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Comparison of BW for RC Coupled Single Stage and Multi Stage Amplifiers

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Abstract— Gain plot is used for the given amplifier to know the lower cut off frequency(f1), upper cut off frequency(f2) and bandwidth(BW), which gives the range of the signals that the amplifier can process. So, in this paper we have simulated the gain for the RC coupled amplifier for single stage and multistage (two stage, three stage), to analyze band width using TINA software. The result shows that multi stage amplifiers are best suited for the applications which require a high bandwidth.

Keywords— lower cut off frequency (f_1), upper cut off frequency (f_2), bandwidth (BW)

I. INTRODUCTION

Amplification is a process of increasing the signal strength by increasing the amplitude of a given signal without changing its characteristics. An RC coupled amplifier is a part of a multistage amplifier wherein different stages of amplifiers are connected using a combination of resistor and a capacitor. An amplifier circuit is one of basic circuits in electronics [1].

An amplifier which is completely based on transistor is basically known as transistor amplifier. The input signal may be a current signal, voltage signal or a power signal. An amplifier will amplify the signal without changing its characteristics and the output will be a modified version of the input signal. Applications of amplifiers are of wide range. They are mainly used in audio and video instruments, communications, controllers, etc. The single-stage amplifier is said to have excellent frequency response and is widely used in many commercial products but MULTISTAGE amplifiers are urgently needed with the advance in technologies, due to the fact that single-stage amplifier is no longer suitable in low-voltage designs. Also, the gain of the single stage amplifier is less compared the multistage amplifiers [2].

This paper is organized in such a way that II section deals with the circuit explanation and III section deals with design of the circuit. Similarly, section IV deals with Limitations on number of stages in the amplifiers, section V the results and followed by conclusion in section VI.

II. CIRCUIT EXPLANATION

A single stage common emitter RC coupled amplifier is a simple and elementary amplifier circuit. The main purpose of this circuit is pre-amplification that is to make weak signals to be stronger enough for further amplification. If designed properly, this RC coupled amplifier can provide excellent signal characteristics.

The capacitor Cin at the input acts as a filter which is used to block the DC voltage and allow only AC voltage to the transistor. If any external DC voltage reaches the base of the transistor, it will alter the biasing conditions and affects the performance of the amplifier. R1 and R2 resistors are used for providing proper biasing to the bipolar transistor. R1 and R2 form a biasing network which provides necessary base voltage to drive the transistor in active region.The region between cut off and saturation region is known as active region. The region where the bipolar transistor operation is completely switched off is known as cut off region and the region where the transistor is completely switched on is known as saturation region.

Resistors Rc and Re are used to drop voltage of Vcc. Resistor Rc are a collector resistor and Re is emitter resistor. Both are selected in such a way that both should drop Vcc voltage by 50% in the above circuit. The emitter capacitor Ce and emitter resistor Re makes a negative feedback for making the circuit operation more stable.

Role of Capacitors in Transistor Amplifiers Regardless of the manner in which a capacitor is connected in a transistor amplifier, its behavior towards d.c. and a.c. is as follows. A capacitor blocks d.c. i.e. a capacitor behaves as an "open" to d.c. Therefore, for d.c. analysis, we can remove the capacitors from the transistor amplifier circuit. A capacitor offers reactance (= $1/2\pi fC$) to a.c. depending upon the values of f and C. In practical transistor circuits, the size of capacitors is so selected that they offer negligible (ideally zero) reactance to the range of frequencies handled by the circuits. Therefore, for a.c. analysis, we can replace the capacitors by a short i.e. by a wire. The capacitors serve the following two roles in transistor amplifiers:

1. As coupling capacitors
2. As bypass capacitors

1. **As coupling capacitors.** In most applications, you will not see a single transistor amplifier. Rather we use a multistage amplifier i.e. a number of transistor amplifiers are connected in series or cascaded. The capacitors are commonly used to connect one amplifier stage to another. When a capacitor is used for this purpose, it is called a coupling capacitor.
2. **As bypass capacitors.** Like a coupling capacitor, a bypass capacitor also blocks d.c. and behaves as a short or wire (due to proper selection of capacitor size) to an a.c. signal. But it is used for a different purpose. A bypass capacitor is connected in parallel with a circuit component (e.g. resistor) to bypass the a.c. signal and hence the name resistance RE. Since CE behaves as a short to the a.c. signal, the whole of a.c. signal (i e) passes through it. Note that CE keeps the emitter at a.c. ground. Thus for a.c. purposes, RE does not exist. We have already seen in the previous chapter that CE plays an important role in determining the voltage gain of the amplifier circuit. If CE is removed, the voltage gain of the amplifier is greatly reduced. Note that Cin is the coupling capacitor in this circuit [3].

III. CIRCUIT DESIGN

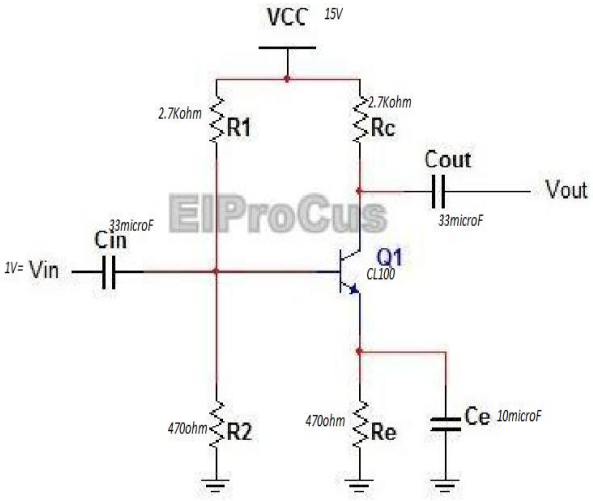

Fig 1. Single stage amplifier

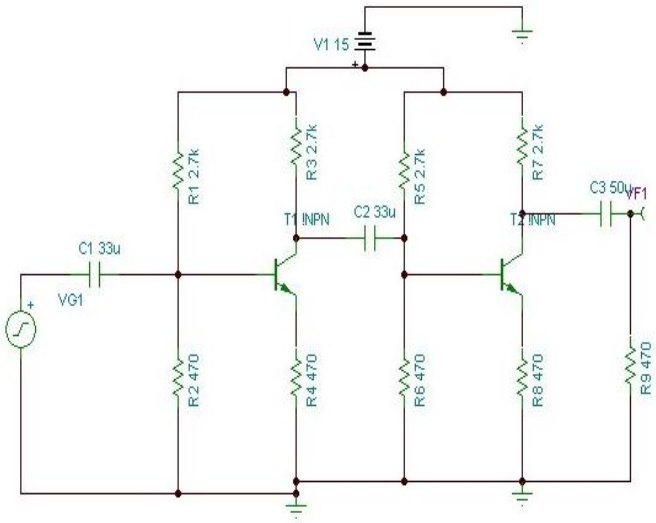

Fig 2. Double stage amplifier

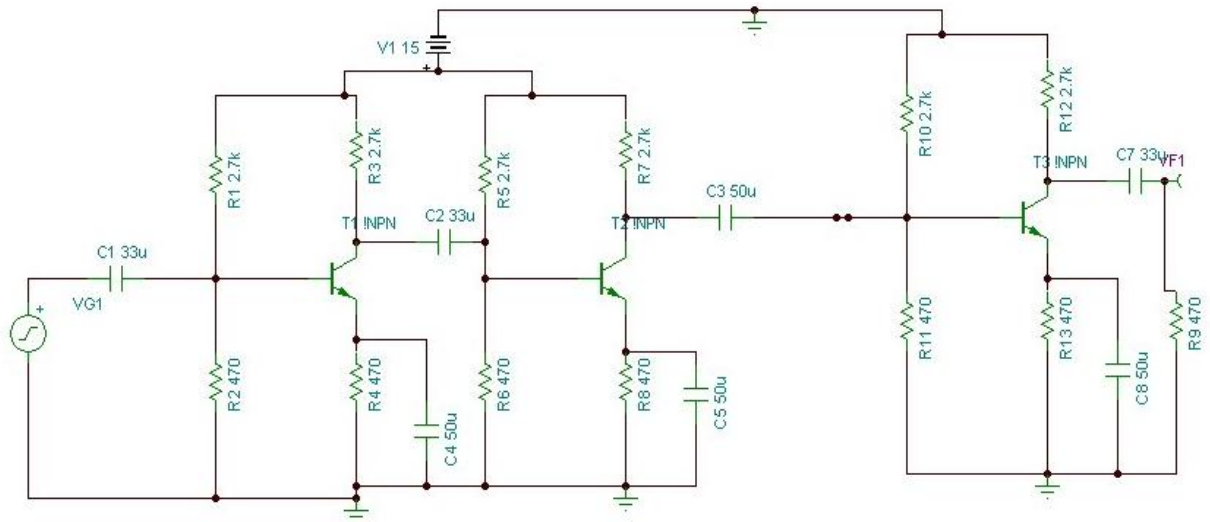

Fig 3.Three stage amplifier

Fig 1 shows the single stage amplifier and the design for the same is as below. For Single stage amplifier,

- Ve= VCC/β
- Ib=Ic/ β
- Ie=Ib+Ic
- Vbe= Vb-Ve
- Re=Ve/Ie
- Vb= VCC*R2/(R1+R2)
- β ≥10R2
- Rc=(VCC-VCE)/ Ic
- Xc=(R2/5) ; C=1/(2π *f*xc)
- Xe=(Re/5)

Fig 2 and fig 3 shows the circuit for the two stage and three stage amplifiers. These circuits are used in TINA software for simulation.

IV. LIMITATIONS ON NUMBER OF STAGES IN THE AMPLIFIERS

As shown in the results the bandwidth gets increases as the number of stages in the amplifiers increases. But issue to be considered is the optimum number of gain stages. Generally, frequency compensation techniques for three-stage amplifiers are adequate for practical purposes since three-stage amplifiers maintain a good compromise between the voltage gain (` 100 dB) and power consumption. Any extra gain stage complicates the circuit structure and increases the complexity of the frequency compensation [4].

V. RESULTS

The simulation results are shown below.

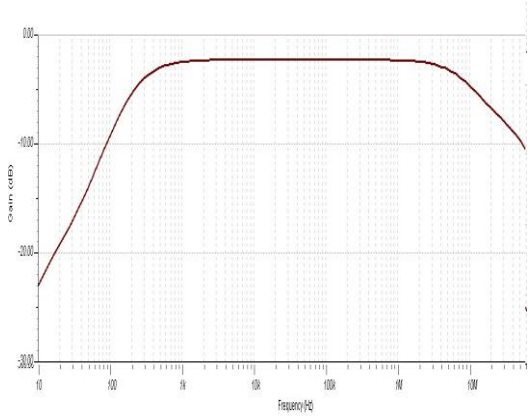

Fig 4: Frequency response of single stage

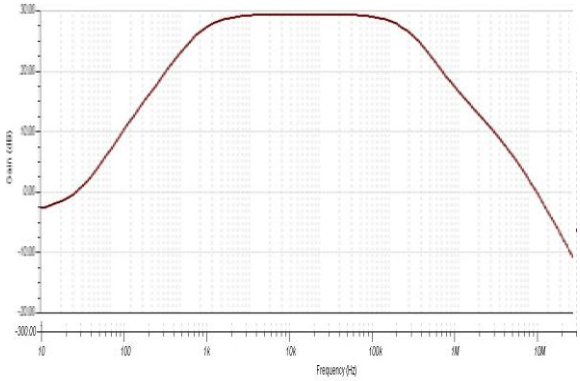

Fig 5: Frequency response of double stage amplifier

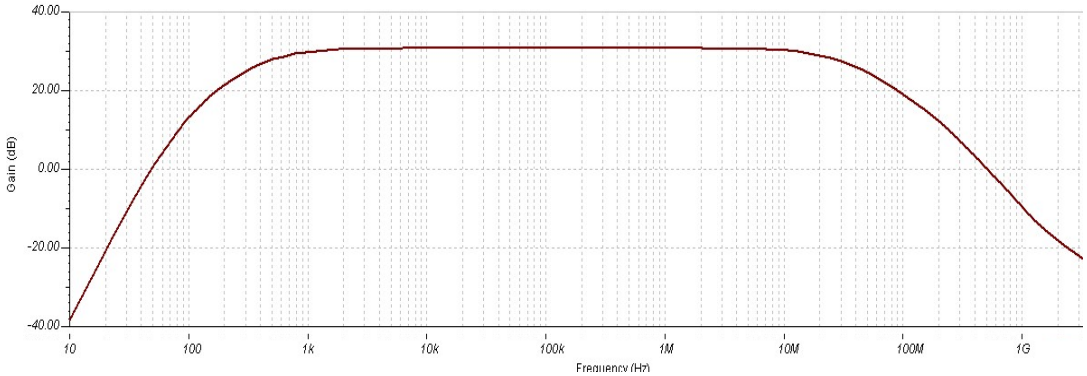

Fig 6: Frequency response of three stage amplifier

The simulated results are shown above. Fig 4, Fig 5, Fig 6 shows the gain plot for the Single stage, double stage and three stage amplifiers. It is observed that the bandwidth is greater in three stage compared to the rest.

VI. CONCLUSION

The results shows that the single stage amplifiers having a BW of 1K to 10MHz, and two stage is having a BW of 1K to 100MHz where as three stage amplifier is having a BW of 1K to 1GHz .So, it can be concluded that for the applications which need a higher BW it is necessary to use a MULTISTAGE amplifiers

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