LMC ELECTRONICS

Ph. 09760096161

11/10/25/1-A, RAM NAGAR, NAWAL GANJ,
NUNHAI ROAD, AGRA-282006

- **Read instruction manual carefully.**
- **The graphical variations shown are exemplary and the numerical values may differ.**
- **Connect the circuit step by step as written in the procedure.**
- **Check the circuit again carefully before switching ON the power supply.**

OPERATING INSTRUCTIONS MANUAL FOR THE STUDY OF TRANSFORMER COUPLED (TC) AMPLIFIER

MODEL: LMC-141

Connection leads Red-10 & Black-3 (2mm)

TRANSFORMER COUPLED AMPLIFIER

OBJECT: - To study two-stage transformer coupled amplifier.

APPARATUS: - **Experimental Board, Digital multimeter, Connection leads Red-10 and Black-3 (2mm).**

THEORY: - In transformer coupling the ac output of stage-1 across the primary (Lp) of the coupling transformer is inductively coupled to the base of the stage-2 through the secondary (Ls) of the transformer. The final output of the stage-2 is delivered to the secondary of the output transformer at O_2. Rest of the circuit is like R-C coupled amplifier.

The fig (1) shows the Transformer – Coupled amplifier.

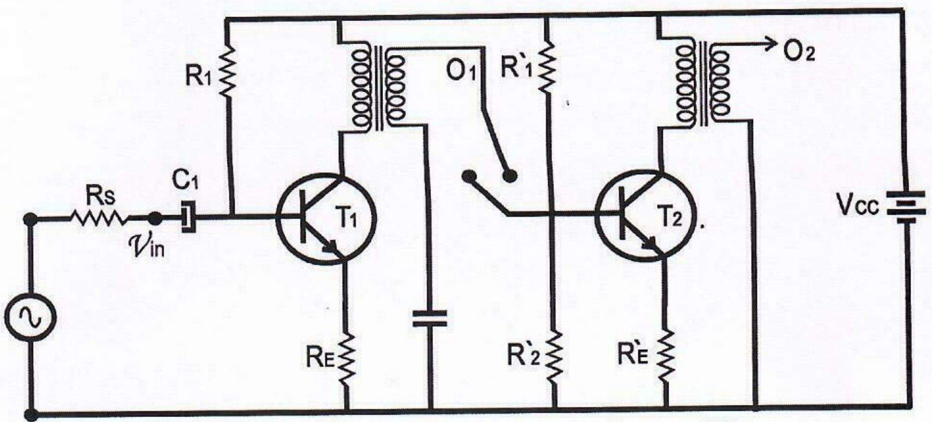


Fig (1): Transformer coupled amplifier.

The loads R_C of stage-1 and stage-2 are replaced by the primaries of transformers; therefore the collectors of the transistors are practically at + Vcc level due to low ohmic resistance of inductance of primary Lp. This results into low power loss but the frequency response is markedly effected. The factors controlling the frequency response and the amplifier gain are:

1. Inductances of primary and secondary (L_p, L_s).
2. The turns ratio of transformers (N_s / N_p).
3. The equivalent values of inductance L_{eq} and capacitance C_{eq} arising due to windings. At high frequencies seriesing of L and C and their reflected values from secondary to primary become important. It may written as:

$$L_{eq} = L_p + \left(\frac{N_p}{N_s}\right)^2 L_s \ldots (1a) \qquad C_{eq} = C_p + \left(\frac{N_p}{N_s}\right)^2 C_s \ldots (1b)$$

As a result a series resonant frequency f_O is given by relation:

$$f_O = \frac{1}{2\pi\sqrt{L_{eq}\,C_{eq}}} \ldots (2)$$

Consequently the upper cut off frequency f_2 (-3dB) is greater than f_0 and a resonant hump is present at high frequency.

The mutual coupling between Ls & Lp is given by $M = \sqrt{L_s L_p}$ and capacitance $C = (C_S + C_P)$. Hence a resonant hump occurs due to M and C.

The hump frequency f_h is given by relation: $$f_h = \frac{1}{2\pi\sqrt{MC}} \quad \ldots (2a)$$

It may be shown that the mid frequency gain is also effected by turns ratio (Np/ Ns). It is given by relation:

$$A_v = \frac{V_{b2}}{V_{b1}} = \frac{(h_{fe})1}{2}\left(\frac{N_p}{N_s}\right)\frac{(h_{ie})2}{(h_{ie})1} = \frac{(h_{fe})1}{2}\left(\frac{N_p}{N_s}\right) \ldots (3)$$

where terms have usual meaning and $(h_{ie})1 = (h_{ie})2$ for two similar transistors.

At low frequencies, the load offered by Lp and that reflected from secondary is small. This makes gain quite poor at low frequencies. The shunting effect of input and output reflected impedances may be written as:

$$Z_1 = \frac{1}{(h_{oe})1}, \quad Z_2 = \left(\frac{N_p}{N_s}\right)^2 (h_{ie})2$$

Therefore the resultant effective impedance Z is given by $\frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2}$

$$\therefore Z = \frac{\frac{1}{(h_{oe})1} \times \left(\frac{N_p}{N_s}\right)^2 (h_{ie})2}{\frac{1}{(h_{oe})1} + \left(\frac{N_p}{N_s}\right)^2 (h_{ie})2} \ldots (4)$$

The reactance of Lp at lower cut off frequency f_1 (-3dB) should be equal to Z, i.e.

$$2\pi f_1 L_p = Z \qquad \therefore f_1 = \frac{Z}{2\pi Lp} \ldots (4a)$$

Evidently f_1 depends upon Z and Lp.

The specific features make transformer coupling advantageous and disadvantageous at different places.

<u>Advantages</u>: (i) Low power loss. (ii) Higher voltage gain.
(iii) Power delivery at output is convenient by impedance matching by controlling transformer turns ratio.
(iv) Useful at higher frequencies.
(v) The resonant hump may be shifted by shunting Lp & Ls by capacitors.

<u>Disadvantages</u>:
(i) Frequency response is poor. (ii) Low frequency transformers are costly.
(iii) Presence of transformer hum. (iv) Presence of resonant humps.

PROCEDURE: - Proceed to study the amplifier in following steps:

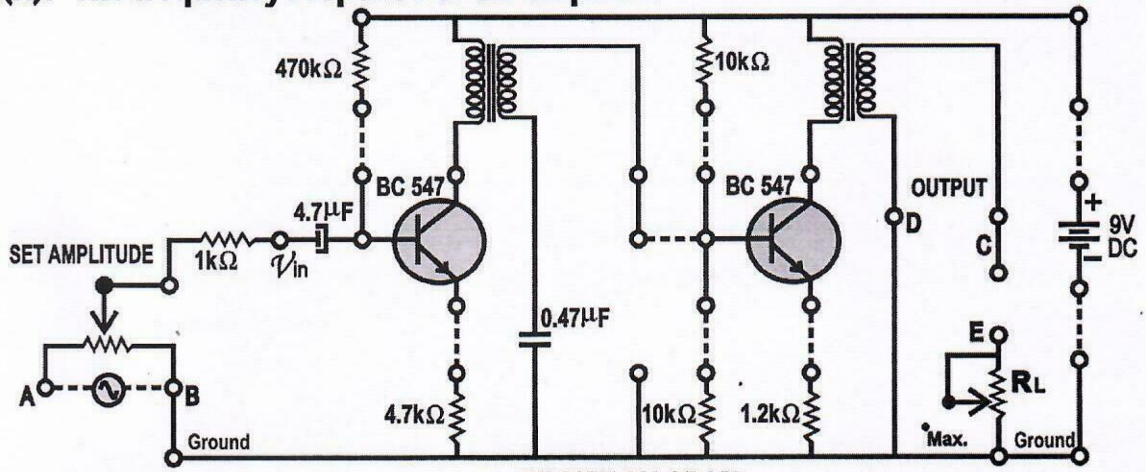
STEP (A):- The frequency response of the amplifier.

STEP (B):- Output impedance (Z_{out}) of the amplifier at different frequency steps.

- ➢ Keep power switch in off position.
- ➢ Remove all the connections, if any, on the exp. board.

NOTE:- The variations shown in graphs are exemplary & the numerical values may differ due to physical conditions and individual's working.

STEP (A):- The frequency response of the amplifier.



CIRCUIT DIAGRAM

1. The oscillator and the AC millivoltmeter are given on the experimental board. Connect terminals A-A, B-B(ground). Connect terminals 1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 7-7 and 8-8. Do not connect terminals C & E.
2. Switch on the power.
3. Set oscillator at 1 kHz frequency and connect AC millivoltmeter at input terminals (**V_{in}**) and D(ground).

NOTE: To measure below 1 volt readings, use range switch (SW) given with AC Millivoltmeter.

4. Keep range switch SW pressed (1 Vp-p) and adjust input voltage (**V_{in}**) at 600mV (0.6V) by using set amplitude pot and record it. Keep this value of V_{in} constant in subsequent measurements at different frequency steps.

$$V_{in} = \ldots \text{ mV} = \ldots \text{ V}$$

5. Connect AC millivoltmeter at output terminals C & D(ground). Now measure and record output voltage V_{out} (volt).
6. Repeat steps 4 and 5 for other frequency steps (2kHz, 3kHz....40kHz) to investigate the frequency response.
7. Calculate voltage gain of amplifier by following relation for each frequency step:

$$A = \frac{V_{out}\text{(volt)}}{V_{in}\text{(volt)}} = \ldots$$

8. Calculate the decibel voltage gain A_{dB} by following relation for each value of A:

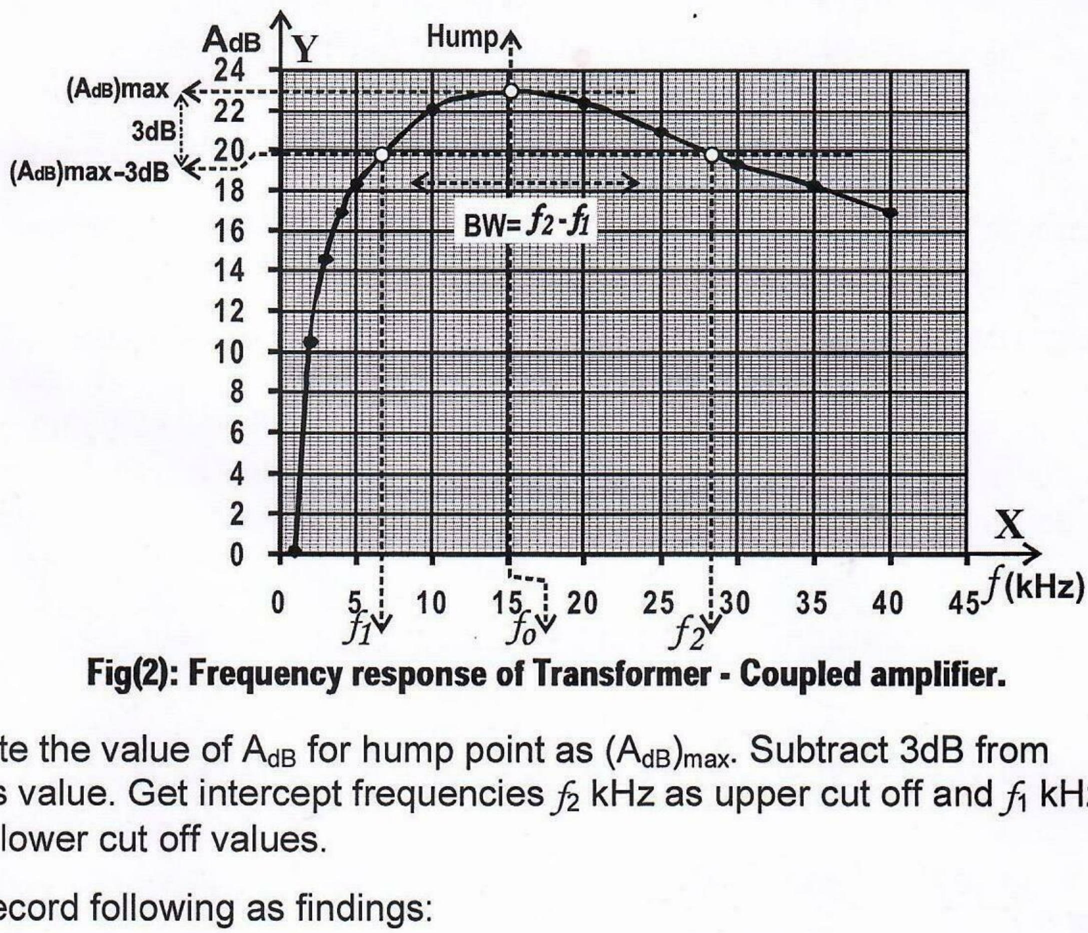
$$A_{dB} = 20(\log_{10} A)...$$

9. Record the measured & calculated values in following table (1).

Table(1): Record input voltage V_{in}, output voltages V_{out}, voltage gain A and decibel voltage gain A_{dB} with frequency f.

Sl. no.	frequency steps f(kHz)	constant input voltage V_{in} (volt)	Output voltage V_{out} (volt)	Gains	
				A	A_{dB}

10. Take frequency steps in kHz on X-axis and decibel voltage gain A_{dB} on Y-axis. Plot a frequency response of type shown in fig (2) by using records in table(1).



Fig(2): Frequency response of Transformer - Coupled amplifier.

11. Note the value of A_{dB} for hump point as $(A_{dB})_{max}$. Subtract 3dB from this value. Get intercept frequencies f_2 kHz as upper cut off and f_1 kHz as lower cut off values.

12. Record following as findings:

(a) Hump frequency f_0 =... kHz.

(b) Upper cut off frequency f_2 =... kHz.

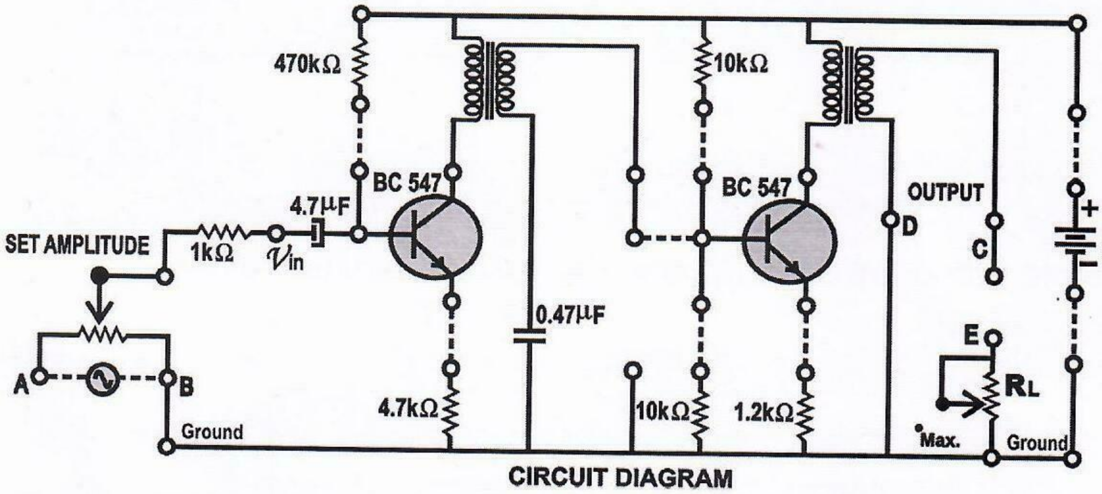
(c) Lower cut off frequency f_1 =... kHz.

(d) Bandwidth BW =($f_2 - f_1$) =... kHz.

PROCEDURE: -

STEP (B):- Output impedance (Z_{out}) of the amplifier at different frequency steps.

- **Keep power switch in off position.**
- **Remove all the connections, if any, on the exp. board.**



CIRCUIT DIAGRAM

1. The oscillator and the AC millivoltmeter are given on the experimental board. Connect terminals A-A, B-B(ground). Connect terminals 1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 7-7 and 8-8. Do not connect terminals C & E.
2. Switch on the power.
3. Set oscillator at 5 kHz frequency and connect AC millivoltmeter at input terminals (**V_{in}**) and D(ground).

NOTE: To measure below 1 volt readings, use range switch (SW) given with AC Millivoltmeter.

4. Keep range switch SW pressed (1 Vp-p) and adjust input voltage (**V_{in}**) at 600mV (0.6V) by using set amplitude pot and record it. Keep this value of V_{in} constant in subsequent measurements at different frequency steps.

   V_{in} = ... mV = ... V

5. Connect AC millivoltmeter at output terminals C & D(ground).

   Now measure and record output voltage **V_{out} = ...V.**

6. Keeping **R_L** at its maximum (max) position connect terminal C to E to include the variable **R_L** in the output.
7. Change the value of **R_L** so that output voltage becomes half, i.e. V_{out} / 2.
8. Disconnect terminals C & E. Use a digital multimeter at resistance range across **R_L** terminals and record the value of **R_L** at which the output voltage becomes V_{out} / 2.
9. Repeat steps from 3 to 8 for following frequency steps:

   10 kHz, 15kHz, 20kHz and 25kHz,

10. Record observations in table (2):

Table (2): Variation of Z_{out} in kΩ with frequency in kHz.

Sl. no.	f kHz	V_{out} Without R_L	V_{out} / 2 With R_L	The value of R_L in kΩ to make V_{out} / 2 $R_L = Z_{out}$

11. To find the output impedance (Z_{out}) at hump (f_0) take frequency steps on X-axis and Z_{out} values on Y-axis.
Plot a graph as shown in fig. (3) using table (2):

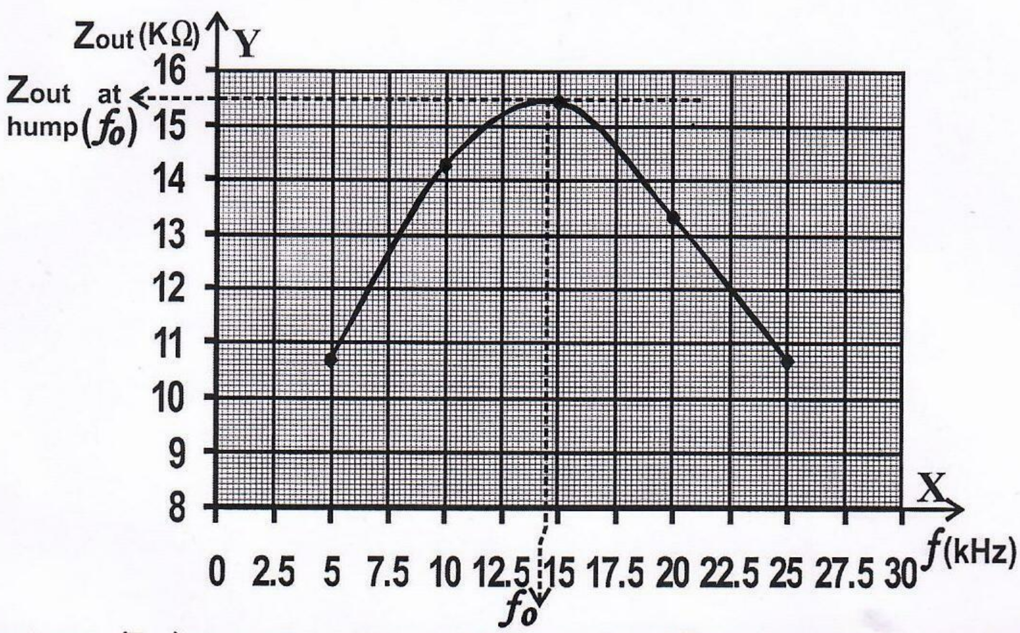


Fig (3): Impedance (Z_{out}) response at different frequencies of Transformer - Coupled amplifier.

12. (i) Note that the delivery of power is frequency dependant.

(ii) The output impedance Z_{out} = ... kΩ at the f_0 =... kHz

Additional Exercise: - (i) The frequency response of single stage transformer coupled amplifier may be studied by decoupling two stages.

(ii) Repeat the procedure for only one stage. Compare the results.