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MIT WORLD PEACE UNIVERSITY | PUNE
TECHNOLOGY, RESEARCH, SOCIAL INNOVATION & PARTNERSHIPS

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Trimester:I **Subject:** Basics of Electrical and Electronics Engineering

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Experiment No: 4

Name of the Experiment: Measurement of transistor amplifier gain in CE configuration

Performed on: 7th January 2020

Submitted on: 11th January 2020

Aim: Measurement of transistor amplifier gain in Common Emitter (CE) configuration

Prerequisite:

- Working of transistor and its CE characteristics
- Transistor as an amplifier

Objective:

- To measure the input and output voltages and observe the waveforms at the input and output terminals of a single stage common emitter amplifier circuit
- To calculate voltage gain of the amplifier

Components and equipment required:

Transistor BC547, resistors, capacitors, function generator, connecting probes and CRO etc.

Theory:

Data sheet specification of transistor BC547:

The transistor is a three terminal device which consists of two P-N junctions. Its main utility lies in the ability to amplify weak signals. Some passive components like resistors, capacitors and biasing supply are connected to transistors to form a circuit called an amplifier. Thus, an amplifier is an electronic circuit which is capable of amplifying or increasing the level of signals.

The BC547 is an NPN epitaxial silicon transistor. The BC547 transistor is a general-purpose transistor available in small plastic packages. It is used in general-purpose switching and amplification applications. Fig. 4.1 indicates symbol and pin out diagram of BC 547. Data sheet specifications of BC 547 are given in Table 4.1. The information provided by the data sheet is useful to analyse or design a transistor circuit. In this experiment, a transistor is used in small signal audio amplifier and hence following are important set of data obtained from the datasheet:

1. Maximum allowable collector-base voltage, 2. Current gain β

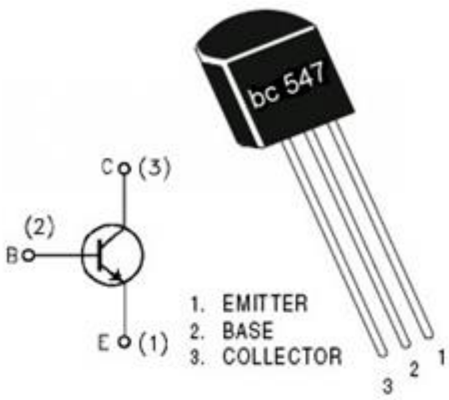


Fig 4.1: Pin out of BC 547

TABLE 4.1: Data sheet specifications

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BC546		–	80	V
	BC547		–	50	V
V_{CEO}	collector-emitter voltage	open base			
	BC546		–	65	V
	BC547		–	45	V
V_{EBO}	emitter-base voltage	open collector			
	BC546		–	6	V
	BC547		–	6	V
I_C	collector current (DC)		–	100	mA
I_{CM}	peak collector current		–	200	mA
I_{BM}	peak base current		–	200	mA
P_{tot}	total power dissipation	$T_{amb} \leq 25$ °C; note 1	–	500	mW
T_{stg}	storage temperature		–65	+150	°C
T_j	junction temperature		–	150	°C
T_{amb}	operating ambient temperature		–65	+150	°C

Working of Common Emitter Amplifier:

As the transistor has three terminals, one of the terminals is made common between input and output side and three configurations viz. CE, CB and CC are possible. Out of these, CE configuration is widely used for amplifier circuits. This configuration provides high voltage gain and current gain as compared to other configurations. All types of transistor amplifiers operate using AC signal inputs which alternate between a positive value and a negative value so some way of "pre-setting" the amplifier circuit to operate between these two maximum or peak values is required. This is achieved using a process known as biasing. Biasing is very important in amplifier design as it establishes the correct operating point of the transistor amplifier ready to receive signals, thereby reducing any distortion to the output signal. Transistor should be biased in the active region when used as an amplifier. Emitter-base junction is forward biased and collector-base junction is reverse biased. The single stage common emitter amplifier circuit shown in Fig. 4.2 uses what is commonly called 'Voltage Divider Biasing'. This type of biasing arrangement uses two resistors as a potential divider network across the supply with their centre point supplying the required base bias voltage to the transistor. Voltage divider biasing is commonly used in the design of bipolar transistor amplifier circuits. This method of biasing the transistor greatly reduces the effects of variation in transistor parameters. The quiescent base voltage (V_b) is determined by the potential divider network formed by the two resistors, R_1, R_2 and the power supply voltage V_{cc} as shown in Fig. 4.2. The voltage level generated at the junction of resistors R_1 and R_2 holds the base voltage (V_b) constant at a value below the supply voltage. Then the potential divider network used in the common emitter amplifier circuit divides the input signal in proportion to the resistance. This bias reference voltage can be easily calculated using the simple voltage divider formula below:

$$V_B = \frac{V_{CC}R_2}{(R_1+R_2)} \tag{4.1}$$

$$\beta = \frac{\Delta I_C}{\Delta I_B} \tag{4.2}$$

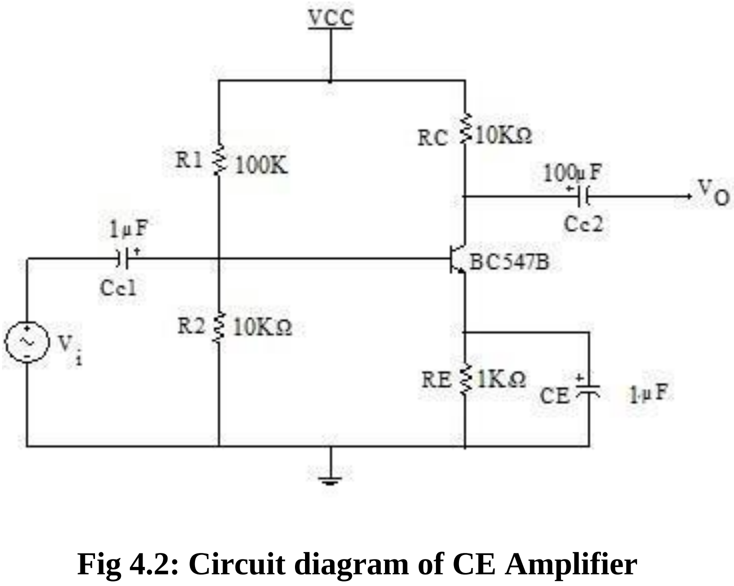


Fig 4.2: Circuit diagram of CE Amplifier

The supply voltage (V_{CC}) also determines the maximum Collector current, I_C when the transistor is switched fully 'ON' (saturation), $V_{CE} = 0$. The Base current I_B for the transistor is found from the collector current, I_C and the DC current gain beta, β of the transistor. β is sometimes referred to as h_{FE} which is the transistors forward current gain in the common emitter configuration. It has no units as it is a fixed ratio of the two currents, I_C and I_B. So a small change in the base current will cause a large change in the collector current. As the base-emitter junction is forward-biased, there will be a difference of 0.7 V between the base and emitter.

Coupling Capacitors:
In Common Emitter Amplifier circuits, capacitors C_{C1} and C_{C2} are used as coupling capacitors to separate the AC signals from the DC biasing voltage. This ensures that the bias condition set up for the circuit to operate correctly is not affected by an additional amplifier stages, as the capacitors will only pass AC signals and block any DC component. The output AC signal is then superimposed on the biasing of the following stages. The emitter bypass capacitor, C_E is connected between the emitter and ground of the transistor circuit. This capacitor is an open circuit component for DC bias meaning that the biasing currents and voltages are not affected by the addition of the capacitor maintaining a good Q-point stability. However, this bypass capacitor short circuits the emitter resistor a high frequency signals and only R_L plus a very small internal resistance acts as the transistors load increasing the voltage gain to its maximum.

Amplification Process:

When a sinusoidal input signal is applied at the input terminals of the circuit during positive half cycle, the forward bias of base emitter junction (V_{be}) is increased resulting in an increase in the base current (I_b), as a result collector current I_c increases due to which the output voltage V_{ce} decreases. Thus in a CE amplifier a positive going input signal is converted to a negative going output signal i.e, a 180° phase shift is introduced between the input and output and is an amplified version of input signal.

Voltage Amplifier Gain:

$$\text{Voltage Gain } (A_v) = \text{Output Voltage / Input Voltage} = V_{out} / V_{in} \qquad (4.3)$$

Procedure:

1. Set up the circuit as per the circuit diagram shown in Fig. 4.2.
2. Apply the supply voltage, V_{CC} = 10 V.
3. Apply ac input signal of 2V, 100 Hz frequency at the input of the amplifier from function generator.
4. Observe the output signal on the CRO and calculate V_{out}.
5. Calculate the gain of the amplifier using the relation Gain = $\frac{V_{out}}{V_{in}}$.
6. Record the readings in the observation table by varying V_{in} from 2V to 5V.
7. Draw the input and output voltage waveforms.

Observation Table:

Input (V_{in})	Output (V_{out})	Gain (V_{out}/V_{in})
50mV	620mV	620/50=12.4
60mV	730mV	730/60=12.1
70mV	860mV	860/70=12.28
80mV	1000mV	1000/80=12.5
90mV	1140mV	1140/90=12.6

Note: Students are instructed to do all the necessary calculations on separate sheets.

Conclusion:

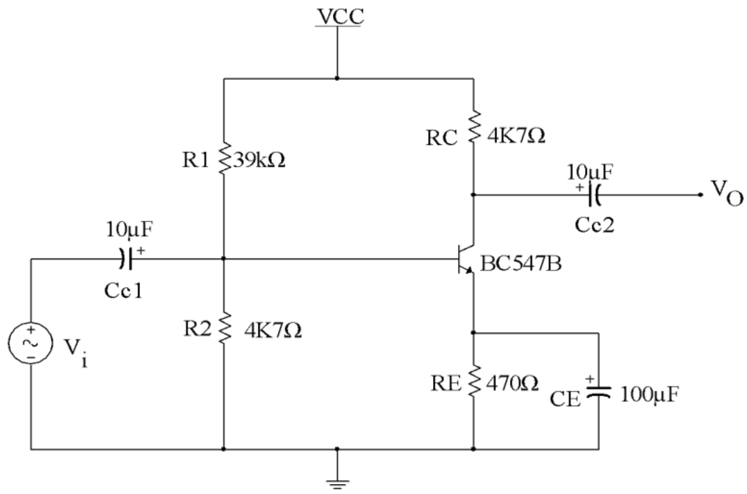
The Amplification Gain of a BJT NPN BC 547 Transistor was studied, understood and found out using observations taken from a circuit made in Tinkercad. It was found to be an average value of 12.3 for the given Transistor.

Post Lab Questions:

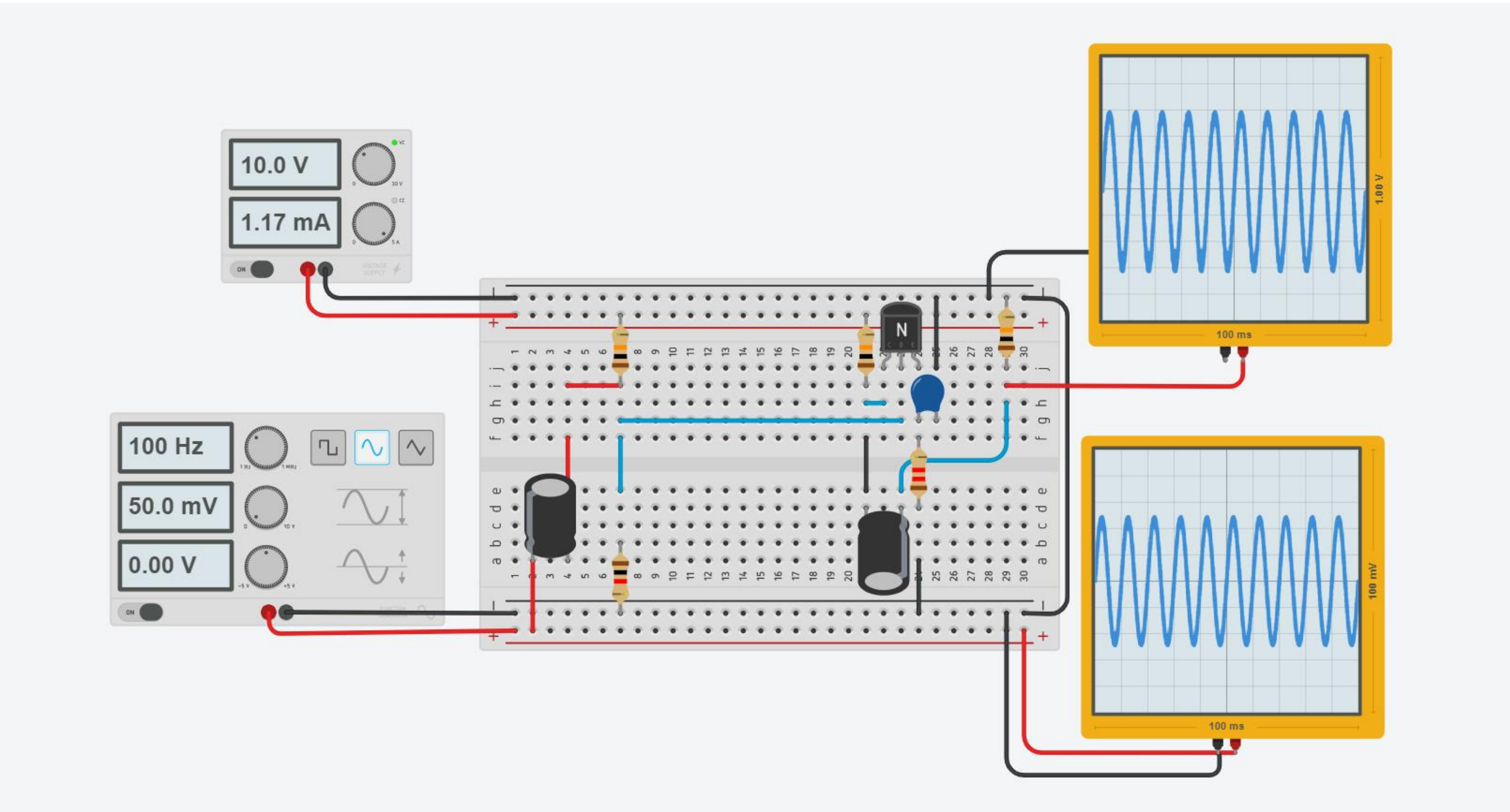
1. Which are the different operating regions of a transistor?
2. What is Voltage Amplification?
3. Why the output signal in a CE amplifier is 180°out of phase with the input?
4. What are the characteristics of a CE amplifier that make it suitable for amplification?
5. What is β for a CE configuration?

Additional links for more information:

- http://www.buildcircuit.com/darklight-sensor-using-transistor/



Tinker Cad Circuit



Component List for Tinkercad Circuit

Name	Quantity	Component
FUNC1	1	100 Hz, 0.05 V, 0 V, Sine Function Generator
P1	1	10 , 5 Power Supply
U1, U2	2	10 ms Oscilloscope
Cce	1	10 uF Capacitor
Rr1, Rrc, Rrl	3	10 kΩ Resistor
Rr2	1	1 kΩ Resistor
Rre	1	1.2 kΩ Resistor
T1	1	NPN Transistor (BJT)
Ccin, Ccout	2	1 uF, 16 V Polarized Capacitor

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Div. 9

1/10/2022

BEEE EXPERIMENT - 4

CE Amplification Circuit

(*) **Calculations**

V_{cc} = 10 V DC (---)

V_{BB} = ↑ ~~~~ 50 mV to 90 mV AC (~)

Capacitors C_1, C_2 = 1 μF

C_3 = 10 μF

R_C = 10 kΩ

R_1 = 10k Ω

R_2 = 1 kΩ

R_L = 10 kΩ

To calculate : Gain $\left(V_{out}/V_{in}\right)$

(1) Reading 1, V_{in} = 50 mV (V_{BB})

V_{out} = 620 mV

$$\text{Gain} = \frac{620}{50} = 12.4$$

(2) Reading 2, V_{in} = 60 mV (V_{BB})

V_{out} = 730 mV

$$\text{Gain} = \frac{730}{60} = 12.1$$

(3) Reading (3), $V_{in} = 70\ mV$ (V_{BB})

$V_{out} = \cancel{\#}\ 860\ mV$

$\cancel{\#}$ gain $= \frac{860}{70} = \underline{12.28}$

(4) Reading (4), $V_{in} = V_{BB} = 80\ mV$

$V_{out} = 1000\ mV$

Gain $= \frac{1000}{80} = \underline{12.5}$

(5) Reading (5), $V_{in} = V_{BB} = 90\ mV$

$V_{out} = 1140\ mV$

Gain $= \frac{1140}{90} = \underline{12.6}$

Average gain $= \frac{(12.6 + 12.5\ 12.28 + 12.1 + 12.4)}{5}$

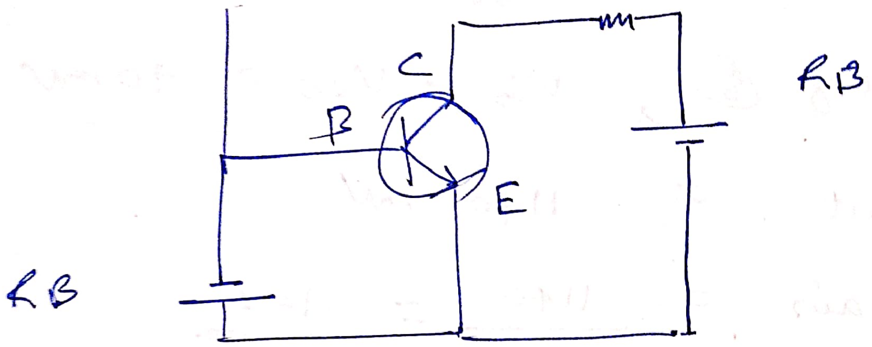
$\underline{A_V} = \underline{12.376}$

(*) Questions

Q(1) Which are the different operating regions of a transistor?

→ (1) Cutoff Region:

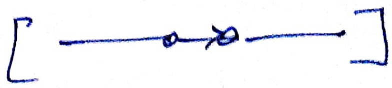
The transistor acts like an off switch. Both the Base Emitter and Base collector junctions are reverse biased.



(cutoff)

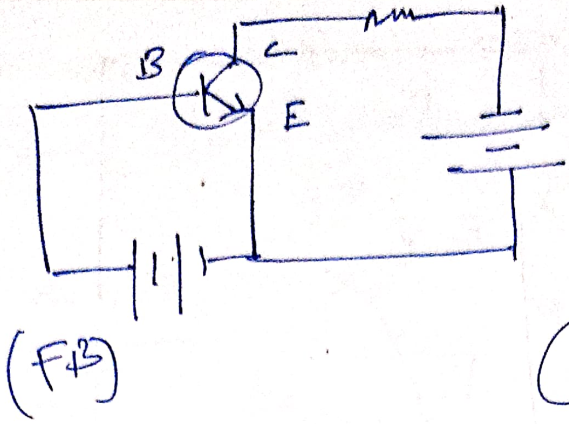
(2) Saturation Region:

Transistor acts like a closed switch and lets current flow. The Base Emitter Region as well as Base collector region is forward Biased.



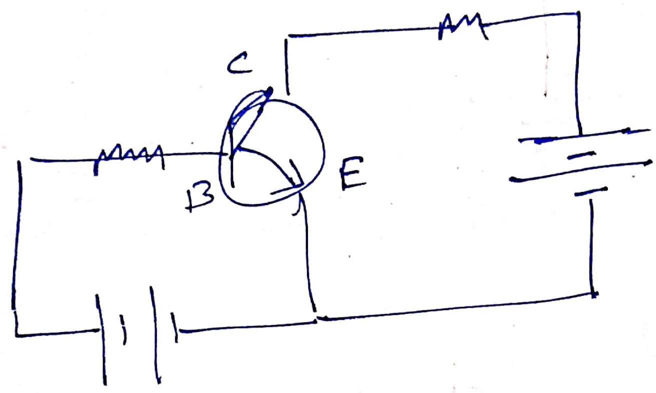
(3) Active Region:

Transistor acts as an amplifier. Base Emitter is forward Biased and Base collector is reverse Biased.

→ 

(Saturation) in CE config.

~~Q~~

→ 

Amplifier (in CE config)

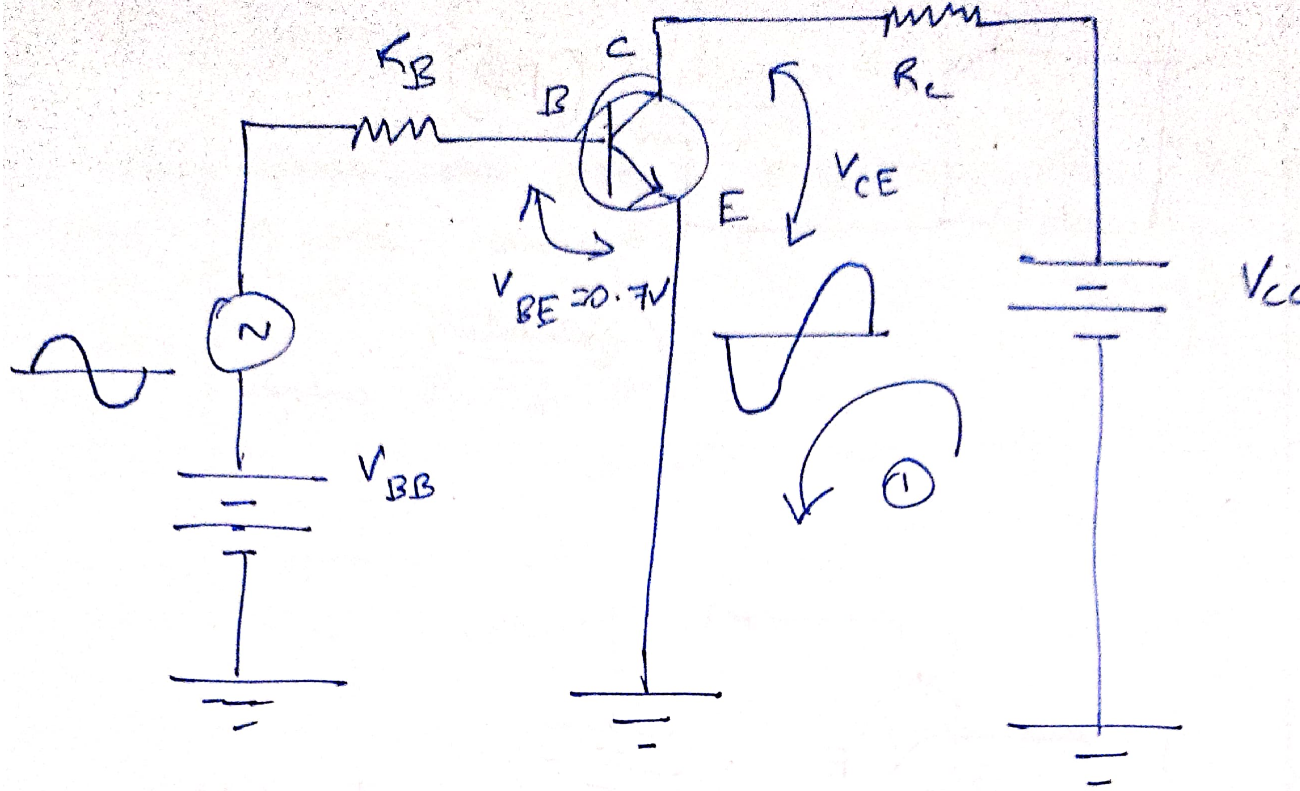
Q.2. What is voltage amplification?

→ The ratio of the output voltage or the alternating voltage produced at at the output terminals of an amplifier to the alternating voltage supplied at the input is called the voltage amplification of an amplifier.

Q.3. Why is the output signal in a CE configuration 180° out of phase from the input?

→

PTO.



In loop 1,

$$V_{CE} = V_{CC} - I_C R_C \quad \text{--- (1)}$$

From Kirchhoff voltage Rule.

But $I_C = \beta_{DC} \cdot I_B$

so if $I_B \uparrow$, $I_C \uparrow$.

But V_{CE} reduces, as I_C is substracted in eq. (1).

So if $I_B \uparrow$, $V_{CE} \downarrow$.

So $V_{CE} \propto \frac{1}{I_B}$

so ~~if~~ for every +ve I_B we have $(-V_{BE})$ and so phase is out by 180°.

Q. (4) What are the characteristics of a CE amplifier that make it suitable for an amplifier?

→ For a CE configuration,

$$I_C = \beta_{DC} \cdot I_B.$$

where β_{DC} is current amplification factor.

But for CE, voltage gain is high, as well as current gain is high.

So The Power gain of CE is better than power gains of all other configurations (CB and CC). Hence its application as an amplifier

Q (5) What is β_{DC} for a CE configuration?

$$\beta = \frac{I_C}{I_B} = \frac{\text{collector current}}{\text{Base current}}$$

for a CE configuration.