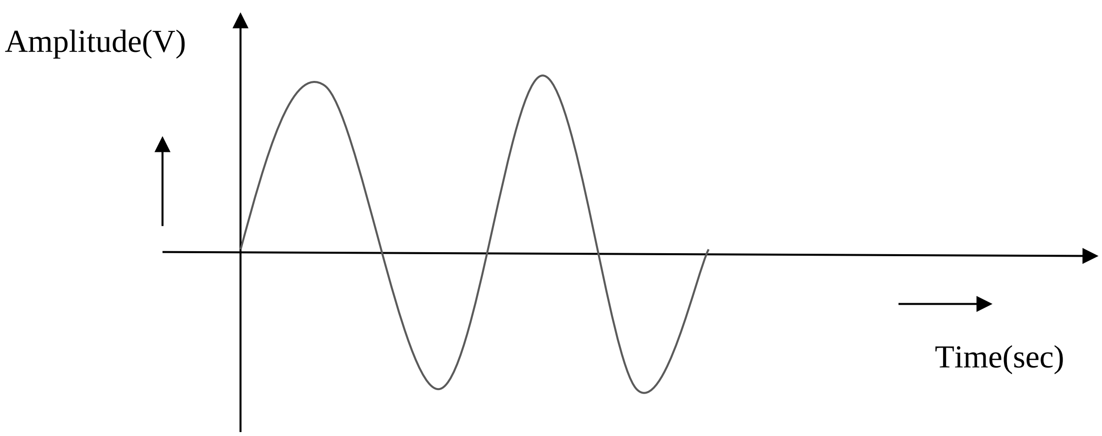
$$f = 1/\sqrt{2\Pi R_1 R_2 C_1 C_2}$$

7. Compare the practical and theoretical values.

TABULAR FORM :

$R_1 = R_2$ (Ω)	C		Theoretical(Hz) $f = 1/\sqrt{2\Pi R_1 R_2 C_1 C_2}$	Output voltage(v)	Time Period T (Sec)	Practical f = 1/T (Hz)	Amplitude (V)
	C_1	C_2					
4.7K	3nf	3nf					
4.7K	4nf	4nf					
4.7K	5nf	5nf					

MODEL GRAPH:



PRECAUTIONS :

1. Avoid loose and wrong connections.
2. Connections should be made properly and the output should be a proper sine wave, such that the time period and amplitude may be obtained accurately.

QUESTIONS:

1. What determines the frequency of oscillations?

A. The R and C components of the bridge circuit.

2. What is the frequency range of oscillations?

A. Audio range=20Hz to 20KHz

3. When frequency of oscillations occur in oscillator.

A. When bridge is balanced.

RESULT

The frequency of oscillations of Wein bridge oscillator is Determined.

8. EFFICIENCY OF CLASS A POWER AMPLIFIER

AIM: To calculate the efficiency of a Class-A power amplifier and compare with theoretical value.

APPARATUS:

Power supply	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No
voltmeter		1 No
Transistors	CL-100	1 No
Bread board		
CRO Probes		

THEORY:

The power into amplifier is provided by supply. Without input signal the dc current drawn is the collector bias I_{CQ}. Then the input power drawn from supply is:

$$P_i(dc)=V_{cc} * I_{CQ}$$

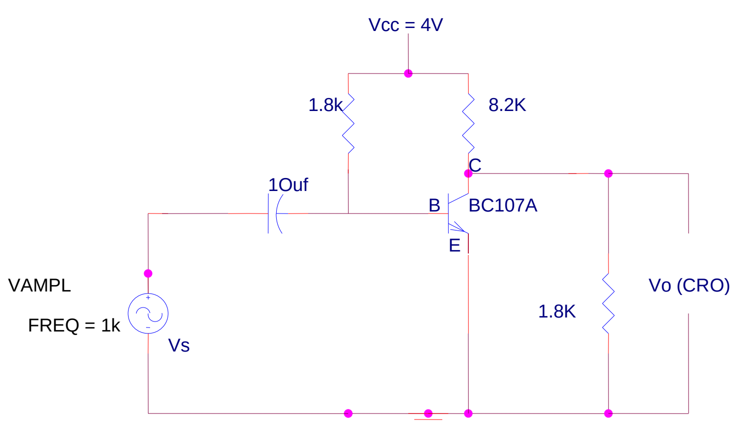
The output power (ac power) is given by :

$$P_o(ac)= V_{CE}(rms) * I_c(rms) \qquad P_o(ac)= I^2_c(rms)*R_c \qquad P_o(ac)= V^2_{CE}(rms)/$$

The efficiency is: $$\%\eta = \frac{P_o(ac)}{P_i(dc)} \times 100\%$$

The maximum efficiency is equal to 25%

CIRCUIT DIAGRAM :



THEORITICAL CALCULATIONS:

$$\%\eta = \frac{P_{AC}}{P_{DC}} \times 100$$ **= 25%**

PRACTICAL CALCULATIONS:

$$P_{DC} = V_{CC} \times I_{DC}$$

$$P_{AC} = V_{rms} \times I_{rms} = \frac{V_{pp} I_{pp}}{8} \left(\because V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{V_{pp}}{2\sqrt{2}}, I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{I_{pp}}{2\sqrt{2}} \right)$$

$$P_{AC} = \frac{V_{pp}{}^2}{8R_L} \text{ or } \frac{I_{pp}{}^2 R_L}{8}$$

PROCEDURE:

1. The circuit is connected as shown in figure
2. An input voltage of 1V and a frequency of 1KHz is applied with the help of signal generator
3. Observe the output undistorted waveform
4. Note the Vpp value
5. Using multimeter calculate the voltage across Rc and calculate the current Ic in R_L
6. Now calculate the practical efficiency using formula given
7. Compare the practical efficiency and theriotical efficiency.

PRECAUTIONS:

1. Loose and wrong connections must be avoided.
2. Readings must be taken without parallax error.

QUESTIONS:

1. In what way the design features of power transistors different from small signal transistors?
2. What is the basis for the classification of power amplifiers? Mention different types of power amplifiers?
3. What reasons will you assign for higher conversion efficiency of Class B amplifier as compared to Class A amplifier?

RESULT: Calculated the efficiency of a Class-A power amplifier and compared with theoretical value.

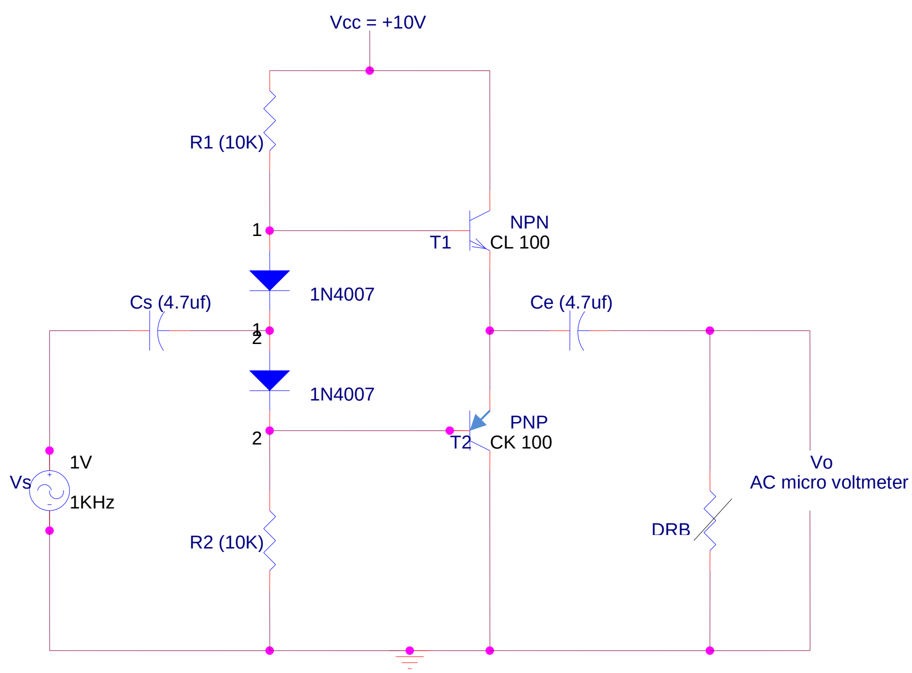
9. LOAD CHARACTERISTICS CLASS – B PUSH PULL AMPLIFIER

AIM: To obtain the Load and power Characteristics of a Class-B push pull amplifier.

APPARATUS:

Power supply	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No
AC micro voltmeter		1 No
Resistors	10kΩ	2 No
DRB		1 No
Capacitors	4.7µF	2 No
diodes	1N4007	2 No.
Transistors	CK-100,CL-100	1 No
Bread board		
CRO Probes		

CIRCUIT DIAGRAM :



CLASS A PUSH PULL AMPLIFIER

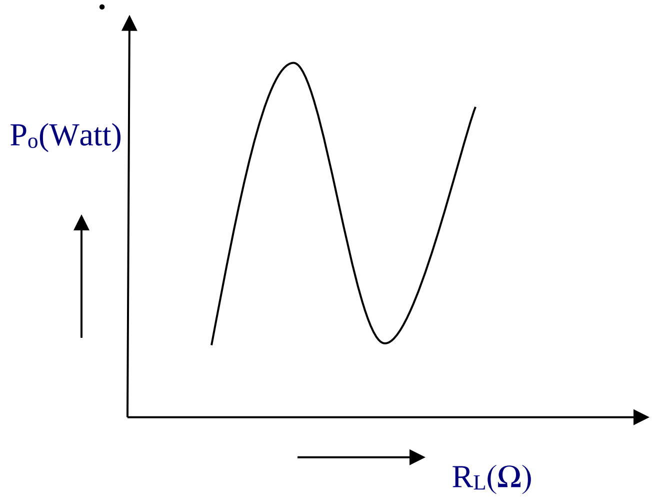
PROCEDURE :

1. The circuit is connected as shown in figure.
2. An input voltage of 20V and a frequency of 1KHz is applied with the help of signal generator
3. The load R_L is varied from 10K to 10Ω with the help of decade resistance box and each time the output voltage is noted from AC micro voltmeter.
4. The power, $P_o = V_o^2 / R_L$ is calculated in each case and a graph is plot between P_o and R_L is drawn.

TABULARFORM : **I/P VOLTAGE, V_i = 20V,1KHz**

R_L (Ω)	V_O (Volts)	$P_o = V_o^2 / R_L$ (Watts)
10KΩ To 10Ω		

MODEL GRAPH :



PRECAUTIONS :

1. Loose and wrong connections must be avoided.
2. Readings must be taken without parallax error.

QUESTIONS:

1. Define class-B amplifier
A. The output current flows only for the half of the input signal
2. What are the advantages of class B over class A amplifier.
A. Efficiency of class B(50%) is more than class A(25%)
3. What is cross over distortion.
A. Crossover distortion is the term given to a type of distortion that occurs in push-pull class AB or class B amplifiers. It happens during the time that one side of the output stage shuts off, and the other turns on.
4. What is complementary symmetry amplifier.
A. A complimentary-symmetry amplifier is a power output stage using two transistors. One is an NPN and the other is PNP

RESULT:

Hence the load Characteristics of the given class-B Push pull amplifier.

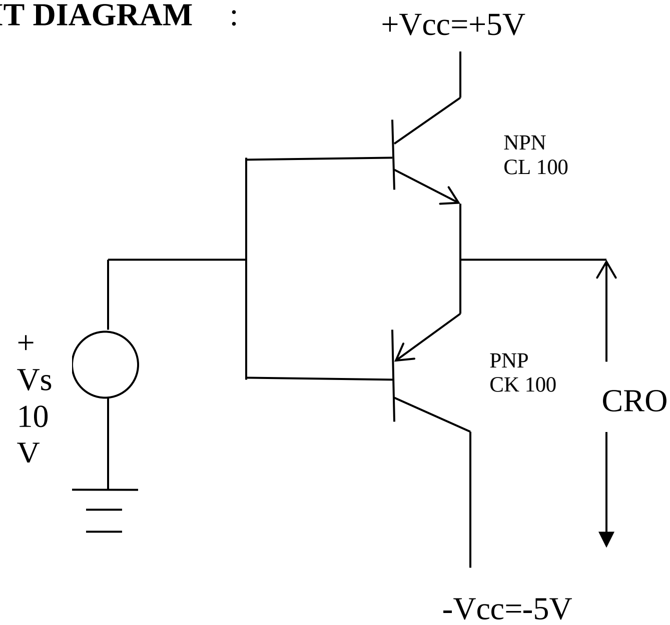
10. EFFICIENCY OF CLASS – B PUSH PULL AMPLIFIER

AIM: To calculate the efficiency of a Class-B push pull amplifier and compare with theoretical value.

APPARATUS:

Power supply	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No
voltmeter		1 No
Transistors	CK-100,CL-100	1 No
Bread board		
CRO Probes		

CIRCUIT DIAGRAM :



Theoretical calculations:

$$\eta_{th} = \left(\frac{V_P}{V_{CC}}\right) \times \left(\frac{\pi}{4}\right) \times 100$$

Practical calculations:

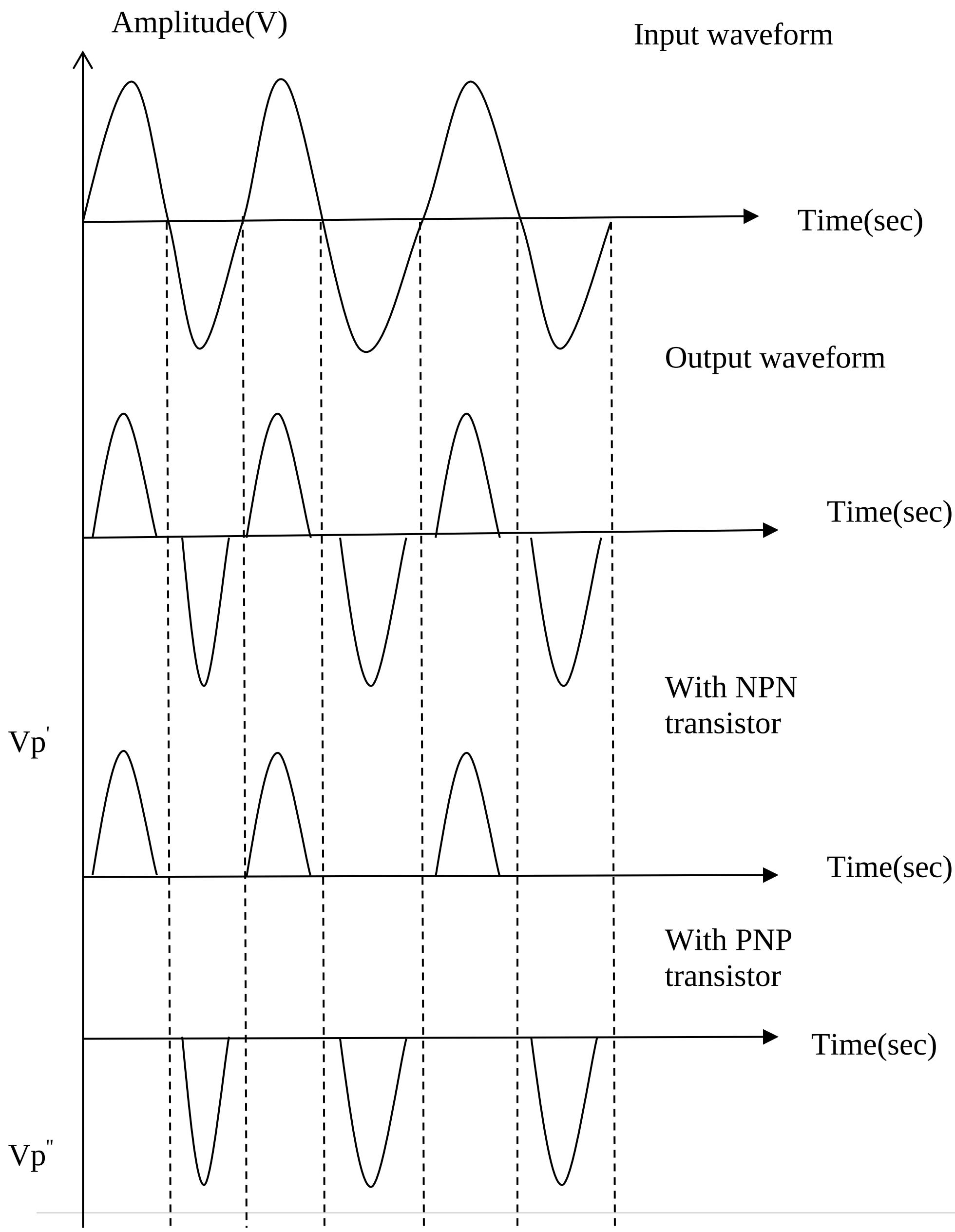
$$\eta_{PR} = \left(\frac{P1}{P2}\right) \times 100 \ ;$$

$$P1 = \left(\frac{Vpp}{2\sqrt{2}}\right) \times \frac{1}{R_L} \quad , \qquad P2 = Vcc\left(\frac{V'_{op}}{\pi R_L} + \frac{V''_{OP}}{\pi R_L}\right)$$

PROCEDURE:

1. The circuit is connected as shown in figure
2. An input voltage of 2V and a frequency of 1KHz is applied with the help of signal generator
3. Observe the output waveform with cross over distortion and note the required values for graph and Vpp voltage
4. Open the pnp transistor and observe the o/p waveform and note down the peak voltage V_p'
5. Open the NPN transistor and observe the o/p waveform and note down the peak voltage V_p''
6. Calculate the efficiency and compared with theoretical value

MODEL GRAPHS:



PRECAUTIONS :

1. Loose and wrong connections must be avoided.
2. Readings must be taken without parallax error.

QUESTIONS:

5. Define class-B amplifier
B. The output current flows only for the half of the input signal
6. What are the advantages of class B over class A amplifier.
B. Efficiency of class B(50%) is more than class A(25%)
7. What is cross over distortion.
B. Crossover distortion is the term given to a type of distortion that occurs in push-pull class AB or class B amplifiers. It happens during the time that one side of the output stage shuts off, and the other turns on.
8. What is complementary symmetry amplifier.
B. A complimentary-symmetry amplifier is a power output stage using two transistors. One is an NPN and the other is PNP

RESULT:

The efficiency of class-B Push pull amplifier is calculated and compared with theoretical value

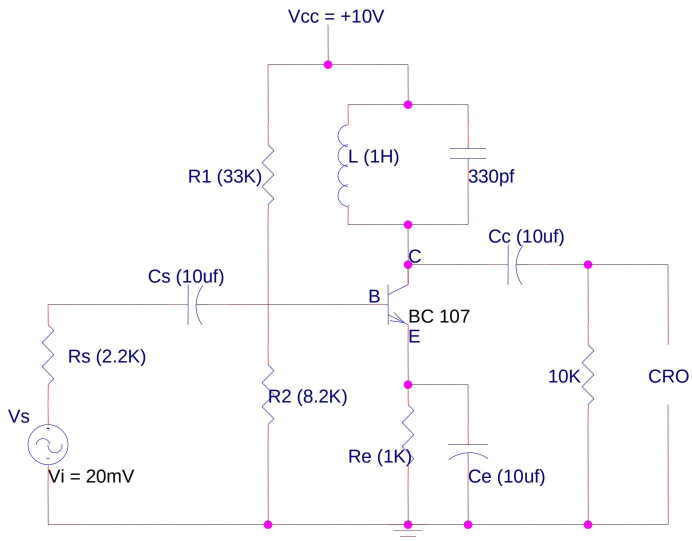
11. TUNED VOLTAGE AMPLIFIER

AIM:
To obtain the frequency response of tuned voltage amplifier and find the resonant Frequency and verify it with practical frequency.

APPARATUS:

Power supply	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No.
Capacitors	10µF	3 No.
Capacitor or DCB	330pF	1 No.
Transistors	BC107	1 No.
Resistor	33KΩ,8.2KΩ	1 No.
Resistor	2.2KΩ,1KΩ,10KΩ	1.No.
Inductor or DIB	1H	1 No
Bread board and connecting wires		

CIRCUIT DIAGRAM:



TUNED VOLTAGE AMPLIFIER

PROCEDURE:

1. The circuit is connected as shown in the figure.
2. A 10V DC supply is given to the circuit for biasing.
3. An input signal of (say 20mV to 30mV) is given from the output of the signal generator.
4. The output voltage V_o is noted for different values of the frequencies.
5. In each case the gain is calculated using the formulae

$$A_V = 20 \log_{10} V_o/V_i \text{ (dB).}$$

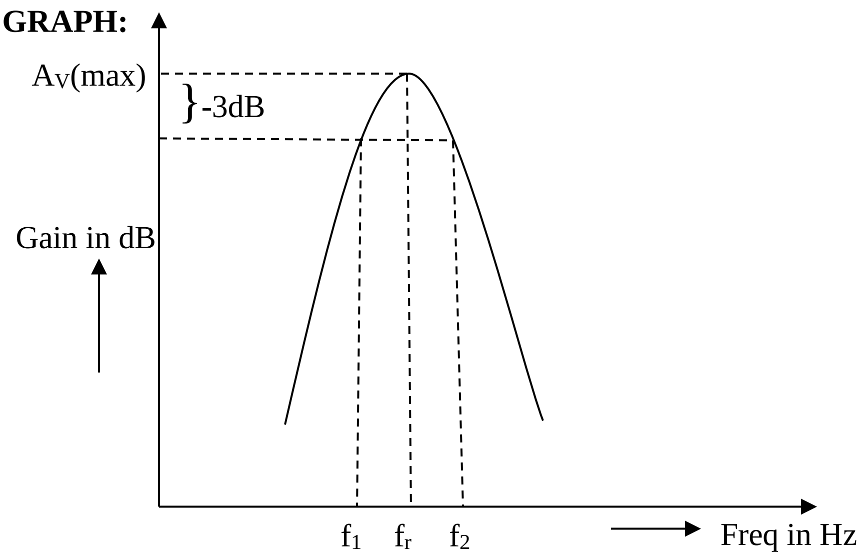
6. It is observed that at certain frequency the gain obtained is maximum. The frequency is known as the resonant frequency at which $\mathbf{X_L = X_C}$ and it approximately

$$f_r \text{ (theoretical)} = 1 / 2\Pi\sqrt{LC}$$

TABULAR FORM : **I/P Voltage, V_i =**

Frequency (Hz)	O/P Voltage, V_o (V)	Gain $A_V = 20 \log_{10} V_o/V_i$ (dB)
100		
200		
300		
500		
700		
1k		
2k		
3k		
5k		
7k		
10k		
20k		
30k		
50k		
70k		
100k		
200k		
300k		
500k		
700k		
1M		

MODEL GRAPH:



PRECAUTIONS:

1. Avoid loose and wrong connections.
2. The amplitude of the input voltage must be maintained constant through out the experiment.
3. Waveforms must be obtained without any distortion.

QUESTIONS:

1. What is resonant frequency.

A. Resonance is the tendency of a system to oscillate at maximum amplitude at certain frequencies, known as the resonance frequencies

2. State the conditions which exist during resonance.

A. The impedance of inductor is equal to the impedance of capacitor.

3. Define Quality factor

A. The quality factor or Q factor is a dimensionless parameter that describes how under-damped an oscillator or resonator is, or equivalently, characterizes a resonator's bandwidth relative to its center frequency.

4. Give the relation between Quality factor and bandwidth.

A. $Q= f_r / BW$

5. What are the applications of tuned voltage amplifier.

A. Radio and TV amplifiers employ tuned amplifiers to select one broadcast channel from among the many concurrently induced

RESULT:

The frequency response and band width of a tuned Voltage amplifier are obtained .

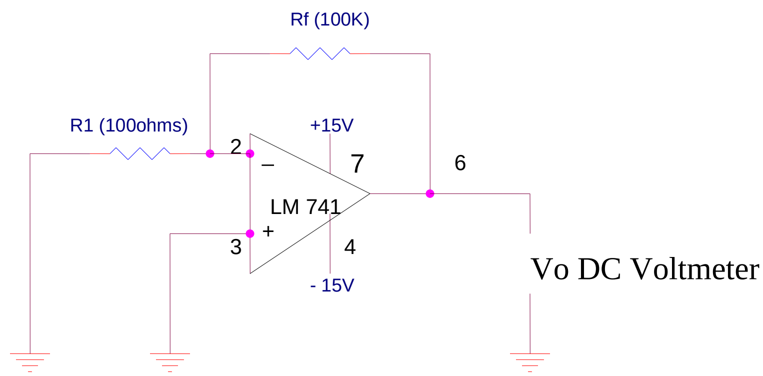
12. MEASUREMENT OF OP – AMP PARAMETERS

AIM : To determine the parameters of operational amplifier.

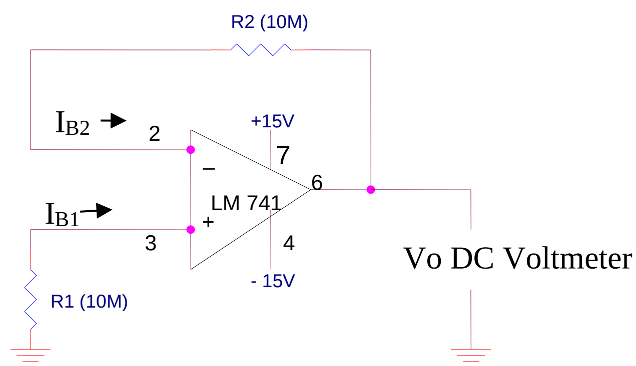
APPARATUS :

Power supply (2-Channel)	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No.
Op-amp	LM 741IC	1 No.
Digital micro voltmeter		1 No.
Resistor	100KΩ,100Ω,10M Ω	2 No.
Resistor	10KΩ	1No.
CRO Probes		2 No.
Bread board and connecting wires		

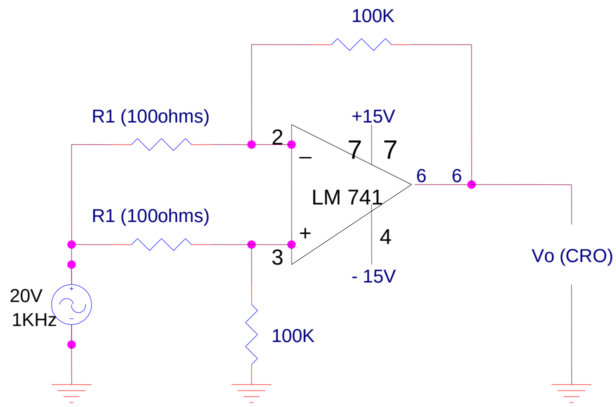
CIRCUIT DIAGRAM :



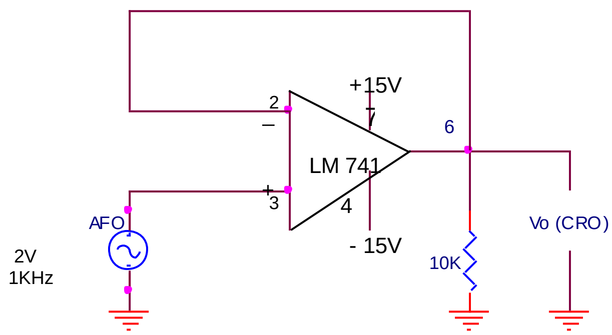
INPUT OFFSET VOLTAGE



INPUT OFFSET CURRENT



CALCULATION OF CMRR



SLEW RATE

PROCEDURE:

INPUT OFFSET VOLTAGE :

1. connect the circuit as shown in diagram (1).
2. A DC voltage of 15V is given.
3. The output voltage V_o is calculated
4. input offset voltage is calculated from the formula,

$$V_{io} = \frac{V_o}{1+(R_F / R_1)}$$

INPUT OFFSET CURRENT and INPUT BIAS CURRENT :

1. Connections are made as shown in circuit diagram(2).
2. The input bias current and input offset current is calculated by obtaining bias currents, I_{B1} & I_{B2}.
3. I_{B1} is obtained by shorting R_2 resistor and the output voltage V_o is measured by a Dc micro voltmeter.
4. I_{B1} is obtained by substituting in the formulae

$$I_{B1} = V_o / R_1$$

5.. I_{B2} is obtained by shorting R_1 resistor and the output voltage V_o is measured by a Dc micro voltmeter.

6. .I_{B2} is obtained by substituting in the formulae.

$$I_{B2} = V_o / R_2$$

$$\textbf{Bias current } I_B = \frac{(I_{B1}) + (I_{B2})}{2}$$

$$\textbf{Input offset current, } I_{io} = I_{B1} \sim I_{B2}$$

COMMON MODE REJECTION RATIO:

1.Connections are made as shown in circuit diagram (3).

2. A DC supply of 15V is given.

3.An input signal of 20V at 1KHz is given from the signal generator.

4. The output voltage V_o is measured from the CRO is calculated by the formula,

$$CMRR = (1 + R_F / R_1)(V_S / V_O)$$

$$CMRR(dB) = 20\log_{10}(CMRR)$$

SLEW RATE :

1. Connections are made as shown in circuit Diagram (4).
2.A Dc dual supply of 15V is given from the TRPS.
3.An input signal of 2V at 1KHz is given from the signal generator.
4.The frequency is increased gradually and the voltage($2V_m$) at which square wave transforms into triangular wave is noted. The value of frequency is also noted.
5.The slew rate is calculated by the formula.,

$$\text{Slew Rate(SR)} = 2\Pi f_m V_m / 10^6 \ (V/\mu.\ Sec)$$

PRECAUTIONS :

1. Loose and wrong connections should be avoided.
2. Readings are to be taken without parallax error.
3. The power should be turned off before making and breaking circuit connections

QUESTIONS:

1. Define Operational amplifier.

A. An operational amplifier ("op-amp") is a direct coupled high gain amplifier with a differential input and, usually, a single-ended output

2. What is virtual ground

A. Virtual ground (or virtual earth) is a node of the circuit that is maintained at a steady reference potential, without being connected directly to the reference potential.

3. What are the ideal characteristics of op-amp.

A. $A=\infty, R_i=\infty, R_o=0, BW=\infty, V_{io}=0V$.

RESULT : The parameters of the given op-amp are determined.

13. FREQUENCY RESPONSE OF OP – AMP

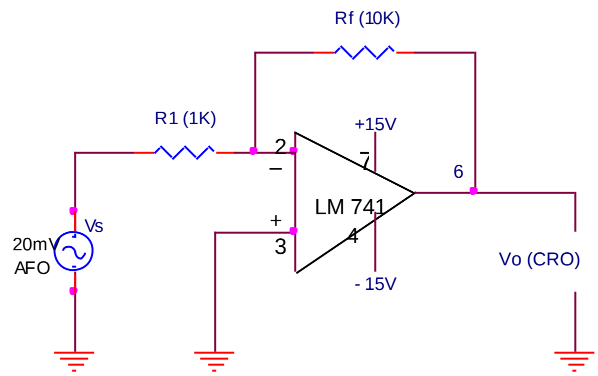
AIM:

To plot the frequency response characteristics for both inverting and non inverting modes of the given OP – AMP and to obtain its bandwidth.

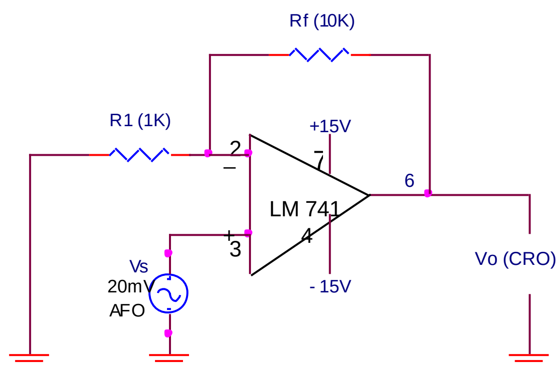
APPARATUS:

Power supply (2-Channel)	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No.
Op-amp	LM 741	1 No.
Resistor	10KΩ,1KΩ	2 No.
CRO Probes		2 No.
Bread board and connecting wires		

CIRCUIT DIAGRAM:

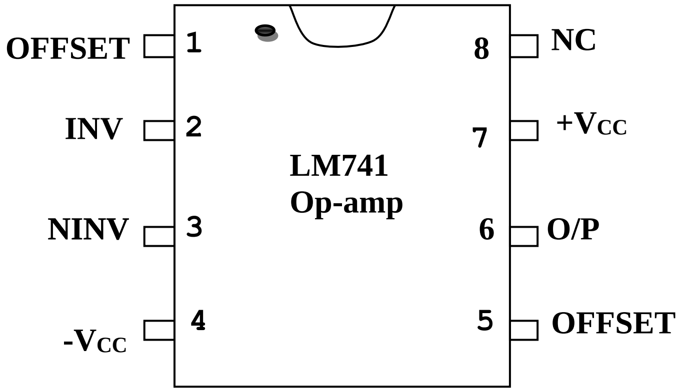


INVERTING MODE



NON – INVERTING MODE

PIN DIAGRAM:



PROCEDURE :

1. The circuit is connected as shown in circuit diagram (1) in inverting mode.
2. A 15V dual supply is given to the op amp from TRPS
3. Now an input voltage of (Say 20mV to 30mV) is given from the signal generator.
4. By varying the frequency, the output voltage V_o is noted from the CRO for different values of frequencies up to 1MHz.
5. For each value, the gain is calculated by the formula,

$$A_V = 20 \log V_o / V_i \text{ dB}.$$

6. Now the circuit diagram (2) is connected in non-inverting mode and the above procedure is repeated.
7. It is observed that the gain (A_V) of an op amp is greater in non inverting mode compared to that in inverting mode.

THEORETICAL CALCULATIONS:

For Inverting mode:

A_V=-Rf/R1

$A_{V(db)}=20\log_{10}(A_V)$

For Non-Inverting mode:

A_V=(1+(Rf/R1))

$A_{V(db)}=20\log_{10}(A_V)$

TABULAR FORM :

INVERTING MODE : V_i =

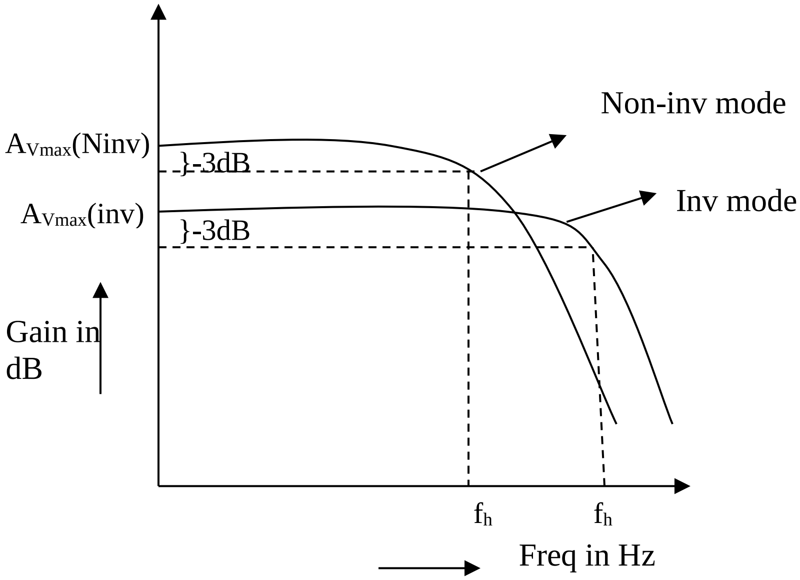
FREQUENCY (Hz)	O/P VOLTAGE V_o (V)	GAIN $A_V = 20 \log V_o / V_i$ (dB)
100		
200		
300		
500		
700		
1k		
2k		
3k		
5k		
7k		
10k		
20k		
30k		
50k		
70k		
100k		
200k		
300k		
500k		
700k		
1M		

NON INVERTING MODE : V_i =

FREQUENCY (Hz)	O/P VOLTAGE V_o (V)	GAIN $A_V = 20 \log V_o / V_i$ (dB)
100		
200		
300		
500		
700		
1k		
2k		
3k		
5k		
7k		
10k		
20k		
30k		
50k		

70k **100k** **200k** **300k** **500k** **700k** **1M**		

MODEL GRAPH :



Bandwidth ≈ f_h

GRAPH:

A graph is plotted between voltage gain (dB) and frequency (Hz) both for inverting and non inverting amplifiers.

PREACAUTION:

1. Avoid loose and wrong connections.
2. The output signal should be free from distortions.
3. Avoid parallax error while taking readings from CRO.

QUESTIONS:

1. Why response of Op-amp starts from constant.

A. As Op-Amp is a direct coupled amplifier there is no coupling capacitor

2. What are the types of packages for op-amp.

A. Flat pack, metal can pack etc.

3. What are the applications of op-amp

A. Summer, scaling, log amplifier etc.

RESULT :

The frequency response characteristics of the given Op-amp in both inverting & non inverting modes are Obtained.

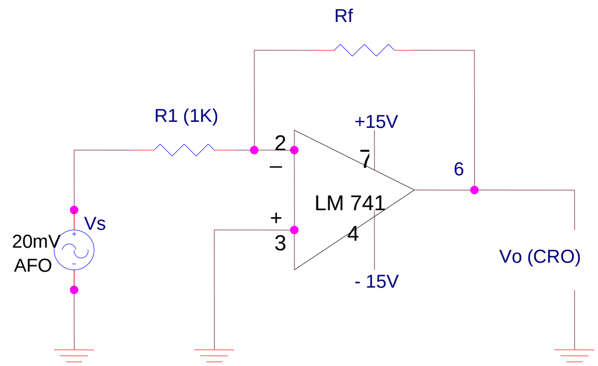
14. GAIN BANDWIDTH PRODUCT OF OP – AMP

AIM: To find bandwidth without plotting frequency response graph and to prove the gain BW product is constant in inverting modes of the given OP – AMP

APPARATUS:

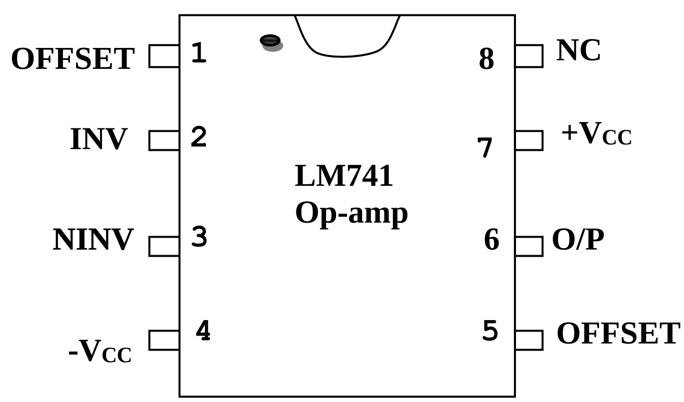
Power supply (2-Channel)	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No.
Op-amp	LM 741	1 No.
Resistor	10KΩ,1KΩ	2 No.
CRO Probes		2 No.
Bread board and connecting wires		

CIRCUIT DIAGRAM:



INVERTING MODE

PIN DIAGRAM:



PROCEDURE :

1. The circuit is connected as shown in circuit diagram (1) in inverting mode.
2. A 15V dual supply is given to the op amp from TRPS
3. Now an input voltage of (Say 20mV to 30mV) is given from the signal generator and a frequency of 1KHz
4. For any value of Rf, the output voltage V_o is noted from the CRO and calculate the gain and compare with theoretical values
5. For each value, the gain is calculated by the formula,

$$A_V = 20 \log V_o / V_i \text{ dB}.$$

6. Find the $V_o/\sqrt{2}$ value and observe/set this value in CRO by increasing the frequency in function generator .Then note the corresponding frequency which is BW
7. Calculate the GBW product
8. Repeat steps 4 to 7 for different values of Rf
9. t is observed that the gain bandwidth product is constant for any value of Rf.

TABULAR FORM :

Rf(Ω)	O/P Voltage(Vo)	$V_o/\sqrt{2}$ value	Av=Vo/Vin	Av(dB)= 20 log Vo / Vi	Bandwidth	GBW product
10K						
22K						
30K						

PREACAUTION:

1. Avoid loose and wrong connections.
2. The output signal should be free from distortions.
3. Avoid parallax error while taking readings from CRO.

QUESTIONS:

1. What is the relation between Gain and Bandwidth.
   a. Gain and BW are inversely proportional to each other
2. What is the gain of inverting amplifier and Non-inverting amplifier
   a. Af=-(Rf/R1)-INV , Af=(1+Rf/R1)-NON-INV
3. What are the blocks of op-amp
   a. Input stage-Dual Input Dual Output DA, Intermediate stage-Dual input Unbalanced output DA, Level Shifting, Output Stage.

RESULT :

The BW is calculated for different values of Rf and proved that GBW product is constant.

15. BJT Differential Amplifier

AIM: To determine the gain and CMRR of a BJT differential amplifier and to prove that CMRR improves with the increase in R_E.

APPARATUS :

Power supply	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No
Resistors	47kΩ,	3 No
Resistors	50kΩ,100kΩ	1 No
Transistors	BC107	2 No
Bread board		
CRO Probes		

THEORY:

The differential amplifier, or differential pair, is an essential building block in all integrated amplifiers.In general, the input stage of any analog integrated circuit with more than one input consists of a differential pair or differential amplifier. The basic differential pair circuit consists of two-matched transistors *Q*1and*Q*2 , whose emitters are joined together and biased a constant current source *I* as shown in Figure 1. The operation mode of the differential amplifier is defined according to the type of the input signal, for example large or small input signal, polarity of the input signals. Three important characteristics of the differential input stage are: the common-mode rejection ratio *CMRR*, the input differential resistance *id R* , and the differential-mode gain Ad

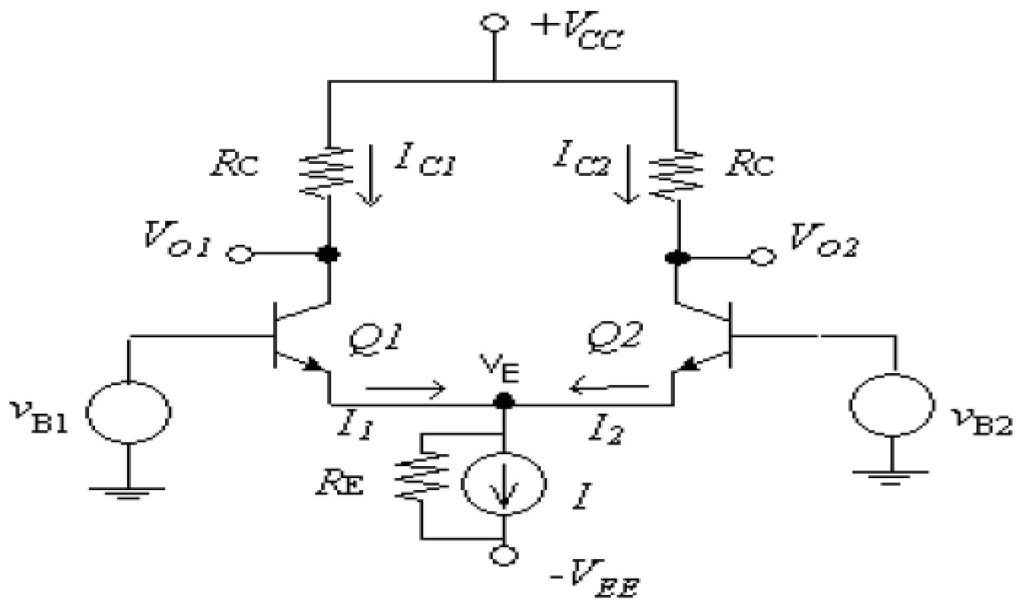


Figure 1

THE DIFFERENTIAL –MODE GAIN

Let $v_{B1} - v_{B2} = v_{id}$, then $v_{01} = -A_d v_{id}$ and $v_{02} = A_d v_{id}$. For perfectly matched transistors pair, the differential gain is given by

$$A_d = \frac{v_{O2}}{v_{id}} = \frac{1}{2} g_m R_C$$

Note that the above equation is obtained using half-circuit concept that is one half of the circuit was used to conduct the small-signal analysis. The trans-conductance of either transistor is $g_m = \frac{|I_C|}{V_T}$ where is the thermal voltage $V_T \cong 25mV$.

THE COMMON –MODE REJECTION RATIO

Let $v_{B1} = v_{B2} = v_{cm}$ in Figure 1 where the voltage v_{cm} is called common-mode voltage. Assume that the two transistors Q_1, Q_2 are perfectly matched. It follows that the current I is divided equally between the two transistors and remain so as long as the transistors are in active region. The voltage at each collector will be $V_{CC} - 0.5\alpha I R_C$, and the difference $V_{O1} - V_{O2} = 0$. Any change in v_{CM} will not affect the balance of the emitter current in both transistors and the collector voltages remain the same this means that the differential pair rejects common-mode input signal. The common-mode gain is given by

$$A_{CM} = \frac{v_{O2}}{v_{cm}} \approx -\frac{R_C}{2R_E}$$

Basically the differential amplifier is designed to amplify differential signal, this requires $A_d >> A_{cm}$. The ideal differential amplifier has $A_d \approx \infty$, and $A_{cm} \approx 0$. The Common-Mode Rejection Ratio $CMRR$ is used as a measure of the differential amplifier performance. It is defined as

$$CMRR = \frac{A_d}{A_{cm}}$$

Substitute the values of the differential and common gains in the above equation

$$CMRR = -g_m R_E$$

As we can see from the above equation increasing the value of R_E, the $CMRR$ will increase, in other words the performance of the differential amplifier can be improved by simply increasing the emitter resistance. **A common practice is to use a current source to replace R_E, the results will be high *CMRR*.** To avoid dealing with large numbers the *CMRR is* expressed in dB as given below

$$(CMRR)_{dB} = 20\log\left|\frac{A_d}{A_{cm}}\right|$$

PRACTICAL INPUT- OUTPUT SIGNALS

So far we have assumed that the input signal is present in either common-mode or differential-mode. In practice the input signals can be decomposed into common-mode and differential-mode components.

The output signal will be given in general by

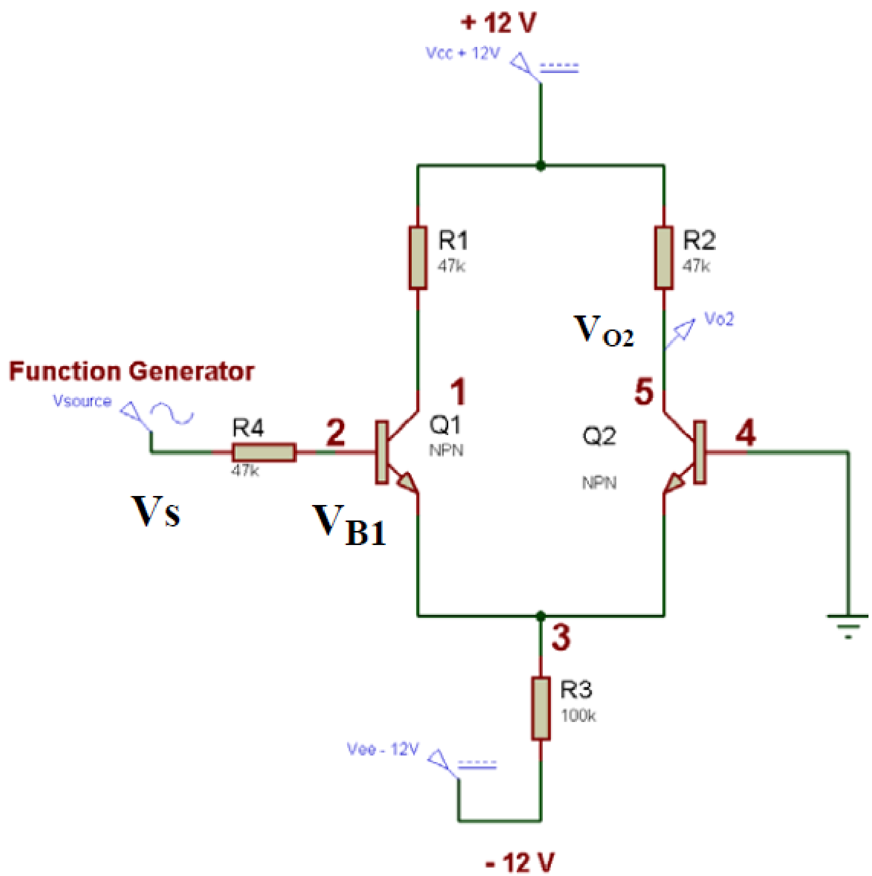
$$v_{O2} = A_d v_{id} + A_{cm} v_{cm} = A_d (v_{B1} - v_{B2}) + A_{cm} (\frac{v_{B1} + v_{B2}}{2})$$

DIFFERENTIAL-MODE INPUT- OUTPUT RESISTANCE

Looking into the collector of either transistor, assume that the transistor load is a passive load as shown in Figure 1. The differential-mode output resistance is simply the output resistance of common-emitter stage and equals R_C. **If R_C is replaced by an active load (current mirror), the output resistance will be r_O as explained in Experiment 1.**

The differential–mode input resistance R_{id} is the resistance seen by the differential signal v_{id} (i.e. looking into the base of the BJT) and is given by $R_{id} = 2r_\pi$, where $r_\pi = \dfrac{V_T}{I_B}$.

CIRCUIT DAIGRAM:



PROCEDURE:

1. Build the differential amplifier shown in Figure with Re=50kΩ
2. Before applying **Function Generator** input, make sure that you have the minimum voltageunder **-40 dB** attenuation with **1 kHz** frequency!! (First press -20 dB **ATT** button, and also pull -20 dB knob located on the right hand side.)
3. Now apply a input of 100mv at any one input V_{B1} or V_{B2} This configuration is called as Differential mode input signal
4. **3.** By connecting Ch1 to the output of the amplifier V_{02} (Collector Voltage)Measure the peak-to-peak values and Calculate the differential gain $A_d = V_{o2}/V_s$

5. Modify the circuit connections as follows: disconnect the ground connection at point V**B2** and connect this point to VB1. This circuit configuration is known as differential amplifier with a **common-mode** input signal.
6. By connecting Ch1 to the output of the amplifier V_{02} (Collector Voltage) Measure the peak-to-peak values and Calculate the

   Common mode gain Ac= V_{o2}/V_c
7. Calculate CMRR= Ad/Ac and in dB $CMRR_{dB} = 20 \log_{10}(A_d / A_c)$
8. Repeat the steps 3 to 6 for different value of Re=100kΩ and find CMRR
9. Observe that with increasing Re value CMRR improves.

TABULAR FORM:

Input condition	Vs1	Vs2	Vo2	V02=Vc	$A_d = V_{o2}/V_s$	$Ac = V_{o2}/V_c$	CMRR= Ad/Ac	$CMRR_{dB} = 20 \log_{10}(A_d / A_c)$
Differential mode	100mV	--		--		--		
Common mode	100mV	100mV	--		--			

PRECAUTIONS :

1. Avoid loose and wrong connections.
2. Avoid parallax error while taking readings.

QUESTIONS:

1. Define Common Mode Rejection Ratio.

A. It is the ratio of Ad/Ac

2. Methods of improving CMRR
3. Increasing Re
4. What are the other methods to improve CMRR without RE

A. A. Replacing Re with Constant current source or Current mirror circuit

RESULT: The gain and CMRR of a BJT differential amplifier are determined and it was proved that CMRR improves with the increase in R_E.

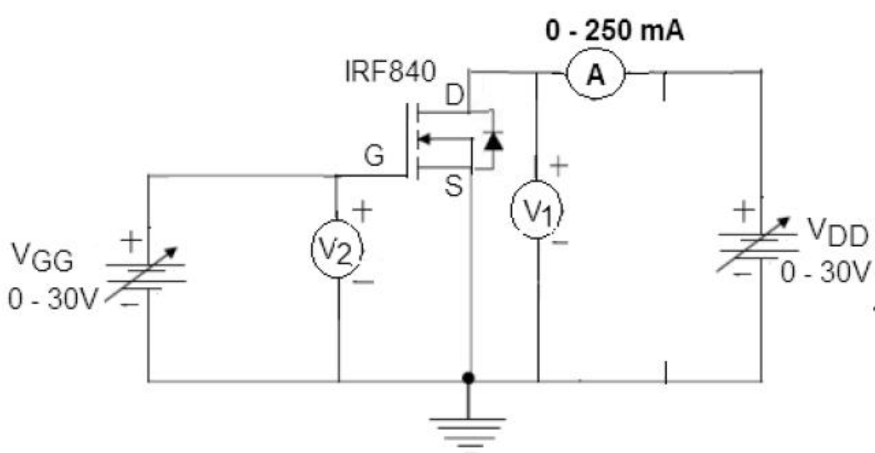
16. N-CHANNEL MOSFET CHARACTERISTICS

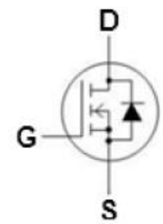
AIM: Plot the transfer and drain characteristics of n-channel MOSFET and calculate its parameters drain resistance, mutual conductance and amplification factor**.**

APPARATUS :

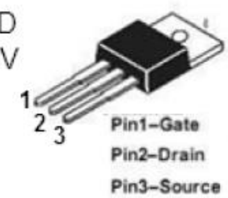
Power supply	0-30V	1No.
CRO	20MHz	1No.
Signal generator	1-1MHz	1 No
Resistors	100Ω	1 No
MOSFET	IRF840	1 No
Bread board		
CRO Probes		

CIRCUIT DIAGRAMS :-





Symbol of IRF 840



PROCEDURE :

Follow the below mentioned steps to obtain the **Drain Characteristics**

1. Set up the connections as indicated in the figure.
2. Keep both VGG and VDD at zero position.
3. By varying VGG set VGS to some value (slightly greater than the Threshold voltage determined from the transfer characteristics) Say 3.0V
4. Increase VDS by varying VDD gradually and note down the corresponding meter readings as shown in the table.
5. Repeat the steps 3 and 4 for VGS=3.2V and VGS = 3.4V
6. Plot the graph of ID Vs VDS

Follow the below mentioned steps to obtain the **Transfer Characteristics**

1. Set up the connections as indicated in the figure.
2. Keep both VGG and VDD at zero position.
3. Vary the VDD and set VDS = 5V.
4. Increase VGS by varying VGG gradually and note down the corresponding meter readings as shown in the table.
5. Note down the minimum value of VGS for which drain current starts flowing and record VTH =
6. Repeat for VDS = 10V and 15V.
7. Plot the graph of ID Vs VGS

TABULAR FORM:

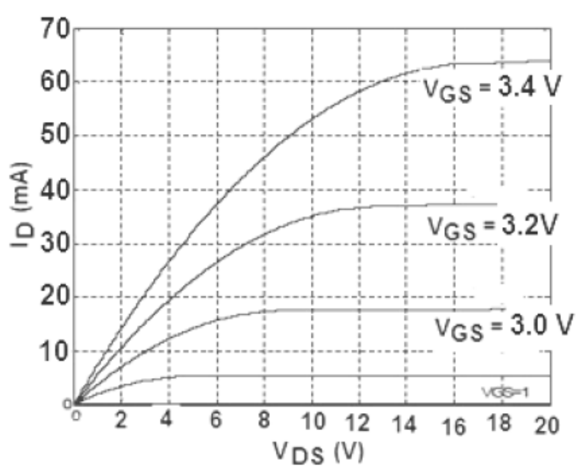
Drain Characteristics
V_{GS} = V_2 = 3.0 (3.2V, 3.4V)

V_{DS}=V_1,V	0.2	0.4	0.6	0.8	1.0	1.5	2.0	3.0	5.0	10.0	12	15	18	20
I_D,mA														

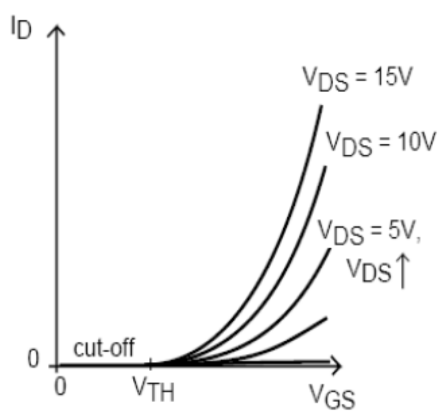
Transfer Characteristics :
VDS = V1 = 5V (10V, 15V)

V_{GS}=V_2,V	1.0	2.0	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.8	4.0	4.2	4.5
I_D,mA														

MODEL GRAPH :



Drain Characteristics



Transfer Characteristics

From the graphs determine

$$g_m = \left(\frac{\Delta I_D}{\Delta V_{GS}}\right) \text{ at } V_{DS} \text{ constant}$$

$$r_d = \left(\frac{\Delta I_D}{\Delta V_{DS}}\right) \text{ at } V_{GS} \text{ constant}$$

PRECAUTIONS:

1. Connections must be made with proper polarity.
2. Avoid loose and wrong connections.

QUESTIONS:

1. What is the difference between MOSFET and BJT
   BJT is a Bipolar Junction Transistor, while MOSFET is a Metal Oxide Semiconductor Field-Effect Transistor. 2. A BJT has an emitter, collector and base, while a MOSFET has a gate, source and drain. ... BJTs are preferred for low current applications, while MOSFETs are for high power functions.
2. What are the types of MOSFET?
   The MOSFET is classified into two types such as;
   Depletion mode MOSFET.
   Enhancement mode MOSFET.
3. What is the difference between depletion mode and enhancement mode MOSFET's?
   Enhancement MOSFET does not conduct at 0 volt, as there is no channel in this type to conduct. Depletion MOSFET conducts at 0 volt.
4. How MOSFET's are suitable for low power high frequency applications?
   MOSFET technology is ideal for use in many power applications, where the low switch on resistance enables high levels of efficiency to be attained. ... This enables high current switching with high efficiency within a relatively small die area. It also enables the device to support high current and voltage switching.
5. What is pinch off voltage?
   Pinch off voltage is the drain to source voltage after which the drain to source current becomes almost constant and JFET enters into saturation region and is defined only when gate to source voltage is zero.
6. In which region the MOSFET is used as a switch?
   In order to operate a MOSFET as a switch, it must be operated in cut-off and linear (or triode) region

RESULT: Plotted the transfer and drain characteristics of n-channel MOSFET and calculated its parameters drain resistance, mutual conductance and amplification factor

17. APPLICATIONS OF OPERATIONAL AMPLIFIER

AIM : To realize Summing Amplifier, Subtracting Amplifier, Integrator and Differentiator by using 741 Op-Amp.

APPARATUS:

1. Op-Amp LM 741
2. Resistors – 1KΩ (4), 100KΩ (1), 10KΩ (1) and 15KΩ(1)
3. Capacitors – 0.001 µf, 0.01µf, 0.022µf
4. Function Generator
5. TRPS
6. CRO & CRO Probes
7. Bread Board
8. Connecting Wires.

THE IDEAL OP AMP:

An ideal op amp would exhibit the following electrical characteristics.

1. Infinite voltage gain A.
2. Infinite input resistance R_i so that almost any signal source can drive it and there is no loading of the preceding stage.
3. Zero output resistance R_0 so that output can drive an infinite number of other devices.
4. Zero output voltage when input voltage is zero.
5. Infinite bandwidth so that any frequency signal from 0 to ∞ Hz can be amplified without attenuation.
6. Infinite common mode rejection ratio so that output common – mode noise voltage is zero.
7. Infinite slew rate so that output voltage changes occur simultaneously with input voltage changes.

APPLICATIONS OF OP AMP:

1. **Summing Amplifier:**

Op amp may be used to design a circuit whose output is the sum of several input signals. Such a circuit is called a summing amplifier or a summer. If V1, V_2 are two input signals given to the inverting terminal, then

$$V_o = -\frac{R_F}{R}(V_1 + V_2)$$

2. **Subtracting Amplifier**:

The function of a subtractor is to provide an output, which is equal to the difference of two input signals (or) proportional to the difference of two input signals. If V_1 and V_2 are the input voltages at inverting and non – inverting terminals, then

$$V_o = \frac{-R_F}{R}(V_1 - V_2)$$

3. **Integrator:**

A circuit in which the output voltage waveform is the integral of the input voltage waveform is the integrator or the integration amplifier. Such a circuit is obtained by using a basic inverting amplifier configuration with the feedback resistor R_F replaced by a capacitor C_F. The output voltage is given by

$$V_o = -\frac{1}{RC}\int V_1\,dt$$

Integrator is used in signal wave shaping circuits and in analog computers. If the input is a sine wave, the output is a cosine wave. If the input is a square wave, the output will be a triangular wave. In the practical integrator, R_F is connected across feedback capacitors C_F. This R_F limits the low frequency gain and minimizes the variation in the output voltage. The input signal will be integrated properly if the time constant

$T = R_1 C_F$ is larger than the time period T of the input signal

4. **Differentiator:**

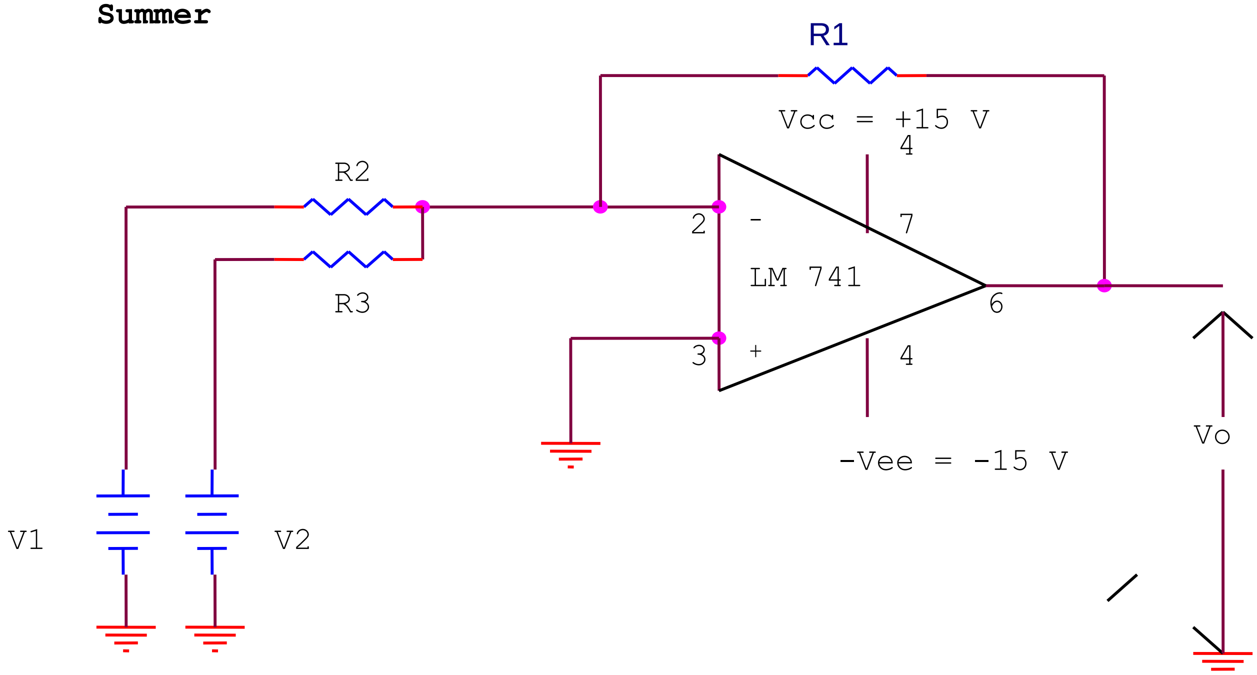
The function of a differentiator is to give an output voltage, which is proportional to the rate of change of input voltage. The differentiator may be constructed from a basic inverting amplifier if an input resistor is replaced by capacitor C_1. The output voltage is given by

$$V_o = -RC\, dV_i / dt$$

The condition for differentiator is << T where = C_1R_F for sine wave and square wave inputs, the resulting differentiated outputs are cosine wave and spike outputs respectively. Differentiator is used to detect high frequency components in an input signal.

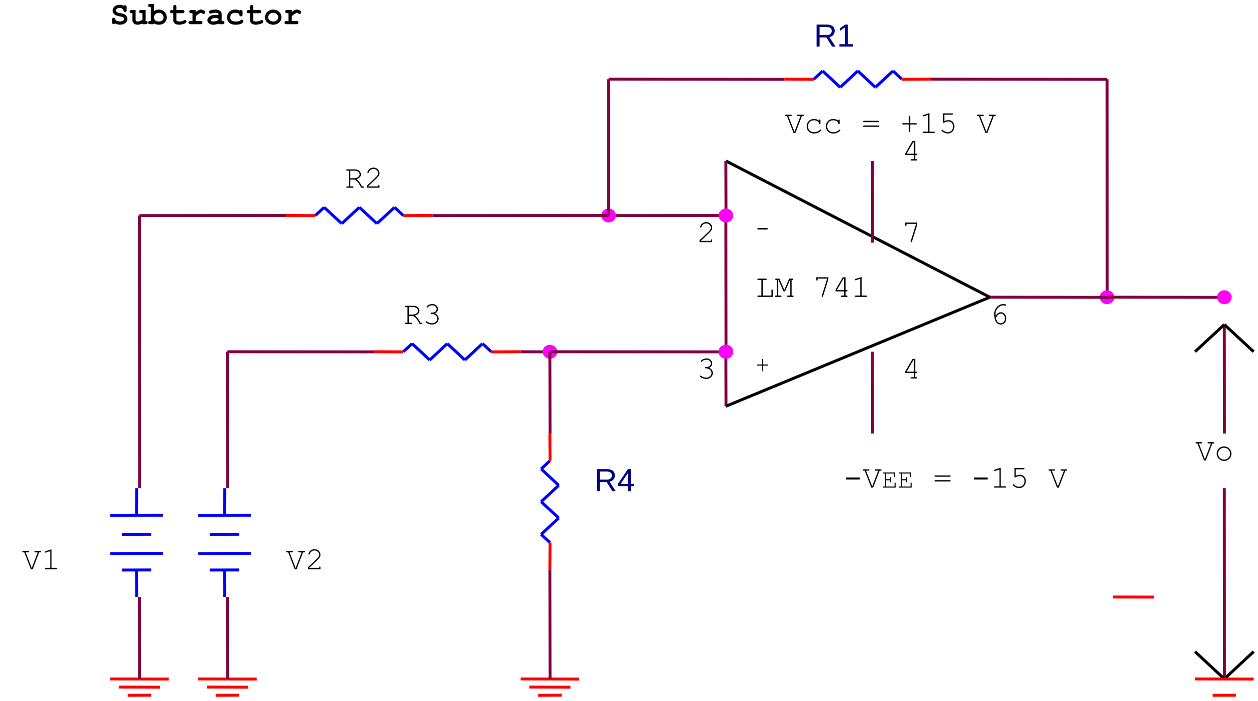
CIRCUIT DIAGRAM

Summer

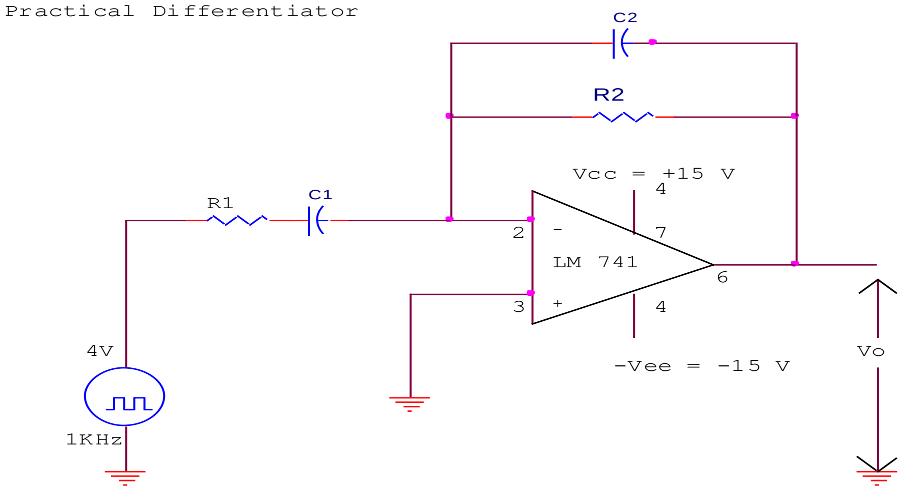


R1=R2=R3=1KΩ

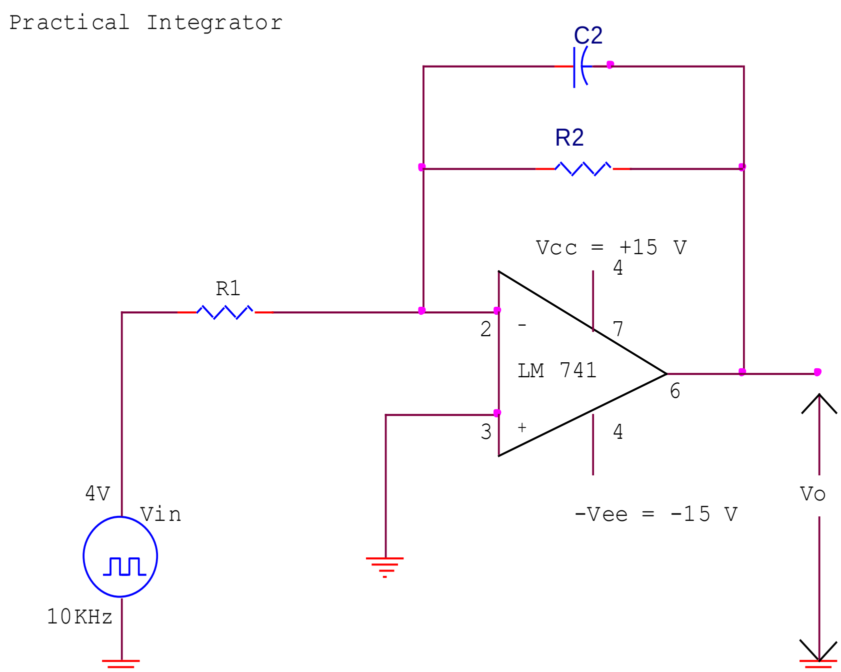
Subtractor



R1=R2=R3=R4=1KΩ



R1=10KΩ, R2=15KΩ C1=330pf, C2=0.001µf



R1=10KΩ, R2=100KΩ, C2=0.01µf

PROCEDURE:

I. Summing Amplifier:

1. Connections are made as per the circuit diagram.
2. Input voltages V_1 and V_2 are given and the corresponding output voltage V_o is measured from CRO.
3. Output varies as $V_o = -(V_1 + V_2)$, since $R_F = R$.

II. Subtracting Amplifier:

1. Connections are made as per the circuit diagram.
2. Input voltage V_1 and V_2 are given to the inverting and non – inverting terminals respectively and corresponding output voltage is measured from CRO.
3. Output varies as $V_o = V_2 - V_1$.

III Differentiator:

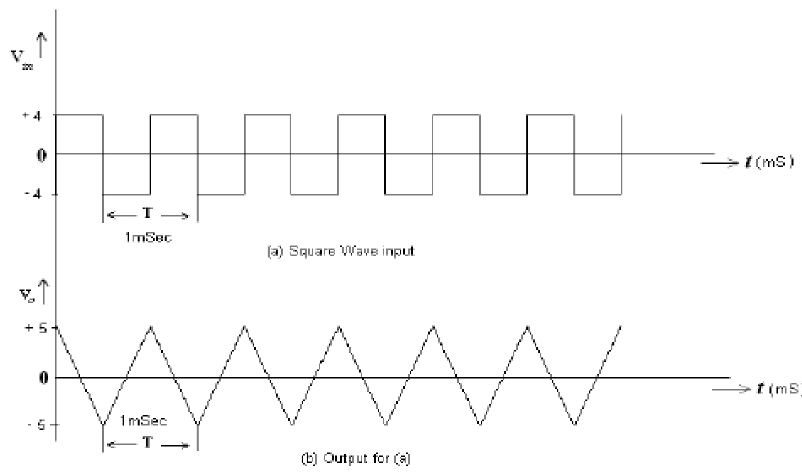
1. Connections are made as per the circuit diagram.
2. A square wave input of 4V (p-p) and frequency of 1KHZ is applied from function generator.
3. Output waveform is observed. Corresponding amplitude and time period is observed and frequency is calculated.
4. With the above data plot the output graphs with time on X-axis and voltage on Y-axis.

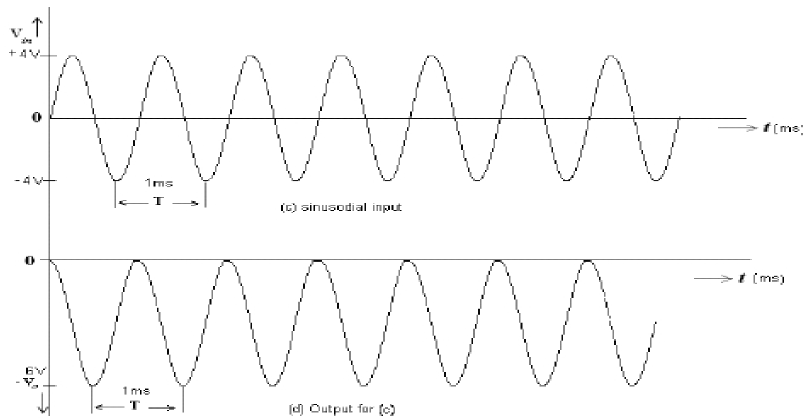
IV. Integrator:

1. Connections are made as per the circuit diagram.
2. By using a function generator, a square wave input 4Vp-p is given.
3. The frequency applied is 10 KHz.
4. A perfect triangular wave is obtained. The peak-to-peak voltage and the time period of input and output waves are measured from CRO.
5. The waveforms are plotted.

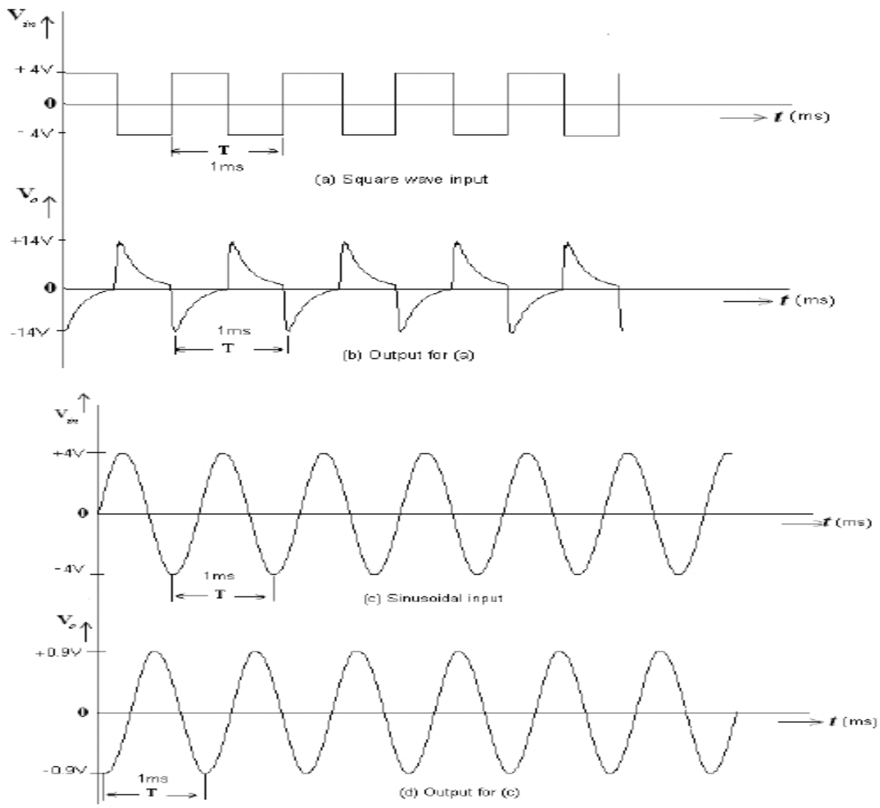
MODEL GRAPHS:

INTEGRATOR:





DIFFERENTIATOR:



PRECAUTIONS:

1. Loose and wrong connections are to be avoided.
2. Waveforms should be obtained without any distortion.

Viva questions

1. What do you mean by CMRR?
   ratio of the common-mode gain to differential-mode gain
2. Define slew rate.
   slew rate is defined as the change of voltage or current, or any other electrical quantity, per unit of time.
3. What are the applications of differentiator?
   Differentiators also find application as wave shaping circuits, to detect high frequency components in the input signal.
4. What are the applications of integrator?
   calculus operations in analog computers, ramp generators, wave shaping circuits, and A/D converters

RESULT: Observed the output values for summer and subtrator amplifier and output waveforms of integrator and differentiator.