LMC ELECTRONICS

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- **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 SINGLE STAGE R-C COUPLED COMMON BASE AMPLIFIER WITH & WITHOUT FEEDBACK

MODEL: LMC-139

Connection leads Red-9 & Black-3 (2mm)

OBJECT: -To study the single stage R-C coupled common base voltage amplifier with & without feedback and current buffer.

APPARATUS: - Experimental Board, connection leads Red-9 & Black-3 (2mm).

BASIC INFORMATION: - The common base or grounded base amplifier is used as current buffer or voltage amplifier. In this case the emitter terminal serves as the input, the collector terminal as the output and the base terminal as common to both. The basic common base circuit with an NPN transistor is shown in fig. (1).

The forward bias on emitter and the reverse bias on collector provide following basic features of common base configuration:

1. Low input impedance (r_i).
2. Practically unit current gain (α, h_{fb}).
3. The high output impedance (r_O).
4. The high voltage gain (A_V).

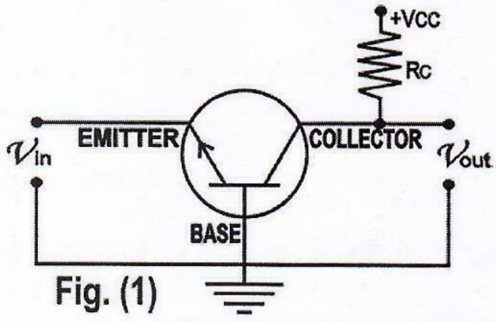


Fig. (1)

The common base amplifier is rarely used at low frequency. However it is popularly used in high frequency amplifiers at VHF and UHF because its input capacitance does not suffer from Miller effect and due to high isolation between the input and the output. The lack of feedback from output to input leads to high stability of the amplifier.

For voltage amplification the collector bias resistor R_C controls the range of output voltage swing. The large value of R_C is required for large voltage gain; but the DC voltage drop across R_C becomes large and thereby V_{CB} becomes smaller and results into distorted output wave. To avoid this situation an active load is used in place of R_C. The DC voltage drop across the active load is of fixed low value which is much smaller than the DC voltage drop for comparable gain by using R_C. In this way an active load imposes less restriction on the output voltage. The R_C does not effect the use of the circuit as current buffer; however it effects the output resistance. Because of the current division, the value of R_C must be much larger than the output load R_L for its use as buffer. The active load provides high ac resistance without serious impact upon the amplitude of output signal swing.

The potential divider formed by resistors R_1 & R_2 with source V_{CC} provides necessary operating bias to emitter-base circuit in accordance with relation:

$$V_{BE} = \left(\frac{V_{CC}}{R_1 + R_2}\right) R_2$$

A bye pass capacitor (C) across R_2 essentially stabilizes V_{BE}. Consequently the frequency response with capacitor slightly improves over the response without capacitor. Of course the nature of responses with capacitor and without capacitor is the same. The higher cutoff frequency increases with capacitor as compared to one without capacitor. It may be observed by plotting frequency responses on the same graph.

On the basis of above consideration an experimental circuit is shown in fig. (2) to study voltage amplifier and current buffer:

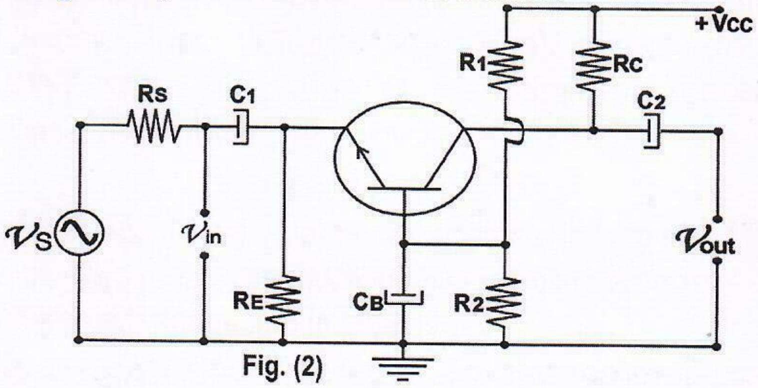


Fig. (2)

PROCEDURE: Perform the experiment in following two parts:

(A) Frequency response of the common base amplifier.

(B) Common base amplifier circuit as current buffer.

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

(A) Frequency response of the common base amplifier.

☞ **Keep power switch in off position.**

☞ ***Remove all the connections, if any, on the exp. board.***

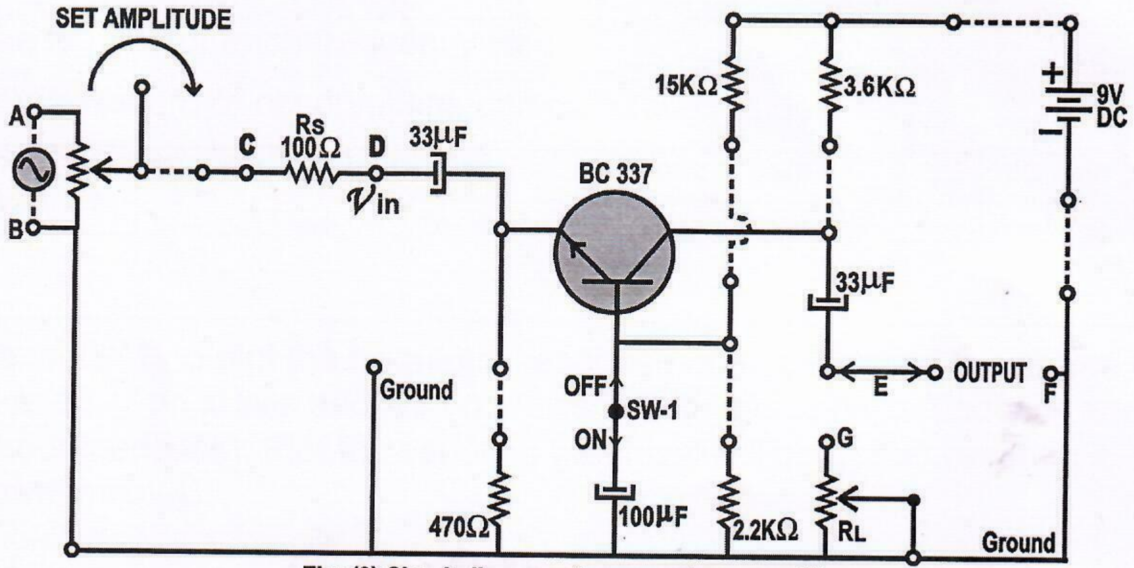


Fig: (3) Circuit diagram of common base amplifier

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 and 7-7. Do not connect terminals E-G.
2. Keep switch (SW-1) in ON position. The switch (SW-1) ON means capacitor (C_B) connected to ground (without feedback amplifier) and OFF means capacitor (C_B) disconnected (with feedback amplifier). Switch on the power.
3. Set oscillator at 1 kHz frequency and connect AC millivoltmeter across output terminals E & F(ground). Adjust output voltage (V_O) at 6V by using set amplitude pot and record it.

NOTE: To measure below 500 mV readings, use meter range switch (SW).

4. Now connect AC millivoltmeter between point D ($\mathcal{V}_{in}$) & ground terminal. Measure and record input voltage ($\mathcal{V}_{in}$) in mV by pressing the meter range switch **(SW)**. Keep this value of $\mathcal{V}_{in}$ constant in subsequent measurements at different frequency steps.

$$\mathcal{V}_{in} = \dots \text{ mV} = \dots \text{ V}$$

5. (i) Set frequency at 100 Hz. Adjust V_{in} at the value determined in step (4). Measure output voltage as $\mathcal{V}_{O(\text{with CB})}$ by connecting AC millivoltmeter across output terminals E & F(ground) and record in table (1).
   (ii) Switch off SW-1 and again measure & record output voltage as $\mathcal{V}_{O(\text{without CB})}$.
   (iii) Now switch on SW-1 for next frequency step.
6. Repeat step (5) for other frequency steps given on the exp. board.
7. Calculate voltage gain ($A_{(\text{with CB})}$ & $A_{(\text{without CB})}$) and the corresponding decibel (dB) voltage gain ($A_{dB(\text{with CB})}$ & $A_{dB(\text{without CB})}$) for each frequency step by following pairs of relations in both cases and record in table (1):

$$A_{(with\,CB)} = \frac{\mathcal{V}_{O(with\,CB)}\,(volt)}{\mathcal{V}_{in}\,(volt)} \qquad A_{dB(\text{with CB})} = 20\log_{10} A_{(\text{with CB})}$$

$$A_{(without\,CB)} = \frac{\mathcal{V}_{O(without\,CB)}\,(volt)}{\mathcal{V}_{in}\,(volt)} \qquad A_{dB(\text{without CB})} = 20\log_{10} A_{(\text{without CB})}$$

8. Take $\log_{10} f$ for each frequency step.

Table (1): Record of observations and calculated values.

Sl. no.	$\mathcal{V}_{in}$ volt	f Hz	$\log_{10} f$ -	output voltage		voltage gain		dB gain	
				$\mathcal{V}_{O(\text{with CB})}$	$\mathcal{V}_{O(\text{without CB})}$	$A_{(\text{with CB})}$	$A_{(\text{without CB})}$	$A_{dB(\text{with CB})}$	$A_{dB(\text{withoutCB})}$

9. Use table (1) to plot the frequency response of amplifier and to analyse it. Take $\log_{10} f$ on x-axis and A_{dB} on y-axis in both cases (with feedback and without feedback). Plot the variation graphically. The typical variation is shown in fig (4).

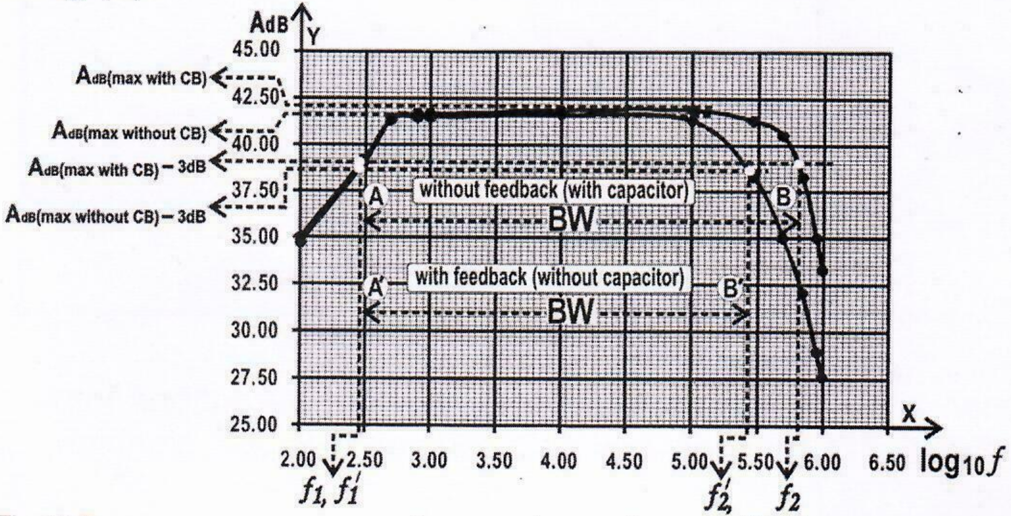


Fig.(4) Frequency response curve of common base voltage amplifier $\log_{10} f$ versus A_{dB}.

10. Record the values of $A_{dB(max)}$ from the plotted graph. Now label dotted lines for dB values = $A_{dB(max)} - 3dB$ in respective cases. These lines say cut the curve at points A & B. Mark $\log_{10} f_1$ for A and $\log_{10} f_2$ for B on x-axis on both curves.

Take the antilog of $\log_{10} f_1$ & $\log_{10} f_2$ to get the values of **lower** & **higher cut off frequencies** f_1 **and** f_2 respectively in both cases, i.e.

$f_1 = \log_{10}^{-1}(\log_{10} f_1)$ **=...Hz** $f_2 = \log_{10}^{-1}(\log_{10} f_2)$ **=...Hz =...kHz**

Calculate the band width (BW) of both amplifiers by following relation:

$BW_{(with\ CB)} = f_2 - f_1$ **= ...kHz** $BW_{(without\ CB)} = f_2 - f_1$ **= ...kHz**

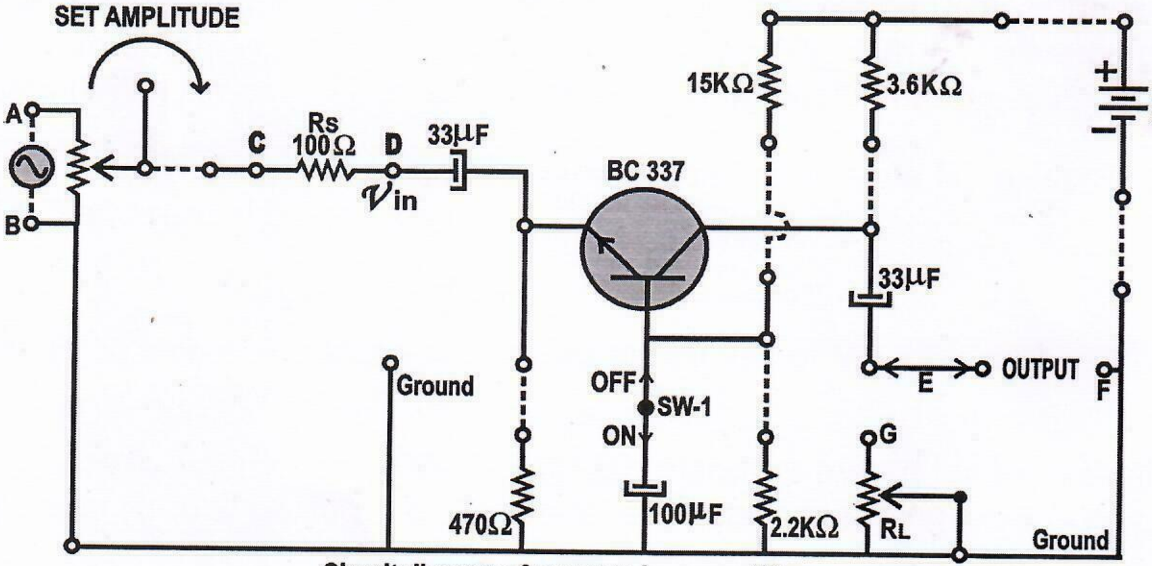
RESULTS:-

Constant value of V_{in} = ... mV									
Without feedback (with CB)					With feedback (without CB)				
$A_{dB(max)}$	Half power point $A_{dB(max)}$ - 3dB	Lower cutoff (f_1) Hz	Higher cutoff (f_2) kHz	BW ($f_2 - f_1$) kHz	$A_{dB(max)}$	Half power point $A_{dB(max)}$ - 3dB	Lower cutoff (f_1) Hz	Higher cutoff (f_2) kHz	BW ($f_2 - f_1$) kHz

(B) Common base amplifier circuit as current buffer: Evaluation of input and output impedance.

☞ **Keep power switch in off position.**

☞ ***Remove all the connections, if any, on the exp. board.***



Circuit diagram of common base amplifier

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 and 7-7. do not connect terminals E & G. keep SW-1 in ON position.

2. Switch on the power.
3. Set oscillator at 1 kHz frequency and connect AC millivoltmeter across output terminals E & F (ground). Adjust output voltage ($\mathcal{V}_O$) at 6V by using set amplitude pot and record it.

<u>NOTE:</u> To measure below 500 mV readings, use meter range switch (SW).

4. Now connect AC millivoltmeter between point D ($\mathcal{V}_{in}$) & ground terminal. Measure and record input voltage ($\mathcal{V}_{in}$) in mV by pressing the meter range switch **(SW)**.

$$\mathcal{V}_{in} = \ldots \text{ mV} = \ldots \text{ V}$$

5. (i) Connect AC millivoltmeter between terminals C & D. Measure & record the voltage drop across resistor R_S as $\mathcal{V}_{RS(\text{with CB})}$ in mV keeping **SW-1** on by pressing the meter range switch **(SW).**

   Note the value of resistor R_S between terminals C & D in ohm (Ω).

   $R_S = \ldots\ \Omega$ $\qquad$ $\mathcal{V}_{RS(\text{with CB})} = \ldots$ mV = … volt

   (ii) Now switch off **SW-1** & repeat above step 5.(i) and record observations as below:

   $R_S = \ldots\ \Omega$ $\qquad$ $\mathcal{V}_{RS(\text{without CB})} = \ldots$ mV = … volt

☞ Determine following parameters without feedback (with C_B) & with feedback (without C_B).

6. Calculate input current i_{in} by relation: $\quad i_{in}(\text{ampere}) = \dfrac{\mathcal{V}_{RS}(\text{volt})}{R_s(\text{ohm})}. = \ldots$ A = … mA

7. Calculate input impedance Z_{in} by relation: $\quad Z_{in}(\text{ohm}) = \dfrac{\mathcal{V}_{in}(\text{volt})}{i_{in}(\text{ampere})} = \ldots\ \Omega$

8. Calculate input power P_{in} by relation: $\quad P_{in} = \mathcal{V}_{in}(\text{mV}).i_{in}(\text{mA}) = \ldots\ \mu\text{W}$

9. Now connect AC millivoltmeter across output terminals E & F(ground) to measure output voltage (V_L) across load resistor (R_L) with C_B by keeping switch (SW-1) in on position and without C_B in off position as:

10. Connect terminals E-G to include variable load resistance R_L. Keep R_L at 100Ω and record the values of $V_{L(\text{with CB})}$ & $V_{L(\text{without CB})}$.

    $V_{L(\text{with CB})} = \ldots$V, $\qquad$ $V_{L(\text{without CB})} = \ldots$V

11. Vary R_L in increasing steps and record the values of $V_{L(\text{with CB})}$ and $V_{L(\text{without CB})}$ for each step of R_L.

    Since R_L varies from 100Ω to 100 kΩ; therefore record the logarithmic values of R_L in Ω i.e. $\log_{10} R_L$. Tabulate readings in following table (2):

Table (2):

Sl. no.	R_L (Ω)	$\log_{10} R_L$	$V_{L(\text{with CB})}$ (volt)	$V_{L(\text{without CB})}$ (volt)

12. Take $\log_{10} R_L$ values on X-axis and $V_{L(\text{with CB})}$ & $V_{L(\text{without CB})}$ (volt) on Y-axis from table (2) with suitable scales and plot a graph for analysis. A typical variation is shown in fig. (5).

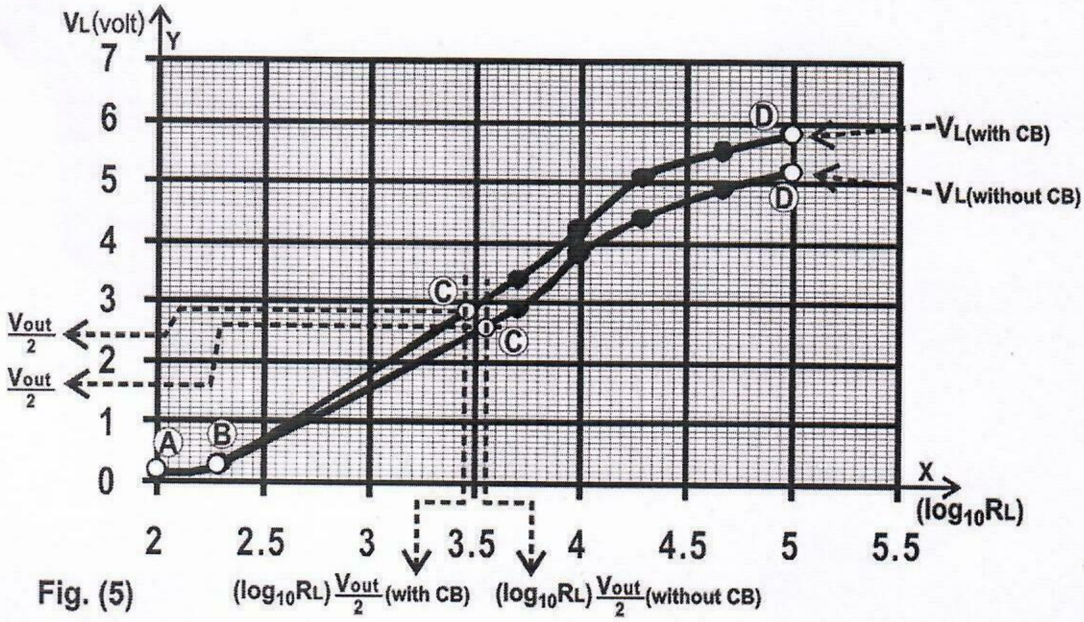


Fig. (5)

13. The open circuit output voltage $\mathcal{V}_O$ = 6V and the variation of V_L with R_L is shown in fig. (5) for R_L values from 100Ω to 100kΩ. The point A for R_L = 100Ω i.e. ($\log_{10}100 = 2$) correspond to current buffer condition.

The variation beyond point D shows that $\mathcal{V}_O$ = 6V is reachable for R_L values above 100 kΩ i.e. Z_{out} is of 100 kΩ or beyond it.

14. Note the recorded values of voltage drop across $\mathcal{V}_{RS}$ with & without CB from step (5) for resistor R_S = 100Ω at the input:

$\mathcal{V}_{RS(\text{with CB})}$ = …mV, $\mathcal{V}_{RS(\text{without CB})}$ = …mV R_S = 100Ω

Also note the values load voltage V_L with & without CB across load resistor R_L = 100Ω at the output either from table (2) or fig. (5):

$V_{L(\text{with CB})}$ = …mV $V_{L(\text{without CB})}$ = …mV R_L = 100Ω

Calculate i_{in}, i_{out} and current gain Ai by following relations for both cases:

With CB $i_{in} = \dfrac{\mathcal{V}_{RS}\,(mV)}{100\Omega}$ =… mA, Without CB $i_{in} = \dfrac{\mathcal{V}_{RS}\,(mV)}{100\Omega}$ =… mA

With CB $i_{out} = \dfrac{\mathcal{V}_L\,(mV)}{100\Omega}$ = … mA Without CB $i_{out} = \dfrac{\mathcal{V}_L\,(mV)}{100\Omega}$ =… mA

With CB $Ai = \dfrac{i_{out}}{i_{in}}$ =… Without CB $Ai = \dfrac{i_{out}}{i_{in}}$ =…

Important: (i) Note that i_{in} i_{out}. This is important feature of common base circuit.

(ii) The value of $R_S = R_L$ to use common base amplifier circuit as current buffer provided R_C is much greater than R_L.

RESULTS:- Record the determined values in following tabular form:

Constant value of $\mathcal{V}_{in}$ = … mV f = 1 kHz									
Without feedback (with CB)					With feedback (without CB)				
$\mathcal{V}_{RS}$ mV	Z_{in}	Z_{out}	P_{in} μW	$A_i \approx 1$	$\mathcal{V}_{RS}$ mV	Z_{in}	Z_{out}	P_{in} μW	$A_i \approx 1$
		Z_{out} 100 kΩ order					Z_{out} 100 kΩ order		

INFERENCES

(i) It is a high gain voltage amplifier. Its power gain is quite low.

(ii) It has wide band width (BW), low input impedance (Z_{in}) and very high output impedance (Z_{out}). The BW with C_B increases over the BW without C_B for stabilization of V_{BE}. The lower cut off is almost the same but the higher cut off increases with C_B.

(iii) It has nearly unity current gain with same phase of input and output current for R_L much smaller than R_C i.e. current buffer.

(iv) Since output voltage ($\mathcal{V}_O$) is in parallel with the voltage drop across R_C, therefore halving $\mathcal{V}_O$ method does not work to find Z_{out}. However either the graphical extrapolation beyond $\mathcal{V}_O/2$ as shown in fig. (5) or the values of almost open $\mathcal{V}_O$ and i_{out} yield Z_{out} of MΩ order.