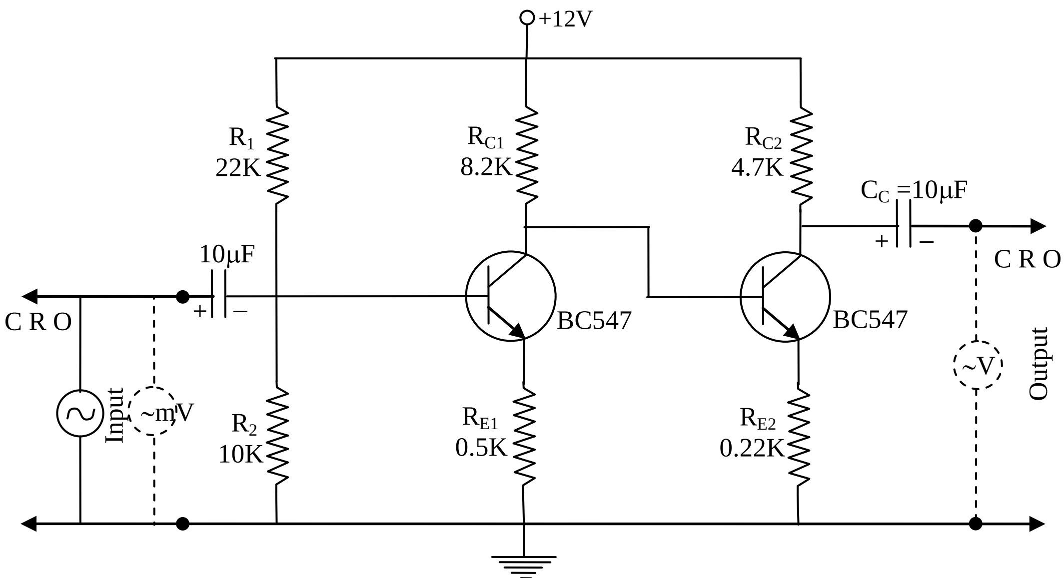
Exp.No.3.13

DC amplifier-Gain

Aim: To construct a direct coupled amplifier and to measure its voltage gain.

Components and accessories: Transistors, resistors, capacitors, signal generator, C R O or a c voltmeters, etc.

Circuit, theory and procedure



Direct coupled, also known as "D C amplifier", refers to a type of amplifier. In this type of amplifier, the output of one stage of the amplifier is connected to the input of the next stage directly without using any reactive components like capacitors, inductors, transformers, and others. As a result, the frequency response of this amplifier is quite flat all the way down to DC (0 Hz).

The connections are made as shown in the figure. Select a suitable input signal, say 10 mV sine wave of any frequency (since the frequency response is almost flat, one can amplify a c of any frequency and even d c). The input and the output can be measured either by a C R O or voltmeters. (Measure input by milli-voltmeter and output by milli-voltmeter or voltmeter). The gain of the amplifier is calculated as,

$$\text{Voltage gain,} \quad A_V = \frac{\text{Output voltage}}{\text{Input voltage}} = \frac{V_O}{V_i}$$

- Care must be given to select the suitable components. Otherwise the waveform will be distorted. The gain can be increased by using R_1 = 68 K. But the output wave shape is distorted.
- Polyester type capacitors of 0.1μF, 0.2μF etc. can also be used. But the gain will be comparatively lower.

Observation and tabulation

Observation using C R O

Peak voltage V_P mV	No. of divisions corresponding to input peak to peak	Volt per division of input mV	Input Voltage V_i mV	No. of divisions corresponding to output peak to peak	Volt per division of output volt	Output Voltage V_O volt	Gain $A_V = \frac{V_O}{V_i}$
10							
20							
30							
40							
50							

Mean ………..

*Observation using a c voltmeters

Input peak voltage V_P mV	r m s a c input mV	r m s a c output mV	Gain $A_V = \frac{V_O}{V_i}$
10	7.07		
20	14.1		
30	21.2		
40	28.3		
50	35.4		

Mean ……………

Result

The direct coupled amplifier is constructed and its voltage gain is determined.

Mean voltage gain of the amplifier A_V = ………

Exp.No.3.14

Feedback circuits-voltage series and current series

Aim: To construct voltage series and current series feedback circuits and study their performance by comparing them with an amplifier without feedback.

Components and accessories required: BC547 (or, BC107) transistor, resistors, capacitors (1 electrolytic 100 μF and 2 polyester type 0.1μF), power supply, C R O or d c voltmeter, signal generator, etc.

Circuit, theory and procedure

If a part of the amplifier output is fed back to the input of an amplifier it is known as a *feedback amplifier*. There is a significant change in the performance of the amplifier when feedback is given. If the feedback is in same phase of the input it is called *positive feedback* and if the feedback is out of phase with the input it is called *negative feedback*. The resulting amplifiers are known as *positive feedback amplifiers* and *negative feedback amplifiers*.

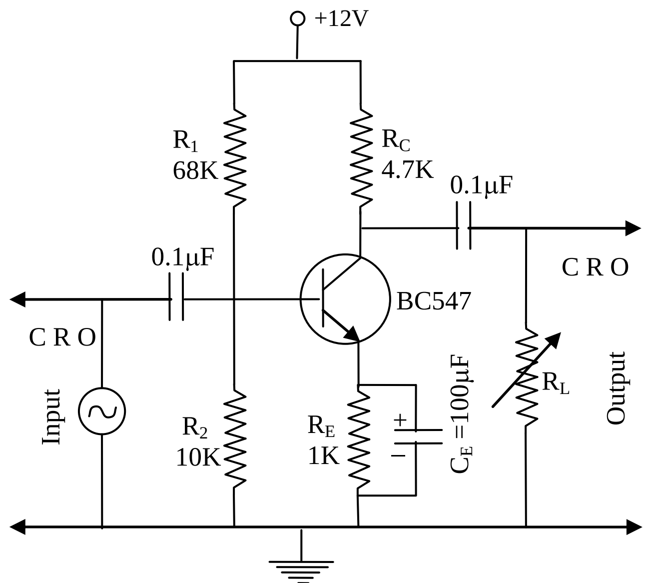


Fig.a: Amplifier without feedback

There are, in general, four types of feedback circuits, voltage series feedback, voltage shunt feedback, current series feedback and current shunt feedback. Now we study only the voltage series feedback and current series feedback circuits.

We first construct a common emitter amplifier without feedback as shown in fig.a and find out its gain for different inputs and different loads. Then we convert this amplifier into voltage series feedback amplifier and current series feedback amplifier by removing the emitter bypass capacitor C_E.

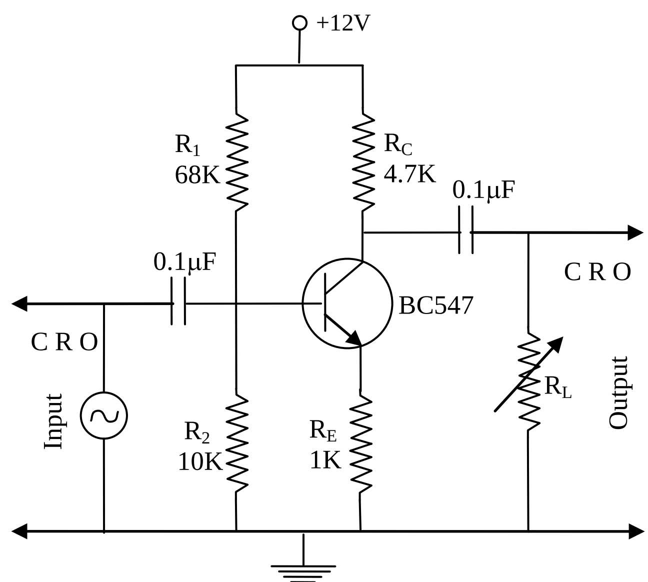


Fig.b: Current series feedback circuit

Current series feedback circuit: Fig.b represents the circuit of a current series feedback circuit. The input and the output are measured by a C R O for different values of input and load resistance. Voltage gain is calculated in each case and compares the result with that of the amplifier without feedback.

Voltage series feedback circuit (emitter follower or voltage follower): The voltage series feedback circuit is shown in fig.c. In this case the output is same as the input. Thus the circuit is also known as emitter follower or voltage follower. The input and the output are measured by a C R O for different values of input and load resistance. Voltage gain is calculated in each case and compares the result with that of the amplifier without feedback.

- Select the range of input voltages for which there is no clipping of output.
- Select one of the frequencies for which the gain is maximum.
- If the transistor is changed there may be changes in values of other components.

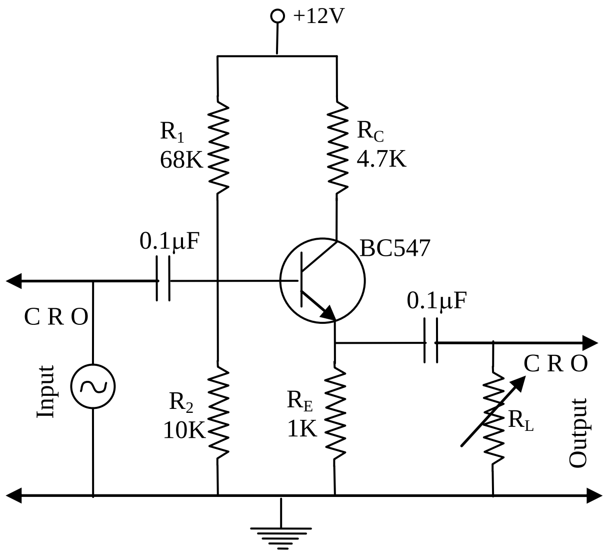


Fig.c: Voltage series feedback circuit

Observation and tabulation

Frequency of the input = ………..Hz

R_L ohm	V_{in} mV	Output voltage V_O in mV			Gain = V_O/V_{in}		
		without feedback	Current series feedback	Voltage series feedback	without feedback	Current series feedback	Voltage series feedback
100K	10						
	20						
	30						
68K	10						
	20						
	30						
33K	10						
	20						
	30						
10K	10						
	20						
	30						
1K	10						
	20						
	30						
330Ω	10						
	20						
	30						

Result

Voltage series and current series feedback circuits are constructed and their performances are studied by comparing them with an amplifier without feedback.

Exp.No.3.15

Hartley Oscillator using Transistor

Aim: To construct a Hartley oscillator and measure its frequency using a C R O.

Components and accessories required: Transistor, resistors, capacitors, inductors, power supply, C R O, etc.

Circuit, theory and procedure

An electronic oscillator is an electronic circuit that converts d c energy into a c energy. It is essentially an amplifier in which a part of the output is fed back in phase to the input. To maintain steady oscillations the feedback circuit must satisfy the Barkhausen criterion for oscillation, which is,

(a) The feedback factor or loop gain $\beta A = 1$, where A is the gain without feedback.

(b) The feedback should be positive.

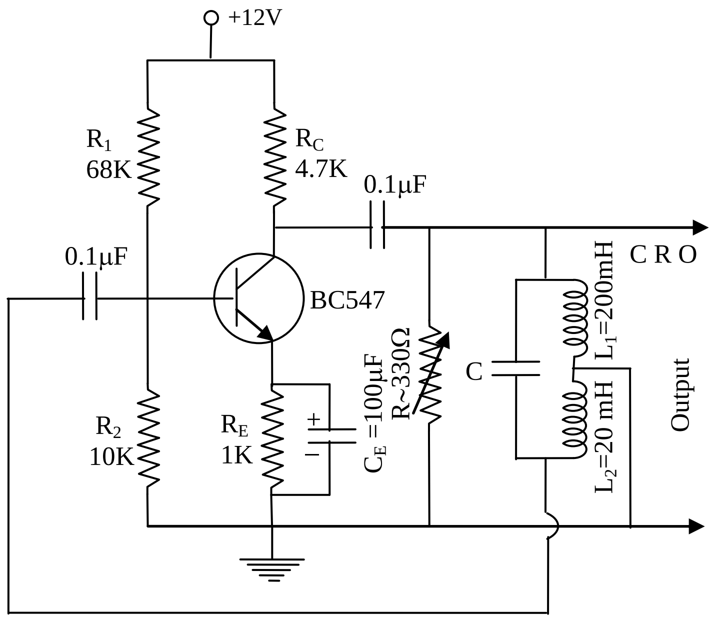


Fig.a: Hartley oscillator

Fig.a shows the circuit of a Hartley oscillator. In this oscillator, the feedback is supplied inductively. The frequency of oscillation is frequency of the tank circuit and is given by,

$$f = \frac{1}{2\pi\sqrt{LC}}, \text{ where, } L \approx L_1 + L_2$$

The circuit is soldered out in a board as shown in the fig.a. The output is measured by a C R O. If T is the time period of the oscillation, then frequency of oscillation is given by,

$$f = \frac{1}{T}$$

The time period can be determined as follows. The time base of C R O is adjusted such that the wave is seen clearly. Measure the number of divisions of the horizontal scale in the C R O screen in between two adjacent points with same phase-length of a wave- (distance between two adjacent negative peaks or positive peaks). Let it be ‘x’. Then the time period T is obtained by multiplying ‘x’ with time per division of the time base.

$$T = \text{‘x’ division} \times \text{time per division}$$

L_1, L_2 and C are measured by an L-C-R meter. The experiment may be repeated for different values of C, L_1 and L_2.

- Try with L_1 ~ 200 mH and L_2 ~ 20 mH.
- C = 0.01μF, 0.02 μF, 0.001μF, etc. preferred.
- In order to achieve the Barkhausaen criterion use a variable resistance R (~330Ω) (potentiometer of resistance 2K or 1K) to reduce the gain of the amplifier.

Observation and tabulation

Length of a wave ‘x’ cm	Time per division ‘t’ sec/cm	T= xt sec	$f = \frac{1}{T}$	Mean f	L_1 henry	L_2 henry	$L \approx L_1+L_2$ henry	C μF	$f = \frac{1}{2\pi\sqrt{LC}}$

Result

The Hartley oscillator is constructed. The frequency is measured and compared with the calculated frequency.

Exp.No.3.16

Colpitt's Oscillator using Transistor

Aim: To construct a Colpitts oscillator and measure its frequency using a C R O.

Components and accessories required: Transistor, resistors, capacitors, inductors, power supply, C R O, etc.

Circuit, theory and procedure

Colpitts Oscillator is also an electronic circuit that converts d c energy into a c energy. It is essentially an amplifier in which a part of the output is fed back in phase to the input.

Fig.a shows the circuit of a Colpitts oscillator. In this oscillator, the feedback is supplied capacitatively. The frequency of oscillation is frequency of the tank circuit and is given by,

$$f = \frac{1}{2\pi\sqrt{LC}},$$

where, $$C = \frac{C_1 C_2}{C_1 + C_2}$$

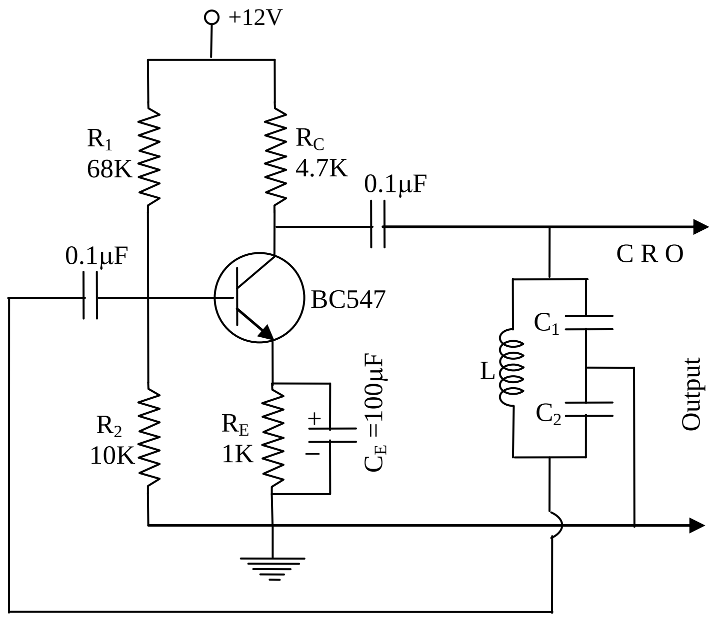


Fig.a: Colpitts oscillator

The circuit is soldered out in a board as shown in the figure. The output is measured by a C R O. If T is the time period of the oscillation, then frequency of oscillation is given by,

$$f = \frac{1}{T}$$

The time period can be determined as follows. The time base of C R O is adjusted such that the wave is seen clearly. Measure the number of divisions of the horizontal scale in the C R O screen in between two adjacent points with same phase-length of a wave- (distance between two adjacent negative peaks or positive peaks). Let it be 'x'. Then the time period T is obtained by multiplying 'x' with time per division of the time base.

$$T = \text{'x' division} \times \text{time per division}$$

L and C are measured by a L-C-R meter. The experiment may be repeated for different values of L, C_1 and C_2.

- L in the range of less than ~2 mH preferred.
- C_1 = 0.01μF, 0.02 μF, etc. and C_2 = 0.01μF, 0.02 μF, etc. preferred.
- In order to achieve the Barkhausaen criterion use a variable large resistance (potentiometer of large resistance) in series with the feedback circuit to reduce the gain of the amplifier.

Observation and tabulation

Length of a wave ‘x’ cm	Time per division ‘t’ sec/cm	T= xt sec	$f = \frac{1}{T}$ Hz	Mean f	C_1 μF	C_2 μF	$C = \frac{C_1 C_2}{C_1 + C_2}$ μF	L mH	$f = \frac{1}{2\pi\sqrt{LC}}$ Hz

Result

The Colpitts oscillator is constructed. The frequency is measured and compared with the calculated frequency.

Exp.No.3.17

Phase shift Oscillator using Transistor

Aim: To construct a phase shift oscillator and measure its frequency using a C R O.

Components and accessories required: Transistor, resistors, capacitors, inductors, power supply, C R O, etc.

Circuit, theory and procedure

Phase shift oscillator is an oscillator with R-C feedback network. No inductor is used in the circuit. This oscillator provides pure sine wave output. They are well suited for frequencies less than 10 KHz.

The value of oscillations in the circuit can be theoretically calculated as,

$$f = \frac{1}{2\pi RC\sqrt{6}}$$

The circuit is soldered out in a board as shown in the figure. The output can be observed by a C R O. If T is the time period of the oscillation, then frequency of oscillation is given by,

$$f = \frac{1}{T}$$

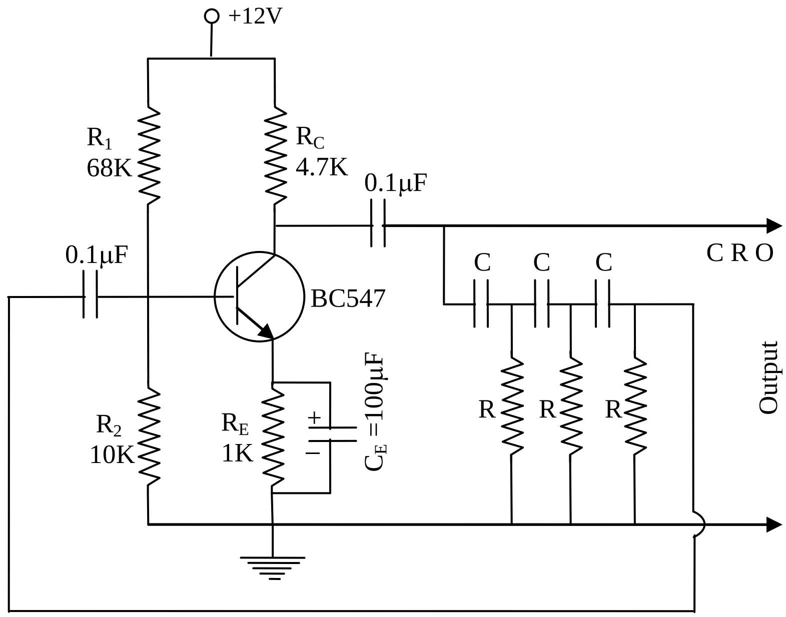


Fig.a: Phase shift oscillator

The time period can be determined as follows. The time base of C R O is adjusted such that the wave is seen clearly. Measure the number of divisions of the horizontal scale in the C R O screen in between two adjacent points with same phase-length of a wave- (distance between two adjacent negative peaks or positive peaks). Let it be ‘x’. Then the time period T is obtained by multiplying ‘x’ with time per division of the time base.

T = ‘x’ division×time per division

The experiment may be repeated for different R-C combinations.

- R = 2K~3K. 2K is preferred.
- C = 10 nF, 20 nF, 30 nF, etc. upto 1000 nF possible.
- It is found that, according to Barkhausen criterion, the feedback fraction β is 1/29. So to obtain oscillations, the gain of the amplifier is greater than 29.

Observation and tabulation

Length of a wave ‘x’ cm	Time per division ‘t’ sec/cm	T= xt sec	$f = \frac{1}{T}$ Hz	Mean f	R Ω	C F	$f = \frac{1}{2\pi RC\sqrt{6}}$ Hz

Result

The phase shift oscillator is constructed. The frequency is measured and compared with the theoretical frequency.

Exp. No.3.18

Multivibrator- using Transistors

Aim: To construct an astable multivibrator using a bipolar junction transistor and measure its frequency.

Components and accessories required: Transistors, resistors, capacitors, power supply, C R O, etc.

Circuit, theory and procedure

Multivibrators are basically two stage amplifiers with positive feedback from the output of one of the amplifiers to the other. These devices are very useful as pulse generating, storing and counting circuits. There are three basic types of multivibrators, (1) *astable multivibrators (free running)*, (2) *monostable multivibrators* and (3) *bistable multivibrators*.

Fig.a shows the circuit of an astable multivibrator. It has no stable state, but has only two quasi-stable states. Fig.b shows the output of such an astable multivibrator.

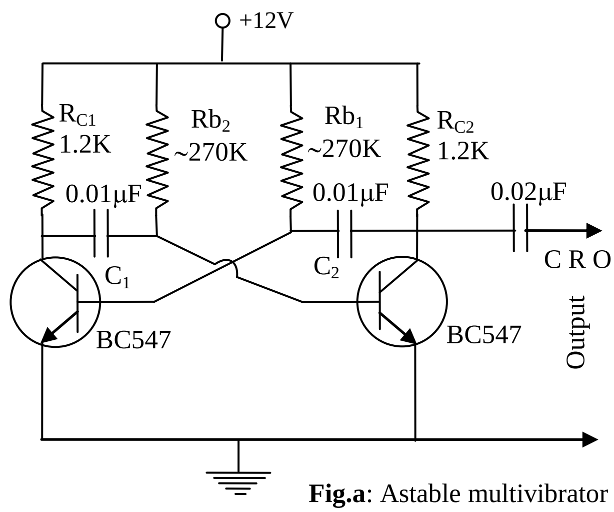


Fig.a: Astable multivibrator

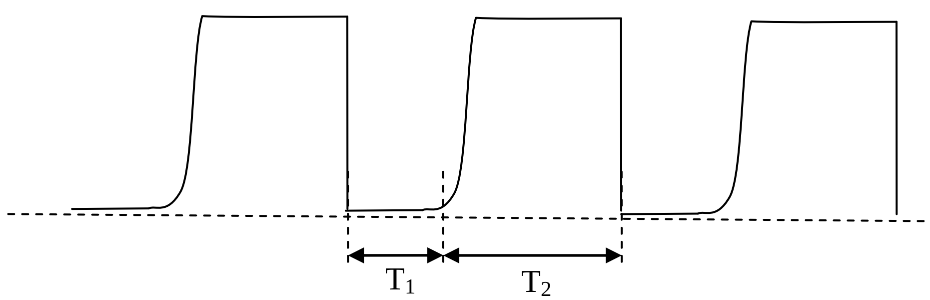


Fig.b: Output of an astable multivibrator

The switching times of the two transistors can be calculated as,

$$T_1 = 0.69R_{b1}C_2$$

$$T_2 = 0.69R_{b2}C_1$$

Hence the time period of the wave is,

$$T = T_1 + T_2 = 0.69\left(R_{b1}C_2 + R_{b2}C_1\right)$$

$$\text{Frequency, } f = \frac{1}{0.69\left(R_{b1}C_2 + R_{b2}C_1\right)}$$

If $R_{b1} = R_{b2} = R$ and $C_1 = C_2 = C$

$$T = 1.38RC$$

$$\text{Frequency, } f = \frac{1}{T} = \frac{0.725}{RC}$$

The circuit is soldered out in a board and the time period is measured using a C R O. Calculate the frequency of the wave. Repeat the experiment for different values of C.

- To ensure oscillations, the β value of the transistors must satisfy the conditions that,

$$\beta_1 \geq \frac{R_{b1}}{R_{c1}} \quad \text{and} \quad \beta_2 \geq \frac{R_{b2}}{R_{c2}}$$

  If $\beta_1 = \beta_2 = \beta$, $R_{b1} = R_{b2} = R_b$ and $R_{c1} = R_{c2} = R_c$, then the condition becomes

$$\beta \geq \frac{R_b}{R_c}$$

  So select R_b and R_c such that the above condition must be satisfied.
- For BC547 transistors R_b = 270 K and R_c = 1.2 K preferred
- Use capacitors C_1 and C_2 in the range of values from 0.02 nF to about 50 nF.

Observation and tabulation

Length of a wave ‘x’ cm	Time per division ‘t’ sec/cm	T= xt sec	$f = \frac{1}{T}$ Hz	Mean f	R Ω	C F	$f = \frac{0.725}{RC}$ Hz

Result

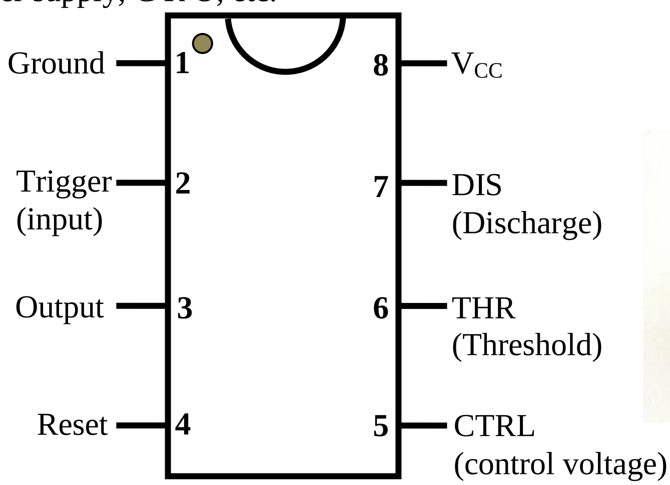
The multivibrator is constructed. The frequency is measured and compared with the theoretical frequency.

Exp.No.3.19

Multivibrator- using IC555

Aim: To construct an astable and monostable multivibrator using the timer IC555 and study their performance.

Components and accessories required: Timer IC555, pillar tag board, resistors, capacitors, power supply, C R O, etc.



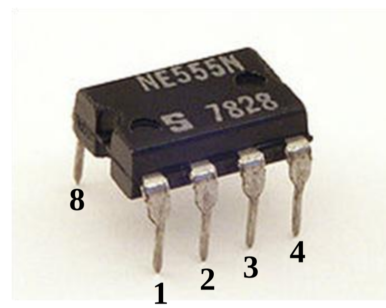


Fig.a: 555 timer IC

Fig.b : Pinout diagram of 555

Circuit, theory and procedure

555 is an analog IC designed in 1971 by Hans Camenzind. It is a combination of linear comparators and digital flip-flops. The standard 555 package includes 25 transistors, 2 diodes and 15 resistors on a silicon chip installed in an 8-pin mini dual-in-line package. They are mainly used for the construction of astable and monostable multivibrators.

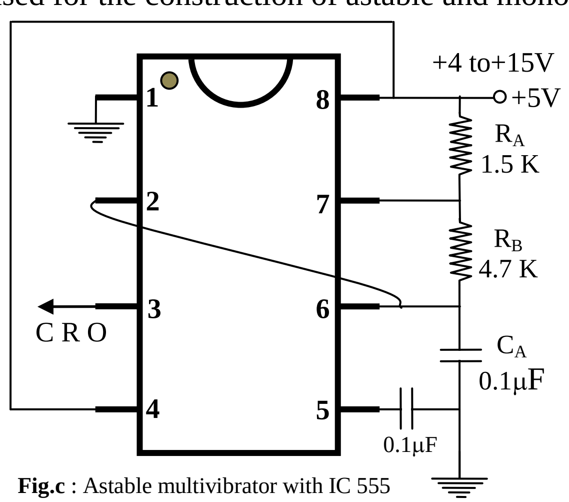


Fig.c : Astable multivibrator with IC 555

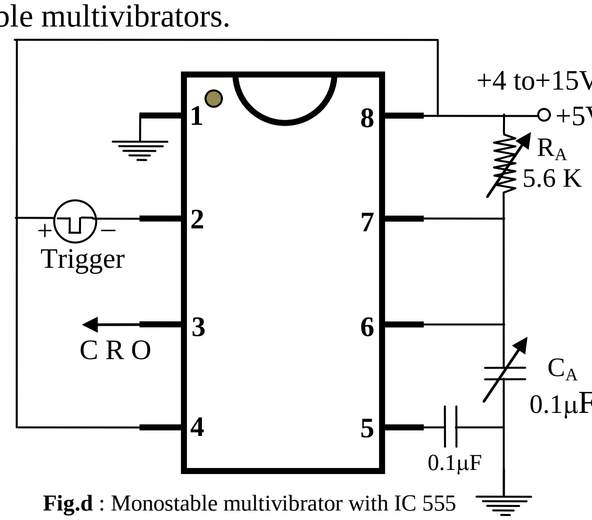


Fig.d : Monostable multivibrator with IC 555

Astable multivibrator

For an astable multivibrator, the connections are soldered on a pillar tag board as shown in fig.c. The output obtained from the pin 3 is observed by a C R O and the frequency is determined. Now we check whether the result obtained agrees with the theoretical value given as follows. The time interval for which the output is high is given by, $T_{high} = \ln(2)(R_A + R_B)C_A$ and that for which it is low is given by, $T_{low} = \ln(2)(R_B C_A)$. Thus the total time interval,

$$T = T_{high} + T_{low} = \ln(2)(R_A + 2R_B)C_A = 0.693(R_A + 2R_B)C_A$$

$$\text{Frequency} \quad f = \frac{1}{T} = \frac{1}{0.693(R_A + 2R_B)C_A}$$

Monostable multivibrator

Connections are soldered on the pillar tag board as shown in the fig.d. The square wave from a C R O is given to the pin number 2 as the trigger input. The output is observed by a C R O and the frequency is measured.

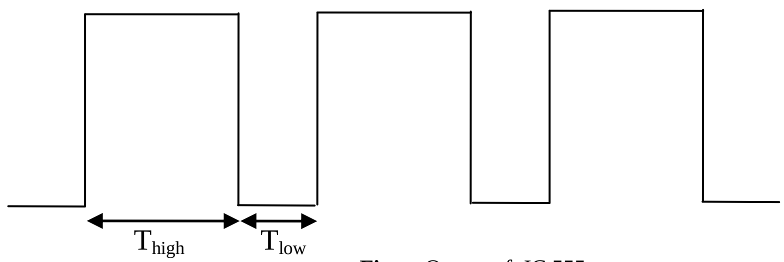


Fig.e : Output of IC 555

The time interval for which the output remains high in this case is, $T_{high} = 1.1R_A C_A$. Compare this with the observed value. Measure T_{high} and T_{low}. Then the,

$$\text{Frequency,} \quad f = \frac{1}{T} = \frac{1}{T_{high} + T_{low}}$$

- Positive of trigger may also be given to pin 2, then negative is to be grounded.
- Trigger input peak to peak voltage is sufficiently large (of the order of 10 volt).
- Change the trigger frequency (lower than the output) till the T_{high} of the output remains constant.

Observation and tabulation

Astable Multivibrator

R_A KΩ	R_B KΩ	C_A μF	T_{high} second	T_{low} second	Observed $T=T_{high}+T_{low}$ second	Calculated, $T = T_{high}+T_{low}$ $=0.693(R_A + 2R_B)C_A$ second	$f = \frac{1}{T}$ Hz

Monostable Multivibrator

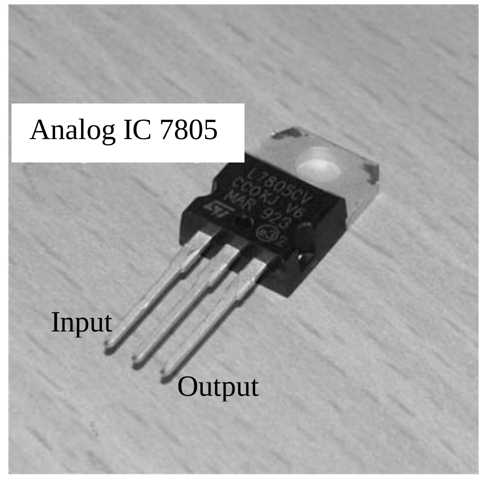
R_A KΩ	C_A μF	Calculated $T_{high} = 1.1R_A C_A$ second	Observed T_{high} second	Observed T_{low} second	Observed $T=T_{high}+T_{low}$ second	$f = \frac{1}{T}$ Hz

Result

Astable and monostable multivibrators are constructed with IC555 and their frequencies are measured and compared with the theoretical values.

Exp.No.3.20

Construction of a IC voltage regulator



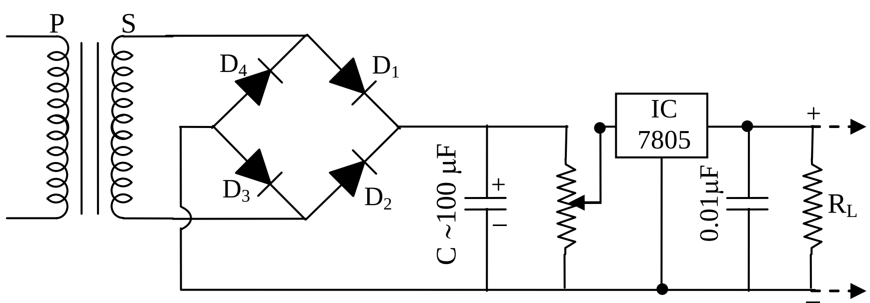
Aim: To construct a voltage regulator using an integrated circuit.

Components and accessories: One of the analog ICs of series 78XX, step down transformer (12-0-12), diodes, capacitors, resistors etc.

Circuit, theory and procedure

78XX is a series of analog integrated circuit (IC) voltage regulators such as 7801, 7802, ….. They are three pin ICs. The symbol XX stands for the regulated output voltage of the IC. The regulated voltage output of 7805 is 5volt.

The output of a bridge rectifier is used as the unregulated power supply of the IC. The regulated output is obtained across the load resistance R_L. The d c voltage across R_L is determined for different values of R_L. Also find out the voltage V_{NL} for no load (no load means load current is zero, i.e. R_L is infinity). The percentage of load regulation can be calculated as



$$\text{Percentage regulation} = \left(\frac{V_{NL} - V_{FL}}{V_{FL}}\right) \times 100\,\%$$

where, V_{FL} is the voltage measured across the load resistance R_L.

- Since the output of LM7805 is 5 volt, the unregulated power supply must be greater than 5 volt.
- If R is a resistance box we can change the unregulated voltage by changing the resistance so that we can study the line regulation also.

Observation and tabulation

Line regulation

V_{in} volt	V_{out} volt	V_{in} volt	V_{out} volt	V_{in} volt	V_{out} volt
1		6		11	
2		7		12	
3		8		13	
4		9		14	
5		10		15	

Percentage of line regulation = 100× Slope of V_{in}-V_{out} graph = ……… %

Load regulation V no load (R_∞), V_{NL} = ……… volt

R_L ohm	V_{out} volt	Load I_L in mA (measured or calculated)	Percentage of voltage regulation $\left(\frac{V_{NL}-V_{FL}}{V_{FL}}\right)\times 100$
100			
200			
300			
400			
500			
600			
700			
800			
900			
1000			
2000			
3000			
4000			
5000			
6000			
7000			
8000			
9000			
10000			

Result

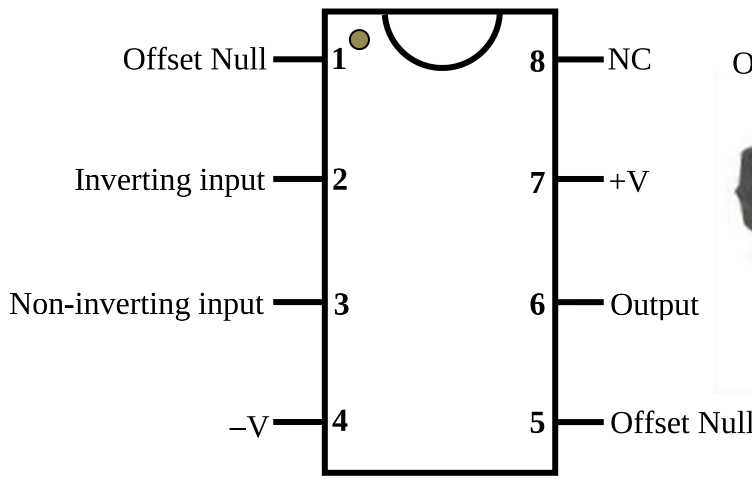
An analog IC7805 voltage regulator is constructed and the variations of output voltage for different load resistances are studied. It is found that the output is regulated at a voltage of 5 volt.

Exp.No.3.21

Op-amp- inverting and non-inverting amplifier, voltage follower

Aim: To construct and demonstrate the functioning of an inverting amplifier, non-inverting amplifier and a voltage follower using operational amplifier 741 (OPAMP741).

Components and accessories: Operational amplifier (IC741), pillar tag board, resistor, capacitor, signal generator, dual power supply C R O, etc.



Pinout diagram of 741

IC741
Operational amplifier

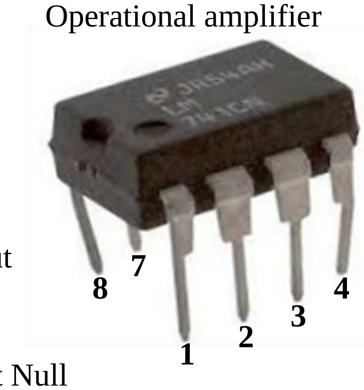


Fig.a

Circuit, theory and procedure

Operational amplifier 741 is an integrated circuit that can be used as an inverting amplifier, non-inverting amplifier and a voltage follower. It can also be used for other purposes as adder, subtractor, differentiator, integrator etc. The symbol of it is shown in the fig.b.

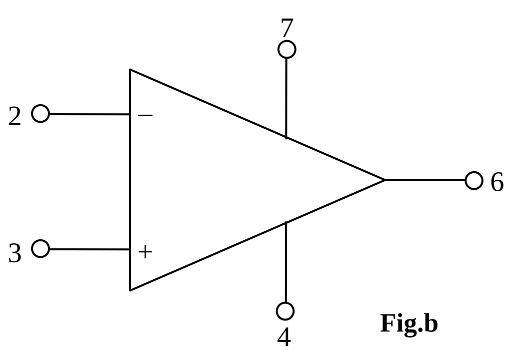


Fig.b

– symbol for inverting
+ symbol for non-inverting

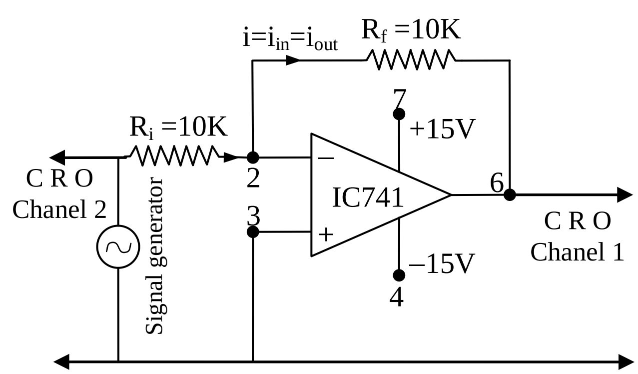


Fig.c

Inverting amplifier: In the inverting amplifier the signal is applied to the inverting terminal 2 of the opamp through the resistor R_i. The non-inverting terminal 3 is grounded. The negative feedback takes place through the resistor R_f. The input and the output are measured by a C R O. For all practical purposes, the inverting terminal (terminal 2) of the op-amp is very nearly zero and thus it act as ‘virtual ground’. Due to the "virtual ground" effect the right-hand side of the resistor R_i is held to a voltage of 0 volts. Since terminal 2 is at zero potential, practically no current flows through the opamp. Hence the same current must pass through R_f and the output voltage v_o must be opposite in sign of the input voltage v_{in}. Current through R_i is given by,

$$i_{in} = \frac{v_{in}}{R_i} = i_{out}$$

Or, input voltage, $v_{in} = i_{in}R_i$

Output voltage, $v_o = -i_{in}R_f$

Voltage gain, $A_v = \frac{v_o}{v_{in}} = -\frac{R_f}{R_i}$

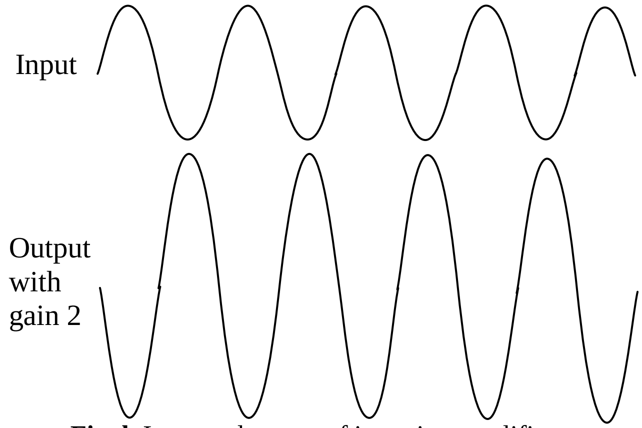


Fig.d: Input and output of inverting amplifier

The negative sign shows that the output is inverted. Take observations for different values of R_i and R_f.

Non-inverting amplifier: Because of the virtual ground of terminal 2 and the short between the terminals 2 and 3 of the opamp, the input voltage in this case is the p d across R_i and the output voltage is the p d across the series combination of R_i and R_f.

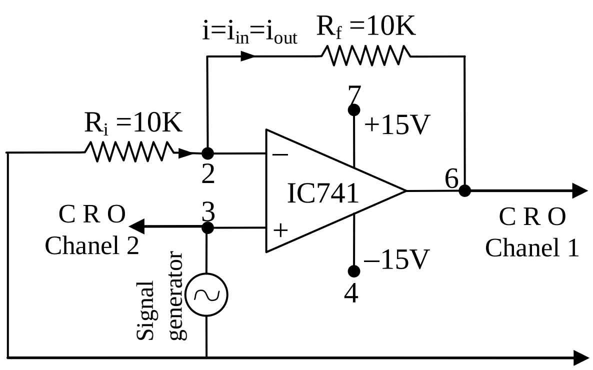


Fig.e

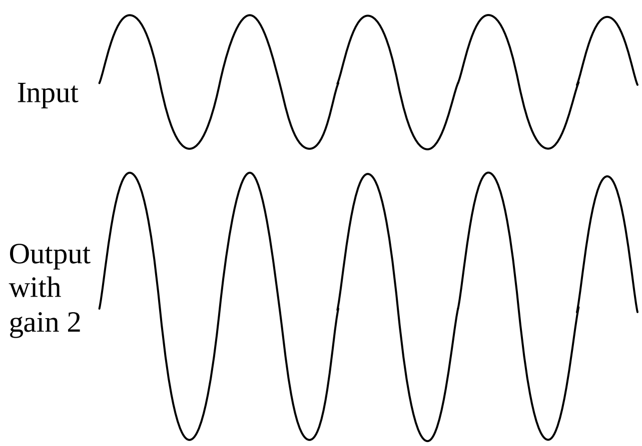


Fig.e: Input and output of non- inverting amplifier

Input voltage, $v_{in} = iR_i$

Output voltage $v_o = i(R_i + R_f)$

Voltage gain, $A_v = \frac{v_o}{v_{in}} = 1 + \frac{R_f}{R_i}$

The input and the output are measured by a C R O for different values of R_i and R_f.

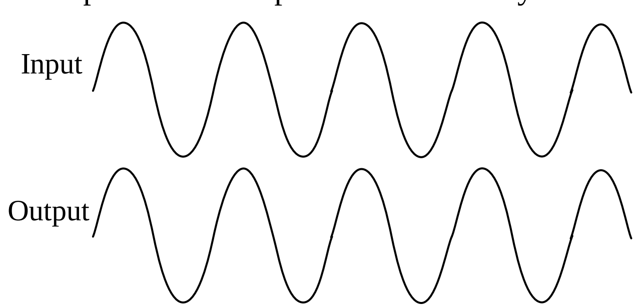


Fig.g: Input and output of a voltage follower

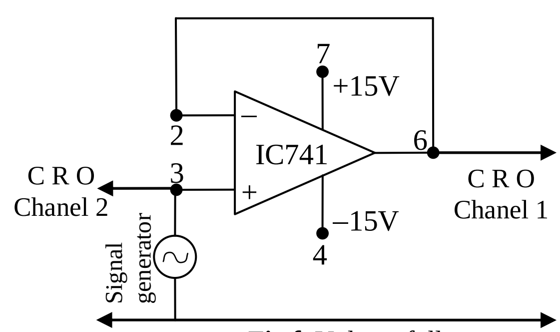


Fig.f: Voltage follower

Voltage follower: A voltage follower provides an output which is same as the input. The gain of the voltage follower is very much closer to unity and there is no phase difference between input and output.

Observation and tabulation

Inverting amplifier

Peak to peak voltage of input signal = 2 volt; Frequency of the signal = 500 Hz

R_i KΩ	R_f KΩ	No. of divisions of peak to peak of output	Volt per division	Output Voltage V_O volt	Observed gain V_O/V_i	Theoretical gain R_f/R_i
10	10					
	20					
	30					
	40					
	50					
	60					
	70					
	80					
	90					
	100					
1K	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
1	1K					
2						
3						
4						
5						
6						
7						
8						
9						
10						

Non-inverting amplifier

R_i KΩ	R_f KΩ	No. of divisions of peak to peak of output	Volt per division	Output Voltage V_O volt	Observed gain V_O/V_i	Theoretical gain $1+R_f/R_i$
10	10					
	20					
	30					
	40					
	50					
	60					
	70					
	80					
	90					
	100					
1	10K					
2						
3						
4						
5						
6						
7						
8						
9						
10						
1	1K					
2						
3						
4						
5						
6						
7						
8						
9						
10						

Voltage follower

Input V_i volt	Output V_O volt	Gain

Result

Inverting amplifier, non-inverting amplifier and voltage follower using opamp741 are constructed and their gains are determined and compared with the theoretical value.

Note: Do the voltage follower experiment first, since it is an IC test.

Exp.No.3.22
Op-amp –differentiator & integrator

Aim: To construct differentiator and integrator circuits using op-amp IC741 and study their operation for different types of input wave.

Components and accessories: Operational amplifier (IC741), pillar tag board, resistor, capacitor, signal generator, dual power supply C R O, etc.

Circuit, theory and procedure

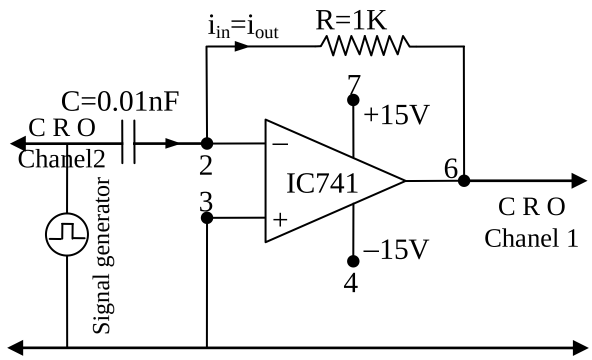


Fig.a

Differentiator: By introducing electrical reactance into the feedback loops of op-amp amplifier circuits, we can cause the output to respond to changes in the input voltage over *time*. The differentiator produces a voltage output proportional to the rate of change of input voltage. The circuit of the differentiator is shown in the fig.a. The negative feedback takes place through the resistor R. For all practical purposes the inverting terminal (terminal 2) of the op-amp is very nearly zero and thus it act as 'virtual ground'. Due to the "virtual ground" effect the right-hand side of the capacitor is held to a voltage of 0 volts. Therefore, current "through" the capacitor is solely due to *change* in the input voltage. The instantaneous charge on the capacitor,

$$q = CV$$

$$\text{Current,} \quad i = \frac{dq}{dt} = C\frac{dV}{dt}$$

With respect to the virtual ground and the inverting effect, the output voltage is given by,

$$V_o = -iR = -RC\frac{dV}{dt}$$

That is, the output voltage is proportional to the derivative of the input voltage.

The connections are made as shown in fig.a. The signal from a signal generator is fed to the input of the differentiator. The input and the output are observed by a C R O. The shape of the output depends on the rate of change of input voltage. As an example a sine wave changes to a cosine wave. Output shapes of different input signals are as shown in figures b, c, d and e.

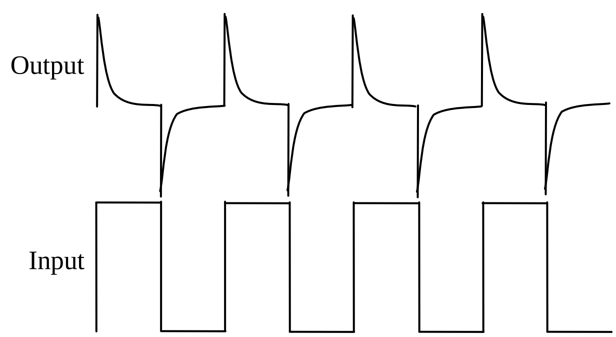


Fig.b: Square wave input

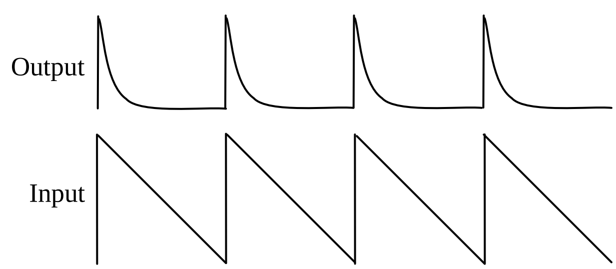


Fig.c: Saw tooth wave input

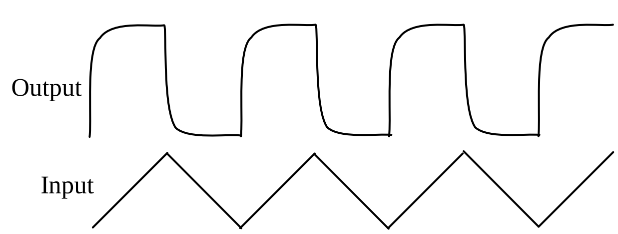


Fig.d: Triangular wave

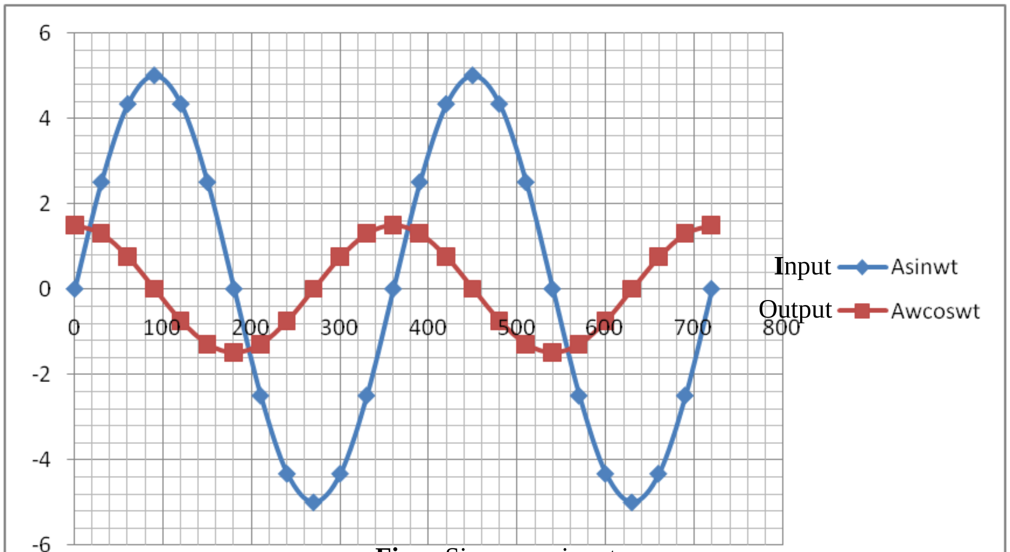


Fig.e: Sine wave input

Note

- Different values of capacitors possible. Try with 0.01nF, 0.001nF, etc.
- Different values of R also possible. Try with 1K, 2K, etc.
- Wait for some time to get the wave form.
- Put C R O in a c mode.
- Input of the order of 6 volt signal from signal generator.
- Output of the order of 100 mV.
- Vary the input frequency from low value to KHz order.
- Try for all type of signal forms, sine, square etc.

Integrator: An op-amp integrator circuit would generate an output voltage proportional to the magnitude and duration that an input voltage signal has deviated from 0 volts. The integrator circuit is shown in the fig.f. The negative feedback takes place through the capacitor.

Treating the inverting terminal 2 as virtual ground, the instantaneous current through the resistance and capacitance is same. Thus,

$$i_{in} = i_o$$

i.e. $$\frac{V_{in}}{R} = \frac{dq}{dt}$$

$$q = \int \frac{V_{in}}{R} dt$$

Output voltage $$V_o = -\frac{q}{C}$$

$$= -\frac{1}{RC}\int V_{in} dt$$

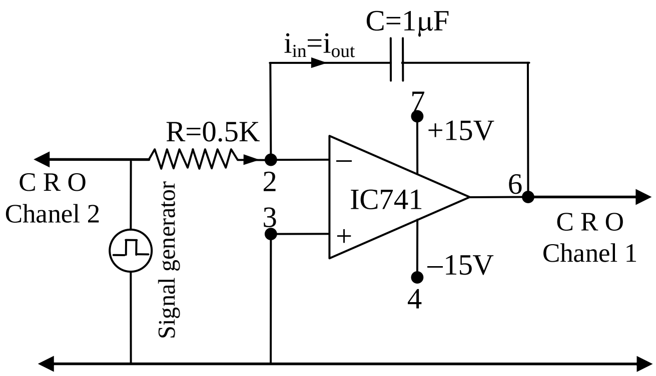


Fig.f

That is, the output voltage is proportional to the integral of the input voltage. To do the experiment connections are made as shown in the fig.f. The input and output are applied to the two channels of the C R O. Find out the shapes of the output for different inputs. The experiment may be repeated by changing R and C.

Wave shapes of certain input and the corresponding outputs of the integrator are given below.

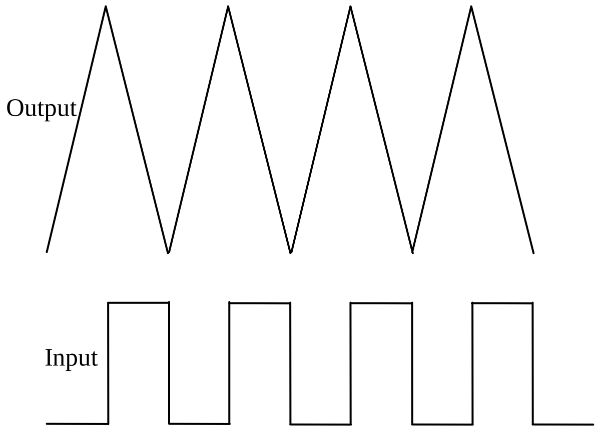


Fig.g: Square wave input

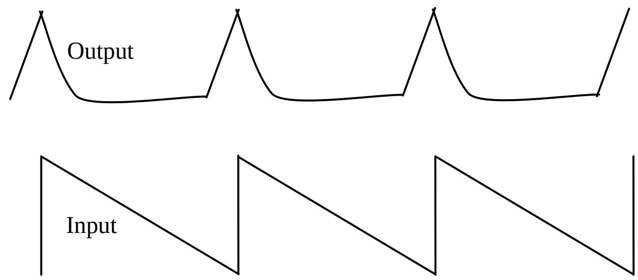


Fig.h: Saw tooth wave input

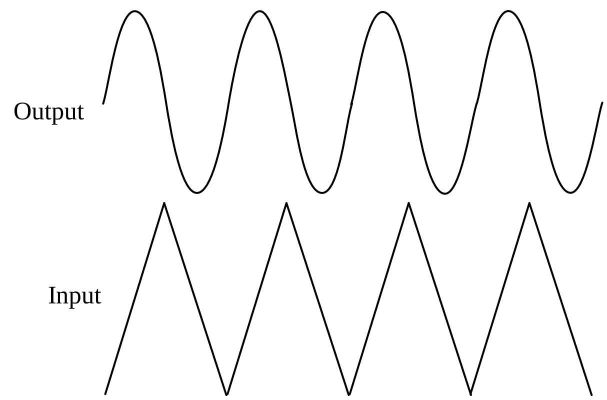


Fig.i: Triangular wave input

Note

- Capacitor of value ≤1μF is preferred for large integrator output. Polyester type and electrolytic type can be used. Polarity of capacitor does not affect the shape of the output.
- Resistor of value ≤1K is preferred for large integrator output.
- Use input signal of the order of peak to peak voltage of 10 V and frequency ≤ 2KHz.
- Put C R O in a c mode.

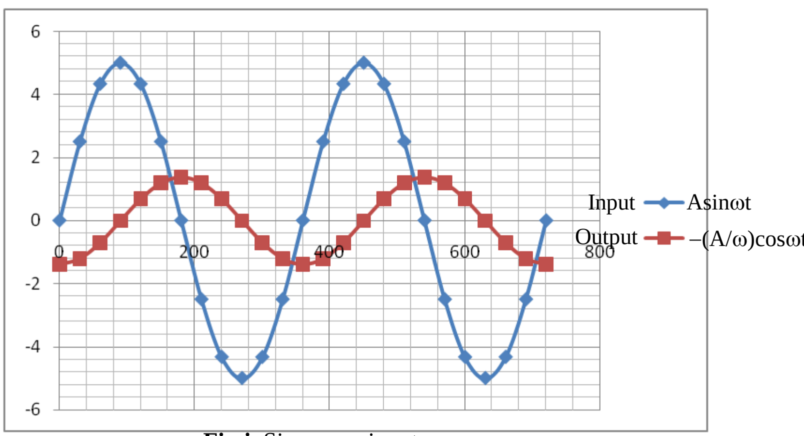


Fig.j: Sine wave input

Result

The differentiator and the integrator using op-amp IC741 are constructed and their outputs with different inputs are studied.

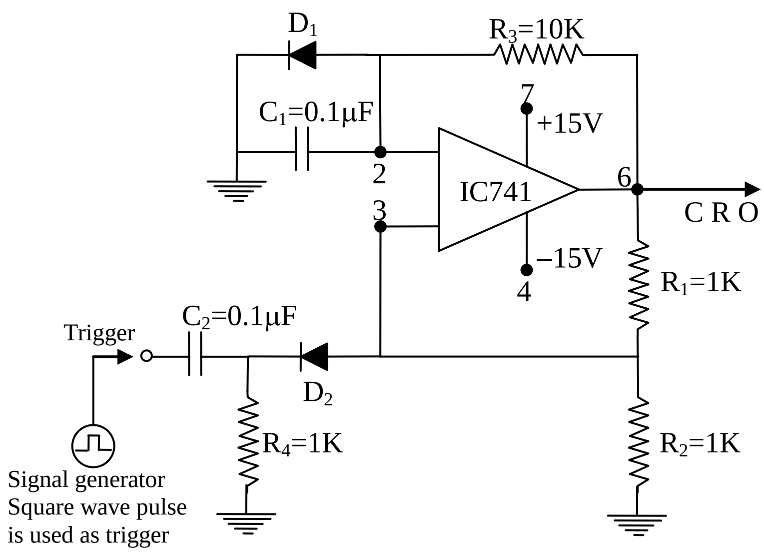
Exp.No.3.23

Op-amp- multivibrator

Aim: To construct a mono-stable multi vibrator using the operational amplifier 741 and find out the time duration of output pulse and compare it with the theoretical value.

Components and accessories: Operational amplifier (IC741), pillar tag board, resistors, capacitors, signal generator, dual power supply, C R O, etc.

Circuit, theory and procedure



Multi-vibrators are devices producing symmetric or asymmetric square output. They are very useful devices as pulse generating, storing and counting circuits. There three basic types of multi-vibrators (1) *astable or free running multi-vibrator*, (2) *monostable multi-vibrator* and (3) *bistable multi-vibrator*.

In this experiment we construct a monostable multi-vibrator using operational amplifier 741. A monostable multi-vibrator has one absolutely stable state and one quasi-stable state. It can be switched to the quasi-stable state by an external trigger pulse. It will return to the stable state after the time delay determined by the values of circuit components.

To do the experiment, connections are made as shown in the figure. The output and the trigger signal are observed by a C R O. The frequency of trigger pulse is decreased. For the circuit given above the frequency may be varied in between 200 Hz to about 700Hz. Measure the time for which the output stays low i.e., in quasi stable state. This time period T is equal to the length of the low state×corresponding time per division. Compare this result with the theoretical value given by,

$$T = R_3C_1 \ln\left(\frac{R_1+R_2}{R_1}\right) \text{ second}$$

If $R_1 = R_2$, $\quad T = 0.693R_3C_1$ second

The experiment can be repeated by changing R_3, C_1, R_1 and R_2. It is easy to change R_3.

- The ground of the dual power supply, ground of the signal generator and the ground shown in the circuit are mutually connected.
- The peak to peak voltage of the trigger pulse is approximately 10 volt.
- For the resistances and capacitors shown in the circuit the frequency of the signal generator is in between 200 Hz and 700 Hz

- See that the length of the lower side of the output does not change and the length of the upper side changes when we change the frequency of the trigger pulse.
- Put C R O either in a c or d c mode.

Observation and tabulation

R_1 ohm	R_2 ohm	R_3 ohm	C_1 μF	Observed T second	Calculated T second

Result

The monostable multi-vibrator using operational amplifier 741 is constructed and the time period measured is found to agree with the theoretical value.

Exp.No.3.24
Characteristics of JFET

Aim: To draw the common source drain characteristics and transfer characteristics of a junction field effect transistor and hence to determine the JFET parameters a c drain resistance r_d, transconductance g_m and the amplification factor μ.

Components and accessories: The JFET (BFW10 or 11), power supplies, voltmeters, milli-ammeter etc.

Circuit, theory and procedure

Field effect transistor is a three terminal unipolar solid state device in which the current is controlled by the field. They are constructed as either n-channel FET or P-channel FET. In n-channel FET two p-type junctions are diffused on opposite sides of a narrow bar of n-type semiconductor. A p-channel FET is constructed by diffusing n-type material on opposite sides of a bar of p-type material.

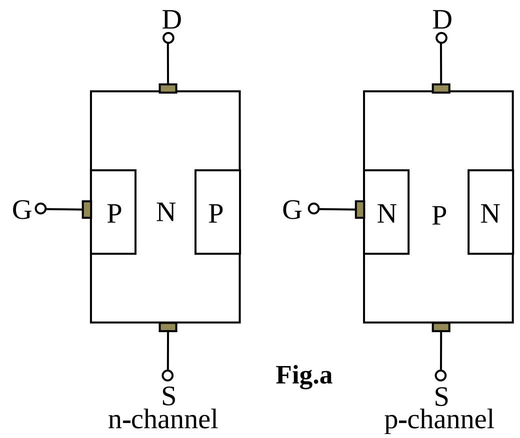


Fig.a

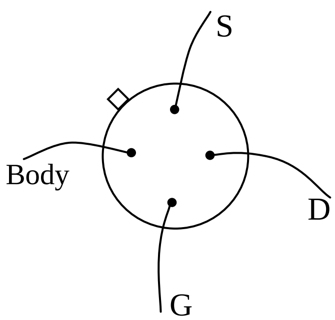


Fig.b: FET with pins upward

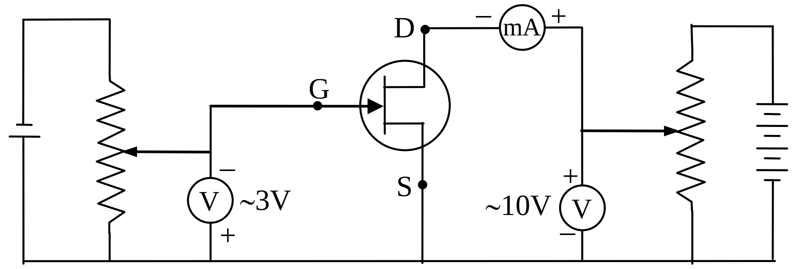


Fig.c

There three terminals connected to FET are *source*, *drain* and *gate*. Source is the terminal through which the majority carriers enter the bar. Drain is the terminal through which the majority carriers leave the bar. Gate is two internally connected heavily doped regions which form two P-N junctions. Gates are always reverse biased. They control the current through the FET. (There is a fourth terminal on a BFW10 or 11 FET. This terminal is connected to the body of the FET.

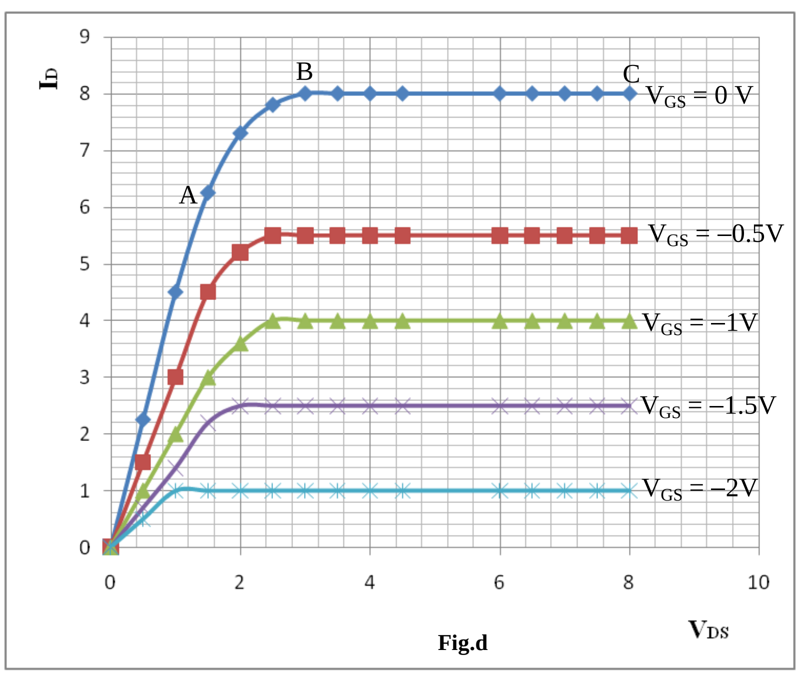


Fig.d

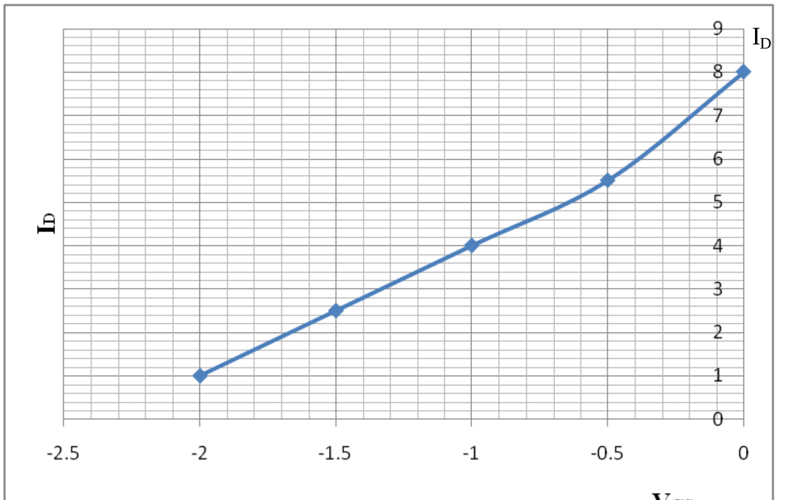


Fig.e

We now draw two characteristics of a JFET. They are *static characteristics* or *common source characteristics* or *drain characteristics* and *transfer characteristics*. The common source characteristics is the graph between drain current I_D and drain-source voltage V_{DS} for constant gate-source voltage V_{GS}. We can draw a family of curves for different gate-source voltages as shown in fig.d.

The region OA of the graph is called the ohmic region in which the current is proportional to the voltage V_{DS}. In the curve region AB the current changes at inverse square law rate. The point B is called the *pinch-off point*. The voltage corresponding to it is called the pinch-off voltage and is denoted as V_{PO}. The region BC is called the *pinch-off region* (C is the point at which the current again increases sharply nearly 20 V, which is not shown in the graph) or *saturation region* or *amplifier region*.

Transfer characteristics is the graph between the drain current I_D and the gate-source voltage V_{GS} as shown in fig.e. The transfer characteristic is obtained from the drain characteristics. For a constant V_{DS} we get different values of I_D corresponding to different values of V_{GS}.

To do the experiment, connections are made as shown in the fig.c. Keep V_{GS} constant, say zero and measure the drain current I_D for different V_{DS}. A graph is drawn between I_D and V_{DS}. Repeat the experiment for different negative voltages for gate and the family of curves is drawn on the same graph paper.

From the drain characteristics (or from the same observations for drain characteristics) we get I_D for different V_{GS}. Draw the graph between I_D and V_{GS}.

To find the FET parameters r_d, g_m and μ: The FET parameters are *a c drain resistance* r_d, *Transconductance* g_m, and the *Amplification factor* μ. They are defined as follows.

When JFET is operating in the pinch off region,

$$\textit{a c drain resistance } r_d = \left(\frac{\Delta V_{DS}}{\Delta I_D}\right)_{V_{GS}}$$

It is the slope of the drain characteristics in the pinch-off region.

$$\textit{Transconductance } g_m, = \left(\frac{\Delta I_D}{\Delta V_{GS}}\right)_{V_{DS}}$$

It is the slope of the transfer characteristic. Its unit is siemen.

$$\textit{Amplification factor } \mu = \left(\frac{\Delta V_{DS}}{\Delta V_{GS}}\right)_{I_D}$$

It can be proved that, $\mu = r_d \times g_m$

- Pins near the projection are either source or body. Using multi-meter check the continuity of pin connected to the body and identifies it. Then the other one is source. In the clockwise direction drain and gate.
- Practically we can find out the FET parameters near the pinch-off region (curved region AB).

Observation and tabulation

To draw drain characteristics

V_{DS} volt	Drain current I_D in mA for V_{GS} =				
	0 V	0.5 V	1 V	1.5 V	2 V
0					
0.5					
1					
1.5					
2					
2.5					
3					
3.5					
4					
4.5					
5					
5.5					
6					
6.5					
7					
7.5					
8					

To draw transfer characteristic

Constant V_{DS} volt	Drain current I_D in mA for V_{GS} =				
	0 V	0.5 V	1 V	1.5 V	2 V

Result

The characteristics of FET are drawn and the FET parameters are determined.

Drain resistance r_d = ……… ohm

Transconductance, g_m = ……… mho

Amplification factor, μ = ………